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Short communication

Application of the index of marsh bird community integrity to coastal wetlands of Georgian Bay and Lake Ontario, Canada

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ABSTRACT

Ecological indicators have gained increasing attention within the scientific community over the past 40 years. Several taxonomic groups have been used successfully as indicators including most prominently fish, invertebrates, plants, and birds because of their ability to indicate environmental changes. In the Laurentian Great Lakes region, there has been recent concern over the applicability of using indicators on a basin-wide scale due to species range restrictions and lake-based differences. The objective of this study was to determine the ability of the Index of Marsh Bird Community Integrity (IMBCI) to indicate land use disturbance surrounding coastal marshes of Georgian Bay and Lake Ontario. To meet this objective, we surveyed birds and vegetation at 14 marshes in Georgian Bay (low land use disturbance) and Lake Ontario (high land use disturbance). Even though Lake Ontario marshes were surrounded by significantly more altered land than Georgian Bay marshes, and had poorer water quality, we found significantly fewer birds in Georgian Bay marshes (mean = 8.2) compared to Lake Ontario (mean = 13.7) and no significant difference in IMBCI scores. This inconsistency could be due to vegetation differences affecting the strength of the index, because Georgian Bay wetlands had significantly more bulrush (*Schoenoplectus* spp.) and floating vegetation, while Lake Ontario wetland vegetation was taller and cattail-dominated (*Typha* spp.). These findings suggest that the IMBCI may not be useful on a basin-wide scale in the Great Lakes region in detecting human disturbance surrounding wetlands.

1. Introduction

Before European settlement (circa 1800), wetlands covered 2.38 million ha of land in southern Ontario (Snell, 1987). By 1982, it was estimated that 90% of these wetlands had been lost, primarily due to draining for agriculture (Snell, 1987). These wetland loss statistics do not provide any information on the quality of the remaining wetlands, and recent studies have shown that many coastal wetlands in southern Ontario are highly degraded (Chow-Fraser, 2006). These degraded wetlands along the shores of Lake Erie and Lake Ontario are in sharp contrast to the relatively undisturbed wetlands along the shoreline of eastern Georgian Bay. Many of these marshes have remained essentially undisturbed due to low levels of watershed disturbance, with many watersheds in the region consisting of primarily forest, with minimal cottage development (Croft and Chow-Fraser, 2009).

The development and use of indicators is essential to ecological monitoring and are therefore very important tools towards the protection of natural areas. Several taxa have been used as environmental indicators including fish (Seilheimer and Chow-Fraser, 2006), insects (Anderson and Vondracek, 1999), plants (Croft and Chow-Fraser, 2007), and birds (DeLuca et al., 2004). Insectivorous birds have been shown to respond as indicators of human disturbance in Great Lakes coastal wetlands (Brazner et al., 2007). The Sedge Wren (*Cistothorus platensis*), Common Yellowthroat (*Geothlypis trichas*), and Sandhill Crane (*Grus canadensis*) are indicators of low disturbance, while the Common Grackle (*Quiscalus quiscula*) and European Starling (*Sturnus vulgaris*) indicate coastal wetlands that have been highly disturbed by humans through agricultural and urban land uses in the drainage area leading to the wetland (Howe et al., 2007).

DeLuca et al. (2004) developed an Index of Biotic Integrity for marsh birds in wetlands of Chesapeake Bay, USA called the Index of Marsh Bird Community Integrity (IMBCI). This index uses species-specific feeding, nesting, migratory, and breeding distribution information to assign each species a score and then a composite score for the entire wetland. IMBCI values were found to be significantly reduced when urbanization covered 25% or more of the land within 1 km of the wetland edge, demonstrating that marsh birds are affected by local land use practices. In this study, we examine (1) the ability of the IMBCI to accurately detect land use impacts in coastal marshes of eastern Georgian Bay and Lake Ontario, and (2)

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discuss the suitability of using the IMBCI as an indicator of wetland health on a basin-wide scale.

2. Methods

2.1. Study sites

Between 2001–2002, and 2006–2007, we visited 14 coastal marshes in southern Ontario, Canada to survey birds, vegetation, and water quality (Fig. 1). Seven of these marshes were along the shore of Lake Ontario and seven were along the eastern shoreline of Georgian Bay. We chose wetlands of approximately equal size to account for prominent species–area relationships that exist for wetland birds (Smith and Chow-Fraser, 2010b).

