GLIC: Implementing Great Lakes Coastal Wetland Monitoring

Semiannual Progress Report

April 1, 2012 – September 30, 2012

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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 even more sites than the first year. This is likely due to experience gained during the first year. Teams have entered and QC'd most of the data from the second field season and are in the process of finishing up identification of difficult fish and vegetation. Macroinvertebrate identification and data entry will continue through winter.

PIs are currently investigating taxonomic issues that seem to be affecting a few of the macrophyte and fish metrics, and Dr. Terry Brown is streamlining calculations programmed into the database. PIs are also developing metrics specific to vegetation zones that currently lack IBIs. . Finally, we are addressing the stability of metrics based on a comparison of the data from the original samples and the revisited sites.

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 been replaced by Anne Hokanson. No major personnel changes have taken place during this reporting period.

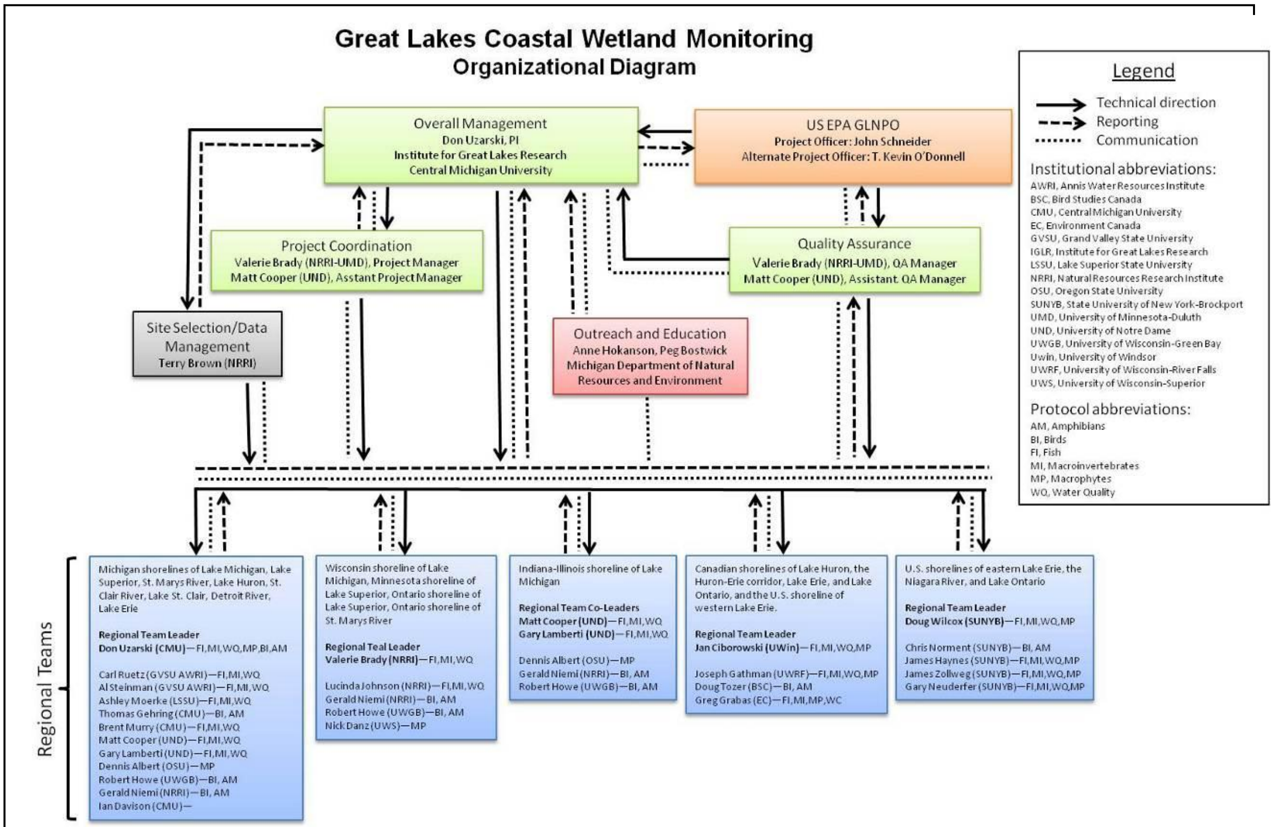

Figure 1. Organizational chart for the project showing lines of technical direction, reporting, and communication separately.

PROJECT TIMELINE

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

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

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

SITE SELECTION

This year, site selection was completed in March, and differed from the year-one site selection because the re-sampling process was initiated. Ten percent of sites sampled the previous year were re-sampled this year to help us start tracking trends in wetland condition and to help assess inter-annual variability in indicator metrics.

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 coastal wetlands, non-woody, with a lake influence 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 by Coastal Monitoring crews, 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 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 is also an area that is 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 dissected by riverine elements.

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).

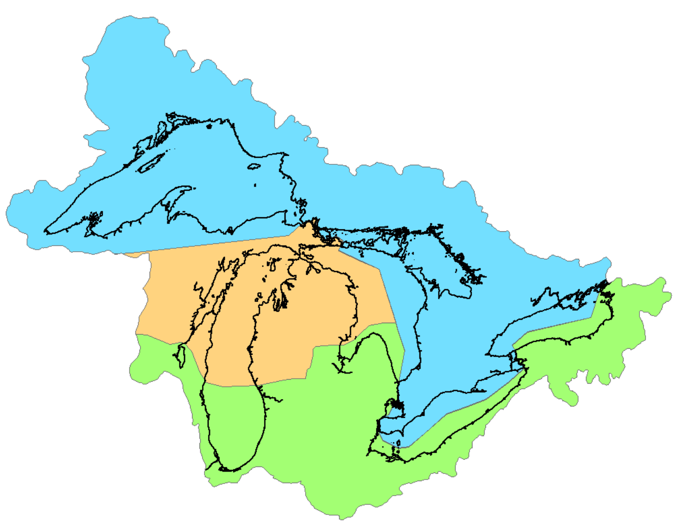

Figure 2. Divisions of lakes into regions. Note that stratification is by region *and* lake, so northern Lake Erie is not the same region as Lake Superior, etc.

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 moved 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
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 (we worked throughout the winter to update and improve boat ramp location information). 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.

2012 Site Selection

Wetlands have a “clustered” distribution around the Great Lakes due to geological differences. As happened in 2011, and will likely happen in coming years, 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 have been asked to 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 swaps.

PIs again identified a number of important sites that should either be sampled more than once in 5 years, or that would not normally be sampled at all because of size or because a wetland no longer exists at the site but are deemed worthy of sampling for other reasons. 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 this year were sampled at the request of other agencies or groups (see individual team reports). The agencies and groups working on many of these wetlands are happy to have pre-restoration data provided to them at no cost, and are hopeful that we can return to re-sample after restoration is complete.

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 a year 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. The trainers are available via phone and email to answer any questions that arise during any of the multiple training sessions.

The following is a synopsis of the training that was conducted by PIs this spring: Each PI trained all field personnel on meeting the data quality objectives for each element of the project; this includes reviewing the updated QAPP and SOPs, covering site verification procedures, providing hands-on training for each sampling protocol, and reviewing record-keeping and archiving requirements, data auditing procedures, and certification exams for each sampling protocol. Crew members were trained in appropriate University laboratory and field safety protocols, and many received various types of first aid training. All field crew members passed all training certifications before they were allowed to work unsupervised. Training was easier and more efficient this year due to the high number of returning field crew members from last year. These experienced crew members helped train and supervise new crew members.

Bird and amphibian field crews were tested on the amphibian call test, the bird vocalization test, and the bird visual test that was established on-line. The test is based on an on-line system established at the University of Wisconsin, Green Bay – see www.birdercertification.org/GreatLakesCoastal. In addition, individuals were tested for proficiency in completing field sheets and audio testing was completed to insure their hearing was within the normal ranges.

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

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.

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 is now nearly complete; all "raw" data is available to PIs of each taxonomic group (Figure 3), 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.

Figure 3. Basic categories available under the data retrieval section of the web site. All queries except those under the "General Summaries" section are password-protected until data QC are completed each year.

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 a new type of data packaging: Excel and Access-ready primary data. These data sets 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.

The Excel format exports as a series of spreadsheets in a single workbook for each taxonomic group. The Access-ready data consists of a ZIP file containing the database contents in CSV and DBF formats, and an Access template file with some VisualBasic code to import the DBF files. The relationships between tables are automatically re-created within Access during the import, which is very valuable given the complexity of some of the data sets. The CSV files are useful for analysis with tools such as SAS and R.

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).

2011/2012 RESULTS SUMMARY

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). When compared to the total number of wetlands targeted to be sampled by this project (Table 2), we achieved 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**	

The sites sampled in 2012 are shown in Figures 4 and 5, color coded by taxonomic team that sampled the sites and wetland types, respectively. Many sites were sampled for all taxonomic groups. Sites not sampled for birds and amphibians typically were sites that were impossible to access safely, and often related to private property access issues. Most bird and amphibian crews do not operate from boats since they need to arrive at sites in the dark or stay until well after dark. There are also a number of sites sampled only by bird and amphibian crews because these crews can complete their site sampling more quickly and thus have the capacity to sample more sites than do the fish, macroinvertebrate, and vegetation crews. The NRRI crews were even able to sample several wetlands on Isle Royale this year despite logistical barriers .

