GLIC: Implementing Great Lakes Coastal Wetland Monitoring

Semiannual Progress Report

October 1, 2012 – March 31, 2013

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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 sub-objectives 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; 3) development of background documents on the indicators, and 4) timely submission of all project reports and publications.

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

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 successfully then entered the field data and QC'd, 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, crews sampled 206 sites. Teams have entered and QC'd all of the data from the second field season, and PIs have resolved taxonomic issues that arose during the second season. Most of the metrics and IBIs can now be calculated within the database.

For 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 samples and the revisited sites. All co-PIs and many field crew leaders met in the Detroit area (January 2013). We decided that our QAPP accurately portrays our work and did not need to be updated; all co-PIs re-signed the QAPP in March 2013. Our site selection system required only minor modification to better handle benchmark sites (sites of special interest for restoration or protection). Teams currently are in full preparation for the upcoming field season.

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.

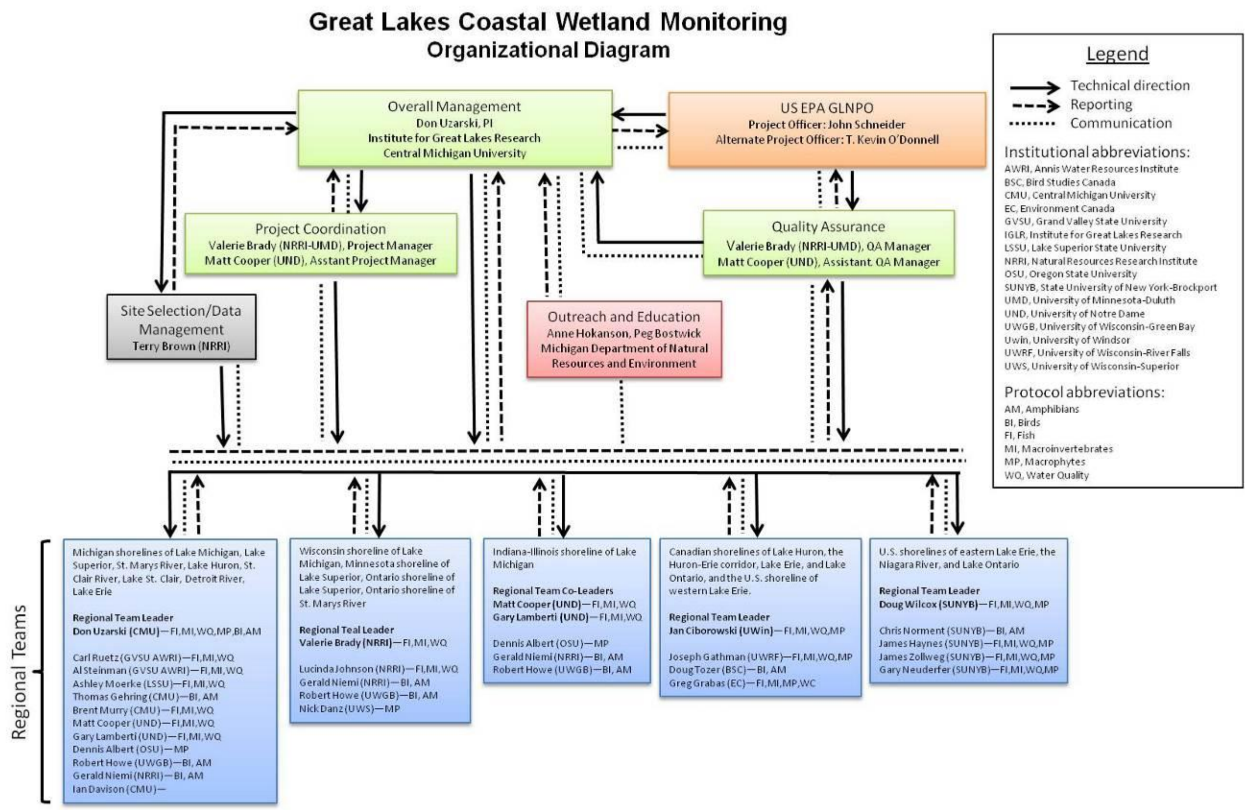

Figure 1. Organizational chart for the project showing lines of technical direction, reporting, and communication separately.

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.

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

SITE SELECTION

This year, site selection was completed in March, and was essentially the same as site selection for year two. The only change was a slight modification in the way the system deals with "benchmark" sites, which are sites of special interest, primarily for restoration or protection. These sites can be sampled more than once in five years, and may be sites that were not on the original sampling list. The site 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 the other crews.

Original data

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

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. Counts, areas, and proportions of the 1014 Great Lakes coastal wetlands deemed sampleable following Great Lakes Coastal Wetland Consortium protocols. 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 in coastal wetlands. Based on the number of wetlands that could be sampled in 2011 and 2012 by monitoring crews, and the continuing drop in Huron-Michigan water levels, the total number of sampleable wetlands may be closer to 900 rather than the initially-estimated 1000.

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

Strata

Geomorphic classes

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

Regions

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

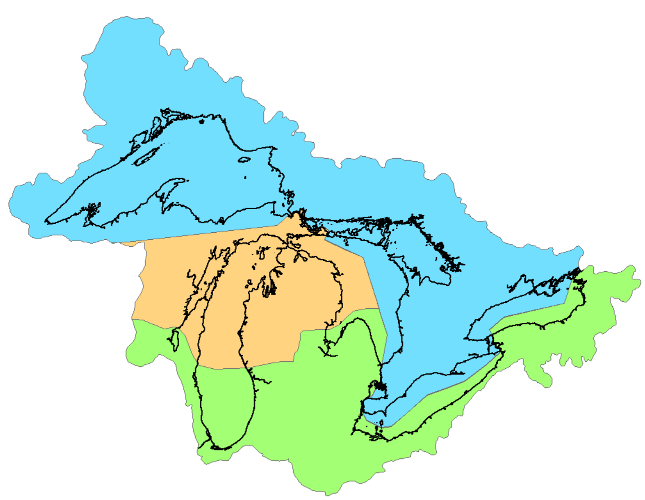

Figure 2. Divisions of lakes into regions. Note that stratification is by region *and* lake, so northern Lake Erie is not the same region as Lake Superior, etc.

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* are candidates for re-sampling in 2012. The 20 sites in sub-panel *a* of panel *B* will be 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 again generated for field crews for each site. 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 is shown in Figure 3, with a total of 244 sites planned for sampling this season. Of these 244, 32 are benchmark sites and 12 are temporal re-sample sites, with the remaining 200 sites selected by the original “random draw” that placed sites in the sampling panels. There are more benchmark sites than is recommended in the protocol because several teams are taking on additional sites at special request. Thus, these teams are not reducing their capacity to sample regular “random draw” sites in order to sample the additional benchmarks.

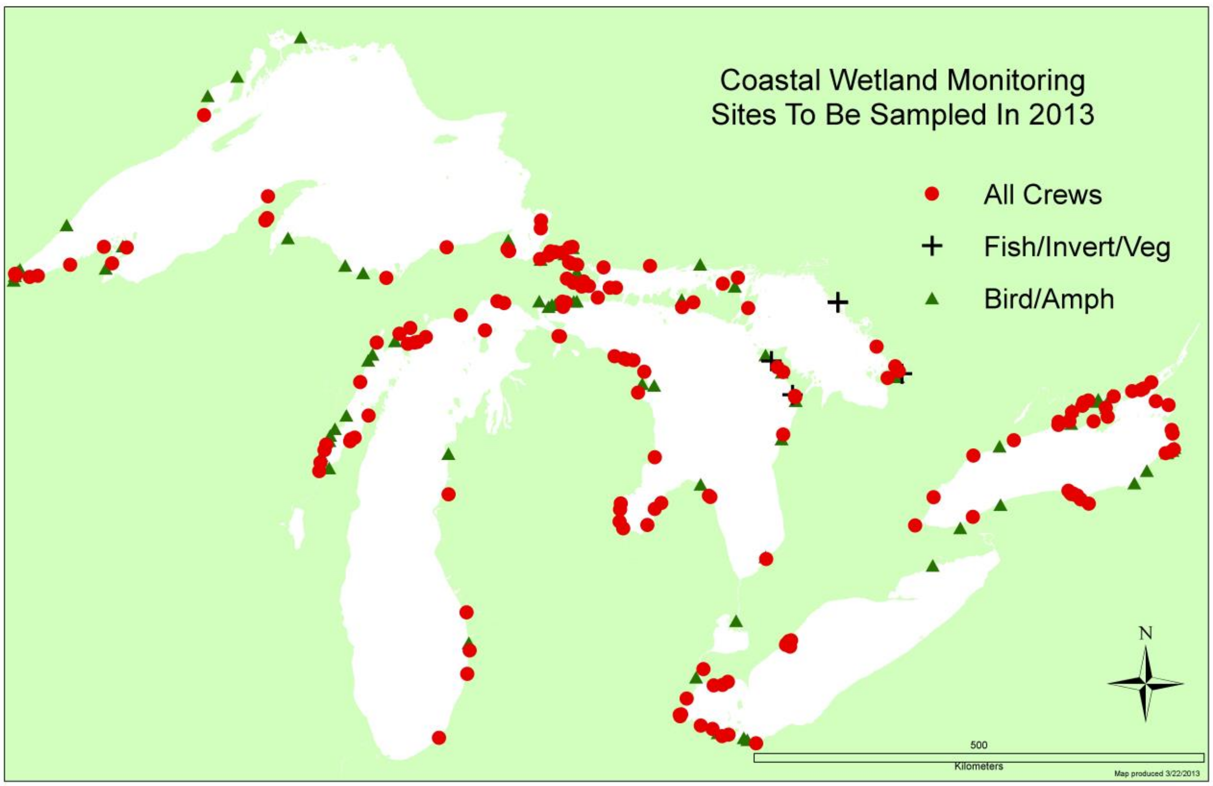

Figure 3. Locations of the 244 Great Lakes coastal wetlands to be sampled in 2013, color-coded by taxonomic groups. Sites assigned only to bird and amphibian crews (due to their greater sampling capacity) are shown with a green triangle.