2.2. Bird surveys

We visited each site once during the breeding season between 15 May and 13 July. Point counts were 10 min in length and a 25 m radius full circle was used. After the 10 min passive period, we broadcasted the songs of secretive marsh birds. We recorded all birds seen and heard regardless of sex and counted all individuals which were landing, flushing, wading, perching, or calling within the point count area. For detailed methodology please see Smith and Chow-Fraser (2010a).

2.3. Vegetation surveys

Vegetation surveys were conducted in conjunction with point counts. All Georgian Bay sites and Bronte Creek, Credit River and Darlington were surveyed for birds and vegetation in 2006 while all other sites were surveyed in 2007. We estimated the percent cover and height of emergent vegetation, floating vegetation, and open water within the 25 m radius point count (Paracuellos and Telleria, 2004).

2.4. Water quality sampling

We sampled water quality between 28 May and 4 July 2001–2002 and 2006–2007. Water quality was sampled in 2001 for Darlington, 2002 for Bronte Creek and Credit River, 2006 for Corbman Bay, North Bay 2, and Parry Island 1, and in 2007 for Van Wagners. Based on water quality samples, we then calculated the Water Quality Index (WQI) for each wetland which was created from 12 water quality variables (Chow-Fraser, 2006). WQI scores range from −3 to +3 with negative scores representing highly degraded wetlands (e.g. high levels of phosphorus, nitrogen, turbidity) and positive scores representing more pristine wetlands (e.g. low levels of phosphorus, nitrogen, turbidity). For detailed water quality sampling protocols and development of WQI scores please see Chow-Fraser (2006).

2.5. Land use

To determine land use within 1 km of each wetland we used ArcMap 9.2 (ESRI Inc., 2006). We used the Southern Ontario Land Resources Information System (SOLRIS; OMNR, 2008) to analyze land use surrounding Lake Ontario wetlands. For Georgian Bay wetlands, we used IKONOS satellite imagery because SOLRIS coverage was limited to south of our study sites in ecoregions 6E and 7E. These ecoregions combined represent the area enclosed by the north shores of Lake Ontario and Lake Erie, along the eastern coast of Lake Huron up to the Bruce Peninsula and around southern Georgian Bay to Midland and across the land eastward to the Ontario–Quebec border near Arnprior, Ontario (Lee et al., 1998). We used the Braun-Blanquet scale (Braun-Blanquet, 1932) to determine if the amount of altered land within the 1 km buffer was <5, 5–25, 25–50, 50–75, or 75–100% of the total buffered area then subsequently assigned each range a number from 1 to 5, respectively.

2.6. Statistical analysis

All analyses were performed using Statistica 6.0 (StatSoft Inc., 2001). To calculate the IMBCI, each species was assigned a score based on four life history characteristics: foraging habitat (habitat generalist–marsh obligate), nesting substrate (non-marsh nester–marsh ground nester), migratory status (resident–Neotropical), and breeding range (North America–North America–east coast only). Species with a high score would be Neotropical migrants, nest and feed only in wetlands, and have a limited breeding range in North America. Species producing a low score would be a resident species, nest outside the wetland, occasionally feed in wetlands, and be widely distributed throughout the continent. Once a score has been calculated for each species, a total IMBCI value can be calculated for the wetland as (DeLuca et al., 2004):

$$W_{\mathrm{IMBCI}} = \left[\left(\frac{\sum S_{\mathrm{IMBCI}}}{S_{\mathrm{N}}} \right) + \mathrm{MO_N} \right] - 4$$

where S_{IMBCI} is each species' individual score, S_{N} is the total number of species, and $\mathrm{MO_N}$ is the number of marsh obligate nesters detected. High IMBCI scores indicate marsh bird communities with many wetland-specialized species, and few generalists. For more details on the IMBCI, please see DeLuca et al. (2004).

Three southern sites were randomly selected to be surveyed twice during the breeding season to determine if conducting one point count over the season detected a similar avian abundance, richness and IMBCI value as conducting two seasonal point counts. We used dependent *t*-tests to examine this difference at Rattray, Van Wagners and Credit River marshes. To examine differences in wetland size, avian richness, avian abundance, the IMBCI, and the WQI between Georgian Bay and Lake Ontario we used independent *t*-tests. For land use using the Braun-Blanquet scale, all vegetation variables, and Julian day we used the non-parametric Mann–Whitney *U*-test and we report *z*-values adjusted for ties. Results are shown as means ± 1SE unless otherwise indicated.

