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 taken 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 proceedures 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 are developing metrics specific to vegetation zones that currently lack IBIs. As part of this process, we are addressing 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 of 2013. Our site selection system required minor modification to better handle benchmark sites (sites of special interest for restoration or protection).

PROJECT ORGANIZATION

Figure 1 shows our project organization. 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 has been replaced by Doug Tozer. At the Michigan Department of Environmental Quality, Peg Bostwick has retired and was replaced by Anne Hokanson. No major personnel changes have taken place during this reporting period.

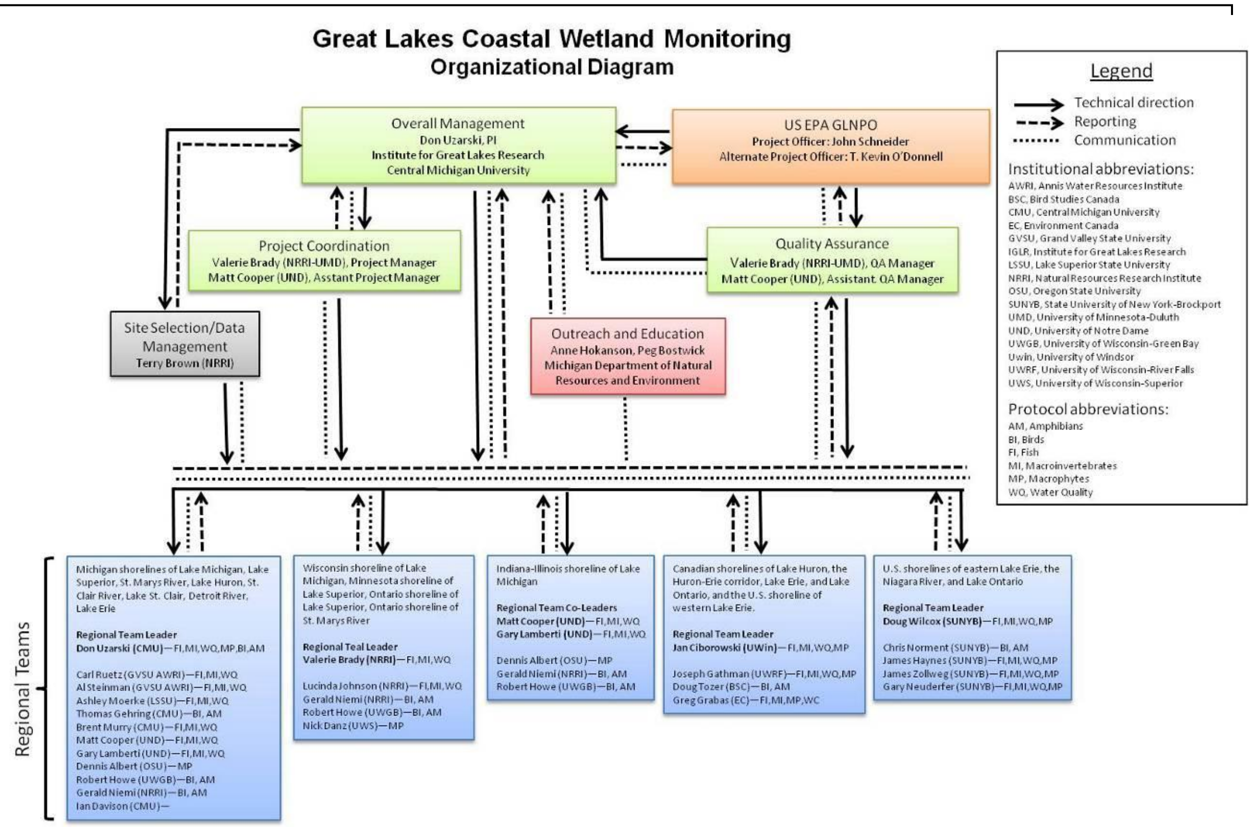

Figure 1. Organizational chart for the project showing lines of technical direction, reporting, and communication separately.

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.

Tasks	‘10	2011				2012				2013				2014				2015			
	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

Site selection was completed in March and was essentially the same as site selection for year two. 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 moderate to large (>4 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 could be sampled in 2011 and 2012 by monitoring crews, and the continuing low water levels in Lakes Huron and Michigan, the total number of sampleable wetlands may be closer to 900 rather than the initially-estimated 1000 plus.

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).

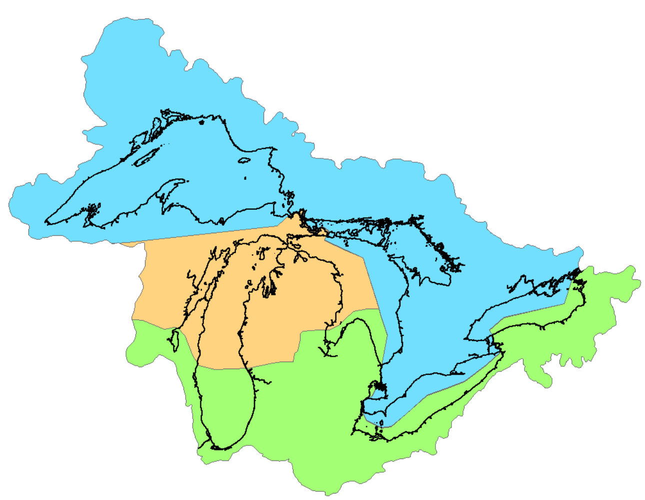

Figure 2. Divisions of lakes into regions. Note that stratification is by region *and* lake, so northern Lake Erie is not in the same region as Lake Superior, etc.

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. 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 QC'd. Users set the workflow state for sites in the web tool, although states 2 and 3 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 distribution of effort matching team 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 were 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.

2013 Site Selection

Site selection for 2013 resulted in 244 sites selected for potential sampling. Of these 244, 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. There were more than 10% benchmark sites because several teams took on additional sites at the special request of other agencies or groups (see *individual team reports* and *letters of support*). Benchmark and resample sites are sorted to the top of the sampling list because they are the highest priority sites to be sampled.

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. Because all PIs, crew chiefs, and most crew leaders had two prior years of experience, field crew training was handled by each PI at each regional location. All crew members still had to pass all training tests, and PIs still did 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 that was conducted by PIs this past spring (2013): 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 QAPP, covering site verification procedures, providing hands-on training for each sampling protocol, and going over 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 has passed all training certifications.

Training for bird and amphibian field crews included 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 were 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 successfully uploaded data for all three field seasons with only minor issues that were relatively easily resolved.

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 were responsible. Personnel who were not certified (e.g., part-time technicians, new students, volunteers) were not 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 the 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 Dr. Don Uzarski at Central Michigan University. 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 QA 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 data from field sheets. 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 on an individual basis.

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 is now nearly complete; all “raw” data are available to PIs of each taxonomic group, and most of the metric calculations have been coded into the database. 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 analysis / indicator calculation 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 are in the process of developing an ESRI ArcGIS Online-based interactive map which will allow users to visualize and download site level attributes such as IBIs and invasive species counts for wetlands basin wide. This will be an in-browser tool requiring 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.

The use of the ESRI ArcGIS Online system, with data served from ESRI's cloud services as part of an ongoing EPA / ESRI partnership, will provide indefinite post-project data availability. Database upgrades and other ongoing costs that can take unfunded single-service systems off-line will be removed from the equation; these functions will become part of ESRI's ongoing cloud services and will impose no financial or effort burden on the GLRI project.

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 (2011-2013)

A total of 176 wetlands were sampled in 2011, with 206 sampled in 2012 and 201 in 2013, for an overall total of 583 Great Lakes coastal wetlands sampled in three years (Table 5). 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, 65% of total sites sampled have been US coastal wetlands, with 80% of the wetland area sampled on the US side. Overall, we have sampled 61% of US coastal wetlands by count, and 60% of US coastal wetlands by area. With respect to the entire Great Lakes, the project has sampled 57% of coastal the wetlands or 58% by area.

Table 5. Counts, areas, and proportions of the 583 Great Lakes coastal wetlands sampled in 2011, 2012, and 2013 by the GLIC: Coastal Wetland Monitoring Project. 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%
CA total	**203**	**35%**	**18,345**	**29%**
US				
2011	126	72%	22,008	87%
2012	124	60%	21,845	73%
2013	130	65%	18,939	73%
US total	**380**	**65%**	**62,792**	**71%**
Overall Totals	**583**		**81,137**	

The sites sampled in 2013 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.

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.

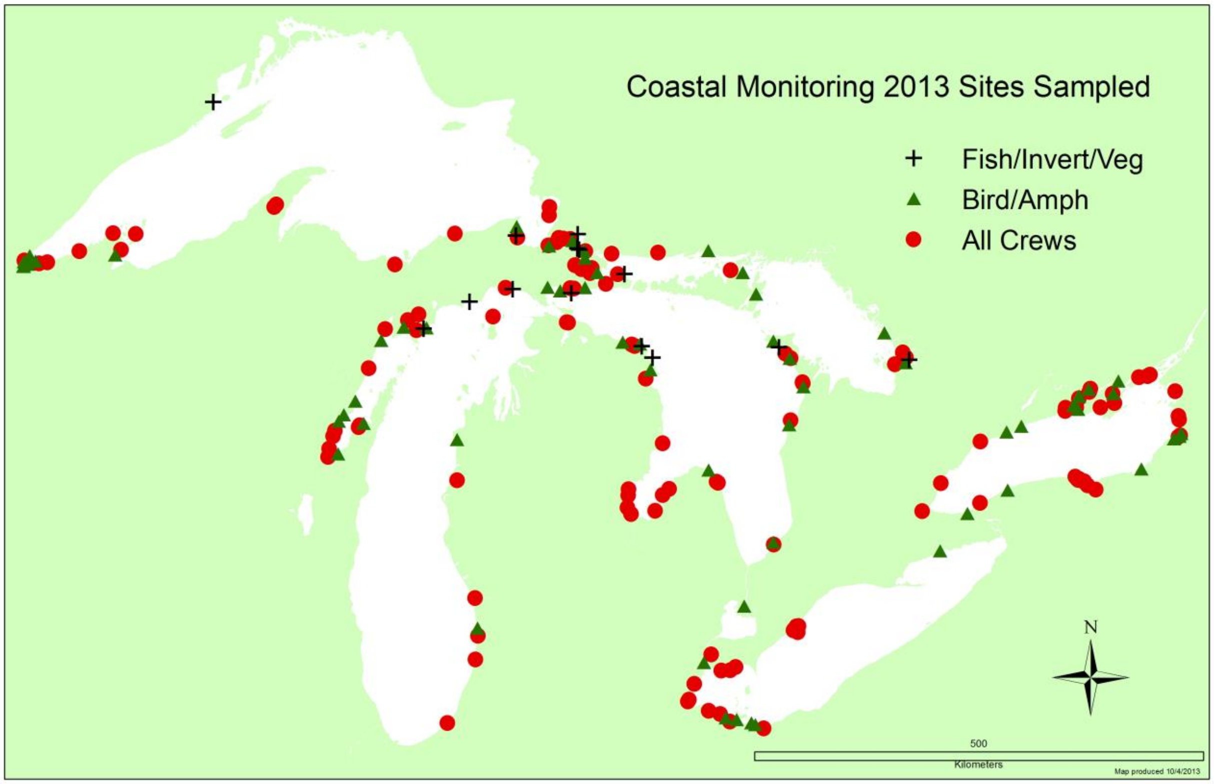

Figure 3. Locations of the 201 Great Lakes coastal wetlands sampled in 2013, color-coded by taxonomic groups. Sites assigned only to bird and amphibian crews (due to their greater sampling capacity) are shown with a green triangle.

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.

As of 2013, we have 57 sites designated as “benchmark”. Of these, 22 (39%) are to help evaluate restoration efforts and 16 (28%) are 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 too 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.