These benchmark sites typically are either sites that are being restored, sites that are very regionally important, sites that represent unusually undisturbed or disturbed conditions, or sites that are especially data-rich. Many benchmark sites are being sampled at the request of other agencies or groups (see *individual team reports* and *letters of support*). To ensure that all benchmark and resample sites get sampled by each team, these sites are sorted to the top of the sampling list.

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

TRAINING

All personnel responsible for sampling invertebrates, fish, macrophytes, birds, amphibians, and water quality received training and were certified prior to sampling in 2011. During that first year, teams of experienced trainers held training workshops at several locations across the Great Lakes basin to ensure that all PIs and crews were trained in Coastal Wetland Monitoring methods. Now that all PIs, crew chiefs, and most crew leaders have had two years of experience, field crew training will be handled by each PI at each regional location. All crew members will still have to pass all training tests, and PIs will still do mid-season QA. A number of regional teams also met at field sites early in the 2012 season to review protocols and ensure consistent implementation. The trainers are available via phone and email to answer any questions that arise during training sessions or during the field season. This system of training and communication worked well in 2012 and the QA managers (Brady and Cooper) determined that it will be sufficient for 2013 field season.

The following is a synopsis of the training to be conducted by PIs this spring (2013): Each PI will train all field personnel on meeting the data quality objectives for each element of the project; this includes reviewing the updated 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 must pass all training certifications before they are allowed to work unsupervised. Those who have not yet passed all training aspects may work under the supervision of a crew leader who has passed all training certifications.

Training for bird and amphibian field crews includes tests on amphibian calls, bird vocalizations, and bird visual identification. These tests are based on an on-line system established at the University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal. In addition, individuals will be tested for proficiency in completing field sheets, and audio testing will be completed to insure their hearing is within the normal ranges. Field training will also be completed to ensure guidelines in the QAPP are followed: rules for site verification, safety issues including caution regarding insects (e.g., Lyme's disease), GPS and compass use, and record keeping.

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

Vegetation crew training also includes both field and laboratory components. Crews will be trained in field sheet completion, transect and point location and sampling, GPS use, and plant curation. Plant identification will be tested as phenology allows. All crew members will be 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 both of the first two field seasons. Additional training on data uploading will be provided as needed in 2013.

Certification

To be certified in a given protocol, individuals must pass a practical exam. Certification exams will be conducted in the field in most cases, either during training workshops or during site visits early in the season. When necessary, exams will be 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, participants will be tested on the protocols for which they are responsible. Personnel who are not certified (e.g., part-time technicians, new students, volunteers) will not be allowed to work independently nor to do any taxonomic identification except under the direct supervision of certified staff members. Certification criteria are listed in the project QAPP. For some criteria, demonstrated proficiency during 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 is 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 (2011-2012)

A total of 176 wetlands were sampled in 2011, with 206 sampled in 2012, for an overall total of 382 Great Lakes coastal wetlands sampled in two years (Table 5). More wetlands were sampled on the US side, due to the uneven distribution of wetlands between the two countries rather than any deliberate attempt to sample more wetlands in the US. The wetlands on the US side also tend to be larger (see area percents, 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. Overall, however, 65% of total sites sampled have been US coastal wetlands, therefore, 80% of the wetland area sampled has been on the US side. Overall, we have sampled 40% of US coastal wetlands by count, and

42% of US coastal wetlands by area. With respect to the entire Great Lakes, the project has sampled 38% of coastal wetlands, or 40% by area.

Table 5. Counts, areas, and proportions of the 176 Great Lakes coastal wetlands sampled in 2011 and the 206 wetlands sampled in 2012 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%
CA total	**132**	**35%**	**11,220**	**20%**
US				
2011	126	72%	22,008	87%
2012	124	60%	21,845	73%
US total	**250**	**65%**	**43,853**	**80%**
Overall Totals	**382**		**55,073**	

At coastal wetland sites, 178 bird species have been identified. Wetlands contained approximately 26 bird species on average, and no sampled wetland had fewer than 8 bird species (Table 6). Some wetlands contained 60 to 70 bird species. There are many fewer frog 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 frog species were heard over the three sampling dates.

Table 6. Bird and frog species in wetlands; summary statistics by country.

Country	Site count	Mean	Max	Min	St. Dev.
Birds					
Can.	111	27.5	58	8	10.7
U.S.	160	25.8	68	8	11.2
Amphibians					
Can.	104	4.1	8	1	1.8
U.S.	154	4.1	7	1	1.3

Bird and amphibian data in Great Lakes coastal wetlands by lake (Table 7) shows that wetlands on most lakes averaged 28-29 bird species, with the exception of Lake Ontario coastal wetlands, which averaged only 21. The greatest number of bird species at a wetland occurred on Lake Superior, and the fewest taxa at a wetland on Lake Ontario. There is a bit more variability among lakes in terms of wetlands with the least number of species, with Lake Huron and Lake Ontario each having at least one wetland containing only 8 bird species. Frog species counts show less variability among lakes simply because fewer frog species occur in the Great Lakes. Wetlands averaged about four frog 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 frog species, and this was almost always spring peeper (*Pseudacris crucifer*) (see Team Reports, below, for further discussion).

Table 7. Bird and amphibian species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of species per wetland.

		Birds			**Frogs**	
Lake	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	28.0	53	15	3.7	7	2
Huron	28.8	58	8	3.9	6	1
Michigan	29.6	51	13	4.1	6	1
Ontario	21.4	49	8	4.6	8	1
Superior	29.1	68	11	3.6	7	1

Means of approximately 11 and 15 fish species were collected in Canadian and US Great Lakes coastal wetlands, respectively (Table 8). Some wetlands had as few as 2 or 3 species, while 21 (CA) and 29 (US) fish species were the most collected in any wetland. The average number of non-native fish species per wetland was approximately one, though some wetlands had as many as 6 (US). There were 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 all sites sampled, 2011 and 2012.

Country	**Mean**	**Max**	**Min**	**St. Dev.**
Overall				
Can.	10.6	21	2	4.1
U.S.	14.8	29	3	5.1
Non-natives				
Can.	0.6	3	0	0.7
U.S.	1.0	6	0	1.2

Combining 2011 and 2012 data, there were no non-native fish species caught at 44% of the Great Lakes coastal wetlands sampled, but 32% had one non-native species captured (Figure 4). 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.

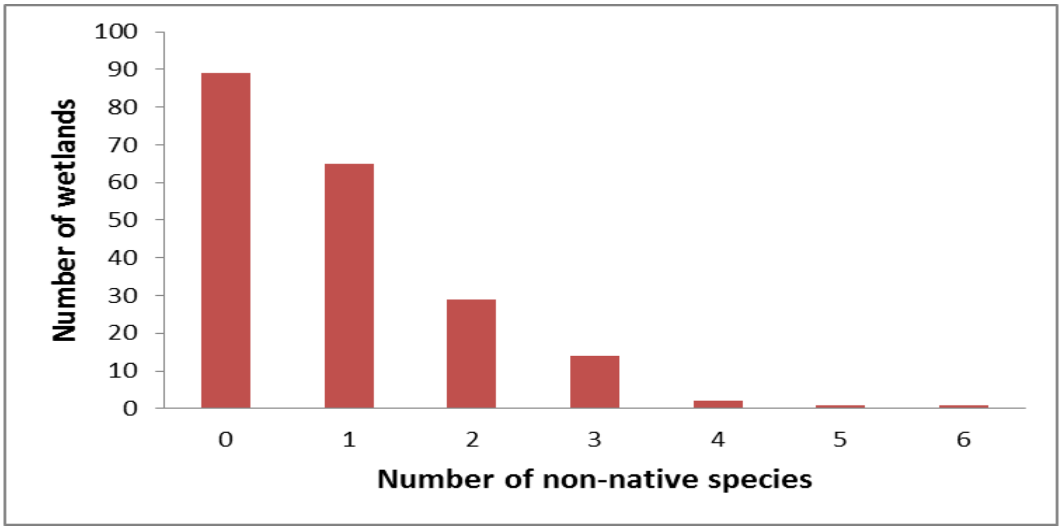

Figure 4. Number of Great Lakes coastal wetlands containing non-native fish species.

Total fish species did not differ greatly by lake, averaging 13-14 species per wetland (Table 9). As with birds, Lake Ontario wetlands had the lowest maximum number of species, with Lake Huron and Erie having the greatest number, and Michigan a very close third. However, the wetland with the fewest fish species was also on Lake Huron, with Lake Superior a close second. Lake Huron wetlands also averaged the lowest mean number of non-native fish. Wetlands with the greatest number of non-native taxa were on lakes Superior and Erie. There were wetlands on each lake in which no non-native fish species were captured.

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.

