Great Lakes Coastal Wetland Monitoring Program

Semiannual Progress Report
April 1, 2023 – September 30, 2023

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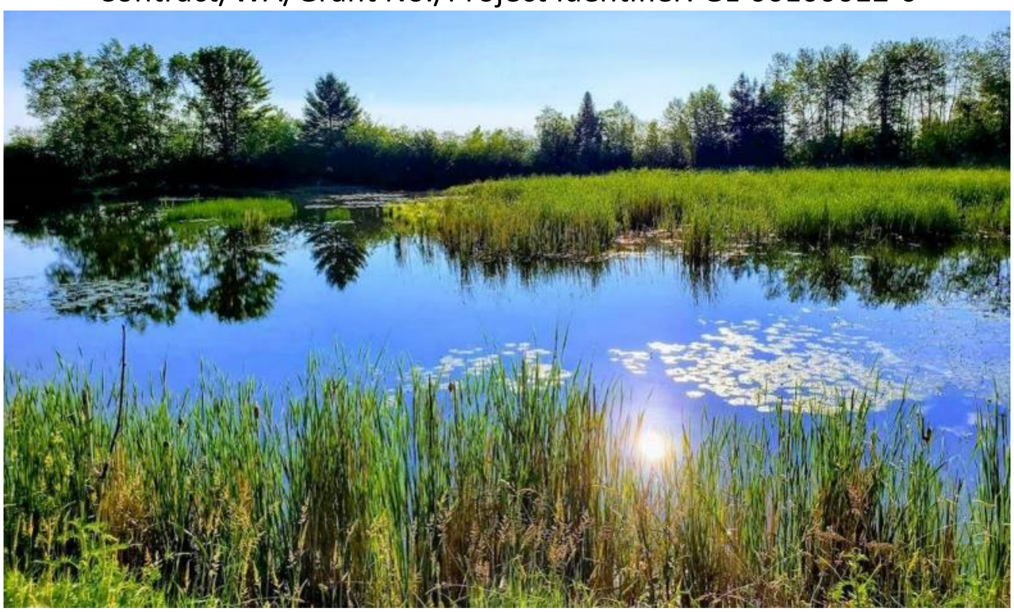

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INTRODUCTION

Monitoring the biota of Great Lakes coastal wetlands began as a project funded under the Great Lakes Restoration Initiative on 10 September 2010. The project had the primary objective of implementing a standardized basin-wide coastal wetland monitoring program. Our first five years of sampling (2011-2015) set the baseline for future sampling years and showed the power of the datasets that can be used to inform decision-makers on coastal wetland conservation and restoration priorities throughout the Great Lakes basin. During round one, we 1) developed a database management system; 2) developed 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) developed background documents on the indicators.

We have completed two five-year rounds of monitoring and this summer embarked on year 3 of the third five-year sampling round. This is our first full 5-year sampling round as a sampling program rather than a project. During the second round (2016-2021) we combated high water levels that made wetland sampling challenging and drowned out some wetlands. Fortunately, Great Lakes water levels have moderated for round 3. In addition, we continue to support wetland restoration projects by providing data, information, and context.

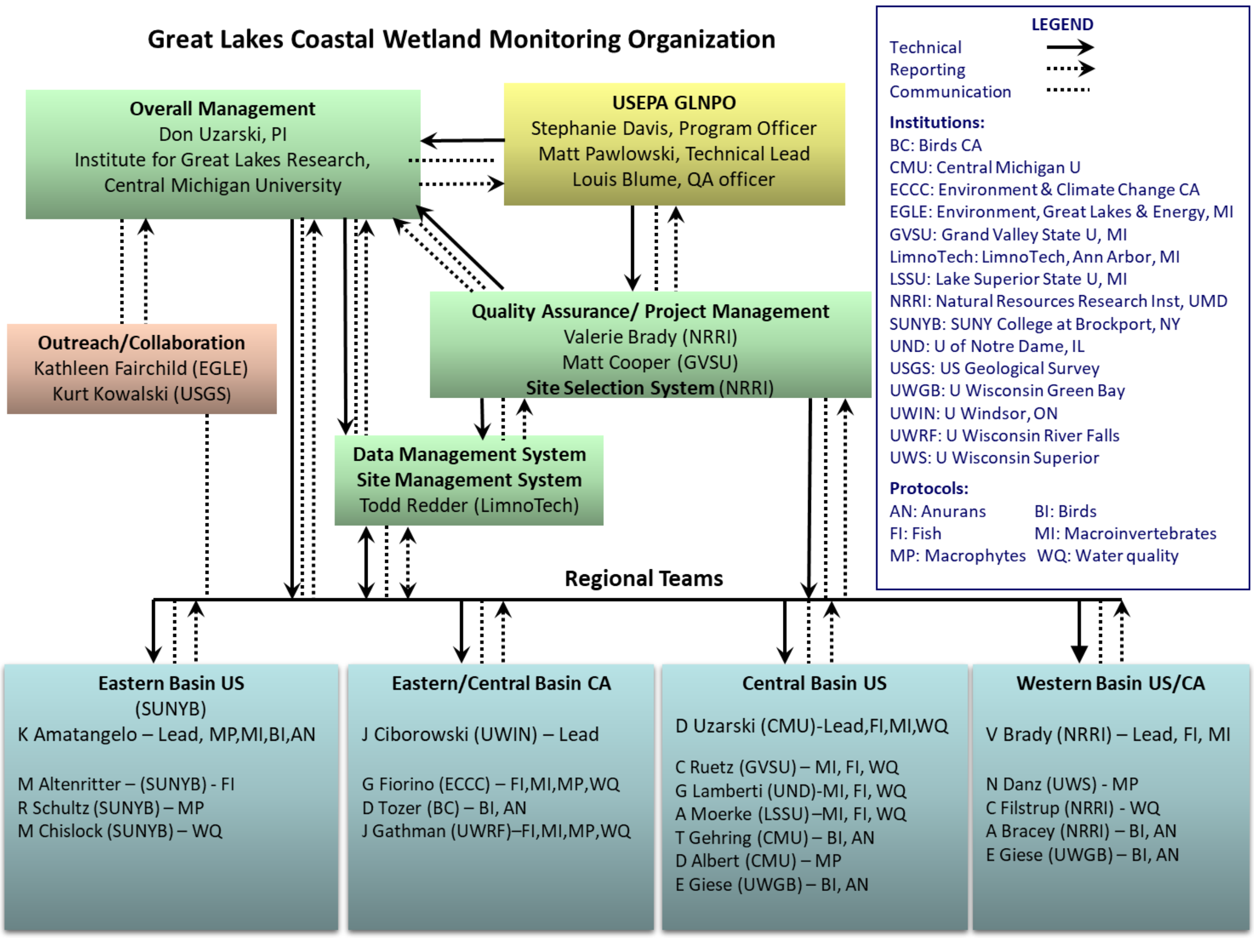
SUMMARY OF SAMPLING SCHEDULE

Our yearly sampling schedule proceeds in this manner: During the winter, PIs and crew chiefs meet to discuss issues, update each other on progress, and ensure that everyone is staying on track for QA/QC. Sites are selected by March using the on-line site selection database system, and field crew training takes place from March – June, depending on sampling type. Anuran sampling typically begins in late March/early April with bird sampling beginning in April or May, and finally vegetation, fish, macroinvertebrate, and water quality sampling begins in June. Sampling start dates are weather and temperature dependent. Phenology is followed across the basin so that the most southerly sites are sampled earlier than more northerly sites. In the fall and early winter, data are entered into the database, unknown fish and plants are identified, and macroinvertebrates are identified. The goal is to have all data entered and QC'd by March. Metrics and IBIs are calculated in late March in preparation for the spring report to US EPA GLNPO.

Full summaries of the first two 5-year rounds of sampling have been submitted to US EPA and are available at http://www.greatlakeswetlands.org/Reports-Publications.vbhtml.

PROGRAM ORGANIZATION

Figure 1 shows our current organization. Our project management team has not changed.



PROGRAM TIMELINE

The program timeline remains unchanged and we are on schedule (Table 1). During the next project period we will process all remaining samples collected this summer, identify the macroinvertebrates and remaining macrophytes, enter all remaining data and QC it, and generate the metrics and indicators for each taxonomic group and water quality. In addition, we plan to finish re-coding and updating the Site Management System (formerly the Site Selection System) and move it from NRRI to Central Michigan University servers, which currently host the Data Management System.

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

Tasks	2021				2022				2023				2024				2025				2026			
	W	Sp	Su	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 updated	X				X				X				X				X							
Site selection for summer		X			X				X				X				X							
Sampling permits acquired		X				X				X				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	X			
Data QC & upload to GLNPO					X	X			X	X			X	X			X	X		X	X	X		
Report to GLNPO		X		X		X		X		X		X		X		X		X		X		X		X
Re-code Site Management System								X	X															

Table 2. GLRI Action Plan II of Measure of Progress. Wetlands are sampled during the summer.

GLRI Action Plan II of Measure of Progress		**Reporting Period (April 1, 2023 – September 30, 2023)**		**Project Status* (February 2021 – January 2026)**	
		Number	**Percent**	**Number**	**Percent**
4.1.3	Number of Great Lakes coastal wetlands assessed for biotic condition	174	20%	538	60%
* (Not Started; Started; Paused; 25% Completed; 50% Completed; 75% Completed; 95% Completed; and 100% Completed)					

SITE SELECTION

Year thirteen site selection was completed in March 2023. We have completed our 5-year sampling scheme twice (round 1: 2011-2015; round 2: 2016-2020) and completed the third year of round 3 sampling (2021-2025) through our list of Great Lakes coastal wetlands. Differences in the site list between successive sampling rounds are most often associated with special benchmark sites or changes due to lake levels and our ability to access sites safely and with permission. Benchmark sites (sites of special interest for restoration or protection) can be sampled more than once in the five-year sampling rotation, may need to be sampled in a different year to accommodate restoration work and may be sites that were not on the original sampling list. The dramatic change in Great Lakes water levels has also affected what wetlands we are able to sample for which biota. The list of wetlands sampled this year (2023) was previously sampled in 2013 and 2018, with some differences due to benchmarks, safe access, and water levels.

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 MANAGEMENT SYSTEM (formerly called the Site Selection Tool), completed in 2011, minor updates in 2012, 2013, 2016, 2020, 2021. Patched back together in 2022 after major crash.

Background

In 2011, a web-based database application was developed to facilitate site identification, stratified random site selection, and field crew coordination. This database is housed at NRRI and backed up routinely. It is also password-protected. Using this database, potential wetland polygons from the GLCWC GIS coverage were reviewed by PIs and those that were greater than four hectares, had herbaceous vegetation, had (or appeared to have) a lake connection navigable by fish, and were influenced by lake water levels were placed into the site selection random sampling rotation (Table 3). That is, these 1014 wetlands became our wetland sampling universe, with minor modifications and additions for benchmark sites, as previously described, and some sites being dropped due to lack of any crew ever being able to access them. See the QAPP for a thorough description of site selection criteria. Note that the actual number of sampleable wetlands fluctuates year-to-year with lake level, continued human activity and safe access for crews. Based on the number of wetlands that proved to be sampleable thus far, we expect that the total number of sampleable wetlands will be between 900 and 1000 in any given year; we sample roughly 200 of these (one fifth) per year.

Table 3. Counts, areas, and proportions of the 1014 Great Lakes coastal wetlands deemed sampleable in 2011 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**	

This wetland coverage shows more wetlands in the US than in Canada, with an even greater percent of wetland area in the US (Table 3). We speculate that this is partly due to poor representation of Georgian Bay (Lake Huron) wetlands in the sampleable wetland database. This area is also losing wetlands rapidly due to a combination of glacial rebound and topography that limits the potential for coastal wetlands to migrate downslope during periods of low lake levels and to recover with rising water levels. Another component of this US/CA discrepancy is the lack of coastal wetlands along the Canadian shoreline of Lake Superior due to the rugged topography and geology. A final possibility is unequal loss of wetlands between the two countries, but this has not been investigated.

Strata

Geomorphic classes

Geomorphic classes (riverine, barrier-protected, and lacustrine) were determined for each site in the original coastal wetland GIS coverage. 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. Note that we typically do not revisit or change the class originally assigned to a wetland during our 2011 initial site review process.

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 was adopted that divided each lake into northern and southern components, with Lake Huron being split into three parts and Lake Superior being treated as a single region (Figure 2). The north-south splitting of Lake Michigan is common to all major ecoregion systems (Omernik / Bailey / CEC).

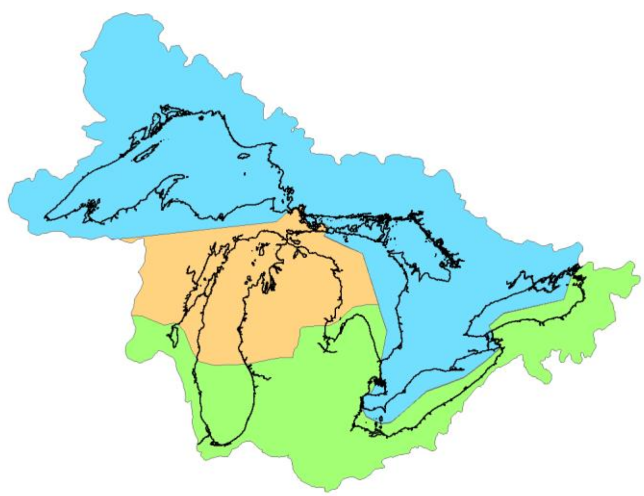


Figure 2. Divisions of lakes into regions. Note that stratification is by region *and* lake, so northern Lake Erie is not in the same region as Lake Superior, etc.

Panelization

Randomization

To create our stratified random wetland site sampling design, the first step was the assignment of selected sites from each of the project's 30 strata (10 regions x 3 geomorphic wetland types) 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. All sites were assigned to panels in 2011, prior to the first round of sampling.

In 2012, sites previously assigned to panels for sampling were assigned to sub-panels for re-sampling. The project's sampling design requires that 10% of sites are re-sampled the year after they were sampled based on their main panel designation to help determine interannual variability and the effects of changing water levels. This design requires five primary panels, *A-E*, one for each year of a five-year rotation, and ten sub-panels, *a-j,* for the 10% resample sites. 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 4.

For the first five-year cycle, sub-panel *a* was 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, panel *A* was sampled for the second time, so the 21 sites in sub-panel *a* of panel *E* became the re-sample sites. This past summer (2023), panel *C* was sampled for the third time and the sites in sub-panel *c* of panel *B* comprised the re-sample sites. The total panel and sub-panel rotation covers 50 years.

Table 4. 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 is assigned a particular 'workflow' status. During the field season, sites selected for sampling in the current year move through a series of sampling states in a logical order, as shown in Table 5. 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. In 2020 we ran into the problem of being unable to sample sites because of the global pandemic, Covid-19. The site status code "could not sample" was added as a workflow state in the site selection list for crews to have more options to indicate problems sampling sites. "Could not access" is used to indicate when a crew cannot safely get to a site for some reason, while "could not sample" is used to indicate the inability to sample a site even though they can get to it (e.g., water is too deep for their sampling gear; for Covid, this would be things like no access onto tribal lands, etc.).

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 is used to exchange sites between teams for efficiency and to better assure that distribution of effort matches each team's sampling capacity.

Field maps

Multi-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. 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 remaining pages list information from the database for the site, including site informational tags, team assignments, and the history of comments made on the site, including information from previous field crew visits intended to help future crews find boat launches and learn about any hazards a site poses.

Table 5. 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 QC'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	Indicates site assignment to a team with intent to sample.	0
could not access site	Site proved impossible to access safely.	-1
could not sample	Added in 2020; indicates inability of crew to sample for some reason other than safety or lack of an appropriate wetland.	-1
visit reject	Visited in field, and rejected (no lake influence, no wetland present, 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 QC-checked.	3

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.

2023 SITE SELECTION

For 2023, 212 sites were ultimately selected for sampling. Of these, 13 were benchmark sites. Another 13 sites were re-sample sites and 19 were pre-sample sites, which will be re-sample sites next year (2024). Benchmark, re-sample, and pre-sample sites were sorted to the top of the sampling list because they were the highest priority sites to be sampled. By sorting next year's resample sites to the top of the list, this helps ensure that most crews sample them, allowing more complete comparison of year-to-year variation when the sites are sampled again the next year. Because this is our third sampling round, crews were familiar with most of the sites on the 2023 site list.

Benchmark sites are sites that are not on the site list, are special interest sites that were too far down the site list and risked not being sampled by all crews, or are sites that are considered a reference of some type and are being sampled more frequently. Sites that were not on the site list typically are too small, disconnected from lake influence, or are not a wetland at this time, and thus do 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 get a number of requests to provide baseline data for restoration work.

We now have approximately 95 sites for which at least a portion of sampling is designated as "benchmark." Of these sites, about 40 are to evaluate restoration efforts and about a dozen serve as reference sites for their area or for nearby restoration sites. 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. Almost all benchmark sites are in the US.

Wetlands have a "clustered" distribution around the Great Lakes due to geological and topographic differences along the Great Lakes coastline. 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.

Site Management System Problems

The Site Management System has gone down a couple of times, with each fix becoming more tenuous due to old software and incompatibility issues with newer servers, image sources, and browser software. For the future integrity of this sampling program, we have been granted additional funding by USEPA to completely re-construct the Site Management System and move it to servers at Central Michigan University. These crashes have emphasized the critical importance of this system to the running of our program.

Funding was not received in time to complete the rebuild of the Site Management System before the need to be using the system to generate the 2023 site list. This necessitated us again relying on the old system. We struggled to get the old system to generate the 2023 site list and correctly assign sites to teams based on the areas each team can sample. We did ultimately get the code to work and a 2023 site list was generated in time for team leaders to begin seeking sampling permits. The 2022 system crash and 2023 struggles emphasized the critical importance of this system to the running of our program.

Using the additional funding granted by USEPA, we are in the process of completely reconstructing the Site Management System, which will be housed on the servers at Central Michigan University. We plan to test the new system this fall and switch over to it during the winter of 2023/2024 when there is little use of the site system.

TRAINING

All personnel responsible for sampling invertebrates, fish, macrophytes, birds, anurans, and water quality received training and were certified prior to this sampling program beginning 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 leaders are experienced, field crew training is being handled by each PI at each regional location, with more experienced trainers providing assistance, including in-person training by the management team, as necessary when major personnel changes take place (e.g., new field crew leader, new PI). As is true every field season, all crew members still had to pass all training tests and mid-season QC were conducted.

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 each spring. See the individual team reports for information on how each team conducted crew training. Some crews were trained by the crew leader; some crews used only experienced personnel who had worked for the project for years and needed minimal retraining. In general, each PI or field crew leader 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 anuran field crews includes tests on anuran calls, bird vocalizations, and bird visual identification. These tests are based on an online system established at the University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal. In addition, individuals 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 points within each site, setting fyke nets, identifying fish, sampling and sorting invertebrates, and collecting water quality and habitat 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.

Training for fish and invertebrate crews now includes specific instructions for sampling in deep water. These techniques were trialed in 2019 and found to work to allow sampling in at least somewhat deeper water than we have been sampling. Specifically, to sample invertebrates in depths greater than 1 m, D-frame dip net handles were extended and sampling was done from the boat by moving around the boat and by allowing the boat to swing around one of its anchors. To set fyke nets in deeper water, the boat can be used to set the cod end of the net and the frame can be set underwater, using rock bag anchors to weight the cod end. These deep-set fyke net data are still considered experimental at this point and data are coded accordingly.

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.

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 was provided in 2016 with the implementation of the updated version of the data entry/data archiving system by Todd Redder at LimnoTech. Training on data entry and QC continues via webinar as needed for new program staff and was done in both 2017 and 2018 as new staff joined the program. Additional training on data entry is provided as needed.

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 anuran 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 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 (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 QC managers (Brady and Cooper).

WEB-BASED DATA ENTRY SYSTEM

The CWMP uses a web-based data management system (DMS) that was originally developed by NRRI in 2011 to collect field and laboratory data, and then redeveloped by LimnoTech during 2015-16. The current web-based system uses Microsoft’s Active Server Pages .NET (ASP.NET) web application framework running on a Windows 2012 Server and hosted on a virtual machine at Central Michigan University (CMU). The open source PostgreSQL Relational Database Management System (RDMS) with PostGIS spatial extensions is used to provide storage for all CWMP data on the same Windows 2012 server that hosts the web application.

The CWMP database includes collections of related tables for each major taxonomic group, including vegetation, fish and macronvertebrates, anurans, and birds. Separate data entry/editing forms are created for data entry based on database table schema information that is stored in a separate PostgreSQL schema. Data entry/editing forms are password-protected and can only be accessed by users that have “Project Researcher” or “Admin” credentials associated with their CWMP user account and permissions for specific taxa group(s).

Specific features of note for the CWMP data management system include:

- Automated processes for individual users to request and confirm accounts;
- An account management page where a limited group of users with administrative privileges can approve and delete user accounts and change account settings as needed;
- Numerous validation rules employed to prevent incorrect or duplicate data entry on the various data entry/editing forms;

- Custom form elements to mirror field sheets (e.g. the vegetation transects data grid), which makes data entry more efficient and minimizes data entry errors;

- Domain-specific “helper” utilities, such as generation of fish length records based on fish count records;

- Dual-entry inconsistency highlighting for anuran and bird groups who use dual-entry for quality assurance;

- Tools for adding new taxa records or editing existing taxa records for the various taxonomic groups; and

- GPS waypoint file (*.gpx) uploading utilities and waypoint processing to support matching of geographic (latitude/longitude) coordinates to sampling points.

The CWMP data management system also provides separate webpages that allow researchers to download “raw” data for the various taxonomic groups as well as execute and download custom queries that are useful for supporting dataset review and QA/QC evaluations as data entry proceeds during and following each field season. Users from state management agencies are able to access the separate download pages for raw data and custom queries. Such organizations include GLNPO and its subcontractors and Michigan EGLE. Index of Biological Integrity (IBI) metrics are currently included as a download option based on static scores that reflect data collection through the 2021 field season. Over the past few years, a standalone .NET-based program has been developed and fully tested to automate the calculation of IBI metric scores for vegetation, invertebrates and fish on an annual (spring) schedule after data have been entered and gone through QA/QC.

Raw data downloads are available in both Microsoft (MS) Excel spreadsheet and MS Access database formats, while custom query results are available in spreadsheet format only. All available data/query export and download options are automatically regenerated every night, and users have the option of either downloading the last automated export or generating a new export that provides a snapshot of the database at the time the request is made (the former option is much faster). Currently, datasets for the major taxonomic groups must be downloaded individually; however, a comprehensive export of all pertinent data tables is generated in a single MS Access database file and provided to GLNPO on a bi-annual schedule in fall and spring of each program year.

In addition to providing CWMP researchers with data entry and download access, the CWMP data management team is providing ongoing technical support and guidance to GLNPO to support its internal management and application of the QA/QC'ed monitoring datasets. GLNPO, with support from subcontractors, maintains a separate, offline version of the CWMP monitoring database within the Microsoft Access relational database framework. In addition to serving as an offline version of the database, this version provides additional querying and reporting options to support GLNPO's specific objectives and needs under GLRI. CWMP data management support staff generate and provide to GLNPO and its contractors a "snapshot" of the master CWMP PostgreSQL database as a Microsoft Access database twice per year, corresponding to a spring and fall release schedule. This database release is then used by GLNPO and its contractors to update the master version of the Microsoft Access database used to support custom querying and reporting of the monitoring datasets.

A full backup of the CWMP PostgreSQL database is created each night at 3:00 AM Eastern time using a scheduled backup with the PostgreSQL Backup software application. Nightly database backups are automatically uploaded to a dedicated folder on LimnoTech's Sharefile system where they are maintained on a 30-day rolling basis. In the event of significant database corruption or other failure, a backup version can be restored within an hour with minimal data loss. The server that houses the DMS has also been configured to use CMU's Veeam Backup Solution. This backup solution provides end-to-end encryption including data at rest. Incremental backups are performed nightly and stored at secure locations (on premise and offsite). Nightly backup email reports are generated and sent to appropriate CMU IT staff for monitoring purposes. Incremental backups are kept indefinitely and restores can be performed for whole systems, volumes, folders and individual files upon request.

RESULTS-TO-DATE (2011-2022, WITH EXCEPTIONS 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 the first round of sampling (2011-2015; Tables 6 and 7), and we have completed sampling these wetlands a second time for the second complete round of coastal wetland assessment, 2016-2020. Note that this total number 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 per 5-year sampling round. For the second round of sampling, we sampled 192 wetlands in 2016, 209 wetlands in 2017, 192 wetlands in 2018, 211 wetlands in 2019, and 174 wetlands in 2020 (fewer wetlands sampled due to the global pandemic).

Round 3 (2021-2015) began summer 2021 with teams sampling 175 wetlands (again, fewer than in Round 2 due to the pandemic; Tables 6 and 7). In 2022 teams sampled 188 wetlands. This year, teams sampled 174 wetlands (Tables 6 and 7, Figures 3 and 4).

In all years, more wetlands are 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, Tables 6 and 7). When compared to the total number of wetlands targeted to be sampled by this project (Table 3), we are achieving our goals of sampling 20% of US wetlands per year, both by count and by area. However, each year 60-65% of total sites sampled are US coastal wetlands, with 75-80% of the wetland area sampled on the US side. Overall, we have sampled most of the large, surface-connected Great Lakes coastal emergent wetlands by count and by area. A few wetlands cannot currently be sampled due to a lack of safe access or a lack of permission to cross private lands.

Table 6. Counts, areas, and proportions of US Great Lakes coastal wetlands sampled in Round 1 (2011 – 2015), Round 2 (2016 – 2020) and Round 3 (2021 – 2025) sampling by the Coastal Wetland Monitoring Program. Percentages are of overall total sampled each year. Area in hectares.

US	Site count	Site %	Site area	Area %
Round 1 (2011 – 2015)				
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 Round 1	**658**	**65%**	**116,309**	**77%**
Round 2: 2016 – 2020				
2016	129	67%	24,446	85%
2017	139	67%	30,703	80%
2018	125	65%	17,715	82%
2019	135	64%	30,281	80%
2020	119	69%	29,325	77%
US total Round 2	**647**	**66%**	**132,470**	**82%**
Round 3: 2021 – 2025				
2021	122	70%	24,734	85%

2022	128	68%	29,625	82%
2023	112	64%	18,648	82%
US total Round 3	**362**	**67%**	**73,007**	**83%**

Table 7. Counts, areas, and proportions of CA Great Lakes coastal wetlands sampled in Round 1 (2011 – 2015), Round 2 (2016 – 2020) and Round 3 (2021 – 2025) sampling by the Coastal Wetland Monitoring Program. Percentages are of overall total sampled each year. Area in hectares.

Canada	Site count	Site %	Site area	Area %
Round 1: 2011 - 2015				
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 Round 1	**352**	**35%**	**35,137**	**23%**
Round 2: 2016 - 2020				
2016	63	33%	4,336	15%
2017	70	33%	7,801	20%
2018	67	35%	3,356	18%
2019	76	36%	7,746	20%
2020	55	32%	8,603	23%
CA total Round 2	**331**	**34%**	**31,843**	**18%**
Round 3: 2021 - 2025				
2021	53	30%	4,264	15%
2022	59	32%	6,637	18%
2023	62	36%	4,097	18%
CA total Round 3	**174**	**33%**	**14,998**	**17%**
Overall Totals Round 1	**1010**		**151,446**	
Overall Totals Round 2	**978**		**164,312**	
Overall Totals Round 3	**536**		**88,005**	

Ability to sample sites depends not only on access but also on water levels. Teams were able to sample more sites in 2014 due to higher lake levels on Lakes Michigan and Huron, which allowed crews to access sites and areas that have been dry or inaccessible in previous years. By 2015 water depths in some coastal wetlands had become so deep that crews had difficulty finding areas shallow enough to set fish nets in zones typically sampled for fish (cattail, bulrush, SAV, floating leaf, etc.). In 2017 Lake Ontario levels reached highs not seen in many decades. Water levels were again near historic highs in 2019 and 2020 and crews continued to report sampling challenges due to the high water, with coastal wetlands flooded out and only beginning to migrate upslope into areas that remain covered by terrestrial vegetation (shrubs, trees, etc.) or being blocked in this upslope migration by human land use or shoreline hardening. This highlights the difficulty of precisely determining the number of sampleable Great Lakes coastal wetlands in any given year, and the challenges crews face with rising and falling water levels.

In 2021, water levels had moderated slightly and crews reported fewer difficulties in sampling. This trend continued in 2022 and 2023, with some crews finding water levels low enough in some wetlands to impact sampling due to low water. The sites sampled in 2023 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 anurans typically were sites that were impossible to access safely, often related to private property access issues, or, during the pandemic, due to border closures. Most bird and anuran 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 anuran 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. In both 2022 and 2023, bird and anuran crews faced a very cold, late spring across much of the region, compressing fieldwork into a shorter timeframe.

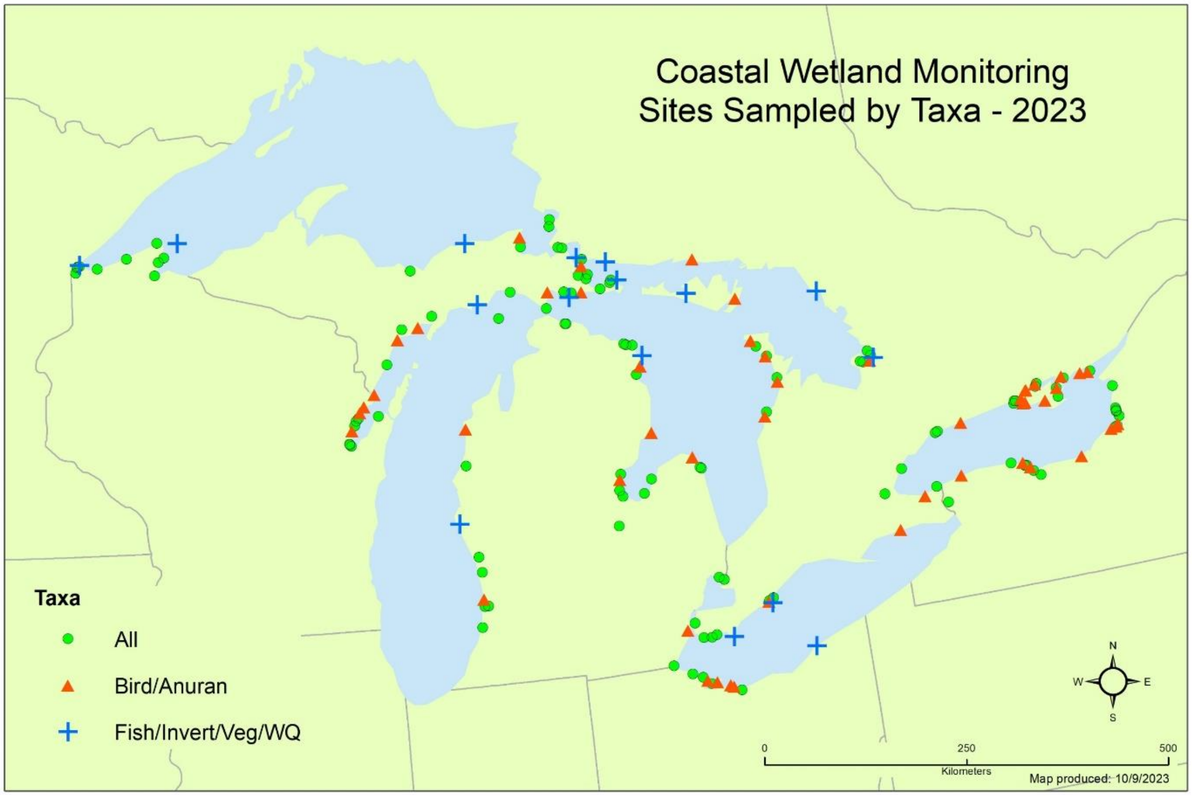


Figure 3. Locations of the 188 Great Lakes coastal wetlands sampled in 2023, color-coded by taxonomic groups. Sites assigned only to bird and anuran crews (due to their greater sampling capacity) are shown with a red triangle.

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 from 2014 – 2020 require that indicators be relatively robust to Great Lakes water level variations, or that data users are very cognizant of water level effects on indicators.

Benchmark sites are sites that are were not on the site list, are special interest sites that were too far down the site list and risked not being sampled by all crews, or are sites that are considered a reference of some type and are being sampled more frequently. Sites that were not on the site list typically are too small, disconnected from lake influence, or are not a wetland at this time, and thus do 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 get a number of requests to provide baseline data for restoration work.

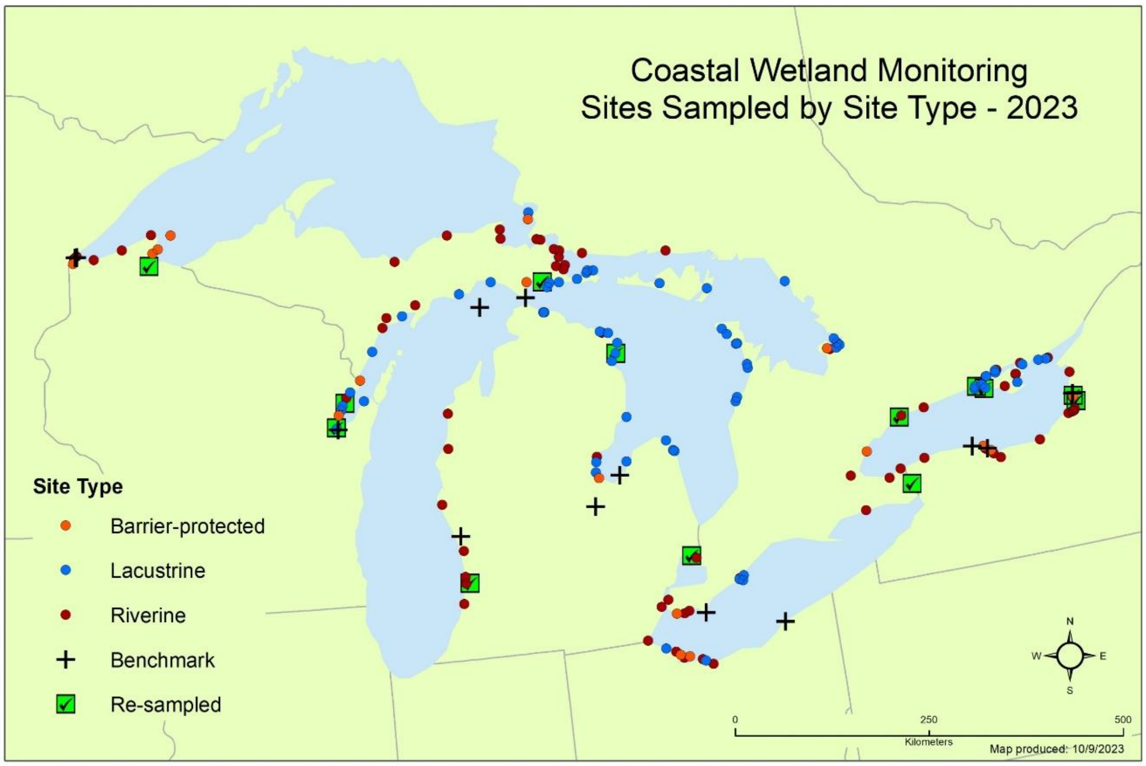


Figure 4. Locations of the 188 Great Lakes coastal wetlands sampled in 2023, color-coded by site type. Wetland types exhibit a clumped distribution across lakes due to geology and topography.

We now have more than 95 sites that are or have been sampled as a “benchmark.” Of these, about 40 are to evaluate restoration efforts and about a dozen serve as reference sites for their area or for nearby restoration sites. The rest are more intensive monitoring sites at which the extra data will help provide long-term context, help us adjust indicators to be robust against water level fluctuations, and gain better ecological understanding of coastal wetlands. Almost all benchmark sites are in the US.

Determining whether some of these benchmark sites would have been sampled at some point as part of the random site selection process is difficult because several 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 were 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 (for 2023, only 2 new benchmarks were added; these are sites [7078, 7079] with major restorations planned for them). These tend to be sites that are degraded former wetlands that no longer appear on any wetland coverage but for which restoration is a goal or, in a few cases, wetlands that are diked and the dike is being breached for restoration.

BIOTIC COMMUNITIES AND CONDITIONS (based on 2011-2022 data)

We can now compile good statistics on Great Lakes coastal wetland biota because we have sampled nearly 100% of the medium and large coastal wetlands that have a surface water connection to the Great Lakes and are hydrologically influenced by lake levels. The following indicators and information are from data collected in 2022 and will be updated again in the spring of 2024 when we have analyzed this summer’s data.

Wetlands average about 25 bird species; some sampled benchmark sites had only a couple of bird species, but richness at high quality sites was as great as 64 bird species (Table 8). There are many fewer calling amphibian species (anurans) in the Great Lakes (8 total), and coastal wetlands averaged about 4 species per wetland, with some benchmark wetlands containing no anurans (Table 8). However, there were wetlands where 8 anuran species were heard over the three sampling dates.

Table 8. Bird and anuran species in wetlands; summary statistics by country. Data from 2011 through 2022, using only the latest year sampled for each wetland.

Country	Site count	Mean	Max	Min	St. Dev.
Birds					
Can.	268	27.0	54	5	9.7
U.S.	482	22.4	54	2	9.2
Anurans					
Can.	218	4.6	8	0	1.6
U.S.	431	4.2	8	1	1.3

Bird and anuran data in Great Lakes coastal wetlands by lake (Table 9) shows that wetlands on most lakes had an average number of bird species in the low-mid twenties. The greatest number of bird species at a wetland occurred on lakes Michigan and Ontario, with Lake Huron not far behind. These data include the benchmark sites, many of which are in need of or undergoing restoration, so the minimum number of species can be quite low.

Calling anuran species counts show less variability among lakes simply because fewer of these species occur in the Great Lakes. Wetlands averaged about four calling anuran species regardless of lake (Table 9). Similarly, there was little variability by lake in maximum or minimum numbers of species. At some benchmark sites, and occasionally during unusually cold spring weather, no calling anurans were heard.

Table 9. Bird and anuran species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of species per wetland for wetlands sampled from 2011 through 2022, using only data from the latest year sampled for each wetland.

	Birds				Anurans			
Lake	Sites	Mean	Max	Min	Sites	Mean	Max	Min
Erie	92	24.8	49	5	86	3.9	7	1
Huron	228	23.6	52	4	195	4.4	8	0
Michigan	133	23.8	54	2	121	4.1	7	1
Ontario	200	25.4	54	9	169	4.8	8	1
Superior	97	22.1	41	5	78	3.9	7	1

An average of 9 to 12 fish species were collected in Canadian and US Great Lakes coastal wetlands, respectively (Table 10). 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 24 (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. 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 10. Total fish species in wetlands, and non-native species; summary statistics by country for sites sampled from 2011 through 2022, using only data from the latest year sampled for each wetland.

Country	Sites	Mean	Max	Min	St. Dev.
Overall					
Can.	155	9.3	24	1	3.9
U.S.	267	12.3	28	3	4.6
Non-natives					
Can.	155	0.8	5	0	0.9
U.S.	267	0.9	5	0	1.0

From 2016-2020, we collected no non-native fish in 44% of Great Lakes coastal wetlands sampled, and we caught only one non-native fish species in 40% of Great Lakes coastal wetlands (Figure 5). We caught more than one non-native fish species in far fewer wetlands. 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.

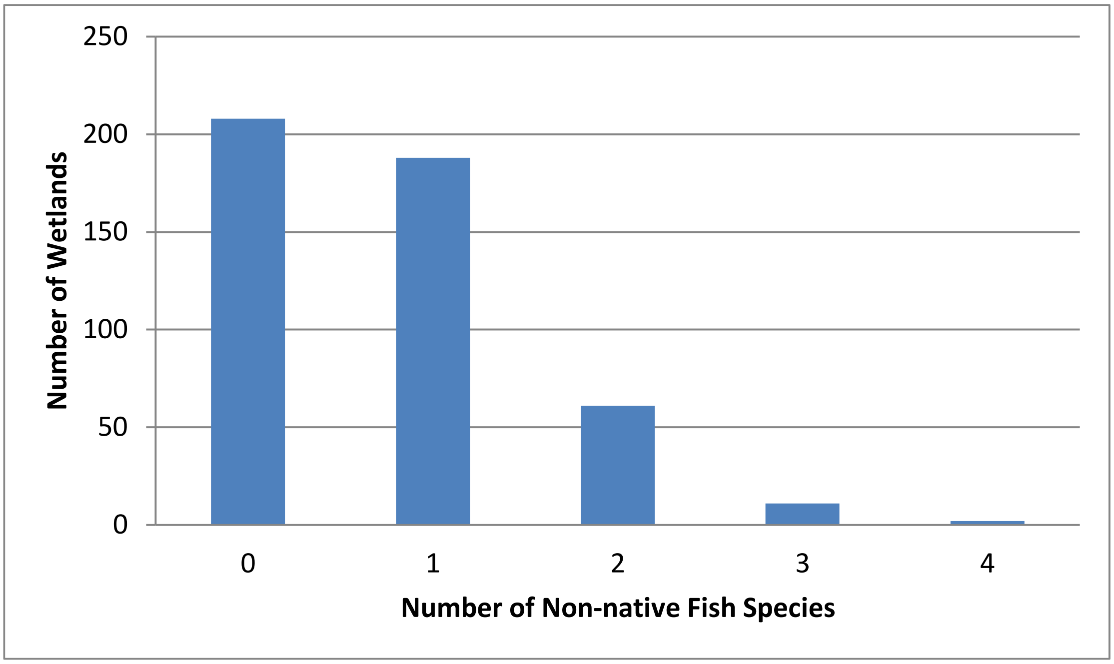


Figure 5. Number of Great Lakes coastal wetlands containing non-native fish species. Data from 2016 through 2020.

Total fish species did not differ greatly by lake, averaging 11-12 species per wetland (Table 11). Lakes Erie and Michigan had the most species of fish in a wetland, 27-28 species; the other lakes had a maximum of 20-22 species in a wetland. Because sites in need of restoration are included, some of these sites had very few fish species, as low as only a single species. Wetlands averaged 1 non-native fish species captured. Having very few or no non-native fish is a positive 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. Our single-night net sets do not catch all fish species in wetlands, and some species are quite adept at avoiding passive capture gear. There are well-documented biases associated with each type of fish 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 11. 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 2022, using only data from the most recent year sampled for each wetland.

		Fish (Total)			Non-native		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	54	11.9	28	4	1.6	5	0
Huron	153	11.1	22	1	0.6	2	0
Michigan	66	12.2	27	4	1.0	4	0
Ontario	96	10.0	20	4	0.9	3	0
Superior	53	11.2	21	3	0.8	4	0

The average number of macroinvertebrate taxa (taxa richness) per site was about 36 (Table 12), but some wetlands had more than twice this number. Sites scheduled for restoration and other taxonomically poor wetlands had fewer taxa. On a more positive note, the average number of non-native invertebrate taxa found in coastal wetlands was less than 1, with a maximum of no more than 5 taxa (Table 12). Note 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 12. Total macroinvertebrate taxa in Great Lakes coastal wetlands, and non-native species; summary statistics by country. Data from 2011 through 2022, using only data from the most recent year sampled for each wetland.

Country	**Sites**	**Mean**	**Max**	**Min**	**St. Dev.**
Overall					
Can.	176	36.7	65	18	9.8
U.S.	312	35.4	69	12	12.2
Non-natives					
Can.	407	0.7	4	0	0.9
U.S.	843	0.8	5	0	1.0

There is little variability among lakes in the mean number of macroinvertebrate taxa per wetland, with averages ranging from 32-40 taxa with lakes Ontario and Erie having lower averages than the upper lakes (Table 13). The maximum number of invertebrate taxa was lowest in Lake Ontario wetlands (57) with the most invertebrate-rich wetlands in the other lakes having a maximum of nearly 70 taxa. Wetlands with the fewest taxa are sites in need of restoration. 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.

Table 13. 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 2011 through 2022, using only data from the most recent year sampled for each wetland.

		Macroinvertebrates (Total)			**Non-native**		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	60	34.4	69	12	1.2	5	0
Huron	172	37.0	65	12	0.5	4	0
Michigan	82	36.0	66	14	1.1	4	0
Ontario	111	32.2	57	16	0.7	3	0
Superior	63	40.4	66	15	0.3	2	0

There is little variability among lakes in non-native taxa occurrence, although Lake Superior and Lake Hron wetlands had fewer non-native taxa (Table 13). In each lake there were some wetlands in which we found no non-native macroinvertebrates. As noted above, however, this does not necessarily mean that these sites do not contain non-native macroinvertebrates.

We found zero non-native aquatic macroinvertebrates in 55% of Great Lakes coastal wetlands sampled from 2016-2020 (Figure 6), but in a handful of wetlands we found as many as 4-5 non-native invertebrate taxa.

