The Marsh Monitoring Program: Evaluating Marsh Bird Survey Protocol Modifications to Assess Lake Ontario Coastal Wetlands at a Site-level

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EXECUTIVE SUMMARY

The Marsh Monitoring Program (MMP) is a bi-national, long-term volunteer monitoring program that was initiated by Bird Studies Canada and Environment Canada with funding support from the United States Environmental Protection Agency and the Great Lakes Protection Fund. This program assists monitoring marsh bird and amphibian populations on the Great Lakes at various spatial scales over long periods of time. Throughout its 10 year history, the MMP has provided information on Great Lakes marsh communities as well as increased public awareness about wetland communities and wetland conservation issues.

Recently, interest has grown in developing multi-metric Indices of Biotic Integrity (IBIs) to evaluate wetland health or condition. Previous studies have used MMP derived data to calculate IBI indices for marsh bird and amphibian communities at a site-level despite concerns about the applicability of using MMP survey protocol beyond its original purpose (i.e., from large-scale long duration studies to annual site-level evaluations). This study evaluated survey modifications that added to the standard MMP marsh bird survey protocol so that annual site-level evaluations as well as standard MMP marsh bird data could potentially be collected together.

The addition of an extra visit and the establishment of interior stations resulted in significantly higher indices of abundance and species richness of most marsh bird guilds, particularly *Emergent Marsh Nesting Obligates*, regardless of wetland size. Results also showed that if only two survey visits are possible, these visits should occur at the beginning and end of the survey window period based on the seasonal timing of breeding vocalization patterns of *Emergent Marsh Nesting Obligates* in that region. Survey protocols for *Marsh Nesting Generalists* should use shoreline survey stations and either an extra visit or take place during the first four weeks of the survey window period. Indices of Biotic Integrity were higher with the addition of interior stations at most Lake Ontario coastal wetlands compared to using the standard MMP marsh bird survey protocol.

As predicted, this study showed that supplementing the standard MMP marsh bird survey protocol resulted in significantly higher avian parameters (e.g., abundance and species richness) for various marsh bird nesting and foraging guilds in Lake Ontario coastal wetlands and still allowed the inclusion of data into the larger scale MMP. Assessing the marsh nesting bird community, particularly the *Emergent Marsh Nesting Obligate* community, is important because it has shown to be an indicator of wetland habitat quality. Therefore, if site-level wetland health and/or various wetland conservation and research initiatives are to be properly assessed, a site-level marsh bird survey protocol should be developed and implemented. Formal development of a second tier site-level marsh bird survey protocol that complements large-scale marsh bird monitoring programs has many benefits. Benefits include the use of the same marsh bird survey data at multiple scales and subsequently increased support for implementation of regional/national bird monitoring programs by local stakeholders given the increased suitability of data use at a scale of interest (e.g., wetland conservation and restoration evaluations).

RÉSUMÉ ADMINISTRATIF

Le Programme de surveillance des marais (PSM) est un programme binational de suivi à long terme exécuté par des bénévoles qu'Études d'oiseaux Canada et Environnement Canada ont mis sur pied avec l'appui financier de l'Environmental Protection Agency et du Great Lakes Protection Fund (Fonds de protection des Grands Lacs) des États-Unis. Les participants à ce programme aident au suivi des populations d'oiseaux des marais et d'amphibiens de la région des Grands Lacs à différentes échelles spatiales sur de longues périodes. Au cours de ses dix ans d'existence, le PSM a fourni de l'information sur les communautés animales des marais des Grands Lacs et sensibilisé davantage la population aux espèces des milieux humides et aux problèmes de conservation de ces milieux.

Depuis peu, on s'intéresse de plus en plus à l'utilisation d'indices multiparamétriques d'intégrité biotique pour l'évaluation de l'état des milieux humides. Les auteurs d'études antérieures ont utilisé des données recueillies dans le cadre du PSM pour calculer de tels indices concernant les populations d'oiseaux des marais et d'amphibiens à l'échelle locale, et ce malgré les doutes soulevés quant à la possibilité d'appliquer le protocole de suivi du PSM à d'autres études (c.-à-d. à des évaluations annuelles à l'échelle locale plutôt qu'à des études de grande portée sur de longues périodes comme le PSM). L'étude dont il est ici question avait pour but d'évaluer les modifications qui pourraient être apportées au protocole standard de suivi des oiseaux des marais du PSM pour permettre de recueillir des données d'évaluation annuelle à l'échelle locale en même temps que les données standard de suivi des oiseaux de marais du programme.

L'ajout d'une troisième visite au protocole et l'établissement de stations d'échantillonnage dans l'intérieur se sont traduits par une forte augmentation des indices d'abondance et de diversité des espèces pour la plupart des guildes d'oiseaux des marais, en particulier les oiseaux qui nichent exclusivement dans la végétation émergente, quelle que soit l'étendue du milieu humide d'accueil. Les résultats montrent que, si seulement deux visites peuvent être effectuées, celles-ci devraient avoir lieu au début et à la fin de la période de surveillance, en fonction des moments où sont entendues les vocalisations nuptiales des oiseaux qui nichent exclusivement dans la végétation émergente dans la région en question. Les protocoles de surveillance des populations d'oiseaux qui peuvent nicher ailleurs que dans des marais devraient se limiter à la visite de stations le long des rives et comprendre une troisième visite ou, autrement, les visites devraient avoir lieu au cours des quatre premières semaines de la période de surveillance. L'établissement de stations d'échantillonnage dans l'intérieur a fait augmenter les indices d'intégrité biotique propres à la plupart des milieux humides côtiers du lac Ontario par rapport aux indices issus de l'utilisation du protocole standard de suivi des oiseaux des marais du PSM.

Tel que prévu, l'étude a révélé que la modification du protocole standard de suivi des oiseaux des marais du PSM permet d'obtenir des indices de suivi des populations d'oiseaux (p. ex., des indices d'abondance et de diversité des espèces) beaucoup plus élevés pour différentes guildes d'oiseaux nichant ou se nourrissant dans les marais des milieux humides des rives du lac Ontario, tout en permettant l'inclusion des données aux données de suivi à grande échelle du PSM. L'évaluation des populations d'oiseaux qui nichent dans les marais, en particulier des oiseaux qui nichent exclusivement dans la végétation émergente, est importante car elle constitue un indicateur de la qualité de l'habitat des milieux humides. Dès lors, il faudrait élaborer et mettre

en oeuvre un protocole de suivi des oiseaux des marais à l'échelle locale pour assurer une évaluation adéquate de l'état des milieux humides à l'échelle locale et/ou de diverses initiatives de conservation de ces milieux et de recherche sur ces milieux. L'instauration en bonne et due forme d'un protocole de suivi des oiseaux des marais à l'échelle locale de deuxième niveau, en complément des programmes de suivi à grande échelle de ces oiseaux, présenterait de nombreux avantages. Ainsi, on pourrait utiliser les mêmes données de suivi des oiseaux de marais à plusieurs échelles différentes et donc, ultérieurement, accroître le soutien à l'exécution de programmes régionaux/nationaux de suivi des populations d'oiseaux par des intervenants locaux vu qu'il serait plus facile d'utiliser les données à l'échelle d'intérêt (p. ex., pour des évaluations de mesures de conservation et de restauration de milieux humides).

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INTRODUCTION

The Marsh Monitoring Program (MMP) is a bi-national, long-term volunteer monitoring program that was initiated by Bird Studies Canada and Environment Canada. Modeled after other volunteer based monitoring programs such as the Breeding Bird Survey and Forest Bird Monitoring Program, data from the MMP are used to derive annual abundance indices and breeding occurrence across broad geographic scales within the Great Lakes basin over long periods of time. Volunteer based programs such as the MMP, have been successfully used to detect broad-scale species trends (Weeber and Vallianatos 2000, Crewe *et al.* 2006).

Throughout its 10 year history, the MMP has provided information on Great Lakes marsh communities as well as increased public awareness about wetland biotic communities and wetland conservation issues. In addition, with growing interest in developing multi-metric Indices of Biotic Integrity (IBIs) to assess wetland health, MMP marsh bird and amphibian data have been analyzed at a site-level. Although these data have been useful in IBI development, several concerns have been raised about using MMP data beyond their original purpose (Environment Canada and Central Lake Ontario Conservation Authority 2005). For example, the applicability of a shoreline based survey route in representing the annual diversity of marsh habitat within a wetland has been questioned. Also, Tozer (2002) and Gibbs and Melvin (1993) showed that two visits to a marsh bird survey station do not annually detect a high percentage of marsh bird species. Moreover, several projects such as the Durham Region Coastal Wetland Monitoring Project (Environment Canada and Central Lake Ontario Conservation Authority 2004) and other studies (e.g., Crewe and Timmermans 2005), have evaluated MMP data for their use in creating IBIs for assessing wetland condition at a site-level and have concluded that MMP marsh bird survey protocol modifications are necessary if this objective is to be met.

Although the purpose of the MMP is to monitor marsh bird and amphibian species populations over broad-scales and long-time frames, the methodology still provides an ideal foundation for developing a supplemental more intensive site-level marsh bird survey protocol. For example, the duration of MMP point counts and species targeted for MMP song broadcasting have a strong scientific foundation (McCracken 1994) and, therefore, should continue to be implemented in any Great Lakes survey protocol used to assess the marsh bird community. Furthermore, the current wide-scale application of the MMP within many Great Lakes wetlands provides a coarse evaluation of research needs which then can provide the basic support for initiating more targeted actions. Consequently, building off of the standard MMP marsh bird survey protocol allows for the collection of large-scale and targeted site-level data.

STUDY OBJECTIVES

The primary objective of this study was to evaluate the influence of supplemental MMP marsh bird survey protocol modifications on avian community parameters (e.g., abundance, species richness, and percent composition of specific marsh bird nesting and foraging guilds) used in multi-metric biotic indices that evaluate wetlands at a site-level. Specific objectives included evaluating the effect of: (1) an additional visit, (2) seasonal timing of visits, and (3) adding interior stations at a site on these parameters.

STUDY HYPOTHESIS

The study hypothesis was that a more intensive and/or time specific survey protocol for marsh birds (i.e., a modified version of the MMP) would result in more representative avian parameters and reduced inter-annual IBI score variability in spatially complex wetlands compared to the standard MMP marsh bird survey protocol.

STUDY DESIGN

Study Area

Coastal wetland study sites were selected to ensure that sampling occurred across the range of wetland size and level of anthropogenic disturbance that occur on Lake Ontario. The twenty study sites surveyed (Figure 1) represent a range of wetlands from those that have been severely impacted due to land development to sites considered to be the least impacted by anthropogenic disturbance.