	Fish (Total)			Non-native		
Lake	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	13.0	29	6	1.6	5	0
Huron	12.8	29	2	0.5	2	0
Michigan	14.9	28	5	1.2	3	0
Ontario	14.6	22	5	1.0	3	0
Superior	14.4	24	3	1.0	6	0

Based on both 2011 and 2012 data, average number of macroinvertebrate taxa (taxa richness) per site was about 43 (Table 10), but some wetlands had more than twice this number. Taxonomically poor wetlands had fewer than 25 (CA) or 13 (US). Note that benchmark sites scheduled for restoration are likely contributing to the lower minimum number of taxa found at sites. So far we have not found that any sites had no non-native macroinvertebrates, emphasizing the widespread distribution of non-native species throughout the Great Lakes. However, the average number of non-native invertebrates in coastal wetlands was less than 2, with a maximum of no more than 4 (Table 10). We should note that our one-time sampling may not be capturing all of the non-native species 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.

Country	**Mean**	**Max**	**Min**
Overall			
Can.	44.5	83	25
U.S.	43.1	104	13
Non-natives			
Can.	1.2	2	1
U.S.	1.4	4	1

There is considerable variability among lakes in the mean number of macroinvertebrate taxa per wetland. Lakes Erie and Ontario wetlands averaged 36 taxa (Table 11), while lakes Huron, Superior, and Michigan averaged 48 taxa. The maximum number of invertebrate taxa found in one wetland is similar across lakes (between 68 and 79), with the exception of Lake Huron, where 104 taxa were found in a single wetland. Minimum numbers are also similar among lakes, although Lake Huron had the fewest taxa in a wetland (13). 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 be driven by benchmark sites that are slated for restoration. There is little variability among lakes in non-native taxa, although a Lake Erie wetland had the most 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.

	Macroinvertebrates (Total)			**Non-native**		
Lake	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	35.7	73	14	1.7	4	1
Huron	48.8	104	13	1.3	3	1
Michigan	47.8	79	22	1.3	2	1
Ontario	36.3	68	18	1.2	2	1
Superior	48.4	79	15	1.3	2	1

On average, there were approximately 45 wetland plant (macrophyte) species per wetland (Table 12), but the maximum number was three times higher (166 species on the US side). The maximum number of macrophyte species in a Canadian wetland was only 73. 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 were designated for restoration efforts. Several restoration groups were seeking baseline data from us to demonstrate eventual recovery of biotic communities.

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

Country	**Site count**	**Mean**	**Max**	**Min**
Overall				
Can.	73	47.0	94	9
U.S.	166	43.7	105	1
Invasives				
Can.	73	3.6	8	0
U.S.	166	3.3	9	0
At risk				
U.S.	166	0.1	2	0

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, cattails (*Typha*) 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, and the maximum found at a site being only two species. This may be partly due to the sampling methods, which do not include a random walk through all habitats to search for at-risk species.

Lake Huron wetlands had the greatest mean number of macrophyte species, with Lake Erie wetlands having much lower mean numbers of species than wetlands on the other Great Lakes (Table 13). Maximum species richness in Lake Erie wetlands was also much lower than wetlands on the other lakes. Average numbers of non-native species were highest in lakes Ontario and Erie wetlands, and lowest in Lake Superior wetlands. The wetlands with the highest numbers of non-native species were also on these lakes. 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.

	Macrophytes (Total)			**Invasive**		
Lake	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	25.0	49	1	4.3	8	0
Huron	52.4	94	19	2.6	7	0
Michigan	46.3	105	10	2.9	7	0
Ontario	42.1	87	15	5.3	9	1
Superior	45.4	78	25	1.6	5	0

Our macrophyte data have reinforced our understanding of the numbers of coastal wetlands that contain invasive plant species (Figure 5). Only 11% of 244 sampled wetlands lacked invasive species, leaving 89% with at least one. Sites were most commonly invaded by 2 – 5 plant species and 18% of sites contained 7 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.

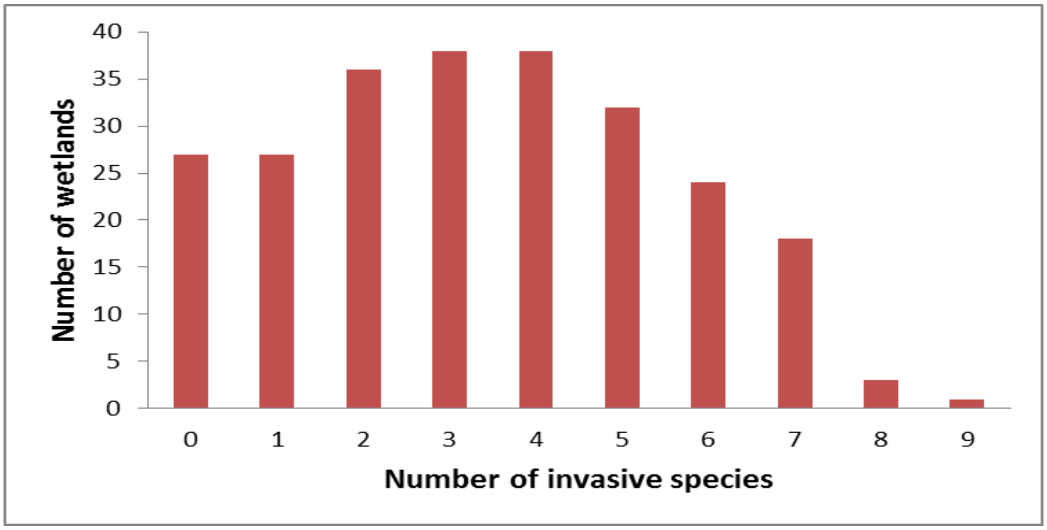

Figure 5. Number of Great Lakes coastal wetlands containing invasive plant species based on 2011 and 2012 data.

In the fall of 2012 we began calculating metrics and IBIs for various taxa. We are evaluating coastal wetland condition using a variety of biota (wetland vegetation, aquatic macroinvertebrates, fish, birds, and amphibians). Macrophytic vegetation (only large plants; algal species were not included) has been used for many years as an indicator of wetland condition. One very common and well-recognized indicator is the Floristic Quality Index (FQI); this evaluates the quality of a plant community using all of the plants at a site. Each species is given a Coefficient of Conservation (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 6, updated from the October 2012 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 agricultural 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.

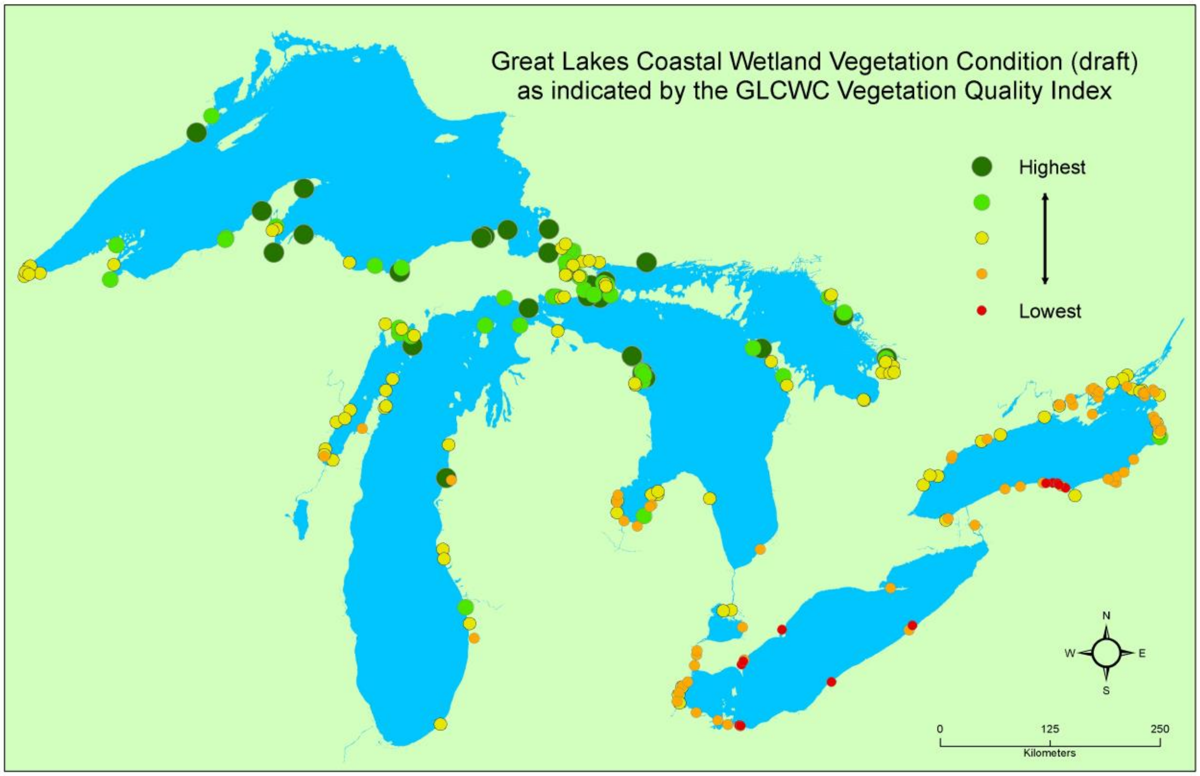

Figure 6. Condition of coastal wetland vegetation at sites across the Great Lakes. Circle size indicates vegetation quality (larger is better). The indicator is labeled “draft” while the effect of recent taxonomic revisions on its values are investigated. Based on data from 2011 and 2012.

We have labeled the wetland vegetation index scores “draft” at this point because we are still investigating the effect on scores of the updated Michigan Flora (2012) with new taxonomic names for many species. We are currently updating species names in the CWM database.

Another of the IBIs that was developed by the Great Lakes Coastal Wetland 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 now calculated these IBIs for 2011 and 2012 sites that contain these habitat zones (Figure 7).

