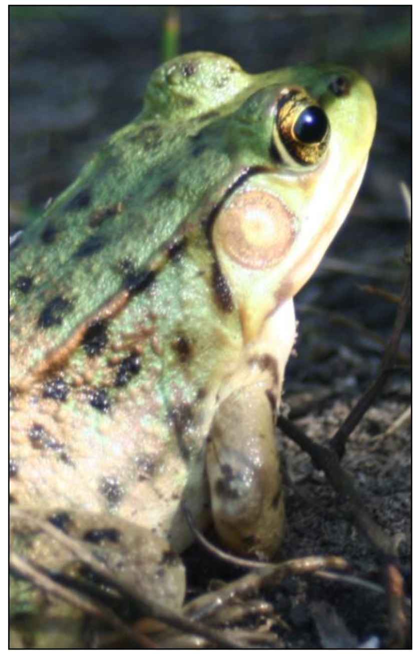
Durham Region Coastal Wetland Monitoring Project:
6-Year Technical Report

Module 3 – Biological Condition



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PREFACE

Contents of the DRCWMP: 6-Year Technical Report are published separately in four modules. Each module may be reviewed independently however, in successive order they constitute a complete document. Module 1 contains the introduction to the report. It is here that the scope of the project is examined along with a complete description of the study sites. The methods used to assess wetland condition are also recounted including the use of Indices of Biological Integrity (IBIs). Module 2 includes the geophysical condition of Durham Region coastal wetlands. That is, it describes the water and sediment quality, water levels and changes in adjacent land cover. Presented here in Module 3, is the condition of biological communities, including that of fish and wildlife, and submerged aquatic vegetation. Subsequently, in the final release, a summary of wetland status is presented in Module 4. Here, components of the preceding modules are compiled offering a detailed description of changes and trends in overall condition of each Durham Region coastal wetland.

This report describes the Durham Region Coastal Wetland Monitoring Project (DRCWMP) in considerable detail and is intended for a technical audience who are interested in using this information to inform their own monitoring projects or to gain specific information about the wetlands included in this report.

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1. BIOLOGICAL CONDITION

1.1 PLANT COMMUNITY CONDITION

1.1.1 Submerged Aquatic Plant Community

Objective

To assess and monitor submerged aquatic vegetation (SAV) community condition.

Method Summary

Environment Canada, CLOCA and the Toronto and Region Conservation Authority (TRCA) sampled SAV community routinely at 15 Durham Region wetlands from 2002/3 to 2007 with some exceptions. Specifically, SAV community sampling did not occur at Carruthers Creek, Duffins Creek, Frenchman's Bay, and Hydro marshes in 2003, and at Oshawa Second Marsh (dewatered) in 2004 following the site-specific water level management. Surveys were not initiated at Cranberry and Pumphouse marshes until 2003 and no surveys were conducted at these sites in 2007 because low water restricted mobility and sampling efforts. Sampling was initiated at Port Newcastle, Rouge River and Westside marshes in 2004. Sampling was conducted from late July to mid-September.

Generally, 20 1-metre by 1-metre quadrats were placed in the open water basin of each wetland. For 28% of surveys conducted (i.e., 19/68 surveys), more than 20 quadrats were used for sampling, notably at some wetlands in 2002 following refinements to sampling methodology while at other wetlands (i.e., Bowmanville and Westside marshes) more quadrats were sampled following management plan development (range in numbers of quadrats=29-45). For one survey conducted at Port Newcastle in 2005, only 10 quadrats were used. Within each quadrat, the total percent cover (up to a maximum of 100%) and the individual percent coverage of each submerged and floating-leaved species were recorded (which could add up to >100%). Further details of the sampling methodology are in the Durham Region Coastal Wetland Monitoring Project: Methodology Handbook (EC and CLOCA 2007).

Data Treatment and Analysis

As described in EC and CLOCA (2004), twelve SAV metrics were tested for suitability in Lake Ontario coastal wetlands based on suggestions by Albert and Minc (2004) and through the Great Lakes Coastal Wetlands Consortium work (EC 2003). Of these, five metrics were retained for use in the IBI, all of which showed a highly significant response to disturbance ($r>0.56$, $p<0.003$). These include:

1) number of turbidity-intolerant species (SINT),
2) number of native species (SNAT),
3) Floristic Quality Index (FQI),
4) relative percent cover turbidity-intolerant species (PINT), and
5) percent cover (PCOV).

A complete listing of SAV including native species, turbidity tolerant and intolerant species and coefficients of conservatism is provided in Appendix A – Table A-1.

Mean values for each of the SAV metrics were calculated across quadrats in a wetland for each year. The raw SAV metric values were transformed into standardized metrics using a linear function with a minimum value of 0 and maximum value of 10, as outlined in Minns et al. (1994). The standardized metric values were each then multiplied by 2 and added together to create an IBI score ranging from 0 to 100. As outlined in EC and CLOCA (2004), 5 IBI classes were identified according to ranges in IBI scores: poor (0-20), fair (20-40), good (40-60), very good (60-80), and excellent (80-100). These same classes and ranges denote community condition in this report. Further details on the use of metrics to assess biotic community condition, statistical properties of the IBI, and other SAV community metrics previously considered are provided in EC and CLOCA (2004). Note that since SAV percent cover for individual species was not recorded for Frenchman's Bay in 2002 and 2005 and Duffins Creek and Rouge River marshes in 2005, calculations of the SAV IBI could not be performed for these wetlands in these years.

To assess temporal trends in the SAV IBI in Durham Region wetlands, the Mann-Kendall trend test was performed at each wetland and a modified version of the Mann-Kendall test was performed to examine overall regional trends from 2003 to 2007. Temporal trend analyses could not be performed at wetlands for which there were three or fewer years of SAV data available (i.e., Rouge River and Frenchman's Bay marshes) or where there were ties in SAV IBI scores (i.e., Carruthers Creek Marsh in 2002, 2004 and 2005 and McLaughlin Bay Marsh in 2004 and 2005 where SAV IBIs=0; USEPA 2000); similarly, these wetlands could not be included in the analysis examining regional temporal trends. Temporal trends were also examined in the raw SAV metrics using the Mann-Kendall test at wetlands where there were no ties in the data. Overall, ties were found in 57% of the tests performed (i.e., 37/65 tests on raw metrics) and primarily for SINT, PINT and SNAT raw metrics; thus temporal trends could not be assessed for most of these metrics at wetlands. Furthermore, due to the presence of numerous ties, regional trend tests of the individual metrics were not performed. Further details of these tests are provided in the water quality chapter of this report. As a measure of year-to-year variability, coefficients of variation (CVs, expressed as a percentage) for SAV IBIs were calculated across all years for each Durham Region wetland. Parametric t-tests were performed to compare mean SAV IBI scores between Durham Region wetlands and other Lake Ontario wetlands. Where the conditions of homogeneity of variances were not met, non-parametric Mann-Whitney tests were performed. To assess associations between the SAV IBI (and individual metrics) and the WQI in Lake Ontario wetlands, correlation analyses were performed using mean values across years for each wetland (i.e., each wetland is represented once in the analysis); similar years of monitoring only were used to calculate means for these analyses. Spearman rank correlation procedures were performed following violations in homogeneity of variances and/or normality in the data.

Results

Within-site and Regional SAV Community IBI Trends

Overall, SAV IBI scores were low in 15 Durham Region coastal wetlands with scores below 40 in 87% of wetland-years (i.e., 59 out of 68 cases) from 2002 to 2007 (Table 4.1.1-1). The majority of Durham Region coastal wetlands had SAV IBI scores in the "poor" or "fair" category. IBI scores of 0 were found at Carruthers Creek Marsh in 3 out of 5 study years (2002, 2004, and 2005), McLaughlin Bay Marsh in 2004 and 2005, Westside Marsh in 2004 and Hydro Marsh in 2007. Oshawa Second Marsh, a managed wetland, had higher IBI scores than other Durham Region wetlands. Its IBI scores ranged from 31.3 in 2002 (“fair”) to 80.9 (“excellent”) in 2006, the highest IBI score in this study. “Good” conditions were found at Pumphouse Marsh in 2003 (56.3), Cranberry Marsh (41.0), Corbett Creek Marsh in 2004 and 2005 (52.2 and 47.3, respectively) and Wilmot Creek Marsh in 2007 (50.3). Mean SAV IBI scores (±SD) for all Durham Region coastal wetlands from 2002 to 2007 ranged from 12.2±14.2 in 2002 to 27.1±17.4 in 2003.

In contrast, SAV IBI scores for the other 32 Lake Ontario wetlands were generally much higher, ranging from 19.1 at Jordan Station Marsh in 2003 to 97.8 at Hay Bay South Marsh in 2005 (Table 4.1.1-1). Mean SAV IBI scores grouping the other Lake Ontario wetland sites ranged from 69.6±24.2 in 2003 to 79.1±8.1 in 2007. For the four years when the two groups of wetlands were sampled, mean SAV IBI scores for Durham Region wetlands were significantly, and consistently, lower than the other Lake Ontario wetlands (two-tailed t-tests, 2003: t_{20}=-4.34, p<0.0003; 2005: t_{18}=-7.70, p<0.0000; 2006: t_{33}=-9.54, p<0.0000; 2007: $U_{13,15}$=191.0, p<0.0001). Overall, SAV community condition in other Lake Ontario coastal wetlands was significantly better than in Durham Region coastal wetlands.

Table 1. SAV IBIs (scored out of 100) for Durham Region coastal wetlands and other Lake Ontario wetlands from 2002-2007, where available. Durham Region coastal wetlands are shaded and their condition based on the average of IBI scores during the study period following ratings in EC and CLOCA (2004). Wetlands are ordered vertically from west to east (See Module 1, Figure 5 for locations).

Wetland	Condition	2002	2003	2004	2005	2006	2007	CV
Jordan Station Marsh			19.1					
Rouge River Marsh	poor			10.5		18.9	17.9	29.0
Frenchman's Bay Marsh	poor			2.7		9.5	20.0	81.1
Hydro Marsh	poor	0.5		0.6	1.6	3.7	0.0	114.1
Duffins Creek Marsh	poor	0.8		0.8		9.8	1.2	142.3
Carruthers Creek Marsh	poor	0.0		0.0	0.0	5.3	2.6	150.2
Cranberry Marsh	fair		35.9	41.0	30.5	10.5		45.3
Lynde Creek Marsh	poor	13.3	22.2	9.4	5.0	1.6	1.3	91.4
Corbett Creek Marsh	fair		31.3	52.2	47.3	31.1	35.7	24.5
Pumphouse Marsh	fair		56.3	26.6	9.3	7.7		90.5
Oshawa Second Marsh	good	31.3	40.2		56.0	80.9	71.6	37.1
McLaughlin Bay Marsh	poor		1.0	0.0	0.0	0.3	6.1	175.5
Westside Marsh	poor			0.0	6.8	23.6	5.9	112.1
Bowmanville Marsh	poor	27.4	14.6	21.9	18.9	17.5	12.2	28.7
Wilmot Creek Marsh	fair		15.4	20.1	25.2	27.8	50.3	48.5
Port Newcastle Wetland	poor			33.6	15.3	13.3	7.8	64.0
Port Britain Marsh			19.4					
Presqu'ile Bay Marsh			72.9					
Dead Creek Marsh						73.5	71.5	
12 O'Clock Point Marsh						69.7		
Carrying Place Marsh						63.2	85.6	
Huyck's Bay Marsh			54.2					
Sawguin Creek Ditched						73.4	90.2	

Wetland	Condition	2002	2003	2004	2005	2006	2007	CV
Marsh								
Sawguin Creek Central Marsh						65.9	71.7	
Sawguin Creek North Marsh					67.2	57.6	83.5	
Blessington Creek Marsh					70.0	69.3	74.7	
Robinson's Cove Marsh			90.8		88.3	89.9	93.1	
Lower Salmon River Marsh						88.1		
Big Island West Marsh					60.4	58.4	74.3	
Big Island East Marsh					77.7	58.2	75.6	
Marysville Creek Marsh						75.9		
Solmesville East Marsh						79.4		
Lower Sucker Creek Marsh						63.2	69.8	
Lower Sucker Creek East Marsh						34.6		
Airport Creek Marsh						88.0	80.5	
Forester's Island Marsh						71.1		
Lower Napanee River Marsh						74.9	88.4	
South Bay Marsh			72.6					
Carnachan Bay Marsh							70.9	
Big Sand Bay Marsh			62.1					
Hay Bay North Marsh			82.7		72.1	74.5	70.9	
Hay Bay South Marsh			90.0		97.8	68.8	86.7	
Parrott's Bay Marsh			71.9		70.9			
Little Cataraqui Creek Marsh			73.3					
Button Bay Marsh			79.7					
Bayfield Bay Marsh			95.9					
Hill Island East Marsh			89.6					
Mean - Durham Region wetlands		**12.2**	**27.1**	**15.7**	**18.0**	**17.4**	**17.9**	
Mean - Other Lake Ontario wetlands			**69.6**		**75.6**	**69.9**	**79.1**	

The Mann-Kendall test revealed a significant increase in SAV IBI scores at Oshawa Second Marsh (S=8, p=0.042) and Wilmot Creek Marsh (S=10, p=0.0083) from 2002/3 to 2007. There were significant decreases in IBI scores at Lynde Creek Marsh (S=-13, p=0.0083), Port Newcastle Wetland (S=-6, p=0.042) and Pumphouse Marsh (S=-6, p=0.042) and a marginally-significant decrease at Bowmanville Marsh (S=-9, p=0.068). There was no significant change in SAV IBI scores over time at the other five Durham Region wetlands (where there were four or more years of data and no ties) during the study period. Generally, SAV condition in Durham Region wetlands is in the poor to fair range with the exception of Oshawa Second Marsh which is in better (i.e., good) condition; Corbett Creek Marsh also had higher SAV IBI scores in some years. Furthermore, conditions in both Oshawa Second and Wilmot Creek marshes have improved significantly, while conditions in Lynde Creek, Port Newcastle, Pumphouse and Bowmanville marshes have deteriorated over the study period. SAV IBI scores for each year with associated categories for all of the DRCWMP wetlands and the results of Mann-Kendall tests with the S statistics where significant are shown in Appendix A – Figure A-1. A regional trend analysis revealed no significant trend in SAV IBI scores in Durham Region wetlands (χ_2=2.37, df=1, p>0.10).

Some SAV community IBIs varied considerably among study years in Durham Region wetlands. The highest coefficients of variation (CV) were found at McLaughlin Bay Marsh (175.51%), Carruthers Creek Marsh (150.24%) and Duffins Creek Marsh (142.25%). Coefficients of variation at other Durham Region wetlands ranged from 24% to 114%.

A highly significant correlation was found between the SAV IBI and WQI when mean index scores were pooled across years for each Lake Ontario wetland (r_s=0.71, p<0.0000, n=47; Figure 1).

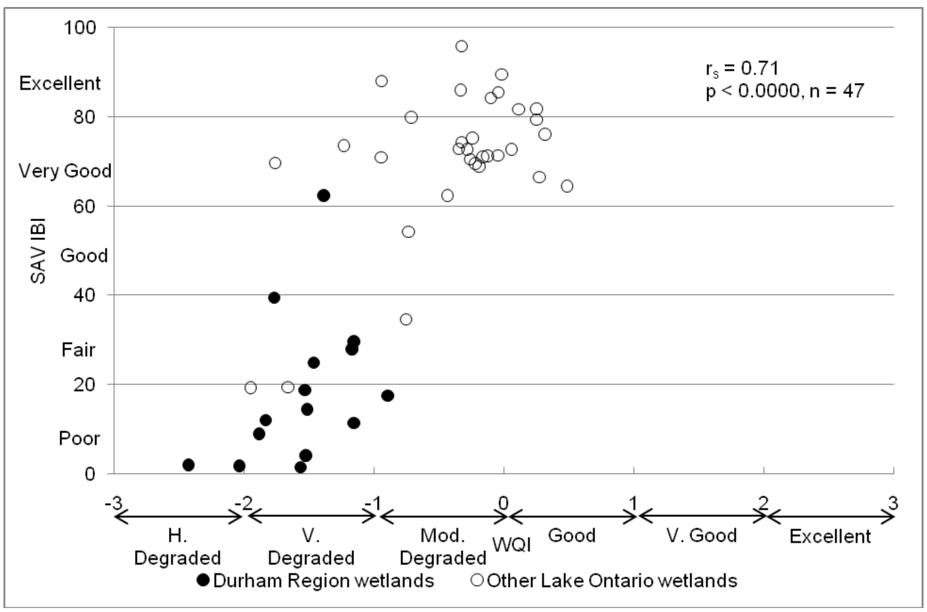

Figure 1. Correlation between SAV community condition as measured using the SAV IBI and water quality as measured using the Water Quality Index using mean index scores for Lake Ontario coastal wetlands from 2002-2007, where available.

Of all Durham Region coastal wetlands, Oshawa Second Marsh showed both a significant increase in water quality and SAV community condition from 2002/3 to 2007 (Figure 2).

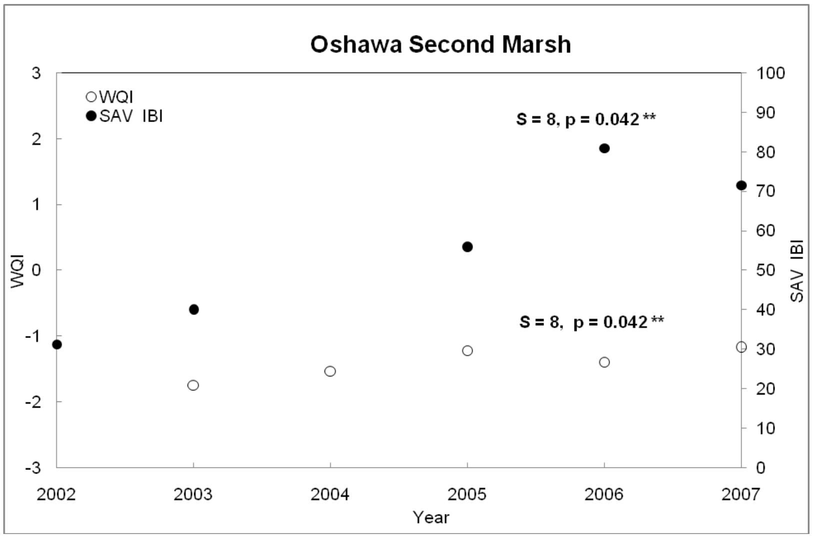

Figure 2. Temporal trends in SAV condition (SAV IBI, filled circles) and water quality (WQI, open circles) at Oshawa Second Marsh from 2002/3-2007. The results of the Mann-Kendall temporal trend analysis with corresponding S statistic for WQI and SAV IBI are also provided.

Within-site and Regional SAV Community Metric Trends

Mean SAV standardized metric values and IBIs for each of the Durham Region coastal wetlands for all study years and the results of temporal trend analyses at each site for each of the raw metrics are shown in Appendix A - Table A-2. Overall, Durham Region coastal wetlands received very low scores for turbidity-intolerant species metrics (SINT and PINT). No turbidity-intolerant species were found in Duffins Creek, Carruthers Creek and Lynde Creek marshes for all years sampled. Of the Durham Region coastal wetlands, the highest scores for turbidity-intolerant metrics were found at Frenchman's Bay, Corbett Creek and Westside marshes, and notably Oshawa Second Marsh where mean SINT and PINT scores were at least three times higher than scores at other Durham Region sites. Northern water milfoil (*Myriophyllum sibiricum*) was the only turbidity-intolerant species found at Oshawa Second Marsh during this study.

FQI metric scores varied among Durham Region coastal wetlands. Mean FQI metric scores for all study years together were lowest at Hydro Marsh (0.19) and highest at Oshawa Second Marsh (7.76). Significant increases in raw FQI metric values were found at Oshawa Second Marsh (S=9, p=0.042, range=4.09 – 9.45) and Wilmot Creek Marsh (S=10, p=0.042, range=2.58 – 7.13) during the study period. In contrast, significant decreases in FQI values were found at Lynde Creek Marsh (S=-13, p=0.0083, range=0.28 – 3.42) and Pumphouse Marsh (S=-6, p=0.042, range=1.72 – 6.19), while a marginally-significant decrease was found at Bowmanville Marsh (S=-9, p=0.068, range=1.84 – 3.88) during the study period.

For all study years, mean total cover (PCOV) metric scores ranged from 0.01 at Hydro Marsh (0.12% per quadrat) to a high of 7.65 (78.21% per quadrat) at Oshawa Second Marsh. Significant decreases in percent cover were found at Lynde Creek Marsh (S=-11, p=0.028, range=0.10% – 27.98%), Pumphouse Marsh (S=-6, p=0.042, range=1.25% – 90.00%) and Port Newcastle Wetland (S=-6, p=0.042, range=8.60% – 38.85%) during the study period.

Mean numbers of native species (SNAT) metric scores were lowest at McLaughlin Bay Marsh (0.09 native species per quadrat) and highest at Corbett Creek Marsh (8.12 native species per quadrat) from 2003 to 2007. A significant increase in SNAT was found at Oshawa Second Marsh from 2002 to 2007 (S=8, p=0.042, range=1.6 - 4.4 native species). Significant decreases in numbers of native SAV species were found at Lynde Creek Marsh (S=-13, p=0.028, range=0.05 – 1.43 native species), Pumphouse Marsh (S=-6, p=0.042, range=0.55 – 3.80 native species) and Port Newcastle Wetland (S=-6, p=0.042, range=0.30 – 1.70 native species) during the study period.

When all Lake Ontario including Durham Region wetlands were grouped together, highly significant correlations were found between the WQI and the individual raw SAV metrics when mean values were pooled across years for each Lake Ontario wetland (r_s>0.57, p<0.0000, n=47; Figure 3).

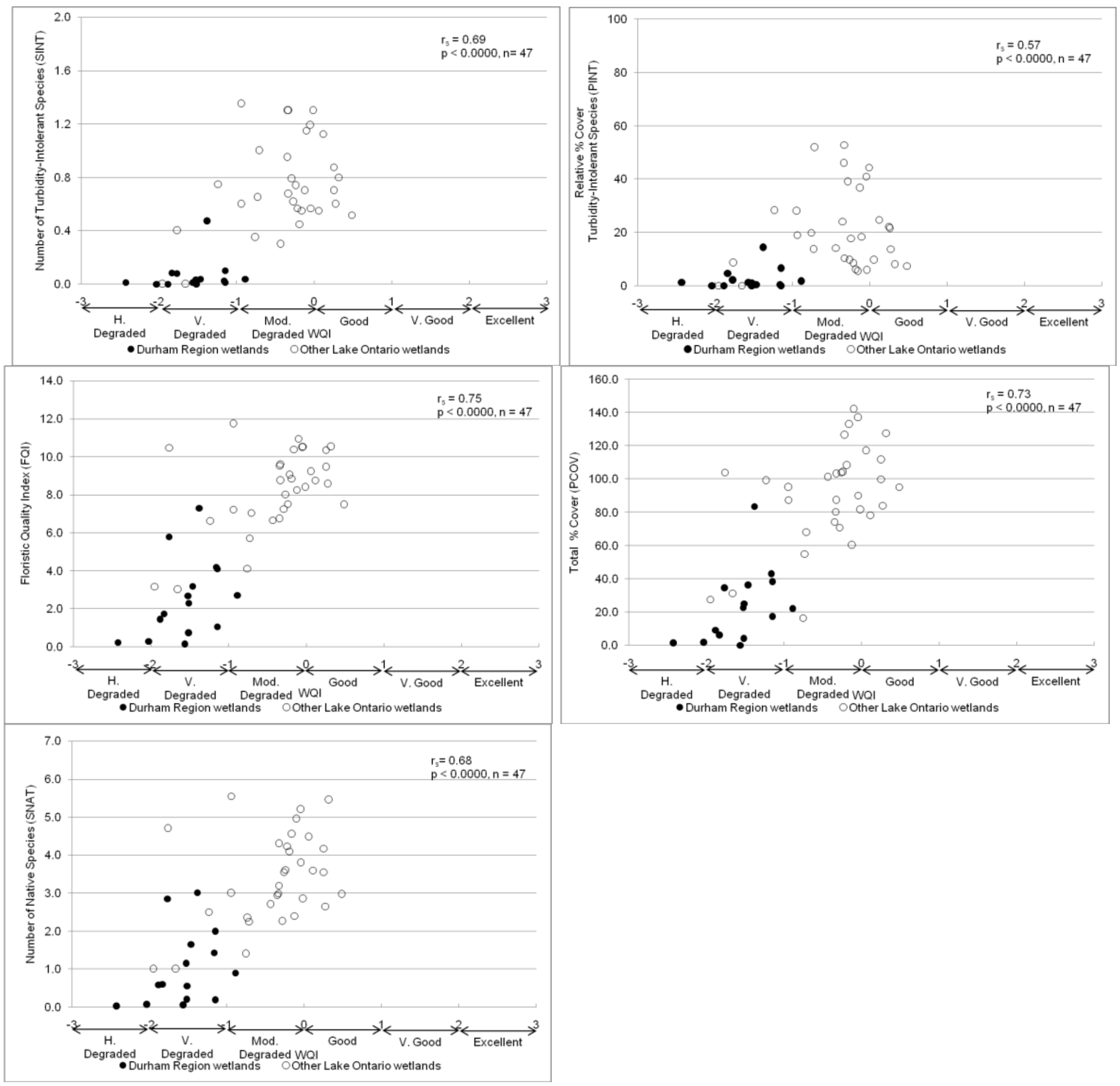

Figure 3. Significant correlations in number of turbidity-intolerant species (SINT), relative percent cover turbidity-intolerant species (PINT), Floristic Quality Index (FQI), percent cover (PCOV) and number of native species (SNAT), on a per quadrat basis, versus water quality (WQI) at all Lake Ontario coastal wetlands 2002-2007, where available.