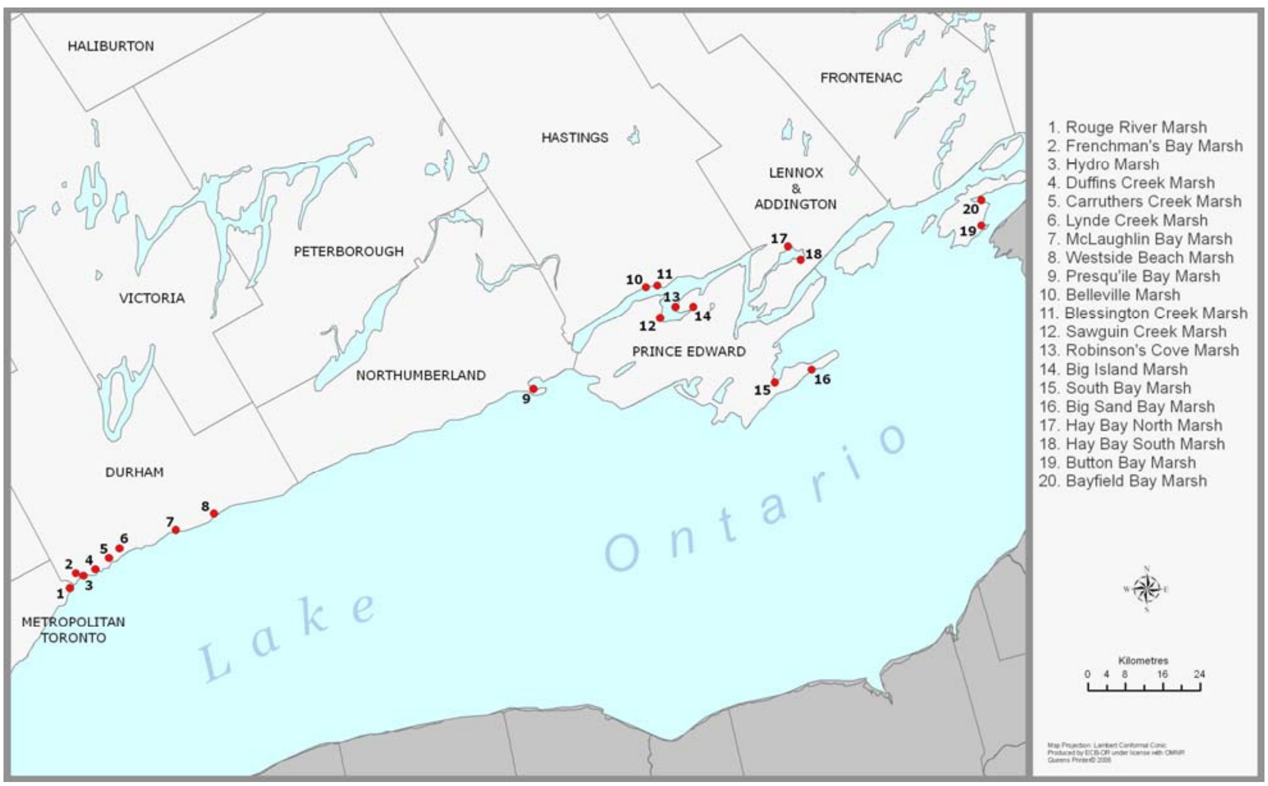


Figure 1. Location of Lake Ontario coastal wetlands surveyed using a modified Marsh Monitoring Program marsh bird survey protocol.

Marsh Bird Survey Protocol

Summary of the Standard MMP Marsh Bird Survey Protocol

MMP bird surveys use a fixed-distance point count method to collect data on bird species. Fixed-distance point counts entail a surveyor standing at a focal point (or survey point) and counting birds seen or heard in a standardized period of time in a defined survey area. MMP marsh bird survey protocol consists of a semi-circular survey station with a 100-metre survey radius. Survey stations are separated by at least 250-metres to ensure independence between stations (i.e., reduce double counting of birds between stations during a visit due to bird movement).

A route consists of one to eight survey stations established within a site and a site can contain a number of routes. Routes are established based on the following protocol:

- Routes occur only in marsh habitat (i.e., greater than 50 percent non-woody emergent plants interspersed with shallow open water);
- Route survey stations are established primarily along the shoreline (e.g., marsh edge) although some sites may contain interior stations;
- Survey stations are placed by volunteers to maximize detectability of birds in the survey area (i.e., from a slightly elevated point);
- Survey direction is positioned to maximize marsh area surveyed; and,
- Landmarks are established so that distances within the survey area can be accurately estimated.

Marsh bird surveys are standardized to occur during a specific survey window (two visits between 20 May and 5 July), time of day (18:00 hrs EST to sunset), duration (10 minutes), weather conditions (good visibility, warm temperatures [greater than 16 °C], no precipitation, and gentle wind [less than 19 kilometres per hour]), and days between surveys (at least 10 days apart).

Finally, bird surveys consist of five minutes of song broadcasting for secretive species (Virginia Rail, Sora, Least Bittern, Common Moorhen / American Coot, and Pied-billed Grebe), to elicit a response and increase their detectability, followed by five minutes of passive listening (see Weeber and Vallianatos 2000 for more information on the standard MMP marsh bird survey protocol).

<u>Summary of MMP Marsh Bird Survey Protocol Modifications</u>
Protocol modifications included changes to better represent wetland habitat surveyed as well as increase survey effort. Modifications to better represent wetland habitat surveyed within MMP survey stations were incorporated due to concerns about the potential bias associated with just surveying shoreline stations and by placing these stations in locations to maximize detectability.

Modifications to MMP Survey Station Placement

- To reduce bias in survey station placement within a wetland, stations were initially established using Geographical Information System (GIS) software. Potential survey stations were located on an ortho-rectified, colour infra-red aerial photograph of each study site at each intersection of a 250-metre grid overlay (Figure 2). Then, a pool of survey stations was selected based on interpreted availability of marsh habitat from the photograph. For example, survey stations in treed/shrub or open water habitat were excluded because they did not meet minimum MMP marsh habitat requirements (i.e., 50 percent marsh habitat). In early May before bird surveys commenced, each survey station was located with sub-metre accuracy in the field using a Trimble GEO XT Global Positioning System unit and the habitat was verified. Only stations that consisted of at least 50 percent marsh habitat (e.g., meadow marsh, emergent vegetation or hemi-marsh habitat) were selected for surveying.

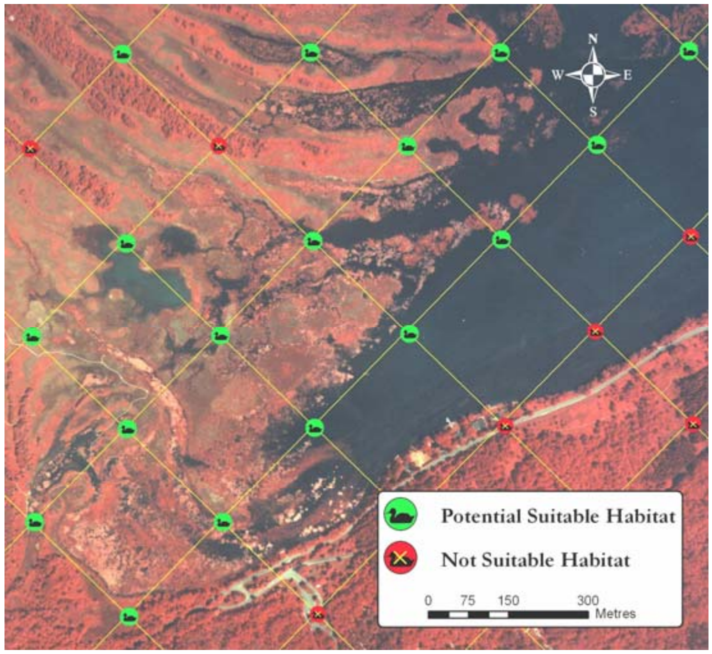


Figure 2. Illustration of 250-metre grid survey station placement and initial selection.

- Routes within each wetland consisted of one to 10 survey stations depending on wetland size, surveying constraints (i.e., time), and accessibility. For example, two or three survey stations typically saturated marsh habitat in a small wetland whereas in a large wetland, a maximum of 10 survey stations could be surveyed within the standardized survey window period. To develop a modified version of the MMP that built off of the standard MMP marsh bird survey protocol, survey stations were placed by first saturating the shoreline and then adding interior stations until a route consisted of 10 stations. Wetlands of sufficient size and complexity contained more than one route with a maximum of three routes per wetland. As such, some wetlands had a route consisting of 10 shoreline stations, 10 interior stations, or a combination of both station locations;

- Direction of the 100-metre survey radius was determined either by maximizing the area encompassed by marsh habitat or by randomly drawing a card with a survey direction on it (i.e., for interior stations); and,

- Routes were surveyed in either the morning or evening. However once a time and direction were established, surveys within each route were standardized to this survey protocol. Morning surveys began thirty minutes before sunrise and finished by 10:00 hrs (EST). Evening surveys started at 18:00 hrs (EST) and finished thirty minutes after sunset.

Modifications to MMP Marsh Bird Survey Protocol Effort

- Each route was surveyed three times instead of two between 20 May and 5 July 2005 with at least 10 days between surveys.

Analysis

Avian Groups and Response Variables

Surveyed birds, or *Marsh Users*, were categorized into one of two guilds based on marsh use identified from published literature and expert opinion (Brown and Dinsmore 1986, Naugle *et al.* 2001, Riffell *et al.* 2001, Poole and Gill [ongoing]) (Figure 3). *Marsh Nesting Birds* included birds that nest within marsh habitat (e.g., meadow marsh, emergent vegetation or hemi-marsh habitat). These birds were further divided based on their nesting dependency on this habitat. *Emergent Marsh Nesting Obligates* included bird species that exclusively depend on emergent or hemi-marsh habitat for nesting excluding meadow marsh vegetation. As a result, Swamp Sparrow was excluded from the *Emergent Marsh Nesting Obligate* guild because this species primarily nests in flooded meadow marsh (Mowbray 1997). *Emergent Marsh Nesting Obligate* birds were divided into *Area* and *Non-Area Sensitive* species. *Marsh Nesting Generalists* included birds that primarily nest within marsh habitat but can also nest elsewhere. *Marsh Foragers* comprised the second guild category and excluded *Marsh Nesting Birds*. This category was divided into *Water*, *Aerial*, and *Non-Aerial Foragers* based upon species-specific foraging behaviour. Lastly, *Marsh Dependent Birds* (i.e., those birds that nest and primarily forage in marshes) were grouped and consisted of all *Marsh Nesting Birds* and *Water Foragers*.

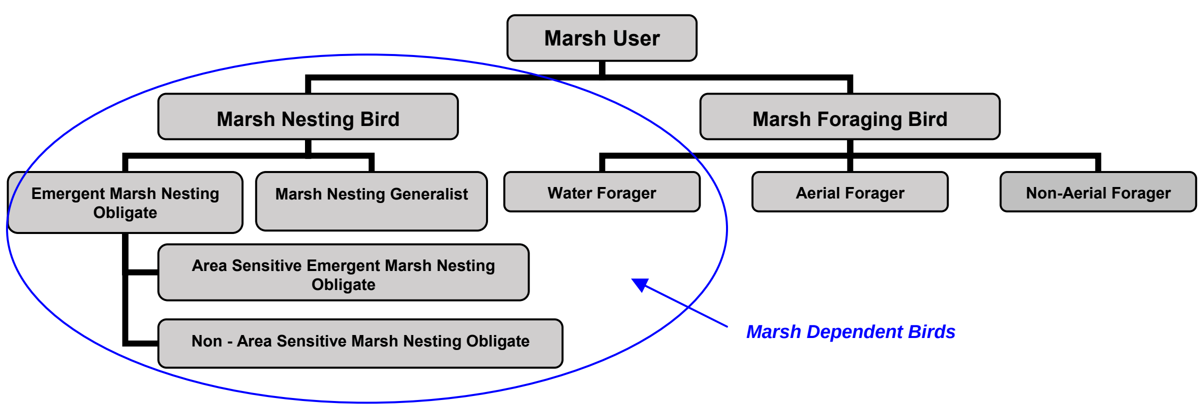


Figure 3. Illustration of marsh user categories for bird species based on marsh use.