The lack of sites on lakes Erie and Ontario and southern Lake Michigan are due to the sites in these areas not having the three specific vegetation zones that the 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.

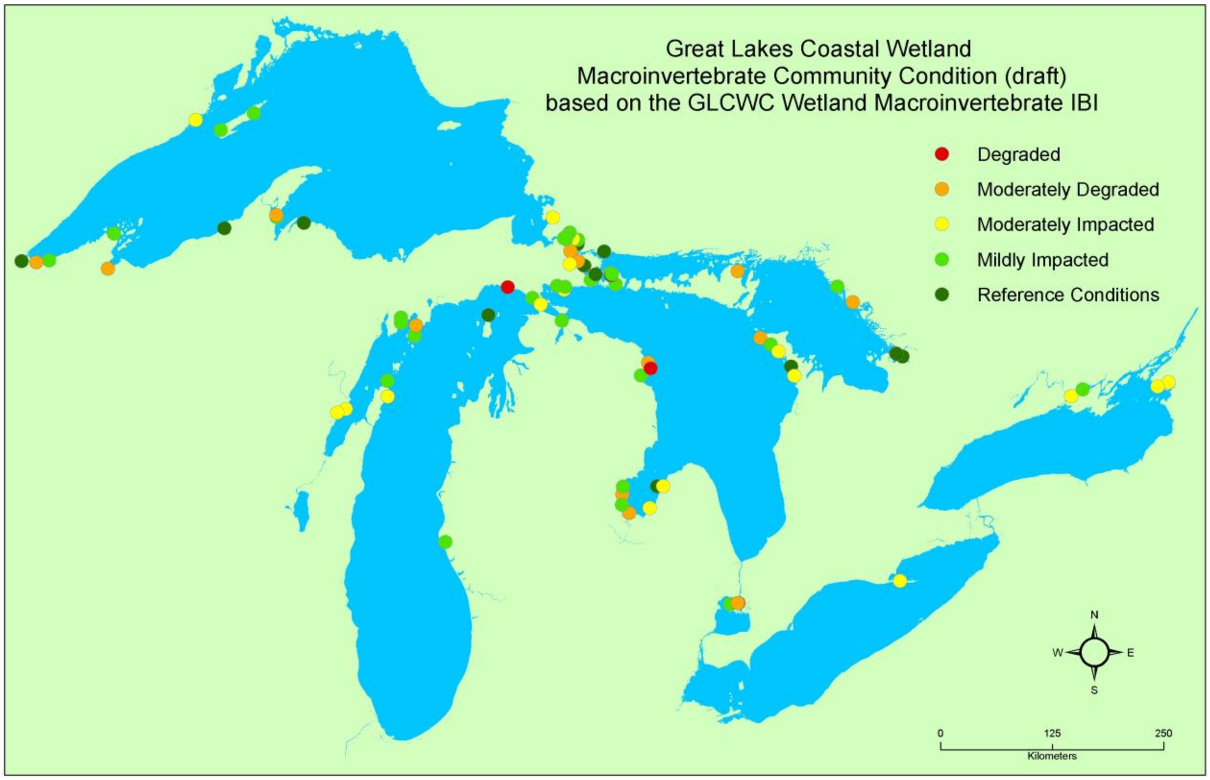

Figure 7. Condition of coastal wetland macroinvertebrate communties at sites with bulrush or wet meadow zones. The indicator is labeled “draft” while more zone IBIs are calculated. Based on data from 2011 and 2012.

We are currently able to report draft fish IBI scores for wetland sites containing bulrush and/or cattail zones (Figure 8). 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 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.

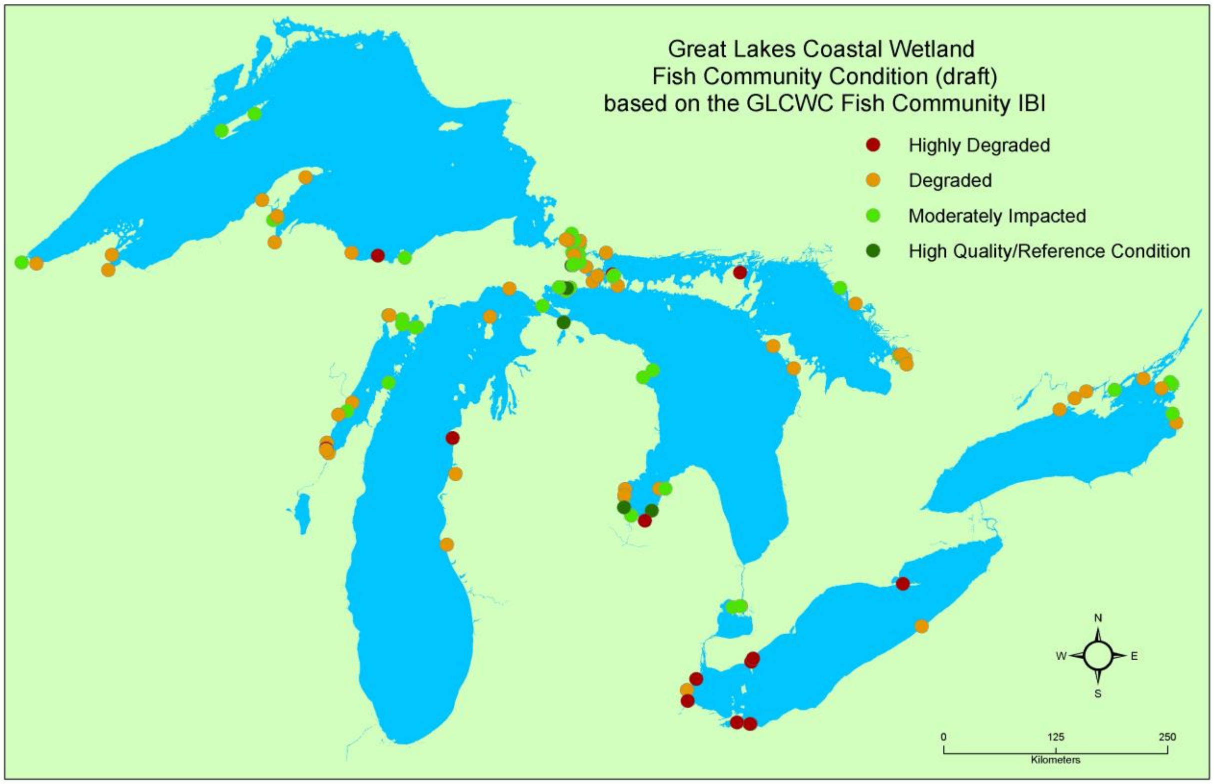

Figure 8. Condition of coastal wetland fish communties at sites with bulrush or cattail zones. The indicator is labeled “draft” while more zone IBIs are developed. Based on data from 2011 and 2012.

Bird indicators had not been validated at the time of the publication of the Great Lakes Coastal Wetland Consortium report (Uzarski *et al*. 2008). We expect to have a bird indicator in draft form shortly.

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.

Conservation Assessment for Amphibians and Birds of the Great Lakes
Several members of the 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. The team has begun assessing the importance of these coastal wetlands as migratory or breeding grounds for birds. A similar effort will also be initiated for amphibians, because many of the amphibians (and birds) living in these coastal wetlands have

been identified as endangered (e.g. Northern Cricket Frog), threatened, or of special concern (e.g. Northern Leopard Frog) in multiple states.

A study (leveraging funding by other sources) is currently underway to specifically target sedge and marsh wren distributions within Great Lakes coastal wetlands. Habitat and landscape characteristics are being modeled against the abundance of each species at multiple spatial scales to determine the role that local and landscape characteristics play in birds choosing breeding habitat. Best fitting models will then be used to create probability maps to help predict breeding habitat and estimate the Great Lakes watershed populations for these species. Once validated, these models can then be applied to other species of interest, within the Great Lakes wetlands. The extensive data that have been gathered by US EPA, such as the Great Lakes Environmental Indicators projects (GLEI I and GLEI II) and the Great Lakes Coastal Wetlands Consortium as well as Bird Studies Canada will provide critical input to this assessment. The proposed large-scale modeling effort will be one of the broadest analyses in terms of sample size and geographic area and will be a valuable tool for future management decisions relating to Great Lakes wetland conservation.

In February, we also began the preliminary analyses of the Coastal Wetland Monitoring data to estimate the detection probability of wetland obligate species and species considered to be indicators of wetland condition (Table 14) recorded during the 2011-2012 field season. We are using the removal model of Farnsworth *et al.* (2002), which is based on temporal stratification, to estimate detection probability for each species. Results can then be used to adjust density estimates and make more accurate inferences about the abundance of given species.

Table 14. List of species considered to be either wetland obligate species (bold) or indicators of wetland condition.

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

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)

2012 Sample Processing and Data Entry

All 2012 data of all types have been completely processed, entered into the CWM database, and QC'd. Macroinvertebrate samples have been exchanged with Central Michigan University for invertebrate identification QC cross-checks.