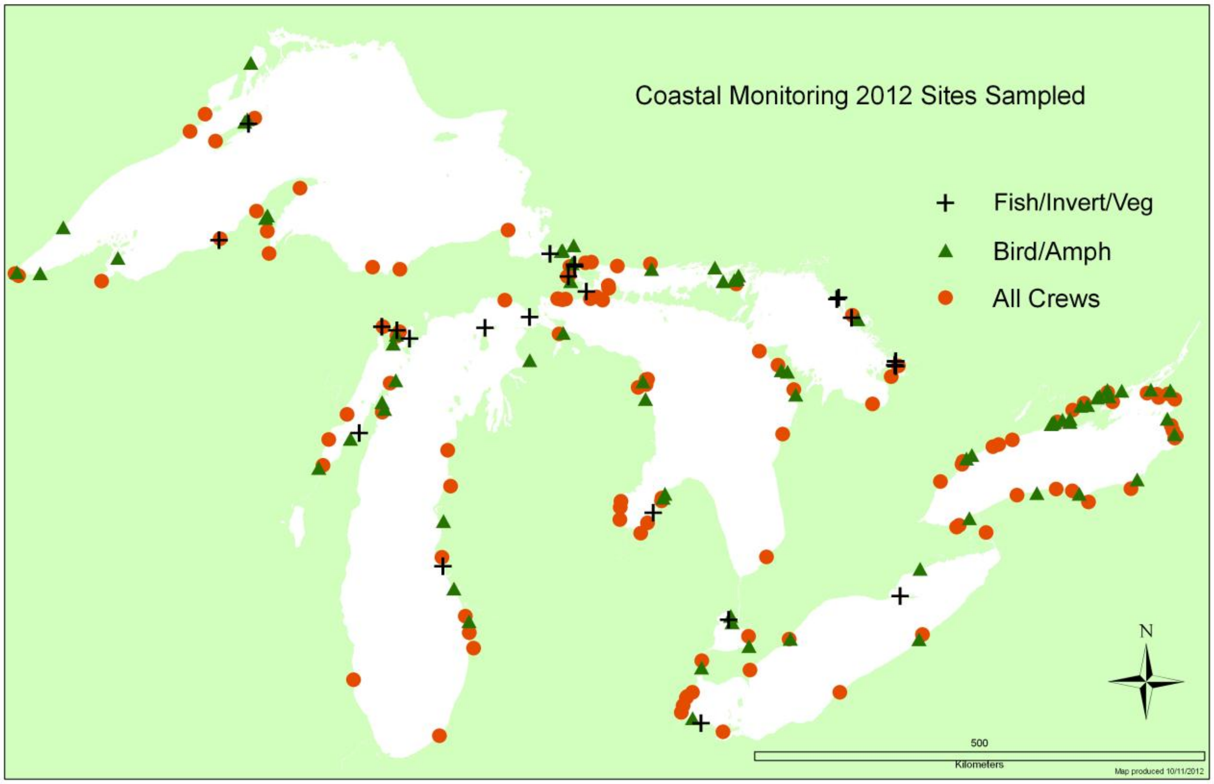

Figure 4. Locations of the 206 Great Lakes coastal wetlands sampled in 2012, color-coded by taxonomic groups. Sites assigned only to bird and amphibian crews (due to their greater sampling capacity) are shown in green.

Wetland types are not distributed evenly across the Great Lakes due to topography and geology (Figure 5). Lacustrine wetlands occur in more sheltered areas of the Great Lakeswithin large bays or adjacent to islands. Barrier-protected wetlands occur along harsher stretches of coastline, particularly in sandy areas, although this is not always the case. Riverine wetlands are somewhat more evenly distributed around the Great Lakes. Note thatrevisit sites are shown in Figure 5 (blue stars); these are sites that were sampled in 2011 and then again in 2012 to account for temporal variation in metrics and indicators. Furthermore, continued reduction in water levels of lakes Michigan, Huron, and Erie, require that all indicators are relatively robust to normal water level variations.

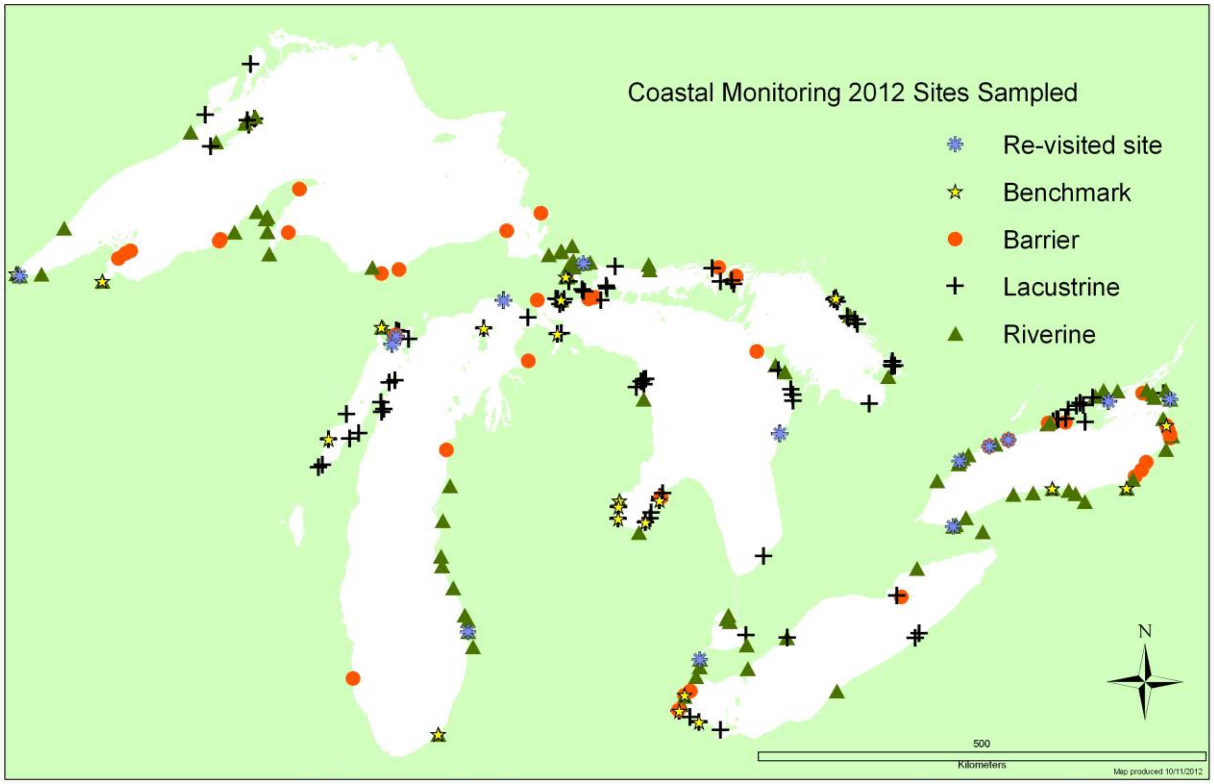

Figure 5. Locations of the 206 Great Lakes coastal wetlands sampled in 2012, color-coded by wetland type. Note that some site types do not occur in some areas of the Great Lakes due to topography and geology.

At coastal wetland sites, 178 bird species have been identified. Wetlands usually contained about 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 diversity among lakes for wetlands with the least 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 there are fewer species occurring 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

A mean of about 11 to 14 fish species were collected in Canadian and US Great Lakes coastal wetlands, respectively (Table 8). Some wetlands had as few as 2 to 3 species, while 20 (CA) or 29 (US) fish species were the most collected in any wetland. An average of one non-native fish species was found in every wetland, although some had as many as 6 (US wetlands). However, there were wetlands in which no exotic fish species were caught.

Table 8. Total fish species in wetlands, and non-native species; summary statistics by country.

Country	**Mean**	**Max**	**Min**	**St. Dev.**
Overall				
Can.	10.5	20	2	4.0
U.S.	14.5	29	3	5.4
Non-natives				
Can.	0.7	2	0	0.7
U.S.	1.0	6	0	1.2

The majority of Great Lakes coastal wetland sites sampled in 2011 were found to contain at least one non-native fish species (66% of wetlands) (Figure 6). Forty-two percent of sites contained only a single non-native fish species, and there were relatively few sites with more than a single non-native species. 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.

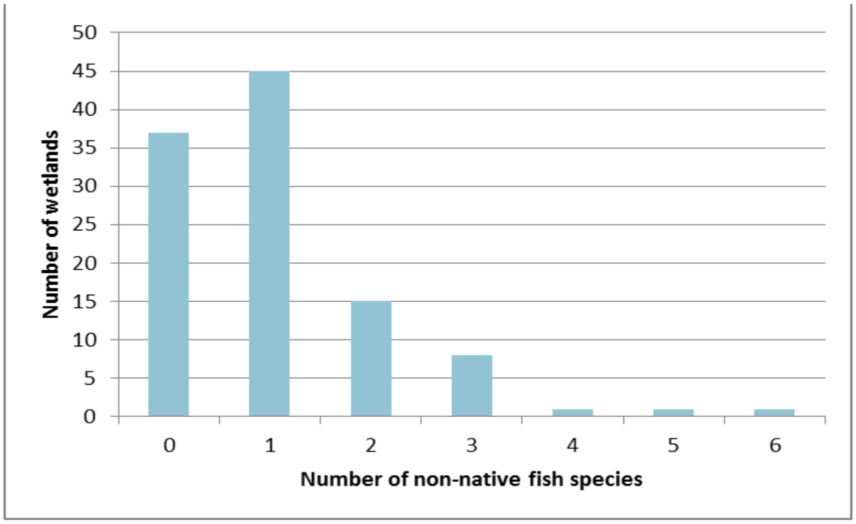

Figure 6. Number of Great Lakes coastal wetlands containing non-native fish species.