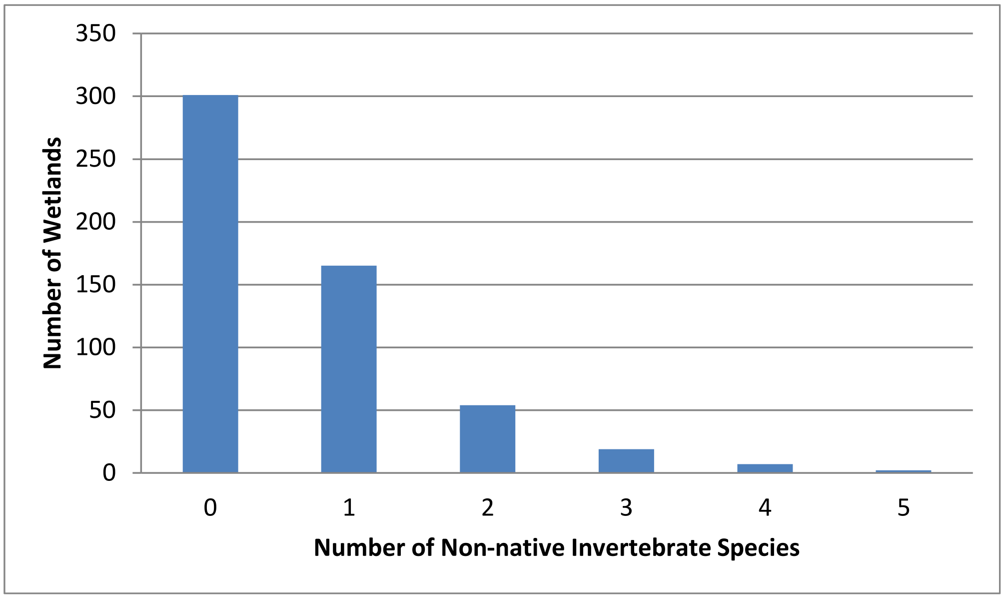


Figure 6. Number of Great Lakes coastal wetlands containing non-native invertebrate species. Data from 2016 through 2020.

In 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 7 and 8 for the faucet snail, *Bithynia tentaculata*. Figure 7 shows the range portrayed on the USGS website for this snail before we reported our findings. Figure 8 shows the locations where our crew found this snail. Finally, Figure 9 shows the USGS website map after it was updated with our crews' reported findings.

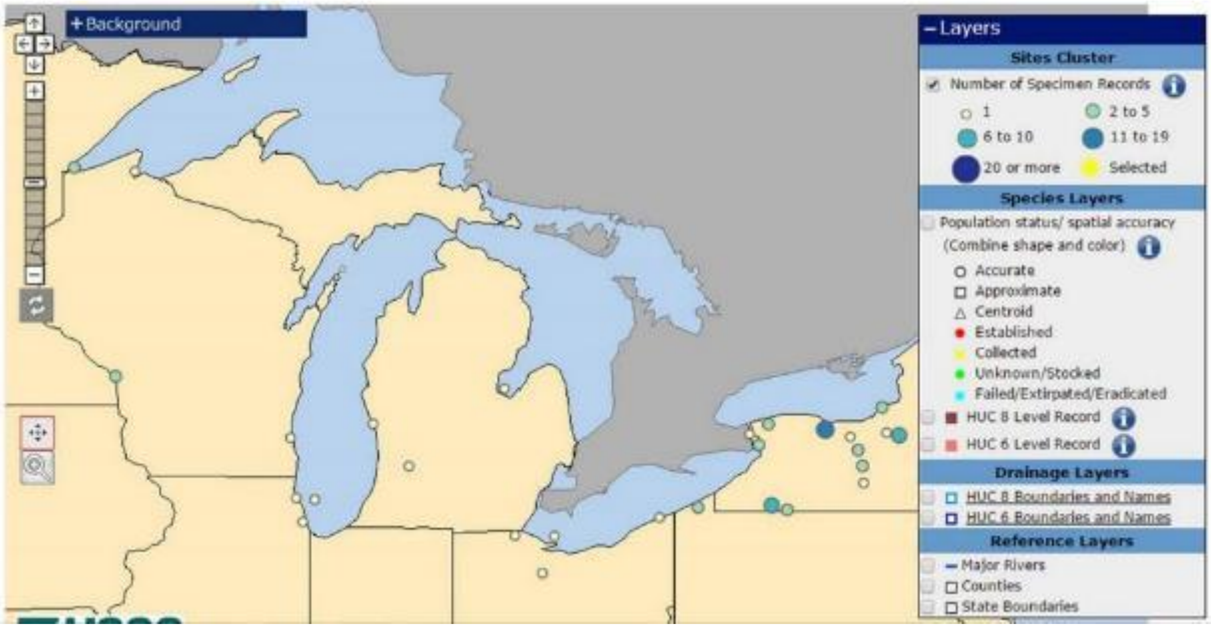


Figure 7. Locations of *Bithynia tentaculata* in USGS NAS website PRIOR to our project providing additional locations where they were collected.

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.

In collaboration with the Great Lakes Environmental Indicators project and researchers at the USEPA Mid-Continent Ecology Division in Duluth and at the University of Wisconsin Superior, a note was published in the Journal of Great Lakes Research about the spread of *Bithynia* in Lake Superior (Trebitz et al. 2015).

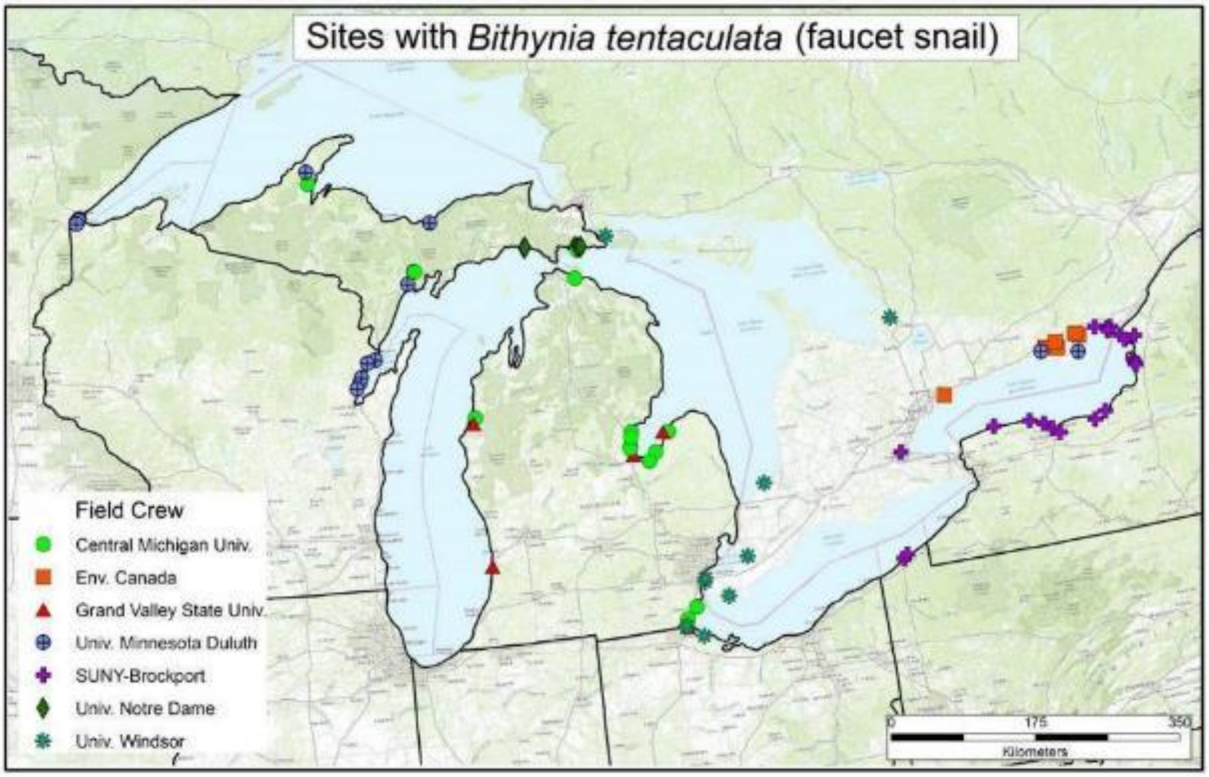


Figure 8. Locations of *Bithynia tentaculata* found by CWM crews, 2011 - 2013.

We also routinely provide data on other non-native macroinvertebrates, fish, and aquatic vegetation to Great Lakes databases and websites that track this information.

On average, there were approximately 40 macrophyte species per wetland (Table 14) with a maximum number of 100 species at exceptionally diverse sites. Some sites were quite depauperate in plant taxa (some having none), particularly in highly impacted areas that were no longer wetlands but were sampled because they are designated for restoration and because of high water levels along higher energy coastlines.

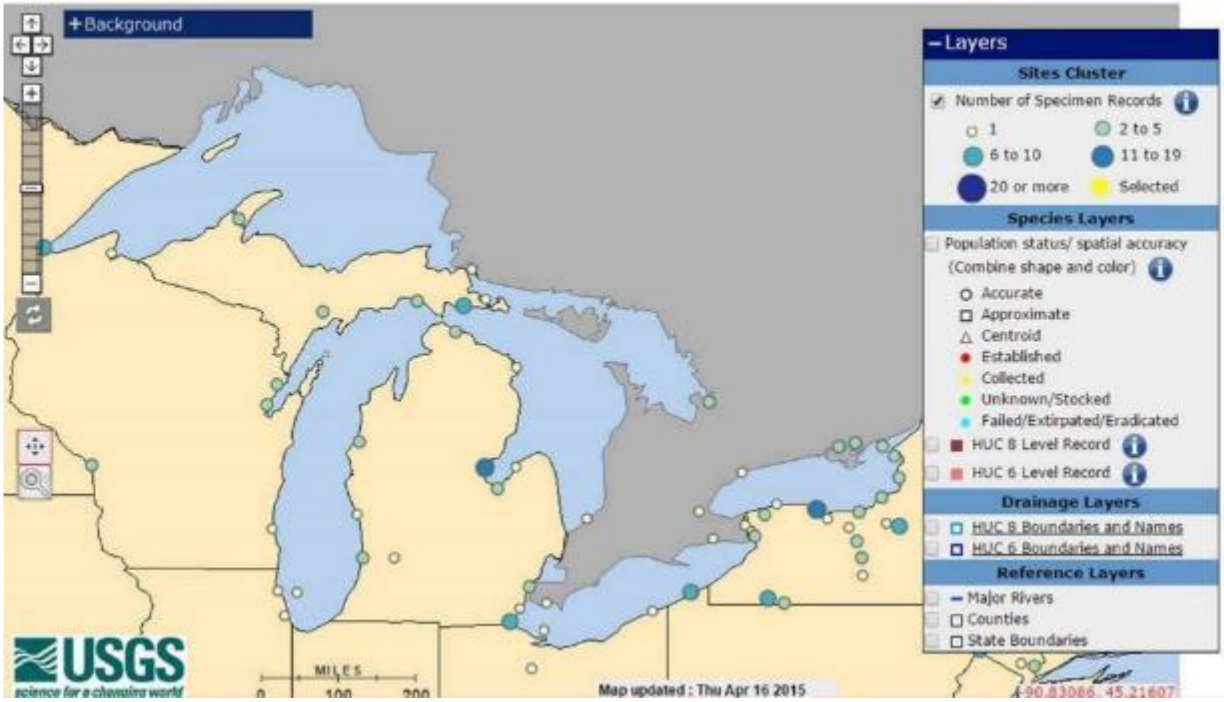


Figure 9. Locations of *Bithynia tentaculata* in USGS NAS website AFTER our project provided additional locations where they were collected; compare to Figure 6.

Non-native vegetation is commonly found in Great Lakes coastal wetlands. We have updated our plant taxa lists to ensure that we are correctly coding all non-native macrophyte taxa, even those that are not currently considered invasive. This update changed the numbers of non-native species for many wetlands because in the past we had focused more on the non-natives that are invasive and are problematic in wetlands.

Coastal wetlands averaged 4-5 non-native species (Table 14). Some wetlands contained as many as 21 non-native macrophyte species, but there were wetlands in which no non-native plant species were found. It is unlikely that our sampling strategy would miss significant non-native plants invading 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 keep restored wetland sites from becoming dominated by invasive plant species.

Table 14. Total macrophyte species and non-native macrophytes in Great Lakes coastal wetlands; summary statistics by country. Data from 2011 through 2022, using only data from the most recent year sampled for each wetland.

Country	Site count	Mean	Max	Min	St. Dev.
Overall					
Can.	181	36.6	88	5	17.1
U.S.	321	38.9	100	0	17.7
Non-native					
Can.	181	4.9	13	0	3.0
U.S.	321	3.9	21	0	3.1

Lake Erie wetlands had by far the lowest mean number of macrophyte species (24, Table 15), with the other lakes' wetlands having higher mean numbers of species (34-42, Table 15). Maximum species richness in Lake Erie wetlands was also lower than wetlands on the other Great Lakes. Average numbers of non-native species were highest in Lake Ontario and lowest in Lake Superior wetlands (Table 15). Lake Superior had the lowest maximum number of non-native macrophytes in a wetland (6) and Lake Huron had the highest maximum number with 21. There are wetlands on all lakes except Lake Ontario in which we did not detect invasive plants.

Table 15. Macrophyte 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 2022, using only data from the most recent year sampled for each wetland.

		Macrophytes (Total)			Non-native		
Lake	Sites	Mean	Max	Min	Mean	Max	Min
Erie	58	24.2	61	5	5.3	14	0
Huron	175	42.4	100	3	3.1	21	0
Michigan	80	37.0	72	7	3.9	11	0
Ontario	127	41.0	91	8	7.0	16	1
Superior	62	34.6	64	0	1.4	6	0

Our macrophyte data have reinforced our understanding of the numbers of coastal wetlands that contain non-native plant species (Figure 10). Only 7% of 556 sampled wetlands lacked non-native species, leaving 93% with at least one. Sites were most commonly invaded by up to 7 non-native plant species and 13% of sites contained 8 or more non-native species.   Detection of non-native 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 non-natives in some wetlands.

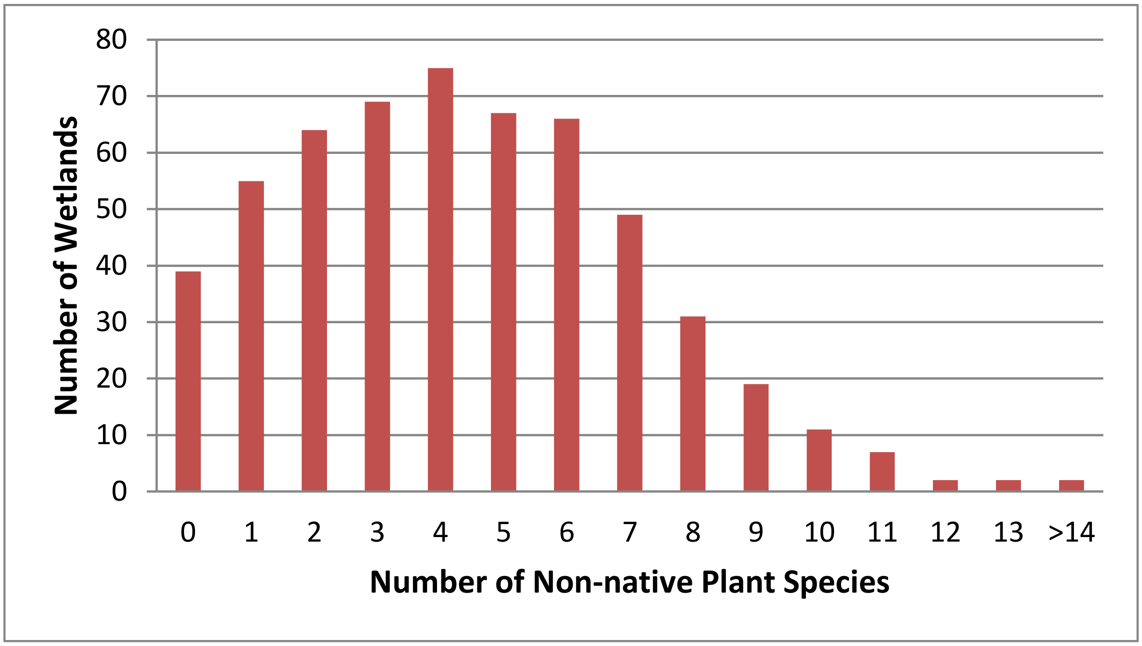


Figure 10. Number of Great Lakes coastal wetlands containing invasive plant species based on 2016 through 2020 data.

As an example for the state of Michigan, we also looked at wetlands with both invasive plants and plant species considered “at risk” (Figure 11). 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.

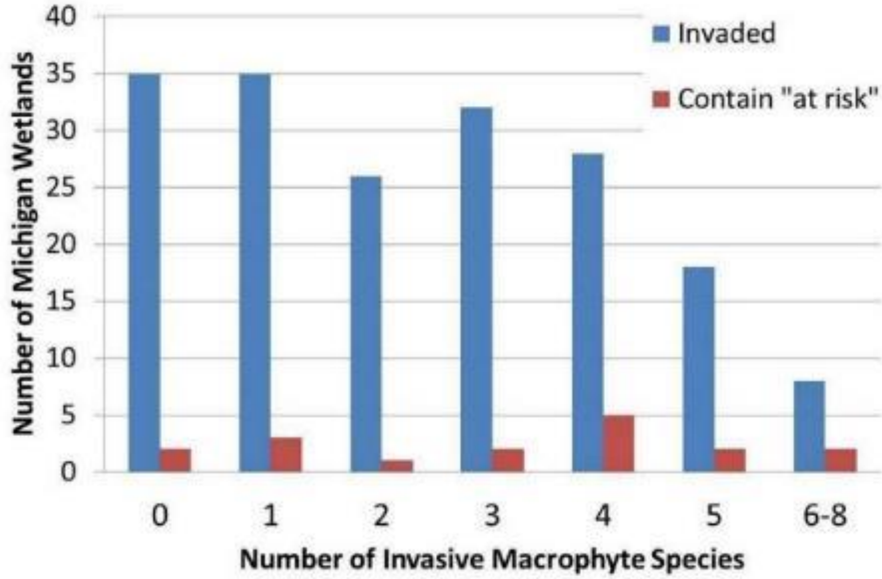


Figure 11. Number of state of Michigan Great Lakes coastal wetlands containing both invasive plant species and “at risk” plant species, based on 2011 through 2014 data.

We created a map of invasion status of Great Lakes coastal wetlands using all invasive species data we collected through 2014 for all taxonomic groups combined (Figure 12). 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.

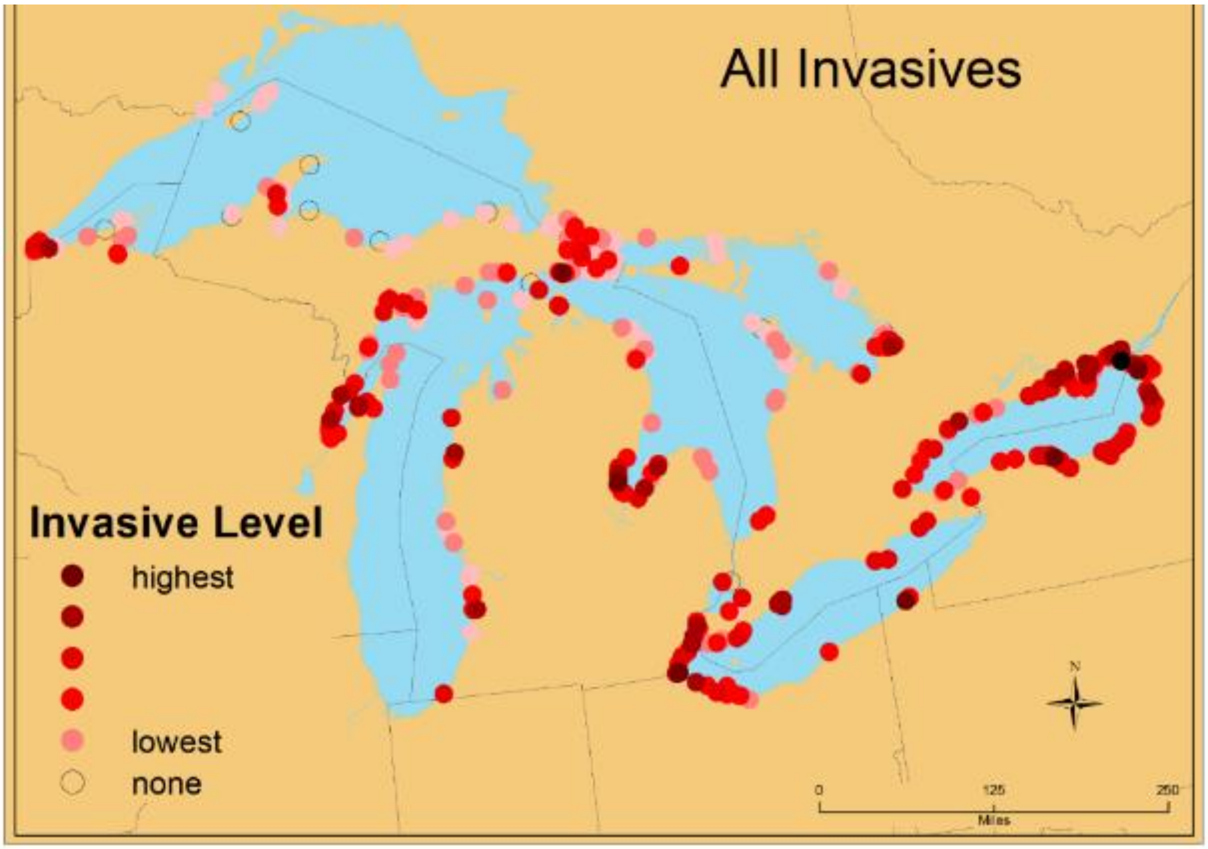


Figure 12. Level of "invadedness" of Great Lakes coastal wetlands for all non-native taxa combined across all taxonomic groups, based on data from 2011-2014.

WETLAND CONDITION (based on 2011 – 2022 data unless otherwise noted)

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 anurans [calling amphibians]).

Macrophytic vegetation has been used for many years as an indicator of wetland condition (only large plants; algal species were not included). 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 Conservatism (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). We also give invasive and non-native species a rank of 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 uses C scores for wetland species, among other metrics.

This IBI has been updated and adjusted multiple times since the start of the project, accounting for the shift in condition scores for some sites. The first adjustment was necessary to reflect changes in the taxonomic treatment of many marsh plants in the 2012 Michigan Flora and Flora of North America. In spring 2020, Dr. Dennis Albert, with assistance from Allison Kneisel, reviewed the data input file for the plants, looking at each individual species (taxa) on the list and observing how many records of each taxon were in the database. First, redundant entries were removed; some taxa had several synonyms in the database. The next step was to remove species that had no occurrences over 9 years of data collection; this eliminated 2082 species or 49.6% of the original species from the data input file.

A final step was to review the database for upland species or species that were outside of their accepted range. Some of these were clearly errors that resulted from the dropdown menu. For example, *Carex oligosperma*, a common northern wetland sedge, was recorded along several transects over several years in a Lake Superior wetland, but then *Carex oligocarpa*, an upland sedge immediately next to *C. oligosperma* on the dropdown list, was recorded at several points along a single transect. This was clearly a data recording error. Similar errors were identified for a handful of species. Another type of error that was identified and corrected in the database occurred when a species was noted that had a range north or south of the Great Lakes but appears very similar to a Great Lakes species so was identified in error. Similarly, cases were found in which an upland species was selected instead of the correct wetland species with very similar characteristics; this was also a rare situation involving less than 10 species.

Collectively, these revisions reduced the plant data input list from 4192 species to 1724 species, a reduction of 59%, which should both speed up and reduce errors in data input.

Allison Kneisel reviewed and modified the existing non-native species list. This process resulted in the addition of 9 species to the non-native species list. For computation of the IBI scores, many of the best-studied non-native species are used in computation of specific IBI metrics. For many of the species that were added to the non-native species list, there are few studies documenting what individual species are responding to, whether the response is to wetland dry down, increased nutrient loading, turbidity tolerance, or other factors.

New for 2023 we are debuting a draft vegetation-based IBI; this IBI was originally developed by Dr. Dennis Albert during the early stage of Great Lakes-wide biotic sampling for the USEPA (Albert 2008) and is now updated (see Dybiec et al. 2020). The structure and many of the metrics of the new IBI are shared with the original, but the new IBI has increased the number of metrics used and refined the metrics for the submergent zone. The original submergent zone metrics were difficult to compute.

Both the old and new IBIs were calculated by vegetation zone, making it possible to identify the source of degradation in a wetland. In many cases the impact of land or water use can result in the level of degradation in one zone being very different than that in other zones, and identifying the degraded zones can facilitate more effective restoration efforts. The advantage of the Dybiec et al. (2020) version is that the zonal scores are more easily accessible than in the original IBI, and the submergent zone metrics are much more dependable and easier to compute. The zonal scores in both IBIs are combined to create a site-wide score, and these site-wide scores are what are used in individual lake (Erie, Huron, Michigan, Ontario, and Superior) comparisons and long-term tracking of wetland quality change for the individual lakes and the entire Great Lakes.

The scores of the old and new IBIs are strongly correlated for the site-wide scores, with R2 = 0.65 for the entire plant database between 2011-2022 (Figure 13), with a similar R2 = 0.63 for the high-water years of 2021-2022 (Figure 14). It appears that the IBI scores of some of the most open lacustrine sites that had the highest IBI scores (5) with the original IBI, scored much lower with the new IBI, especially during high-water years of 2021 and 2022. Our interpretation is that the new IBI is providing a more effective evaluation of the submergent zone, a weakness in the original IBI.

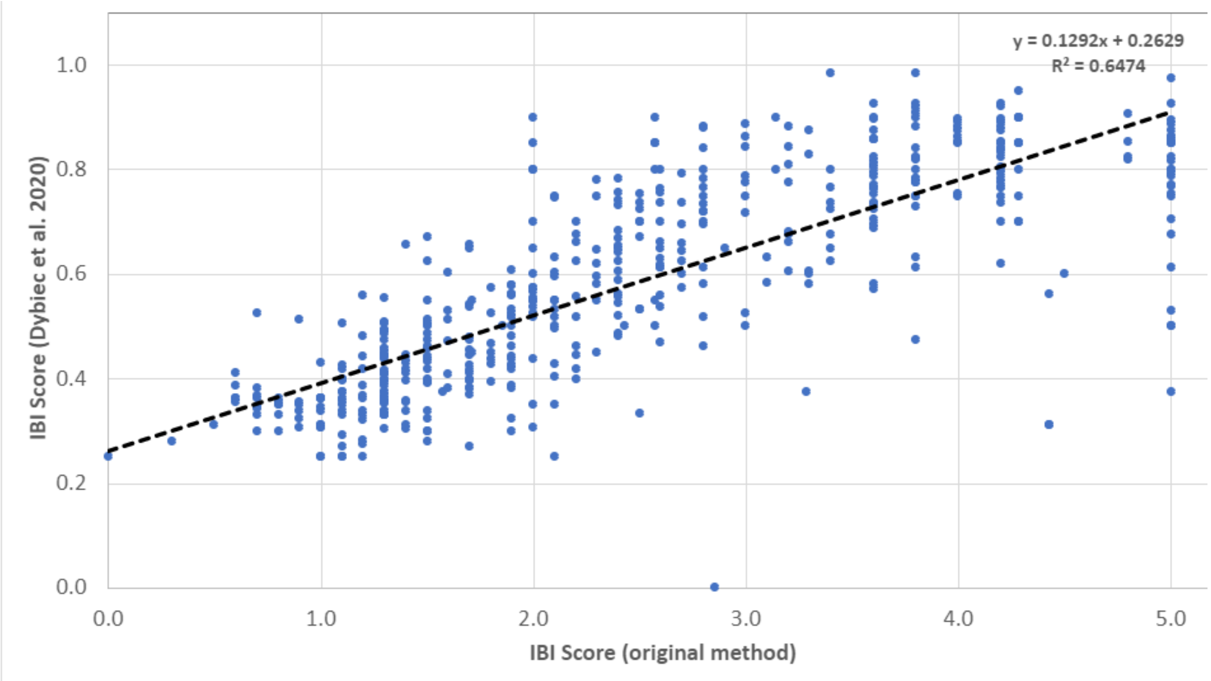


Figure 13. Comparison of original vs. revised vegetation IBI (2011-2022).

Using the new IBI, the site-wide scores appear to be slightly lower for the most degraded sites (old IBI scores <2) and slightly higher for the less degraded sites (old IBI scores >2). This is likely the result of adding metrics based on specific taxa, Carex spp. for the Wet Meadow, and Cyperaceae cover for the emergent zone, both taxonomic groups well represented in less degraded wetlands and often groups missing from highly degraded wetlands.

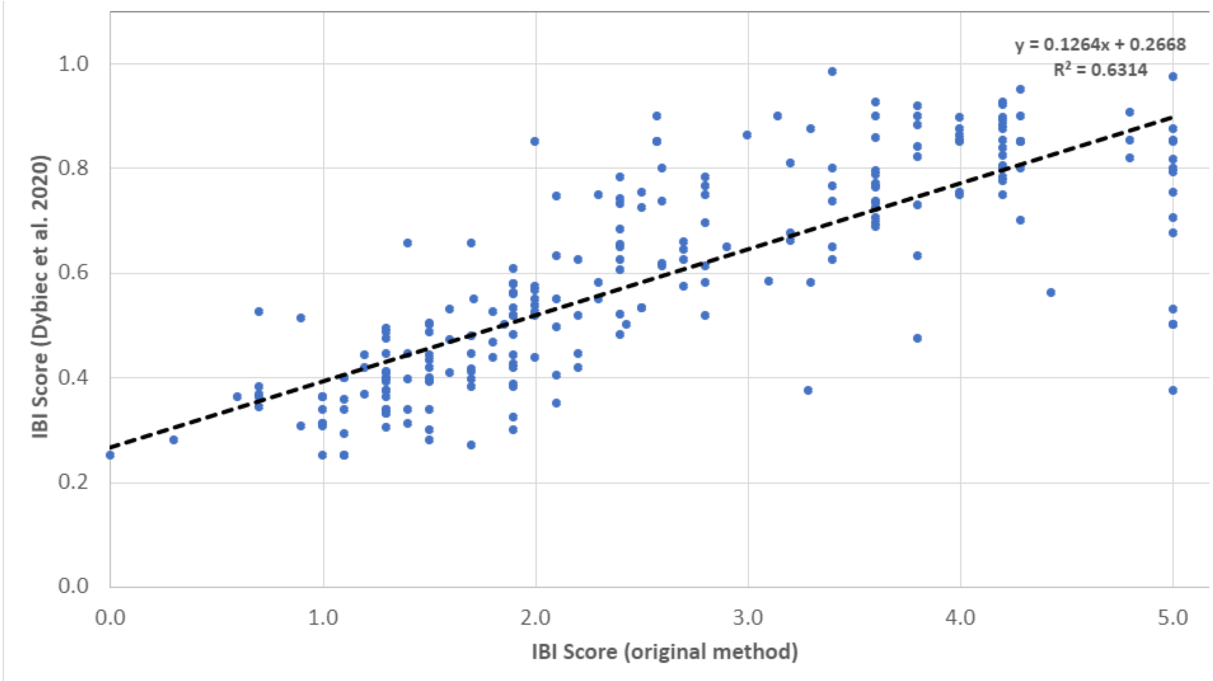


Figure 14. Comparison of original vs. revised vegetation IBI (2021-2022 data only).

Lake-wide comparison of the old and new IBIs produce similar results. The order of lake-wide quality remains the same, with Lake Superior having the highest IBI scores, followed in order by Lake Huron, Lake Michigan, Lake Ontario, and Lake Erie.

The map (Figure 15) shows the distribution of Great Lakes coastal wetland vegetation index scores across the basin. Note that there are long stretches of Great Lakes coastline that do not have coastal wetlands due to topography and geology. Sites with low FQI scores are concentrated in the southern Great Lakes, where there are large amounts of both agriculture and urban development, and where water levels may be more tightly regulated (e.g., Lake Ontario), while sites with high FQI scores are concentrated in the northern Great Lakes. Even in the north, an urban area like Duluth, MN may have high quality wetlands in protected sites and lower quality degraded wetlands in the lower reaches of estuaries (drowned river mouths) where there are legacy effects from the pre-Clean Water Act era, along with nutrient enrichment or heavy siltation from industrial development and/or sewage effluent. Benchmark sites in need of restoration will also have lower condition scores.

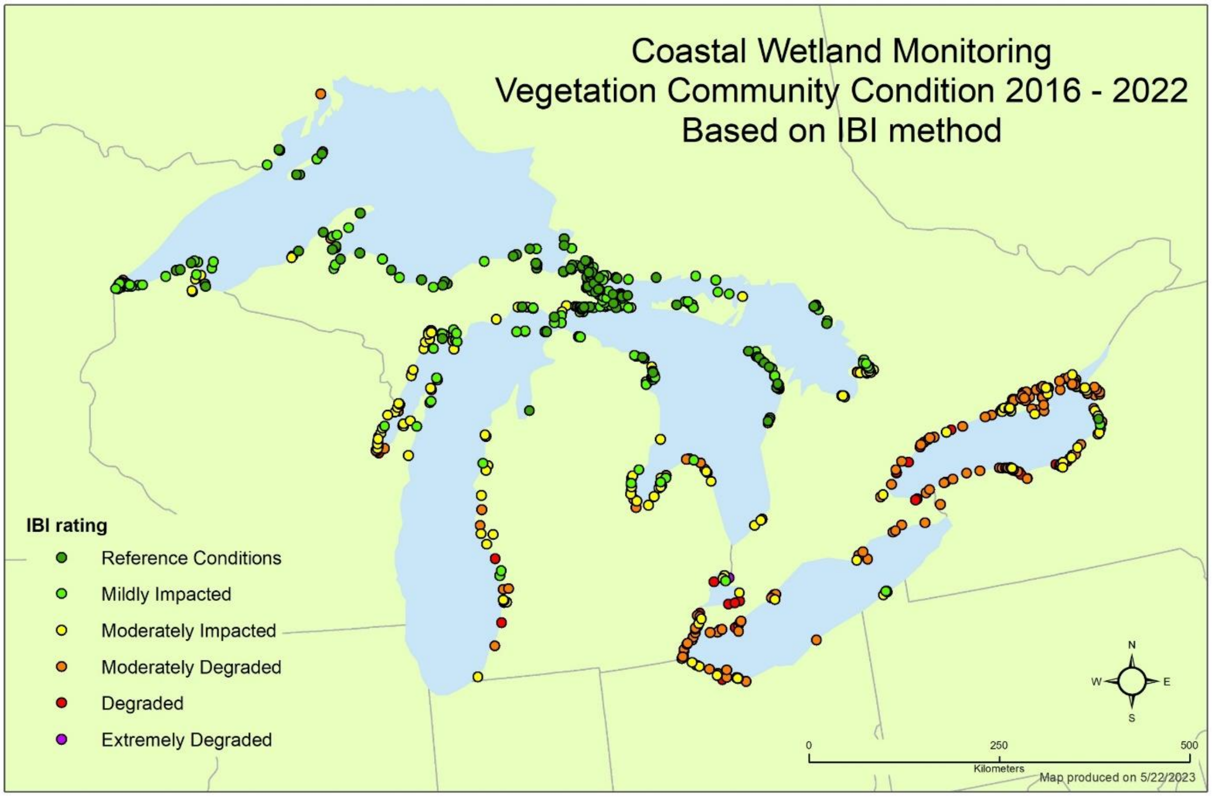


Figure 15. Condition of coastal wetland vegetation at sites across the Great Lakes. Circle color indicates vegetation community quality. Map shows IBI for the most recent year sampled for each site. IBI newly updated for 2023; see text for description.

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 (Figure 16). In 2019 we had a major shift in the taxonomy of some invertebrates (primarily snails and mollusks) used in the calculation of some indicator metrics due to taxonomic updates and revisions. Thus, the invertebrate IBI map (Figure 16) in this report should not be compared to the maps shown in previous reports. However, this IBI has been calculated for all sites with appropriate zones and invertebrate data for all years.

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 published macroinvertebrate IBI. We are developing IBIs for additional vegetation zones to cover these sites, but these IBIs have not yet been validated so they are not included here.

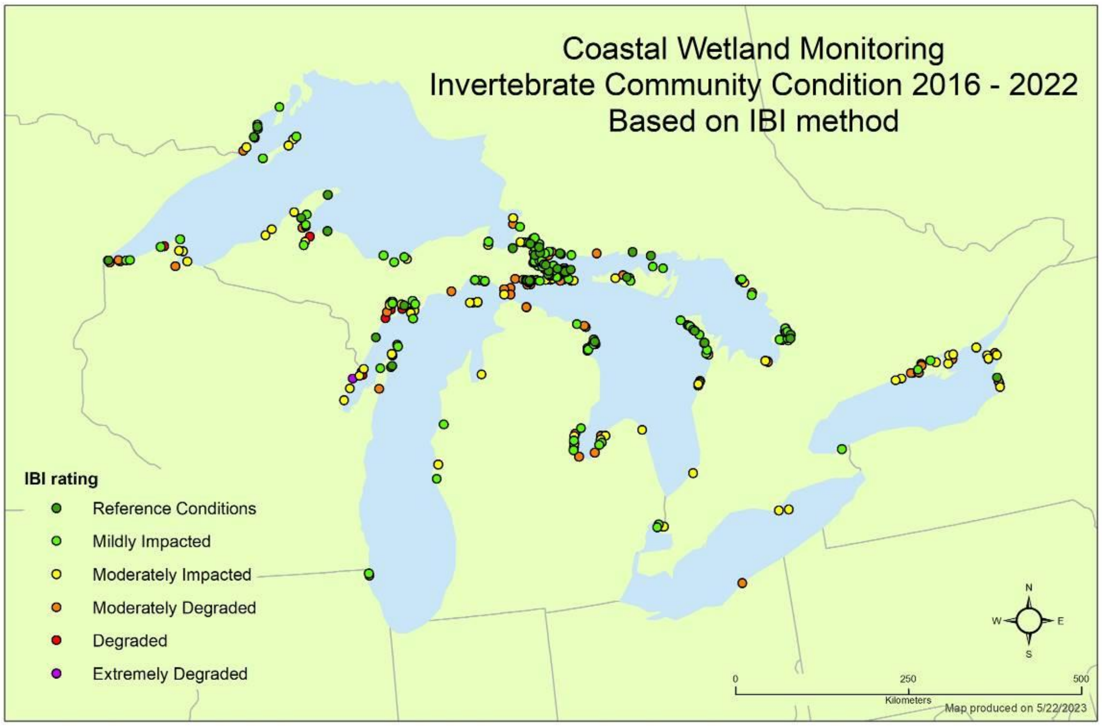


Figure 16. Condition of coastal wetland macroinvertebrate communties at sites with bulrush or wet meadow zones. Map shows IBI for the most recent year sampled for each site.

We are now able to report updated and improved fish IBI scores for wetland sites containing bulrush, cattail, lily, or SAV zones (Figure 17). Because of the prevalence of these vegetation types in wetlands throughout the Great Lakes basin, this indicator provides more site scores than the macroinvertebrate indicator. Because these are updated and adjusted indicators, the map image in this report should not be compared to fish IBI map images in previous reports. However, all sites reporting fish data from zones applicable to the new fish IBIs are shown here, regardless of the year they were sampled.

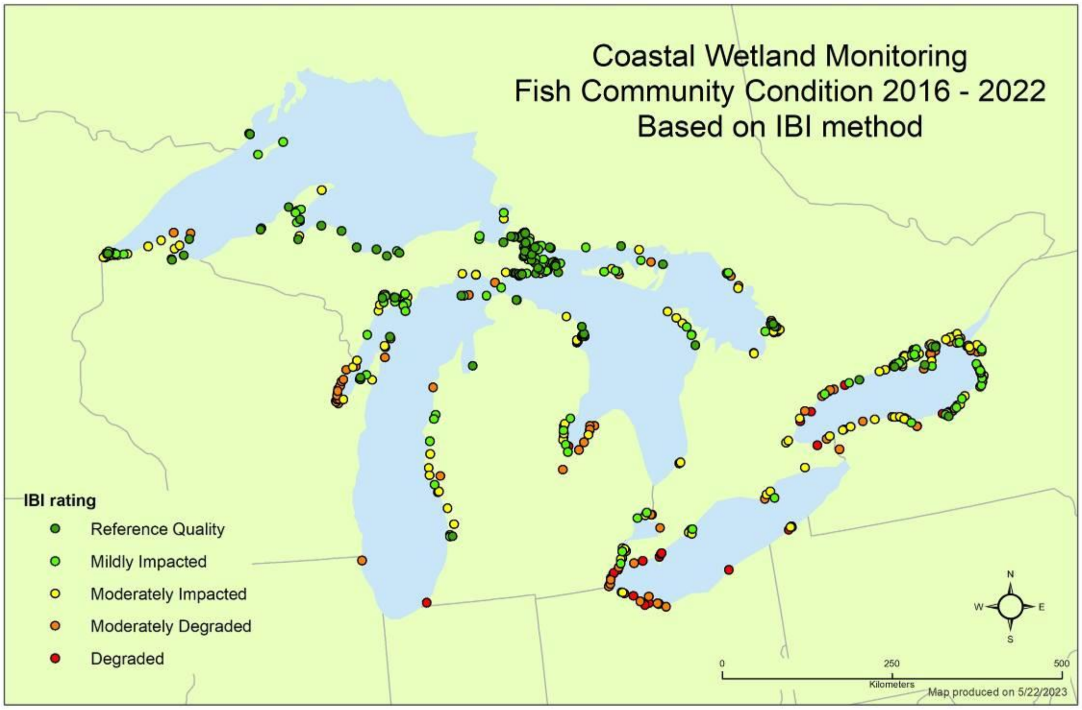


Figure 17. Condition of coastal wetland fish communties at sites with bulrush, cattail, lily, or submerged aquatic vegetation zones. Map shows IBI for the most recent year sampled for each site.

To develop the new fish IBI, fish community 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 (SumRank; 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 (2011-2015 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 10-11 fish assemblage 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 five years. A manuscript describing development and testing of this IBI has been published (Cooper *et al.* 2018).

Bird indicators were calculated using the same approach described in previous years (Howe *et al.* 2007a, Howe *et al.* 2007b, Gnass Giese *et al.* 2015, Jung *et al.* 2020). In short, we applied a two-stage process: 1) quantify the responses of selected bird species to an *a priori* reference gradient based on a multivariate measure of disturbance or stress (the "human footprint"), and 2) use these parameterized biotic responses (BR functions) to iteratively assess the condition of wetlands according to the species present (or absent) in each wetland. The result for a given wetland site, called the Index of Ecological Condition (IEC), is scaled from 0 (worst condition) to 10 (best condition) in the context of all sites evaluated.

The IEC2 metric replaces the likelihood metric (Index of Ecological Condition, Howe et al. 2007a, 2007b, Gnass Giese et al. 2015, Jung et al. 2020, and Howe et al. 2021) used during previous years of the Great Lakes Coastal Wetland Monitoring Program. When the number of species is relatively small, IEC estimates are often unstable and tend to gravitate to IEC = 0; likewise, when a moderate number of the most sensitive ("high quality") species are present, the index trends to IEC = 10. Values of the new IEC2 are highly correlated with the original IEC (Figure 18), but they do not exhibit convergence at IEC=0 and IEC=10, yielding a distribution of values that is nearly normally distributed (Figure 19). However, this means that there are fewer sites in the two best condition categories and it is very important that only the new IEC2 scores are used for sites. Scores for all sites have been recalculated using this new metric and their scores are provided.

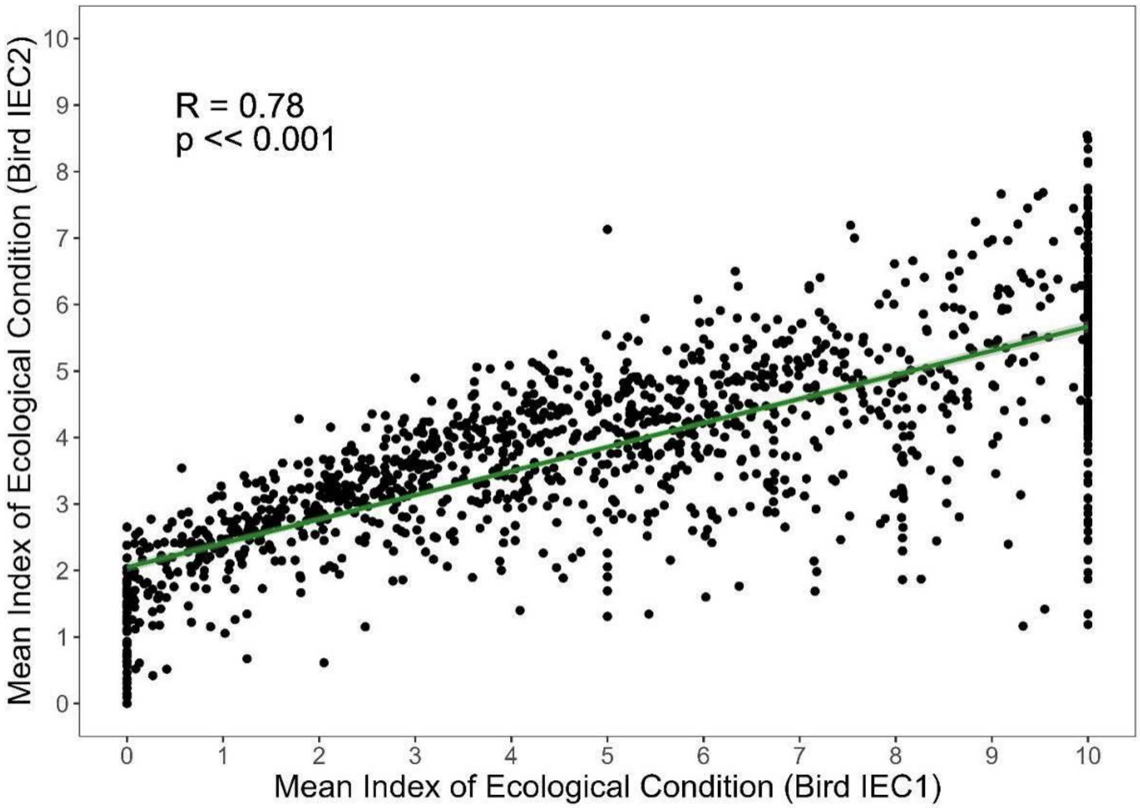


Figure 18. Correlation between the original Index of Ecological Condition (IEC1) and the new, much simpler metric, IEC2, for coastal wetland birds. Symbols (black dots) represent 1,909 wetland sites sampled 2011-2021. At wetlands where two or more points were sampled, the IEC values plotted are the mean IEC1 and IEC2 of all points. Note that disproportionate numbers of values occur at IEC1 = 0 and IEC1 = 10, an undesirable artifact that does not exist for IEC2.

