GLIC: Implementing Great Lakes Coastal Wetland Monitoring

Semiannual Progress Report

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INTRODUCTION

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

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

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

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

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

During our fourth year, project PIs and field crew chiefs again met (Midland Michigan, January 15, 2014) to discuss aspects of the project needing attention and to help ensure that all teams continue to sample in the same manner across the entire Great Lakes basin. Topics at the 2014 meeting included adding other options for some of the water quality analyses (the QAPP and water quality SOP were updated for this purpose in March 2014), and issues with hybridization among fish species within certain genera (bullheads, gar, sunfishes). Site selection resulted in 251 sites, and of these we sampled 216 sites.

PROJECT ORGANIZATION

Figure 1 shows our project organization.

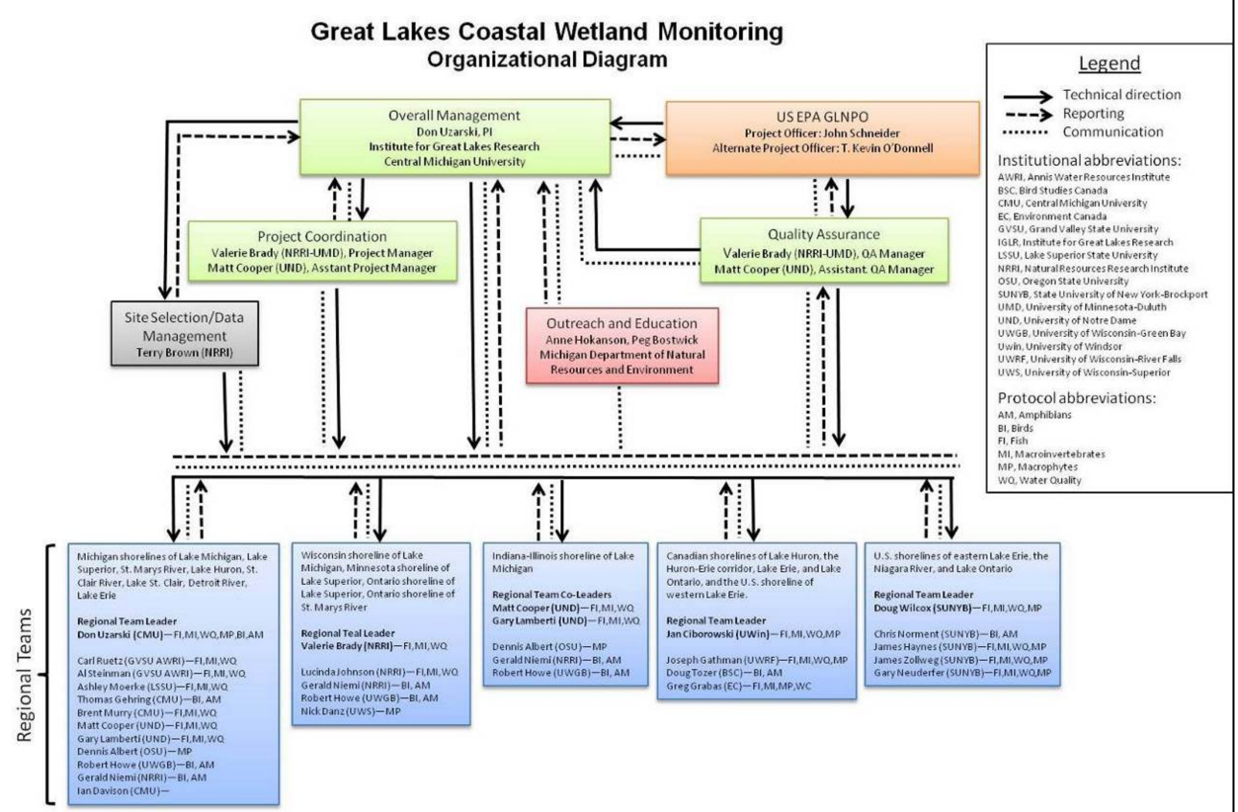

Figure 1. Organizational chart for the project showing lines of technical direction, reporting, and communication separately.

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

Anne Hokanson, who recently changed her name to Anne Garwood. No major personnel changes have taken place during this reporting period, although Matt Cooper has been awarded his doctoral degree and has relocated to Central Michigan University. He continues to hold the same roles on the project as he did previously. Finally, Greg Grabas is on special detail for the current time period and his portion of the project is being run by Dan Rokitnicki-Wojcik, who has been working as the field crew chief for Greg since the beginning of the project.

PROJECT TIMELINE

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

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

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

SITE SELECTION

Year five site selection was completed in March 2015 and was essentially the same as the previous years. Benchmark sites (sites of special interest for restoration or protection) can be sampled more than once in five years, and may be sites that were not on the original sampling list. The selection modification for these sites involved specifying exactly which teams will sample these sites each year, allowing bird and amphibian crews, which have greater sampling capacity, to visit these sites more often than other crews.

Original data on Great Lakes coastal wetland locations

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

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

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

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

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

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

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

Strata

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

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

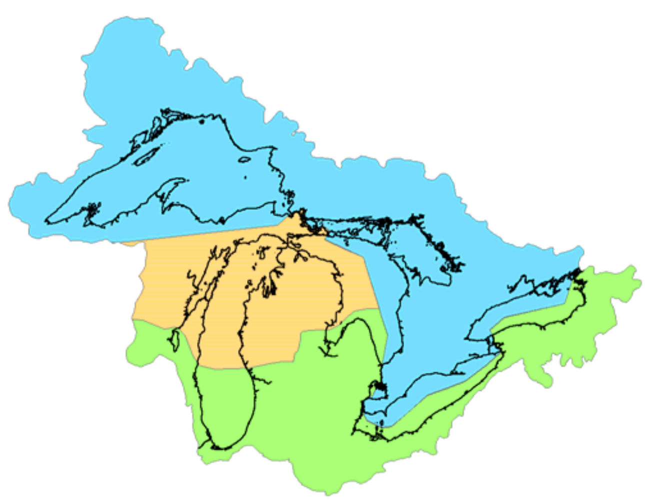

Figure 2. Divisions of lakes into regions. Note that stratification is by region *and* lake, so northern Lake Erie is not in the same region as Lake Superior, etc.

Panelization

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

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

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

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

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

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

Workflow states

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

Team assignment

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

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

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

Field maps

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

Browse map

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

2015 Site Selection

For 2015, 260 sites have been initially selected for sampling. Of these, 41 are benchmark sites. There are more than 10% of sites in the "benchmark" category because several teams have taken on additional sites at the special request of other agencies or groups (see *individual team reports* and *letters of support*) without sacrificing the number of random sites sampled. Another 16 sites are resample sites. Benchmark and resample sites are sorted to the top of the sampling list because they are the highest priority sites to be sampled. A number of sites will end up being dropped because the sites can't be safely accessed by field crews or because they are not actually influenced by a great lake or connecting channel.

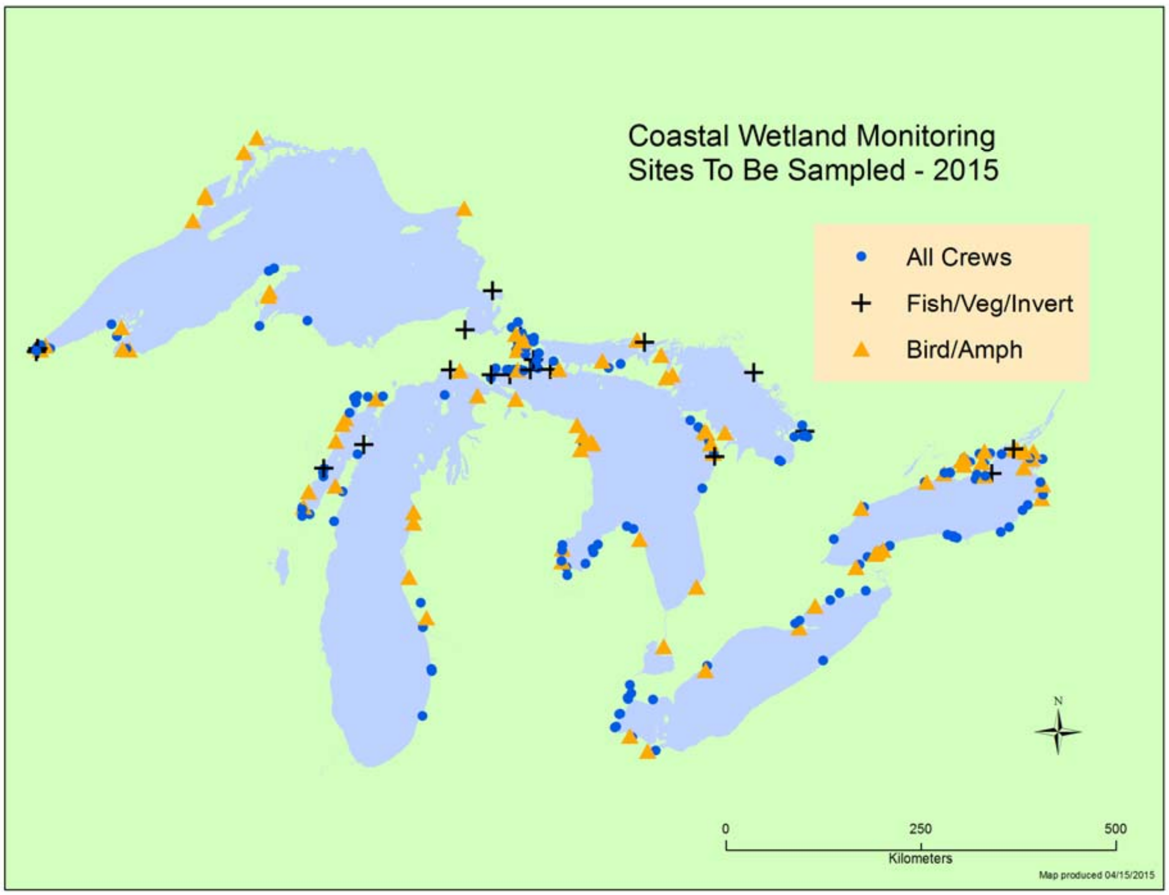

Figure 3. Locations of the 260 Great Lakes coastal wetlands to be sampled in 2015, color-coded by taxonomic groups. Sites assigned only to bird and amphibian crews (due to their greater sampling capacity) are shown with a gold triangle.

Wetlands have a "clustered" distribution around the Great Lakes due to geological differences. As has happened each sampling season so far, several teams ended up with fewer sites than they had the capacity to sample, while other teams' assigned sites exceeded their sampling capacity. Within reason, teams with excess sampling capacity have 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 are used to make these changes.

TRAINING

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

The following is a synopsis of the training to be conducted by PIs this spring (2015): Each PI or field crew chief trains all field personnel on meeting the data quality objectives for each element of the project; this includes reviewing the most current version of the QAPP, covering site verification procedures, providing hands-on training for each sampling protocol, and reviewing record-keeping and archiving requirements, data auditing procedures, and certification exams for each sampling protocol. All field crew members will be required to pass all training certifications before they were allowed to work unsupervised. Those who do not pass all training aspects are only allowed to work under the supervision of a crew leader who has passed all training certifications.

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

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

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

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

Certification

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

Documentation and Record

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

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

Web-based Data Entry System

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

Features of note include:

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

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

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

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

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

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

RESULTS-TO-DATE (2011-2014, updated)

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

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

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

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

Teams may have been able to sample more sites in 2014 due to higher lake levels on Lakes Michigan and Huron, which allowed crews to access sites and areas that have been dry or inaccessible in previous years. This highlights the difficulty of precisely determining the number of sampleable coastal wetlands in the Great Lakes.

Wetland types are not distributed evenly across the Great Lakes due to fetch, topography, and geology (Figure 4). Lacustrine wetlands occur in more sheltered areas of the Great Lakes within large bays or adjacent to islands. Barrier-protected wetlands occur along stretches of coastline that are exposed to relatively high wave energy, particularly where substrate is unconsolidated. Riverine wetlands are somewhat more evenly distributed around the Great Lakes. Note that revisit sites (Figure 4, blue stars) were sampled in 2013 and then again in 2014 to track and account for temporal variation in metrics and indicators.

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

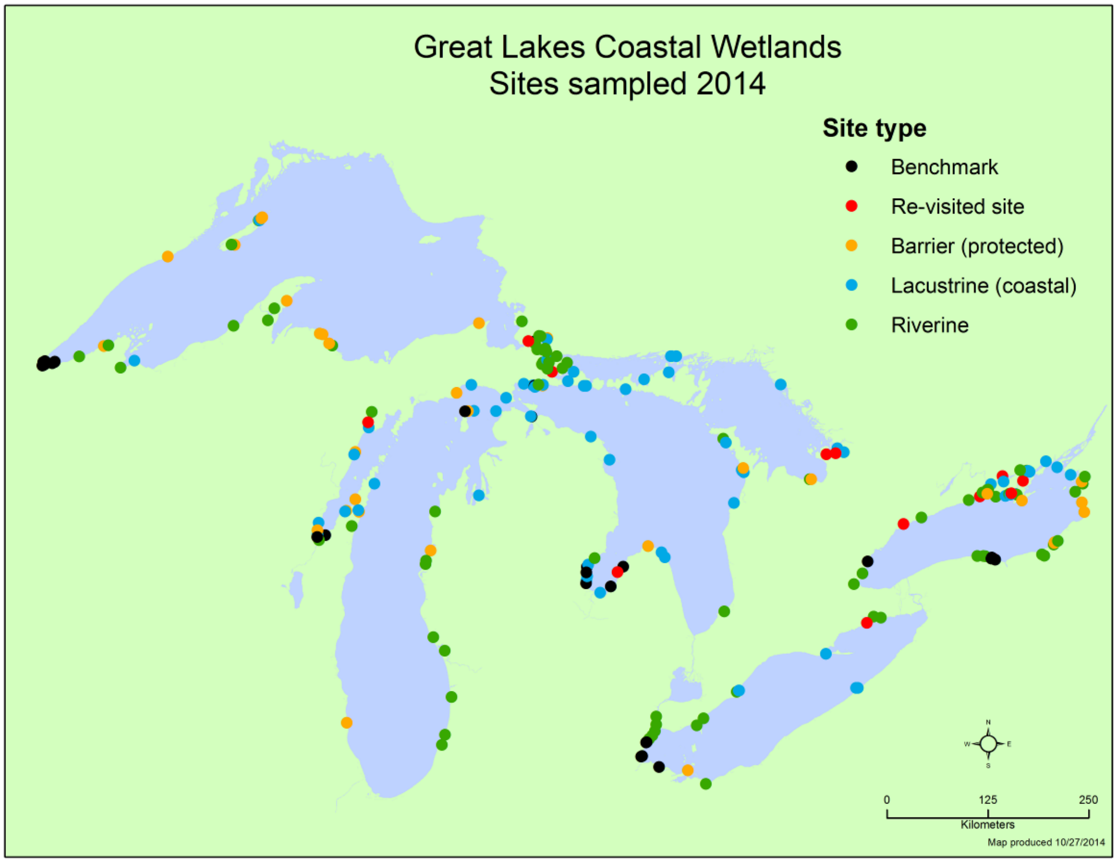

Figure 4. Locations of the 216 Great Lakes coastal wetlands sampled in 2014, color-coded by site type. Wetland types exhibit a clumped distribution across lakes due to geology and topography.

As of 2014, we have 59 sites designated as "benchmark." Of these, 23 (39%) are to evaluate restoration efforts and 17 (28%) serve as reference sites for their area or for nearby restoration sites. Almost all benchmark sites are in the US. We will update this to a final list after completion of 2015 sampling.