Total fish species did not differ greatly by lake, averaging 12-14 species per wetland (Table 9). As with birds, Lake Ontario wetlands had the lowest maximum number of species, with Lake Huron having the greatest number. However, the wetland with the fewest fish species was also on Lake Huron. 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 exotic species of fish 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	12.2	27	6	1.8	5	0
Huron	12.9	29	2	0.6	2	0
Michigan	14.5	27	5	1.2	3	0
Ontario	12.9	22	6	0.9	3	0
Superior	14.1	25	3	1.0	6	0

Macroinvertebrate taxa were sampled at a number of Great Lakes coastal wetlands. Average number of taxa (taxa richness) per site was around 40 (Table 10), but some wetlands had nearly twice this number. Taxonomically poor wetlands had fewer than 20. 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 wide spread distribution of exotic 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 speicies 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**	**St. Dev.**
Overall				
Can.	43.2	79	16	17.0
U.S.	40.4	76	13	16.2
Non-natives				
Can.	1.5	4	1	0.9
U.S.	1.3	2	1	0.5

There is quite a bit of variability in the mean number of wetland macroinvertebrate taxa by lake, with lakes Erie and Ontario wetlands only averaging 29-30 taxa (Table 11), while lakes Huron, Superior, and Michigan average 46-50 taxa. The same pattern is seen for the maximum and minimum numbers of taxa in wetlands, with the exception of Lake Huron, where some wetlands had as few taxa as wetlands on Erie and Ontario. This difference among lakes may be in part due to the loss of wetland habitat complexity on lakes Erie and Ontario from diking (Erie) and water level control (Ontario). This has been documented in numerous peer-reviewed publications. There is little variability among lakes in 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	28.3	42	14	2.3	4	1
Huron	46.0	79	13	1.3	3	1
Michigan	50.2	76	26	1.4	2	1
Ontario	29.6	49	14	1.3	2	1
Superior	47.3	68	24	1.3	2	1

On average, there were approximately 45 wetland plant (macrophyte) specie per wetland (Table 12), but the maximum number was nearly twice this (78-87 species, depending on the country). However, some sites were quite depauperate in plant taxa, 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 recoverory 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.	45	47.8	87	9
U.S.	96	42.0	78	1
Invasives				
Can.	45	4.0	8	0
U.S.	96	3.2	8	0
At risk				
U.S.	96	0.3	2	0

Invasive vegetation is commonly found in these wetlands. Those that we sampled averaged 3-4 invasive species (Table 12). Note that species classified as “invasives” are often non-native as well, but do not have to be to receive that designation. For example, cattails (*Typha*) are considered invasive but can be native. Some wetlands contained as many as 8 invasive macrophyte species, but there were wetlands in which no invasive plant species were found. Restoration groups often struggle to restore wetland sites without invasive species dominating.

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 much less than one, with many sites having no at-risk species, and the maximum found at a site being only two 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 Lake Ontario wetlands followed by Erie wetlands, and lowest in Lake Superior wetlands. The wetlands with the highest numbers of non-native species were also on Lake Ontario.

Table 13. Macrophyte total species and non-native species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of species per wetland.

	Macrophytes (Total)		**Non-native**	
Lake	**Mean**	**Max**	**Mean**	**Max**
Erie	20.3	40	3.9	6
Huron	53.7	82	2.6	6
Michigan	42.9	70	2.6	5
Ontario	41.9	87	5.2	8
Superior	46.6	78	1.6	4

Our 20ll data reinforced our understanding of the numbers of coastal wetlands that contain invasive plant species (Figure 7). Only 12% of 123 wetlands lacked invasive species, leaving 88% with at least one.. Sites were often invaded by multiple plant species. Twenty percent of sites contained two invasive plant species, and 15% of sites contained 6 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.

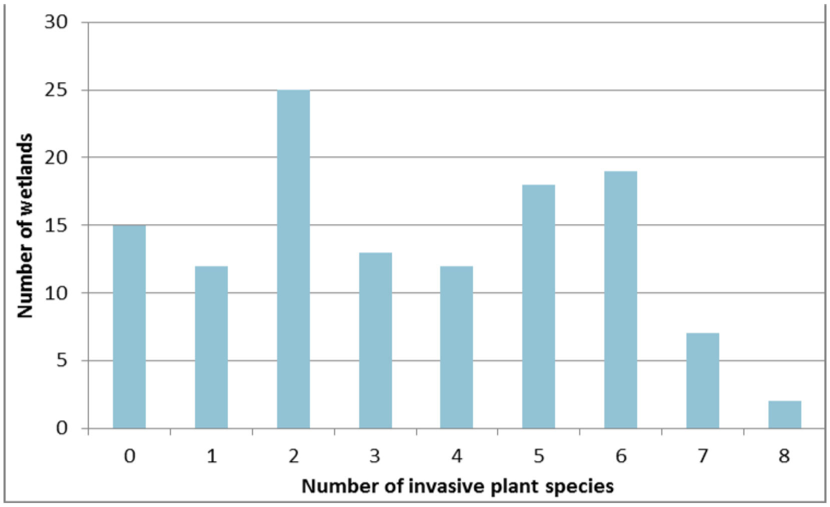

Figure 7. Number of Great Lakes coastal wetlands containing invasive plant species in 2011 (of 123 total).

Enough 2011 and 2012 data have been entered into the data management system and QC'd to begin calculating some of the metrics and indicators for these wetlands. 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 the site, divided by the square root of the number of species.

The map (Figure 8) shows the distribution of Great Lakes coastal weltand FQI 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. Low score FQI sites are concentrated in the southern Great Lakes, where there is large amounts of both agricultural and urban development, while high score FQI sites 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.

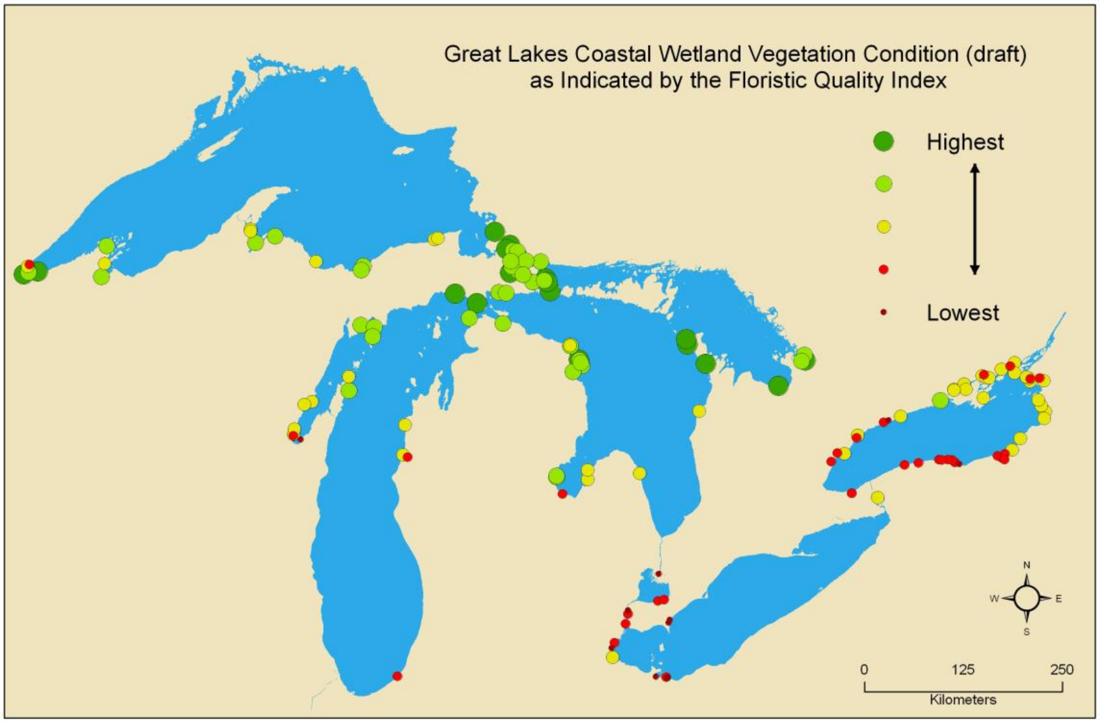

Figure 8. Condition of coastal wetland vegetation at sites across the Great Lakes. Circle size indicates floristic quality (larger is better). The indicator is labeled “draft” while the effect of recent taxonomic revisions on its values are investigated.

The FQI for Michigan was used, since Michigan includes large expanses of shoreline of all of the Great Lakes except Lake Ontario, but it also shares most Lake Ontario shoreline plants. We have labeled the FQI 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 FQI.

Besides providing an indication of the condition of the wetland vegetation community, FQI is a tool that can also be used to determine where wetland restoration or mitigation could be most effective. Sites with mid-level FQI scores may be more easily restored, while a low FQI site will often require more intensive and expensive restoration activities.

Another one 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. While our invertebrate identification laboratories have not yet completed invertebrate identification for sites sampled in 2012 because most crews have only completed fieldwork within the last month, we have calculated these IBIs for 2011 sites that contain these habitat zones (Figure 9).

