GLIC: Implementing Great Lakes Coastal Wetland Monitoring

Semiannual Progress Report

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INTRODUCTION

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

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

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

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

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

During our fourth year, project PIs and field crew chiefs again met (Midland Michigan, January 15, 2014) to discuss any aspects of the project needing attention and to help ensure that all teams continue to sample in the same manner across the entire Great Lakes basin. Topics at the 2014 meeting included adding other options for some of the water quality analyses (the QAPP and water quality SOP were updated 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.

During our fifth year, project PIs and field crew chiefs again met in Midland, Michigan (Jan. 23, 2015). Topics discussed included IBI development and manuscript topics. 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. Benchmark site sampling, data analysis, and conclusions were also discussed, along with EPA’s desire that we assist with the assessment of future coastal wetland restoration projects. The QAPP (Rev. 5) was revised to update personnel changes and to provide an alternate vegetation sampling protocol for wide, dense *Phragmites* stands. Site selection resulted in an initial draw of 260 sites, of which 41 were benchmark sites and 16 sites were resample sites.

PROJECT ORGANIZATION

Figure 1 shows our project organization.

Please note that since our project started we have had two changes in primary personnel (both approved by US EPA). Ryan Archer of Bird Studies Canada 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 then relocated to Central Michigan University. He has just recently (Sept. 2015) taken a position with Northland College in Ashland, WI, but he continues to hold the same roles on the project as he did previously.

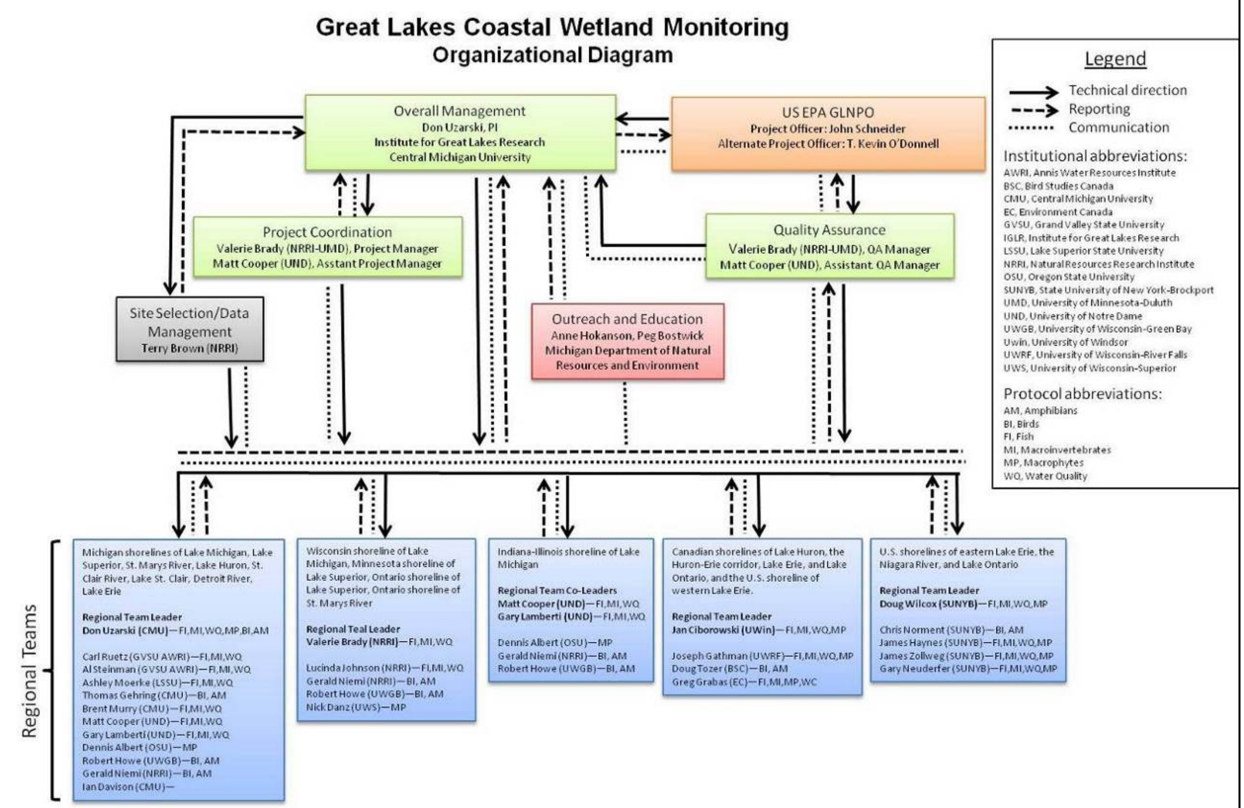

Figure 1. Organizational chart for the project showing lines of technical direction, reporting, and communication separately.

PROJECT TIMELINE

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

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

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

SITE SELECTION

Year five site selection was completed in March 2015 and was essentially the same as site selection for 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 (or appeared to have) 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.

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. Another component of this US/CA discrepancy is the lack of coastal wetlands along the Canadian shoreline of Lake Superior due to the rugged topography and geology. A final possibility is unequal loss of wetlands between the two countries, but this has not been investigated.

Strata

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

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

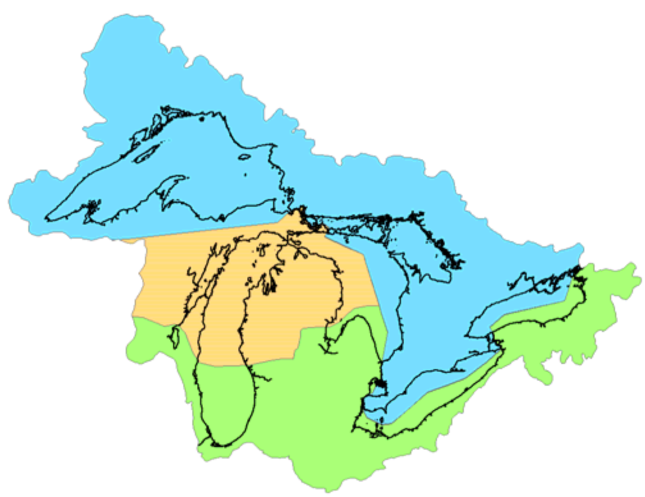

Figure 2. Divisions of lakes into regions. Note that stratification is by region *and* lake, so northern Lake Erie is not in the same region as Lake Superior, etc.

Panelization

Randomization
The first step in randomization was the assignment of selected sites from each of the project's 30 strata (10 regions x 3 geomorphic classes) to a random year or panel in the five-year rotating panel. Because the number of sites in some strata was quite low (in a few cases less than 5, more in the 5-20 range), simple random assignment would not produce the desired even distribution of sites within each strata over time. Instead it was necessary to assign the first fifth of the sites within a stratum, defined by their pre-defined random ordering, to one year, and the next fifth to another year, etc.

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

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

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

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

Workflow states

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

Team assignment

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

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

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

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

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

2015 Site Selection

Site selection for 2015 resulted in an initial draw of 260 sites, of which 41 were benchmark sites and 16 sites were resample sites, with the remaining 203 sites selected by the original "random draw" that places sites in the sampling panels. There are more than 10% of sites in the "benchmark" category because several teams have taken on additional sites at the special request of other agencies or groups (see *individual team reports* and *letters of support*) without sacrificing the number of random sites sampled. Benchmark and resample sites are sorted to the top of the sampling list because they are the highest priority sites to be sampled.

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

TRAINING

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

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

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

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

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

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

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

Certification

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

Documentation and Record

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

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

Web-based Data Entry System

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

Features of note include:

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

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

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

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

We have also developed an interactive map available as a website that will allow users to visualize and download site level attributes such as IBI scores. 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).

Though our current data management system has worked well over the past 5 years, an updated database and web interface is being developed for the project. Central Michigan University has contracted with LimnoTech Inc. to develop the new system, which will provide improved functionality and security. LimnoTech is also developing an updated interactive map for data visualization. We anticipate that these new systems will be online in early 2016.

RESULTS-TO-DATE (2011-2015, EXCEPT AS NOTED)

A total of 176 wetlands were sampled in 2011, with 206 sampled in 2012, 201 in 2013, 216 in 2014, and 211 in 2015, our 5th and final summer of sampling for the first project round. Overall, 1010 Great Lakes coastal wetland sampling events were conducted in this five-year effort (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 1010 Great Lakes coastal wetlands sampled from 2011 through 2015 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%
2015	77	36%	10,011	27%
CA total	**352**	**35%**	**35,137**	**23%**
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%
2015	134	64%	26,681	73%
US total	**658**	**65%**	**116,309**	**77%**
Overall Totals	**1010**		**151,446**	

Teams may have been able to sample more sites in 2014 and 2015 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 Great Lakes coastal wetlands in any given year.

The sites sampled in 2015 are shown in Figures 3 and 4 and are color coded by which taxonomic groups were sampled at the sites and by wetland types, respectively. Many sites were sampled for all taxonomic groups. Sites not sampled for birds and amphibians typically were sites that were impossible to access safely, and often related to private property access issues. Most bird and amphibian crews do not operate from boats since they need to arrive at sites in the dark or stay until well after dark. There are also a number of sites sampled only by bird and amphibian crews because these crews can complete their site sampling more quickly and thus have the capacity to sample more sites than do the fish, macroinvertebrate, and vegetation crews.

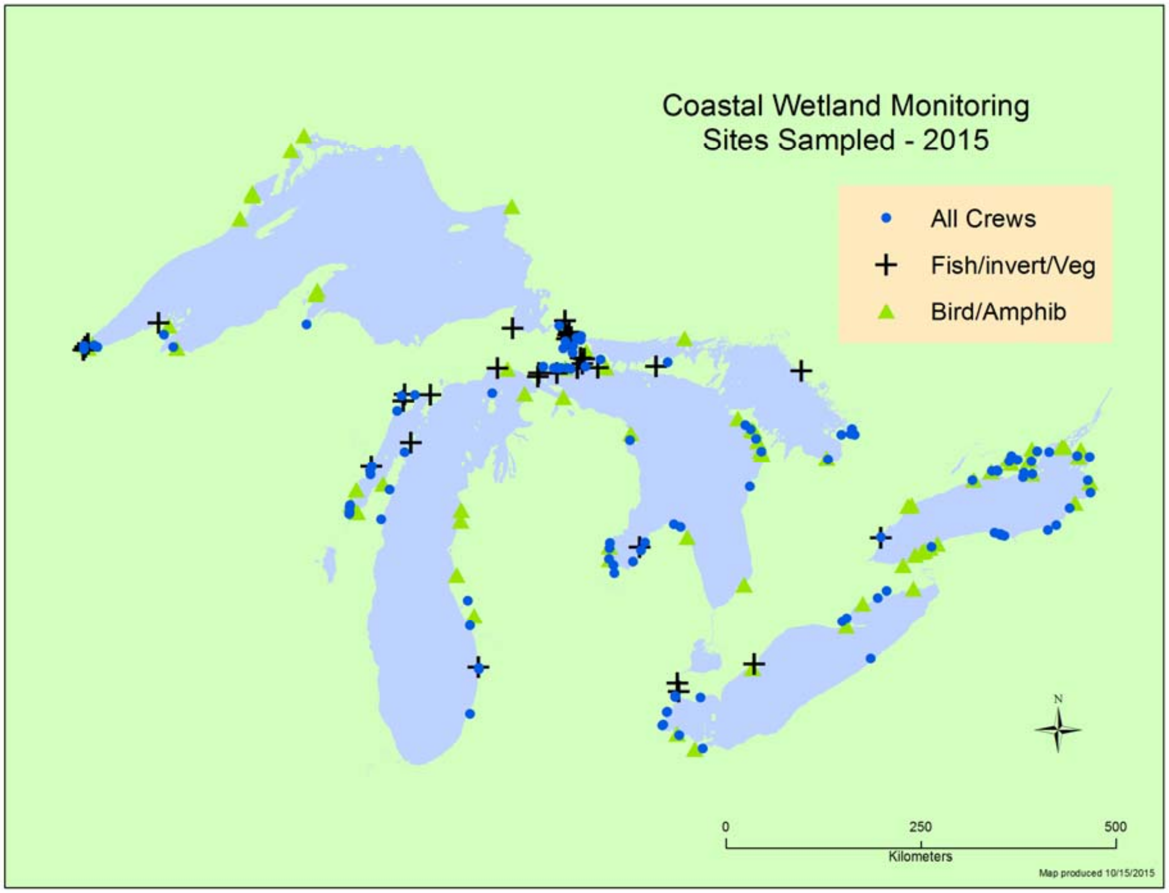

Figure 3. Locations of the 211 Great Lakes coastal wetlands sampled in 2015, color-coded by taxonomic groups. Sites assigned only to bird and amphibian crews (due to their greater sampling capacity) are shown with a green triangle.

Wetland types are not distributed evenly across the Great Lakes due to fetch, topography, and geology (Figure 4). Lacustrine wetlands occur in more sheltered areas of the Great Lakes within large bays or adjacent to islands. Barrier-protected wetlands occur along harsher stretches of coastline, particularly in sandy areas, although this is not always the case. Riverine wetlands are somewhat more evenly distributed around the Great Lakes. Low water levels in 2011-2013 and much higher water levels in 2014 and 2015 require that indicators be relatively robust to Great Lakes water level variations.

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

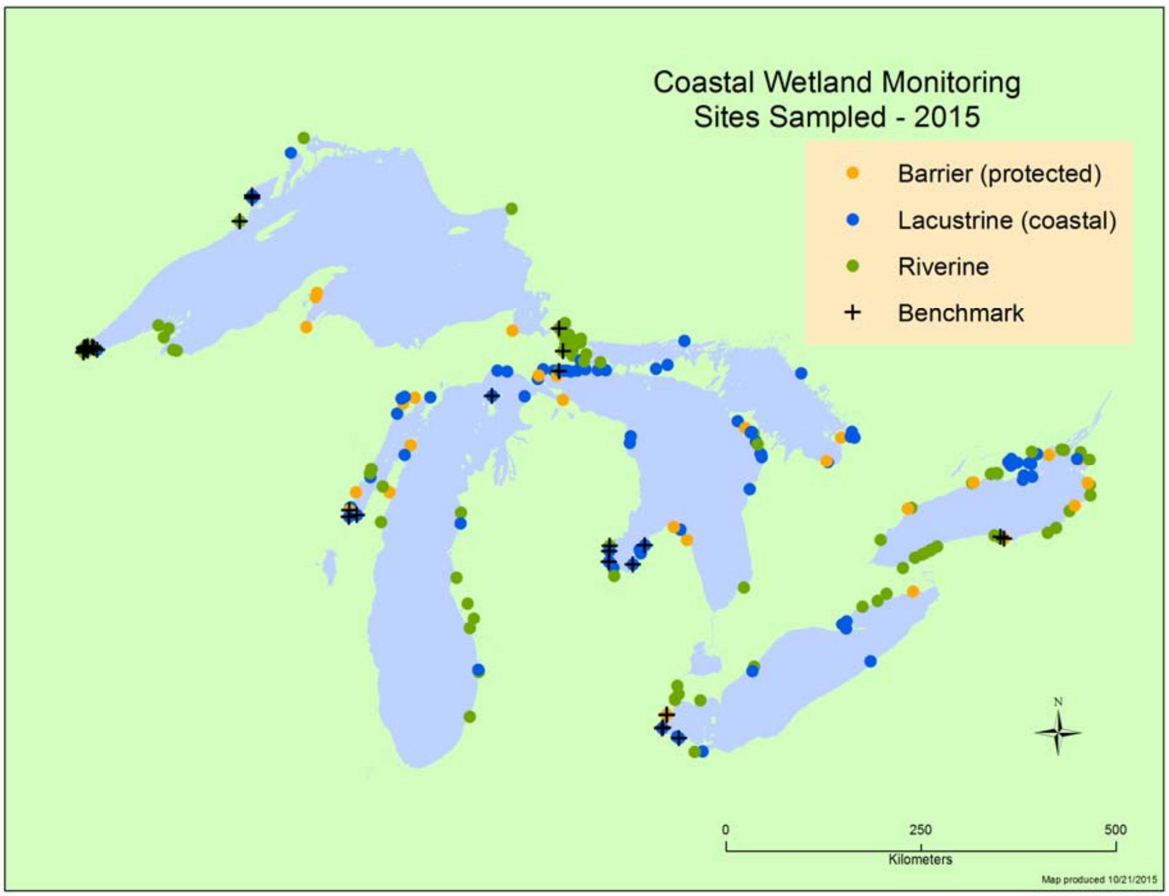

Figure 4. Locations of the 211 Great Lakes coastal wetlands sampled in 2015, color-coded by site type. Wetland types exhibit a clumped distribution across lakes due to geology and topography.

As of 2015, we have 60 sites designated as “benchmark.” Of these, 20 (30%) 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. The rest are more intensive monitoring sites at which the extra data will help provide long-term context and better ecological understanding of coastal wetlands.

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. Thus, we are adding relatively few new sites as benchmarks each year. These tend to be sites that are very degraded former wetlands that no longer appear on any wetland coverage, but for which restoration is a goal.

We can now compile good statistics on Great Lakes coastal wetlands because we have sampled nearly 100% of the medium and large, hydrologically-connected coastal wetlands on the Great Lakes. Wetlands contained approximately 25 bird species on average; some sampled benchmark sites had as few as 1 species, but richness at high quality sites was as great as 60 bird species (Table 6). There are many fewer calling amphibian species in the Great Lakes (8 total), and coastal wetlands averaged about 4 species per wetland, with some benchmark wetlands containing no calling amphibians (Table 6). However, there were wetlands where all 8 calling amphibian species were heard over the three sampling dates.