SAV communities in Durham Region are markedly different than those found in other coastal wetlands of Lake Ontario (Appendix A – Tables A-2 and A-3). SAV community metrics FQI, PCOV and SNAT in Durham Region were one-quarter to one-third of those found in coastal wetlands from other regions of Lake Ontario. Furthermore, turbidity-intolerant species metrics SINT and PINT were approximately one-tenth of mean values for coastal wetlands elsewhere, which contributed heavily to the overall low SAV IBI scores for Durham Region wetlands.

Discussion

Overall, the condition of the SAV community in Durham Region coastal wetlands was "poor" with no significant change in the IBI within the region between 2002 and 2007. Although this indicates that the SAV community within most Durham Region coastal wetlands is either degraded or requires further monitoring to properly assess changes at a regional level, within-site results also show some major improvements and setbacks in some wetlands. Regardless of whether restoration is pursued or which restoration technique is used, these results also show that SAV monitoring can be used to help adaptively manage restoration activities at a site-level and assess the effect of anthropogenic activities on coastal wetland health locally and regionally.

Within sites, SAV community conditions at Oshawa Second Marsh and Wilmot Creek Marsh improved from 2002 to 2007; Oshawa Second Marsh improved from "fair" to "very good," improving in all metrics , while Wilmot Creek Marsh improved from "poor" to "good" improving in FQI. While other wetlands also significantly improved in some metric scores (e.g., SINT and PINT at Corbett Creek) insufficient sample sizes resulted in an inability to analyze these wetlands for temporal changes. This emphasizes the need for continued monitoring to determine if improvements are occurring at a site-level as well as regionally. These results, however, show that the SAV community can respond to changes in both managed (e.g. Oshawa Second Marsh) and unmanaged marshes (e.g., Wilmot Creek Marsh).

Unfortunately, these results also show that a number of wetlands are declining in SAV community condition. In particular, Pumphouse ("good" to "poor"), Port Newcastle ("fair" to "poor") and Lynde Creek marshes ("fair" to "poor") showed a significant declining trend from 2002 to 2007 with Bowmanville Marsh ("fair" to "poor") and Cranberry Marsh ("good" to "poor") also declining but not significantly. These declines were due to a decrease in the FQI, SNAT and PCOV metrics. No turbidity-intolerant plant species were detected at Lynde Creek, Duffins Creek and Carruthers Creek marshes. SAV community condition at Duffins Creek, however, remained unchanged (i.e., "fair") over the study period while there were insufficient survey years to properly assess Carruthers Creek Marsh. An absence of turbidity-intolerant species at these wetlands is likely due to low water quality because these sites also showed the highest turbidity means over the survey period which likely affected plant growth. Regardless of turbidity values, there was a strong significant relationship between SAV community condition and WQI with high SAV IBIs associated with high WQI scores. This result shows that, for the most part, SAV community condition is indicative of local water quality conditions, with some exceptions. For example, the condition of the SAV community at Cranberry Marsh seems to follow WQI scores except in 2006 when WQI improved to "moderately degraded" but SAV IBI declined to "fair". This may be due to improved habitat conditions in the marsh which attracted more wildlife, particularly waterfowl, using this marsh compared to previous conditions. As a result, grazing by herbivorous ducks and geese may have affected the presence and growth of various submerged aquatic plants. This highlights the importance of assessing a number of biotic communities to properly understand the ecological health of wetlands on a regional level.

With the exception of Oshawa Second Marsh and Wilmot Creek Marsh, no improvements were detected in the SAV IBI among Durham Region coastal wetlands. However, further years of monitoring will improve reporting, and improvement in SAV community condition may be detected at sites undergoing restoration (Duffins Creek Marsh and Cranberry Marsh). Data from other study sites indicate opportunities exist for improving land-use practices surrounding these wetlands to improve coastal wetland health in Durham Region. Moreover, Durham Region coastal wetlands support SAV communities in significantly poorer condition than other Lake Ontario coastal wetlands. This indicates that further improvements can be made to restore the health of Durham Region wetlands so that they are comparable to other Lake Ontario wetlands.

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1.2 FISH AND WILDLIFE COMMUNITY CONDITION

1.2.1 Fish Community

Objective

To assess and monitor fish community condition.

Method Summary

Fish sampling was routinely performed at Durham Region coastal wetlands from 2003 to 2007 once per year with some exceptions. In 2004, fish sampling was conducted on two occasions (within one week of each other) at selected Durham Region wetlands (i.e., Bowmanville, Duffins Creek, Lynde Creek, and Wilmot Creek marshes) to assess IBI score repeatability within the year. Sampling was also initiated in 2007 in a recently evaluated provincially significant wetland, Whitby Harbour Wetland Complex. Sampling did not occur at Oshawa Second Marsh and Westside Marsh in 2003, at Carruthers Creek Marsh in 2005 or at Pumphouse Marsh in 2005 and 2007. No fish sampling was conducted at Cranberry Marsh in any study year due to low water levels and the inability to launch the electrofishing boat. Sampling occurred from mid-August to mid-September with the exception of Pumphouse Marsh where, in 2003, sampling was conducted in the last week of September.

Fish were captured by electrofishing six points along 44-metre transects stratified by habitat types (e.g., shoreline, inlet, outlet, open water) within each wetland. There were generally eight to twelve transects per wetland each year; however, in 22% of surveys conducted (i.e., 13/55 surveys), fewer than eight transects were used (e.g., Pumphouse Marsh where only four transects were done in the two study years). This was due to a variety of reasons including: wetland size, and mechanical difficulties precluding sampling the entire wetland. For each transect, fish species were identified and fork length and weight measurements were recorded for each fish. When large numbers of conspecific fish were captured, ten randomly chosen individuals were weighed and measured; the remainder were then counted and batch-weighed. Further details of the fish sampling methodology are found in the Durham Region Coastal Wetland Monitoring Project: Methodology Handbook (EC and CLOCA 2007). CLOCA and Toronto and Region Conservation Authority staff, with assistance from EC and Ganaraska Region Conservation Authority staff, conducted fish community sampling at Durham Region wetlands.

Data Treatment and Analysis

Following testing of thirteen metrics for suitability in Lake Ontario wetlands by EC and CLOCA (2004), six metrics were retained for use in the IBI, all of which showed a significant or moderate response to wetland disturbance ($r>0.42$, $p<0.20$). Note that when these six metrics were standardized and integrated, fish IBIs were strongly associated with wetland disturbance ($r=-0.72$, $p=0.01$). Metrics used in the calculation of the IBI include:

1) number of native species (SNAT),
2) number of centrarchid species (SCEN),
3) percent piscivore biomass (PPIS),

4) number of native individuals (NNAT),
5) percent non-indigenous biomass (PBNI), and
6) biomass of yellow perch (BYPE).

A complete listing of species caught in Durham Region coastal wetlands and in other Lake Ontario wetlands including their species characteristics (e.g., native, piscivorous) is in Appendix B – Table B-1. While fish sampling did occur at some Durham Region wetlands in 2002, these data were collected using a different methodology (i.e., a “punt” electrofisher was used) and could not be used in the IBI calculations; however, they were included in fish species richness counts reported for each wetland in Section 5.

Mean values for each of the metrics were calculated across transects in a wetland for each year. In the case of wetlands sampled in 2004 (i.e., on two separate occasions), mean metrics values for each sampling effort were first determined and then an average was taken. Raw mean values were then transformed to standardized metrics using a linear function with a minimum value of zero and maximum value of 10, as described in Minns et al. (1994). The standardized values were added together and the sum multiplied by 1.66667 to generate an IBI score ranging from zero to 100. Five IBI classes were identified using methods outlined in EC and CLOCA (2004) according to ranges in IBI scores: poor (0-20), fair (20-40), good (40-60), very good (60-80), and excellent (80-100). Further details of the use of metrics to assess biotic community condition, statistical properties of the IBI, as well as other fish community metrics previously considered are provided in EC and CLOCA (2004). Note that migrant species such as Chinook Salmon (*Oncorhynchus tshawytscha*) were not included in calculations of biomass metrics since these species generally use wetlands only to migrate upstream and their typical large size would tend to skew IBI calculations for wetlands where they were caught.

To assess temporal trends in fish IBI in Durham Region coastal wetlands, the Mann-Kendall trend test was performed at each wetland and a modified version of the Mann-Kendall test was performed to examine overall regional trends from 2003 to 2007. Temporal trend analyses could not be performed at wetlands for which there were three or fewer years of fish data available (i.e., Carruthers Creek, Oshawa Second, Pumphouse, Westside and Whitby Harbour marshes). Temporal trends were also examined using the raw SAV metrics at each wetland using the Mann-Kendall test where there were no ties in the data, since adjustments for ties cannot be performed when there are fewer than 10 years of available data; regional trends of the individual metrics could not be performed due to numerous tied observations. Refer to Section 3.1.2 for further details regarding these statistical tests.

As a measure of year-to-year variability, coefficients of variation (CVs, expressed as a percentage) for fish IBIs were calculated across all years for each Durham Region coastal wetland. Parametric t-tests were performed to compare mean SAV IBI scores between Durham Region wetlands and other Lake Ontario wetlands where the conditions of homogeneity of variances and normality were met. To assess associations between the fish IBI vs WQI and SAV IBI (and individual SAV metrics) in Lake Ontario wetlands, correlation analyses were performed using mean values across years for each wetland (i.e., each wetland is represented once in the analysis); similar years of monitoring only were used to calculate means for these analyses. Spearman rank correlation procedures were performed following violations in homogeneity of variances and/or normality in the data.

Results

Within-site and Regional Fish Community IBI Trends

Overall, fish IBI scores were moderate in 15 Durham Region coastal wetlands with scores between 20 and 60 out of 100 in 95% of wetland-years (i.e., 52 out of 55 cases) from 2003 to 2007 (Table 4.2.1-1). Consequently, the large majority of Durham Region coastal wetlands had fish IBI scores in the “fair” or “good” category. Whitby Harbour Wetland Complex in 2007 had the lowest IBI score (9.4 – poor). Corbett Creek Marsh in 2005 had the highest score (65.9 – very good), corresponding to a “very good” condition. The grand mean fish IBI (±SD) for all Durham Region coastal wetlands from 2003 to 2007 ranged from 33.8±10.9 in 2003 to 50.1±10.1 in 2005.

In contrast, fish IBI scores for the other Lake Ontario wetlands were generally much higher relative to Durham Region wetlands, from 70.9 at Sawguin Creek Central Marsh (“very good”) to 99.9 at Big Island East Marsh (“excellent”), both sampled in 2005 (Table 4.2.1-1). Mean fish IBI scores grouping other Lake Ontario wetland sites were 79.7±8.1 and 83.7±10.7 in 2003 and 2005, respectively. For the two years in which there were sufficient data to compare fish IBI scores, mean IBI scores for Durham Region wetlands were significantly lower than those in the other Lake Ontario group of wetlands (two-tailed t-tests, 2003: t_{12}=-5.63, p=0.0001; 2005: t_{14}=-6.07, p=0.00003). Overall for years where there were sufficient data, fish community condition in other Lake Ontario coastal wetlands was significantly better than in Durham Region coastal wetlands.

Table 2. Fish community IBIs (scored out of 100) for Durham Region coastal wetlands and other Lake Ontario wetlands from 2003-2007, where available. Durham Region coastal wetlands are shaded and their condition based on the average of IBI scores during the study period following ratings in EC and CLOCA (2004). Coefficients of variation (CV, expressed as a percentage) are indicated for only Durham Region wetlands where there were sufficient annual data. Wetlands are ordered vertically from west to east (See Module 1, Figure 5 for locations).

Wetland	Condition	2003	2004	2005	2006	2007	CV
Rouge River Marsh	fair	31.5		49.9	48.7	25.0	32.1
Frenchman's Bay Marsh	good	44.9		56.4	30.0	48.7	24.6
Hydro Marsh	good	17.2		47.3	47.5	52.4	39.1
Duffins Creek Marsh	fair	26.0	32.4	37.6	23.2	49.1	30.5
Carruthers Creek Marsh	fair	29.5			32. 9	47.3	26.0
Lynde Creek Marsh	good	40.7	34.3	59.8	47.6	50.0	20.7
Whitby Harbour Wetland Complex	poor					9.4	
Corbett Creek Marsh	good	27.1		65.9	31.1	40.2	42.5
Pumphouse Marsh	fair	26.6			34.4		18.0
Oshawa Second Marsh	fair			45.6	40.9	26.5	26.5
McLaughlin Bay Marsh	fair	36.0		57.1	30.5	35.3	29.8
Westside Marsh	fair			30.1	35.1	51.5	28.7
Bowmanville Marsh	good	43.7	36.3	49.6	26.5	59.7	29.3
Wilmot Creek Marsh	good	56.5	45.4		35.9	46.8	18.2
Port Newcastle Wetland	good	26.4		52.0	31.0	55.6	35.6
Huyck's Bay		74.0					
Sawguin Creek Central				70.9			

Wetland	Condition	2003	2004	2005	2006	2007	CV
Marsh							
Robinson's Cove Marsh				84.6			
Big Island East Marsh				99.9			
Hay Bay North Marsh				84.5			
Hay Bay South Marsh				78.5			
Parrott's Bay Marsh		85.4					
Mean - Durham Region wetlands		**33.8**	**37.1**	**50.1**	**35.4**	**42.7**	
Mean - Other Lake Ontario wetlands		**79.7**		**83.7**			

Mann-Kendall tests revealed a significant increasing trend in annual fish IBI scores at Hydro Marsh from 2003 to 2007 (S=6, p=0.042), due in part to the lower IBI score in 2003. No significant change in annual fish IBI scores over time was found at the other nine Durham Region wetlands (where there were four or more years of data) from 2003 to 2007. Additional years of data collection are required at Whitby Harbour Wetland Complex (where a low fish IBI was found in 2007) as well as at wetlands for which there were only a few years of data collection (i.e., Pumphouse, Carruthers Creek, Oshawa Second and Westside marshes) to examine temporal trends. IBI scores for each year with corresponding classes identifying condition for all of the DRCWMP wetlands and the results for significant Mann-Kendall tests are shown in Appendix B – Figure B-1. An overall regional trend analysis revealed no significant trend across Durham Region wetlands (X_2=2.01, df=1, p>0.10).

IBIs varied among study years. The highest coefficient of variation (CV) was found at Corbett Creek Marsh (42.5%) and the lowest at Pumphouse Marsh (18.0%) where fish were sampled in two of the five study years. CVs at other Durham Region wetlands ranged from 18.2% to 39.1%.

Significant correlations were found between fish IBI and WQI (r_s=0.64, p=0.001, n=22) and between fish IBI and SAV IBI (r_s =0.52, p=0.020, n=20) when mean index scores were pooled across years for each Lake Ontario wetland (Figure 4).

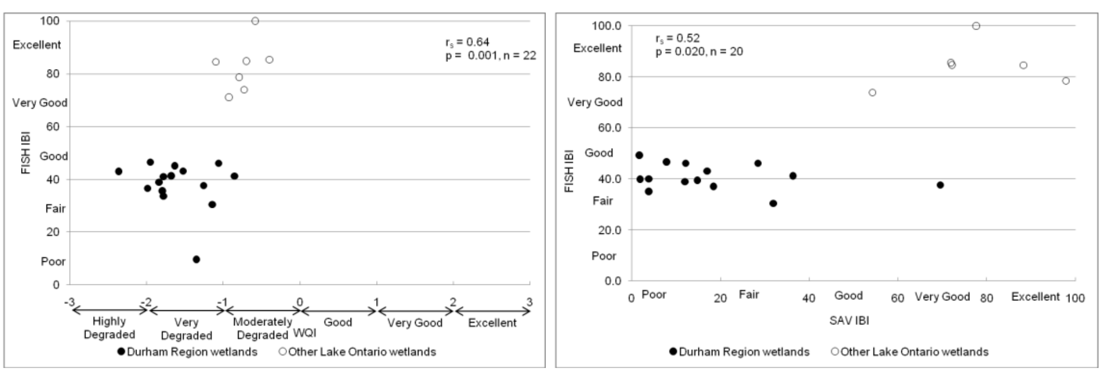

Figure 4. Correlations between fish community condition, as measured using the fish IBI, and water quality (WQI) and SAV condition (SAV IBI) using mean index scores for Lake Ontario coastal wetlands from 2003-2007, where available.

Within-site and Regional Fish Community Metric Trends

Mean standardized fish metric scores and IBIs for each of the Durham Region wetlands for all study years and the results of temporal trend analyses at each site for each of the raw metrics are shown in Appendix B – Table B-2. Generally, mean metric scores for numbers of native fish species (SNAT) ranged from 4 to 6 at Durham Region wetlands during the study period. The lowest metric scores were found at Bowmanville Marsh (1.33), Frenchman's Bay Marsh (2.00) in 2006, and Whitby Harbour Wetland Complex (2.39) in 2007 (0.56, 0.82 and 1.00 native species per transect, respectively). The highest mean SNAT score was found at Oshawa Second Marsh from 2005 to 2007 (7.53; 3.18 native fish species per transect). In total, 26 native fish species were found in Durham Region coastal wetlands; Pumpkinseed (*Lepomis gibbosus*), Brown Bullhead (*Ameiurus nebulosus*), Fathead Minnow (*Pimpephales promelas*) and Gizzard Shad (*Dorosoma cepedianum*) were the most abundant species. There were no significant temporal trends in raw SNAT values at any Durham Region wetlands.

Mean metric scores for numbers of centrarchid species (SCEN) per transect generally ranged from 4 to 6 at Durham Region wetlands during the study period. The lowest mean SCEN metric score was found at Duffins Creek Marsh from 2003 to 2007 (1.75, equal to 0.24 centrarchid species per transect) and no centrarchid species were found at some wetlands in some years (Bowmanville Marsh in 2006, Pumphouse Marsh in 2003 and Whitby Harbour Wetland Complex in 2007). The highest mean SCEN scores were found at McLaughlin Bay Marsh (7.25, equal to 0.99 centrarchid species per transect) and Oshawa Second Marsh (7.01, equal to 0.95 centrarchid species per transect). In total, six centrarchid species were found in Durham Region wetlands: Black Crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), Largemouth Bass (*Micropterus salmoides*), Pumpkinseed, Rock Bass (*Ambloplites rupestris*), and Smallmouth Bass (*Micropterus dolomieui*). There were no significant temporal trends in raw SCEN values at any Durham Region wetlands.

Mean metric scores for percentage of piscivore biomass (PPIS) varied among Durham Region wetlands. The lowest were found at Pumphouse Marsh, Oshawa Second Marsh and Whitby Harbour Wetland Complex; PPIS was zero and no piscivorous species were found in any study years. All Durham Region wetlands had at least one study year where no piscivorous species were found, with two exceptions: Frenchman's Bay Marsh and Lynde Creek Marsh. The highest mean PPIS scores were found at Wilmot Creek Marsh (7.23) and Frenchman's Bay Marsh (6.75) during the study period (15.40% and 11.29% piscivore biomass per transect, respectively). In total, six piscivorous fish species were caught in Durham Region wetlands, five of which were included in the calculation of PPIS metric; these included Bowfin (*Amia calva*), Largemouth Bass, Northern Pike (*Esox lucius*), Smallmouth Bass and Walleye (*Stizostedion vitreum vitreum*). Chinook Salmon was also caught (three in Duffins Creek Marsh in 2005 and six in Wilmot Creek Marsh in 2004) but as described previously, this species was not included in calculations of PPIS metric scores. There were no significant temporal trends in raw PPIS values at any Durham Region wetlands.

Mean metric scores for numbers of native individuals (NNAT) were generally low, ranging from 0.87 at Whitby Harbour Marsh to 7.9 at Oshawa Second Marsh. The lowest NNAT score for a single year was at Bowmanville Marsh (0.15) in 2006 and Whitby Harbour Wetland Complex (0.87) in 2007 (0.56 and 3.22 native individuals per transect, respectively). Oshawa Second Marsh had the highest mean NNAT score, where there were numerous Pumpkinseed, Fathead Minnow, Brown Bullhead and some Banded

Killifish (*Fundulus diaphanous*) collected (7.90, equal to 26.58 native individuals per transect). Pumphouse Marsh also had a higher mean NNAT score (7.03, equal to 72.63 native individuals per transect) during the study period, due in part to the collection of large numbers of Fathead Minnow, Central Mudminnow (*Umbra limi*) and some Brown Bullhead in 2003 (i.e., over 500 individuals in four transects). Other wetlands with a NNAT maximum score of 10 included McLaughlin Bay and Port Newcastle marshes in 2005, Oshawa Second Marsh in 2005 and 2006 and Bowmanville Marsh in 2007. No significant temporal trends in raw NNAT values were evident at any of the Durham Region wetlands.

Percent non-indigenous biomass of fish (PBNI) varied widely among Durham Region wetlands whereby low metric scores indicated high percentage biomass of non-indigenous fish. The lowest mean PBNI metric scores (zero) were found at Pumphouse Marsh and Oshawa Second Marsh where Goldfish (*Carassius auratus*), as the only non-native fish collected at these sites, were abundant, comprising large percentages of the total biomass per transect in 2006 (67.0% and 63.1% non-indigenous biomass per transect, respectively). In fact, Goldfish were caught in every year of study in the two wetlands (range=30-69); one Goldfish was also caught in Corbett Creek Marsh in 2006. The highest mean PBNI score was at Bowmanville Marsh (8.89), where percent biomass of non-indigenous fish was lower than other wetlands from 2003 to 2007 (range=0 – 10.6% non-indigenous biomass per transect). Wetlands in which no non-indigenous fish were caught (and native fish were caught) included Bowmanville Marsh in 2005, Duffins Creek Marsh in 2005 and 2007 and Corbett Creek and Westside marshes in 2007. In total, seven non-indigenous fish species were caught in Durham Region wetlands, five of which were included in the calculation of PBNI metric; these included Alewife (*Alosa pseudoharengus*), Common Carp (*Cyprinus carpio*), Goldfish, Round Goby (*Neogobius melanostomus*) and White Perch (*Morone americana*). Chinook Salmon and Rainbow Trout (*Oncorhynchus mykiss*) were also caught in Wilmot Creek and Duffins Creek marshes, but these species were not included in calculations of the PBNI metric scores. A significant increase in raw PBNI was found at McLaughlin Bay Marsh from 2003 to 2007 (S=6, p=0.042, range=11.17%–25.08% non-indigenous biomass per transect).

Overall, mean metric scores for biomass of Yellow Perch (BYPE) were low with scores below 2.52 at all Durham Region wetlands. No Yellow Perch were caught at Pumphouse Marsh in 2003 and 2006, Carruthers Creek, Lynde Creek and Hydro marshes in 2003, Bowmanville Marsh in 2004, Oshawa Second Marsh in 2005, Frenchman's Bay Marsh in 2006 and Rouge River Marsh and Whitby Harbour Wetland Complex in 2007. The highest mean BYPE score (2.52) was found at Duffins Creek Marsh where in 2005 and 2007 a total of six and seven Yellow Perch were caught during sampling efforts, respectively (mean of 14.00g Yellow Perch per transect from 2003 to 2007). Between one and nine Yellow Perch were also caught in Wilmot Creek Marsh from 2003 to 2007 resulting in a high BYPE mean score (2.37) for this wetland (13.19g Yellow Perch per transect). A significant increase in raw BYPE was found at Lynde Creek Marsh from 2003 to 2007 (S=8, p=0.042, range=0.00–32.63g Yellow Perch per transect).