2012 Interesting Findings (previously reported in the October 2012 report)

Interesting Bird Observations
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 2012 (Table 15). The most unique and important observations included 7 bald eagles, 3 of which were observed in riverine wetlands in Lake Superior, 2 in a barrier protected wetland on Grand Island, MI, and 2 in coastal lacustrine wetlands, one of which was a benchmark site. In the Duluth-Superior area alone there are at least 4 nesting pairs of bald eagles: 3 nests within the St. Louis River Estuary and one within 0.5 mi of the shoreline within the city limits of Duluth. Additional species of interest include: 1) 18 common loons, all of which were observed in various wetland types within island complexes, including 13 observations in a barrier protected wetland on Madeline Island, WI , 2 in riverine wetlands, and 3 in coastal lacustrine wetlands; 2) 17 common terns, a threatened species in Minnesota and Wisconsin, with 3 observations in a coastal lacustrine wetland which is also a benchmark site and 14 observations in a riverine wetland located within the Duluth-Superior Harbor; 3) 13 sandhill cranes – all well distributed in many wetland types including 2 observations in a coastal lacustrine wetland (also a benchmark site), 4 observations in riverine wetlands, and 7 in barrier protected wetlands on 2 island complexes; 4) 3 sora rails observed in riverine wetland complexes including a benchmark site; and 5) mute swan (an invasive, non-native species) observed near Ashland, Wisconsin. There were multiple observations of this species at this same wetland complex in 2011.

Birds of special concern were observed in 15 of the 23 wetland sites surveyed, and of these, 8 were located on islands, accounting for 27 of the 59 observations. Three of the 5 benchmark sites surveyed annually also had birds of special concern including: 1) Allouez Bay, WI (1 bald eagle, 3 common terns, and 2 sandhill cranes); 2) 40th Avenue West, MN (1 bald eagle); and 3) Fish Creek Wetland, WI (1 mute swan and 1 sora rail). The lack of observations of black tern, Forster's tern, Caspian tern, Virginia rail, and pied-billed grebe (all species of concern throughout the Great Lakes) is of particular interest and concern.

Table 15. List of birds of special interest recorded during 2012 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**	**Wetland Type**	**Benchmark Site***
Bald eagle (*Haliaeetus leucocephalus*)	7	barrier, riverine, lacustrine	yes
Common loon (*Gavia immer*)	18	barrier, riverine, lacustrine	no
Common tern (*Sterna hirundo*)	17	riverine, lacustrine	yes
Sandhill crane (*Grus canadensis*)	13	barrier, riverine, lacustrine	yes
Sora rail (*Porzana carolina*)	3	riverine	yes
Mute swan (*Cygnus olor*)	1	lacustrine	yes

* at least one observation occurred within a benchmark site

2013 Off-season and fieldwork plans

Most co-PIs (Danz could not attend) and several technicians attended the CWM organizational and coordination meeting in Detroit, Michigan, in mid-January. Co-PIs will be assisting the Central Michigan team with metric and IBI assessment. Terry Brown, in particular, will be supplying co-PIs with the data necessary for data analyses.

Site Selection

Birds and Amphibians

In 2013, a total of 57 sites have been selected to be surveyed by the western regional team for birds and amphibians. Of the 57 sites, 5 are sites that were previously sampled and are being revisited and 12 are benchmark sites selected because they are in the St. Louis River Estuary. The St. Louis River Estuary is going through the AOC delisting process, and has many wetland areas slated for restoration or enhancement. 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.

The sites selected to be surveyed in 2013 stretch 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 Upper Peninsula of Michigan and extending to northern Lake Huron in Ontario. In March 2013, each of the 58 sites were reviewed to assure that they meet the sampling requirements (e.g. lake connectivity and size requirements (>4 ha)) and were deemed safe and accessible to field crews. Reconnaissance of each wetland is scheduled for April 2013 and will be completed prior to beginning the first round of amphibian surveys in late April.

Fish, Macroinvertebrates, Vegetation, and Water Quality
For 2012, the Brady-Danz fish, invertebrates, and vegetation crews will be attempting 30 sites on lakes Superior and Michigan. Of those 30, five are benchmark sites and four are re-visit sites. Benchmark sites were added in Green Bay to sample ahead of planned restoration work, and in the St. Louis River Estuary for the same reason. The St. Louis River Estuary sites were already on the sampling list, but were moved up to ensure that they are sampled before restoration begins. We anticipate that low water levels in Green Bay and northern Lake Michigan may complicate sampling this summer.

Field Training and Preparation

Birds and Amphibians
The training for amphibian surveys will be held on 11 April 2013 and bird crew training will take place 24 – 26 May 2013. Training involves instructing crews on how to conduct standardized field surveys, on basic travel procedures, and on appropriate field safety measures. Individuals are trained to proficiently complete field sheets and audio testing is also completed to insure that their hearing is within the normal range. Rules for site verification, safety issues including caution regarding insects (e.g., Lyme's disease), GPS and compass use, and record keeping are also included in field training to insure that the guidelines in the QAPP are being followed. All individuals involved in conducting the surveys will have taken and passed each of the following tests on 1) amphibian calls, 2) bird vocalization, and 3) bird visual identification that are based on an on-line system established at the University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal, prior to conducting surveys. All of the individuals who participated in sampling in 2012 passed the required tests prior to sampling. Individuals planning to conduct surveys in 2013 for either birds or amphibians must have taken and passed the necessary test(s) by the following dates: 1) 31 March for amphibian surveys, and 2) 25 May for bird surveys.

Fish, Macroinvertebrates, Vegetation, and Water Quality
We are in the process of hiring crew members for fish/invertebrate/water quality crews and for the vegetation sampling crew. Several fish/invertebrate/water quality crew members will be returning from previous seasons, so we anticipate an efficient field season. Fish, macroinvertebrate, vegetation, and water quality sampling training is planned for mid-June in Duluth, Minnesota. Individual technician aptitude for completing standard procedures will be tested for all parameters, including a field-based fish or vegetation identification exam (depending on the crew). Much of this training will take place in the field at a typical coastal site

to ensure field members learn appropriate techniques and trainers can observe field staff applying techniques appropriately.

All reports from last summer's sampling that are due to the permit granting agencies have been completed. We are in the process of obtaining scientific collection permits from all the relevant entities for this summer's sampling, including the 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 are sending our primary fish identification specialist to special training in Ontario this spring. We are also in the process of getting our University of Minnesota Institutional Animal Care and Use Committee renewal approved for fish sampling.

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

Sample Processing and Data Entry

Central Michigan University:
All bird and amphibian survey data from the 2012 season has been uploaded to the central CWM database. 100% of aquatic macroinvertebrate identification has been completed and all data has been entered into the online database and checked by a second person. Macroinvertebrate samples have been exchanged between collaborating institutions to ensure accurate identification as part of the QA/QC protocols. Central Michigan University obtained samples from GVSU and NRRI-UMD to conduct QA/QC while samples from CMU were sent to UND. Water quality analysis was completed in November 2012 and all data have been entered into the data management system and checked per QA/QC protocols.

Lake Superior State University:
Data entry for all parameters sampled in 2012, except macroinvertebrates, was completed and 75% of the data have been checked following the QA/QC procedures. QA/QC of data should be completed by the end of March 2013. Jake Riley, LSSU technician and Oakland University graduate student, is completing identification of 2012 macroinvertebrate samples. Jake spent two days at CMU working with CMU technicians to verify his identifications and troubleshoot where necessary. He plans to complete all identifications by the end of March and exchange samples with NRRI for QA/QC. Macroinvertebrate data entry will be completed after identifications are complete.

Grand Valley State University:
All field data (i.e., fish, invertebrates, and water quality) were entered and checked for quality control. Aquatic macroinvertebrate identification of the samples collected during the 2012 field season was completed in February 2013 (and that data was entered and checked for quality control). We recently sent macroinvertebrate samples to Central Michigan University for QC checks.

University of Notre Dame:
All laboratory analyses of water samples were completed by December 2012. Sediment processing for %organic matter was completed in January. Jess Kosiara spent one week at the CMU laboratory for assistance with invertebrate identification. Invertebrate identification was completed in March and data have been entered. Invertebrate samples were exchanged with CMU for QA/QC and have been re-identified for validation. Water chemistry data have been entered and QC checked by a second crew member.

Oregon State University:
Plant sampling data collected in 2012 by the Oregon State/Central Michigan crew (55 sites) were quality controlled in the electronic database. Floristic quality indices were calculated for all sites. Data from the 7 benchmark sites was shared with 4 organizations involved in restoration projects. All previously collected data for the project have been entered and have undergone QA/QC.

UW Green Bay
All bird and amphibian survey data from the 2012 season has been uploaded to the central database. Significant progress was made this quarter on refining the quantitative Index of Ecological Condition for general applications in this project. We have developed computer code that streamlines calculations and incorporates the new conceptual advances. This algorithm is ready to apply and awaits information about a standard reference gradient from other researchers.

2012 Interesting Findings (previously reported in the October 2012 report)

Interesting vegetation findings:

1. Expansion of the invasive species frog-bit (*Hydrocharis morsus-ranae*) was further documented. The plant is now well established in western Lake Erie, Lake St. Clair, and the St. Marys River. To date, no occurrences in lakes Michigan or Huron have been documented.
2. Separation of *Phragmites australis* occurrences into native and invasive populations to improve tracking of invasiveness of this species. The native population is relatively common in the northern half of Lakes Michigan and Huron, but is not aggressive.

