An association between marsh-nesting obligate bird species and submergent vegetation in lower Great Lakes coastal wetlands

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Introduction

Great Lakes coastal wetlands are areas of high diversity of flora and fauna and many studies have explored the relationships between the extent and/or types of vegetation and the quality of marsh bird communities (Steen *et al.* 2006, Peterson and Niemi 2007, Grabas *et al.* 2008). These wetlands support over 150 breeding bird species (Howe *et al.* 2007) including a number of species at risk such as King Rail (*Rallus elegans*), Least Bittern (*Ixobrychus exilis*) and Yellow Rail (*Coturnicops noveboracensis*). Floristically, coastal marshes are complex systems with different zones that are based on species' varying tolerances to water. These zones can be organized from lake to upland as follows: submergent, floating, emergent, meadow, and shrub (Environment Canada 2002, Simon and Stewart 2006). The most productive wetland habitat for marsh-nesting bird species is the hemi-marsh, a combination of emergent vegetation and open aquatic areas with submergent and floating vegetation (Gibbs *et al.* 1991, Crewe *et al.* 2006, Rehm and Baldassare 2007). Submergent and floating vegetation are primarily used by wetland birds for foraging but also for nesting and refugia (Sandilands 2005, Steen *et al.* 2006). The recent decline in populations of wetland obligate bird species (Tozer 2013) and historical loss of coastal wetlands in the Great Lakes basin (Snell 1987, Ducks Unlimited Canada 2010) has resulted in efforts to monitor the status of this guild and determine the factors that contribute to their distribution and abundance.

Submergent and floating vegetation at Big Creek National Wildlife Area *(Photo: Canadian Wildlife Service – Ontario).*

Marsh-nesting obligate bird species (hereafter marsh-nesting obligates) comprise a guild that depends on emergent vegetation and hemi-marsh habitat for nesting. This guild is a key indicator of the condition of the overall health of marshes in the region because their abundance is negatively associated with anthropogenic disturbance (EC and CLOCA 2004, Grabas *et al.* 2008). Past studies have illustrated relationships between the ecological condition of submergent vegetation communities and breeding marsh bird communities using indices of biotic integrity in Lake Ontario coastal wetlands (Grabas *et al.* 2012, CWS-ON unpub data).

In addition, positive relationships have been reported between the abundance of marsh birds and the quality of vegetation communities in coastal riverine wetlands in the upper Great Lakes and lakes Superior and Michigan (Peterson and Niemi 2007). The objective of this study was to determine whether there is a relationship between a component of the bird community and a component of the vegetation community; namely, the abundance of marsh-nesting obligates and the percent cover of submergent and floating-leaved vegetation at a regional scale in coastal wetlands of the lower Great Lakes (Fig. 1).