Bird data for each survey station were summarized into either a mapped observation or an aerial forager. Mapped observations included only birds that contacted the vegetation or water during the point count inside the survey area. Aerial foragers included only birds actively foraging overhead inside the survey area and no higher than 100-metres in the air. Total number of individuals for each species was calculated for each survey station and visit. Because point counts provide only a crude estimate of individual numbers due to differing detection probabilities among days, habitats, etc., counts represented indices of relative abundance as opposed to true values (Ralph *et al.* 1995). Abundance indices for each guild were obtained for each station and visit by summing appropriate species. Mean values of maximum abundance and species richness per survey station were used to obtain a standardized index for each route. Finally, the percentage of each *Emergent Marsh Nesting Obligate* guild in relation to the total abundance of all *Marsh Dependent Birds* was calculated to assess possible differences in the relative abundance of each marsh bird guild with survey protocol.

Dependent Variables and Statistics

Several treatment effects were examined for each dependent variable (Table 1).

Table 1. Codes, data transformations, rationale, and statistical tests performed for each dependent variable.

Rationale	Code	Dependent Variable	Data Transformation	Statistical test *
Indicator of wetland habitat quality	MU Abd	Marsh User Abundance	None	Repeated-measures ANOVA
	MU SR	Marsh User Species Richness	Log	Repeated-measures ANOVA
	AF Abd	Aerial Forager Abundance	Log	Repeated-measures ANOVA
	AF SR	Aerial Forager Species Richness	Box-Cox	Repeated-measures ANOVA
	MDep Abd	Marsh Dependent Abundance	None	Repeated-measures ANOVA
	MDep SR	Marsh Dependent Species Richness	Box-Cox	Repeated-measures ANOVA
	MNG Abd	Marsh Nesting Generalist Abundance	None	Repeated-measures ANOVA
	MNG SR	Marsh Nesting Generalist Species Richness	None	Friedman's ANOVA
Indicator of emergent marsh habitat quality	EMNO Abd	Emergent Marsh Nesting Obligate Abundance	None	Repeated-measures ANOVA
	EMNO SR	Emergent Marsh Nesting Obligate Species Richness	None	Repeated-measures ANOVA
	AS EMNO Abd	Area Sensitive Emergent Marsh Nesting Obligate Abundance	None	Friedman's ANOVA
	AS EMNO SR	Area Sensitive Emergent Marsh Nesting Obligate Species Richness	None	Friedman's ANOVA
	NAS Abd	Non-Area Sensitive Marsh Nesting Obligate Abundance	None	Repeated-measures ANOVA
	NAS SR	Non-Area Sensitive Marsh Nesting Obligate Species Richness	None	Friedman's ANOVA
Indicator of marsh bird community composition	PEMNO	Percent Abundance of Emergent Marsh Nesting Obligates comprising the Marsh Dependent Bird community	Arcsine	Repeated-measures ANOVA
	PAS EMNO	Percent Abundance of Area Sensitive Emergent Marsh Nesting Obligates comprising the Marsh Dependent Bird community	None	Friedman's ANOVA
	PNAS	Percent Abundance of Non-Area Sensitive Marsh Nesting Obligates comprising the Marsh Dependent Bird community	Arcsine	Repeated-measures ANOVA

* All ANOVAs were balanced designs.

Treatment effects included,

Treatment 1 – Visit 1 + 2, shoreline stations only,
Treatment 2 – Visit 1 + 3, shoreline stations only,
Treatment 3 – Visit 2 + 3, shoreline stations only,
Treatment 4 – Visit 1 + 2 + 3, shoreline stations only,
Treatment 5 – Visit 1 + 2, interior stations (where applicable),
Treatment 6 – Visit 1 + 3, interior stations (where applicable),
Treatment 7 – Visit 2 + 3, interior stations (where applicable),
Treatment 8 – Visit 1 + 2 + 3, interior stations (where applicable).

Each treatment variable was examined for conformity to assumptions of parametric statistics (i.e., homoscedasticity and normality). There were no serious violations of homoscedasticity,

but in many cases data were not normally distributed. Non-normal data were transformed using arcsine (generally for percentage data), log, and Box-Cox transformations.
Data that could be normalized were analyzed using a repeated-measures ANOVA (RMA) with location (interior/shoreline) and visit combination (1&2, 1&3, 2&3 and 1,2&3) as within-subject factors. When the RMA detected significant differences among means ($p < 0.05$), a Tukey HSD post-hoc test was used to discover which treatments were significantly different from each other. In addition, means ± standard errors were plotted for wetlands individually. Possible trends among wetlands were then visually assessed.

Data that could not be normalized were analyzed using a non-parametric Friedman's RMA. This test cannot evaluate within-subject factors, so all eight treatments (visit/location combinations) were analyzed as separate dependent variables. When the RMA detected significant differences among treatments ($p < 0.05$), multiple comparisons testing for ranked data was performed (Zar 1999: Section 12.9) to determine where the significant differences occurred.

RESULTS

One hundred and eighty survey stations (96 shoreline and 84 interior) were placed in the 20 study site coastal wetlands and surveyed three times between 25 May and 4 July 2005 (Table 2). In total, 5,526 individuals of 66 bird species were observed as mapped observations. These birds included 23 exotics, 2,600 *Marsh Nesting Generalists*, 1,234 *Area Sensitive Emergent Marsh Nesting Obligates*, 767 *Non-Area Sensitive Marsh Nesting Obligates*, 299 *Water Foragers*, 101 *Aerial Foragers*, and 502 *Non-Aerial Foragers*. Eight hundred and ninety-seven birds were observed actively foraging in the survey area (Table 3).

Table 2. Wetland, wetland code, closest town, number of survey stations, and wetland area surveyed for Lake Ontario coastal wetlands surveyed using a modified Marsh Monitoring Program marsh bird survey protocol.

Wetland	Wetland Code	Closest Town	Number of Stations		Area of Wetland Surveyed (ha)
			Shoreline	Interior	
Rouge River Marsh	RRM	Toronto, ON	0	4	45.52
Frenchman's Bay Marsh	FBM	Toronto, ON	2	4	32.35
Hydro Marsh	HYM	Toronto, ON	2	1	24.33
Duffins Creek Marsh	DUM	Ajax, ON	4	1	71.99
Carruthers Creek Marsh	CCW	Ajax, ON	4	0	17.89
Lynde Creek Marsh	LCM	Whitby, ON	8	1	86.31
McLaughlin Bay Marsh	MBM	Courtice, ON	2	0	41.73
Westside Beach Marsh	WSB	Bowmanville, ON	0	3	45.12
Presqu'ile Bay Marsh	PPP	Brighton, ON	12	13	235.37
Belleville Marsh	BVM	Belleville, ON	2	0	17.68
Blessington Creek Marsh	BLM	Belleville, ON	9	5	113.91
Sawguin Creek Marsh	SAC	Belleville, ON	9	9	272.08
Robinson's Cove Marsh	ROC	Picton, ON	2	0	8.83
Big Island Marsh	BIM	Picton, ON	10	16	564.91
South Bay Marsh	SOB	Picton, ON	5	4	60.24
Big Sand Bay Marsh	BSB	Picton, ON	4	4	130.67
Hay Bay North Marsh	HBN	Napanee, ON	7	8	226.30
Hay Bay South Marsh	HBS	Napanee, ON	5	4	121.96
Button Bay Marsh	BUB	Kingston, ON	2	0	39.55
Bayfield Bay Marsh	BFB	Kingston, ON	7	7	275.11
		Total	96	84	

Table 3. Total species abundance within each marsh bird guild observed in 20 Lake Ontario coastal wetlands.

Marsh Bird Guild	AOU Code	Common Name	Scientific Name	Total Abundance
Exotic Species	MUSW	Mute Swan	*Cygnus olor*	23
Marsh Nesting Generalist	AMWO	American Woodcock	*Scolopax minor*	1
	TRSW	Trumpeter Swan	*Cygnus buccinator*	1
	NOHA	Northern Harrier	*Circus cyaneus*	2
	SEWR	Sedge Wren	*Cistothorus platensis*	3
	COYE	Common Yellowthroat	*Geothlypis trichas*	207
	COGR	Common Grackle	*Quiscalus quiscula*	210
	RWBL	Red-winged Blackbird	*Agelaius phoeniceus*	2,176
Area Sensitive Emergent Marsh Nesting Obligate	KIRA	King Rail	*Rallus elegans*	1
	SORA	Sora	*Porzana carolina*	2
	LEBI	Least Bittern	*Ixobrychus exilis*	15
	AMBI	American Bittern	*Botaurus lentiginosus*	23
	PBGR	Pied-billed Grebe	*Podilymbus podiceps*	33
	VIRA	Virginia Rail	*Rallus limicola*	71
	SWSP	Swamp Sparrow (*)	*Melospiza georgiana*	1,089
Non-Area Sensitive Marsh Nesting Obligate	AMCO	American Coot	*Fulica americana*	11
	COMO	Common Moorhen	*Gallinula chloropus*	61
	MAWR	Marsh Wren	*Cistothorus palustris*	695
Water Forager	COME	Common Merganser	*Mergus merganser*	1
	HOME	Hooded Merganser	*Lophodytes cucullatus*	1
	BWTE	Blue-winged Teal	*Anas discors*	3
	GADW	Gadwall	*Anas strepera*	6
	GBHE	Great Blue Heron	*Ardea herodias*	21
	MALL	Mallard	*Anas platyrhynchos*	59
	CAGO	Canada Goose	*Branta canadensis*	60
	WODU	Wood Duck	*Aix sponsa*	148
Aerial Forager	BEKI	Belted Kingfisher	*Ceryle alcyon*	1
	EWPE	Eastern Wood-Pewee	*Contopus virens*	1
	FLYC	Unknown Flycatcher	Family: Tyrannidae	1
	GCFL	Great Crested Flycatcher	*Myiarchus crinitus*	1
	LEFL	Least Flycatcher	*Empidonax minimus*	1
	RBGU	Ring-billed Gull	*Larus delawarensis*	1
	ALFL	Alder Flycatcher	*Empidonax alnorum*	2
	NRWS	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	2
	EAKI	Eastern Kingbird	*Tyrannus tyrannus*	6
	TRES	Tree Swallow	*Tachycineta bicolor*	15
	WIFL	Willow Flycatcher	*Empidonax traillii*	70
Non-Aerial Forager	BBCU	Black-billed Cuckoo	*Coccyzus erythropthalmus*	1
	CERW	Cerulean Warbler	*Dendroica cerulea*	1
	HOFI	House Finch	*Carpodacus mexicanus*	1
	HOSP	House Sparrow	*Passer domesticus*	1
	HOWR	House Wren	*Troglodytes aedon*	1
	OVEN	Ovenbird	*Seiurus aurocapillus*	1
	RTHU	Ruby-throated Hummingbird	*Archilochus colubris*	1
	SPAR	Unknown Sparrow	Family: Emberizidae	1
	WOTH	Wood Thrush	*Hylocichla mustelina*	1
	YRWA	Yellow-rumped Warbler	*Dendroica coronata*	1
	CWAX	Cedar Waxwing	*Bombycilla cedrorum*	2
	DOWO	Downy Woodpecker	*Picoides pubescens*	2
	EABL	Eastern Bluebird	*Sialia sialis*	2
	KILL	Killdeer	*Charadrius vociferus*	2
	NOFL	Northern Flicker	*Colaptes auratus*	2
	SPSA	Spotted Sandpiper	*Actitis macularia*	2
	BLJA	Blue Jay	*Cyanocitta cristata*	3
	BAOR	Baltimore Oriole	*Icterus galbula*	4
	BGGN	Blue-gray Gnatcatcher	*Polioptila caerulea*	4
	BHCO	Brown-headed Cowbird	*Molothrus ater*	4
	NOCA	Northern Cardinal	*Cardinalis cardinalis*	4
	GRCA	Gray Catbird	*Dumetella carolinensis*	5
	MODO	Mourning Dove	*Zenaida macroura*	5
	WAVI	Warbling Vireo	*Vireo gilvus*	6
	EUST	European Starling	*Sturnus vulgaris*	7
	AMGO	American Goldfinch	*Carduelis tristis*	9
	CHSP	Chipping Sparrow	*Spizella passerina*	11
	BCCH	Black-capped Chickadee	*Parus atricapillus*	12
	AMRO	American Robin	*Turdus migratorius*	37
	SOSP	Song Sparrow	*Melospiza melodia*	76
	YWAR	Yellow Warbler	*Dendroica petechia*	293
			Total	5,526