3. Comparison of St. Marys River data from 1987 through 1990s to current data indicates that the extended low water conditions has resulted in loss of relatively extensive emergent marsh beds along Lake Nicolet and possibly other nearby areas. This may be the result of freighter wakes eroding the emergent beds from the front face, where rhizome and root mats are less developed and more sensitive to wave action, or as the result of winter shipping plucking blocks of bulrush rhizome frozen to surface ice.
4. Signs of invasive *Phragmites australis* treatment with herbicides were seen at several sites in Saginaw Bay, Lake Huron, Green Bay, Lake Michigan, and Lake Erie. There may be opportunity to document successional changes resulting from this management in future years of this study, allowing evaluation of the level of success associated with this management.
5. A few sites were visited that had been plowed or mowed and the effect of this management on plant diversity will be examined.
6. A known location for Michigan monkey-flower (federally threatened) at the edge of Epoufette Bay was visited to familiarize samplers with the plant. Other rare plants potentially found in Great Lakes coastal wetlands were identified and training materials were presented to samplers. Some of these rare plants included dwarf lake iris (*Iris lacustris*) and Houghton's goldenrod (*Solidago houghtonii*). Although not a federally or state listed species, several orchids have been found within the coastal wetlands, including Loesel's twayblade (*Liparis loeselii*), rose pogonia (*Pogonia ophioglossoides*), grass-pink (*Calopogon tuberosus*), and hooded ladies'-tresses (*Spiranthes romanzoffiana*).
7. At least three western Lake Erie marshes had populations of rare plants; populations of *Nelumbo lutea* (American lotus) and *Sagittaria montevidensis* (Montevidense's arrowhead). Both occupy organic rich sediments in protected bays, and the *Sagittaria* can become very common after a Great Lakes water-level drop, rapidly getting outcompeted by other more aggressive perennial species.

Interesting bird findings:
Species of special interest or concern are listed below (Table 16) and included both colonial nesting waterbirds such as American white pelican (*Pelecanus erythrorhynchos*), black-crowned night-heron (*Nycticorax nycticorax*), and secretive marsh birds like Wilson's snipe (*Gallinago delicata*), Virginia rail (*Rallus limicola*) and American bittern (*Botaurus lentiginosus*). Bald eagles were recorded during 10 counts, and terns (caspian, common, Forster's and black) were recorded at 9 point counts.

Other interesting findings include the occurrences of (presumably) non-breeding birds or migrants, underscoring the ecological importance of the Great Lakes ecosystem at all times of the year. For example shorebirds, including marbled godwit, lesser yellowlegs, and greater yellowlegs, were observed during our point counts and are known to use Great Lakes coastal wetlands during migration. We even observed a pair of long-tailed ducks in early June, a species that winters in large numbers in Lake Michigan but breeds in the Arctic.

Table 16. Bird species of special interest or conservation concern recorded during 2012 point counts (121 counts at 36 wetlands) in western Lake Michigan and northern Lake Huron).

Species	**Total Individuals**	**# Counts (max = 121)**
American white pelican (*Pelecanus erythrorhynchos*)	133	19
Great egret (*Ardea alba*)	34	23
Great blue heron (*Ardea herodias*)	34	29
Wilson's snipe (*Gallinago delicata*)	25	23
Virginia rail (*Rallus limicola*)	20	20
Common loon (*Gavia immer*)	19	15
Mute swan (*Cygnus olor*)	18	9
Pied-billed grebe (*Podilymbus podiceps*)	12	12
Bald eagle (*Haliaeetus leucocephalus*)	12	10
Unidentified tern	8	2
Caspian tern (*Hydroprogne caspia*)	7	5
American bittern (*Botaurus lentiginosus*)	7	7
Belted kingfisher (*Megaceryle alcyon*)	6	6
Wilson's phalarope (*Phalaropus tricolor*)	3	2
Black-crowned night heron (*Nycticorax nycticorax*)	2	2
Northern harrier (*Circus cyaneus*)	2	1
Sora rail (*Porzana carolina*)	2	2
Forster's tern (*Sterna forsteri*)	2	2
Common tern (*Sterna hirundo*)	1	1
Black tern (*Chlidonias niger*)	1	1

Notable observations outside the point counts themselves include yellow rails calling in the Munuscong River Delta in Michigan during frog surveys. A nesting colony of black terns was observed in a northern Lake Michigan. At an Ontario wetland, a family of otters and two beavers watched our field team during their bird survey. These and other observations suggest that our brief point counts only scratch the surface in documenting the ecological significance of Great Lakes coastal wetlands.

2013 Field Season Preparations

The lead PI (Uzarski), all co-PIs, and many technicians attended an organizational meeting in Detroit, Michigan, on January 16th. During this meeting, Uzarski volunteered to lead macroinvertebrate metric and IBI evaluation and expansion efforts, and Cooper volunteered to lead fish metric and IBI evaluation and expansion efforts.

Site Selection:
A total of 55 sites were selected for the central basin regional team. Of the 55 selected sites, 13 are designated as benchmark sites and three are Year-2 sites that will be revisited. For fish, invertebrates, and water quality, CMU will sample up to 25 sites, Notre Dame will sample up to 9 sites, LSSU will sample up to 13 sites (including four sites in Ontario), and GVSU will sample up to 8 sites. Our experience over the past two field seasons has shown that during this period of low Great Lakes water levels, many wetlands are not inundated and cannot be sampled for fish or invertebrates. Therefore, we anticipate sampling fewer than the total of 53 (probably 40-45).

Central Michigan University:
CMU submitted the annual scientific collector's permit report for 2012 to the MDNR in December and received the 2013 scientific collector's permit in February 2013. CMU has also renewed its IACUC approval status. CMU is currently preparing for the 2013 field season by ensuring all gear has received maintenance and any needed repairs are made, supplies are being re-ordered and stocked, and field technicians are being evaluated for hiring.

Lake Superior State University:
In February, summer technician hiring was initiated. Announcements were posted and interviews were conducted, and two technicians were hired by early March. Both will work alongside the lead technician. One technician is a returning crew member from 2012, and both technicians are planning to conduct undergraduate research projects related to this larger project. They are studying how physical disturbances associated with freighter traffic impacts macroinvertebrate community structure, including resistance and resilience to future disturbances. Both students received supplemental funding from the LSSU Undergraduate Research Committee to conduct their research in 2013. Reporting to the MDNR for the scientific collector's permit was completed by early March and we are awaiting the collector's permit for 2013 sampling. A collector's permit will be filed with the Ontario Ministry of Natural Resources for the four Ontario sites that are scheduled for sampling in 2013. Equipment and supplies are being evaluated and replaced as needed.

Grand Valley State University:
Annual IACUC reporting and renewal for fish sampling (for the 2012 field season) was completed in February, and Ruetz applied for and received a scientific collector's permit to sample fish for the 2013 field season. Jessica (Comben) Wesolek will serve as the crew leader for GVSU again this year. Equipment and supplies will be evaluated and repaired prior to field sampling.

University of Notre Dame:
A renewal of the MDNR scientific collector's permit was requested and is currently pending. An IACUC renewal form was submitted on April 1st to the UND Animal Care and Use Committee. Jessica Kosiara will serve as the crew leader for UND again this year. One additional technician has also been hired and will be trained in May, prior to field sampling. All field equipment will be evaluated and repaired or replaced in May. State special use permits are being acquired from the State of Michigan for sites on state land.

Oregon State University:
Dennis Albert participated in the Detroit planning meeting in January, 2013. Taxonomic changes to Michigan Flora were reviewed for the 2013 field season. Preparations for 2013 summer vegetation sampling have begun, with 53 sites identified. Sampling will begin in mid-summer. Photo interpretation of the 2013 sampling sites to facilitate rapid deployment of field teams during the summer sampling season has begun. Locations of approximate sampling transects on aerial photos will be followed by in-field location of random transect starting points. Hiring of summer crews has begun, along with acquisition of equipment and reservation of field vehicles. Dennis Albert has organized a symposium at the 2013 Society of Wetland Scientists Conference in Duluth, MI. Dennis Albert is working with Terry Brown to automate Plant IBI calculations.

UW Green Bay:
Bob Howe participated in the Detroit planning meeting in January. 2013 sampling sites have been evaluated on satellite imagery. Field technicians (including 8 UW-Green Bay students) have been hired and tested for appropriate sampling protocols and bird and amphibian identifications and are ready to begin surveying. We also have worked with staff from The Nature Conservancy to establish benchmark sites in Lower Green Bay that are associated with ongoing GLRI-funded ecological restoration efforts.

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

2012 Data Entry and Quality Assurance
Data entry personnel at the College at Brockport have completed 100% of 2012 bird, amphibian, fish, water quality, field-based aquatic macroinvertebrate, and vegetation data entry. Also, 100% of these data have been quality assured by a second individual performing a thorough recheck.

Aquatic macroinvertebrate personnel began processing replicate-level macroinvertebrate samples in October of 2012. Identifications continued throughout the winter of 2012-2013 with various personnel specializing in particular taxa to increase accuracy and identification speed. All macroinvertebrate identification was complete by the end of January 2013, with data entry and quality assurance ongoing. Laboratory macroinvertebrate personnel have entered and quality controlled 100% and 40% of all 2012 laboratory-level identification data, respectively. A small number (~6) of unknown minnow specimens are currently undergoing laboratory level identification checks.

Important 2012 Findings

The tables listed below show general summaries of invasive species and species of conservation interest in the region Brockport sampled. Only one plant species of conservation interest, Beck's water marigold (*Megalodonta beckii*), was found during vegetation sampling during 2012 (Table 17). In contrast, there were numerous invasive plant species found, many of which were both common and found in high densities (Table 18). The three most prevalent species found were Eurasian water-milfoil (*Myriophyllum spicatum*), narrow-leaf cattail (*Typha angustifolia*), and hybrid cattail (*Typha X glauca*). These were typically found in high densities within the wetlands (Table 18). The fish crew did not find any species of conservation interest while sampling; however, six invasive or non-native species were found (Table 19). Only one of these, round goby (*Negobius melanostomus*), made up at least one percent of the total fish caught during the summer. The spring bird and amphibian crews detected no amphibian species and only two bird species of conservation interest (Table 20). Only one black tern (*Chlidonias niger*), and two individual least bitterns (*Ixobrychus exilis*) and were detected during 2012 sampling, with each of the least bitterns occurring at the same site.