Like the original IEC, the new metric (IEC2) is highly correlated with species richness (Figure 20), but it "weighs" species according to 1) their sensitivity to wetland disturbance and 2) their likelihood of occurrence and detection in highest quality wetlands. Species weights are derived from parameters of BIOTIC RESPONSE (BR) FUNCTIONS representing each of the targeted bird species or species groups, identical to the approach underlying the original IEC (Howe et al. 2007a, 2007b, Gnass Giese et al. 2015). Our BR functions are based on a best-fit normal distribution depicting the response of bird species or species groups to a multivariate gradient representing wetland area and the "human footprint" in the landscape surrounding the wetland Elliott (2019).

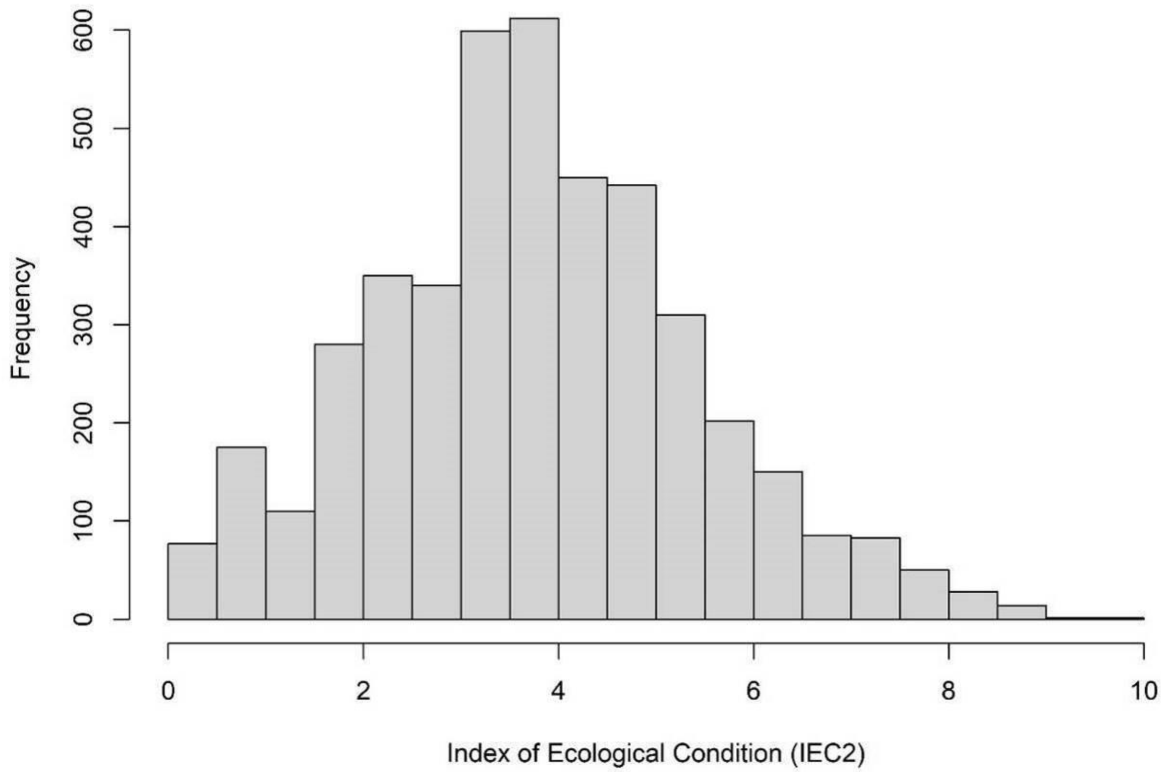


Figure 19. Distribution of IEC2 values from 4,369 point counts between 2011-2022. Although the theoretical range of IEC2 values ranges from 0-10, the median value of IEC2 = 3.726 (mean=3.758), illustrating the tendency of this metric to fall in the lower portion of the 0-10 scale. IEC2 values of 4.79 or higher represent high quality bird assemblages in the upper quartile (25%) of all point samples.

BR functions are estimated using a maximum likelihood algorithm written by Robert Howe and Nicholas Walton in the R statistical computing environment (R Core Team 2023). Variables used to derive the "human footprint" include wetland size, % developed land and roads within 2 km of the wetland's center, % agricultural land within 2 km, % developed/agricultural land in the watershed flowing into the wetland, and human population within the watershed. Note: BR functions resemble the pre-determined COEFFIENTS OF CONSERVATISM often used for plant species indicator metrics (Bourdaghs et al. 2006), although our BR functions are an empirically derived, quantitative functional response rather than a subjective number assigned by experts.

Weights for each species or species group are calculated as the product of two parameters: 1) the mean of the BR function and 2) the value of the BR function when the reference (environmental) gradient = 10. The BR function mean reflects the sensitivity of the species to the reference gradient; the more sensitive the species, the larger will be the mean. The shape of BR functions might reflect normal distribution functions whose means extend beyond the limits (0-10) of the reference gradient (Gnass Giese et al. 2015). The second parameter reflects the probability of encountering the species at highest quality sites, influenced by the ubiquity (commonness) of the species and the probability of detecting individuals when the species is present. This parameter effectively imposes a penalty for bird assemblages where common wetland species are absent; the absence of rarer species does not reduce the metric as significantly. The value of IEC2 is the sum of weights for all species present at the wetland during the two seasonal point counts, scaled from 0 (when no species are present) to 10 (when all species are present except those with negative weights).

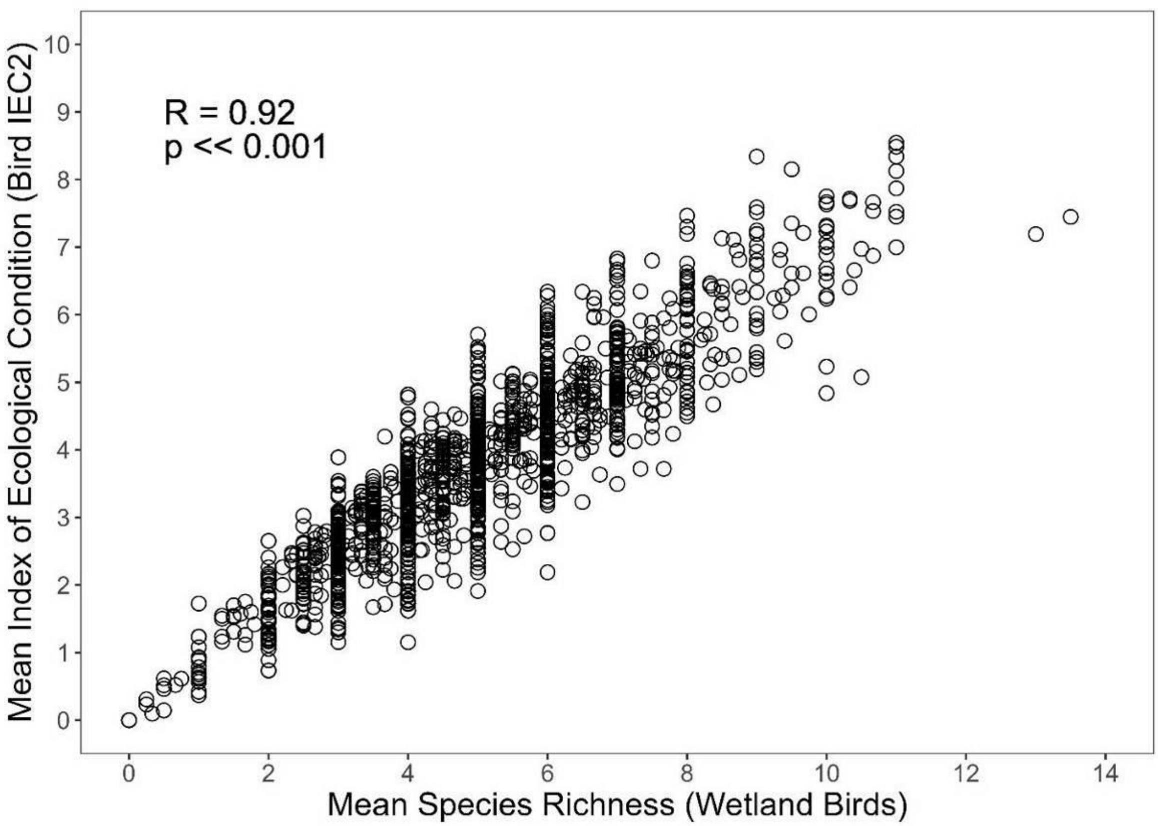


Figure 20. Relationship between species richness (number of bird species/taxa) and the Index of Ecological Condition 2 (IEC2). Points (open circles) represent wetland sites (n = 1947) sampled between 2015-2022. Note that for a given number of bird species (e.g. = 4), a point may have different values of IEC2 depending on the composition of species/taxa; points with a high IEC2 were characterized by species/taxa with higher weights (i.e., higher “quality” species).

IEC2 calculations for birds include one species with a negative weight, European Starling (*Sturnus vulgaris*, abbreviation = EUST). The negative weight reflects this species’ monotonically negative response to the environmental gradient; in other words, it is most common at the lowest quality sites and least common at the highest quality sites. The maximum IEC2 condition (W_{max}) therefore occurs where all species/species groups are present except EUST, whose presence lowers the calculated index.

Like the environmental reference gradient, IEC2 values can range from 0 (most disturbed condition with lowest quality species assemblage) to 10 (least disturbed site with the highest quality species assemblage).

In addition to its simplicity, the IEC2 metric retains several qualities that make it a desirable biotic indicator. High scores are attained when the target site supports a broad range of functional taxonomic groups, including species that represent the full gradient of coastal wetland zones from coastal marsh (preferred by piscivores like Pied-billed Grebe) to seasonally flooded wet meadows (suitable for species like Sandhill Crane and Sedge Wren). The use of a limited set of indicator species and a fixed-effort sampling protocol also eliminates or at least reduces the influence of sampling effort, which can be problematic for unconstrained application of metrics like the Floristic Quality Index or other indices that are correlated with species richness. Finally, the design of this metric creates the possibility that a comprehensive index could combine field data from birds, anurans, plants, and other taxonomic groups if objective species weights are available.

Note that high quality and reference values occur in all regions (Figure 21), suggesting that quality coastal wetlands for birds are widely distributed across the Great Lakes.

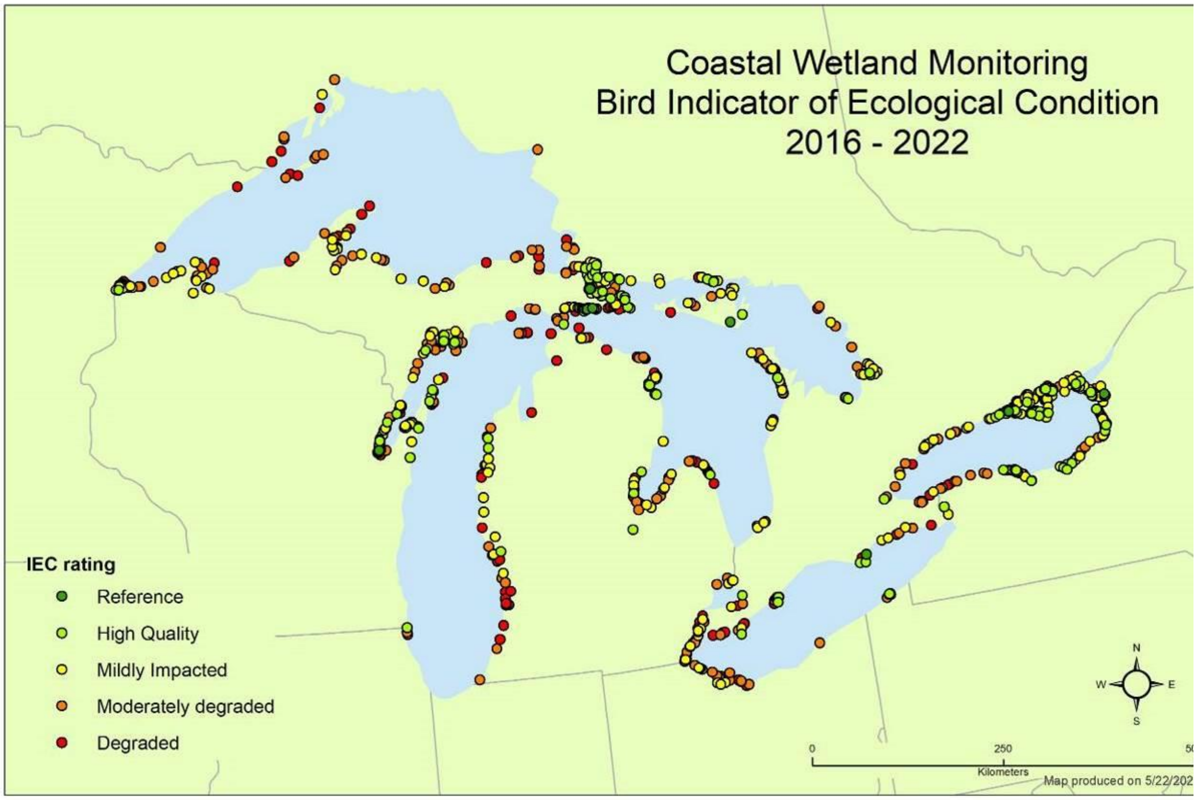


Figure 21. Condition of coastal wetland bird communties. This indicator is based on the IEC2 method (see text) using data collected primarily between 2016 and 2022, with data from 2011-2015 used to create the the baseline for the indicator but used to to calculate the actual wetland condition at a site only when more recent data were unavailable.

Coastal Wetland Monitoring field teams have recorded 13 species of anurans (2 toads and 11 frogs) since 2011, but 4 of these (northern [Blanchard's] cricket frog, *Acris crepitans*; Fowler's toad, *Anaxyrus fowleri*; mink frog, *Lithobates septentrionalis*; and pickerel frog, *Lithobates palustris*) are seldom observed. Cope's gray treefrog (*Dryophytes chrysoscelis*) and eastern gray treefrog (*Dryophytes versicolor*) are sibling species that are difficult to differentiate in the field, so we combined records into a single taxon. We also did not separate geographically distinct species of chorus frogs, *Pseudacris*. IEC calculations for anurans therefore were based on 8 taxa (American toad or Fowler's Toad, *Anaxyrus spp*.; gray treefrogs*, Dryophytes spp*.; bullfrog, *Lithobates catesbeianus*; northern leopard frog, *Lithobates pipiens*; green frog, *Lithobates clamitans*; wood frog, *Lithobates sylvaticus*; chorus frogs, *Pseudacris spp*., and spring peeper, *Pseudacris crucifer*). A ninth category combines other less-common species such as pickerel frog and mink frog (*Lithobates spp*.).

We used the arithmetic Index of Ecological Condition 2 (IEC2) to compare anuran (frog and toad) assemblages among Great Lakes coastal wetland sites. This metric uses occurrences of targeted wetland species (listed above) during standardized samples (described in Uzarski et al. 2017). Scores for species or species groups at a given site during a given year are determined by the occurrence (value = 1) or absence (value = 0) during any of 3 counts. In other words, the value for a given taxon is 0 only if the species was absent during all 3 seasonal samples.

The IEC2 metric replaces the likelihood metric (Index of Ecological Condition; Howe et al. 2007a, 2007b, Gnass Giese et al. 2015, Jung et al. 2020, and Howe et al. 2021) used during early years of the Great Lakes Coastal Wetland Monitoring Program. When the number of species is relatively small, IEC estimates are often unstable and may provide misleading results if just one or a few key species are present at a site. Frogs and toads are often impossible to count during evening auditory surveys, so analyses are limited to presence/absence data or highly subjective estimates of abundance; the IEC metric can be estimated with presence/absence data, but it tends to be more effective when abundance data are used. Finally, all anuran species regularly found in Great Lakes coastal wetlands are native, and all are at least somewhat sensitive to habitat degradation. Some species clearly are more vulnerable than others, but presence of any anuran species generally reflects positively on the quality of a wetland.

The new metric is highly correlated with species richness (Figure 22), but it “weights” species according to 1) their sensitivity to wetland disturbance and 2) their likelihood of occurrence and detection in highest quality wetlands. Species weights are derived from parameters of a BIOTIC RESPONSE (BR) FUNCTION representing each of the targeted anuran species, like the approach underlying the Index of Ecological Condition (Howe et al. 2007a, 2007b, Gnass Giese et al. 2015). Our BR functions are based on a multivariate gradient representing wetland area and the “human footprint” impacts on the wetland Elliott (2018). Variables used to derive the “human footprint” include wetland size, developed land and roads within 2 km of the wetland’s center, agricultural land within 2 km, developed/agricultural land in the watershed flowing into the wetland, and human population within the watershed. Note: BR functions resemble the pre-determined COEFFIENTS OF CONSERVATISM often used for plant species indicator metrics (Bourdaghs et al. 2006), although the BR functions represent an empirically-derived, quantitative functional response rather than a subjective number assigned by experts.

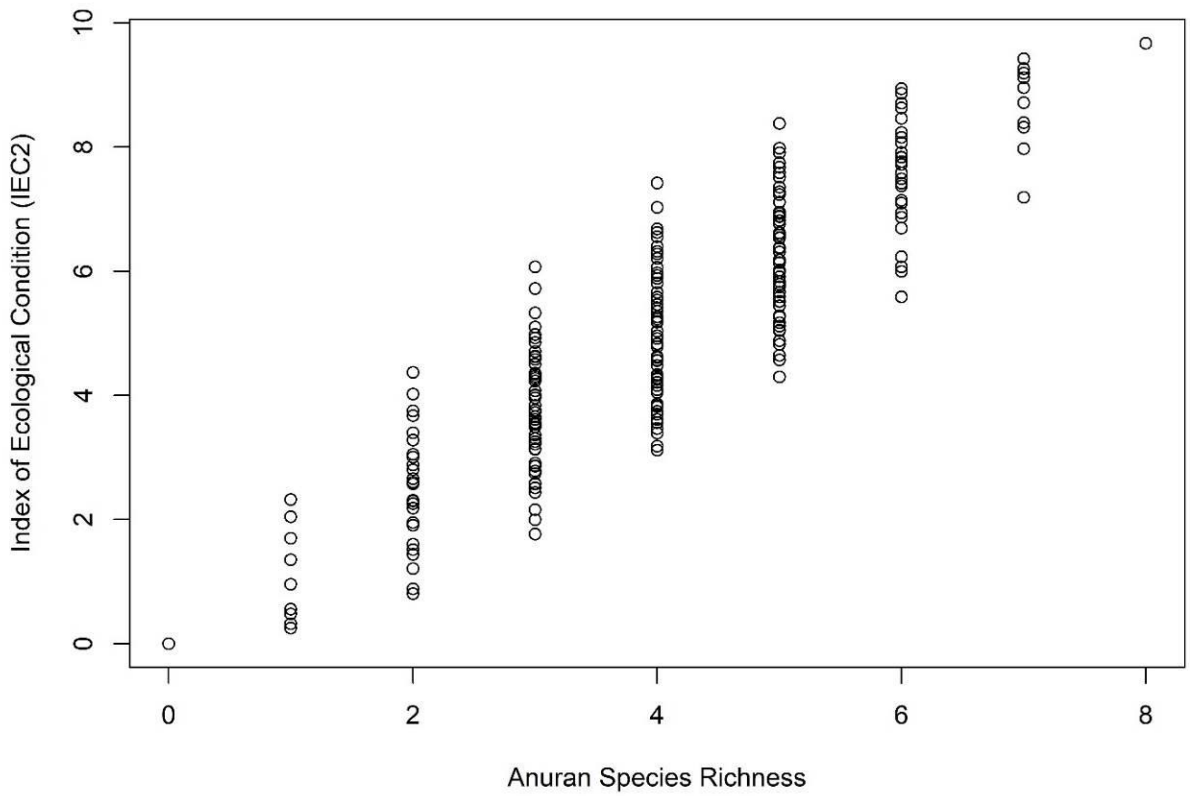


Figure 22. Relationship between species richness (number of anuran species/taxa) and the Index of Ecological Condition 2 (IEC2). Points (open circles) represent wetland points (n = 3299) sampled between 2015-2022. Note that for a given number of anuran species (e.g. 4), a point may have different values of IEC2 depending on the composition of species/taxa; points with a high IEC2 were characterized by species/taxa with higher weights (i.e., higher "quality" species).

Weights for each species are calculated as the product of two parameters: 1) the mean of the BR function and 2) the value of the BR function when the reference (environmental) gradient = 10. The BR function mean reflects the sensitivity of the species to the reference gradient; the more sensitive the species, the larger the mean will be. We limited the range of weights from 0 (least sensitive) to 10 (most sensitive), although the shape of BR functions might reflect normal distribution functions whose means extend beyond these limits (Gnass Giese et al. 2015). The second parameter reflects the probability of encountering the species at highest quality sites, influenced by the ubiquity (commonness) of the species and the probability of detecting individuals when the species is present. The value of IEC2 is the sum of weights for all species present at the wetland during the three seasonal counts, scaled from 0 (when no species are present) to 10 (when all species are present) (Figure 23).

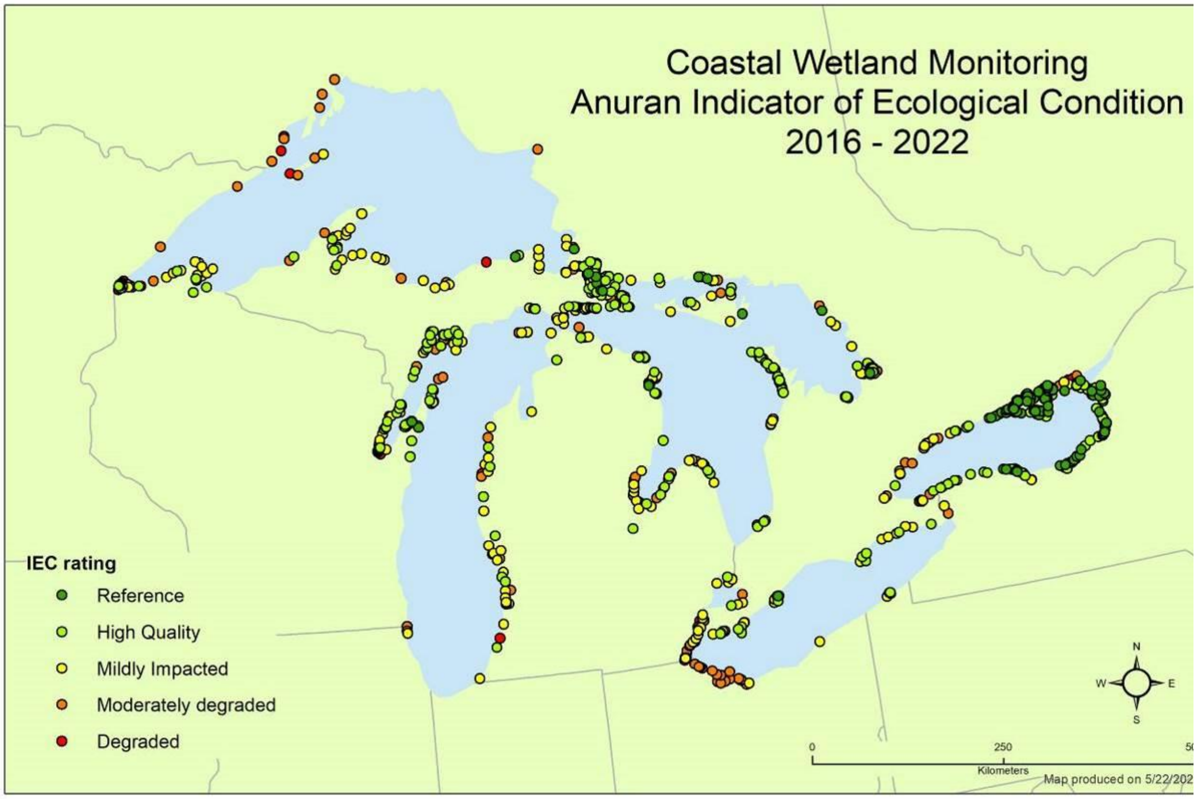


Figure 13. Condition of coastal wetland calling anuran communities. This indicator is based on the IEC method (see text) using data collected primarily between 2016 and 2022, with data from 2011-2015 used to create the the baseline for the indicator but only used to calculate the actual wetland condition at a site if no other data were available.

Finally, we have developed a water quality and land use indicator (Harrison et al. 2019). This indicator is based on landscape stressor data and water quality data collected from each aquatic plant morphotype (Figure 24).

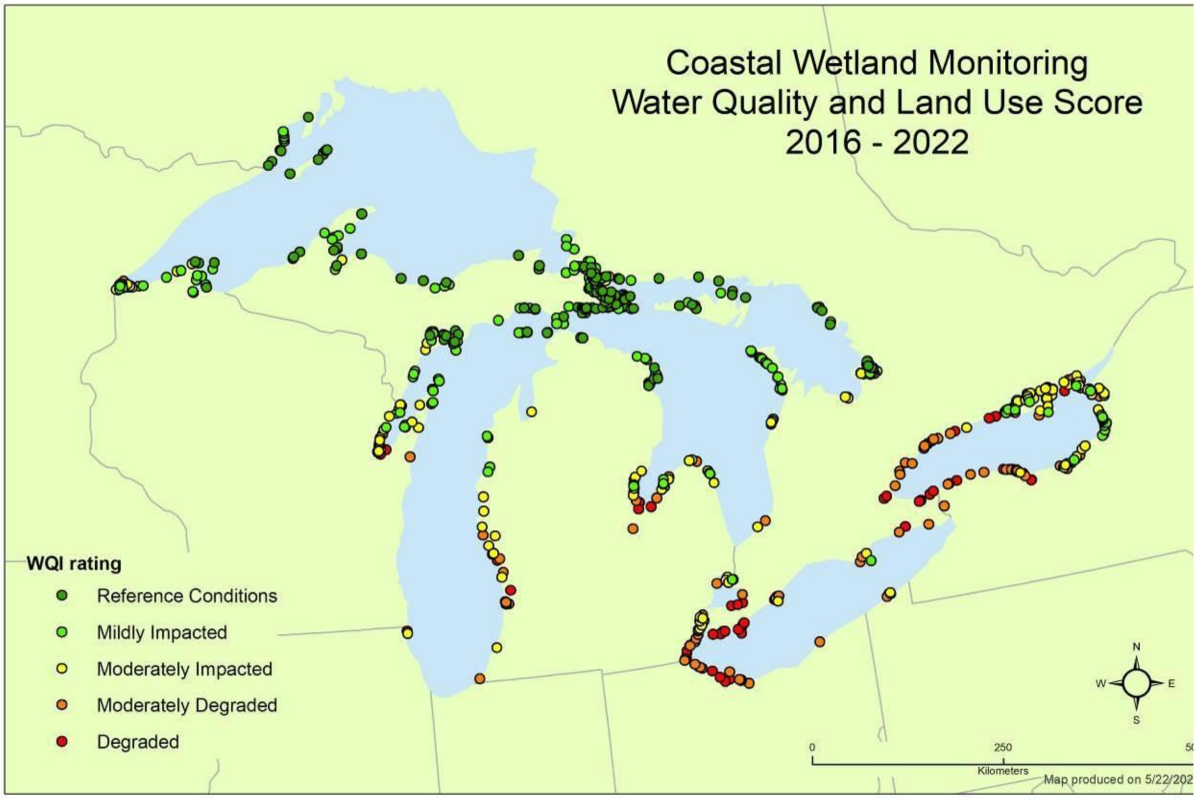


Figure 24. Disturbance gradient (SumRank) indicator. This indicator is based on landscape stressor data, site-based stressor data, and site water quality data. This is based primarily on data collected from 2016 through 2020.

PUBLIC ACCESS WEBSITE

The Coastal Wetlands Monitoring Program (CWMP) website provides efficient access to program information and summary results for coastal managers, agency personnel, and the interested public (Figure 25). As previously noted, the CWMP website was redeveloped and upgraded by LimnoTech and transitioned from an NRRI server to a permanent web hosting environment at Central Michigan University in spring 2016. The official launch of the new CWMP website occurred on April 26, 2016, including the public components of the website and data management tools for CWMP principal investigators and collaborators. Since that time, coastal managers and agency personnel have used the website's account management system to request and obtain accounts that provide access to the wetland site mapping tool, which includes reporting of Index of Biotic Integrity (IBI) scores. CWMP researchers have also obtained user accounts that provide access to data upload, entry, editing, download, and mapping tools. LimnoTech is providing ongoing maintenance and support for the website, including modifying and enhancing the site as required to meet CWMP and GLNPO needs, as well as other end user needs.

Figure 25. Front page of the Great Lakes Coastal Wetland Monitoring public website, www.greatlakeswetlands.org.

The CWMP website provides a suite of interrelated webpages and associated tools that allow varying levels of access to results generated by the CWMP, depending on the user's data needs and affiliation. Webpages available on the site allow potential users to request an account and for site administrators to approve and manage access levels for individual accounts. Specific levels of access for the website are as follows:

- **Public** – this level of access does not require a user account and includes access to a basic version of the wetland mapping tool, as well as links to CWMP documents and contact information;
- **Site metrics (level 1)** – provides access to index of biological integrity (IBI) scores by wetland site via the coastal wetland mapping tool;

- **Agency/manager-basic (level 2)** - access to IBI scores and full species lists by wetland site via mapping tool;
- **CWMP scientists (level 4)** - access to data entry/editing tools (+ Level 3 capabilities); and
- **Admin** - access to all information and data included on the website plus administrative tools. A small team of CWMP principal investigators have been given "Admin" access and will handle approval of account requests and assignment of an access level (1-4).

The following sub-sections briefly describe the general site pages that are made available to all users ("Public" level) and the coastal wetland mapping tool features available to "Level 1" and "Level 2" users. User requests for CWMP datasets are handled through a formal process which involves the requestor submitting a letter detailing the request and providing assurances regarding maintaining the publication rights of the CWMP team. Additional pages and tools available to "Level 4", and "Admin" users for exporting raw monitoring data, entering and editing raw data, and performing administrative tasks are not documented in detail in this report.

COASTAL WETLAND MAPPING TOOL

The enhanced CWMP website provides a new and updated version of the coastal wetland site mapping tool described in previous reports (http://www.greatlakeswetlands.org/Map). The basic version of the mapping tool, which is available at the "Public" access level, provides the following features and capabilities (Figure 26):

- Map navigation tools (panning, general zooming, zooming to a specific site etc.);
- Basemap layer control (selection of aerial vs. "ocean" basemaps);
- Display of centroids and polygons representing coastal wetlands that have been monitored thus far under the CWMP;
- Capability to style/symbolize wetland centroids based on: 1) geomorphic type (default view; Figure 26), or 2) year sampled (Figure 27); and
- Reporting of basic site attributes (site name, geomorphic type, latitude, longitude, and sampling years) and general monitoring observations for the site (e.g., hydrology, habitat, disturbances).

In addition to the features made available at the "Public" access level, users with "Level 1" (*Site Metrics*) access to the website can currently obtain information regarding IBI scores for vegetation, invertebrates, and fish; *Index of Ecological Condition* (IEC) scores for anurans and birds; and a *Water Quality and Land Use Index*.

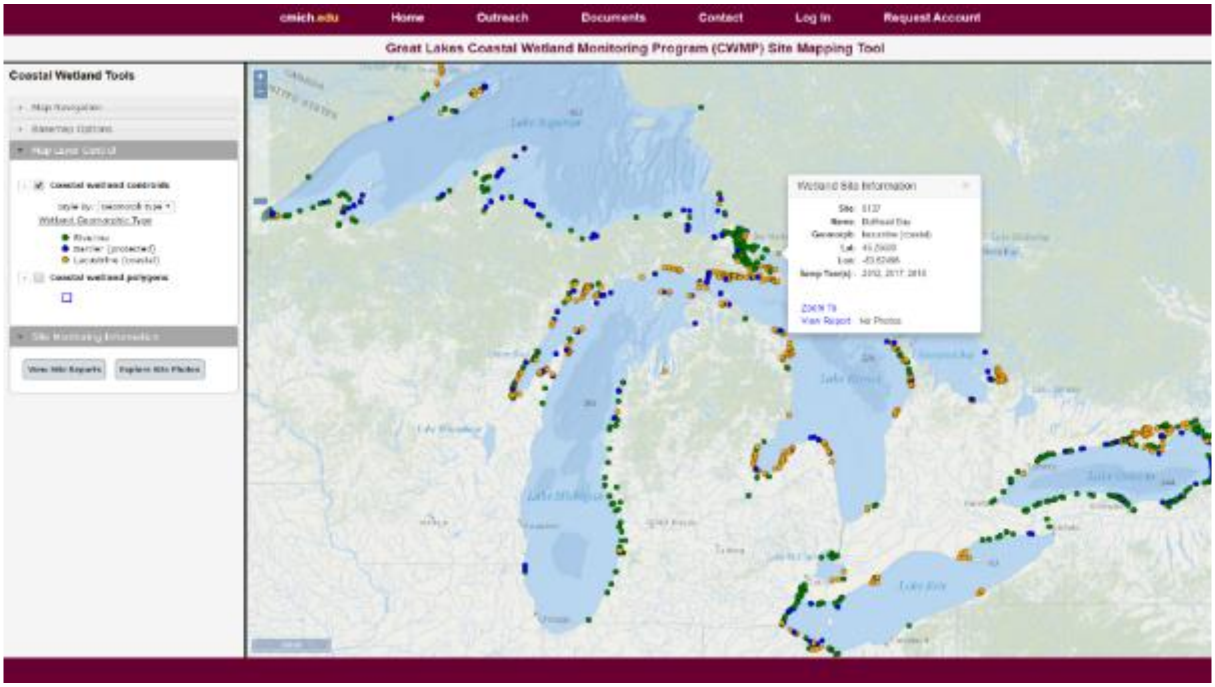


Figure 26. Coastal Wetland Mapping Tool – Public Version (geomorphic type view).

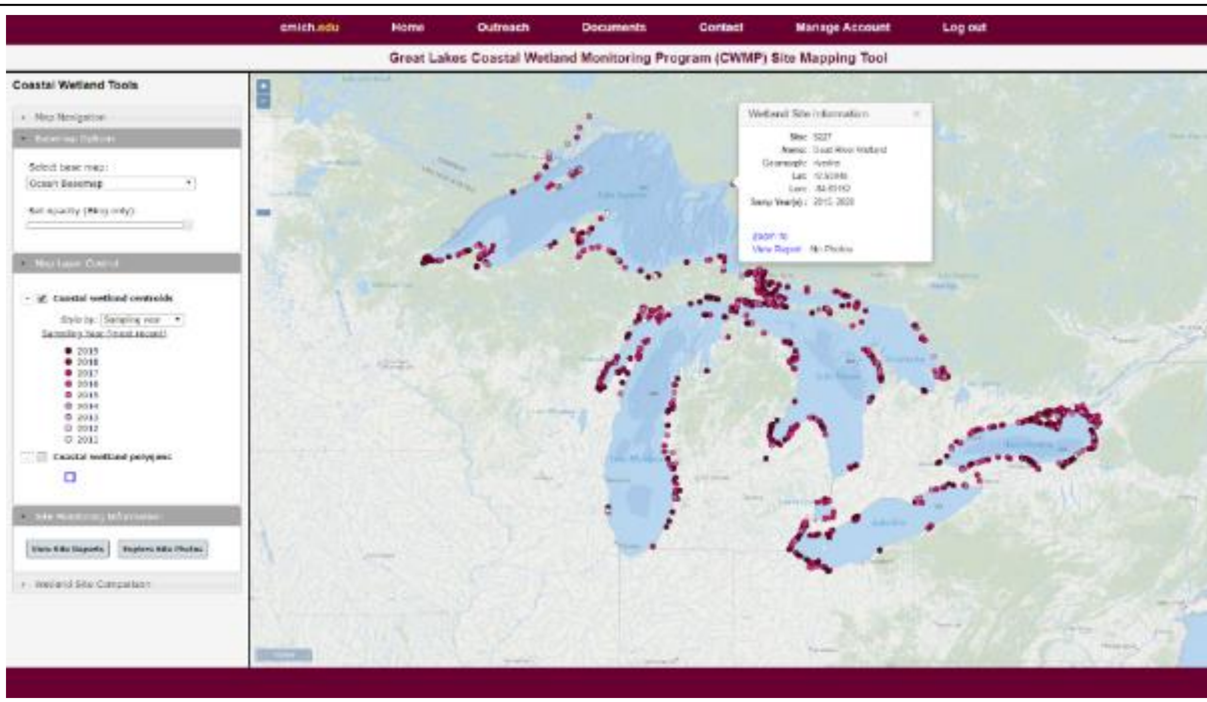


Figure 27. Coastal Wetland Mapping Tool – Public Version (sampling year view)

Wetland centroids can be symbolized based on IBI scores for a specific biological community, as well as based on geomorphic type and year sampled. For example, vegetation IBI scores calculated for individual sites can be displayed by selecting the "Vegetation IBI" option available in the "Style by:" pull-down menu (Figure 28). In addition, the actual IBI scores can be viewed by clicking on an individual wetland centroid.

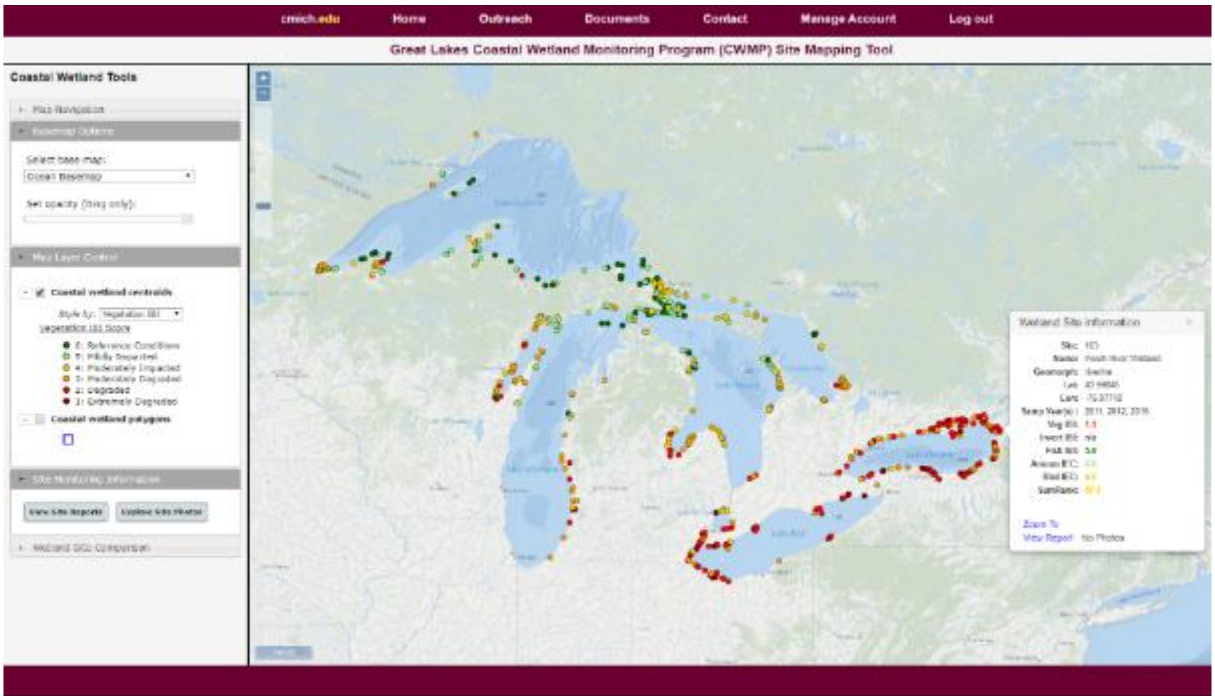


Figure 28. Coastal Wetland Mapping Tool with IBI scores displayed.

Users with "Level 2" (Agency/Manager (basic)) access to the website are provided with the same visualization options described above for the "Public" and "Level 1" access levels, but also have the capability of viewing a complete listing of species observed at individual wetland sites. Species lists can be generated by clicking on the "Species List" link provided at the bottom of the "pop-up" summary of site attributes (Figure 29), and the information can then be viewed and copied and pasted to another document, if desired.

"Level 1" and "Level 2" users may also access the following tools that are available in the site mapping tool:

- **Wetland Site Report** – a tool that provides monitoring design information, monitoring observations, and the entire matrix of IBI/IEC/SumRank scores on an individual site basis.
- **Wetland Site Photos** – a photo viewer that allows users to review CWMP-approved digital photos taken during site sampling events.
- **Wetland Site Comparison** – a tool that allows users to select a geographic area of interest on the map and then generate a matrix comparing characteristics and IBI/IEC/SumRank scores across the selected sites.

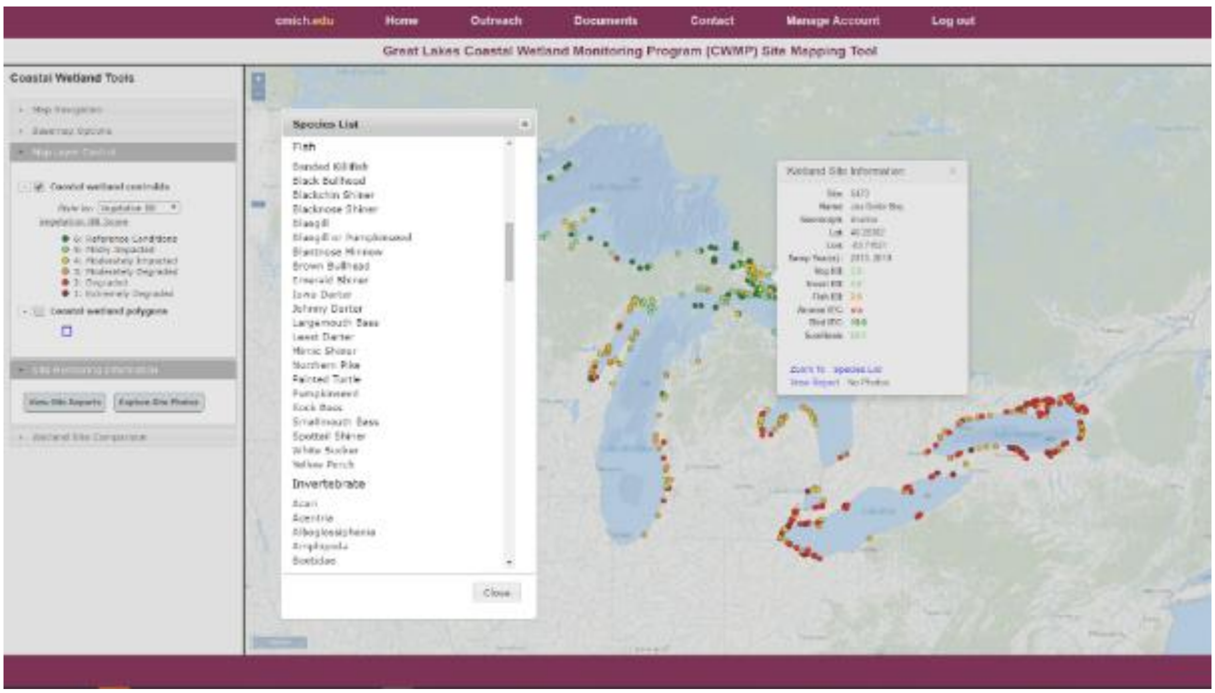


Figure 29. Coastal Wetland Mapping Tool with wetland macrophyte IBI scores and species list displayed.

OUTREACH TO MANAGERS

There have been many improvements to the website which assist external users with accessing and understanding the results, in particular the site reports and photos. Michigan Department of Environment, Great Lakes and Energy (EGLE) and Central Michigan University hosted a workshop at the Michigan Wetlands Association annual meeting in Kalamazoo on September

12, 2023. The workshop focused on data collection methodology, data access, and data applications and was attended by 22 wetland management professionals.