Table 6. Bird and calling amphibian species in wetlands; summary statistics by country. Data from 2011 through 2015.

Country	Site count	Mean	Max	Min	St. Dev.
Birds					
Can.	309	28.5	58	8	10.0
U.S.	573	22.1	60	1	11.5
Amphibians					
Can.	310	4.5	8	0	1.8
U.S.	543	3.7	8	0	1.5

Bird and amphibian data in Great Lakes coastal wetlands by lake (Table 7) shows that wetlands on most lakes averaged around 25 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 and Superior. Lake Ontario had 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 nearly five 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 2015.

	Birds				Calling amphibians			
Lake	**Sites**	**Mean**	**Max**	**Min**	**Sites**	**Mean**	**Max**	**Min**
Erie	116	24.8	54	4	103	3.4	7	0
Huron	271	25.0	58	2	268	4.0	8	0
Michigan	146	23.8	60	1	135	3.6	7	0
Ontario	230	22.3	47	8	231	4.7	8	1
Superior	119	27.1	52	11	116	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., common carp).

Table 8. Total fish species in wetlands, and non-native species; summary statistics by country for sites sampled from 2011 through 2015.

Country	Sites	Mean	Max	Min	St. Dev.
Overall					
Can.	156	10.0	23	2	3.9

U.S.	365	13.3	28	2	5.2
Non-natives					
Can.	156	0.7	3	0	0.7
U.S.	365	0.7	5	0	0.9

Combining 2011 through 2015 data, there were no non-native fish species caught at 48% of the Great Lakes coastal wetlands sampled, but 37% 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.

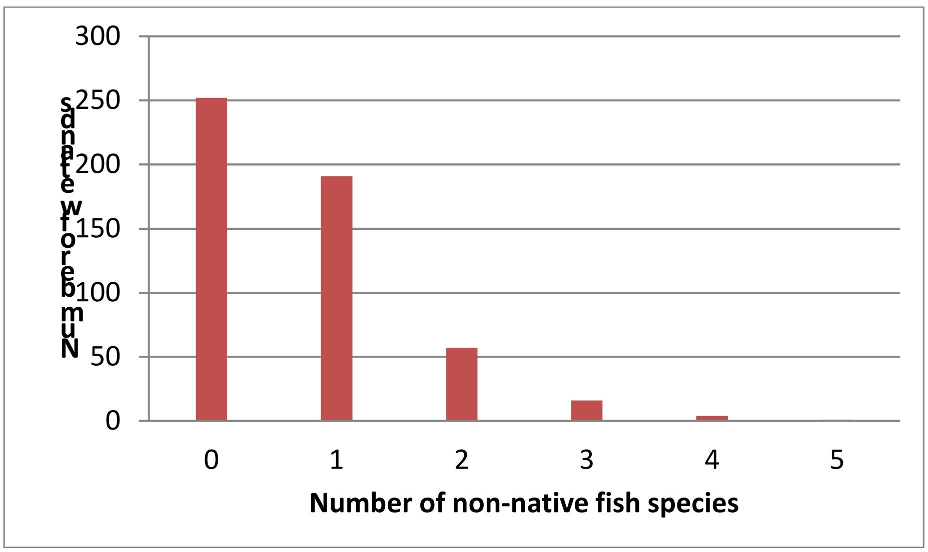

Figure 5. Number of Great Lakes coastal wetlands containing non-native fish species. Data from 2011 through 2015.

Total fish species did not differ greatly by lake, averaging 12-14 species per wetland (Table 9). Lake Ontario wetlands had the lowest maximum number of species, with the other lakes all having similar maximums of 27-28 species. Since sites in need of restoration are included, some of these sites had very few fish species, as low as two. Lake Huron wetlands averaged the lowest mean number of non-native fish taxa. All other lakes had a similar average number of non-native fish species per wetland, about 1. Having very few or no non-native fish is a positive, however, and all lakes had some wetlands in which we caught no non-native fish. This result does not necessarily mean that these wetlands are free of non-natives, unfortunately. Our single-night net sets do not catch all fish species in wetlands, and some species are quite adept at avoiding passive capture gear. For example, common carp are known to avoid fyke nets. When interpreting fish data it is important to keep in mind the well-documented biases associated with each type of sampling gear. For example, active sampling gears (e.g., electrofishing) are better at capturing large active fish, but perform poorly at capturing smaller fish, forage fish, and young fish that are sampled well by our passive gear.

Table 9. Fish total species and non-native species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of species per wetland. Data from 2011 through 2015.

		Fish (Total)			Non-native		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	66	12.2	27	2	1.1	4	0
Huron	180	11.5	27	2	0.4	2	0
Michigan	75	13.1	28	5	0.8	4	0
Ontario	135	12.3	23	4	0.8	3	0
Superior	65	14.1	28	3	0.9	5	0

Macroinvertebrates from 2015 sampling are still being identified and entered into the database. Thus, the following information has not been updated since the previous report. The average number of macroinvertebrate taxa (taxa richness) per site was about 40 (Table 10), but some wetlands had more than twice this number. Sites scheduled for restoration and other taxonomically poor wetlands had fewer taxa, 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). On a more positive note, 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

Last year (2014) we realized that we are finding some non-native, invasive species in significantly more locations around the Great Lakes than are 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.

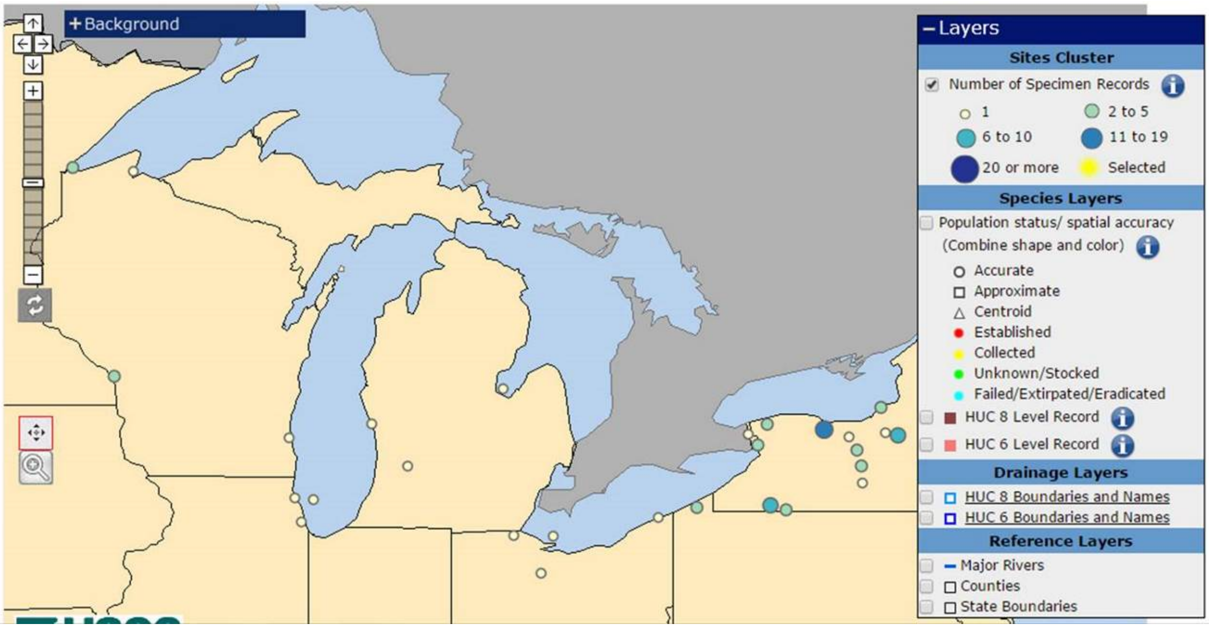

Figure 6. Locations of *Bithynia tentaculata* in USGS NAS website PRIOR to our project providing additional locations where they were collected.

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 about 40 articles were generated in the news that we are aware of. 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.

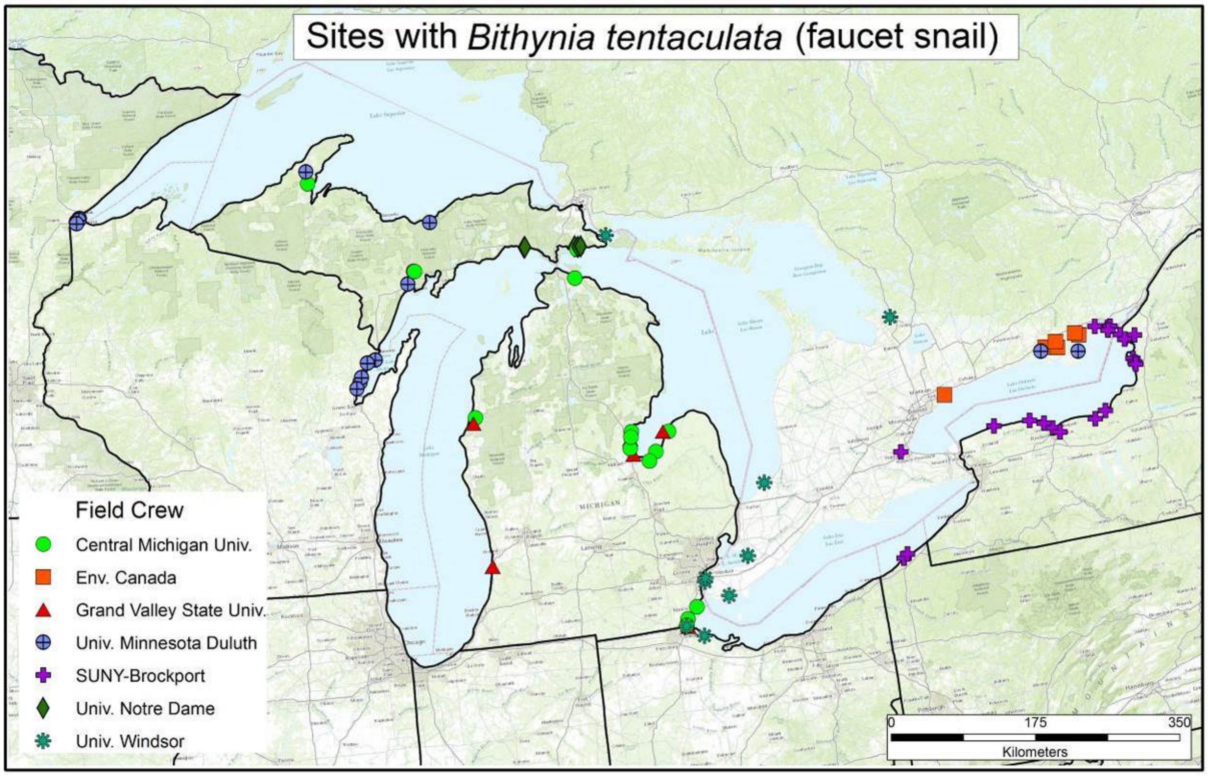

Figure 7. Locations of *Bithynia tentaculata* found by CWM crews, 2011 - 2013.

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.

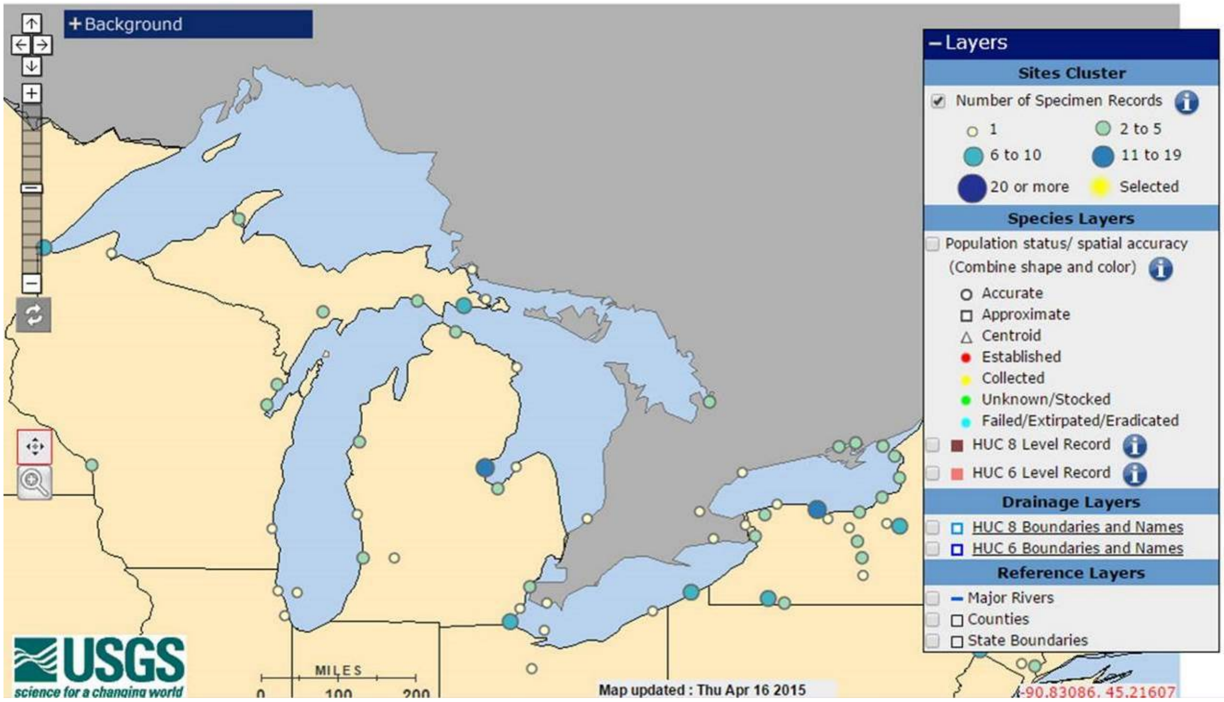

Figure 8. Locations of *Bithynia tentaculata* in USGS NAS website AFTER our project provided additional locations where they were collected; compare to Figure 6.

On average, there were approximately 45 wetland plant (macrophyte) species per wetland (Table 12), but the maximum number has risen to 100 species at a very diverse site. 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.

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.

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 2015.

Country	Site count	Mean	Max	Min	St. Dev.
Overall					
Can.	196	45.3	87	7	17.1
U.S.	417	43.9	100	1	16.4
Invasives					
Can.	196	3.7	8	0	2.0
U.S.	417	3.3	9	0	2.1
At risk					
U.S.	417	0.1	2	0	0.33

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 2015.

		Macrophytes (Total)			Invasives		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	77	28.1	69	1	4.5	8	0
Huron	221	53.2	100	15	2.6	8	0
Michigan	84	45.8	83	4	3.3	7	0
Ontario	152	40.7	87	8	5.1	9	1
Superior	79	40.7	78	2	1.7	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 631 sampled wetlands lacked invasive species, leaving 91% with at least one. Sites were most commonly invaded by 2 – 5 invasive plant species and 6% 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 fauna, but we may still be missing small patches of invasives in some wetlands.

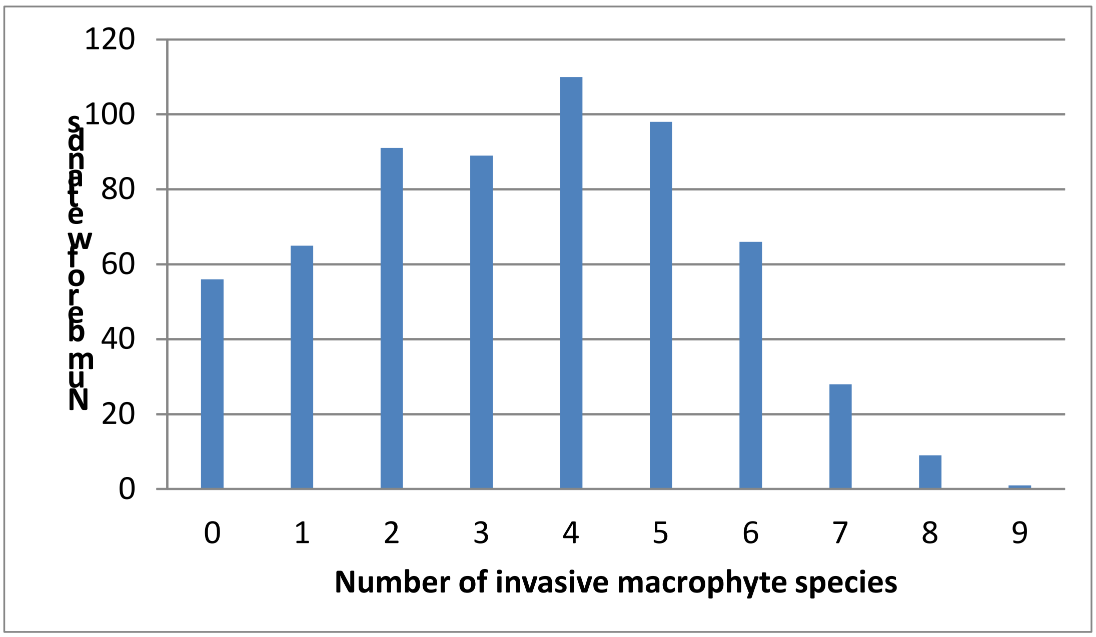

Figure 9. Number of Great Lakes coastal wetlands containing invasive plant species based on 2011 through 2015 data.