Table 17. Plant species of conservation concern encountered during during 2012 sampling.

Common Name	**Scientific Name**	**Number of Sites Present**	**Status (NY)**
Beck's Water Marigold	*Megalodonta beckii*	4.5	Threatened

Table 18. Invasive plant species encountered by The College at Brockport during 2012 sampling.

Species	**Scientific Name**	**Percent of Sites Present**
Eurasian Water-Milfoil	*Myriophyllum spicatum*	90.9
Narrow-Leaf Cattail	*Typha angustifolia*	86.4
Hybrid Cattail	*Typha X glauca*	81.8
Sago Pondweed	*Stuckenia pectinatus*	72.7
Reed Canary Grass	*Phalaris arundinacea*	54.5
European Frogbit	*Hydrocharis morsus-ranae*	50.0
Curly Pondweed	*Potamogeton crispus*	40.9
Common Reed	*Phragmites australis*	27.3
Field Thistle	*Cirsium arvense*	18.2
Flowering-Rush	*Butomus umbellatus*	13.6
Curly Dock	*Rumex crispus*	4.5
Water Chestnut	*Trapa natans*	4.5

Table 19. Number of sites present, total captured, and percent of all fish captured of exotic or invasive species encountered by The College at Brockport during 2012 sampling.

Species	Scientific Name	Sites Present	Total Caught	% of 2012 catch
Round Goby	*Negobius melanostomus*	9	152	1.32
Alewife	*Alosa pseudoharengus*	1	23	0.20
Eurasian Carp	*Cyprinus carpio*	6	14	0.12
White Perch	*Morone americana*	2	9	0.08
Goldfish	*Carassius auratus*	2	7	0.06
Rudd	*Scardinius erythropthalmus*	3	3	0.03
Total			**208**	**1.81**

Table 20. Number of sites present and total detections of bird species of conservation need by The College at Brockport during 2012 sampling.

Species	Scientific Name	Sites Present	Total Observed	Status
Least Bittern	*Ixobrychus exilis*	1	2	Threatened (NY)
Black Tern	*Chlidonias niger*	1	1	Endangered (NY)

2013 Field Season Preparations

The College at Brockport, with assistance of personnel from Environment Canada, spent winter months finalizing their 2013 site list by adding benchmarks and reassigning sites. Eight sites initially slated for completion by Environment Canada have been reassigned to The College at Brockport for fish, aquatic macroinvertebrate, water quality, and vegetation sampling. These swaps were performed to both maximize the logistical efficiency of sampling and to ensure proportionally representative sampling across strata. The College at Brockport also designated three benchmark sites, Braddock Bay, Buck Pond, and Cranberry Pond, all located within the Rochester embayment. These sites were selected due to a request from the US Fish and Wildlife Service for all data possible from wetlands within the Rochester Area of Concern. The benchmark designation for Braddock Bay will serve a dual purpose, as it will also help provide preliminary data for an upcoming joint project between US Army Corps of Engineers and The College at Brockport, whose goal is to restore sedge-grass meadow within the embayment. The random site selection system did not designate any repeat sites for The College at Brockport to perform.

Summer Preparation and Crew Assignments

Preparation for 2013 fieldwork is underway, with the greatest focus on gearing up bird and amphibian crews. The College at Brockport personnel are currently filling out access permits for sites that are on state or federal property now that the site list is finalized. Most field maps, datasheets, and site schedules have been completed, again with heavy emphasis on those required for bird and amphibian sampling. Bird and amphibian training has begun; however, official certification is not complete yet. Finally, crews are starting equipment checks and inventory to prepare for the summer fish, aquatic macroinvertebrate, water quality, and vegetation sampling.

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)

Sample Processing and Data Entry

All field data collected during the 2012 field season have been uploaded and QC'd. All fish, macroinvertebrate, macrophyte and water quality data were compiled and entered into the database and quality assured over the winter. Specimens received from companion labs (part of the reciprocal exchange of macroinvertebrate specimens to ensure consistency of identification) have been identified and returned to the sample owners.

Reports to the permit granting agencies for 2012 collections were submitted and approved in late fall. Records of fishes caught were sent to local conservation and refuge managerial groups in Ontario and Ohio where appropriate.

2012 Analyses
In 2012, fish data from Canadian vegetation-dominated wetlands were analysed by Curtis Makish, Honours undergraduate thesis student, to assess the effect of *Phragmites* monocultures on fish species richness and community composition. Preliminary analyses indicated that the fish assemblages caught in fyke nets adjacent to *Phragmites* beds are similar to catches made beside *Typha* (cattail) beds, and were distinct from the fauna of *Schoeneplectis* (bulrush) beds. These data are being validated by examination of data from other Great Lakes sites collected in 2011 and 2012. Fish data are also being analyzed by M.Sc. student Jeffrey Buckley to compare the consistency of classification of wetland condition using analytical metrics derived by several different investigators. Buckley is comparing the wetland IBI of Uzarski *et al.* with the fish quality indices of Seilheimer *et al.*, and a new multivariate index based on the reference-degraded continuum approach.

Honours undergraduate thesis students Jasmine St Pierre and Alexandra Pollock collected supplemental data during the 2012 field season to assess macroinvertebrate-submerged macrophyte associations. St. Pierre is determining the extent to which zoobenthic taxa richness is affected by macrophyte structural complexity or its variability. Pollock is assessing how structural complexity influences predator prey relationships. Makish, Buckley, St Pierre and Pollock all gave presentations at the 2013 Canadian Conference on Freshwater Fisheries Research. Other presentations included documentation of range extensions and new records of aquatic invasive fish and zoobenthic species and Species at Risk (Gathman *et al*.) and a study of similarities in community composition changes among fish, birds, invertebrates, diatoms, and aquatic plants across Great Lakes stressor gradients (Kovalenko *et al*.). St. Pierre also presented at the 2013 Ontario Biology Day Symposium for undergraduate students.

Significant 2012 Macroinvertebrate, Fish, and Vegetation Observations (previously reported in October 2012 report)

Species of note were observed at several locations during the 2012 field season. One grass pickerel (*Esox americanus vermiculatus*) was captured at Presqu'ile Bay Marsh (Lake Ontario). Two map turtles (*Graptemys geographica*) were found in fyke nets and released at Pine Point (Lake Ontario). Eastern musk turtles (*Sternotherus odoratus*) were found in fyke nets (one specimen per site) at Roberts Island and Tobie's Bay sites near Honey Harbor, Ontario. A specimen provisionally identified as a pugnose shiner (*Notropis anogenus*) was caught at Anderson Creek (Lake Huron). Three invasive tubenose gobies were found at Quarry Island Wetland (Georgian Bay of Lake Huron). Another distinctive invader – the very large 'Chinese mystery snail' (*Cipangopaludina sinensis*) was commonly observed at the Tobie's Bay wetland.

Small cells of invasive *Phragmites* (*P. australis*) were observed getting a foothold in some the Georgian Bay wetlands. Native *Phragmites* (*P. americanus*), along with the invasive strain, was present at Long Point Wetland. Invasive *Phragmites* was quite prevalent at wetlands in Lake St. Clair and Lake Erie wetlands. *Solidago houghtonii* (a vegetation species of special concern) was present at the Scott Point Wetland Complex. Wild rice (*Zizania aquatica*) was present at Lake St. Clair wetlands and along Long Point. Wildlife observations while conducting the vegetation assessments included a young Eastern fox snake (*Eleaphe gloyd*i; threatened) observed at Point Au-Baril site, black terns (*Chlidonias niger*; special concern) observed at the Lake St Clair Marshes and a least bittern *(Ixobrychus exilis*; threatened) and Sora rail (*Porzana carolina*) both observed at the Hebblethwaite Drain 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 our project, as well as other sources of turtle observations, have identified multiple suitable habitat locations for proposal as candidate critical habitat in the Recovery Strategy for Multiple Turtle Species.

2013 Field Season Preparations

New sites for 2013 have been (amphibians and birds) or are being (fish, macroinvertebrate, and vegetation) assessed by remote examination. Preliminary assessments of site accessibility and suitability for sampling by the other teams is partially complete. 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). Permit renewal applications are in progress to ensure approval by the start of the sampling season.

The majority of individuals participating in fieldwork in 2012 have been retained for 2013. Consequently, there has been relatively little need for training new personnel. Furthermore, only minor alterations to last year's sampling protocols were proposed at the January 2013 All Investigators meeting, meaning that minimal retraining will be required prior to the start of the 2013 field season. However, all crew members will be re-tested and re-certified on all aspects appropriate for their crew. New recruits include one individual for the Tozer amphibian and bird team. Five people will be collecting data for the project in 2013. Amphibian surveys are currently in progress and bird surveys will begin shortly. Cold spring weather has likely delayed the onset of amphibian breeding activity, especially relative to the very warm 2012 season.

Field crew members working with fishes, macroinvertebrates, and water quality sampling will receive orientation during the last week of April 2012 and will conduct pilot sampling at a local site (Turkey Creek, ON) during early May. All members of the 6-person Windsor field crew from 2012 will be involved in field work in 2013, one or two of whom will become graduate students in fall 2013. The Canadian Wildlife Service will again have 7 personnel to conduct work on Lake Ontario in 2013, two of whom will be new recruits (receiving training in April). Training review will include GPS use, determination of whether sites meet project criteria (open water connection to lake, presence of a wetland, safe access for crew), identification of vegetation zones to be sampled, collection of water quality samples (including preprocessing for shipment to water quality labs) and calibrating and read field instruments and meters. Other review will include refresher instructions in setting, removing, cleaning and transporting fyke nets, and special emphasis on collection of voucher information (proper photographic procedures, collection of fin clips for DNA analysis, or retention of specimens for lab verification of identity), protocols for collecting and preserving macroinvertebrates using D-frame dip nets and field-picking. Crews will review field data sheet entry procedures, including changes to the data sheets implemented since last field season. All field personnel will be given refreshers in basic fish identification training and must pass the fish identification tests before identifying fish unassisted.