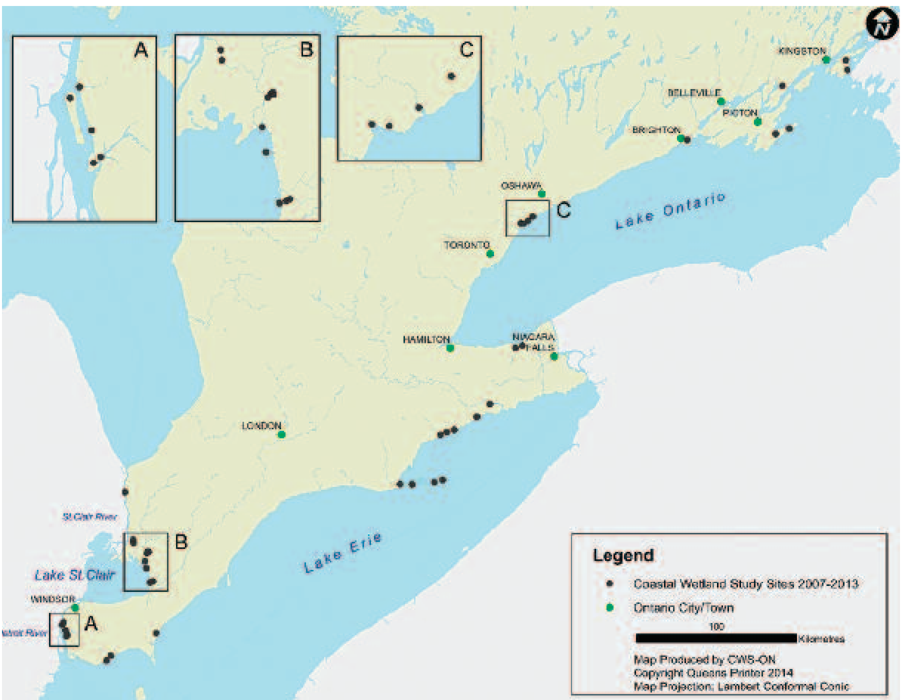


Figure 1: Coastal wetland study sites from 2007-2013 that were included in the analysis (Site names can be found in Table A1, Appendix 1).

Table 1. Marsh-nesting obligate birds identified in this study. Asterisks denote species targeted using call broadcast.

COMMON NAME	SCIENTIFIC NAME
Pied-billed Grebe*	*Podilymbus podiceps*
American Bittern	*Botaurus lentiginosus*
Least Bittern*	*Ixobrychus exilis*
Virginia Rail*	*Rallus limicola*
Sora*	*Porzana carolina*
Common Gallinule*	*Gallinula galeata*
American Coot*	*Fulica americana*
Black Tern	*Chlidonias niger*
Forster's Tern	*Sterna forsteri*
Marsh Wren	*Cistothorus palustris*
Swamp Sparrow	*Melospiza georgiana*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*

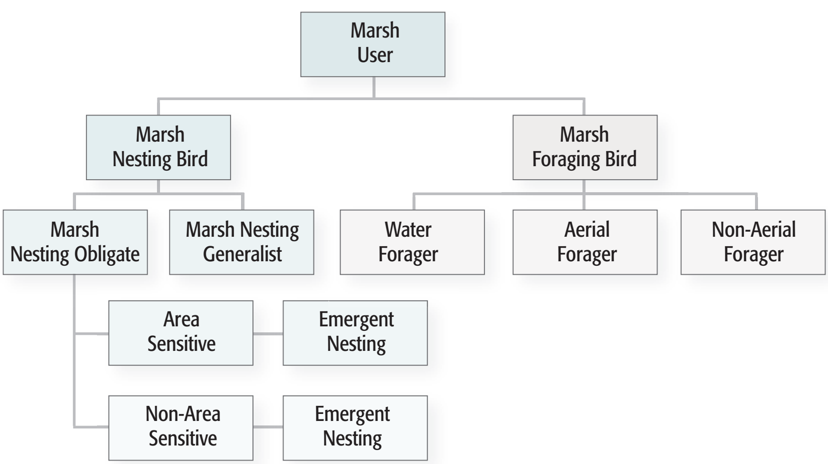
Common Gallinule at Mitchell's Bay, Lake St. Clair.
Photo: Denby E. Sadler

Methods

Marsh bird and submergent vegetation data from 41 coastal wetlands (Table A1 in Appendix 1) were compiled from surveys conducted during 2007-2013. Study sites were located along the shores of lakes Ontario, Erie, St. Clair and the Detroit and St. Clair rivers (Fig. 1). Sites were selected to include the full range of ecological conditions in coastal wetlands in the lower Great Lakes (CWS-ON 2012). Marsh birds were surveyed within 100m radius semicircular stations as per Great Lakes Marsh Monitoring Program protocol (Bird Studies Canada 2009). Where possible, stations were surveyed three times each year and were placed systematically throughout each wetland including throughout the interior following Meyer *et al.* (2006). Surveys included call broadcasts of especially secretive marsh obligate species to increase detections (Table 1). Marsh bird surveys were conducted during the May-July period. Marsh-nesting obligates in this study were based on those categorized by Meyer *et al.* (2006) and include area-sensitive and non-area-sensitive species that nest in emergent vegetation or hemi-marsh habitat (Fig. 2).

