Coastal Wetland Monitoring Survey Report: Clough Island

By Josh Dumke, Valerie Brady, Nicholas Danz, Annie Bracey, and Gerald Niemi

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University of Minnesota Duluth

Driven to Discover

Introduction

Fish, aquatic macroinvertebrates, aquatic vegetation, birds, amphibians and water quality were sampled at three sites around Clough Island during summer field seasons of 2011 through 2013 as part of the Great Lakes Coastal Wetland Monitoring project funded by the Great Lakes Restoration Initiative via USEPA's Great Lakes National Program Office. One site (1102) was sampled in 2012, only a month after the great 2012 flood, and two more (1201 and 1089) were sampled in 2013 (Figure 1). Fish, macroinvertebrates, aquatic vegetation, birds, amphibians and water quality parameters were sampled at all three sites.

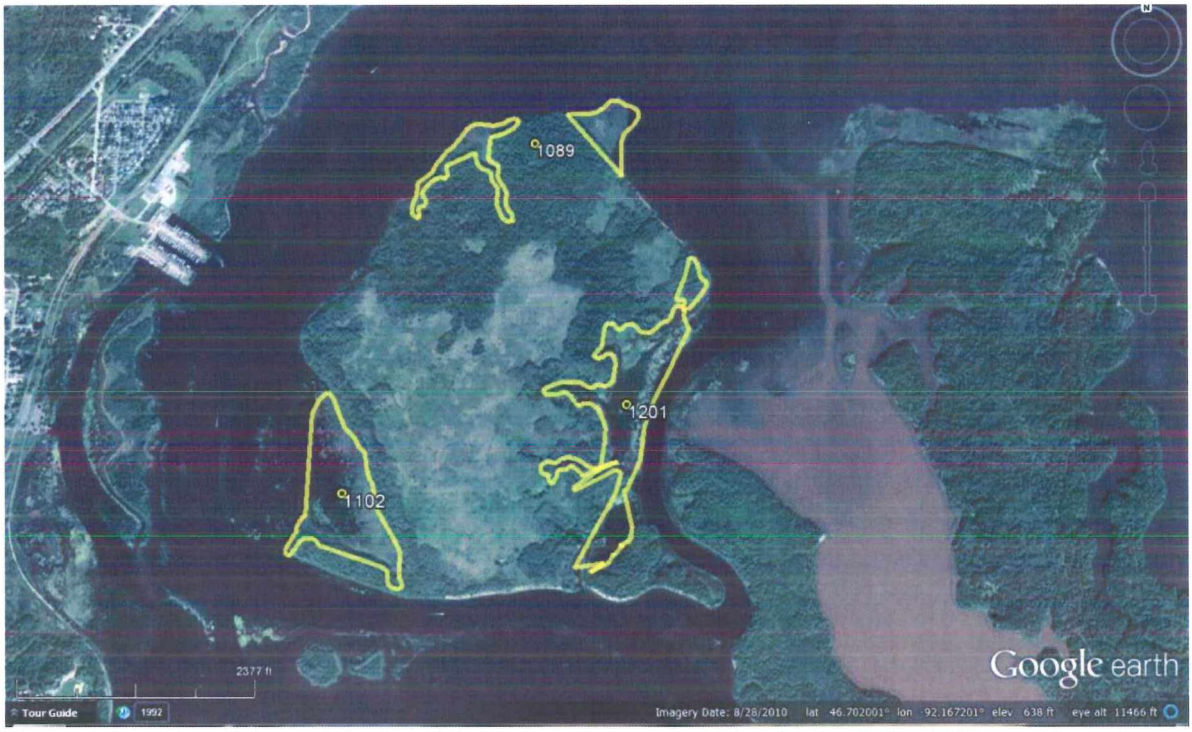


Figure 1. Location of Coastal Wetland Monitoring sites around Clough Island. Site 1089 combines the northern two polygons.

Site 1089 is comprised of the two northern polygons in the aerial photo (Figure 1). These two polygons total about 6 hectares, but wetland sizes vary year by year due to water level fluctuations and levels of turbidity in the estuary, not to mention flood events. The western polygon is located at -92.18901, 46.70984, while the eastern one is located at -92.18332, 46.71033. Site 1102, on the southwest side of the island, is about 10 hectares. The center of this wetland area is located at -92.19446, 46.69888. The year we sampled the site (2012), the cattail was growing on a floating bog mat, making walking conditions treacherous. Site 1201 covers most of the eastern shore of the island and its sampling polygon encompasses about 14 hectares. The centroid of this wetland (used by crews to navigate to the area and ensure they were in the right location) is -92.18247, 46.70145.

Clough Island Coastal Wetland Monitoring Survey of Aquatic Macroinvertebrates, Fish, and Water Quality

Josh Dumke and Valerie Brady

Introduction

The St. Louis River Estuary is now generally recognized as one of the most invaded areas in the upper Great Lakes by non-native species, particularly fish and macroinvertebrates. However, there remain some very nice wetland areas, particularly at the upstream end of the estuary and in the back bays. Clough Island occupies a geographically central location in the estuary, and is just off of the main channel rather than in a protected back bay. The island proper was historically farmed, but little other development has occurred. Because it is inaccessible except by boat, the shorelines have received much less disturbance in recent years than other estuary shorelines that are more accessible. Because of all of these factors, we were curious about how the Clough Island wetlands would compare to more remote, more protected versus less remote and less protected wetlands in the estuary.

Methods

Full details of our sampling methods can be found in Uzarski *et al.* 2014. Those methods are summarized here. Wetlands were surveyed within the polygon boundary of each site for dominant vegetation morphotypes (e.g. lily, cattail, submerged aquatic vegetation, etc.). Dominance was determined as any given morphotype contributing >75% coverage in a mixed stand. A "zone" constitutes at least 400 m^2 of dominant morphotype present contiguously or in up to 3 patches. Up to three of the most dominant vegetation morphotypes were sampled at each site. Dominant vegetation morphotypes at the sites were: site 1089 - cattail and submerged aquatic vegetation (SAV); site 1102 - lily and sparse bulrush morphotypes; and site 1201 – cattail. All sampled areas were in water depths less than 1 m.

Three fyke nets (replicates) were set overnight in each vegetation morphotype at each site. Large (1 m) or small (0.5 m) frame nets were set based on the water depth, with a minimum fishable water depth of 0.2 m. Fish were identified, enumerated, and 25 individuals were measured for total length (mm) from representative age classes of "YOY" (young-of-year) and "Other" (any fish older than age 1).

Three replicate d-frame dip net (d-net) macroinvertebrate samples were collected from each zone where water depths were at least 0.05 m deep. If the zone was also fished, the macroinvertebrate replicate locations were near fyke nets. D-nets were bounced off the bottom substrates and swept through vegetation; each sweep covered about a 1 m distance. D-net mesh size was 0.5 mm. Multiple D-net samples were combined for each replicate. Up to 150 macroinvertebrates per replicate were live-picked in the field and preserved in 95% EtOH. Preserved macroinvertebrates were identified in the NRRI microscopy lab using standard keys (see list in Uzarski *et al.* 2014).

Water chemistry and quality parameters were collected just prior to fish and macroinvertebrate sampling. Water quality meter readings of temperature (°C), dissolved oxygen (% and mg/L), pH, and specific conductivity (µS/cm) were recorded in the field at each fish net location (or the general area where macroinvertebrate sweeps were made if no fyke nets were set in that area). Grab samples were also collected from each replicate location and mixed to create a zone composite. The water composite was subsampled and sent to the NRRI analytical lab for values of chlorophyll a (µg/L), phaeophytin (µg/L), total phosphorus (mg/L), soluble reactive phosphorus (mg/L), total nitrogen (mg/L), ammonia (mg/L), nitrate/nitrite-N (mg/L), color (color units), turbidity (NTU), and chloride (mg/L).

Data analysis

We made three separate but similar comparisons. The first comparison involved all the parameters measured during the Coastal Wetland Monitoring project from the three sites immediately around Clough Island (Figure 1). The second set of analyses broadened the area of comparison to include other sites within the St. Louis River Estuary (SLRE) (Figure 2), which puts the condition of Clough Island wetlands in context with nearby wetlands. The final set of analyses broadened the area of comparison again to include sites sampled in the nearby Lake Superior area East from Duluth to Ashland, WI.

Most of the data are presented as means with standard errors, and where appropriate we also provide the sample size for each comparison. Unless reported otherwise, all fish percent compositions include only age 1+ individuals, as the catch can be too variable between replicates when young-of-year are included. Fish percent contributions were determined at the site level for each sample event (totals summed and divided by number of nets used). Significant differences are results from Student's T-tests, alpha 0.05, though not all comparisons were tested for significance due to low sample numbers.

Findings from three sites surrounding Clough Island

Fish

The three sites around Clough Island had similar fish species dominating the community. Rock bass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), and golden shiner (*Notemigonus crysoleucas*) were all well represented among the three sites (Table 1). Interestingly, spottail shiner (*Notropis hudsonius*) was only found at site 1089, where it comprised nearly 18% of the total catch. Spottails are a schooling minnow species so it is likely a school happened to swim into one net. Mean taxa richness collected in net replicates was very similar among the three sites at 10.8 (1.9 SE) in 1089, 9.8 (1.4) at 1102, and 10.7 (1.8) at 1201.

Total taxa observed at sites differed around Clough Island. We identified 17 total taxa (of age 1+ fish) from site 1089, 14 at 1102, but only 9 at site 1201 (Table 1). The number of taxa found is largely correlated with the abundance of fish captured, which in turn is correlated with the amount of sample effort. Sites 1089 and 1102 were surveyed with 5 (one net did not fish) and 6 nets, respectively, while site 1201 only received 3 nets (Table 1). Therefore, direct comparison of numbers of fish taxa encountered at these three sites is not appropriate because they received unequal sampling effort.

Table 1. Taxa percent contribution to total catch by site around Clough Island. Only fish identified as age 1+ (older than YOY) are presented here. Sample sizes (# of nets) were: 1089=5, 1102=6, 1201=3.

Taxa	1089	1102	1201
Northern Rock Bass - *Ambloplites rupestris*	23.2%	8.0%	14.3%
Spottail Shiner - *Notropis hudsonius*	17.9%	0.0%	0.0%
Bluegill Sunfish - *Lepomis macrochirus*	10.5%	7.2%	20.4%
Pumpkinseed Sunfish - *Lepomis gibbosus*	7.4%	43.5%	24.5%
Golden Shiner - *Notemigonus crysoleucas*	6.3%	13.8%	6.1%
Tadpole Madtom - *Noturus gyrinus*	5.3%	0.0%	2.0%
Tubenose Goby - *Proterorhinus marmoratus*	5.3%	0.7%	0.0%
Troutperch - *Percopsis omiscomaycus*	4.2%	0.0%	0.0%
Yellow Perch - *Perca flavescens*	4.2%	2.9%	18.4%
Black Crappie - *Pomoxis nigromaculatus*	3.2%	13.0%	6.1%
Northern Pike - *Esox lucius*	3.2%	0.7%	0.0%
Shorthead Redhorse - *Moxostoma macrolepidotum*	3.2%	1.4%	0.0%
Silver Redhorse - *Moxostoma anisurum*	2.1%	0.7%	0.0%
Emerald Shiner - *Notropis atherinoides*	1.1%	0.0%	0.0%
Logperch - *Percina caprodes*	1.1%	0.0%	0.0%
Walleye - *Sander vitreus*	1.1%	0.0%	0.0%
White Sucker - *Catostomus commersonii*	1.1%	2.2%	2.0%
Johnny Darter - *Etheostoma nigrum*	0.0%	2.9%	0.0%
Largemouth Bass - *Micropterus salmoides*	0.0%	1.4%	6.1%
Smallmouth Bass - *Micropterus dolomieu*	0.0%	1.4%	0.0%

Macroinvertebrates

Slightly more macroinvertebrate taxonomic groups were collected per sample, on average, from sites 1102 and 1201 than 1089 (22 vs. 17 taxa per sample) (Table 2). On a whole-site basis, site 1102 had the greatest total macroinvertebrate taxa richness, with sites 1201 and 1089 quite a bit lower (Table 2, Appendix 1). Ephemeroptera, Trichoptera, and Odonata (mayflies, caddisflies, and dragonflies/damselflies or ETO) are among the more sensitive aquatic insects present in wetland habitats. Per sample, an average of 3-5 different ETO taxa were found in Clough Island sites, which made up about 15-20% of the sampled macroinvertebrate community (Table 2). The percent abundance of ETO is the number of ETO individuals in proportion to the total number of other macroinvertebrates collected. Percent ETO abundance was highest at 1089 (≈16%) and lowest at 1201 (≈5%). At the site level, site 1102 had many more ETO taxa overall than did the other two sites. Site 1102 had a diversity of habitats, including a floating bog mat, which may have contributed to its macroinvertebrate assemblage diversity. Interestingly, this wetland had this high diversity only a month after the 2012 flood.

Only a single invasive macroinvertebrate taxon was detected at the Clough Island sites. At each site we found *Bithynia*, the faucet snail, which is a relatively recent invader. Relatively few *Bithynia* were

collected by our methods at site 1102, but they were 4 to 7% of invertebrate assemblages at the other two Clough Island sites (Table 2). Finally, each of the three sites contained at least one invertebrate taxon that may be of special interest (Appendix 1). Sites 1089 and 1201 contained *Hexagenia*, the large burrowing mayfly. Sites 1102 and 1201 contained larval *Anax*, one of the largest of the dragonflies. Site 1201 also contained *Ranatra*, the water scorpion, which is a very interesting macroinvertebrate and not commonly encountered.

Table 2. Macroinvertebrate metrics for samples or sites for the three CWM sites around Clough Island. ETO = Ephemeroptera, Trichoptera, and Odonata . Standard error of means is in parenthesis: mean (SE). Site-level information combines all samples, so it is not a mean nor is there a measure of variability.

Site	1089	1102	1201
Sample size (n)	6	9	6
Invert Taxa Richness	17.2 (1.9)	21.6 (1.9)	22.5 (2.0)
Site-level Taxa Richness	46	69	51
ETO Taxa Richness	3.3 (1.3)	4.9 (0.9)	3.2 (0.5)
Site-level ETO Richness	9	17	10
Percent ETO Taxa Richness	18.2 (7.1)	22.4 (2.8)	14.3 (2.8)
Percent ETO Abundance	16.2 (7.5)	12.1 (2.9)	4.8 (1.6)
Percent Invasive Abundance	4%	1%	7%

Water quality

The three sites surrounding Clough Island differed little in water quality parameters measured *in situ* (Table 3). The mean temperature at site 1102 was 3.5-4.5 degrees warmer than sites 1201 and 1089, respectively. However, site 1102 was sampled in 2012 and the others were sampled in 2013. Summer 2012 was warmer than other years, based on other data comparisons not reported here, so the temperature difference is likely confounded by sample year.

Table 3. Mean values of water quality parameters sampled in the field (in situ) at the replicate level for sites around Clough Island. Means and standard error of the mean are provided: mean (SE).

Site	1089	1102	1201
Sample size (n)	6	9	6
pH	7.05 (0.04)	6.81 (0.09)	7.23 (0.06)
Specific conductivity (µS/cm)	181.28 (0.75)	177.03 (0.77)	190.20 (0.64)
Temperature (°C)	23.60 (0.09)	28.32 (0.79)	24.90 (0.18)
Dissolved oxygen (mg/L)	6.74 (0.13)	6.37 (0.66)	7.87 (0.20)
Dissolved oxygen (%)	83.70 (1.62)	87.68 (10.01)	99.43 (2.74)

Comparisons of water quality parameters from morphotype sample composites also demonstrate that these parameters are confounded by sample year for site 1102. In June 2012 the St. Louis River watershed experienced two significant flood events in quick susccession. The effects are noticeable as higher mean values for turbidity and color, and lower mean chloride due to flushing and dilution of the estuary from the large volume of water that moved through during the floods (Table 4). In addition, other work in the estuary in 2012 and 2013 by ourselves and USEPA researchers revealed that macrophyte densities were much lower than in 2011, which may further confound data comparisions among years. The two sites sampled in 2013 (1089 and 1201) had similar mean values for most water quality parameters measured in the lab.

Table 4. Mean values of water quality parameters sampled at the zone level for sites around Clough Island. Means and standard error of the mean are provided: mean (SE).

Site	1089	1102	1201
Sample size (n)	2	3	2
Chlorophyll-a (µg/L)	5.05 (0.45)	15.87 (8.75)	6.65 (0.55)
Phaeophytin (µg/L)	3.0 (0.0)	5.0 (2.61)	3.05 (0.75)
Total Phosphorus (mg/L)	0.044 (0.001)	0.073 (0.012)	0.054 (0.001)
Soluble Reactive Phosphorus (mg/L)	0.008 (0.0)	0.013 (0.001)	0.007 (0.001)
Total Nitrogen (mg/L)	0.824 (0.009)	1.268 (0.093)	0.854 (0.015)
Ammonia (mg/L)	0.023 (0.001)	0.025 (0.006)	0.013 (0.006)
Nitrate/Nitrite-N (mg/L)	0.114 (0.013)	0.058 (0.035)	0.029 (0.001)
Color (color units)	124.5 (2.5)	372.3 (32.8)	145.5 (9.5)
Turbidity (NTU)	8.85 (0.15)	12.47 (3.91)	11.05 (0.25)
Chloride (mg/L)	6.6 (0.20)	5.6 (0.38)	6.4 (0.20)

Clough Island sites compared to other estuary wetlands

We grouped the three sites around Clough Island together and calculated means for these three sites and compared the means of the Clough Island sites to other wetlands sampled in the St. Louis River Estuary (SLRE). Some estuary wetlands, notably sites 1077 and 1096, were sampled twice (in different years) and these sites are represented by sample event means. In the following figures the sites are identified by a more useful "short name" rather than our site ID code (Table 5). The geographic locations are shown in Figure 2.