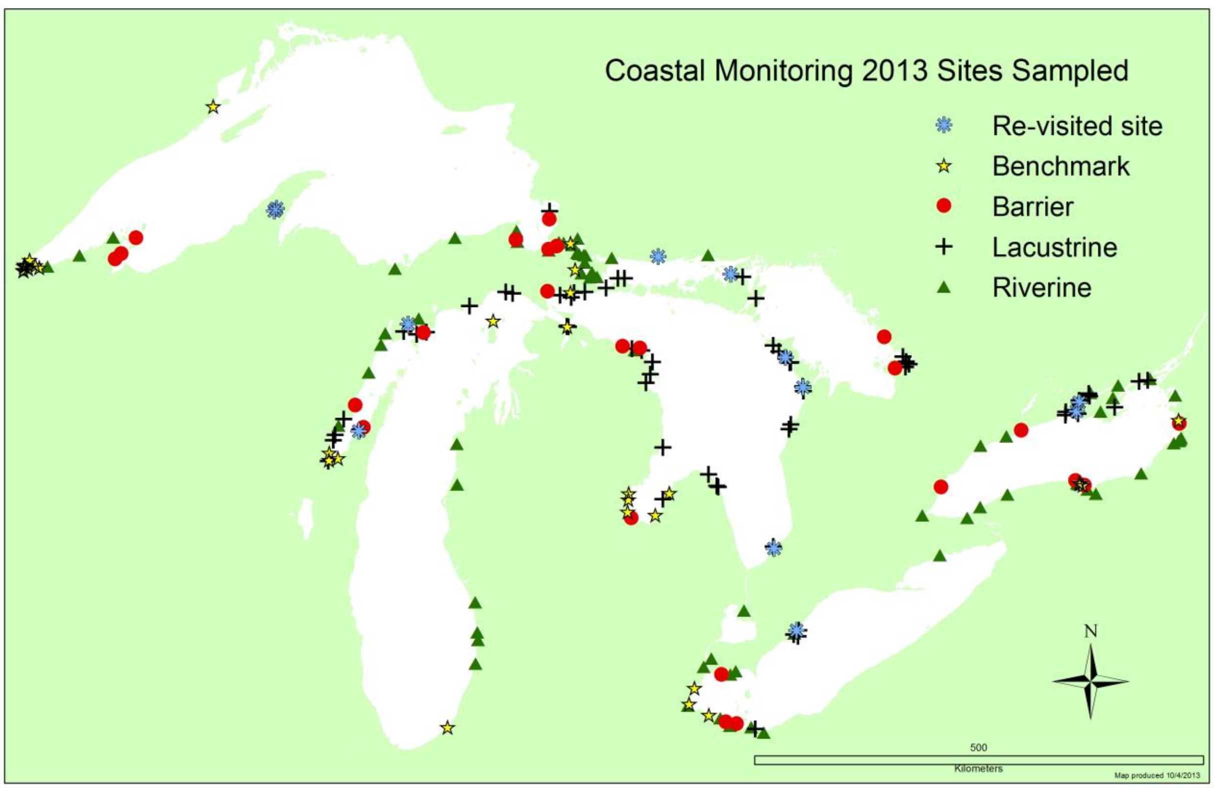

Figure 4. Locations of the 201 Great Lakes coastal wetlands sampled in 2013, color-coded by site type. Wetland types exhibit a clumped distribution across lakes due to geology and topography.

Our efforts to assist restoration efforts by providing pre- and potentially post-restoration sampling of almost all wetland biota and water chemistry were highlighted at the National

Conference on Ecological Restoration in Chicago in June. Uzarski and 3 co-PIs gave presentations highlighting CWM support of restoration projects and the numerous requests for this support that all co-PIs are receiving.

We can now compile good statistics on Great Lakes coastal wetlands because we have sampled more than 50% 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 2 species, but richness at high quality sites was as great as 60 to 70 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 wetlands containing only a single calling species (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 2013.

Country	Site count	Mean	Max	Min	St. Dev.
Birds					
Can.	168	27.0	60	7	11.3
U.S.	234	22.8	68	2	12.6
Amphibians					
Can.	165	4.2	8	1	1.7
U.S.	267	3.9	7	1	1.4

Bird and amphibian data in Great Lakes coastal wetlands by lake (Table 7) shows that wetlands on most lakes averaged 20-30 bird species, with Lake Ontario coastal wetlands averaging the fewest species. The greatest number of bird species at a wetland occurred on Lake Superior, with Lake Huron being a distant second. Lakes Erie, Ontario, and Michigan had about the same maximum number of species in 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 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. Similarly, there was little variability by lake in maximum or minimum numbers of species. Note that all wetlands had at least one calling amphibian species, and this was almost always spring peeper (*Pseudacris crucifer*).

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 in 2011, 2012, and 2013.

	Birds				Calling amphibians			
Lake	**Sites**	**Mean**	**Max**	**Min**	**Sites**	**Mean**	**Max**	**Min**
Erie	34	26.6	53	15	49	3.3	7	1
Huron	126	25.8	60	2	127	4.0	7	1
Michigan	50	25.5	51	4	60	4.1	7	1
Ontario	128	19.5	52	5	129	4.4	8	1
Superior	64	30.1	68	11	67	3.8	7	1

Means of approximately 11 and 15 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 36 (US) fish species. The average number of non-native fish species per wetland was approximately one, though some wetlands had as many as 6 (US). An encouraging sign is that there are wetlands in which no non-native fish species were caught.

Table 8. Total fish species in wetlands, and non-native species; summary statistics by country for sites sampled in 2011, 2012, and 2013.

Country	**Sites**	**Mean**	**Max**	**Min**	**St. Dev.**
Overall					
Can.	96	10.9	23	2	4.1
U.S.	203	14.7	36	2	5.6
Non-natives					
Can.	96	0.5	3	0	0.7
U.S.	203	0.7	6	0	1.0

Combining 2011 through 2013 data, there were no non-native fish species caught at 55% of the Great Lakes coastal wetlands sampled, but 30% had one non-native species captured (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 net-night, so these numbers are likely quite conservative, and wetlands where we did not catch non-native fish may actually harbor them.

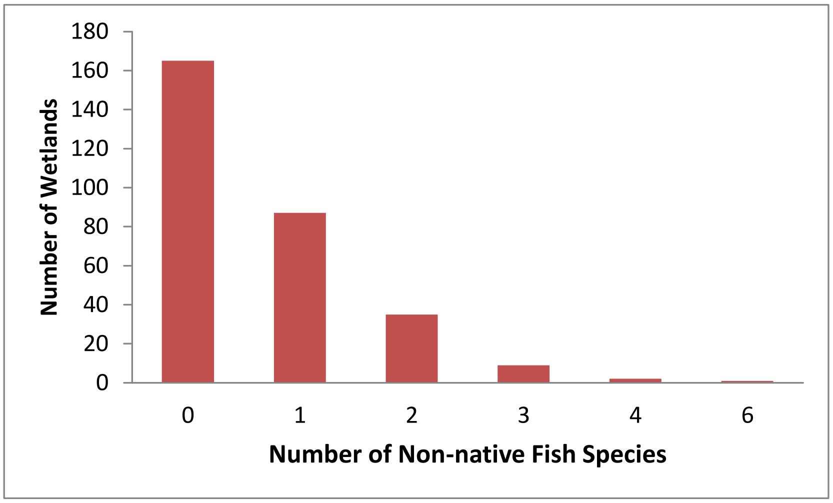

Figure 5. Number of Great Lakes coastal wetlands containing non-native fish species. Data from 2011 through 2013.

Total fish species did not differ greatly by lake, averaging 13-15 species in wetlands (Table 9). As with birds, Lake Ontario wetlands had the lowest maximum number of species, with Lake Superior having the greatest number. 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. Wetlands with the greatest number of non-native taxa were on lakes Superior, Erie, and Michigan. 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 excel at avoiding 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, 2012, and 2013.

		Fish (Total)			Non-native		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	36	13.0	31	2	1.2	5	0
Huron	103	12.8	31	2	0.3	2	0
Michigan	47	14.7	28	5	0.9	4	0
Ontario	68	13.1	23	5	0.8	3	0
Superior	55	15.1	36	3	0.6	6	0

Data for wetland macroinvertebrates are not yet available for 2013. Based on both 2011 and 2012 data, the average number of macroinvertebrate taxa (taxa richness) per site was about 44 (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 at 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 and 2012.

Country	Sites	Mean	Max	Min	St. Dev.
Overall					
Can.	80	44.7	83	17	15.2
U.S.	153	44.0	104	12	17.6
Non-natives					
Can.	80	1.2	2	1	0.4
U.S.	153	1.4	4	1	0.7

There is considerable 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 49 taxa. The maximum number of invertebrate taxa found in a single wetland was much higher for at least one Lake Huron wetland (with 104 taxa) than for the most invertebrate-rich wetlands in the other lakes, which have a maximum of 68 to 87 taxa. Wetlands with the fewest taxa may be sites in need of restoration and have between 12 taxa (Erie) to 22 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 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 and 2012.

		Macroinvertebrates (Total)			Non-native		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	33	35.1	73	12	1.6	4	1
Huron	79	50.1	104	13	1.3	4	1
Michigan	32	48.8	87	22	1.3	2	1
Ontario	58	36.3	68	18	1.2	2	1
Superior	31	49.2	79	15	1.3	2	1

On average, there were approximately 47 wetland plant (macrophyte) species per wetland (Table 12), but the maximum number was 124 species (US) or 94 species (CA). 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, 2012, and 2013.

Country	Site count	Mean	Max	Min	St. Dev.
Overall					
Can.	92	47.7	94	9	18.2
U.S.	244	46.6	124	1	19.9
Invasives					
Can.	92	3.6	8	0	2.0
U.S.	244	3.3	9	0	2.2
At risk					
U.S.	244	0.1	2	0	0.35

Invasive vegetation is commonly found in Great Lakes coastal wetlands. Those that we sampled averaged 3 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. 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) 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 lakes Erie, Ontario, and Superior wetlands was much lower than wetlands on lakes Huron and Michigan. 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, 2012, and 2013.

		Macrophytes (Total)			Invasives		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	29	26.8	79	1	4.3	8	0
Huron	113	57.1	124	15	2.6	8	0
Michigan	44	45.5	105	4	2.9	7	0
Ontario	87	42.2	87	15	5.3	9	1
Superior	43	44.8	78	21	1.6	5	0

Our macrophyte data have reinforced our understanding of the numbers of coastal wetlands that contain invasive plant species (Figure 6). Only 10% of 316 sampled wetlands lacked invasive species, leaving 90% with at least one. Sites were most commonly invaded by 2 – 5 plant species and 8% 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.

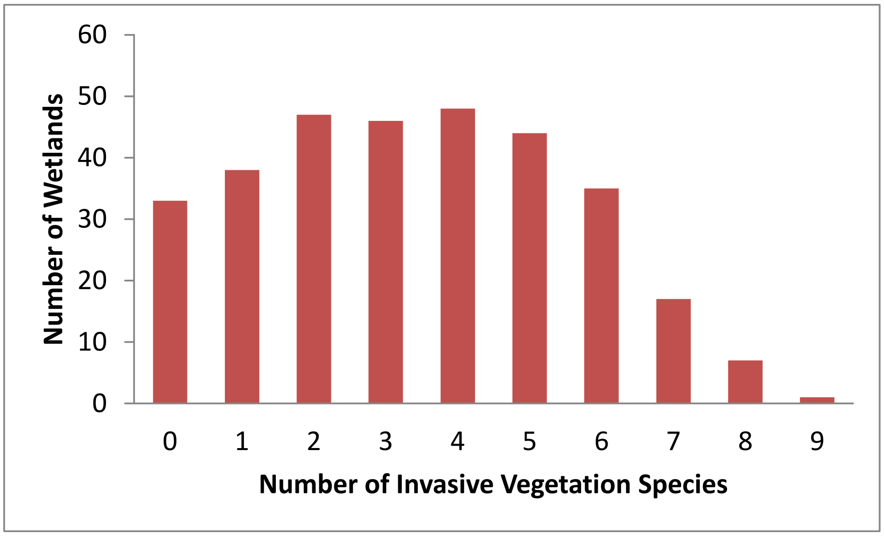

Figure 6. Number of Great Lakes coastal wetlands containing invasive plant species based on 2011 through 2013 data.