The lack of sites on lakes Erie and Ontario and southern Lake Michigan are due to the 2011 sites in these areas not having the three specific vegetation zones that the GLCWC used to develop and test the invertebrate IBI. We are adding additional zones to cover these sites, but

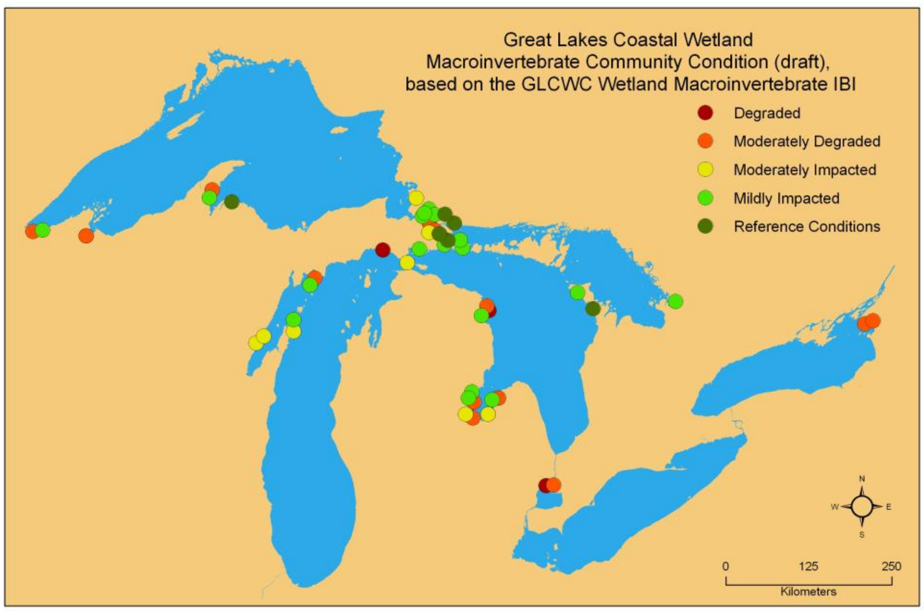

Figure 9. Condition of coastal wetland macroinvertebrate communties at sites with bulrush or wet meadow zones. The indicator is labeled “draft” while more zone IBIs are calculated.

these IBIs have not yet been validated so they are not included here. We also were able to sample some bulrush and wet meadow zones in these areas in 2012. Thus, we will soon be able to report macroinvertebrate community condition at more sites.

We had hoped to be able to report fish community condition at wetland sites containing bulrush and cattail zones. These are the two zone types with GLCWC validated fish IBIs. However, there is new information published that points out the difficulties involving differentiation between brown and black bullhead species, especially small specimens. We have discovered that the published characteristics that we have been using to separate small specimens do not seem to be working in the field. Complicating matters, these two species hybridize where they occur together. This affects the calculation of the black bullhead metric, and thus the overall IBI. Fisheries PIs have contacted other fisheries experts to resolve this issue. The USEPA is having some bullhead specimens identified using DNA analysis, but the results will not be available for some time. Fisheries PIs will be working through the next 6 months to resolve this issue and to develop fish community metrics and IBIs for other zones that we have commonly encountered in wetlands.

Bird indicators had not been validated at the time of the publication of the Great Lakes Coastal Wetland Consortium report (Uzarski *et al*. 2008). However, we have been working diligently on indicators and have a suite ready for coding so that they can be generated by the database. These indicators should be ready for reporting within the next 6 months.

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. We will continue to work on amphibian metrics over the next 6 months.

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 Fieldwork

Site Selection

Birds and Amphibians
In 2012, a total of 37 sites were initially selected to be surveyed for birds and amphibians. Of these sites, 14 were rejected either prior to visiting the wetland (web reject) or following reconnaissance visits to each remaining site (visit reject) for one of the following reasons: 1) inaccessible or unsafe to access, 2) no trespassing signs and owners could not be contacted, 3) wetland areas were unsuitable for sampling (e.g. wetland size did not meet site selection requirements, wetland lacked connectivity to the lake), or 4) exceeded the sampling capacity or was logistically infeasible for the crew to complete in 2012.

Fish, Macroinvertebrates, Vegetation, and Water Quality
For 2012, the Brady-Danz fish, invertebrates, and vegetation crews were assigned 29 sites to sample on Lakes Superior and Michigan. Of those 29 sites, four were benchmark sites, three

were re-visit sites, and five sites were on Isle Royale. All of the benchmark sites this year were on the regular sampling list, but were either too far down the list to be sampled, or needed to be sampled sooner than they were scheduled because of planned restoration work. Because of the cost and logistical difficulty of getting a boat, and sampling gear to Isle Royale, the decision was made to try to get to the island during two of the five years of the study, 2012 and probably 2014. Sampling two sites on the island each year was not logistically possible. Of the 29 sites, 22 were sampled, 3 could not be accessed, and 4 were rejected for lack of lake influence or due to very low water levels.

PI Brady also worked with personnel at the National Park Service-Great Lakes and the Wisconsin Nature Conservancy to identify coastal wetlands of importance to these groups, determine which of these wetlands are already selected for sampling, and add a few of the sites to the “benchmark” list for inclusion in future years’ sampling efforts. Both groups are pleased that they will be provided with background data on wetlands that they cannot easily sample themselves.

Field Training and Preparation

Birds and Amphibians

The training for amphibian surveys was held on 11 April 2012 and bird training took place 24 – 26 May 2012. Training involved instruction on how to conduct standardized field surveys, on basic travel procedures, and on appropriate field safety measures. Individuals were trained to proficiently complete field sheets and audio testing was also completed to insure that their hearing was within the normal range. Rules for site verification, safety issues including caution regarding insects (e.g., Lyme’s disease), GPS and compass use, and record keeping were also included in field training to insure that the guidelines in the QAPP were being followed. All individuals involved in conducting the surveys 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 www.birdercertification.org/GreatLakesCoastal - prior to conducting surveys.

Fish, Macroinvertebrates, Vegetation, and Water Quality

Fish, macroinvertebrate, and water quality field personnel included a number of returning members, and we hired three additional members. Returning personnel and permanent staff were a great help in training the new members, and also served as a good refresher/reminder for returning personnel . Fish, macroinvertebrate, vegetation, and water quality sampling training took place in mid-June in Duluth, Minnesota. Training began with an introductory presentation providing an overview of the project and assisting field technicians in visualizing the types of sites and situations they might encounter during fieldwork. Particular emphasis was provided on determining site selection or rejection using project criteria and determining appropriate sampling locations within each site. Training also included water sample collection (including lab processing); GPS tutorials; field meter calibration; data record-keeping; proper fyke net deployment, retrieval, and disinfection techniques; macrophyte coverage estimates; macrophyte preservation techniques (for unidentifiable specimens); macroinvertebrate collection, and proper sample preservation and inventory. Individual technician aptitude for completing standard procedures was tested for all parameters, and culminated with a fish or vegetation identification exam (depending on the crew). Much of this training took place in the field at a typical coastal site to ensure field members learned appropriate techniques and trainers could observe field staff applying techniques appropriately.

In addition to the standard University field and lab safety training, many field staff were also given CPR and AED training, and an introductory course on avoiding and responding to injuries when in a wilderness situation. Boater safety training was provided to those working from motorized boats.

University of Minnesota Institutional Animal Care and Use Committee renewal was approved for fish sampling. Scientific collection permits were obtained from the Ministry of Natural Resources Canada, and the states of Minnesota, Wisconsin, and Michigan. Sampling permits were also obtained from 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). Reports to the permit granting agencies are being drafted and will be provided to regional or state administrators, and field records will be sent to local conservation officers and refuge managerial groups making prior requests.

Fieldwork and Results

Bird and Amphibians

Amphibian work started 23 April and bird surveys began 4 June. Sampling was completed by mid-July 2012. The 23 sites that were sampled for birds and amphibians in 2012 stretched from the Duluth-Superior harbor area both northeast along the shore of Lake Superior and Ontario and eastward along the south shore of Lake Superior to the eastern end of the Upper Peninsula of Michigan. In 2012, multiple island sites were also sampled, including four sites on Isle Royale, MI; one site on Grand Island, MI; one site on Madeline Island, WI; and one site within the Duluth-Superior harbor. Of the 23 sites sampled, five were benchmark sites selected because they were of particular interest for restoration potential. Three of these sites, located in the St. Louis River Estuary, are in some stage of planning for restoration work. Restoration activities for the sites are being coordinated by the Minnesota Pollution Control Agency and the US Fish and Wildlife Service, with many collaborators from multiple agencies and university research groups.

Each of the 23 sites sampled in 2012 were visited a total of four times between 23 April and 12 July. Amphibians were sampled three times during this period. Birds were surveyed twice during this period, once in the morning and once in the evening. There were a total of 95 species and 3,981 individual birds recorded. All data entry and QA for bird and amphibian records was completed (100%) during the fall of 2012. Sites scheduled to be sampled in 2013 will be visited beginning in late April and bird surveys will begin in late May.

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 13). 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 13. 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

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; many of which have been identified as endangered, threatened, or special concern in North America. The participants will use the extensive data that have been gathered by USEPA from this project and the Great Lakes Environmental Indicators project, as well as Bird Studies Canada, as critical input to this assessment.

Fish and Macroinvertebrates

Fish and macroinvertebrate sampling started on in mid-June and was completed by the beginning of September. Low water levels on lakes Michigan and Huron reduced the numbers of wetlands that could be sampled, and made site access difficult. Because most of the map sources for boat ramps were not current, many launches shown on the best available maps of the lake shoreline were not functional or no longer exist. Although we had better boat launch information because of all the sampling effort last year, and because we spent part of the off season searching for information about functional boat launches, low water levels had rendered even more launches unusable this year.
The PI and field leaders sampled with field staff during their first two weeks to address any unresolved details that remained following training workshops. This was repeated in mid-

season for QA. All field staff were sampling as trained, and were very thoughtful and thorough in the way they approached and surveyed new sites.