Table 5. Sites and code names used in the Clough Island versus St. Louis River Estuary sites comparison.

Site Name	Year	Abbrev.	Site numbers
Clough Island	2012, 2013	Clough	1089, 1102, 1201
21st Avenue West	2011	21st	7049
40th Avenue West	2011	40th	7048
Allouez Bay	2011, 2013	Allouez	1077 (2 sampling events)
Pokegema Bay	2011, 2012	Pokeg.	1096 (2 sampling events)
Radio Tower Bay	2011	RTB	7050
Tallas Island	2013	Tallas	1090

Sites 7049 (21st Avenue West) and 7048 (40th Avenue West) are not wetlands and would not have been sampled by the Coastal Wetland Monitoring project. However, these two locations are slated for restoration, and MPCA requested that these areas be sampled using CWM protocols to provide pre-restoration data for comparison with post-restoration data. There was almost no aquatic vegetation at 21st Ave West and plants were only growing around the very nearshore margins of the 40th Ave West site, providing very little wetland habitat as compared to the other sites. This habitat difference clearly influenced the fish and macroinvertebrates found at these sites. Note also that the 21st Ave West site receives direct runoff from downtown Duluth and effluent discharged from the Western Lake Superior Sanitary District.

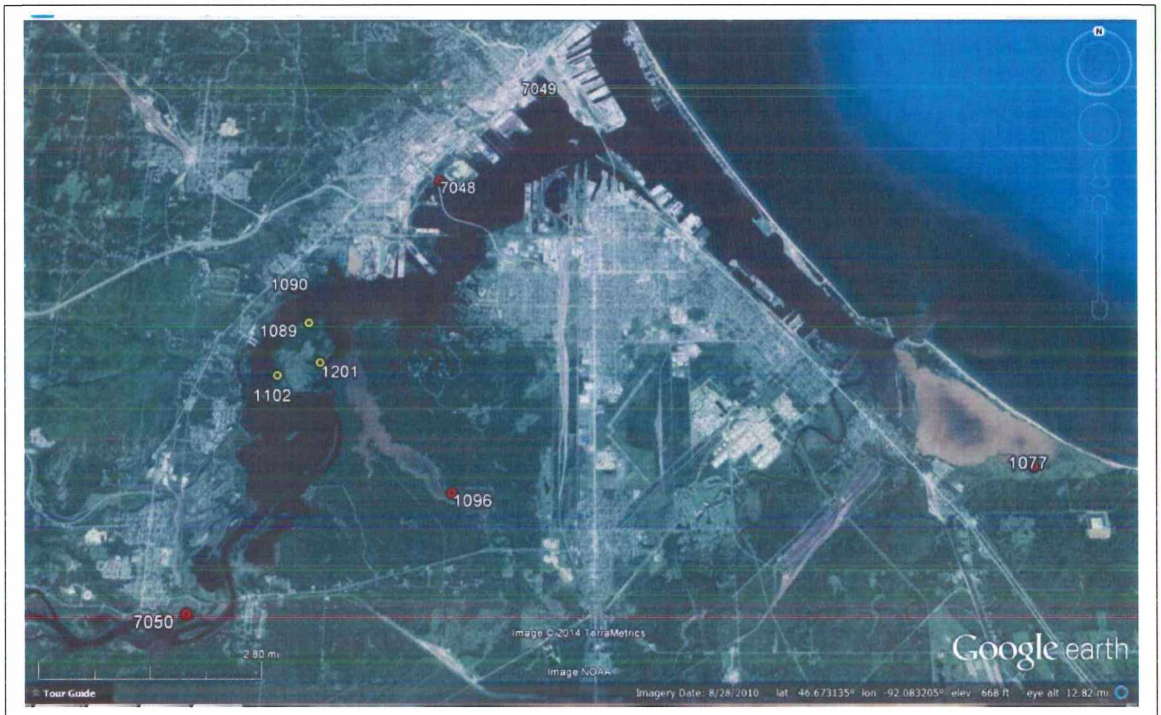


Figure 2. Site locations around Clough Island (yellow) and other St. Louis River Estuary sites (red).

Fish

There was little difference among the mean number of fish taxa captured at Clough Island sites and other sites within the St. Louis River estuary. On average, 9 to 12 taxa were found at each site, with a standard error of 1 to 2 taxa. There were some differences among sites, however, in fish abundance and the number of young-of-year (YOY) fish captured. Radio Tower Bay (RTB) averaged over 400 (±145 SE) fish per net (replicate), while all other sites in the estuary averaged 150 to 200 fish (Figure 3a). The proportion of the fish catches identified as YOY varied greatly among the sites in the SLRE (Figure 3b). 21st and 40th Avenue sites had the lowest proportion of YOY catches, while the fish catches in Pokegama and Radio Tower bays each had nearly 90% of the total fish represented by YOY. High percentages of YOY fish indicate nearby spawning locations and suitable rearing habitat for juveniles. Clough Island and Allouez Bay were similar in the mean percentage of YOY fish captured per net replicate at around 68%, (Figure 3b). Radio Tower and Pokegama bays supported the greatest mean percent YOY (nearly 90%), which signifies the importance of the vegetated areas of these secluded bays for fish reproduction.

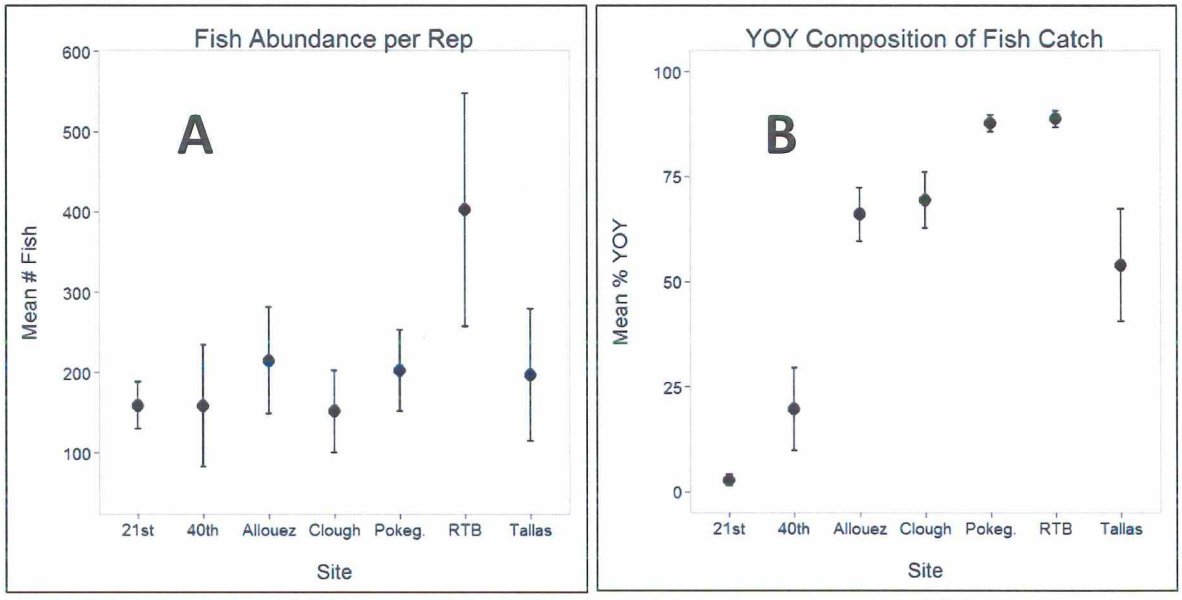


Figure 3. Mean number of fish captured per net replicate (A), and mean percent of fish in young-of-year age class per replicate (B) from sites in the St. Louis River Estuary. Error bars are standard error.

Macroinvertebrates

Amphipods (sideswimmers or scuds), combined with isopods (aquatic sowbugs or pill bugs), and gastropods (snails) dominated most sites within the estuary (Figure 4). Interestingly, the locations whose macroinvertebrate assemblages were comprised by roughly 50% insects were the non-wetland sites at 21st and 40th avenue west areas that are scheduled for restoration. The insects at these sites were primarily Chironomidae (non-biting midges) and Hemiptera (true bugs). The sites that were all truly wetlands (including the Clough Island sites) had macroinvertebrate assemblages made up of about 30-40% aquatic insects. Although zebra mussels are common in the estuary, they were only a small proportion of macroinvertebrates collected in estuary wetlands, if they were found at all. However, D-net samples are not particularly efficient at collecting bivalves.

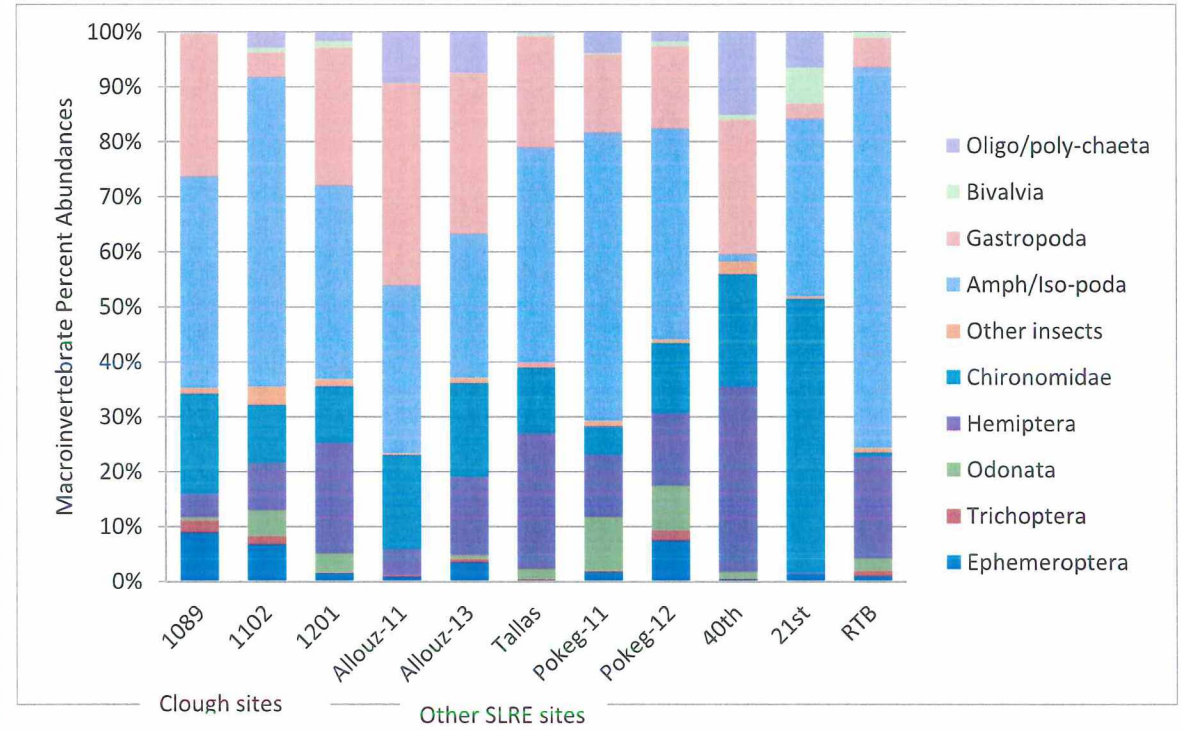


Figure 4. Proportional abundance of macroinvertebrates at Clough Island wetlands (1089, 1102, and 1201) as compared to other wetlands in the St. Louis River estuary. Two sites have been sampled twice, as indicated by the years following their site names.

Compared to other sites in the estuary, Clough Island wetlands supported a high percentage of mayfly, caddisfly, and dragonfly/damselfly (ETO) taxa. Clough Island and Pokegama Bay sites supported an average of about 18% ETO taxa per sample (Figure 5a), and also support the highest abundances of ETO individuals per sample at around 12 and 14%, respectively (Figure 5b). Compared to other areas in the estuary, Clough Island and Pokegama Bay supported proportionately more sensitive ETO taxa than any other locations sampled with CWM methods in the estuary to date.

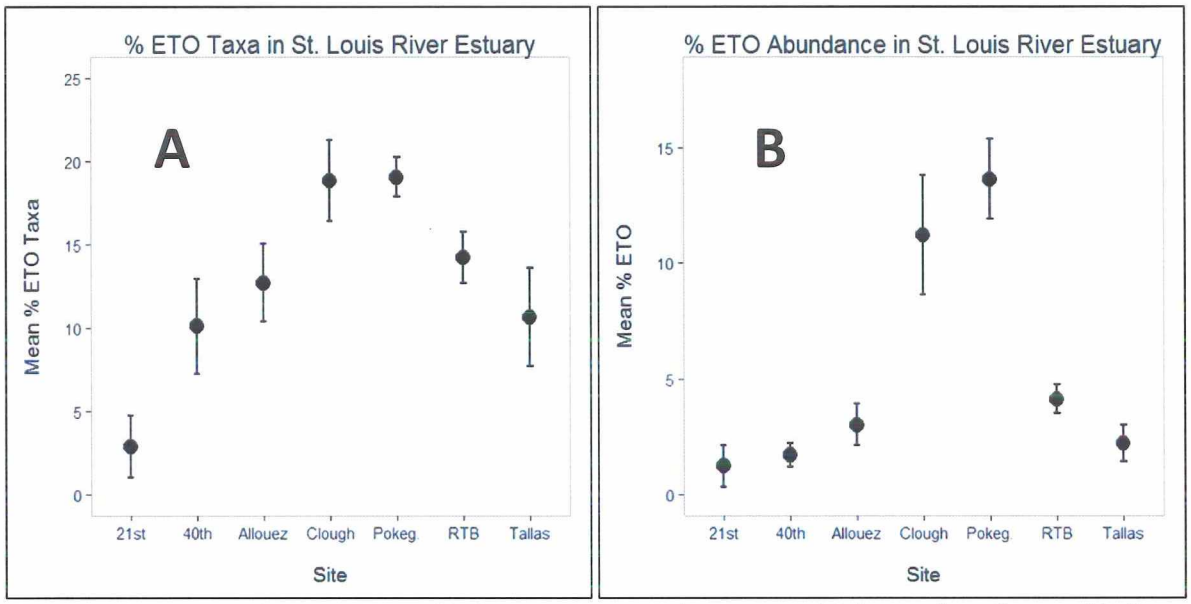


Figure 5. Mean percent composition of Ephemeroptera, Trichoptera, and Odonata (mayflies, caddisflies, and dragonflies/damselflies) by taxa richness (A) and by abundance (B) from sites in the St. Louis River Estuary. Error bars are standard error.

Although there are many invasive species in the estuary, we did not collect many using D-frame dip net sampling in wetlands. Table 6 shows all estuary sites sampled thus far by CWM, and only 5 of 11 sampling events detected invasive macroinvertebrates, primarily *Bithynia*. *Bithynia* presence was greatest at Clough Island wetlands, comprising 7% of invertebrate abundance at one wetland.

Table 6. Percentage of invasive taxa and invasive abundance at Clough Island and estuary wetland sites, as sampled by D-frame dip net in 2011-2013.

Site	% invasive taxa	% invasives	# invasive taxa	Invasive
1089	2%	4%	1	*Bithynia*
1102	1%	1%	1	*Bithynia*
1201	2%	7%	1	*Bithynia*
Allouz-11	0%	0%	0	
Allouz-13	0%	0%	0	
Tallas	0%	0%	0	
Pokeg-11	0%	0%	0	
Pokeg-12	0%	0%	0	
40th	5%	0%	2	*Dreissena & Bithynia*
21st	0%	0%	0	
RTB	2%	0%	1	*Gammarus tigrinus*

Water quality

Some interesting differences among estuary sites are also apparent in the water quality parameters measured in morphotype water sample composites. Clough Island was in the mid-range of estuary sites for measures of ammonia, nitrate/nitrite, and turbidity (Figure 6), but had the lowest measured values for chloride (Figure 6c). Chloride often increases as proximity to roads increases due to road salt, which explains Clough Island's low mean value. Levels of ammonia (Figure 6a) and nitrate/nitrite (Figure 6b) were much higher at 21st Avenue West than any other site in the estuary. 21st Avenue West contains the mouths of two creeks that drain the Duluth hillside and is near the outflow of WLSSD. Allouez and Pokegama bays were the most turbid (Figure 6d), likely due to the high clay particulate loading from their upper watersheds. Testing for significant differences of means was not appropriate because the sample sizes were too low. Samples sizes were: 21st = 2, 40th = 3, Allouez = 6, Clough = 7, Pokeg. = 6, RTB = 3, and Tallas = 3.