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

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

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

Country	Site count	Mean	Max	Min	St. Dev.
Birds					
Can.	242	28.0	58	8	10.3
U.S.	461	21.6	60	1	11.6
Amphibians					
Can.	240	4.2	8	1	1.7
U.S.	446	3.6	7	0	1.5

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

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

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

	Birds				Calling amphibians			
Lake	**Sites**	**Mean**	**Max**	**Min**	**Sites**	**Mean**	**Max**	**Min**
Erie	88	22.5	53	4	81	3.1	7	0
Huron	219	24.9	58	2	214	3.8	7	0
Michigan	118	23.2	60	1	109	3.5	7	0
Ontario	181	21.4	45	8	183	4.4	8	1
Superior	96	27.7	52	11	98	3.6	7	0

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

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

Country	**Sites**	**Mean**	**Max**	**Min**	**St. Dev.**
Overall					
Can.	120	10.1	23	2	3.9
U.S.	289	13.5	28	2	5.3
Non-natives					
Can.	120	0.7	3	0	0.7
U.S.	289	0.7	5	0	0.9

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

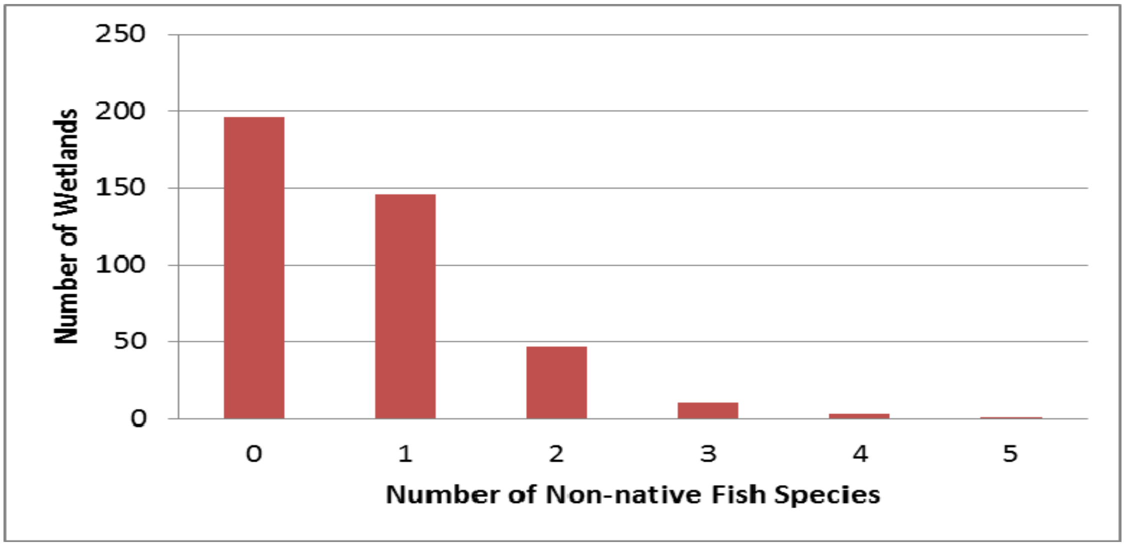

Figure 5. Number of Great Lakes coastal wetlands containing non-native fish species. Data from 2011 through 2014.

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

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

		Fish (Total)			Non-native		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	54	12.6	27	2	1.2	4	0
Huron	136	11.6	27	2	0.4	2	0
Michigan	55	13.6	28	5	0.9	4	0
Ontario	108	12.4	23	4	0.8	3	0
Superior	54	14.1	28	3	0.9	5	0

The average number of macroinvertebrate taxa (taxa richness) per site was about 40 (Table 10), but some wetlands had more than twice this number. Sites scheduled for restoration and other taxonomically poor wetlands had fewer taxa, as low as 10 in Canada, but we now have restoration sites in the US in which no wetland taxa were found using our sampling techniques (Tables 10 and 11). If there is good news about these sites in need of restoration, it is that we did not find non-native invertebrates at these locations. The average number of non-native invertebrate taxa in coastal wetlands was less than 1, with a maximum of no more than 5 taxa (Table 10). Again, we must point out that our one-time sampling may not be capturing all of the non-native taxa at wetland sites. In addition, some non-native macroinvertebrates are quite cryptic, resembling native taxa, and may not yet be recognized as invading the Great Lakes.

Table 10. Total macroinvertebrate taxa in Great Lakes coastal wetlands, and non-native species; summary statistics by country. Data from 2011 through 2014.

Country	Sites	Mean	Max	Min	St. Dev.
Overall					
Can.	149	39.8	76	10	13.5
U.S.	326	40.7	85	0	15.2
Non-natives					
Can.	149	0.8	3	0	0.9
U.S.	326	0.7	5	0	1.0

There is some variability among lakes in the mean number of macroinvertebrate taxa per wetland. We are also noticing an effect of the benchmark sites in these summaries. Lake Ontario and Erie wetlands averaged 32 and 35 taxa, respectively (Table 11), while lakes Huron, Superior, and Michigan averaged about 42-47 taxa. The maximum number of invertebrate taxa was higher in lakes Huron and Michigan wetlands (>80) than for the most invertebrate-rich wetlands in the other lakes, which have a maximum of 60-70 taxa. Wetlands with the fewest taxa are sites in need of restoration and have as few as no taxa found at all (in both Erie and Ontario). Patterns are likely being driven by differences in habitat complexity, which may in part be due to the loss of wetland habitats on lakes Erie and Ontario from diking (Erie) and water level control (Ontario). This has been documented in numerous peer-reviewed publications. There is little variability among lakes in non-native taxa occurrence, although Erie and Huron had wetlands with 4-5 non-native taxa. In each lake, we found that a portion of wetlands had zero non-native macroinvertebrates. As noted above, however, this does not necessarily mean that these sites do not contain non-native macroinvertebrates.

Table 11. Macroinvertebrate total taxa and non-native species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of taxa per wetland. Data from wetlands sampled in 2011 through 2014.

		Macroinvertebrates (Total)			**Non-native**		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	58	34.9	70	0	1.1	4	0
Huron	168	44.7	81	13	0.7	5	0
Michigan	66	42.1	85	19	0.7	3	0
Ontario	114	32.3	63	0	0.8	3	0
Superior	67	46.7	69	15	0.1	2	0

This year, we realized that we are finding some non-native, invasive species in significantly more locations around the Great Lakes than is being reported on nonindigenous species tracking websites such as the USGS's Nonindigenous Aquatic Species (NAS) website (http://nas.er.usgs.gov/). Locations of aquatic macroinvertebrates are particularly under-reported. The best example of the difference is shown in Figures 6 and 7 for the faucet snail, *Bithynia tentaculata*. Figure 6 shows the range portrayed on the USGS website for this snail before we reported our findings. Figure 7 shows the locations where our crew found this snail. Finally, Figure 8 shows the USGS website map after it was updated with our crews' reported findings.

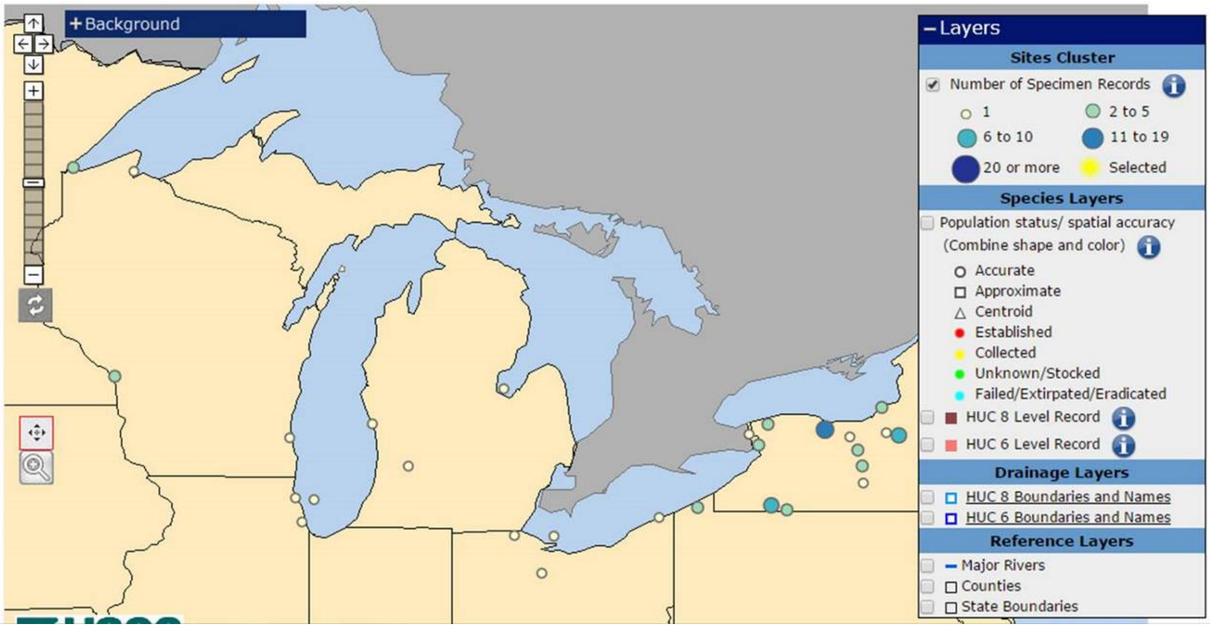

Figure 6. Locations of *Bithynia tentaculata* in USGS NAS website PRIOR to our project providing additional locations where they were collected.

The faucet snail is of particular interest to USFWS and others because it carries parasites that can cause disease and die-offs of waterfowl. Because of this, we produced numerous press releases reporting our findings (collaborating universities produced their own press releases). The Associated Press ran the story and, to date, 41 articles (print and on-line) have run. See Appendix for a mock-up of our press release and a list of articles that ran based on this press release.

One reason that we were able to increase the geographic range and total number of known locations occupied by faucet snails is the limited number of ecological surveys occurring in the Great Lakes coastal zone. Furthermore, those surveys that do exist tend to be at a much smaller scale than ours and sample wetlands using methods that do not detect invasive species with the precision of our program.

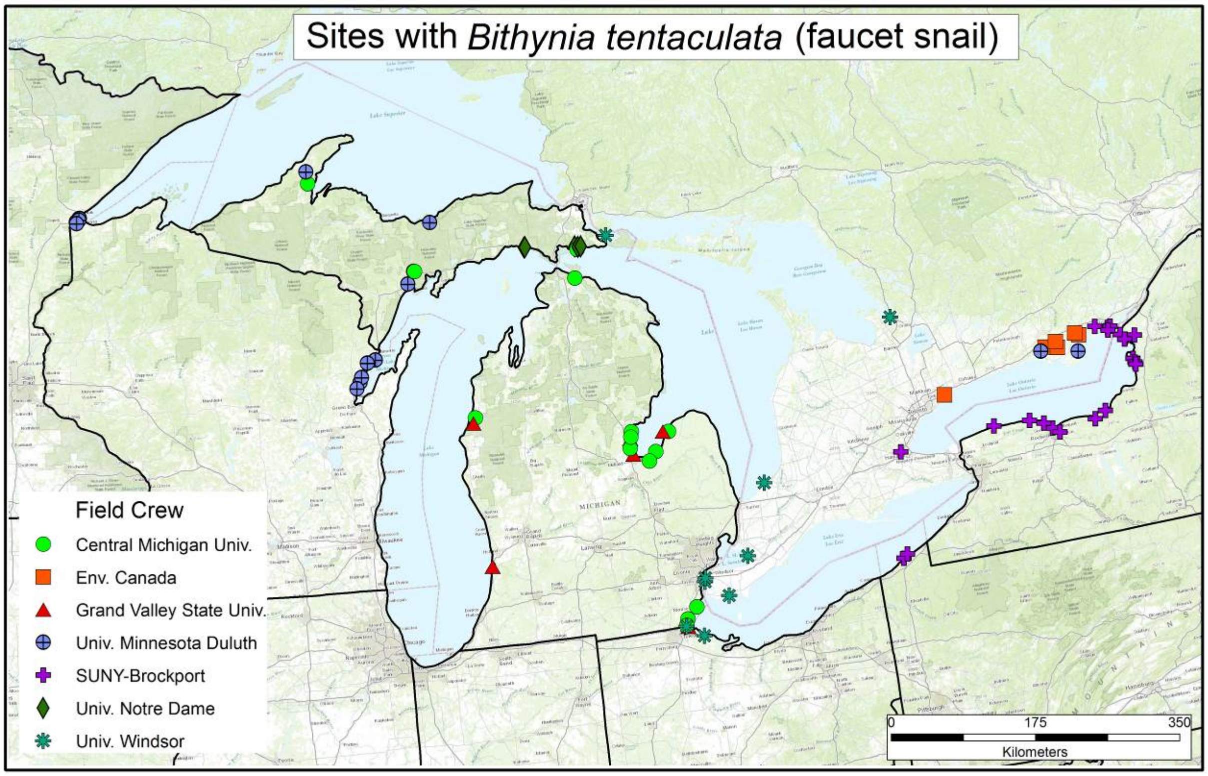

Figure 7. Locations of *Bithynia tentaculata* found by CWM crews, 2011 - 2013.

We also provided USGS with locations of other non-native macroinvertebrates and fish. The invasive macrophyte information had previously been provided to websites that track these locations, and reported to groups working on early detection and eradication.

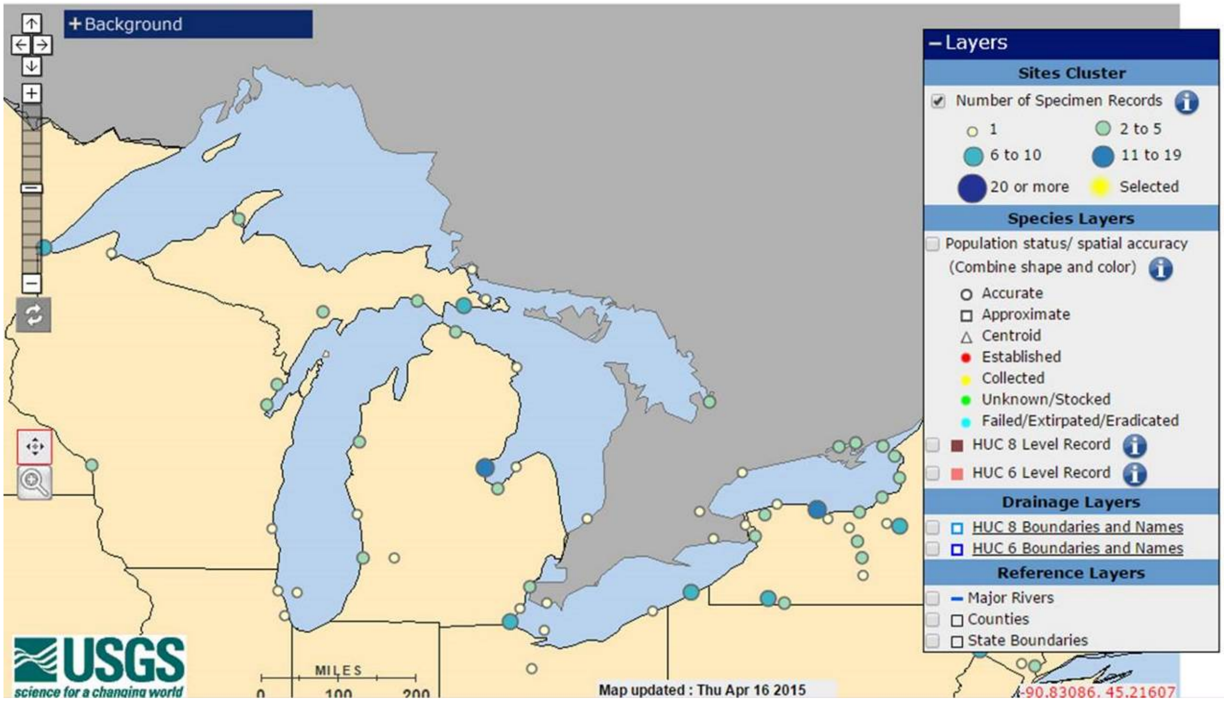

Figure 8. Locations of *Bithynia tentaculata* in USGS NAS website AFTER our project provided additional locations where they were collected; compare to Figure 6.

On average, there were approximately 45 wetland plant (macrophyte) species per wetland (Table 12), but the maximum number is now at 100 species. Some sites were quite depauperate in plant taxa (some having almost none), particularly in highly impacted areas that were no longer wetlands but were sampled because they are designated for restoration.