In each wetland, submergent vegetation was surveyed from a boat or canoe at 20 1m x 1m quadrats within the open water portion of the marsh. Quadrat locations were generated randomly prior to sampling and were located by GPS navigation. Within each quadrat, total percent cover (0-100%) and individual species percent covers (0-100%) were recorded for rooted floating and rooted submergent vegetation. Floating vegetation (*e.g.* pond lillies) was included in this analysis as it does not persist during winter but grows through the water to the surface each spring. Wetlands with extensive submergent communities are typically surveyed visually from above, and a rake is used to methodically sweep the water column, to collect and estimate the percent cover of species at different

Figure 2: Categorization of marsh bird species for Great Lakes coastal wetlands (Grabas *et al.* 2008 [adapted from Meyer *et al.* 2006]).



Identifying submergent plant species using a rake at Long Point NWA.
Photo: Canadian Wildlife Service –Ontario.

depths (Croft and Chow-Fraser 2009, Grabas *et al.* 2012). Care is taken when using a rake during surveys to limit disruption of the vegetation. Wetlands were sampled in July-August during maximal vegetative growth to capture the full extent of the submergent vegetation communities (EC and CLOCA 2004, Grabas *et al.* 2012).

Wetlands with complete data for both marsh birds and submergent vegetation were included in the analysis, which resulted in 80 wetland-years of data for 41 different wetlands (Table A1, Appendix 1). To investigate the relationship between submergent vegetation cover and marsh-nesting obligates, two variables were calculated for each wetland: the average maximum abundance (AMA) of marsh-nesting obligates and the average cumulative percent cover (CPC) of submergent vegetation species. A correlation was then calculated to determine the relationship between AMA and CPC. For descriptions of how the variables were created and other statistical details, please refer to Appendix 1.

Results

The abundance of marsh-nesting obligates recorded per wetland ranged from one to 15 with an average of five across 41 coastal wetlands in the lower Great Lakes. Submergent vegetation cover at these same wetlands ranged from 2% to 173% with an average of 73%. Submergent

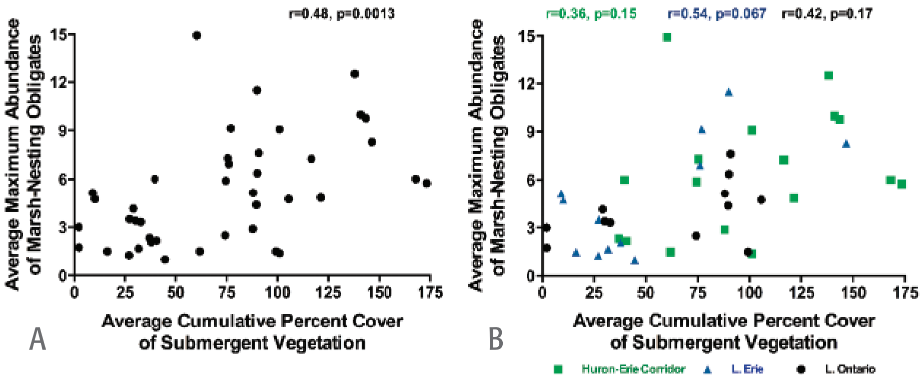


Figure 3. Average maximum abundance (AMA) of marsh-nesting obligates as a function of mean cumulative percent cover (CPC) of submergent vegetation for all of the data (A) and categorized by lake basin (B). Each data point represents a single coastal wetland (wetlands sampled in more than one year were averaged).

vegetation communities can occupy the entire water column; for instance, basal rosettes occupy the zone at the bottom, canopy species grow throughout, and floating species remain on the surface. Due to this stratification of submergent and floating vegetation at different depths, CPC was greater than 100% cover in many cases (x-axis, Fig. 3).