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.

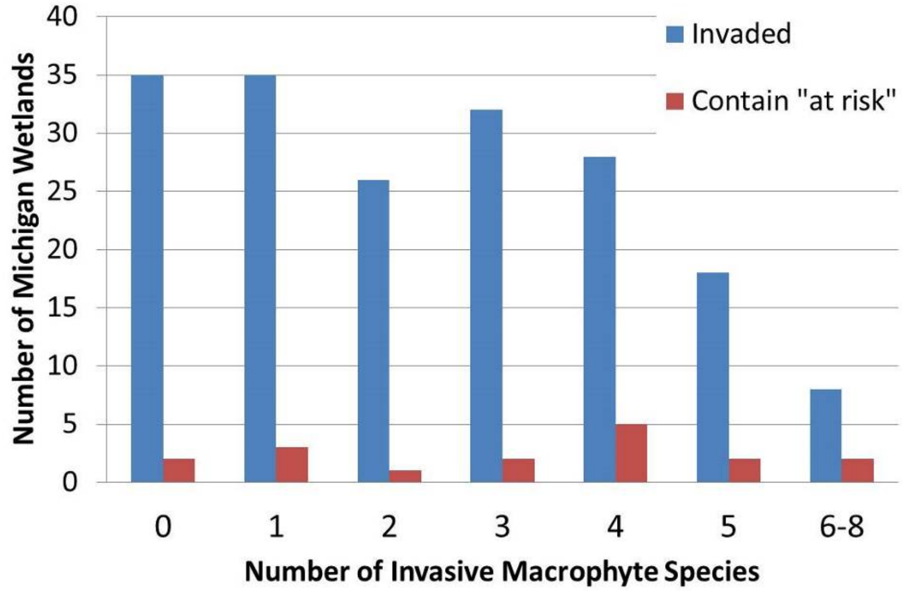

Figure 10. Number of state of Michigan Great Lakes coastal wetlands containing both invasive plant species and “at risk” plant species, based on 2011 through 2014 data.

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.

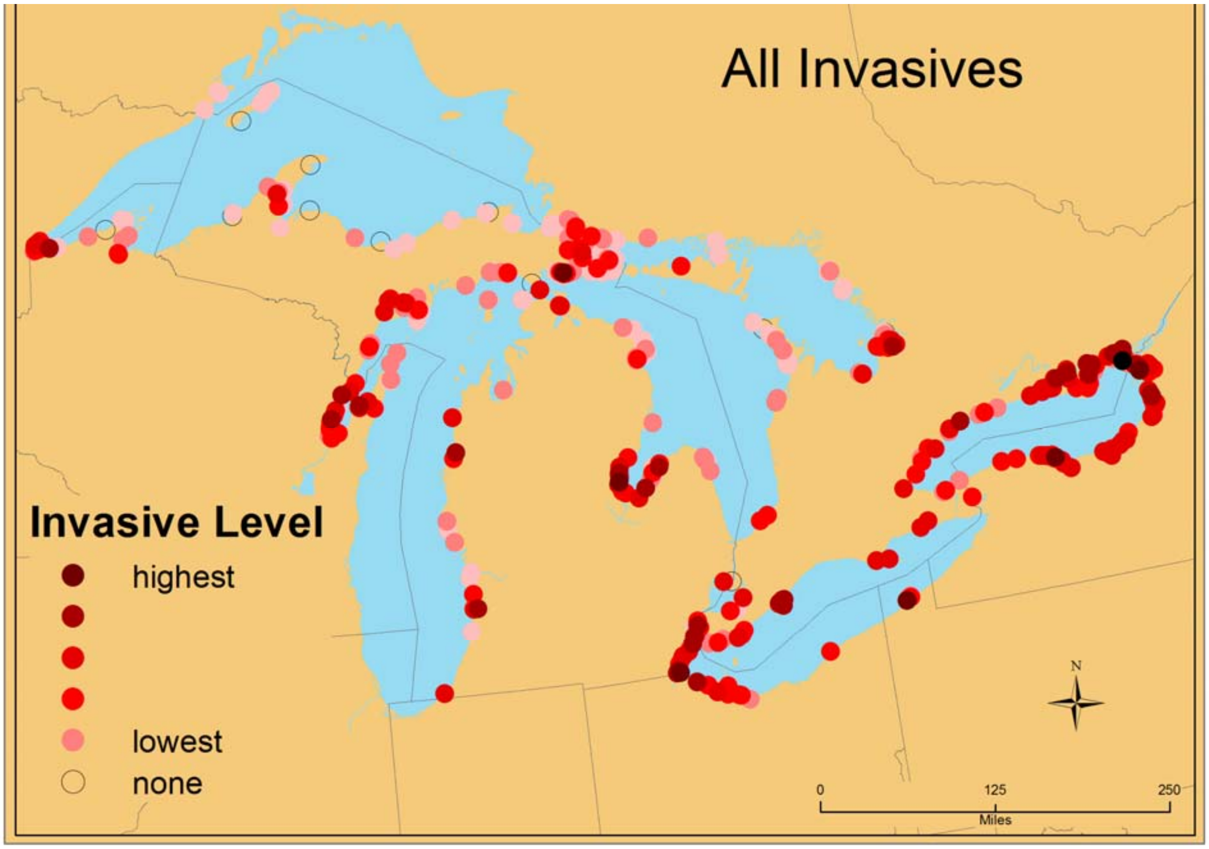

Figure 11. Level of "invadedness" of Great Lakes coastal wetlands for all non-native taxa combined across all taxonomic groups, based on data from 2011-2014.

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.

The map (Figure 12, updated and revised for this report) shows the distribution of Great Lakes coastal wetland vegetation index scores across the basin. Note that there are long stretches of Great Lakes coastline that do not have coastal wetlands due to topography and geology. Sites

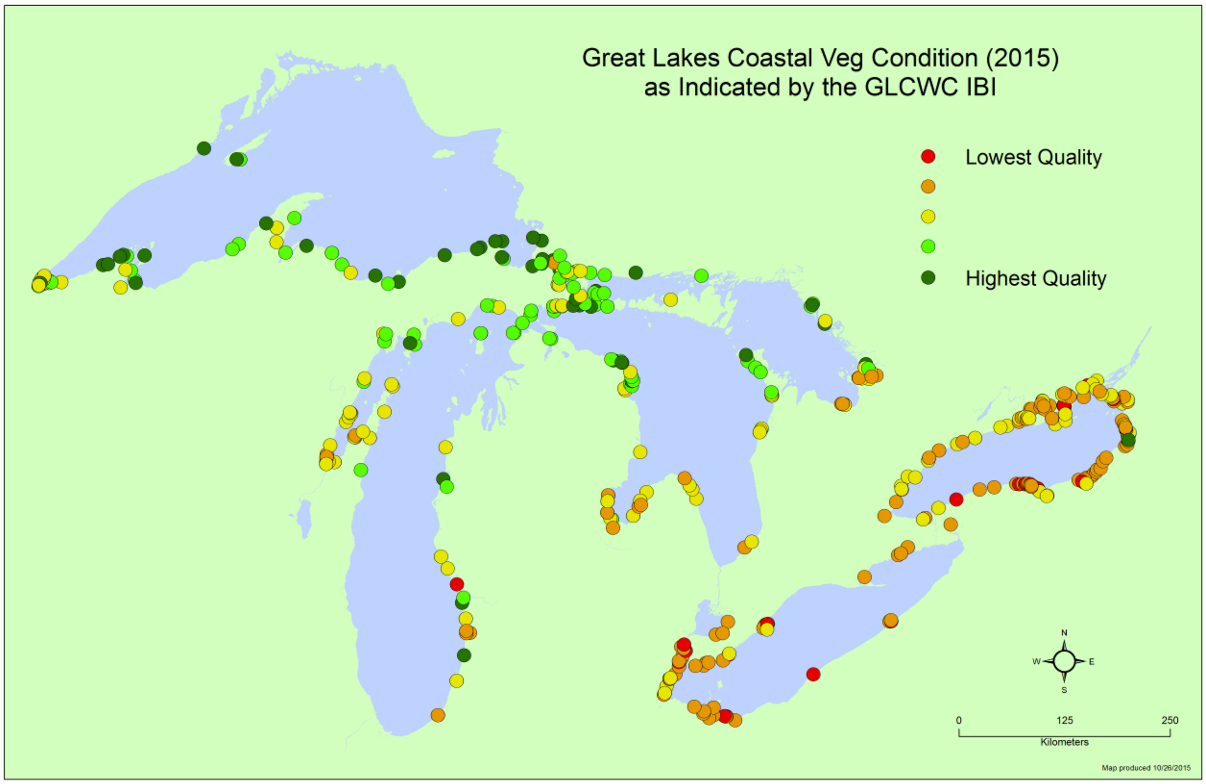

Figure 12. Condition of coastal wetland vegetation at sites across the Great Lakes. Circle color indicates vegetation community quality. The indicator is labeled “draft” while this indicator is investigated for robustness against varying water levels and latitude. Based on data from 2011 through 2015.

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.

Another of the IBIs that was developed by the Great Lakes Coastal Wetlands Consortium uses the aquatic macroinvertebrates found in several of the most common vegetation types in Great Lakes coastal wetlands: sparse bulrush (*Schoenoplectus*), dense bulrush (*Schoenoplectus*), and wet meadow (multi-species) zones. We have calculated these IBIs for 2011 through 2014 sites that contain these habitat zones (Figure 13). This will be updated in the spring report once the macroinvertebrates from the 2015 samples have been identified and their data entry has been QC'd. Minor adjustment of metrics is continuing, so maps are not directly comparable across reports.

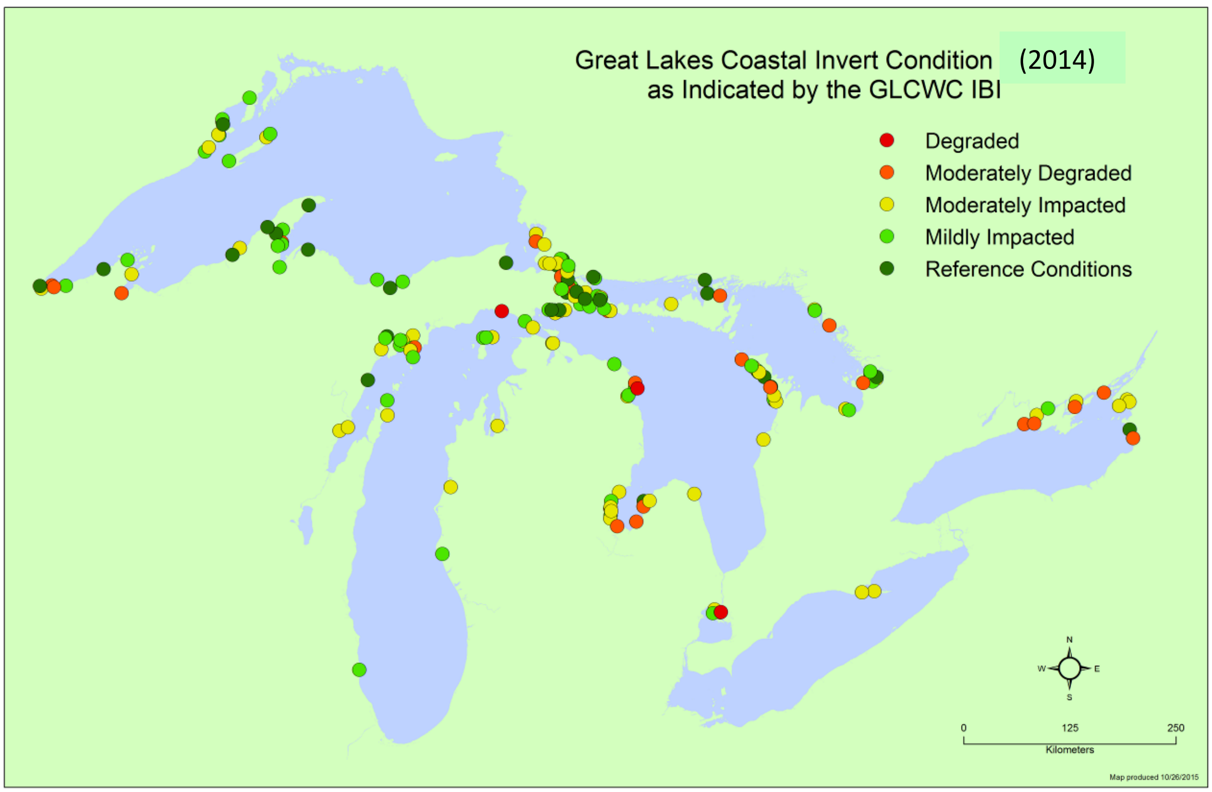

Figure 13. Condition of coastal wetland macroinvertebrate communties at sites with bulrush or wet meadow zones. The indicator is labeled "draft" while more zone IBIs are calculated. Based on data from 2011 through 2014.

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.

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.

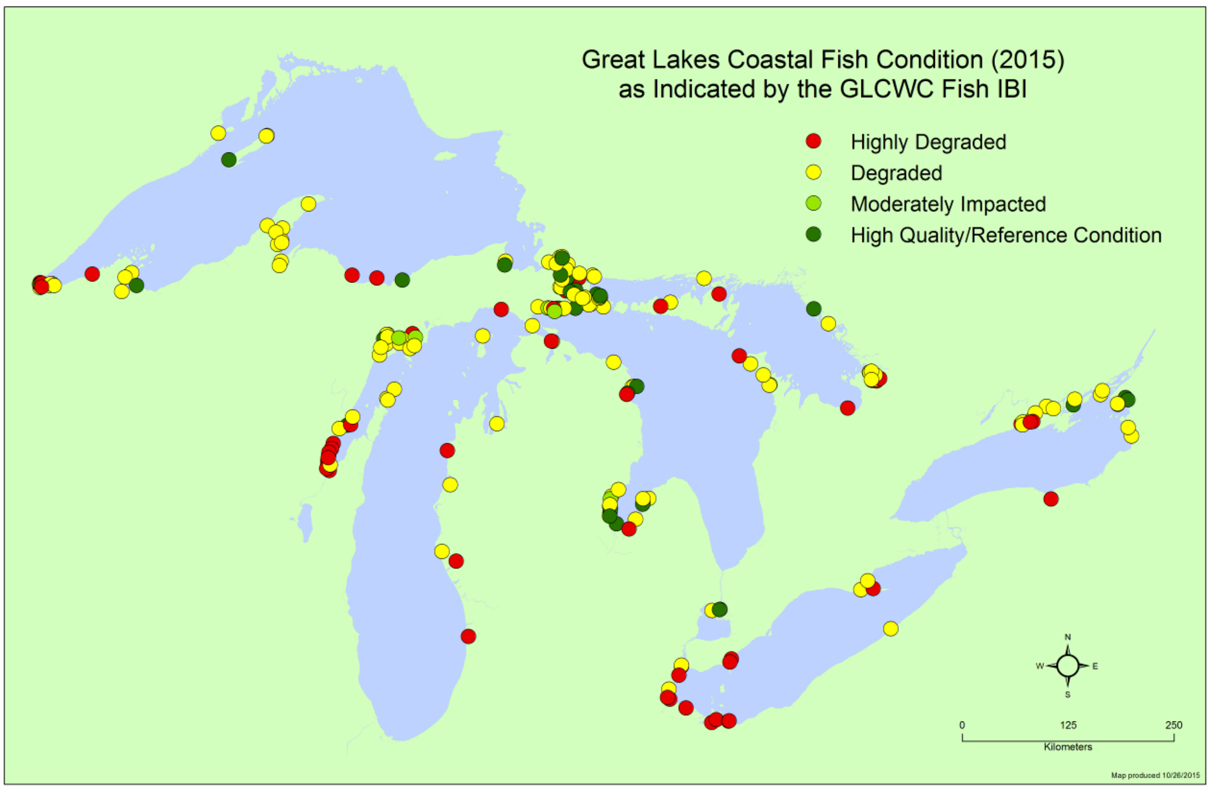

Figure 14. Condition of coastal wetland fish communties at sites with bulrush or cattail zones. The indicator is labeled "draft" while more zone IBIs are developed. Based on data from 2011 through 2015.

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.

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

The indicator is shown on separate scales for the northern and southern parts of the Great Lakes basin because of the differences in amounts of agriculture and development between these two areas (Figure 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. This indicator has not been updated with 2015 data and will be updated in the spring report.