Based on the results of the individual metric scores and IBIs, and with the exception of Whitby Harbour Wetland Complex, fish communities in Durham Region are in very similar condition (fair to good) overall with only slight differences among wetlands. Lynde Creek Marsh consistently ranked high for fish community metrics with high numbers of native species including centrarchids and a high percentage of piscivore biomass and low percentage of non-indigenous fish biomass. Wilmot Creek Marsh and Frenchman's Bay Marsh also consistently scored high for fish metrics and IBIs from year-to-year relative to other wetlands. Oshawa Second Marsh and Pumphouse Marsh were similar with no piscivores caught, numerous Goldfish comprising a large percentage of the total biomass caught and few to no Yellow Perch caught at these wetlands during the study period; numbers of native species and individuals were high however at these wetlands. Fish community condition at Whitby Harbour Wetland Complex in 2007 was considered the poorest with no centrarchids, piscivores or Yellow Perch caught and few numbers of native species caught.

When all Lake Ontario, including Durham Region, coastal wetlands were grouped together, several significant correlations were also found between each of the individual (i.e., raw) fish metrics and the individual SAV metrics using mean index scores for a single wetland (Table 4.2.1-2). Fish metrics SNAT and SCEN showed stronger relationships with SAV metrics (i.e., with higher r_s values, where $p<0.02$) relative to other fish metrics while PBNI showed lowest degree of association with the SAV metrics.

Table 3. Spearman rank correlations (r_s) between individual raw fish community metrics and IBI and SAV community metrics and IBI for Lake Ontario wetlands from 2003-2007. Analyses were performed using mean index scores across years for a single wetland (n=20). Red numbers in bold denote significant correlations ($p<0.05$). Asterisks denote marginally-significant correlations where $0.05<p<0.10$.

		Fish Community						
		Native Species Richness (SNAT)	Centrarchid Species Richness (SCEN)	% Piscivore Biomass (PPIS)	Native Individuals Richness (NNAT)	% Non-indigenous Biomass (PBNI)	Biomass Yellow Perch (BYPE)	Fish IBI
SAV Community	Number of Turbidity-Intolerant Species (SINT)	**0.62**	**0.66**	**0.49**	**0.50**	-0.39*	0.41*	**0.50**
	Relative % Cover Turbidity-Intolerant Species (PINT)	**0.67**	**0.74**	0.43*	**0.49**	-0.30	0.37	**0.49**
	Floristic Quality Index (FQI)	**0.58**	**0.53**	**0.46**	**0.49**	-0.43*	**0.51**	**0.49**
	Total % Coverage (PCOV)	**0.62**	**0.54**	**0.49**	**0.52**	-0.43*	**0.52**	**0.52**
	Total Number of Native Species (SNAT)	**0.59**	**0.55**	**0.46**	**0.49**	**-0.54**	**0.55**	**0.55**
	SAV IBI	**0.60**	**0.58**	**0.53**	**0.51**	-0.44*	**0.50**	**0.52**

Fish communities in Durham Region coastal wetlands are different from those in other coastal wetlands of Lake Ontario (Appendix B – Tables B-2 and B-3). A comparison of the grand mean values between the two groups indicates that fish community metrics SCEN and PBNI in Durham Region were found roughly half of mean values found in coastal wetlands from other regions of Lake Ontario. Metrics relating to numbers of native species and individuals (i.e., SNAT and NNAT) were roughly two-thirds of those in other Lake Ontario wetlands. Finally, yellow perch were not nearly as abundant in Durham Region wetlands with a mean value in BYPE only one-fifth of that found elsewhere. Overall, the lower values of these fish metrics resulted in lower fish community IBIs, in Durham Region wetlands - approximately half of that found in other Lake Ontario wetlands.

Additional information relating to descriptions of fish species richness and other fish metrics not discussed here (e.g., trophic structure, abundance, condition) is provided in Appendix B of this report.

Discussion

Water levels at Oshawa Second Marsh were partially lowered in 2003 and the marsh was dewatered in 2004 as part of a management plan led by Ducks Unlimited Canada. Comparisons of fish IBIs before and after the drawdown indicate an initial slight increase in fish community condition. Mean fish IBI for 2003 was scored as "good" (43.9). The overall condition remained the same for 2005, the next sampling year, while IBI scores increased slightly (45.6). IBI scores for 2006 were "good" as well, but dropped slightly to 40.9. The most significant drop in mean IBI score occurred in 2007 (26.5), to "fair". Thus, water drawdown has not resulted in an observable increase in fish community condition in the marsh (see Appendix B – Figure B-1 for fish IBI temporal trends for Oshawa Second Marsh).

The quality of Durham Region wetlands ("fair" or "good," in relation to a multi-year mean fish IBI of 37.97 from 2003 to 2007) was approximately one-half of that calculated for other Lake Ontario wetlands ("very good" or "excellent," in relation to a multi-year mean fish IBI of 82.55 from 2003 to 2007). Other Lake Ontario wetlands had fewer non-native species (Common Carp and Round Goby) than Durham Region wetlands, where seven species were collected (see Appendix B – Table B-1 for a complete list of non-native species). The SNAT and NNAT values calculated for Durham Region wetlands were roughly two-thirds of those calculated for other Lake Ontario wetlands.

Better community conditions in other Lake Ontario wetlands compared to Durham Region wetlands are also evident in the most frequently caught fish: Yellow Perch, Bluegill and Pumpkinseed in other Lake Ontario wetlands compared to Pumpkinseed, Brown Bullhead and Fathead Minnow collected in Durham Region. Two of the most commonly caught fish in Durham Region wetlands (Brown Bullhead and Fathead Minnow) are generalists, while the most commonly caught fish in other Lake Ontario wetlands were specialists (e.g., herbivores, planktivores, insectivores, arthropodivores). Proportional biomass of specialists is considered a positive fish assemblage indicator (Minns, et al. 1994). Generalists have multitrophic, highly adaptable diets; as a result, they tend to destabilize fish communities (Minns et al. 1994). Additional native species collected in other Lake Ontario wetlands included cyprinid species such as Blackchin Shiner (*Notropis heterodon*), Blacknose Shiner (*Notropis heterolepis*), Sand Shiner (*Notropis stramineus*), Iowa Darter (*Etheostoma exile*) and Brook Silverside (*Labidesthes sicculus*) (see Appendix B – Table B-1 for a complete native species list). Of interest here is that Blackchin Shiner, Brook Silverside and Iowa Darter are also species identified as turbidity-intolerant species. The only turbidity-intolerant species found in Durham Region wetlands was Rock Bass, collected in Duffins Creek Marsh in 2003, Frenchman's Bay Marsh in 2007, Port Newcastle Wetland in 2005 and 2007 and Wilmot Creek Marsh in 2003 and 2007. This species was also found in other Lake Ontario wetlands.

Among the native species, Brown Bullheads were ranked second in abundance of fish species caught (comprising 17% of total catch) in Durham Region wetlands. EC and CLOCA (2005) discussed excluding Brown Bullhead from NNAT calculations, since their ubiquity, abundance and tolerance to disturbance may not provide much information about biotic integrity of the fish community. Brown Bullheads are known to tolerate poor water quality, low dissolved oxygen and are ubiquitous in Durham Region coastal wetlands (EC and CLOCA 2005). As a result, it is suspected the presence of this species in Durham Region coastal wetlands may not relay much information regarding fish habitat quality. The highest mean NNAT score was found at Oshawa Second Marsh where there were numerous Brown Bullheads caught. The capture of high numbers of Brown Bullhead likely inflated NNAT values. Although the capture of numerous Brown Bullheads may inflate the NNAT values, the inflated values still do not contribute to the overall IBI enough that these sites are comparable to less disturbed coastal wetlands on Lake Ontario. Furthermore, in the context of more disturbed sites (i.e., Durham Region coastal wetlands), Brown Bullhead numbers may help provide IBI resolution among sites – i.e., a wetland that could support high numbers of Brown Bullheads could be considered incrementally better than one that does not.

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1.2.2 Breeding Bird Community

Objective

To assess and monitor marsh breeding bird community condition.

Method Summary

The Marsh Monitoring Program (MMP) protocol, administered by Bird Studies Canada, was used to survey bird communities within various Lake Ontario coastal wetlands. Bird surveys were conducted at 15 Durham Region wetlands from 2002 to 2007 with some exceptions, most notably at Frenchman's Bay, Hydro Marsh, and Duffins Creek Marsh, where only two annual surveys were conducted. Surveys used a fixed distance point count method at established survey stations for collection of bird data; they are based on two site visits per survey station following MMP protocol. This methodology has been adopted by the Great Lakes Coastal Wetland Consortium (2008). A complete listing of all routes and number of stations at each wetland is provided in Appendix D – Table D-1. Further details of marsh bird sampling methodology used are found in the Durham Region Coastal Wetland Monitoring Project: Methodology Handbook (EC and CLOCA 2007). Data were collected by volunteers and, in the absence of volunteers, Conservation Authority and Canadian Wildlife Service staff.

Data Treatment and Analysis

Bird species were grouped into various guilds based on marsh use based on expert opinion within CWS and Bird Studies Canada (see Meyer et al. 2006). Recently, Burton et al. (2008) developed an IBI by combining the methods used by EC and CLOCA (2004) and Crewe and Timmermans (2005). See Section 2.1 of this report for additional information. In all, three metrics were found to be suitable for inclusion in the IBI:

1) mean species richness of area-sensitive marsh nesting obligates for the route (SAMNO),
2) mean relative abundance (i.e., proportion) of marsh nesting obligates for the survey route (PMNO), and
3) mean relative abundance (i.e., proportion) of non-aerial foragers for the survey route (PNAF).

Marsh nesting obligates depend exclusively on emergent or hemi-marsh habitat for nesting. Area-sensitive marsh nesting obligate species, a subset of marsh nesting obligates, are known to prefer large wetlands areas. Non-aerial foragers use marsh habitat only for foraging purposes specific to their type of foraging behaviour. A complete listing of species associated with each of the three guilds is provided in Appendix C – Table C-2. Species found in Durham Region wetlands during the study period are also indicated.

Species richness and abundance estimates were calculated based on two site visits using the maximum number of individuals of each species across visits per station. Mean values of species richness and abundance were then calculated across survey stations in a wetland for each year. For wetlands where there were two or three survey routes in a given year, mean values were first calculated for each route and then mean values across routes were determined. Methods for calculating bird IBI scores are provided in Burton et al. (2008). Although the IBI has undergone changes, the five IBI classes identified in EC and CLOCA (2004) have been retained for this reporting i.e., poor (0-20), fair (20-40), good (40-60), very good (60-80), and excellent (80-100). Details of the use of metrics to assess biotic community condition of Lake Ontario wetlands, statistical properties of the IBI, as well as other bird community metrics previously considered are provided in EC and CLOCA (2004).

To assess temporal trends in the bird IBI in Durham Region wetlands, the Mann-Kendall trend test was performed at each wetland and a modified version of the Mann-Kendall test was performed to examine overall regional trends from 2003 to 2007. Temporal trend analyses could not be performed at wetlands for which there were three or fewer years of bird data available (i.e., Carruthers Creek, Duffins Creek, Frenchman's Bay, Hydro marshes) or where there were ties in bird IBI scores since adjustments for ties cannot be performed when there are fewer than 10 years of available data (i.e., Port Newcastle Wetland in 2006 and 2007; USEPA, 2000). Temporal trends were also examined in the raw bird metrics using the Mann-Kendall test at wetlands where there were no ties in the data. Overall, ties were found in 30% of the tests performed (i.e., 10/33 tests on raw metrics) and only for the raw metric SAMNO; thus temporal trends could not be assessed for this metric at wetlands. Furthermore regional trend tests of the individual metrics were not performed. Further details of these tests are provided in the water quality chapter of this report. As a measure of year-to-year variability, coefficients of variation (CVs, expressed as a percentage) for bird IBIs were calculated for all years for each Durham Region wetland. To assess associations between the bird IBI vs. water quality, SAV IBI (and SAV metrics) and fish IBI in Lake Ontario wetlands, correlation analyses were performed using mean values across years for each wetland (i.e., each wetland is represented once in the analysis); similar years of monitoring only were used to calculate means for these analyses. Spearman rank correlation procedures were performed following violations in homogeneity of variances and/or normality in the data.

Results

Within-site and Regional Bird Community IBI Trends

Overall, marsh breeding bird community IBI scores were moderate in 15 Durham Region coastal wetlands with scores between 20 and 60 in 73% of wetland-years (i.e., 48 out of 66 cases) from 2002 to 2007 (Table 4.2.2-1). Consequently, based on the ratings by EC and CLOCA (2004), the large majority of Durham Region coastal wetlands had breeding bird IBI scores in the “fair” or “good” category. The lowest IBI score was found at Carruthers Creek Marsh in 2007 (3.7) corresponding to a “poor” rating. High scores corresponding to an “excellent” condition were found at Cranberry Marsh in 2003 and 2004 (83.9 and 90.5, respectively), Oshawa Second Marsh and McLaughlin Bay Marsh in 2005 (93.2 and 89.2, respectively) and Westside Marsh in 2007 (84.7). The grand mean marsh breeding bird IBI (±SD) for all Durham Region coastal wetlands from 2002 to 2007 ranged from 43.1±20.9 in 2007 to 58.0±16.1 in 2004.

In contrast, breeding bird IBI scores for the other 26 Lake Ontario wetlands were generally much higher relative to values at Durham Region wetlands, ranging from 31.8 at Button Bay Marsh in 2005 to 89.4 at Sawguin Creek Central Marsh in 2005 (Table 4.2.2-1). Mean marsh breeding bird IBI scores grouping these other Lake Ontario wetland sites ranged from 39.0 in 2007 (where only one wetland, Robinson's Cove Marsh, was sampled) to 66.0±18.3 in 2005. For the two years in which there were sufficient data to compare bird IBI scores, mean IBI scores for Durham Region wetlands were either significantly lower or marginally-significantly lower than those in the other Lake Ontario group of wetlands (two-tailed t-tests, 2006: t_{38}=-3.08, p=0.004; 2005: t_{25}=-1.92, p=0.07). In 2002 and 2007 where only one non-Durham Region site was surveyed (i.e., Parrott's Bay and Robinson's Cove marshes, respectively), no significant differences between the single IBI and the mean IBI at the Durham Regions sites were found (t>-0.20, p>0.72). Overall for years where there are sufficient data, breeding bird community condition in other Lake Ontario coastal wetlands was at least marginally-significantly better than in Durham Region coastal wetlands; additional years of data collection are needed at other Lake Ontario sites to explore this spatial pattern further.

Table 4. Breeding bird community IBIs (scored out of 100) for Durham Region coastal wetlands and other Lake Ontario wetlands from 2002-2007, where available. Durham Region coastal wetlands are shaded and their condition based on the average of IBI scores during the study period following ratings in EC and CLOCA (2004). Coefficients of variation (CV, expressed as a percentage) are indicated for Durham Region wetlands only (i.e., where there are sufficient annual data). Wetlands are ordered vertically from west to east (See Module 1, Figure 5 for locations).

Wetland	Condition	2002	2003	2004	2005	2006	2007	CV
Rouge River Marsh	good		40.0	58.4	51.6	39.8	34.2	22.1
Frenchman's Bay Marsh	fair				46.9	24.9		43.3
Hydro Marsh	fair				45.3	25.4		39.8
Duffins Creek Marsh	good				42.9	39.4		6.0
Carruthers Creek Marsh	poor				28.7	24.6	3.7	70.6
Cranberry Marsh	v. good	64.4	83.9	90.5	75.0	73.9		12.9
Lynde Creek Marsh	good	43.0	41.1	57.5	50.9	52.0	53.9	12.8
Corbett Creek Marsh	good	41.4	39.6	60.3		38.3	31.0	25.9
Pumphouse Marsh	fair			45.6	40.5	38.9	33.6	12.4
Oshawa Second Marsh	v. good	51.5	59.3	69.1	93.2	78.5	62.2	21.7
McLaughlin Bay Marsh	v. good			59.7	89.2	66.2	57.2	21.4
Westside Marsh	v. good	66.7	57.7	63.8	58.8	64.5	84.7	14.8
Bowmanville Marsh	fair	45.8	37.7		26.5	42.7	38.7	19.2
Wilmot Creek Marsh	fair	15.0	57.0	45.2	39.1	28.8	37.2	38.6
Port Newcastle Wetland	fair		42.1	29.9	30.7	38.1	38.1	14.8
Presqu'ile Bay Marsh					82.9	80.2		
Dead Creek Marsh						54.6		
12 O'clock Point Marsh						44.6		
Carrying Place Marsh						37.2		
Sawguin Creek Ditched Marsh						81.3		
Sawguin Creek Central Marsh					89.4	69.9		
Sawguin Creek North Marsh						78.1		
Belleville Marsh					37.7	43.1		
Blessington Creek Marsh					76.0	67.5		
Robinson's Cove Marsh					65.0	39.5	39.0	
Big Island West Marsh					70.2	79.6		
Big Island East Marsh					72.0	77.5		
Marysville Creek Marsh						83.9		
Solmesville East Marsh						40.0		
Lower Sucker Creek Marsh						51.3		

Wetland	Condition	2002	2003	2004	2005	2006	2007	CV
Lower Sucker Creek East Marsh						38.6		
Airport Creek Marsh						58.6		
Forester's Island Marsh						44.9		
Lower Napanee River Marsh						81.3		
South Bay Marsh					39.5	70.8		
Big Sand Bay Marsh					74.0	77.8		
Hay Bay North Marsh					83.3	91.7		
Hay Bay South Marsh					67.8	71.2		
Parrott's Bay Marsh		53.8						
Button Bay Marsh					31.8	38.5		
Bayfield Bay Marsh					68.2	76.0		
Mean - Durham Region wetlands		**46.8**	**50.9**	**58.0**	**51.4**	**45.1**	**43.1**	
Mean - Other Lake Ontario wetlands		**53.8**			**66.0**	**63.1**	**39.0**	

Trend analyses using the Mann-Kendall test revealed a significant decrease in bird IBI scores at Pumphouse Marsh (S=-6, p=0.042) from 2004 to 2007. No significant change in bird IBI scores over time were found at the other nine Durham Region wetlands (where there were four or more years of data and no ties) during the study period. Bird condition in Durham Region wetlands is in the fair to good range with the exceptions of Oshawa Second, Cranberry, McLaughlin Bay and Westside marshes which, with higher IBI scores, are in very good to excellent range and Carruthers Creek Marsh, which dipped down to poor condition in 2007 (and where only one station was surveyed). At wetlands where only two years of data are available (i.e., Frenchman's Bay, Hydro and Duffins Creek marshes), additional years of data collection are required to determine temporal trends in breeding bird condition. Bird IBI scores for each year with associated categories for all of the DRCWMP wetlands and the results of Mann-Kendall tests with the S statistics where significant are shown in Appendix C – Figure C-1. A regional trend analysis revealed no significant evidence of an overall trend in bird IBI scores in Durham Region wetlands from 2003 to 2007 (X_2=2.26, df=1, p>0.10).

Some marsh breeding bird community IBIs varied considerably among study years. The highest coefficient of variation (CV) was found at Carruthers Creek Marsh (70.6%) due to the low 2007 IBI score which incidentally was also the year when only one station was surveyed compared to four stations which were surveyed previously in 2005 and 2006 (Appendix C – Table C-1). Frenchman's Bay Marsh had a relatively high CV (43.3%) where six stations were surveyed in 2005 and 2006 as well as Wilmot Creek Marsh (38.6%) where three stations have been surveyed annually since 2002. Coefficients of variation at other Durham Region wetlands were between 13% to 26% with the exception of Duffins Creek Marsh where a low CV (5.98%) was found for the two survey years. Note that where there are relatively fewer years of data available such as at Duffins Creek Marsh, this will influence the calculated CV and its comparison to CVs at other wetlands.

Significant correlations were found between the bird IBI and the WQI (r_s=0.48, p=0.003, n=35) and between the bird IBI and the SAV IBI (r_s=0.50, p=0.003, n=34) when mean index scores were pooled across years for each Lake Ontario wetland (Figure 5). No significant correlation was found between the bird IBI and the fish IBI (r_S=0.37, p=0.12 n=19).

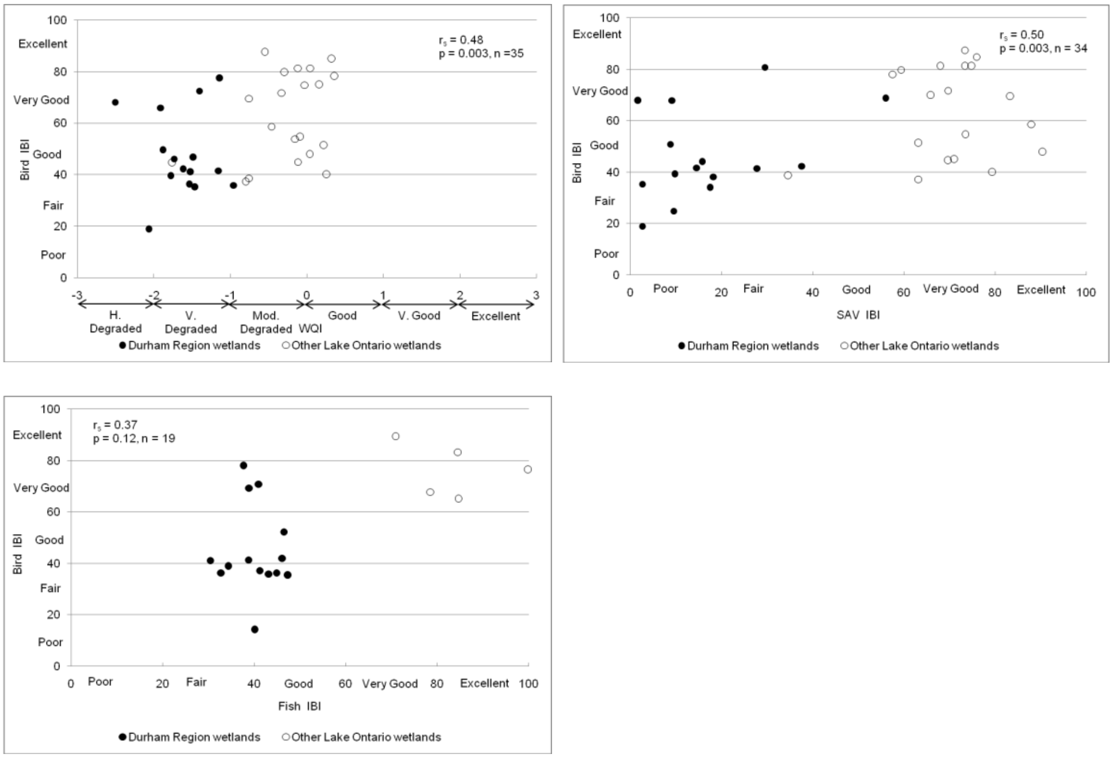

Figure 5. Correlations between marsh breeding bird community condition as measured using the bird IBI and water quality (WQI), submerged aquatic vegetation condition (SAV IBI) and fish community condition (fish IBI) using mean index scores for Lake Ontario coastal wetlands from 2002-2007, where available.

Of all Durham Region wetlands comparing temporal trends for assorted indices, Pumphouse Marsh showed both a significant decrease in the SAV IBI and a significant decrease in the bird IBI from 2003/4-2006/7 (Figure 6).

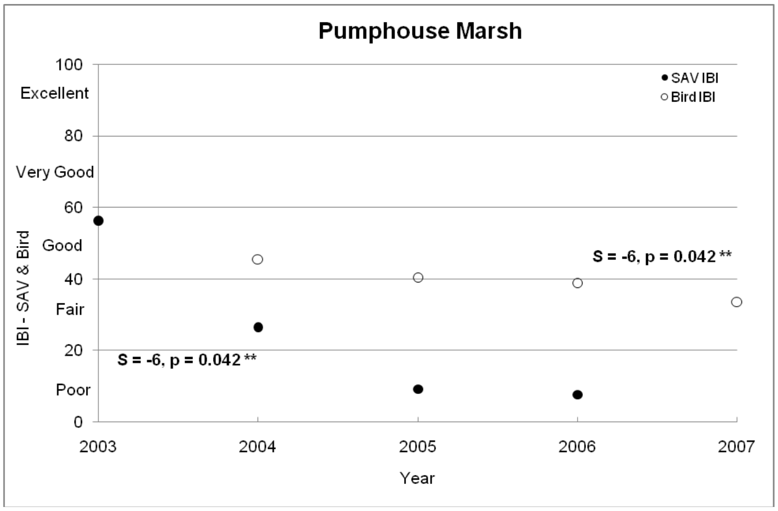

Figure 6. Temporal trends in IBIs for SAV community condition (filled circles) and marsh bird community condition (open circles) at Pumphouse Marsh from 2003/4-2006/7.