There was a significant positive relationship between AMA and CPC in 41 lower Great Lakes coastal marshes (r= 0.48, p<0.05) over the entire study period (2007-2013) (Fig. 3A). To account for the potential effect that larger wetlands may support greater abundances of birds, these data also were analyzed controlling for the number of stations (*i.e.* larger wetlands have more point counts). The significant positive relationship persisted when the number of stations was taken into account (r=0.47, p<0.05).

Analyzing the data by lake basin showed less agreement with the general trend, with the exception of wetlands along Lake Erie, which exhibited only a marginally significant positive relationship (r=0.54, p=0.067; Fig. 3B). Lake Ontario wetland data did not exhibit as large of a range in CPC values, with an upper limit near 100; although it did exhibit a great deal of variation in AMA at sites in the 80-105 CPC range (Fig. 3B).

The general relationships between marsh-nesting obligates and submergent vegetation presented above used a single averaged AMA and CPC value for a wetland over time (Fig. 3), however, over 70% of wetlands in the dataset were sampled in more than one year over the period of 2007-2013 (Table A1, Appendix 1). Repeating the analysis for each year and each year-lake combination separately did not yield any significant results with the exception of data collected in 2012. The 2012 data exhibited a significant positive relationship (r=0.69, p<0.05).

A representative wetland from each lake basin is presented in Fig. 4 and illustrates that generally, neither AMA nor CPC changed greatly from year to year for a given wetland. This consistency and relatively small variation over time provides some added confidence in the overall relationship presented in Fig. 3A, as each data point represents an average of the yearly data.

Discussion

In this study, a significant positive relationship between the number of marsh-nesting obligates and the cover of submergent vegetation in coastal marshes in the lower Great Lakes is presented. Although many of the target bird species nest exclusively in emergent vegetation, the fact that the extent of submergent vegetation is related to their abundance is of particular interest. Marsh bird communities are affected by a number of factors such as emergent vegetation cover, wetland size and isolation, and urban and rural land uses. This study suggests that submergent vegetation cover may also be an important factor that influences the abundances of marsh-nesting obligate birds in the region. In addition, a sizable portion of the differences (*i.e.* variation) in the abundance of marsh-nesting obligates (20%) can be explained by the amount of submergent vegetation at a

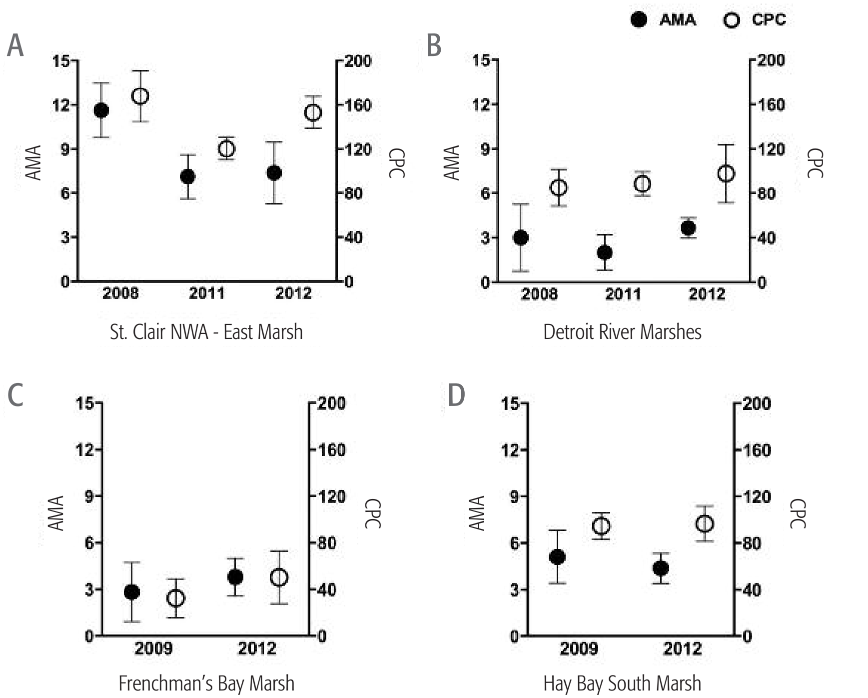


Figure 4. Regional examples (A-D) of the annual variation in average maximum abundance of marsh-nesting obligate birds (AMA) and mean cumulative percent cover of submergent vegetation (CPC) for wetlands with multiple years of data. Error bars represent the 95% confidence interval.