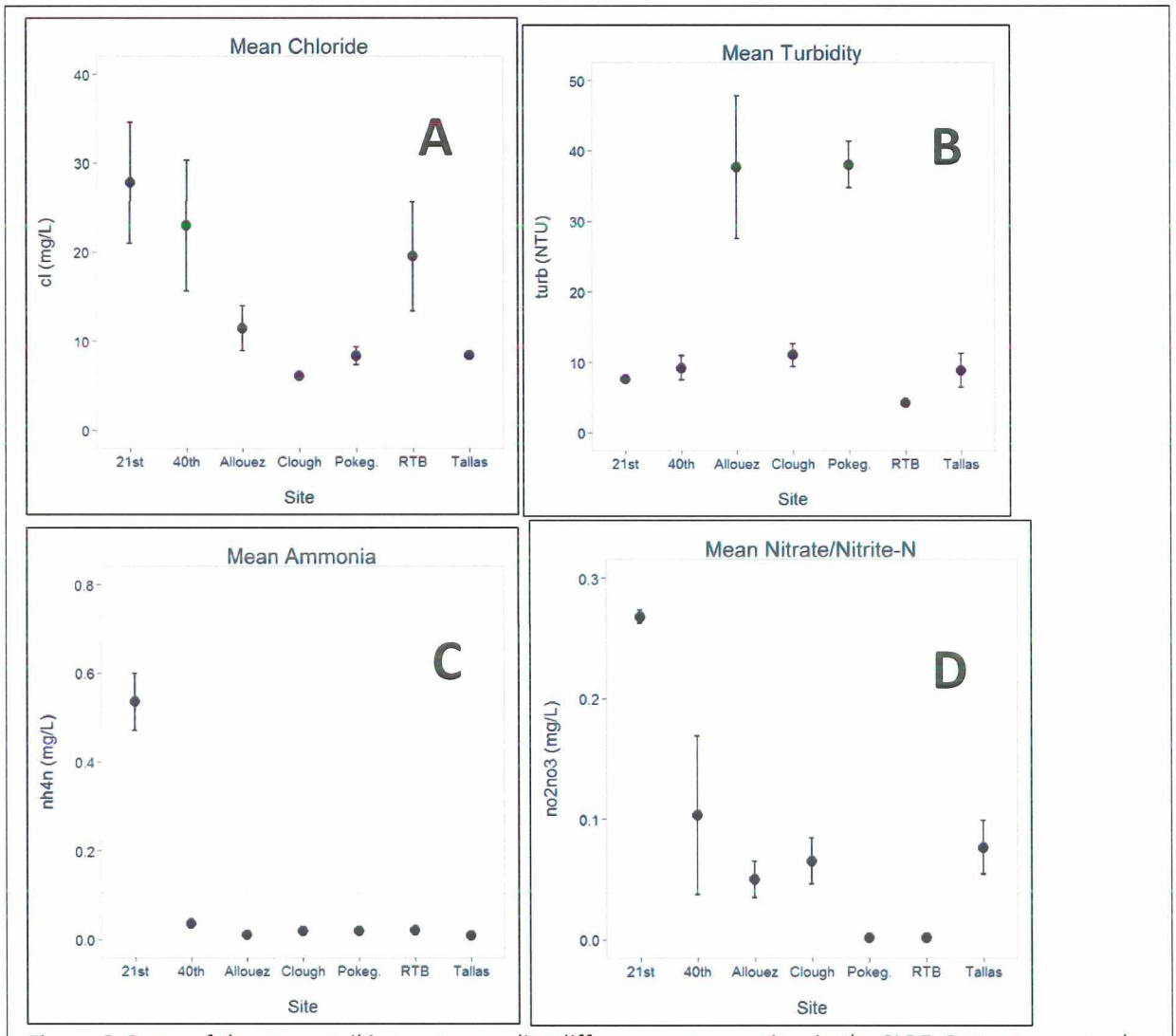


Figure 6. Some of the more striking water quality differences among sites in the SLRE. Data are means by site of composite water samples for each vegetation morphotype sampled. Error bars are standard error.

Comparison of replicate (*in situ*) water quality revealed that Clough Island and Allouez Bay had the warmest water temperatures among the estuary sites sampled (Table 7). Mean pH values at Clough Island and all other estuary sites were very close to 7.0. Specific conductivity was highly variable among sites, but was greatest at 21st Ave West at nearly 292 µS/cm, while the mean at Clough Island was 182 (Table 7). Mean dissolved oxygen percent and saturation (mg/L) varied greatly among the sites sampled in the estuary (Table 7). Factors which affect DO include the abundance of aquatic vegetation or decomposing organic material present, length of wind fetch, time of day when sampled, and abundance of phytoplankton. Mean water quality values not presented in Figure 4 are provided in Table 8.

Table 7. Mean values of water quality parameters sampled in the field (in situ) at the replicate level for sites sampled in the SLRE. Means and standard error of the mean are provided: mean (SE).

Site	n	Temp (°C)	pH	Specific Cond. (µS/cm)	DO (%)	DO (mg/L)
21st Avenue	6	22.6 (0.4)	7.08 (0.04)	291.95 (13.27)	145.1 (4.7)	11.95 (0.37)
40th Avenue	9	20.3 (0.2)	7.06 (0.14)	224.24 (30.93)	79.6 (8.2)	6.77 (0.68)
Allouez Bay	18	25.8 (0.3)	7.07 (0.06)	143.17 (3.06)	88.2 (2.4)	6.96 (0.20)
Clough Island	21	26.0 (0.6)	7.00 (0.06)	182.01 (1.45)	89.9 (4.5)	6.91 (0.31)
Pokegema Bay	18	23.6 (0.6)	7.00 (0.06)	217.17 (8.46)	86.0 (3.9)	6.96 (0.29)
Radio Tower Bay	9	23.3 (0.2)	6.87 (0.06)	208.74 (4.52)	110.8 (4.0)	9.15 (0.33)
Tallas Island	9	22.8 (0.1)	7.15 (0.10)	187.23 (4.0)	69.8 (10.0)	5.72 (0.82)

Table 8. Mean values of water quality parameters sampled by composite within each morphotype for sites sampled in the SLRE. Means and standard error of the mean are provided: mean (SE).

Site	n	Chl-a (µg/L)	Phaeo (µg/L)	Total P (mg/L)	Sol. React. P (mg/L)	Total N (mg/L)	Color (color units)
21st Avenue	2	3.40 (2.50)	2.40 (0.50)	0.074 (0.002)	0.031 (0.000)	1.609 (0.078)	232.00 (5.00)
40th Avenue	3	5.40 (1.45)	8.03 (2.84)	0.064 (0.006)	0.018 (0.005)	1.075 (0.042)	239.67 (32.84)
Allouez Bay	6	6.53 (0.50)	4.13 (1.17)	0.070 (0.016)	0.007 (0.001)	0.758 (0.070)	135.17 (31.87)
Clough Island	7	10.14 (3.89)	3.87 (1.08)	0.059 (0.007)	0.010 (0.001)	1.022 (0.094)	236.71 (49.68)
Pokegema Bay	6	5.63 (1.77)	3.05 (0.81)	0.110 (0.009)	0.035 (0.006)	1.174 (0.091)	287.00 (33.27)
Radio Tower Bay (RTB)	3	3.23 (0.34)	3.03 (0.34)	0.041 (0.005)	0.009 (0.003)	0.978 (0.063)	247.67 (38.35)
Tallas Island	3	5.80 (1.32)	2.83 (0.67)	0.051 (0.002)	0.007 (0.001)	0.824 (0.023)	134.67 (3.67)

Clough Island and estuary sites compared to nearby Lake Superior wetlands

In this section we group all Clough Island sites, all other estuary sites, and nearby Lake Superior coastal wetlands out to the Ashland, WI area (Figure 7) to compare Clough Island and estuary sites to nearby Lake Superior coastal wetlands.

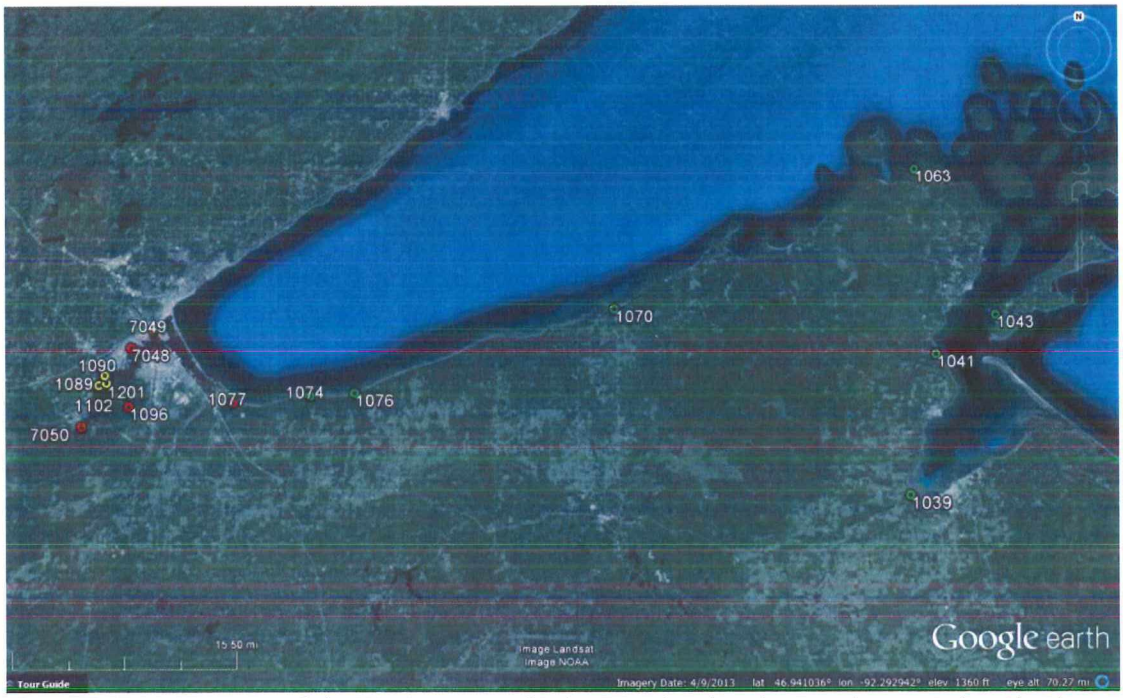


Figure 7. Greater extant of the Western arm of Lake Superior showing nearby coastal wetland monitoring sites (green) used in this comparison.

Fish

In general, the fish catches from Clough Island sites were more similar to other estuary sites than to those of nearby Lake Superior wetlands in mean taxa richness and the mean percent YOY-age fish in the overall fish catch (Figure 8). There were significantly ($p<0.05$) fewer taxa and YOY fish collected from Lake Superior wetlands than from either Clough Island or other sites in the estuary. Student's T-tests (alpha 0.05) were performed to determine significance because there were high enough sample sizes (net replicates) to support these analyses. Sample sizes were: "Clough Island" = 14, "Other SLRE" = 57, "Nearby LS" = 38.

Figure 8. Fish taxa richness (A) and percentage of fish catch comprised of young-of-year fish (B) at Clough Island, other estuary, and nearby Lake Superior sites. Means and standard errors presented. Means that are significantly different have different letters.

Mean contribution of older fish taxa (age 1+) were also more similar between Clough Island and other estuary sites (Figure 9; Table 9), which is expected due to their geographical proximity. When grouped together, the Clough Island sites were collectively dominated by pumpkinseed, rock bass, bluegill, golden shiners and yellow perch. These five species comprised 70% of all age 1+ fish caught around Clough Island. Grouping all other sites in the estuary introduced many more taxa because data collection covered a wide area, many different vegetation types, and several years. However, there were some similar species contributing to major components of the fish community between Clough Island and other estuary sites. In the estuary, spottail shiner, black crappie, pumpkinseed, golden shiner, yellow perch, and the invasive round goby contributed the most to our catches (Figure 9; Table 9).

The fish community at nearby Lake Superior coastal wetlands was different than assemblages within the estuary and around Clough Island. While pumpkinseed sunfish were still present in high proportion, the contribution of yellow perch was higher, and black crappie lower, than seen within the estuary. Bullheads were more prevalent within wetlands adjacent to Lake Superior than within the estuary, and blacknose shiners were not present in any samples within the estuary, but were common in Lake Superior sites and were collectively over 14% of the age 1+ fish mean catch (Table 9).

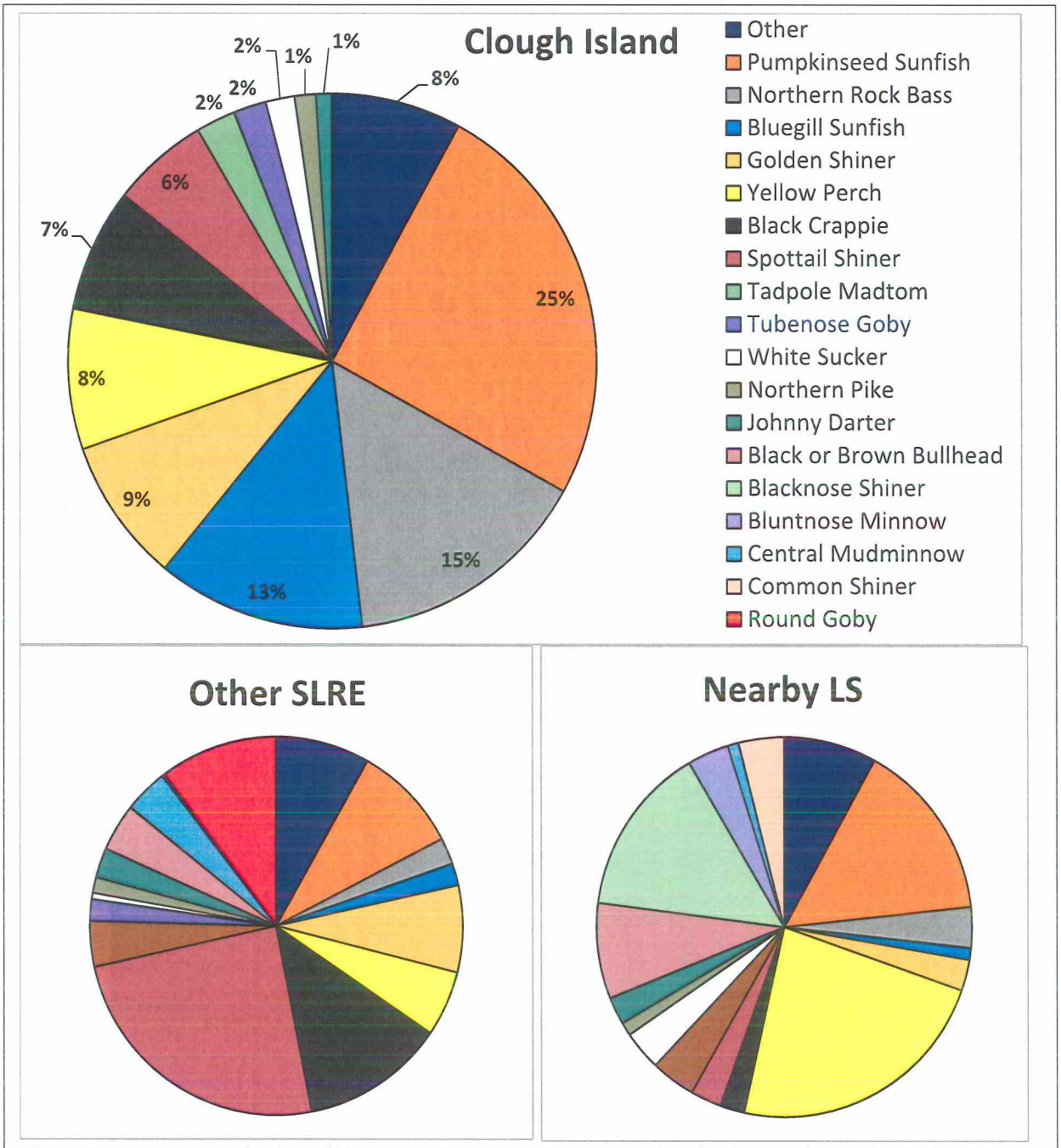


Figure 9. Percent contribution of the 18 most common taxa from Clough Island, other St. Louis River estuary locations, and nearby Lake Superior wetlands. Only fish of age 1+ were used (i.e., no YOY). The "Other" category contains 26 taxa of infrequent occurrence and comprises ≈ 8% composition of all groups. The same data are listed in Table 9.

Table 9. Taxa percent contribution to age "other" (older than YOY) total catch for sites grouped as Clough Island, other St. Louis River Estuary sites (Other SLRE), and sites west of Ashland, WI (Nearby LS). Sample sizes (# of nets) were: Clough Island=14, Other SLRE=57, Nearby LS=38.