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). 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 of biotic integrity (IBI) has now been calculated for Great Lakes coastal wetlands following the methods of Crewe and Timmermans (2005). Crew and Timmermans (2005) developed this IBI for Great Lakes coastal wetland bird communities from data collected from Bird Studies Canada's Marsh Monitoring Program. This IBI should be considered a draft because our data expand the IBI quite a bit beyond the area where it was developed. We are still analyzing whether adjustments sufficiently account for differences due to latitude across the entire Great Lakes basin.

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 from the April 2013 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, 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 tweaked since the previous report, accounting for the shift in condition scores of sites. This tweaking is partially due to updating taxonomy to reflect new major changes in the taxonomic treatment of many of the marsh plants in the 2012 Michigan Flora and Flora of North America.

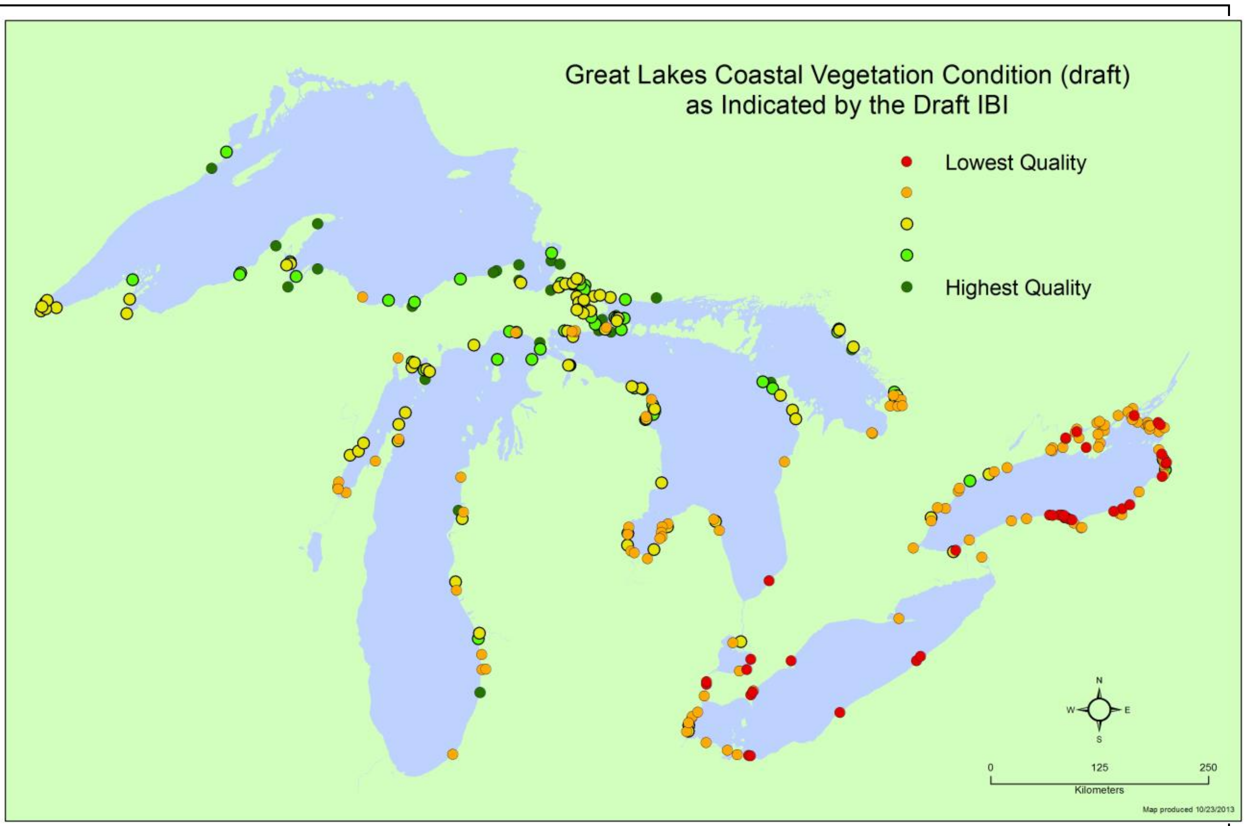

Figure 7. Condition of coastal wetland vegetation at sites across the Great Lakes. Circle color indicates vegetation quality. The indicator is labeled “draft” while the effect of recent taxonomic revisions on its values are investigated. Based on data from 2011 through 2013.

We are still investigating the effect on IBI scores of the updated Michigan Flora (2012) with new taxonomic names for many species.

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 vegetative habitats of Great Lakes coastal wetlands: sparse bulrush (*Schoenoplectus*), dense bulrush (*Schoenoplectus*), and wet meadow (multi-species) zones. We have calculated these IBIs for 2011 and 2012 sites that contain these habitat zones (Figure 8); 2013 invertebrates are still being identified. Minor tweaking of metrics since the April report has resulted in slight changes to some site calculations, so the map has minor differences with the April report.

The lack of sites on lakes Erie and Ontario and southern Lake Michigan is due to the wetlands in these areas not having the three specific vegetation zones that GLCWC used to develop and test the invertebrate 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.

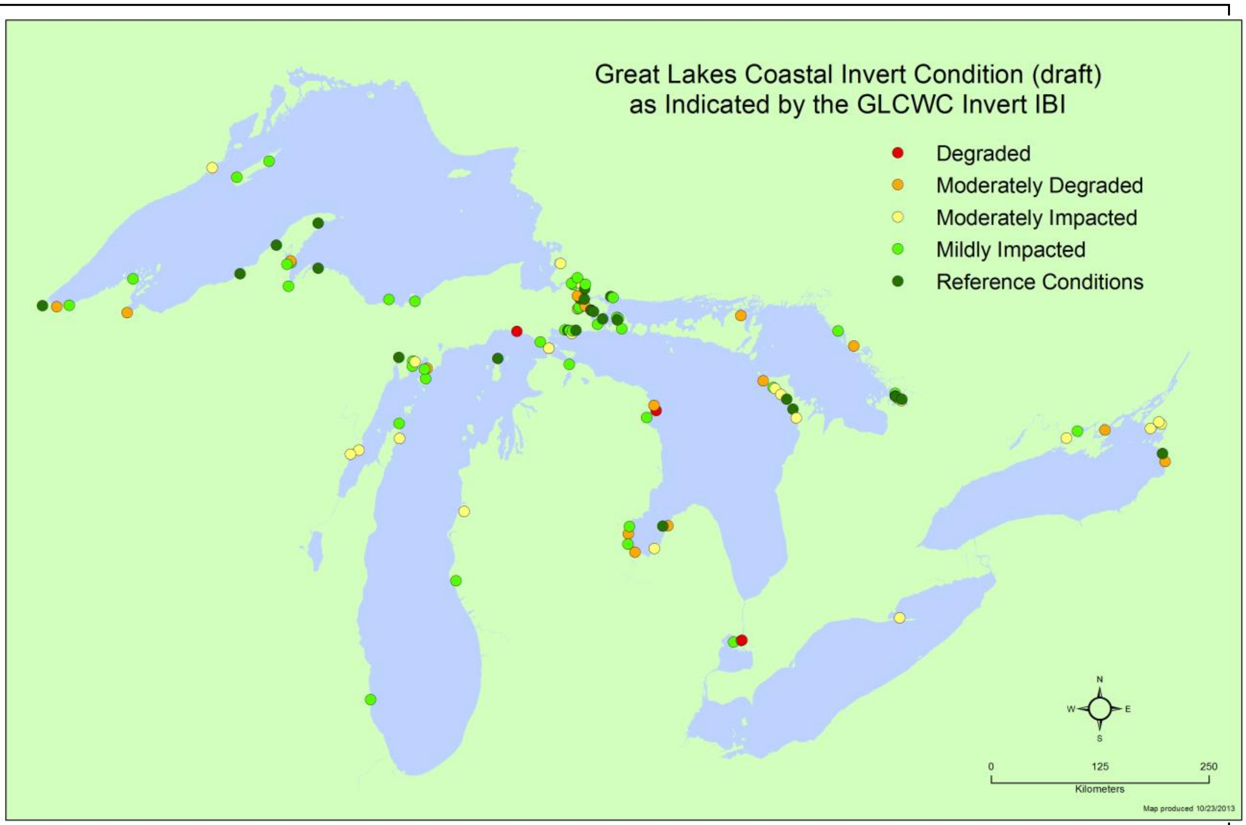

Figure 8. Condition of coastal wetland macroinvertebrate communties at sites with bulrush or wet meadow zones. The indicator is labeled “draft” while more zone IBIs are calculated. Based on data from 2011 and 2012.

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 (until we validate cattail zone metrics for macroinvertebrates). 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.

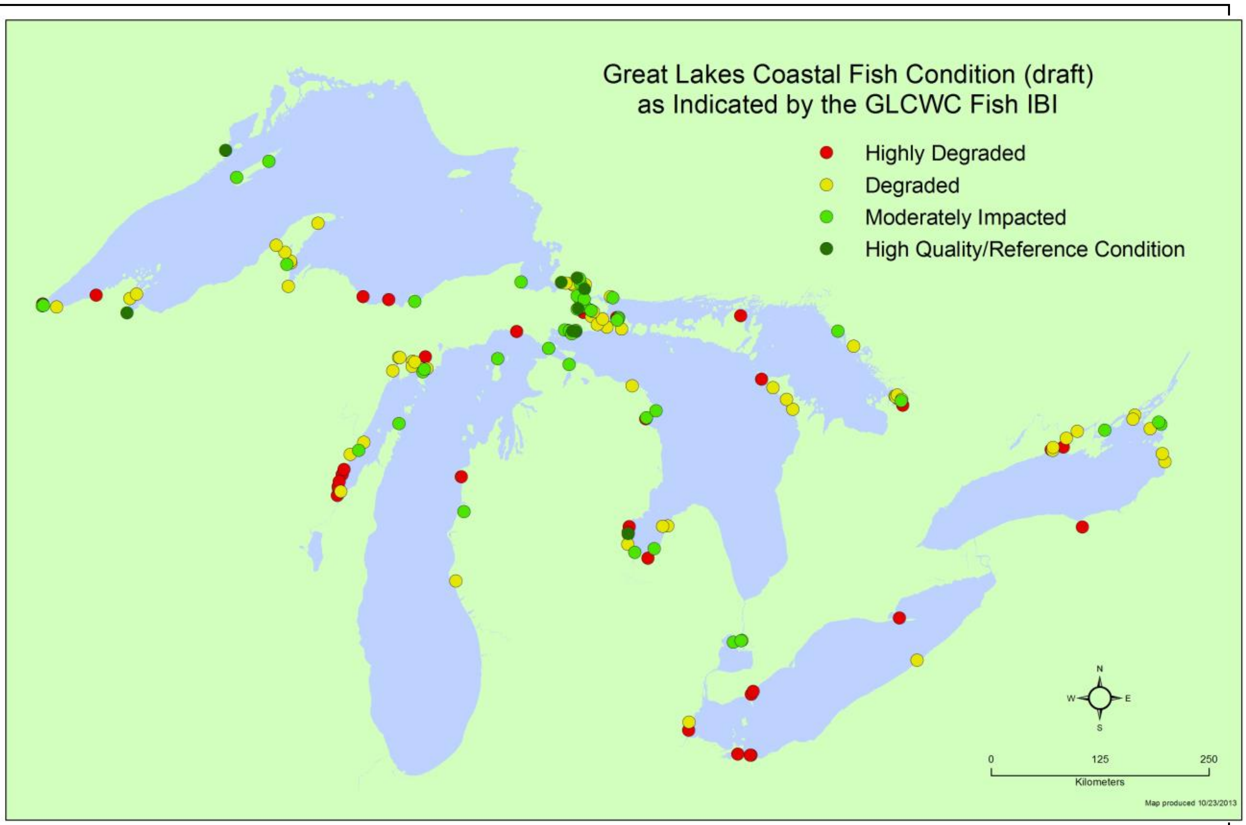

Figure 9. Condition of coastal wetland fish communties at sites with bulrush or cattail zones. The indicator is labeled "draft" while more zone IBIs are developed. Based on data from 2011 through 2013.