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

Country	Site count	Mean	Max	Min	St. Dev.
Overall					
Can.	162	45.6	87	8	16.8
U.S.	356	44.7	100	1	17.0
Invasives					
Can.	162	3.7	8	0	2.0
U.S.	356	3.3	9	0	2.1
At risk					
U.S.	356	0.1	2	0	0.33

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

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

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

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

		Macrophytes (Total)			**Invasives**		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	63	27.5	69	1	4.6	8	0
Huron	190	53.8	100	15	2.6	7	0
Michigan	74	47.1	83	4	3.3	7	0
Ontario	123	40.9	87	8	5.2	9	1
Superior	67	41.8	78	21	1.6	5	0

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

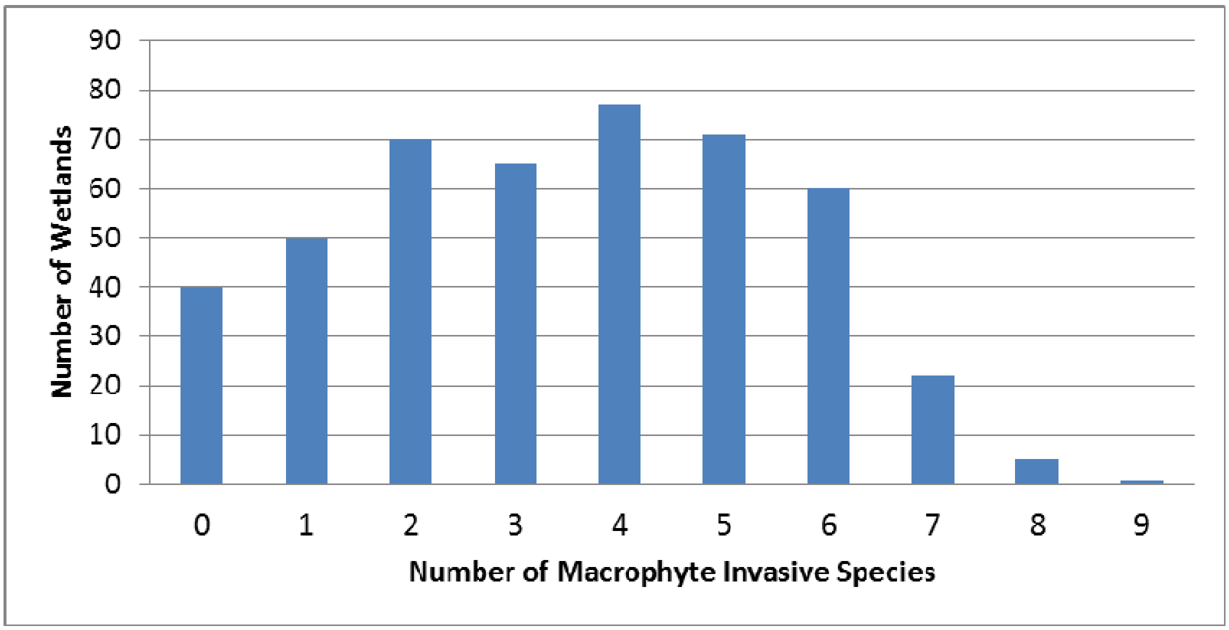

Figure 9. Number of Great Lakes coastal wetlands containing invasive plant species based on 2011 through 2014 data.

As an example for the state of Michigan, we also looked at wetlands with both invasive plants and plant species considered “at risk” (Figure 10). We found that there were a few wetlands at all levels of invasion that also had at-risk plant populations. This information will be useful to groups working to protect at-risk populations by identifying wetlands where invasive species threaten sensitive native species.

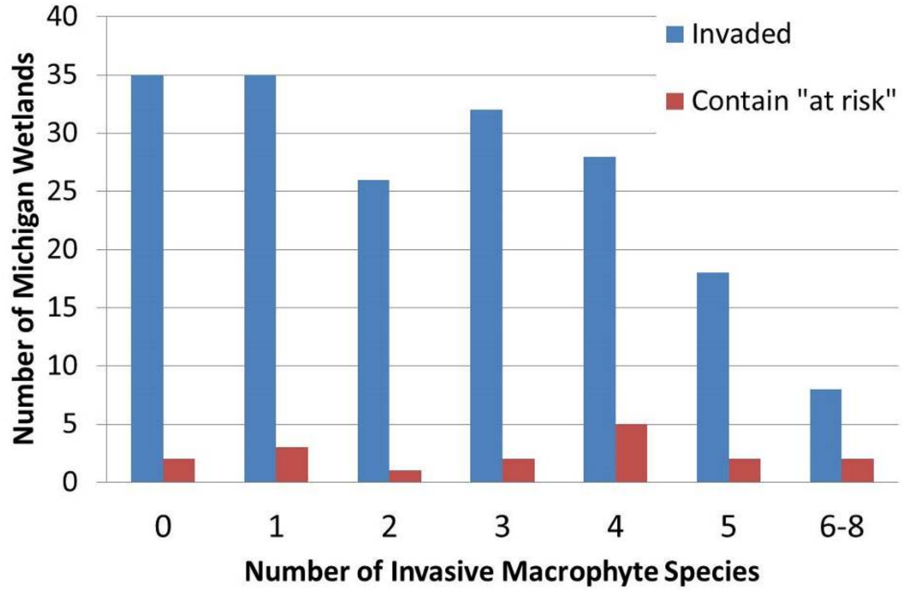

Figure 10. Number of state of Michigan Great Lakes coastal wetlands containing both invasive plant species and "at risk" plant species, based on 2011 through 2014 data.

We created a map of invasion status of Great Lakes coastal wetlands using all invasive species data we have collected so far for all taxonomic groups combined (Figure 11). Unfortunately, this shows that most sites have some level of invasion, even on Isle Royale. However, the more remote areas clearly have fewer invasives than the more populated areas and areas with relatively intense human use.

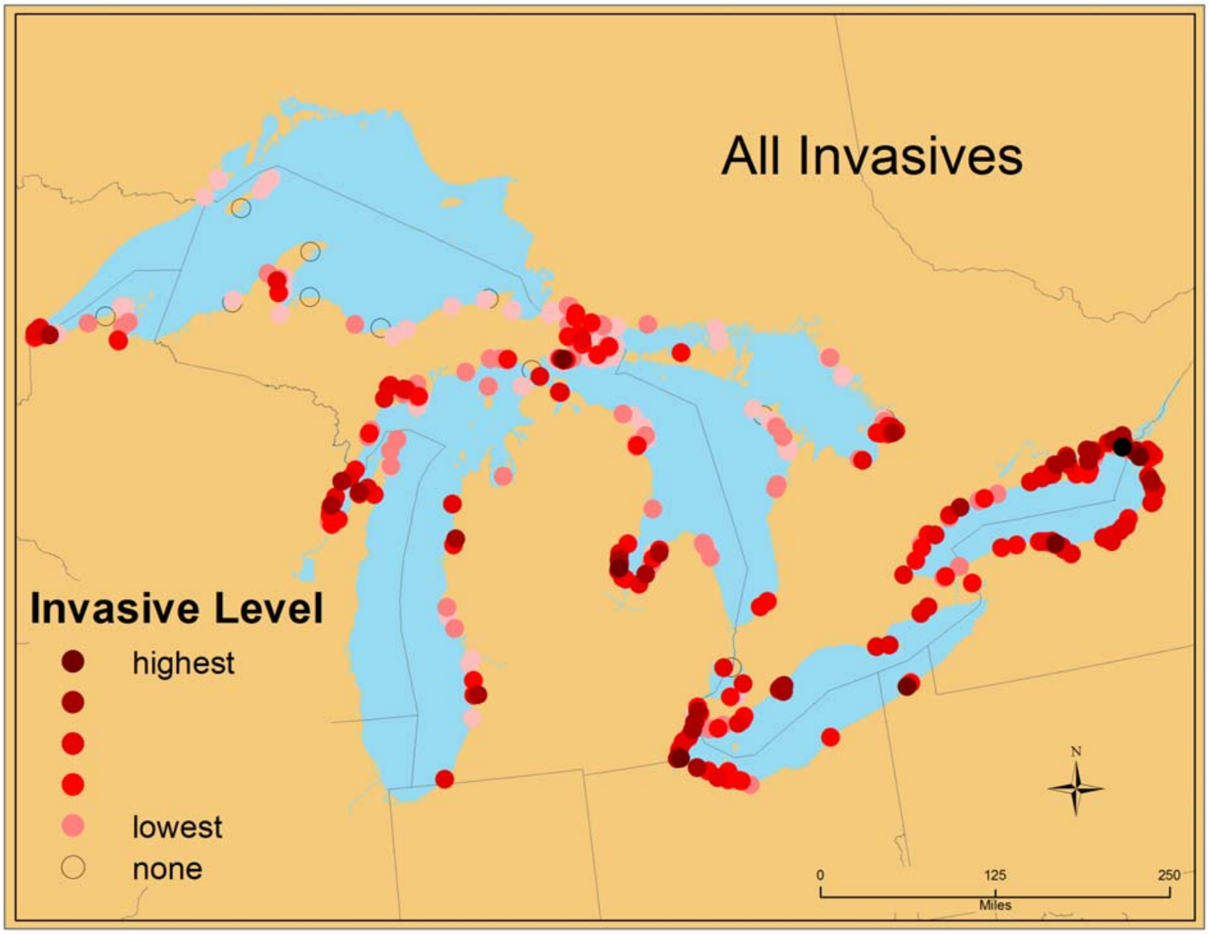

Figure 11. Level of "invadedness" of Great Lakes coastal wetlands for all non-native taxa combined across all taxonomic groups, based on data from 2011-2014.

Wetland Condition

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

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

Figure 12 shows the distribution of Great Lakes coastal wetland vegetation index scores across the basin. Note that there are long stretches of Great Lakes coastline that do not have coastal wetlands due to topography and geology. Sites with low FQI scores are concentrated in the southern Great Lakes, where there are large amounts of both agriculture and urban development, and where water levels may be more tightly regulated (e.g., Lake Ontario), while sites with high FQI scores are concentrated in the northern Great Lakes. Even in the north, an urban area like Duluth, MN may have high quality wetlands in protected sites and lower quality degraded wetlands in the lower reaches of estuaries (drowned river mouths) where there are legacy effects from the pre-Clean Water Act era, along with nutrient enrichment or heavy siltation from industrial development and/or sewage effluent. Benchmark sites in need of restoration will also have lower condition scores. Note that this IBI has been updated and adjusted since the start of the project, accounting for the shift in condition scores for a handful of sites. This adjustment was necessary to reflect changes in the taxonomic treatment of many marsh plants in the 2012 Michigan Flora and Flora of North America.

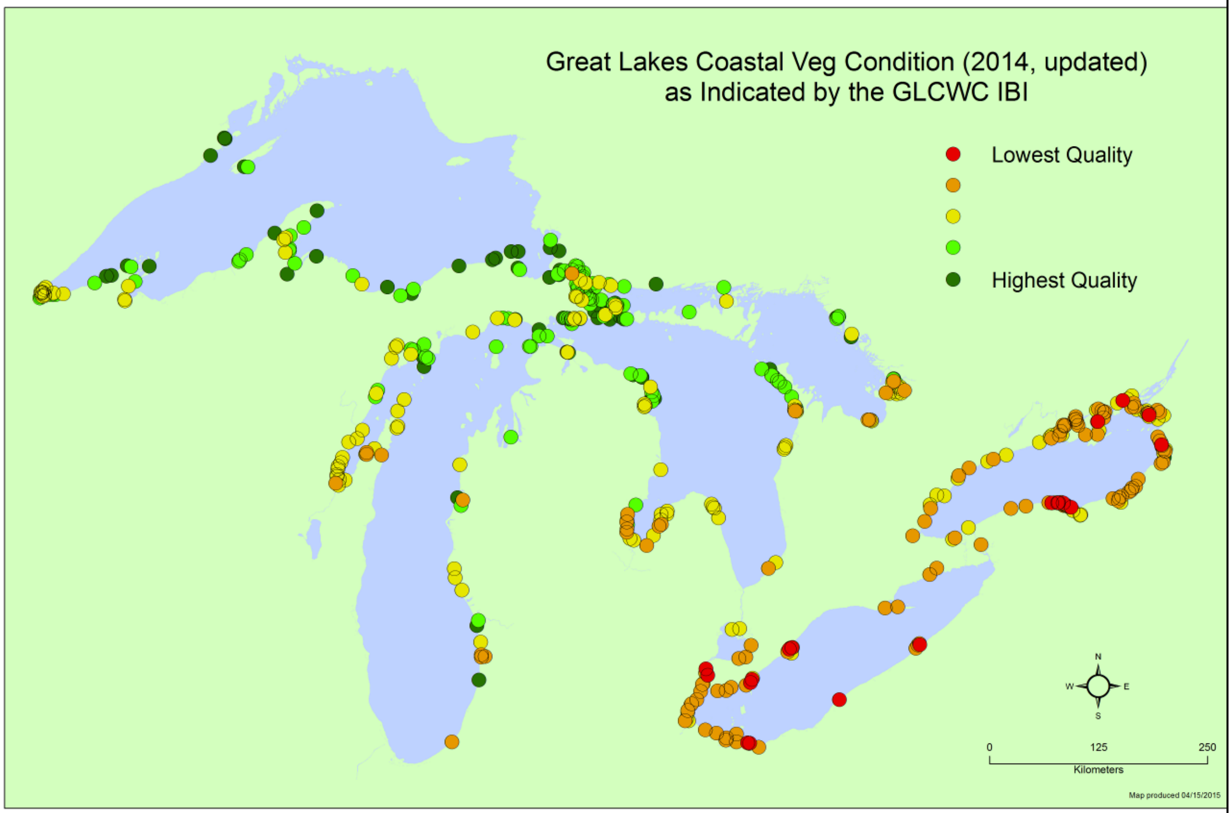

Figure 12. Condition of coastal wetland vegetation at sites across the Great Lakes. Symbol color indicates vegetation community quality. The indicator is labeled “draft” while this indicator is investigated for robustness against varying water levels and latitude. Based on data from 2011 through 2014.

Another set of the IBIs that was developed by the Great Lakes Coastal Wetlands Consortium uses the aquatic macroinvertebrates found in several of the most common vegetation types in Great Lakes coastal wetlands: sparse bulrush (*Schoenoplectus*), dense bulrush (*Schoenoplectus*), and wet meadow (multi-species) zones. We have calculated these IBIs for sites sampled in 2011 through 2014 that contain these habitat zones (Figure 13). Minor adjustment of metrics is continuing, so maps are not directly comparable across reports.

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

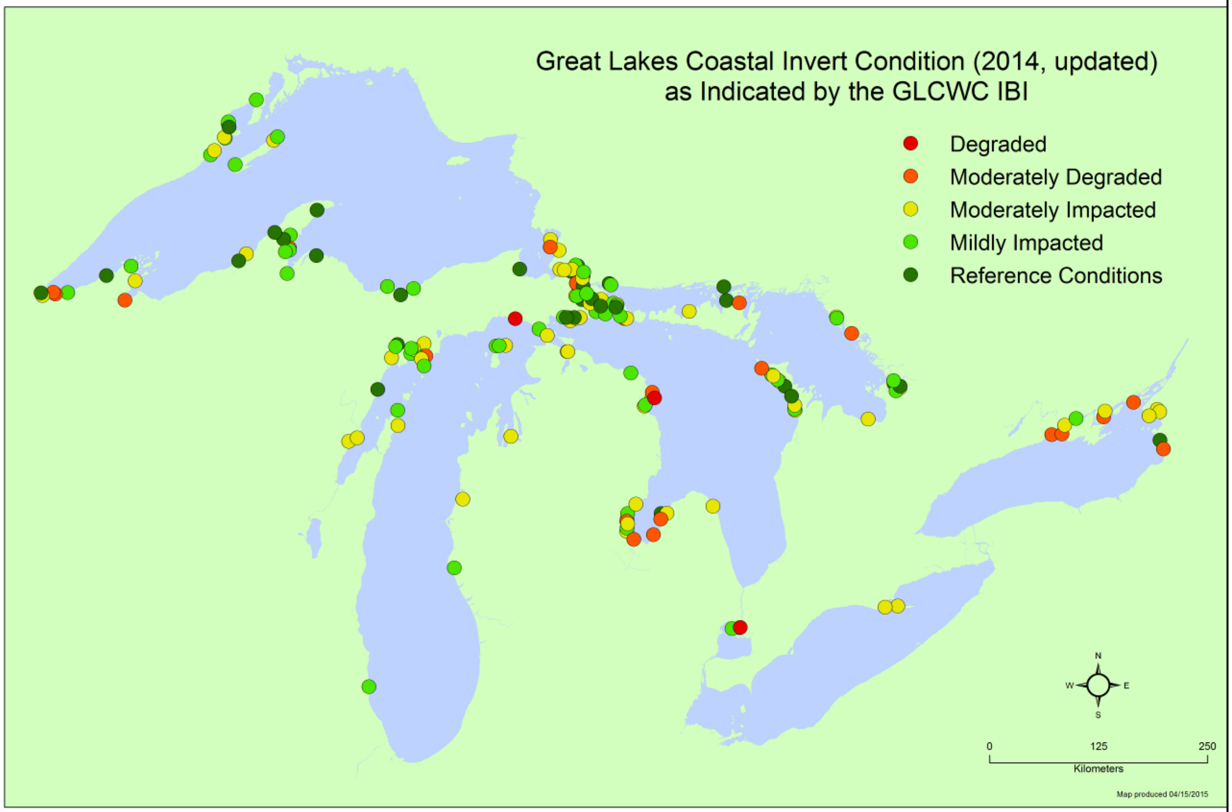

Figure 13. Condition of coastal wetland macroinvertebrate communties at sites with bulrush or wet meadow zones. The indicator is labeled “draft” while more zone IBIs are calculated. Based on data from 2011 through 2014.