Taxa	Clough Is	Other SLRE	Nearby LS
Alewife - *Alosa pseudoharengus*	0.0%	0.3%	0.0%
Black or Brown Bullhead - *Ameiurus melas* or *A. nebulosas*	0.0%	4.1%	8.1%
Black Crappie - *Pomoxis nigromaculatus*	7.4%	12.4%	2.1%
Blacknose Shiner - *Notropis heterolepis*	0.0%	0.0%	14.5%
Bluegill Sunfish - *Lepomis macrochirus*	12.7%	1.9%	1.0%
Bluntnose Minnow - *Pimephales notatus*	0.0%	0.0%	3.6%
Brook Stickleback - *Culaea inconstans*	0.0%	0.1%	0.2%
Central Mudminnow - *Umbra limi*	0.0%	3.7%	0.9%
Channel Catfish - *Ictalurus punctatus*	0.0%	0.2%	0.0%
Common Carp - *Cyprinus carpio*	0.0%	0.8%	0.0%
Common Shiner - *Luxilus cornutus*	0.0%	0.2%	3.9%
Eastern Slimy Sculpin - *Cottus cognatus*	0.0%	0.0%	0.4%
Emerald Shiner - *Notropis atherinoides*	0.4%	2.5%	0.0%
Eurasian Ruffe - *Gymnocephalus cernuus*	0.0%	0.9%	0.0%
Fathead Minnow - *Pimephales promelas*	0.0%	0.1%	3.3%
Golden Shiner - *Notemigonus crysoleucas*	8.7%	7.4%	2.6%
Great Lakes Muskellunge - *Esox masquinongy*	0.0%	0.0%	0.0%
Horneyhead Chub - *Nocomis biguttatus*	0.0%	0.0%	0.6%
Johnny Darter - *Etheostoma nigrum*	1.0%	2.5%	2.3%
Lake Chub - *Couesius plumbeus*	0.0%	0.0%	1.3%
Largemouth Bass - *Micropterus salmoides*	2.5%	0.1%	0.0%
Logperch - *Percina caprodes*	0.4%	0.8%	0.0%
Mottled Sculpin - *Cottus bairdii*	0.0%	0.0%	0.2%
Northern Brook Silverside - *Labidesthes sicculus*	0.0%	0.1%	0.0%
Northern Mimic Shiner - *Notropis volucellus*	0.0%	0.3%	0.2%
Northern Pike - *Esox lucius*	1.3%	1.3%	1.1%
Northern Redbelly Dace - *Phoxinus eos*	0.0%	0.0%	0.1%
Northern Redhorse - *Moxostoma macrolepidotum*	1.5%	0.5%	0.0%
Northern Rock Bass - *Ambloplites rupestris*	15.1%	2.3%	3.5%
Pumpkinseed Sunfish - *Lepomis gibbosus*	25.1%	9.3%	15.3%
Round Goby - *Neogobius melanostomus*	0.0%	10.2%	0.0%
Sand Shiner - *Notropis stramineus*	0.0%	0.3%	0.2%
Sea Lamprey - *Petromyzon marinus*	0.0%	0.0%	0.4%
Silver Redhorse - *Moxostoma anisurum*	0.9%	0.4%	0.1%
Smallmouth Bass - *Micropterus dolomieu*	0.5%	0.3%	0.0%
Spottail Shiner - *Notropis hudsonius*	6.0%	24.5%	2.7%
Tadpole Madtom - *Noturus gyrinus*	2.4%	3.9%	3.8%
Threespine Stickleback - *Gasterosteus aculeatus*	0.0%	0.0%	0.7%
Troutperch - *Percopsis omiscomaycus*	1.4%	0.2%	0.2%
Tubenose Goby - *Proterorhinus marmoratus*	2.0%	1.9%	0.0%
Walleye - *Sander vitreus*	0.4%	0.0%	0.2%
White Perch - *Morone americana*	0.0%	0.3%	0.0%
White Sucker - *Catostomus commersonii*	1.8%	0.5%	3.4%
Yellow Perch - *Perca flavescens*	8.5%	5.6%	23.1%

Macroinvertebrates

Clough Island wetlands had slightly lower proportions of aquatic insects than other wetlands in the estuary and nearby Lake Superior, and somewhat more non-insect macroinvertebrates, mostly amphipods, isopods and gastropods (snails) (Figure 10). Overall, there were few differences among groups of wetlands, and proportional macroinvertebrate assemblages for these areas appear relatively similar (Figure 10).

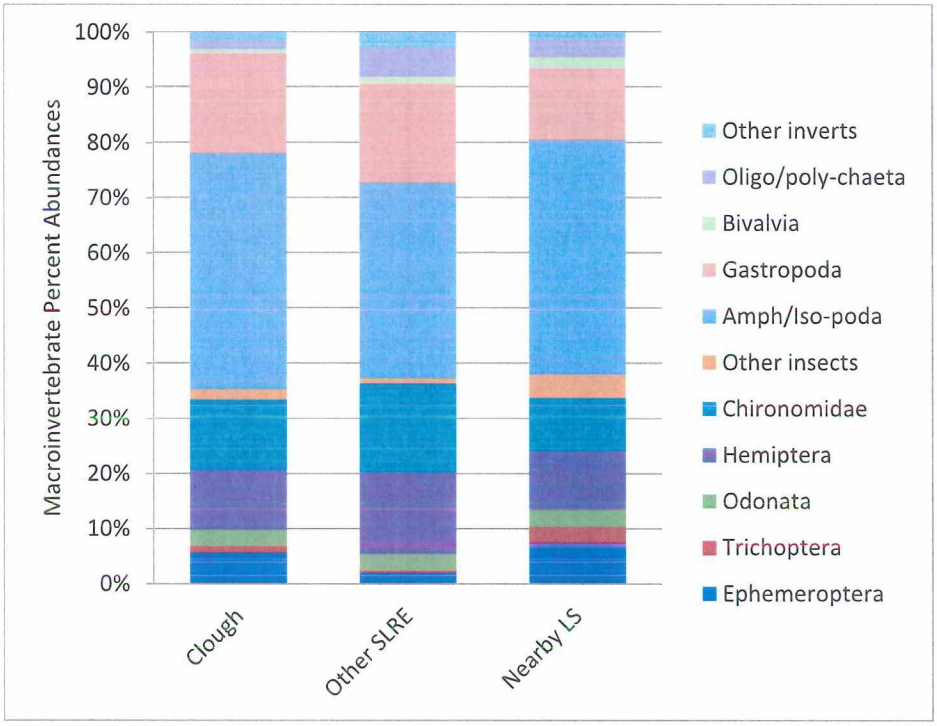


Figure 10. Mean macroinvertebrate assemblage composition at wetlands around Clough Island, other SLRE estuary wetlands, and nearby Lake Superior wetlands between Duluth and Ashland, Wisconsin.

However, when we used the replicate D-net samples to test whether groups of wetlands were different for specific, high-value macroinvertebrates, we found that Clough Island sites supported a significantly greater mean proportion of mayfly, caddisfly, and dragonfly/damselfly (ETO) abundances than other estuary sites (Figure 11a). However, ETO proportional abundances were similar to other nearby Lake Superior wetlands. ETO taxa richness per sample were, as proportions of all taxa in each sample, higher at Clough Island sites than in other sites in the estuary and Lake Superior (Figure 11b). This indicates that each sample collected at the Clough Island wetlands generally had more ETO taxa (greater taxa richness) than did samples collected in the estuary or in other nearby Lake Superior wetlands.

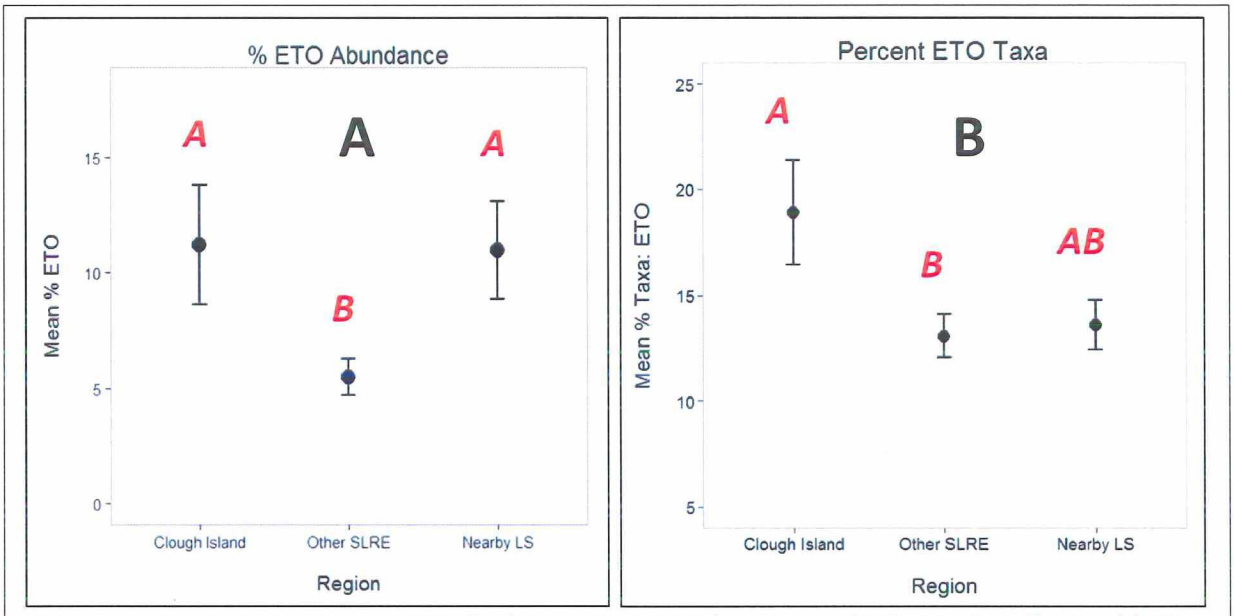


Figure 11. Mean percent composition of Ephemeroptera, Trichoptera, and Odonata (mayflies, caddisflies, and dragonflies/damselflies) by abundance (A) and by taxa richness (B) from sites at Clough Island, the St. Louis River Estuary (SLRE), and nearby Lake Superior. Error bars are standard error. Different letters indicate significant differences ($p<0.05$) among means.

Averaging percentages of invasive taxa and invasive abundances by site location confirms that the estuary is the hot spot for invasive species in this area. No invasive macroinvertebrates were collected at the 7 other wetlands sampled nearby in Lake Superior (Table 10).

Table 10. Average percentage of invasive taxa, invasive invertebrate abundance, and number of invasive taxa at wetlands around Clough Island, other wetlands in the estuary, and wetlands nearby in Lake Superior, as sampled by Coastal Wetland Monitoring methods using a D-frame dip net, 2011-2013.

Location	% invasive taxa	% invasives	# invasive taxa
Clough Is	2%	4%	1
Other SLRE	1%	0%	0.375
Nearby LS	0%	0%	0

Water quality

Sample sizes of replicate-level (*in situ*) water quality parameters were 21 at "Clough Island", 69 at "Other SLRE", and 54 for "Nearby LS". The pH in the St. Louis River estuary and around Clough Island was 7.0 on average, while the mean pH from sites of nearby Lake Superior was significantly lower at 6.0 (±0.23 SE). Mean water temparature was significantly ($p<0.001$) lower in Lake Superior wetlands than

either Clough Island or other SLRE sites (Figure 12a), and mean specific conductivity (µS/cm) was lowest in Lake Superior wetlands at 150.5 (± 3.8 SE), and highest in the estuary at 200.3 (±6.9 SE) (Figure 12b).

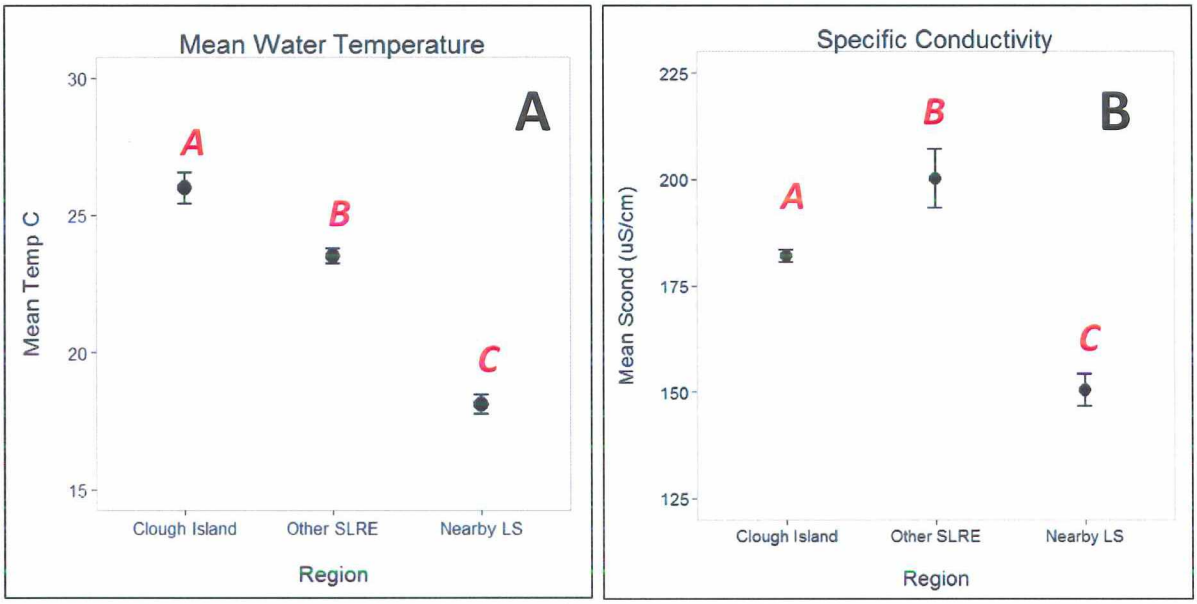


Figure 12. Mean water temperature (A) and specific conductivity (B) from site composite water samples for each vegetation morphotype sampled. Error bars are standard error. Different letters indicate significant differences ($p<0.05$) among means.

Sample sizes of composite water samples used in laboratory water quality analyses were 7 at "Clough Island", 23 at "Other SLRE", and 18 for "Nearby LS". Mean chlorophyll-a was highly variable from Clough island samples. However, nearby Lake Superior wetlands had significantly lower mean values than SLR estuary sites (Figure 13a). Lake Superior wetlands also had significantly less total nitrogen and lower mean color values than either Clough Island or other SLRE sites (Figure 13b,c). Mean chloride was greatest at estuary sites, which were often adjacent to populated areas of Duluth and Superior. However, chloride levels may not be homogenously mixed throughout the estuary because Clough Island mean chloride levels were not different than mean values found at nearby Lake Superior wetlands (Figure 13d).

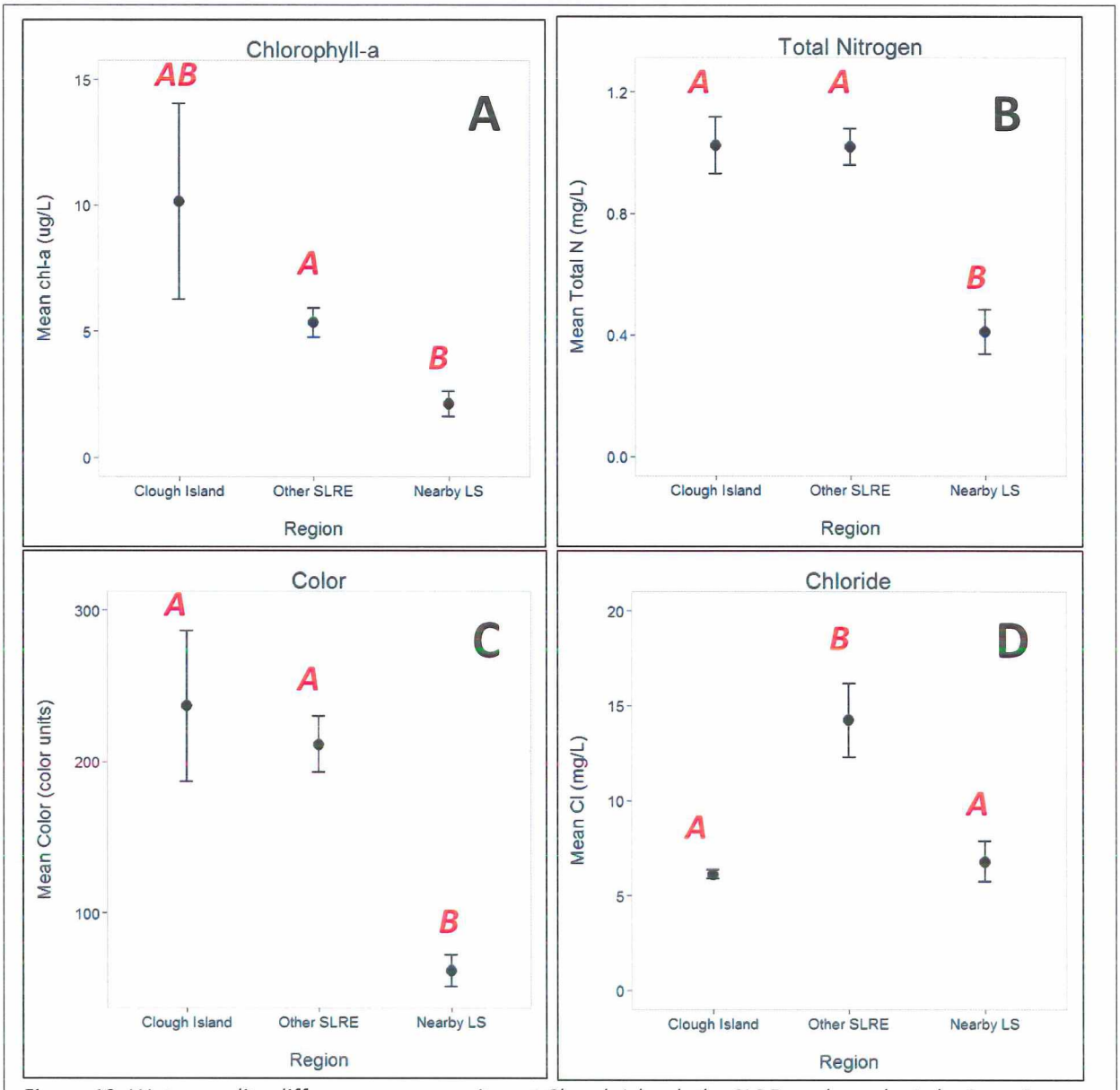


Figure 13. Water quality differences among sites at Clough Island, the SLRE, and nearby Lake Superior coastal wetlands. Data are means by region of composite water samples for each vegetation morphotype sampled. Error bars are standard error. Different letters indicate significant differences ($p<0.05$) among means.

Summary

Clough Island wetland fyke net fish catches were dominated by sunfish, yellow perch, and golden shiner, while other sites in the estuary (averaged together) were dominated by bullheads, black crappie, round goby, and golden shiner. Nearby Lake Superior wetlands were dominated by yellow perch, golden shiner, blacknose shiner, and bullheads. Tubenose goby made up 5% of the fish at site 1089, but were not found frequently at other sites at Clough or in the estuary. Of the three Clough Island wetlands, fish taxa richness was highest at site 1089 and lowest at site 1201. These differences were partly due to the number of habitats, and thus sampling effort, which was lowest at 1201 for both fish and macroinvertebrates. Clough Island wetlands did not provide as much habitat for YOY fish as did highly vegetated, secluded bays like Pokegama and Radio Tower, but was much better fish habitat than the "to be restored" sites of 21st and 40th Ave West.