Three team members (Joseph Gathman, Jasmine St Pierre and Justin Landry) will take the Royal Ontario Museum course in fish identification, which is required of at least one team member in possession of an Ontario Scientific license to collect fishes. Crew leader Janice Gilbert and graduate student Jeffrey Buckley have previously completed the course. All field team members will receive field and lab safety training. Vegetation survey training will be led in early June by team leader Janice Gilbert near Windsor, ON. Vegetation assistants will be introduced to the specific vegetation sampling methodology and data recording methods outlined in the QAPP.

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 this winter and was discussed at the January coordination meeting in Detroit. 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 6 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. The Central Basin Team met at Central Michigan University to discuss and come to consensus on invertebrate taxonomy that were particularly challenging for laboratory staff.

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

- 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 nearly all data that has been entered into the database over the past six months and is a requirement before data is analyzed or used to calculate IBI metrics. Data that still require QC have been identified and regional labs were notified and are currently finishing these checks.

- Macroinvertebrate QC checks: Each regional lab that is processing macroinvertebrate samples has 'blindly' traded samples with the next closest regional lab. Swaps were made between labs that sampled wetlands at a similar latitude to ensure familiarity with the taxa being evaluated. Labs sent two previously-processed samples with relatively high taxa diversity to their assigned QC lab, and then sent the corresponding IDs and counts to the QA managers. Each sample was contained in a single vial that was identified with a unique code that precluded the receiving lab from determining the site or vegetation zone that the sample originated from. The receiving lab will then process the sample as usual and send the IDs and counts to the QA managers. The QA managers will compare the original IDs with the QC IDs to determine correspondence between the two labs. Inconsistencies in taxa IDs will be resolved by a 3rd or 4th lab or by additional taxonomic experts, if necessary, depending on the nature of the discrepancies. At present, most labs have made the required swaps for 2012 samples and many have completed the required processing. After QA managers compare original and QC taxa IDs and counts, and resolve discrepancies, they will communicate results and necessary corrections to the various labs.

- Mid-season QC checks: The only mid-season QC check that was required over the previous six-month period was for macroinvertebrate processing. Regional lab leaders conducted these mid-season checks and were responsible for remedying any problems that were detected. The macroinvertebrate sample swaps are an additional measure to ensure consistent taxonomy.

- Creation/maintenance of specimen reference collections: Reference collections for macroinvertebrates, fish, and plants are being created or maintained by each regional team. Macroinvertebrate reference collections, in particular, were developed or expanded over the previous six months as these samples have been processed.

- Correction of the bullhead fish mis-identification problem: We discovered a problem with separating young-of-the-year brown and black bullheads, with at least one crew probably mis-identifying a number of these individuals. We have determined better identification procedures, back-corrected identifications for those samples for which we had preserved specimens, and converted the other identifications to a combined category of "black or brown bullhead". Crews will be directed to preserve several individuals of all YOY bullheads at each site for positive identification in the laboratory, where it can be done much more accurately.

- Integration of the new vegetation taxonomic work: This new reference work changes the names for many of the Great Lakes flora. Researchers have students working on summarizing the changes in the form of a crosswalk between the former taxonomic names and the new names, which will provide both the pre-2012 and the 2012 Voss and Reznicek flora names. The new list is updated to the Flora of North America, and should cause no problems in terms of the database. The Floristic Quality Index scores are being updated as part of this process, and these revised scores, which will reflect all new species, collapsed species, and expanded species, should be available for autumn FQI/wetland condition index computations. The final challenge will be to update all of the previously-entered species in the database to the new names.

- 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 were calculated over the past six months and will be linked to the primary data that is being generated.

- Bird and amphibian crews began their field season in early April. All training and certification of crew members was conducted prior to crew members working independently. Records of this training and certification are being compiled and archived at each respective regional lab as well as with the project QA managers.

Example Water Quality QC Information

Water quality analyses for all 2012 samples have been completed. Laboratory results have passed the criteria shown below (Table 21) and all results have been entered into the GLIC-CWC database.

Table 21. Data acceptance criteria for water quality analyses.

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

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

Variability in Water Quality Field Duplicates

An analysis of sample variability is shown in Table 22. 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) or limit of detection (LOD), 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, the mean is 0.6, resulting in an RPD of 91%, 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. Table 22 summarizes the QA/QC data for 2012 and indicates that data quality objectives were met. Higher than expected RPDs were associated with a preponderance of near detection limit sample values.

Table 22. Sample variability expressed as relative percent difference of duplicate samples for various water quality parameters measured at regional laboratories. 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). Metrics are based on 2012 analyses. N=number of field duplicates unless noted otherwise.

Analyte	MDL	Mean Value	Average RPD (%)	Max expected RPD (%)
NRRI				
Chlorophyll-a	< 0.5 µg/L	6.6 (n = 5)	20	30
Phaeophytin	< 0.5 µg/L	2.5 (n = 5)	[A]75	30
Total phosphorus	< 0.002 mg/L	0.049 (n = 5)	18	30
Ortho-phosphorus	< 0.002 mg/L	0.009 (n = 5)	16	10
Total nitrogen	< 0.010 mg/L	0.662 (n = 5)	7.1	30
NH4-N	< 0.002 mg/L	0.029 (n = 5)	11	10
NO2/NO3-N	< 0.002 mg/L	0.038 (n = 5)	12.3	10
True color	< 5 units	106 (n = 5)	5.0	10
Turbidity	< 0.4 NTU	15.6 (n = 2)	[B]30	10
chloride	< 0.5 mg/L	15.5 (n = 5)	2.6	20
ANC	< 0.5 mg/L	74 (n = 1)	2.9	10
Central Michigan U.				
NH4-N	0.01 mg/L	0.049 (n = 4)	11.9	10
NO2/NO3-N	0.01 mg/L	0.058 (n = 4)	[C]57.8	10
Ortho-phosphorus	0.01 mg/L	0.085 (n = 5)	5.6	10
Total nitrogen	0.04 mg/L	1.044 (n=4)	8.1	30
Total phosphorus	0.03 mg/L	0.085 (n=4)	9.1	30
Notre Dame				
Chlorophyll-a	0.5 µg/L	3.08 (n=11)	[D]13.1; 50.9	30
Grand Valley State				
Chloride	0.01 mg/L	32.5 (n=1)	9.2	10
Total phosphorus	0.01 mg/L	0.030 (n = 1)	[E]39	30
Ortho-phosphorus	0.005 mg/L	<0.005 (n = 1)	[F]NA	10
Total nitrogen	0.01 mg/L	0.62 (n = 1)	14.2	30
NH4-N	0.02 mg/L	0.03 (n = 1)	[E]66.7	10
NO2-N	0.01 mg/L	<0.01 (n = 1)	[F]NA	10

[A]6 out of 10 phaeophytin field replicates were < 2 µg/L or 4 times the MDL (range 0.2 – 7.5).
[B]The variability in the turbidity data is due to one replicate set as well as the small sample set (n = 2).
[C]High RPD for NO2/NO3-N resulted from 2 sample pairs being very close to MDL.
[D]The first RPD value is for duplicated analyses on the same collected samples (extraction through analysis), the second is for field duplicates (separate water samples filtered, extracted, and analyzed).
[E]These high RPD values resulted from duplicate samples being very close to LOD.
[F]RPD could not be calculated because concentrations were below LOD.

Communication among Personnel

Regional team leaders and co-PIs continue to maintain close communication as the project enters into the third year of data collection. All major project members met in Detroit on January 16, 2012 to discuss and resolve methodological questions and discuss progress on IBI refinement. It was determined at the January meeting that no edits to the QAPP or SOPs were necessary for the 2013 season.

Good communication has also been maintained among technical staff responsible for processing macroinvertebrate samples collected in 2012. For example, many phone calls and e-mails continue to be exchanged between staff to resolve taxonomic questions as they arise. Additionally, numerous staff members have traveled to other regional labs to work side-by-side with other project taxonomists to ensure consistent IDs. We will continue to maintain this level of communication among staff members as it promotes consistency among labs.

From the QA managers' perspective, the first two years of the project were highly successful. The quality management system developed for this project has been fully implemented and is functioning well. The current version of the QAPP and SOPs (Revision 3) continues to function very well. We anticipate that very little revision will be required in subsequent years, though we will review each protocol carefully each year to determine whether improvements can be made.

Nearly every crew will consist of >50% returning and experienced personal in 2013, which will make the training period for 2013 very efficient. PIs will oversee training and visit their teams during the middle of the season to ensure that all sampling is being conducted in accordance with the training and the QAPP.

Overall

From the PI and QA managers' perspectives, the second field and laboratory seasons were 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 second year of this project was extremely successful and the third year is expected to be as well. We are looking forward to an efficient and safe third field season.

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.

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 using methods closely related to CWM methods by CWM crews to 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.

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 both the St. Louis River (Lake Superior) and Maumee Bay (Lake Erie) 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; 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 and in Sodus Bay, Lake Ontario.

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 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.

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).
- Invasive plant species in Lake Ontario 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 summer 2012):

- 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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