3. Results

Conducting one point count as opposed to two point counts over the breeding season did not significantly affect the abundance ($t = 0.122$, $p = 0.914$), richness ($t = 2.77$, $p = 0.109$) or IMBCI values ($t = 0.887$, $p = 0.469$) obtained at a sub-set of marshes. Therefore, we were confident that our point counts detected a comparable bird community to conducting two seasonal point counts. We found no significant difference in wetland size or bird species richness between Georgian Bay and Lake Ontario (Table 1). There was a significant difference in the number of wetland birds per site, with significantly fewer individuals in Georgian Bay wetlands (8.2 ± 1.9) than Lake Ontario wetlands (13.7 ± 1.6; $t = 2.25$, $p = 0.044$). Even though IMBCI values did not show a difference between lakes, wetlands of Lake Ontario were significantly more disturbed than those in Georgian Bay according to the degree of urbanization and agricultural development (Table 1). Lake Ontario sites also showed significantly poorer water quality than did Georgian Bay sites.

When examining species composition between lakes, there were several species that were only recorded in Georgian Bay or only in Lake Ontario (Table 2). Most notably, several wetland-dependent species were not recorded in Georgian Bay but were recorded in Lake Ontario including the Sora (*Porzana carolina*),

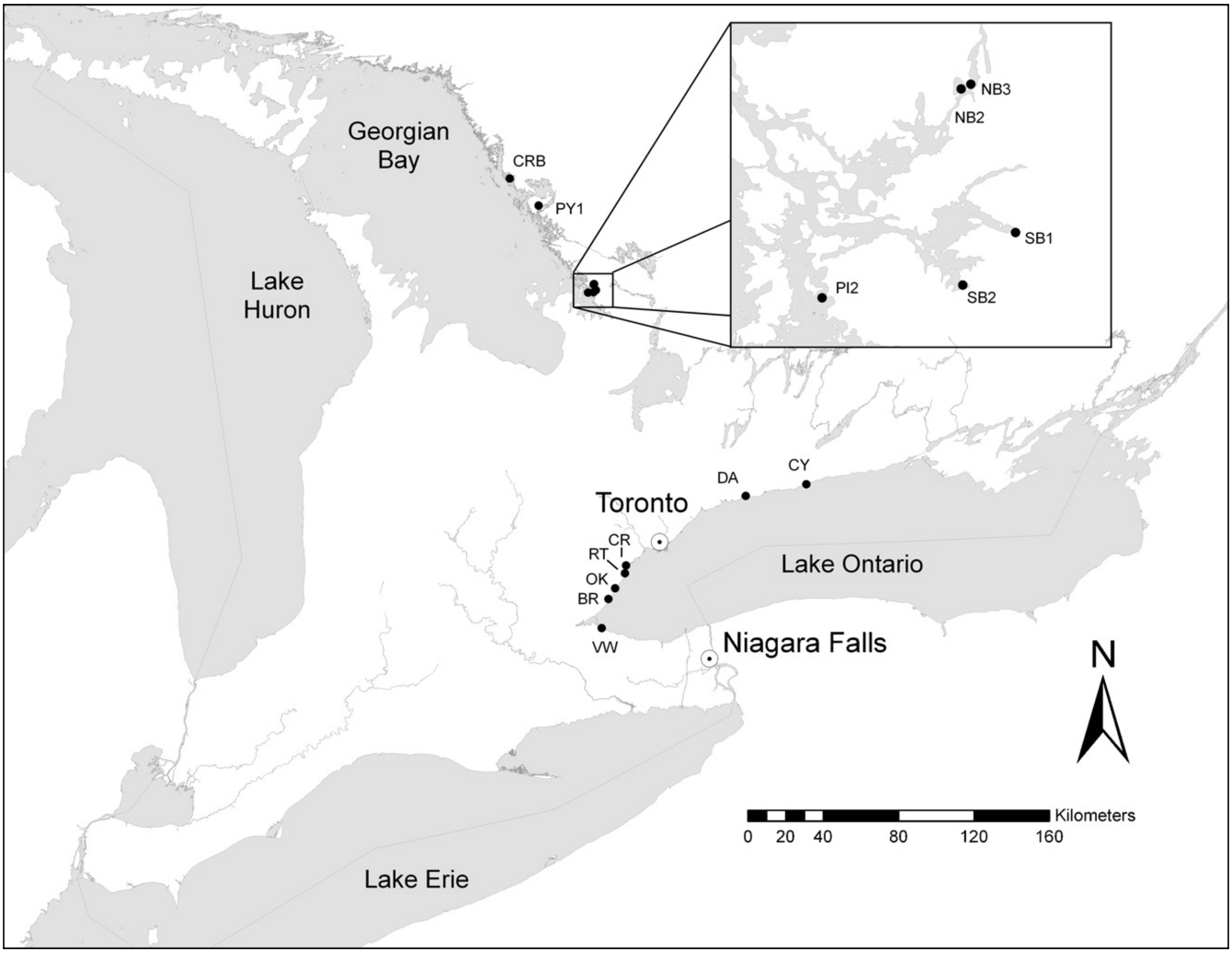

Fig. 1. A map of the lower Laurentian Great Lakes showing coastal wetland study sites surveyed along the shoreline of Lake Ontario and Georgian Bay. Site codes represent Corbman Bay (CRB), North Bay 2 (NB2), North Bay 3 (NB3), Parry Island 1 (PY1), Picnic Island 2 (PI2), South Bay 1 (SB1), South Bay 2 (SB2), Bronte Creek (BR), Credit River (CR), Crysler (CY), Darlington (DA), Oakville Marsh (OK), Rattray Marsh (RT), and Van Wagners Pond (VW).