wetland. This is important because this study examined just the percent cover of vegetation and not the quality of this habitat, such as incorporating the number of native or pollution intolerant species. This is not to say that submergent vegetation drives bird communities, but simply highlights that the degree of cover of aquatic plants can provide a reasonable indication of the abundance of marsh-nesting obligate birds. There is still a great deal of variation in bird abundance that is not explained by submergent vegetation. It was not the purpose of this study to provide an exhaustive investigation into the factors that influence these communities but to use data that were available from wetland monitoring programs to identify an association with submergent vegetation. This study does however, provide some evidence that the existence of submergent vegetation may play a role in influencing how marsh-nesting birds select specific coastal wetlands for breeding and nesting. This has implications that managing wetlands for marsh birds should also include considerations for the submergent vegetation community.

Submergent vegetation may be an important habitat feature for marsh birds because it provides key habitat for common prey items such as aquatic macroinvertebrates, aerial insect larvae, amphibians and fish, and acts as a food source for herbivorous species such as Common Gallinule and American Coot who eat the vegetation directly. Submergent vegetation may also be used as nesting materials and refugia for young broods/fledgings. Sandilands (2005) identifies all of these uses in the species accounts for all of the focal species in the surveys (Table 1). In this study, it was shown that greater cover of submergent vegetation was related to higher abundances of marsh-nesting birds. It is likely that wetlands that can provide greater coverage of foraging habitat can support larger food sources and in turn sustain greater abundances of birds.

This study also illustrates that for some cases and scales, submergent vegetation cover may not be associated with the abundance of marsh-nesting obligates. For example, Tic Tac Point (TTP) on Lake St. Clair supports a large AMA and a variety of aquatic bird species in general (CWS unpub. data), but has relatively little CPC, which does not fit the general relationship presented in the study. Some wetlands such as TTP act as hotspots due to their size, local habitat availability or context in the landscape (*e.g.* proximity to a migration corridor or flyway) and have high conservation value. Conversely, at some disturbed sites such as Four Mile Creek on the Niagara Peninsula, submergent vegetation cover is high with few marsh-nesting birds. The submergent vegetation community at sites that support relatively few marsh-nesting birds may have a different composition and is perhaps less likely to support a faunal forage base. Wetland isolation and relatively low extent of emergent vegetation (*i.e.* nesting habitat) may also explain some instances where submergent vegetation cover is relatively high but there are few marsh-nesting birds. And so, although the general relationship presented between submergent vegetation and marsh-nesting obligates is noteworthy, there are likely other parameters

Aerial view of submergent and floating vegetation within a 1m x 1m quadrat.
Photo: Canadian Wildlife Service – Ontario.

or combinations of parameters at various scales (*e.g.* urban encroachment or extent of emergent habitat) that contribute more strongly to governing the abundances of this guild.

Few relationships were found at regional or annual scales with the exception of Lake Erie wetlands and the year 2012. The Lake Erie wetlands sampled may cover a more comprehensive range of habitat and bird community conditions (Canadian Wildlife Service - Ontario 2012) compared to other lake basins sampled, thus strengthening the observed AMA:CPC relationship. Similarly, the significant relationship observed in 2012 may be the result of a larger sample size because both the Huron-Erie Corridor and Lake Ontario wetlands were surveyed (providing more statistical power to detect the correlation), as opposed to only one lake basin in remaining years. Annual variability in climatic and hydrological conditions may have resulted in differences in the abundances of marsh-nesting birds (Timmermans *et al.* 2008). Continuing with regional assessments will provide data from a variety of hydrological conditions (*e.g.* high, low and stable water levels) to strengthen current marsh bird and habitat associations.