Within-site and Regional Bird Community Metric Trends

Mean marsh breeding bird standardized metric values and IBIs for each of the Durham Region wetlands for all study years and the results of temporal trend analyses at each site for each of the raw metrics are shown in Appendix C – Table C-3. Overall, mean metric scores for species richness of area-sensitive marsh nesting obligates (SAMNO) were generally low at Durham Region wetlands. Mean scores ranged from zero with no species found at eight marshes in any study year (i.e., Rouge River, Hydro, Duffins Creek, Carruthers Creek, Corbett Creek, Pumphouse, Wilmot Creek marshes and Port Newcastle Wetland) to a mean score of 7.00 at Cranberry Marsh from 2002 to 2006 (0.54 area-sensitive marsh nesting obligate species per station). American Coot (*Fulica americana)* was the only area-sensitive marsh nesting obligate species found in Cranberry Marsh. Although low overall, higher mean SAMNO scores were found at Oshawa Second Marsh and McLaughlin Bay Marsh relative to other sites (3.40 and 2.19, respectively). In total, four area-sensitive marsh species, American Coot, American Bittern (*Botaurus lentiginosus*), Black Tern (*Chlidonias niger*) and Least Bittern *(Ixobrychus exilis)*, were found at Oshawa Second Marsh in three out of six study years (0.24 species per station). One species, Black Tern, was found at McLaughlin Bay Marsh in 2005 while none were found in other years (0.13 species per station).

Mean metric scores for relative abundance of marsh nesting obligates (PMNO) varied among Durham Region wetlands. Mean PMNO metric scores were lowest at Carruthers Creek Marsh from 2005 to 2007 (1.86) and Bowmanville Marsh from 2002 to 2007 (2.05) and highest at Westside Marsh from 2002 to 2007 (9.78) and Cranberry Marsh from 2002 to 2006 (9.14). In total, thirteen marsh nesting obligate species were found in Durham Region coastal wetlands: American Bittern, American Coot (*Fulica americana*), Black Tern, Common Moorhen (*Gallinula chloropus*), Least Bittern, Marsh Wren (*Cistothorus palustris*), Pied-billed Grebe (*Podilymbus podiceps*), Ring-necked Duck (*Aythya collaris*), Sora (*Porzana carolina*), Swamp Sparrow (*Melospiza georgiana*), Trumpeter Swan (*Cygnus buccinators*), Virginia Rail (*Rallus limicola*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). At least one marsh nesting obligate species was found in Durham Region wetlands in all years of study. No significant temporal trends in raw PMNO values were evident at any of the Durham Region wetlands.

With the exception of Carruthers Creek Marsh, mean metric scores for relative abundance of non-aerial foragers (PNAF) were high and above 5.5 at all Durham Region wetlands. Mean PNAF metric scores ranged from 3.83 at Carruthers Creek Marsh from 2005 to 2007 (equal to 29.5% non-aerial foraging birds per station) to 10.00 at McLaughlin Bay Marsh from 2004 to 2007 (equal to 86.9% birds per station). A total of forty-one non-aerial forager species were found in Durham Region wetlands with Red-winged Blackbird (*Agelaius phoeniceus*), Swamp Sparrow (*Melospiza georgiana*) and Yellow Warbler (*Dendroica petechia*) as the most abundant species within this group. A complete listing of non-aerial forager species found in Durham Region wetlands is included in the Appendix C – Table C-2. No significant temporal trends in raw PNAF values were evident at any of the Durham Region wetlands.

Marsh breeding bird communities in four Durham Region coastal wetlands appear to be in better condition than other Durham Region wetlands based on mean metric and IBI scores: Cranberry Marsh, Oshawa Second Marsh, McLaughlin Bay Marsh, and Westside Marsh (Appendix C – Table C-3). Breeding bird condition at Carruthers Creek Marsh, notably in 2007, was considered the poorest relative to other Durham Region wetlands. Note however that only one station at Carruthers Creek Marsh was surveyed in 2007 compared to four stations in earlier surveys.

When all surveyed Lake Ontario, including Durham Region, wetlands were grouped together, several significant correlations were also found between each of the individual raw bird metrics and the individual SAV metrics using mean index scores for a single wetland (Table 4.2.2-2). Notably the metric PNAF shows stronger relationships to SAV metrics (i.e., with higher r_s values where $p<0.01$) than the other two bird metrics while the SAV metric PCOV was more closely associated to all three bird metrics (where $r_s>0.33$) relative to the other SAV metrics.

Table 5. Spearman rank correlations (r_s) between individual raw marsh bird metrics and IBI and SAV community metrics and IBI for Lake Ontario wetlands from 2002-2007. Analyses were performed using mean index scores across years per wetland (n=34). Red numbers in bold denote significant correlations ($p<0.05$). Asterisks denote marginally-significant correlations where $0.05<p<0.10$.

		Marsh Bird Community			
		Area-sensitive Species Richness (SAMNO)	% Marsh-Nesting Obligates (PMNO)	% Non-aerial Foragers (PNAF)	Bird IBI
SAV Community	Number of Turbidity-Intolerant Species (SINT)	**0.29***	**0.33***	**0.44**	**0.49**
SAV Community	Relative % Cover Turbidity-Intolerant Species (PINT)	**0.18**	**0.20**	**0.43**	**0.35**
SAV Community	Floristic Quality Index (FQI)	**0.19**	**0.23**	**0.38**	**0.42**
SAV Community	Total % Coverage (PCOV)	**0.33***	**0.36**	**0.46**	**0.54**
SAV Community	Total Number of Native Species (SNAT)	**0.31***	**0.33***	**0.46**	**0.52**
SAV Community	SAV IBI	**0.25**	**0.33***	**0.44**	**0.50**

In addition, breeding bird communities are different between coastal wetlands found in Durham Region compared to those found in other coastal wetlands of Lake Ontario (Appendix C – Tables C-3 and C-4). A comparison of the grand mean values between the two groups indicates that breeding bird community metrics PMNO and PNAF in Durham Region were roughly three-quarters of mean values found in coastal wetlands from other regions of Lake Ontario. Furthermore, SAMNO was less than half of the mean values for coastal wetlands elsewhere, which contributed heavily to the overall lower bird IBI scores calculated for Durham Region wetlands.

Discussion

Bird community condition reporting through IBIs has changed with the DRCWMP. As was the intention of the DRCWMP stakeholders, the DRCWMP has come into line with larger Great Lakes coastal wetland assessment and reporting initiatives. The adoption of the GLCWC bird IBI within the DRCWMP is prudent, as it is more compatible and comparable with other Great Lakes marsh bird assessments (e.g., SOLEC, Great Lakes AOCs) and will streamline results reporting. Because the GLCWC bird IBI is based on the original DRCWMP IBI, the two are highly correlated ($r=0.88$, $p<0.001$, $n=40$; 2006 data); adopting the GLCWC method has had an effect on past DRCWMP results. The change has had an overall effect of lowering Durham Region coastal wetland IBIs in comparison to previously published values. In 80% of the cases the IBI has been lowered. When recalculated site IBIs have been lowered, the mean decrease was by 17 IBI points (for Durham Region coastal wetlands assessed between 2002 and 2006). The decrease does not indicate that these sites were generally in poorer condition than originally estimated. It is an artifact of the process of comparing Durham Regions sites in the context of sites within a larger geographic area, i.e., Ecoregion 8 (See section 2.1) – not just Lake Ontario, as was previously the case.

An important advantage of the GLCWC IBI relates to the guilds used in the IBI. Using both response guilds (e.g., area-sensitive species) and functional guilds (e.g., non-aerial foragers) incorporates a broad suite of species. This allows the IBI to detect various sources of disturbance that may not affect different guilds in the same manner.

The IBI scores for Durham Region coastal wetlands were generally lower than other Lake Ontario wetlands, for comparable years (2005-2006). In fact, the mean IBI value calculated for the bird community in Durham sites have consistently scored below those calculated for other Lake Ontario coastal wetlands (Table 4.2.2-1). However, availability of comparable datasets (i.e., number of sites) for other Lake Ontario coastal wetlands is generally low for most years. This makes trend analysis and comparison between Durham wetlands and other Lake Ontario wetlands less robust than comparison among Durham wetlands alone. In addition, most other Lake Ontario sites are found in the Bay of Quinte, which are generally in very good condition (EC 2007).

The coefficient of variation (CV) is an important measure to consider, as it illustrates the year-to-year variation at each site. A number of factors can contribute to year-to-year variation, including: disturbance, such as drawdowns in managed wetlands; change in surveyors over time; and differences in the number and location (i.e., interior or shoreline) of stations surveyed each year (See Meyer et al. 2006). A high degree of variability in IBI among years can influence the ability to detect significant change in bird condition over time at Durham Region wetlands.

Area-sensitive marsh nesting obligate species are very low in Durham Region coastal wetlands compared to other Lake Ontario wetlands. The size of wetlands surveyed in Durham may partially account for this result. Habitat availability may be important in determining species diversity and richness. For example, the footprint of some Durham Region coastal wetlands is quite large, but a relatively small portion of the wetland exists as marsh nesting habitat, while the remaining area is treed swamp or meadow marsh. This type of habitat may affect the suitability for area-sensitive species, despite a large wetland area available.

In Durham Region, both Cranberry and Oshawa Second marshes reported higher metric scores and better bird community conditions (IBI) than other sites in the region. This is likely linked to restoration activities at both of these sites. Oshawa Second Marsh was drawn down in 2003-2004, and the subsequent increase in bird IBI is apparent. The lower IBI scored in 2007 for Oshawa Second Marsh is possibly a result of management activities at the marsh, whereby water levels were raised in 2007 to control aggressive cattail establishment. Cranberry Marsh was drawn down in 2001, and much like Oshawa Second Marsh, shows an increase in IBI score in subsequent years. These two examples illustrate the positive effect management can have on wetland systems. Continued efforts in this regard will likely result in healthy and productive wetland systems.

Water supply influences the dynamics of wetland systems. This may account for some of the site-level variability observed among IBI scores over time. One way to provide insight is by documenting long-term trends in wetland hydroperiod (Buldoc and Afton 2008). There is a relationship among water depth, feeding strategy, morphological features and resources abundance. There may also be effects of surveyor bias, and number and location of survey stations on site results; however, it is likely that variable water levels affect the abundance, diversity, and richness of bird species at a site to a greater extent. For example, due to low water supply, Pumphouse Marsh was essentially dewatered by the end of the 2007 field season. The decrease in water level was mirrored by a decline in the bird IBI score.

The SAV community at Pumphouse Marsh also experienced significant decreases in the mean total cover (PCOV), mean FQI and mean number of native species (SNAT) resulting in the significant decrease in the SAV IBI from 2003 to 2006. These characteristics of the SAV community have been shown to influence aspects of the marsh breeding bird community (Table 4.2.2-2). While there was no significant temporal trend in WQI, it was categorized as very degraded/highly degraded from 2003 to 2007. A significant correlation was found between the bird IBI and the WQI ((r_s=0.48, p=0.003, n=35). The decline in aquatic habitat quality at Pumphouse Marsh is influencing abundance and diversity of marsh bird species.

Interpretation of IBI results at relatively small (less than 10 hectares) wetlands should be approached with caution (EC 2007; Burton et al 2008). Environment Canada (2007) suggests that sites of different sizes but of similar environmental quality may have differing capacities to support robust marsh breeding bird assemblages. Sites less than 10 hectares appear to be less likely to have a high IBI (EC 2007). The cause/effect nature of this occurrence has not been examined in-depth, but is expected to be related, in part, to suitability for area-sensitive marsh-nesting obligate species. Within the realm of wetland size and area-sensitive marsh-nesting obligate species richness, there are two main factors that may be at play.

First, there is variation among species' area requirements – not all area-sensitive require the same area for nesting See Naugle *et al.* (2000; Black Tern), Riffle *et al.* (2001; American Bittern, Virginia Rail, Sora, Swamp Sparrow) and Brown and Dinsmore (1986; Black Tern, Swamp Sparrow, Pied-billed Grebe, and Least Bittern) and Poole and Gill [ongoing] for more information on area-sensitive species designation and justification. Some area sensitive marsh nesting species may find a particular wetland suitable for nesting, while others do not. Furthermore, within a species, the exact requirements for nesting area are not categorically known.

Second, evidence suggests that area-sensitive marsh nesting obligate presence and abundance may not respond to the size of the marsh, but may be influenced by the size of suitable habitat within the wetland (EC and CLOCA 2004). This guild not only requires larger areas for nesting, but requires larger areas of *suitable* (i.e., not highly disturbed) habitat. This may explain why some larger Durham Region coastal wetlands do not support expected numbers of area-sensitive marsh nesting obligate species (e.g., Duffins Creek Marsh). As such, small sites such as Pumphouse Marsh or Port Newcastle Marsh may not be able to accommodate the minimum area requirements of this guild. A reduction in site IBI linked to an inherent quality of the site (i.e., small size) would not be a fair analysis. However, for these sites it is likely the main driver of bird habitat suitability is not size, but disturbance (e.g., water quality, urban encroachment). Nonetheless, this issue should be investigated further such that more comparable results can be drawn. As a suggestion, small sites in less disturbed locales of Lake Ontario (e.g., Forester's Island, Carrying Place and Robinson's Cove Marshes of the Bay of Quinte) could be used for comparison with small Durham Region sites.

In 2007, Carruthers Creek Marsh had the lowest bird IBI score in the study. Carruthers Creek Marsh was also among the wetlands with the lowest SAV IBI scores (poor) with water quality categorized as very/highly degraded, notably in 2007. A marginally-significant increase in turbidity was also found in this wetland during the study period from 2002 to 2007. It should be noted that the number of bird survey stations was reduced from four to one in 2007, which likely played a role in the substantially reduced IBI score. In addition, a relatively small portion of this wetland supports marsh habitat suitable for MMP marsh bird surveys. However, conditions measured for other biota substantiate the poor rating found for birds in 2007; additional years of data collection, and possible reestablishment of dropped survey stations, are required to make a more complete assessment. Results from this site should be approached with caution.

Meyer *et al.* (2006) recommended inclusion of both marsh-interior and shoreline stations to gather a representative sample of marshbird diversity. Durham sites range from entirely interior stations to exclusively shoreline stations. In addition, sites now have interior stations that originally were exclusively surveyed from the shoreline. Inclusion of interior stations will affect the diversity because of an increase in the delectability of some species based on habitat preferences. Westside Marsh is composed of entirely interior stations, which might increase the delectability of some marsh-obligate species, and thus account for its relatively higher IBI score.

Differences in percentages of available marsh habitat among Durham Region sites influence a surveyor's ability to completely survey these wetlands. All coastal wetlands in the Durham Region are comprised of marsh and swamp areas. Of these wetlands, four have more than one-third of their area as swamp habitat; namely, Rouge River Marsh (41%), Carruthers Creek Wetland Complex (75%), Lynde Creek Marsh (40%) and Port Newcastle Wetland Complex (43%). The MMP was designed for use in marsh habitats only and cannot be easily extended to survey wooded areas. To conform to MMP protocol, only stations consisting of mostly marsh areas are sampled. Wooded areas of the wetlands cannot be surveyed for breeding birds (EC and CLOCA 2007). As such, it is important to view these results in the context of marsh breeding bird communities. If the DRCWMP finds interest or a need to survey wooded areas, the use of the Forest Bird Monitoring Program should be considered for use.

No single indicator can measure the health of a wetland system. A number of confounding factors, such as weather and temporal variation, can make it difficult to assess the condition of Durham Region coastal wetland marsh breeding bird communities. However, bringing together a number of variables like the various IBI scores of different communities within a wetland system can lead to a better understanding of the system condition and perhaps point to problem areas that may not be immediately apparent. The bird IBI scores for Durham Region coastal wetlands indicate that their condition is impaired. When taken together with the other communities' IBI scores, it is evident that this section of Lake Ontario coast is in need of attention.

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1.2.3 Amphibian Community

Objective

To assess and monitor amphibian community condition.

Method Summary

The Marsh Monitoring Program (MMP) protocol, administered by Bird Studies Canada, was used to survey amphibian communities within various Lake Ontario coastal wetlands. Amphibian surveys were conducted at 15 Durham Region wetlands from 2002 to 2007 with some exceptions; only two annual surveys were conducted during this period at Frenchman's Bay, Duffins Creek, Cranberry Creek, Hydro, and Carruthers Creek marshes. Surveys used a point count method at established survey stations within designated routes for collection of amphibian data. Generally, one survey route per wetland was completed, with the exception of Rouge River, Lynde Creek, Oshawa Second and Port Newcastle marshes, where two designated routes were surveyed in some or all of the study years. Ideally, three visits were made, generally from April to early July, to capture the various breeding times of calling amphibian species in this region. There was some variability in numbers of stations surveyed from year to year in each wetland which may have been due to either changes in habitat availability or volunteer effort; data analyzed for this report include all available MMP data. A complete listing of all routes, number of stations and number of visits at each station is provided in the Appendix D – Table D-1. Further details of amphibian sampling methodology are found in the Durham Region Coastal Wetland Monitoring Project: Methodology Handbook (EC and CLOCA 2007). Volunteers were relied upon for the majority of data collection. In the absence of volunteers, Conservation Authority and Canadian Wildlife Service staff collected data.

Data Treatment and Analysis

Amphibian species were grouped into species guilds as identified in published literature and/or based on expert opinion (see EC and CLOCA (2004) and Crewe and Timmermans (2005)). A number of metrics were evaluated for suitability using data from Great Lakes coastal wetlands within Ecoregion 8 of the Great Lakes basin. Three metrics were retained for use in the amphibian IBI, all of which responded significantly to landscape disturbance (Burton et al 2008):

1) mean total species richness across survey stations in a wetland (rTOT),
2) mean species richness of woodland associated amphibian species across survey stations in a wetland (rWOOD), and
3) probability of detection of woodland associated amphibian species across survey stations in a wetland (pWOOD).

A complete listing of amphibian species associated with the guilds is provided in the Appendix D – Table D-2.

Species richness and occurrence were calculated using the maximum number of species and presence counts across visits. Species richness values for rTOT and rWOOD metrics were then corrected based on the total number of species expected in the region given their species range. In Durham Region wetlands, for instance, ten amphibian species, including four woodland species, would be expected (Appendix D – Table D-2); therefore, total species richness for each Durham Region wetland was divided by 10. Mean values of species richness and presence/absence were then calculated across survey stations in a wetland for each year. For wetlands where there were two survey routes in a given year, mean values were first calculated for each route and then mean values across routes were determined. Details of calculations of amphibian IBI scores are provided in GLCWC (2008). As outlined in EC and CLOCA (2004), five classes were identified according to ranges in IBI scores: poor (0-20), fair (20-40), good (40-60), very good (60-80), and excellent (80-100). Further details of the use of metrics to assess biotic community condition of Lake Ontario wetlands, statistical properties of the IBI, and other amphibian community metrics previously considered are provided in EC and CLOCA (2004). There was a highly significant correlation between the revised amphibian IBI developed through the GLCWC (and adopted here) and the original DRCWMP amphibian IBI ($r=0.92$, $p<0.001$, $n=19$) reported in EC and CLOCA (2004). The use of the revised amphibian IBI allows for comparisons of amphibian condition across a broader geographic area (i.e., in Ecoregion 8 of the Great Lakes basin) and not only Lake Ontario.

To assess temporal trends in the amphibian IBI in Durham Region wetlands, the Mann-Kendall trend test was performed at three wetlands: Bowmanville Marsh, Cranberry Marsh and Oshawa Second Marsh. The remaining 13 wetlands had either insufficient data for data analysis (i.e., fewer than four years) or ties in amphibian IBI scores for which the adjustments for ties cannot be performed when there are fewer than 10 years of available data. Consequently, regional trend analysis of the IBIs could not be examined. Similarly, temporal trends in the raw amphibian metrics and regional trends of the metrics could not be performed due to insufficient data or the presence of ties. Further details of these tests are provided in the water quality chapter of this report. As a measure of year-to-year variability, coefficients of variation (CVs, expressed as a percentage) for amphibian IBIs were calculated for all years for each Durham Region coastal wetland. Parametric t-tests were performed to compare mean amphibian IBI scores between Durham Region wetlands and other Lake Ontario wetlands. Where the conditions of homogeneity of variances were not met, non-parametric Mann-Whitney tests were performed. To assess associations between the amphibian IBI versus water quality index, SAV IBI (and SAV metrics), fish IBI and bird IBI in Lake Ontario wetlands, correlation analyses were performed using mean values across years for each wetland (i.e., each wetland is represented once in the analysis); similar years of monitoring only were used to calculate means for these analyses. Spearman rank correlation procedures were performed following violations in homogeneity of variances and/or normality in the data.

Results

Within-site and Regional Amphibian Community IBI Trends

Overall, amphibian IBI scores were low in 15 Durham Region coastal wetlands with scores below 40 in 80% of wetland-years (i.e., 49 out of 61 cases) from 2002 to 2007 (Table 4.2.3-1). Thus, the large majority of Durham Region coastal wetlands had amphibian IBI scores in the “poor” or “fair” categories. IBI scores of zero were found at Duffins Creek Marsh in 2005, and Bowmanville Marsh in 2004, where three stations were surveyed per wetland (see also Appendix D – Table D-1). Scores of zero were also found at Westside Marsh in 2004, McLaughlin Bay Marsh and Port Newcastle Wetland in 2006, and Hydro Marsh in 2007, where one station was surveyed per wetland. High IBI scores corresponding to a “very good” condition were found at Port Newcastle Wetland in 2004 (74.4) and Wilmot Creek Marsh in 2002 and 2006 (66.27 and 60.84, respectively). The only Durham Region wetland with an annual IBI scores within the “excellent” range was Hydro Marsh in 2002. The grand mean amphibian IBI (±SD) for all Durham Region coastal wetlands from 2002 to 2007 ranged from 16.33±15.48 in 2007 to 38.71±28.14 in 2002.

In contrast, amphibian IBI scores for the other 13 Lake Ontario wetlands were generally much higher than values at Durham Region wetlands, ranging from 0 at Robinson's Cove Marsh in 2002 to 99.2 at Big Island East Marsh in 2002 (Table 4.2.3-1). Mean amphibian IBI scores grouping these other Lake Ontario wetland sites ranged from 40.40±54.26 in 2004 to 83.45±15.38 in 2005. Mean amphibian IBI scores for Durham Region wetlands were significantly lower than those in the other Lake Ontario group of wetlands in five of the six study years (two-tailed t-tests, 2002: t_{15}=-2.67, p=0.0176; 2003: t_{12}=-2.43, p=0.0319 2005: t_{11}=-4.57, p=0.0008; 2006: t_{10}=-3.30, p=0.0080, 2007: $U_{5,13}$=8.5, p=0.018). There was no significant difference between mean IBIs in 2004 (t_9=-0.-49, p=0.633). Overall, amphibian community condition in other Lake Ontario coastal wetlands in most study years was significantly better than in Durham Region coastal wetlands.

Table 6. Amphibian community IBIs (out of 100) for Durham Region coastal wetlands and other Lake Ontario wetlands from 2002-2007, where available. Durham Region coastal wetlands are shaded and their condition based on the average of IBI scores during the study period following ratings in EC and CLOCA (2004). Coefficients of variation (CV, expressed as a percentage) are indicated for Durham Region wetlands only (i.e., where there are sufficient annual data). Wetlands are ordered vertically from west to east (See Module 1, Figure 5 for locations).

Wetland	Condition	2002	2003	2004	2005	2006	2007	CV
Rouge River Marsh	Fair		8.13	66.27	24.8	8.13	30.22	86.56
Frenchman's Bay Marsh	Fair	37.2					5.42	105.45
Hydro Marsh	Good	82.93					0	141.42
Duffins Creek Marsh	Poor				0		13.56	141.42
Carruthers Creek Marsh	Poor				8.13		8.13	0.00
Cranberry Marsh	Good	8.13	52.44					103.46
Lynde Creek Marsh	Fair	4.07	3.25	33.13	28.13	14.88	59.76	89.66
Corbett Creek Marsh	Poor			10.84	8.13	8.13	8.13	15.38
Pumphouse Marsh	Fair		8.13	8.13	58.13	58.13		87.13
Oshawa Second Marsh	Fair	23.9	20.67	36.52	44.21	37.73	21.17	32.69
McLaughlin Bay Marsh	Fair	58.13	58.13		33.13	0	19.38	74.58
Westside Marsh	Poor		8.13	0	8.13	12.2	8.13	60.87
Bowmanville Marsh	Poor	29.07	4.07	0		8.13	22.09	97.67
Wilmot Creek Marsh	Fair	66.27	24.8	24.8	19.38	60.84	8.13	69.70
Port Newcastle Marsh	Fair		16.27	74.4	16.27	0	8.13	128.21
Port Britain Marsh		70.33						
Presqu'ile Bay Marsh								
Huyck's Bay Marsh		82.93						
Sawguin Creek Central Marsh						90	90	
Belleville Marsh			39.23	2.03			8.13	
Blessington Creek Marsh						66.27		
Robinson's Cove Marsh		0	16.27				66.27	
Big Island East Marsh		99.2	95.95		94.32		89.44	
South Bay Marsh		95.13						
Hay Bay South Marsh		74.4					66.27	
Parrott's Bay Marsh		80.7	70.43	78.77	72.57			
Button Bay Marsh		99.2						
Bayfield Bay Marsh		90.93						

	2002	2003	2004	2005	2006	2007
Mean - Durham Region wetlands	38.71	20.40	28.23	22.59	20.82	16.33
Mean - Other Lake Ontario wetlands	76.98	55.47	40.40	83.45	78.14	64.02

Trend analyses using the Mann-Kendall test revealed no significant changes in amphibian IBI scores at any Durham Region wetland from 2002 to 2007. Amphibian condition in Durham Region wetlands was generally in the poor to fair range with the exception of Cranberry Marsh which had an overall condition of good. Amphibian IBI scores for each year with associated categories for all of the DRCWMP wetlands are shown in Appendix D – Figure D-1.