The number and type of wetland habitats influenced aquatic macroinvertebrates assemblages, and thus site 1102 had more invertebrates per sample, relatively high proportions of sensitive taxa (Ephemeroptera, Trichoptera, and Odonata), and higher taxa richness. *Bithynia* (invasive faucet snails) was more commonly detected at Clough Island sites than in other SLR estuary wetlands. We did not find invasive macroinvertebrates in nearby Lake Superior wetlands. Overall, wetland macroinvertebrate assemblages at all locations were dominated by amphipods and snails, and the aquatic insect portion was dominated by Chironomidae (non-biting midge larvae). Hemiptera (true bugs) and Ephemeroptera (mayflies) also comprised large percentages of other Lake Superior wetlands.

Compared to other estuary wetlands, Clough Island sites had relatively lower chloride and conductivity levels, but these were still much higher than what was measured in nearby Lake Superior wetlands. Estuary wetlands were all warmer than other Lake Superior wetlands by at least 5 C, and had a neutral pH (about 7.0), compared to an average pH of 6.0 in nearby Lake Superior wetlands.

Clough Island Coastal Wetland Monitoring Survey of Aquatic Vegetation

Nicholas Danz, University of Wisconsin-Superior

Introduction

Wetland vegetation of the St. Louis River estuary is characterized by a mix of low and high quality sites found in fringing marshes along the main river channel and numerous protected bays. Generally, lower quality sites harbor plants with greater tolerance to stressors including sediments, nutrients, and human disturbance. In the St. Louis River estuary, these sites tend to be more downstream and surrounded by a greater amount of human development. For example, in the industrial bays at 21st and 40th Ave. west, and in Radio Tower Bay, plants such as invasive cattail species, Sago-pondweed, nutrient-tolerant *Elodea*, and algae are prevalent (Danz unpublished data) and indicate lower-quality wetlands.

Higher quality sites harbor more sensitive plant communities and are more common upstream, away from surrounding human disturbance. The Oliver area marshes and Pokegama Bay are good examples of high quality sites, and have a wider variety of distinctive plants including sedges, bur-reeds, arrowheads, and wild rice. Allouez Bay is another example of a higher quality site, although this site is further downstream, but not extensively surrounded by human disturbance.

Clough Island wetland plant assemblages are of mixed quality. This mixed quality plant communities may be attributed to the island's history of human habitation and geographic position midway between high-quality upstream wetlands and lower quality industrial bays. In this report, we describe wetland plant community data collected from Clough Island as part of the Great Lakes Coastal Wetland Monitoring (CWM) project that surveyed plants across the Great Lakes in 2011-2013.

Methods

Plants were surveyed at three CWM wetland sites on Clough Island in summers of 2012 and 2013 using methods described in (Uzarski *et al.* 2014). At each site, three survey transects were located perpendicular to the water depth gradient (Figure 14). Along each transect, three vegetation zones were delineated (if three were present), including wet meadow (WM), emergent (EM), and submergent/floating leaf (SU). Wet meadow is dominated by sedges and grasses, the emergent zone has permanent standing water and is dominated by bur-reeds, cattail, rushes, and other emergent plants. The submergent zone is dominated by plants at or below the water surface. In the vegetation

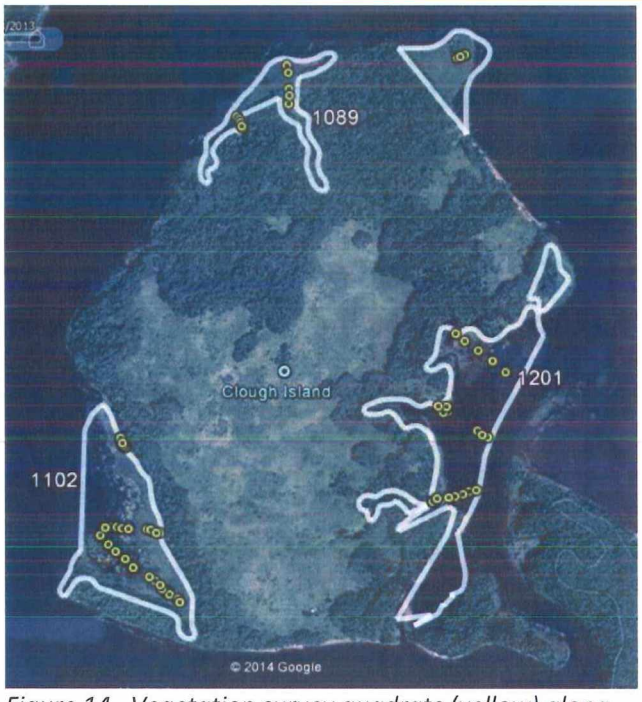


Figure 14. Vegetation survey quadrats (yellow) along three transects at each wetland.

zones present along each transect, we recorded the percent cover of all species in five 1-m^2 survey quadrats. Total quadrat number was variable between wetlands due to the varying presence of vegetation zones along transects (Table 11). Seventy quadrats total were surveyed.

Table 11. Number of quadrats sampled in vegetation zones for three Clough Island wetlands 2012-2013.

		Vegetation Zone			
Site	Year	WM	EM	SU	Overall
1089	2013		15		15
1102	2012	10	10	10	30
1201	2013		10	15	25

Data Analysis

We used non-metric multidimensional scaling (NMDS) in PC-ORD (McCune and Mefford 2011) to ordinate wetland sites based on plant community composition. In one ordination, we included 50 sites from Lake Superior coastal wetlands surveyed in 2011-2013 as part of the GLIC-CM project. In a second ordination, we included a subset of 11 sites from the St. Louis River estuary.

We used Coefficient of Conservatism (*C*) to indicate floristic quality of plants in each wetland (Bourdaghs *et al.* 2006). In this approach, species are assigned values 0-10, with a value of 0 equating to non-native species or native species found in a wide variety of habitats, and values of 10 indicating high specificity for natural, undisturbed habitats. Our *C* values were developed for Michigan and have been used to characterize the entire Great Lakes region. In Appendix 1, we list *C* values from Wisconsin DNR for comparison, although all statistical calculations used the Michigan values. To characterize overall floristic quality, mean *C* and weighted mean *C* were calculated for each quadrat based on species observed, and then averaged across vegetation zones within wetlands and for the entire wetland.

Results and Discussion

In the three Clough Island wetlands, emergent vegetation was the most prevalent type along the transects surveyed. When wet meadow was present it was a narrow fringing zone, while the occurrence of plants in the submergent zone was highly spatially variable. In another recent study, submergent aquatic beds were found surrounding the island (Roesler 2013). Combining the 70 quadrats from the three wetlands, we observed fifty species total, with 12 species observed on all three sites (Appendix 2). Commonly occurring species included coontail, broad-leaved arrowhead, lake sedge, and broad-fruit bur-reed.

A number of the observed species were those typically found in high-quality sites, including 14 species with Wisconsin-based C-values ≥7. Five of these species were pondweeds (Appendix 2). Notably, wild

calla was recorded on six quadrats, marsh cinquefoil on 11 quadrats, and Thryse loosestrife on seven quadrats.

The three wetlands also contained several species typical of low-quality sites, including four non-native species. Purple loosestrife (18/70 quadrats) and invasive cattail (34/70 quadrats) were both present on all three sites. Lady's thumb (*Polygonum persicaria*) was noted on one quadrat.

NMDS ordination of 50 coastal wetland sites from all across Lake Superior demonstrated that the Clough Island sites are typical of the western end of the lake, harboring what Johnston *et al.* (2009) referred to as a bur-reed/lake sedge community type. In this community type, distinctive species include broad-fruit bur-reed, lake sedge, broad-leaved arrowhead, marsh cinquefoil, rostrate sedge, and broad-leaved cattail (Figure 15). Sites further to the east in Lake Superior, beginning near the Bayfield Peninsula and moving eastward, are more likely to harbor northern poor fen vegetation, with typical bog plants including *Carex lasiocarpa* and a variety of ericaceous shrubs. Bluejoint/tussock plant communities occur further east, in the Whitefish Bay region.

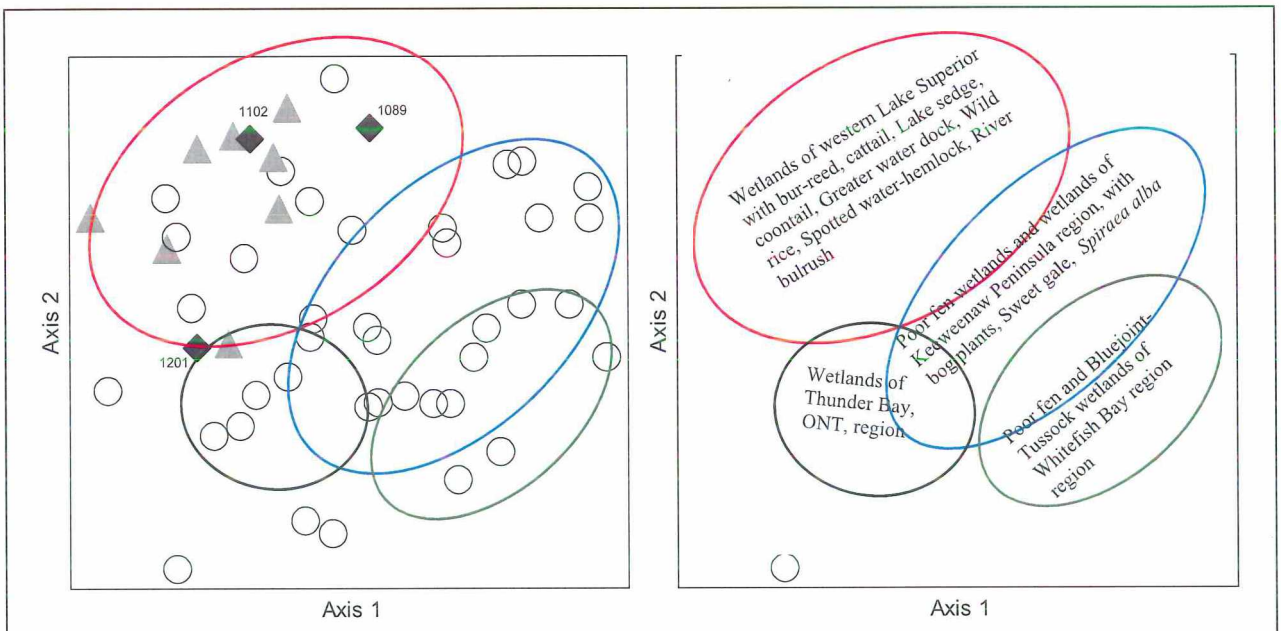


Figure 15. NMDS ordination of 109 plant species on 50 coastal wetland sites from Lake Superior 2011-2013. Only species present on at least 5 sites were included. Sites from Clough Island (solid black diamonds) are labeled with their site identification number. For comparison, sites from the SLR estuary (gray triangles) and Lake Superior (open circles) are also included in the ordination. The panel on the right has a brief interpretation of community composition.

NMDS ordination of 11 wetland sites in the St. Louis River estuary showed the Clough Island sites are lacking in extensive wet meadow vegetation compared to other SLR estuary sites. In the ordination diagram, the three Clough Island sites are found midway along Axis 1 and near the bottom of Axis 2 (Figure 16). This ordination may change with the addition of more sites from the SLR estuary. However, in the current ordination Axis 1 represents a gradient from wetlands with shrubby wet meadow zones

harboring sweet gale and a well-developed submergent community (floating pondweed, wild calla, white water lily) at the lower end to more heavily degraded wetlands with reed canary grass and Sago pondweed at the upper end. Axis 2 represents a gradient of sites with tag alder and river bulrush at the lower end and sites with extensive wet meadow vegetation at the upper end. Compared to other sites not heavily degraded in the estuary, the Clough Island sites are more notable for species that are absent (e.g. spotted water-hemlock, Joe Pye-weed, stiff arrowhead, terrestrial loosestrife, bog willow, flat-leaved willow, marsh skullcap, and wild rice) than for a set of distinctive species not found elsewhere. Site 1102 on the southwest corner of the island has the most well-developed wet meadow zone and, therefore, occurs at the highest location along Axis 2 in the ordination (Figure 16).

Additional surveys using meander approaches in the Clough Island sites may yield more complete species lists than our quadrat-based surveys from this project.

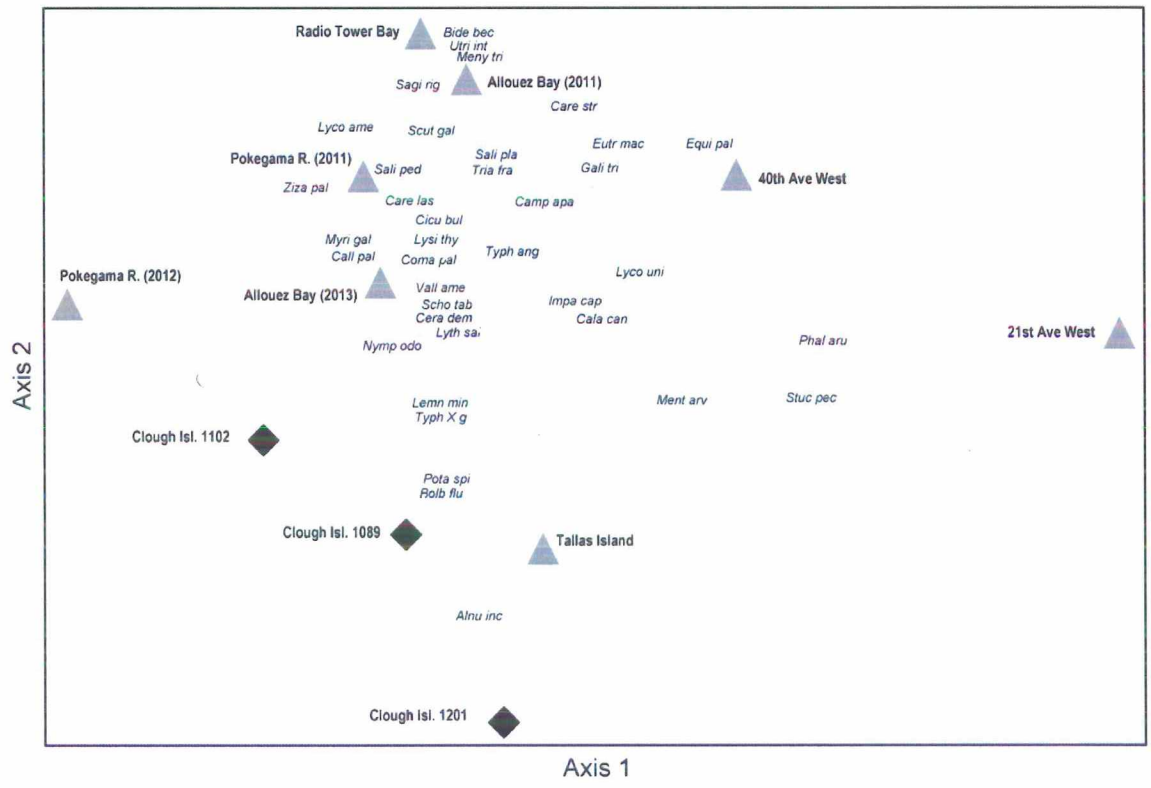


Figure 16. NMDS ordination of 61 species on 11 wetland surveys from the St. Louis River estuary 2011-2013. Only species present on at least 2 sites were included. To simplify the graph, species are labeled in ordination space only if they had Pearson correlation r ≥ 0.50 with at least one axis (see Appendix 1 for codes). Two sites (Pokegama River and Allouez Bay) were surveyed in two years each and are each included twice in the ordination.

Floristic quality of the three Clough Island sites was lower than average when compared to 50 sites from around Lake Superior, but about average compared to other sites from the St. Louis River estuary

(Figure 17). Many northern poor fen wetlands in more eastern Lake Superior locations had among the highest *C* indices in the entire Great Lakes because the species in those communities are habitat-specific and have accordingly high C scores. Thus, sites in bur-reed/lake sedge communities of western Lake Superior have slightly lower average *C* index values.

Within the St. Louis River estuary, Site 1089 had fairly low *C* indices (Table 12), likely due to the high frequency of purple loosestrife and hybrid cattail in the wet meadow zone of this wetland. When considering wetland zones separately, the emergent zone of site 1201 was also low, in part due to the presence of hybrid cattail, but also because of the widespread occurrence of coontail, a disturbance-tolerant native species with a wide distribution and low C-score of 3. Overall, sites 1102 and 1201 had very similar floristic quality index scores.

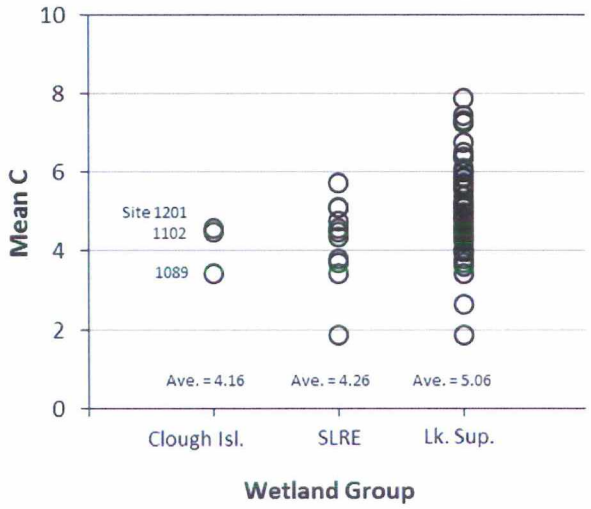


Figure 17. Mean Coefficient of Conservatism for coastal wetland sites surveyed from Clough Island, the St. Louis River Estuary (SLRE), and Lake Superior 2011-2013.