Logistics for sampling Isle Royale sites, especially for fish, were challenging. Field crew leaders began working on these logistics in February and ran through a number of options before selecting the plan most likely to be successful in sampling five wetlands. Three individuals spent nine days on the island, gaining access aboard the National Park Service vessel Ranger 3, which carried the camping gear and sampling equipment, as well as an 18' workboat. The distances between some of the wetlands were too great to safely traverse with the 18'vessel, so transport services aboard the island ferry Voyager were purchased to move from the eastern to the western end of the island and back. Travel arrangements were time consuming and complicated due to the limitations of vessels which could transport equipment. Further complications arose when returning to the eastern end of the island to discover that the 18' vessel had been damaged from the wave action during a thunderstorm, rendering the motor useless. Communications to the mainland were only possible with a satellite phone, island personnel were not able to assist much with transportation, and moving between sites with sample gear proved to be a formidable challenge. Two sites were sampled for fish, macroinvertebrates, and water quality; one site was rejected due to lack of lake influence; one site was impossible to reach; and one site was only sampled for macroinvertebrates and water quality because fish sampling equipment could not be transported.

Water quality samples from all sites were returned to the NRRI Central Analytical Laboratory for analysis. All samples except those from Isle Royale were returned to the laboratory and processed within required holding times. The crew on Isle Royale faced great difficulties in keeping water quality samples chilled and/or frozen (depending on sample type). Shopkeepers on the island were good about allowing use of freezer space, and the crew sometimes had access to dry ice or ice, but the samples could not be kept frozen for the entire nine days. Preliminary indications from the Central Analytical Laboratory are that the samples were not jeopardized by the holding problems, and that our water quality parameters are not particularly sensitive to such issues. Water quality sample data were just received from the laboratory and are being checked before data entry.

Interesting Observations
We had hoped to sample *Phragmites* zones at several sites in lower and central Green Bay, as they had done in 2011. An undergraduate student had planned an honors thesis on a comparison of fish species found in *Phragmites* versus *Typha* vegetation types. However, Phragmites all around lower Green Bay was dead. Local residents reported that *Phragmites* had been sprayed with herbicide as a control measure. Investigation of one of these areas showed almost no living plants except for the very occasional dicot. Sampling the dead stands was not possible water levels rendered all encountered stands unsampleable, due to no standing water.

There were high numbers of stickleback fish in nets of Isle Royale. These included brook (*Culaea inconstans*) and ninespine (*Pungitius pungitius*) stickleback, as well as the non-native three-spine stickleback (*Gasterosteus aculeatus*).

Wetland Vegetation

Surveys in the St. Louis River, Duluth, Minnesota, began on June 28 and 19 wetlands were sampled over the course of the summer, finishing on August 11. Throughout the survey region, three wetlands were excluded from surveys due to inaccessibility or inappropriate vegetation types present (e.g. dominated by woody vegetation).
We intended to survey 4-5 wetlands on Isle Royale. However, a staff member health issue prevented completion of these sites. We are investigating the possibility of surveying them in a future year.

Approximately 100 unidentified specimens were collected, dried, and are awaiting identification in the University of Wisconsin-Superior herbarium. All other field data were entered into the project database by early September. Few rare species were encountered during the surveys. Notably, the wetlands in the Green Bay area were completely dominated by nearly impenetrable *Phragmites australis,* which had been herbicided.

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

2012 Fieldwork

2012 Sites

Site selection was completed in a previous reporting period (Oct 2010—April 2011) by assessing all wetlands in the region using the web-based site selection tool. After wetland polygons were scrutinized, the randomization and selection procedure produced a list of 55 sites for potential monitoring in the Central Basin in 2012. Sites consisted of 21 riverine, 24 lacustrine, and 10 barrier-protected wetlands. While this was more than our team's expected sampling capacity of 40 sites for fish, macroinvertebrates, and plants, we assumed that some sites would be rejected in the field because they lacked a surface connection to a Great Lake or were inaccessible. The Central Basin team sampled sites in southeastern Lake Superior, northwestern Lake Michigan (the Big Bay de Noc area), drowned river mouth wetlands along the eastern shore of Lake Michigan, southern Lake Michigan (along the Indiana and Illinois shoreline), northern Lake Huron into the St. Mary's river, the entire eastern shorelines of Lake Huron, Lake St. Clare, and Lake Erie.

The CMU fish/invertebrate/water quality staff sampled 15 sites on northern Lake Michigan and Huron, Saginaw Bay, and western Lake Erie. The GVSU staff sampled six wetlands on Michigan's Lower Peninsula. LSSU sampled eight wetlands on the eastern end of Lake Superior and the St. Marys River. UND sampled one site on southern Lake Michigan in Illinois, five sites on northern Lake Huron, and two sites on Lake Superior. LSSU sampled one benchmark site, UND sampled two benchmark sites, and CMU sampled seven benchmark sites. Selection of benchmark sites was done in consultation with the Michigan Department of Natural Resources, Michigan Department of Environmental Quality, and the Nature Conservancy. Each agency provided a list of sites with current and ongoing coastal wetland restoration projects in the region and identified the highest priority sites for data collection.

The vegetation field staff, led by D. Albert of Oregon State University, sampled 52 sites within Michigan. These included sites on Lakes Superior, Michigan, Huron, St. Clair, and Erie, and the St. Marys River, including 14 benchmark sites. Birds and Amphibians , led by T. Gehring of CMU and B. Howe of UW-Green Bay, were sampled at 46 sites within Michigan, including 10 benchmark sites.

QAPPs and SOPs

Members of the Central Basin Team, both co-PIs and their staff, assisted with updating the Quality Assurance Project Plan for 2012. Members also helped to update Standard Operating Procedures. The Central Basin Team used the approved QAPP and relevant SOPs during fieldwork preparation/training and throughout the sampling season to ensure consistent methodology among sampling crews and years.

Training and Certification

Central Basin Team members responsible for fish, macroinvertebrate, and water quality monitoring conducted their own training among their respective field teams. This was deemed sufficient given that all teams had a majority of technicians returning from 2011. As an extra measure of quality assurance, fish/invertebrate/water quality staff from GVSU, UND, and LSSU met to sample two sites together to ensure consistent methodology. All field staff conducted pre-season certification and certification records were sent to the project QA officers. All staff also completed a mid-season check to verify that protocols were being followed correctly and these records were also sent to the project QA officers.

Central Basin bird and amphibian staff members were tested for identification of frog and bird calls and were trained in proper field procedures prior to initiation of 2012 field work. Amphibian training was completed by March 15, 2012 and bird training was completed by May 15, 2012. Online testing was again used for identification of amphibians and birds by sight and sound and all members reached proficiency before sampling. Central Basin plant personnel were trained and certified by D. Albert in Pellston, MI on June 17-22, 2012.

Other Fieldwork Preparation

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

Field Work

Central Michigan University

From mid-June through mid-August, the CMU visited 24 sites along western Lake Erie, Lake Huron, and Lake Michigan. Upon site evaluation, seven of these sites were deemed un-sampleable because low water levels left wetland vegetation not inundated, one site did not have a surface connection, and one site could not be accessed safely. The remaining 15 sites were sampled, including seven benchmark sites. Within the 15 sites, 31 vegetation zones were identified and sampled. Twenty one of these zones met the requirements for the full set of monitoring protocols. In the remaining 10 zones, fish sampling was not possible because water was too shallow but invertebrate sampling was conducted. Fish and physical habitat data entry have been completed and macro-invertebrate identification and data entry is in progress. Water nutrient analysis is also underway and the data will be uploaded upon completion.

The CMU bird and amphibian technicians sampled coastal wetlands of the Lower Peninsula of Michigan, eastern Upper Peninsula of Michigan, and western Lake Erie. Two teams, each with two members, were used throughout the sampling season, except at the beginning of the season when a third team was used. Field crews consisted of undergraduate student technicians and two graduate student field assistants. Of the 64 sites selected for possible bird and amphibian sampling, 46 were sampled. Eighteen of the non-sampled sites were either islands (13 sites) that could not be accessed safely for night sampling or were not accessible because access through private property could not be acquired (5 sites). For all sites with landowner permission issues, staff members attempted to gain permission by talking to landowners in person. All amphibian and bird survey data were uploaded to the digital database and underwent QC.

Grand Valley State University

Eight wetland sites were visited during the 2012 field season and six of these eight were found to be sampleable. The remaining two sites did not have inundated herbaceous vegetation. Four sites were sampled for fish and all six were sampled for invertebrates and water quality during July-August. Water depth was less than required for fish sampling at the two sites where only invertebrates and water quality were sampled. In total, 11 plant zones were sampled. Data entry has been completed for fish and habitat data. Invertebrate identification will be completed over the winter and will be finished prior to Year 3 field work. Measurements of phosphorus (SRP and TP), nitrogen (NH_3 and $NO_{3)}$, and chloride (Cl) have been completed and those data will be entered soon. Challenges encountered during the field season included daily water fluctuations and adverse weather condition, which were addressed by revisiting sites when necessary.

Lake Superior State University

From June to August, the LSSU crew visited 11 sites to determine if they met the sampling criteria and if there were access issues. Three sites were not sampled because of low water levels and lack of vegetation zones that met the size/area criteria for the project. Crews returned to 8 sites and collected water quality data and samples, macroinvertebrate samples, and fish data for all vegetation zones. Water from each site was separated, some was filtered, some frozen, and some analyzed for alkalinity in the lab. Water samples were sent to Central Michigan University for dissolved nutrient analyses and filters were sent to the University of Notre Dame for chlorophyll a analyses. Unknown fish identifications were verified in the laboratory and corrected on the datasheets. All 2012 data have been entered into the on-line database and QC'ed. Incomplete data entry for 2011 data (e.g., macroinvertebrates, lab data) was entered as well and will be completed by October 15, 2012.

University of Notre Dame

The Notre Dame fish/invertebrate/water quality staff visited 12 sites in 2012 and rejected four of these sites due to lack of inundated vegetation or lack of a surface connection to the Great Lakes. The remaining eight sites were sampled for all parameters. These eight sites included five on Lake Huron, two on Lake Superior, and one on southern Lake Michigan in Illinois. Two of these sites were benchmarks. All field data have been entered into the database and QC'ed. UND analyzed chlorophyll a samples for UND, CMU, GVSU, LSSU, Windsor, and the Canadian Wildlife Service. UND also analyzed water color for GVSU and UND.