Marsh amphibian community IBIs varied considerably among study years with coefficients of variation above 70% for ten out of 15 Durham Region wetlands. Of the five wetlands with coefficients of variation above 100%, four (Frenchman's Bay Marsh, Hydro Marsh, Duffins Creek Marsh, and Cranberry Marsh) had IBIs calculated in only two years. Furthermore, the highest coefficient of variation (141.42%) was found at both Hydro Marsh and Duffins Creek Marsh, where an IBI score of zero was found in 2005 and 2007, respectively. A high coefficient of variation (CV) was also found at Port Newcastle Marsh (128.21%). The lowest CVs were found at Carruthers Creek Marsh (0.0%), Corbett Creek Marsh (15.38%) and Oshawa Second Marsh (32.69%).

There were significant correlations between the amphibian IBI and the WQI (r_s=0.6855, p=0.0001, n=26), the amphibian IBI and the SAV IBI (r^2=0.5405, p<0.0000, n=26), and the amphibian IBI and the FISH IBI (r^2=0.5322, p=0.0004, n=19). There was only a marginally significant correlation between the amphibian IBI and the bird IBI (r_s=0.3983, p=0.0539, n=24). Mean index scores were pooled across years for each Lake Ontario wetland (Figure 7).

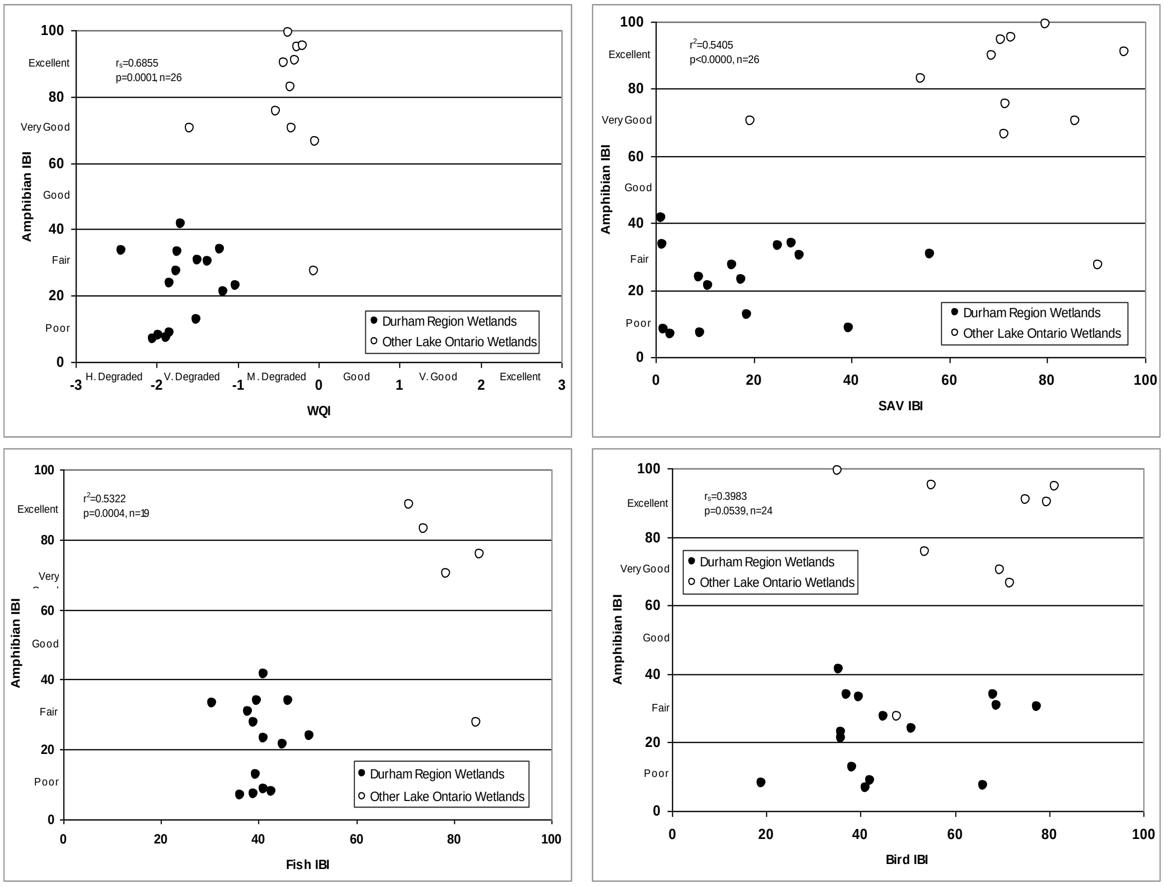

Figure 7. Correlations between amphibian community condition as measured using the amphibian IBI and water quality index (WQI), submerged aquatic vegetation condition (SAV IBI), fish community condition (Fish IBI) and marsh breeding bird community condition (Bird IBI) using mean index scores for Lake Ontario coastal wetlands from 2002-2007, where available.

Within-site and Regional Amphibian Community Metric Trends

Mean amphibian standardized metric values and IBIs for each of the Durham Region wetlands for all study years are shown in Appendix D – Table D-3. In summary, using all available data, eight of ten species were found in Durham Region wetlands during the study with American Toad (*Bufo americanus*) as the most frequently detected species; Mink Frog (*Rana septentrionalis*) and Pickerel Frog (*Rana palustris*) were not detected in Durham Region. Overall, Durham Region wetlands received very low scores for mean total species richness across survey stations (rTOT) ranging from 1.30 at Bowmanville Marsh (2002-2004, 2006, 2007) to 3.90 at Port Newcastle Wetland from 2003 to 2007 (0.05 and 0.16 species per station at each of these wetlands, respectively).

For all study years, mean metric scores for woodland associated amphibian species richness across survey stations (rWOOD) were also very low ranging from zero (i.e., none found) at four Durham Region wetlands (Duffins Creek Marsh, Carruthers Creek Marsh, Corbett Creek Marsh and Westside Marsh) to 5.00 at Hydro Marsh. Of the four woodland associated amphibian species found in Durham Region during the study, Wood Frog (*Rana sylvatica*) was detected most frequently in wetlands followed by Spring Peeper

(*Pseudacris crucifer*), Gray Treefrog (*Hyla versicolor*) and lastly, a single Chorus Frog (*Pseudacris maculata*) found in Bowmanville Marsh in 2002.

Mean metric scores for probability of detection of woodland species (pWOOD) were lowest at Duffins Creek Marsh, Carruthers Creek Marsh, Corbett Creek Marsh and Westside Marsh (zero) and highest at McLaughlin Bay Marsh (5.67) during the study period.

Overall, based on the results of the individual metric scores and IBIs, amphibian community conditions ranged from poor to fair, with the exception of Cranberry Marsh listed in good condition. Amphibian communities in Duffins Creek Marsh, Carruthers Creek Marsh, Corbett Creek Marsh and Westside Marsh were among those in the poorest condition relative to other Durham Region wetlands with no woodland associated species present in any of the study years. Future amphibian monitoring in Frenchman's Bay and Hydro marshes is necessary to further examine low IBIs and poor amphibian community condition reported in 2007 relative to earlier study years.

When all Lake Ontario wetlands were grouped together, significant positive correlations were found between each of the individual (i.e., raw) amphibian metrics and the individual SAV metrics using mean index scores across years for a single wetland (Table 4.2.3-2). The SAV metrics FQI, PCOV and SNAT showed stronger relationships with amphibian metrics (i.e., with higher r_s values, where $p < 0.0006$) relative to SAV metrics SINT and PINT (where $p < 0.04$).

Table 7. Spearman rank correlations between individual raw amphibian metrics and IBI and SAV community metrics and IBI for Lake Ontario wetlands from 2002-2007. Analyses were performed using mean index scores across years for a single wetland (n=24). All correlations are significant at the p<0.05 level.

		Amphibian Community			
		Total Species Richness(rTOT)	Woodland Species Richness (rWOOD)	Prob. Of Detection Woodland Species (pWOOD)	Amphibian IBI
SAV Community	No. of Turbidity-Intolerant Species (SINT)	**0.59**	**0.45**	**0.44**	**0.51**
	Relative % Cover Turvidity-Intolerant Species (PINT)	**0.50**	**0.44**	**0.44**	**0.50**
	Floristic Quality Index (FQI)	**0.73**	**0.50**	**0.56**	**0.59**
	Total % Coverage (PCOV)	**0.74**	**0.59**	**0.62**	**0.65**
	Total Number of Native Species (SNAT)	**0.67**	**0.47**	**0.51**	**0.55**
	SAV IBI	**0.72**	**0.51**	**0.55**	**0.59**

In summary, amphibian communities are different between Durham Region coastal wetlands and other coastal wetlands of Lake Ontario (Appendix D – Tables D-3 and D-4). Amphibian community metrics rTOT, rWOOD, and pWOOD in Durham Region were one-fifth to one third of mean values found in coastal wetlands from other regions of Lake Ontario resulting in the relatively poorer condition attributed to amphibian communities observed overall in Durham Region wetlands.

Discussion

IBI data presented here represent the best available information and include data for all survey stations and visits, which also likely contributed to the IBI variability observed (Appendix D -Table D-1). Changes in station numbers over time, which may influence IBI variability among years, may be due to changes in habitat or volunteer effort. Influence of station number is most pronounced at Hydro Marsh where in 2002, three stations were surveyed resulting in an IBI of 82.93 versus in 2007 where one station was surveyed resulting in an IBI of zero.

Timing for surveys, with three visits per season, is set to capture the breeding of all species. However, with many routes surveyed only once or twice in a breeding season, the likelihood of missing a species increases, thus having a potential effect on the species richness. In addition, some species such as Wood Frogs are known as "explosive" breeders, as most males migrate in one night to breeding ponds once conditions are right. Thus, there is a higher probability of missing the peak breeding time of this species compared to others during the surveys. Since this species contributes the most to both rWOOD and pWOOD metrics in Durham Region, the "patchiness" of its detectability from one year to the next could result in huge differences in the annual IBI scores that are unrelated to wetland condition. For example, there was a large jump in amphibian IBI score at Pumphouse Marsh from 8.1 in 2003/4 when no woodland associated species were found to 58.13 in 2005/06, due to the presence of Wood Frogs. Concurrently, Pumphouse Marsh showed both a significant decrease in the SAV IBI and a significant decrease in the bird IBI from 2003/4-2006/7, which is not the expected direction if all are responding to disturbance.

Water levels also need to be considered. The rTOT metric responded consistently and significantly to wetland disturbance during high water level years, but not consistently during low water years (GLCWC 2008). While the IBI is considered appropriate for all water levels, the response to disturbance will be stronger during high water levels. GLCWC (2008) recommends additional analysis to quantify the effect of changing water level on the coastal wetland community IBI. Ideally, water levels during each of the survey time periods (perhaps monthly averages) should be used to help quantify potential effects of water level on amphibian community.

Wetland size may also be a limiting factor. Houlahan and Findlay (2003) found a weak positive relationship between wetland area and species richness. Smaller wetlands (e.g., Pumphouse Marsh where one station surveyed) may show less variability among years. Furthermore, the effect of wetland size may be more pronounced at wetlands surveyed in only a few years, such as at Frenchman's Bay and Hydro Marsh, where CV scores were also high for both amphibians and marsh birds relative to other Durham Region sites.

To better identify trends in IBIs over years, a consistent number of stations should be surveyed for each visit to ensure that all habitats and breeding periods are covered annually. Additionally, where possible, the same surveyor should continue to survey the route to avoid any potential for inter-observer variability.

Literature Cited

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1.2.4 Aquatic Macroinvertebrate Community

Objective

To assess and monitor aquatic macroinvertebrate community condition.

Method Summary

Methods were based on Burton et al. (1999), which were the methods used in the recent Great Lakes Coastal Wetland Consortium indicators research. For each wetland, three replicate sub-samples of approximately 150 aquatic macroinvertebrates (≥500μm) were taken by sweep-netting through the water column in the cattail (*Typha* spp.) dominated emergent communities. These samples represent a combination of primarily nektonic and epiphytic species assemblages – not benthic. Macroinvertebrates were identified to the lowest taxonomic group possible.

Burton et al (2008) include recommendations for an aquatic macroinvertebrate (nektonic and epiphytic) community IBI through the Great Lakes Coastal Wetland Consortium (www.glc.org/wetlands). The lead investigators have developed an IBI for macroinvertebrates inhabiting vegetation zones such as meadow marsh and dense *Scirpus* zones, while conceding that they were unable to identify suitable metrics in the *Typha* vegetation zone. However, unlike meadow marsh and *Scirpus* vegetation zones, *Typha* zones are omnipresent in Lake Ontario coastal wetlands. With access to more extensive Lake Ontario-based data than those used by GLCWC lead investigators, EC-CWS developed the aquatic macroinvertebrate IBI (EC and CLOCA 2004) which was used in this report. GLCWC lead investigators for the aquatic macroinvertebrate community condition IBIs recognize the suitability of the EC and CLOCA (2004) IBI for use in Lake Ontario coastal wetlands. The EC and CLOCA (2004) IBI was included and endorsed as the preferred method to report on Lake Ontario coastal wetland macroinvertebrate community condition in the Great Lakes Coastal Wetlands Consortium Monitoring Plan (Burton et al 2008).

Data Treatment and Analysis

Since the release of Burton et al (2008), the EC and CLOCA (2004) aquatic macroinvertebrate IBI has undergone some minor refinements. The original IBI consisted of 11 metrics (EC and CLOCA 2004). Although this IBI was effective at determining the condition of Lake Ontario aquatic macroinvertebrate communities, the use of so many metrics appeared to affect the resolution of the IBI. Examining data from 2002-2008 revealed that not all of the metrics responded to disturbance to the same extent in all years. All metrics considered in EC and CLOCA (2004) were re-evaluated for suitability based on several years of data from Durham sites and others around Lake Ontario. For the analysis, Chow-Fraser's (2006) water quality index was used as a surrogate for disturbance. This WQI was determined to have a strong correlation with the disturbance estimates used in EC and CLOCA (2004; $r=0.85$, $p<0.001$, $n=28$). Metrics that showed a consistent and significant response to disturbance in five or more years (out of seven) were retained (See EC and CLOCA 2004 for disturbance response criteria.) Table 4.2.4-1 shows the EC and CLOCA (2004) metrics versus the metrics retained for the refined IBI.

Table 8. Aquatic macroinvertebrate community metric codes and descriptions from Burton et al (1999). Metrics retained for use in the EC and CLOCA (2004) IBI and the refined IBI (this document) are also shown.

Code	Metric Description	EC and CLOCA 2004	Refined IBI
Richness of Measures			
NCMG	No. of Crustacea* + Mollusca genera	NCMG	
NETG	No. of Ephemeroptera + Trichoptera genera	NETG	NETG
NEPH	No. of Ephemeroptera genera		
NODO	No. of Odonata genera	NODO	
NTRI	No. of Trichoptera genera		
NGEN	Total no. of genera		
NFAM	Total no. of families	NFAM	NFAM
Relative Abundances			
PAMP	% Amphipoda	PAMP	
PCHI	% Chironomidae		
PCRM	% Crustacea* + Mollusca	PCRM	PCRM
PEPH	% Ephemeroptera	PEPH	
PGAS	% Gastropoda		
PISO	% Isopoda	PISO	
PODO	% Odonata		
PSPH	% Sphaeriidae		
PTAN	% Tanytarsini		
PTRI	% Trichoptera	PTRI	PTRI
PDIP	% Diptera	PDIP	PDIP
PCRU	% Crustacea*	PCRU	
Diversity Indices			
EVEN	Evenness (J')		
SHAN	Shannon index (H')		
SIMP	Simpson index (D)		

*not including microcrustaceans (see Burton et al. 1999)

Once it was determined that a metric responded to disturbance, the values of the metric were transformed into a measure of integrity. The DRCWMP: Year 2 Technical Report (EC and CLOCA 2004) describes a method which uses a linear function to transform raw metric data into standardized metrics with a minimum value of zero and a maximum value of 10, as in Minns *et al.* (1994). The standardized metrics were then added, multiplied by 10, and divided by the total number of metrics to create an Index of biotic Integrity (IBI) with scores between 0 and 100. Higher scores indicate biotic communities in better condition.

There is a highly significant correlation between the refined aquatic macroinvertebrate IBI and the original DRCWMP IBI ($r=0.86$, $p<0.001$, $n=37$: 2006 data) reported in EC and CLOCA (2004). However, the revised IBI tends to rate sites more strictly resulting in an average decrease in IBI by approximately 17 points.

To assess temporal trends in the macroinvertebrate IBI in Durham Region wetlands, the Mann-Kendall trend test was performed at 14 wetlands. Both Whitby Harbour Marsh and Oshawa Second Marsh had insufficient data for data analysis (i.e., fewer than four consecutive years of data). As a measure of year-to-year variability, coefficients of variation (CVs, expressed as a percentage) for macroinvertebrate IBIs were calculated for all years for each Durham Region coastal wetland. Parametric t-tests were performed to compare mean macroinvertebrate IBI scores between Durham Region wetlands and other Lake Ontario wetlands. To assess associations between the macroinvertebrate IBI versus water quality index, SAV IBI (and SAV metrics), fish IBI and bird IBI in Lake Ontario wetlands, correlation analyses were performed using mean values across years for each wetland (i.e., each wetland is represented once in the analysis); similar years of monitoring only were used to calculate means for these analyses. Spearman rank correlation procedures were performed following violations in homogeneity of variances and/or normality in the data.

Results

Within-site and Regional Aquatic Macroinvertebrate Community IBI Trends

A summary of aquatic macroinvertebrate species found in Durham region coastal wetlands can be found in Appendix E (Table E-1). Overall, aquatic macroinvertebrate IBI scores were low in 16 Durham Region coastal wetlands with scores below 40 in 57% of wetland-years (i.e., 43 out of 75 cases) from 2002 to 2007 (Table 9). Over the study period, most Durham Region coastal wetlands were on average in “good” or “fair” condition, with Hydo Marsh being notable at “poor”. Individual year scores ranged from 0 at Hydro Marsh in 2003 to ‘very good’ at Duffins Creek Marsh (69.42) and Rouge River Marsh (70.92) in 2005 and 2007 respectively. The grand mean aquatic macroinvertebrate IBI (±SD) for all Durham Region coastal wetlands from 2002 to 2007 ranged from 26.22±19.81 in 2003 to 43.39±11.61 in 2007.

In contrast, aquatic macroinvertebrate IBI scores for the other Lake Ontario wetlands (between 6 and 20 sites surveyed per year) were generally much higher than values at Durham Region wetlands, ranging from 15.11 at Port Britain Marsh in 2003 to 98.62 at Hay Bay South Marsh in 2003 (Table 9). Mean aquatic macroinvertebrate IBI scores grouping these other Lake Ontario wetland sites ranged from 54.98±11.37 in 2005 to 64.66±12.16 in 2007. Mean aquatic macroinvertebrate IBI scores for Durham Region wetlands were significantly lower than those in the other Lake Ontario group of wetlands in four of the six study years (Table 9). Overall, aquatic macroinvertebrate community condition in other Lake Ontario coastal wetlands in most study years was significantly better than in Durham Region coastal wetlands.

Table 9. Aquatic macroinvertebrate community IBIs (out of 100) for Durham Region coastal wetlands and other Lake Ontario wetlands from 2002-2007, where available. Durham Region coastal wetlands are shaded and their condition based on the average of IBI scores during the study period following ratings in EC and CLOCA (2004). Coefficients of variation (CV, expressed as a percentage) are indicated for Durham Region wetlands only (i.e., where there are sufficient annual data). Wetlands are ordered vertically from west to east (See Module 1, Figure 5 for locations). Results of two-tailed t-test are shown at the bottom of the table.

Wetland	Condition	2002	2003	2004	2005	2006	2007	CV
Rouge River Marsh	Good		39.53	56.67	45.53	35.68	70.92	42.56
Frenchman's Bay Marsh	Fair	26.29	9.16	20.77	31.99	43.67	48.16	42.59
Hydro Marsh	Poor		0.00	6.67	13.54	5.05	37.37	26.57

Wetland	Condition	2002	2003	2004	2005	2006	2007	CV
Duffins Creek Marsh	Good		4.82	46.06	69.42	53.87	39.77	28.77
Carruthers Creek Marsh	Fair		19.04	44.90	46.64	42.83	40.99	40.97
Cranberry Marsh	Fair		34.16	51.95	37.51	31.59		36.33
Lynde Creek Marsh	Fair	43.49	3.24	45.40	40.42	40.56	34.95	15.48
Whitby Harbour Marsh	Good						49.64	
Corbett Creek Marsh	Good		26.73	45.05	39.26	38.82	51.90	52.69
Pumphouse Marsh	Good		58.57	61.11	21.23	43.94		30.96
Oshawa Second Marsh	Good		52.49		47.90	39.09	40.45	52.48
McLaughlin Bay Marsh	Fair		37.89	39.43	20.20	30.50	48.66	21.80
Westside Marsh	Fair		13.34	37.38	17.13	38.63	52.50	50.88
Bowmanville Marsh	Fair		7.76	51.37	29.47	20.32	33.72	25.53
Wilmot Creek Marsh	Good		31.49	52.31	41.94	44.59	36.85	61.06
Port Newcastle Marsh	Fair		55.07	39.55	25.18	27.10	21.51	36.36
Jordan Station Marsh			19.37					
Port Britain Marsh		17.50	15.11					
Presqu'ile Bay Marsh		69.02	48.99					
Dead Creek Marsh						59.43	61.71	
Huyck's Bay Marsh		60.48	46.80	68.29				
12 O'Clock Point Marsh						41.05		
Carrying Place Marsh						56.96	70.72	
Blessington Creek Marsh					51.17	64.80	77.15	
Sawguin Creek North Marsh						52.45	46.13	
Sawguin Creek Central Marsh					64.87	50.23	53.38	
Sawguin Creek Ditched Marsh						40.07	48.42	
Robinson's Cove Marsh		54.07	81.59		50.00	47.94	73.67	
Lower Salmon River Marsh						90.36		
Big Island West Marsh					50.14	52.66	64.77	
Big Island East Marsh					35.90	33.24	60.08	
Marysville Creek Marsh						57.75		
Solmesville East Marsh						72.77		
Lower Sucker Creek Marsh						59.37	49.04	
Lower Sucker Creek East Marsh						62.86		
Airport Creek Marsh						73.57	72.57	
Forester's Island Marsh						64.46		
South Bay Marsh		72.68	82.18					
Big Sand Bay Marsh			51.21	51.38				
Carnachan Bay Marsh							56.27	
Lower Napanee River Marsh						66.90	79.89	
Hay Bay North Marsh		78.50	89.52	70.16	58.73	71.19	83.71	
Hay Bay South Marsh			98.62		74.11	55.48	72.40	
Amherst Island Diked Marsh				32.57				
Amherst Island Undiked Marsh				45.04				
Parrott's Bay Marsh		75.12	50.90	69.28	54.89			
Button Bay Marsh		45.39	43.43					
Bayfield Bay Marsh		68.14	72.06					
Mean - Durham Region		34.89	26.22	42.76	35.16	35.75	43.39	
Mean - Other Lake Ontario		60.10	58.32	56.12	54.98	58.68	64.66	

	2002	2003	2004	2005	2006	2007
t-statistic	na	3.58	1.87	3.3	5.31	4.81
p-value	na	**0.001**	0.08	**0.003**	**<0.001**	**<0.001**

Trend analyses using the Mann-Kendall test revealed a significant increase in macroinvertebrate IBI scores at Frenchman's Bay Marsh (S=11, p=0.028) and Westside Marsh (S=8, p=0.042). Notably, evaluations displayed a significant decline in IBI score at Port Newcastle Marsh (S=8, p=0.042). Significant changes in IBI score were not detected in any of the remaining 13 wetlands from 2002 to 2006/7. Macroinvertebrate condition in Durham Region wetlands was generally in the fair to good range with the exception of Hydro Marsh which, with markedly lower IBI scores since 2003, was rated in poor condition. Macroinvertebrate IBI scores for each year with associated categories for all of the DRCWMP wetlands and the results of Mann-Kendall tests with the S statistics, where significant, are shown in Appendix E – Figure E-1.