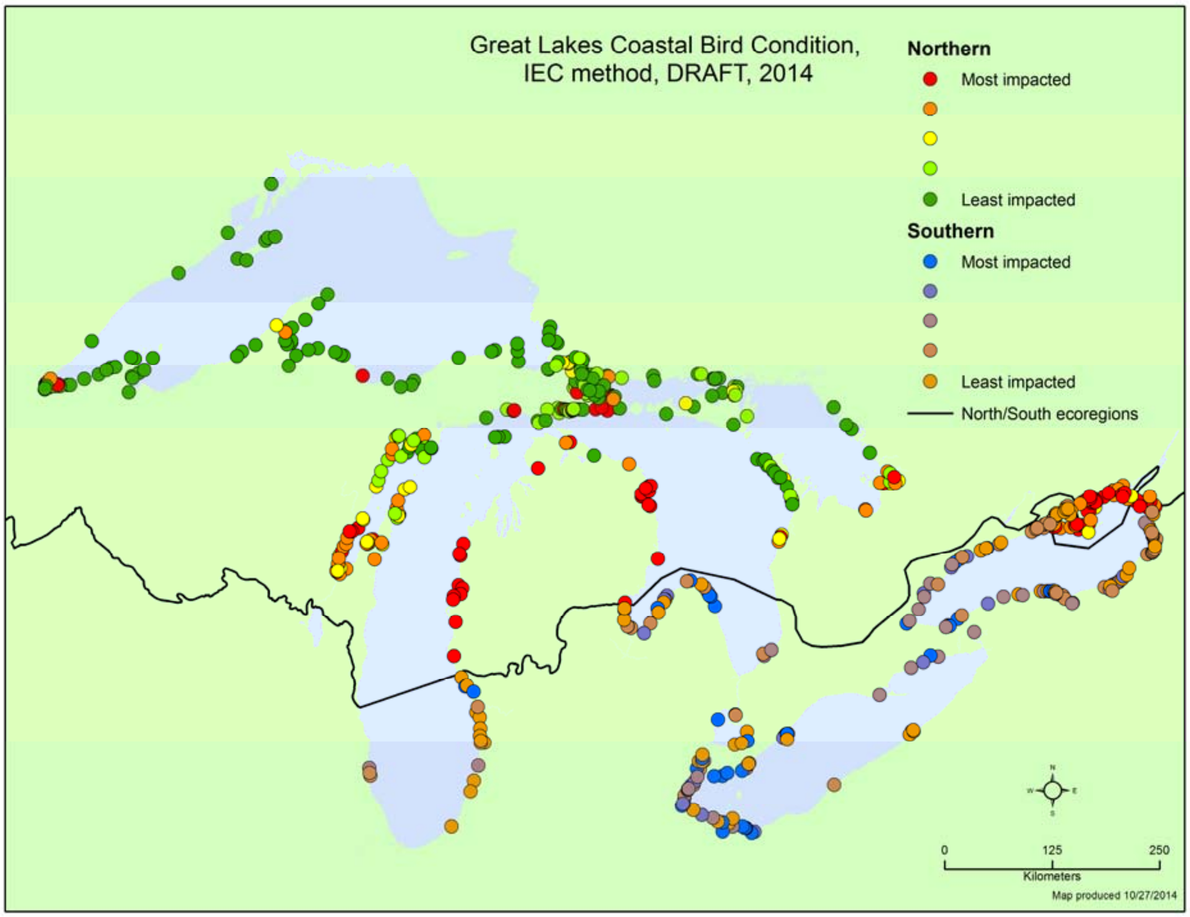

Figure 15. Condition of coastal wetland bird communties. This indicator is based on the IEC method, and it works best when shown separately for the northern and southern areas of the Great Lakes because of the differences in the amount of agriculture and developed land between these two areas (see text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

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.

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 who they work for.

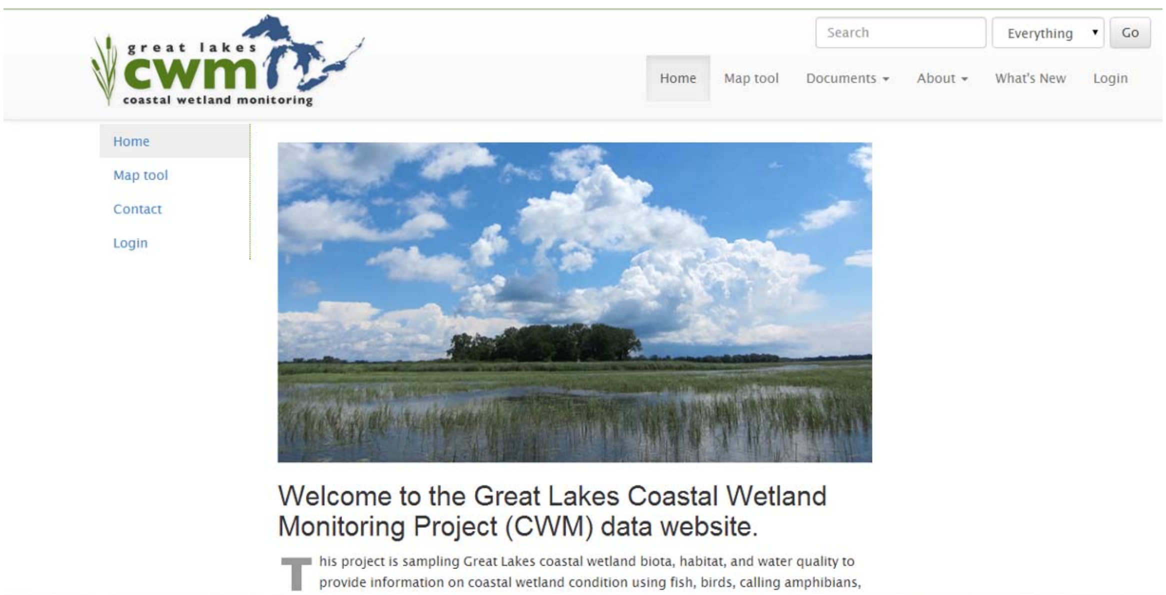

Figure 16. Front page of the new Great Lakes Coastal Wetland Monitoring public website, www.greatlakeswetlands.org.

In addition to features commonly found in map-based web interfaces (e.g., layer switching, swapping of base-maps, panning and zooming), the tool provides custom functionality relevant to coastal wetland monitoring (Figure 17). Users are 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.

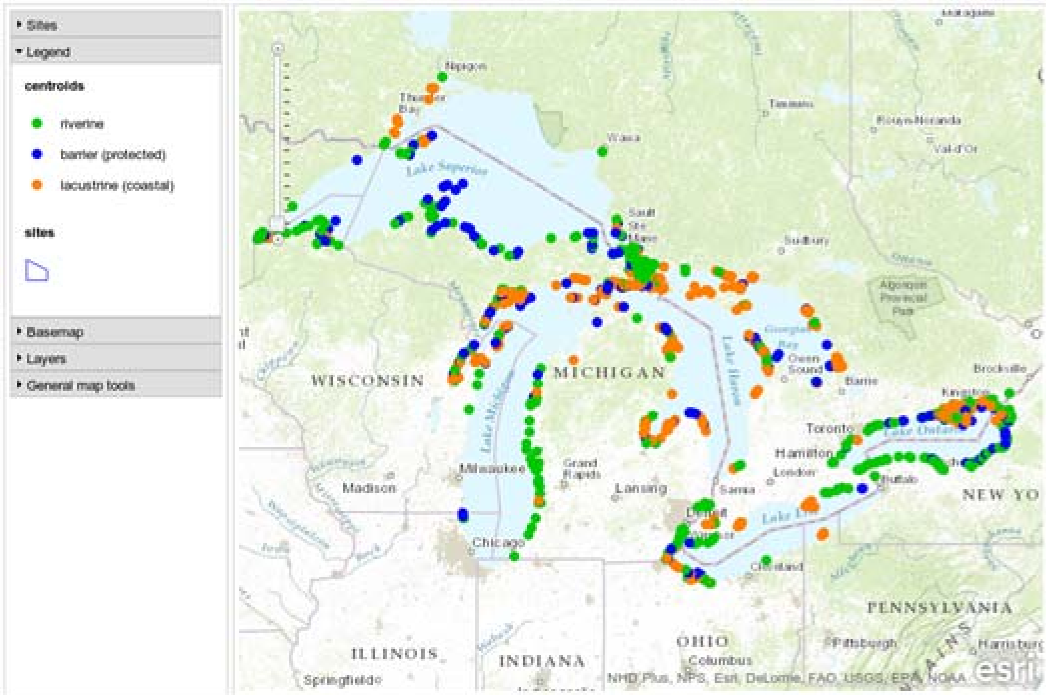

Figure 17. Default view of all sites in the database, color-coded by wetland type (riverine, barrier-protected, or lacustrine).

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.

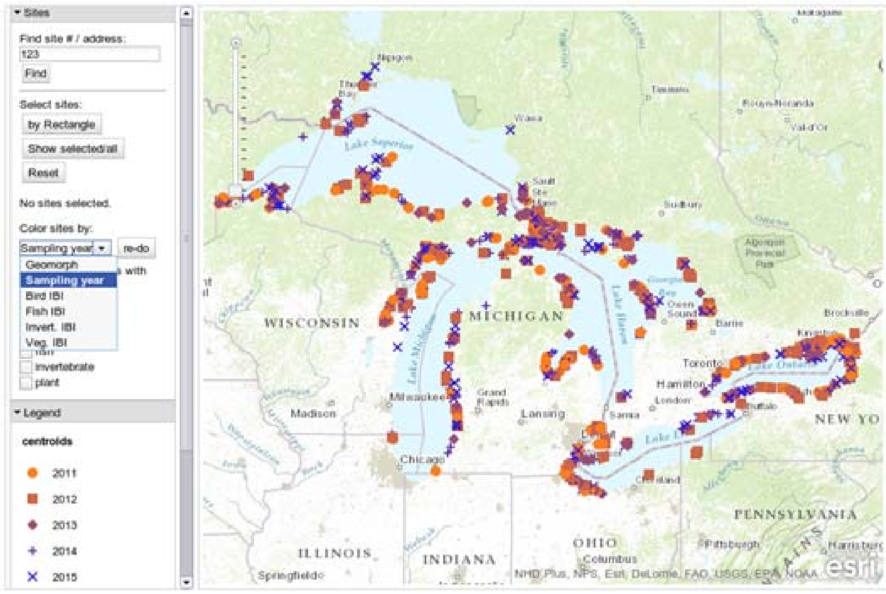

Figure 18. View by sampling year. Sites sampled in more than one year show the most recent year of sampling.

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

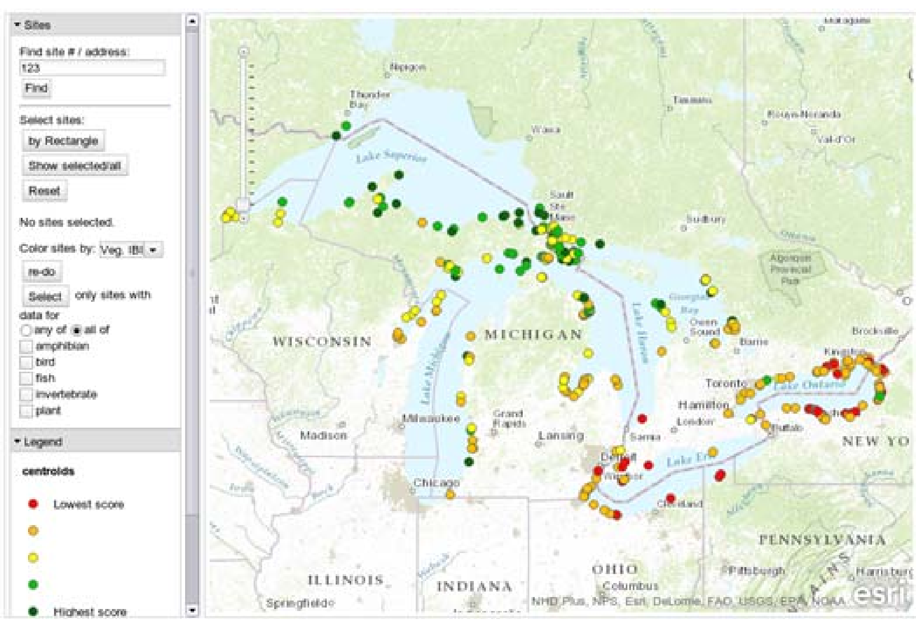

Figure 19. Wetland condition based on the wetland macrophyte IBI displaying sites for the whole basin for which there are data.

calculated normal scaling for the IBI (Figure 19).

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 19). 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

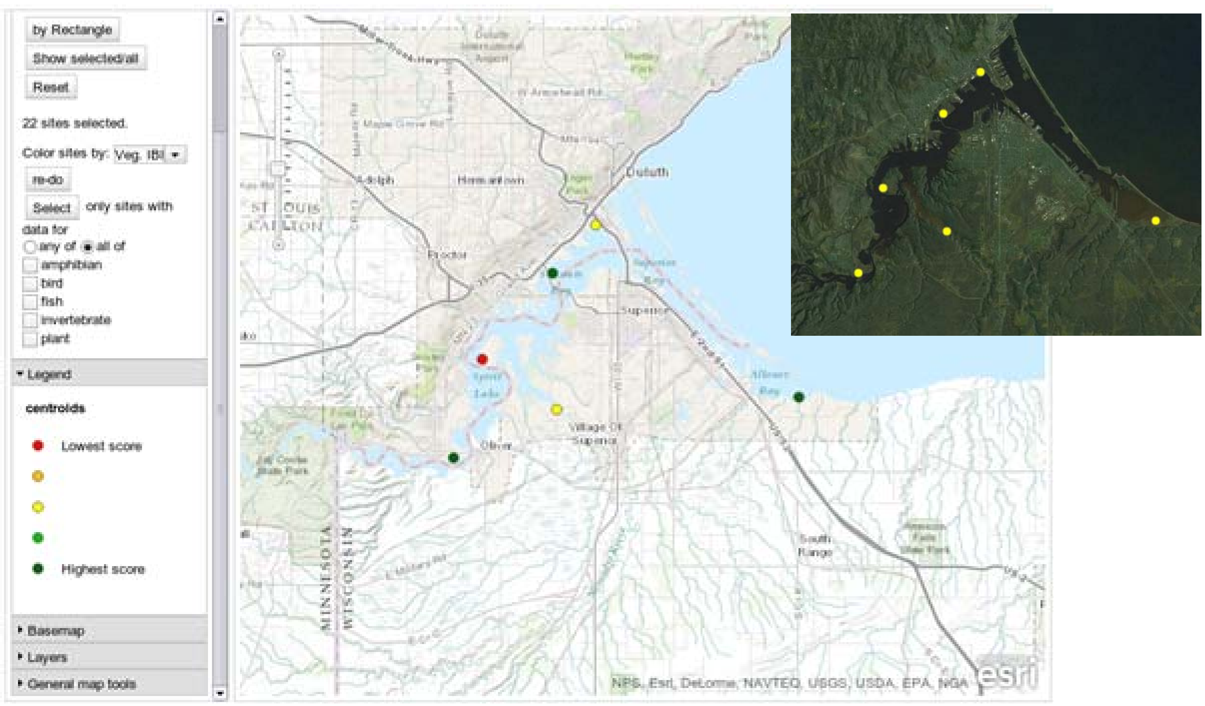

Figure 20. Wetlands in the St. Louis River estuary, Lake Superior, color-coded by wetland vegetation IBI scores that have been re-scaled for the sites shown. Inset shows original site coding for these wetlands in the context of all the wetlands across the Great Lakes.

have the highest and lowest scores for their area of management or interest (Figure 20).

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.

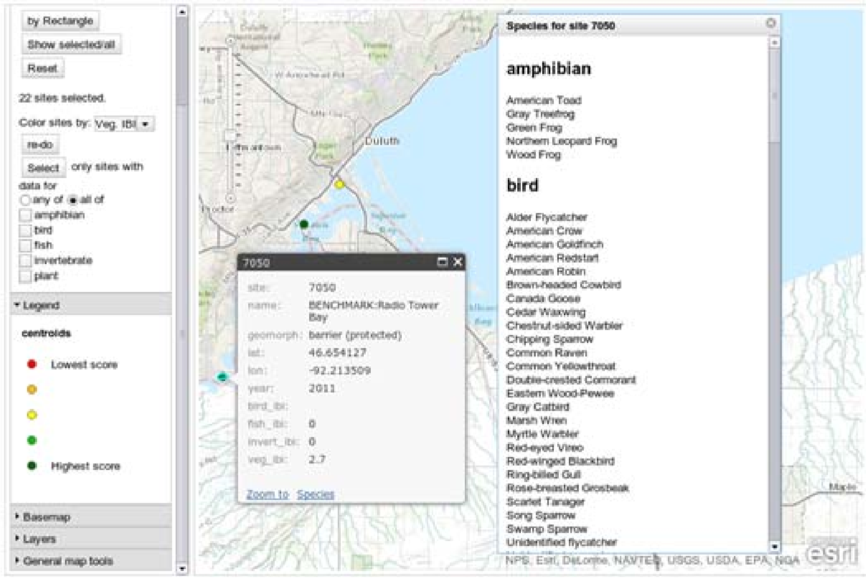

Figure 21. Example display of species lists for a specific site.

While the current mapping tool is functioning well and is gaining attention by users, we have initiated substantial improvements to the tool. Central Michigan University has contracted with LimnoTech Inc. to overhaul the site and provide ongoing support for the project. 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. Arrangements for the long-term post-project hosting of the website by CMU have also been finalized. Currently development, deployment, and management systems are being transferred from the staging site hosted at NRRI to CMU with support from LimnoTech.

TEAM REPORTS

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

Field Training

Birds and Amphibians
Training for amphibian surveys was held on 23 April 2015 and bird crew training took place 24 – 26 May 2015. Training involved instructing crews on how to conduct standardized field surveys, on basic travel procedures, and on appropriate field safety measures. Individuals are trained to proficiently complete field sheets and audio testing is also completed to insure that their

hearing is within the normal range. Rules for site verification, safety issues including caution regarding insects (e.g., Lyme's disease), GPS and compass use, and record keeping are also included in field training to insure that the guidelines in the QAPP are being followed. All individuals involved in conducting the surveys have taken and passed each of the following tests on 1) amphibian calls, 2) bird vocalization, and 3) bird visual identification that are based on an on-line system established at the University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal, prior to conducting surveys.