(*) Area Sensitive Emergent Marsh Nesting Obligate that primarily nests in flooded meadow marsh.

Overall, a modified MMP marsh bird survey protocol resulted in more birds being detected in Lake Ontario coastal wetlands compared to the standard version. Of the 17 dependent variables analyzed, statistically significant differences were detected in 16 cases. Species richness of *Area Sensitive Emergent Marsh Nesting Obligates* was the only dependent variable that showed no difference between protocols (i.e., timing of visits, additional visit or station location effect). This lack of a difference was likely due to the overall low abundance of the four main species comprising this nesting guild (i.e., Least Bittern, American Bittern, Pied-billed Grebe, and Virginia Rail) (Tables 3 and 4).

Effect of Additional Visit at Shoreline Stations

For 12 of the 17 dependent variables analyzed, mean indices of abundance and species richness were statistically higher with three visits compared to two for pooled Lake Ontario coastal wetland data (Table 4). Except for species richness of *Marsh Nesting Generalists* and *Area Sensitive Emergent Marsh Nesting Obligates*, every variable was significantly increased by the addition of a third visit (Figures 4 and 5). (These two variables were analyzed using non-parametric tests and, hence, the statistical power may have been too low to detect possible differences in visit number). Higher abundance indices for *Emergent* and *Non-Area Sensitive Marsh Nesting Obligates* were detected with three visits compared to two at large (e.g., Big Sand Bay Marsh), medium (e.g., South Bay Marsh), and small wetlands (e.g., Robinson's Cove Marsh). Surveyors also tended to detect more *Emergent Marsh Nesting Obligates* at all wetlands and *Non-Area Sensitive Marsh Nesting Obligates* at all wetlands except Carruthers Creek Marsh during three visits compared to two (Figure 6).

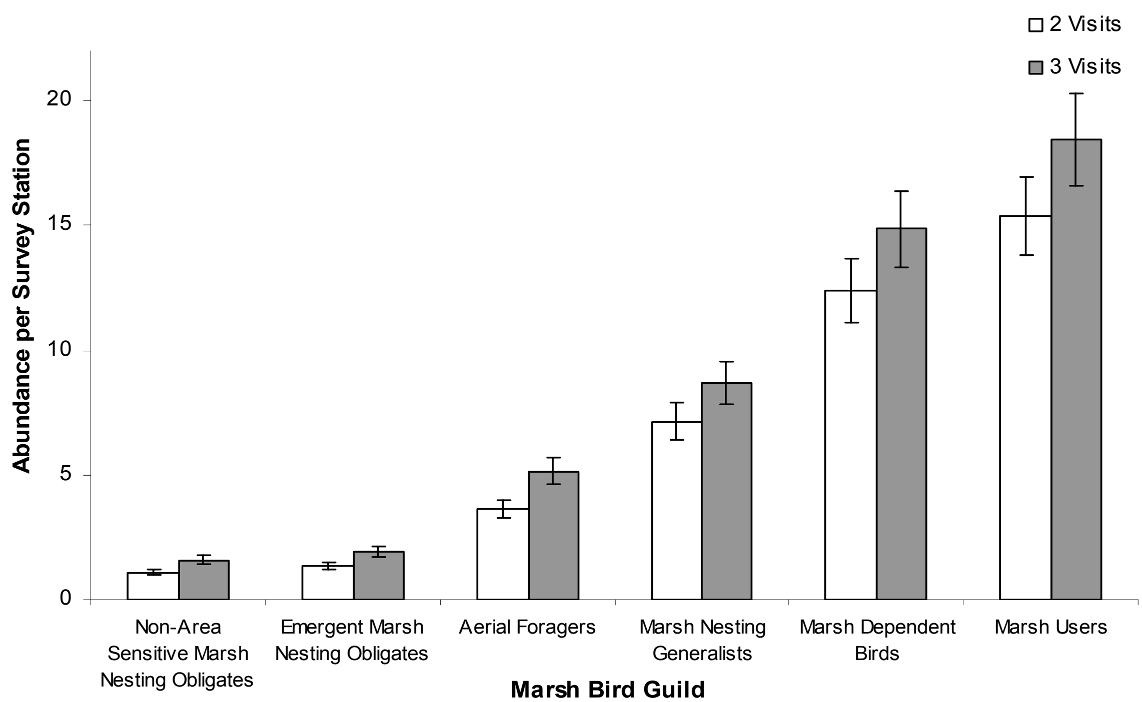


Figure 4. Mean Abundance ± SE for various marsh bird guilds in relation to number of visits to a shoreline survey station for 18 Lake Ontario coastal wetlands.

Table 4. Summary of treatment effects on dependent variables for Lake Ontario coastal wetland bird communities.

Code	Dependent Variable	Visit Effect			Station Location Effect		
		p value	**Timing of Two Visits**	**Three Visits**	***p* value**	**Shoreline Station**	**Interior Station**
MU Abd	Marsh User Abundance	**$p < 0.0001$**	-	↑	**$p < 0.005$**	↑	-
MU SR	Marsh User Species Richness	**$p < 0.0001$**	-	↑	**$p < 0.008$**	↑	-
AF Abd	Aerial Forager Abundance	**$p < 0.0001$**	-	↑	$p < 0.364$	-	-
AF SR	Aerial Forager Species Richness	**$p < 0.0001$**	-	↑	$p < 0.424$	-	-
MDep Abd	Marsh Dependent Abundance	**$p < 0.0001$**	-	↑	$p < 0.313$	-	-
MDep SR	Marsh Dependent Species Richness	**$p < 0.0001$**	-	↑	$p < 0.254$	-	-
MNG Abd	Marsh Nesting Generalist Abundance	**$p < 0.0001$**	**2,3 < 1,3 < 1,2**	↑	**$p < 0.001$**	↑	-
MNG SR	Marsh Nesting Generalist Species Richness	* $p > 0.050$	-	-	*** $p < 0.050$**	↑	-
EMNO Abd	Emergent Marsh Nesting Obligate Abundance	**$p < 0.0001$**	**1,2 < 1,3**	↑	**$p < 0.028$**	-	↑
EMNO SR	Emergent Marsh Nesting Obligate Species Richness	**$p < 0.0001$**	-	↑	**$p < 0.024$**	-	↑
AS EMNO Abd	Area Sensitive Emergent Marsh Nesting Obligate Abundance	*** $p < 0.050$**	-	↑	* $p > 0.050$	-	-
AS EMNO SR	Area Sensitive Emergent Marsh Nesting Obligate Species Richness	* $p < 0.130$	-	-	* $p < 0.130$	-	-
NAS Abd	Non-Area Sensitive Marsh Nesting Obligate Abundance	$p < 0.0001$	**1,2 < 1,3**	↑	$p < 0.048$	-	↑
NAS SR	Non-Area Sensitive Marsh Nesting Obligate Species Richness	*** $p < 0.050$**	-	↑	*** $p < 0.050$**	-	↑
PEMNO	Percent Abundance of Emergent Marsh Nesting Obligates comprising the Marsh Dependent Bird community	$p < 0.225$	-	-	**$p < 0.010$**	-	↑
PAS EMNO	Percent Abundance of Area Sensitive Emergent Marsh Nesting Obligates comprising the Marsh Dependent Bird community	***$p < 0.050$**	**1,2 < 2,3**	-	*$p > 0.050$	-	-
PNAS	Percent Abundance of Non-Area Sensitive Marsh Nesting Obligates comprising the Marsh Dependent Bird community	$p < 0.572$	-	-	**$p < 0.036$**	-	↑

* indicates non-parametric test ~ visit and station location effects were interpreted from the multiple comparison tables.

↑ indicates a higher value.

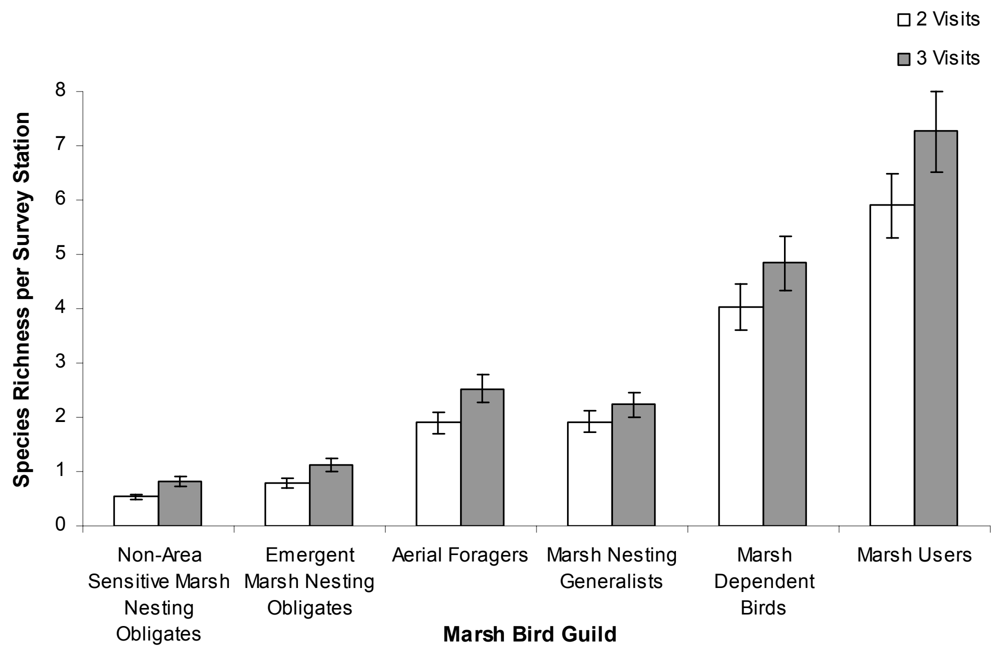


Figure 5. Mean Species Richness ± SE for various marsh bird guilds in relation to number of visits to a shoreline survey station for 18 Lake Ontario coastal wetlands.