We are currently able to report draft fish IBI scores for wetland sites containing bulrush and/or cattail zones (Figure 14). These are the two zone types with GLCWC validated fish IBIs. Because of the prevalence of cattail zones in Erie and Ontario wetlands, this indicator provides more site scores than the macroinvertebrate indicator. Only a few wetlands rank as high quality with the fish IBI. We are still working to determine whether we have set the criteria for this indicator too stringently, or if fish communities really are relatively degraded in many areas.

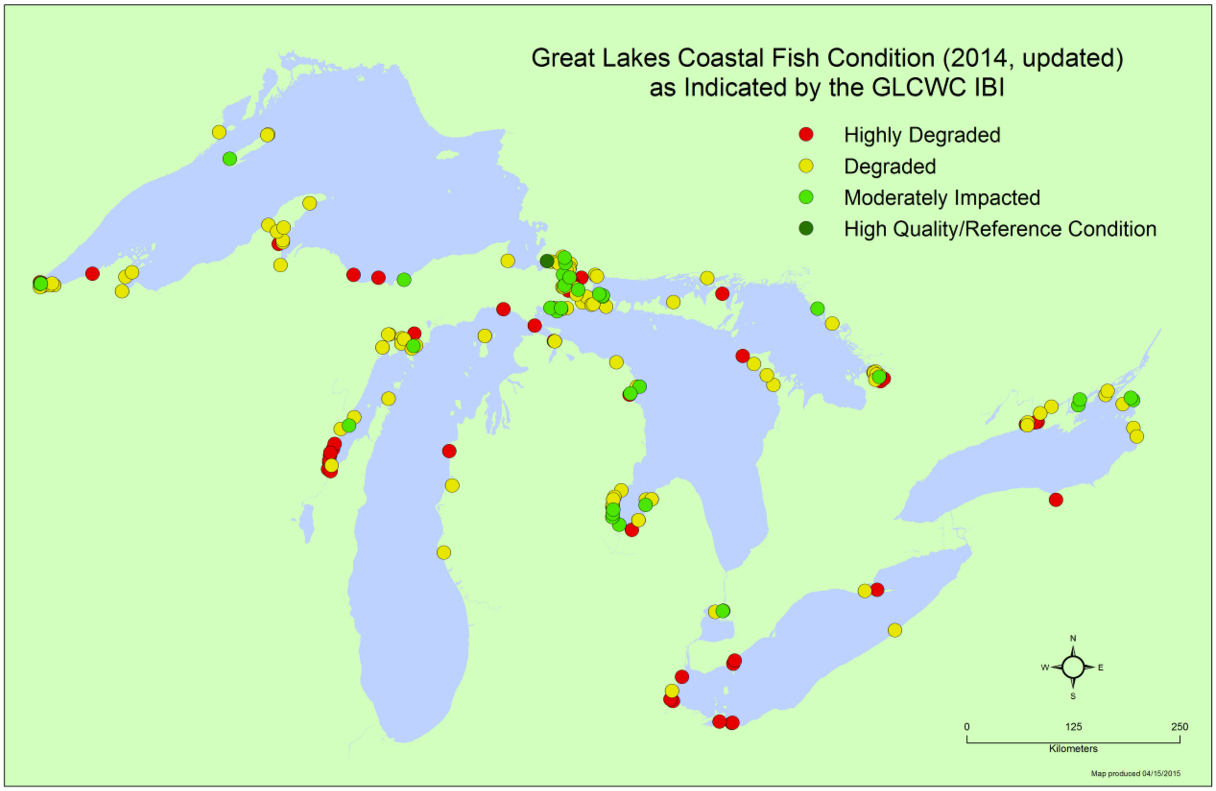

Figure 14. Condition of coastal wetland fish communties at sites with bulrush or cattail zones. The indicator is labeled “draft” while more zone IBIs are developed. Based on data from 2011 through 2014.

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

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

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

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

The indicator is shown on separate scales for the northern and southern parts of the Great Lakes basin because of the differences in amounts of agriculture and development between these two areas (Figure 15). This can be seen in particular along the eastern coast of Lake Michigan on either side of the north/south split in the basin. We may have to do some adjustments to avoid discrepancies in treatment of sites that are close to the boundary line. However, benchmark sites also exhibit low bird IBI scores even in locations such as Duluth, on Lake Superior.

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

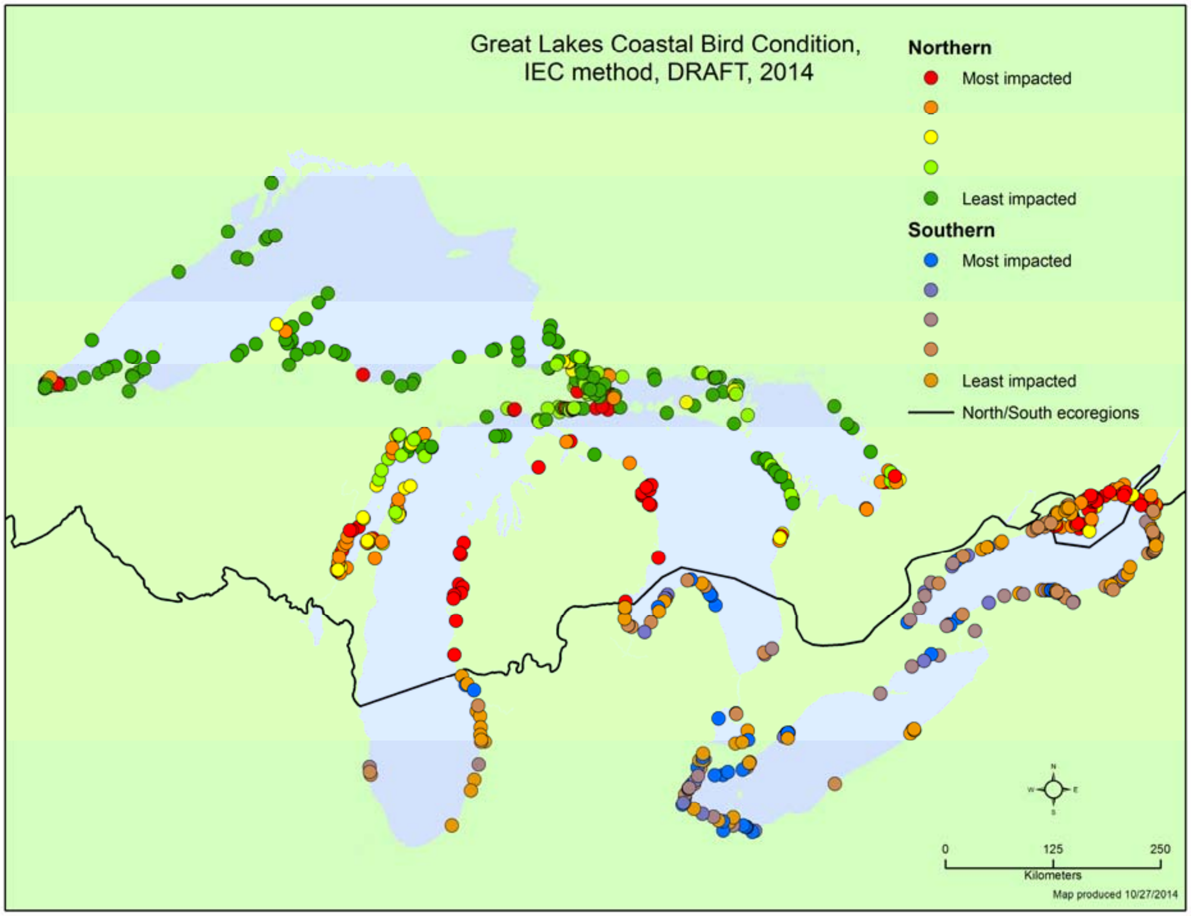

Figure 15. Condition of coastal wetland bird communties. This indicator is based on the IEC method, and it works best when shown separately for the northern and southern areas of the Great Lakes because of the differences in the amount of agriculture and developed land between these two areas (see text for details). Based on data from 2011 through 2014.

PUBLIC ACCESS WEBSITE

We have created a publically accessible website to inform managers, agency personnel, and the interested public about the basics of our project (Figure 16). The website's primary function is to house a web-based tool that allows varying levels of access to our results, depending on the user's data needs and their affiliation.

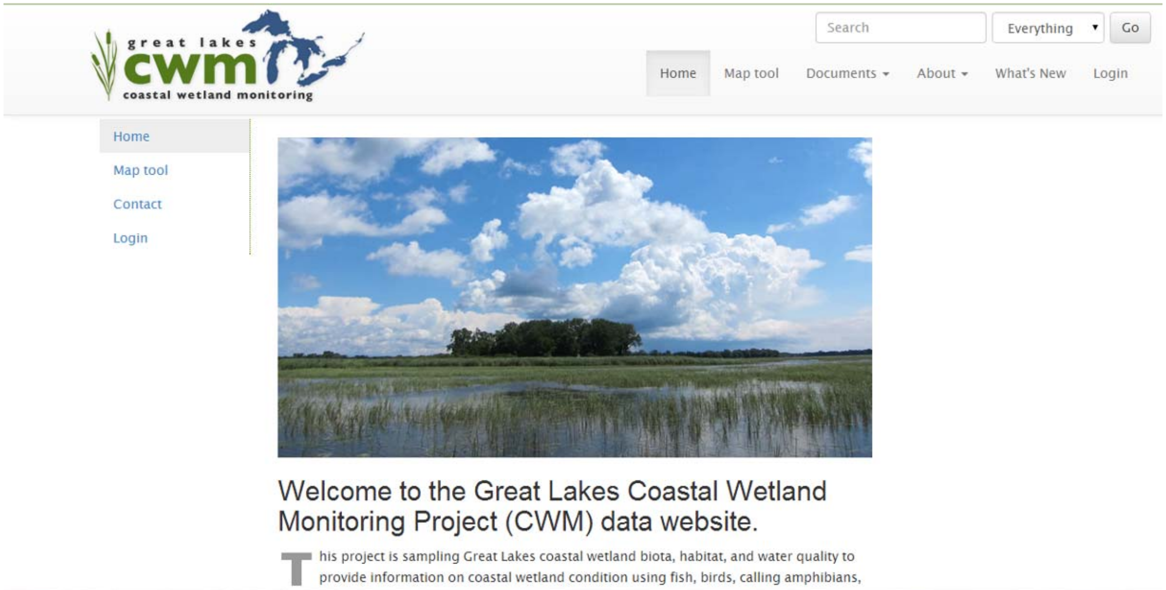

Figure 16. Front page of the new Great Lakes Coastal Wetland Monitoring public website, www.greatlakeswetlands.org.

In addition to features commonly found in map-based web interfaces (e.g., layer switching, swapping of base-maps, panning and zooming), the tool will provide custom functionality relevant to coastal wetland monitoring (Figure 17). Users will be able to examine sites ranked by Indices of Biological Integrity (IBIs) and other attributes, look at taxa lists, and peruse site information in the context of a particular region of interest, as well as whole lakes or the entire basin.

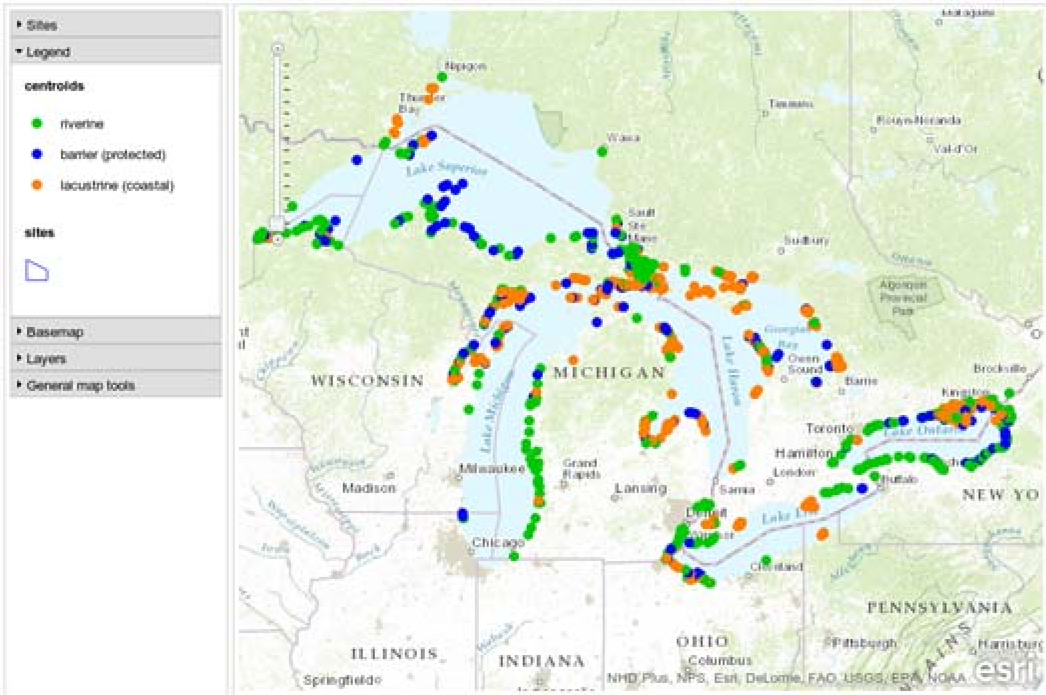

Figure 17. Default view of all sites in the database, color-coded by wetland type (riverine, barrier-protected, or lacustrine).

Users can change the coding schema for the sites shown in the display map to show what year(s) sites were sampled (Figure 18), what types of data are available for a site, and what the site condition is as indicated by the various biotic groups sampled. Users can select areas of the map to zoom to so that they can better view site information.

Wetland condition values can be selected for any of the IBIs currently available (fish, macroinvertebrates, or wetland vegetation) and displayed for the whole basin using the calculated normal scaling for the IBI (Figure 19).

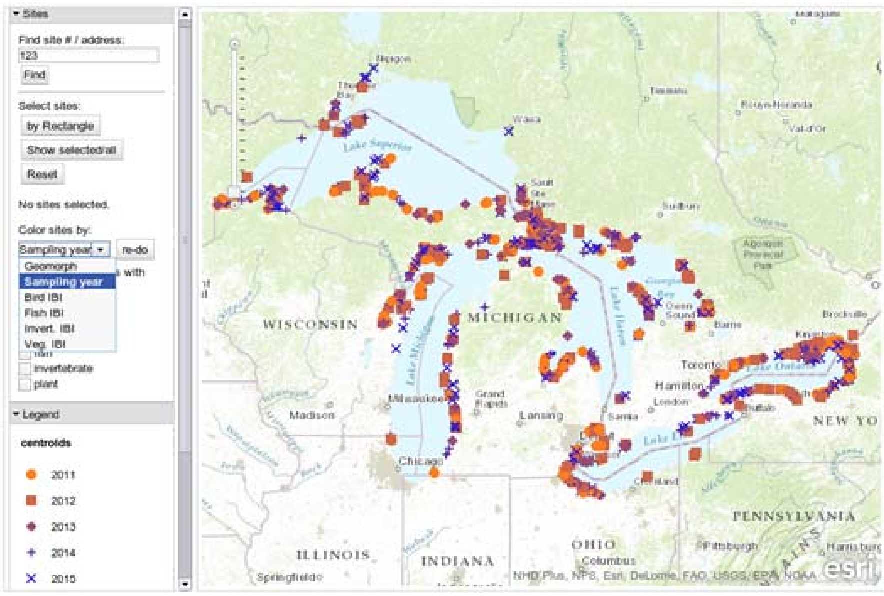

Figure 18. View by sampling year. Sites sampled in more than one year show the most recent year of sampling.

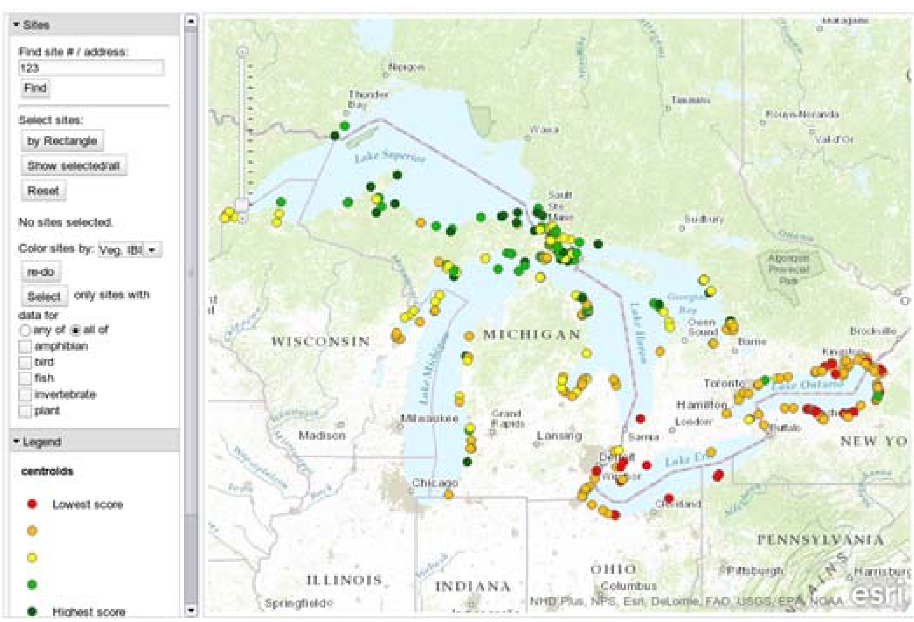

Figure 19. Wetland condition based on the wetland macrophyte IBI displaying sites for the whole basin for which there are data.