Fish, Macroinvertebrates, Vegetation, and Water Quality
Fish, macroinvertebrate, vegetation, and water quality sampling training was in Duluth, Minnesota, and Superior, Wisconsin, in mid-June 2015 and continued in Green Bay, Wisconsin at the end of June/early July. Several fish/invertebrate/water quality crew members returned from previous seasons, but the crew also included 3 new members. This year the vegetation crew included a trained botanist who helped sample sites in the UP and northern Lake Michigan. All field technicians were trained in and tested on all standard procedures, including a field-based fish or vegetation identification exam (depending on the crew). Training included how to determine if a site meets project criteria, all aspects of sampling the site, proper recording of data on datasheets, GPS use and uploading, water quality sample collection and meter calibration (fish/invert crew only), as well as sample processing. Much of the training took place in the field at a typical coastal site to ensure field members learned (or reviewed) appropriate techniques. Safety training covered aspects of field safety including safe boating; protection against the elements, animals, insects, and plants; and what to do when things go wrong. A CPR/AED/first aid class was also provided to fish/invert crew members.

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

Site selection

Birds and Amphibians
In 2015, a total of 63 sites were initially selected to be surveyed for birds and amphibians. Of these sites, 37 were rejected either prior to visiting the wetland (web reject) or following reconnaissance visits to each remaining site (visit reject) for one of the following reasons: 1) inaccessible or unsafe to access, 2) no trespassing signs and owners could not be contacted, 3) wetland areas were unsuitable for sampling (e.g. wetland size did not meet site selection requirements, wetland lacked connectivity to the lake), 4) exceeded the sampling capacity or was logistically infeasible for the crew to complete all surveys, or 5) benckmark site was not being sampled (Table 14). Amphibian crews were able to sample sites in northern Lake Huron beginning 05 May and bird surveys began 09 June. Sampling was completed by 08 July 2015.

Table 14. List of reasons sites were rejected in 2015. The number of sites rejected for birds and amphibians are listed by reason for site rejection. Of the 63 sites initially selected to be surveyed by the western regional team, 37 were rejected for amphibian sampling and 32 for birds.

Reason for site rejection	**Bird**	**Amphibian**
Not sampling benchmark	5	8
Could not access site	13	15
Web reject	9	9
Visit reject	5	5

The 31 sites that were sampled by bird and amphibian field crews stretched from the Duluth-Superior harbor area both northeast along the shore of Lake Superior and Ontario and eastward along the south shore of Lake Superior to the eastern end of the Upper Peninsula of Michigan and into northeast Lake Huron. In 2015, one island site was sampled (Clough Island in WI), nine benchmark sites were surveyed for birds and six for amphibians. These sites were selected because they were of interest for restoration potential. These sites were located in the St. Louis River estuary and are in some stage of planning for restoration work. Restoration activities for the sites are being coordinated by the Minnesota Pollution Control Agency and the US Fish and Wildlife Service, with many collaborators from multiple agencies and university research groups (see attached letters of support).

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

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

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

Field sampling and preliminary interesting findings

PIs and crews have quite a bit more data to work with after 5 years of sampling. Researchers, graduate students, and technical staff have been spreading the word about our project and results at national, regional, and local conferences, meetings, and workshops. A list of these presentations is included.

Birds and Amphibians
Each of the sites sampled in 2015 were visited a total of four times between 05 May and 08 July. At each site, three surveys were conducted for amphibians and two surveys were completed for birds, one of which occurs on the same evening as an amphibian survey.

Amphibians
In 2015, a total of nine species were recorded throughout our study sites, with 868 individuals and 124 full choruses counted (Table 15). The average number of individuals recorded per site visit was 9.97. The average number of species detected per wetland was 4.81 with a minimum of one and a maximum of eight. The two sites with one species recorded were a lacustrine (coastal) wetland and benchmark site on Lake Superior near Thunder Bay, and a riverine wetland in NE Lake Huron. There were three sites with eight species recorded: two lacustrine coastal wetlands on Lake Ontario and western Lake Huron, and a riverine wetland on western Lake Huron.

Spring peepers (*Pseudoacris crucifer*) were the most abundant species observed in all wetlands sampled, accounting for nearly a third of the amphibian observations and the majority of full chorus observations (Table 15). Bullfrogs (*Rana catesbeiana*), regarded as an invasive species in Great Lakes region, were observed in eight wetland sites, one in Lake Superior, one in northern Lake Ontario, two in western Lake Huron, and four in NE Lake Huron. There were multiple sites where Mink Frog (*Rana septentrionalis*) were observed this year, six of which were in wetlands on Lake Superior and two in NE Lake Huron.

Table 15. List of amphibians recorded during 2015 surveys. The number of individuals counted and the number of full choruses observed (# of individuals cannot be estimated) are provided for each species.

Species	Number of Individuals	Number of Observations (Full Chorus)
American toad (*Bufo americanus*)	40	1
Blanchard's cricket frog (*Acris crepitans blanchardi*)	0	0
Bullfrog (*Rana catesbeiana)*	29	0
Chorus frog (western/ boreal –*P.triseriata & P.maculatas*)	33	0
Green frog (*Rana clamitansmelanota*)	145	7
Gray treefrog (*Hyla versicolor*)	149	18
Mink frog (*Rana septentrionalis*)	14	4
Northern leopard frog (*Rana pipiens*)	78	5
Spring peeper (*Pseudoacris crucifer*)	329	88
Wood frog (*Rana sylvatica*)	51	1
Total	868	124

Birds

Birds were surveyed twice at each site between 29 May and 08 July. Surveys occurred once in the morning and once in the evening. There were a total of 106 identifiable species observations and 4,111 individual birds recorded. The five most abundant species observed accounted for approximately 40% of all observations. These species, in order of decreasing abundance, were Red-winged Blackbird (*Agelaius phoeniceus*), Canada Goose (*Branta canadensis*), Ring-billed Gull (*Larus delawarensis*), Common Yellowthroat (*Geothlypis trichas*), and Yellow Warbler (*Setophaga petechia*).

In the Western Great Lakes region there have been many observations of birds of special concern in the vicinity of the wetlands or using the wetland complexes in 2015 (Table 16). The most noteworthy observations included secretive marsh birds such as American Bittern (*Botaurus lentiginosus*), Virginia Rail (*Rallus limicola*), and Least Bittern (*Ixobrychus exilis*). American Bittern were observed in two wetlands including one site in Lake Superior, and one site in NE Lake Huron. There were seven sites where Virginia Rails were observed, four of which were sites in Lake Superior, all benchmark sites in the St. Louis River estuary (SLR) in the Duluth-Superior harbor, and three sites in NE Lake Huron. The Least Bittern observations were in the Chequamegon Wetland, a riverine wetland on the Bad River Indian Reservation on Lake Superior.

Seven Bald eagles (*Haliaeetus leucocephalus*) were observed at six sites. In the Duluth-Superior area alone there are at least four nesting pairs of Bald Eagles; three nests within the St. Louis River estuary and one within 0.5 mi of the shoreline within the city limits of Duluth. Additional species of interest include: Common Loon (*Gavia immer*), which were observed in six wetlands. Sandhill Crane (*Grus canadensis*) observed in 10 wetlands. Common Tern (*Sterna hirundo*) observations occurred at eight wetland locations in Lake Superior and NE Lake Huron.

Birds of special concern were observed in 30 of the 31 wetland sites surveyed in 2015 (Table 16). The lack of observations of Black Tern, Forster's Tern, and Caspian Tern (all species of concern throughout the Great Lakes) is of particular interest and concern.

Table **16**. List of birds of special interest recorded during 2014 surveys. The number of individuals observed is listed for each species.

Species	**Number of Individuals**
Sandhill Crane (*Grus canadensis*)	21
Wilson's Snipe (*Gallinago delicata*)	7
Common tern (*Sterna hirundo*)	19
American Bittern (*Botaurus lentiginosus*)	2
Virginia rail (*Rallus limicola*)	12
Bald Eagle (*Haliaeetus leucocephalus*)	7
Common Loon (*Gavia immer*)	8
Sora Rail (*Porzana carolina*)	23
Great Blue Heron (*Ardea herodias*)	13
Belted Kingfisher (*Megaceryle alcyon*)	2
Least Bittern (*Ixobrychus exilis*)	4

In early June 2013 and 2015, our team volunteered to assist the Wisconsin DNR in deploying geolocator units on Common Terns nesting on Interstate Island in the Duluth/Superior harbor. 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 eight birds that returned to nest on the island. Of the retrieved geolocators, four were from female birds and four from males. In 2015, 21 additional geolocators were deployed on birds nesting on Interstate Island and in Chequamegon Bay in Ashland, WI. The data collected during the year will be used to better understand the migratory routes of Common Terns nesting on Interstate Island and Ashland. 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.

Fish, Macroinvertebrates, and Vegetation
The NRRI field crew visited 30 coastal wetlands of Great Lakes Superior (13 wetlands) and Michigan (17 wetlands). Ten of the wetlands were benchmark sites, two were resamples, and 18 were new sites. Of the 30 total sites we rejected one as not meeting Coastal Wetland Monitoring (CWM) sample criteria, and one site could not be sampled because restoration activities were actively taking place (Figure 20). We fished a total of 40 vegetation zones, and collected invertebrate samples from 51 zones. In total, we sampled fish at 25 CWM project sites and captured more than 30,000 fish represented by 49 species. Invasive fish species were present at 17 of the 25 fished sites and round goby were the most frequently detected (present at 12 sites) and also the most abundant invasive species (representing 50% of all captured invasive fish). Other invasive fish detected were common carp, tubenose goby, alewife, and white perch. The NRRI crew collected rusty crayfish at only two sites in 2015. Painted turtles were common by-catch and Eastern snapping turtles were less common in fyke nets, with 59 and 3 captured, respectively.

Figure 20. Active restoration to remove bottom sediments at Radio Tower Bay in St. Louis River Estuary. NRRI sampled this site in 2011, but could not resample in 2015 due to continued restoration activity. It will be important to re-visit and collect more data within the next round of CWM sampling.

Two sites within the Menominee River harbor area of Marinette, WI were sampled by special request from the Wisconsin Department of Natural Resources. These data are not entered into the CWM database because the sites do not meet normal site criteria, even for restoration sites. The information gathered by NRRI field crews performing CWM methods will help WDNR resource managers assess environmental status as restoration progress is made. The area surrounding the two sites is a riverine port and ship yard. Portions of the harbor have arsenic-impacted sediments and restoration efforts have been completed in some areas and are ongoing or planned for others. NRRI field technicians found fish taxa common to other wetlands in the area, but observed an uncommonly-high density of large bryozoan colonies in the two wetlands visited (Figure 21).

Figure 21. NRRI field technician Nick Winter holding a bryozoan colony attached to a cattail stalk, and Jon Utecht setting fyke net (background) at benchmark restoration site 7067. Large bryozoan colonies were common at site 7067 and neighboring benchmark restoration site 7068.

NRRI continues to work with WDNR and The Nature Conservancy (TNC) to collect and provide data on site 1697 (BENCHMARK: Suamico River Area Wetland). Both entities are involved in the restoration activities of this wetland within Green Bay. In 2011 NRRI sampled outside a diked area following CWM methods, and in 2013 we sampled within the diked area as a special request. In 2015 the NRRI field crew sampled 1697 outside the diked area again, and in a newly created habitat called the "pike fingers" (Figure 22). The "pike finger" construction was performed in 2013 and was designed to provide shallow wetland habitat for spawning fish, particularly pike and muskellunge. In 2015 NRRI technicians observed abundant vegetative growth and detected young-of-year largemouth bass, yellow perch, and bowfin. Several other juvenile and adult fish species were captured, including northern pike.

Figure 22. NRRI sampled the newly-created "pike fingers" of Suamico River wetland (site 1697) by special request from WDNR and TNC. Numbers are sample replicate locations.

NRRI collected 62 tissue samples from black and brown bullhead throughout the entire region that NRRI samples (southern Green Bay to Thunder Bay, Ontario), and 10 tissue samples from suspected longnose X shortnose gar hybrids from just the Green Bay area. Tissue collection of specific species is part of a CWM spin-off project to detect hybridization of closely related species, and we hope to secure future funding to conduct the genetic analysis.

Two sites were sampled with special permission from the Red Cliff Band of Lake Superior Chippewa and the Bad River Band. The Bad River Band has requested that a wetland of interest on Madeline Island be sampled within the next 5 year term of the CWM project because they have limited data from that area of their Tribal land.

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

2015 Sample Processing, Data Entry, and QC

All data entry and QC for bird and amphibian, fish, vegetation, and field habitat records were completed (100%) during August-September 2015. The PIs conducted mid-season checks by visiting a few sites and verifying that proper protocol was being implemented. Macroinvertebrate identification will take place throughout the winter, with data entry and QC completed in time for the spring report. Lab water quality data should be completed, entered, and QC'd by the end of November.

Metrics and Indicator Calculations

PIs on the vegetation project have been working to analyze temporal patterns in floristic quality metrics (e.g. mean Coefficient of Conservatism, FQI). We are asking how much these metrics change from year to year in typical situations and in other cases where water level changes or human influences have been substantial through time. Throughout 2015, N. Danz has undertaken statistical analysis of the entire CWM vegetation dataset to assist the development of SOLEC plant community indicators. In addition, several hundred CWM point vegetation surveys from the St. Louis River estuary have been combined with data from a variety of other studies to develop a database with >5000 vegetation surveys. These data are being used to characterize plant condition throughout the estuary, identify reference sites, and measure the success of restoration activities.

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). Data that has been entered into the data management system and QCd to date (2011-2015) are being used to calculate some of the metrics and indicators for these wetlands.

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

Field Training

Most Central Basin Team members conducted their own training among their respective field teams in 2015. This was deemed sufficient given that all teams had a majority of technicians returning from 2014. Additionally, GVSU crew members joined the CMU crew to receive hands-on training and to review field sampling protocols on 23 June 2015. All field crews, regardless of whether they had returning technicians, conducted pre-season certification and certification records were sent to the project QA officers. All crews also completed a mid-season check to verify that protocols were being followed correctly and these records were also sent to the project QA officers.

Central Basin bird and amphibian crews were tested for identification of calling amphibian and bird calls and were trained in proper field procedures prior to initiation of 2015 field work. Amphibian training was completed by 20 March 2015 and bird training was completed on 30 April 2015. Online testing was used for identification of amphibians and birds by sight and sound and all data collectors reached proficiency before sampling. Michigan plant crews were trained and certified by Dennis Albert in Pellston, MI June 28-30, 2015.

Other Fieldwork Preparation

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

Central Michigan University

Fish, Macroinvertebrate and Habitat Crew:
From the middle of June through the middle of August, the CMU sampling crews visited 34 sites that were located on the shores of Western Lake Erie, Lake Huron, and Lake Superior. The Notre Dame crew assisted at sites in Western Lake Erie and in the Les Cheneaux Islands region. Upon site evaluation, 4 of these wetland habitats were deemed un-fit for sampling due to the lack of access or because weather conditions made it unsafe to travel to the selected wetlands. Within the 30 sampled sites, 57 mono-dominant vegetation zones were identified and sampled. Eight of these were benchmark sites for the CMU crew (5 Saginaw Bay sites, 2 Lake Erie site and 1 Northern Lake Michigan site). Thirty five vegetation zones met the requirements for sampling the full host of variables. Fish collection was not done at 22 vegetation zones because water depth did not meet the 20 cm minimum. Vegetation zones that had greater than 5 cm of water were sampled for macroinvertebrates, water quality, and physical habitat conditions. All macroinvertebrate samples collected this season have been identified and will soon be put through QA/QC procedures. Fish and physical habitat data entry is complete and is currently being put through QA/QC procedures. Water nutrient analysis is also underway and those data will also be uploaded to the database and put through QA/QC procedures upon completion of entry. Notre Dame is currently processing all chlorophyll samples collected by the Central Basin Team.

In addition to the EPA samples collected, a number of related projects have begun and/or are continuing from previous years. In addition, three graduate students in Dr. Uzarski's lab are using the EPA wetland data to contribute to ongoing manuscripts. Additionally, one undergraduate is using the data to study implications of macrophyte change on invertebrate assemblages. See "Uzarski Lab Spin-off Projects" for a more in-depth review of each project.

Amphibian & Bird Crew

All 2015 amphibian and bird survey data have been uploaded and QC'd in the database. CMU crews sampled amphibians and birds in coastal wetlands on all lakes bordering the Lower Peninsula of Michigan, eastern Upper Peninsula of Michigan, and sites in western Lake Erie bordering Michigan and Ohio during the summer 2015. Three teams, each with two members, were used throughout the sampling season. Field crews consisted of undergraduate student technicians and graduate student field crew leaders.

The CMU amphibian and bird crews surveyed 38 wetland sites, of which 12 were benchmark sites. Of the original number of wetlands we were assigned to sample, 2 sites were web rejected, 6 sites were not sampled because they could not be accessed safely for night sampling, and 4 sites were not sampled because private landowners would not grant access.

We sampled amphibians during the period from April 6 to July 10 2015 and birds from May 20 to July 10 2015. Wetlands were sampled three separate times for amphibians and two separate times for birds.