Marsh macroinvertebrate community IBIs varied among study years, but far less than other community IBIs reported in this document. Coefficients of variation were between 15.48% (Lynde Creek Marsh) and 61.06% (Wilmot Creek Marsh), but were generally in the 20-40% range.

There were significant correlations between the macroinvertebrate IBI and the WQI (r_s=0.62, p<0.0001, n=47), the SAV IBI (r_s =0.80, p<0.0001, n=45), the fish IBI (r^2=0.45, p=0.0013, n=20) and the bird IBI (r_s =0.40, p=0.0108, n=40).

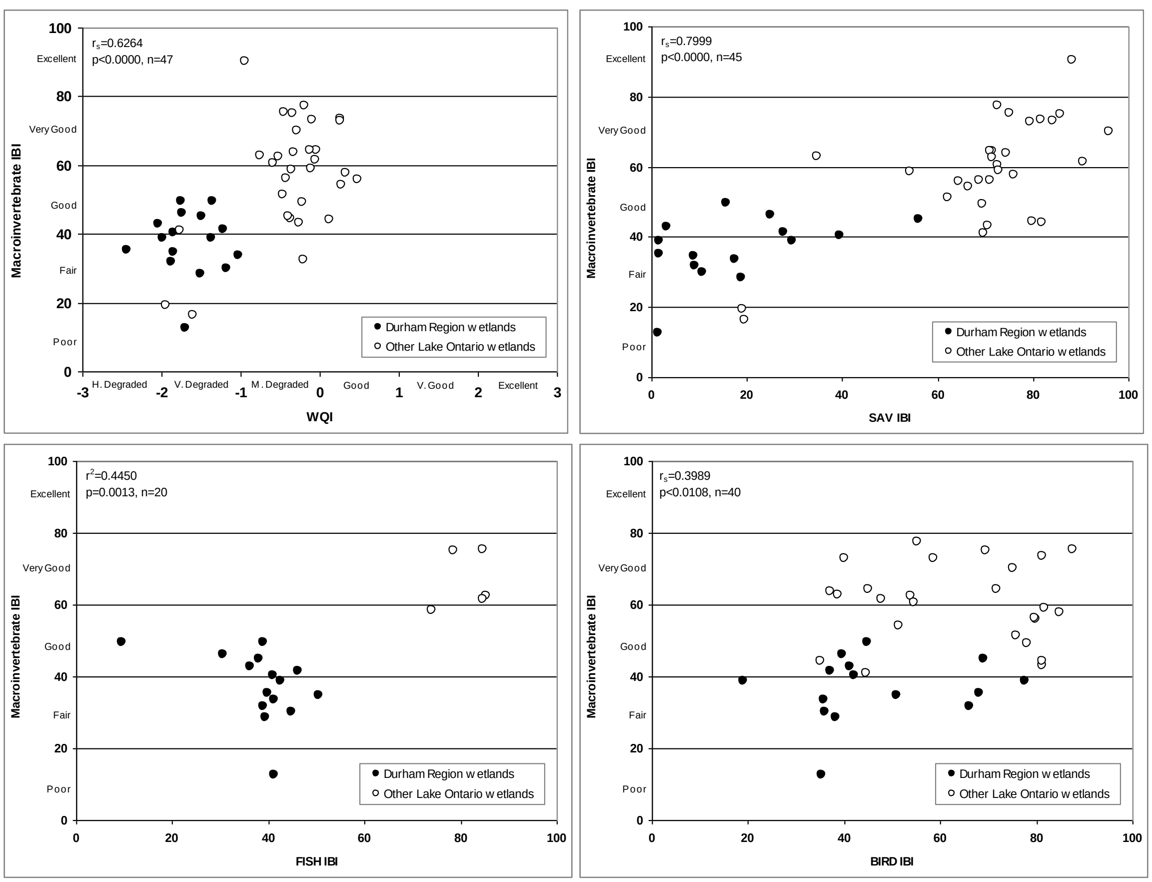

Figure 8. Correlations between macroinvertebrate community condition as measured using the macroinvertebrate IBI and water quality index (WQI), submerged aquatic vegetation condition (SAV IBI), fish community condition (Fish IBI) and marsh breeding bird community condition (Bird IBI) using mean index scores for Lake Ontario coastal wetlands from 2002-2007, where available.

Within-site and Regional Macroinvertebrate Community Metric Trends

Mean macroinvertebrate standardized metric values and IBIs for each of the Durham Region wetlands for all study years and the results of temporal trend analyses at each site for each of the raw metrics are shown in Appendix E – Table E-3. Overall, Durham Region coastal wetlands received low scores for the mean number of Ephemeroptera and Trichoptera metric (NETG). The highest mean number of Ephemeroptera and Trichoptera genera was found at Rouge River Marsh (8.50) and the lowest at Hydro marsh (1.33). A significant increase in NETG metric score occurred at Westside Marsh between 2003 and 2007 (S=8, p=0.042, range=0.83 - 5.00). Scores for the % Trichoptera (PTRI) were also very low with 10 out of 15 wetlands receiving a score of less than 1.00. PTRI was highest at McLaughlin Bay Marsh (4.22) and lowest at Corbett Creek Marsh (0.00), where no Trichoptera were found. Compared to other macroinvertebrate metrics, Durham Region coastal wetlands scored lowest on average in the % number of Trichoptera (0.96±1.30).

NFAM metric scores varied among Durham Region coastal wetlands. Mean NFAM metric scores for all study years together were lowest at Cranberry Marsh (1.02) and highest at Corbett Creek Marsh (6.54). Mean % Crustacea and Mollusca (PCRM) metric scores were somewhat higher with six wetlands scoring over 5.00. Hydro Marsh again had the lowest mean metric score (1.33) followed closely by Rouge River Marsh (1.36). Cranberry Marsh had the highest mean PCRM score at 7.26.

For all study years, mean % Diptera (PDIP) metric scores were lowest at Hydro Marsh (1.19) and highest at Cranberry Marsh (9.25). A significant decrease in % Diptera was found at Hydro Marsh (S=-8, p=0.042, range=0.00 – 4.71), Duffins Creek Marsh (S=-8, p=0.042, range=0.00 - 10.00), Carruthers Creek Marsh (S=-8, p=0.042, range=0.00 – 9.05), Cranberry Marsh (S=-6, p=0.042, range=7.07 - 10.00), Corbett Creek Marsh (S=-8, p=0.042, range=0.00 – 8.23), and Bowmanville Marsh (S=-8, p=0.042, range=0.00 – 5.74) during the study period. A marginally-significant decrease in mean metric score was also seen at Frenchman's Bay Marsh (S=-8, p=0.068, range=0.00 – 6.40).

Based on the results of individual metric scores and IBIs, aquatic macroinvertebrate community condition ranged from fair to good condition, with the exception of Hydro Marsh listed in poor condition. Macroinvertebrate communities at Frenchman's Bay, Hydro and Westside Marshes were among those in the poorest condition relative to other Durham Region wetlands with consistently low mean metric scores. Overall, metric scores of Durham Region wetlands were among the lowest when compared to other Lake Ontario wetlands.

When all Lake Ontario wetlands were grouped together, significant positive correlations were found between each of the SAV metrics and the raw NETG and PDIP metrics, as well as the aquatic macroinvertebrate IBI (Table 10). Correlations between the SAV metrics FQI, PCOV and SNAT were also significant with NFAM. Neither PCRM nor PTRI were significantly correlated with total % coverage and the total number of native species with respect to the SAV community.

Table 10. Spearman rank correlations between individual raw macroinvertebrate metrics and IBI and SAV community metrics and IBI for Lake Ontario wetlands from 2002-2007. Analyses were performed using mean index scores across years for a single wetland (n=47). Significant correlations (highlighted) are so at the p<0.05 level.

		Aquatic Macroinvertebrate Community					
		No. of Ephemeroptera + Tricoptera genera (NETG)	Total No. of Families (NFAM)	% Crustacea + Mollusca (PCRM)	% Tricoptera (PTRI)	% Diptera (PDIP)	Aquatic Macro-invertebrate IBI
SAV Community	No. of Turbidity-Intolerant Species (SINT)	0.55	0.20	0.55	0.49	0.59	0.79
	Relative % Cover of Turbidity-Intolerant Species (PINT)	0.59	0.09	0.55	0.51	0.53	0.76
	Floristic Quality Index (FQI)	0.55	0.33	0.39	0.32	0.71	0.74
	Total % Coverage (PCOV)	0.47	0.52	0.21	0.20	0.58	0.63
	Total Number of Native Species (SNAT)	0.48	0.50	0.28	0.25	0.63	0.67
	SAV IBI	0.56	0.26	0.50	0.46	0.64	0.80

Discussion

Overall, the condition of the aquatic macroinvertebrate community in Durham Region coastal wetlands was fair-good with no apparent trend in the IBI within the region from 2002 to 2007. Although this ranking may suggest a positive situation in terms of macroinvertebrate condition, it is important to note that in relation to other Lake Ontario wetlands, macroinvertebrate communities in Durham Region are in significantly poorer condition. Despite this, some substantial improvements have been identified within individual wetlands, including those at Frenchman's Bay and Westside marshes. In an effort to improve overall wetland quality, adaptive management strategies have been implemented at Oshawa Second and Cranberry marshes which called for a drawdown of water levels in 2003-2004 and 2001, respectively. While these actions may have coincided with an increase in other indices at these sites (e.g. bird IBI), no effect on macroinvertebrate condition was identified.

Large year-to-year variations in IBI within wetlands, as measured by the coefficient of variance (CV), can influence the ability to detect significant changes in condition over time. Although variation in macroinvertebrate communities were relatively small, increases in variation may be the result of disturbance such as the drawdowns conducted in managed wetlands. This reinforces the need for continued monitoring to determine changes in condition both within sites and regionally.

Characteristic community responses to disturbance have enabled the use of macroinvertebrates in monitoring water quality. In fact, changes in macroinvertebrate community structure can result from alterations in the chemical and biological conditions within a wetland (Kashian and Burton 2000). Correlation assessments comparing the macroinvertebrate IBI and the WQI shows a significant positive relationship exists between these two indices (Figure 8). Species belonging to the orders Ephemeroptera and Trichoptera respond negatively to disturbance, existing in lower abundance and lower taxa richness where water quality has been compromised (Kashian and Burton 2000). Decreases in these taxa contributed to a lower macroinvertebrate IBI score in wetlands including Hydro Marsh, Cranberry Marsh and Corbett Creek Marsh (Table E-2) all of which were listed as having very degraded water quality (Module 2, Table 8).

As expected, a significant positive correlation also exists between the macroinvertebrate and SAV IBIs (Figure 8). It has been shown that submerged aquatic vegetation provides habitat to which invertebrates can attach and indirectly provides a food source for those preying upon periphyton (Chow-Fraser et al. 1998). Therefore, the abundance of macroinvertebrates in a wetland is positively related to the biomass of submerged aquatic vegetation. This is shown in Table 10 where total % coverage of SAV (PCOV) is significantly correlated with all but two macroinvertebrate metrics. Furthermore, the composition of SAV community has been shown to influence the abundance of macroinvertebrates (van den Berg et al. 1997). As the quality of the SAV community increases (represented by the presence of ecologically sensitive species and measured as FQI), so does NFAM. However, it is unclear why no significant relationship exists between this macroinvertebrate metric and the number of turbidity-intolerant SAV species.

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APPENDIX A

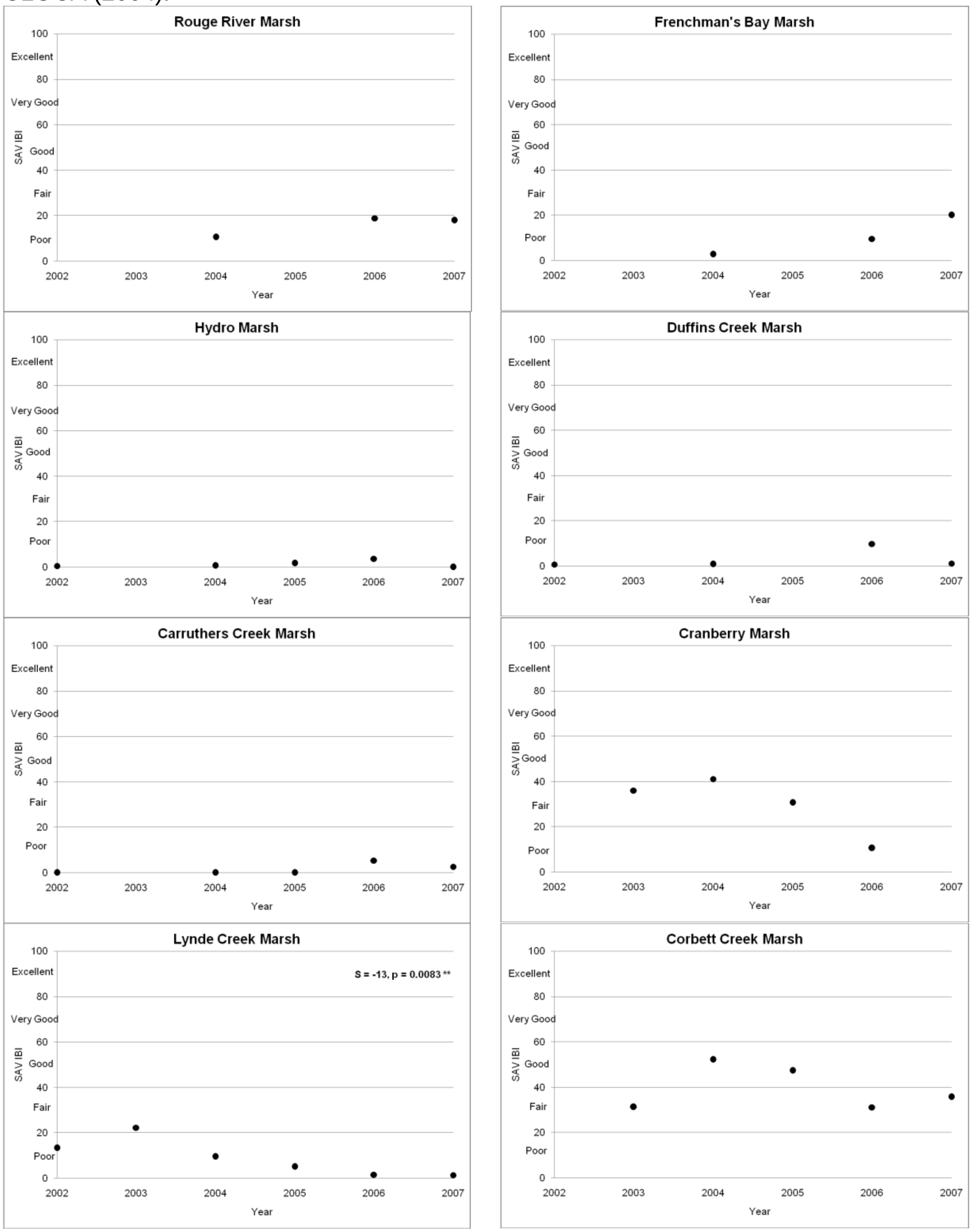
Table A-1. Listing of submerged aquatic vegetation species found in Durham Region wetlands from 2002 to 2007 denoted as native (√) or non-native (X), turbidity-tolerant (√) or turbidity intolerant (X), and corresponding coefficients of conservatism used in the calculation of the FQI for the SAV IBI.

Common Name	Genus/Species	Native	Turbidity -Tolerant	Coefficient of Conserv.
Algae[1]	*Algae sp.*	√		
Arum-leaved Arrowhead	*Sagittaria cuneata*	√		7
Brittlewort	*Nitella sp.*	√		
Broadleaf Cattail	*Typha latifolia*	√		3
Broad-leaved Arrowhead	*Sagittaria latifolia*	√		4
Burreed	*Sparganium sp.*	√		
Canada Waterweed	*Elodea canadensis*	√	√	4
Cattail	*Typha sp.*	√		
Common Bladderwort, Spatterdock	*Utricularia vulgaris*	√		4
Common burreed	*Sparganium eurycarpum*	√		3
Coontail, Hornwort	*Ceratophyllum demersum*	√	√	4
Curly Pondweed	*Potamogeton crispus*	X	√	
Curly White Water Crowfoot	*Ranunculus longirostris*	√	√	5
Eurasian Water Milfoil	*Myriophyllum spicatum*	X	√	
European Frog-bit	*Hydrocharis morsus-ranae*	X		
Filamentous algae[2]	*Algae sp.* (fil. surface)	√		
Flat-stemmed Pondweed	*Potamogeton zosteriformis*	√	X	5
Floating Slender Liverwort	*Riccia fluitans*	√		
Floating-leaved Pondweed	*Potamogeton natans*	√		5
Greater Duckweed	*Spirodela polyrhiza*	√		4
Leafy Pondweed	*Potamogeton foliosus*	√	√	4
Lesser Duckweed	*Lemna minor*	√		2
Milfoil species	*Myriophyllum sp.*	X		
Northern Water Milfoil	*Myriophyllum sibiricum*	√	X	6
Pondweed sp.	*Potamogeton sp.*	√		
Purple-fringed Liverwort	*Ricciocarpos natans*	√		
Richardson's, Clasping Leaved Pondweed	*Potamogeton richardsonii*	√		5
Sago Pondweed	*Potamogeton pectinatus*	√	√	4
Sandbar Willow	*Salix exigua*	√		3
Slender Naiad	*Najas flexilis*	√	X	5
Slender Pondweed	*Potamogeton pusillus*	√	√	5
Slender Waterweed	*Elodea nuttallii*	√		8
Small Pondweed	*Potamogeton pusillus spp. tenuissimus*	√	√	5
Star Duckweed	*Lemna trisulca*	√		4
Stonewort, Muskgrass	*Chara sp.*	√		
Tape Grass, Wild Celery, Water Celery	*Vallisneria americana*	√	X	6
Water Smartweed	*Polygonum amphibium*	√		5
Water Star-grass	*Heteranthera dubia*	√	√	7
Water-Marigold	*Megalodonta beckii*	√		8
Watermeal	*Wolffia sp.*	√		
White Water Lily, Fragrant Water Lily	*Nymphaea odorata*	√		5

Common Name	Genus/Species	Native	Turbidity -Tolerant	Coefficient of Conserv.
Yellow Pond Lily, Bullhead Lily, Spatterdock	*Nuphar variegata*	√		4

[1] Includes submerged, floating and mossy algae
[2] Includes surface and underwater filamentous algae

Figure A-1. SAV community IBI temporal trends for 15 Durham Region coastal wetlands from 2002-2007, where available, and associated conditions as identified in EC and CLOCA (2004).



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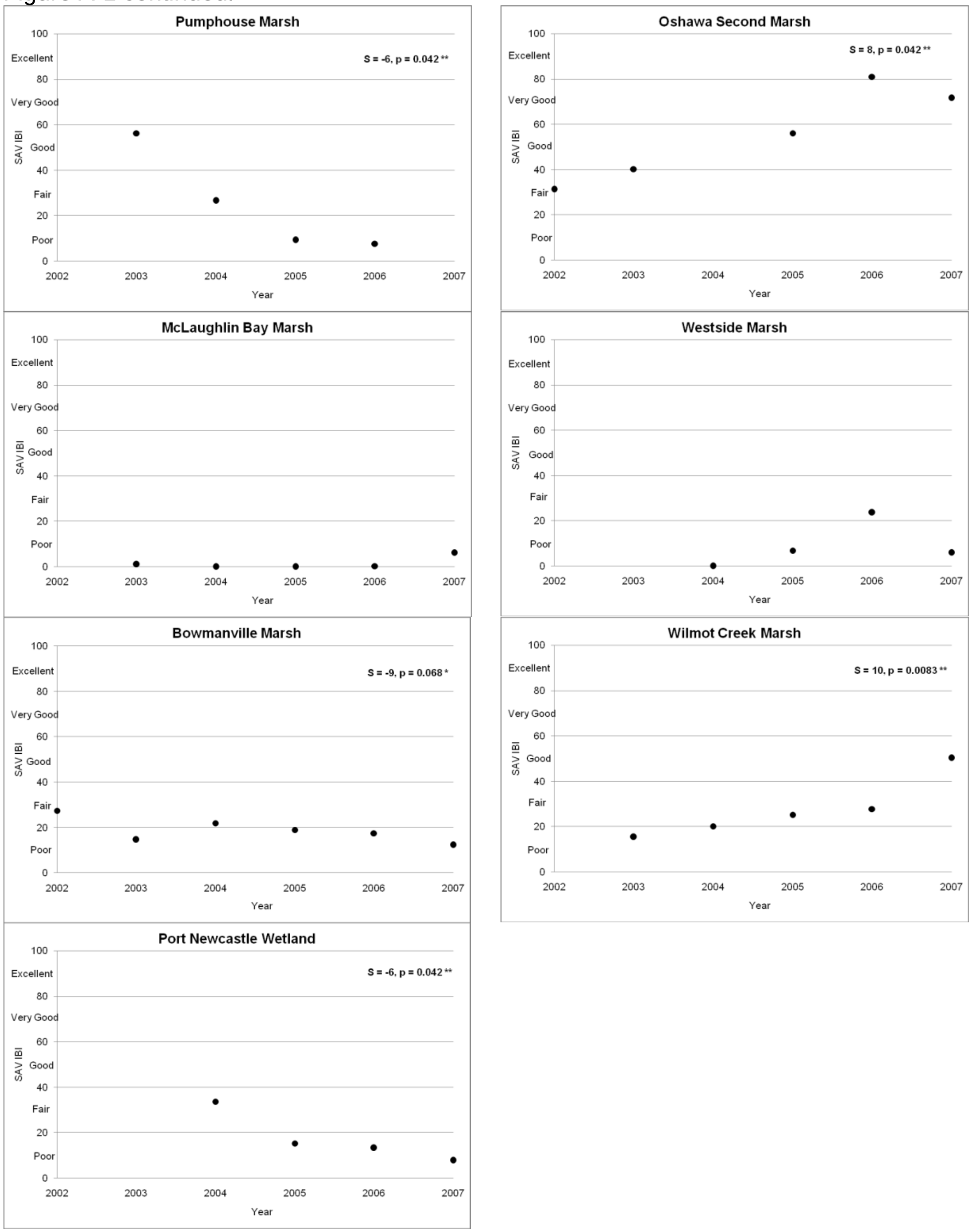


Table A-2 Mean standardized SAV community metrics and IBIs for Durham Region coastal wetlands from 2002-2007, where available. Metrics used in the calculation of the IBI include: number of turbidity-intolerant species (SINT), relative percent cover turbidity-intolerant species (PINT), Floristic Quality Index (FQI), percent cover (PCOV) and number of native species (SNAT). Asterisks specify the results of temporal trend analyses based on raw data for the parameter of interest, whereby "**" denotes a significant trend ($p<0.05$) and "*" denotes a marginally-significant trend ($p<0.1$); arrows denote the direction of trend. Wetlands are ordered vertically from west to east.

Durham Region Wetland	Years	SINT	PINT	FQI	PCOV	SNAT	SAV - IBI
Rouge River Marsh	2004, 2006, 2007	0.09	0.02	3.10	2.78	1.89	15.76
Frenchman's Bay Marsh	2004, 2006, 2007	0.67	0.89	1.50	1.40	0.91	10.75
Hydro Marsh	2002-2007[a]	0.08	0.19	0.19	0.01	0.16	1.28
Duffins Creek Marsh	2002, 2004, 2006, 2007	0.00	0.00	0.75	0.32	0.49	3.12
Carruthers Creek Marsh	2002-2007[a]	0.00	0.00	0.36	0.20	0.23	1.57
Cranberry Marsh	2003-2006	0.10	0.00	5.04	3.84	5.76	29.49
Lynde Creek Marsh	2002-2007	0.00	0.00	1.79**↓	0.92**↓	1.70**↓	8.80**↓
Corbett Creek Marsh	2003-2007	0.64	0.39	7.13	3.47	8.12	39.49
Pumphouse Marsh	2003-2006	0.30	0.08	3.93**↓	3.65**↓	4.52**↓	24.94**↓
Oshawa Second Marsh	2002-2007[b]	3.06	2.17	7.76**↑	7.65	7.35**↑	55.99**↑
McLaughlin Bay Marsh	2003-2007	0.08	0.19	0.22	0.16	0.09	1.48
Westside Marsh	2004-2007	0.50	0.66	1.60	0.47	1.30	9.06
Bowmanville Marsh	2002-2007	0.26	0.20	3.31*↓	2.27	3.34	18.76*↓
Wilmot Creek Marsh	2003-2007	0.20	0.07	5.16**↑	4.32	4.12	27.75**↑
Port Newcastle Wetland	2004-2007	0.30	0.30	3.34	2.22**↓	2.59**↓	17.49**↓
Mean		**0.42**	**0.34**	**3.01**	**2.24**	**2.84**	**17.72**
±SD		**0.76**	**0.57**	**2.43**	**2.12**	**2.63**	**15.69**

a = sampling not performed in 2003; b = sampling not performed in 2004

Table A-3. Mean standardized SAV community metrics and IBIs for other Lake Ontario coastal wetlands from 2003-2007, where available. Metrics used in the calculation of the IBI include: number of turbidity-intolerant species (SINT), relative percent cover turbidity-intolerant species (PINT), Floristic Quality Index (FQI), percent cover (PCOV), and number of native species (SNAT). Wetlands are ordered vertically from west to east. No temporal trend analyses were performed on these data.