Table 12. Mean Coefficient of Conservatism (C) and weighted mean C (wC) for three wetlands on Clough Island 2012-2013.

	Wet Meadow		Emergent		Submergent		Entire Wetland	
Site	*C*	*wC*	*C*	*wC*	*C*	*wC*	*C*	*wC*
1089	3.42	3.57					3.42	3.57
1102	4.68	5.39	4.15	4.03	4.58	4.19	4.47	4.54
1201			3.85	3.93	5.11	5.21	4.48	4.68

Clough Island Coastal Wetland Monitoring Survey of Avian Use

Annie Bracey and Gerald Niemi

Introduction

This report presents a summary of bird use at three wetland sites around Clough Island (Figure 1). These sites were sampled 1) for breeding birds in 2012 and/or 2013 as part of the Great Lakes Coastal Wetland Monitoring project (GLCWC 2008) and 2) during autumn migration 2013 as part of the MPCA R2R Ecological Monitoring and Assessment of the St. Louis River (Niemi and Bracey 2013). These data are here summarized for Clough Island and include species richness, relative abundance, and guild type for both breeding and migratory bird use. We also provide a brief comparison to other sites surveyed in the St. Louis River estuary that used the same sampling methods (Figure 18), with an emphasis on bird species of special interest.

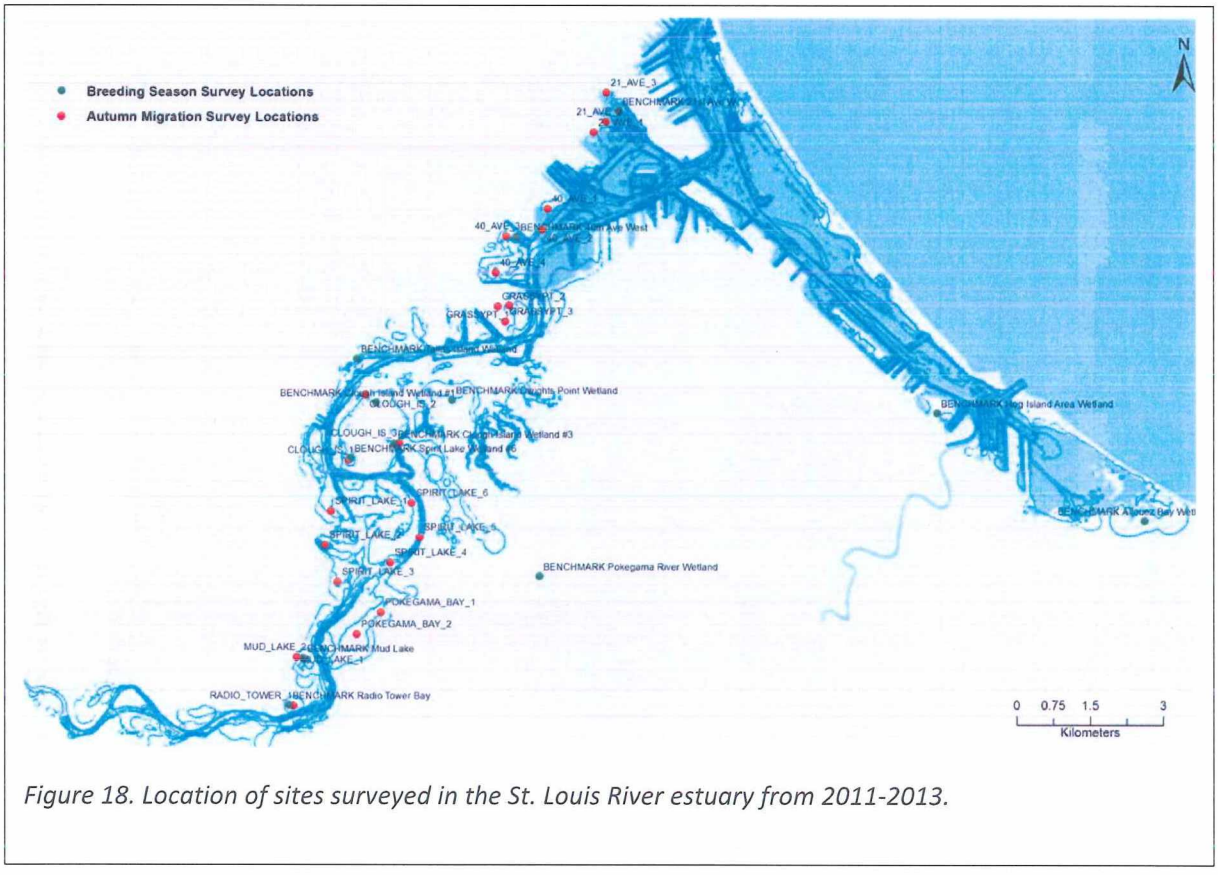


Figure 18. Location of sites surveyed in the St. Louis River estuary from 2011-2013.

Methods

Sampling protocols for breeding and migratory surveys varied due to differences in the seasonal distribution of species. Specific sampling methods for each season are detailed below. For all surveys,

unlimited-distance counts of bird observations were recorded at each site. Samples from both seasons were collected from a boat or canoe at fixed locations within each wetland (Figure 19). All bird observations were recorded by observation type (e.g., singing, visual observation). All surveys were completed by individuals experienced in conducting avian field surveys including those who have passed identification tests for bird songs, a visual bird species test, and a hearing test to ensure no hearing loss.

Breeding Season

Full details of our methods for sampling breeding birds can be found in Uzarski *et al.* (2014) or upon request. Briefly, depending on wetland size, from 1-6 point count locations were established in each wetland. If there was more than one survey point, then they were separated by a minimum of 250 m. At each point count location, all bird observations were recorded using unlimited-distance point counts, but estimated within 50 m, 100 m, or greater than 100 m. Each survey consisted of a 15-minute observation period (5 minutes of passive observation, 5 minutes of broadcast playback, and 5 minutes of passive observation). The playback recordings included broadcast calls of five focal species, which were pre-designated by GLCWC (2008). They include the Least Bittern, Sora, Virginia Rail, Common Moorhen, and Pied-billed Grebe. During the breeding season, two surveys separated by a minimum of 15 days were completed at each point count location within each wetland. One survey was a morning survey (0.5 hr before sunrise to 4 hr after sunrise) and the other survey was an evening survey (4 hr before sunset to sunset).

Fall Migration

Full details for our methods for sampling migratory birds in the St. Louis River estuary can be found in Niemi and Bracey (2013). Sampling methods for documenting migratory bird use vary from that of breeding season surveys in several ways. The survey period is reduced from 15 minutes to 10 minutes with the elimination of the 5 minute callback recordings. Bird observations were also mapped on aerial photo field sheets to document spatial use of the area and to allow comparison to studies completed in the 1970's (Niemi *et al.* 1979). Surveys were completed weekly from early September through early November 2013 for a total of 5 samples per site. Fall surveys were completed from approximately 0800-1400 hrs.

Site Summarization

Species richness and abundance were summarized for each of the three sites within Clough Island and for other sites sampled within the St. Louis River (Table 13). Observations are presented as raw numbers for each site. Some sites were sampled multiple times from 2011-2013, so effort is also provided for sampling during the breeding season and autumn migration (Table 13). Birds were also combined into seven groups (corvid, gull, raptor, shorebird, songbird, waterbird, and waterfowl) to simplify comparisons among sites.

Table 13. Site names, abbreviations, and numbers are listed for each site surveyed for birds in the St. Louis River estuary. The number of surveys for each site is listed by season (autumn migration or breeding season).

Site Name	Abbrev.	Site numbers	No. point counts	No. visits/site	
				Autumn migration	Breeding Season
21st Avenue West	21st	7049	3	5	7
40th Avenue West	40th	7048	4	5	4
Allouez Bay	Allouez	1077	3	0	6
Cedar Yard Bay	Cedar Yd	7050	1	5	6
Clough Island	Clough	1089, 1102, 1201	3	5	2
Dwights Point Wetland	Dwights Pt	1088	1	0	2
Grassy Point	Grassy Pt	NA	3	5	0
Hog Island Area Wetland	Hog Isl	1079	2	0	2
Mud Lake	Mud LK	7064	2	5	2
Pokegama River Wetland	Pokeg.	1096	2,3	0	6
Spirit Lake East	Spirit_West	7063	3	5	0
Spirit Lake West	Spirit_East	NA	3	5	0
Tallas Island Wetland	Tallas	1090	1	0	1

Autumn Migration

Clough Island Sites

Each of the three wetland sites within Clough Island were sampled a total of 5 times for migrating birds from 5 Sept – 14 Nov 2013. During this time, 168 individual birds and 27 species were recorded within the three wetland sites (Table 14). Species observations of 10 or more individuals included the following: Common Goldeneye (COGO), Mallard (MALL), Ring-billed Gull (RBGU), Canada Goose (CAGO), American Goldfinch (AMGO), Bufflehead (BUFF), and Double-crested Cormorant (DCCO; Table 15). Within the three sites, waterbirds and waterfowl were most commonly observed during autumn migration, followed by songbirds (Figure 19b). Bald Eagles (BAEA) were also commonly observed roosting or hunting in the area.

Other sites in the St. Louis River Estuary

Observations from seven other wetland locations were summarized by bird groups for comparison to Clough Island data (Figures 20 and 21).

Table 14. Species richness and abundance of birds observed during autumn migration 2013 at the three Clough Island sites and several other locations within the St. Louis River estuary. Each location was surveyed 5 times between early September and early November.

Sites	Species Richness	No. of Individuals	No. of Surveys	Mean no. of birds/survey	Std Error
Clough Island					
1089	13	52	5	9.8	4.9
1102	15	49	5	10.4	4.0
1201	18	67	5	13.4	8.3
Other St. Louis River sites					
21st	30	4412	5	294.1	86.1
40th	25	669	5	34.9	19.1
Cedar Yd	16	268	5	53.6	15.0
Grassy Pt	30	311	5	29.0	8.4
Mud LK	23	291	5	29.1	15.5
Spirit_East	17	615	5	41.4	38.0
Spirit_West	23	833	5	57.0	21.6

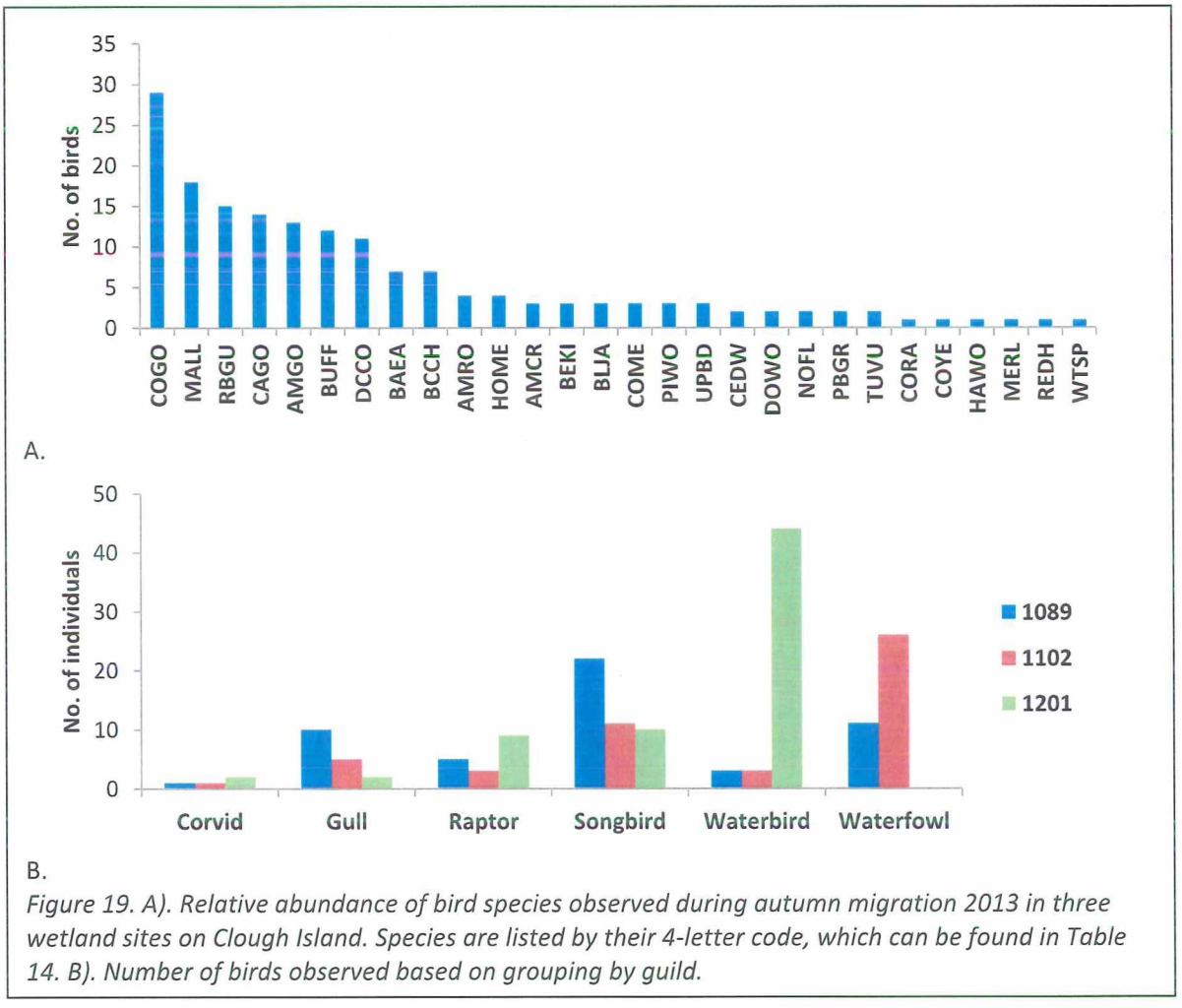


Figure 19. A). Relative abundance of bird species observed during autumn migration 2013 in three wetland sites on Clough Island. Species are listed by their 4-letter code, which can be found in Table 14. B). Number of birds observed based on grouping by guild.

Table 15. Bird observations made during autumn migration 2013 and breeding season surveys (2011-2013) at the three Clough Island sites. Numbers of observations are listed by taxa along with the 4-letter alpha code used in graphs. Note that these data are from unlimited distance point counts and, thus, are not restricted to the wetlands.

Taxa	Alpha Code	Migration	Breeding
Alder Flycatcher (*Empidonax alnorum*)	ALFL	0	1
American Bittern (*Botaurus lentiginosus*)	AMBI	0	1
American Coot (*Fulica americana*)	AMCO	0	1
American Crow (*Corvus brachyrhynchos*)	AMCR	3	2
American Goldfinch (*Spinus tristis*)	AMGO	13	3
American Redstart (*Setophaga ruticilla*)	AMRE	0	13
American Robin (*Turdus migratorius*)	AMRO	4	0
Bald Eagle (*Haliaeetus leucocephalus*)	BAEA	7	2
Belted Kingfisher (*Megaceryle alcyon*)	BEKI	3	0
Black-and-white Warbler (*Mniotilta varia*)	BAWW	0	2
Black-capped Chickadee (*Poecile atricapillus*)	BCCH	7	1
Black-throated Green Warbler (*Setophaga virens*)	BTNW	0	2
Blue Jay (*Cyanocitta cristata*)	BLJA	3	0
Bufflehead (*Bucephala albeola*)	BUFF	12	0
Canada Goose (*Branta canadensis*)	CAGO	14	7
Cedar Waxwing (*Bombycilla cedrorum*)	CEDW	2	3
Chipping Sparrow (*Spizella passerina*)	CHSP	0	3
Common Goldeneye (*Bucephala clangula*)	COGO	29	0
Common Merganser (*Mergus merganser*)	COME	3	0
Common Raven (*Corvus corax*)	CORA	1	0
Common Tern (*Sterna hirundo*)	COTE	0	12
Common Yellowthroat (*Geothlypis trichas*)	COYE	1	15
Chestnut-sided Warbler (*Setophaga pensylvanica*)	CSWA	0	1
Double-crested Cormorant (*Phalacrocorax auritus*)	DCCO	11	0
Downy Woodpecker (*Picoides pubescens*)	DOWO	2	0
Hairy Woodpecker (*Picoides villosus*)	HAWO	1	0
Hooded Merganser (*Lophodytes cucullatus*)	HOME	4	0
Least Bittern (*Ixobrychus exilis*)	LEBI	0	2
Mallard (*Anas platyrhynchos*)	MALL	18	1
Marsh Wren (*Cistothorus palustris*)	MAWR	0	1
Merlin (*Falco columbarius*)	MERL	1	0
Northern Flicker (*Colaptes auratus*)	NOFL	2	2
Ovenbird (*Seiurus aurocapilla*)	OVEN	0	4
Pied-billed Grebe (*Podilymbus podiceps*)	PBGR	2	0
Pileated Woodpecker (*Dryocopus pileatus*)	PIWO	3	0
Red-breasted Nuthatch (*Sitta canadensis*)	RBNU	0	1
Red-eyed Vireo (*Vireo olivaceus*)	REVI	0	9

Table 15 (cont.).