The tool also allows users to draw a box around sites of interest at any scale, such as all of Lake Erie, or just Green Bay, or just the St. Louis River estuary (Figure 20). Once selected, any IBI can be re-scaled for just the sites on display to color-code the sites based on their range of scores. This removes the sites from the basin-wide condition narrative and simply shows the user which sites are in best to worst condition for that indicator for that area. Thus, rescaled maps must be carefully explained to others and should not be shown without explanation because this view forces sites to be displayed from best to worst even if there is very little actual difference in site scores. The advantage is that this allows easy color-coded separation of sites that, when compared to all Great Lakes wetlands, appear to all have about the same condition scores (Figure 20 inset). By rescaling these sites, managers can see at a glance which wetlands have the highest and lowest scores for their area of management or interest (Figure 20).

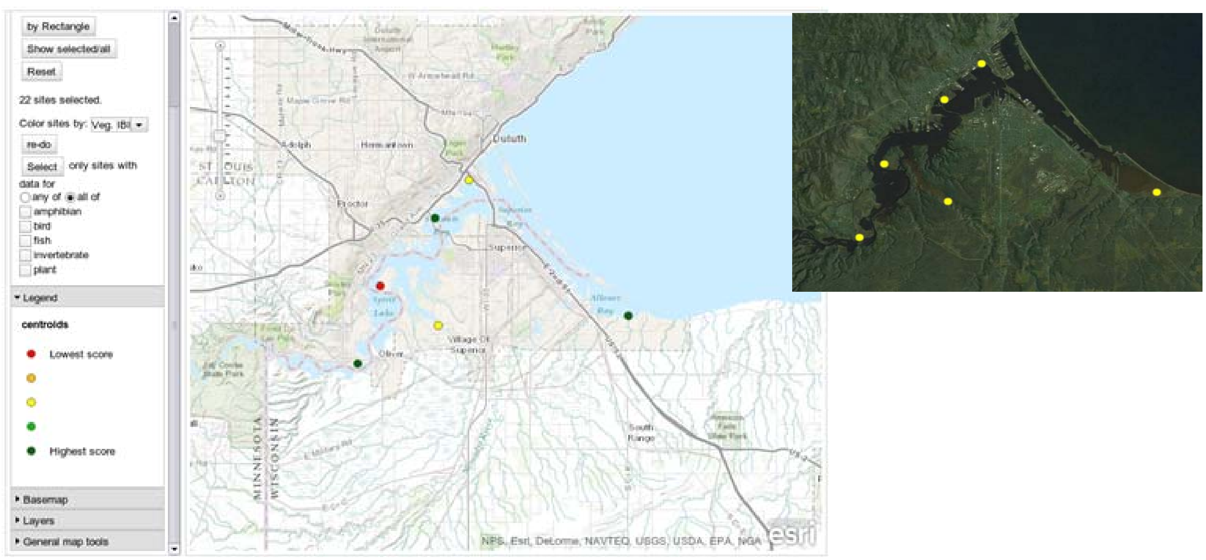

Figure 20. Wetlands in the St. Louis River estuary, Lake Superior, color-coded by wetland vegetation IBI scores that have been re-scaled for the sites shown. Inset shows original site coding for these wetlands in the context of all the wetlands across the Great Lakes.

The web tool will have different levels of access based on the type of user (e.g., general public, management, researcher, etc.). This will be controlled by user login. Depending on their level of access, users will be able to drill down at individual sites to see lists of species found (Figure 21), non-native species, IBI scores and their composite metrics, and potentially other site information.

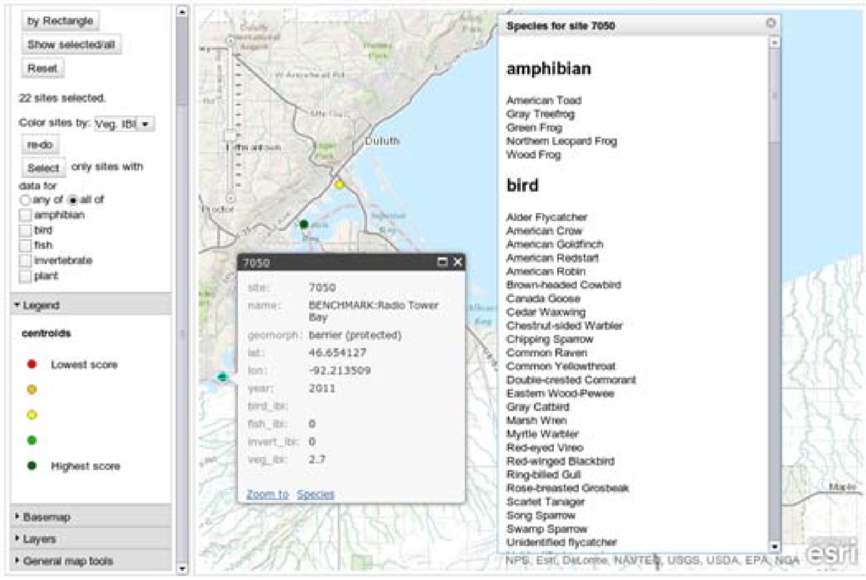

Figure 21. Example display of species lists for a specific site.

Arrangements for the long-term post-project hosting of the public website have now been finalized. Central Michigan University will be providing hosting and maintenance. Currently development, deployment, and management systems are being transferred from the staging site hosted at NRRI to CMU. A substantial update to the project database, website, and other data management tools is also being conducted with support from Central Michigan University's College of Science and Technology. The intent of these IT updates and provisions for long-term storage and maintenance is to preserve the integrity and usefulness of the project data for many years to come.

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)**

2014 Sample Processing, Data Entry, and QC

All 2014 bird, amphibian, macroinvertebrate, fish, habitat, and field and lab water quality data have been entered into the database and QC'd. Blinded macroinvertebrate samples were exchanged between NRRI and Lake Superior State University for identification QC. Vegetation data were subject to QA/QC procedures by visually checking every piece of entered data in the data management system against the field sheets. Errors were corrected in the database and noted on field sheets. Error rates were very low, <1% of all data entries. Approximately 100 unknown specimens from northern Lake Michigan and western Lake Superior wetlands were identified through herbarium work with the help of regional experts and updated in the database.

Birds and Amphibians:
All data gathered for bird samples across the Great Lakes region are being reviewed by Co-Principal Investigator Niemi. This review is concentrating on any unusual species or unusual number of individuals that have been recorded among all years of the study. This is being completed as an extra assurance to insure the integrity of these data. Any observations that are in question will be referred to the original investigation team, double-checked with the original field sheets, and any changes necessary will be completed.

Metrics and Indicator Calculations

Birds and amphibians:
Avian and amphibian responses to landscape stressors can be used to inform land managers about the health of coastal wetlands and the landscape stressors that affect these systems (Howe et. al. 2007a, 2007b). Data that has been entered into the data management system and undergone quality control checks (2011-2013) are being used to calculate some of the metrics and indicators for these wetlands. Bird and amphibian indices of ecological condition (IEC) and biotic integrity (IBI) have been calculated for the Great Lakes coastal wetlands following the methods of Crewe and Timmermans (2005). These indices were developed for Great Lakes coastal wetland bird and amphibian communities from data collected from Bird Studies Canada's Marsh Monitoring Program (MMP).

Aquatic macrophytes:
PIs focusing on the vegetation aspects of the project have been analyzing temporal patterns in floristic quality metrics (e.g. mean Coefficient of Conservatism, FQI). We are asking how much these metrics change from year to year in typical situations and in other cases where water level changes or human influences have been substantial through time. Throughout 2014, N. Danz has been analyzing data from 2011-2013 surveys to characterize interannual variability in wetland floristic quality. Additionally, we are working to statistically evaluate the draft Vegetation Index of Biotic Integrity (Albert et al. 2008) for all Great Lakes coastal wetlands. Our first three years of the project was a period of low water levels, while water levels rebounded in year 4. We are checking to see the influence of these changes on IBI performance. For 36 wetlands that experienced no human disturbance and were surveyed in more than one year, mean coefficient of conservatism (C) and weighted mean coefficient of conservatism (wC) differed very little between years. Mean annual differences were within ±1.2 for C and ±1.5 for wC. These patterns of change may serve as a baseline amount of temporal variability against which future changes in floristic quality can be judged.

Leveraged benefits

Joel Hoffman from the US EPA MED in Duluth, MN requested that location data from captured invasive species be entered into the USGS Nonindigenous Aquatic Species (NAS) database. The purpose was so that a graduate student could mine the NAS as thesis research for the Integrated Biosciences Program at the University of Minnesota, Duluth.

Data from the benchmark site Suamico River Area Wetland was requested by and shared with personnel from the Wisconsin Department of Natural Resources and The Nature Conservancy, who are involved in the restoration activities to re-connect a diked area with Green Bay. In 2011 NRRI sampled outside the diked area following CWM methods, and in 2013 we sampled within the diked area as a special request. The data were summarized for fish, invertebrates, water quality, birds, and vegetation and shared with David Halfmann (WDNR) and Nicole Van Helden (TNC). We have ongoing communication with TNC members and plan to re-sample of this site in 2015.

The Wisconsin Department of Natural Resources requested (and funded) a special report on sites sampled using CWM protocols around Clough Island within the St. Louis River Area of Concern (AOC). Their interests were to see if CWM data indicated any differences in habitat or species composition/abundances among Clough Island and other St. Louis River sites, and also how Clough Island compared to other nearby Lake Superior coastal wetlands. The 46 page report was submitted to Cherie Hagan of the WDNR in May of 2014. Clough Island was recently acquired by the Nature Conservancy and they are using the data in the report for their development of conservation plans for the area.

Dumke, J., V. Brady, N. Danz, A. Bracey, G. Niemi. 2014. St. Louis River Report: Clough Island. NRRI TR2014/26 for Wisconsin DNR.

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

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

Field Training

Birds and Amphibians:
Training for amphibian surveys will be held in April 2015 and bird crew training will take place 18-21 May 2015. Training involves instructing crews on how to conduct standardized field surveys, on basic travel procedures and appropriate field safety measures, and includes basic first aid and CPR certification. Individuals are trained to proficiently complete field sheets and audio testing is conducted to insure that their hearing is within the normal range. Rules for site verification, safety issues including caution regarding insects (e.g., tick-borne diseases), GPS and compass use, and record keeping are also included in field training to ensure that the guidelines in the QAPP are being followed. All individuals involved in conducting the surveys have taken and passed each of the following tests on 1) amphibian calls, 2) bird vocalization, and 3) bird visual identification that are based on an on-line system established at the University of Wisconsin, Green Bay, prior to conducting surveys – see http://www.birdercertification.org/GreatLakesCoastal. All individuals who participated in sampling in 2014 passed the required tests prior to sampling. Individuals planning to conduct surveys in 2015 for either birds or amphibians must have taken and passed the necessary test(s) by the following dates: 1) Friday, 20 March 2015 for amphibian surveys, and 2) Friday, 15 May 2015 for bird surveys. Field observers who have become certified in previous years are not required to become certified again in future years.

All new and returning field observers will review the QAPP and SOPs and complete the online certification requirements (see above) prior to conducting field surveys. The supervising PI will conduct mid-season checks by visiting survey locations and verifying that proper protocol is being implemented.

Fish, Macroinvertebrates, Vegetation, and Water Quality:
Fish, macroinvertebrate, vegetation, and water quality sampling training will be held in Duluth, Minnesota, and Superior, Wisconsin, in mid-June 2015 and will continue in Green Bay, Wisconsin at the end of June/early July. All but one of our fish/invertebrate/water quality crew members is returning from last year, so we expect a very efficient training and sampling season. The vegetation crew will also include some returning crew members. All field technicians will be trained in and tested on all standard procedures, including a field-based fish or vegetation identification exam (depending on the crew). Training includes how to determine if a site meets project criteria, all aspects of sampling the site, proper recording of data on datasheets, GPS use and uploading, water quality sample collection and meter calibration (fish/invert crew only), as well as sample processing. Much of the training takes place in the field at a typical coastal site to ensure field members learn (or review) appropriate techniques. Safety training covered aspects of field safety including safe boating; protection against the elements, animals,

insects, and plants; and what to do when things go wrong. A CPR/AED and first aid review class will also be offered to fish/invert crew members.

We have renewed our University of Minnesota Institutional Animal Care and Use Committee permit for fish sampling. We are in the process of obtaining all appropriate sampling permits from the various state agencies and property owners.

Site selection

Birds and Amphibians:
In 2015, a total of 61 sites have been selected to be surveyed by the western regional team for birds and amphibians. Of these sites, 4 sites have been sampled in a previous year and are being revisited, 43 are new sites, and 14 are benchmark sites selected because they are of particular interest for restoration potential. Many of the benchmark sites are located in the St. Louis River Estuary and are in some stage of planning for restoration work. Restoration activities for the sites are being coordinated by the Minnesota Pollution Control Agency and the US Fish and Wildlife Service, with many collaborators from multiple agencies and university research groups.

All of the 61 sites selected in 2015 were reviewed to assure that they meet the sampling requirements (e.g., lake connectivity and size requirements (>4 ha)) and were deemed safe and accessible to field crews. Based on this review, 12 sites have been rejected prior to being visited (web reject) for one of the following reasons: 1) inaccessible or unsafe to access, 2) no trespassing signs and owners could not be contacted, or 3) wetland areas were unsuitable for sampling (e.g., wetland lacked connectivity to the lake). Reconnaissance of each of the remaining wetlands is scheduled for April 2015 and will be completed prior to beginning the first round of amphibian surveys, which will begin as soon as minimum nighttime temperature requirements have been reached.

The 49 sites that will be visited and potentially sampled by bird and amphibian field crews stretch from the Duluth-Superior harbor area both northeast along the shore of Lake Superior past Thunder Bay and eastward along the south shore of Lake Superior to the eastern end of the Upper Peninsula of Michigan and into Northeast Lake Huron. In 2015, several island sites are also scheduled to be sampled, including 2 sites on Sugar Island in Lake Michigan and 5 sites in the St. Louis River Estuary, Lake Superior.

Fish, Macroinvertebrates, Vegetation and Water Quality:
Site selection for fish/macroinvertebrate and vegetation crews was 60 sites. Of these, 10 were over the crew capacity limit, 2 were traded to the Central Basin Team because the sites are closer to their area, another 7 are benchmark sites specific to bird/amphibian crews, and 12 sites were picked up from the Central Basin Team because they are over capacity with their site

allocation (even more than the Western Basin Team). Crews will be assessing and sampling approximately 35 sites, of which 13 are benchmark sites and 2 are revisit sites.

Field sampling plans

Birds and Amphibians:
Each of the 49 potential sites will be visited a total of four times between 01 May and 15 July. Amphibians will be sampled three times during this period and birds will be surveyed twice, once in the morning and once in the evening.

Fish, Macroinvertebrates, and Vegetation:
NRRI crews will be sampling sites between the end of June and the end of August, starting in Green Bay and moving north and west following phenology.

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

Sample Processing and Data Entry (2014)

Central Michigan University:
All field survey and fish collection data from the 2014 season has been uploaded to the central database and has been verified by a second person. 100% of the aquatic macroinvertebrate identification and the QA/QC process has been completed for all 2014 samples. All incorrectly identified macroinvertebrate taxa discovered through the QA/QC process have been updated on the database and on their respective datasheets. All data collected through the 2014 sample season has been entered onto the database and data entry has been verified by a second person. Water quality analysis is 99% done with one outstanding ammonium sample yet to be processed. This data has also been entered and put through QA/QC procedures.

Lake Superior State University:
Data for all parameters, except the one outstanding nutrient sample, were entered and 100% of the entered data have been checked following the QA/QC procedures. Our macroinvertebrate taxonomist reviewed all 2013 specimens that were potentially misidentified and corrections were made to the datasheets and the database. In March, summer technician hiring was initiated. Announcements were posted and interviews were conducted, and three technicians were hired. Two of them had assisted for two weeks on the project last year, so they are familiar with sampling protocols, but the entire crew will receive training in the early summer to ensure their competency in all parts of the project. Reporting to the MDNR for the scientific collector's permit was completed in March and we are awaiting the collector's permit for 2015 sampling. A collector's permit will need to be filed with the Ontario Ministry of Natural Resources for the two Ontario sites that are scheduled for sampling in 2015.