Lake Superior State University

Fish, Macroinvertebrate and Habitat Crew
LSSU Crew members were trained and certified in sampling protocols in June. From late June to August, the LSSU crew visited 11 sites to determine if they met the sampling criteria and if there were access issues. One site was not sampled because of a lack of connection to the Great Lakes. Crews returned to 10 sites and collected water quality and macroinvertebrate samples along with fish and habitat data for all vegetation zones identified. A composite water sample was collected from each site. Water samples were mailed to Central Michigan University in September for total and dissolved nutrient analyses and glass fiber filters were sent to the University of Notre Dame for chlorophyll analysis. Unknown fish identifications were verified in the laboratory and corrected on the datasheets. All 2015 field data, not including lab water and macroinvertebrate data, have been entered into the database, and were put through QA/QC procedures. Approximately 20% of our macroinvertebrate collection has been identified. In addition to processing 2015 samples, incomplete data entry for 2014 (e.g., lab data) was entered and QC'd this summer. Macroinvertebrate data identification issues for 2013 and 2014 were also corrected and updated in the database. In August, one of our technicians spent four days at NRRI working with the invertebrate taxonomists to enhance his identification skills.

As was mentioned in previous reports, NOAA is leading efforts on a restoration of flow through the Little Rapids in the St. Mary's River. Construction was delayed and is now expected to begin in spring 2016, and it is projected to restore over 50 acres of critical spawning habitat for many native freshwater fishes and provide important nursery and rearing habitat in backwater areas. Site 814 (Sugar Island 3) was added as a benchmark in 2013 to characterize changes in fish communities. Continued monitoring of this site before and after restoration will help identify changes to existing wetlands and to their use by fishes and other aquatic organisms at various life stages.

Two undergraduate students conducted their senior thesis projects in conjunction with the coastal wetland monitoring program. Both students used GLCWM protocols to compare macroinvertebrate, fish, and habitat structure between *Typha* wetlands with and without European frog-bit. Both students submitted abstracts to present their work at the Midwest Fish and Wildlife Conference in January 2016.

Finally, biologists from the DNR and DEQ recently requested data from around Raber Point (St. Marys River) to evaluate permits to install new docks for freighters. They would like to add this site (871) as a benchmark in future years. They also sent a letter of support for the project.

Grand Valley State University

Fish, Macroinvertebrate and Habitat Crew

GVSU crew members joined the CMU crew to receive hands-on training on the field sampling protocols on 23 June 2015, and Travis Ellens performed the midyear QA/QC check on 7 July 2015. The GVSU crew was able to sample 8 of 11 wetland sites that were assigned. The GVSU crew was not able to sample site 427 (Detroit River) due to access restrictions (the site was too contaminated to allow safe access). Site 1310 was rejected because water depth was less than 5 cm, and site 1656 had no plant zones large enough to meet the requirements for sampling. All remaining sampling was conducted during July-August 2015. We sampled eight wetland sites for invertebrates and water quality, and we sampled six sites for fish. In total, we sampled nine plant zones, and have completed all data entry and QA/QC procedures for habitat and fish data. We are in the process of completing data entry for macroinvertebrate and lab water quality data. Macroinvertebrate identification began in late August, and we are on schedule to have all macroinvertebrates entered and processed through the QA/QC procedures by the end of November. Samples collected for total and dissolved nutrients have been shipped to CMU and chlorophyll *a* samples have been sent to Notre Dame for processing. All remaining data will be entered and put through QA/QC when completed.

In addition to the completion of all 2015 field work, the Ruetz lab worked on a manuscript summarizing the results of an investigation to evaluate morphological and genetic (DNA barcoding and microsatellites) techniques for the identification of brown and black bullheads. Greg Chorak (a GVSU graduate student) currently is leading the writing of the manuscript for the Ruetz Lab. We are collaborating with Josh Dumke (University of Minnesota, Duluth) and Ryan Thum (Montana State University) on this work.

University of Notre Dame

Fish, Macroinvertebrate and Habitat Crew

UND crew members assisted the 2015 CMU sampling effort by providing humanpower and equipment for seven sites in western Lake Erie and Lake Michigan. At these sites, the UND crew assisted with deploying and retrieving fyke nets, collecting macroinvertebrates, and site habitat characterization (Figure 23). We have also received frozen plankton filters for chlorophyll-*a* from researchers at University of Windsor, GVSU, Environment Canada, LSSU, and CMU, which should be similar in number to last year's effort of 172 samples. Analyses of chlorophyll-*a* samples are in progress and data will be returned to the various crews after completion/verification of QA/QC procedures. One graduate student and one undergraduate student, along with a seasonal technician, were supported by this project and a leveraged project (see below).

Figure 23. UND and CMU crews setting up fyke nets for fish sampling at Site 1898 (Woodtick Peninsula - Western Lake Erie)

Figure 24. UND and University of Wisconsin-Green Bay personnel using a UND electrofishing boat to collect fish at Burns Harbor wetland in Portage, IN, as part of a leveraged project on wetland-nearshore linkages funded by Illinois-Indiana Sea Grant and Wisconsin Sea Grant.

In addition to assisting the CMU sampling effort, UND conducted field work for a related Sea Grant-funded project to quantify coastal wetland – nearshore linkages for sustaining sport fishes (Figure 24). We are now processing zooplankton, macroinvertebrate, and fish samples collected in 2015 for stable isotope-based food web analysis; additionally, otoliths from collected sport fish samples have been removed for microchemical analyses by CMU. This project is a collaboration with Patrick Forsythe (University of Wisconsin – Green Bay), Don Uzarski (Central Michigan University), and Martin Berg (Loyola University Chicago).

Oregon State University

Field Work and Data Entry

One graduate student from Oregon State University, one graduate student from Central Michigan University (CMU), and one undergraduate paid intern from CMU were hired prior to the 2015 field season. Michigan plant crews were trained and certified by Dennis Albert in Pellston, MI June 28-30, 2015. Two plant samplers passed the test and were certified to lead a sampling team, and a third was certified to work as assistant.

Field sampling for vegetation was completed at 51 sites within Michigan, including sites on Lakes Superior, Michigan, Huron, St. Clair, and Erie, and the St. Marys River, including 14 benchmark sites. The sampling team had weather-related access problems on site 781 Potagannassing River on Drummond Island, where only one transect was sampled. The plant team director, Dennis Albert, reviewed all unknown plants collected by the sampling crews.

Dennis Albert reviewed all field forms prior to data entry. Data entry has been hampered by early loss of sampling staff; plant data entry is expected to be complete by October 15, and QCed by Dennis Albert by late October, 2015.

Related Research Projects

The OSU team continued to work with Laura Chavez to assist in training plant samplers and also provided plant data for studying paired treated and untreated *Phragmites* plots. Dennis Albert met on Neebish Island with tribal biologists of the Sault Ste. Marie tribe, Loyola University Chicago researchers, Dartmouth University professor Nick Reo, and a post-doc to discuss how Coastal Wetland Monitoring data that was collected on the St. Marys River and Neebish Island could be used as base-line data for a tribal coastal restoration project on Sand Island, a small island between Sugar and Neebish Islands. Coastal Wetland Monitoring data were also used as baseline data for two additional GLRI projects: "Sustainable Restoration for Great Lakes Coastal Wetlands", with a second phase titled " Furthering capacity to maintain high quality coastal wetlands in N. MI. " Partners in these projects were Loyola University Chicago, De Paul Univerity, University of Michigan, Lake Superior State, and Oregon State University, and the projects resulted in the harvest of 30 acres of hybrid cattail (*Typha* x *glauca*) at Cheboygan (Figures 25 and 26) and 7 acres at Cedarville, as well as additional hybrid cattail harvests on Sand Island in the St. Marys River and Mentor Marsh near Cleveland, OH. Plant sampling was also conducted at the Maumee Bay (Erie Marsh Hunt Club) restoration site, where an underwater channel was constructed to reconnect 250 acres of diked marsh back to Lake Erie, and other dike upgrades and treatment of invasive plants continued into 2015.

Figure 25. One of several hybrid cattail harvest and restoration sites at Cheboygan, MI. This project is using data from the Coastal Wetland Monitoring Project but is funded by other sources.

Figure 26. Harvesting hybrid cattail as part of Cheboygan, MI coastal restoration project. This project is using data from the Coastal Wetland Monitoring Project but is funded by other sources.

Presentations: A presentation summarizing work from this project was made at a June meeting of Midwestern and Canadian biologists involved with restoration of wetlands through the harvest of invasive plants, including hybrid cattail and *Phragmites australis*.

Important results:

1. A high quality Lakeplain Prairie complex, a rare plant community throughout the Great Lakes region, was found during our plant survey of St. Johns marsh in an area that had been proposed for a dike enhancement project by the Michigan DNR (Figure 27). The site contains abundant milkweed plants, which appear to include both common milkweed (*Asclepias syriaca*) and rare Sullivant's milkweed (*A. sullivantii*, avaiting confirmation), both of which were being used by monarch butterflies. The survey has resulted in ongoing discussions concerning the proposed boundaries of the project.
2. No new invasive plant species were documented in Michigan.
3. No expansions of the invasive species frog-bit (*Hydrocharis morsus-ranae*) were documented in either Lake Michigan or Lake Superior.
4. Both sampling teams continued to separate *Phragmites australis* occurrences into native and invasive populations to improve tracking of invasiveness of this species. There did not seem to be any problems making this separation.
5. Sites with ongoing mowing and *Phragmites* treatment by private landowners were greatly reduced in 2015 due to high water levels.
6. One rare plant, Houghton's goldenrod (*Solidago houghtonii*) was encountered on a large stretch of privately owned shoreline along the northern shore of Lake Michigan, but no plants occurred in any of the sampling plots. As in past years, several orchids were found in the coastal wetlands, including Loesel's twayblade (*Liparis loeselii*), rose pogonia (*Pogonia ophioglossoides*), grass-pink (*Calopogon tuberosus*), and hooded ladies'-tresses (*Spiranthes romanzoffiana*), but these were less abundant than in past years because of high water levels. None of these orchids are federally or state listed species, but as orchids they have protection from commercial harvest under state regulations.
7. Sampling was much slower with increased water levels on all of the lakes due to high water levels.
8. Some signs of *Phragmites australis* mortality was seen resulting from storm waves, but these dead plants were at the outer edge of the beds, and were pushed into a thick, dense wrack that reduced storm damage to the Phragmites beds closer to shore. This appears to indicate that Phragmites beds may be protected from large-scale destruction in many of the beds that expanded during the 1999-2013 low water years.
9. The meter increase in water depth in 2014 and 2015 has resulting in wide-scale erosion of many wetland macrophytes, including shrubs. These destroyed plants formed a significant wrack along the shore of many of the sampled marshes. Bulrush species (*Schoenoplectus pungens* and *S. acutus*) were much less prone to damage than more shallow rooted plants.

Figure 27. GLRI sampling site at St. Johns Marsh, July 23, 2015.

Quality Assurance / Quality Control

All Central Basin field crews (CMU, GVSU, UND, LSSU, and OSU) reviewed and signed the QAPP and SOPs during the spring, prior to field sampling. Crew members were then certified or re-certified for each protocol they would be responsible for conducting. Supervising PIs/Co-PIs conducted the mid-season checks in most cases. All field crews passed these evaluations and no corrective actions were necessary during the 2015 field season. Documentation for these mid-season QA/QC checks has been filed with the QA managers and lead PI Uzarski. All data entered into the data management system has already or will soon be QC'd. Quality issues were detected in 2014 for a subset of invertebrate taxa identified in 2013 samples. These issues were rectified by having an expert macroinvertebrate IDer from the GVSU crew join the LSSU staff to re-process LSSU's 2013 invertebrate samples. Identification and data entry for these samples has been completed and the database was updated.

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

Site Selection

The College at Brockport worked with Environment Canada and Bird Studies Canada in late winter to redistribute site assignments to match crew capacities relative to the spatial distribution of sites. Six Environment Canada sites were reassigned to Brockport for fish, aquatic macroinvertebrate, water quality, and vegetation sampling, and two additional sites were also reassigned to Brockport for bird and amphibian sampling. Four sites within the Rochester embayment were added to the 2015 Brockport list as benchmarks related to restoration projects that are currently being planned or have been implemented in the Rochester Embayment Area of Concern. Finally, The College at Brockport received two “repeat sampling” sites which, in addition to the randomly selected and benchmark lists, brought The College at Brockport’s list up to 24 sites for fish, aquatic macroinvertebrates, water quality, and vegetation sampling, and 30 for bird and amphibian sampling.

Training

Over half of the crew members from 2014 returned in 2015; thus, training sessions with principal investigators served as refreshers for many of the crew members. Dr. Christopher Norment certified the bird and amphibian crew members on species ID using visual and auditory cues, distance estimations, and appropriate data collection methods. All surveyors passed the appropriate certification exams prior to the beginning of sampling.

Fish, aquatic macroinvertebrate, and water quality crew members were trained and certified on setting fyke nets, sweeping macroinvertebrates, water quality meter use and calibration, proper QA skills, fish identification, and vegetation-zone identification by Dr. James Haynes (co-PI, fish), Gary Neuderfer (co-PI, macroinvertebrates), and Brad Mudrzynski (field crew chief) in spring 2015. All fish, macroinvertebrate, and water quality crew members met all sampling standards set by the project. Finally, all crew members passed the mid-season QA check administered by Dr. Douglas Wilcox (PI) at Port Bay on July 15 and 16.

Vegetation crew members were trained on plant identification, proper transect layout, percent cover estimations, GPS use, and data collection methods by Dr. Douglas Wilcox in early June at Brush Creek. All crew members met the standards set forth in the project QAPP, including a species identification exam in the field. All crew members also passed the mid-season QA check at Port Bay on July 15 and 16.

Sampling

Bird and Amphibian Sampling
The Brockport bird and amphibian crew successfully sampled 27 of 30 assigned sites between 1 April and 10 July 2015. Two of the sites were not sampled because they did not meet the size and/or habitat requirements defined in the Quality Assurance Project Plan, and one did not have a safe access location.

Fish, Macroinvertebrate, Water Quality, and Vegetation Sampling
The Brockport sampling crew began sampling on 29 June and finished on 12 August. One of the 24 assigned sites lacked a semi-permanent connection to the lake, one site was not safely accessible, and two sites did not have the appropriate habitats to sample as they only contained forested wetland and rocky beach habitats; therefore, sampling was limited to 20 sites.

Laboratory Work

Fish crew members have identified all six of the unknown fish samples that were brought back for further investigation. Laboratory-generated water quality analyses by NRRI are 90% complete, with the remaining 10% of the data yet to be generated. Macroinvertebrate identification is approximately 50% done and is anticipated to be complete by December 2015. Data quality control checks have not started on laboratory-generated water quality data.

Data Entry and QA

Data entry for birds, amphibians, field-level water quality, macroinvertebrates, fish, and vegetation are 100% complete. All bird, amphibian, fish, and vegetation data have received quality control checks, while water quality and macroinvertebrate data quality checks have not started yet since data are still being generated.

Interesting Findings and Observations

Invasive Species
Mute Swan (*Cygnus olor*) continues to increase in numbers in the region that The College at Brockport samples. However, it was only detected in two sites, Brush Creek and Buck Pond, during actual surveys this year. The College at Brockport continued to find an increasing amount of water chestnut (*Trapa natans*) in Lake Ontario. Water chestnut was present in over one third of the sites sampled for vegetation; however, not all detections occurred in official quadrats. One site, Rice Creek, contained an infestation that was both large and dense enough to be sampled as a zone for fish, water quality, and aquatic macroinvertebrates. Invasive cattails (*Typha X glauca* and *Typha angustifolia*) continued to be the most common invasive plant species throughout The College at Brockport's sampling range, mainly Lake Ontario, and

were present in all sites sampled. Other invasive plant species that were detected include Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), curly-leaf pondweed (*Potamogeton crispus*), and European frogbit (*Hydrocharis morsus-ranae*), all of which were detected in at least 30% of sites sampled. Invasive fish species were less common, with round goby (*Neogobius melanostomus*) and common carp (*Cyprinus carpio*) being the most common and were found at 6 and 3 sites, respectively. White perch (*Morone americana*), rudd (*Scardinius erythrophthalmus*), and alewife (*Alosa pseudoharengus*) were not as common and were found at 2, 1, and 1 site, respectively.

Working with Local Groups

The College at Brockport designated four sites as benchmarks for 2014: Buck Pond (51), Buttonwood Creek (7026), Long Pond (29), and Braddock Bay (7052). Data collection at Buck Pond will assist two GLRI-funded restoration projects. One project was completed in the winter of 2014/2015 and the other will start in the winter of 2015/2016. Data collected will serve all projects. Buttonwood Creek was also restored in 2014/2015; therefore, data collected in the summer of 2015 will serve as post-restoration data. Long Pond will be restored in fall of 2015 by the U.S. Fish and Wildlife Service using GLRI funds, and our sampling will expand the pre-restoration dataset to two years of data. Surveys at Salmon Creek, a randomly selected site for 2015, also extended the pre-restoration dataset to two years at that site for its upcoming restoration by FWS in fall 2015 as well. Finally, the U.S. Army Corps of Engineers will begin GLRI-funded restoration at Braddock Bay in the fall of 2015, and our 2015 sampling will add to its ongoing pre-restoration dataset.