Taxa	Alpha Code	Migration	Breeding
Redhead (*Aythya americana*)	REDH	1	0
Red-winged Blackbird (*Agelaius phoeniceus*)	RWBL	0	140
Ring-billed Gull (*Larus delawarensis*)	RBGU	15	28
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	RBGR	0	3
Song Sparrow (*Melospiza melodia*)	SOSP	0	17
Swamp Sparrow (*Melospiza georgiana*)	SWSP	0	7
Turkey Vulture (*Cathartes aura)*	TUVU	2	0
Veery (*Catharus fuscescens*)	VEER	0	8
Virginia Rail (*Rallus limicola*)	VIRA	0	1
White-throated Sparrow (*Zonotrichia albicollis*)	WTSP	1	3
Yellow Warbler (*Setophaga petechia*)	YWAR	0	26
Unknown		3	8

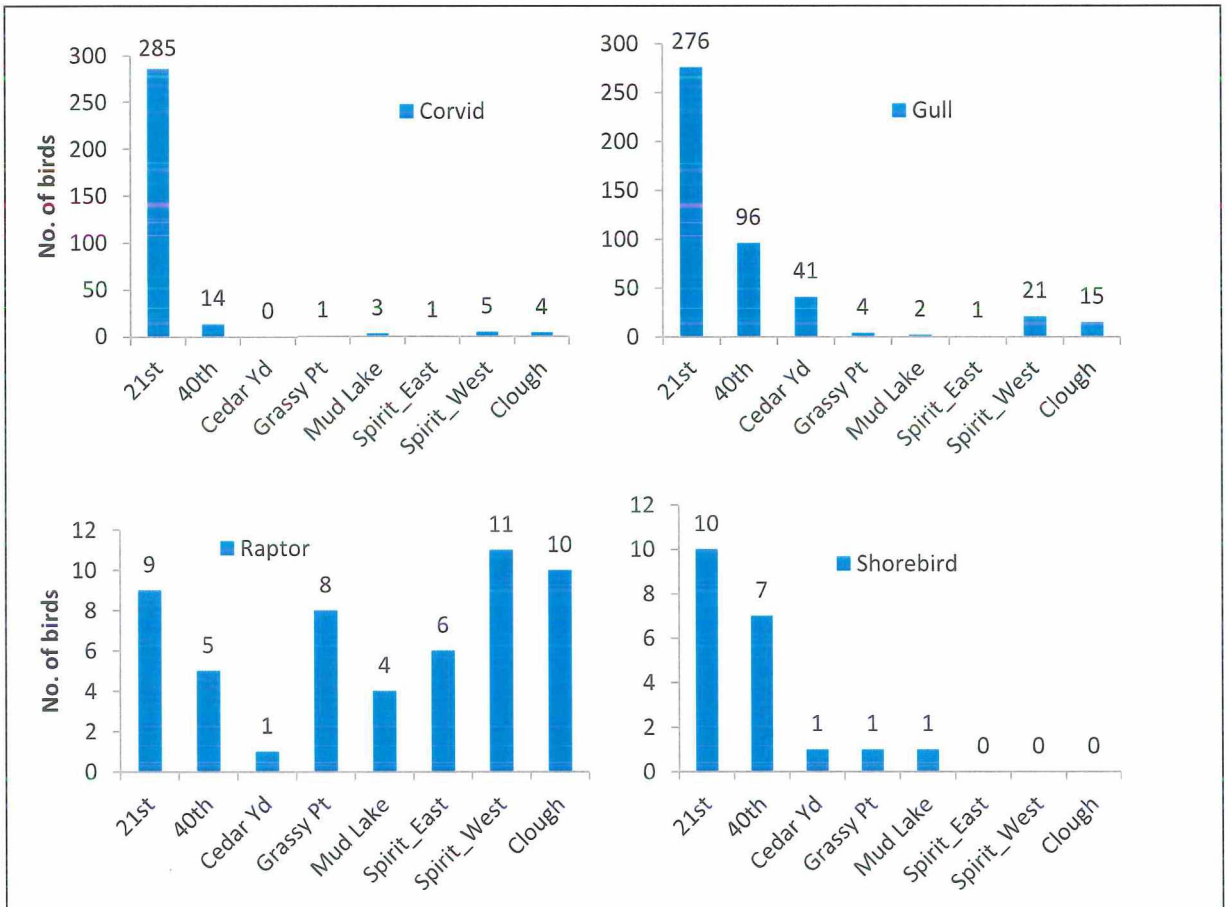


Figure 20. Bird observations by guild for the eight sites surveyed in the St. Louis River. Numbers represent the total number of birds from each guild observed at a site.

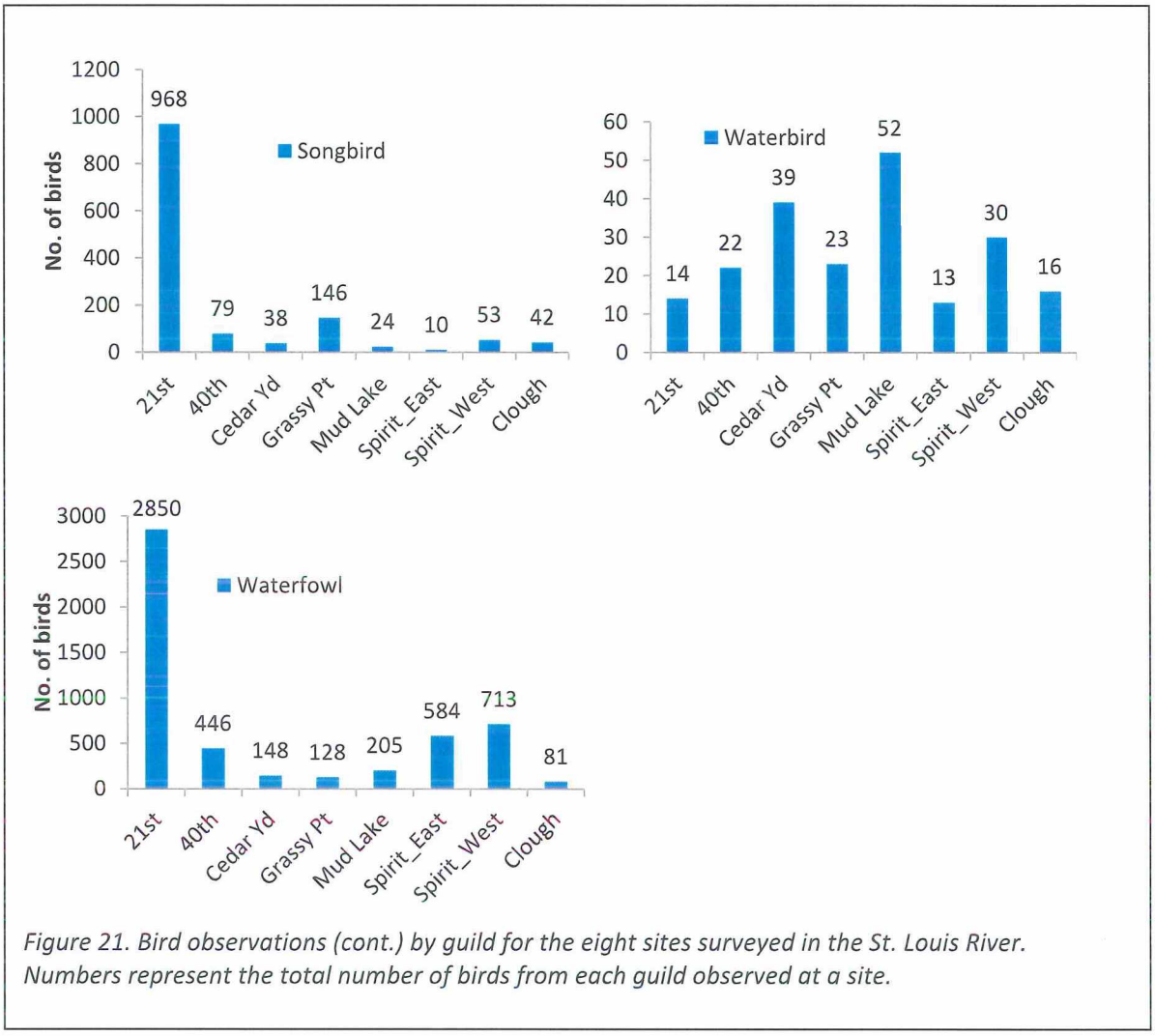


Figure 21. Bird observations (cont.) by guild for the eight sites surveyed in the St. Louis River. Numbers represent the total number of birds from each guild observed at a site.

Bird use at Clough Island relative to other sites in the estuary during migration

During migration many species rely on the St. Louis River as a stopover location to rest and forage en route to and from their breeding grounds. Birds seek areas that offer protection from predators and adverse weather (e.g. a protected bay), while also offering good foraging opportunities. Corvid observations decreased at sites surveyed farther up river, away from the highly industrialized locations near 21st and 40th Avenue West. Corvid observations, primarily American Crow, were most heavily concentrated near 21st Avenue West. Gull use, primarily by Ring-billed and Herring Gull were also concentrated near 21st and 40th Avenue West, foraging near the Western Lake Superior Sanitary District (WLSSD). Raptor observations on Clough Island were high relative to other sites and were primarily observations of Bald Eagle. Shorebird observations were low at all sites surveyed, but were highest at 21st and 40th Avenue West. Although songbird observations were highest at 21st Avenue West, the majority were European Starling (66%), a non-native species. The greatest songbird diversity was observed at Grassy Point. Waterbird observations were highest at Mud Lake and Cedar Yard Bay. The two species observed most frequently at these sites were American Coot and Pied-billed Grebe.

Waterbird observations at Clough Island were Double-crested Cormorant (11), Belted Kingfisher (3), and Pied-billed Grebe (2). Waterfowl observations were lowest at Clough Island relative to other sites. The highest numbers of waterfowl observations were at 21st Avenue West, with 98% of the observations being Canada Goose (56%) and Mallard (42%). However, species richness at Clough Island was comparable to other locations. Seven species of waterfowl were observed at Clough Island; Common Goldeneye (29), Mallard (18), Canada Goose (14), Bufflehead (12), Hooded Merganser (4), Common Merganser (3), and Redhead (1). Species richness ranged from five to ten species, with the highest richness observed at Mud Lake. Clough Island is more exposed to wind and wave action than many of the other protected wetland locations within the St. Louis River, which may explain lower use of the area by waterfowl and waterbirds.

Breeding Season

Clough Island

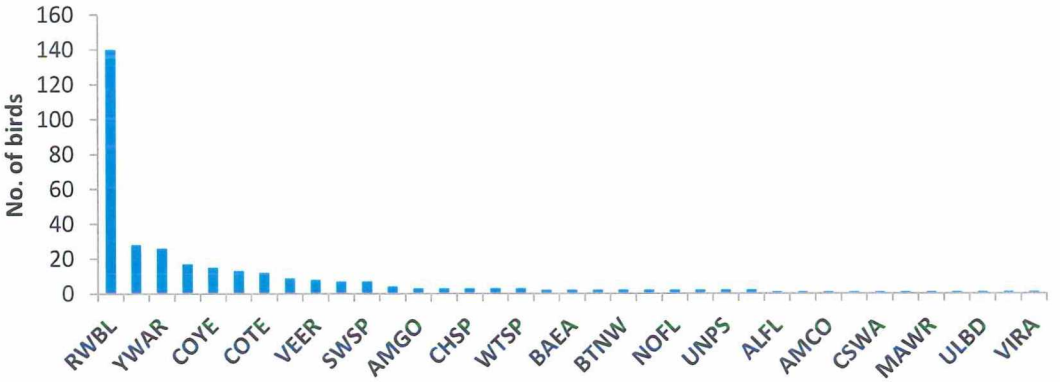
Each of the three Clough Island sites was sampled twice during the breeding season. Site 1102 was surveyed in June 2012 and sites 1089 and 1201 were surveyed in June 2013. A total of 330 individual birds and 36 species were observed during these surveys (Table 16). Species observations of 10 individuals or more included the following: Red-winged Blackbird (RWBL), which was the dominant species observed at each site, followed by Ring-billed Gull (RBGU), Yellow Warbler (YWAR), Song Sparrow (SOSP), Common Yellowthroat (COYE), American Redstart (AMRE), and Common Tern (COTE). For all three sites, the majority of observations consisted of songbirds (Figure 22b.), many of which were wetland-associated species such as Red-winged Blackbird, Yellow Warbler, Swamp Sparrow, and Common Yellowthroat. Other songbird observations consisted of shrub (American Redstart) or forest dwelling species such as Red-eyed Vireo, Black-throated Green Warbler, Veery, and Ovenbird.
In general, the taxa observed at each Clough Island site were similar. Species diversity was higher at sites 1089 and 1201 than at site 1102. There were also higher densities of individual birds observed at 1089 and 1201. Several species of interest occurred at these sites including the Least Bittern (site 1089), American Bittern, and Virginia Rail (both at site 1201). The Least and American Bittern are both species of special concern in Wisconsin. All three species are secretive wetland birds that are often difficult to detect. Each of these individuals responded to the playback recordings. Another important observation was that Common Tern, a state endangered species in Wisconsin, were frequently observed foraging at the Clough Island study sites. This species currently only nests at Interstate Island in St. Louis River Estuary.

Other sites in the St. Louis River estuary

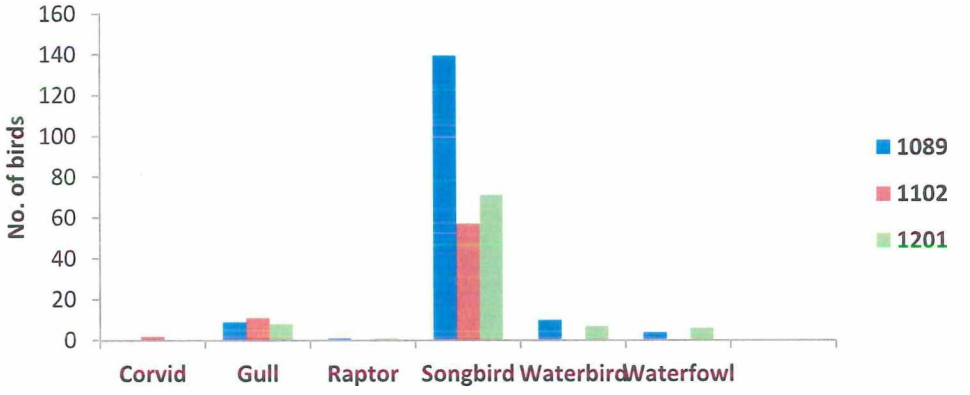
To compare bird use during the breeding season on Clough Island to other wetland locations within the St. Louis River estuary, species were placed into guilds for ease of summarization. Data from nine other wetland locations were summarized by guild along with Clough Island data (Table 16; Figure 23).

Table 16. Species richness and abundance of birds observed during breeding season surveys (June-early July), at the three Clough Island sites and several other locations within the St. Louis River estuary. Each location was surveyed at least twice from 2011-2013.

Sites	Species Richness	No. of Individuals	No. of surveys	Mean #/survey	Std Error
Clough Island					
1089	21	164	2	82	6
1102	13	73	2	36.5	18.5
1201	23	93	2	46.5	8.5
Other St. Louis River estuary sites					
21st Ave W	24	537	4	134.3	26.3
40th Ave W	35	473	3	157.7	93.3
Allouez	44	380	3	126.7	27.1
Cedar Yd	28	109	6	36.3	7.22
Dwights Pt	29	76	2	76.0	0.0
Hog Isl	27	160	3	104.0	28.0
Mud LK	34	105	1	105.0	0.0
Pokeg.	50	346	3	115.3	13.9
Tallas	20	70	1	70.0	0.0



A.



B.

Figure 22. A). Relative abundance of bird species observed during the breeding season in three wetland sites on Clough Island. B). Number of birds observed based on grouping by guild.