A coastal wetland bird IBI condition map is presented here for the first time, based on the guidelines presented in Crew and Timmermans (2005). There is quite a bit of variability in bird IBI site condition on each lake (Figure 10), although wetlands on lakes Erie and Ontario fare the poorest overall. 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.

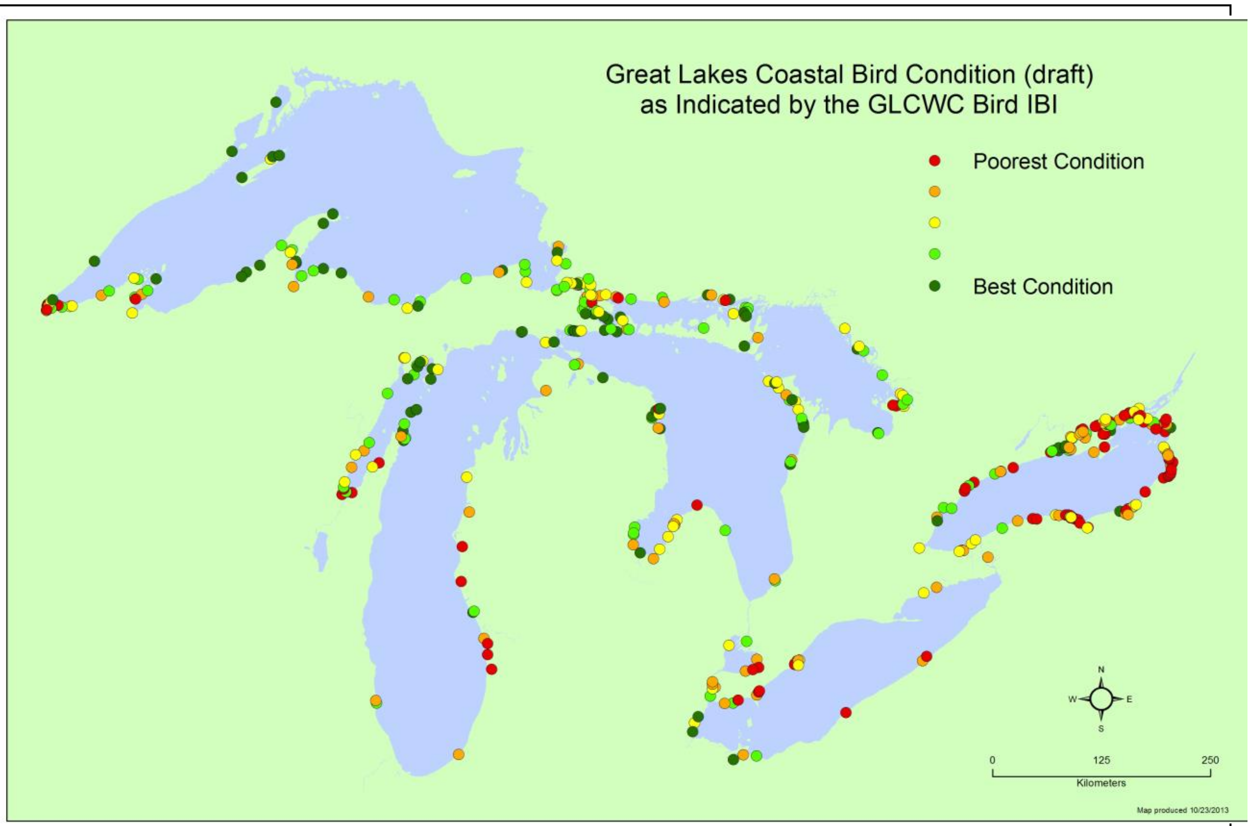

Figure 10. Condition of coastal wetland bird communties. The indicator is calculated here for the first time and is labeled “draft” while we explore whether enough adjustment has been made for latitute and longitude differences across the basin. Based on data from 2011 through 2013.

PUBLIC ACCESS WEBSITE

Work has begun on the implementation of an end-user web-based tool (Figure 11) to provide user-friendly access to monitoring results. 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. Users will be able to examine sites ranked by Indices of Biological Integrity (IBIs) and other attributes, look at threatened/imperiled/endangered species information, find lists of species for each site, and peruse site information in the context of a particular region of interest, as well as whole lakes or the entire basin.

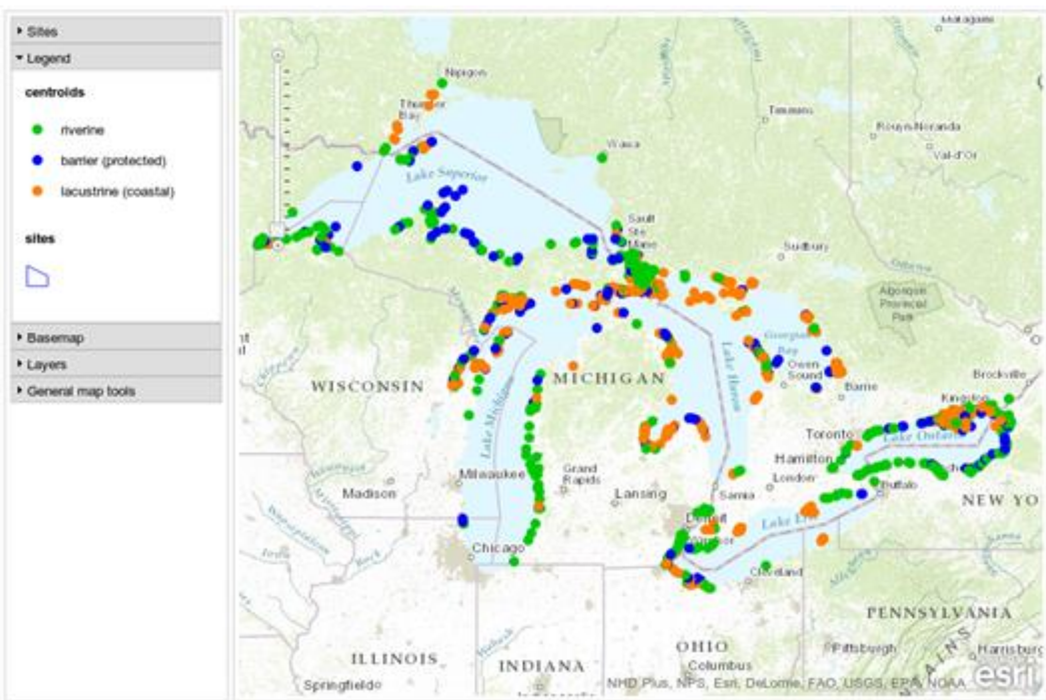

Figure 11. Default view of all sites in the database, color-coded by wetland type (riverine, barrier-protected, or lacustrine).

Users can change the coding schema for the sites shown in the display map to show what year(s) sites were sampled (Figure 12), 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 in to so that they can better view site coding.

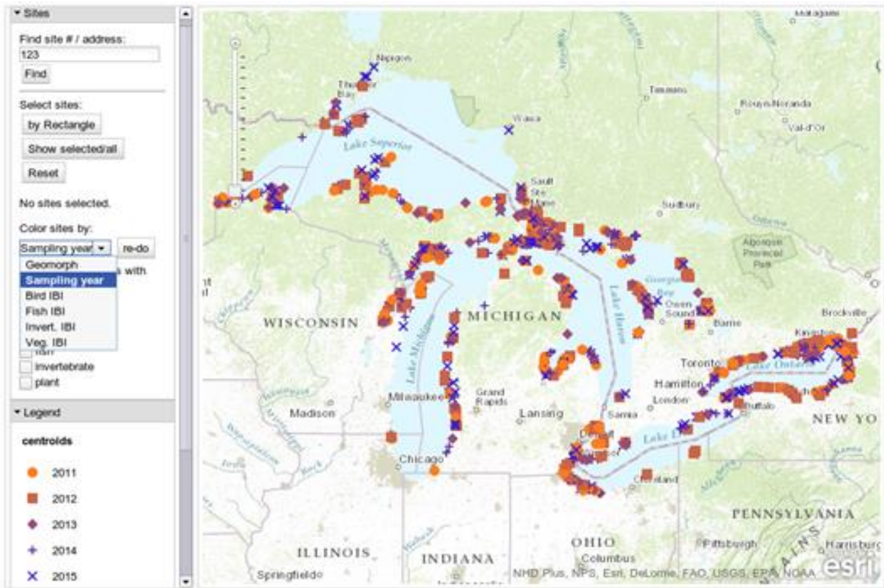

Figure 12. View by sampling year. Sites sampled in more than one year show the most recent year of sampling.

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 calculated normal scaling for the IBI (Figure 13).

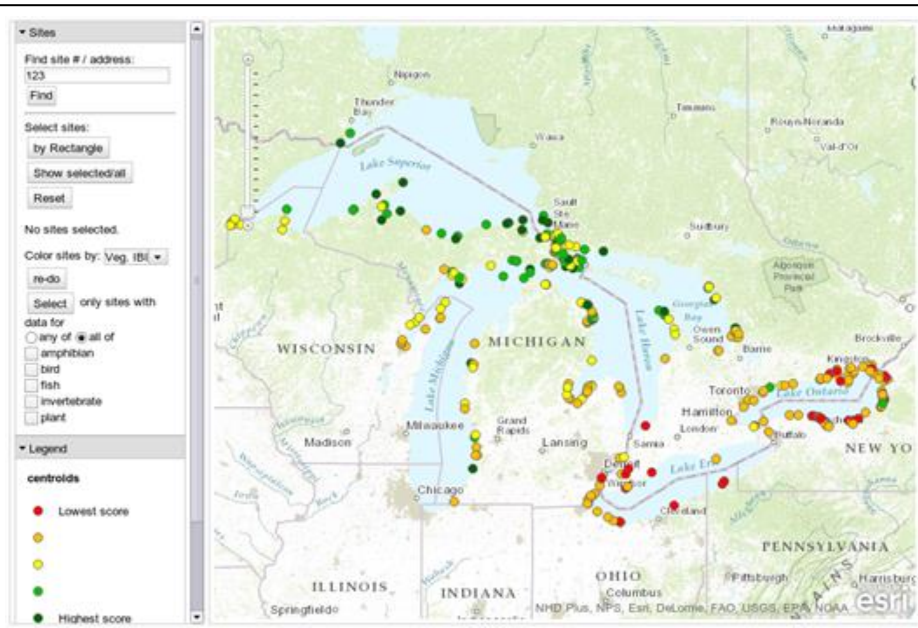

Figure 13. Wetland condition based on the wetland macrophyte IBI displaying sites for the whole basin for which there are data.

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 just 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. 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 14 inset). By rescaling these sites, managers can see at a glance which wetlands have the highest and lowest scores for their area of management or interest (Figure 14).