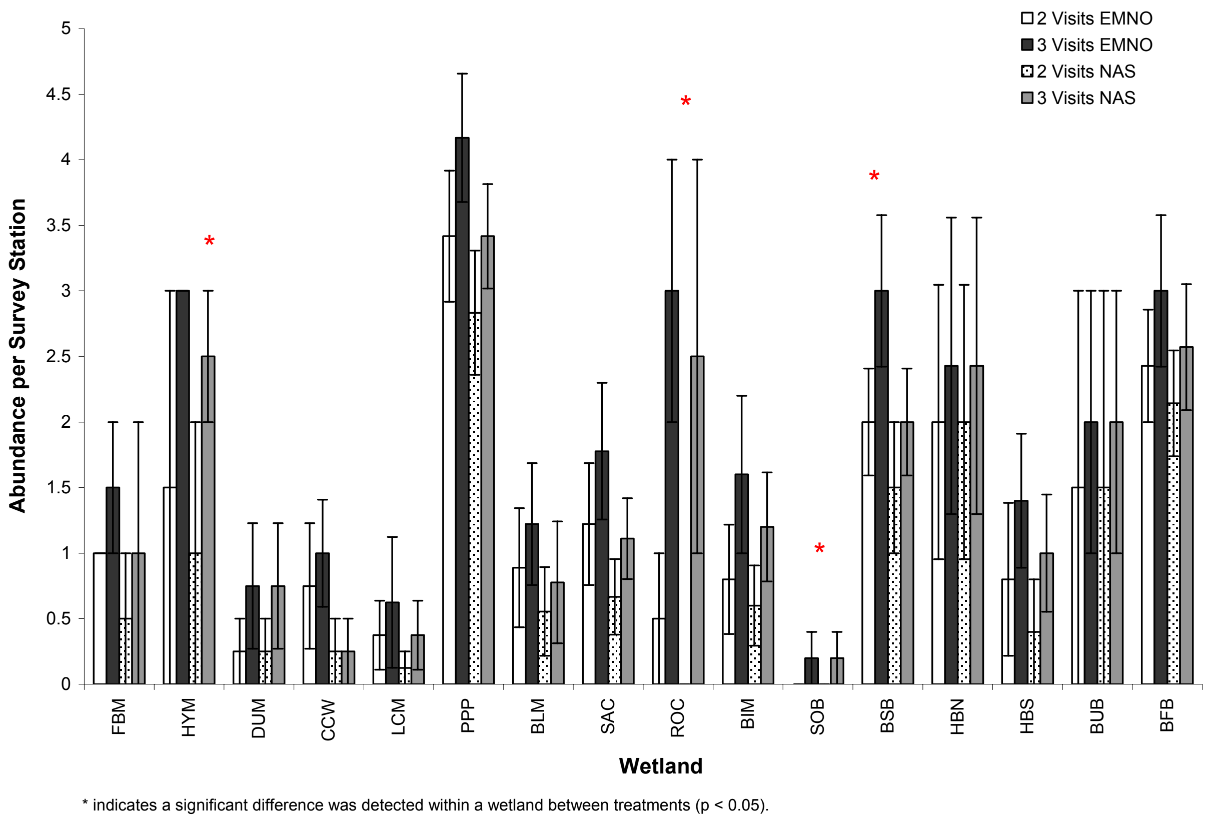


Figure 6. Mean Abundance ± SE for *Emergent Marsh Nesting Obligates* (EMNO) and *Non-Area Sensitive Marsh Nesting Obligates* (NAS) for two and three visits at each Lake Ontario coastal wetland in 2005. Only wetlands that had shoreline survey stations and where *Emergent Marsh Nesting Obligates* were observed are included.

Species richness indices for *Emergent Marsh Nesting Obligates* were significantly higher at large (e.g., Presqu'ile Bay Marsh), medium (e.g., South Bay Marsh), and small (e.g., Hydro Marsh) wetlands between three and two visits (Figure 7). Similar to mean abundance indices, surveyors also tended to observe more *Emergent Marsh Nesting Obligate* species during three visits than two for all Lake Ontario coastal wetlands.

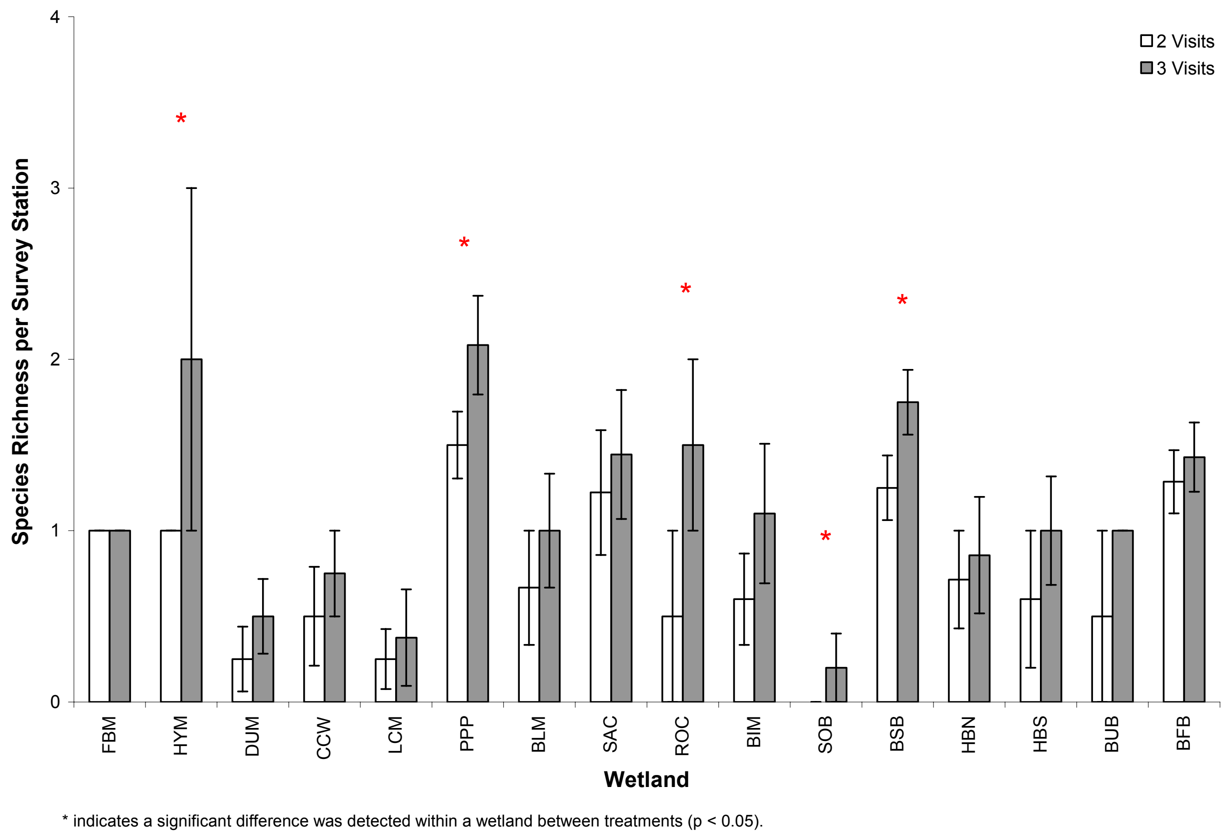


Figure 7. Mean Species Richness ± SE for *Emergent Marsh Nesting Obligates* for two and three visits at each Lake Ontario coastal wetland in 2005. Only wetlands that had shoreline survey stations and where *Emergent Marsh Nesting Obligates* were observed are included.

Recommendation for Additional Visit

These results show that abundance and species richness indices at shoreline stations are affected by an additional visit, regardless of wetland size. An additional visit resulted in more individuals and species being detected in every wetland except Carruthers Creek Marsh. At this wetland, there was no difference in the abundance index of *Non-Area Sensitive Marsh Nesting Obligates* between protocols. This is likely due to less suitable breeding habitat within each survey station at this wetland. For example, Robinson's Cove Marsh, which is a smaller wetland than Carruthers Creek Marsh, had an average of 67.5, 70, and 80 percent cattail coverage within the survey radius for Visits 1, 2, and 3 respectively. Also, during these surveys an average of 50, 65, and 30 percent of the survey area was flooded. Conversely, Carruthers Creek Marsh had an average of 36.5, 35, and 37.5 percent for cattail coverage and 45, 42.5, and 36.5 percent for flooded survey radius. *Non-Area Sensitive Marsh Nesting Obligates* such as Marsh Wren and Common Moorhen, tend to use flooded cattails as nesting habitat (Kroodsma and Verner 1997, Bannor and Kiviat 2002, Timmermans and McCracken 2004).

Abundance indices for *Emergent Marsh Nesting Obligates* were higher with three visits than two at every wetland. This was likely due to a higher probability of detecting a bird species with an additional visit. Many *Marsh Nesting Birds* breed during specific intervals based on environmental cues (e.g., seasonal temperature) as well as habitat conditions. For many species, breeding involves vocalizing for mate solicitation and territorial defense; this behaviour is affected by environmental conditions (e.g., weather). Therefore, an additional visit likely resulted in a greater probability of detecting a vocalizing species. Results from this and other studies have documented seasonal variations in abundance indices of marsh birds based on song broadcasting (Gibbs *et al.* 1992, Conway 1995, Tozer 2002). For example, in this study, American Bittern tended to call more frequently during Visit 1 than Visits 2 and 3 likely because this species breeds relatively earlier than other obligates (Figure 8, Gibbs *et al.* 1992). Virginia Rail and Common Moorhen vocalizations were more frequent during Visits 1 and 3 compared to Visit 2 possibly because these times coincide with courtship (Visit 1) and chick hatching (Visit 3). Lastly, vocalization patterns for Least Bittern generally increased with visit number likely due to the later breeding phenology of this species in Ontario (Peck and James 1983).