The College at Brockport communicated with a number of groups, including the NYS Department of Environmental Conservation, The Nature Conservancy, The Finger Lakes Partnership for Regional Invasive Species Management (PRISM), and the U.S. Fish and Wildlife Service on the increasing number of areas affected by water chestnut. Additionally, Brockport helped to coordinate and perform a few water chestnut pulls based on the results of their summer sampling at Braddock Bay in hopes of preventing the small infestation from taking over larger portions of the bay. Finally, sampling at Rice Creek by this project uncovered a previously unknown large stand of water chestnut. The College at Brockport notified the St. Lawrence and Eastern Lake Ontario PRISM and Oswego County Soil and Water Conservation District immediately, who then began efforts to remove the infestation.

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

Field Training

Birds and Amphibians
Training for birds and amphibians was delivered by PI Doug Tozer on March 26, 2015 at Bird Studies Canada National Headquarters in Port Rowan, Ontario. Field crew were instructed in the project's objectives and methodology, and site selection procedures and station placement guidelines within selected wetlands. The amphibian and bird survey field protocols were covered in detail. The crew leader was also instructed in methods of reporting, safety, data entry, and assessed for his ability to use GPS instruments with adequate precision and accuracy as per the quality assurance project plan. The crew's comprehension of the topics was evaluated with a written and practical test. All people collecting data also successfully completed the online amphibian and bird identification tests. A mid-field-season check was subsequently made in June at Long Point on Lake Erie by Doug Tozer. No problems were identified.

Fish, Macroinvertebrates, and Water Quality
Canadian Wildlife Service (CWS) field crew members who worked with fishes, macroinvertebrates, and water quality sampling were trained by Daniel Rokitnicki-Wojcik in the Toronto Region during June and July field visits**.** A number of crew members returned from previous years and all members participated in training on project protocols. The sampling protocol, technical equipment use, occupational health and safety, and field-based decision-making were covered in detail over multiple days. Crew members were assessed in the field and lab for proper sample collection, data recording, GPS use, field lab water processing, equipment calibration, and lab sample preparation and storage. An experienced staff member was paired with new personnel to reinforce project protocols and ensure high data quality. A mid field-season check was conducted in late-July/early August. No problems were identified.

Continuing University of Windsor field crew members who worked with fishes, macro-invertebrates, and water quality sampling had worked on the project in 2014, and so only a review and refresher of protocols was needed for those individuals. They were also engaged in training new field crew members. The training and review included instruction in GPS use, assessment of whether sites met project criteria (open water connection to lake, presence of a wetland, safe access for crew), identification of vegetation zones to be sampled, water quality sample collection, preprocessing and shipping to water quality labs, calibrating and reading field instruments and meters, setting, removing, cleaning and transporting fyke nets, and protocols for collecting and preserving macroinvertebrates. Crews received additional training and testing in field data and lab entry. All field personnel were given refreshers in basic fish identification training. Celine Lajoie attended the Royal Ontario Museum's courses in fish identification and Ontario Species at Risk.

University of Windsor crew leaders in 2015 were Janice Gilbert, Joseph Gathman, Jeff Buckley and Jasmine St. Pierre (M.Sc. students). Returning crew members were research assistants Jessica Owen and Celine Lajoie. All field team members were also given field and lab safety training, and were required to re-read the Standard Operating Procedures for the project. New field assistants included Katharina Garland, Rebecca Glover and Courtney Ochs and Chantal Dings-Avery. All accompanied the field teams on preliminary reconnaissance trips, and were instructed in basic sampling protocols prior to beginning the formal field season.

For the CWS crew, field lead Daniel Rokitnicki-Wojcik trained the fish sampling crew led by Jon Midwood. Daniel refreshed the water quality and invertebrate sampling crew comprised of all returning member.

Vegetation

Vegetation surveys were conducted by expert botanists Janice Gilbert (returning each year since 2011) and Carla Huebert (returning from 2012 and 2013). They received the same general instructions and project orientation as did the other groups. In addition, they reviewed the specific vegetation sampling methodology and data recording methods outlined in the QAPP and modified at the January 2015 Principal Investigators meeting. For the CWS crew, Daniel Rokitnicki-Wojcik led the vegetation sampling and identification and was assisted by Jennifer Jung. Various summer students and Canadian Wildlife Service personnel assisted in data collection and acted as data recorders.

Water Quality Samples

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

Site selection and field sampling, and results

Birds and Amphibians
Bird and amphibian field crews evaluated 64 sites that had been selected and ordered for potential sampling in 2015 (32 on Lake Ontario, 21 on Lake Huron, and 11 on Lake Erie). Of these, 6 were not surveyed because access was unobtainable (despite valiant efforts by surveyors) and 5 were rejected because the sites did not meet the project's criteria for sampling. Six of these 11 "missed" sites were on Lake Huron, 3 were on Lake Ontario, and 2 were on Lake Erie. Forty-three sites were visited (each on 5 occasions) and sampled for amphibians and birds.

Fish, Macroinvertebrates, Water Quality, and Wetland Vegetation
The CWS crew visited and evaluated 11 locations along the north shore of Lake Ontario. All but one of these sites had been assessed by the bird and amphibian field crews. Three sites were rejected prior to field visits because of land tenure and physical characteristics. Forester's Island (5306) and Big Sand Bay (5090) were rejected due to their locations on aboriginal and private lands, respectively, for which for which access could not be secured. Martindale pond (5589) was located upstream of a hydroelectric dam and did not meet the coastal influence criteria of the project. One site was visited but was deemed only suitable for vegetation sampling (West Lake Wetland 6) due to a lack of inundated vegetation zones that met the size criteria. Of the 11 sites, 2 were resamples from 2014, and an additional site was resampled as a benchmark site (Rattray Marsh). Rattray Marsh was included as an additional site at the request of Credit Valley Conservation Authority to provide post-restoration data to track the success of the second phase of their wetland restoration project.

The fish, macroinvertebrate and vegetation crews evaluated 47 sites (11 on Lake Ontario as described above), and 36 on lakes Erie and Huron or the connecting channels. All of these sites had also been assessed by the bird and amphibian field crews. Three sites were not sampled because permission was not granted either by a landowner (one case) or because they were on aboriginal land for which we did not have permission to sample (two sites). Six sites were visited but deemed unsuitable (too small, not connected to a Lake or lacking in wetland habitat). Thus, a total of 43 sites was actually sampled (11 by CWS on Lake Ontario, 9 on Lake Erie (2 of which were in Ohio) and 23 in Lake Huron (including the North Channel, St. Marys River and Manitoulin Island).

Vegetation was sampled at 42 sites. Of these, 37 sites were also suitable for water quality and macroinvertebrate sampling, while only 35 of these sites were also suitable for fish sampling. The full suite of water quality, fishes, macroinvertebrates and wetland vegetation was assessed at these 35 sites by our group (25 by Windsor, 10 by CWS on Lake Ontario).

Other sites sampled in Canada
To help address regional differences in sampling capacity, the SUNY Brockport crew sampled four wetlands in northern Lake Ontario. One additional wetland was visited and rejected due to a lack of wetland habitat within the sampling polygon (Sand Bay 3 – 5857) and another wetland was rejected due to lack of access (Four Mile Pond -5312).

5406R- Hay Bay Marsh 7
5088- Big Island Marsh
5536- Long Point Bay Marsh 1
5312- Four Mile Creek Estuary - could not access site
5005- Adolphustown Marsh 2
5857- Sand Bay 3 - visit reject – no wetland habitat

Benchmark sites
Six benchmark sites were identified for sampling in 2015 (Crane Creek, in the Ottawa National Wildlife Refuge, OH, Rattray Marsh, on the north shore of Lake Ontario, Stokes Bay Wetland 1 and Old Woman's River on the Bruce Peninsula of Lake Huron, and Collingwood Harbour Marsh 5 and Sturgeon Bay on the eastern shore of Georgian Bay). The Crane Creek site continues to be a study area of interest to the USGS, who wished to see how the findings of their GLRI-funded work compared with the results of surveys using the standardized Coastal Wetland Monitoring methodology (K. Kowalski, USGS, Ann Arbor, MI, *pers. Comm.*). This site had been sampled annually beginning in 2012. We expect to continue our collaboration with the USGS team to compare our among-year estimates of variation with their repeated-sampling-within-year design. This will provide important information on the degree to which a single, synoptic visit represents the community as assessed by repeated sampling over the course of a field season. Rattray Marsh was sampled by CWS at the request of the Credit Valley Conservation Authority. The Bruce Peninsula sites were sampled at the request of local Conservation Authorities. The Sturgeon Bay site was sampled to provide ongoing information to Environment Canada on possible eutrophication problems.

Data Entry and Quality Assurance

All amphibian, bird, fish, vegetation and field-collected water quality data have been compiled, entered into the database, and quality assured. Some macroinvertebrate samples collected by the Windsor team have been examined, identified to the family level, entered into the database, and the identifications quality checked according to QAPP protocols. Identification of invertebrate samples from the Lake Ontario sites sampled by CWS is in progress. We have received, entered and Quality Assured laboratory analyses of Water quality data from all but 6 sites.

Significant Observations:

Birds and Amphibians:

Of note were 229 point occurrences of 14 Ontario bird species at risk. This is a substantial increase over the number of point occurrences observed in 2014:

		No. Occurrences	
Species	**COSEWIC Status**	**2014**	**2015**
Bald Eagle	special concern	6	7
Barn Swallow	threatened	39	110
Bank Swallow	threatened	23	40
Black Tern	special concern	4	21
Bobolink	threatened	3	5
Chimney Swift	threatened	1	9
Common Nighthawk	threatened	2	3
Eastern Meadowlark	threatened	6	5
King Rail	endangered	1	1
Least Bittern	threatened	24	27
Red-headed Woodpecker	special concern	0	1
Total		**109**	**229**

Also of note were 43 occurrences of Chorus Frog, which is listed as threatened in Canada (vs. 12 observations in 2014).

Fishes and Invertebrates:

Non-native Round Goby (*Neogobius melanostomus*) were found at 4 wetlands, which were situated in the Bay of Quinte (3 sites) and along the north shore of Lake Ontario (Grafton Swamp - 5358).

Relatively few other species of note were observed during the 2015 field season. A Mottled Sculpin was captured for the first time in our sampling program, from a site on St. Joseph Island of the St. Marys River. This occurrence possibly reflects the higher water levels that were a feature observed at most wetland locations in 2015. Fish catches overall, but especially in Georgian Bay of Lake Huron were qualitatively larger than had been observed in the two preceding years of the project. The stratified repeated sampling design of the CWM program, which allows us to track year-to-year variation in wetland communities is providing us with an unparalleled opportunity to observe the biological variation associated with cyclic changes in water levels of Great Lakes coastal wetlands. We will also be able to document whether resilience (the ability of communities to recover from marked natural and human-caused perturbations) of wetlands whose boundaries are limited by coastal structures differs greatly from the resilience of unconstrained wetlands.

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

Reptiles

The Canadian Wildlife Service is responsible for developing recovery strategies and management plans for turtle species listed as at risk in Canada. As required under the Species at Risk Act (SARA), critical habitat is a required component of the Recovery Strategy for four at risk turtles: Blanding's Turtle (*Emydoidea blandingii*), Eastern Musk Turtle (*Sternotherus odoratus*), Spotted Turtle (*Clemmys guttata*), and Spiny Softshell Turtle (*Apalone spinifera*). Critical habitat is based on the suitable habitat where turtles have been observed. Examples of suitable habitat are wetlands and watercourses; such as marshes, rivers, and some lakes. Incidental observations from the Great Lakes coastal wetland monitoring project of the Great Lakes Restoration Initiative (GLRI), as well as other sources of turtle observations have identified many suitable habitat locations for proposal as candidate critical habitat for species specific recovery strategies. The data provided from GLRI were invaluable in providing multiple turtle sightings, this identifying additional critical habitat sites.

Twenty-four Eastern Musk Turtles (*Sternotherus odoratus*) were recorded at 4 wetlands – 14 at 5257 (East Lake 5) and 8 at 5256 (East Lake 4), respectively. These observations in particular are significant and suggest that there could be a robust population in East Lake. This species is listed as threatened in Canada, and these new records will be of use in recovery planning for the species. In addition, 23 Eastern Snapping Turtles (*Chelydra serpentina*) were recorded at 9 of 11 wetlands – this will help identify additional coastal wetlands of conservation significance for this species of special concern.

Vegetation

With new knowledge of the presence of Starry Stonewort (*Nitellopsis obtusa*) in the Lower Great Lakes, surveyors made extra effort to look for and positively identify this non-native macroalgae during wetland surveys.

In total, 8 of 11 Lake Ontario wetlands sampled contained *Nitellopsis,* which was identified during both vegetation and fish sampling. All wetlands with positive records were located in eastern Lake Ontario, which has been shown to have both a greater areal extent of wetland habitat and higher IBI scores than western portions of Lake Ontario. With the recent arrival of another aquatic invasive plant (water chestnut, *Trapa natans*) to two wetlands located at the inflow of the St. Lawrence River, eastern Lake Ontario wetlands could become increasingly affected by aquatic invasive species in the near future. Ongoing efforts such as the CWM project are critical to identifying sites for management and restoration, in addition to providing important information to better understand the potential impacts and provide surveillance of these species.

It is not currently known whether there are direct impacts of *Nitellopsis* on wildlife. However, in many instances where it has been observed, *Nitellopsis* is dominant in the aquatic portion of the marsh, where native submerged and floating vegetation would typically exist. Although no explicit *Nitellopsis* zone was fished, it did occur abundantly within a few lily zones. Water levels in Lake Ontario were relatively high this sampling year, rendering a number of *Nitellopsis* beds too deep to qualify as a sampling zone. Depending on future water level conditions, it is possible that *Nitellopsis* zones will be sampled in subsequent years. Anecdotal observations indicate that *Nitellopsis* growth is able to completely fill the water column from substrate to surface at water depths greater than 2 m. This represents a tremendous amount of biomass that could act as a significant barrier to fish and wildlife movement in coastal wetlands.

To fully account for *Nitellopsis* in the CWM project data, it is suggested that all *Nitella sp.* records from the Lower Lakes be examined and noted for potential future follow up. In addition to Lake Ontario, the Canadian Wildlife Service has identified *Nitellopsis* in Lake St. Clair and the Detroit River and so it is suggested that CWM regional partners in both Canada and the US be trained in proper identification of the species; and determine if any other misidentified macroalgal records (Characeae) exist.

We made some potentially significant observations regarding the distribution of invasive *Phragmites* in wetland on the southeast shore of Lake Huron. During the period of successive low water years, many wetlands in this area, up to the Bruce Peninsula, were left stranded, or perched, above a rocky shoreline that was exposed by the low water. The bedrock shelves prevented wetland expansion into the lower-elevation rocky substrates. However, *Phragmites* colonized these areas though outgrowth of horizontal rhizomes. This had led to the establishment of *Phragmites* beds at a lower elevation than these wet meadows, and lower even than some of the more hydrophilic marsh plants (e.g., bulrush), now that the water has risen. It would be informative to establish a standard protocol for monitoring these *Phragmites* patches relative to water levels to see how these new monoculture areas develop. This could represent a significant new mode of expansion of this aggressively invasive species. We are considering designating some of these locations as special benchmark sites for a sub-project on *Phragmites* patch development.

Another observation with regard to invasive *Phragmites* was the remnant viability of stem portions from previous year's growth. During the winter months, established *Phragmites* along the lake shorelines becomes exposed to shifting ice and wave action which can break the brittle stalks. These stalks become mobile and are eventually deposited elsewhere. Except for creating a barrier to plant growth, where the piles are thick, the distribution of these dead stalks was not thought to be a concern. In June of this year, a thick *Phragmites* strandline was observed within an embayment on the Lake Huron side of North Bruce (Figure 28). The stalks appeared dead but upon closer inspection small portions of the brown, dried stalks were still green. And, on some of these stalks, particularly those lying in moist areas, new shoots and roots were emerging from the nodes (Figure 29). This finding provides even greater evidence of the adaptable nature of this highly problematic invasive plant.

Figure 28. Thick strand line of *Phragmites* stalks from the previous year's growth that had deposited onto a Lake Huron shoreline, June 2015.

Figure 29. New shoots and roots emerging from prostrate stalks from the previous year's growth that had deposited onto a Lake Huron shoreline, June 2015.

Another invasive plant that has been observed within most of the Lake Erie and Lake St. Clair wetlands is *Hydrocharis morsus-ranae* (European Frogbit). This small floating plant appears to be most plentiful and potentially problematic within high nutrient sites. Wetlands located in agriculturally dominated watersheds tend to experience the highest populations and in some locations the biomass was of sufficient density to prevent access by fish and other aquatic wildlife. In many of the wetlands in which this species is present it is not mono-dominant. *H. morsus-ranae* was observed being heavily eaten by insects in the Gates Creek wetland this year (Figure 30).


Figure 30. Heavily eaten *Hydrocharis morsus-ranae* in the Gates Creek wetland, Lake Erie.

Collaborations

The CWS team engaged in discussion and/or site visits with the following individuals or groups during the 2015 field season.

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

We spoke with local landowners adjacent to or near the following sites – Sawguin Creek 1, Presqu'ile Bay 9, South Bay 2, and Grafton Swamp. In cases where it was necessary, we were granted access but otherwise provided background on the project and the results of our findings.

Project Leverage Examples

The Canadian Wildlife Service – Ontario Region has been working to better understand factors related to the presence of *Nitellopsis obtusa* in the Great Lakes coastal wetlands. The CWM project has allowed the program to extend surveillance to additional wetlands in Lake Ontario.