In 2021, EGLE hired a new Wetland Monitoring and Coastal Wetland Analyst to fill the vacancy left by Anne Garwood. In transitioning into the position, Katie Fairchild met with many of the partners of the GLCWMP. Training included virtual meetings, introduction to the website and Coastal Wetlands Decision Support Tool, and a 2-day GLCWMP field training hosted by CMU. Katie will be leading the outreach efforts for EGLE going forward, including meeting planning, webinar scheduling and facilitation, and convening PIs and restoration partners to encourage application of the monitoring data in wetland restoration projects.

EGLE has also been encouraging restoration practitioners to use the GLCWMP data in project planning, goal setting, and development of adaptive management plans through Michigan's interagency Voluntary Wetland Restoration (VWR) Program. In the past year there have been a few VWR projects undergoing regulatory review by EGLE where we requested that the practitioners identify if/how the GLCWMP data were used in planning or design of the project, and whether or not the project would be monitored as a benchmark site. Although there is still some uncertainty in how practitioners can or should use these data in project planning, there is momentum in the VWR Program to increase awareness and application of these results.

In 2019, a one-hour documentary on the CLCWMP was release on PBS. The documentary aired across the U.S. "Linking Land and Lakes: Protecting the Great Lakes' Coastal Wetlands" chronicled the work of all 15 universities and government agencies documenting our scientists collecting data to help restore and protect these ecosystems. The WCMU production team traveled the entire Great Lakes basin over 18 months covering 5,000 miles in Michigan, Wisconsin, Indiana, Illinois, New York, Ohio, Pennsylvania, and Ontario, Canada. More than 40 coastal wetland scientists shared their expertise in the documentary. This documentary aired on 275 PBS stations in 46 states, the Virgin Islands, and Washington D.C. beginning in July of 2020. It can be viewed at https://www.pbs.org/video/linking-land-and-lakes-hdo22u/

TEAM REPORTS

WESTERN BASIN BIRD/ANURAN TEAM AT THE NATURAL RESOURCES RESEARCH INSTITUTE, UNIVERSITY OF MINNESOTA DULUTH

Team Members

Dr. Annie Bracey (PI, team lead – Bird & Anuran Surveys) –permanent/year-round (returning)
Dr. Alexis Grinde (Avian Ecology Lab Director) – permanent/year-round (returning)
Josh Bednar (field tech – Anuran & Bird Surveys) – permanent/year-round (returning)
Jessie Green (field tech – Anuran & Bird Surveys) – temporary casual appointment (new)
Hannah Leabhart (field tech – Anuran & Bird Surveys) – temporary casual appointment (new)

Training

Training for anuran surveys was held remotely on 05 May & May 27, 2023 and for bird surveys on 24 May 2023. During the 2023 field season, three individuals conducted the anuran and bird surveys, the person who did the first round of anuran surveys has conducted surveys for this project since 2012. The other two individuals who surveyed anurans & birds on this project were new employees both of whom received a week of survey training and field safety. Training involved instructing individuals on how to conduct standardized field surveys, on basic travel procedures, and on appropriate field safety measures. Individuals were trained to proficiently complete field sheets. Rules for site verification, safety issues including caution regarding insects (e.g., Lyme's disease), GPS and compass use, boat safety, working near traffic or roadways, and record keeping were also included in field training to ensure that the guidelines in the QAPP were being followed.

All individuals involved in conducting the surveys had previously taken and passed each of the following tests on 1) anuran calls, 2) bird vocalization, and 3) bird visual identification via an on-line testing system established at the University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal. Training documents, including SOPs and QAQC measures , specifically related to sampling procedures are available on the program website – see https://www.greatlakeswetlands.org/Sampling-protocols.vbhtml. Training documents related to field safety were provided by NRRI and were reviewed with the PI at the time of training.

Challenges and Lessons Learned

There were no significant challenges that our team encountered this field season. Travel to and from Canada was allowed, so there were no issues with border crossing which we had experienced during Covid travel restrictions.

Site Visit List

In 2023, 35 wetland sites, located in the U.S. and Canada, were selected to be surveyed for birds and anurans by the western basin bird and anuran team. Although all of these sites had been surveyed at least once during the 2011-2021 project period, by at least one taxonomic group, we still needed to determine accessibility and site conditions, which may have changed during this time (e.g., changes in property ownership or water levels). A total of six sites were marked as 'could not access site' for anurans and for birds. The majority of these situations were associated with not being able to contact land ownership or due to travel safety issues or lack of roads. One site was listed as a visit reject (Site 7071) because there was poor access by road and it was gated off and eight sites were listed as a web rejects as they did not meet sampling criteria or were clearly not accessible.

A total of 21 wetlands were sampled in 2023 for anurans and birds by the western basin bird and anuran team. These sites were located along the south shore of Lake Superior in Minnesota, Wisconsin, and in the upper peninsula of Michigan and on the eastern shoreline in Canada and along northern Lake Huron. Of these 21 sites, two were designated as benchmark sites (7073B, 7074B), both located in the St. Louis River in the Duluth-Superior Harbor. One site was designated a panel re-sample site (1039R) located in Ashland Wisconsin on the shore of Lake Superior. The remaining 18 sites surveyed were regular panel-year sites. Anuran surveys began April 27 and bird surveys began May 30, 2023. Anuran sampling was completed by June 27 and bird surveys were completed by June 26, 2023.

Panel Survey Results

The data collected in 2023 by the western basin bird and anuran team were entered and error checked into the online data entry system and completed in August 2023.

Anurans: In 2023, six species of anurans were recorded throughout our study sites, with 471 individuals and 105 full choruses counted (Table 16). The average number of species detected per wetland was four, with a minimum of one and a maximum of six. Spring peepers were the most abundant species detected in all wetlands sampled, accounting for 45% of the anuran observations and the majority of full chorus observations (Table 1). There were also large numbers of Green frog and Gray treefrog detections (Table 1). There were no Chorus Frog or Mink Frog detections in 2023, which have been common in years past. The extended cold temperatures and extended ice-out period in the Lake Superior Basin in April and May could have delayed or reduced detections of Chorus Frogs. There were also fewer benchmark sites surveyed in Lake Superior in 2023 in locations where we typically detect Mink Frogs.

Table 16**.** List of anurans recorded during 2023 surveys. The number of individuals counted and the number of full choruses observed (i.e., number of individuals cannot be estimated) are provided for each species.

Species	**Number of Individuals**	**Number of Observations (Full Chorus)**
American toad (*Anaxyrus americanus*)	28	3
Blanchard's cricket frog (*Acris blanchardi*)	0	0
Bullfrog (*Lithobates catesbeianus)*	0	0
Chorus frog (western/ boreal – *Pseudoacris triseriata & P.maculatas*)	0	0
Green frog (*Lithobates clamitans*)	89	10
Gray treefrog (*Hyla versicolor*)	62	27
Mink frog (*Lithobates septentrionalis*)	0	0
Northern leopard frog (*Lithobates pipiens*)	29	9
Spring peeper (*Pseudoacris crucifer*)	210	56
Wood frog (*Lithobates sylvatica*)	53	0
Total	**471**	**105**

Birds: Birds were surveyed twice at each site between May 30 and June 26. A total of 77 identifiable species observations and 2,063 individual birds were recorded. The five most abundant species observed accounted for approximately 48% of all observations. These species, in order of decreasing abundance, were Red-winged Blackbird, *Larus* gulls, Canada Goose, American Robin, and Common Yellowthroat.

Interesting bird observations: In the Western Great Lakes region there have been many observations of birds of special concern in the vicinity of the wetlands or using the wetland complexes in 2023 (Table 17). Birds of special concern were observed in 15 of the 21 wetland sites surveyed in 2023. There were relatively low numbers of detections for both Virginia and Sora rails which seems to be consistent with lower observations in recent years.

Table 17. List of birds of special interest recorded during 2023 surveys. The number of individuals observed is listed for each species.

Species	Number of Individuals
Sandhill Crane (*Grus canadensis*)	11
Pied-billed Grebe (*Podiymbus podiceps*)	1
American Bittern (*Botaurus lentiginosus*)	1
Virginia Rail (*Rallus limicola*)	4
Bald Eagle (*Haliaeetus leucocephalus*)	3
Common Loon (*Gavia immer*)	1
Sora Rail (*Porzana carolina*)	2
Great Blue Heron (*Ardea herodias*)	3
Green Heron (*Butorides virescens*)	3
Belted Kingfisher (*Megaceryle alcyon*)	14

Wetland Condition Observations and Results

The western basin bird and anuran team does not have any noteworthy observations to report regarding wetland condition of sites sampled in 2023.

Data Processing

All bird, anuran, and point-count level vegetation surveys have been electronically scanned and digitally stored as .pdfs at NRRI. Data entry and QAQC were completed by the end of August 2023. All of the GPS coordinates associated with 2023 field sampling have been uploaded to the CWMP database. The physical data sheets from the point-count level vegetation surveys will be mailed to Doug Tozer at Bird Studies Canada for processing by November 2023.

Mid-season QC Check Findings

In-person mid-season QC checks were conducted to ensure protocols were being followed. The surveyors also reported to the PI daily during fieldwork. Surveyors also took pictures of sites where habitat was suspected to be inappropriate. These photos were then sent to the PI to verify whether the sites in question met sampling criteria or not. Surveyors also described general field conditions and any issues associated with accessing sites. Data sheets were scanned and sent to the PI periodically throughout the field season to identify any potential issues with an individual’s data collection methods. Surveyors were able to effectively communicate with the PI throughout the field season and therefore there were no QC issues that arose or needed to be addressed.

Additional Funding and Projects

Nothing to report

Other Collaboration Activities

Nothing to report

Other Data Requests

No data requests have occurred since the previous semi-annual report.

Related Student Research

Currently no student research projects are associated with the bird and anuran group at NRRI.

WESTERN BASIN FISH, INVERTEBRATE AND WATER QUALITY TEAM AT THE NATURAL RESOURCES RESEARCH INSTITUTE, UNIVERSITY OF MINNESOTA DULUTH

Team Members

- Dr. Valerie Brady, PI, aquatic invertebrate ecologist, QC manager (12 years since 2011)
- Dr. Chris Filstrup, co-PI, limnologist (4 years since 2019)
- Kristi Nixon, GIS specialist (7 years since 2016)
- Josh Dumke, team leader, fisheries ecologist (12 years since 2011)
- Kari Pierce, crew leader, fish, invertebrate, and water quality sampling (9 years since 2014)
- Bob Hell, aquatic invertebrate taxonomist (12 years since 2011)
- Holly Wellard Kelly, aquatic invertebrate taxonomist (8 years since 2015)
- Paul Jeffrey, permanent field and lab crew member (1.5 years)
- Two part-time computer programmers (1 @ 7 yrs, 1 @ 2 yr)
- Four summer field techs, 3 new summer 2023, 1 returning from summer 2022.

Training

The NRRI fish/invert/WQ team held in-person safety and classroom project training from June 5 – 9, 2023. All participants received course completion certificates valid for 2 years. Classroom training (June 5-9, 2023) was attended by all NRRI fish/invert/wq staff (10 participants). Classroom training material was presented by permanent staff who have been working on the Coastal Wetland Monitoring Program for >5 years. Topics covered were: field safety from environmental hazards, safe boating practices, approved scientific collection permits and responsibilities of the field teams to give prior notification to local fisheries managers and conservation officers before collecting fish from a wetland, Coastal Wetland Monitoring Program overview and introduction to Standard Operating Procedures and datasheets, GPS use and annual QC check, uploading GPS files to the program website, fish collection methods and identification, proper euthanasia and preservation methods for retained fish, water quality data and sample collection, post-collection processing of water samples (filtration and titration), daily calibration of water quality multiparameter instruments, invertebrate collection and field picking of samples, vegetation identification and habitat quadrats. After classroom safety and method training was completed, we provided hands-on training for new summer technicians during their first site visit in Green Bay, WI (June 21 – 27, 2023). The hands-on field safety and method training in Green Bay, WI was led by PI Dr. Valerie Brady and experienced crew chiefs Kari Pierce and Bob Hell who have both worked on CWMP for more than 5 years. During hands-on training the experienced NRRI crew chiefs (n=2) guided new summer technicians (n=4) on fish identification (with real fish rather than pictures), how to determine vegetation zones, vegetation identification, setting and pulling fyke nets, and which invertebrates to pick from trays (e.g., don't pick terrestrial insects, spiders, or large zooplankton).

Challenges and Lessons Learned

The 2023 field season did not have any atypical challenges. Water levels were lower at some sites due to the drought conditions in the Midwest and some areas of sites that were sampled in the past could not be sampled this year. Stopping sampling to avoid storms and then returning to the wetland to finish sampling was a significant challenge faced in 2023. Lessons learned included being careful about timing for accessing sites. For example, at site 945, access is through a river mouth that is very popular for swimming, especially during the week of the 4th of July when the crew was at this site. The crew had to be very cautious navigating the boat through the river mouth because of the many people in the water. In future years, it may be best to access this site at a different time or access it from another location. In addition, we had more sites on islands this year, creating longer boat rides across open water. Checking the weather and wind prior to sampling was important to safely navigate to these sites.

Site Visit List

The NRRI fish/invert/wq team was assigned 24 sites in 2023, which is the typical amount our team is usually assigned. 23 sites were sampled because one site was not able to be sampled. There were 18 regular sites, 3 resample sites, 0 pre-sample sites, and 3 benchmark sites:

- 945 (Au Train River Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1039 (Fish Creek Wetland #1): regular panel re-sample from 2022; sampled fish, inverts, and water quality.
- 1043 (La Pointe Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1049 (Stockton Island Wetland): regular panel site; did not sample due to no lake connection, permanent vegetation on sand bar where site would connect to the lake.
- 1051 (Presque Isle Point Wetland): regular panel site; sampled inverts and water quality.
- 1063 (Little Sand Bay Wetland): regular panel site; sampled inverts and water quality.
- 1070 (Bibon Lake-Flag River Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1074 (Amnicon River Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1090 (Tallas Island Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1187 (Sioux River Area Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1438 (Henderson Point Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1444 (Atkinson Marsh): regular panel site; sampled fish, inverts, and water quality.
- 1446 (Peats Lake Wetland #2): regular panel re-sample site from 2022; sampled fish, inverts, and water quality.
- 1464 (Charles Pond Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1465 (Pensaukee River Wetland): regular panel site; sampled fish, inverts, and water quality.
- 1467 (Pensaukee River Area Wetland #2): regular panel re-sample site; sampled fish, inverts, and water quality.
- 1475 (Cedar River Wetland #1): regular panel site; sampled for inverts and water quality.
- 1489 (Escanaba River Wetland): regular panel site; sampled for fish, inverts, and water quality.
- 1516 (Upper Big Bay De Noc Wetland): regular panel site; sampled for fish, inverts, and water quality.
- 7048 (40th Ave West): regular panel site; sampled for fish, inverts, and water quality.
- 7050 (Radio Tower Bay): regular panel site; sampled for fish, inverts, and water quality.
- 7073 (Kingsbury Creek Wetland): BENCHMARK; sampled for fish, inverts, and water quality.

- 7074 (Grassy Point Wetland): BENCHMARK; sampled for fish, inverts, and water quality.
- 7078 (Tank Farm Marsh): BENCHMARK; sampled for inverts and water quality.

Panel Survey Results

Regular Panel Sites:

945 – First sampled on 7-17-2013 by the NRRI team. Last visit by NRRI on 7-7-2023 and sampled SAV and Lily zones for fish, invertebrates, and water quality. Nets at this site (n=6) captured Rock Bass, Blackchin Shiner, Largemouth Bass, Brown Bullhead, Yellow Perch, Pumpkinseed, Three-spined Stickleback, Bluegill, Spottail Shiner, Bluntnose Minnow, White Sucker, Johnny Darter, Northern Pike, Walleye, Golden Shiner, Smallmouth Bass, and Emerald Shiner. No invasive fish were detected. There were 3 native crayfish, 38 Painted Turtles, and 1 Common Snapping Turtle as bycatch in fyke nets.

1039 – First sampled on 7-25-2011 by the NRRI team. Last visit by NRRI on 7-20-2023 and sampled Typha, Outer Schoenoplectus, and Peltandra/Pontedaria zones for fish, invertebrates, and water quality. This site is a temporal re-sample site in 2023. This site was very large and split into East and West wetlands, so two teams worked at this site over two days to adequately cover the site area. Nets at this site (n=9) captured Brown Bullhead, Golden Shiner, Emerald Shiner, Bluntnose Minnow, Spottail Shiner, Pumpkinseed, Walleye, Black Bullhead, Yellow Perch, Rock Bass, Black Crappie, Three-spined Stickleback, Bluegill, Northern Pike, and Mimic Shiner. There have only been 18 past occurrences that Mimic Shiners have been captured (n=246) by the NRRI crew for this project. Invasive fish captured were Ruffe (n=10). There were 16 native crayfish and 6 Painted Turtles as bycatch in fyke nets.

1043 – First sampled on 7-29-2013 by the NRRI team. Last visit by NRRI on 7-23-2023 and sampled a SAV zone for fish, invertebrates, and water quality, as well as a Typha zone for invertebrates and water quality. Crew leader Bob Hell noted that the Southwest shoreline of the site was cleared for boat docks and had a concrete wall as a shoreline. He also noted that the Northeast section of the site was very different as it had been mowed to create a lawn for some apartment buildings. Nets at this site (n=3) captured Northern Pike, Golden Shiner, Pumpkinseed, Yellow Perch, Black Bullhead, Brown Bullhead, Rock Bass, and Central Mudminnow. No invasive fish were detected. There were 11 native crayfish and 27 Painted Turtles as bycatch in fyke nets.

1049 – Site has never been sampled by any crew because it is an island site with a 10–12-mile boat ride. NRRI crew was able to access the site this year on 7-21-2023 but found that the wetland is not connected to the lake. There is permanent vegetation on the sand bar where a lake connection would be. The wetland is mostly woody plants and shrubs with little herbaceous vegetation as well.

1051 – First sampled on 7-30-2013 by the NRRI crew. Last visit by NRRI on 7-21-2023 and sampled a SAV zone for invertebrates and water quality. There was no way to access the wetland by boat this year, so the crew walked in after boating to the island. Crew leader Bob Hell noted that a person walking by mentioned that the wetland was connected to the lake in 2022. This was confirmed by Matt Cooper who noted that the wetland connects to Lake Superior regularly and especially after large rain events.

1063 – First sampled on 7-22-2013 by the NRRI crew. Last visit by NRRI on 7-22-2023 and sampled a SAV zone for invertebrates and water quality. Crew sampled this site using inflatable zodiac boats because the connection to the lake was a small shallow stream. The SAV zone was noted as being too deep to sample with fyke nets.

1070 – First sampled on 7-24-2013 by the NRRI crew. Last visit by NRRI on 7-22-2023 and sampled Typha and Lily zones for fish, invertebrates, and water quality. Crew leader Bob Hell noted that SAV was common within the site boundaries but did not meet the depth criteria for the project. Phragmites was also present but was mixed with Typha. Nets at this site (n=6) captured White Sucker, Yellow Perch, Black Bullhead, Northern Pike, Golden Shiner, Central Mudminnow, Blacknose Shiner, Brown Bullhead, Pumpkinseed, and Shorthead Redhorse. There were 18 native crayfish and 4 Painted Turtles as bycatch in fyke nets.

1074 – First sampled on 7-31-2013 by the NRRI crew. Last visit by NRRI on 8-8-2023 and sampled a SAV zone for fish, invertebrates, and water quality, as well as a Sparganium zone for invertebrates and water quality. Crew leaders noted that the Sparganium zone was very narrow and therefore could not fit fyke nets. Typha was also present at this site but water depths within the zone did not meet project criteria. Crew noted that there were two beaver lodges within the site boundaries. Nets at this site (n=3) captured Golden Shiner, Walleye, Pumpkinseed, Black Crappie, Rock Bass, Black Bullhead, Tadpole Madtom, Common Shiner, Yellow Perch, Northern Pike, Spottail Shiner, and Johnny Darter. Invasive fish captured was Common Carp young-of-year (n=1), so abundances of invasive fish was low. There were 14 native crayfish and 3 Painted Turtles as bycatch in fyke nets.

1090 – First sampled on 8-20-2013 by the NRRI crew. Last visit by NRRI on 8-1-2023 and sampled a Lily zone for fish, invertebrates, and water quality. Crew leaders noted that Typha was also present but the total area did not meet the project criteria. Nets at this site (n=3) captured Black Crappie, Largemouth Bass, White Sucker, Round Goby, Spottail Shiner, Rock Bass, Tadpole Madtom, Yellow Perch, Smallmouth Bass, Pumpkinseed, and Bluegill. Invasive fish captured was Freshwater Tubenose Goby (n=22). There were 5 Painted Turtles and 1 native crayfish and as bycatch in fyke nets.

1187 – This site has never been sampled before by any Fish/Bug crew. It is unknown the cause of this as there are no notes suggesting a reason. NRRI crew was able to sample this site. Last visit on 7-21-2023 and sampled a SAV zone for fish, invertebrates, and water quality, as well as a Typha zone for invertebrates and water quality. Crew leader Kari Pierce noted that the Typha zone was a floating mat of Typha roots, so fyke nets could not be set in the zone. Lily was also present at the site but did not meet project qualifications for zone size, the zone was too small. Nets at this site (n=3) captured Black Bullhead, Rock Bass, Brown Bullhead, Northern Pike, Pumpkinseed, Spottail Shiner, Yellow Perch, and Central Mudminnow. No invasive fish were detected. There was 1 Common Snapping Turtle, 2 Painted Turtles, and 13 Native Crayfish as bycatch in fyke nets.

1438 – First sampled on 6-25-2013 by the NRRI crew. Last visit by NRRI on 6-24-2023 and sampled a SAV zone for fish, invertebrates, and water quality. Crew leader Kari Pierce noted that Typha was present at the site but was very dry. Nets at this site (n=3) captured Brown Bullhead, Pumpkinseed, Rock Bass, Bluegill, Northern Pike, Banded Killifish, Spottail Shiner, Bluntnose Minnow, Bowfin, and Yellow Perch. Round Goby (n=5) were the only invasive fish captured at this site. There were 17 Painted Turtles as bycatch in fyke nets.

1444 – First sampled on 6-28-2013 by the NRRI crew. Last visit by NRRI on 6-25-2023 and sampled a Typha zone for fish, invertebrates, and water quality. Nets at this site (n=3) captured Yellow Bullhead, Brown Bullhead, Yellow Perch, Emerald Shiner, Longnose and Shortnose Hybrid Gar, Golden Shiner, Tadpole Madtom, White Sucker, Largemouth Bass, Pumpkinseed, Banded Killifish, Black Bullhead, and Common Shiner. Invasive fish captured were Round Goby (n=3), Alewife young-of-year (n=1), White Perch (n=9), and Common Carp young-of-year (n=14). There was 1 Painted Turtle as bycatch in fyke nets.

1446 – First sampled on 6-16-2022 by the NRRI crew. Last visit by NRRI on 6-24-2023 and sampled a SAV zone for fish, invertebrates, and water quality. Crew leader Dr. Valerie Brady noted that a deceased Common Carp was present within the site. Nets at this site (n=3) captured Brown Bullhead, Yellow Perch, White Sucker, Largemouth Bass, Black Crappie, Pumpkinseed, Banded Killifish, Logperch, and Emerald Shiner. Invasive fish captured were Round Goby (n=7), Common Carp young-of-year (n=27), Common Carp (n=1), and White Perch (n=13). There was 1 Painted Turtle as bycatch in fyke nets.

1464 – First sampled on 6-30-2013 by the NRRI team. Last visited by NRRI on 6-23-2023 and sampled an SAV zone for fish, invertebrates, and water quality. Sparse Bulrush was also present but was not sampled because it did not meet zone size criteria. Nets at this site (n=3) captured Brown Bullhead, Yellow Perch, Banded Killifish, Spotfin Shiner, White Sucker, Emerald Shiner, Spottail Shiner, Common Shiner, Pumpkinseed, Northern Redbelly Dace, Longnose and Shortnose Hybrid Gar, Tadpole Madtom, and Logperch. Young-of-year Yellow Perch were the most abundant fish caught at this site (n=2,067), indicating it may be an important spawning and rearing area for Yellow Perch. Invasive fish captured were Round Goby (n=71), Common Carp (n=1), White Perch (n=15), and Alewife (n=3). Common Carp were also noted as a disturbance at this site. There were no crayfish or turtle bycatch in nets at this site.

1465 – First Sampled on 7-9-2013 by NRRI. Last visited by NRRI on 6-23-2023 and sampled Typha, SAV, and Outer Schoenoplectus zones for fish, invertebrates, and water quality. Crew leaders noted that the southern portion of the site was not able to be sampled this year because of drought conditions contributing to lower lake levels. Nets at this site (n=9) captured Longnose and Shortnose Hybrid Gar, Bowfin, Yellow Perch, Spotfin Shiner, Banded Killifish, Largemouth Bass, Spottail Shiner, White Sucker, Emerald Shiner, Common Shiner, Black Bullhead, Brown Bullhead, Yellow Bullhead, Northern (Longear) Sunfish, Logperch, Tadpole Madtom, Green Sunfish, Pumpkinseed, Rock Bass, Bluegill, Northern Redbelly Dace, and Bluntnose Minnow. This site is an important spawning and rearing area for Yellow Perch, as the field team counted ca. 3,628 young-of-year Yellow Perch at this site. A Longear Sunfish was also caught in the SAV zone. Northern (Longear) Sunfish have only been captured 3 other times in 2014 and 2016 by the NRRI crew in the Green Bay area (Figure 30). Invasive fish captured were Round Goby (n=342), White Perch (n=2), and Alewife (n=1). Bycatch in fyke nets included 5 Painted Turtles and 2 Common Snapping Turtles. Carp were noted as a disturbance at this site but were not caught in nets.

Figure 30. A Northern (Longear) Sunfish (*Lepomis peltastes*) captured from a SAV vegetation zone at site 1465. This species has only been captured 3 other times by the NRRI team in this region since the beginning of GLCWMP.

1467 – First Sampled on 7-13-2012 by NRRI. Last visited by NRRI on 6-23-2023 and sampled Typha and Outer Schoenoplectus zones for fish, invertebrates, and water quality. Crew leaders noted SAV was present and too sparse to sample on this date. Muddy and unvegetated shorelines were noted due to low water and drought conditions. Nets at this site (n=6) captured Longnose and Shortnose Hybrid Gar, Yellow Perch, Yellow Bullhead, Banded Killifish, Brown Bullhead, Black Bullhead, Common Shiner, Spottail Shiner, White Sucker, Spotfin Shiner, Rock Bass, Largemouth Bass, Bowfin, and Tadpole Madtom. The most abundant fish species caught in nets was young-of-year Yellow Perch (n=1,710). Invasive fish captured were Round Goby (n=113), and White Perch (n=1). Bycatch in fyke nets included 6 Painted Turtles. Carp were noted as a disturbance at this site, but not caught in nets.

1475 – First sampled on 7-10-2013 by NRRI. Last visited by NRRI on 7-11-2023 and sampled an SAV zone for invertebrates and water quality. Fish were not sampled at this site. Crew leader Paul Jeffrey noted that most of the site polygon was located outside of the river or breakwall, but the SAV zone sampled was within the river channel and partially protected by a submerged sandbar. A Typha zone was noted as being sampled in previous years on the shoreline outside of the river breakwall, but this year the area was only sand beach with dried vegetation on the shoreline.

1489 – First sampled on 7-11-2013 by NRRI. Last visited by NRRI on 7-9-2023 and sampled an SAV and Typha zone for fish, invertebrates, and water quality. Crew leader Paul Jeffrey noted that most of the Typha on the lake side was on dry land, so only a small area was sampled. In the river area all Typha was on dry land and mixed with woody vegetation. Nets at this site (n=6) captured Northern Pike, Rock Bass, Yellow Perch, Brown Bullhead, Common Shiner, Black Crappie, White Sucker, Smallmouth Bass, Bowfin, Pumpkinseed, Bluegill, Longnose Gar, and Golden Shiner. Round Goby (n=5) was the only invasive fish caught at this site. Bycatch in fyke nets included 9 Painted Turtles and 2 native crayfish.

1516 – First sampled on 7-13-2013 by NRRI. Last visited by NRRI on 7-9-2023 and sampled a Typha zone for fish, invertebrates, and water quality. Crew leader Paul Jeffrey noted that vegetation growth extended 400+ meters past the original polygon into the lake. Bulrush was also present at the site but was mixed with Typha. Wet meadow was present in the center of the site in an area that was too shallow to access or sample. Nets at this site (n=3) captured Golden Shiner, Rock Bass, Blackchin Shiner, Emerald Shiner, White Sucker, Smallmouth Bass, Brown Bullhead, Bowfin, Yellow Perch, and Bluegill. Bycatch in fyke nets included 1 native crayfish. No invasive fish were detected.

7050 – First sampled on 8-24-2011 by NRRI. Last visited by NRRI on 7-31-2023 and sampled a SAV zone for fish, invertebrates, and water quality, as well as a Typha zone for invertebrates and water quality. Crew leader Kari Pierce noted that most of the SAV in the site was too deep to set nets in and SAV sampled was near the edge of the site. In contrast, the Typha zone was too shallow and narrow to set nets in. Crew also noted that portions of the site were not accessible because there was a submerged electrical grounding wire between the radio towers that made the area unsafe. Nets at this site (n=3) captured Black Crappie, Rock Bass, Pumpkinseed, Yellow Perch, Brown Bullhead, Golden Shiner, Tadpole Madtom, Johnny Darter, and Spottail Shiner. Invasive fish captured were Round Goby (n=1) and Freshwater Tubenose Goby (n=4). Bycatch in fyke nets included 1 Painted Turtle.

Benchmark sites

7048 – First sampled on 8-29-2011 by NRRI. Last visited by NRRI on 8-15-2023 and sampled a SAV zone for fish, invertebrates, and water quality and a Lily zone for only invertebrates and water quality. Restoration work was conducted in 2019 and 2020 at this site. This is a large site, but it is mostly unvegetated. Crew leader Kari Pierce noted there was no vegetation present to sample in the Erie Ponds area of the site under the bridge that was restored in 2020. She also noted the Lily zone was too deep to set nets. Typha was present at the site but was too shallow and narrow to sample and most was on dry land. Nets at this site (n=3) captured Rock Bass, Yellow Perch, White Sucker, Spottail Shiner, Black Crappie, Johnny Darter, Pumpkinseed, Logperch, Shorthead Redhorse, Silver Redhorse, and Golden Shiner. Invasive fish captured were Round Goby (n= 12), White Perch young-of-year (n=2), and Ruffe (n=7), so the abundances of invasive fish were low. There were no crayfish or turtle bycatch in nets at this site. A beaver lodge was noted as a disturbance at this site.

7073 – First sampled on 8-7-2019 by NRRI. Last visited by NRRI on 8-2-2023 and sampled a SAV and Lily zone for fish, invertebrates, and water quality, as well as a Typha zone for only invertebrates and water quality. Crew leader Kari Pierce noted that the Typha was too narrow and shallow to sample for fish. Wild rice enclosures were present at this site and avoided. Nets at this site (n=6) captured Black Crappie, Yellow Perch, Largemouth Bass, Pumpkinseed, Rock Bass, Golden Shiner, Bluegill, Northern Pike, Johnny Darter, Tadpole Madtom, Brown Bullhead, and Spottail Shiner. Invasive fish captured were Round Goby (n=1) and Tubenose Goby (n=65). Bycatch in fyke nets included 29 Painted Turtles and 1 Common Snapping Turtle.

7074 – First sampled on 8-28-2019 by NRRI. Last visited by NRRI on 8-2-2023 and sampled a SAV zone for fish, invertebrates, and water quality, as well as a Typha zone for only invertebrates and water quality. This visit was the first time the NRRI crew sampled the site since it was restored in 2019. Crew leader Kari Pierce noted that the Typha was too shallow and dry to sample for fish. Nets at this site (n=3) captured Black Crappie, Pumpkinseed, Golden Shiner, Smallmouth Bass, Yellow Perch, Tadpole Madtom, Silver Redhorse (Figure 31), Walleye, Northern Pike, Johnny Darter, White Sucker, Rock Bass, Bluegill, Black Bullhead, Central Mudminnow, and Brown Bullhead. Invasive fish captured were Tubenose Goby (n=39). Bycatch in fyke nets included 19 Painted Turtles and 2 Common Snapping Turtles.

Figure 31. A rare catch at site 7074 was a 'Silver Redhorse' (*Moxostoma anisurum*). This species has only been caught 25 times (n=59) by NRRI in Lake Superior.

Extra Sites and Data

7078 – New site sampled on 6-25-2023 by NRRI team as a special request for the Wisconsin Department of Natural Resources. WDNR requested we collect pre-restoration data for invertebrates and water quality, but not fish. The crew accessed the site by walking in because it was too shallow and mucky to operate boats with outboard motors. An open water zone was sampled for invertebrates and water quality. The site does have fish access and carp have previously been noted at the site. Crew leader Kari Pierce noted the presence of Phragmites, but it was not sampled because it was either on dry land or in an area that was too mucky to access. Waist deep muck was present in some areas of the site.

Extra Data: In collaboration with Amanda Suchy at Central Michigan University NRRI crews collected greenhouse gas and pore water samples while conducting their standard CWMP water quality sampling. All samples were sent to Amanda for future laboratory analyses. We collected samples at sites: 1464, 1465, 1467, 1475, 1489, 1516, 7050. In total we collected 102 samples including 11 air, 66 gas, and 25 pore water samples.

Wetland Condition Observations and Results

Some vegetation zones at sites this year were not sampled because of lower water levels due to the drought conditions in the Midwest. In particular, vegetation zones that are more common closer to the shore in shallower water (e.g., Typha or Phragmites) were often too dry or not large enough to sample based on CWMP sampling criteria.

Data Processing

As of October 2023, the NRRI fish/invert/WQ team has invertebrate and water quality samples from 23 sites (39 zones x 3 = 117) in storage and will start processing in 4-6 weeks. Field datasheets have been digitized and staff working remotely have begun entering field data into the CWMP database.

Mid-season QC Check Findings

Primary long-time crew leaders Kari Pierce and Bob Hell administered mid-season QC check of fish identification with new crew members. In 2023 the NRRI fish/invert/wq team surveyed sites as one 3-person crew or 2-4 person crews. New crew members were always working directly with experienced crew leaders, so the training and evaluation of new crew members was continuous. No issues were noted.

Audit and QC Report and Findings

None. QC of invertebrate samples between team labs has not occurred yet.

Additional Funding and Projects

None.

Other Collaboration Activities

PI Brady continues to collaborate with MPCA, MNDNR, and WDNR on restoration planning and evaluation for sites in the St. Louis River Estuary. We also communicate with tribal nations such as the Red Cliff Band of Lake Superior Chippewa for site access and data sharing. CWMP data and observations are provided as requested by the planning team. Crews from NRRI and UW-Green Bay collaborated with a reporter and photographer from the Milwaukee Journal Sentinel to create a news story on the Coastal Wetland Monitoring Project. They joined the NRRI fish/invertebrate crew at site 1444 and the UW-Green Bay bird crew at Sensiba State Wildlife Area to take pictures and conduct interviews.

Other Data Requests

None.

Related Student Research

PI Brady's graduate student, Adam Frankiewicz, continues his work on updating a key to the sphaeriid (fingernail) clams of the Great Lakes region. He has used CWMP samples to help with this effort and CWMP field crews have collected clams for him. Adam requested additional help with clam collection this summer from eastern basin crews.

US CENTRAL BASIN BIRD & ANURAN TEAM AT THE COFRIN CENTER FOR BIODIVERSITY, UNIVERSITY OF WISCONSIN-GREEN BAY

Team Members

- Erin Giese, PI, bird/anuran ecologist (12 years since 2011)
- Dr. Robert Howe, project advisor, bird/anuran ecologist (12 years since 2011)
- One full-time summer field tech (3 years since 2021)
- Three full-time summer field techs (2 years since 2022)
- One part-time summer field tech, new summer 2023

Training

Between January and June 2023, multiple trainings with summer field technicians were led by Erin Giese and conducted at UW-Green Bay either in person or online. Our one new bird field technician passed the online bird identification tests and became certified to conduct bird surveys.

Challenges and Lessons Learned

This year was not a particularly challenging year given Great Lakes water levels have lowered; however, we were assigned several sites located on inaccessible private property or sites that were impossible to access due to private roads, unimproved roads, or remote islands. We were able to access 5 points via kayak.

Site Visit List

Our team was assigned 44 total wetland complexes to survey in 2023: two benchmarks (“B”), three re-samples (“R”), and three pre-samples (“P”). We surveyed 30 of the 44 sites and all benchmarks, re-samples, and pre-samples and 55 total point count locations. Unlike the past several years, we only had one “drowned” site (609) due to high water, which we only surveyed for birds due to access, and thus assigned “could not sample” in the online site status database. However, we did still sample this “drowned” site for the sake of historical continuity and future water level analyses. We were unable to survey 14 wetland sites largely due to sites being located along inaccessible private property or sites that were impossible to access due to private roads, unimproved roads, lack of roads, or remote islands.

Benchmark site 1598, which is located close to the line 5 oil pipeline in the Mackinac Straits, was requested as a benchmark to gather historical data in the event of an oil spill. The WI Department of Natural Resources requested sampling be conducted at newly created site 7078 (benchmark) since they are planning AOC wetland restoration here and seek pre-restoration data to inform design plans.

Panel Survey Results

Our first anuran surveys of the 2023 season took place on April 14, 2023 at sites 1438, 1446, and 7078 in Green Bay and Sturgeon Bay, Wisconsin. Our last surveys occurred in the far eastern Upper Peninsula of Michigan on July 8, 2023 at sites 615, 635, 646, 790, 1578, and 1598. Cumulatively across all sites and samples, we recorded seven anuran species: American toad, spring peeper, gray treefrog, green frog, northern leopard frog, wood frog, and bullfrog, which are each relatively common and expected species in Great Lakes coastal wetlands. We did not detect any uncommon, unusual, or listed anuran species, and we did not detect chorus frog, as we did in 2021. At 22 of our 120 total anuran point count surveys (120 = 40 point count locations × 3 rounds), we did not detect any anurans calling.

Our first bird surveys of the 2023 season took place on May 25, 2023 at sites 1438, 1444, 1467, 1468, and 7078 in Green Bay, Suamico, and Sturgeon Bay, Wisconsin. Our last survey occurred in the far eastern Upper Peninsula of Michigan on July 8, 2023 at site 1598. Cumulatively across all sites and samples, we recorded 104 bird species, including many target marsh-obligate bird species: rails (Sora and Virginia Rail), bitterns (American and Least Bitterns), wrens (Marsh and Sedge), Pied-billed Grebe, Forster’s Tern, American Coot, Common Gallinule, Swamp Sparrow, Yellow-headed Blackbird, and Wilson’s Snipe.

- Listed Bird Species:
    - American Bittern: Imperiled–Vulnerable in Wisconsin (S2S3B) during breeding
        - Sites 777, 790, 791, and 1468
    - American Woodcock: Vulnerable–Apparently Secure in Wisconsin (S3S4)
        - Sites 777 and 1475
    - Black-crowned Night-Heron: Imperiled in Wisconsin (S2B) during breeding
        - Sites 777, 922, and 1444
    - Caspian Tern: Endangered in the state of Wisconsin
        - Sites 1444, 1464, 1475, 1704, and 1739
    - Common Tern: U.S. Species of Concern, Endangered in the state of Wisconsin
        - Sites 922, 1444, 1468, and 1739
    - Forster’s Tern: Endangered in the state of Wisconsin
        - Sites 1444, 1468, and 1700

- Great Egret: Threatened in the state of Wisconsin
  - Sites 777, 1444, 1467, 1468, 1516, 1700, 1704, and 7078
- Least Bittern: Imperiled–Vulnerable in Wisconsin (S2S3B) during breeding
  - Site 780
- Least Flycatcher: Vulnerable in Wisconsin (S3B) during breeding
  - Site 1739
- Purple Martin: Imperiled–Vulnerable in Wisconsin (S2S3B) during breeding
  - Sites 922, 1462, 1464, 1465, 1467, 1468, 1489, and 7068
- Yellow-headed Blackbird: Critically Imperiled–Imperiled in Wisconsin (S1S2B) during breeding
  - Sites 1444, 1446, 1462, and 1468

- Invasive Bird Species:
  - European Starling: sites 615, 1475, 1704, 7068, and 7078
  - House Sparrow: sites 1464 and 1489
  - Mute Swan: site 635
  - Rock Pigeon: site 7068

Extra Sites and Data

We surveyed special request benchmark site 7068 (Menominee S Channel) for birds at two new survey locations. The WI Department of Natural Resources' Brie Kupsky requested that data be collected here due to the restoration work completed at the Lower Menominee River Area of Concern (AOC). We conducted bird surveys on June 14 and June 30, 2023 and documented 27 bird species, including American Crow, American Goldfinch, American White Pelican, Belted Kingfisher, Brown-headed Cowbird, Canada Goose, Chimney Swift, Common Grackle, Eastern Kingbird, European Starling (invasive species), Great Blue Heron, Hairy Woodpecker, House Finch, House Wren, Killdeer, Mourning Dove, Northern Rough-winged Swallow, Northern Cardinal, Northern Flicker, Purple Martin (Imperiled–Vulnerable in Wisconsin [S2S3B] during breeding), Red-bellied Woodpecker, Red-winged Blackbird, Rock Pigeon (invasive species), Song Sparrow, Tree Swallow, Warbling Vireo, and White-breasted Nuthatch.

Like we have done for the last several years, we collected local habitat variables at every point count location following methods outlined by Birds Canada. These data are not entered into the online CWMP DMS. Instead, hard copies are mailed to Dr. Doug Tozer with Birds Canada who then scan the data forms and conduct OCR so they may be automatically and digitally entered into a database.

Wetland Condition Observations and Results

For the first time since the early years of this project, our team did not have many issues pertaining to high water levels since Great Lakes levels have been dropping over the last few years. Only one wetland site for our team was described as "drowned," site 609 in the eastern Upper Peninsula (UP) of Michigan. In terms of wetland quality, sites 777, 780, 790, and 791 in the eastern UP and sites 1462 and 1468 along the west shore of Green Bay produced high quality bird species, such as American Bittern, Least Bittern, Sora, and Virginia Rail. Many of these sites consisted of few invasive plant species and instead contained native sedges, grasses, rushes, bulrushes, and cattails.

Data Processing

Summer anuran and bird field technicians have completed double data entry for all 2023 anuran and bird point counts and conducted QA/QC such that all double entries match.

Mid-season QC Check Findings

Four field technicians who conducted surveys in 2022 returned for the 2023 field season, though Erin Giese and Field Crew Leader and Anuran Expert, Brenna Nicholson, ensured the crew collected data correctly. Erin Giese also regularly checked bird and anuran observations reported by all team members and addressed any issues as needed. However, because one of our team's bird technicians was fairly new to marsh bird surveys, Erin spent >75 hours training her on bird visual and auditory identification both online and in the field.

Audit and QC Report and Findings

Summer anuran and bird field technicians have completed double data entry for all 2023 anuran and bird point counts and conducted QA/QC such that all double entries match. We finished conducting QA/QC checks in the Data Verification Interface portal of the CWMP website.

Additional Funding and Projects

Nothing to report.

Other Collaboration Activities

In collaboration with CWMP bird/anuran PIs and others, Dr. Robert Howe submitted a manuscript entitled "An Index of Biotic Condition (IBC) using Birds as Indicators of Coastal Wetland Quality in the Laurentian Great Lakes" for publication in the journal *Ecological Indicators*. This manuscript uses CWMP bird data to build an indicator metric for evaluating coastal wetland health in the Great Lakes. The manuscript was returned for editing and will soon be resubmitted for publication.

Other Data Requests

In July 2022 Audubon Great Lakes (AGL) requested CWMP bird data to assist them with assessing the impact of National Fish and Wildlife Foundation's Sustain Our Great Lakes (SOGL) Program on waterbirds, which includes breeding marsh birds. In order to assess the impact of SOGL funding, they will implement a Before-After-Control-Impact study design, which includes compiling bird survey data that were collected prior to the onset of SOGL funding. CWMP marsh bird data would be used as part of the "before" treatment data set. AGL implemented surveys in 2021 and 2022 (representing the "after" treatment), which will be compared to survey data collected prior to 2021. CWMP data may also guide potential survey point locations for these surveys. CWMP PIs unanimously agreed to proceed with sharing their data and will collectively write a data sharing agreement with AGL over the coming months. Erin Giese is AGL's main point of contact for this exchange.

Species lists were provided to the Wisconsin Department of Natural Resources in agreement for allowing our team to survey on State Natural Areas.

Related Student Research

UW-Green Bay undergraduate Sarah Baughman initiated a study of coastal birds at river mouths along the western shoreline of Lake Michigan in Wisconsin. She compared both breeding and migratory birds at these locations with "control" sites nearby along the coast but at least 500 m from a river mouth. Funding for her project came from UW-Green Bay's Cofrin Center for Biodiversity and the University of Wisconsin Freshwater Collaborative. We are currently drafting a manuscript summarizing this work and will submit it for publication in the *Journal of Great Lakes Research*, hopefully by the end of 2023.