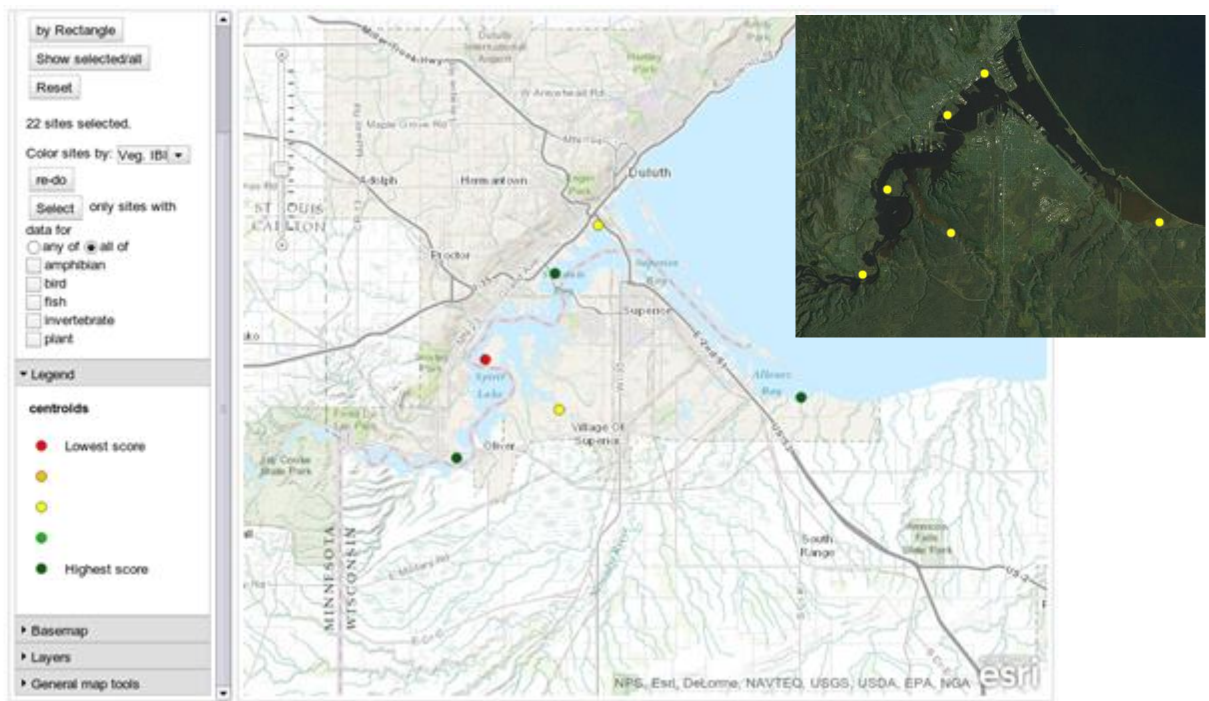

Figure 14. Wetlands in the St. Louis River estuary, Lake Superior, color-coded by wetland vegetation IBI scores that have been re-scaled for the sites shown. Inset shows original site coding for these wetlands in the context of all the wetlands across the Great Lakes.

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. Users will be able to drill down at individual sites to see lists of species found (Figure 15), non-native species, threatened/imperiled/endangered species, IBI scores and their composite metrics, and potentially other site information.

The tool is implemented using ESRI's ArcGIS Javascript API. This approach isolates all the custom code in the user's browser, limiting the site serving requirements to simple hosting of static pages. Spatial queries and data storage are provided by an ArcGIS Mapserver. During development a server hosted at the University of Minnesota Duluth is being used. When the site is stable, data will be moved to ESRI's cloud services. Data hosting and querying are generic services of the ESRI platform. While this approach is not quite as flexible as custom code on a dedicated server, it ensures that the data and tool will be available for an indefinite period beyond the end of the current project because server upgrades and other ongoing maintenance requirements are rolled into ESRI's cloud operations.

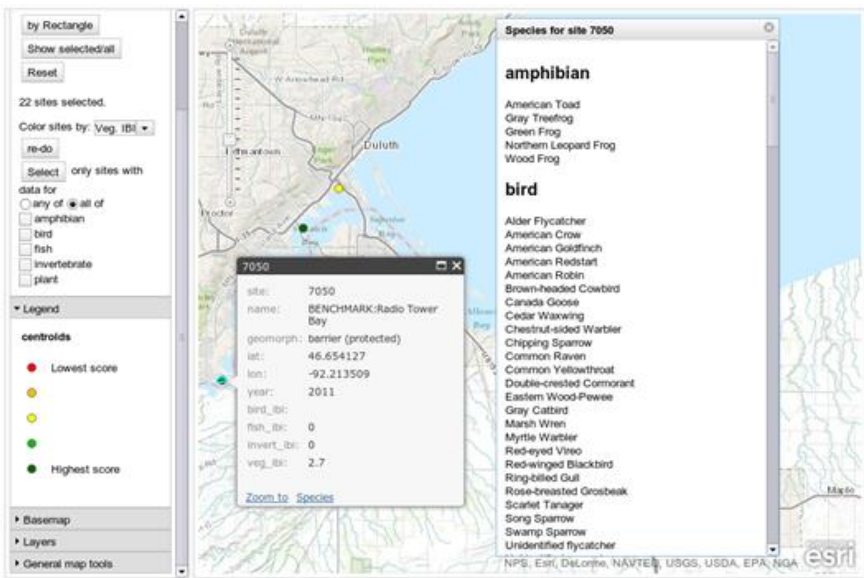

Figure 15. Example display of species lists for a specific site.

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 2013 and bird crew training took place 24 – 26 May 2013. Training involved instructing crews on how to conduct standardized field surveys, on basic travel procedures, and on appropriate field safety measures. Individuals were trained to proficiently complete field sheets, and audio testing was also completed to insure that their hearing was 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 were also included in field training to insure that the guidelines in the QAPP were being followed. All individuals involved in conducting the surveys took and passed each of the following tests on 1) amphibian calls, 2) bird vocalization, and 3) bird visual identification (based on an on-line system established at the University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal) prior to conducting surveys.

Fish, Macroinvertebrates, Vegetation, and Water Quality
Fish, macroinvertebrate, vegetation, and water quality sampling training was conducted in Duluth, Minnesota, and Superior, Wisconsin, in June 2013. Several fish/invertebrate/water quality crew members returned from previous seasons, helping ensure efficient and accurate field sampling. 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, as well as sample processing. 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. Much of this training took place in the field at a typical coastal site to ensure field members learned (or reviewed) appropriate techniques. Field training continued at the first sampling sites in Green Bay, WI, with either western team PI Brady or western team field crew chiefs Dumke and Hell supervising all crews for the entire 9 day trip.

All sampling permits were successfully obtained from state or provincial fisheries management agencies, parks, and various other entities (Ministry of Natural Resources Canada, and 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. 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 and Oceans Canada). To help comply with Canadian regulations, we sent our primary fish identification specialist to special training in Ontario in May. We also renewed our University of Minnesota Institutional Animal Care and Use Committee permit for fish sampling.

Site selection results

Birds and Amphibians

In 2013, a total of 58 sites were initially selected to be surveyed for birds and amphibians. Of these sites, 18 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 size did not meet site selection requirements, wetland lacked connectivity to the lake), or 4) exceeded the sampling capacity or was logistically infeasible for the crew to complete in 2013 but should be visited in subsequent years. Amphibian crews started sampling 01 May and bird surveys began 02 June. Sampling was completed by 03 July 2013 and we reached our objective of sampling a total of 40 sites.

The 40 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 2013, several island sites were also sampled, including 3 sites in Wisconsin (Stockton Island, Madeline Island, and Clough Island) and 1 site in Ontario (Snake Island). Of the 40 sites sampled, 10 were benchmark sites selected because they were of particular interest for restoration potential. Many of 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 (see attached letters of support).

Fish, Macroinvertebrates, Water Quality, and Wetland Vegetation

Initial site selection for fish/macroinvertebrate and vegetation crews was also 58 sites. Of these, 10 were over the crew capacity limit and another 9 were benchmark sites specific to bird/amphibian crews. Of the remaining sites, 31 were sampled (7 were benchmark sites paid for under a separate contract to Environment Canada), 7 were rejected due to not meeting project criteria for connectivity, wetland presence, lake influence, or safe access. Thus, 24 Coastal Wetland Monitoring benchmark (5 sites), resample (4 sites), and regular selection sites (15) were sampled over the summer. Field crews began sampling wetlands in the Green Bay area at the end of June and finished in the Duluth and Thunder Bay areas in early September.

Fish/macroinvertebrate crews reached sites by motorboat, while the vegetation crew surveyed sites via canoe. The vegetation crew went by boat with the fish/macroinvertebrate crew to the two Apostle Island sites sampled (one site each on Stockton and Madeline Islands).

Summary of Findings for 2013

Most western team PIs or their technicians and/or students presented Coastal Wetland Monitoring results at the Society of Wetland Scientists annual meeting, held in Duluth, Minnesota, in early June. In addition, Brady presented CWM results and support of restoration work at the National Conference on Ecosystem Restoration Conference in Chicago in early August.

Birds and Amphibians
Each of the 40 sites sampled in 2013 was visited a total of four times between 01 May and 03 July. Amphibians were sampled three times during this period. A total of seven species were recorded throughout our study sites (Table 13). The average number of amphibian species recorded at each site was four, with a minimum of two species counted at seven wetland sites, including Allouez Bay, a benchmark site in Superior WI, and several highly developed locations such as Carpin Beach in Northeast Lake Huron and Neebing Marsh (also a benchmark location) in Thunder Bay, Ontario. Mud Lake, a benchmark site in the St. Louis River, on the MN side also had only two amphibian species heard. However, in several of these locations, amphibian species were found in high abundance. In both the La Pointe wetland, a barrier wetland on Madeline Island, WI and in the Bibon Lake-Flag River, a riverine wetland on the south shore of Lake Superior, seven species were observed. 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 13). There were no observations of bullfrog (*Rana catesbeiana*) or mink frog (*Rana sylvatica*) at any of the wetlands sampled by our crews. However, this is not unusual for this region of the Great Lakes because the bullfrog amphibian has a more southern distribution and the mink frog prefers aquatic areas that are more acidic than those found in the coastal region of the Great Lakes.

Birds were surveyed twice during this period, once in the morning and once in the evening. There were a total of 124 species and 6,297 individual birds recorded. The 5 most abundant species observed accounted for approximately 45% of all observations. These species, in order of decreasing abundance, were red-winged blackbird (*Agelaius phoeniceus*), Canada goose (*Branta canadensis*), ring-billed gull (*Larus delawarensis*), yellow warbler (*Setophaga petechia*), and common yellowthroat (*Geothlypis trichas*).

Table 13. List of amphibians recorded during 2013 surveys. The number of individuals counted and the number of full choruses observed (# of individuals cannot be estimated) are provided for each species.

Species	**#Individuals**	**# Obs. - Full Chorus**
American toad (*Bufo americanus*)	106	3
Chorus frog (western/ boreal -*Pseudacris*)	20	0
Green frog (*Lithobates clamitans*)	243	10
Gray treefrog (*Hyla versicolor*)	212	17
Northern leopard frog (*Lithobates pipiens*)	80	2
Spring peeper (*Pseudoacris crucifer*)	613	113
Wood frog (*Lithobates sylvaticus*)	185	2
Total	**1459**	**147**

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 2013 (Table 14). Some of the most unique and important observations included secretive marsh birds such as American bittern (*Botaurus lentiginosus*), Virginia rail (*Rallus limicola*), Wilson's snipe (*Gallinago delicata*) and least bittern (*Ixobrychus exilis*). Both observations of the least bittern occurred in a riverine wetland located on Clough Island, a benchmark site located in the St. Louis River estuary. It has been several years since this species has been observed in the St. Louis River estuary and this represents either a small signal of recovery for this species or that environmental conditions may be improving in the estuary, or both. The common tern (*Sterna hirundo*), a threatened species in Minnesota and Wisconsin, was observed during our surveys in 2013. Interstate Island, located within the St. Louis River in the Duluth-Superior Harbor, is one of only three active nesting sites for this species on Lake Superior, and is where many of the observations occurred.