Lake Ontario Wetland	Years	SINT	PINT	FQI	PCOV	SNAT	SAV - IBI
Jordan Station Marsh	2003	0.00	0.00	3.90	2.76	2.88	19.07
Port Britain Marsh	2003	0.00	0.00	3.71	3.13	2.88	19.43
Presqu'ile Bay Marsh	2003	7.66	4.58	8.28	7.43	8.50	72.90
Dead Creek Marsh	2006, 2007	4.43	1.82	10.00	10.00	10.00	72.51
12 O'Clock Point Marsh	2006	3.22	1.63	10.00	10.00	10.00	69.71
Carrying Place Marsh	2006, 2007	5.44	1.96	10.00	9.79	10.00	74.38
Huyck's Bay Marsh	2003	5.24	2.59	7.03	5.47	6.77	54.19
Sawguin Creek Ditched Marsh	2006, 2007	8.83	4.70	10.00	7.82	9.54	81.76
Sawguin Creek Central Marsh	2006, 2007	3.63	1.15	10.00	9.65	9.97	68.78
Sawguin Creek North Marsh	2005-2007	4.57	1.58	9.77	8.80	10.00	69.43
Blessington Creek Marsh	2005-2007	4.57	1.10	10.00	10.00	10.00	71.33
Robinson's Cove Marsh	2003, 2005-2007	9.15	7.66	10.00	8.83	9.48	90.23
Lower Salmon River Marsh	2006	10.00	5.31	10.00	8.75	10.00	88.12
Big Island West Marsh	2005-2007	4.16	1.40	9.19	8.89	8.52	64.33
Big Island East Marsh	2005-2007	4.97	1.82	9.31	9.94	9.21	70.50
Marysville Creek Marsh	2006	6.45	1.51	10.00	10.00	10.00	75.92
Solmesville East Marsh	2006	5.64	4.07	10.00	10.00	10.00	79.40
Lower Sucker Creek Marsh	2006, 2007	4.84	2.60	9.78	8.40	7.63	66.50
Lower Sucker Creek East Marsh	2006	2.82	3.76	5.07	1.64	4.03	34.64
Airport Creek Marsh	2006, 2007	8.63	3.49	10.00	10.00	10.00	84.24
Forester's Island Marsh	2006	5.64	6.96	10.00	6.02	6.91	71.05
Lower Napanee River Marsh	2006, 2007	7.05	4.22	10.00	9.57	9.97	81.62
South Bay Marsh	2003	6.05	7.03	8.91	7.23	6.34	71.10
Carnachan Bay Marsh	2007	4.43	1.02	10.00	10.00	10.00	70.90

Table A-3 continued

Lake Ontario Wetland	Years	SINT	PINT	FQI	PCOV	SNAT	SAV - IBI
Big Sand Bay Marsh	2003	2.42	2.68	8.20	10.00	7.78	62.15
Hay Bay North Marsh	2003, 2005-2007	5.94	3.36	9.25	9.63	9.34	75.05
Hay Bay South Marsh	2003, 2005-2007	8.32	7.96	10.00	8.04	8.58	85.82
Parrott's Bay Marsh	2003, 2005	4.63	2.55	9.44	9.75	9.32	71.40
Little Cataraqui Creek Marsh	2003	6.05	5.36	8.17	9.91	7.20	73.35
Button Bay Marsh	2003	8.06	9.85	8.67	6.82	6.48	79.74
Bayfield Bay Marsh	2003	10.00	10.00	10.00	8.73	9.22	95.89
Hill Island East Marsh	2003	10.00	8.43	10.00	8.15	8.21	89.57
Mean		**5.71**	**3.82**	**9.02**	**8.28**	**8.40**	**70.47**
±SD		**2.60**	**2.81**	**1.74**	**2.26**	**2.06**	**17.57**

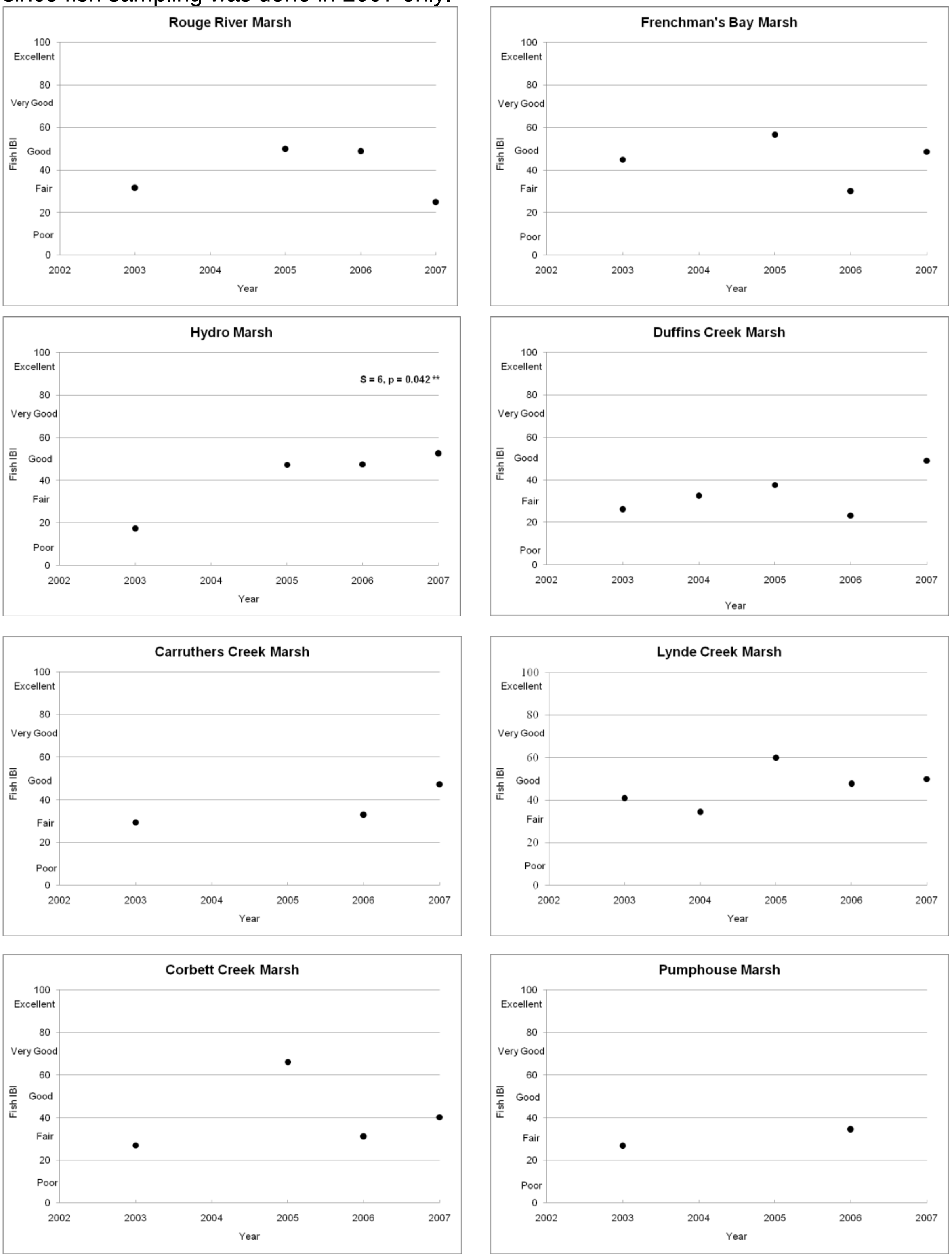
APPENDIX B

Table B-1. Listing of fish species caught in Durham Region wetlands and seven other Lake Ontario wetlands (see Table 1 for wetland names). Fish have been identified as native (√) or non-native (X), turbidity-tolerant (√)) or intolerant (X) and given a trophic level designation (P=piscivorous species, S=specialist species, and G=generalist species).

Common Name	Genus/Species	Native	Turbidity -Tolerant	Trophic
Alewife	*Alosa pseudoharengus*	X	√	S
Banded Killifish	*Fundulus diaphanus*	√	√	S
Black Crappie	*Pomoxis nigromaculatus*[T]	√	√	S
Blackchin Shiner	*Notropis heterodon*[C]	√	√	S
Blacknose Shiner	*Notropos heterolepis*[C]	√	X	S
Bluegill	*Lepomis macrochirus*[T]	√	√	S
Bluntnose Minnow	*Pimephales notatus*[C]	√	√	G
Bowfin	*Amia calva*	√	√	P
Brook Silverside	*Labidesthes sicculus*	√	X	S
Brook Stickleback	*Culaea inconstans*	√	X	S
Brown Bullhead	*Ameiurus nebulosus*	√	√	G
Central Mudminnow	*Umbra limi*	√	√	G
Chinook Salmon	*Oncorhynchus tshawytscha*	X	√	P
Common Carp	*Cyprinus carpio*	X	√	G
Emerald Shiner	*Notropis atherinoides*[C]	√	√	S
Fathead Minnow	*Pimephales promelas*[C]	√	√	G
Freshwater Drum	*Aplodinotus grunniens*	√	√	S
Gizzard Shad	*Dorosoma cepedianum*	√	√	S
Golden Shiner	*Notemigonus crysoleucas*[C]	√	√	G
Goldfish	*Carassius auratus*	X	√	G
Iowa Darter	*Etheostoma exile*	√	X	S
Johnny Darter	*Etheostoma nigrum*	√	√	S
Largemouth Bass	*Micropterus salmoides*[T]	√	√	P
Logperch	*Percina caprodes*	√	√	S
Northern Pike	*Esox lucius*	√	√	P
Pumpkinseed	*Lepomis gibbosus*[T]	√	√	S
Rainbow Trout	*Oncorhynchus mykiss*	X	√	S
Rock Bass	*Ambloplites rupestris*[T]	√	X	S
Round Goby	*Neogobius melanostomus*	X	√	S
Sand Shiner	*Notropis stramineus*[C]	√	√	G
Smallmouth Bass	*Micropterus dolomieui*[T]	√	√	P
Spotfin Shiner	*Cyprinella spiloptera*[C]	√	√	S
Spottail Shiner	*Notropis hudsonius*[C]	√	X	S
Walleye (Yellow Pickerel)	*Stizostedion vitreum vitreum*	√	√	P
White Perch	*Morone americana*	X	√	S
White Sucker	*Catostomus commersoni*	√	√	S
Yellow Perch	*Perca flavescens*	√	√	S

[T] = Centrarchid species
[C] = Cyprinid species

Figure B-1. Fish community IBI temporal trends for 14 Durham Region coastal wetlands from 2003-2007, where available, and associated conditions as identified in EC and CLOCA (2004). Note that data for Whitby Harbour Wetland Complex are not included here since fish sampling was done in 2007 only.



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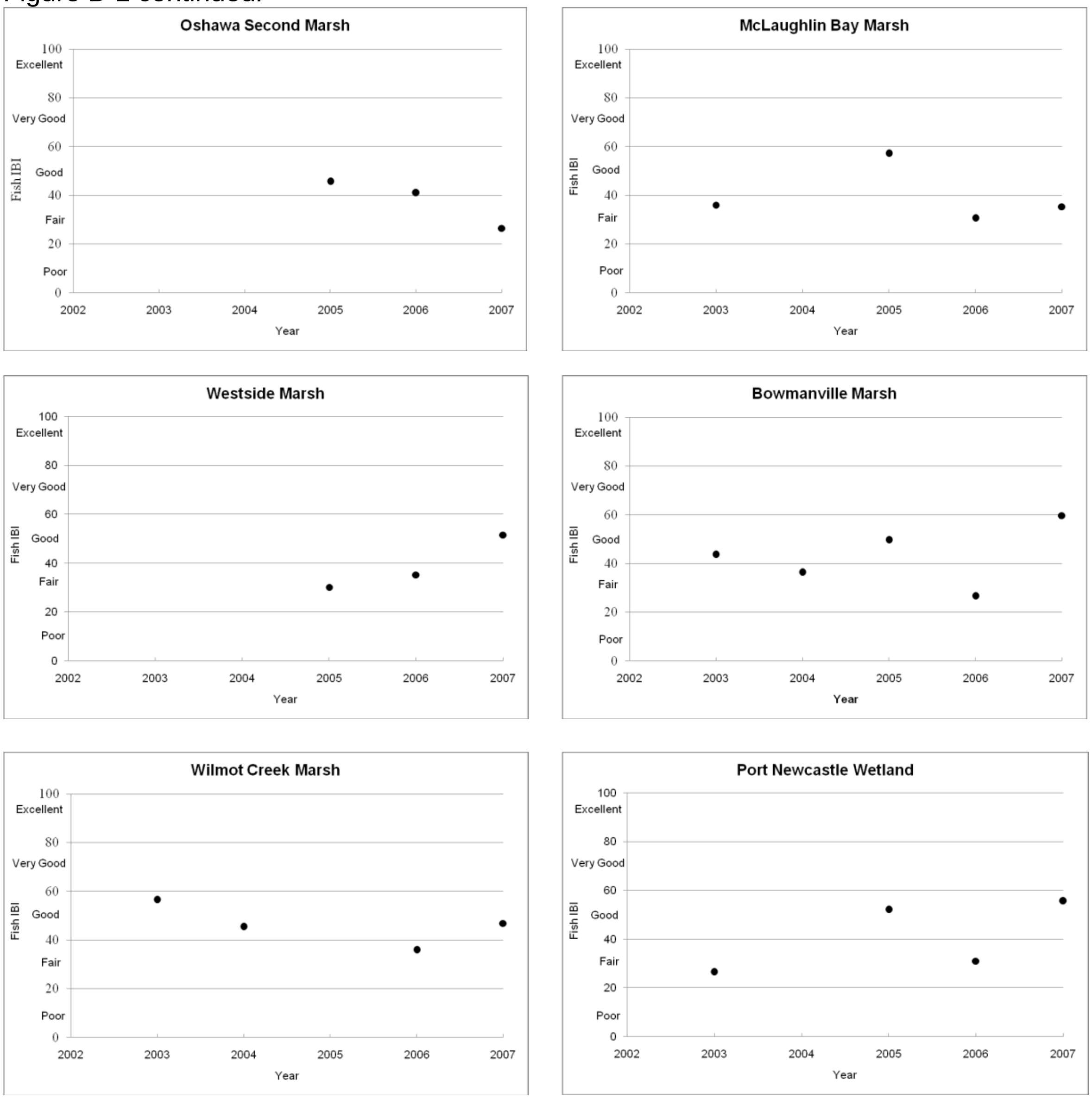


Table B-2. Mean standardized fish community metrics and IBIs for Durham Region coastal wetlands from 2003-2007, where available. Metrics used in the calculation of the IBI include: number of native species (SNAT), number of centrarchid species (SCEN), percent piscivore biomass (PPIS), number of native individuals (NNAT), percent non-indigenous biomass (PBNI), and biomass of yellow perch (BYPE). Asterisks specify the results of temporal trend analyses based on raw data for the parameter of interest, whereby "**" denotes a significant trend ($p<0.05$); arrows denote the direction of trend. Wetlands are ordered vertically from west to east.

Durham Region Wetland	Years	SNAT	SCEN	PPIS	NNAT	PBNI	BYPE	Fish - IBI
Rouge River Marsh	2003-2007[a]	5.87	4.80	3.30	2.59	6.01	0.70	38.78
Frenchman's Bay Marsh	2003-2007[a]	4.76	6.36	6.75	2.38	4.83	1.92	45.00
Hydro Marsh	2003-2007[a]	5.07	6.24	5.53	2.41	5.05	0.37	41.13**↑
Duffins Creek Marsh[1]	2003-2007	5.43	1.75	2.03	1.80	6.67	2.52	33.66
Carruthers Creek Marsh	2003, 2006, 2007	6.11	6.81	0.07	4.57	3.97	0.40	36.56
Lynde Creek Marsh[1]	2003-2007	6.08	4.76	4.73	2.90	7.66	1.75**↑	46.49
Whitby Harbour Wetland	2007	2.39	0.00	0.00	0.87	2.40	0.00	9.43
Corbett Creek Marsh	2003-2007[a]	4.93	5.11	2.82	2.39	8.06	1.33	41.06
Pumphouse Marsh	2003, 2006	6.27	5.00	0.00	7.03	0.00	0.00	30.50
Oshawa Second Marsh	2005-2007	7.53	7.01	0.00	7.90	0.00	0.17	37.68
McLaughlin Bay Marsh	2003-2007[a]	6.58	7.25	0.18	3.80	4.09**↑	1.95	39.75
Westside Marsh	2005-2007	6.47	5.04	1.03	3.25	6.73	0.84	38.93
Bowmanville Marsh[1]	2003-2007	5.57	4.44	1.99	3.75	8.89	1.18	43.14
Wilmot Creek Marsh[1]	2003- 2007[b]	5.68	4.59	7.23	2.23	5.58	2.37	46.15
Port Newcastle Wetland	2003-2007[a]	5.18	4.91	1.37	4.52	6.66	2.11	41.24
Grand Mean		**5.60**	**4.94**	**2.47**	**3.49**	**5.11**	**1.17**	**37.97**
±SD		**1.15**	**1.93**	**2.53**	**1.90**	**2.67**	**0.89**	**9.03**

[a] = sampling not performed in 2004; [b] = sampling not performed in 2005
[1] denotes that two surveys were conducted in 2004 at these wetlands and mean value of metric was used for temporal trend analysis.

Table B-3. Mean standardized fish community metrics and IBIs for other Lake Ontario coastal wetlands from 2003-2007, where available. Metrics used in the calculation of the IBI include: number of native species (SNAT), number of centrarchid species (SCEN), percent piscivore biomass (PPIS), number of native individuals (NNAT), percent non-indigenous biomass (PBNI), and biomass of yellow perch BYPE). Wetlands are ordered vertically from west to east. No temporal trend analyses were performed on these data.

Lake Ontario Wetland	Year	SNAT	SCEN	PPIS	NNAT	PBNI	BYPE	Fish - IBI
Huyck's Bay	2003	8.76	9.81	8.22	4.08	10.00	3.50	73.97
Sawguin Creek Central Marsh	2005	8.37	10.00	5.72	3.44	10.00	4.69	70.90
Robinson's Cove	2005	9.86	10.00	10.00	3.95	10.00	6.98	84.64
Big Island East Marsh	2005	10.00	10.00	10.00	10.00	10.00	9.92	99.87
Hay Bay North	2005	10.00	10.00	10.00	3.75	10.00	6.98	84.54
Hay Bay South	2005	10.00	10.00	10.00	5.37	6.38	5.38	78.55
Parrott's Bay	2003	10.00	10.00	7.07	5.01	9.15	10.00	85.38
Grand Mean		**9.57**	**9.97**	**8.72**	**5.09**	**9.36**	**6.78**	**82.55**
±SD		**0.70**	**0.07**	**1.76**	**2.27**	**1.35**	**2.50**	**9.50**

APPENDIX C

Table C-1. Routes and associated numbers of stations for bird surveys performed in Lake Ontario wetlands from 2002-2007, where available. Durham Region coastal wetlands are shaded. All stations were visited two times.

Route	Wetland	2002	2003	2004	2005	2006	2007
ON607	Rouge River Marsh		1	1	5	5	5
ON560	Frenchman's Bay Marsh				6	6	
ON561	Hydro Marsh				3	3	
ON559	Duffins Creek Marsh				5	5	
ON557	Carruthers Creek Marsh				4	4	1
ON107	Cranberry Marsh	7	7	7	7	7	
ON510	Lynde Creek Marsh	3	7	4	5	5	5
ON541	Lynde Creek Marsh	4	4	4	4	4	4
ON509	Corbett Creek Marsh	4	4	5		5	4
ON546	Pumphouse Marsh			2	2	2	2
ON042	Oshawa Second Marsh	6	6	6	6	7	6
ON545	McLaughlin Bay Wetland			1	2	2	3
ON540	Westside Beach Marsh	4	3	3	3	3	3
ON542	Bowmanville Marsh	6	6	6	6	7	6
ON291	Wilmot Creek Marsh	3	3	3	3	3	3
ON604	Port Newcastle Wetland		1	1	1	1	1
ON580	Presqu'ile Bay Marsh				8	8	
ON581	Presqu'ile Bay Marsh				8	8	
ON582	Presqu'ile Bay Marsh				8	8	
ON586	Dead Creek Marsh					6	
ON587	Dead Creek Marsh					6	
ON597	12 O’clock Point Marsh					4	
ON585	Carrying Place Marsh					1	
ON594	Sawguin Creek Ditched Marsh					8	
ON571	Sawguin Creek Central Marsh				6	6	
ON572	Sawguin Creek Central Marsh				6	6	
ON573	Sawguin Creek Central Marsh				6	6	
ON595	Sawguin Creek North Marsh					5	
ON564	Belleville Marsh				2	2	
ON565	Blessington Creek Marsh				7	7	
ON566	Blessington Creek Marsh				7	7	
ON570	Robinson's Cove Marsh				2	2	2
ON574	Big Island West Marsh				8	8	
ON576W	Big Island West Marsh				4	4	
ON575	Big Island East Marsh				8	8	
ON576E	Big Island East Marsh				3	3	
ON591	Marysville Creek Marsh					6	
ON592	Marysville Creek Marsh					5	
ON593	Marysville Creek Marsh					5	
ON596	Solmesville East Marsh					1	
ON590	Lower Sucker Creek Marsh					4	
ON584	Lower Sucker Creek East Marsh					1	
ON583	Airport Creek Marsh					3	
ON588	Forester's Island Marsh					3	
ON589	Lower Napanee River Marsh					4	

Route	Wetland	2002	2003	2004	2005	2006	2007
ON562	South Bay Marsh				8	8	
ON563	Big Sand Bay Marsh				8	8	
ON577	Hay Bay North Marsh				8	8	
ON579	Hay Bay South Marsh				8	8	
ON505	Parrott's Bay Marsh	2					
ON567	Button Bay Marsh				2	2	
ON568	Bayfield Bay Marsh				5	5	
ON569	Bayfield Bay Marsh				8	8	

Table C-2. Marsh bird members of each of the three guilds used in the calculation of the bird IBI: a) area-sensitive marsh nesting obligate species, b) marsh nesting obligate species, and c) non-aerial forager species. Common names indicated with an asterisk denote those species found in Durham Region wetlands from 2002 to 2007.