Virginia Rail (*Rallus limicola*), Least Bittern (*Ixobrychus exilis*), and Marsh Wren (*Cistothorus palustris*). These species contribute a proportionally larger species score to the IMBCI because they rely on wetlands for both foraging and nesting, and are long-distance migrants.

These differences in bird communities could be a result of differences in dominant wetland vegetation between the lakes and species-specific habitat preferences (Table 1). Wetlands in Georgian Bay had significantly more bulrushes and floating species than those in Lake Ontario which contained significantly more cattails, and taller vegetation. These vegetation differences were not related to differences in sampling dates since the periods overlapped (15 May to 3 July for Lake Ontario wetlands, and 31 May to 20 June for Georgian Bay wetlands).

Table 1
Differences in wetland size, avian species richness, avian abundance, IMBCI, land use, WQI values, vegetation and Julian day of vegetation sampling between Georgian Bay and Lake Ontario coastal wetlands. Shown are means ± 1SE and significant results are indicated with an *.

Variable	Lake		Test statistic	p
	Georgian Bay (n = 7)	Lake Ontario (n = 7)		
Wetland size (ha)	6.44 ± 2.17	8.26 ± 1.55	t = 0.680	0.509
Species richness	5.9 ± 0.88	7.9 ± 1.0	t = 1.49	0.162
Average abundance per wetland	8.2 ± 1.9	13.7 ± 1.6	t = 2.25	0.044*
IMBCI	3.04 ± 0.37	4.23 ± 0.90	t = 1.22	0.245
Land use (Braun-Blanquet and % altered, 1 km buffer)	1.29 ± 0.18 (<5%)	4.86 ± 0.14 (76–100%)	z = 3.34	<0.001*
WQI	1.22 ± 0.12	−1.39 ± 0.24	t = 8.59	<0.001*
%Cattails (*Typha* spp.)	0.14 ± 0.14	44.3 ± 5.45	z = 3.26	<0.01*
%Bulrush (*Schoenoplectus* spp.)	20.0 ± 7.2	0 ± 0	z = 2.25	0.025*
Average vegetation height (m)	0.54 ± 0.07	1.63 ± 0.19	z = 3.04	<0.01*
%Open water	27.9 ± 9.0	40.1 ± 5.3	z = 1.16	0.247
%Floating	33.6 ± 10.3	0 ± 0	z = 2.61	<0.01*
Julian day	160 ± 2.5	162 ± 8.7	z = 0.19	0.848

Table 2
Similarities and differences in species composition recorded during point counts in coastal marshes of Georgian Bay and Lake Ontario.