The extent of submergent vegetation cover is a function of light availability, substrate affinity, reproductive success, nutrients and level of physical disturbance from the elements (Lacoul and Freedman 2006). Coastal wetlands in the lower Great Lakes are impacted from nutrient and sediment run-off from urban and agricultural inputs, wind and wave action and are affected by wildlife such as Common Carp (*Cyprinus carpio*) and Mute Swans (*Cygnus olor*). All of these factors can lead to an impairment in the submergent vegetation community and limit its distribution in wetlands (Lougheed *et al.* 2001). Although this analysis does not provide any insight into the quality of the bird and plant communities, higher CPC and AMA values are generally associated with wetlands in better ecological condition (Canadian Wildlife Service - Ontario 2012, Grabas *et al.* 2012). This study has shown that the abundance of marsh obligate birds residing in lower Great Lakes marshes is related to the percent cover of submergent vegetation regardless of the size of the wetland. Further exploration into the relationships among submergent vegetation diversity and condition and various marsh bird community attributes beyond AMA could help to understand marsh bird habitat selection to a greater extent.

Submergent vegetation is also considered an essential component of hemi-marsh habitat. Wetlands with higher complexity at the interface of emergent and open water habitats have been shown to have higher diversity and abundances of both bird (Rehm and Baldassarre 2007) and invertebrate species (Schummer *et al.* 2012). Submergent vegetation typically occurs as part of the complex array of microhabitats in highly interspersed areas. A portion of the vegetation data collected in this study occurred within hemi-marsh habitat but was not distinguished from open water habitat. Quantifying the extent of this habitat type for these wetlands may be a key factor to investigate for future study.

In Lake Ontario, where water levels are regulated, submergent vegetation has been identified as a vegetation type of conservation concern for marsh-nesting birds that rely heavily on, and are adapted to, aquatic microhabitats (Steen *et al.* 2006). Regulated water levels have been linked to lakeward and inland expansion of cattail (*Typha* sp.) in Lake Ontario (Wilcox *et al.* 2008). Despite providing additional nesting area for emergent marsh-nesting obligates, including species at risk, cattails may reduce the extent of submergent vegetation. Peterson and Niemi (2007) reported that in coastal riverine wetlands of western lakes Michigan and Superior, the abundance of obligate wetland birds was positively associated with wetlands with a mix of vegetative types (*e.g.* submergent vegetation, emergents, shrubs, mud flats) but also with larger patches (*i.e.* area) of these types. Here it has been shown that in the lower Great Lakes, for a wider variety of wetland types (*e.g.* embayments, barrier beaches, drowned river mouths) that the extent of submergent vegetation in discrete samples is associated with an abundance of marsh-nesting obligates. Both Steen *et al.* (2006) and Peterson and Niemi (2007) have highlighted the importance of the extent and cover of aquatic vegetation to marsh-nesting birds regardless of location in the Great Lakes basin.

The abundance of marsh-nesting obligates and CPC are both important measures used to assess wetland condition basin-wide (Crewe and Timmermans 2005, Environment Canada and Central Lake Ontario Conservation Authority 2004, Grabas *et al.* 2008, 2012). The goal of this study was to investigate, in a general way, the relationship between this specific guild of marsh birds and submergent vegetation. Based on the positive association presented in this study, submergent vegetation should be included when managing wetlands for marsh bird communities. Continued assessments are required to fully understand the relationships among marsh birds, landscape and habitat attributes including submergent vegetation, and to continue to promote the conservation of these coastal systems in the Great Lakes basin.

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Appendix 1

Table A1. Coastal wetlands included in the analysis presented from east to west by lake basin and alphabetically. Lake basins are denoted as follows: St. Lawrence River (SLR), Lake Ontario (LKO), Lake Erie (LKE), Detroit River (DR), Lake St. Clair (LSC) and St. Clair River (SCR). For analysis, SLR sites were included with LKO and the Huron-Erie Corridor (HEC) was comprised of DR, LSC and SCR sites.