US CENTRAL BASIN, CENTRAL MICHIGAN UNIVERSITY (CMU), BIRD/ANURAN TEAM

Team Members

- Dr. Thomas Gehring, PI (since 2011)
- Bridget Wheelock, full time technician, team lead (since 2013)
- Megan Casler, team lead (since 2022)

- Mary Benjamin, team lead (new 2023)
- Sarah Heimberger (since 2022) and Brendan Jankowski (new 2023), summer field technicians

Training

Megan Casler completed the anuran ID certification (audio) prior to 15 March 2022, and the bird ID certification (audio and visual) prior to 15 May 2022. Mary Benjamin and Sarah Heimberger completed the anuran ID certification (audio) prior to 15 March 2023, and the bird ID certification (audio and visual) prior to 15 May 2023. A one hour training was held on 20 March 2023 with all anuran certified individuals and CMU PI to review anuran survey protocol and new audio equipment function. A one hour training meeting to review the bird and habitat assessment survey protocols, and to go over function of new sound equipment, was held on 4 May 2023 with all bird certified individuals and CMU PI. The new team lead was trained by the returning team lead on providing survey permission notices and data management, back-up, and upload before 15 May 2023. New technician job responsibility and equipment function training occurred 15 May 2023 prior to their first field day.

Challenges and Lessons Learned

No major challenges. Bird/anuran teams may benefit from additional training on what makes a survey point drowned out or so dry as to disqualify it from being an emergent wetland as water levels continue to change, and continued training to get constancy between team leads on the estimation of distances: 50 m, 100 m.

Site Visit List

The CMU bird/anuran team was assigned 46 sites. 40 sites were sampled. We web rejected 4 sites: 3 sites (467, 552, 557) because they were distant islands requiring boating, 1 site (1303) because of a failed visit attempt due to the road no longer existing in the 2022 season. We visit rejected 1 site (675) because there were no wetlands meeting the protocol requirements of emergent wetland vegetation with <50% woody vegetation. We never gained permission to access one site (575); the landowners quit responding. We surveyed 30 regularly scheduled bird/anuran 2023 sites (425, 447, 451, 488, 496, 507, 521, 523, 535, 567, 571, 573, 589, 663, 1275, 1282, 1319, 1650, 1652, 1818, 1849, 1855, 1864, 1870, 1872, 1883, 1885, 1888, 1896; 760 was sampled for birds only because all points required canoeing; Site 1650 was sampled but is under consideration for quarantine based on the habitat assessment indicating no emergent vegetation), 3 resample bird/anuran 2023 sites (432, 538, 1281, 1651), 3 pre-sample bird/anuran 2023 sites (436, 444, 591), and 4 bird/anuran benchmark sites (515, 7061, - benchmarked by Dr. Don Uzarski because they represent low and high extremes along the disturbance gradient and have long term data sets; 7075- United States Geological Survey (USGS) to monitor restoration progress; 7079- NOAA requested monitoring because the site will be undergoing work to restore hydrological connectivity in coming years).

Panel Survey Results

Anurans: First sample date – 9 April 2023; Last sample date 8 July 2023

Anurans – 8 species
American Toad (*Anaxyrus americanus*)
Bullfrog (*Lithobates catesbeiana*)
Chorus Frog (Western/Boreal) (*Pseudacris triseriata/Pseudacris maculata*)
Gray Treefrog (*Hyla versicolor*)
Green Frog (*Lithobates clamitans*)
Northern Leopard Frog (*Lithobates pipiens*)
Spring Peeper (*Pseudacris crucifer*)
Wood Frog (*Lithobates sylvaticus*)

Birds: First sample date – 24 May 2023; Last sample date 9 July 2023

Birds – 106+ species	**Alpha Code**
Alder Flycatcher	ALFL
American Bittern	AMBI
American Coot	AMCO
American Crow	AMCR
American Goldfinch	AMGO
American Redstart	AMRE
American Robin	AMRO
American White Pelican	AWPE
Bald Eagle	BAEA
Baltimore Oriole	BAOR
Barn Swallow	BARS
Belted Kingfisher	BEKI
Black Tern	BLTE
Black-and-white Warbler	BAWW
Black-billed Cuckoo	BBCU

Black-capped Chickadee	BCCH
Black-crowned Night Heron	BCNH
Blackpoll Warbler	BLPW
Black-throated Green Warbler	BTNW
Blue Jay	BLJA
Blue-gray Gnatcatcher	BGGN
Bonaparte's Gull	BOGU
Brown Thrasher	BRTH
Brown-headed Cowbird	BHCO
Canada Goose	CANG
Caspian Tern	CATE
Cedar Waxwing	CEDW
Chimney Swift	CHSW
Chipping Sparrow	CHSP
Cliff Swallow	CLSW
Common Gallinule	COGA
Common Grackle	COGR
Common Loon	COLO
Common Merganser	COME
Common Nighthawk	CONI
Common Raven	CORA
Common Tern	COTE
Common Yellowthroat	COYE
Double-crested Cormorant	DCCO
Eastern Kingbird	EAKI
Eastern Towhee	EATO
Eastern Wood-Pewee	EAWP
European Starling	EUST
Forster's Tern	FOTE
Golden-crowned Kinglet	GCKI
Gray Catbird	GRCA
Great Blue Heron	GBHE
Great Crested Flycatcher	GCFL
Great Egret	GREG
Greater Yellowlegs	GRYE
Green Heron	GRHE
Hairy Woodpecker	HAWO
Hermit Thrush	HETH

Herring Gull	HERG
House Finch	HOFI
House Sparrow	HOSP
House Wren	HOWR
Indigo Bunting	INBU
Killdeer	KILL
Least Bittern	LEBI
Least Flycatcher	LEFL
Least Sandpiper	LESA
Mallard	MALL
Marsh Wren	MAWR
Merlin	MERL
Mourning Dove	MODO
Mute Swan	MUSW
N. Rough-winged Swallow	NRWS
Nashville Warbler	NAWA
Northern Cardinal	NOCA
Northern Flicker	NOFL
Orchard Oriole	OROR
Osprey	OSPR
Ovenbird	OVEN
Pied-billed Grebe	PBGR
Prothonotary Warbler	PROW
Purple Martin	PUMA
Red-bellied Woodpecker	RBWO
Red-eyed Vireo	REVI
Red-winged Blackbird	RWBL
Ring-billed Gull	RBGU
Rose-breasted Grosbeak	RBGR
Ruby-throated Hummingbird	RTHU
Sandhill Crane	SACR
Scarlet Tanager	SCTA
Sedge Wren	SEWR
Solitary Sandpiper	SOSA
Song Sparrow	SOSP
Spotted Sandpiper	SPSA
Swamp Sparrow	SWSP
Tree Swallow	TRES

Trumpeter Swan	TRUS
Tufted Titmouse	TUTI
Turkey Vulture	TUVU
Unidentified duck	UDUC
Unidentified flycatcher	UFLY
Unidentified gull	UGUL
Unidentified large bird	ULBD
Unidentified medium bird	UMBD
Unidentified passerine	UPBD
Unidentified Raptor	URAP
Unidentified sparrow	USPA
Unidentified swallow	USWA
Unidentified Tern	UTER
Unidentified thrush	UTHR
Unidentified vireo	UVIR
Unidentified woodpecker	UWPR
Veery	VEER
Virginia Rail	VIRA
Warbling Vireo	WAVI
White-breasted Nuthatch	WBNU
White-throated Sparrow	WTSP
Willow Flycatcher	WIFL
Wilson's Snipe	WISN
Winter Wren	WIWR
Wood Duck	WODU
Wood Thrush	WOTH
Yellow Warbler	YEWA
Yellow-rumped Warbler	YRWA

Extra Sites and Data

Sites 515 and 7061 were benchmarked by Dr. Don Uzarski because they represent low and high extremes, respectively, along the disturbance gradient and have long term data sets. These data will be used for developing and improving our indices of biotic integrity and indices of environmental condition. Site 7075 was requested as a benchmark by the United States Geological Survey (USGS) to monitor restoration progress at the Shiawassee National Wildlife Refuge where diked units have been reconnected to the riverine system. No additional data is collected at any of these benchmarked sites. Site 7079 was added as a benchmark this year. The request was made by NOAA who has plans to undergo hydrological re-connectivity restoration work. Monitoring began now to have baseline data of pre-restoration conditions.

Figure 32. A loud, synchronous chorus of leopard frogs with spring peepers, followed later by green frog and gray treefrogs, plus several Virginia rails, some possibly exhibiting nesting behavior, were recorded at Pottawattomi Bayou (Site 1818). Surveys were possible thanks to permission granted by the Hofma Preserve.

Wetland Condition Observations and Results

The lacustrine wetlands found along the shores of the northeast ‘Thumb’ region of the Lower Peninsula of Michigan had little to no emergent vegetation (sites 444, 447), potentially due to high water levels in most recent past years. There were two points at which there was active construction during the bird and survey season. Site 447 (Figure 33) had construction in the lawn area at the survey point but did not immediately affect the wetland. Point 1864 underwent the removal of shoreline armoring (chunks of sidewalk) between the first and second bird surveys; this did affect the wetland edge and surrounding area.

Figure 33. Construction disturbance and minimal emergent vegetation at St. Margaret Mission Wetland (Site 447). The site hosted three species of shorebirds: killdeer, spotted sandpipers, and least sandpipers. Green frog, gray treefrog, and American toad were detected here during the third anuran survey.

Data Processing

All 2023 data (species surveys, habitat assessments, GPS coordinates, audio recordings) has been double entered, backed up, and sent to respective parties.

Mid-season QC Check Findings

On 20 June 2023, mid-year QC checks were completed for each team lead/data collector (Mary Benjamin, Megan Casler, Sarah Heimberger, Bridget Wheelock) at 2 sites each for anurans and birds this year. Data collectors were 100% proficient in the performance criteria including: 1) correct location of sampling points; 2) accuracy of species-level identification; 3) accuracy of abundance category estimates; 4) correct criteria and techniques used for identification of rare species; and 5) correct use of field survey forms.

Figure 34. With permission from the Saginaw Chippewa Nation, we were able to survey Nayanguing Point Wildlife Area Wetland (Site 496), where pie-billed grebes were detected during both bird surveys and a Virginia rail was detected in the second bird survey.

Audit and QC Report and Findings

As of 15 August 2023 all data has been QA'd with no flags. As of 13 September 2023, all GPS waypoints are confirmed matching. All data 2016-present has been QA'd in the Data Verification Interface.

Additional Funding and Projects

N/A

Other Collaboration Activities

N/A

Other Data Requests

Data has been requested by and sent to seven landowner organizations as a condition of accessing their lands. This includes data collected at 9 sites. Additionally, the fall report will be sent to the Michigan DNR for surveys conducted at 10 sites. Site 1849 data went to the Ohio DNR Department of Natural Areas & Preserves. Site 1855 data went to Ohio's Erie Metroparks. Sites 1864 and 1888 partial data went to Ohio DNR Division of Wildlife. Site 1888 and partial 1883 data went to Ottawa National Wildlife Refuge. Site 589 data went to Little Traverse Conservancy. Site 7075 data will be shared with Shiawassee National Wildlife Refuge. Michigan DNR will receive data for sites 432, 488, 515, 571, 573, 760, 1275, 1651, 1896, and 7061.

Figure 35. Extra effort was applied this year to conduct the first ever round of bird surveys at the island site, East Saginaw Bay Coastal Wetland # 10, otherwise known as Wildfowl Bay State Wildlife Area. Focal species including American coot, many common gallinule, least bittern, and pied-billed grebe were recorded here.

Related Student Research

Megan Casler continues research on the multi-season occupancy modeling of Rallidae species using basin-wide bird, invertebrate, and vegetation data from the years 2011-2022. This research was presented at the Michigan Wildlife Society and American Fisheries Society Conference in March of 2023, and at the International Association of Great Lakes Research Conference in Toronto in May of 2023.

Megan Bos is currently writing her M.S. thesis examining the influence of muskrat houses on water chemistry and plant communities in Great Lakes coastal wetlands.

Kylie McElrath is currently writing her M.S. thesis examining the factors influencing muskrat abundance in Great Lakes coastal wetlands and changes in muskrat spatial distribution patterns over time.

Mary Benjamin began research on the use of passive recording for secretive marsh bird detection. Of the sites sampled for 2023, eight wetland sites were chosen as having suitable habitat for marsh birds, which were 1273, 7061, 591, 589, 571, 523, 515, and 7075. Between 1 and 4 autonomous recording units (ARUs) were deployed at each site, resulting in 18 ARUs. The first recording began on May 10th and the last on July 13th. Currently, Mary is working on analyzing her data using BirdNet, an AI-powered bird sound recognition program.

US CENTRAL BASIN FISH, INVERTEBRATE AND WATER QUALITY TEAM

Team Members

The US Central Basin Fish, Invertebrate and Water Quality Team consists of PIs and members from the following universities:

Central Michigan University (CMU) crew:

- Dr. Donald G. Uzarski, PI (since 2011)
- Bridget Wheelock, Uzarski lab manager, team leader (since 2018)
- Molly Gordon, lead invertebrate taxonomist (since 2011)
- Matthew Sand, water quality technician (since 2020)
- Anna Harrison, postdoctoral researcher (since 2018)
- Morgan Noffsinger, graduate student technician, new 2023
- Julia Shablin, student lab technician, new 2023
- Ezekial Anderson and Alexsandria Wallett, summer field technicians, new 2023

Grand Valley State University (GVSU) crew:

- Dr. Carl Ruetz III, PI (since 2011)
- Dr. Matthew Cooper, PI (since 2011)
- Matthew Silverhart, team leader, graduate research assistant (since 2021)
- Jacob Yingling, summer intern (since 2022)
- John Lawrence, summer intern (new 2023)

University of Notre Dame (UND) crew:

- Dr. Gary Lamberti, PI (since 2011)
- Sarah Klepinger, Lamberti lab manager, team leader (since 2019)
- Kemjika Emenike, summer Technician
- Corbin Hite, former summer technician

Lake Superior State University (LSSU) crew:

- Dr. Ashley Moerke, PI (since 2011)
- Michael Hillary, crew lead (since 2022), research technician
- Cameron Leitz, research technician
- Chris Wedding and Connor Arnold, undergraduate technicians

Training

Central Michigan University and GVSU hosted the Central Basin training at site 515 in Saginaw Bay on 15 June 2023 and 16 June 2023 attended by GVSU and LSSU. The training was led by CMU crew leader Bridget Wheelock who has been part of the CWMP since 2012 and GVSU crew leader Matthew Silverhart who was certified as a crew member in 2020 and certified as a crew leader in 2021. The topics covered were water quality collection, *in situ* data collection, GPS navigation, vegetation zone selection, invertebrate sampling and picking, fyke net setting/retrieval and fish handling and identification. Each team used their own equipment to familiarize themselves with their equipment. Teams conducted additional water quality processing training and certification on their own to familiarize themselves with their equipment.

Training for the CMU crew was conducted in Mt. Pleasant and Littlefield Lake M-F the weeks of May 29th and June 5th. The topics covered were lab and field safety, boater safety, IACUC, water quality collection, titration, filtering, in situ data collection, GPS navigation, invertebrate sampling and picking, fyke net setting/retrieval/repair, fish identification, boat operation and trailering.

Fish ID training was provided for the LSSU crew by LSSU PI (Moerke) at the Barch Center for Freshwater Research and Education using the centers preserved specimens. All three crew members identified at least 95% of fish correctly. GPS training also occurred before field season began. Initial field training was provided by LSSU crew leader (Hillary) at Ashmun Bay where the crew went through equipment deployment and sample collection process, and then reviewed lab protocols with water quality lab manager, Shawnee McMillian. Mid-season checks were provided by our returning crew lead, Michael Hillary, to ensure protocols were being followed.

The UND crew completed BOATUS online training, laboratory and fire safety, Notre Dame IACUC training and practical fieldwork training for new crew members.

Challenges and Lessons Learned

CMU had challenges finding inundated vegetation zones as water levels were lower than 2018. Vegetation zones that were sampled in 2018 were on land in 2023 (see Figure 36).

Figure 36. Phragmites zone at site 1546 in 2018 (left) and 2023 (right). Photo credit: GVSU

With several GVSU sites being in Saginaw Bay, one of the main challenges faced this season was navigating shallow and rocky waters during times of higher wind. Coordinating sampling efforts while having these sites be on the other side of the state was difficult.

At UND there were some issues with work expectations that caused minor frustration within the crew this semester. The management team discussed the issue and developed new measures to avoid it in the future. In addition, Sarah Klepinger's unexpected illness required her to sit out sampling trips to three of the six sites. Gary Lamberti and Corbin Hite (former summer technician from 2001) joined the crew to help out during this time.

For LSSU, satellite maps seem to be outdated which inaccurately represented an access point into Sucker River Wetland (845). Further scouting indicated that we could access the wetland as water levels had risen considerably.

The US Central Basin was assigned 46 sites (18 CMU, 13 GVSU, 9 LSSU, 6 UND), five of which were benchmarks (515, 1598, 7061, 7075 and 7079), and four of which were re-sample sites (432, 538, 615 and 1651). Dr. Don Uzarski requested that three sites were benchmarked. Sites 515 and 7061 were benchmarked because they represent low and high extremes, respectively, along the disturbance gradient and have long term data sets. Site 1598 is close to the line 5 oil pipeline in the Mackinac Straits and was requested as a benchmark to gather historical data in the event of an oil spill. Site 7079 was requested as a benchmark by Dr. Alan Steinman of GVSU to document the restoration of the Mona Lake celery flats. Site 7075 was requested as a benchmark by the United States Geological Survey (USGS) to monitor restoration progress. We sampled 35 sites, visit rejected 8 and could not access three sites (538, 575 and 1585) due to land ownership issues. Sites 444 and 447 were not sampled because of strong winds, which made accessing the shoreline unsafe due to large waves that exposed rocky outcrops.

Additionally, there were no visible plant zones at sites 444 and 447, which was determined using binoculars from a boat approximately 100 yards from the shoreline. Site 507 was visited and found to not have any connection (permanent or seasonal) to the Great Lakes. There is a culvert that was installed by local landowners, which now serves as a barrier preventing the influence of water levels from the Great Lakes. Site 507 has also been further isolated by recent construction of residential homes and roads, which suggests this site should be further evaluated by members of the leadership team for removal from the population of sites sampled.

Panel Survey Results

Sampling started on 6 June 2023 and the last site was sampled on 18 August 2023. The following tables list zones sampled for each site, non-native species by site and reptile species captured in fyke nets, respectively.

Vegetation Zones by Site

Site	Vegetation Zone
432	*Phragmites*
	Typha
436	Lily
	Typha
488	Lily
496	Dense Bulrush
	Lily
	Typha
515	Sparse Bulrush
	Phragmites
	Typha
521	Dense Bulrush
535	Dense Bulrush
	Typha
571	Lily
	Wet Meadow
573	Sparse Bulrush
	Typha
591	Dense Bulrush
	Typha

615	Lily
635	Lily
	SAV
	Sparse Bulrush
736	Sparse Bulrush
760	*Phragmites*
	PSP
	Typha
777	SAV
780	Lily
	Sparse Bulrush
	Typha
790	Dense Bulrush
	Phragmites
	Sparse Bulrush
	Typha
791	Dense Bulrush
	Typha
809	Dense Bulrush
	Typha
	Wet Meadow
828	Lily
	Wet Meadow
845	Lily
847	Dense Bulrush
	Typha
	Wet Meadow
922	Dense Bulrush
	Typha
1282	SAV
	Typha
1303	SAV
1319	*Phragmites*
1546	SAV
1598	*Phragmites*
	Sparse Bulrush
	Typha
1651	PSP

	Typha
1652	PSP
	SAV
1818	Lily
1896	Lily
7061	Sparse Bulrush
7075	Lily
	PSP
	Typha
7079	Open Water

<u>Non-native Species by Site</u>

Site	Common Name	Taxa Name
432	Round Goby	*Neogobius melanostomus*
436	Round Goby	*Neogobius melanostomus*
496	Round Goby	*Neogobius melanostomus*
515	Sea Lamprey	*Petromyzon marinus*
	Round Goby	*Neogobius melanostomus*
521	White Perch	*Morone americana*
	Alewife	*Alosa Pseudoharengus*
	Round Goby	*Neogobius melanostomus*
573	Freshwater Tubenose Goby	*Proterorhinus semilunaris*
	Round Goby	*Neogobius melanostomus*
591	Freshwater Tubenose Goby	*Proterorhinus semilunaris*
	Round Goby	*Neogobius melanostomus*
615	Round Goby	*Neogobius melanostomus*
635	Round Goby	*Neogobius melanostomus*
736	Round Goby	*Neogobius melanostomus*
760	Goldfish	*Carassius auratus*
777	Freshwater Tubenose Goby	*Proterorhinus semilunaris*
828	Eurasian Ruffe	*Gymnocephalus cernua*
1598	Round Goby	*Neogobius melanostomus*
1651	Common Carp	*Cyprinus carpio*
1896	Common Carp	*Cyprinus carpio*
	White Perch	*Morone americana*
7061	Round Goby	*Neogobius melanostomus*
7075	Goldfish	*Carassius auratus*

7079	Goldfish	*Carassius auratus*

Reptile and Amphibian Species Captured in Fyke Nets

Site	Common Name	Taxa Name
436	Northern (Common) Map Turtle	*Graptemys geographica*
488	Common Snapping Turtle	*Chelydra serpentina*
571	Common Snapping Turtle	*Chelydra serpentina*
	Painted Turtle	*Chrysemys picta*
573	Common Snapping Turtle	*Chelydra serpentina*
	Painted Turtle	*Chrysemys picta*
591	Painted Turtle	*Chrysemys picta*
635	Painted Turtle	*Chrysemys picta*
736	Common Snapping Turtle	*Chelydra serpentina*
	Painted Turtle	*Chrysemys picta*
777	Painted Turtle	*Chrysemys picta*
780	Painted Turtle	*Chrysemys picta*
790	Painted Turtle	*Chrysemys picta*
791	Painted Turtle	*Chrysemys picta*
809	Painted Turtle	*Chrysemys picta*
828	Painted Turtle	*Chrysemys picta*
845	Painted Turtle	*Chrysemys picta*
922	Painted Turtle	*Chrysemys picta*
1651	Northern (Common) Map Turtle	*Graptemys geographica*
	Painted Turtle	*Chrysemys picta*
1818	Blanding's Turtle	*Emydoidea blandingii*
	Common Snapping Turtle	*Chelydra serpentina*
	Painted Turtle	*Chrysemys picta*
	Stinkpot (Common Musk Turtle)	*Sternotherus odoratus*
1896	Common Snapping Turtle	*Chelydra serpentina*
	Northern (Common) Map Turtle	*Graptemys geographica*

Extra Sites and Data

Site 7075 was requested as a benchmark by the United States Geological Survey (USGS) to monitor restoration progress at the Shiawassee National Wildlife Refuge where diked units have been reconnected to the riverine system. Site 7079 was requested as a benchmark by Dr. Alan Steinman of GVSU to document the restoration of the Mona Lake celery flats. Sites 515 and 7061 were benchmarked by Dr. Don Uzarski because they represent low and high extremes, respectively, along the disturbance gradient and have long term data sets. These data will be used for developing and improving our indices of biotic integrity and indices of environmental condition. Site 1598 is close to the line 5 oil pipeline in the Mackinac Straits and was requested as a benchmark to gather historical data in the event of an oil spill.

Extra soil cores, water samples (pore and surface) and air samples were collected by all central basin teams at all sampled sites for dissolved greenhouse gas analyses. These samples were shipped to Dr. Amanda Suchy who is leading the project at CMU. These data are not entered into the CWM data management system and are stored on drives and hard copies at the CMU Wetland Ecology Lab. Hobo DO loggers were deployed at each site that was fished and measured dissolved oxygen, water pressure, air pressure, water temperature, air temperature. These data were sent to Nathan Tuck and Dr. Jan Ciborowski at the University of Windsor and are not stored in the database.

Wetland Condition Observations and Results

The CMU team noticed that water levels were low to the point that some zones could not be sampled (predominantly Wet Meadow and *Phragmites* zones). Overall, the wetlands sampled by the GVSU team were accessible and mostly intact. For the LSSU team, water levels remained relatively low during the sampling season. They also observed that sites in Rabor Bay had been colonized by zebra/quagga mussels. Overall, the wetlands UND surveyed ranged in condition from moderate to pristine. Fish populations seemed robust, but they struggled to secure macroinvertebrate samples of appropriate size in sites 1896 and 436.

Data Processing

Central basin teams are still in the process of entering habitat, fyke, and *in situ* field data. These data are expected to be entered and QC'd within the next month. On 29 August 2023, 25 chlorophyll-a samples were shipped to the UND Lamberti Lab from the CMU Lab. Samples were received and noted that they were barely cool but otherwise in good condition. Twenty-one chlorophyll-a samples were mailed from the GVSU Ruetz Lab to the UND Lamberti Lab at the University of Notre Dame on 11 September 2023 for processing. The chlorophyll-a samples were received by the lab on 12 September 2023 with results expected in December 2023. Chlorophyll-a analysis will be conducted in November and December. Water samples from LSSU have been shipped and received by the CMU lab. The LSSU chlorophyll-a samples were shipped on 9/27/23 to Notre Dame. Sixty-three water samples (raw, filtered nutrients, and dissolved ions) were delivered to Matt Sand at Central Michigan University by Matthew Silverhart of GVSU on 13 September 2023. Three macroinvertebrate samples were given to Bridget

Wheelock from Central Michigan University on 16 June 2023 at the wetlands training of site 515. Fifty-seven additional sample jars containing macroinvertebrates were delivered to Matt Sand at Central Michigan University by Matthew Silverhart of GVSU on 13 September 2023. Macroinvertebrate identification is underway in the CMU, UND and LSSU labs and expected to be completed by 31 March 2024.

Mid-season QC Check Findings

The CMU crew leader Bridget Wheelock provided the mid-season QC check and observed that sampling occurred in accordance with the SOP at site 7061 on 19 July 23 and 20 July 23 and no issues were noted. The crew correctly located sampling points, collected data and identified fish species. The GVSU mid-season QC check did not occur this season as Dr. Carl Ruetz was unable to participate in the mid-season QC check. Crew leader Matthew Silverhart was with the GVSU field crew during all stages of sampling and observed that sampling occurred in accordance with the SOP. LSSU crew leader Michael Hillary provided the mid-season QC and observed that sampling occurred in accordance with the SOP.

Audit and QC Report and Findings

No issues currently.

Additional Funding and Projects

Two senior undergraduate thesis projects are ongoing at LSSU. CWMP data was used (with permission) by Ben McCarthy (Summer technician 2022) of UND for his senior project involving alpha and beta diversity of wetland macroinvertebrates. Ben graduated spring of 2023. Postdoc Dr. Amanda Suchy is leading a project funded by CIGLR where they are investigating spatial and temporal drivers of dissolved greenhouse gases (GHGs) in coastal wetlands of the Great Lakes. By leveraging the sampling done by the CWMP they are able to collect dissolved gas samples across a large spatial scale which would not be possible with one sampling crew alone. They will examine how dissolved GHGs are affected by water chemistry, vegetation cover, and surrounding land use. With a few measurements of this kind, this study will provide baseline data for emissions of GHGs from coastal wetlands of the Great Lakes, which can inform future investigations and climate models for the region. She is also investigating patterns of microplastic deposition in coastal wetlands of the Great Lakes and whether wetland connectivity to the open water environment, vegetation cover, or land use are predictive of microplastic concentrations. For this project, sediments are collected at a subset of coastal wetlands sampled by the CWMP and microplastics are quantified using density separation.

Preliminary results suggest that wetland connectivity and vegetation cover are more predictive of microplastic concentrations than nearby land use.

Other Collaboration Activities

GVSU collaborated with the University of Michigan, USGS and the US Fish and Wildlife Service to sample site 7075.

Other Data Requests

None

Related Student Research

CMU undergraduate student Viktoria Huber is looking at microplastics composition in soil and additional water samples collected by central basin teams at all sampled 2023 sites. CMU undergraduate student Marta Kendziorski (former vegetation and fish/invertebrate/water quality crew member), is using CWMP data to look at relationships between focal bird species presence and invertebrate community data. LSSU undergraduate student Chris Wedding is conducting a freshwater mussels surveys within Great Lakes coastal wetlands in the St. Marys River to compare to USFWS trawl data. Preliminary data indicate that unionid species diversity is higher in the wetlands, but mussels in downriver wetlands are being colonized by dreissenid mussels and resulting in high mortality of some species. In addition, LSSU undergraduate student Clayton Robertson will be using data collected throughout the GLCWMP to compare largemouth and smallmouth bass populations in wetlands throughout the St. Marys River. Matthew Silverhart, a graduate student and crew leader, is using data collected throughout the GLCWMP for his thesis regarding fish assemblages within Great Lakes coastal wetlands. He presented this research at the national American Fisheries Society conference and at the Michigan Wetlands Association conference.

US CENTRAL BASIN VEGETATION TEAM

Team Members

- Dr. Dennis Albert, PI, wetland vegetation ecologist/botanist (since 2011)
- Matthew Sand, crew leader, wetland plants and water chemistry (since 2017)
- Emma Waatti, crew leader, wetland plants (new 2023)
- Katlyn Groulx, CMU summer field technician (new 2023)
- Emily Schultheis, CMU summer field technician (since 2022)

Training

Matthew Sand (4 years of crew leader experience), trained Emma Waatti (new graduate student) during the week of June 5th – June 9th. This included SOP training and sampling logistics as a crew leader. On June 14th, Matt Sand trained Emma and the 2 new technicians in Mt. Pleasant wetlands. Topics covered included: identification of common Michigan coastal wetland macrophytes, proper use of GPS for taking waypoints, using a compass to set transect bearings, percent cover estimation, collection of plants for expert ID, and completion of datasheets.

Matt Sand then trained Emma Waatti and two new summer field technicians on in-situ vegetation sampling protocols at Tobico Lagoon Wetland in Essexville, MI on June 21st, 2022. They also calibrated individual percent cover estimates.

On June 22nd, 2023, the crew met with Dr. Dennis Albert via Webex to discuss the upcoming sample year and ask questions about macrophyte identification and sampling protocols. Following the meeting, crew members were tested on a subset of specimens covered in training PowerPoints and collected from Mt. Pleasant wetlands. Crew leaders Emma Waatti and Matt Sand both correctly identified at least 90% of the specimens.

Challenges and Lessons Learned

Due to water levels dropping from the previous high-water years of 2020 and 2021, the patterns of vegetation zonation continue to be in flux within the wet meadow, emergent, and submergent vegetation zones. This made determination of the start waypoint difficult for certain wetlands. Some start waypoints were identified through satellite image interpretation at tree lines where the trees are now flooded out and standing dead. In these cases, the start waypoint was pushed further inland to the current tree line following the same transect bearing. When samplers were unclear on how to treat zones, they consulted one of the more experienced crew leaders for confirmation and included information on the zonation in the notes section of datasheets. At some sites, crews also experienced difficult or dangerous sampling conditions due to the drop in water levels. One site in particular, Stony Creek Wetland (1303), was rejected in 2022 because the receding water level exposed thick, mucky sediment that could not be canoed through, but was thick enough to be dangerous to wade through. This site was to be re-sampled in 2023 but was again rejected due to thick, impassable sediments (Figure 37).

Figure 37. Receding water levels left Stony Creek Wetland (1303) sediments inaccessible in 2022 and 2023.

Site Visit List

The Central Basin vegetation crews sampled 39 sites: 26 panel sites from 2023, 3 resampled panel sites from 2022, 6 pre-sampled panel sites from 2024, and 4 benchmark sites. Canadian sites (3) that were drawn for the central basin crew were sampled instead by Joe Gathman's University of Wisconsin vegetation crew, who were already sampling other Canadian sites. These were Carpin Beach (5155), Marlette's Bay (5596), and Sand Bay (5854). Had these not been sampled by the other crew, the Central Basin crew would have sampled 42 sites as originally planned. Three of the benchmarks were requested by Dr. Don Uzarski: East Saginaw Bay Coastal Wetland #5 (515), Indian Harbor Wetland (7061), and Point St. Ignace Wetland (1598). Two of these sites (515 and 7061) represent extremes along the disturbance gradient. Site 515 is highly disturbed, while site 7061 is characterized by its low level of disturbance. Point St. Ignace Wetland (1598) is being monitored as a benchmark to track potential environmental changes in the Straits of Mackinac. A new benchmark, Mona Lake - Celery Flats

(7079) was added to the sample schedule to monitor the reconnection to the Great Lakes and the re-establishment of wetland vegetation to a previously diked and cultivated celery pond.

Crews could not access 4 sites due to either landowner permissions or access issues. Au Sable Point Wetland (507), Whitefish Bay Wetland (538), and Black River Wetland (1319) were sites where no landowner permission could be obtained to sample. Stony Creek Wetland (1303) was rejected as inaccessible due to deep, fine-textured, saturated sediments, as was the case in 2022.

Panel Survey Results

In the US Central Basin, the first day of vegetation sampling took place on June 21st, 2023 and the last day of sampling took place on August 24th, 2023. In general, we noted few expansions of invasive species and few new sites for rare species. Exceptions are in Indian Harbor Wetland (7061) where a new population of invasive *Typha* x *glauca* was identified. *Iris lacustris* was documented in both Albany Bay Wetland (567) and West Thompson's Harbor Wetland (573). These two documentations are not new, *Iris lacustris* is well established in these areas of the state but its presence is still noteworthy. *Carex richardsonii*, a Michigan special concern species, occurred in plots at Middle Island (557) and Marquette Island (623). *C. richardsonii* had previously been noted at West Thompson's Harbor (573), but was absent this year, however a new special-concern plant, *Arnoglossum plantagineum* (Indian-plantain), occurred within sampling plots.

Extra Sites and Data

Benchmark site East Saginaw Bay Coastal Wetland #5 (515) was sampled on July 10th, 2023. It was selected as a benchmark to track long-term trends at a site that was highly degraded throughout earlier long-term sampling. This site continued to be dominated by invasive *Phragmites australis* during 2023 sampling, with few other species encountered.

The high-quality Indian Harbor Wetland (7061) benchmark was sampled on July 19th, 2023. The crew noted the presence of *Typha* x *glauca* which was not recorded in 2022. *Myriophyllum spicatum* was still present in the wetland after its first documentation by the sampling program in 2022. The most visible shift in wetland condition for this site was the overall decrease in water depth throughout the site.

Point St. Ignace Wetland (1598) was sampled on July 31st – August 1st, 2023 to track potential environmental changes in the Straits of Mackinac, but no notable changes were observed from previous years.

New to the sampling program for this sample year was Mona Lake – Celery Flats (7079). This wetland was designated as a possible restoration site, following its use as a celery pond. This site was sampled on July 5th, 2023 and August 2nd, 2023. Transect one and three were sampled in July and the crew was unable to sample transect two due to inaccessibility. A new transect two was created by Dennis Albert and the crew returned to sample in August. The crew noted reduced aquatic vegetation zonation at this site (Figure 38). Two transects had emergent zones only. The remaining transect had a wet meadow and submergent zone with only small free-floating *Lemna* and *Spirodela* sp.

Wetland Condition Observations and Results

The most visible trend noted by sampling crews is that the vegetation zonation was impacted by receding water levels. In many sites, the remains of dead woody plants persist in the wet meadow and emergent zones. Some sites, however, appear to be establishing more distinct zonation following the fluctuating water levels. The Central Basin crew noted an observation at Hughes Point Area Wetland (1546) where in transect 3, the wet meadow vegetation had higher coverage values than the last time it was sampled in 2021 (Figure 39).

Another trend that was noted at many sites in the current lower water level conditions was an increase in the number of Carex (sedge) species and *Cyperaceae* (sedge family), both metrics in the plant IBI. The sedge family, contains several genera common in Great Lakes coastal wetlands, including *Bolboschoenus, Carex*, *Cladium*, *Cyperus*, *Dulichium*, *Eleocharis*, *Rhynchospora*, *Schoenoplectus*, and *Scirpus*. The number of species associated with the current water level for these metrics is midway between the low number of species found during high water levels and the higher number of species associated with the lowest water levels. This trend is strongest among open lacustrine sites.

Figure 38. Reduced wetland vegetation zones were found at Mona Lake – Celery Flats (new site 7079) in 2023.

Data Processing

Dr. Dennis Albert has finished the last of the plant identifications, and data entry will begin in October 2023. All data should be entered and quality-checked by Spring of 2024.

Mid-season QC Check Findings

Matthew Sand and his crew finished a site that was started by Emma and her crew on August 9th, 2023. The site was Duck Island Wetland (736) on Drummond Island. Matt Sand checked the transect set up by Emma and re-sampled the first two quadrats to verify percent cover estimates and plant identification. No corrections were needed for the sampling crew. Crews have also shipped unknown plants to Dr. Dennis Albert for confirmation throughout the summer.

Audit and QC Report and Findings

A CMU technician will begin entering 2023 vegetation data to GreatLakesWetlands.org in October. When the entry is completed, data will be confirmed by a second technician or by a CMU staff member. Finally, all data will be reviewed by Dr. Dennis Albert. Any data entry issues will be noted in the Spring report.

Additional Funding and Projects

None

Figure 39. Sample point 3 of Transect 3 for Hughes Point Wetland (site 1546) in 2021 (left) and 2023 (right).

Other Collaboration Activities

There are no external collaboration activities to report for the 2023 field season.

Other Data Requests

A list of species encountered in 2022 from Mackinaw Creek Wetland (616) was sent to the Little Traverse Conservancy in exchange for permission to sample Cheboygan Area Wetland #1 (589) and Duck Island Area Wetland (736). A list of species was also sent to the Saginaw Basin Land Conservancy from site Caseville Township Wetland (460) in order to obtain sample permission for Nayanguing Point Wildlife Area Wetland #5 (496) in 2023.

Related Student Research

Data from 2023 is not currently being used in any student research projects. However, CMU graduate student and crew leader, Emma Waatti is interested in using CWMP vegetation data for her thesis research.

CANADIAN CENTRAL/EASTERN BASIN BIRD/ANURAN TEAM AT BIRDS CANADA, PORT ROWAN/LONG POINT, ONTARIO

Team Members

- Dr. Doug Tozer, PI, waterbird and anuran ecologist (since 2011)
- Jeremy Bensette, bird and anuran field crew (since 2014)
- Tim Arthur, bird and anuran field crew (since 2017)
- Tyler Hoar, bird and anuran contractor (since 2011)
- Nadine Litwin, bird and anuran contractor (since 2011)

Training

All 4 field crew members / contractors received training refreshers via Zoom or phone in early April 2023. Topics included site selection procedures and station placement guidelines; specifics of anuran and bird survey field protocols; what's involved with reporting; safety procedures; overview of data entry; and GPS procedures. All members previously showed comprehension of the topics through written and practical in-person tests and successfully completed the online anuran and bird identification tests.

Challenges and Lessons Learned

Field work in 2023 went smoothly with no noteworthy challenges. With all team members having 7–13 years of experience working on the project, sampling progressed as planned.

Site Visit List

We considered 60 sites for sampling in 2023, which consisted of 2 benchmark sites, 3 resample sites, 7 pre-sample sites, and 48 panel sites. We surveyed 45 of the 60 sites for anurans and/or birds. We were unable to survey 15 of the sites due to issues with obtaining landowner access or safety.

Panel Survey Results

Sampling for anurans occurred from 4 April until 3 July 2023 and sampling for birds occurred from 22 May to 5 July 2023. Of note were 116 point occurrences of 8 Ontario bird species at risk or of conservation concern (Table 17).

Table 17. Ontario bird species at risk or of conservation concern observed at sites in 2023.

		No. Occurrences	
Species	**ON-ESA/SARA Status***	**2022 (*n* = 40 sites)**	**2023 (*n* = 45 sites)**
Bald Eagle	Special concern	4	14
Bank Swallow	Threatened	8	12
Barn Swallow	Threatened	34	49
Black Tern	Special concern	4	0
Bobolink	Threatened	0	1
Chimney Swift	Threatened	5	7
Common Nighthawk	Threatened	0	2
Eastern Meadowlark	Threatened	1	0
Least Bittern	Threatened	26	30
Red-headed Woodpecker	Endangered	0	1
Total		82	116

*Status is the assessment of greatest concern based on Ontario's Endangered Species Act (ON-ESA) or Canada's Species at Risk Act (SARA).

Also of note were 10 occurrences of Chorus Frog, some populations of which are listed as threatened in Canada (we logged 9 occurrences in 2022).

Extra Sites and Data

We did not sample any benchmark sites in 2023.

We collected additional habitat data at each bird and anuran sample point following a slightly modified version of Birds Canada's Great Lakes Marsh Monitoring Program habitat sampling protocol. These data are being collected to augment species-habitat relationship models, especially for certain marsh bird species, some of which are strongly influenced by local vegetation characteristics (i.e., within a few hundred meters of the sampling point), and are stored in an Access database on Birds Canada's secure servers in Port Rowan, Ontario.

Wetland Condition Observations and Results

We noted that lake levels in 2023 were lower than in 2022 at many of our sites, although levels were higher than most years during the past decade. Like the previous year, we sensed that abundance of secretive marsh birds was lower in 2023 at sites with suitable emergent vegetation likely because of the lower lake levels. By contrast, these species were absent or at lower abundance at some sites with especially high water where emergent vegetation was relatively sparse. These observations are to be expected based on Homan et al. (2021), which used CWMP bird data from throughout the Great Lakes and across several years to document the relationship between fluctuating water levels and wetland bird occurrence and abundance.

Data Processing

All of our data have been entered into and checked in the CWMP database.

Mid-season QC Check Findings

Mid-season checks were performed in mid-June; no issues were identified.

Audit and QC Report and Findings

No issues to report.

Additional Funding and Projects

We received additional funding to augment the bird and anuran team's capacity to complete a 10-year trend analysis for birds, as well as for anurans, using all of the CWMP data from Canada and the US. These projects are described further in the next section.

Other Collaboration Activities

The CWMP bird and anuran team is collaborating with Danielle Ethier, Bird Population Scientist at Birds Canada in Port Rowan, Ontario, to calculate bird and frog trends in coastal wetlands throughout Canada and the US based on CWMP data. The draft abstract for the bird paper is included at the end of this document. The frog paper is in preparation.

The CWMP bird and anuran team is also collaborating with the other CWMP teams on a book entitled "Limnology of Coastal Wetlands Associated with Large Freshwater Lakes." We are co-authoring the "Vertebrate Wildlife" chapter in the book, which will include various information based on CWMP data. The draft abstract for the chapter is included at the end of this document.

Other Data Requests

Nothing to report, but see student project descriptions in the next section.

Related Student Research

We continue to provide advice and guidance to Megan Casler, a MSc student at Central Michigan University, under the supervision of Tom Gehring. Megan plans to use CWMP data to test whether and how much the addition of invertebrate and water quality covariates improve bird habitat relationship models based on vegetation and land cover covariates.

CANADIAN CENTRAL BASIN FISH, INVERTEBRATE AND WATER QUALITY TEAM AT THE UNIVERSITY OF WINDSOR AND UNIVERSITY OF WISCONSIN RIVER FALLS

Team Members

- Dr. Jan Ciborowski (UW), PI, aquatic ecologist, (since 2011)
- Dr. Joseph Gathman (UWRF), co-PI, aquatic ecologist, team leader (since 2011)
- Li Wang (UW), GIS specialist, data/QC manager (since 2011)
- Michelle Dobrin (UW), lead invertebrate taxonomist (since 2011)
- Stephanie Johnson (UW), crew leader and permanent lab member (since 2016)
- Emilee Mancini (UW), field crew member (since 2020)
- Julia Santini (UW), field-crew member (new in 2023)

Training

All but one crew member were permanent members for multiple years. Training of one new member, as well as refresher training for others, was carried out at University of Windsor in May under the supervision of Stephanie Johnson who had seven years of experience in field and laboratory operations for the CWM program. All field crew members reviewed updates to the QAPP and SOP documents, and received instruction in GPS use, assessment of whether sites met project criteria (open water connection to lake, presence of a wetland, safe access), 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 refresher training and review in field data and lab entry. All field personnel were given refreshers in basic fish identification. Field-crew members were certified for identifying common fishes and Species at Risk through the Royal Ontario Museum's course in fish identification in 2023.

The crew leader in 2023 was co-PI Joseph Gathman who led the crew in the field at almost all sites, so all sampling operations were under his supervision, except at three sites where the field crew was led by Stephanie Johnson. Gathman also prescreened the suitability of sample sites, coordinated all logistics, secured accommodations, obtained sampling permissions where necessary, and directly supervised field sampling.

Challenges and Lessons Learned

Lake levels in 2023 continued the decline of recent years. According to the Great Lakes Water Level Dashboard managed by Great Lakes Environmental Research Laboratory (https://www.glerl.noaa.gov/data/dashboard/GLD_HTML5.html) Lake Hurons 2023 midsummer lake-level peak was approximately 11 cm lower than in 2022 and 75 cm lower than the recent high level reached in 2020 (highest since 1986). Lake Erie's year-on-year decrease was minimal - only 3 cm lower than in 2022 – but it was 49 cm lower than the long-term peak reached in 2019.