Grand Valley State University:
All field data (i.e., fish, invertebrates, and water quality) were entered and checked for quality control. Aquatic invertebrate identification of the samples collected during the 2014 field season was completed in February 2014 (and that data was entered and checked for quality control). We completed the aquatic invertebrate sample QA/QC procedure with Central Michigan University.

University of Notre Dame:
Because two lead field crew members relocated to Central Michigan University in August 2014, much of the work originally assigned to Notre Dame was done at CMU. Water and invertebrate samples collected by the UND crew in 2014 were transferred to Central Michigan University and were processed during the fall and winter and data have been uploaded. Chlorophyll *a* samples collected by the UND, LSSU, GVSU, CMU, and U. Windsor crews will continue to be processed at Notre Dame for the remainder of the project. Chlorophyll *a* samples collected in 2014 were analyzed and resulting data were distributed to the labs that collected the samples. Required QA/QC procedures were followed for chlorophyll analyses and were reviewed by the QA managers. A renewal of the 2014 MDNR scientific collector's permit has been requested and is currently pending. The IACUC protocol under which the field sampling will be conducted is valid through May 2017. The UND crew will receive necessary training prior to field sampling. All field equipment will be evaluated and repaired or replaced in May.

Oregon State University:
All 2014 data have been entered (52 sites) and quality controlled in the electronic database along with their corresponding GPS points. Floristic quality indices were calculated for all sites. Data from the 9 benchmark sites was shared with 4 organizations involved in restoration projects, Loyola University Chicago, DePaul University Chicago, Dartmouth College (New Hampshire), and the Sault Ste. Marie Tribe. A report was provided to the Isle Royale National Park on the results of the summer 2014 field sampling. A review of the sites sampled in 2014 and the photo interpretation of the 2015 sampling sites to facilitate rapid deployment of field teams during summer has been underway. Locations of approximate location of sampling transects on aerial photos will be followed by in-field location of random transect starting points. Hiring of summer crews has begun, along with acquisition of equipment and reservation of field vehicles. Organizing data for publication on plant metrics with other plant sampling teams has also been in progress.

2015 Field Season Preparations

Site Selection

A total of 54 sites were selected for the central basin regional team. Of those sites, 13 are designated as benchmark sites and 5 are sites that will be revisited. For fish, invertebrates and water quality, CMU and Notre Dame will sample up to 33 sites, GVSU will sample up to 10 sites, LSSU will sample up to 11 sites. With the continued increase Lake Huron and Michigan water levels, we expect a minimal number of sites to be rejected due to lack of inundation (fish and invertebrate sampling).

Central Michigan University:
CMU submitted their annual scientific collector's permit report for 2014 to the MDNR in early January and is expecting to receive their 2015 permit by the end of April. CMU is preparing for the 2015 field season by ensuring all gear has received maintenance, and any needed repairs are made. Supplies are being re-ordered and stocked, and field technicians are being evaluated for hiring. CMU potentially has three returning crew members including two field crew leaders who have been with the project for multiple years. Additional hiring of technical staff will occur through late April.

CMU Amphibian and Birds:
Site selection for 2015 currently includes 47 wetland sites to sample for amphibians and birds. These sites are located in Michigan and Ohio on the borders of Lakes Erie, Huron, and Michigan. Six technicians have been hired (i.e., 3 crews) to complete surveys. Training for amphibian surveys was completed at CMU on 15 March 2015. Crew members have been tested and certified for identification of frog and toad calls and proper field procedures. Amphibian surveys will likely begin by 6 April 2015, dependent on temperature. Training for bird surveys, procedures, and certification of bird identification will occur in April 2015 prior to sampling.

Data usage/side projects

Central Michigan University:
CMU is in the process of finalizing a disturbance gradient that is similar to a published gradient by Uzarski *et al.* 2005. The new gradient will incorporate 1 km, 20 km, and watershed (for riverine sites only), land use/land cover buffers, along with 11 abiotic factors collected at each wetland site. We will be testing biological metrics with these gradients. Each vegetation zone type has an individual disturbance gradient associated with it that encompasses the entire basin. Disturbance gradients only encompass a single year's worth of data for the purpose of metric validation and removal of temporal variation of wetland conditions between years. Other research efforts include the investigation of hydrologic gradients within coastal wetlands and a manuscript describing this work is in preparation. This will provide valuable insight on the importance of the measurement of on-site chemical and physical variables due to the variation of conditions within wetland habitats. As water levels continue to rebound, we are also using the increased rate of wet meadow and *Phragmites* sampling to investigate how invasive macrophytes change habitat conditions and macroinvertebrate communities in these areas.

Grand Valley State University:

GVSU (Ruetz and collaborators) has continued to collaborate with Dumke at NRRI on a project regarding the identification of black and brown bullheads. GVSU had previously conducted genetic barcoding (based on mitochondrial DNA) to identify bullheads collected by the NRRI crew. Over past year we completed an analysis of microsatellites (i.e., nuclear DNA) to reconcile discrepancies in the identification of brown and black bullheads based on genetic barcoding and morphometric characteristics. The original graduate student on the project (Wesolek) has graduated, so a new graduate student (Chorak) has completed the analysis of the microsatellite data. Dr. Ryan Thum (a molecular ecologist formerly at GVSU and now at Montana State University) assisted with overseeing the laboratory work and interpretation of genetic data at no cost to the project. Chorak presented a poster on this work at the Michigan Chapter of the American Fisheries Society. Dumke (NRRI) also gave a presentation on this work, and we provided him input on his presentation. We are currently working on a manuscript to summarize the results of this work. Ruetz updated the group on this work at the January planning meeting in Midland. Ruetz also provided Cooper (CMU) with comments on the fish IBI manuscript.

Oregon State University:
Dennis Albert is working with Nick Danz, Joe Gathman, and Doug Wilcox on a presentation for the Joint Aquatic Science Conference, as well as manuscript. Dennis Albert is submitting a USFWS Joint Venture proposal to utilize the GLRI plant database in combination with historic and rare species data to foster restoration of Saginaw Bay wetlands through invasive plant harvest. Harvest sites will be monitored for native plant and rare species response. Anaerobic digestion and pelletizing of invasive plants for conversion to biofuel will be investigated, as well as pilot restoration of three-square bulrush (*Schoenoplectus pungans*, formerly *Scirpus americanus*).

University of Notre Dame:
A project recently jointly funded by Illinois-Indiana Sea Grant College Program and Wisconsin Sea Grant College Program will take advantage of data collected from a specific array of coastal wetlands in Lake Michigan (Green Bay, southern Lake Michigan, and the east shore of Lake Michigan). This new project focuses on sport fish use of coastal wetlands and nearshore areas, and GLIC-CWM enables a broader array of measurements to be used to interpret ontogenetic habitat shifts of these fishes and food web connections.

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

Sample Processing, Data Entry, and Quality Control Checks

The College at Brockport has a new aquatic macroinvertebrate lead, Dr. Ely Kosnicki, who replaces Gary Neuderfer. The Brockport macroinvertebrate lab has completed 100% of all macroinvertebrate identification from 2014 sampling. Graduate students and undergraduate technicians, overseen by Dr. Douglas Wilcox and Mr. Brad Mudrzynski, have both entered and performed quality control checks on all data generated from the 2014 sampling season, including all bird, amphibian, fish, water quality, aquatic macroinvertebrate, and vegetation data.

Important 2014 Findings

The plant, fish, and bird summaries shown below give a coarse snapshot of wetland biotic trends within the area that The College at Brockport sampled, primarily on the US shore of Lake Ontario. Only one plant species of conservation, beck's water-marigold (*Bidens beckii*), was found during sampling and was present in 20.0% of the sites sampled (Table 14). However, invasive plants were very common throughout Lake Ontario. Narrow-leaf cattail (*Typha angustifolia*), hybrid cattail (*Typha x glauca*), common frogbit (*Hydrocharis morsus-ranae*), and Eurasian water-milfoil (*Myriophyllum spicatum*) were all found in at least 75% of the sites that The College at Brockport sampled in 2014 (Table 15). Common reed (*Phragmites australis*), an invasive that has become very common in the upper great lakes, was found in only 10% of the sites sampled by The College at Brockport, with half of those sites being in Lake Erie. Despite its low frequency of occurrence in Lake Ontario, it was found in monocultures where it was able to establish.

Table 14: Plant species of conservation need encountered The College at Brockport during 2014 sampling. All individuals were found on Lake Ontario.

Species	Common Name	Percent of Sites Present	Status (NY)
Beck's water-marigold	*Bidens beckii*	20.0	Threatened

Table 15: Invasive plant species encountered by The College at Brockport during 2014 sampling.

Species	Scientific Name	Percent of Sites Present
Narrow-Leaf Cattail	*Typha angustifolia*	95.0
Hybrid Cattail	*Typha x glauca*	95.0
Common Frogbit	*Hydrocharis morsus-ranae*	90.0
Eurasian Watermilfoil	*Myriophyllum spicatum*	75.0

Curly-Leaf Pondweed	*Potamogeton crispus*	65.0
Reed Canary Grass	*Phalaris arundinacea*	52.6
Purple Loosestrife	*Lythrum salicaria*	45.0
Bittersweet Nightshade	*Solanum dulcamara*	45.0
Field Thistle	*Cirsium arvense*	20.0
Common Reed	*Phragmites australis*	10.0
Flowering Rush	*Butomus umbellatus*	5.0
Morrow's Honeysuckle	*Lonicera x bella*	5.0
Moneywort	*Lysimachia nummularia*	5.0
Water Chestnut	*Trapa natas*	5.0

No fish species of conservation need were captured in 2014 by The College at Brockport crews; however, a few introduced species were detected. Round goby (*Negobius melanostomus*) was the most prevalent introduced species found by The College at Brockport crews in Lake Ontario, yet was detected at less than 30% of the sites with a total of 15 individuals caught (Table 16). Common carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) were the other two introduced species detected, both of which occurred at 17.6% of the sites sampled and had 3 individuals captured per species.

Table 16: Introduced and invasive fish species encountered by The College at Brockport during 2014 sampling.

Species	**Scientific Name**	**Percent of Sites**	**Total Caught**
Round Goby	*Negobius melanostomus*	29.4	15
Common Carp	*Cypinus carpio*	17.6	3
Goldfish	*Carassius auratus*	17.6	3

Seven bird species of interest were detected by The College at Brockport surveyors in 2014. Only one of these, Mute Swan (*Cyngus olor*), was considered an invasive species and was detected at 14.3% of the sites sampled (Table 17). Most of its six detections came within the Rochester embayment on the south shore of Lake Ontario. The remaining species of interest were either New York State listed threatened or special concern species. Least Bittern (*Ixobrychus exilis*), American Bittern (*Botaurus lentiginosus*), and Osprey (*Pandion haliaetus*) were the most prevalent threatened or special concern species and were all found in at least 9.5% of the sites sampled. The remaining threatened or special concern species, Bald Eagle (*Haliaeetus leucocephalus*), Common Nighthawk (*Chordeiles immer*), and Pied-billed Grebe (*Podilymbus podiceps*), were found in less than 5.0% of the sites sampled by The College at Brockport crews. No endangered, threatened, special concern, or invasive amphibian species were detected in 2014 by The College at Brockport.

Table 17: Bird species of conservation interest, either due to threatened, special concern, or invasive status, encountered by The College at Brockport during 2014 sampling.

Species	Scientific Name	Percent of Sites Present	Number Observed	Status
Least Bittern	*Ixobrychus exilis*	14.3	8	Threatened
Mute Swan	*Cygnus olor*	14.3	6	Invasive
American Bittern	*Botaurus lentiginosus*	9.5	8	Special Concern
Osprey	*Pandion haliaetus*	9.5	4	Special Concern
Bald Eagle	*Haliaeetus leucocephalus*	4.8	2	Threatened
Common Nighthawk	*Chordeiles immer*	4.8	2	Special Concern
Pied-billed Grebe	*Podilymbus podiceps*	4.8	4	Threatened

2014 Benchmarks and Data Sharing

The College at Brockport continued to sample many sites within the Rochester embayment as benchmarks to aid in numerous restoration projects. Buck Pond and Buttonwood Creek were sampled to provide data for an ongoing Ducks Unlimited restoration project that aims to reduce the impacts of invasive cattail, provide spawning and nursery areas for northern pike (*Esox lucius*), and habitat for waterfowl. Braddock Bay was also sampled as a benchmark in 2014 to provide more pre-restoration data for the upcoming US Army Corps of Engineers restoration project that will reduce wave attack, wetland loss, and turbidity by re-creating the lost barrier beach and reduce cattail to provide spawning and nursery areas for northern pike and potential habitat for black terns. Finally, The College at Brockport worked with various rapid-response, invasive species removal crews by providing them with new sightings of infestations. The most notable of these was water chestnut (*Trapa natans*), which was detected in one site with standard vegetation surveys and was observed in at least six other wetlands by sampling crews.

2015 Site List and Crew Assignments

The College at Brockport is finalizing its 2015 site list, with the greatest focus on gearing up bird and amphibian survey crews since they will be the first in the field. Five sites have received benchmark designation to collect pre- and post-restoration data for various Ducks Unlimited, US Army Corps of Engineers, and US Fish and Wildlife Service GLRI-funded restoration projects. The College at Brockport personnel are currently filling out access permits for sites that are on New York State Department of Environmental Conservation and New York States Parks Recreation and Historic Preservation property. Bird and amphibian training has begun and crew-members have passed amphibian certification exams; however, they have not attempted the bird identification exams yet. Finally, crew members are starting equipment and inventory checks to prepare for the summer fish, aquatic macroinvertebrate, water quality, and vegetation sampling.

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

Sample Processing and Data Entry (2014)

All field data collected during the 2014 field season have been uploaded and QA'd. All fish, macroinvertebrate, macrophyte and water quality data were compiled and entered into the database and quality assured over the winter. Specimens received from companion labs (part of the reciprocal exchange of macroinvertebrate specimens to ensure consistency of identification) have been identified and returned to the sample owners.

Sampling for fishes in Canada requires approval by the University of Windsor's Animal Use and Care Committee as well as permits for Scientific Collection of Aquatic Species (Ontario Ministry of Natural Resources), compliance with the Province of Ontario's Environmental Protection Act (Ontario Ministry of Natural Resources), and Species At Risk (Fisheries & Oceans Canada), and Wild Animal Collection (Ohio Department of Natural Resources). Permit renewal applications are in progress to ensure approval by the start of the sampling season. Preliminary reports to the permit granting agencies for 2014 collections were submitted and approved in late fall. Detailed records of fishes caught were sent to local conservation and refuge managerial groups in Ontario and Ohio where appropriate. A final, detailed report on fish species at risk is being prepared for submission

Field Training

Many of the individuals who will participate in fieldwork in 2015 were involved in sampling during the 2014 field season. The Tozer amphibian and bird team will have one new recruit (trained and tested at Port Rowan, ON in early March 2015 as described in earlier spring semiannual reports). Five people will be collecting data for the project in 2015. Amphibian surveys are beginning late again this year because of the especially cold winter (currently in progress) and bird surveys will begin shortly. Cold spring weather has likely delayed the arrival and onset of bird breeding activity.

Field crew members working with fishes, macroinvertebrates, and water quality sampling will receive orientation during the last week of April 2015 and will conduct pilot sampling at a local site (Turkey Creek, ON) during late May. All members of the 6-person Windsor field crew from 2014 will be involved to some extent in field work in 2015. They will train 3 new senior undergraduate students who will assist during selected field trips. The Canadian Wildlife Service will have 8 personnel to conduct work on Lake Ontario in 2015, four of whom will be new recruits (receiving training in April). Training review will include GPS use, determination of whether sites meet project criteria (open water connection to lake, presence of a wetland, safe access for crew), identification of vegetation zones to be sampled, collection of water quality samples (including preprocessing for shipment to water quality labs), and calibrating and reading field instruments and meters. Other training will include refresher instructions in setting, removing, cleaning and transporting fyke nets, and special emphasis on collection of voucher information (proper photographic procedures, collection of fin clips for DNA analysis, or retention of specimens for lab verification of identity), protocols for collecting and preserving macroinvertebrates using D-frame dip nets, and field-picking. Crews will review field data sheet entry procedures. All field personnel will be required to again pass fish identification tests.

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

New sites for 2015 have been assessed by remote examination. Preliminary assessments of site accessibility and suitability for sampling by the other teams are also complete.