Sample region	Species
Recorded in both Georgian Bay and Lake Ontario	Red-winged Blackbird (*Agelaius phoeniceus*)[a,b], Ring-billed Gull (*Larus delawarensis*)[a], Common Grackle (*Quiscalus quiscula*)[a], Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)[b], American Goldfinch (*Carduelis tristis*), Canada Goose (*Branta canadensis*), Tree Swallow (*Tachycineta bicolour*), Barn Swallow (*Hirundo rustica*), Great Blue Heron (*Ardea herodias*), Caspian Tern (*Sterna caspia*), Yellow Warbler (*Dendroica petechia*), Song Sparrow (*Melospiza melodia*), Swamp Sparrow (*Melospiza Georgiana*), Spotted Sandpiper (*Actitis macularia*), Common Yellowthroat (*Geothlypis trichas*)
Only recorded in Georgian Bay	Purple Martin (*Progne subis*), Blue-winged Teal (*Anas discors*), American Bittern (*Botaurus lentiginosus*), Eastern Kingbird (*Tyrannus tyrannus*), Herring Gull (*Larus argentatus*)
Only recorded in Lake Ontario	Mute Swan (*Cygnus olor*)[b], Cliff Swallow (*Petrochelidon pyrrhonota*), Mallard (*Anas platyrhynchos*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Common Tern (*Sterna hirundo*), European Starling (*Sturnus vulgaris*), American Robin (*Turdus migratorius*), Northern Cardinal (*Cardinalis cardinalis*), Sora (*Porzana carolina*), Virginia Rail (*Rallus limicola*), Least Bittern (*Ixobrychus exilis*), Marsh Wren (*Cistothorus palustris*), Belted Kingfisher (*Ceryle alcyon*), Chimney Swift (*Chaetura pelagica*)

[a] Indicates the three most abundant species in Georgian Bay marshes.
[b] Indicates the three most abundance species in Lake Ontario marshes.

4. Discussion

The overall goal of this paper was to determine the ability of the IMBCI to differentiate between levels of land use disturbance in Georgian Bay and Lake Ontario. This index has been successfully applied to both wetlands of Chesapeake Bay, USA and coastal marshes of Lake Erie and Lake Ontario (DeLuca et al., 2004; Smith and Chow-Fraser, 2010a). It is also currently recommended for use at "marshes in any landscape context" in the Mid-Atlantic Region by the United States Environmental Protection Agency (U.S. EPA, 2006). Contrary to its previous success, we found that this index did not explain land use disturbance when comparing bulrush-dominated, Georgian Bay coastal marshes to cattail-dominated wetlands of Lake Ontario.

The inability of this index to relate the bird communities to land use in our study could be attributed partially to vegetation and/or breeding range restrictions in Georgian Bay. Several species were absent from our point counts in Georgian Bay including the Sora, Virginia Rail, Least Bittern, and Marsh Wren, that would have contributed largely to the resulting IMBCI scores because they are wetland-dependent species. The Sora and Marsh Wren (Verner and Engelsen, 1970; Melvin and Gibbs, 1996) both prefer to build nests in cattails over other available vegetation, and the Marsh Wren might be limited additionally in eastern Georgian Bay because this is approaching the northern limit of its breeding range (Kroodsma and Verner, 1997). The absence of the Virgnia Rail is difficult to explain because vegetation is not a good indicator for habitat selection because they will nest in a wide variety of emergent species (Walkinshaw, 1937), and they are not limited by breeding range. For this species water depth may be more important as they prefer shallow water (<30 cm) and mud flats for foraging (Conway, 1995), but since we did not measure water depth at each site it is difficult infer a relationship. The Least Bittern is limited by distribution because the northern limit of its breeding range is southern Georgian Bay, and in addition, it prefers tall, dense, emergent vegetation for nesting and the vegetation in Georgian Bay was shorter than that of Lake Ontario (Poole et al., 2009).

This is not the first time that the applicability of indicators on a basin-wide scale has been called into question. Bird indicator species, such as the Common Yellowthroat, have previously been identified as good indicators of human disturbance; however, when used at a basin-wide scale these trends were not apparent (Brazner et al., 2007; Howe et al., 2007). Common Yellowthroats are found in varying abundance between lakes and therefore may not be good indicators of human disturbance. Several other indicator groups have shown significant variation between lakes including wetland obligate plants, amphibian species richness, and native fish species (Brazner et al., 2007). Several insect indicator species also show greater variation based on ecoregion than landscape disturbance (Anderson and Vondracek, 1999). The results of this study and others suggest that it may be difficult to develop accurate indicators of coastal marsh health in the Great Lakes Region without taking into account lake-based differences (Brazner et al., 2007).

5. Conclusion

We suggest that indicators should be thoroughly tested before being considered for use across large geographic areas. Future research should test the ability of the IMBCI to detect land use changes among only cattail-dominated marshes of Georgian Bay and Lake Ontario to determine if wetland vegetation or geographic region was the driving factor causing the differences found in this study. It is our hope that this study will stimulate both future research into indicator variation between regions, and discussion on appropriate indicators for use in the Great Lakes Region.

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