While the decreasing lake levels alleviated some difficulties of recent years (e.g., excessively flooded boat ramps, many vegetation zones too deep to sample), they resulted in many zones (particularly wet meadows) with little to no surface water, rendering them unsampleable for fish, invertebrates, and water quality.

Site Visit List

The UW team was initially assigned 35 candidate sites on Lakes Erie and Huron or the connecting channels. From this list we were to sample our team quota of 30 sites. However, several of these sites were deemed inaccessible so we agreed to sample three sites on the Canadian shore of Lake Superior which were originally assigned to the Lake Superior State University team. These sites, near Sault Ste Marie, ON, were Site 5155 (Carpin Beach), Site 5596 (Marlette's Bay), and Site 5854 (Sand Bay).

We visited 31 sites during the summer – one of these (site 5298, Fishing Islands 9) was rejected upon observing that there was no lake-connected wetland there. Of the 30 sampled sites, 24 were on Lake Huron, thirteen were on Lake Erie (eight on the Ontario shore and five on the Ohio shore), and three were on Lake Superior. Also, 28 of the 30 sites were regular panel sites and one site was a panel-resample site that was sampled in 2022 (site 5632, Midland Swamp). The two non-panel (benchmark) sites were site 1847, Mentor Marsh, and site 5762, Point Pelee Marsh 2).

All 30 sites sampled in 2023 were sampled for vegetation and water quality; 29 were sampled for invertebrates (the one non-sampled site had insufficient flooded wetland area to qualify for invertebrate sampling); and 19 were sampled for fish. This relatively low number of fished sites was the result of decreasing lake levels, which left many higher-elevation plant zones with no standing water, or water too shallow to qualify for fish sampling. Meanwhile, many areas at lower elevations that were vegetated in the early, low-water years of the CWM program had been de-vegetated as lake levels rose to very high levels - peaking in 2020 in Lake Huron and in 2019 in Lake Erie - and they have not yet revegetated. If the current downward trend in lake levels continues, we expect to see vegetation re-establishing itself in these areas soon.

Panel Survey Results

Field sampling began on June 8 at site 5145, River Canard Marshes, just 20 minutes from the University of Windsor campus. Our last day of sampling was August 20, at site 1847, Mentor Marsh, in Ohio.

Fish collected over the summer largely consisted of the usual species, but we encountered some species more often than in most years. These included green sunfish (Lepomis cyanellus), black and white crappie (Pomoxis nigrimaculatus and annularis, respectively), yellow bullhead (Ameiurus natalis), and emerald shiner (Notropis atherinoides). We caught one fish species listed as Species-At-Risk (SAR) in Canada: Spotted Gar (Lepisosteus oculatus), collected at site 5634, Mill Creek Wetland, on the Canadian shore of Lake Erie. Other interesting catches included one juvenile muskellunge (Esox masquinongy), one large adult bigmouth buffalo (Ictiobus cyprinellus), and two spotted suckers (Minytrema melanops). As for non-native species, we caught the now naturalized common carp (Cyprinus carpio) and goldfish (Carassius auratus), but only a relatively small number of round gobies (Neogobius melanostomus) (at sites 1849, 5145, 5375, 5518, 5661) and tubenose gobies (Proterorhinus semilunaris) (at sites 5429 and 5661). Regarding reptiles, we caught and released the usual species, painted turtles (Chrysemys picta) and snapping turtles (Chelydra serpentina), but also found a rather large number of musk turtles (Sternotherus odoratus) at several sites, as well as one northern map turtle (Graptemys geographica). No northern water snakes (Nerodia sipedon) were caught in fish nets, but we observed them at several sites.

A noteworthy observation on invertebrate samples is that we had an unusually large number of samples with relatively few invertebrates, i.e., fewer samples had 150 individuals than is usually the case (Figure 40). With samples from 16 sites processed so far, about 45% had 150 invertebrates as compared to 75% of all samples in 2018 (one panel rotation ago).

Non-native invertebrates collected included a small number of zebra mussels and the amphipod *Gammarus tigrinus*. It is unusual for us to collect living zebra mussels in our invertebrate samples because they tend to occur in water deeper than our usual sampling locations but the significant decrease in lake levels over the past two years is likely responsible for them occurring at shallower depths. Not all invertebrate samples have been processed yet, but some of the relatively rare invertebrates encountered so far include immatures of the mayfly *Siphlonurus*, the dragonflies *Arigomphus* and *Macromia*, and the biting gnat *Atrichopogon*.

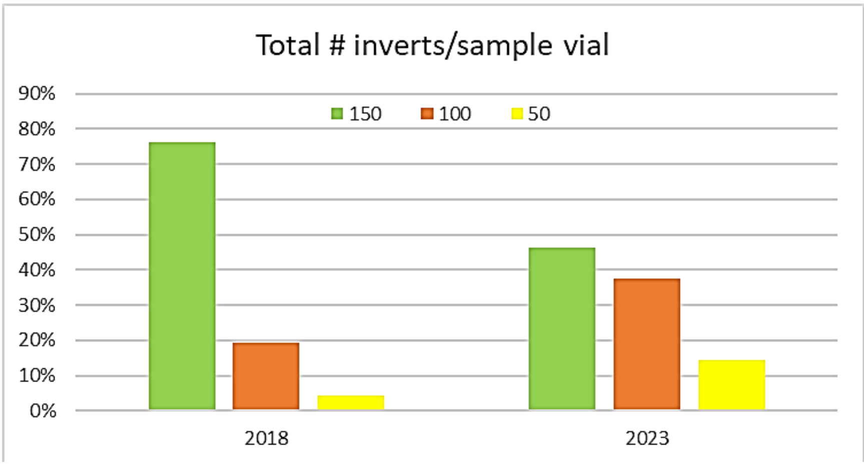


Figure 40. Total number of invertebrates in samples for 2018 and 2023.

Extra Sites and Data

Benchmark sites:

Point Pelee Marsh 2 (5762), in Point Pelee National Park, was sampled for the fifth time in 2023 in cooperation with Parks Canada, which is conducting a 5-year restoration project to increase the amount of open water area at Point Pelee. In 2018, the barrier beach which protected the marsh broke open during a series of strong storms/ seiche events, and the breach had remained open until 2022. Park personnel are interested in our monitoring changes as they proceed with their restoration work as well as changes resulting from the breach and recreation of the barrier beach. The water in the marsh has been too deep for fish sampling for the last four years, so we collected water quality samples/data and invertebrate samples.

Mentor Marsh is a large wetland in Ohio administered by the Cleveland Museum of Natural History and has been the subject of a long-term restoration effort. We have sampled this site several times over the years at the request of museum personnel to assist them in tracking changes occurring during and after the restoration project. We were able to sample macroinvertebrates and water quality at the marsh, but not fish because the water was not deep enough for fish sampling.

Wetland Condition Observations and Results

As in 2022, we observed continued decline in Lake Huron water levels, and to a lesser extent in Lake Erie, since the recent peak year of 2020. Wet meadow plant diversity seems to be increasing as a result, but these meadows were mostly too shallow/unflooded to allow us to sample them for fish and invertebrates. Also, many previously devegetated areas (resulting from high water) have not yet recovered their vegetation, making them unsuitable for sampling. 2023 lake levels were still above long-term averages; if they stay at 2023 levels or drop further, we expect to see vegetation filling in these areas.

Data Processing

All field-collected data - fish, *in situ* water-quality, and habitat - have been entered into the database. GPS waypoints and photographs are being uploaded at present. Our laboratory water-quality analyses are performed off-site, at the National Laboratory for Environmental Testing (NLET) in Burlington, Ontario. We have received results for 12 of 30 sites from NLET to date. Results for the remaining sites are expected in October. We have sent our chlorophyll-a samples to the Lamberti lab at the University of Notre Dame for processing and data will be entered once results are returned to us. We sampled invertebrates from 29 sites, generating 114 individual samples. Of these, 69 have been processed and entered into the database.

Mid-season QC Check Findings

No difficulties or anomalies were observed during mid-season checks. Each crew member has multiple years of prior experience on our team (from three to ten years) except for our new crew member this year, who was always working under direct supervision of co-PI Joseph Gathman or experienced crew leader Stephanie Johnson.

Audit and QC Report and Findings

All data for fish, in situ water-quality, and habitat data have been QC'ed, as well as those invertebrate samples that have been entered. Lab water quality data will be entered and QC'ed upon reception of results. Remaining invertebrate data will be QC'ed in the coming weeks, likely finished by mid to late November.

Additional Funding and Projects

None to report for 2023.

Other Collaboration Activities

As noted above, we sampled two benchmark sites in collaboration with Point Pelee National Park (PPNP) and the Cleveland Museum of Natural History (CMNH) to provide pre- and post-restoration data. PPNP is interested in monitoring changes resulting from the implementation of a vegetation-removal exercise meant to reduce *Phragmites* and *Typha* encroachment and improve hydrological connectivity. CMNH is interested in monitoring changes resulting from large-scale removal of *Phragmites* and restoration of native vegetation. We expect to continue this monitoring work, although not necessarily every year, to document post-restoration changes.

Other Data Requests

We have not received any requests in 2023.

Related Student Research

Mona Farhani, who is a PhD student working with former team member Paul Weidman and professor Ken Drouillard at University of Windsor's Great Lakes Institute for Ecological Research, continues to work with machine learning approaches to analyzing river flow and water exchange between nearshore regions and coastal wetlands. Most of Mona's work so far has been focused on modeling sediment transport and contaminants in the Detroit River. We are starting to plan how Mona might use machine learning approaches to analyze remote sensing data and water quality in coastal wetlands and nearshore regions. This work has now reached the stage of manuscript preparation intended for eventual publication in a research journal.

CANADIAN CENTRAL BASIN VEGETATION TEAM AT THE UNIVERSITY OF WINDSOR AND UNIVERSITY OF WISCONSIN RIVER FALLS

Team Members

- Dr. Jan Ciborowski (UW), PI, aquatic ecologist (since 2011)
- Dr. Joseph Gathman (UWRF), co-PI, aquatic ecologist, team leader (since 2011)
- Carla Huebert (UW), crew leader, plant taxonomist (since 2013)
- Li Wang (UW), GIS specialist, data/QC manager (since 2011)

Training

The crew leader in 2023 was Carla Huebert who directly conducted all vegetation field sampling. Co-PI Joseph Gathman prescreened the suitability of sample sites, coordinated all logistics, secured accommodations, and obtained sampling permissions where necessary.

Carla Huebert has led the vegetation component of the project since 2013, and so only a review and refresher of protocols was needed as outlined in the QAPP. The review included instruction in GPS use, assessment of whether sites met project criteria (open water connection to lake, presence of a wetland, safe access), and identification of vegetation zones to be sampled, Carla also received refresher training and review in field data and lab entry to become familiar with changes to the database.

Challenges and Lessons Learned

Lake levels in 2023 continued the decline of recent years. According to the Great Lakes Water Level Dashboard managed by Great Lakes Environmental Research Laboratory (https://www.glerl.noaa.gov/data/dashboard/GLD_HTML5.html) Lake Hurons 2023 midsummer lake-level peak was approximately 11 cm lower than in 2022 and 75 cm lower than the recent high level reached in 2020 (highest since 1986). Lake Erie's year-on-year decrease was minimal - only 3 cm lower than in 2022 – but it was 49 cm lower than the long-term peak reached in 2019. This decline in lake levels did not present new challenges but rather alleviated some challenges encountered during the recent high-water years.

Site Visit List

The UW team was initially assigned 35 candidate sites on Lakes Erie and Huron or the connecting channels. From this list we were to sample our team quota of 30 sites. However, several of these sites were deemed inaccessible so we agreed to sample three sites on the Canadian shore of Lake Superior which were originally assigned to the Lake Superior State University team. These sites, near Sault Ste Marie, ON, were Site 5155 (Carpin Beach), Site 5596 (Marlette's Bay), and Site 5854 (Sand Bay).

We visited 31 sites during the summer – one of these (site 5298, Fishing Islands 9) was rejected upon observing that there was no lake-connected wetland there. Of the 30 sampled sites, 24 were on Lake Huron, thirteen were on Lake Erie (eight on the Ontario shore and five on the Ohio shore), and three were on Lake Superior. Also, 28 of the 30 sites were regular panel sites and one site was a panel-resample site that was sampled in 2022 (site 5632, Midland Swamp). The two non-panel (benchmark) sites were site 1847, Mentor Marsh, and site 5762, Point Pelee Marsh 2).

All 30 sites sampled in 2023 were sampled for vegetation. Areas at lower elevations that were vegetated in the early, low-water years of the CWM program had been de-vegetated as lake levels rose to very high levels - peaking in 2020 in Lake Huron and in 2019 in Lake Erie - and they have not yet revegetated reflecting the time-lagged response of coastal wetland vegetation to lake-level changes. If the current downward trend in lake levels continues, we expect to see vegetation re-establishing itself in these areas soon.

Panel Survey Results

Vegetation sampling for the UWindsor team began on June 13th, 2023 and ended on September 25th, 2023. A total of 30 sites were sampled, including 28 panel sites (including one resample site), and two benchmark sites.

Water levels continued their downward trend in 2023 in the basin areas sampled by the UWindsor team, with the lower water levels expanding the wet meadow zones even further than in 2022.

A marked decrease in water levels also permitted full length sampling of emergent zones again. In previous, high-water years, it became unsafe to sample many *Phragmites* and/or *Typha* emergent zones due to the water being over the sampler's head, allowing for partial zone or outer zone sampling only. The full length of these zones was able to be traversed and sampled again safely for the majority of sites in 2023.

In 2023 the UWindsor team sampled several sites on Lake Superior, including a wetland with somewhat bog-like conditions, Sand Bay (5854). While many species typical of bogs were found, such as pitcher plant (*Sarracenia purpurea*), white beak rush (*Rhynchospora alba*), buckbean (*Menyanthes trifoliata*), and large cranberry (*Vaccinium macrocarpon*), several rare plants were also observed there, including club-spur orchid (*Platanthera clavellata*), bog aster (*Oclemena nemoralis*), bog cotton (*Eriophorum tenellum*), and Michaux's sedge (*Carex michauxiana*).

Invasive species:

A relatively new arrival to the Great Lakes, creeping water primrose (*Ludwigia peploides*) was observed for the first time in 2023 at two of our sites, Fox Creek (5314) and Lypps Beach Wetland (5574). Both sites are located in western Lake Erie on the Canadian side. In both instances, this floating-leaf emergent was fairly well established in the wetland, with large cells of the plant inhabiting the quiet, slow-moving water sections of the wetland, similar to another invasive, European frog's bit (*Hydrocharis morsus-ranae*). At both sites, both species were found growing together (Figure 41).

Other Invasives Species:

Flowering rush (*Butomus umbellatus*) was observed at several of our Lake Erie wetlands, but in two of those wetlands, Rondeau Bay 10 (5822) and Mill Creek Wetland (5634), the plant had expanded its range out into deeper water in the submergent zone. Prior to 2023, flowering rush had been found at both sites in shallow water closer to shore, with other emergent vegetation.

However, in 2023, it was found growing in a different, floating-leaf form, similar to floating leaf bur-reeds (*Sparganium* sp.), and wild rice (*Zizania* sp.). It was found in the submergent zone in water depths up to 190 cm, something that the vegetation crew had not observed prior to this.

Figure 41. New invasive species Creeping Water Primrose (*Ludwigia peploides*) found at Lypps Beach Wetland (5574), Lake Erie.

<u>Species at risk:</u>

Flat-stemmed pondweed (*Potamogeton zosteriformis*; Ohio DNR Status: Threatened) was found at one of our western Ohio sites, Touissaint River Wetland (1885). While it was only found in two quadrats at the site, individual plants were visually observed while travelling down the river within the site.

American water-willow (Justicia americana; Canadian COSEWIC Status: Threatened) was observed again in 2023 at Point Pelee Marsh 2 (5762). It had also been found in several areas of the site throughout the five years the site has been sampled, beginning in 2019.

Swamp rose mallow (*Hibiscus moscheutos*; Canadian COSEWIC Status: Special Concern) was found at a record six Canadian sites in 2023: Fox Creek (5314), Rondeau Bay 10 (5822), Point Pelee Marsh 2 (5762), Lypps Beach Wetland (5574), Mill Creek Wetland (5634), and Rondeau Povincial Park Wetland 1 (5831). It had been found at Point Pelee Marsh, Lypps Beach Wetland, Mill Creek Wetland, and Rondeau Provincial Park Wetland in previous sampling years, however this was the first time it was observed in the other two wetlands.

Benchmark sites:

Point Pelee Marsh 2 (5762), in Point Pelee National Park, was sampled for the fifth time in 2023 in cooperation with Parks Canada, which is conducting a 5-year restoration project to increase the amount of open water area at Point Pelee. In 2018, the barrier beach which protected the marsh broke open during a series of strong storms/ seiche events, and the breach had remained open since that time. In 2022 we observed that the barrier beach had re-formed and this was still the case in 2023.

In 2023 the UWindsor team sampled Mentor Marsh, located in Mentor, Ohio and administered by the Cleveland Museum of Natural History. A large restoration project was begun in 2015 to eradicate invasive giant reed grass, *Phragmites australis*, which had overtaken most of the 801 acre wetland. Our team had visited the site several times since 2012, including in 2016, after the marsh had been sprayed and treated for *Phragmites* (Figure 42, top). The only vegetation growing during that sampling period was newly emerged *Phragmites* shoots. In the years that followed, thousands of native vegetation plugs were hand-planted by community members, and aerial seeding was also done via helicopter.

In 2023 our team revisited Mentor Marsh to find a flourishing wetland, mostly absent of *Phragmites* (Figure 42, bottom). Dominant vegetation in the areas sampled included: rice-cut grass (*Leersia oryzoides*), swamp-rose mallow (*Hibiscus moscheutos*), tuckahoe (*Peltandra virginica*), and giant bur-reed (*Sparganium eurycarpum*). The restoration work at the marsh continues, including spot treatment of any new *Phragmites* cells.

Extra Sites and Data

We did not sample any extra sites in 2023.

Wetland Condition Observations and Results

As in 2022, we observed continued decline in Lake Huron lake level, and to a lesser extent in Lake Erie since the recent peak year of 2020. Wet meadow plant diversity seems to be increasing as a result. Also, many previously devegetated areas (resulting from high water) have not yet recovered their vegetation, making them unsuitable for sampling. 2023 lake levels were still above long-term averages; if they stay at 2023 levels or drop further we expect to see vegetation filling in these areas.

Figure 42. Mentor Marsh (site 1847), shown in 2016 (top), after site had been sprayed and treated for invasive *Phragmites australis* and again in 2023 (bottom), 7 years after *Phragmites* treatment and restoration planting. Native grasses, wildflowers, and other vegetation are flourishing again.

Data Processing

All vegetation data and GPS waypoints have been entered into the database.

Mid-season QC Check Findings

No difficulties or anomalies were observed during mid-season checks, which were self-administered, because field crew leaders have at least 13 years experience with the CWM teams.

Audit and QC Report and Findings

QC will be carried out in October.

Additional Funding and Projects

None to report for 2023.

Other Collaboration Activities

Over the last four years, Point Pelee National Park (PPNP) has been sampled as part of the CWMP to provide Parks Canada personnel with pre- and post-restoration baseline information relating to the implementation of a vegetation-removal exercise meant to reduce *Phragmites* and *Typha* encroachment and improve hydrological connectivity among several connected waterbodies. This work is also helping to identify the changes that have occurred as the result of a breach in the protective sand-spit cause by high lake levels. Sampling at PPNP is planned to continue to document post-restoration changes.

Other Data Requests

No data requests were received in 2023.

Related Student Research

No additional projects to report

CANADIAN EASTERN BASIN FISH, INVERTEBRATE AND WATER QUALITY TEAM AT CANADIAN WILDLIFE SERVICE

Team Members

- Joe Fiorino, PI, wetland ecologist (since 2016)
- Ian Smith, crew leader, fish sampling, GIS tech (since 2014)
- Hayley Rogers, team leader, vegetation sampling (since 2017)
- Patrick Rivers, team leader, WQ/invert sampling (intermittent since 2014)
- Albert Garofalo, field crew member, vegetation sampling (intermittent since 2018)
- Marissa Zago, field crew member, vegetation/fish/WQ/invert sampling (2 years, 2018, 2023)
- Alexis VanEsch, summer student field tech, vegetation/fish/WQ/invert sampling (2023)

Training

Environment and Climate Change Canada – Canadian Wildlife Service (ECCC-CWS) field crew members were trained by Joe Fiorino, Ian Smith, and Hayley Rogers. The sampling protocol, technical equipment use, occupational health and safety, and field-based decision-making were covered in detail over multiple days; staff were assessed in the field and lab for proper sample collection, data recording, GPS use, water processing, equipment calibration, and lab sample preparation and storage. A practice session at a nearby wetland and in our lab facility was conducted in June 2023 to provide hands-on training to new staff. 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 mid-August. No problems were identified.

Challenges and Lessons Learned

None

Site Visit List

As in previous years, the number of sites originally assigned to our group exceeded the capacity of the ECCC-CWS field crew, so four sites were given to SUNY-Brockport (5008, 5151, 5568, 5635). Typically, sites are also given to University of Windsor, but they were at capacity and could not take on additional sites.

Five sites were not attempted (exceeded capacity) and one site was inaccessible (too far from boat launch). Twelve sites were sampled (Table 18). Four Mile Pond (5313) had no suitable vegetation zones of sufficient size to set fyke nets. The open water section of Rattray Marsh (5799) is typically accessed through a narrow channel, but it had filled in with cattails in 2023. The crew was able to portage with canoes to access the site for water quality, inverts, and vegetation sampling, but there was no reasonable/safe was to transport fyke nets.

Panel Survey Results

Sampling occurred July 31, 2023, to August 23, 2023. Data are currently being entered into the DMS.

<u>Reptiles:</u>

Painted Turtle (*Chrysemys picta*) were caught at Blessington Creek Marsh 1 (5103; 1 individual), Cootes Paradise 1 (5198; 4 individuals), Hay Bay Marsh 6 (5405; 3 individuals), Presqu'ile Bay Marsh 4 (5784; 2 individuals), Presqu'ile Bay Marsh 7 (5785; 3 individuals), and Waupoos Creek Swamp 1 (6025; 1 individual). Musk Turtle (*Sternotherus odoratus*) was caught at Blessington Creek Marsh 1 (5103; 1 individual). Blanding’s Turtle (*Emydoidea blandingii*) was caught at Hay Bay Marsh 6 (5405; 1 individual) (Figure 43).

Table 18. Sites sampled by ECCC-CWS for fish, invertebrates, and water quality.

Site ID	Site Name	Site Status
5103	Blessington Creek Marsh 1 (panel)	Sampled
5160	Carruthers Creek Marsh (resample)	Sampled
5198	Cootes Paradise 1 (panel)	Sampled
5313	Four Mile Pond (panel)	Sampled (WQ/inverts), Could not sample (fish)
5405	Hay Bay Marsh 6 (panel)	Sampled
5573	Lynde Creek Marsh (panel)	Sampled
5777	Presqu'ile Bay Marsh 11 (resample)	Sampled
5782	Presqu'ile Bay Marsh 4 (panel)	Sampled
5785	Presqu'ile Bay Marsh 7 (panel)	Sampled
5799	Rattray Marsh (panel)	Sampled (WQ/inverts), Could not access (fish)
5872	Sawguin Creek Marsh 4 (panel)	Sampled
6025	Waupoos Creek Swamp 1 (panel)	Sampled
5698	Oak Point (panel)	Could not access
5765	Port Britian (panel)	Exceeded capacity
5563	Lower Salmon River Wetland 3 (panel)	Exceeded capacity
6033	Wellers Bay Wetland 12 (resample)	Exceeded capacity
6034	Wellers Bay Wetland 14 (panel)	Exceeded capacity
6049	West Lake Wetland 6 (panel)	Exceeded capacity

Figure 43. Blanding's Turtle caught at Hay Bay Marsh 6 (5405).

Non-native species:

Round Goby (*Neogobius melanostomus*) were caught at Blessington Creek Marsh 1 (5103; 2 individuals), Presqu'ile Bay Marsh 4 (5784; 1 individual), and Waupoos Creek Swamp 1 (6025 ; 4 individuals). Rudd were caught at Cootes Paradise 1 (5198; 469 individuals). Tubenose Goby were caught at Waupoos Creek Swamp 1 (6025; 2 individuals).

Other notes:

Rattray Marsh (5799) has undergone significant restoration over the last decade. A previously installed carp exclusion fence was recently revitalized and appears to have resulted in improved marsh condition. The section of the marsh to the west of the fence appeared to have lower turbidity and supported a relatively dense population of lilies, whereas the rest of the site supported little aquatic vegetation. Two Least Bittern were observed during sampling (designated as Threatened in New York State, Ontario, and federally in Canada).

One Least Bittern was also observed at Cootes Paradise 1 (5198).

Extra Sites and Data

No benchmark sites were sampled.

Continued to collect data on short-term variation in dissolved oxygen and water levels for Dr. Jan Ciborowski (University Windsor). These data are managed by Dr. Ciborowski's lab.

Collected dissolved gas samples, air samples, and porewater samples for Amanda Suchy (Central Michigan University). These data are managed by Amanda Suchy.

Collected eDNA samples for the Ontario's Invasive Species Centre to aid in the detection of aquatic invasive species, especially water soldier. These data are managed by the Invasive Species Centre.

Wetland Condition Observations and Results

Water levels on Lake Ontario were consistent with the long-term average. Nothing else to add beyond what was mentioned in the Panel Survey Results above.

Data Processing

Entry of fish and field-collected water quality and invertebrate data is nearly complete. Records will be quality-assured by an experienced member of the team. We are currently awaiting laboratory water quality results from the National Laboratory for Environmental Testing (NLET);

we expect they will be ready by the end of October. Macroinvertebrate sample vials have been inventoried and will be sent to University of Windsor for identification this fall. Chlorophyll-a samples will be sent to University of Notre Dame this fall.

Mid-season QC Check Findings

No difficulties or anomalies were observed during mid-season checks.

Audit and QC Report and Findings

Data entry is currently ongoing. All data entry will be QCed by an experienced team member. Most issues identified in the Data Verification Interface and past point-matching issues have been addressed.

Since 2021, ECCC-CWS received funding from the International Joint Commission to update marsh bird ecological performance indicators used for adaptive management of outflow regulation on Lake Ontario. ECCC-CWS received support from the bird/anuran team in December 2021 to conduct an analysis using CWMP data, and ultimately identified six potential bird-based indicators for consideration by the IJC. This work was published in the Journal of Great Lakes Research in early 2023. Work to further improve these indicators is ongoing, and we are also currently investigating the use of anuran-based indicators.

Other Collaboration Activities

ECCC-CWS is funding a project on trends in anuran populations in collaboration with Birds Canada and various CWMP PIs and team members. Birds Canada will utilize contemporary statistical techniques to assess trends in anuran populations in the Great Lakes basin. The primary source of data will be the Great Lakes Coastal Wetland Monitoring Program (including data from 2011 to 2022). All species with sufficient data will be considered in the analysis.

Other Data Requests

See vegetation report.

Related Student Research

None at this time.

CANADIAN EASTERN BASIN VEGETATION TEAM AT CANADIAN WILDLIFE SERVICE

Team Members

- Joe Fiorino, PI, wetland ecologist (since 2016)
- Ian Smith, crew leader, fish sampling, GIS tech (since 2014)
- Hayley Rogers, team leader, vegetation sampling (since 2017)
- Patrick Rivers, team leader, WQ/invert sampling (intermittent since 2014)
- Albert Garofalo, field crew member, vegetation sampling (intermittent since 2018)
- Marissa Zago, field crew member, vegetation/fish/WQ/invert sampling (2 years, 2018, 2023)
- Alexis VanEsch, summer student field tech, vegetation/fish/WQ/invert sampling (2023)

Training

Environment and Climate Change Canada – Canadian Wildlife Service (ECCC-CWS) field crew members were trained by Joe Fiorino, Ian Smith, and Hayley Rogers. The sampling protocol, technical equipment use, occupational health and safety, and field-based decision-making were covered in detail over multiple days; staff were assessed in the field for GPS use, measuring and spacing of transects, filling out datasheets properly, ensuring species coverages were recorded correctly and standardized, and collecting and taking notes for unknown plant specimens. A practice session at a nearby wetland and in our lab facility was conducted in June 2023 to provide hands-on training to new staff. 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 mid-August. No problems were identified.

Challenges and Lessons Learned

High wind while sampling at Presqu'ile Bay Marsh 7 (5785) made SAV quadrats in open water especially challenging. A canoe/kayak anchor continues to be an essential piece of equipment.

Site Visit List

As in previous years, the number of sites originally assigned to our group exceeded the capacity of the ECCC-CWS field crew, so four sites were given to SUNY-Brockport (5008, 5151, 5568, 5635). Typically, sites are also given to University of Windsor, but they were at capacity and could not take on additional sites.

Five sites were not attempted (exceeded capacity) and one site was inaccessible (too far from boat launch). Twelve sites were sampled (Table 19).

Table 19. Sites sampled by ECCC-CWS for vegetation

Site ID	Site Name	Site Status
5103	Blessington Creek Marsh 1 (panel)	Sampled
5160	Carruthers Creek Marsh (resample)	Sampled
5198	Cootes Paradise 1 (panel)	Sampled
5313	Four Mile Pond (panel)	Sampled
5405	Hay Bay Marsh 6 (panel)	Sampled
5573	Lynde Creek Marsh (panel)	Sampled
5777	Presqu'ile Bay Marsh 11 (resample)	Sampled
5782	Presqu'ile Bay Marsh 4 (panel)	Sampled
5785	Presqu'ile Bay Marsh 7 (panel)	Sampled
5799	Rattray Marsh (panel)	Sampled
5872	Sawguin Creek Marsh 4 (panel)	Sampled
6025	Waupoos Creek Swamp 1 (panel)	Sampled
5698	Oak Point (panel)	Could not access
5765	Port Britian (panel)	Exceeded capacity
5563	Lower Salmon River Wetland 3 (panel)	Exceeded capacity
6033	Wellers Bay Wetland 12 (resample)	Exceeded capacity
6034	Wellers Bay Wetland 14 (panel)	Exceeded capacity
6049	West Lake Wetland 6 (panel)	Exceeded capacity

Panel Survey Results

Sampling occurred July 31, 2023, to August 23, 2023. Data are currently being entered into the DMS.

Non-native species:

Typha x glauca dominates most wetlands on Lake Ontario. Many invasive species are common (e.g., *Hydrocharis morsus-ranae, Myriophyllum spicatum, Lythrum salicaria, Nitellopsis obtusa, Phalaris arundinacea*). Less common invasive species that were observed in 2023 included *Glyceria maxima* (very abundant at Cootes Paradise 1 and Hay Bay Marsh 6) and *Butomus umbellatus* (incidental observation at Carruthers Creek Marsh).

Other notes:

Rattray Marsh (5799) has undergone significant restoration over the last decade. A previously installed carp exclusion fence was recently revitalized and appears to have resulted in improved marsh condition. The section of the marsh to the west of the fence appeared to have lower turbidity and supported a relatively dense population of lilies (Figure 44), whereas the rest of the site supported little aquatic vegetation. Two least bitterns were observed during sampling (designated as Threatened in New York State, Ontario, and federally in Canada).

Figure 44. Section of Rattray Marsh (5799) to the west of the carp exclusion fence.

Extra Sites and Data

No benchmark sites were sampled and no extra data were collected.

Wetland Condition Observations and Results

Water levels on Lake Ontario were consistent with the long-term average. Nothing else to add beyond what was mentioned in the Panel Survey Results above.

Data Processing

Entry of vegetation data is nearly complete. Records will be quality-assured by an experienced member of the team.

Mid-season QC Check Findings

No difficulties or anomalies were observed during mid-season checks.

Audit and QC Report and Findings

Data entry is currently ongoing. All data entry will be QCed by an experienced team member. Most issues identified in the Data Verification Interface and past point-matching issues have been addressed.

Additional Funding and Projects

See fish, invertebrate, and water quality report.

Other Collaboration Activities

See fish, invertebrate, and water quality report.

Other Data Requests

In March 2023, Meteorological Services of Canada requested quadrat-level plant data (species, cover, GPS coordinates) for Lake Ontario sites (2011 to present). These data will be used to assist in the calibration of a model that predicts coastal wetland vegetation response to key physical variables (e.g., slope, water depths, currents, wet-dry cycles) in support of adaptive management of water-level regulation on Lake Ontario.

In May 2023, Credit Valley Conservation requested plant, bird, and anuran data for three sites (5213, 5799, 6002) on Lake Ontario (2011 to present). These data will be compared to similar data collected for local monitoring initiatives.

Related Student Research

None at this time.

US EASTERN BASIN BIRD AND ANURAN TEAM AT SUNY BROCKPORT

Team Members

- Dr. Kathryn Amatangelo, PI (since 2014)
- Gregory Lawrence, acting bird and anuran PI, project manager (2011-14, since 2018)
- Ray Marszalek, graduate research assistant and bird and anuran team lead (since 2021)
- William Sidore, undergraduate research assistant (new in 2023)

Training

Both field technicians (R. Marszalek and W. Sidore) were trained by project manager and field crew lead Gregory Lawrence on proper field sampling techniques, field work safety, bird and anuran identification and counting techniques, distance estimation, GPS use, and proper use of field equipment. Anuran training was held on April 17, 2023 at SUNY Brockport campus and at site 15-Yanty Marsh. Bird training was held on May 21, 2023 at SUNY Brockport campus and site 15-Yanty Marsh. Both technicians were trained on data entry and QC checks using the project database. Both field technicians successfully passed the bird and anuran identification tests, were successfully trained, and met pre-season training performance criteria described in the project QAPP.

Challenges and Lessons Learned

Travel restrictions across the United States-Canada border were loosened and crews were able to cross the border and sample sites in Ontario.

Lake Ontario water levels returned from record highs in 2017 and 2019 to about average to slightly above average in summer 2023 reducing site access and sampling issues associated with extraordinarily high and low water levels.

Site Visit List

SUNY Brockport crews successfully sampled birds and anurans at 25 of the 27 assigned sites including 19 regular panel sites, two panel pre-sample site (28-Salmon Creek and 116-Ramona Beach Marsh), and three non-panel benchmark sites (site 50-Cranberry Pond, 7024-Floodwood Pond, and site 15-Yanty Marsh). Site 200-Fox Island Marsh was not sampled due to lack of access to a private island in the middle of Lake Ontario and site 106 was not sampled due to lack of access across private property to the site’s shoreline.

Site 50-Cranberry Pond Wetland was sampled again as a non-panel benchmark site to supplement targeted surveys as part of post-restoration monitoring for a NFWF-funded

Audubon Great Lakes/Ducks Unlimited restoration project within the Rochester Embayment AOC completed in Spring 2021. Site 7024-Floodwood Pond was sampled as a non-panel benchmark site as it had higher bird and anuran IEC scores and is slated for restoration work in the next few years by Ducks Unlimited and Audubon New York. Site 15-Yanty Marsh was sampled as a non-panel benchmark site to provide pre-restoration data for an upcoming USEPA-funded project supported by New York State Office of Parks and Historic Preservation.

Panel Survey Results

SUNY Brockport crews sampled anurans starting on April 17, 2023 and finished sampling on July 10, 2023. Crews detected nine anuran species, including American toad (*Anaxyrus americanus*), bullfrog (*Lithobates catesbeianus*), chorus frog (Pseudacris triseriata), gray treefrog (*Hyla versicolor*), green frog (*Lithobates clamitans*), northern leopard frog (*Lithobates pipiens*), pickerel frog (*Lithobates palustris*), spring peeper (*Pseudacris crucifer*), and wood frog (*Lithobates sylvaticus*).

SUNY Brockport crews sampled birds starting on May 20, 2023 and finished sampling on July 10, 2023. Crews detected one species listed as endangered, threatened, and special concern in New York State, which was Least Bittern (*Ixobrychus exilis*), listed as a threatened species in New York State, at sites 113-Sage Creek Wetland, and 116-Ramona Beach Marsh.

Extra Sites and Data

Site 50-Cranberry Pond, was sampled for birds and anurans as a non-panel benchmark site to supplement continued post-restoration monitoring of a National Fish and Wildlife Foundation-funded project in conjunction with partners at the New York State Department of Environmental Conservation, Ducks Unlimited, National Audubon Society, and Audubon New York. Crews detected a Bald Eagle (Haliaeetus leucocephalus), listed as a threatened species in New York State at this site on May 24. Site 7024-Floodwood Pond was sampled as a non-panel benchmark site as it had higher bird and anuran IEC scores and is slated for restoration work in the next few years by Ducks Unlimited and Audubon New York. Site 15-Yanty Marsh was sampled as a non-panel benchmark site to provide pre-restoration data for an upcoming USEPA-funded project supported by New York State Office of Parks and Historic Preservation.

Data collected at these sites will help inform stakeholders, partners, and land managers on post-restoration wetland conditions and will help guide adaptive management actions. All data from these benchmark sites were included in the data management system as these sites are panel sites too and data collection followed all protocols in this project’s SOP and QAPP.

Wetland Condition Observations and Results

Water levels on Lake Ontario and Erie were about average to slightly above average in summer 2023, which resulted in fairly standard wetland conditions. We did not detect any other significant disturbances across the sites in the US Eastern basin that would affect birds and anurans.

Data Processing

SUNY Brockport crews have completed 100% data entry and QC checks for bird and anuran data and the dual entry process is complete with all issues resolved.

Mid-season QC Check Findings

The bird and anuran mid-season QC check was completed on May 24, 2023 at site 50-Cranberry Pond Wetland. Both crew members (R. Marszalek and W. Sidore) successfully met mid-season check performance criteria described in the project QAPP and had no issues requiring corrective action.

Audit and QC Report and Findings

SUNY Brockport crews have completed 100% data entry and QC checks for bird and anuran data and the dual entry process is complete with all issues resolved. Data review by project manager Gregory Lawrence found no issues and thus, no corrective actions were required.

Additional Funding and Projects

No additional funding was used for any related projects or additional sampling.

Other Collaboration Activities

Site 50-Cranberry Pond, was sampled for birds and anurans as a non-panel benchmark site to supplement continued post-restoration monitoring of a National Fish and Wildlife Foundation-funded project in conjunction with partners at the New York State Department of Environmental Conservation, Ducks Unlimited, National Audubon Society, and Audubon New York.

Bird survey data from all sites in New York State were included in the Third New York State Breeding Bird Atlas to help supplement efforts aiming to determine the current distribution and occupancy of breeding birds in New York State. This project is in collaboration with partners at New York Natural Heritage Program, New York State Department of Environmental

Conservation, Audubon New York, Cornell Lab or Ornithology, and New York State Ornithological Association.

Further, SUNY Brockport crews shared state listed bird and anuran species found at sites 1830-Buckhorn Island Wetland and 15-Yanty Marsh with colleagues at the New York State Office of Parks and Historic Preservation.

US EASTERN BASIN FISH, INVERTEBRATE, AND WATER QUALITY TEAM AT SUNY BROCKPORT

Team Members

- Dr. Kathryn Amatangelo, PI (since 2014)
- Dr. Matthew Altenritter, PI (since 2020)
- Dr. Michael Chislock, PI (since 2018)
- Gregory Lawrence, project manager (2011-14, since 2018)
- Madelynn Edwards, invertebrate laboratory technician (since 2019)
- Jakob Scholeno, graduate research assistant (since 2022)
- Dillon Vandemortel, graduate research assistant (new in 2023)
- Caleb Roller and Jacob Bulich, undergraduate research assistants (new in 2023)

Training

All four field technicians were trained by PIs Dr. Kathryn Amatangelo, Dr. Michael Chislock, Dr. Matthew Altenritter, and project manager Gregory Lawrence on proper field sampling techniques, lab data collection and recording, GPS use, boat use and safety. Invertebrate and water quality team members were trained by PIs Dr. Michael Chislock and Dr. Kathryn Amatangelo, and project manager Gregory Lawrence on proper water quality sample storage, processing, and analysis, and proper invertebrate sample processing and storage. Both fish team members were trained by Dr. Matthew Altenritter and former graduate research assistant Jarrod Ludwig on fish identification, and sample preservation and storage. All training took place June 20-23, 2023 at the SUNY Brockport campus and site 16-Sandy Harbor Wetland for field training. Lastly, all four field technicians were trained on data entry and QC checks in the database. All four field technicians were successfully trained and met pre-season and mid-season training performance criteria described in the project QAPP.

Challenges and Lessons Learned

Travel restrictions due to the COVID-19 pandemic were loosened and crews were able to cross the border and sample sites in Ontario near Kingston and Napanee, Ontario.

Lake Ontario water levels returned from record highs in 2017 and 2019 to about average to slightly above average in summer 2023 reducing site access and sampling issues associated with extraordinarily high and low water levels. Most sites had good sampling conditions for setting fyke nets in multiple vegetation zones.

Site Visit List

The SUNY Brockport team successfully sampled water quality and invertebrates at 15 of the 18 assigned sites including ten regular panel sites, three panel resample sites (123-Little Sandy Creek Marsh, 7021-South Colwell, and 1830-Buckhorn Island Wetland), two panel pre-sample sites (28-Salmon Creek and 116-Ramona Beach Marsh), and three non-panel benchmark sites (50-Cranberry Pond, 7024-Floodwood Pond, and 15-Yanty Marsh). The SUNY Brockport team successfully sampled fish at 10 of the 19 assigned sites. Many assigned sites had no access for the boats used to sample fish due to lack of landowner access despite multiple attempts at visiting the site as well as impossible access to due lack of appropriate boat launches. For some sites with difficult access, crews were able to sample and collect as much data as possible from shore and canoe access.

Panel Survey Results

SUNY Brockport crews sampled fish, water quality, and invertebrates at panel sites starting on June 28, 2023 at site 28-Salmon Creek, and finished on August 4, 2022 at site 50-Cranberry Pond Wetland.

Notable fish included young-of-year northern pike (*Esox lucius*) at site 112-Little Salmon River Marsh and 28-Salmon Creek. Crews also caught bowfin (*Amia calva*) at sites 112-Little Salmon River Marsh and site 54-Genesee River Wetland and a golden redhorse (*Moxostoma erythrurum*) at site 54-Genesee River Wetland. Invasive species included common carp (*Cyprinus carpio*) at site 5635-Mill Point Wetland and round goby (*Neogobius melanostomus*) at 123-Little Sandy Creek Marsh and 54-Genesee River Wetland.

Reptiles included common snapping turtles (*Chelydra serpentina*) and painted turtles (*Chrysemys picta*) at numerous sites. Crews also caught musk turtles (*Sternotherus odoratus*), listed as a high priority species of greatest conservation need in New York State, at site 123-Little Sandy Creek Marsh (Figure 45).

Figure 45. Musk turtle (*Sternotherus odoratus*) at site 123-Little Sandy Creek.

Extra Sites and Data

Site 50-Cranberry Pond, was sampled for water quality and invertebrates as a non-panel benchmark site to supplement continued post-restoration monitoring of a National Fish and Wildlife Foundation-funded project in conjunction with partners at the New York State Department of Environmental Conservation, Ducks Unlimited, National Audubon Society, and Audubon New York. Site 7024-Floodwood Pond, was sampled for fish, water quality, and invertebrates as a non-panel benchmark site as bird and anuran index of ecological condition values indicated it was a very high quality site and has been identified as a candidate for upcoming restoration work by Ducks Unlimited and Audubon New York. Notable species caught by crews at this site included bowfin and invasive common carp. Site 15-Yanty Marsh was sampled as a non-panel benchmark site to provide pre-restoration data for an upcoming USEPA-funded project supported by New York State Office of Parks and Historic Preservation. Notable species caught at Yanty Marsh include bowfin and many green sunfish (*Lepomis cyanellus*) as well as invasive common carp, goldfish (*Carassius auratus*), and rudd (*Scardinius erythrophthalmus*).

Data collected at these sites will help inform stakeholders, partners, and land managers on post-restoration wetland conditions and will help guide adaptive management actions. All data from these benchmark sites were included in the data management system as these sites are panel sites too and data collection followed all protocols in this project's SOP and QAPP.

Wetland Condition Observations and Results

Water levels on Lake Ontario were about average to slightly above average in summer 2023 resulting in good access at almost all sites and boat launches. Water levels were adequate at all sites for setting fyke nets in multiple vegetation zones. Sampling at site 112-Little Salmon River

Marsh occurred shortly after very heavy rainfall and crews observed some flooding overtop docks and in lawns along the shoreline of the site.

Data Processing

SUNY Brockport crews have completed 100% data entry and QC checks for fish, field water quality, and field invertebrate data. 100% unknown fish were identified and entered in the database. 100% laboratory water quality analyses, data entry, and QC checks were completed. Laboratory invertebrate processing and identification has been completed and is on target to be completed later in winter 2023-24.

Mid-season QC Check Findings

The water quality and invertebrate mid-season QC check was completed on July 12, 2023 at site 7021-South Colwell by Dr. Michael Chislock and project manager Gregory Lawrence. Both crew members (J. Scholeno and C. Roller) successfully met mid-season check performance criteria described in the project QAPP and had no issues requiring corrective action. The fish mid-season QC check was completed on July 19, 2023 at site 7024-Floodwood Pond, by Jarrod Ludwig and Gregory Lawrence. Both crew members (D. Vandemortel and J. Bulich) successfully met mid-season performance criteria described in the project QAPP and had no issues requiring corrective action.