Oregon State University

Field sampling for vegetation was completed at 52 sites within Michigan, including sites on Lakes Superior, Michigan, Huron, St. Clair, and Erie, and the St. Marys River, and included 14 benchmark sites. All sites that were visited were sampled, although there were landowner permission issues limiting sampling at one site, and two sites were not visited due to lack of marsh vegetation or connection to a Great Lake. An additional site, Illinois Beach State Park along Lake Michigan, was not visited due to recent herbicide treatments and concern for the sensitive nature of the wetland by the land managers. The plant team director, D. Albert, reviewed all unknown plants collected. Gaining access to island sites was a challenge, but this was overcome through coordinated trips with fish and invertebrate technicians for several island sites.

Plant team director D. Albert reviewed all field forms prior to data entry. GPS points have also been entered into the project database. OSU students have completed entry of 40 sites into the electronic database and the remaining 12 sites are expected to be in the database by the end of October, 2012. Major changes in the taxonomic treatment of many of the marsh plants has slowed data input, but this should be resolved for 2013 data entry. QC of the plot data following entry into the electronic database is expected to be completed by the end of October, 2012.

Important results from Central Basin vegetation sampling:

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 Lake Michigan or Lake Huron.
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, 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 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.

University of Wisconsin-Green Bay

During 2012, field work in the central region (western Lake Michigan and northern Lake Huron) was conducted by mainly the same observers as in 2011. PI R. Howe visited 4 sites in the field with new observers to ensure that prescribed protocols were being followed. Audio recordings were acquired for all but a few of the field surveys, providing another level of quality control. These recordings have been archived at the Cofrin Center for Biodiversity's data management center at the University of Wisconsin-Green Bay.

The UWGB field team was assigned 46 sites based on work at the February 12 meeting in Detroit. By the end of the summer we had surveyed 35 of these, 23 for amphibians and all 35 for birds. With one exception, sites that required boat or canoe access were not sampled for frogs, which require nocturnal sampling. Reasons for rejection of the 11 sites that were not sampled are the following:

- Air photo analysis showed no suitable habitat (2)
- Access was unavailable or deficient (4)
- Suitable wetland habitat could not be found during field visit (2)
- Assigned wetland was on private property; landowners could not be reached (1)
- Assigned wetland was on private property; landowner refused access (1)
- Weather prevented second visit (1)

Geographic locations of sites ranged from northern Illinois (Illinois Beach State Park) along western Lake Michigan to the northern shores of Lake Huron in Ontario (south of Provincial Highway 17). Ten of the sites were accessed by boat or canoe. One site with foot access was surveyed for birds but not for frogs because the point of access was not discovered until after the initial frog sampling period.

Amphibian sampling was conducted between 21 April and 3 July 2012 at 36 points within 23 wetlands or wetland complexes. We sampled 3 points at the 3 largest wetlands, 2 points at 7 wetlands, and only a single point at the remaining 13 wetland sites. Spring Peeper was by far the most widespread amphibian species, recorded at 91.7% of the points. Altogether we recorded 9 species, including virtually all of the frogs and toads known to occur recently in this study area. Note that we did not attempt to distinguish Cope's Gray Treefrog (*Hyla chrysoscelis*) from the Gray Treefrog (*Hyla versicolor*). Only Blanchard's Cricket Frog (*Acris crepitans blanchardi*) and Fowler's Toad (*Bufo fowleri*), species that generally occur south and east of our sampling area, were not documented at the 36 points.

In most cases, the number of amphibian species at each point was 3-4 including all 3 counts. Lowest species richness (1 species) was recorded at points in heavily developed watersheds and the highest species richness (5 species) was recorded at a northern Lake Michigan site.

Bird sampling in the Western Central Region began on 5 June and was completed on 9 July 2012. Data were entered and reviewed for quality control during late summer 2012. At one site, the second count was not possible due to inclement weather.

During the 2012 field season UWGB observers recorded 5,363 individual birds representing 123 species. (Individuals that could not be identified as species were included in the individual total but not in the species tally.) The most common taxon in terms of overall abundance was "Unidentified Gull," followed by ring-billed gull (*Larus delawarensis*), which probably comprised most of the individuals in the first category. Next, in order of decreasing abundance, were red-winged blackbird (*Agelaius phoeniceus*), European starling (*Sturnus vulgaris*), common grackle (*Quiscalus quiscula*), double-crested cormorant (*Phalacrocorax auritus*), and common yellowthroat (*Geothlypis trichas*).

Species of special interest or concern are listed below (Table 14) 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 14. 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.

Quality Assurance / Quality Control

All Central Basin field crews (CMU, GVSU, UND, LSSU, and OSU) reviewed the QAPP and SOPs during the spring, prior to field sampling. Members were then certified or re-certified for each protocol they would be responsible for conducting. Supervising PIs/Co-PIs conducted the mid-season checks in most cases. All field crews passed these evaluations and no corrective actions were necessary. Documentation for these mid-season QA/QC checks has been filed with Brady, Cooper, and Uzarski. All data entered into the data management system have already or will soon be QC checked.

Future work

The Central Basin team is currently conducting laboratory work (e.g., remaining water quality and sediment analyses and macroinvertebrate identification). Water quality and sediment analyses will be completed by early November and processing of 2012 macroinvertebrate samples is currently on schedule for completion by early spring 2013. Macroinvertebrate quality control procedures, including trading samples among laboratories will also be conducted over the coming months. All Central Basin crews will also begin photo interpretation of sampling sites for the 2013 field season and develop a strategy for efficient sampling.

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

Site Selection

The College at Brockport modified their geographic sampling boundaries early in the spring of 2012 to help ensure proportionate sampling across lakes. Seven Canadian Lake Ontario sites were added to The College at Brockport's initial fish, macroinvertebrate, and vegetation site list as a result, while the bird and amphibian crew added one southern Lake Erie and two north shore, Canadian Lake Ontario sites. Three sites were selected as "benchmark" sites to assist local conservation and management organizations in their restoration and management efforts by producing baseline condition data. Seven potential sites were excluded from the Eastern Team's list because they exceeded the team's sampling capacity while three sites were excluded prior to fieldwork because they failed to meet the lake-connection criteria.

Training

Most 2011 crew members returned for the 2012 field-season; thus, the training sessions served more as a refresher and re-certification than an initial training session. Bird and amphibian field technicians were trained and certified on bird and amphibian ID, distance estimates, and appropriate survey methods by C. Norment on April 5 at various wetlands near Brockport, NY. All surveyors passed the appropriate on-line bird and amphibian call identification tests prior to sampling to ensure accurate field identification.

Fish, aquatic macroinvertebrate, and water quality field staff were trained and certified on setting fyke nets, D-netting for macroinvertebrates, water quality meter use and calibration, proper QA skills, and vegetation zone identification by J. Haynes (co-PI, fish) and G. Neuderfer (co-PI, macroinvertebrates) in the field on June 18, 2012. All fish, macroinvertebrate, and water quality crew members were certified in accordance with the standards required by the project. Finally, a mid-summer QA check at a field site was performed to ensure that field staff continued to perform sampling correctly.

Vegetation crew members were trained on plant identification, proper transect layout, percent cover estimations, GPS use, and data recording methods by D. Wilcox (PI, vegetation) in the field on June 15, 2012. All vegetation field staff passed the standards set forth in the project QAPP. Finally, a mid-summer vegetation QA check was performed in the field in July to ensure that vegetation crew members continued to sample correctly.

Sampling

Bird and Amphibian

The College at Brockport bird and amphibian team successfully sampled 24 of 25 sites on their list between 20-April and 2-July. One site was not sampled due to a private landowner being unwilling to grant access. Sampling proved to be fairly efficient, as many of the randomly-selected sites were spatially clumped, thus allowing us to sample up to four sites per day.

Fish, Macroinvertebrate, Water Quality, and Vegetation

Fish, macroinvertebrate, water quality, and vegetation crew members of the Eastern Team sampled all but two of their 25 sites. One site was not sampled due to lack of safe access, and another site was perched above the lake and had no lake influence. A few sites had special access issues that precluded fish sampling but still allowed for vegetation, water, and macroinvertebrate sampling. All sites were sampled between 18- June and 10- August, with four sites being sampled per week. Individual sites appeared to be sampled more quickly and efficiently this year because of returning experienced field staff. Few major problems were encountered in the field this year. The most common problem was determining access to individual sites; however, access was determined for many of the sites before the field season, with the remaining sites requiring discussion with local landowners, who were generally agreeable.

Laboratory Work

Laboratory identification of the approximately 20 unknown fish is roughly 50% complete and is anticipated to be finished by mid-October. Identification of macroinvertebrate samples has not yet begun; however, sorting of samples and planning has started. No unknown plants required laboratory-level analysis.

Data Entry and QA/QC

Data entry and QC checks of bird and amphibian data are both 100% complete. All vegetation data have been entered and QC is approximately 10% complete. In-field water quality, lab-based water quality, and macroinvertebrate site-level data are 100% entered; however, QC has not begun for these data yet. Fish data are approximately 65% entered, with no QC complete at this time.