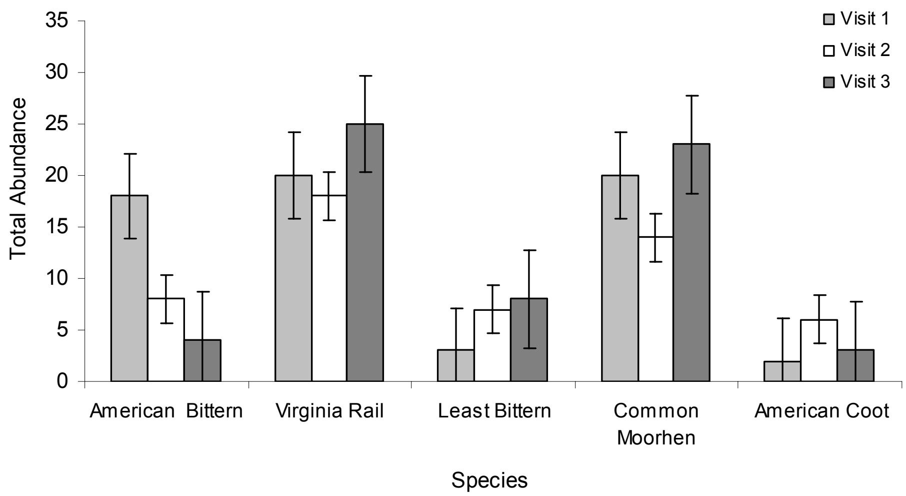


Figure 8. Total Abundance ± SE for American Bittern, Virginia Rail, Least Bittern, Common Moorhen, and American Coot in relation to visit number for Lake Ontario coastal wetlands surveyed between 25 May (Visit 1) and 4 July 2005 (Visit 3).

Although this study was limited to Lake Ontario coastal wetlands, differences in vocalization patterns between species are also present in other Great Lakes wetlands because of interspecific evolutionary differences. Therefore, an additional visit will capture more species and overall higher guild abundance regardless of lake basin because three survey visits result in a higher potential for overlap of peak vocalization times for each species compared to two visits. Consequently, an additional visit to each survey station should be implemented.

Effect of Visit Timing at Shoreline Stations

When data for Lake Ontario coastal marsh birds from only two visits were analyzed, four of the dependent variables were significantly affected by survey date (Table 4). *Emergent Marsh Nesting Obligates* had the highest abundance index during Visits 1&3 and the lowest during Visits 1&2 in the majority of Lake Ontario coastal wetlands (Figure 9). Significantly more *Emergent Marsh Nesting Obligates* were recorded during visits 1&3 than 1&2 at medium (e.g., Frenchman's Bay Marsh) and small (e.g., Robinson's Cove Marsh) wetlands. Percent of *Area Sensitive Emergent Marsh Nesting Obligates* was generally highest for Visits 1&3. Conversely, abundance indices from Visits 1&2 had more *Marsh Nesting Generalists* compared to that collected from other visit combinations (Figure 10).

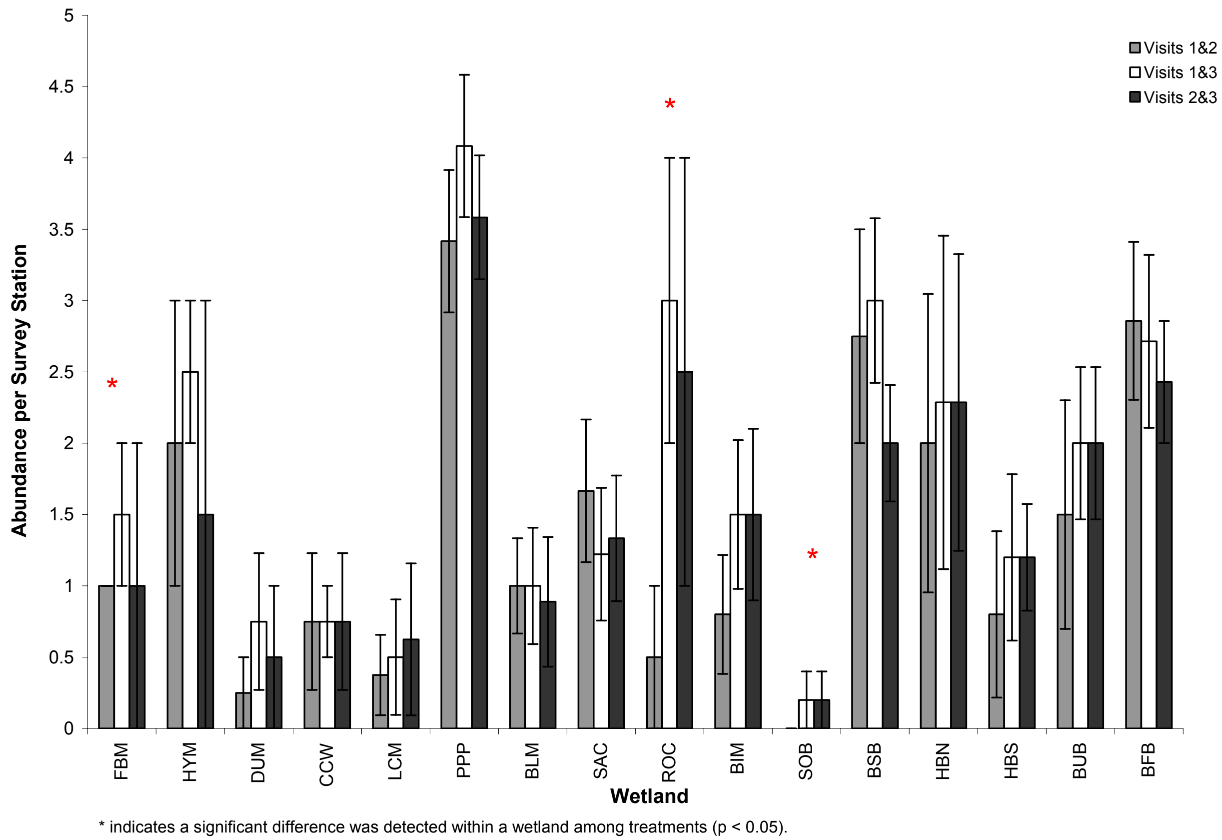
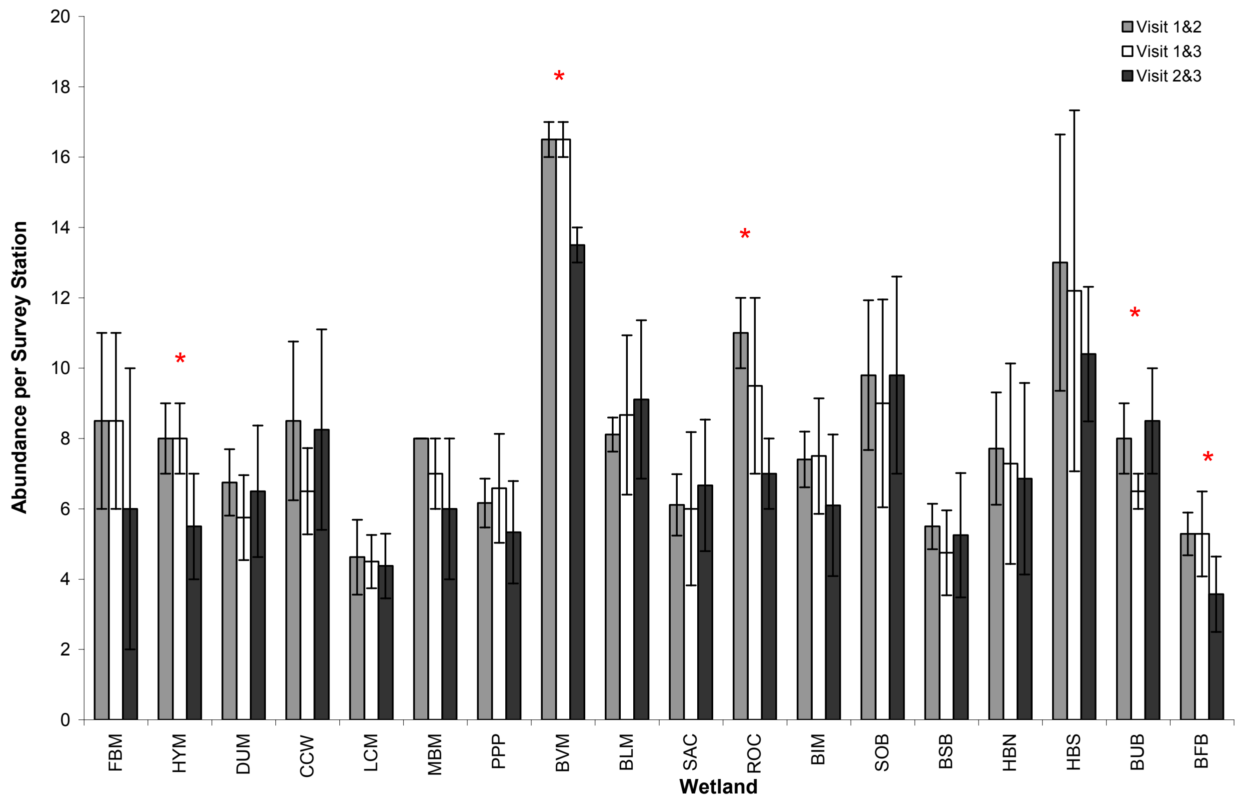


Figure 9. Mean Abundance for *Emergent Marsh Nesting Obligates* ± SE in relation to visit schedule and Lake Ontario coastal wetland.

Table 5. Percent of *Area Sensitive Emergent Marsh Nesting Obligates* within the *Marsh Dependent Bird* community observed in relation to visit schedule in Lake Ontario coastal wetlands in 2005. Only wetlands where *Area Sensitive Emergent Marsh Nesting Obligates* were observed are included.

Wetland	Percent of *Area Sensitve Emergent Marsh Nesting Obligates*		
	Visit 1&2	Visit 1&3	Visit 2&3
Frenchman's Bay Marsh	2.63	**2.78**	0.00
Hydro Marsh	3.13	0.00	**4.17**
Carruther's Creek Marsh	1.61	**3.33**	2.58
Lynde Creek Marsh	**1.79**	0.78	1.39
Presqu'ile Provincial Park	3.55	**3.75**	3.65
Blessington Marsh	**2.76**	2.10	0.74
Sawguin Creek	4.12	**4.81**	2.12
Robinson's Cove	**2.94**	2.63	0.00
Big Island Marsh	1.14	**2.58**	2.16
Big Sand Bay	6.25	**8.01**	4.91
Hay Bay South	**1.91**	1.18	1.00
Bayfield Bay	1.79	**2.61**	2.12

• highest values are bolded.



* indicates a significant difference was detected within a wetland among treatments ($p < 0.05$).

Figure 10. Mean Abundance for *Marsh Nesting Generalists* ± SE in relation to visit schedule and Lake Ontario coastal wetland.

Recommendation for Visit Timing

Each wetland should be surveyed three times during the breeding season between May and July. If only two visits are possible, however, visit one and two should be scheduled during the first and last two weeks of the specified survey window period. Furthermore, this survey window period should be region or basin specific to maximize the detectability of vocalization patterns for *Emergent Marsh Nesting Obligates* in that region. Based upon study results, this visit schedule will result in a better overlap with the different peaks in species-specific vocalization patterns (i.e., increased probability of detection). Adequately surveying these birds is essential because this suite of species and the corresponding guilds are often used to assess wetland health (e.g., Environment Canada and Central Lake Ontario Conservation Authority 2004, Crewe and Timmermans 2005) or evaluate wetland management techniques and restoration efforts (e.g., wetland dyking; see Mortsch *et al.* 2006). Conversely, if *Marsh Nesting Generalists* are the priority nesting guild, surveys should occur during the first four weeks of the specified survey window period or, in some regions, perhaps even earlier. Common Grackle and Red-winged Blackbird have been shown to initiate nesting building and territorial defense in late March / early April in some years (Yasukawa and Searcy 1995, Peer and Bollinger 1997, Haggeman 2006). Presumably, less vegetative cover early in the breeding season, in conjunction with the highly visible and vocal territorial defense of these species during this time, will maximize the detectability of Red-winged Blackbird and Common Grackle.