Audit and QC Report and Findings

SUNY Brockport crews have completed 100% data entry QC checks for fish, field water quality, and field invertebrate data. 100% laboratory water quality analyses, data entry, and QC checks were completed.

Additional Funding and Projects

No additional funding was used for any related projects or additional sampling.

Other Collaboration Activities

Other Collaboration Activities

Site 50-Cranberry Pond, was sampled for water quality and invertebrates as a non-panel benchmark site to supplement continued post-restoration monitoring of a National Fish and Wildlife Foundation-funded project in conjunction with partners at the New York State Department of Environmental Conservation, Ducks Unlimited, National Audubon Society, and Audubon New York. SUNY Brockport collaborated with Finger Lakes and St. Lawrence-Eastern

Lake Ontario Partnerships for Regional Invasive Species Management by reporting invasive species, such as round goby, detected at each wetland to assist in further management, monitoring, and/or eradication.

SUNY Brockport shared state listed fish species found at sites 1830-Buckhorn Island Wetland and 15-Yanty Marsh with colleagues at the New York State Office of Parks and Historic Preservation. These data will be used to help guide management activities and future wetland restoration projects at the sites.

US EASTERN BASIN VEGETATION TEAM AT SUNY BROCKPORT

Team Members

- Dr. Kathryn Amatangelo, PI (since 2014)
- Dr. Rachel Schultz, PI (since 2019)
- Gregory Lawrence, project manager (2011-14, since 2018)
- Kendalyn Town, graduate research assistant (since 2022)
- Kendall Hastings (new in 2023)

Training

Both field technicians (K. Town and K. Hastings) were trained by PIs Dr. Kathryn Amatangelo, Dr. Rachel Schultz, and project manager Gregory Lawrence on proper field sampling techniques, data collection and recording, GPS use, and boat use and safety. Both technicians were trained by Dr. Rachel Schultz on plant identification and sample preservation and storage. All training took place June 20-23, 2023 at the SUNY Brockport campus and site 16-Sandy Harbor Wetland, for field training. Lastly, both field technicians were trained on data entry and QC checks in the database. Both field technicians were successfully trained, passed the plant identification quiz, and met pre-season training performance criteria described in the project QAPP.

Challenges and Lessons Learned

Loosened restrictions regarding the COVID-19 pandemic greatly reduced travel restrictions and logistical issues in 2023 allowing crews to travel across the United States-Canada border to sample assigned sites in Canada.

Lake Ontario water levels returned from record highs in 2017 and 2019 to about average to slightly above average in summer 2023, reducing site access and sampling issues associated with extraordinarily high and low water levels. Most sites were readily accessible for crews to sample vegetation.

Site Visit List

The SUNY Brockport team successfully sampled vegetation at 16 of the 18 assigned sites including ten regular panel sites, three panel resample sites (123-Little Sandy Creek Marsh, 7021-South Colwell, and 1830-Buckhorn Island Wetland), two panel pre-sample sites (28-Salmon Creek and 116-Ramona Beach Marsh), and three non-panel benchmark sites (50-Cranberry Pond, 7024-Floodwood Pond, and 15-Yanty Marsh). Sites 52-Round Pond, 26-Bogus Point Wetland, and 106-Otter Branch Wetland were all inaccessible even by canoe due to lack of property access from landowners and Bogus Point was blocked off by vegetation preventing canoe access.

Site 7024-Floodwood Pond was sampled as a non-panel benchmark site as it had higher bird and anuran IEC scores and has been proposed for restoration work in the next few years so data collection can help supplement pre-restoration monitoring activities. Site 15-Yanty Marsh was sampled as a non-panel benchmark site to provide pre-restoration data for an upcoming USEPA-funded project supported by New York State Office of Parks and Historic Preservation.

Panel Survey Results

SUNY Brockport crews sampled vegetation at panel sites starting on June 28, 2022 at site 28-Salmon Creek and finished on August 2, 2022 at site 1830-Buckhorn Island Wetland. Crews sampled in the rare coastal fen at site 7026-Buttonwood Creek and noted increased cover of invasive *Typha* x *glauca* from recent years. This site was restored previously in an effort to reduce invasive cattail invasion in the fen area. Crews also found wild rice (*Zizania palustris*) at sites 116-Ramona Beach Marsh, 126-Cranberry Pond Marsh, and 7021-South Colwell but did not record it on any transects. Lastly, crews found one species on the New York State Protected Native Plants list, *Equisetum pratense*, at site 7021-South Colwell.

Crews noted multiple invasive species including *Alnus glutinosa*, listed as a Tier 3 invasive species by Western New York PRISM, at site 1830-Buckhorn Island Wetland. Finger Lakes PRISM lists *Typha* x *glauca* as a Tier 3 invasive species and crews found it at sites 56-Irondequoit Bay Wetland 2, 54-Genesee River Wetland, 28-Salmon Creek, and 7026-Buttonwood Creek. Saint Lawrence-Eastern Lake Ontario PRISM lists *Phragmites australis* spp. *australis* as a Tier 3 invasive species and crews found it at sites 112-Little Salmon River Marsh and 7021-South Colwell. Crews also detected *Lythrum salicara* and *Phalaris arundinacea*, both listed as unwanted invasive plant species by the Canadian Council on Invasive Species, at site 5635-Mill

Point Wetland. Crews also detected *Phalaris arundinacea* and *Myriophyllum spicatum*, also listed as an unwanted invasive plant species by the Canadian Council on Invasive Species at site 5151-Carnachan Bay Wetland 2. Lastly, crews noted invasive water chestnut (*Trapa natans*) at sites 28-Salmon Creek, 7026-Buttonwood Creek, and 112-Little Salmon River Marsh.

Extra Sites and Data

Site 15-Yanty Marsh was sampled as a non-panel benchmark site to provide pre-restoration data for an upcoming USEPA-funded project supported by New York State Office of Parks and Historic Preservation. Crews noted extensive *Typha* x *glauca*, listed as a Tier 3 invasive species by Finger Lakes PRISM at this site, likely a major reason for the need for restoration.

Site 7024-Floodwood Pond was sampled as a non-panel benchmark site as it is slated for restoration work in the next few years by Ducks Unlimited and Audubon New York. Crews noted invasive *Phragmites australis* spp. *australis*, listed as a Tier 3 invasive species by Saint Lawrence-Eastern Lake Ontario PRISM, at this site along with *Equisetum pratense*, listed as a threatened native plant on the New York State Protected Native Plants List.

Data collected at these sites will help inform stakeholders, partners, and land managers on pre- and post-restoration wetland conditions and will help guide adaptive management actions. All data from these benchmark sites were included in the data management system as these sites are panel sites too and data collection followed all protocols in this project's SOP and QAPP.

Wetland Condition Observations and Results

Water levels on Lake Ontario were about average to slightly above average in summer 2023 resulting in good access at almost all sites and boat launches. Crews noted extensive *Typha* cover at almost all sites, noting increased cover at previously restored sites like the site 7026-Buttonwood Creek coastal fen.

Data Processing

SUNY Brockport crews have completed 100% data entry and QC checks for vegetation data. 100% unknown plants were identified and entered in the database.

Mid-season QC Check Findings

The vegetation mid-season QC check was completed on July 18, 2023 at site 126-Cranberry Pond Marsh by Dr. Rachel Schultz. Both crew members (K. Town & K. Hastings) successfully met mid-season check performance criteria described in the project QAPP and had no issues requiring corrective action.

Audit and QC Report and Findings

SUNY Brockport crews have completed 100% data entry and QC checks for vegetation data. 100% unknown plants were identified and entered in the database.

Additional Funding and Projects

No additional funding was used for any related projects or additional sampling.

Other Collaboration Activities

Site 15-Yanty Marsh, was sampled for vegetation as a non-panel benchmark site to supplement continued pre-restoration monitoring for a future project funded by the USEPA and conducted by NYS Parks. SUNY Brockport collaborated with Finger Lakes and St. Lawrence-Eastern Lake Ontario Partnerships for Regional Invasive Species Management by reporting invasive species, such as water chestnut, detected at each wetland to assist in further management, monitoring, and/or eradication.

SUNY Brockport shared state listed plant species found at sites 1830-Buckhorn Island Wetland and 15-Yanty Marsh with colleagues at the New York State Office of Parks and Historic Preservation. These data will be used to help guide management activities and future wetland restoration projects at the sites.

ASSESSMENT AND OVERSIGHT

The Quality Assurance Project Plan (QAPP) for this program was originally written, signed by all co-PIs, and approved by USEPA in the spring of 2011, prior to beginning any fieldwork. Throughout the first round of the project (2011-2015), five revisions were made to the QAPP. These revisions were necessary to improve methodology, better clarify protocols, and ensure the safety of all personnel. After each revision, all co-PIs and US EPA reviewed and signed the updated document prior to commencing fieldwork. The final QAPP revision for round 1 of the project was signed in March 2015. This 2015 revision (QAPP_r5) served as the basis for the second round of monitoring (2016-2020).

For the second 5-year sampling rotation, no substantial methodological or quality assurance/quality control changes were necessary. The QAPP_r5 document was reviewed by project PIs prior to our February 19, 2016 project meeting. The only changes that were required to QAPP_r5 related to the data management system. Project PIs signed the updated QAPP (QAPP_CWMII_v1) at the February 19, 2016 meeting. In thoroughly reviewing the QAPP and SOPs in early 2018, crews found inconsistencies between the QAPP and SOPs and another handful of minor corrections and clarifications. PIs signed off on these changes at the 2018 PI meeting in Michigan in February. These fixes were incorporated into the QAPP in 2018 and PIs again signed off on the QAPP at the March 1, 2019, meeting in Michigan. The updated QAPP (QAPP_CWMII_rev 1) and SOPs were submitted to EPA in April of 2019.

For the third 5-year sampling rotation, again no substantial methodological or QA/QC changes were necessary. The QAPP was updated to reflect turnover in program personnel, to continue to strive for clarity and understandability by others and to make the QAPP more of a stand-alone document without reference to proposals or reports, and to remove inconsistencies between the QAPP and SOPs. The only substantive change was to update the water chemistry section to better reflect the updated EPA guidance on calculating error and variability in various water chemistry measurements. This QAPP (QAPP_CWMPIII_2021) was signed by PIs in the spring of 2021. The QAPP was updated in spring of 2023 (signed by all PIs) to reflect the re-creation of the Site Management System by Limnotech to be housed at Central Michigan University.

Major QA/QC elements that are on-going for this program:

- Training of all new laboratory staff responsible for macroinvertebrate sample processing: This training is conducted by experienced technicians at each regional lab and is 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. Macroinvertebrate IDers communicate with each other via their own email list and assist each other with difficult identifications and other questions that arise. Every few years, typically when a major identification guide is updated, IDers for all teams meet either in-person or virtually to discuss taxonomic issues and questions.

- Training of all fish, macroinvertebrate, vegetation, bird, anuran 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 anurans. Training certification documents were archived with the lead PI and QA managers.

- GPS testing: Every GPS unit used during the 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 managers (Brady and Cooper) then reviewed these records to ensure consistency among crews. Occasionally, field crew leaders contacted Uzarski, Brady, or Cooper when deciding whether to reject a site. The frequency of these consultations increased in 2018 and 2019 as high water levels made sampling particularly challenging, but had returned to normal by 2020 as crews have become more accustomed to the high water levels and because water levels dropped quite a bit in 2021 and again in 2023 due to drought across the upper Great Lakes.

- Collection of all training/certification documents and mid-season QA/QC forms from regional labs: These documents 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 in conjunction with approximately every 10th WQ sample collected.

- 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. QC should be complete for all data by the spring semi-annual report submission each year.

- Linking of GPS points with field database: Inevitably, some errors occur when crew members type in GPS waypoint names and numbers. All non-linking points between these two databases were assessed and corrected in 2014, which took a hundred or more person-hours. We now have a more automated way to link GPS waypoints with data, crews are paying more attention to waypoint name/number accuracy, and the lat/longs for critical locations are being typed directly into the data management system. These three actions have greatly reduced number of GPS waypoints that cannot be linked to data in the DMS system.

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

- Creation/maintenance of specimen reference collections: Reference collections for macroinvertebrates, fish, and plants have either been created or are being maintained and updated by each regional team. Macroinvertebrate reference collections, in particular, were developed or expanded as these samples were processed. Vegetation reference collections are often being kept in collaboration with local herbaria.

- Data Quality Objectives (DQO) for laboratory analyses: Participating water quality laboratories have generated estimates of precision, bias, accuracy, representativeness, completeness, comparability, and sensitivity for all water quality analyses.

DATA VERIFICATION

This past winter we, in collaboration with GDIT, implemented a data verification protocol that is being used to identify and resolve, or otherwise flag, issues related to data accuracy, consistency, and compliance with the Quality Assurance Project Plan (QAPP) and SOPs established for sampling the various taxa groups. The overall goal of this process is to establish the usability of each data record to ensure that the CWMP datasets are properly communicated to and applied by end data users. Initially, approximately 120 data verification criteria (rules) were developed by GDIT (USEPA's contractor) to conduct a suite of checks for specific components of the anuran, bird, vegetation, fish, macroinvertebrate, and water quality datasets. Examples of data verification checks include:

- Identifying bird surveys that took place outside the sampling seasonal frame (e.g., after breeding season).
- Identifying fish surveys for which nets did not fish correctly and yet the crew entered data from those nets.
- Identifying vegetation surveys for which some other number of transects than three was sampled.

The data verification checks have been automated by GDIT to run against the semi-annual CWMP database release (MS Access format) that is delivered to GLNPO in May and October of each year. Each record that fails to meet specific verification criteria (such as they listed above) is flagged with an appropriate data qualifier code (e.g., “LINTC” – lack of internal consistency, or “MRV” – missing required value). The results from the automated checks are written to a set of comma-separated variable (CSV) files (i.e., one file per check type), which are delivered by GDIT to LimnoTech for integration into the CWMP DMS. Over the past six months, LimnoTech has incorporated additional tables (“data_rev_*”) into the DMS and developed a utility application to ingest the CSV files into those dedicated tables. The enhanced DMS provides the capability to store and manage multiple sets of data verification results, including tracking of issue resolution and the assignment of data usability flags on a record-specific basis. Verification check results are stored in a set of dedicated tables, which are readily linked to any CWMP taxa data table that the results may be associated with. While this approach supports linking the raw data to verification results/flags when needed, it also avoids burdening the raw data tables with the detailed verification information.

Due to the large variety and number of verification checks and results, a dedicated “Data Verification” page was implemented by LimnoTech on the CWMP main website to provide a platform for CWMP team members to efficient review and respond to individual verification results (Figure 46). The tool will allow any “Level 4” CWMP user to efficiently filter for verification results that are pertinent to their specific taxa team, to download the results to an Excel spreadsheet, and then to provide appropriate feedback for each individual result, including documenting the resolution of the issue (if any). Ultimately, each record will be assigned an appropriate data usability flag based on assessment by lead PIs.

The CWMP lead PIs reviewed the verification criteria information provided by GLNPO and GDIT, as well as the data verification tool described above. The tool was introduced and training provided to all taxonomic groups in the fall of 2022. This first round of data verification covers years 2016 – 2021. Over the winter, teams reviewed hundreds of items in the database that failed these data verification checks. A few items showed that checks need to be re-written (for example, fish lengths for young-of-year cutoffs), but most checks worked well and flagged things that needing correction, updating, or decisions about whether or not to quarantine the data. To data, teams have resolved 50-90% of the issues found by the checks and will work on finishing this work in the fall.

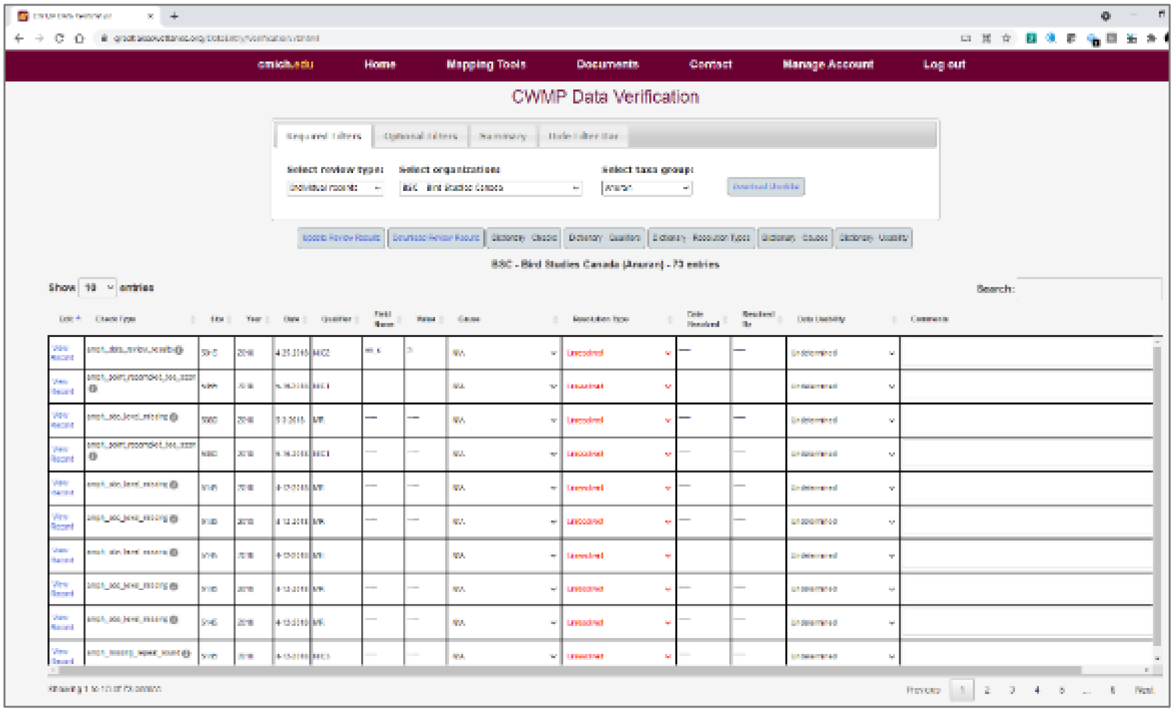


Figure 46. CWMP data verification user interface.

EXAMPLE WATER QUALITY QC INFORMATION

Laboratory Quality Assurances:

Water quality analyses from 2022 have been completed by the NRRI Central Analytical Laboratory, Central Michigan University's Wetland Ecology Laboratory, Grand Valley State University's Annis Water Resources Institute, Brockport's water quality lab, and Environment Canada's national water quality lab. Laboratory results from 2022 have passed the criteria shown below (Table 20) or were excluded from the database.

Table 20. 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 (not updated for 2023)

An analysis of field duplicate variability for samples collected in 2020 and 2021 is shown in Table 23. 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 21 below lists average RPD values for each year of round 2 of this sampling program (2016-2019). 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 Total N, had values that were well above detection limits 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. 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).

Table 21. Field duplicate sample variability for 2020-2021 in relative percent difference for water quality parameters with the acceptance criteria.. The maximum expected RPD values are based on the MN Pollution Control Agency quality monitoring requirements for integrated assessments (https://www.pca.state.mn.us/sites/default/files/wq-s1-15n.pdf). Average RPD (n), min-max RPD.

Analyte	Maximum expected RPD	MDL	2020	2021
Chlorophyll-a (µ/L)	30	0.5 µg/l All Labs 0.025 µg/L Brockport 0.25 µg/L U Windsor	22 (15) 0-113	31 (18) 0-133
Total phosphorus (mg/L)	30	0.002 mg/L Brockport 0.01 mg/L CMU 0.0005 mg/L Env Can 0.006 mg/L GVSU 0.005 mg/L NRRI 0.0005 mg/L U Windsor	15 (15) 0-37	17 (18) 0-97
*Soluble Reactive phosphorus (mg/L)	10	0.0003 mg/L Brockport 0.006 mg/L CMU 0.0002 mg/L Env Can 0.005 mg/L GVSU 0.006 mg/L NRRI 0.0002 mg/L U Windsor	34 (12) 0-119	38 (16) 0-150
Total nitrogen (mg/L)	30	0.023 mg/L Brockport 0.03 mg/L CMU 0.015 mg/L Env Can 0.1 mg/L GVSU 0.03 mg/L NRRI 0.015 mg/L U Windsor	9 (15) 0-23	9 (18) 0-48
*NH4-N (mg/L)	10	0.002 mg/L Brockport 0.01 mg/L CMU 0.005 mg/L Env Can 0.01 mg/L GVSU 0.009 mg/L NRRI 0.005 mg/L U Windsor	18 (14) 0-93	17 (16) 0-42
*NO2/NO3-N (mg/L)	10	0.003 mg/L Brockport 0.01 mg/L CMU 0.005 mg/L Env Can 0.01 mg/L GVSU 0.008 mg/L NRRI 0.005 mg/L U Windsor	10 (13) 0-33	16 (18) 0-57

Table 21. Field duplicate sample variability for 2020-2021 in relative percent difference for water quality parameters with the acceptance criteria.. The maximum expected RPD values are based on the MN Pollution Control Agency quality monitoring requirements for integrated assessments (https://www.pca.state.mn.us/sites/default/files/wq-s1-15n.pdf). Average RPD (n), min-max RPD.

Analyte	Maximum expected RPD	MDL	2020	2021
True color (Pt-Co Units)	10	2 CU Brockport 5 CU Env Can 2 CU NRRI 0.5 CU U Windsor	5 (12) 0-12	14 (12) 0-44
Chloride (mg/L)	20	0.2 mg/L CMU 0.1 mg/L Env Can 1 mg/L GVSU 1.67 mg/L NRRI 0.01 mg/L U Windsor	8 (14) 0-43	7 (16) 0-42

Notes:
*The variability between soluble reactive phosphorus, ammonium-N and nitrate/nitrite-N field replicates often exceeded the criteria, however many values for each were < 10 X the MDL

Field duplicates are a second sample taken immediately after an initial sample in the exact same location to assess the site, sampling and possible temporal variability. Duplicate samples are collected in the exactly the same manner as the first sample, including the normal sampling equipment cleaning procedures. The relative percent difference (RPD) between the duplicate samples is calculated with the following equation:

RPD = (|Result 1 - Result 2|)/ ((Result 1 + Result 2)/2) x 100

COMMUNICATION AMONG PERSONNEL

Regional team leaders and co-PIs continue to maintain close communication as the program enters its thirteenth year (third year of round 3 sampling). Nearly all program members virtually attended an all-hands Zoom program organizational meeting in March of 2023. Holding the meeting virtually meant that field and laboratory technicians and grad students could attend without worrying about having a travel budget. The PIs discussed issues pertaining to the upcoming field season, how we could keep diverse teams safe, data validation and correction, manuscripts, and report products. Individual taxonomic teams held their meetings virtually just before or after the overall program meeting.

Regional team leaders and co-PIs have held many conference calls and e-mail discussions regarding fieldwork, taxonomic changes, data analysis, indicator refinement, and publications throughout the duration of the project. Typically, most PIs spend the first week of field season in the field with their crews to ensure that all protocols are being followed according to the standards set forth in the QAPP and SOPs and to certify or re-certify crew members. That changed because of Covid-19 (depending on the field crew and PI), but we expect that this field season will be more normal. However, again this year most crews have returning and experienced personal, and the PIs will be in contact and do training and provide advice in the manner that best suits their circumstances, at a minimum via phone calls and webinars. Under all circumstances, PIs keep in close contact with crews via cell phone, text, and email, and the leadership team is also always available via cell phone and text to answer crew questions.

OVERALL

The quality management system developed for this project has been fully implemented and PIs and their respective staff members continue to follow 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.

Despite the somewhat dangerous nature of this work, injury rates continue to be very low. We are very proud of what our field crews accomplished safely despite a global pandemic. Crews sampled safely, accurately, and without spreading Covid-19. The entire CWM team is relieved that crews continue to maintain an exemplary safety record. This is due to the leadership and safety consciousness of PIs, field crew chiefs, and field team leaders. PIs are not complacent about the lack of injuries and are grateful for the willingness of their crews to work long hours day after day, to successfully sample under often adverse conditions (including a global pandemic), and to conduct that sampling in accordance with strict QA procedures.

LEVERAGED BENEFITS OF PROJECT (2010 – 2023)

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)

Investigating the Use of eDNA to Determine Fish Use of Otherwise Unsampleable Habitats: Some habitats cannot be sampled using fyke nets because of inappropriate water depth, unstable or unconsolidated bottom sediments or because that habitat is too fragile (e.g. wild rice). CoPI Valerie Brady with NRRI researcher Chan Lan Chun are investigating how well fyke net fish catches agree with fish eDNA collected from nearby benthic sediment to determine if eDNA could be used as a surrogate in situations where fish cannot be physically collected to determine habitat use.

Macroinvertebrate Monitoring for Delisting the Degradation of Benthos Beneficial Use Impairment in the Muskegon Lake Area of Concern: The West Michigan Shoreline Regional Development Commission, with support from the Michigan Department of Environment, Great Lakes, and Energy funded a project to conduct macroinvertebrate sampling at 2 coastal wetlands in the Muskegon Lake Area of Concern in an effort to evaluate "Degradation of Benthos" BUI in the AOC. Samples were collected in 2021 and 2023 and data from several Lake Michigan reference wetlands were used to compare the AOC restoration sites. Dr. Matt Cooper led this project with students from Muskegon Community College.

Compiling and Assessing IBI and Environmental Stress Data to Assess Habitat Condition in the Detroit River Area of Concern (AOC): The Detroit River Canadian Clean-up (convened by Environment and Climate Change Canada and the Province of Ontario) is evaluating the weight of evidence with regard to delisting several Beneficial Use Impairments in the Detroit River AOC (Degradation of Fish and Wildlife, Degradation of Benthos, and Loss of Fish and Wildlife Habitat. However, years of monitoring and assessment have failed to demonstrate clear time trends in the condition of biota (aquatic vegetation, aquatic macroinvertebrates, fishes, birds) of the Detroit River's aquatic and riparian habitats. Attempts to evaluate indices of biotic integrity (IBIs) using the Reference Condition Approach (RCA) have been limited by an inability to achieve consensus on appropriate reference conditions. CoPIs Jan Ciborowski, Greg Grabas and Doug Tozer compiled land-based stressor data at the scale of second-order watersheds for the Detroit River AOC to let us assess how the IBI scores for sites in the Detroit River and adjacent areas (Lake Erie, Lake St. Clair, St. Clair River) vary as a function of environmental stress. We compiled all available biological monitoring datasets relating to aquatic vegetation, macroinvertebrates, fishes and birds within the study region and calculated composite measures of condition (IBIs) for each of the groups of biota and plotted the resulting scores against the stressor measures. We found provisional evidence of environmental stress thresholds for at least one IBI of each of the taxa investigated. Mapping the distribution of nondegraded vs. degraded watersheds for each of the biological groups will help the DRCC identify whether and where further remediation is necessary to allow delisting of the BUIs.

Minnesota Land Trust Natural Areas Project and Grassy Point Restoration: In 2018, the Minnesota Land Trust contracted a project with the Natural Resources Research Institute in

Duluth, MN to conduct bird surveys along the St. Louis River Estuary (SLRE), within nine project areas that were nominated for inclusion in the Duluth Natural Areas Program (DNAP). This program was created in 2002 to manage Duluth's environmentally significant areas to ensure the preservation of services and values such as habitat diversity and water quality. In addition to data collected for this project, we also included breeding bird data collected by the CWMP at benchmark sites located within the SLRE that aligned spatially with the nine DNAP project areas. Collectively these data were used to determine if the proposed land parcels included in the nomination met the criteria of qualifying as an Important Bird Congregation Area (criteria included numeric thresholds for different guilds of species). Use of these data qualified all nine parcels as meeting the Important Bird Congregation Area criteria.

These data were then used in a spin-off project with Minnesota Land Trust, where bird communities were associated with spatially-explicit environmental and habitat variables to help guide conservation and management effort in the SLRE. In this project we were also able to identify habitat availability at the landscape-level to identify specific features that are under-represented in the SLRE but likely important to avian species (specifically wetland-dependent species). These analyses have been used to guide restoration plans at specific locations within the SLRE, including Grassy Point (a wetland located in a heavily industrialized area of the SLRE). Efforts to restore this wetland site are being developed by using the habitat requirements of wetland-dependent marsh bird species as a guide and restoration goal. The plans for Grassy Point are complete and on-the-ground restoration is scheduled to begin in the spring of 2020. NRRI CWMP teams will be involved in post-restoration monitoring of this site as well.

Deriving and Calibrating Environmental and Biological data for Lake Erie in Support of the Great Lakes Water Quality Agreement's Nearshore Framework: As part of the Annex 2 and Annex 7 plans of the revised GLWQA, Environment and Climate Change Canada (ECCC) and GLNPO began work to jointly develop an Integrated Nearshore Framework for the Great Lakes. The goal was to assemble scientific and technical recommendations for nearshore assessment. The assessment was expected to be used to set priorities and design an approach to identify areas of high quality for protection and areas under stress requiring restoration. ECCC and GLNPO convened several workshops beginning in 2014. In 2016, ECCC initiated a pilot project on the Canadian side of Lake Erie to come up with a workable methodology and approach to combining assessments of different condition measures. CWM coPIs Jan Ciborowski and Greg Grabas took part in a series of workshops and contributed information collected in part from CWM wetland surveys on Lake Erie. The first overall assessment of the nearshore in Lake Erie was reported in 2018. The weight of evidence indicated that there is a strong east to west gradient in nearshore condition with the highest quality habitat and biota observed in the eastern basin, and low quality in the western basin, influenced largely by seasonal occurrences of cyanobacteria. The nearshore of the Detroit River and Lake St. Clair was classified as being of moderate quality. Insufficient data were available to assess the St. Clair River. Assessments of the condition of coastal wetland across the study area were limited by variation in the types of data collected by different programs. A future goal will be to determine how best to align data collected from other programs with information collected using the CWM protocols.

Real-Time Logging of Water Level, DO, Light, and Wind to Assess Hydrological Conditions in Great Lakes Coastal Wetlands: The University of Windsor is coordinating a project to test the hypothesis that the numbers and species of fishes caught in wetland fyke nets are related to temporal variation in dissolved-oxygen (DO), and that such DO variation is partly driven by seiche activity causing temporary movement of cool, well-oxygenated lakewater into and out of wetlands. This variation in DO may be especially important in the densely vegetated, shoreline-associated wetland zones (usually wet meadow, under high-water conditions). An SOP document was developed in spring 2019 and circulated to all field crews.
Each field team has been encouraged to deploy water level and DO loggers at their fyke net sites over the course of the summer. In addition to providing important basic hydrological information about the condition of coastal wetlands, the resulting Great Lakes-wide dataset will be used to help account for variation in fish catches and ultimately improve the precision of fish IBI estimates. Preliminary data collected over the field season and suggestions for improvement will be discussed at the winter field meeting.

Bathymetry and mapping of wetlands in Point Pelee National Park during a period of hydrologic change: In 2018 Point Pelee National Park (PPNP) received approval through the Parks Canada Conservation and Restoration Project to begin a 4-year marsh restoration project. The project was focused 1) on increasing open water habitat and interspersion within the marsh and 2) reducing invasive vegetation. Members of the Ciborowski CWM team were asked if they would be able to conduct a preliminary survey of PPNP wetlands to determine the bottom profile and distribution of submerged aquatic vegetation. There was especial interest in the bathymetry of Lake Pond, whose eastern shoreline had been breached by wave action from Lake Erie during the summer as a consequence of the historically high water levels. In fall 2018 and during the 2019 field season, we conducted a benchmark survey of vegetation, aquatic invertebrates and water chemistry. We also assessed water depth, macrophyte distribution and cover and sediment characteristics throughout the wetland using the remotely-operated ROVER, which was developed for shallow-water data collection in remote locations. Water level and dissolved oxygen loggers set in place in the spring provided a full-season record of the frequency of seiches and associated changes in water quality. CWM researchers are anticipated to be involved as collaborators throughout the restoration project.

Inventory and distribution of zooplankton in coastal wetlands: As part of ongoing interest in assessing the condition of CWM wetlands we began assessing the community composition of zooplankton in the wetlands visited as part of the annual program. Pilot samples were first collectedin 2017. In 2018, zooplankton samples were collected at 16 Great Lakes coastal wetlands, situated off Manitoulin Island, northern Lake Huron, the western basin of Lake Erie, the Bruce Peninsula and Georgian Bay. In each wetland, samples were collected at 3 shallow-water points along a dissolved oxygen gradient. Records of water depth, substrate characteristics and vegetation density and composition were also tabulated. The sampling methods were based on techniques proposed by Lougheed and Chow-Fraser (2002) in developing their Zooplankton Quality Index. Seven Lake Huron wetlands were sampled in 2019.

Evaluating Fish and Invertebrate Distribution in Great Lakes Coastal Wetlands - an Occupancy Modeling Approach: Led by University of Windsor postdoctoral fellow student Martin Jeanmougin, this project involves fish PIs Joseph Gathman, Carl Ruetz, Dennis Higgs and Jan Ciborowski. Occupancy modelling is a statistical approach that allows one to estimate the probability that a taxon is present in an area and the probability that it can be detected by sampling. Applying this approach to the invertebrate and fish CWM data could help us to identify important environmental factors influencing the likelihood that selected taxa occur in particular habitats and to more accurately estimate their distribution across the Great Lakes. Also, an analysis of the detection patterns can provide important information on potential biases in the protocols we use to sample the biota. The previous work done by K. Dykstra of Grand Valley State University (Carl Ruetz's lab) for the thesis on Yellow Perch distribution will be a good starting point for this project.

Genetic Barcodes for Wetland Macroinvertebrates: Surveillance of aquatic macroinvertebrates in the Great Lakes is of utmost importance. However, many organisms, particularly aquatic macroinvertebrates, lack information that can assist in their identification, whether through molecular barcodes or morphological characteristics. We are using previously collected aquatic macroinvertebrate samples from throughout the Great Lakes basins to generate genetic barcodes that will assist in identification of species (MOTUs) and expand the currently available molecular genetic databases. Our work is targeting specific groups to improve morphological identification to lowest taxonomic levels. Finally, we will be able to use these data to test the usefulness of metabarcoding for Great Lakes surveillance to provide managers with valuable monitoring information.

Assessing Climate Vulnerability in Apostle Islands Coastal Wetlands: Funded by the National Park Service and GLRI, a team from Northland College sampled fish, macroinvertebrates, vegetation, and hydrologic variables in lagoon wetlands throughout the Apostle Islands National Lakeshore to identify species and communities that may be particularly vulnerable to climate change. This work represents an intensification of sampling effort within a sensitive and relatively pristine area of the Great Lakes. Data from this project were analyzed in relation to CWMP data to put Apostle Islands wetlands into a broader Great Lakes context.

Functional Indicators of Coastal Wetland Condition: Funded by the USGS through a Cooperative Ecosystem Studies Unit (CESU), this pilot project ran from fall 2016 through fall of 2019 to better determine functional indicators of Great Lakes coastal wetland usage by Great Lakes fish species. Sampling was done during the spring and fall at about 15 US wetlands already being assessed for CWM indicators during the summer. Data collected focus on fish usage of wetlands and the forage base for those fish, evaluated using macroinvertebrate sampling and examination of fish gut contents. Special emphasis was placed on determining usage of wetlands by young or spawning fish.

Conservation Assessment for Amphibians and Birds of the Great Lakes: Several members of the CWM project team have initiated an effort to examine the role that Great Lakes wetlands play in the conservation of amphibians and birds in North America. The Great Lakes have many large, intact freshwater wetlands in the interior portion of the North American continent. Their unique character, size, and plant composition supports populations of many species of amphibians and birds, many of which have been identified as endangered, threatened, or of special concern in North America. CWM PIs will use the extensive data that have been gathered by USEPA, such as the Great Lakes Environmental Indicators project and the Great Lakes Wetlands Consortium, as well as Bird Studies Canada, as critical input to this assessment.
The initial stages in the development of the conservation assessment will be to analyze habitat and landscape characteristics associated with Great Lakes coastal wetlands that are important to wetland-obligate bird species occupying these habitats. By combining breeding bird data from the sources above and incorporating landscape variables, classification trees can be developed to predict presence and relative abundance of these species across the Great Lakes Basin. These methods, outlined in Hannah Panci's thesis; 'Habitat and landscape characteristics that influence Sedge Wren (*Cisthorus platensis*) and Marsh Wren (*C. palustris*) distribution and abundance in Great Lakes Coastal Wetlands'(University of Minnesota Duluth). She compiled data for over 800 wetlands in her analysis, which will provide a basis for analyzing additional wetland-obligate species.

Bird and Anuran Metrics and Indicator Calculations: Avian and anuran 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 QC'd are being used to calculate some of the metrics and indicators for these wetlands.

Influence of broadcast timing and survey duration on marsh breeding bird point count results: Several members of the project team, with D. Tozer as lead, examined the importance of survey duration and timing of broadcast playbacks on occurrence and counts of wetland breeding birds. The results of this analysis suggest that 10-min point counts are superior to 15-min counts which have important implications for future monitoring and cost-effectiveness. These findings have been published in the journal of Avian Conservation and Ecology (Tozer et al. 2017).

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 were analyzed by Kettering University and their Swedish Biogas partner to determine the amount of methane that can be generated from this invasive. These samples was compared to their data set of agricultural crops, sewage sludge, and livestock waste that are currently used to commercially generate methane. Results demonstrated that hybrid cattail and reed canary grass both generated adequate levels of methane for use as feedstocks for biodigestion. The result of this and other CWM data collection are summarized in the Carson *et al.* 2018 journal article. 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.

Using Monitoring Results to Improve Management of Michigan's State-Owned Costal Wetlands: One year project, 2016-2017, awarded to Central Michigan University by the Michigan Department of Environmental Quality. The project will focus on the prioritization of high-quality and important state-owned coastal wetlands that have been monitored as part of the Great Lakes CWM program, and development of site-specific management plans for these wetlands which address diverse management goals and objectives with a broad focus including biodiversity, ecological services, habitat for fish and wildlife, climate change adaptation, and rare species.

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 project, funded by the Upper Midwest and Great Lakes Landscape Conservation Cooperative, the Michigan Office of the Great Lakes, and the US Army Corp. of Engineers, has developed a DSS for wetlands along the US shoreline of the Great Lakes.

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. Clough Island was recently acquired by the Nature Conservancy and they are using the data in the report for their development of conservation plans for the area.

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 fish and wildlife beneficial use impairment (BUI) removal targets for the Lower Green Bay and Fox River AOC (2015-2017) 1) Protocols for intensive sampling of bird, anurans, and emergent wetland plants 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 anurans and from CWM on birds and anurans 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 the removal of two important BUIs (fish and wildlife populations and fish and wildlife habitats). 4. Application of the Index of Ecological Condition method (e.g., Howe et al. 2007) for measuring the condition of birds, anurans, and other fish and wildlife groups. Follow-up work was funded for 2018-2020 at $87,000 to continue refining field monitoring methods and metrics of 40 fish and wildlife habitats and populations.

SOGL/SOLEC Indicators: CWM project PIs have developed a set of indicator metrics for the State of the Great Lakes/State of the Lakes Ecosystem Conference (SOLEC). These metrics fill a much-needed gap in quantifying responses of biotic communities to environmental stress throughout the Great Lakes. Sites for all coastal wetlands sampled by the GLEI, CWM, and Marsh Monitoring Program 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. This discovery received media attention from the Illinois-Indiana Sea Grant College Program.

Chlorophyll-*a* Modeling: The UND team, in collaboration with Northland College, CMU, and others, is investigating the drivers that influence water column chlorophyll-*a* in coastal wetlands. Our hypothesis is that chlorophyll-*a* will be related to nutrient status of wetlands and degree of development of adjoining land. Along with CWM water data, we are utilizing GIS land use and connectivity data. Specifically, we seek to answer the following questions: (1) What variables best predict chlorophyll-*a* in coastal wetlands across the entire Great Lakes basin? (2) How do these variables change across each basin (i.e., Lake Michigan, Lake Erie, Lake Ontario, Lake Superior, Lake Huron)? (3) Are there differences in predictor variables across sub-basins (e.g., Lake Erie North vs. Lake Erie South)? (4) Does wetland type (lacustrine, riverine, or barrier) change chlorophyll-*a* predictors? (5) How do other potential variables, such as vegetation zone type or year, change chlorophyll-*a* predictors?

Invasion Vulnerability Index: The UND team, in collaboration with other CWM teams, aims to create a usable tool that predicts which aquatic invasive species from a list of 10 Great Lakes Aquatic Nuisance Species Information System (GLANSIS) watchlist species are of highest concern for prevention and early detection. We will combine Habitat Suitability Indexes (HSIs) made using wetland site-specific physio-chemical measurements and potential pathway data (distance to potential introduction pathways and distance to known established populations). Ultimately, we will produce an interactive, exploratory tool where a wetland can be selected, and a table will appear that shows the breakdown of invasion risk by species as invasion likelihood scores. If more information is desired about how the invasion likelihood score was calculated, an attribute table will display the numerical values for each criterion in the model. One of the main concerns with invasive species is how climate change will alter habitat suitability. To accommodate this concern, we will also include versions with future climate change scenarios using published IPCC environmental conditions. This information will be packaged together in an IVI for Great Lakes wetlands usable by scientists, managers, and the general public.

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

Hybridizing fish: In 2013 the NRRI field crew encountered gar around the Green Bay area of Lake Michigan which exhibited mixed morphological traits of shortnose and longnose species. At that time, John Lyons at the Wisconsin Department of Natural Resources was working on a project to confirm hybrid individuals in the Fox River watershed (which drains into Green Bay, WI). Josh Dumke at NRRI contributed photos of gar captured in Green Bay during Coastal Wetland Monitoring fish surveys to John Lyons, and those contributions were acknowledged in a recently-published article: (Lyons, J., and J.T. Sipiorski. 2020. Possible large-scale hybridization and introgression between Longnose Gar (Lepisosteous osseus) and Shortnose Gar (Lepisosteous platostomus) in the Fox River drainage, Wisconsin. *American Midland Naturalist*, 183:105-115). In 2014 and 2015 Coastal Wetland Monitoring fish teams collected gar fin clips across the entire Great Lakes basin for a much more comprehensive look at species distributions and hybridization, but sample processing and analysis of those stored samples is dependent upon securing additional funds.

Management alternatives for hybrid cattail (*Typha x glauca*) 2011- 2014: Differing harvest regimes for hybrid cattail were evaluated at Cheboygan, Cedarville, and Munuscong Bay in northern Michigan with USEPA GLRI funding. At all of these sites plant data was collected by CWM and used as baseline data that was compared to control sites. Analyses demonstrated that during low-water conditions, native plant diversity was increased by harvest of hybrid cattail.

Impacts of hybrid cattail management on European frogbit (*Hydrocharis morsus-ranae*); This study, funded by MI DNR in 2016-2017 for research by Loyola Chicago and Oregon State University studied the response of European frogbit to cattail management, using CWM plant data collected in Munuscong Bay as baseline data. CWM data collected from 2011 to 2015 provided documentation of the expanding range of frogbit into the western Great Lakes. The study found that open, flooded stands of hybrid cattail provided important habitat for European frogbit, but that management to remove cattail was not effective for frogbit control.

Nutrient limitation in Great Lakes coastal wetlands: GLCWMP water quality data indicate that reactive nitrogen concentration is often much lower in wetland habitats than the adjacent Great Lake nearshore. With funding from Illinois-Indiana Sea Grant and the Wisconsin DNR we have evaluated the role of nitrogen limitation on benthic algal growth in wetlands throughout Lakes Michigan, Huron, and Superior.

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 mapped 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 provided her with vegetation data and sampling locations each year to assist with this effort. Dr. Bourgeau-Chavez was also 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/). Wetland vegetation PIs contributed new SOLEC indicator guidelines and reports and continue to participate in the indicator review process.

Wetland Floristic Quality in the St. Louis River Estuary: With support from WI Sea Grant 2014-2017, vegetation PI N. Danz has integrated vegetation surveys from the CWM project with data from 14 other recent projects in the estuary. A new relational database was created that is being used to assess spatial and temporal patterns in floristic quality and to develop materials to inform and monitor wetland restorations in this AOC.

Coordination and Partnership with National Audubon: Per the agreement to share CWMP bird data with the National Audubon Society, we have provided data and guidance on appropriate use of these data for their project "Prioritizing coastal wetlands for marsh bird conservation in the U.S. Great Lakes". The resulting manuscript from this project is currently in review with the journal '*Biological Conservation*' and per the agreement all CWMP bird and anuran co-investigators have had the opportunity to contribute to the manuscript and be included as co-authors. We expect to maintain communications regarding any potential future use of the CWMP data by National Audubon and will continue to provide guidance on appropriate uses in future projects and analyses.

Targeting Invasive Plant Species in Wisconsin Coastal Wetlands: In collaboration with WI Department of Natural Resources and Lake Superior Research Institute, vegetation PIs have summarized patterns of invasive plant occurrence in Wisconsin coastal wetlands. These summaries are being used to develop a more comprehensive invasive plant monitoring strategy throughout the Wisconsin basin.