Interesting Findings

Invasive Species

The common carp (*Cyprinus carpio*) was the most common invasive fish species encountered in the US side of Lake Ontario. Round goby (*Neogobius melanostomus*), while widespread and abundant in Lake Ontario, showed up only occasionally, as the wetlands in Lake Ontario are sediment and organic matter rich. The majority of round gobies were found in bulrush stands, which are relatively uncommon in Lake Ontario. A few common rudd (*Scardinius erythropthalmus*) were found sporadically throughout Lake Ontario, although never in large quantities. Many invasive plant species were found in 2012 on the US side of Lake Ontario, with invasive cattail (*Typha angustifolia* and *Typha* x *glauca*), Eurasian watermilfoil (*Myriophyllum spicatum*), and curly-leaf pondwood (*Potamogeton crispus*) being the most common, while common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and European frogbit (*Hydrocharis morsus-ranae*) were locally dominant, but not as wide-spread. Water chestnut (*Trapa natans*), a floating invasive that was found in a couple sites in high densities last year near Sodus Bay, was found in only one site, again near Sodus Bay, and was only in moderate densities

Rare Species

Only one threatened plant species, water marigold (*Bidens beckii*), was found during the 2012 summer sampling in very low densities at one site. No threatened, endangered, or rare bird or amphibian species were detected in actual surveys, and only one focal bird species, Virginia rail (*Rallus limicola*), was detected during the surveys and was only found at a single site. Black terns (*Chlidonias niger*), a New York State-listed endangered species, were spotted outside of the actual bird sampling protocol, mainly during the summer vegetation sampling. Most of these sightings occurred on the eastern shore of Lake Ontario.

Working With Local Groups and Landowners

The College at Brockport designated Yanty Creek Marsh as a “benchmark site” since it is slated for restoration activities in the near future. Goals of the project include invasive *Phragmites* removal and creation of black tern nesting habitat. Data generated from our project will help to identify locations and densities of invasive *Phragmites* and bird community characteristics, both of which will be useful in developing a restoration plan.

The College at Brockport also designated Southern Sodus as a “benchmark site” since local governmental, non-profit, and academic groups are discussing the potential for restoration at this site. Sodus Bay, the larger bay that this riverine wetland feeds, has experienced increased levels of toxic algae blooms recently. Potential restoration of this site would aim at reducing nutrient inputs to the bay. Data generated by this project would provide baseline data, including current nutrient levels, which would assist in restoration planning.

The College at Brockport sampled Little Pond (53), a small riverine site in Rochester, NY, which abutted a small coal-fired power plant. By chance, fish crew members met the environmental health and safety coordinator, who was interested in the fish community within the stream. Per his request, The College at Brockport will provide him a list of fish species and densities found in the stream to help him understand the health of the fish community.

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

Field Training

Training for birds and amphibians was delivered by PI D. Tozer on March 26, 2012 at Bird Studies Canada headquarters in Port Rowan, Ontario. All people scheduled to collect data in the field were in attendance; several crew members returned from 2011. Attendees were instructed in the project's objectives and methodology, and site selection procedures and station placement guidelines within selected wetlands. The amphibian and bird survey field protocols were demonstrated in detail in both the "classroom" and the field. Crew members were also instructed in methods of reporting, safety, data entry, and were tested for their ability to use GPS instruments with adequate precision and accuracy as per the quality assurance project plan. Each individual's comprehension of the topics was evaluated with a written and practical test. All attendees also successfully completed the online amphibian and bird identification tests. A mid-field-season check was subsequently made in June at a site on Lake Huron by D. Tozer. No problems were identified.

Field crew members who worked with fishes, macroinvertebrates, and water quality sampling were trained by co-PI J. Gathman in the Windsor region during May and early June (University of Windsor crew), or by G. Grabas in the Toronto Region during June and July field visits (Canadian Wildlife Service crew). Training included instruction in GPS use, determination of whether sites met project criteria (open water connection to lake, presence of a wetland, safe access), identification of vegetation zones to be sampled, collection of water quality samples (including preprocessing for shipment to water quality labs), and learning to calibrate and read field instruments and meters. Other instruction and testing was conducted to train field staff in setting, removing, cleaning and transporting fyke nets, and protocols for collecting and preserving macroinvertebrates using D-frame dip nets and field-picking. Members were trained and tested in field data sheet entry. All field personnel were given basic fish identification training. University of Windsor crew leaders returned from 2011 and have much experience sampling fish, including specialized training as required by Ontario. Several other crew members returned from 2011. All field team members were also given field and lab safety training. Vegetation surveys were conducted by expert botanists, one of which returned from 2011. They received the same general instructions and project orientation as did the other groups. In addition they reviewed the specific vegetation sampling methodology and data recording methods outlined in the QAPP and used in 2011.

Co-PI G. Grabas led the eastern Canadian water quality and invertebrate sampling crew and trained new members. D. Rokitnicki-Wojcik led the vegetation sampling and identification and was assisted by various summer students and Canadian Wildlife Service personnel, who served as data recorders.

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 and Oceans Canada), and Wild Animal Collection (Ohio Department of Natural Resources). All permits had been approved at the start of the sampling season. Reports to the permit granting agencies have been completed in draft form and will be sent to both regional administrators and to local offices in whose jurisdiction sampling took place. Records of fishes caught will also be sent to local conservation and refuge managerial groups in Ontario and Ohio where appropriate.

Site Selection and Field Sampling

Bird and amphibian field crews evaluated 65 sites that had been selected for potential sampling in 2012 (41 on Lake Ontario, 16 on Lake Huron, and 8 on Lake Erie or Lake St. Clair). Of these, 13 were rejected due to unsafe working conditions for over-water nighttime amphibian surveys, 2 were inaccessible due to landowner permission failure, and 1 was inaccessible for amphibians but was surveyed for birds because the landowners allowed daytime but not nighttime access to the site. Most of the rejected sites were located on Lake Huron. However, 2 Lake Erie sites and 1 Lake Ontario site was rejected. Forty-nine sites were visited (each on 5 occasions) and sampled for amphibians and birds. An additional 2 sites on Lake Ontario were sampled by the Brockport, NY team. All amphibian and bird data have been compiled and entered into the database, and QC'ed.

An especially noteworthy sighting of a pair of least bitterns, a threatened species under the Species at Risk Act in Canada and the Endangered Species Act in Ontario, was made during point count playback at Mud Creek Wetland in Windsor, Ontario. The sighting is of interest because the area where the observation took place was dominated by invasive *Phragmites* within a heavily urbanized landscape, which is thought to be poor-quality habitat for the species, plus according to the Great Lakes Marsh Monitoring Program and Ontario Breeding

Bird Atlases, the general area is not known to have been occupied by the species since the early 1980s.

The fish and macroinvertebrate and vegetation crews evaluated 46 sites, all of which had also been assessed by the bird and amphibian field crews. Two were rejected based on remote (web) assessment – one site was inaccessible and the other was on aboriginal land for which we did not have permission to sample. Three of the 47 sites were visited but rejected as unsuitable for any form of sampling. Thus, in total, 41 sites were actually sampled. Two additional Canadian Lake Ontario sites were sampled by Brockport.

The full suite of water quality, fishes, macroinvertebrates, and wetland vegetation was assessed at 26 sites by our group. Six sites were suitable only for vegetation sampling, resulting in a total of 40 sites for which vegetation was assessed. Macroinvertebrates were collected at 35 sites but fish nets could only be set at 28 of those locations.

Two benchmark sites were identified for sampling in 2012 (Crane Creek, OH and Sturgeon Bay, Georgian Bay, ON). The Sturgeon Bay site had been identified as being of interest to Environment Canada researchers (S. Watson, CCIW, Burlington, ON, *pers. Comm.)*. The Crane Creek site is a study area of interest to the USGS, who wished to see how the findings of their GLRI-funded work compared with the results of surveys using the standardized Coastal Wetland Monitoring methodology (K. Kowalski, USGS, Ann Arbor, MI, *pers. Comm.*). A preliminary request to identify and evaluate a candidate benchmark site within the Maumee River Area of Concern was received too late in the season to be acted upon in 2012. We will continue to communicate with the Maumee River RAP team to designate a site that we can sample in 2013

All fish data have been compiled and entered into the database and quality assured. All of the macroinvertebrate samples have been examined and specimens identified to the family level, and the identifications quality checked according to QAPP protocols. We are in the process of identifying Chironomidae to subfamily or tribe level as practicable. Data are being entered into the database as identifications for each site are completed. Quality assurance of the vegetation data is almost complete. Approximately 25% of those data have been entered into the database. All water quality data have been uploaded to the database, but quality assurance is still in progress.

Significant Macroinvertebrate, Fish, and Vegetation Observations
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 in 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.

Water Quality Samples

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

ASSESSMENT AND OVERSIGHT

The project QAPP was approved and signed on March 21, 2011. It was reviewed this winter and updated. The update to the project QAPP ('Revision 3') was approved and signed on March 28, 2012. No major changes to the QAPP were made, and the majority of updates were clarifications of methodology based on our crews' collective experiences during Year 1. Other changes included reformulating some certification criteria and mid-season QA metrics. All Standard Operating Procedures (SOPs) were also updated and appended to QAPP Revision 3. Similar to the QAPP, changes to SOPs were mostly minor, including clarifications and additional detail based on our experience in Year 1.

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

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

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

- GPS testing: Every GPS unit used during the 2012 field season was tested for accuracy and its ability to upload data to a computer. Field staff collected a series of points at locations that could be recognized on a Google Earth image (e.g., sidewalk intersections) then uploaded the points to Google Earth and viewed the points for accuracy. Precision was calculated by using the measurement tool in Google Earth. Results of these tests have been archived and referenced to each GPS receiver by serial number.

- Review of all sites rejected after initial site visits: In cases where a site was rejected during a site visit, the reason for rejection was documented by the field crew. The project QA officers (Brady and Cooper) then reviewed these records to ensure consistency among crews. Additionally, in most cases, field crew leaders contacted Uzarski, Brady, or Cooper by cell (or even satellite) phone when deciding whether to reject a site.