Wetland Name	Lake Basin	Number of Years Sampled
Bayfield Bay Marsh	SLR	2
Button Bay Marsh	SLR	2
Big Sand Bay Marsh	LKO	2
Carruthers Creek Marsh	LKO	2
Duffins Creek Marsh	LKO	2
Four Mile Pond Marsh	LKO	2
Frenchman's Bay Marsh	LKO	2
Hay Bay South Marsh	LKO	2
Hydro Marsh	LKO	2
Jordan Station Marsh	LKO	2
Presqu'ile Bay Marsh	LKO	2
South Bay Marsh	LKO	2
Big Creek NWA - Impoundment Marsh	LKE	1
Cedar Creek Marsh	LKE	1
Dunnville Marsh	LKE	2
East Two Creeks Marsh	LKE	1
Fox Creek Marsh	LKE	1
Hickory Creek Mouth Marsh	LKE	1
Long Point NWA - Bluff Marsh	LKE	2
Long Point NWA - Boucks Pond Marsh	LKE	2
Long Point NWA - Thoroughfare Marsh	LKE	2
Nanticoke Creek Mouth Marsh	LKE	2
Selkirk Provincial Park Marsh	LKE	2
Wardells Creek Mouth Marsh	LKE	2
Canard River Marsh	DR	3
Canard River Mouth Marsh	DR	1
Detroit River Marshes	DR	3
Fighting Island Diked Marsh	DR	1
Turkey Creek Marsh	DR	3
Lake St. Clair Marsh	LSC	3
Mitchell's Bay Marsh	LSC	3
Moon Cove - Tic Tac Point Marsh	LSC	3
St. Clair NWA - East Marsh	LSC	4
St. Clair NWA - West Marsh	LSC	1
Roberta Stewart Marsh	SCR	1
Snye River Marsh	SCR	3
St. Clair NWA: Bear Creek Unit- - Maxwell Marsh	SCR	3
St. Clair NWA: Bear Creek Unit - OPG Marsh	SCR	3
St. Clair NWA: Bear Creek Unit - Snye Marsh	SCR	1
St. Clair NWA: Bear Creek Unit- Lozon Marsh	SCR	1
Stag Island	SCR	2

AMA and CPC Calculations

The AMA variable was calculated as the maximum abundance of marsh-nesting obligates. Marsh-nesting obligates observed using the marsh within the radius of a station (*i.e.* point count) were included in our analyses. Station abundance values were averaged to obtain a single value for a given wetland-year. In a given year, each wetland was visited three times and the maximum abundance refers to the visit with the highest average number of marsh-nesting obligates.

CPC was calculated as the sum of each individual species' percent cover observed within a quadrat. CPC was then averaged over the 20 quadrats sampled to obtain a single value for a given wetland-year. For each variable, site-level data were averaged where multiple years were available to obtain a single value for AMA and CPC for a wetland.

Statistical Analyses

To meet the assumptions of normality for the statistical tests employed in the analyses, AMA was Log10 transformed and CPC was first standardized to range from 0-1, and then Arcsine square root transformed. Transformed variables did not significantly deviate from normality (Shapiro-Wilk, $p>0.05$). A Pearson correlation was performed to determine the relationship between the two variables. To control for the effect of wetland size on the abundance of marsh-nesting obligates, a partial correlation was conducted controlling for the mean number of stations (*i.e.* point counts) per wetland. The augmented Marsh Monitoring Program protocol (Meyer *et al.* 2006) does not limit the number of stations within a wetland granted they are sufficiently spaced and meet the survey requirements, and so the total number of stations can therefore be used as a proxy of wetland size. Spearman rank correlation was used to determine annual and/or regional relationships between AMA and CPC. This test was used because the sample sizes were small and the data did not meet the assumptions of normality even after transformation. Statistical analyses were conducted in Statistica (ver.12; Statsoft 2013) with significance reported at $p<0.05$.

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