This species is of great conservation concern because its current distribution and potential impacts on fish and wildlife are unknown. It was first recorded in the Great Lakes basin in the late 1970s and has not received a great deal of attention until it was more recently rediscovered.

In addition, the CWS is interested in determining the natural variability in Index of Biotic Integrity values during sampling events in coastal wetlands. This will allow agencies to determine the minimum change in an index score that represents a measurable change in biotic metrics or chemical parameters. This type of information is of great interest for resource management agencies and partners who are looking for assistance in interpreting changes in biotic indices through time, especially with respect to pre- and post-restoration projects. The CWM project has allowed CWS staff to collect information at additional sites to supplement its current study.

Special efforts were continued in 2015 to develop and foster good stakeholder relationships and to establish collaborations with local groups around the Great Lakes with whom we could interact, explain the purpose and value of the project, and possibly solicit collaborations. Although we continue our efforts to contact the environmental liaison individuals for First Nations lands we again had limited success in collaborating with them

We engaged in discussion and/or site visits with the following individuals or groups during the 2015 field season:

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

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

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

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

ASSESSMENT AND OVERSIGHT

The project QAPP was approved and signed on March 21, 2011. A revised QAPP (r3) was approved and signed on March 19, 2012. The QAPP_r3 was reviewed again by project co-PIs and their technical staffs during the fall of 2013 and was discussed at the January 2014 coordination meeting in Midland, MI. After review, three areas required updates prior to the 2014 field season: Adding an ion chromatography method for determination of SRP; switching to the new edition of the field guide for Great Lakes coastal wetland flora (*The Field Manual of Michigan Flora* by Voss and Reznicek 2012); and adjusting vegetation sampling slightly for detection of invasive species.

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 2015 project meeting and the following changes were made:

Personnel changes:

- Dr. Brent Murray, formerly a Research Professor at Central Michigan University, took a 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 was filled by Dr. Ely Kosnicki. (Note: since the spring meeting, Dr. Kosnicki left Brockport and Dr. Neuderfer resumed his 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: 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: 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 12 months include:

- Training of all new laboratory staff responsible for macroinvertebrate sample processing: This training was conducted by experienced technicians at each regional lab and was overseen by the respective co-PI or resident macroinvertebrate expert. Those labs without such an expert sent their new staff to the closest collaborating lab for training. 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. The taxonomist for Lake Superior State U traveled to Duluth to train with NRRI taxonomists for 4 days.

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

- GPS testing: Every GPS unit used during the 2015 field season was tested for accuracy and its ability to upload data to a computer. Field staff collected a series of points at locations that could be recognized on a Google Earth image (e.g., sidewalk intersections) then uploaded the points to Google Earth and viewed the points for accuracy. Precision was calculated by using the measurement tool in Google Earth. Results of these tests have been archived and referenced to each GPS receiver by serial number.

- Review of sites rejected after initial site visits: In cases where a site was rejected during a site visit, the reason for rejection was documented by the field crew in the site selection database. The project QA officers (Brady and Cooper) then reviewed these records to ensure consistency among crews. Occasionally, field crew leaders contacted Uzarski, Brady, or Cooper by cell phone when deciding whether to reject a site. However, given that most crew leaders have been with the project for over 4 years, they are able to make these decisions more independently than in previous years.

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

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

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

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

2011-2014 data and is mostly complete for 2015 data. QC should be complete for 2015 data in the spring.

- Linking of GPS points with field database: Inevitably, errors creep in when crew type in GPS waypoint names and numbers. Even a space or capitalization in the wrong place can break the link between the GPS database file and the field data database. All non-linking points between these two databases were assessed and corrected in 2014. Each winter this correction will be done for the previous field season's GPS waypoints.

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

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

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

Example Water Quality QC Information

Laboratory Quality Assurances:
Water quality analyses from 2015 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 2015 have passed (or will pass) the criteria shown below (Table 17).

Table 17. Data acceptance criteria for water quality analyses.

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

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

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

The same can occur with analyte lab duplicates, and in these instances the QA officer will determine whether data are acceptable. It is also important to note that RPD on field duplicates incorporates environmental (e.g., spatial) variability, since duplicate samples are collected from adjacent locations, as well as analytical variability (e.g., instrument drift). Therefore, RPD of field duplicates is generally higher than RPD of laboratory duplicates. Table 18 below lists average RPD values for each year of the project (2011-2014). Higher than expected average RPD values were associated with a preponderance of near detection limit values for ammonium, nitrate, and soluble reactive phosphorus (SRP), and high spatial variability for chlorophyll and turbidity. Other variables, such as alkalinity and chloride, had values that were well above detection limit and low spatial variability; therefore, these values had much lower average RPD. Acceptance of data associated with higher than expected RPD was determined by the QA officers. As the full set of water quality data become available, the 2015 RPD table will be expanded as in the spring 2015 report.

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

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

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

Communication among Personnel

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

The current version of the QAPP and SOPs (Revision 5) is an improvement over the previous version in that some minor inconsistencies have been eliminated, some additional clarification has been added, additional methodology for soluble reactive P, total P, and ammonium has been added, a new wetland flora has been approved for use, and vegetation sampling has been streamlined to make things safer and more efficient for field teams.

Regional team leaders and co-PIs have held conference calls and e-mail discussions regarding site selection and field work preparation throughout the duration of the project. Most PIs spent the first week of field season in the field with their crew to ensure that all protocols were being followed according to the standards set forth in the QAPP and SOPs and to certify or re-certify crew members. Nearly every crew consisted of >50% returning and experienced personal, which made the training period for 2015 again very efficient. PIs then visited their teams again during the middle of the season to ensure that all sampling was conducted in accordance with the training and the QAPP. PIs kept in close contact with crews via cell phone, text, and email, and the leadership team was also always available via cell phone and text to answer the most difficult crew questions. In 2014 and 2015, questions were often about how to deal with higher water levels and unusual vegetation zones created by these greater depths.

Required Corrective Action

Identification of a subset of invertebrate taxa at one regional laboratory was found to be inconsistent with other labs. These inconsistencies were discovered during blind trading of 2013 samples. Corrective actions to rectify this issue have included auditing samples for the entire project (2011-2013) for the lab in question and hiring an experienced taxonomist from a different regional lab to re-process samples for the samples in question. This process was completed by the end of 2014. To alleviate the risk of this problem occurring in 2015, the new taxonomist from the lab in question traveled to another regional lab for invertebrate identification training. In addition, all macroinvertebrate ID labs were reminded that there should be no guessing in an attempt to more specifically identify damaged or young specimens. We anticipate that no additional corrective actions will be necessary for this issue.

Overall

No major injuries were reported by any field crew members during this fifth and final sampling season for round one of this project. Because of the potentially dangerous nature of the work, the entire project team is very relieved to have all their crew members kept safe. This is due to the leadership and safety consciousness of PIs, field crew chiefs, and field team leaders. PIs have been very impressed by the work ethics of their field crews, their willingness to work long hours day after day, to successfully sample under quite adverse conditions, and to conduct that sampling in accordance with strict QA procedures. From the PI and QA managers' perspectives, the fifth field season was highly successful.

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

LEVERAGED BENEFITS OF PROJECT (2010 – 2015)

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 many jobs (jobs created/retained). All of these are detailed below.

Spin-off Projects (cumulative since 2010)

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.

Plant IBI Evaluation: A presentation at the 2014 Joint Aquatic Science meeting in Portland, Oregon evaluated Floristic Quality Index and Mean Conservatism score changes over time utilized data collected during the first three years of the GLRI study. Mean C scores showed little change between years from 2011 through 2013 due to stable water levels.

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 and Barrier Beach 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 and the potential of restoring the eroded barrier beach to reduce wetland loss. CWM crews collected pre-restoration data to help plan and implement restoration activities and will collect post-restoration data to help plan and implement restoration activities and assess results. 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.

Developing a Decision Support System for Prioritizing Protection and Restoration of Great Lakes Coastal Wetlands: While a number of large coastal wetland restoration projects have been initiated in the Great Lakes, there remains little regional or basin-scale prioritization of restoration efforts. Until recently we lacked the data necessary for making systematic prioritization decisions for wetland protection and restoration. However, now that basin-wide coastal wetland monitoring data is available, development of a robust prioritization tool is possible and we propose to develop a new Decision Support System (DSS) to prioritize protection and restoration investments. This 2-year project, funded by the Upper Midwest and Great Lakes Landscape Conservation Cooperative, will develop a DSS for wetlands from Saginaw Bay to Western Lake Erie.

Quantifying Coastal Wetland – Nearshore Linkages in Lake Michigan for Sustaining Sport Fishes: With support from Sea Grant (Illinois-Indiana and Wisconsin programs), personnel from UND and CWM are comparing food webs from coastal wetlands and nearshore areas of Lake Michigan to determine the importance of coastal wetlands in sustaining the Lake Michigan food web. The project emphasis is on identifying sport fish-mediated linkages between wetland and nearshore habitats. Specifically, we are (1) constructing cross-habitat food webs using stable C and N isotope mixing models, (2) estimating coastal wetland habitat use by sport fishes using otolith microchemistry, and (3) building predictive models of both linkage types that account for the major drivers of fish-mediated linkages in multiple Lake Michigan wetland types, including some wetlands sampled by the coastal wetland monitoring project. Collaborators are the University of Wisconsin – Green Bay and Loyola University Chicago.

Clough Island (Duluth/Superior) Preservation and Restoration. 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.

Floodwood Pond and Buck Pond South, Lake Ontario, Wetland Pothole Restoration: Open water potholes were established in these two wetlands by The Nature Conservancy to replace openings that had filled with cattail following lake-level regulation. CWM crews collected pre- and post-restoration data as benchmark sites in both wetlands to allow TNC to assess changes.

Buck Pond West and Buttonwood Creek, Lake Ontario, Sedge Meadow Restoration: These two wetlands in the Rochester Embayment AOC are actively being restored by a consortium involving Ducks Unlimited, The College at Brockport, NYS Department of Environmental Conservation, and the Town of Greece. CWM crews collected pre-restoration data as a benchmark site to help plan and implement restoration activities. Post-restoration data collection is underway under CWM to help assess results and 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.

Salmon/West Creek, Long Pond, and Buck Pond East, Lake Ontario, Emergent Marsh Restoration: These three wetlands in the Rochester Embayment AOC are being studied as benchmark sites by CWM crews to provide the U.S. Fish and Wildlife Service with pre-restoration data for projects currently in the design phase. Future CWM data collection has been requested to assist in post-restoration assessment.

Lower Green Bay and Fox River AOC

Results from the Coastal Wetland Monitoring (CWM) Project and the Great Lakes Environmental Indicators (GLEI) Project are playing a central role in a $471,000 effort to establish de-listing targets for the Lower Green Bay and Fox River AOC. 1) Protocols for intensive sampling of bird and amphibians in the project area have followed the exact methods used in the CWM project so that results will be directly comparable with sites elsewhere in the Great Lakes. 2) Data from GLEI on diatoms, plants, invertebrates, fish, birds, and amphibians and from CWM on birds and amphibians have been used to identify sensitive species that are known to occur in the AOC and have shown to be sensitive to environmental stressors elsewhere in the Great Lakes. These species have been compiled into a database of priority conservation targets. 3) Methods of quantifying environmental condition developed and refined in the GLEI and CWM projects are being used to assess current condition of the AOC (as well as specific sites within the AOC) and to set specific targets for de-listing of two important beneficial use impairments (fish and wildlife populations and fish and wildlife habitats).

SOLEC Indicators: The bird and amphibian team has developed a draft set of indicator metrics for submission to the State of the Lake Indicator Conference (SOLEC) in October 2015. These metrics will fill a much-needed gap in quantifying responses of bird and amphibian communities to environmental stress throughout the Great Lakes. Sites for all coastal wetlands sampled by the GLEI, CWM, and March Monitoring projects have been scored according to several complementary indices that provide information about local and regional condition of existing wetlands.

Roxana Marsh Restoration (Lake Michigan): The University of Notre Dame (UND) team, led by graduate student Katherine O'Reilly and undergraduate Amelia McReynolds under the direction of project co-PI Gary Lamberti, leveraged the GLCWM monitoring project to do an assessment of recently-restored Roxana Marsh along the south shore of Lake Michigan. Roxana Marsh is a 10-ha coastal wetland located along the Grand Calumet River in northwestern Indiana. An EPA-led cleanup of the west branch of the Grand Calumet River AOC including the marsh was completed in 2012 and involved removing approximately 235,000 cubic yards of contaminated sediment and the reestablishment of native plants. Ms. McReynolds obtained a summer 2015 fellowship from the College of Science at UND to study the biological recovery of Roxana Marsh, during which several protocols from the GLCWM project were employed.

During summer 2015 sampling of Roxana Marsh, an unexpected inhabitant of the Roxana Marsh was discovered -- the invasive oriental weatherfish (*Misgurnus anguillicaudatus*). Oriental weatherfish are native to southeast Asia and believed to have been introduced to the U.S. via the aquarium trade. Although there have been previous observations of *M. anguillicaudatus* in the river dating back to 2002, it had not been previously recorded in Roxana Marsh, and little information is available on its biological impacts there or elsewhere. We are currently using stable carbon and nitrogen isotopes, along with diet analysis, to determine the role of *M. anguillicaudatus* in the wetland food web and its potential for competition with native fauna for food or habitat resources.

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 per 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, for the Rochester NY AOC, and for the St. Marys River restoration in 2015 by tribal biologists at Sault Ste Marie.

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 Wisconsin DNR has requested data for the Fish Creek Wetland as part of an Environmental Impact Assessment related to a proposed Confined Animal Feeding Operation upstream of the wetland.

We have received a request from the USFWS for data to support development of a black tern distribution/habitat model for the Great Lakes region. The initial effort will focus on Lakes Huron, Erie and their connecting channels. Various FWS programs (e.g., Migratory Bird, Joint

Venture, and Landscape Conservation Cooperatives) are interested in this model as an input to conservation planning for Great Lakes wetlands.

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)
- Novel Diagnostics for Biotransport of Aquatic Environmental Contaminants (University of Notre Dame, with additional funding from Advanced Diagnostics & Therapeutics program)

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).
- Structure and function of restored Roxana Marsh in southern Lake Michigan (University of Notre Dame, with additional funding from the UND College of Science)
- Nutrient limitation in Great Lakes coastal wetlands (Central Michigan University, CMU Biological Station on Beaver Island).

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).

- Coastal wetland – nearshore linkages in Lake Michigan for sustaining sport fishes (University of Notre Dame)
- Anthropogenic disturbance effects on bird and amphibian communities in Lake Ontario coastal wetlands (The College at Brockport)
- A fish-based index of biotic integrity for Lake Ontario coastal wetlands (The College at Brockport)

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, complete).

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 + 1[OSU]
- Paid undergraduate internship (summer): 1[OSU]
- 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 summer 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.

Cooper, M.J. Where worlds collide: ecosystem structure and function at the land-water interface of the Laurentian Great Lakes. Sigurd Olson Environmental Institute, Northland College. Public Seminar. May 4, 2015.

Cooper, M.J., and D.G. Uzarski. Great Lakes coastal wetland monitoring for protection and restoration. Lake Huron Restoration Meeting. Alpena, MI. May 14, 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.

Des Jardin, K. and D.A. Wilcox. 2014. Water chestnut: germination, competition, seed viability, and competition in Lake Ontario. New York State Wetlands Forum, Rochester, NY.

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. 150 attendees, including scientists, managers, agency personnel, and others.

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

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

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

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

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

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

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

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

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

Johnson, L., M. Cai, D. Allan, N. Danz, D. Uzarski. 2015. Use and interpretation of human disturbance gradients for condition assessment in Great Lakes coastal ecosystems. International Association for Great Lakes Research Conference, Burlington, VT.

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.J. Ciborowski, G.P. Grabas, D.A. Wilcox, R.W. Howe, and D. C. Tozer. 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.

Lamberti, G. A. The Global Freshwater Crisis. The Richard Stockton College of New Jersey and South Jersey Notre Dame Club. November 18, 2014.

Lamberti, G. A. The Global Freshwater Crisis. Smithsonian Journey Group and several University Alumni Groups. March 1, 2015.

Lamberti, G. A. Pacific Salmon in Natal Alaska and Introduced Great Lakes Ecosystems: The Good, the Bad, and the Ugly. Annis Water Resources Institute, Grand Valley State University. December 12, 2014.

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.J., D.A. Albert, D.A. Wilcox, B.M. Mudrzynski, J. Gathman, N.P. Danz, D. Rokitnicki-Wojcik, and G.P. Grabas. 2014. Correlation of physical factors to coastal wetland vegetation community distribution in the Laurentian Great Lakes. Society of Wetland Scientists/Joint Aquatic Sciences Meeting, Portland, OR.

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.

Mudrzynski, B.M. and D.A. Wilcox. 2014. Effect of coefficient of conservatism list choice and hydrogeographic type on floristic quality assessment of Lake Ontario wetlands. Society of Wetland Scientists/Joint Aquatic Sciences Meeting, Portland, OR.

Mudrzynski, B.M., K. Des Jardin, and D.A. Wilcox. 2015. Predicting seed bank emergence within flooded zones of Lake Ontario wetlands under novel hydrologic conditions. Society of Wetlands Scientists. Providence, RI.

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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/
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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
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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
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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
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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/
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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
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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.