There were also seven species of raptor observed in 2013, including 11 bald eagle (*Haliaeetus leucocephalus*) and five osprey (*Pandion haliaetus*). In the Duluth-Superior area alone there are at least four nesting pairs of bald eagles; three nests within the St. Louis River Estuary and one within 0.5 mi of the shoreline within the city limits of Duluth. This represents continued support on the long-term recovery of these populations. Additional species of interest include: common loon (*Gavia immer*), pied-billed grebe (*Podilymbus podiceps*), sandhill crane (*Grus canadensis*), and one mute swan (an invasive, non-native species) observed on the west shore of St. Joseph Island in Northeastern Lake Huron.

Table 14. List of birds of special interest recorded during 2013 surveys. The number of individuals observed, type of wetland where observations occurred, and whether observations occurred in benchmark locations is listed for each species.

Species	# Individuals
Bald eagle (*Haliaeetus leucocephalus*)	11
Common loon (*Gavia immer*)	9
Common tern (*Sterna hirundo*)	22
Least bittern (*Ixobrychus exilis*)	2
Mute swan (*Cygnus olor*)	1
Pied-billed grebe (*Podilymbus podiceps*)	8
Sandhill crane (*Grus canadensis*)	42
Sora rail (*Porzana carolina*)	6
Virginia rail (*Rallus limicola*)	5
Great blue heron (*Ardea herodias*)	15
Belted kingfisher (*Megaceryle alcyon*)	10
Osprey (*Pandion haliaetus*)	5
Wilson's snipe (*Gallinago delicata*)	5

Birds of special concern were observed in 31 of the 40 wetland sites surveyed in 2013. Seven of the 10 benchmark sites surveyed also had birds of special concern including 5 sites in Wisconsin (Allouez Bay, Hog Island, Clough Island (3 sites around this island), and Pokegama River), 1 site in Minnesota (Mud Lake, scheduled for restoration), and 1 site in Freer Point, on Manitoulin Island, Ontario. The lack of observations of black tern, Forster's tern, and Caspian tern (all species of concern throughout the Great Lakes) is of particular concern. All of these species formerly occurred throughout the western Great Lakes region, but have been absent in recent years except as occasional migrants.

Common Tern Geolocator Project

In early June, our team volunteered to assist Wisconsin DNR in deploying geolocator units on common terns nesting on Interstate Island, an island in the Duluth/Superior Harbor on the border between Minnesota and Wisconsin. On 12 June 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 will be removed from birds returning to nest on the island. 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. Given the status of this species in Minnesota and Wisconsin, tracking terns throughout their annual cycle will help identify locations that are important during the non-breeding portion of their life cycle.

Fish, Macroinvertebrates, Water Quality, and Wetland Vegetation
Approximately 100 unidentified wetland plant specimens were collected, dried, and are awaiting identification in the University of Wisconsin-Superior herbarium. All other field data were entered into the project database by early-September. Few rare species were encountered during the surveys. Notably, the plants that impressed the field crew the most were the wetlands in the Green Bay area, e.g. Dead Horse Bay wetlands, which were completely dominated by nearly impenetrable stands of the invasive *Phragmites australis*. Crews sampled live *Phragmites* in 2011. In 2012, crews arrived to find that most *Phragmites* in Green Bay coastal wetlands had been killed with an herbicide. In 2013, crews observed that some areas had been re-herbicided, but coverage appeared to be less comprehensive than in 2012 because some *Phragmites* that had been killed in 2012 was regrowing, while other stands were still dead. We are curious to see the condition of the *Phragmites* in 2014, and are collaborating with Dr. Laura Bourgeau-Chavez at Michigan Tech University on her project to document recovery of treated Phragmites stands in Green Bay and Saginaw Bay.

2013 Sample Processing and Data Entry

Most 2013 data have been entered into the database and QC'd. This includes habitat, water quality, bird, amphibian, and fish data. QC remains for wetland vegetation at a few sites. Macroinvertebrate identification is underway.

2013-2014 Off-season plans

Co-PIs and some technicians will attend the PI meeting, held each January. In addition, during the off-season, work will continue on macroinvertebrate identification, data entry, and QC; additional QC of entered data; and site selection and field season planning for the 2014 field season will commence.

In summer 2013, N. Danz completed a literature review of studies involving Great Lakes coastal wetlands or floristic quality indices. He is working on a manuscript that will involve investigating spatial and temporal patterns in floristic quality across the Great Lakes. Statistical analysis of floristic quality data from wetland surveys is ongoing.

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 2013. This was deemed sufficient given that all teams had a majority of technicians returning from 2012. 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 2013 field work. Amphibian training was completed on 15 March 2013 and bird training was completed by 15 May 2013. 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 17-21, 2013. All four plant samplers passed the test and were certified to lead a sampling team.

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.

Site selection results

Site selection was completed in a previous reporting period (Oct 2010—March 2011) by assessing all wetlands in the region using the web-based site selection tool. After wetland polygons were scrutinized, the randomization and selection procedure produced a list of 56 sites for potential monitoring in the Central Basin in 2013. Sites consisted of 20 riverine, 27 lacustrine, and 9 barrier-protected wetlands. While this was more than our team's expected sampling capacity of 40 sites for fish, macroinvertebrates, and plants, we assumed that some sites would be rejected in the field because they lacked a surface connection to a Great Lake or were inaccessible. This was the case in previous years as lakes Michigan and Huron water levels remain below their long-term average, which leaves many coastal wetlands dry or disconnected from their lake. The Central Basin team sampled sites in southeastern Lake Superior, northern Lake Michigan, drowned river mouth wetlands along the eastern shore of Lake Michigan, northern Lake Huron into the St. Mary's river, the entire eastern shorelines of Lake Huron, Lake St. Clair, and Lake Erie. Central Basin Team members sample primarily in the state of Michigan, though occasionally sample wetlands in Ohio, Illinois, Indiana, and Ontario.

All 56 assigned wetlands were visited by Central Basin crews. Of these 56 wetlands, 36 were sampled for fish/invertebrates/water quality, 53 for vegetation, and 44 for birds and amphibians. The CMU fish/invertebrate/water quality crew sampled 17 wetlands on Lakes Michigan, Huron, and western Lake Erie. The GVSU crew sampled four Lake Michigan drowned river mouth wetlands and one wetland on Saginaw Bay. The LSSU crew sampled nine wetlands on the eastern end of Lake Superior and the St. Marys River. The UND crew sampled six wetlands on northern Lake Huron and one wetland on the St. Marys River. Field sampling for vegetation, led by Dennis Albert (Oregon State University), was completed at 53 sites within Michigan, including sites on Lakes Superior, Michigan, Huron, St. Clair, and Erie, and the St. Marys River. Bird and Amphibian crews, led by Dr. Tom Gehring (CMU), sampled 44 sites within Michigan.

The CMU crew sampled eight benchmark sites, the LSSU crew sampled one benchmark site, the UND crew sampled one benchmark site, the vegetation crew (led by Dennis Albert, OSU) sampled 13 benchmark sites, and the bird/amphibian crew (led by Dr. Tom Gehring, CMU) sampled 11 benchmark sites. Selection of benchmark sites was done in consultation with the Michigan Department of Natural Resources, Michigan Department of Environmental Quality, and the Nature Conservancy. Each agency provided a list of sites with current and ongoing coastal wetland restoration projects in the region and identified the highest priority sites for data collection.

Field Work

<u>Central Michigan University</u>

From mid-June through the early August, the CMU sampling crew visited 22 sites that were located on the shores of Western Lake Erie, Lake Huron, Lake Michigan and Lake Superior. Upon site evaluation, 5 of these wetlands were deemed un-sampleable because low Great Lakes water levels left coastal wetland vegetation uninundated. Within the remaining 17 sites, 35 vegetation zones were identified and sampled. Eight of the 22 wetlands were benchmark sites, including five on Saginaw Bay, two on Lake Erie, and one on Northern Lake Michigan. Twenty two of the 35 vegetation zones met the requirements for the full set of monitoring protocols. Fish sampling could not be conducted at 13 vegetation zones because water depth was insufficient. These 13 zones were sampled for macroinvertebrates, water quality, and physical habitat conditions only. Macroinvertebrate samples collected in 2013 have already been identified and are currently being put through QA/QC procedures. Fish and physical habitat data entry is nearly completed. Water nutrient analysis is also underway and the data will be uploaded upon completion.

Central Michigan University bird and amphibian crews sampled coastal wetlands in the Lower Peninsula of Michigan, eastern Upper Peninsula of Michigan, and sites in western Lake Erie, Ohio during summer 2013. Two teams, each with two members, were used throughout the sampling season, except at the beginning of the season when a third crew of 2 members was used. Field crews consisted of undergraduate student technicians and two graduate student field assistants. Amphibians were sampled from May 3 to July 22, 2013 and birds were sampled from May 15 to July 22, 2013. Wetlands were sampled three separate times for amphibians and two separate times for birds. Four wetlands were rejected by bird and amphibian crews because they could not be accessed safely for night sampling.

Grand Valley State University

The GVSU fish/invertebrate/water quality sampling crew visited the eight sites assigned to them. Three of these sites were rejected because either permission to access was denied (1319), the site contained no water (507), or was inaccessible (760). All sampling was conducted during July-August 2013. The GVSU crew sampled five wetlands for invertebrates and water quality, and three wetlands for fish, invertebrates, and water quality. In total, seven plant zones were sampled. Data entry and QA/QC has been completed for fish and invertebrate data sheets. Invertebrate identification will be completed this winter and all data will be entered before Year 4 fieldwork begins. Water quality data collected in the field (i.e., dissolved oxygen (mg/L, %), temperature, pH, specific conductivity, total dissolved solids, turbidity, redox pot, *in situ* chlorophyll *a*, total alkalinity, and phenol alkalinity) has been entered for each site. Measurements of SRP, TP, NH3, NO3, and Cl have been completed, and data entry will be completed in the coming months.

Lake Superior State University

From late June to August, 2013 the LSSU crew visited 13 sites to determine if they met the sampling criteria and if there were access issues. Three sites (810, 821, 829) were determined to not be sampleable because of low water levels and lack of vegetation zones that met the size/area criteria. One site (5760) was not sampled because of access issues (private landowners that did not want us sampling). Crews returned to 9 sites (792B, 809, 814, 828, 920, 922, 5155, 5596, 5854) and collected water quality, macroinvertebrate, and fish data and samples (along with other associated measurements) for all vegetation zones identified. Water from each site was separated, some was filtered, some frozen, and some analyzed for alkalinity in the lab. Water samples were delivered to Central Michigan University for dissolved nutrient analyses and filters were sent to the University of Notre Dame for chlorophyll *a* analyses. Unknown fish identifications were verified in the laboratory and corrected on the datasheets. All 2013 data, except for lab data and macroinvertebrate identification data, have been entered into the project database and were QA/QC checked by a second reader. Incomplete data entry from 2012 (e.g., lab data) was completed this summer as well.

University of Notre Dame

The Notre Dame fish/invertebrate/water quality crew visited 10 sites in 2013 and rejected three of these sites (571, 575, and 623). Sites 571 and 623 were rejected because they lacked a direct surface connection to the Great Lakes. Site 575 was located on property owned by a large mining/quarrying corporation and permission to sample could not be obtained. The remaining seven sites were sampled for all parameters. These sites included six on Lake Huron and one on the St. Marys River. One site (630) is a benchmark. All field data has been entered into the database and QC'ed. The UND crew analyzed chlorophyll *a* samples for UND, CMU, GVSU, LSSU, Windsor, and the Canadian Wildlife Service crews. The UND crew is in the process of analyzing lab water quality and sediment samples and will enter these data when they become available.