Related Research in Progress

In 2014 zoobenthic data from Lake Huron wetlands were analyzed by honors undergraduate thesis students Celine Lajoie and Jessica Owen.

Owen contrasted zoobenthic assemblages from sites designated as being at risk of degradation vs. those thought to be non-degraded according to Titan thresholds of watershed-based development and agriculture identified by Kovalenko *et al.* (2013). These stress measures serve as proxies of the anticipated effects of climate change (warming temperatures, increased hydrographic flashiness and greater nutrient transport). Taxa whose relative abundances are expected to increase under climate warming include hemipterans (Corixidae, Notonectidae), oligochaetes, and chironomids. Relative abundances of amphipods, dragonflies and baetid mayflies are expected to decline. Such changes may ultimately result in altered productivity by predators that depend on these fauna (insectivorous fishes and benthivorous waterfowl).

Lajoie determined whether the effects of watershed-based anthropogenic stress on invertebrate predators varies with wetland hydrogeomorphology in Lake Huron coastal wetlands. She compared the stress-response relationships of various predator-related metrics for coastal, riverine and barrier-protected wetlands. She found no relationship between anthropogenic stress and predator species richness, relative abundance, diversity, or evenness for lacustrine coastal wetlands. Non-significant negative relationships between these predator measures and anthropogenic stress were observed for riverine and barrier protected wetlands, suggesting that the dominant source of water may influence zoobenthic community measures. However, larger sample sizes are needed to properly evaluate these hypotheses.

Fish data were analyzed by M.Sc. student Jeffrey Buckley to compare the consistency of classification of wetland condition using analytical metrics derived by several different investigators. Buckley compared the wetland IBI of Cooper *et al.* with the fish quality indices of Seilheimer *et al*., and a new multivariate index based on the reference-degraded continuum approach. The Cooper *et al*. and Seilheimer *et al*. indices both exhibited high degrees of sensitivity and specificity to degradation by anthropogenic stress.

M.Sc. students Buckley and Jasmine St Pierre gave presentations at the 2014 IAGLR conference and are scheduled to present again in 2015.

Examples of Leveraged Project Benefits

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

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

- Greg Mayne (Environment Canada, Canadian Cochair, Lake Huron Binational Partnership), Scott Parker (Parks Canada, Fathom Five National Park), and Geoff Peach (Lake Huron Center for Coastal Conservation) We provided summaries of coastal wetland condition on the Bruce Peninsula and other Lake Huron locations. We will continue to work with these individuals in summarizing wetland condition in anticipation of preparing a report for the Lake Huron Binational Partnership on the current status of Lake Huron and research needs leading to the 2016 Intensive Study Year for Lake Huron.

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

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

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

ASSESSMENT AND OVERSIGHT

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

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

2) Addition of a new wetland flora for use in Great Lakes coastal wetlands. The new flora, *The Field Manual of Michigan Flora* (Voss and Reznicek 2012) from the University of Michigan Press, incorporates the most recent taxonomic treatments of the Flora of North America and contains all wetland plants found throughout the region. All taxonomic changes in the new flora were reviewed by project plant experts over the previous field season and appropriate cross-walks were formulated to ensure data consistency among project years.

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

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

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

All project co-PIs reviewed the QAPP_r4 prior to our January project meeting and the following changes were made:

Personnel changes:

- Dr. Brent Murray, formerly a post-doc at Central Michigan University, took a faculty position outside the region and is no longer part of this project.
- Matt Cooper, formerly of University of Notre Dame, received his Ph.D. and was hired by Central Michigan University; his roles and responsibilities on the project remain unchanged.
- Dr. Gary Neuderfer retired from SUNY-Brockport and his position has been filled by Dr. Ely Kosnicki, who has assumed Dr. Neuderfer's roles and responsibilities on this project.
- Anne Hokanson (MDEQ) changed her name to Anne Garwood.
- Dr. John Schneider retired from USEPA GLNPO and his project officer duties have been assumed by Dr. Thomas K. O'Donnell.

Vegetation sampling (pages 41-42): A paragraph has been added giving crews an easier, safer option for sampling very wide *Phragmites* zones. This additional option reads,

> "In many coastal wetlands along the southern Great Lakes, invasive *Phragmites australis* has formed a dense monoculture more than 200 m wide. With increased water levels in Lakes Huron and Michigan in 2014 and 2015 [projected], sampling across this entire zone has greatly increased crew effort, reduced efficiency, and increased the likelihood of crew injury. To mitigate these issues without reducing data quality, sampling will be conducted as needed within this zone at 5, 10, 15, 20, and 25 m from the *Phragmites* bed edge (either shoreward or lakeward edge, depending on accessibility), rather than spacing sampling points across the entire width of the zone. The actual width of the zone will be calculated from the most recent year's Google photos. Correlations between Google image interpretation and field surveys are high, and difficulty maintaining a straight transect line in *Phragmites* typically results in reduced accuracy from the field transects. Prior experience and data analysis show virtually no variability in vegetation composition within the *Phragmites* zone, indicating that there will be minimal loss of information by spatially restricting *Phragmites* sampling. When this modified protocol is used, it will be referenced in the comment box and recorded in the database. The direction of entry into the *Phragmites* beds, either from the upland shoreline or from the water, will also be noted."

Bird Surveys (page 69): The minimum number of days between site visits is changed to match the protocol in the SOP, from 10 days to 15 days, as highlighted in the excerpted paragraph below (note that the SOP and what crews were doing was always 15 days),

> "Point count surveys will be conducted either from one-half hr before sunrise to four hr after sunrise or 4 hr before sunset. The number of birds seen or heard will be recorded during 15-minute observation periods (5 minutes of passive observation, 5 minutes of

broadcast calling, 5 minutes of passive observation) at each point count station (GLCWC 2008). Wetlands will be surveyed twice per breeding season, with a minimum of 15 days between visits, unless unforeseen circumstances prohibit return visits. One count will be in the morning and one count in the evening. In addition to the above sampling, we will conduct additional sampling over an extended point count duration with digital audio recorders at approximately 50 wetlands over the course of the study (5 yr) to potentially improve the monitoring protocols. Issues investigated will include number of samples within a wetland, number of visits to a wetland, detectability of birds, utility of audio playbacks, and distance detection."

The revised QAPP_r5 was signed by all co-PIs on January 23, 2015 and was signed by US EPA on March 25, 2015.

Major QA/QC elements that were carried out over the previous 6 months include:

- Training of all new laboratory staff responsible for macroinvertebrate sample processing: This training was conducted by experienced technicians at each regional lab and was overseen by the respective co-PI or resident macroinvertebrate expert. Those labs without such an expert sent their new staff to the closest collaborating lab for training. Several members of the Central Basin Team met at Central Michigan University to discuss and come to consensus on invertebrate taxonomy that were particularly challenging for laboratory staff. This meeting has become an annual occurrence and helps to ensure accurate and consistent taxonomy among labs.

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

- QC checks for all data entered into the data management system (DMS): Every data point that is entered into the DMS is being checked to verify consistency between the primary record (e.g., field data sheet) and the database. This has been completed for nearly all data that has been entered into the database over the past six months and is a requirement before data are analyzed or used to calculate IBI metrics. Data that still require QC have been identified and regional labs were notified and are currently finishing these checks.

- Macroinvertebrate QC checks: Each regional lab that is processing macroinvertebrate samples has 'blindly' traded samples with the next closest regional lab. Swaps were made between labs that sampled wetlands at a similar latitude to ensure familiarity with the taxa being evaluated. Labs sent two previously processed samples with relatively high taxa diversity to their assigned QC lab, and then sent the corresponding IDs and counts to the QA managers. Each sample was contained in a single vial that was identified with a unique code that precluded the receiving lab from determining the site or vegetation zone that the sample originated from. The receiving lab then processes the sample as usual and sends the IDs and counts to the QA managers. The QA managers then compare the original IDs with the QC IDs to determine correspondence between the two labs. Inconsistencies in taxa IDs are resolved by a 3rd or 4th lab when necessary or by additional taxonomic experts, depending on the nature of the discrepancy. At present, most labs have made the required swaps for 2014 samples and many have completed the required processing. After QA managers compare original and QC taxa IDs and counts, and resolve discrepancies, they will communicate results and necessary corrections to the various labs. In the past two years, the QC swaps have identified very few inconsistencies among regional labs and all inconsistencies have been addressed.

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

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

- Data Quality Objectives (DQO) for laboratory analyses: Participating water quality laboratories have generated estimates of precision, bias, accuracy, representativeness, completeness, comparability, and sensitivity for all water quality analyses. These metrics were calculated over the past six months and will be archived by each regional laboratory.

- Database audit: QA managers Brady and Cooper have begun an audit of all water quality data from 2014. This audit picks up where the previous audit left off. The previous audit noted QC flags were related to 1) the use of incorrect units (345 occurrences; 77% of total), 2) incorrect calculations for total alkalinity (78; 17%), 3) questionable pH readings (21; 5%), and 4) values entered in the wrong location (6; 1%). Each of these QC flags was brought to the attention of the PI at respective regional laboratory. Nearly every one of these errors was either easily corrected in the database (e.g., change units, recalculate alkalinity values, move data to correct location), or was confirmed as accurate (pH readings). We anticipate considerably fewer QC flags for 2014 data and will pursue corrective actions where necessary.

- Nutrient detection limits: QA managers discovered that some regional labs have been entering data that are below the analytical detection limits established in the QAPP. These higher-precision data reflect the heightened capabilities of some regional labs. Having data from multiple labs with differing detection limits can present problems when analyzing nutrient data that is near detection limit. Therefore, we developed a standard way for labs to enter their data at the precision of their lab's instrumentation and have the data management system archive and deliver both these higher-precision data and data at the standard detection limit. In other words, observations falling below the detection limits listed in the QAPP will be "brought up" to the standard level while the original data will still be available for those interested in using it.

- Bird and amphibian crews begin their field season in mid-April. All training and certification of crew members has been completed or will be completed soon, prior to crew members working independently. Records of this training and certification are being compiled and archived at each respective regional lab and with the QA managers.

Example Water Quality QC Information

Laboratory Quality Assurances:
Water quality analyses from 2014 have been partially completed by the NRRI Central Analytical Laboratory, Central Michigan University's Wetland Ecology Laboratory, Grand Valley State University's Annis Water Resources Institute, and Environment Canada's National Laboratory for Environmental Testing. Laboratory results from 2014 have passed (or will pass) the criteria shown below (Table 18).

Table 18. Data acceptance criteria for water quality analyses.

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

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

Variability in Field Replicates:

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

The same can occur with analyte lab duplicates, and in these instances the QA officer will determine whether data are acceptable. It is also important to note that RPD on field duplicates incorporates environmental (e.g., spatial) variability, since duplicate samples are collected from adjacent locations, as well as analytical variability (e.g., instrument drift). Therefore, RPD of field duplicates is generally higher than RPD of laboratory duplicates. Table 19 below lists average RPD values for each year of the project (2011-2014). Higher than expected average RPD values were associated with a preponderance of near detection limit values for ammonium, nitrate, and soluble reactive phosphorus (SRP), and high spatial variability for chlorophyll and turbidity. Other variables, such as alkalinity and chloride, had values that were well above detection limit and low spatial variability; therefore, these values had much lower average RPD. Acceptance of data associated with higher than expected RPD was determined by the QA officers. As the full set of water quality data become available, the 2014 RPD table will be expanded as in the spring 2014 report.

Table 19. Assessment of field duplicate sample variability in relative percent difference (RPD) for water quality parameters. Each value represents a mean for all RPDs calculated for the given year. Results from 2011-2013 are shown, with the number of duplicate pairs in parentheses.

		Mean Relative Percent Difference (n)			
	Max expected	2011	2012	2013	2014
Alkalinity	10%	4.1% (12)	8.9% (11)	3.6% (13)	6.8% (15)
Ammonium	10%	54.8% (14)	21.9% (13)	58.5% (11)	50.6% (7)
Chloride	20%	1.9% (12)	6.6% (10)	8.9% (12)	13.2% (9)
Chlorophyll	30%	36.8% (10)	31.0% (11)	39.8% (8)	45.1% (4)
Color	10%	11.7% (14)	5.1% (11)	6.9% (13)	10.3% (9)
Nitrate	10%	23.8% (12)	23.3% (11)	10.2% (5)	6.8% (7)
SRP	10%	19.3% (9)	21.8% (9)	13.6% (7)	47.4% (7)
Total N	30%	10.3% (13)	9.9% (13)	7.4% (12)	7.3% (3)

Total P	30%	19.6% (13)	26.7% (13)	29.0% (12)	45.5% (5)
T-tube	NA	12.9% (7)	7.9% (6)	17.9% (8)	9.1% (15)
Turbidity	10%	26.6% (9)	22.7% (6)	23.2% (5)	10.0% (5)

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

Communication among Personnel

Regional team leaders and co-PIs continue to maintain close communication as the project enters the fifth year. The lead PI, all co-PIs, and many technicians attended an organizational meeting in Midland, Michigan on January 23rd, 2015. During this meeting, the group discussed issues pertaining to IBI development and also allocated ideas for manuscript topics to all interested PIs. Ruetz coordinated efforts for the collection of fish tissue for the bullhead DNA study. The group also discussed issues regarding the development of a "new" disturbance gradient with all PI's using both land use/land cover data as well as abiotic variables collected in the field. Conclusions from the sampling of benchmark sites over the past five years was also a conversation topic with ideas being shared about what conclusions could be made from these data. Dr. Kevin O'Donnell (EPA) also discussed future coastal wetland restoration projects and how our group could contribute by monitoring the success of these efforts.

The current version of the QAPP and SOPs (Revision 5) updates personnel changes in the last several years and provides an alternate vegetation sampling protocol for wide, dense *Phragmites* stands. It has been signed by all personnel and the EPA.

Regional team leaders and co-PIs have held conference calls and e-mail discussions regarding site selection and field work preparation throughout the duration of the project. Most PIs spend the first week of field season in the field with their crew to ensure that all protocols are being followed according to the standards set forth in the QAPP and SOPs and to certify or re-certify crew members. Most crews have many returning and experienced personal, which will make training and sampling efficient in 2015. PIs keep in close contact with crews via cell phone, text, and email, and the leadership team is also always available via cell phone and text to answer the most difficult crew questions.

Overall

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

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

LEVERAGED BENEFITS OF PROJECT

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

Spin-off Projects (cumulative since project inception)

Conservation Assessment for Amphibians and Birds of the Great Lakes:
To examine the role of Great Lakes wetlands in the conservation of birds in North America, an effort has been initiated to assess the importance of these coastal wetlands as migratory or breeding grounds. A similar effort will also be initiated for amphibians, because many of the amphibians (and birds) living in these coastal wetlands have been identified as endangered (e.g. Northern Cricket Frog), threatened, or of special concern (e.g., Sedge Wren, Northern Leopard Frog) in multiple states.

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

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

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

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

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

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

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

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

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

Support for Un-affiliated Projects

CWM PIs and data managers continue to provide data and support to other research projects around the Great Lakes even though CWM PIs are not collaborators on these projects. Dr. Laura Bourgeau-Chavez at Michigan Tech University is working on a project to map the spatial extent of Great Lakes coastal wetlands using GIS and satellite information to help in tracking wetland gains and losses over time (Implementation of the Great Lakes Coastal Wetlands Consortium Mapping Protocol, funded by GLRI). We have provided her with vegetation data and sampling locations each year to assist with this effort. Dr. Bourgeau-Chavez was also just given funding to assess herbicide effectiveness against *Phragmites* in Green Bay and Saginaw Bay. CWM data are being used to find the best locations, provide baseline data, and provide pointers on site access (from field crew notes) in support of this project.

Reports on new locations of non-native and invasive species

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

Requests for Assistance Collecting Monitoring Data

Project PIs provided monitoring data and interpretation of data for many wetlands where restoration activities were being proposed by applicants for "Sustain Our Great Lakes" funding. This program is administered by the National Fish and Wildlife Foundation (NFWF) and includes GLRI funding. Proposal writers made data/information requests via NFWF, who communicated the requests to us. Lead PI Don Uzarski, with assistance from co-PIs, then pulled relevant project data and provided interpretations of IBI scores and water quality data. This information was then communicated to NFWF, who communicated with the applicants. This information sharing reflects the value of having coastal wetland monitoring data to inform restoration and protection decisions. We anticipate similar information sharing in the coming years as additional restoration and protection opportunities arise.