Effect of Adding Interior Stations

The addition of interior stations resulted in significantly higher indices of abundance and species richness for *Non-Area Sensitive* and *Emergent Marsh Nesting Obligates* compared to shoreline stations for Lake Ontario coastal wetlands (Table 4 and Figure 11). Moreover, proportionately more *Emergent Marsh Nesting Obligates* were surveyed in the interior of the wetland than along the shoreline (Figure 12). In contrast, shoreline stations resulted in a high *Marsh Nesting Generalist* species richness index.

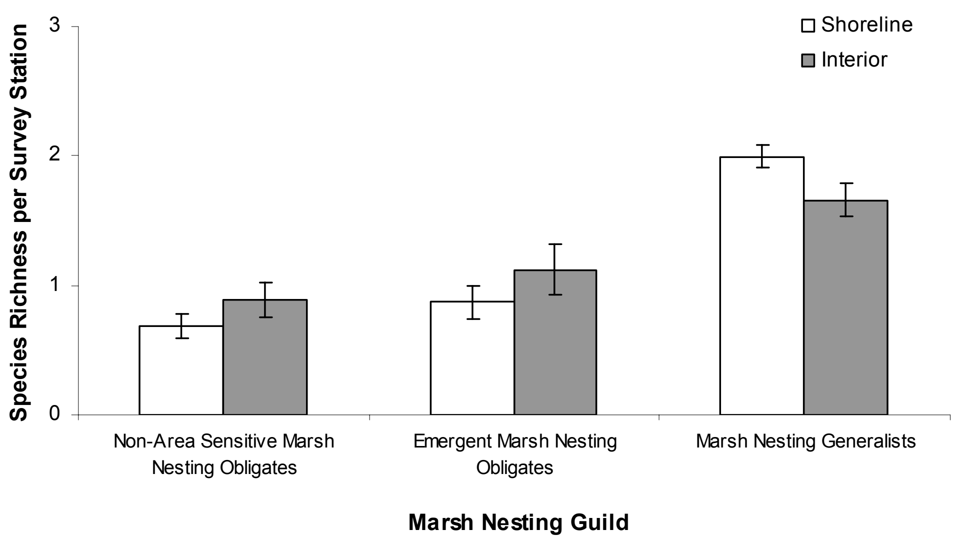


Figure 11. Mean Species Richness for various marsh nesting guilds ± SE observed in relation to survey station location for Lake Ontario coastal wetlands.

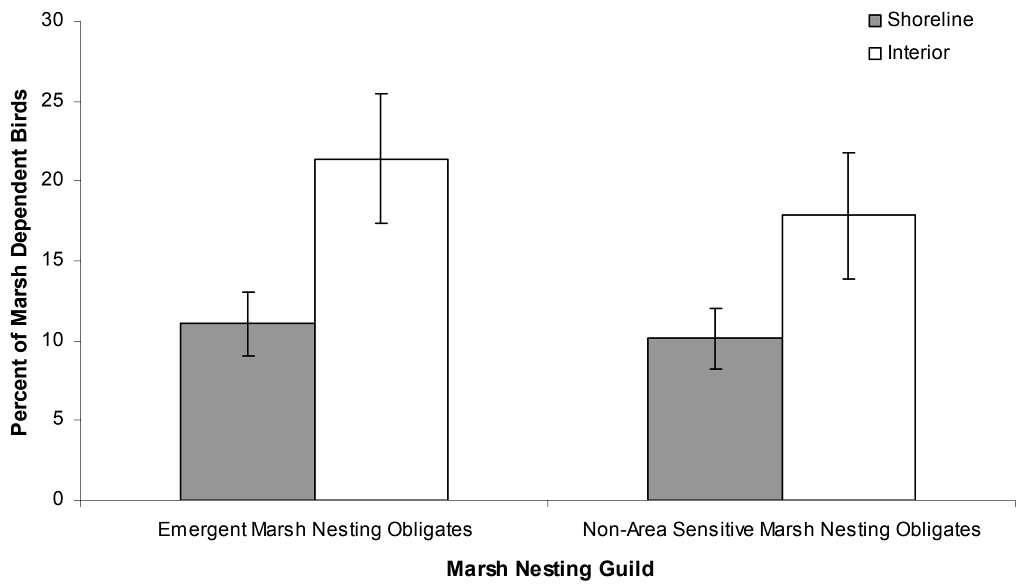


Figure 12. Percent of various marsh nesting guilds ± SE observed in relation to survey station location for 20 Lake Ontario coastal wetlands.

Recommendation for Adding Interior Stations

Study results show that adding interior stations to a route significantly increased the indices of abundance and species richness for *Emergent Marsh Nesting Obligates* within Lake Ontario coastal wetlands. Differences in the abundance and species richness indices of various marsh nesting bird guilds between interior and shoreline stations were likely due to the use of specific habitats by these marsh birds. For example, American Coot and Pied-billed Grebe tend to use habitats with a high proportion of open water while Virginia Rail and American Bittern tend to use habitats with a high proportion of tall emergent vegetation and little open water (Timmermans and McCracken 2004). Furthermore, water depth affects the suitability of wetland habitat for many marsh breeding birds (Craigie *et al.* 2003; Poole and Gill, ongoing). Indices of abundance for *Emergent Marsh Nesting Obligates* and *Marsh Nesting Generalists* tend to peak in suitable wetland habitats flooded in approximately 100 cm and 60 cm of water, respectively (Mortsch *et al.* 2006). On average, shoreline stations in this study had less open water, more tall emergent vegetation, and shallower water depths than interior stations (Table 6). Consequently, certain species were only surveyed at either shoreline or interior stations (Table 7). Therefore, a survey route consisting of shoreline and interior stations is more likely to detect a higher index of abundance and species richness of *Emergent Marsh Nesting Obligates* and *Marsh Nesting Generalists* because of the potential of surveying a wider diversity of habitats and water depths.

Table 6. Average percent cover of Open Water and Tall Emergent Vegetation and average Water Depth ± SE for shoreline and interior stations surveyed using the marsh habitat survey protocol from the Marsh Monitoring Program for 20 Lake Ontario coastal wetlands.

Station Location	Average Percent Cover		Average Water Depth (cm)
	Open Water	Tall Emergent Vegetation	
Shoreline	25.85 ± 2.18	59.6 ± 6.08	21.63 ± 0.48
Interior	50.53 ± 2.38	54.50 ± 3.04	52.98 ± 0.41

Table 7. Station location for *Marsh Dependent Birds* observed at Presqu'ile Bay Marsh (a) and Sawguin Creek Marsh (b) in 2005. *Marsh Dependent Birds* include all *Marsh Nesting Birds* and *Water Foragers*. Only Presqu'ile Bay Marsh and Sawguin Creek Marsh are shown because they represent wetlands that had a balanced number of interior and shoreline survey stations.

(a) Presqu'ile Provincial Park

Species	Interior Station	Shoreline Station
American Bittern	√	√
American Coot	√	
American Woodcock		√
Common Grackle	√	√
Common Moorhen	√	√
Common Yellowthroat	√	√
Great Blue Heron	√	√
Least Bittern	√	
Mallard		√
Marsh Wren	√	√
Pied-billed Grebe	√	√
Red-winged Blackbird	√	√
Swamp Sparrow	√	√
Virginia Rail	√	√
Wood Duck	√	√

(b) Sawguin Creek Marsh

Species	Interior Station	Shoreline Station
American Bittern	√	√
Common Grackle	√	√
Common Moorhen	√	√
Common Yellowthroat	√	√
Great Blue Heron	√	
Least Bittern	√	
Mallard		√
Marsh Wren	√	√
Red-winged Blackbird	√	√
Swamp Sparrow	√	√
Virginia Rail	√	√
Wood Duck	√	

Shoreline and Interior Stations within a Route

Although wetland size determines the total number of survey stations within a wetland (see Table 2), other factors such as shoreline convolution and habitat interspersion can affect whether interior stations are possible. For example, Hydro Marsh and Button Bay Marsh are relatively small wetlands. Button Bay Marsh, however, has a narrow band of fringing emergent marsh while Hydro Marsh has a cattail fringe with many peninsulas. As such, only two shoreline stations were possible in Button Bay Marsh while Hydro Marsh had two shoreline and one interior station despite its smaller size. As a result, recommendations on when to include interior stations within a wetland are difficult to provide unless wetland size and habitat complexity are known. Generally, interior stations should be considered for spatially complex wetlands.

Recommending how many stations to survey is possible based on species accumulation curves. These curves plot the relationship between the number of species detected and survey stations. Theoretically, when the curve begins to asymptote all species have been detected. In reality, some *Emergent Marsh Nesting Obligates* are rare (e.g., King Rail) or may be difficult to survey (e.g., Pied-billed Grebe) and, therefore, may not be detected regardless of how intensely a wetland is surveyed. A species accumulation curve, however, provides a general guideline to maximize logistical and financial resources in order to detect a high percentage of species richness at a site. For example, at Presqu'ile Bay Marsh, a total of 15 *Marsh Dependent Bird* species were recorded. Of these, 13 species (approximately 87 percent) were detected with an interior or shoreline route that consisted of eight stations (Figure 13 see *). To detect the same number of species, six stations (three interior and three shoreline) would need to be surveyed. The addition of interior stations to a route also resulted in more *Emergent Marsh Nesting Obligate* species surveyed (e.g., American Coot and Least Bittern) compared to a shoreline route (Table 7). Furthermore, a route consisting of a combination of shoreline and interior stations resulted in more species recorded than that obtained from a route with just shoreline or just interior stations.