Oregon State University

Michigan plant crews were trained and certified by Dennis Albert (OSU) in Pellston, MI June 17-21, 2013. All four plant samplers passed the test and were certified to lead a sampling team. Field sampling for vegetation was completed at 53 sites within Michigan, including sites on lakes Superior, Michigan, Huron, St. Clair, and Erie, and the St. Marys River, including 13 benchmark sites. One site was not sampled due to lack of permission from the landowner (site 575 Swan Lake on Lake Huron). Two sites had only one transect because landowners denied access (Site 557 Middle Island on Lake Huron and Site 1319 Black River on Lake Michigan) The meadow zones were not sampled due to denial of access on additional transects (Site 507 Au Sable Point on Lake Huron,and 1933B/1899 North Maumee on Lake Erie). Coordinated trips with fish and invertebrate crews allowed island sites to be visited during the 2013 sampling season. The plant team director, Dennis Albert, reviewed all unknown plants collected by the sampling crews.

Dr. Dennis Albert reviewed all field forms prior to data entry. GPS points have also been entered into the project database. OSU students have completed entry of 52 sites into the electronic database and the one remaining site sampled by University of Windsor collaborators is expected to be in the database by November 1, 2013. Major changes in the taxonomic treatment of many of the marsh plants in 2012 have been incorporated into 2013 data entry. A complete crosswalk of earlier flora treatments with 2012 Michigan Flora and Flora of North America treatments has been completed and was used during the 2013 sampling by all plant sampling teams. Further QC of these crosswalks will occur in winter of 2013 and spring of 2014. QC of the plot data following entry into the electronic database is expected to be completed by mid-November, 2013.

Summary of Findings for 2013

1. No new invasive plant species were documented in Michigan, but new populations of *Phragmites australis* were found near Cheboygan on Lake Huron and locational data was shared with Michigan's Invasive Species Information Network (MISIN) and Rapid Response Team. Detailed locational data for the invasive species frog-bit (*Hydrocharis morsus-ranae*) was also provided to the team to allow them to plan future herbicide or removal treatments.

2. No expansions of the invasive species frog-bit (*Hydrocharis morsus-ranae*) were documented in either Lake Michigan or Lake Superior.

3. Both sampling teams separated *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.

4. Signs of invasive *Phragmites australis* treatment with herbicides were seen again in the 2013 sampling season at several sites in Saginaw Bay, Lake Huron, and Lake Erie. Indications are that native plant diversity has increased following the treatments, but a more in-depth analysis will be required to document successional changes.

5. Plowing and mowing was documented at sites on Lake Huron, the St. Marys River, and Lake Michigan. Plant diversity appears to be greatly reduced by plowing, but is more difficult to evaluate with mowing, as several species can be identified to genus, but not species, as they are immature or flowers have been cut off. Sampling is often incomplete or partial at these heavily managed sites, as land owners are often unwilling to allow samplers access to the shorelines.

6. No new rare plants were encountered in any of the plots in 2013. As in 2012, 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.

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. Documentation for these mid-season QA/QC checks has been filed with Brady, Cooper, and Uzarski. All data entered into the data management system has already or will soon be QC checked.

Other Items of Interest

Several members of the Central Basin Team (Albert, Cooper, Uzarski) participated in a special session on Great Lakes Coastal Wetland Monitoring at the National Conference on Ecosystem Restoration Conference in Chicago, July 29-August 2, 2013. Members of the Central Basin Team (Cooper, Uzarski, and a number of graduate students) also presented data originating from this project at the annual meeting of the International Association for Great Lakes Research, held at Purdue University, June 3-6.

Dr. Dennis Albert organized a special session highlighting GLRI-funded research at the Society of Wetland Scientists conference in Duluth (first week of June 2013). The session included presentations by Elena Tuttle on the plant IBI and Brad Mudrzynski (College of Brockport) on modeling the movement of invasive frogbit throughout the Great Lakes. Dennis Albert presented on the use of the plant surveys for Great Lakes wetland restoration projects.

Several member of the Central Basin Team (Uzarski, Cooper, Ruetz) participated in a conference call with the International Joint Commission on August 28 to discuss sampling methodology for Great Lakes coastal wetlands.

Future work

All Central Basin crews are currently conducting laboratory work (e.g., remaining water quality and sediment analyses and macroinvertebrate identification). Water quality and sediment analyses will be completed by early November and processing of 2013 macroinvertebrate samples is currently on schedule for completion by early spring 2014. 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 2014 field season and develop a strategy for efficient sampling. Matt Cooper (University of Notre Dame) is leading efforts to update the fish IBI with additional vegetation types that were not included in the original Great Lakes Coastal Wetlands Consortium protocols. The IBI update will be written as a manuscript for publication.

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

Field Training

Over half of the field crew members from 2012 returned for 2013; thus, the training sessions with principle investigators served as refreshers for most of the crew. Bird and amphibian crew members were trained and certified on bird and amphibian identification, distance estimates, and appropriate survey methods by Dr. Chris Norment on 10 April at various wetlands near Brockport, NY. All surveyors passed the appropriate bird and amphibian call identification tests prior to sampling to ensure accurate field identification.

Fish, aquatic macroinvertebrate, and water quality crew members were trained and certified on setting fyke nets, dip-netting for macroinvertebrates, water quality meter use and calibration, proper QA skills, and vegetation zone identification by Dr. James Haynes (co-PI, fish) and Gary Neuderfer (co-PI, macroinvertebrates) at Sandy Creek on 11 June. All fish, macroinvertebrate, and water quality crew members were certified in accordance to the standards required by the project. Finally, a mid-summer QA check at Little Salmon River (112) was performed to ensure that crew members continued to sample correctly.

Vegetation crew members were trained on plant identification, proper transect layout, percent cover estimations, GPS use, and data recording methods by Dr. Douglas Wilcox (PI, vegetation) on 14 June at Brush Creek. All vegetation crew members passed the standards set forth in the project QAPP. Finally, a mid-summer vegetation QA check was performed at Little Salmon River (112) in July to ensure that vegetation crew members continued to sample correctly. All training test documentation was provided to QA officers Brady and Cooper, as well as lead PI Uzarski.

Site selection results

The College at Brockport modified their geographic sampling boundaries early in 2013 to help ensure proportionate sampling across lakes. Eight Canadian Lake Ontario sites were added to The College at Brockport's initial fish, macroinvertebrate, and vegetation site list as a result, while the bird and amphibian crew added a total of 15 Canadian Lake Ontario sites to their list. Three sites, Buck Pond (site 51), Braddock Bay (7052), and Buttonwood Creek (50) were selected as "benchmark" sites at the request of the US Army Corps of Engineers and the US Fish and Wildlife Service to provide data for various restoration, conservation, and management projects.

Field Work

Birds and Amphibians

The College at Brockport bird and amphibian crew sampled between 15 April and 4 July. Crews ran into a number of access limitations due to both safety and private landowner reasons, with the majority of these access issues occurring in low population density areas near Kingston, Ontario. As a result, crews were only able to reach 29 of their 35 assigned sites. Bird and amphibian crews were aided by the fact that wetlands along the southern, eastern, and northeastern shore of Lake Ontario are spatially clumped, allowing for multiple site visits per day.

Fish, Macroinvertebrates, Water Quality, and Vegetation
The summer crews for The College at Brockport began sampling in late June and finished by mid-August; they encountered many of the same access issues as the spring bird and amphibian crew. The fish and macroinvertebrate/water quality crews were unable to sample seven sites, while the vegetation crew was unable to sample five sites. Many of these inaccessible sites were due to safety concerns that would have required >2.0 mile long boat rides on the open lake with small jon boats because the wetland did not have a boat launch nearby. One of these sites, Cranberry Pond (50) did not have suitable conditions for fish, water, or macroinvertebrate sampling; the open water area was all >1.2 meters deep, while there was no standing water in the cattail zone. Despite the access issues, crews worked hard in ensuring as many sites as possible were sampled. For example, a number of sites were inaccessible for the larger fish boat. These sites were still sampled by the fish crew setting nets from the canoe while the plant crew sampled the site on foot.

Laboratory identification of the 10 unknown fish began at the beginning of September and is now approximately complete. All macroinvertebrate zone-level vials have been split by taxa to allow personnel to specialize in identification. Chironomidae and Amphipoda samples are 100% identified, and identification of the remaining taxa is approximately 40% complete.

Data Entry and QC

Data entry for birds, amphibians, fish, field-level water quality, field-level macroinvertebrates, and vegetation are 100% complete. QC checks are 100% complete for amphibians, birds, and fish, while QC is just beginning for macroinvertebrates, water quality, and vegetation.

Summary of Findings for 2013

Invasive Species
The most alarming finding from the 2013 sampling season is the range expansion of water chestnut (*Trapa natans*). The Brockport summer crew found water chestnut in six sites along the southern and eastern shore of Lake Ontario, including one site it was absent from during the 2012 survey. Water chestnut's documented range now includes roughly 40% of the southern and eastern shore of Lake Ontario, as determined by the efforts of this project, where it was limited to one or two wetlands previously. The most common invasive plant species found in 2013 include cattail (*Typha angustifolia* and *Typha* x *glauca*), Eurasian water milfoil (*Myriophyllum spicatum*), and curly-leaf pondwood (*Potamogeton crispus*), while common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and European frogbit (*Hydrocharis morsus-ranae*) were patchy and locally dominant, but not as widespread.

The College at Brockport's fish crew caught few invasive fish species. Only one common carp (*Cyprinus carpio*) adult was found, but juveniles were found at five sites throughout Lake

Ontario. Round Goby (*Neogobius melanostomus*), while widespread and abundant in Lake Ontario as a whole, was only recorded in four sites, probably because the wetlands in Lake Ontario are sediment and organic matter rich and not preferred habitat.

Working with Local Groups
The College at Brockport designated Buck Pond (51), Braddock Bay (7052), and Cranberry Pond (50) as benchmarks due to a request from the United States Fish and Wildlife Service for wetland data within the Rochester Area of Concern. These sites, along with the four randomly selected sites for 2013 will give them a good snapshot of the wetland community in the Rochester AOC. Braddock Bay (7052) was also benchmarked to provide a second year of pre-restoration monitoring of the wetland fish and vegetation community for The College at Brockport's collaborative restoration effort with the United States Army Corps of Engineers.

The College at Brockport notified 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.

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 March 25, 2013, in London, Ontario. A number of crew members returned from previous years. The amphibian and bird survey field protocols were covered in detail. Crew members were instructed in methods of reporting, safety, data entry, and assessed for their ability to use GPS instruments with adequate precision and accuracy as per the quality assurance project plan. Field personnel's comprehension of the topics was evaluated with 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 Kettle Point on Lake Huron by Doug Tozer. No problems were identified.

Fish, Macroinvertebrates, and Water Quality
Field crew members who worked with fishes, macroinvertebrates, and water quality sampling were trained by co-PI Joseph Gathman in the Windsor region during late May and early June (University of Windsor crew), or by Greg Grabas in the Toronto Region during June and July field visits (Canadian Wildlife Service crew). All members of the University of Windsor teams had worked on the project in 2012, and so only a review and refresher of protocols was

needed. 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. In addition, two crew received training in fish identification at the Royal Ontario Museum in May 2013, complementing the expertise of three other team members who have previously completed this training. 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.

For the Canadian Wildlife Service crew, Denby Sadler (fish ID training: Royal Ontario Museum) returned as the fish crew lead. Co-PI Greg Grabas led and trained the water quality and invertebrate sampling crew. Daniel Rokitnicki-Wojcik led the vegetation sampling, and identification and was assisted by various summer students and Canadian Wildlife Service personnel who served as data recorders.

Vegetation surveys were led by expert botanists Janice Gilbert and Dan Barcza (returning from 2012). 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.