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, the Great Lakes National Park Service, the Nature Conservancy (sites across lakes Michigan and Huron for both groups), as well as state natural resource departments. 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; a New York state project to increase nesting habitat for state-endangered black tern; and projects in Wisconsin to restore degraded coastal wetlands on the Lake Superior shore. 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, wetlands along Wisconsin's Lake Superior shoreline, 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 Creak 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:

- Using advanced morphometrics to improve identification of Sphaeriidae (fingernail clams) of the Great lakes as informed by DNA analyses (University of Minnesota Duluth; other field crews providing specimens).
- 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 coastal wetlands of the Great Lakes: 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)
- Conservation of Common Terns in the Great Lakes Region (University of Minnesota; with additional funding from USFWS, MNDNR, and multiple smaller internal and external grants).
- Distribution of yellow perch in Great Lakes coastal wetlands (Grand Valley State University; with additional funding from GVSU).
- Variation in aquatic invertebrate assemblages in coastal wetland wet meadow zones of Lake Huron, of the Laurentian Great Lakes (University of Windsor; with additional funding from the University of Windsor).
- Influence of water level fluctuations and diel variation in dissolved oxygen concentrations on fish habitat use in Great Lakes coastal wetlands (University of Windsor; with additional funding from the University of Windsor).
- Bird community response to changes in wetland extent and lake level in Great Lakes coastal wetlands (University of Wisconsin-Green Bay with additional funding from Bird Studies Canada)
- Inferential measures for a quantitative ecological indicator of ecosystem health (University of Wisconsin-Green Bay)
- Per- and polyfluorinated alkyl substances (PFAS) in Great Lakes food webs and sportfish (University of Notre Dame)

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 loads in freshwater turtle species inhabiting coastal wetlands of Lake Michigan (University of Notre Dame; additional funding by the UND College of Science, and ECI – Environmental Change Institute). Online coverage, TV and radio.
- Nitrogen-limitation in Lake Superior coastal wetlands (Northland College; additional funding from the Wisconsin DNR and Northland College).
- Patterns in chlorophyll-*a* concentrations in Great Lakes coastal wetlands (Northland College; additional funding provided by the college).
- *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 presented at the International Association for Great Lakes Research annual meeting).
- 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; awarded Best Student Poster award at LSSU Research Symposium; presented at MI American Fisheries Society annual meeting).
- 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, (presented at MI American Fisheries Society annual meeting and Midwest Fish and Wildlife Conference).
- 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)
- Effects of wetland size and adjacent land use on taxonomic richness (University of Minnesota Duluth, with additional funding from UMD's UROP program)
- Water depth optima and tolerances for St. Louis River estuary wetland plants (University of Wisconsin-Superior, with additional funding from WI Sea Grant)
- Mapping Wetland Areal Change in the St. Louis River Estuary Using GIS (University of Wisconsin-Superior, with additional funding from WI Sea Grant)
- An analysis of Microcystin concentrations in Great Lakes coastal wetlands (Central Michigan University; additional funding by CMU College of Science and Engineering).

- Bathymetry and water levels in lagoonal wetlands of the Apostle Islands National Lakeshore (Northland College; additional funding from the National Park Service). Several presentations at regional meetings and IAGLR.
- Non-native fish use of Great Lakes coastal wetlands (Northland College funding). Poster presentations by Northland College students at Wisconsin Wetland Science Meeting and IAGLR.

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).
- Chemical and physical habitat variation within Great Lakes coastal wetlands; the importance of hydrology and dominant plant zonation (Central Michigan University)
- Macroinvertebrate-based Index of Biotic Integrity for Great Lakes coastal wetlands (Central Michigan University)
- Habitat conditions and invertebrate communities of Great Lakes coastal habitats dominated by Wet Meadow, and *Phragmites australis*: implications of macrophyte structure changes (Central Michigan University)
- The establishment of *Bithynia tentaculata* in coastal wetlands of the Great Lakes (Central Michigan University)
- Environmental covariates as predictors of anuran distribution 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 anuran 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)
- Modeling potential nutria habitat in Great Lakes coastal wetlands (Central Michigan University)
- Modeling of Eurasian ruffe (*Gymnocephalus cernua*) habitat preferences to predict future invasions (University of Minnesota Duluth in collaboration with USEPA MED)
- Modeling species-specific habitat associations of Great Lakes coastal wetland birds (University of Minnesota)
- The effect of urbanization on the stopover ecology of Neotropical migrant songbirds on the western shore of Lake Michigan (University of Minnesota Duluth).
- Nutrient limitation in Great Lakes coastal wetlands: gradients and their influence (Central Michigan University; with additional funding from the CMU College of Science and Engineering)

- Invasive *Phragmites australis* management (Central Michigan University; with additional funding from the CMU College of Science and Technology)
- The relationship between vegetation and ice formation in Great Lakes coastal wetlands (Central Michigan University; with additional funding from CMU College of Science and Engineering)
- PFAS accumulation by Dressenidae *spp* in Great Lakes Coastal Wetlands (Central Michigan University)
- Development of a vegetation based IBI for Great Lakes Coastal Wetlands (Central Michigan University)
- Development of a model for Great-Lakes wide invasive plant harvest for bioenergy production and nutrient recycling (Loyola Chicago and Oregon State University)
- Updating the Macroinvertebrate-based Index of Biotic Integrity for Great Lakes coastal wetlands (Central Michigan University)
- Great Lakes coastal wetland bird and anuran habitat associations (UW-Green Bay)

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; Published in *Ecosphere*).
- Modeling American coot habitat relative to faucet snail invasion potential (Central Michigan University).
- Nutrient uptake by *Phragmites australis* and native wetland plants (Central Michigan University).
- Comparison of the diagnostic accuracy two aquatic invertebrate field collection and laboratory sorting methods (University of Windsor, complete).
- Validation of a zoobenthic assemblage condition index for Great Lakes coastal wetlands (University of Windsor, complete).

- Water depth-related variation in net ecosystem production in a Great Lakes coastal wet meadow (University of Windsor, complete).
- Anuran habitat use in the Lower Green Bay and Fox River Area of Concern (University of Wisconsin-Green Bay with support from GLRI/AOC funding).
- Impacts of European frog-bit invasion on wetland macroinvertebrate communities (Lake Superior State University; presented at Midwest Fish and Wildlife Conference).
- Effects of European frog-bit on water quality and fish assemblages in St. Marys River coastal wetlands (Lake Superior State University; presented at Midwest Fish and Wildlife Conference).
- Functional diversity of macroinvertebrates in coastal wetlands along the St. Marys River (Lake Superior State University; awarded Best Student Poster award at LSSU Research Symposium; presented at Midwest Fish and Wildlife Conference).
- A comparison of macroinvertebrate assemblages in coastal wetlands exposed to varying wave disturbance (Lake Superior State University; presented at MI American Fisheries Society annual meeting).
- Coastal wetlands as nursery habitat for young-of-year fishes in the St. Marys River (Lake Superior State University; presented at MI American Fisheries Society annual meeting)
- Relationship between water level and fish assemblage structure in St. Marys River coastal wetlands (Lake Superior State University; presented at MI American Fisheries Society annual meeting)
- Dominance patterns in macroinvertebrate communities in Great Lakes coastal wetlands: does environmental stress lead to uneven community structure? Northland College.
- Understanding drivers of chlorophyll-a in Great Lakes coastal wetlands. University of Notre Dame
- Evaluating fish assemblage changes throughout the summer in St. Marys River coastal wetlands (Lake Superior State University)
- Quantifying litter decomposition in wetlands of varying condition (Lake Superior State University)

JOBS CREATED/RETAINED (2020)

- Principal Investigators (partial support): 22
- Post-doctoral researchers (partial support): 4
- Total graduate students supported on project (part-time): 19
- Unpaid undergraduate internship (summer): Not possible in 2020 due to Covid-19
- Undergraduate students (paid; summer and/or part-time): 21

- Technicians, jr. scientists (summer and/or partial support): 39
- Volunteers: Could not have volunteers in 2020 or 2021 due to Covid-19

Total jobs at least partially supported in 2020: 105.
Students and post-doctoral researchers trained in 2020: 44.

JOBS CREATED/RETAINED (CUMULATIVE SINCE 2011, LAST UPDATED 2020)

- Principal Investigators (partial support): 20 (average per year)
- Post-doctoral researchers (partial support; cumulative): 7
- Total graduate students supported on project (part-time; cumulative): 113
- Unpaid undergraduate internship (summer, cumulative): 35
- Undergraduate students (paid; summer and/or part-time; cumulative): 194
- Technicians, jr. scientists (summer and/or partial support; cumulative): 135
- Volunteers (cumulative): 47

Total jobs at least partially supported: 469.
Students and post-doctoral researchers trained: 349.

At our annual meetings in 2021 and 2023, we conducted a formal discussion session on Diversity, Equity, and Inclusion (DEI). In 2021, we split into 10 breakout groups to discuss three questions related to best practices for enhancing DEI in the CWMP workforce. In brief, the three questions concerned 1) current practices used to enhance DEI, 2) perceived barriers to enhancing DEI, and 3) potential mechanisms for enhancing DEI in the future. These discussion notes were compiled and organized, and then redistributed to all CWMP participants. In 2023 we focused our discussion on how to increase crew safety as field crews diversify, acknowledging that people from differing backgrounds, ethnicities, and identities may be treated differently and feel less safe. Our goal, as always, is for all field crew members to both feel and be safe. CWMP leadership will continue to monitor and encourage DEI goals for the program.

PRESENTATIONS ABOUT THE COASTAL WETLAND MONITORING PROJECT

(INCEPTION THROUGH 2023)

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.

Albert, Dennis, et al. 2015. Restoration of wetlands through the harvest of invasive plants, including hybrid cattail and *Phragmites australis*. Presented to Midwestern and Canadian biologists. June.

Albert, Dennis, et al. 2015. Great-Lakes wide distribution of bulrushes and invasive species. Coastal and Estuarine Research Federation Conference in Portland, Oregon. November.

Amatangelo, K., D. Wilcox, R. Schultz, M. Altenritter, M. Chislock, and G. Lawrence. 2021. Application of the Great Lakes Coastal Wetlands Monitoring Program to Restoration Projects in Lake Ontario Wetlands. State of Lake Ontario Conference. March 9-11, 2021, online.

Baldwin, R., B. Currell, and A. Moerke. 2014. Effects of disturbance history on resistance and resilience of coastal wetlands. Midwest Fish and Wildlife Conference, January, Kansas City, MO.

Baldwin, R., B. Currell, and A. Moerke. 2014. Effects of disturbance history on resistance and resilience of coastal wetlands. MI American Fisheries Society annual meeting, February, Holland, MI.

Bergen, E., E. Shively, M.J. Cooper. Non-native fish species richness and distributions in Great Lakes coastal wetlands. International Association for Great Lakes Research Annual Conference, June 10-14, 2019, Brockport, NY. (poster)

Bergen, E., E. Shively, M.J. Cooper. Drivers of non-native fish species richness and distribution in the Laurentian Great Lakes. February 19-21, 2019. Madison, WI. (poster)

Bozimowski, S. and D.G. Uzarski**.** 2016. The Great Lakes coastal wetland monitoring program. 2016 Wetlands Science Summit, Richfield, OH. September, Oral Presentation.

Bozimowski, A.A., B.A. Murry, and D.G. Uzarski. 2012 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.

Bozimowski, A.A., B.A. Murry, P.S. Kourtev, and D.G. Uzarski. 2015. Aquatic macroinvertebrate co-occurrence patterns in the coastal wetlands of the Great Lakes. 58th International Conference on Great Lakes Research, Burlington, VT.

Bozimowski, A.A. and D.G. Uzarski. 2017. Monitoring a changing ecosystem: Great Lakes coastal wetlands. Saginaw Bay Watershed Initiative Network's State of the Bay Conference.

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.

Brady, V.J., D.G. Uzarski, M.J. Cooper, D.A. Albert, N. Danz, J. Domke, T. Gehring, E. Giese, A. Grinde, R. Howe, A.H. Moerke, G. Niemi, H. Wellard-Kelly. 2018. How are Lake Superior's wetlands? Eight years, 100 wetlands sampled. State Of Lake Superior Conference. Houghton, MI. Oral Presentation.

Brady, V., G. Niemi, J. Dumke, H. Wellard Kelly, M. Cooper, N. Danz, R. Howe. 2019. The role of monitoring data in coastal wetland restoration: Case studies from Duluth and Green Bay. International Association of Great Lakes Research Annual Meeting, Brockport, NY, June 2019. Invited oral presentation.

Buckley, J.D., and J.J.H. Ciborowski. 2013. A comparison of fish indices of biological condition at Great Lakes coastal margins. 66th Canadian Conference for Freshwater Fisheries Research, Windsor, ON, January 3-5 2013. Poster Presentation.

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.

Cooper, M.J., D.G. Uzarski, and V.J. Brady. Developing a decision support system for restoration and protection of Great Lakes coastal wetlands. Wisconsin Wetlands Association Annual Meeting. February 24-25, 2016. Green Bay, WI.

Cooper, M.J., Stirratt, H., B. Krumwiede, and K. Kowalski. Great Lakes Resilient Lands and Waters Initiative, Deep Dive. Remote presentation to the White House Council on Environmental Quality and partner agencies, January 28, 2016.

Cooper, M., Redder, T., Brady, V. and D. Uzarski. 2016. Developing a decision support tool to guide restoration and protection of Great Lakes coastal wetlands. Annual Meeting of the Wisconsin Wetlands Association, Stevens Point, WI. February. Presentation.

Cooper, M.J.. Nutrient limitation in wetland ecosystems. Wisconsin Department of Natural Resources, February 12, 2016, Rhinelander, WI.

Cooper, M.J., D.G. Uzarski and V.J. Brady. 2016. Developing a decision support system for restoration and protection of Great Lakes coastal wetlands. Wisconsin Wetlands Association Annual Meeting, Green Bay, WI. February 24-25. Oral Presentation.

Cooper, M.J.. Monitoring biotic and abiotic conditions in Great Lakes coastal wetlands. Wisconsin DNR Annual Surface Water Quality Conference. May 2016, Tomahawk, WI.

Cooper, M.J. The Depth of Wisconsin's Water Resources. Panel Discussion, Wisconsin History Tour, Northern Great Lakes Visitors Center, June 15, 2016, Ashland, WI.

Cooper, M.J.. Great Lakes Coastal Wetlands. The White House Resilient Lands and Waters Initiative Roundtable. Washington, DC, November 17, 2016.

Cooper, M.J. Translating Science Into Action in the Great Lakes. Marvin Pertzik Lecture Series. Northland College, May 2016.

Cooper, M.C., C. Hippensteel, D.G. Uzarski, and T.M. Redder. Developing a decision support tool for Great Lakes coastal wetlands. LCC Coastal Conservation Working Group Annual Meeting, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, Oct. 6, 2016.

Cooper, M.J., T.M. Redder, C. Hippensteel, V.J. Brady, D.G. Uzarski. Developing a decision support tool to guide restoration and protection of Great Lakes coastal wetlands. Midwest Fish and Wildlife Conference, Feb. 5-8, 2017, Lincoln, NE.

Cooper, M.J., T.M. Redder, V.J. Brady, D.G. Uzarski. Developing a decision support tool to guide restoration and protection of Great Lakes coastal wetlands. Wisconsin Wetlands Association Annual Conference, February 28-March 2, 2017, Steven's Point, WI.

Cooper, M.J. Coastal Wetlands as Metabolic Gates, Sediment Filters, Swiss Army Knife Habitats, and Biogeochemical Hotspots. Science on Tap, Ashland, WI, March 21, 2017.

Cooper, M.J., Brady, V.J., Uzarski, D.G., Lamberti, G.A., Moerke, A.H., Ruetz, C.R., Wilcox, D.A., Ciborowski, J.J.H., Gathman, J.P., Grabas, G.P., and Johnson, L.B. An Expanded Fish-Based Index of Biotic Integrity for Great Lakes Coastal Wetlands. International Association for Great Lakes Research 60th Annual Meeting, Detroit, MI, May 15-19, 2017.

Cooper, M.J., D.G. Uzarski, and A. Garwood. Great Lakes Coastal Wetland Monitoring." Webinar hosted by Michigan Department of Environmental Quality, April 14, 2017. 78 attendees.

Cooper, M.J., A. Hefko, M. Wheeler. Nitrogen limitation of Lake Superior coastal wetlands. Society for Freshwater Science Annual Conference, May 20-24, 2018, Detroit, MI.

Cooper, M.J. The Role of Wetlands in Maintaining Water Quality. Briefing to the International Joint Commission, Ashland, WI, September 26, 2019.

Cooper, M.J., V.J. Brady, and D.G. Uzarski. Great Lakes Coastal Wetland Monitoring. Plenary Presentation, Great Lakes Coastal Wetland Symposium, Oregon, OH, September 19, 2019.

Cooper, M.J. and S. Johnson. Life on the Soggy Edges. Madeline Island Wilderness Preserve Lecture Series, Madeline Island Museum, La Pointe, WI, June 19, 2019.

Cooper, M.J., T.M. Redder, V.J. Brady, D.G. Uzarski. A data visualization tool to support protection and restoration of Great Lakes coastal wetlands. International Association for Great Lakes Research Annual Conference, June 10-14, 2019, Brockport, NY

Cooper, M.J., V.J. Brady, and D.G. Uzarski. 2022. Detecting Human Disturbance in Coastal Wetlands Across Temporal and Spatial Scales Using Biotic Indicators. Great Lakes Coastal Symposium. Sept. 19-21, 2022. Sault Ste. Marie, MI

Cooper, M.J., V.J. Brady, and D.G. Uzarski. 2023. Monitoring Great Lakes Coastal Wetlands. Michigan Wetlands Association Annual Meeting. Sept. 12-14, 2023. Kalamazoo, MI

Curell, Brian. 2014. Effects of disturbance frequency on macroinvertebrate communities in coastal wetlands. MI American Fisheries Society annual meeting, February, Holland, MI.

Dahlberg, N., N.P. Danz, and S. Schooler. 2015. Integrating prior vegetation surveys from the St. Louis River estuary. Poster presentation at the 2015 Annual St. Louis River Summit, Superior, WI.

Dahlberg, N., N.P. Danz, and S. Schooler. 2017. 2012 Flood Impacts on St. Louis River Plant Communities. Poster presentation at St. Louis River Summit, Superior, WI.

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.

Danz, N.P. Floristic Quality of Coastal and Inland Wetlands of the Great Lakes Region. Invited presentation at the University of Minnesota Duluth, Duluth, MN.

Danz, N.P., S. Schooler, and N. Dahlberg. 2015. Floristic quality of St. Louis River estuary wetlands. Oral presentation at the 2015 Annual St. Louis River Summit, Superior, WI.

Danz, N.P. 2016. Floristic quality of St. Louis River estuary wetlands. Invited presentation at the Center for Water and the Environment, Natural Resources Research Institute, Duluth, MN.

Danz, N.P. 2017. Connections Between Human Stress, Wetland Setting, and Vegetation in the St. Louis River Estuary. Oral presentation at the Wetland Science Conference, Stevens Point, WI.

Danz, N.P. 2017. 10 Things We Learned from Your Vegetation Data. Oral presentation at the St. Louis River Summit, Superior, WI.

Daly, D., T. Dunn, and A. Moerke. 2016. Effects of European frog-bit on water quality and fish assemblages in St. Marys River wetlands. Midwest Fish and Wildlife Conference, Grand Rapids, MI. January 24-27.

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.

Dunn, T., D. Daly, and A. Moerke. 2016. Impacts of European frog-bit invasion on Great Lakes wetlands macroinvertebrate communities. Midwest Fish and Wildlife Conference, Grand Rapids, MI. January 24-27.

Dykstra, K.M., C.R. Ruetz III, M.J. Cooper, and D.G. Uzarski. 2018. Occupancy and detection of yellow perch in Great Lakes coastal wetlands. Poster presentation at the Annual Meeting of the Society for Freshwater Science, Detroit, Michigan. May 20-24.

Dykstra (Emelander), K.M., C.R. Ruetz III, M.J. Cooper, and D.G. Uzarski. 2018. Occupancy and detection of yellow perch in Great Lakes coastal wetlands: preliminary results. Poster presentation at the annual meeting of the Michigan Chapter of the American Fisheries Society, Port Huron, Michigan. February 13-14.

Elliot, L.H., A.M. Bracey, G.J. Niemi, D.H. Johnson, T.M. Gehring, E.E. Gnass Giese, G.P. Grabas, R.W. Howe, C.J. Norment, and D.C. Tozer. Habitat Associations of Coastal Wetland Birds in the Great Lakes Basin. American Ornithological Society Meeting, East Lansing, Michigan. Poster Presentation. 31 July-5 August 2017.

Elliott, L.H., A. Bracey, G. Niemi, D.H. Johnson, T. Gehring, E. Giese, G. Grabas, R. Howe, C. Norment, and D.C. Tozer. 2018. Hierarchical modeling to identify habitat associations of secretive marsh birds in the Great Lakes. IAGLR Conference, Toronto, Canada. Oral Presentation. 18-22 June 2018.

Fraley, E.F. and D.G. Uzarski 2017. The relationship between vegetation and ice formation in Great Lakes coastal wetlands. 60th Annual Meeting of the International Association of Great Lakes Research. Detroit, MI. Poster.

Fraley, E.F. and D.G. Uzarski. 2016. The Impacts of Ice on Plant Communities in Great Lakes Coastal Wetlands. 7th Annual Meeting of the Michigan Consortium of Botanists, Grand Rapids, MI. October. Poster.

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.

Gathman, J.P., J.J.J. Ciborowski, G. Grabas, V. Brady, and K.E. Kovalenko. 2013. Great Lakes Coastal Wetland Monitoring project: progress report for Canada. 66th Canadian Conference for Freshwater Fisheries Research, Windsor, ON, January 3-5, 2013. Poster Presentation.

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.

Gil de LaMadrid, D., and N.P. Danz. 2015. Water depth optima and tolerances for St. Louis River estuary wetland plants. Poster presentation at the 2015 Annual St. Louis River Summit, Superior, WI.

Gnass Giese, E.E. 2015. Great Lakes Wetland Frog Monitoring. Annual Lower Fox River Watershed Monitoring Program Symposium at the University of Wisconsin-Green Bay, Green Bay, Wisconsin. April 14, 2015. Oral Presentation.

Gnass Giese, E.E. 2015. Wetland Birds and Amphibians: Great Lakes Monitoring. Northeastern Wisconsin Audubon Society meeting at the Bay Beach Wildlife Sanctuary, Green Bay, Wisconsin. February 19, 2015. Oral Presentation.

Gnass Giese, E.E., R.W. Howe, N.G. Walton, G.J. Niemi, D.C. Tozer, W.B. Gaul, A. Bracey, J. Shrovnal, C.J. Norment, and T.M. Gehring. 2016. Assessing wetland health using breeding birds as indicators. Wisconsin Wetlands Association Conference, Radisson Hotel & Convention Center, Green Bay, Wisconsin. February 24, 2016. Poster Presentation.

Gnass Giese, E., R. Howe, A. Wolf, and G. Niemi. 2017. Breeding Birds and Anurans of Dynamic Green Bay Coastal Wetlands. State of Lake Michigan Conference, Green Bay, Wisconsin. Oral Presentation. 8 November 2017.Gnass Giese, E.E., R.W. Howe, A.T. Wolf, N.A. Miller, and N.G. Walton. An ecological index of forest health based on breeding birds. 2013. Webpage: http://www.uwgb.edu/biodiversity/forest-index/

Gnass Giese, E.E., R.W. Howe, A.T. Wolf, N.A. Miller, and N.G. Walton. 2014. Using Bird Data to Assess Condition of Western Great Lakes Forests. Midwest Bird Conservation and Monitoring Workshop, Port Washington, Wisconsin. Poster Presentation. 4-8 August 2014.Gnass Giese, E.E. 2013. Monitoring forest condition using breeding birds in the western Great Lakes region, USA. Editors: N. Miller, R. Howe, C. Hall, and D. Ewert. Internal Report. Madison, WI and Lansing, MI: The Nature Conservancy. 44 pp.

Gunsch, D., J.P. Gathman, and J.J.H. Ciborowski . 2018. Variation in dissolved-oxygen profiles along a depth gradient in Lake Huron coastal wet meadows relative to vegetation density and agricultural stress over 24 hours. IAGLR Conference, Toronto, Canada. Poster Presentation. 18-22 June 2018.

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.

Harrison, A.M., M.J. Cooper, and D.G. Uzarski. 2019. Spatial and temporal (2011-2018) variation of water quality in Great Lakes coastal wetlands. International Association for Great Lakes Research. Brockport, NY. Presentation.

Hefko, A.G., M. Wheeler, M.J. Cooper. Nitrogen limitation of algal biofilms in Lake Superior coastal wetlands. International Association for Great Lakes Research Annual Conference, June 10-14, 2019, Brockport, NY. (poster)

Hein, M.C. and Cooper, M.J. Untangling drivers of chlorophyll a in Great Lakes coastal wetlands. International Association for Great Lakes Research 60th Annual Meeting, Detroit, MI, May 15-19, 2017.

Hirsch, B. E.E. Gnass Giese, and R. Howe. 2021. Anuran Occurrences in High and Low Water within the Lower Green Bay & Fox River AOC. Wisconsin Wetlands Association Conference, Virtual. Poster Presentation. February 2021.

Hohman, T., B. Howe, E. Giese, A. Wolf, and D. Tozer. 2019. Bird Community Response to Changes in Wetland Extent and Interspersion in Great Lakes Coastal Wetlands. Heckrodt Birding Club Meeting, Menasha, Wisconsin. Oral Presentation. 6 August 2019.

Hohman, T.R., R.W. Howe, A.T. Wolf, E.E.Gnass Giese, D.C. Tozer, T.M. Gehring, G.P. Grabas, G.J. Niemi, and C.J. Norment. 2019. Bird Community Response to Changes in Wetland Extent and Interspersion in Great Lakes Coastal Wetlands. Presented at the 62nd Annual Meeting of the International Association of Great Lakes Research (IAGLR), 12 June 2019, Brockport, NY.

Houghton, C.J., C.C. Moratz, P.S. Forsythe, G.A. Lamberti, D.G. Uzarski, and M.B. Berg. 2016. Relative use of wetland and nearshore habitats by sportfishes of Green Bay. 59th International Conference on Great Lakes Research, Guelph, Ontario Canada. May. Oral Presentation.

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.

Howe, B., E. Giese, A. Wolf, and B. Kupsky. 2019. Restoration Targets for Great Lakes Coastal Wetlands in the Lower Green Bay & Fox River AOC. International Association for Great Lakes Research, Brockport, New York. Oral Presentation. 12 June 2019.

Howe, R.W., G.J. Niemi, N.G. Walton, E.E.G. Giese, A.M. Bracey, 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, and E.D. Reavie. 2014. Measurable Responses of Great Lakes Coastal Wetland Biota to Environmental Stressors. International Association for Great Lakes Research Annual Conference, Hamilton, Ontario (Canada). May 26-30, 2014. Oral Presentation.

Howe, B., A. Wolf, E. Giese, V. Pappas, B. Kupsky, M. Grimm, and N. Van Helden. 2018. Lower Green Bay & Fox River Area of Concern Wildlife and Habitat Assessment Tools. AOC RAP Meeting, Green Bay, Wisconsin. Oral Presentation. 25 April 2018.

Howe, B., A. Wolf, E. Giese, V. Pappas, B. Kupsky, M. Grimm, and N. Van Helden. 2018. Assessing the Fish and Wildlife Habitat BUI for the Lower Green Bay and Fox River Area of Concern. Annual Great Lakes Areas of Concern Conference, Sheboygan, Wisconsin. Oral Presentation. 16 May 2018.

Howe, R.W., A.T. Wolf, and E.E. Gnass Giese. 2016. What's so special about Green Bay wetlands? Wisconsin Wetlands Association Conference, Radisson Hotel & Convention Center, Green Bay, Wisconsin. February 23-25, 2016. Oral Presentation.

Howe, R.W., N.G. Walton, E.G. Giese, G.J. Niemi, and A.M. Bracey. 2013. Avian responses to landscape stressors in Great Lakes coastal wetlands. Society of Wetland Scientists, Duluth, Minnesota. June 2-6, 2013. Poster Presentation.

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

Howe, R.W., A.T. Wolf, J. Noordyk, and J. Stoll. 2017. Benefits and outcomes of Green Bay restoration: ecosystem and economic perspectives. Presented at the Summit on the Ecological and Socio-Economic Tradeoffs of Restoration in the Green Bay, Lake Michigan, Ecosystem (July 18-20, 2017).

Howe, R.W., A.T. Wolf, and E.E. Giese. 2016. Proposed AOC de-listing process. Presentation to Lower Green Bay and Fox River AOC stakeholders. 16 December 2016.

Howe, R.W., A.T. Wolf, and E.E. Giese. 2017. Lower Green Bay & Fox River Area of Concern: A Plan for Delisting Fish and Wildlife Habitat & Populations Beneficial Use Impairments. A paper presented to AOC Technical Advisory Group. 3 August 2017.

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.

Johnson, Z., M. Markel, and A. Moerke. 2019. Functional diversity of macroinvertebrates in coastal wetlands along the St. Marys River. Midwest Fish and Wildlife Conference, Cleveland, OH.

Kneisel, A.N., M.J. Cooper, and D.G. Uzarski. 2016. The impact of Phragmites australis invasion on macroinvertebrate communities in the coastal wetlands of Thunder Bay, MI. Institute for Great Lakes Research, 4th Annual Student Research Symposium, Central Michigan University, Mt. Pleasant, MI. February. Oral Presentation.

Kneisel, A.N., M.J. Cooper, and D.G. Uzarski. 2016. Impact of *Phragmites* invasion on macroinvertebrate communities in wetlands of Thunder Bay, MI. 59th International Conference on Great Lakes Research, Guelph, Ontario Canada. May. Oral Presentation.

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.

Kneisel, A.N., M.J. Cooper, and D.G. Uzarski. 2017. The impact of Phragmites australis invasion on Great Lakes coastal wetlands. 60th International Conference on Great Lakes Research, Detroit, MI. May. Presentation.

Kneisel, A.K., M.J. Cooper, D.G. Uzarski. 2018. Coastal wetland monitoring data as a resource for invasive species management. ELLS-IAGLR Big Lakes Small World Conference. Évian, France. September. Poster.Kosiara, J.K., J.J. Student, and D.G. Uzarski. 2017. Exploring coastal habitat-use patterns of Great Lakes yellow perch with otolith microchemistry. 60th International Conference on Great Lakes Research, Detroit, MI. May. Presentation.

Kosiara, J.M., J. Student and D.G. Uzarski. 2016. Assessment of yellow perch movement between coastal wetland and nearshore waters of the Great Lakes. 59th International Conference on Great Lakes Research, Guelph, Ontario Canada. May. Oral Presentation.

Kowalke, C.J. and D.G. Uzarski. 2019. Assessing the competitive impacts of invasive round goby on lake whitefish in northern Lake Michigan. International Association for Great Lakes Research. Brockport, NY. Poster.

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. The Global Freshwater Crisis. Newman University and Notre Dame Alumni Club of Wichita. September 28, 2016.

Lamberti, G.A. The Global Freshwater Crisis. Air and Wastewater Management Association and Notre Dame Alumni Club of Northeastern New York. December 2, 2016.

Lamberti, G.A. The Global Freshwater Crisis: Lessons for the Amazon. Association of University Alumni Clubs. Iquitos, Peru. September 9, 2019.

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.

Lamberti, G.A., M.A. Brueseke, W.M. Conard, K.E. O'Reilly, D.G. Uzarski, V.J. Brady, M.J. Cooper, T.M. Redder, L.B. Johnson, J.H. Ciborowski, G.P. Grabas, D.A. Wilcox, R.W. Howe, D.C. Tozer, and T.K. O'Donnell. Great Lakes Coastal Wetland Monitoring Program: Vital resources for scientists, agencies and the public. Society for Freshwater Science Annual Metting. Raleigh, NC. June4-9, 2017. Poster.

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.

MacDonald, J.L., L.S. Schoen, J.J. Student, and D.G. Uzarski. 2016. Variation in yellow perch (*Perca flavescens*) growth rate in the Great Lakes. 59th International Conference on Great Lakes Research, Guelph, Ontario Canada. May. Oral Presentation.

Makish, C.S., K.E. Kovalenko, J.P. Gathman, and J.J.H. Ciborowski. 2013. invasive phragmites effects on coastal wetland fish communities of the Great Lakes basin. 66th Canadian Conference for Freshwater Fisheries Research, Windsor, ON, January 3-5, 2013. Poster Presentation.

Markel, M., Z. Johnson, and A. Moerke. 2019. A comparison of macroinvertebrate assemblages in coastal wetlands exposed to varying wave disturbance. March 13-15, Gaylord, MI.

McReynolds, A.T., K.E. O'Reilly, and G.A. Lamberti. 2016. Food web structure of a recently restored Indiana wetland. University of Notre Dame College of Science Joint Annual Meeting, Notre Dame, IN.

Miranda, D.A., Zachritz, A.M., Whitehead, H.D., Peaslee, G.F., Cressman, S. R., Lamberti, G.A. PFAS Permeates Native and Introduced Salmonids from Lake Michigan, USA. Joint Aquatic Sciences Meeting, Grand Rapids, MI. May 2022.

Miranda, D.A., Zachritz, A.M., Whitehead, H.D., Peaslee, G.F., Cressman, S. R., Lamberti, G.A., A Survey of Sportfish for Per-and Polyfluoroalkyl Substances (PFAS): An Emerging Contaminant in the Great Lakes. Portage, IN, October 2022

Miranda, D.A., Zachritz, A.M., Whitehead, H.D., Peaslee, G.F., Cressman, S. R., Lamberti, G.A. "PFAS in Prey and Predator Fish from Lake Michigan", USA. SETAC North America 43 rd. Annual Meeting. November 2022.

Miranda, D.A., Zachritz, A.M., Whitehead, H.D., Cressman, S., Klepinger, S., Peaslee, G.F. Lamberti, G.A. "Biomagnification of PFAS in Lake Michigan food web". Colleges of Science and Engineering Joint Annual Meeting, Notre Dame IN. December 9, 2022.

Miranda, D.A., PFAS in Lake Michigan Fish, Annual Great Lakes Conference, Institute of Water Research– Michigan State University MI. March 7, 2023.

Moerke, A. 2015. Coastal wetland monitoring in the Great Lakes. Sault Naturalist meeting, Sault Sainte Marie, MI; approximately 40 community members present.

Monks, A., S. Lishawa, D. Albert, B. Mudrzynski, D.A. Wilcox, and K. Wellons. 2019. Innovative management of European frogbit and invasive cattail. International

Association for Great Lakes Research. Brockport, NY

Moore, L.M., M.J. Cooper, and D.G. Uzarski. 2017. Nutrient limitation in Great Lakes coastal wetlands: gradients and their influence. 60th International Conference on Great Lakes Research, Detroit, MI. May 17. Presentation.

Mudrzynski, B.M., N.P. Danz, D.A. Wilcox, D.A. Albert, D. Rokitnicki-Wojcik, and J. Gathman. 2016. Great Lakes wetland plant Index of Biotic Integrity (IBI) development: balancing broad applicability and accuracy. Society of Wetland Scientists, Corpus Christi, TX.

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.

Newman, W.L., L.P. Moore, M.J. Cooper, D.G. Uzarski, and S.N. Francoeur. 2019. Nitrogen-Fixing Diatoms as Indicators of Historical Nitrogen Limitation in Laurentian Great Lakes Coastal Wetlands. Society for Freshwater Science. Salt Lake City, UT. Presentation.

O'Donnell, T.K., Winter, C., Uzarski, D.G., Brady, V.J., and Cooper, M.J. 2017. Great Lakes coastal wetland monitoring: moving from assessment to action. Ecological Society of America Annual Conference. Portland, OR. August 6-11. Presentation.

O'Donnell, T.K., D.G. Uzarski, V.J. Brady, and M.J. Cooper. 2016. Great Lakes Coastal Wetland Monitoring: Moving from Assessment to Action. 10th National Monitoring Conference; Working Together for Clean Water, Tampa, Florida. May. Oral Presentation.

O'Reilly, K.E., A. McReynolds, and G.A. Lamberti. Quantifying Lake Michigan coastal wetland-nearshore linkages for sustaining sport fishes using stable isotope mixing models. Annual Meeting of the Ecological Society of America. Baltimore, MD. August 9-14, 2015.

O'Reilly, K.E., A. McReynolds, C. Stricker, and G.A. Lamberti. Quantifying Lake Michigan coastal wetland-nearshore linkages for sustaining sport fishes. State of Lake Michigan Conference. Traverse City, MI. October 28-30, 2015.

O'Reilly, K.E., A. McReynolds, C. Stricker, and G.A. Lamberti. 2016. Quantifying Lake Michigan coastal wetland-nearshore linkages for sustaining sport fishes. Society for Freshwater Science, Sacramento, CA.

O'Reilly, K.E., A. McReynolds, C. Stricker, and G.A. Lamberti. 2016. Quantifying Lake Michigan coastal wetland-nearshore linkages for sustaining sport fishes. International Association for Great Lakes Research, Guelph, ON.

O'Reilly, K.E., J.J. Student, B.S. Gerig, and G.A. Lamberti. 2019. Metalheads: What can sport fish otoliths reveal about heavy metal exposure over time? Annual Meeting of the Society for Freshwater Science, Salt Lake City, UT.

Otto, M., J. Marty, E.G. Gnass Giese, R. Howe, and A. Wolf. Anuran habitat use in the Lower Green Bay and Fox River Area of Concern (Wisconsin). University of Wisconsin-Green Bay Academic Excellence Symposium, Green Bay, Wisconsin. April 6, 2017. Poster Presentation.

Otto, M., J. Marty, E.G. Gnass Giese, R. Howe, and A. Wolf. Anuran habitat use in the Lower Green Bay and Fox River Area of Concern (Wisconsin). Green Bay Conservation Partners Spring Roundtable Meeting, Green Bay, Wisconsin. April 25, 2017. Poster Presentation.

Redder, T.M., D.G. Uzarski, V.J. Brady, M.J. Cooper, and T.K. O'Donnell. 2018. Application of data management and decision support tools to support coastal wetland management in the Laurentian Great Lakes. National Conference on Ecosystem Restoration. New Orleans, LA. August 26-30, 2018. Oral Presentation.

Reisinger, L. S., Pangle, K. L., Cooper, M. J., Learman, D. R., Uzarski, D. G., Woolnough, D. A., Bugaj, M. R., Burck, E. K., Dollard, R. E., Goetz, A., Goss, M., Gu, S., Karl, K., Rose, V. A., Scheunemann, A. E., Webster, R., Weldon, C. R., and J., Yan. 2017. The influence of water currents on community and ecosystem dynamics in coastal Lake Michigan. 60th International Conference on Great Lakes Research, Detroit, MI. May. Presentation.

Reisinger, A. J., and D. G., Uzarski. 2017. Natural and anthropogenic disturbances affect water quality of Great Lakes coastal wetlands. 60th International Conference on Great Lakes Research, Detroit, MI. May. Presentation.

St.Pierre, J.I., K.E. Kovalenko, A.K. Pollock, and J.J.H. Ciborowski.2013. Is macroinvertebrate richness and community composition determined by habitat complexity or variation in complexity? 66th Canadian Conference for Freshwater Fisheries Research, Windsor, ON, January 3-5, 2013. Poster Presentation.

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

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

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

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

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

Schock, N.T., Schuberg, D.H., and Uzarski, D.G. 2015. Chemical and physical habitat gradients within Great Lakes coastal wetlands. 58th International Association for Great Lakes Research Conference, Burlington, VT. May.

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

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

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

Sierszen, M., Schoen, L., Hoffman, J., Kosiara, J., and D. Uzarski. 2017. Support of coastal fishes by nearshore and coastal wetland habitats. 60th International Conference on Great Lakes Research, Detroit, MI. May. Presentation.

Sierzen, M., L. Schoen, J. Hoffman, J. Kosiara and D. Uzarski. 2018. Tracing multi-habitat support of coastal fishes. Association for the Sciences of Limnology and Oceanography-Ocean Sciences Meeting. Portland, OR. February 2018. Oral Presentation.

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

Stirratt, H., M.J. Cooper. Landscape Conservation Design for the Great Lakes. International Union for the Conservation of Nature World Conservation Congress, September 6-10, 2016, Honolulu, Hawai'i.

Thoennes, J., and N.P. Danz. 2017. Mapping Wetland Areal Change in the St. Louis River Estuary Using GIS. Poster presentation at the St. Louis River Summit, Superior, WI.

Tozer, D.C., and S.A. Mackenzie. Control of invasive *Phragmites* increases breeding marsh birds but not frogs. Long Point World Biosphere Research and Conservation Conference, Simcoe, Ontario, Canada. Oral Presentation. 8 November 2019.

Tozer, D.C., M. Falconer, A. Bracey, E. Giese, T. Gehring, G. Grabas, R. Howe, G. Niemi, and C. Norment. 2018. Detecting and monitoring elusive marsh breeding birds in the Great Lakes. IAGLR Conference, Toronto, Canada. Oral Presentation. 18-22 June 2018. (INVITED).

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

Tuttle, E., T.N. Brown, D.A. Albert, and *T.J. Lemein. 2013. Comparison of two plant indices: Floristic Quality Index (FQI) and an index based on non-native and invasive species. Annual Society of Wetland Scientists Conference, Duluth, MN. June 4, 2013.

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

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

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

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

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

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

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

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

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

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

Uzarski, D.G., Schock, N.T., Schuberg, D.H., Clement, T.A., and Cooper, M.J. 2015. Interpreting multiple organism-based IBIs and disturbance gradients: Basin wide monitoring. 58th International Conference on Great Lakes Research, Burlington, VT. May.

Uzarski, D.G., N. Schock, T.M. Gehring, and B.A. Wheelock. 2016. Faucet snail (*Bithynia tentaculata*) occurrence across the Great lakes basin in coastal wetlands. 59th International Conference on Great Lakes Research, Guelph, Ontario Canada. May. Oral Presentation.

Uzarski, D.G., V.J. Brady, M.J. Cooper, D.A. Wilcox, A.A. Bozimowski. 2017. Leveraging landscape level monitoring and assessment program for developing resilient shorelines throughout the Laurentian Great Lakes. Society of Wetland Scientists Annual Meeting. San Juan, Puerto Rico. June. Presentation.

Uzarski, D.G., V.J. Brady, and M.J. Cooper. 2017. The Great Lakes Coastal Wetland Monitoring Program: Seven Years of Implementation. 60th International Conference on Great Lakes Research, Detroit, MI. May. Presentation.

Uzarski, D.G. 2017. Emerging Issues in Wetland Science. Michigan Wetland Association Conference. Gaylord, Michigan. Plenary Presentation.

Uzarski, D.G. 2018. Monitoring multiple biological attributes in Great Lakes coastal wetlands: database access for invasive species management. Association of State Wetlands Managers. Webinar Presentation.

Uzarski, D.G. Global Significance & Major Threats to the Great Lakes. 2018. Frey Foundation Strategic Learning Session. The Great Lakes: Global Significance, Major Threats & Innovative Solutions. Petoskey, MI.

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APPENDIX

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

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

26. http://www.greenfieldreporter.com/view/story/4cde108b10b84af7b9d0cfcba603cf7a/MI--Invasive-Snails
27. http://www.natureworldnews.com/articles/11259/20141217/invasive-snails-killing-great-lake-birds.htm
28. http://www.wsbt.com/news/local/snail-harmful-to-ducks-spreading-in-great-lakes/30251286
29. http://www.wtkg.com/articles/wood-news-125494/invasive-and-deadly-snail-found-in-13073963
30. http://www.techtimes.com/articles/22378/20141218/invasive-snail-problem-in-great-lakes-difficult-to-deal-with-says-experts.htm
31. http://perfscience.com/content/214858-invasive-snails-kill-birds-great-lakes
32. http://www.hollandsentinel.com/article/20141216/NEWS/141219279
33. http://www.woodradio.com/articles/wood-news-125494/invasive-and-deadly-snail-found-in-13073963
34. http://www.full-timewhistle.com/science-27/great-lake-invasive-snails-kill-birds-265.html
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36. http://americanlivewire.com/2014-12-17-invasive-snail-species-attack-birds-great-lakes/
37. http://www.seattlepi.com/news/science/article/Snail-harmful-to-ducks-spreading-in-Great-Lakes-5959538.php
38. http://www.pendletontimespost.com/view/story/4cde108b10b84af7b9d0cfcba603cf7a/MI--Invasive-Snails/
39. http://www.wilx.com/home/headlines/Invasive-Snail-Spreading-in-Great-Lakes-285933261.html
40. http://www.watertowndailytimes.com/article/20150119/NEWS03/150118434
41. http://howardmeyerson.com/2015/01/15/scientists-invasive-snail-more-prevalent-than-thought-poses-grave-danger-to-waterfowl/

Mock-up of press release produced by collaborating universities.

FOR IMMEDIATE RELEASE: December 9, 2014

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

USEPA-sponsored project greatly expands known locations of invasive snail

DULUTH, Minn. – Several federal agencies carefully track the spread of non-native species. This week scientists funded by the Great Lakes Restoration Initiative in partnership with USEPA's Great Lakes National Program Office greatly added to the list of known locations of faucet snails (*Bithynia tentaculata*) in the Great Lakes. The new locations show that the snails have invaded many more areas along the Great Lakes coastline than anyone realized.

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

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

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

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

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

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

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

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

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