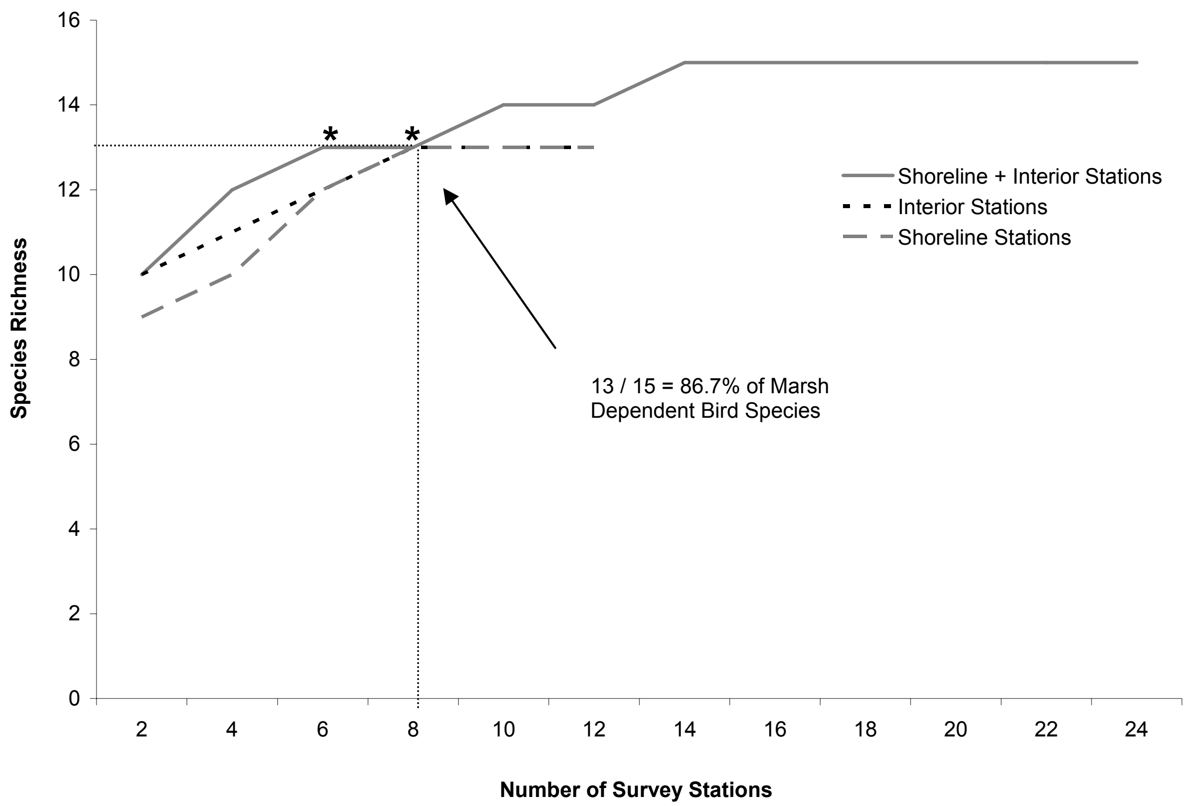


Figure 13. Species Accumulation Curve (in three visits) and number of survey stations by station location for *Marsh Dependent Birds* observed at Presqu'ile Bay Marsh, Ontario.

Similarly, at a regional scale, on average at wetlands that had interior and shoreline stations (n = 13), four shoreline and four interior stations (total = eight stations per route) would need to be surveyed to detect most *Emergent Marsh Nesting Obligate* bird species (Table 8).

Table 8. Species Accumulation of *Emergent Marsh Nesting Obligates* at a station in relation to station location for 13 Lake Ontario coastal wetlands in 2005 (based on three visits to a survey station).

Common Name	# of Shoreline Stations									
	1	2	3	4	5	6	7	8	9	10
American Coot	√	√	√	√	√	√	√	√	√	√
Common Moorhen	√	√	√	√	√	√	√	√	√	√
Marsh Wren	√	√	√	√	√	√	√	√	√	√
Virginia Rail	√	√	√	√	√	√	√	√	√	√
American Bittern		√	√	√	√	√	√	√	√	√
Least Bittern				√	√	√	√	√	√	√
Pied-billed Grebe								√	√	√
	# of Interior Stations									
	1	2	3	4	5	6	7	8	9	10
Marsh Wren	√	√	√	√	√	√	√	√	√	√
Virginia Rail	√	√	√	√	√	√	√	√	√	√
Least Bittern	√	√	√	√	√	√	√	√	√	√
Pied-billed Grebe	√	√	√	√	√	√	√	√	√	√
American Bittern		√	√	√	√	√	√	√	√	√
Common Moorhen			√	√	√	√	√	√	√	√
American Coot				√	√	√	√	√	√	√
King Rail									√	√

CASE STUDY: DETERMINING THE BIOTIC INTEGRITY OF THE MARSH BIRD COMMUNITY

An Index of Biotic Integrity (IBI) incorporates several biological metrics into a combined, standardized score to increase the accuracy in describing the condition of a particular biological community. Biological metrics are selected based on a known response to changes in wetland condition (e.g., disturbance). For example, more exotic species and fewer native species are likely found in a heavily disturbed wetland compared to a relatively pristine wetland (for more information on calculating IBI see Environment Canada and Central Lake Ontario Conservation Authority 2004). Marsh bird IBIs were calculated for each treatment using the following four metrics that were previously shown to significantly respond to disturbance: *Area Sensitive Marsh Nesting Obligate* species richness, relative percentage of *Marsh Nesting Obligates* within the Total Bird community, relative percentage of *Marsh Dependent Birds* in the Total Bird community and relative percentage of *Area Sensitive Marsh Nesting Obligates* within the Total Bird community.

IBI scores were calculated for various visit treatments for combined shoreline and interior stations and only shoreline stations. Scores were arcsine transformed and analyzed using a repeated-measures ANOVA with significance set at $p < 0.05$. There was no effect on IBI scores from an additional visit or the timing of two visits. Station location significantly affected IBI scores (Figure 14). For pooled wetland data, the addition of interior stations to a shoreline route resulted in higher marsh bird IBI scores than that obtained from the standard shoreline based MMP marsh bird survey protocol. When each site was examined, nine wetlands had higher IBI scores with the addition of interior stations to a shoreline based survey route while four had lower scores (Table 9).

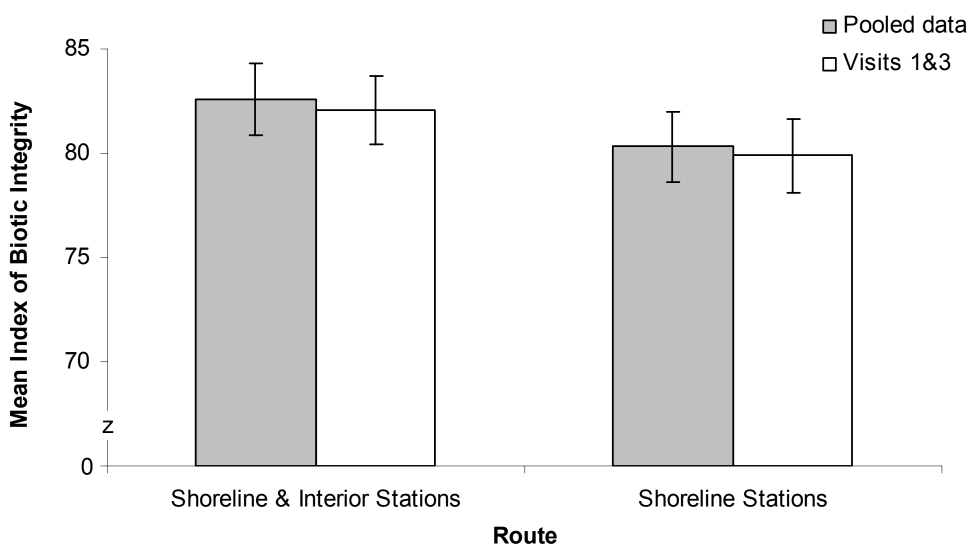


Figure 14. Mean Index of Biotic Integrity for the Marsh Bird Community using pooled data and Visits 1&3 for all routes containing shoreline and interior stations and only shoreline stations. Data from Visits 1&3 were used because these visits likely represent MMP surveys.

Table 9. Indices of Biotic Integrity for the Marsh Bird Community using Visits 1&3 in Lake Ontario coastal wetlands surveyed in 2005. Only wetlands that had shoreline and interior stations in a route are shown. Visits 1&3 were used because these visits likely represent MMP surveys.

Wetland	Interior & Shoreline Stations	Shoreline Stations	Difference
FBM	68.82	73.39	-4.57
BSB	92.76	94.65	-1.89
BIM	91.35	92.50	-1.15
BFB	90.18	91.07	-0.89
PPP	92.87	91.90	0.97
SOB	62.14	59.20	2.94
BLM	89.15	85.99	3.16
LCM	74.30	71.05	3.25
DUM	71.44	67.87	3.57
HYM	69.54	64.51	5.03
SAC	97.22	92.06	5.16
HBN	91.67	86.18	5.49
HBS	75.50	68.11	7.39

Although the inter-annual variability in wetland IBI scores for marsh bird communities could not be examined due to only one year of data, these results suggest that adding interior stations at most spatially complex wetlands would decrease this variability. In general, a more intensive site-level marsh bird survey protocol (i.e., adding interior stations) resulted in higher avian metrics that comprise IBI scores. Consequently, if individual metrics are consistently higher and only a limited number of individuals and species of birds can breed within a wetland due to breeding territory size and habitat availability, higher avian metrics must provide a more accurate representation of the marsh bird community compared to lower values.

SUMMARY

This study showed that modifying the standard MMP marsh bird survey protocol to incorporate an additional visit and interior stations resulted in higher indices of abundance and species richness for marsh birds, particularly *Emergent Marsh Nesting Obligates*, and higher IBIs for most wetlands compared to standard MMP marsh bird survey protocol. These results are relevant to evaluating wetlands at a site-level because the community of *Emergent Marsh Nesting Obligates* and the corresponding sub-guilds are often used to assess wetland habitat quality. Adequately surveying this bird community is essential to assessing the overall health, or biotic integrity, of the wetland bird community. Consequently, results from this study will assist in the refinement of site-level marsh bird survey protocol. This is important for various Great Lakes conservation and research initiatives. Overall, better site-level marsh bird data, in conjunction with other site-level assessments (e.g., habitat, herptile, invertebrate, water quality, and species at risk surveys), will, (1) facilitate the focusing of restoration efforts for site-specific degraded wetlands, (2) provide information so that wetland securement for conservation initiatives can be prioritized and assessed to maximize ecological gains, (3) provide data for monitoring wetland communities so that management techniques can be assessed as well as possible ecological changes in wetland communities can be detected early and acted on, and (4) provide marsh bird data to further understand the habitat requirements of many wetland dependent birds.

This study showed that a modified MMP marsh bird survey protocol can be implemented that builds off an existing volunteer survey protocol and is still intensive enough to collect site-level data. Although the modified MMP marsh bird survey protocol will not provide a better site-level assessment than a full-scale survey (e.g., point counts, nest searching, plant quadrats, etc.), it still provides a practical compromise between volunteer and intensively focused surveys. This is important if a range of wetlands are to be surveyed in a given time frame in order to provide an overall marsh bird assessment of a given location or region. Moreover, formal development of a second tier site-level marsh bird survey protocol that complements large-scale marsh bird monitoring programs such as the MMP has many benefits. Benefits include the use of the same resources and marsh bird survey data at multiple scales and subsequently increased support for implementation of regional/national bird monitoring programs by local stakeholders given the increased suitability of data use at a scale of interest (e.g., wetland conservation and restoration evaluations).

If marsh bird survey protocol from the MMP is implemented to evaluate the marsh bird community annually at a site-level, the following modifications should be made:

- Wetland spatial complexity and marsh habitat should be visually assessed from a recent aerial photograph before visiting the site,
- Potential survey stations should be identified within the wetland based on at least a 250-metre grid system with interior stations required for spatially complex wetlands. Survey stations should be initially selected according to MMP habitat criteria,
- Survey stations should be visited before surveying and selected based on habitat criteria, accessibility, safety, and to maximize surveying time,
- An equal number of interior and shoreline stations should be selected for spatially complex wetlands, where possible,
- Each station should be visited three times during the breeding season (i.e., peak vocalization time) for *Emergent Marsh Nesting Obligates* in that ecoregion.

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