Sampling for fishes in Canada requires approval by the University of Windsor's Animal Use Care Committee as well as 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), and Wild Animal Collection (Ohio Department of Natural Resources). All permits were approved 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 and to local offices in whose jurisdiction sampling took place. Records of fishes caught will also be sent to local conservation and refuge managerial groups in Ontario and Ohio where appropriate.

Site selection results

Birds and Amphibians
Field crews evaluated 51 sites that had been selected for potential sampling in 2013 (18 on Lake Ontario, 22 on Lake Huron, and 11 on Lake Erie). Of these, 6 were rejected due to unsafe working conditions for over-water nighttime amphibian surveys, and one site was rejected because it was gauged to be <4 ha in size. Most of the rejected sites were located on Lake

Huron. However, 1 Lake Erie site was rejected. Forty-four sites were visited (each on 5 occasions) and sampled for amphibians and birds.

Fish, Macroinvertebrates, Water Quality, and Wetland Vegetation
Field crews evaluated 58 sites (10 on Lake Ontario and 48 on lakes Erie and Huron or the connecting channels). All of these sites had also been assessed by the bird and amphibian field crews. Two sites were rejected based on aerial photography – one site was inaccessible and the other was on aboriginal land for which we did not have permission to sample. Three sites were visited but rejected as unsuitable for any form of sampling. Thus, a total of 46 sites was actually sampled (10 on Lake Ontario, 13 on Lake Erie and 23 in Lake Huron (including the North Channel, St. Marys River and Manitoulin Island).

Vegetation was sampled at 38 sites. Of these, 34 sites were also suitable for water quality and macroinvertebrate sampling, while only 25 of these sites were suitable for fish sampling. There was one additional site (a new benchmark site requested by a stakeholder in midsummer) where water quality, invertebrates, and fish were sampled, but vegetation was not assessed. Thus, the full suite of water quality, fishes, macroinvertebrates and wetland vegetation was assessed at 26 sites by our group.

Water quality sampling followed the protocols dictated by the QAPP as developed by the CWM 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 analysed by colleagues at University of Notre Dame), 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 compliance with QAPP-specified holding times. All analyses have been completed. Field-based measurements have been entered into the water quality database.

Two benchmark sites were identified for sampling in 2013 (Crane Creek, OH and Hay Bay, Bruce Peninsula, ON). The Crane Creek site is 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. Comm.*). This site had been sampled in 2012, and was randomly selected for re-sampling in 2013. The Hay Bay site was selected after consultation with staff at Fathom Five National Marine Park, who have been sampling coastal wetlands within the park boundary and wanted to compare their results to ours.

Data Entry and Quality Assurance

All amphibian and bird data have been compiled, entered into the database, and QC'd. All fish data have been compiled and entered into the database and quality-assured. Most of the macroinvertebrate samples have been examined, specimens identified to the family level, and the identifications quality checked according to QAPP protocols. We are in the process of identifying Chironomidae to subfamily or tribe level as practicable. Data are being entered into the database as identifications for each site are completed. Quality assurance of the vegetation data is almost complete. However, none of these data have yet been entered into the database. All water quality data have been uploaded to the database. Quality assurance is still in progress.

Summary of Findings for 2013

Birds and Amphibians
Of note were 40 occurrences of 9 Ontario bird species at risk: bald eagle (3 occurrences; special concern), barn swallow (8 occurrences; threatened), black tern (1 occurrence; special concern), bobolink (4 occurrences; threatened), chimney swift (2 occurrences; threatened), common nighthawk (2 occurrences; threatened), Eastern meadowlark (8 occurrences; threatened), king rail (1 occurrence; endangered), and least bittern (11 occurrences; threatened). Also of note were 19 occurrences of chorus frog, which is listed as threatened in Canada.

Fishes and Invertebrates
Species of note were observed at several locations during the 2013 field season. One warmouth (*Lepomis gulosus*) at a wetland in Rondeau Bay. Eastern musk turtles (*Sternotherus odoratus*) were found in fyke nets at a site near Honey Harbor, Ontario. One tubenose goby was found at 5375 Green Island Island wetland (Georgian Bay of Lake Huron), confirming the range extension observed in the previous field season. Another distinctive invader, the very large 'Chinese mystery snail' (*Cipangopaludina sinensis*), was commonly observed at the Stokes Bay wetland (site 5952).

Vegetation
Small cells of invasive *Phragmites* (*P. australis*) were observed establishing footholds in the Georgian Bay wetlands (5746 Point Au-Baril and 5320 Franklin Is. in 2012) Native *Phragmites* (*P. americanus*), along with the invasive strain, were present at many sites on lakes Erie and St.Clair in 2012 and 2013.

In 2012, *Solidago houghtonii (*special concern) was found at one site. Wild rice (*Zizania aquatica*) was present at three wetlands in lake St. Clair and Lake Erie. In 2013, the provincially-important stiff yellow flax (*Linum medium var. medium*) was observed at one wetland.

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, 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 this project, as well as other sources of turtle observations, have identified multiple suitable habitat locations for proposal as candidate critical habitats in the Recovery Strategy. The data provided from CWM and other GLRI projects were very valuable in this recovery effort.

Collaborations

Special efforts were made in 2013 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. We made a special effort to contact the environmental liaison individuals for First Nations lands. Telephone or e-mail contact was achieved in most instances. We are optimistic that the contacts made in 2013 will result in closer collaboration and interactions in 2014.

We engaged in discussion and/or site visits with the following individuals or groups during the 2013 field season.

- Greg Mayne (Environment Canada, Canadian co-chair, Lake Huron Binational Partnership): providing a summary report of coastal wetland condition on the west shore of the Bruce Peninsula.
- Scott Parker (Parks Canada, Fathom Five National Park): sampling sites to provide data/compare results with monitoring to establish an International Biodiversity Preserve.
- Kurt Kowalski (USGS; work at Crane Creek marsh, Ottawa National Wildlife Reserve): comparing methods and presumably results of USGS vs. CWM initiatives.
- 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): have coordinated with them last two years, mainly for information sharing on sites.
- Sturgeon Bay Provincial Park (near Point Au Baril, ON): benchmark site sampled last year, possibly resampled in future.
- Wikwemikong Unceded Indian Reserve: established contact and agreement to cooperate on surveys of sites identified in future field seasons.
- Geoff Peach, Lake Huron Center for Coastal Conservation: information sharing on sites.
- Seija Deschenes, Manitoulin Streams (Manitoulin Island of Georgian Bay): helping act as liaison with First Nations.

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 in January and February, 2013. After review, it was determined that no updates were necessary for the 2013 field season. All project co-PIs re-signed the QAPP_r3 on March 14, 2013. Standard Operating Procedures were also reviewed by each regional lab and, like the QAPP, no changes were necessary for the 2013 season.

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 was conducted by experienced technicians at each regional lab and was 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 2013 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. Additionally, in most cases, field crew leaders contacted Uzarski, Brady, or Cooper by cell phone when deciding whether to reject a site.

- 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 and 2012 data and is nearly complete for 2013.

- 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.

- Macroinvertebrate QC checks: Each regional lab that is processing macroinvertebrate samples 'blindly' traded 2012 samples with another other lab over the past winter. 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.

- 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. 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 2013 have been completed by the NRRI Central Analytical Laboratory, Central Michigan University's Wetland Ecology Laboratory, Grand Valley State University's Annis Water Resources Institute, University of Notre Dame's Stream Ecology Laboratory, and Environment Canada's National Laboratory for Environmental Testing. All laboratory results from 2013 have passed the criteria shown below (Table 15).

Table 15. 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 = $((|x1\text{-}x2|)/\text{mean}) *100$.
** 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 16. 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 16 below lists average RPD values for each year of the project (2011-2013). 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.

Table 16. 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
Alkalinity	10%	4.1% (12)	8.9% (11)	3.6% (13)
Ammonium	10%	54.8% (14)	21.9% (13)	58.5% (11)
Chloride	20%	1.9% (12)	6.6% (10)	8.9% (12)
Chlorophyll	30%	36.8% (10)	31.0% (11)	39.8% (8)
Color	10%	11.7% (14)	5.1% (11)	6.9% (13)
Nitrate	10%	23.8% (12)	23.3% (11)	10.2% (5)
SRP	10%	19.3% (9)	21.8% (9)	13.6% (7)
Total N	30%	10.3% (13)	9.9% (13)	7.4% (12)
Total P	30%	19.6% (13)	26.7% (13)	29.0% (12)
T-tube	NA	12.9% (7)	7.9% (6)	17.9% (8)
Turbidity	10%	26.6% (9)	22.7% (6)	23.2% (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 third year of macroinvertebrate identification, data QC, and metric calculation. All primary project members will again meet in Detroit during the winter to discuss and resolve taxonomic issues that may affect metrics calculations. Revised IBI metrics for additional zones will also be discussed during this meeting.

The current version of the QAPP and SOPs (Revision 3) is an improvement over the previous version in that some minor inconsistencies have been eliminated and additional clarification has been added. We anticipate that very little revision will be required in subsequent years.

Since the February 2011 meeting and QAPP update, regional team leaders and co-PIs have held conference calls and e-mail discussions regarding site selection and field work preparation. 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 2013 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 to answer the most difficult crew questions.

Overall

No major injuries were reported by any field crew members during this third sampling season. 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. All this makes the safety record even more impressive.

From the PI and QA managers' perspectives, the third 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 arose. The third year of this project was extremely successful.

LEVERAGED BENEFITS OF PROJECT

This project has generated several spin-off projects and serves as a platform for a number of graduate and undergraduate thesis topics. In addition, project PIs are collaborating with a number of 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

Conservation Assessment for Amphibians and Birds of the Great Lakes: Several members of the CWM project team have initiated an effort to examine the role that Great Lakes wetlands play in the conservation of amphibians and birds in North America. 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, many of which have been identified as endangered, threatened, or of special concern in North America. CWM PIs will use the extensive data that have been gathered by USEPA, such as the Great Lakes Environmental Indicators project and the Great Lakes Wetlands Consortium, as well as Bird Studies Canada, as critical input to this assessment.

The initial stages in the development of the conservation assessment will be to analyze habitat and landscape characteristics associated with Great Lakes coastal wetlands that are important to wetland-obligate bird species occupying these habitats. By combining breeding bird data from the sources above and incorporating landscape variables, classification trees can be developed to predict presence and relative abundance of these species across the Great Lakes Basin. These methods, outlined in Hannah Panci's thesis, 'Habitat and landscape characteristics that influence sedge wren (*Cisthorus platensis*) and marsh wren (*C. palustris*) distribution and abundance in Great Lakes Coastal Wetlands' (University of Minnesota Duluth). Panci compiled data for over 800 wetlands in her analysis, which will provide a basis for analyzing additional wetland-obligate species.

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 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 US EPA Mid-Continent Ecology Division. USEPA MED researchers are studying wetland macrophyte and wetland soil nutrient correlations. The MED laboratory is running the sediment nutrient analyses and will share the data with Coastal Wetland Monitoring 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 will collect pre- and post-restoration data to help plan and implement restoration activities at this site. 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 at four nearby wetlands, pending funding from NOAA.

Thunder Bay AOC, Lake Superior, Wetland Restoration: Nine wetlands around Thunder Bay are being assessed by CWM crews using methods closely related to CWM methods. These data will provide pre-restoration baseline data as part of the AOC delisting process. Wetlands being sampled include both wetlands in need of restoration and wetlands being used as a regional reference. All of this sampling is in addition to normal CWM sampling, and is being done in collaboration with Environment Canada.

Support of 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 (see attached letter of support).

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 US ACE 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

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).
- 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).

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).
- 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).

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).

- Effects of habitat complexity on predator-prey ratios: macrophytes as a study system (University of Windsor, under the Zoobenthos - macrophyte relationships in Great Lakes coastal wetlands framework).

Jobs Created/Retained (project inception through 2013):

- Principle Investigators (partial support): 14
- Post-doctoral researchers (partial support): 1 (0.25 FTE)
- Graduate students (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)

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