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

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

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

Other managers have also requested data to help them better manage wetland areas. For example, the Michigan Clean Water Corps requested CWM data to better understand and manage Stony Lake, Michigan. Staff of a coal-fired power plant abutting a CWM site requested our fish data to help them better understand and manage the effects of their outfalls on the resident fish community. The Michigan Natural Features Inventory is requesting our data as part of a GLRI-funded invasive species mapping project. The US Fish and Wildlife Service requested all data possible from wetlands located within the Rochester, NY, Area of Concern as they assess trends in the wetlands and compare data to designated delisting criteria. The NERR on Lake Erie (Old Woman Creek) has requested our monitoring data to add to their own. The University of Wisconsin Green Bay will use our data to monitor control of *Phragmites* in one of their wetlands, and hope to show habitat restoration. Thunder Bay National Marine Sanctuary (Lake Huron) has requested our data to facilitate protection and management of coastal resources within the Sanctuary.

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

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

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

Student Research Support

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 and the US Fish and Wildlife Service).
- Spatial variation in macroinvertebrate communities within two emergent plant zones in Great Lakes coastal wetlands (Central Michigan University; with additional funding from CMU).
- Invertebrate co-occurrence patterns in the wetlands of Northern and Eastern Lake Michigan: the interaction of the Harsh-Benign Hypothesis and community assembly rules (Central Michigan University; additional funding from CMU)
- Functional indicators of Great Lakes coastal wetland health (University of Notre Dame; additional funding by Illinois-Indiana Sea Grant).
- Evaluating environmental DNA detection alongside standard fish sampling in Great Lakes coastal wetland monitoring (University of Notre Dame; additional funding by Illinois-Indiana Sea Grant).
- Nutrient-limitation in Great Lakes coastal wetlands (University of Notre Dame; additional funding by the UND College of Science).
- A summary of snapping turtle (*Chelydra serpentina*) by-catch records in Lake Ontario coastal wetlands (with additional funding by University of Toronto).
- Evaluating a zoobenthic indicator of Great Lakes wetland condition (with additional funding from University of Windsor).
- Testing and comparing the diagnostic value of three fish community indicators of Great Lakes wetland condition (with additional funding from GLRI GLIC: GLEI II and University of Windsor).
- Quantifying Aquatic Invasion Patterns Through Space and Time: A Relational Analysis of the Laurentian Great Lakes (University of Minnesota Duluth; with additional funding and data from USEPA)

Undergraduate Research with Leveraged Funding:

- Production of a short documentary film on Great Lakes coastal wetlands (University of Notre Dame; 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 (University of Notre Dame; additional funding by the UND College of Science).

- *Phragmites australis* effects on coastal wetland nearshore fish communities of the Great Lakes basin (University of Windsor; with additional funding from GLRI GLIC: GLEI II).
- Sonar-derived estimates of macrophyte density and biomass in Great Lakes coastal wetlands (University of Windsor; with additional funding from GLRI GLIC: GLEI II).
- Effects of disturbance frequency on the structure of coastal wetland macroinvertebrate communities (Lake Superior State University; with additional funding from LSSU's Undergraduate Research Committee).
- Resistance and resilience of macroinvertebrate communities in disturbed and undisturbed coastal wetlands (Lake Superior State University; with additional funding from LSSU's Undergraduate Research Committee).

Graduate Research without Leveraged Funding:

- Impacts of drainage outlets on Great Lakes coastal wetlands (Central Michigan University).
- Effects of anthropogenic disturbance affecting coastal wetland vegetation (Central Michigan University).
- Great Lakes coastal wetland seed banks: what drives compositional change? (Central Michigan University).
- Spatial scale variation in patterns and mechanisms driving fish diversity in Great Lakes coastal wetlands (Central Michigan University).
- Building a model of macroinvertebrate functional feeding group community through zone succession: Does the River Continuum Concept apply to Great Lakes coastal wetlands? (Central Michigan University).
- Impacts of mute swan herbivory in Great Lakes coastal wetlands (Central Michigan University).
- Impacts of muskrat herbivory in Great Lakes coastal wetlands (Central Michigan University).
- Mute swan interactions with native waterfowl in Great Lakes coastal wetlands (Central Michigan University).
- Effects of turbidity regimes on fish and macroinvertebrate community structure in coastal wetlands (Lake Superior State University and Oakland University).
- Scale dependence of dispersal limitation and environmental species sorting in Great Lakes wetland invertebrate meta-communities (University of Notre Dame).
- Spatial and temporal trends in invertebrate communities of Great Lakes coastal wetlands, with emphasis on Saginaw Bay of Lake Huron (University of Notre Dame).
- Model building and a comparison of the factors influencing sedge and marsh wren populations in Great Lakes coastal wetlands (University of Minnesota Duluth).

- The effect of urbanization on the stopover ecology of Neotropical migrant songbirds on the western shore of Lake Michigan (University of Minnesota Duluth).

- Assessing the role of nutrients and watershed features in cattail invasion (*Typha angustifolia* and *Typha* x *glauca*) in Lake Ontario wetlands (The College at Brockport).

- Developing captive breeding methods for bowfin (*Amia calva*) (The College at Brockport).

- Water chestnut (*Trap natans*) growth and management in Lake Ontario coastal wetlands (The College at Brockport).

- Functional diversity and temporal variation of migratory land bird assemblages in lower Green Bay (University of Wisconsin Green Bay).

- Effects of invasive *Phragmites* on stopover habitat for migratory shorebirds in lower Green Bay, Lake Michigan (University of Wisconsin Green Bay).

- Plant species associations and assemblages for the whole Great Lakes, developed through unconstrained ordination analyses (Oregon State University).

- Genetic barcoding to identify black and brown bullheads (Grand Valley State University).

Undergraduate Research without Leveraged Funding:

- Sensitivity of fish community metrics to net set locations: a comparison between Coastal Wetland Monitoring and GLEI methods (University of Minnesota Duluth).
- Larval fish usage and assemblage composition between different wetland types (Central Michigan University).

- Determining wetland health for selected Great Lakes Coastal Wetlands and incorporating management recommendations (Central Michigan University).

- Invertebrate co-occurrence trends in the wetlands of the Upper Peninsula and Western Michigan and the role of habitat disturbance levels (Central Michigan University).

- Is macroinvertebrate richness and community composition determined by habitat complexity or variation in complexity? (University of Windsor, under the Zoobenthos - macrophyte relationships in Great Lakes coastal wetlands framework).

- Effects of habitat complexity on trophic structure of macroinvertebrate communities

(University of Windsor, under the Zoobenthos - macrophyte relationships in Great Lakes coastal wetlands framework).

Jobs Created/Retained (per year, except grad students):

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

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

Presentations about the Coastal Wetland Monitoring Project (inception through spring 2015)

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

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

Albert, Dennis, N. Danz, D. Wilcox, and J. Gathman. 2014. Evaluating Temporal Variability of Floristic Quality Indices in Laurentian Great Lakes Coastal Wetlands. Society of Wetland Scientists, Portland, OR. June.

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

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

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

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

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

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

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

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

Chorak, G.M., C.R. Ruetz III, R.A. Thum, J. Wesolek, and J. Dumke. 2015. Identification of brown and black bullheads: evaluating DNA barcoding. Poster presentation at the Annual Meeting of the Michigan Chapter of the American Fisheries Society, Bay City, Michigan. January 20-21.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Cooper, M.J., G.A. Lamberti, and D.G. Uzarski. Supporting Great Lakes coastal wetland restoration with basin-wide monitoring. Great Lakes Science in Action Symposium. Central Michigan University. April 4, 2014.

Cooper, M.J. Expanding fish-based monitoring in Great Lakes coastal wetlands. Michigan Wetlands Association Annual Meeting. Grand Rapids, MI. August 27-29, 2014.

Cooper, M.J. Structure and function of Great Lakes coastal wetlands. Public seminar of Ph.D. dissertation research. University of Notre Dame. August 6, 2014.

Cooper, M.J., D.G. Uzarski, and T.N. Brown. Developing a decision support system for protection and restoration of Great Lakes coastal wetlands. Biodiversity without Borders Conference, NatureServe. Traverse City, MI. April 27, 2015.

Cooper, M.J. and D.G. Uzarski. Great Lakes coastal wetland monitoring for protection and restoration. Lake Superior Monitoring Symposium. Michigan Technological University. March 19, 2015.

Cooper, M.J.. Where worlds collide: ecosystem structure and function at the land-water interface of the Laurentian Great Lakes. Central Michigan University Department of Biology. Public Seminar. February 5, 2015.

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

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

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

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

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

Dumke, J., C.R. Ruetz III, G.M. Chorak, R.A. Thum, and J. Wesolek. 2015. New information regarding identification of young brown and black bullheads. Oral presentation at the Annual Meeting of the Wisconsin Chapter of the American Fisheries Society, Eau Claire, Wisconsin. February 24-26.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Lemein, T., D. Albert, et al. 2014. Correlation of Physical Factors to Coastal Wetland Vegetation Community Distribution in the Laurentian Great Lakes. Society of Wetland Scientists, Portland, OR. June.

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

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

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

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

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

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

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

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

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

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

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

Trebitz, A., J. Hoffman, G. Peterson, G. Shepard, A. Frankiewicz, B. Gilbertson, V. Brady, R. Hell, H. Wellard Kelly, and K. Schmude. 2015. The faucet snail (*Bithynia tentaculata*) invades the St. Louis River Estuary. St. Louis River Estuary Summit, Superior, Wisconsin. Mar. 30 – Apr. 1.

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

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

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

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

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

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

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

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

Uzarski, D.G., Cooper, M.J., Brady, V., Sherman, J.J., and D.A. Wilcox. 2013. Use of a Basin Wide Great Lakes Coastal Wetland Monitoring Program to inform and Evaluate Protection and Restoration Efforts. 56th International Conference on Great Lakes Research, West Lafayette, IN.

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

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

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

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

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Appendix

News articles about faucet snail detection in Great Lakes coastal wetlands.

1. http://www.upnorthlive.com/news/story.aspx?id=1136758
2. http://www.wwmt.com/news/features/top-stories/stories/Snail-harmful-to-ducks-spreading-in-Great-Lakes-63666.shtml
3. http://fox17online.com/2014/12/16/gvsu-researchers-find-more-of-invasive-snail-species-in-lake-michigan/
4. http://www.ourmidland.com/news/cmu-scientists-identify-spread-of-invasive-species/article_e9dc5876-00f4-59ff-8bcd-412007e079e8.html
5. http://www.therepublic.com/view/story/4cde108b10b84af7b9d0cfcba603cf7a/MI--Invasive-Snails
6. http://media.cmich.edu/news/cmu-institute-for-great-lakes-research-scientists-identify-spread-of-invasive-species
7. http://www.veooz.com/news/qHv4acl.html
8. http://www.gvsu.edu/gvnow/index.htm?articleId=1E55A5C5-D717-BBE7-E79768C5213BB277
9. http://hosted2.ap.org/OKDUR/99dded7a373f40a5aba743ca8e3d4951/Article_2014-12-16-MI--Invasive%20Snails/id-b185b9fd71ea4fa895aee0af983d7dbd
10. http://whitehallmontague.wzzm13.com/news/environment/327493-my-town-waterfowl-killer-spreads-great-lakes-basin
11. http://www.timesunion.com/news/science/article/Snail-harmful-to-ducks-spreading-in-Great-Lakes-5959538.php
12. http://grandrapidscity.com/news/articles/gvsu-researchers-find-more-of-invasive-snail-species-in-lake-michigan
13. http://myinforms.com/en-us/a/8645879-gvsu-researchers-find-more-of-invasive-snail-species-in-lake-michigan/
14. http://usnew.net/invasive-snail-in-the-great-lakes-region.html
15. http://www.cadillacnews.com/ap_story/?story_id=298696&issue=20141216&ap_cat=2
16. http://theoryoflife.com/connect/researchers-track-invasive-9251724/
17. http://snewsi.com/id/1449258811
18. http://www.newswalk.info/muskegon-mich-new-scientists-say-742887.html
19. http://www.petoskeynews.com/sports/outdoors/snail-harmful-to-ducks-spreading-in-great-lakes/article_b94f1110-9572-5d18-a5c7-66e9394a9b24.html
20. http://www.chron.com/news/science/article/Snail-harmful-to-ducks-spreading-in-Great-Lakes-5959538.php
21. http://usa24.mobi/news/snail-harmful-to-ducks-spreading-in-great-lakes
22. http://www.wopular.com/snail-harmful-ducks-spreading-great-lakes
23. http://www.news.nom.co/snail-harmful-to-ducks-spreading-in-14203127-news/

24. http://www.mlive.com/news/muskegon/index.ssf/2014/12/hard_to_kill_invasive_faucet_s.html
25. http://wkar.org/post/researchers-eye-spread-invasive-faucet-snails
26. http://www.greenfieldreporter.com/view/story/4cde108b10b84af7b9d0cfcba603cf7a/MI--Invasive-Snails
27. http://www.natureworldnews.com/articles/11259/20141217/invasive-snails-killing-great-lake-birds.htm
28. http://www.wsbt.com/news/local/snail-harmful-to-ducks-spreading-in-great-lakes/30251286
29. http://www.wtkg.com/articles/wood-news-125494/invasive-and-deadly-snail-found-in-13073963
30. http://www.techtimes.com/articles/22378/20141218/invasive-snail-problem-in-great-lakes-difficult-to-deal-with-says-experts.htm
31. http://perfscience.com/content/214858-invasive-snails-kill-birds-great-lakes
32. http://www.hollandsentinel.com/article/20141216/NEWS/141219279
33. http://www.woodradio.com/articles/wood-news-125494/invasive-and-deadly-snail-found-in-13073963
34. http://www.full-timewhistle.com/science-27/great-lake-invasive-snails-kill-birds-265.html
35. http://www.islamabadglobe.com/invasive-deadly-snails-are-more-dangerous-than-we-thouht-805.html
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37. http://www.seattlepi.com/news/science/article/Snail-harmful-to-ducks-spreading-in-Great-Lakes-5959538.php
38. http://www.pendletontimespost.com/view/story/4cde108b10b84af7b9d0cfcba603cf7a/MI--Invasive-Snails/
39. http://www.wilx.com/home/headlines/Invasive-Snail-Spreading-in-Great-Lakes-285933261.html
40. http://www.watertowndailytimes.com/article/20150119/NEWS03/150118434
41. http://howardmeyerson.com/2015/01/15/scientists-invasive-snail-more-prevalent-than-thought-poses-grave-danger-to-waterfowl/

Mock-up of press release produced by collaborating universities.

FOR IMMEDIATE RELEASE: December 9, 2014

CONTACT: June Kallestad, NRRI Public Relations Manager, 218-720-4300

USEPA-sponsored project greatly expands known locations of invasive snail

DULUTH, Minn. – Several federal agencies carefully track the spread of non-native species. This week scientists funded by the Great Lakes Restoration Initiative in partnership with USEPA's Great Lakes

National Program Office greatly added to the list of known locations of faucet snails (*Bithynia tentaculata*) in the Great Lakes. The new locations show that the snails have invaded many more areas along the Great Lakes coastline than anyone realized.

The spread of these small European snails is bad news for water fowl: They are known to carry intestinal flukes that kill ducks and coots.

"We've been noting the presence of faucet snails since 2011 but didn't realize that they hadn't been officially reported from our study sites," explained Valerie Brady, NRRI aquatic ecologist who is collaborating with a team of researchers in collecting plant and animal data from Great Lakes coastal wetlands.

Research teams from 10 universities and Environment Canada have been sampling coastal wetlands all along the Great Lakes coast since 2011 and have found snails at up to a dozen sites per year [See map 1]. This compares to the current known locations shown on the USGS website [see map 2].

"Our project design will, over 5 years, take us to every major coastal wetland in the Great Lakes. These locations are shallow, mucky and full of plants, so we're slogging around, getting dirty, in places other people don't go. That could be why we found the snails in so many new locations," explained Bob Hell, NRRI's lead macroinvertebrate taxonomist. "Luckily, they're not hard to identify."

The small snail, 12 – 15 mm in height at full size, is brown to black in color with a distinctive whorl of concentric circles on the shell opening cover that looks like tree rings. The tiny size of young snails means they are easily transported and spread, and they are difficult to kill.

According to the Minnesota Department of Natural Resources, the faucet snail carries three intestinal trematodes that cause mortality in ducks and coots. When waterfowl consume the infected snails, the adult trematodes attack the internal organs, causing lesions and hemorrhage. Infected birds appear lethargic and have difficulty diving and flying before eventually dying.

Although the primary purpose of the project is to assess how Great Lakes coastal wetlands are faring, detecting invasives and their spread is one of the secondary benefits. The scientific team expects to report soon on the spread of non-native fish, and has helped to locate and combat invasive aquatic plants.

"Humans are a global species that moves plants and animals around, even when we don't mean to. We're basically homogenizing the world, to the detriment of native species," Brady added, underscoring the importance of knowing how to keep from spreading invasive species. Hell noted, "We have to make sure we all clean everything thoroughly before we move to another location."

For more information on how to clean gear and boats to prevent invasive species spread, go to www.protectyourwaters.net.