- 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.

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

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

- QC checks for all data entered into the data management system (DMS): Every data point that is entered into the DMS is being checked to verify consistency between the primary record (e.g., field data sheet) and the database. This has been completed for 2011 data and is in process for 2012.

- Macroinvertebrate QC checks: Each regional lab that is processing macroinvertebrate samples 'blindly' traded samples with another other lab over the winter. Swaps were made between labs that sampled wetlands at a similar latitude to ensure familiarity with the taxa being evaluated. For swapped samples, the sending laboratory had previously identified the samples and labeled vials with a coding system so that the receiving laboratory did not have the ID or the location where the sample had been collected. The receiving lab then processed the sample as usual and sent the IDs and counts to the QA managers. For IDs that differed between the labs, the source of variation was determined. In many cases a slight difference in counts was due to the integrity of the archived sample (e.g., a small specimen being broken in two at some point in the process). For cases where taxa IDs varied, the true taxon ID is being determined by regional experts. Where necessary, archived samples are being re-evaluated and the database updated accordingly.

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

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

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

Example Water Quality QC Information

Water quality analyses from 2012 have been completed by the NRRI Central Analytical Laboratory. All laboratory results from 2012 have passed the criteria shown below (Table 15).

Variability in Field Replicates
An analysis of sampling variability is shown in Table 16. It is important to note that for many constituents, the variability within sample sets is related to the mean concentration, and as concentrations approach the method detection limit (MDL), the variability increases dramatically. A calculation of field replicate variability with values at or near the level of detection will often result in high RPDs. For example, if the chlorophyll measurements on a set of field duplicates are 0.8 µg/L and 0.3 µg/L, mean = 0.6 resulting in a RPD of 91% (RPD = [abs (rep a-rep b)/ (rep a+ rep b)/2)]*100, but since the MDL is ± 0.5 µg/L, this can be misleading. The same can occur with analyte lab duplicates, and in these instances the QA officer will determine whether data are acceptable.

Table 15. Data acceptance criteria for water quality analyses.

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

**Relative Percent Difference (RPD):* While our standard laboratory convention is to analyze 10% of the samples in duplicate and use %RSD (100 * CV) of the duplicates as a guide for accepting or rejecting the data, another measure of the variation of duplicates is RPD: RPD = ((|x1-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).

Table 16 and Figure 10 below summarize the QC data for 2012 and indicate that data quality objectives were met. Higher than expected RPD's were associated with a preponderance of near detection limit sample values.

Table 16. An assessment of sample variability in relative percent difference for water quality parameters with the acceptance criteria. A table showing field replicate detail is attached. 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).

Analyte	MDL	Mean Value	Average RPD (%)	Max expected RPD (%)
Chlorophyll-a	< 0.5 µg/L	6.6 (n = 5)	20	30
Phaeophytin	< 0.5 µg/L	2.5 (n = 5)	*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)	**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

*6 out of 10 of the phaeophytin field replicates were < 2 µg/L or 4 times the MDL (range 0.2 – 7.5).
**The variability in the turbidity data is due to one replicate set as well as the small sample set (n = 2). More detail can be found in Figure 10.
n= number of field duplicates.

Project_ID	Lake Name	Site	QA	Date Sampled	Chl (ppb)	%RPD	Phaeo (pp	%RPD
GLCWC	1467	SAV		7/13/2012	3.8		0.7	
GLCWC	1467	SAV Fld Rep	Fld Rep	7/13/2012	3.1	20	1.0	30
GLCWC	1102	Lilly		7/30/2012	11.2		4.1	
GLCWC	1102	Lilly Fld Rep	Fld Rep	7/30/2012	18.2	48	7.5	58
GLCWC-SUNY	163	SAV		8/1/2012	12.1		4.9	
GLCWC-SUNY	163	SAV-DUP	Fld Rep	8/1/2012	10.4	15	3.7	28
GLCWC-SUNY	5003	SAV-DUP	Fld Rep	8/7/2012	1.8		1.0	
GLCWC-SUNY	5003	SAV		8/7/2012	2.0	11	0.2	133
GLCWC-SUNY	5003	In Shoen DUP	Fld Rep	8/7/2012	1.9		0.3	
GLCWC-SUNY	5003	In Shoen		8/7/2012	1.8	5	1.3	125
				mean	6.6	20	2.5	75

Project_ID	Lake Name	Site	QA	Date Sampled	TP (ppb)	%RPD	OP (ppb)	%RPD	TN (ppb)	%RPD	NH4-N (pp	%RPD	NO2/NO3	%RPD
GLCWC	1467	SAV		7/13/2012	0.020		0.003		0.440		0.026		0.000	
GLCWC	1467	SAV Fld Rep	Fld Rep	7/13/2012	0.025	20	0.003	0	0.482	9	0.025	6	0.000	0
GLCWC	1102	Lilly		7/30/2012	0.083		0.015		1.318		0.037		0.121	
GLCWC	1102	Lilly Fld Rep	Fld Rep	7/30/2012	0.105	24	0.016	10	1.322	0	0.029	24	0.132	9
GLCWC-SUNY	163	SAV		8/1/2012	0.107		0.012		0.972		0.064		0.018	
GLCWC-SUNY	163	SAV-DUP	Fld Rep	8/1/2012	0.086	22	0.018	43	0.805	19	0.060	6	0.023	26
GLCWC-SUNY	5003	SAV-DUP	Fld Rep	8/7/2012	0.019		0.004		0.337		0.016		0.003	
GLCWC-SUNY	5003	SAV		8/7/2012	0.020	5	0.004	0	0.333	1	0.016	2	0.004	22
GLCWC-SUNY	5003	In Shoen DUP	Fld Rep	8/7/2012	0.009		0.005		0.296		0.009		0.040	
GLCWC-SUNY	5003	In Shoen		8/7/2012	0.011	18	0.004	27	0.314	6	0.007	16	0.042	4
				mean	0.049	18	0.009	16	0.662	7	0.029	11	0.038	12

Project_ID	Lake Name	Site	QA	Date Sampled	ANC (mg (	%RPD	color (pt-(	%RPD	Turbidity	%RPD	Cl (mg/L)	%RPD
GLCWC	1467	SAV		7/13/2012			7.3		7.4		16.7	
GLCWC	1467	SAV Fld Rep	Fld Rep	7/13/2012			7.3	0	7.9	7	15.7	6
GLCWC	1102	Lilly		7/30/2012	74.0		438		17.2		6.3	
GLCWC	1102	Lilly Fld Rep	Fld Rep	7/30/2012	73.3	1	418	5	29.7	53	6.2	2
GLCWC-SUNY	163	SAV		8/1/2012			69.2				9.5	
GLCWC-SUNY	163	SAV-DUP	Fld Rep	8/1/2012			58.9	16			9.1	4
GLCWC-SUNY	5003	SAV-DUP	Fld Rep	8/7/2012			16.6				23.0	
GLCWC-SUNY	5003	SAV		8/7/2012			16.6	0			22.9	0
GLCWC-SUNY	5003	In Shoen DUP	Fld Rep	8/7/2012			14.1				22.6	
GLCWC-SUNY	5003	In Shoen		8/7/2012			13.5	4			22.5	0
				mean	73.7	1	106.0	5	15.6	30	15.5	3

Figure 10. Coastal Wetland Monitoring field replicate water quality data quality control.

Communication among Personnel

Regional team leaders and co-PIs continue to maintain close communication as the project enters into the second year of macroinvertebrate identification, data QC, and metric calculation. All primary project members will again meet in Detroit during the winter to discuss and resolve taxonomic issues that may affect metrics calculations. Metrics for additional zones will also be discussed during this meeting.

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

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

Most PIs spent the first week of field season in the field with their crew to ensure that all protocols were being followed according to the standards set forth in the QAPP and SOPs and to certify or re-certify crew members. Nearly every crew consisted of >50% returning and experienced personal, which made the training period for 2012 very efficient. PIs then visited their teams again during the middle of the season to ensure that all sampling was conducted in accordance with the training and the QAPP. PIs kept in close contact with crews via cell phone, and the leadership team was also always available via cell phone to answer specific crew questions.

Overall

No major injuries were reported by any field crew members during this second sampling season. PIs continued to be impressed by the work ethics of their field crews, their willingness to work long hours day after day, to successfully sample under quite adverse conditions, and to conduct that sampling in accordance with strict QA procedures.

From the PI and QA managers' perspectives, the second field season was highly successful. The quality management system developed for this project was 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.

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.

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 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; 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 we are able to assist other projects and save them money.

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 from the St. Louis River AOC delisting committee to provide target data for restoration work (i.e., what should a restored site "look" like). 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 thoroughly sample one of these 3 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 fish. The Michigan Natural Features Inventory is requesting our data as part of a GLRI-funded invasive species mapping project.

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).

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).
- Scale dependence of dispersal limitation and environmental species sorting in Great Lakes wetland invertebrate meta-communities (Notre Dame University).
- 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 (SUNY Brockport).
- Developing captive breeding methods for bowfin (*Amia calva*) (SUNY Brockport).
- Invasive plant species in Lake Ontario wetlands (SUNY 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).

Undergraduate Research without Leveraged Funding:

- Influence of vegetation patch characteristics on macroinvertebrate community composition (Lake Superior State University).
- 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).

- Fish species co-occurrence in northern Michigan Wetlands (Central Michigan University).

- Zoobenthos - macrophyte relationships in Great Lakes coastal wetlands: contrasting the effects of spatial variation with macrophyte structural complexity (University of Windsor).

- Zoobenthos - macrophyte relationships in Great Lakes coastal wetlands: Effects of plant complexity on predator-prey associations (University of Windsor)

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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