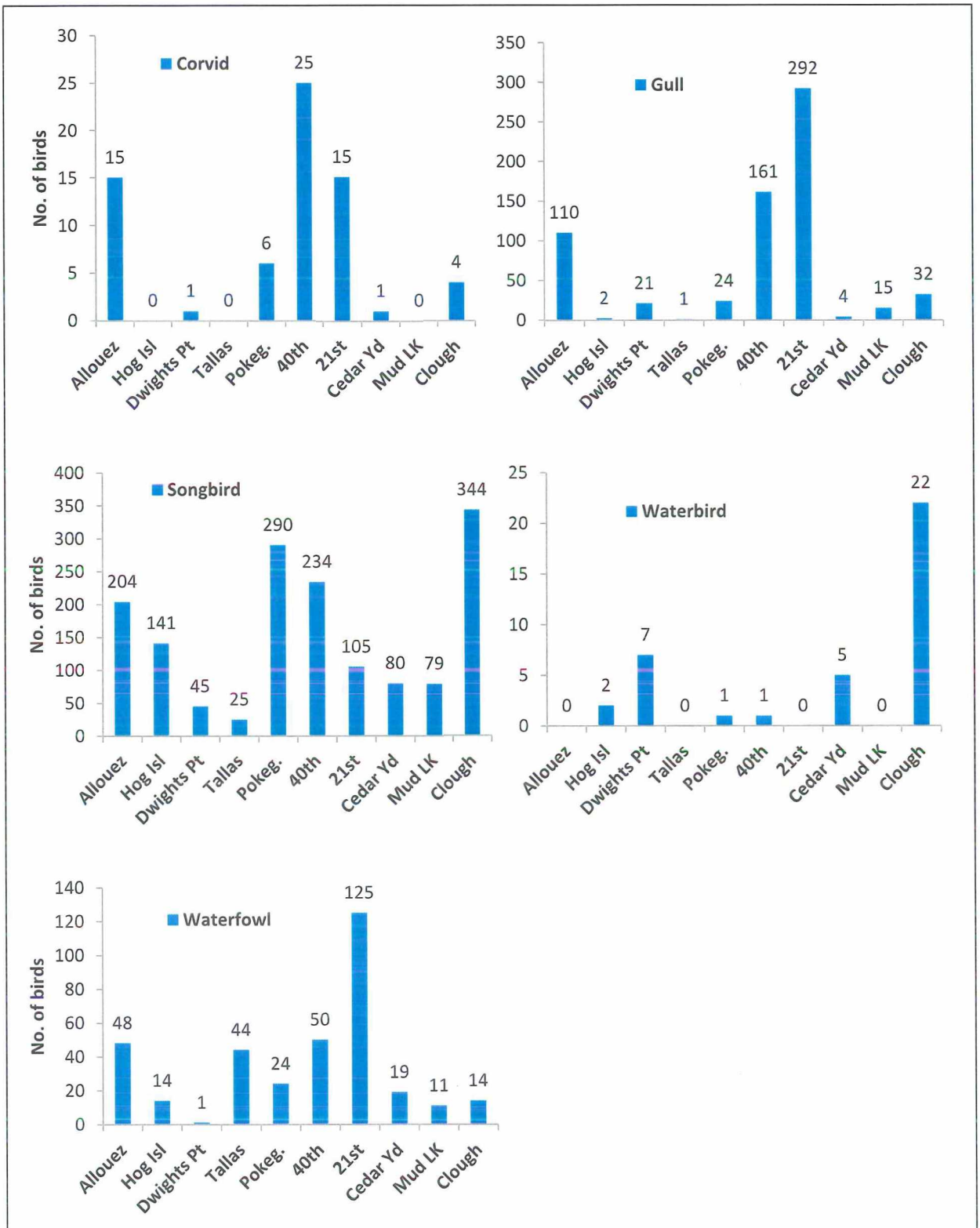


Figure 23. Bird observations by guild for the 9 sites surveyed in the St. Louis River estuary. Numbers represent the total number of birds from each guild observed at a site.

Breeding season bird use at Clough Island relative to other sites in the estuary

During the breeding season, Corvid observations, primarily American Crow, remained low at all sites. The number of American Crow observations at 21st Avenue West were also lower. Gull observations (Ring-billed and Herring) were similar to those observed during migration. There were only 4 raptor observations, one at 40th Avenue West and the other 3 at Clough Island; all observations were of Bald Eagle. Note that the Bald Eagle nests on one of the small islands to the southwest of Clough Island in Minnesota. There were no shorebird observations at Clough Island and only two detected at Allouez Bay (American Woodcock and Wilson's Snipe). Songbird observations on Clough Island were high relative to the other locations surveyed. There were 27 species of songbird observed (Table 16), the four most common species were Red-winged Blackbird, Yellow Warbler, Common Yellowthroat, and American Redstart. Waterbird observations on Clough Island were higher than all other locations during the breeding season. There were 22 individual observations which consisted of American Bittern, Least Bittern, Virginia Rail, and Common Tern. Common Terns foraging near Clough Island made up the largest proportion of waterbird observations (77%). In all other sites combined, there were a total of 16 waterbird observations, which consisted of Virginia Rail, Common Tern, Great Blue Heron, and Double-crested Cormorant. A total of 12 identifiable waterfowl were observed at Clough Island (9 Canada Goose and 3 Mallard). The largest number of waterfowl observations was at 21st Avenue West, where 81 Canada Goose and 28 Mallard were observed.

Summary

Bird use at Clough Island varied between autumn migration and the breeding season. Clough Island wetlands are more exposed to the elements than many of the other wetlands within the St. Louis River. This may explain why migrating waterfowl and waterbirds were observed infrequently in these locations, relative to other wetlands in the estuary. However, the isolation of the island may benefit breeding birds, because there is less human disturbance on Clough Island and potentially reduced predation pressure. The presence of secretive marsh birds indicates that these sites are receiving minimal disturbance. Documenting Common Tern foraging in the area is also an important observation because of their conservation status. The forested landscape of Clough Island also provides suitable habitat for forest dwelling songbirds, which were recorded in large numbers during the breeding season. Waterfowl numbers were low during both breeding season and migration likely because of the relatively exposed shoreline.

Overall summary

Better than average water quality at Clough Island wetlands (for chloride and conductivity), as compared to most other SLR estuary wetlands, demonstrates the island's distance from human development. However, these wetlands still are located in the St. Louis River estuary, and thus have poorer quality by many measures than nearby Lake Superior wetlands.

In particular, Clough Island wetlands had poorly-developed wet meadow zones compared to Lake Superior wetlands. Most of the Clough Island wetland areas were dominated by an emergent vegetation zone. Submergent vegetation was very patchy, and research by US EPA (Angradi, pers. comm.) found that SAV abundance across the whole estuary varies yearly depending on turbidity levels. In addition, Island wetlands have higher exposure to wind and wave action than do wetlands in secluded bays, which also affects the development of extensive aquatic vegetation beds.

Clough wetlands had both high quality and low quality vegetation species, with purple loosestrife and invasive cattail particularly prevalent at 1089. Therefore, floristic quality values were very similar to other estuary sites, but lower than nearby Lake Superior wetlands that had fen components.

Clough Island wetland fyke net fish catches were skewed toward warmer water fish (e.g., sunfish) than nearby Lake Superior sites, and water temperatures were substantially higher in the SLR estuary than in Lake Superior wetlands. Clough Island wetland site 1089 also had the most invasive tubenose gobies comprising a fish catch. In contrast, site 1089 had the greatest fish taxa richness. Clough Island wetlands did not provide as much habitat for YOY fish as did highly vegetated, secluded bays.

Site 1102 had the greatest number of habitats and included a floating bog mat. Thus, macroinvertebrate richness was highest at site 1102, and more sensitive macroinvertebrates were present at this site. Site 1201 had the fewest habitats, and it had the lowest taxa richness for fish and macroinvertebrates (although sampling effort was also lowest at this site due to the lack of habitats). An invasive, non-native snail (*Bithynia*, the faucet snail) was found in all wetlands, but made up 7% of the macroinvertebrates collected from site 1201. This was different from nearby Lake Superior wetlands, in which no invasive macroinvertebrates were found.

Bird use at Clough Island was different in some ways from other estuary wetlands. Wind and wave exposure and lack of protection may explain why migrating waterfowl and waterbirds were less commonly observed at Clough Island wetlands relative to other estuary wetlands. However, the island's isolation, lack of human usage, and potential for lower numbers of predators may benefit breeding birds, and forest-dwelling songbirds that were detected in large numbers during the breeding season. This idea is reinforced by the detection of secretive marsh birds and the foraging by Common Tern.

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Appendix 1. Aquatic macroinvertebrates collected in each of the three Clough Island wetlands sampled in 2011 and 2013 following methods used by the Great Lakes Coastal Wetland Monitoring Project (Uzarski et al. 2014).

phylum	class	order	family	taxa	1089	1102	1201
Annelida	Clitellata			Hirudinea		X	
Annelida	Clitellata			Oligochaeta	X	X	X
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Glossiphoniidae	X	X	X
Arthropoda	Arachnida			Acari	X	X	X
Arthropoda	Insecta	Coleoptera	Chrysomelidae	Chrysomelidae		X	
Arthropoda	Insecta	Coleoptera	Curculionidae	Curculionidae		X	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus		X	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Liodessus		X	
Arthropoda	Insecta	Coleoptera	Elmidae	Macronychus	X		
Arthropoda	Insecta	Coleoptera	Gyrinidae	Dineutus	X	X	X
Arthropoda	Insecta	Coleoptera	Gyrinidae	Gyrinus	X		X
Arthropoda	Insecta	Coleoptera	Haliplidae	Haliplus	X	X	
Arthropoda	Insecta	Coleoptera	Haliplidae	Peltodytes		X	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia or Palpomyia	X	X	
Arthropoda	Insecta	Diptera	Chironomidae	Chironomidae	X		X
Arthropoda	Insecta	Diptera	Chironomidae	Chironomini or Pseudochironomini	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	Tanytarsini	X		
Arthropoda	Insecta	Diptera	Ephydridae	Ephydridae	X	X	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	X	X	X
Arthropoda	Insecta	Ephemeroptera	Baetidae	Procloeon	X	X	X
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis	X	X	
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Ephemeridae	X		
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Hexagenia	X		X
Arthropoda	Insecta	Hemiptera	Belostomatidae	Belostoma	X	X	
Arthropoda	Insecta	Hemiptera	Belostomatidae	Belostomatidae	X	X	X
Arthropoda	Insecta	Hemiptera	Corixidae	Corixidae	X	X	X
Arthropoda	Insecta	Hemiptera	Corixidae	Hesperocorixa		X	
Arthropoda	Insecta	Hemiptera	Corixidae	Palmacorixa	X	X	X
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara		X	
Arthropoda	Insecta	Hemiptera	Corixidae	Trichocorixa	X	X	X
Arthropoda	Insecta	Hemiptera	Gerridae	Gerridae			X
Arthropoda	Insecta	Hemiptera	Gerridae	Gerris	X	X	
Arthropoda	Insecta	Hemiptera	Hydrometridae	Hydrometra			X
Arthropoda	Insecta	Hemiptera	Mesoveliidae	Mesovelia	X	X	X
Arthropoda	Insecta	Hemiptera	Nepidae	Ranatra		X	X
Arthropoda	Insecta	Hemiptera	Notonectidae	Notonecta		X	X
Arthropoda	Insecta	Hemiptera	Notonectidae	Notonectidae		X	X
Arthropoda	Insecta	Hemiptera	Pleidae	Neoplea		X	X
Arthropoda	Insecta	Hemiptera	Veliidae	Veliidae	X		
Arthropoda	Insecta	Lepidoptera		Lepidoptera	X		
Arthropoda	Insecta	Lepidoptera	Crambidae	Crambidae			X
Arthropoda	Insecta	Odonata		Libellulidae or Corduliidae		X	
Arthropoda	Insecta	Odonata	Aeshnidae	Anax		X	X

Appendix 1, cont.

phylum	class	order	family	taxa	1089	1102	1201
Arthropoda	Insecta	Odonata	Coenagrionidae	Coenagrionidae	X	X	X
Arthropoda	Insecta	Odonata	Coenagrionidae	Ischnura		X	X
Arthropoda	Insecta	Odonata	Corduliidae	Corduliidae	X	X	X
Arthropoda	Insecta	Odonata	Libellulidae	Leucorrhinia		X	
Arthropoda	Insecta	Odonata	Libellulidae	Libellulidae		X	
Arthropoda	Insecta	Odonata	Libellulidae	Sympetrum		X	X
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	X		
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira		X	
Arthropoda	Insecta	Trichoptera	Leptoceridae	Leptoceridae		X	
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis		X	X
Arthropoda	Insecta	Trichoptera	Phryganeidae	Phryganeidae		X	
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Neureclipsis	X		
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus		X	
Arthropoda	Malacostraca	Amphipoda		Amphipoda	X	X	X
Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx		X	
Arthropoda	Malacostraca	Amphipoda	Gammaridae	Gammaridae	X	X	X
Arthropoda	Malacostraca	Amphipoda	Gammaridae	Gammarus	X	X	X
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	Hyalella azteca	X	X	X
Arthropoda	Malacostraca	Isopoda	Asellidae	Caecidotea	X	X	X
Cnidaria	Hydrozoa	Anthoathecatae	Hydridae	Hydra	X		X
Mollusca	Bivalvia	Veneroida	Pisidiidae	Musculium		X	X
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidiidae		X	X
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium		X	
Mollusca	Bivalvia	Veneroida	Pisidiidae	Sphaerium	X	X	
Mollusca	Gastropoda	Basommatophora	Ancylidae	Ancylidae		X	
Mollusca	Gastropoda	Basommatophora	Ancylidae	Ferrissia	X		
Mollusca	Gastropoda	Basommatophora	Ancylidae	Laevapex		X	
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaea		X	
Mollusca	Gastropoda	Basommatophora	Physidae	Physella or Physa	X	X	X
Mollusca	Gastropoda	Basommatophora	Planorbidae	Gyraulus	X	X	X
Mollusca	Gastropoda	Basommatophora	Planorbidae	Helisoma		X	X
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbella		X	X
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbidae	X	X	X
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbula	X	X	
Mollusca	Gastropoda	Basommatophora	Planorbidae	Promenetus			X
Mollusca	Gastropoda	Heterostropha	Valvatidae	Valvata	X	X	X
Mollusca	Gastropoda	Neotaenioglossa	Bithyniidae	Bithynia	X	X	X
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	Hydrobiidae	X	X	X
Platyhelminthes	Turbellaria			Turbellaria	X	X	X

Appendix 2. Plant species observed in quadrats at Clough Island wetland sites in 2012-2013. Coefficient of Conservatism (C^M) values were taken from a Great Lakes-wide list from the state of Michigan; C- values from Wisconsin (C^W) are presented for comparison. Wetland site values represent the proportion of quadrats where species were observed (1089 had 15 quadrats, 1102 had 30, and 1201 had 25).

Species	Code	Common Name	C^M	C^W	1089	1102	1201
Alisma plantago-aquatica	Alis pla	Water-plaintain	1	3		0.07	
Alnus incana	Alnu inc	mountain alder	5	4	0.07		0.04
Bolboschoenus fluviatilis	Bolb flu	river bulrush	6	6	0.27	0.03	0.08
Calamagrostis canadensis	Cala can	Blue-joint	3	5			0.04
Calla palustris	Call pal	Wild Calla	10	9	0.07	0.17	
Carex lacustris	Care lac	Lake Sedge	6	6	0.20	0.40	0.12
Carex lasiocarpa	Care las	Woolly-fruit Sedge	8	9		0.23	
Carex utriculata	Care utr	Rostrate Sedge	5	7	0.07	0.03	0.04
Ceratophyllum demersum	Cera dem	Coontail	1	3	0.27	0.37	0.68
Chamaedaphne calyculata	Cham cal	Leatherleaf	8	9		0.10	
Cicuta maculata	Cicu mac	Spotted Water-hemlock	4	6	0.07		
Comarum palustre	Coma pal	Marsh Cinquefoil	7	8	0.33	0.20	
Eleocharis palustris	Eleo pal	common spikerush	5	6	0.07	0.03	0.24
Galium tinctorium	Gali tin	Bedstraw	5	5		0.10	
Impatiens capensis	Impa cap	Orange Touch-me-not	2	2	0.20		0.04
Iris versicolor	Iris ver	Varicolored Iris	5	5	0.13	0.03	
Lemna minor	Lemn min	Duckweed	5	4	0.47	0.03	0.08
Lemna trisulca	Lemn tri	Star Duckweed	6	6		0.10	
Lycopus uniflorus	Lyco uni	Water-horehound	2	4	0.07		
Lysimachia thyrsiflora	Lysi thr	Thyrse Loosestrife	6	7	0.13	0.17	
Lythrum salicaria	Lyth sal	Purple Loosestrife	0	0	0.73	0.17	0.08
Mentha arvensis	Ment arv	Field Mint	3	3			0.04
Myrica gale	Myri gal	Sweet Gale	6	9	0.60	0.17	
Myriophyllum sibiricum	Myri sib	Common Water-milfoil	10	6	0.07	0.07	
Najas flexilis	Naja flex	Naiad	5	5			0.28
Nymphaea odorata	Nymp odo	White Water-lily	6	6		0.13	0.32
Onoclea sensibilis	Onoc sen	Sensitive Fern	2	5	0.07		
Polygonum persicaria	Poly per	Lady's-Thumb	0	0		0.03	
Potamogeton epihydrus	Pota epi	Pondweed	8	8		0.03	
Potamogeton foliosus	Pota fol	Leafy Pondweed	4	6		0.03	
Potamogeton natans	Pota nat	Floating Pondweed	5	5			0.40
Potamogeton nodosus	Pota nod	Node Pondweed	6	7			0.12
Potamogeton richardsonii	Pota ric	Richardson's Pondweed	5	5		0.10	0.24
Potamogeton spirillus	Pota spi	Spiral Pondweed	8	8		0.07	0.24
Potamogeton zosteriformis	Pota zos	Flat-stem Pondweed	5	6			0.12
Rumex orbiculatus	Rume orb	Great Water Dock	9	8	0.07		
Sagittaria latifolia	Sagi lat	Broad-leaved Arrowhead	1	3	1.00	0.33	0.04
Salix exigua	Sali exi	Sandbar Willow	1	2			0.04
Salix nigra	Sali nig	Black Willow	5	4		0.03	
Schoenoplectus tabernaemontani	Scho tab	Soft-stem Bulrush	4	4	0.13	0.10	0.28
Sparganium eurycarpum	Spar eur	Broad-fruit Bur-reed	5	5	0.67	0.07	0.12
Sparganium fluctuans	Spar flu	Floating Bur-reed	10	10		0.23	
Spirodela polyrrhiza	Spir pol	Greater Duckweed	6	5	0.40	0.07	0.08
Stuckenia pectinata	Stuc pec	Sago Pondweed	3	3			0.04
Triadenum fraseri	Tria fra	Fraser's St. John's-wort	6	8		0.03	
Typha angustifolia	Typh ang	Narrow-Leaf Cattail	0	0		0.43	
Typha latifolia	Typh lat	Broad-leaved Cattail	1	1		0.13	
Typha X glauca	Typh x g	Hybrid Cattail	0	0	0.67	0.20	0.20
Utricularia vulgaris	Utri vul	Common Bladderwort	6	7	0.07		
Vallisneria americana	Vall ame	Wild-celery	7	6		0.07	0.36