a) Area-sensitive marsh nesting obligate species

Code	Common Name	Species
AMBI	American bittern*	*Botaurus lentiginosus*
AMCO	American coot*	*Fulica americana*
BLTE	black tern*	*Chlidonias niger*
FOTE	Forster's tern	*Sterna forsteri*
KIRA	king rail	*Rallus elegans*
LEBI	least bittern*	*Ixobrychus exilis*
REDH	redhead	*Aythya americana*
RNGR	red-necked grebe	*Podiceps grisegena*
SACR	sandhill crane	*Grus canadensis*
YERA	yellow rail	*Coturnicops noveboracensis*

b) Marsh Nesting Obligate Species

Code	Common Name	Genus/Species
AMBI	American bittern*	*Botaurus lentiginosus*
AMCO	American coot*	*Fulica americana*
BLTE	black tern*	*Chlidonias niger*
COMO	common moorhen*	*Gallinula chloropus*
COSN	common snipe	*Gallinago gallinago*
FOTE	Forster's tern	*Sterna forsteri*
HOGR	horned grebe	*Podiceps auritus*
KIRA	king rail	*Rallus elegans*
LEBI	least bittern*	*Ixobrychus exilis*
LIGU	little gull	*Larus minutus*
MAWR	marsh wren*	*Cistothorus palustris*
PBGR	pied-billed grebe*	*Podilymbus podiceps*
REDH	redhead	*Aythya americana*
RNDU	ring-necked duck*	*Aythya collaris*
RNGR	red-necked grebe	*Podiceps grisegena*
SACR	sandhill crane	*Grus canadensis*
SORA	sora*	*Porzana carolina*
SWSP	swamp sparrow*	*Melospiza georgiana*
TRUS	trumpeter swan*	*Cygnus buccinator*
VIRA	Virginia rail*	*Rallus limicola*
YERA	yellow rail	*Coturnicops noveboracensis*
YHBL	yellow-headed blackbird*	*Xanthocephalus xanthocephalus*

c) Non-aerial Foragers Species

Code	Common Name	Species
AMCR	American crow*	*Corvus brachyrhynchos*
AMGO	American goldfinch*	*Carduelis tristis*
AMRE	American redstart*	*Setophaga ruticilla*
AMRO	American robin*	*Turdus migratorius*
AMWO	American woodcock*	*Scolopax minor*
ATSP	American tree sparrow	*Spizella arborea*
BAOR	Baltimore oriole*	*Icterus galbula*
BAWW	black-and-white warbler	*Mniotilta varia*
BBCU	black-billed cuckoo	*Coccyzus erythropthalmus*
BCCH	black-capped chickadee*	*Parus atricapillus*
BGGN	blue-gray gnatcatcher*	*Polioptila caerulea*
BHCO	brown-headed cowbird*	*Molothrus ater*
BLJA	blue jay*	*Cyanocitta cristata*
BOBO	bobolink	*Dolichonyx oryzivorus*
BRBL	Brewer's blackbird	*Euphagus cyanocephalus*
BRTH	brown thrasher	*Toxostoma rufum*
BTNW	black-throated green warbler	*Dendroica virens*
BWWA	blue-winged warbler	*Vermivora pinus*
CARW	carolina wren	*Thryothorus ludovicianus*
CAWA	Canada warbler	*Wilsonia canadensis*
CCSP	clay-colored sparrow	*Spizella pallida*
CHSP	chipping sparrow*	*Spizella passerina*
CMWA	Cape May warbler	*Dendroica tigrina*
COGR	common grackle*	*Quiscalus quiscula*
CORA	common raven	*Corvus corax*
COSN	common snipe	*Gallinago gallinago*
COYE	common yellowthroat*	*Geothlypis trichas*
CSWA	chestnut-sided warbler	*Dendroica pensylvanica*
CEDW	cedar waxwing*	*Bombycilla cedrorum*
DOWO	downy woodpecker*	*Picoides pubescens*
DUNL	dunlin*	*Calidris alpina*
EABL	eastern bluebird	*Sialia sialis*
EAME	eastern meadowlark	*Sturnella magna*
ETTI	eastern tufted titmouse	*Baeolophus bicolor*
FISP	field sparrow	*Spizella pusilla*
GRSP	grasshopper sparrow	*Ammodramus savannarum*
GRYE	greater yellowlegs	*Tringa melanoleuca*
HAWO	hairy woodpecker	*Picoides villosus*
HETH	hermit thrush	*Catharus guttatus*
HOFI	house finch*	*Carpodacus mexicanus*
HOWR	house wren*	*Troglodytes aedon*
INBU	indigo bunting	*Passerina cyanea*
KILL	killdeer*	*Charadrius vociferus*

Code	Common Name	Species
LESA	least sandpiper	*Calidris minutilla*
LCSP	Le Conte's sparrow	*Ammodramus leconteii*
LEYE	lesser yellowlegs*	*Tringa flavipes*
LISP	Lincoln's sparrow	*Melospiza lincolnii*
LOWA	Louisiana waterthrush	*Seiurus motacilla*
MAWA	magnolia warbler*	*Dendroica magnolia*
MAWR	marsh wren*	*Cistothorus palustris*
MODO	mourning dove*	*Zenaida macroura*
MOWA	mourning warbler	*Oporornis philadelphia*
NAWA	Nashville warbler	*Vermivora ruficapilla*
NOCA	northern cardinal*	*Cardinalis cardinalis*
NOFL	northern flicker*	*Colaptes auratus*
NOMO	northern mockingbird	*Mimus polyglottos*
NOPA	northern parula	*Parula americana*
NOWA	northern waterthrush	*Seiurus noveboracensis*
NSTS	Nelson's sharp-tailed sparrow	*Ammodramus nelsoni*
OROR	orchard oriole*	*Icterus spurius*
OVEN	ovenbird	*Seiurus aurocapillus*
PISI	pine siskin	*Carduelis pinus*
PIWA	pine warbler	*Dendroica pinus*
PIWO	pileated woodpecker	*Dryocopus pileatus*
PROW	prothonotary warbler	*Protonotaria citrea*
PUFI	purple finch	*Carpodacus purpureus*
RBGR	rose-breasted grosbeak*	*Pheucticus ludovicianus*
RBNU	red-breasted nuthatch	*Sitta canadensis*
RBWO	red-bellied woodpecker	*Melanerpes carolinus*
RCKI	ruby-crowned kinglet	*Regulus calendula*
REVI	red-eyed vireo*	*Vireo olivaceus*
RHWO	red-headed woodpecker	*Melanerpes erythrocephalus*
RIPH	ring-necked pheasant	*Phasianus colchicus*
RTHU	ruby-throated hummingbird*	*Archilochus colubris*
RUBL	rusty blackbird	*Euphagus carolinus*
RUGR	ruffed grouse	*Bonasa umbellus*
RUTU	ruddy turnstone	*Arenaria interpres*
RWBL	red-winged blackbird*	*Agelaius phoeniceus*
SAVS	Savannah sparrow	*Passerculus sandwichensis*
SBDO	short-billed dowitcher*	*Limnodromus griseus*
SCTA	scarlet tanager	*Piranga olivacea*
SEPL	semipalmated plover*	*Charadrius semipalmatus*
SEWR	sedge wren*	*Cistothorus platensis*
SORA	sora*	*Porzana carolina*
SOSA	solitary sandpiper	*Tringa solitaria*
SOSP	song sparrow*	*Melospiza melodia*
SPSA	spotted sandpiper*	*Actitis macularia*

Code	Common Name	Species
STSP	unidentified sharp-tailed sparrow	*Ammodramus spp.*
SWSP	swamp sparrow*	*Melospiza georgiana*
SWTH	Swainson's thrush	*Catharus ustulatus*
TEWA	Tennessee warbler	*Vermivora peregrina*
TUTI	tufted titmouse	*Parus bicolor*
VEER	veery	*Catharus fuscescens*
VIRA	Virginia rail*	*Rallus limicola*
WAVI	warbling vireo*	*Vireo gilvus*
WBNU	white-breasted nuthatch	*Sitta carolinensis*
WEVI	white-eyed vireo	*Vireo griseus*
WIPH	Wilson's phalarope	*Phalaropus tricolor*
WIWR	winter wren	*Troglodytes troglodytes*
WOTH	wood thrush	*Hylocichla mustelina*
WTSP	white-throated sparrow	*Zonotrichia albicollis*
YBCH	yellow-breasted chat	*Icteria virens*
YBCU	yellow-billed cuckoo	*Coccyzus americanus*
YBSA	yellow-bellied sapsucker	*Sphyrapicus varius*
YERA	yellow rail	*Coturnicops noveboracensis*
YHBL	yellow-headed blackbird*	*Xanthocephalus xanthocephalus*
YPWA	yellow palm warbler	*Dendroica palmarum*
YTVI	yellow-throated vireo	*Vireo flavifrons*
YWAR	yellow warbler*	*Dendroica petechia*

Figure C-1. Bird community IBI temporal trends for 15 Durham Region coastal wetlands from 2002-2007, where available, and associated conditions as identified in EC and CLOCA (2004).

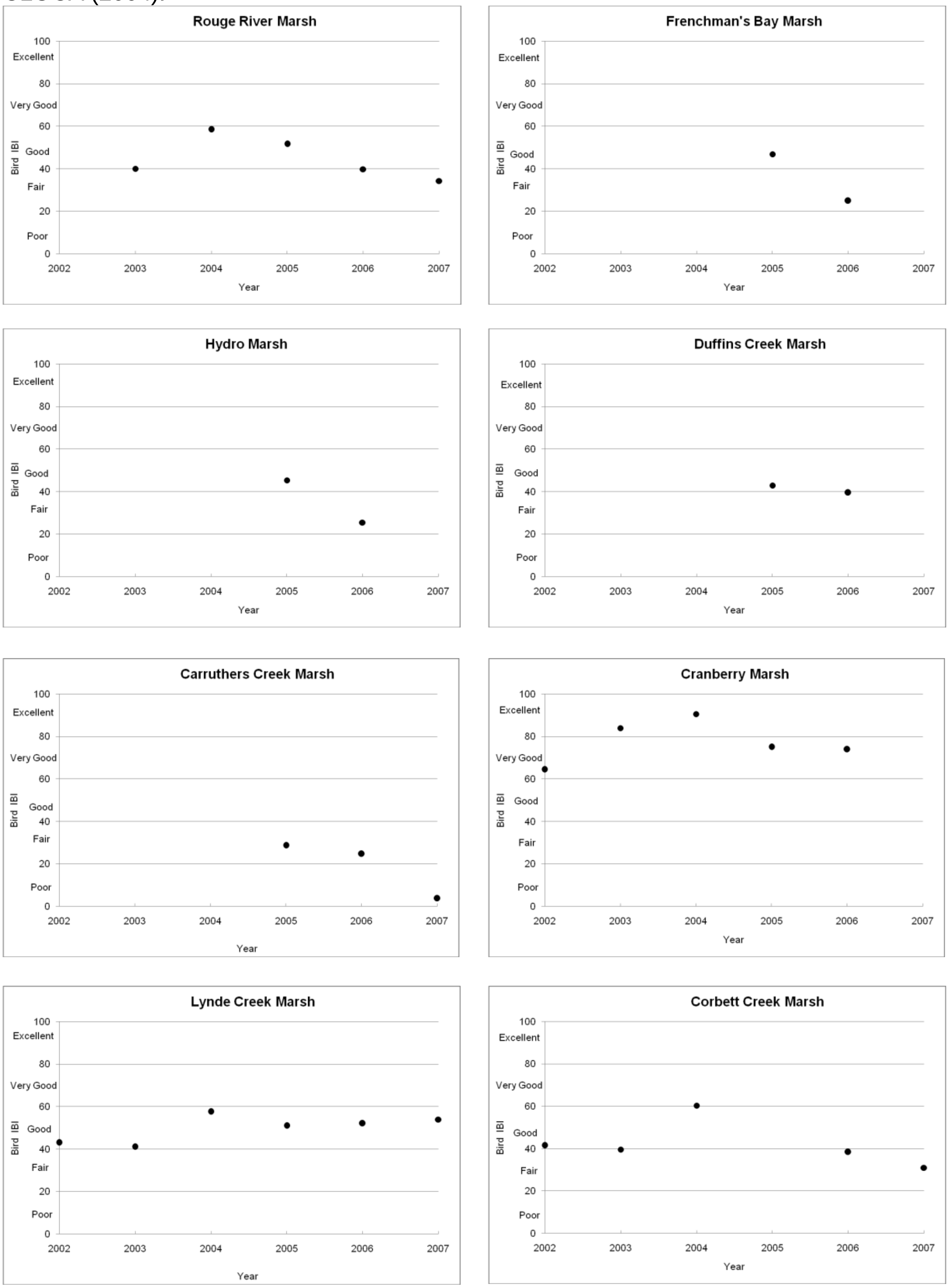
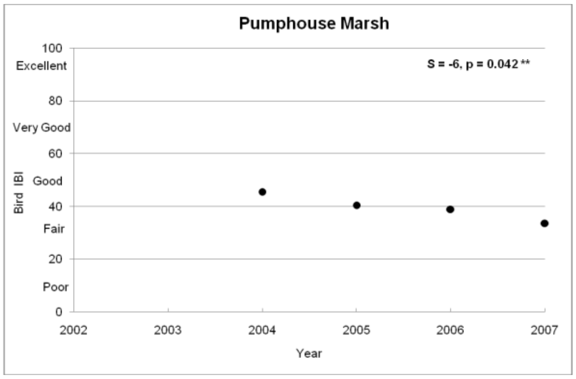
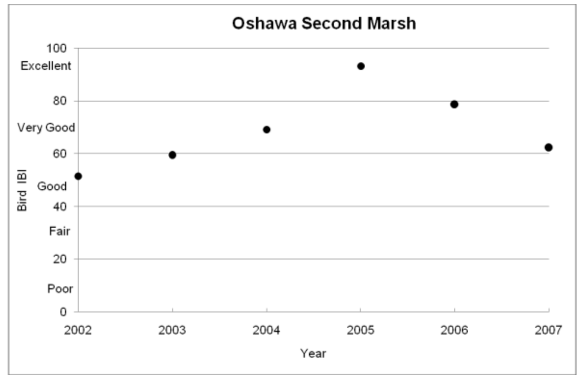
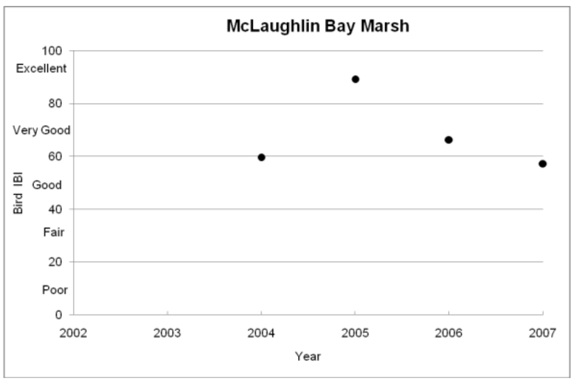
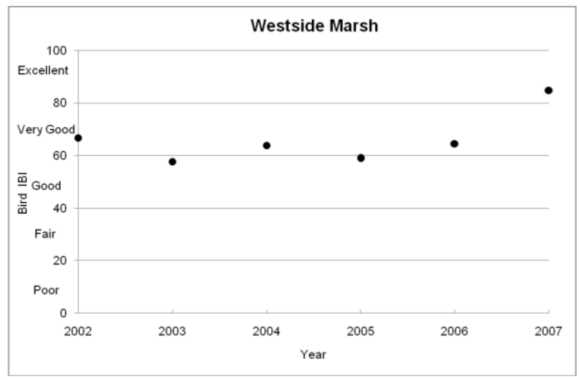


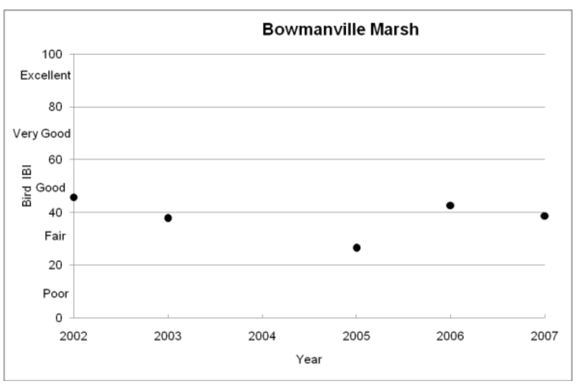
Figure C-1 continued.

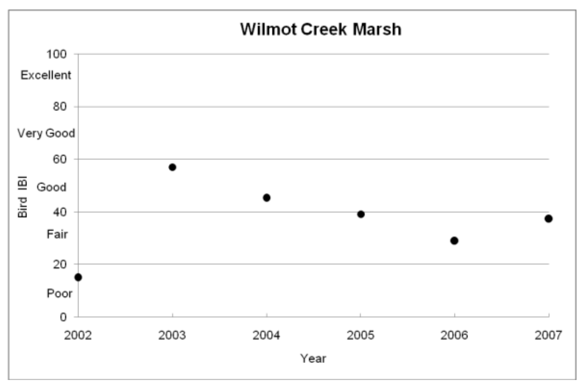












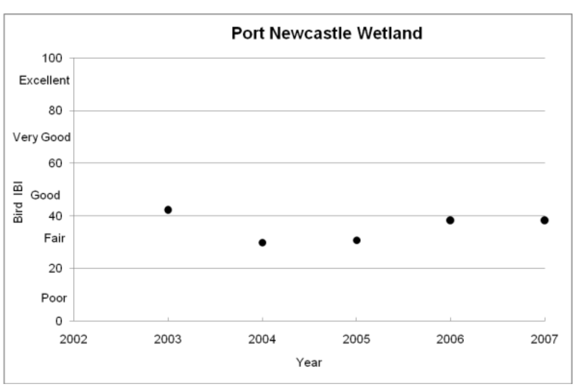


Table C-3. Mean standardized breeding bird community metrics and IBIs for Durham Region coastal wetlands from 2002-2007, where available. Metrics used in the calculation of the IBI include: mean species richness of area-sensitive marsh nesting obligates for the survey route (SAMNO), mean relative abundance (i.e., expressed as a percentage) of marsh nesting obligates for the survey route (PMNO) and mean relative abundance (i.e., expressed as a percentage) of non-aerial foragers for the survey route (PNAF). Asterisks specify the results of temporal trend analyses based on raw data for the parameter of interest, whereby "**" denotes a significant trend ($p<0.05$) and "*" denotes a marginally-significant trend ($p<0.1$); arrows denote the direction of trend. Wetlands are ordered vertically from west to east.

Durham Region Wetland	Years	SAMNO	PMNO	PNAF	Bird IBI
Rouge River Marsh	2003-2007	0.00	4.01	9.43	44.81
Frenchman's Bay Marsh	2005, 2006	1.46	3.76	5.55	35.87
Hydro Marsh	2005, 2006	0.00	3.82	6.78	35.34
Duffins Creek Marsh	2005, 2006	0.00	5.04	7.32	41.17
Carruthers Creek Marsh	2005-2007	0.00	1.86	3.83	18.98
Cranberry Marsh	2002-2006	7.00	9.14	7.12	77.54
Lynde Creek Marsh	2002-2007	0.36	5.32	9.25	49.73
Corbett Creek Marsh	2002-2007[a]	0.00	3.99	8.65	42.14
Pumphouse Marsh	2004-2007	0.00	3.22	8.68	39.63**↓
Oshawa Second Marsh	2002-2007	3.40	7.75	9.53	68.96
McLaughlin Bay Marsh	2004-2007	2.19	8.23	10.00	68.06
Westside Marsh	2002-2007	0.97	9.78	9.06	66.04
Bowmanville Marsh	2002-2007[b]	0.58	2.05	8.84	38.24
Wilmot Creek Marsh	2002-2007	0.00	3.74	7.38	37.05
Port Newcastle Wetland	2003-2007	0.00	2.28	8.46	35.79
Grand Mean		**1.06**	**4.93**	**7.99**	**46.62**
±SD		**1.93**	**2.59**	**1.68**	**16.23**

a = sampling not performed in 2005; b = sampling not performed in 2004

Table C-4. Mean standardized breeding bird community metrics and IBIs for other Lake Ontario coastal wetlands from 2002-2007, where available. Metrics used in the calculation of the IBI include: mean species richness of area-sensitive marsh nesting obligates for the survey route (SAMNO), mean relative abundance (i.e., expressed as a percentage) of marsh nesting obligates for the survey route (PMNO) and mean relative abundance (i.e., expressed as a percentage) of non-aerial foragers for the survey route (PNAF). Wetlands are ordered vertically from west to east. No temporal trend analyses were performed on these data.

Lake Ontario Wetland	Years	SAMNO	PMNO	PNAF	Bird IBI
Presqu'ile Bay Marsh	2005, 2006	5.47	10.00	9.01	81.58
Dead Creek Marsh	2006	1.46	5.79	9.13	54.61
12 O'clock Point Marsh	2006	0.00	3.76	9.61	44.57
Carrying Place Marsh	2006	0.00	1.58	9.58	37.19
Sawguin Creek Ditched Marsh	2006	4.38	10.00	10.00	81.25
Sawguin Creek Central Marsh	2005, 2006	3.89	10.00	10.00	79.63
Sawguin Creek North Marsh	2006	3.50	9.92	10.00	78.08
Belleville Marsh	2005, 2006	0.00	2.22	9.90	40.38
Blessington Creek Marsh	2005, 2006	2.50	9.03	10.00	71.75
Robinson's Cove Marsh	2005-2007	0.00	5.73	8.62	47.85
Big Island West Marsh	2005, 2006	3.28	9.44	9.79	74.94
Big Island East Marsh	2005, 2006	3.28	9.89	9.27	74.70
Marysville Creek Marsh	2006	5.47	9.87	9.84	83.87
Solmesville East Marsh	2006	0.00	2.00	10.00	40.00
Lower Sucker Creek Marsh	2006	4.38	3.41	7.60	51.28
Lower Sucker Creek East Marsh	2006	0.00	1.58	10.00	38.60
Airport Creek Marsh	2006	0.00	7.58	10.00	58.60
Forester's Island Marsh	2006	0.00	4.04	9.44	44.92
Lower Napanee River Marsh	2006	4.38	10.00	10.00	81.25
South Bay Marsh	2005, 2006	3.28	5.69	7.58	55.17
Big Sand Bay Marsh	2005, 2006	3.29	9.71	9.79	75.90
Hay Bay North Marsh	2005, 2006	6.25	10.00	10.00	87.50
Hay Bay South Marsh	2005, 2006	2.19	8.73	9.93	69.48
Parrott's Bay Marsh	2002	0.00	6.25	9.89	53.78
Button Bay Marsh	2005, 2006	0.00	3.43	7.12	35.15
Bayfield Bay Marsh	2005, 2006	2.19	10.00	9.48	72.14
Grand Mean		**2.28**	**6.91**	**9.44**	**62.08**
±SD		**2.10**	**3.20**	**0.83**	**17.35**

APPENDIX D

Table D-1. Routes and associated numbers of stations for amphibian surveys performed in Lake Ontario wetlands from 2002-2007. Durham Region coastal wetlands are shaded. All stations were surveyed three times per year.

Route	Wetland	2002	2003	2004	2005	2006	2007
ON043	Rouge River Marsh				2		3
ON607	Rouge River Marsh		1	1	1	1	
ON550	Frenchman's Bay Marsh	2					3
ON147	Hydro Marsh	1					1
ON551	Duffins Creek Marsh				3		3
ON547	Carruthers Creek Marsh				2		2
ON107	Cranberry Marsh	3	3				
ON510	Lynde Creek Marsh	2	3		3	3	3
ON548	Lynde Creek Marsh		2	2	2	2	2
ON509	Corbett Creek Marsh			3	3	3	3
ON546	Pumphouse Marsh		1	1	1	1	
ON042	Oshawa Second Marsh	4	6	6	6	6	6
ON222	Oshawa Second Marsh	5	6	6	6	5	6
ON558	Oshawa Creek Marsh						2
ON508	McLaughlin Bay Marsh	1	1		2	1	3
ON549	Westside Marsh		1	1	2	2	2
ON542	Bowmanville Marsh	2	2	3		3	3
ON291	Wilmot Creek Marsh	1	3	3	3	3	3
ON544	Port Newcastle Marsh		1	1	1	1	1
ON604	Port Newcastle Marsh					1	
ON501	Port Britain Marsh	2					
ON511	Huyck's Bay Marsh	1					
ON668	Sawguin Creek Central Marsh					5	5
ON602	Belleville Marsh		4	4			2
ON672	Blessington Creek Marsh					1	
ON539	Robinson's Cove Marsh	1	1				
ON570	Robinson's Cove Marsh						1
ON201	Big Island East Marsh	5	5		5		5
ON502	South Bay Marsh	2					
ON503	Hay Bay South Marsh	2					2
ON556	Parrott's Bay Marsh	4	4	4	4		
ON500	Button Bay Marsh	2					
ON506	Bayfield Bay Marsh	3					

Table D-2. Listing of Great Lakes amphibian species (GLCWC, 2008). Species marked with a "1" are ten species which are expected to be found in Durham Region wetlands. Of these, four species marked with an "*" are woodland species used in the calculation of the amphibian IBI (i.e., metrics rWOOD and pWOOD).

Code	Common Name	Genus Species
AMTO	American Toad[1]	*Bufo americanus*
BCFR	Blanchard's Cricket Frog[2]	*Acris crepitans blanchardi*
BULL	Bullfrog[1]	*Rana catesbeiana*
CHFR	Boreal Chorus Frog[1]*	*Pseudacris maculata*
FOTO	Fowler's Toad[2]	*Bufo woodhousei fowleri*
GRTR	Gray Treefrog[1]*	*Hyla versicolor*
GRFR	Green Frog[1]	*Rana clamitans melanota*
MIFR	Mink Frog[1]	*Rana septentrionalis*
NLFR	Northern Leopard Frog[1]	*Rana pipiens*
PIFR	Pickerel Frog[1]	*Rana palustris*
SPPE	Spring Peeper[1]*	*Pseudacris crucifer*
WOFR	Wood Frog[1]*	*Rana sylvatica*

[2] Species range of this species does not include Durham Region (Ministry of Natural Resources, 2001a,b).

Figure D-1. Amphibian community IBI temporal trends for 15 Durham Region coastal wetlands from 2002-2007, where available, and associated conditions as identified in EC and CLOCA (2004).

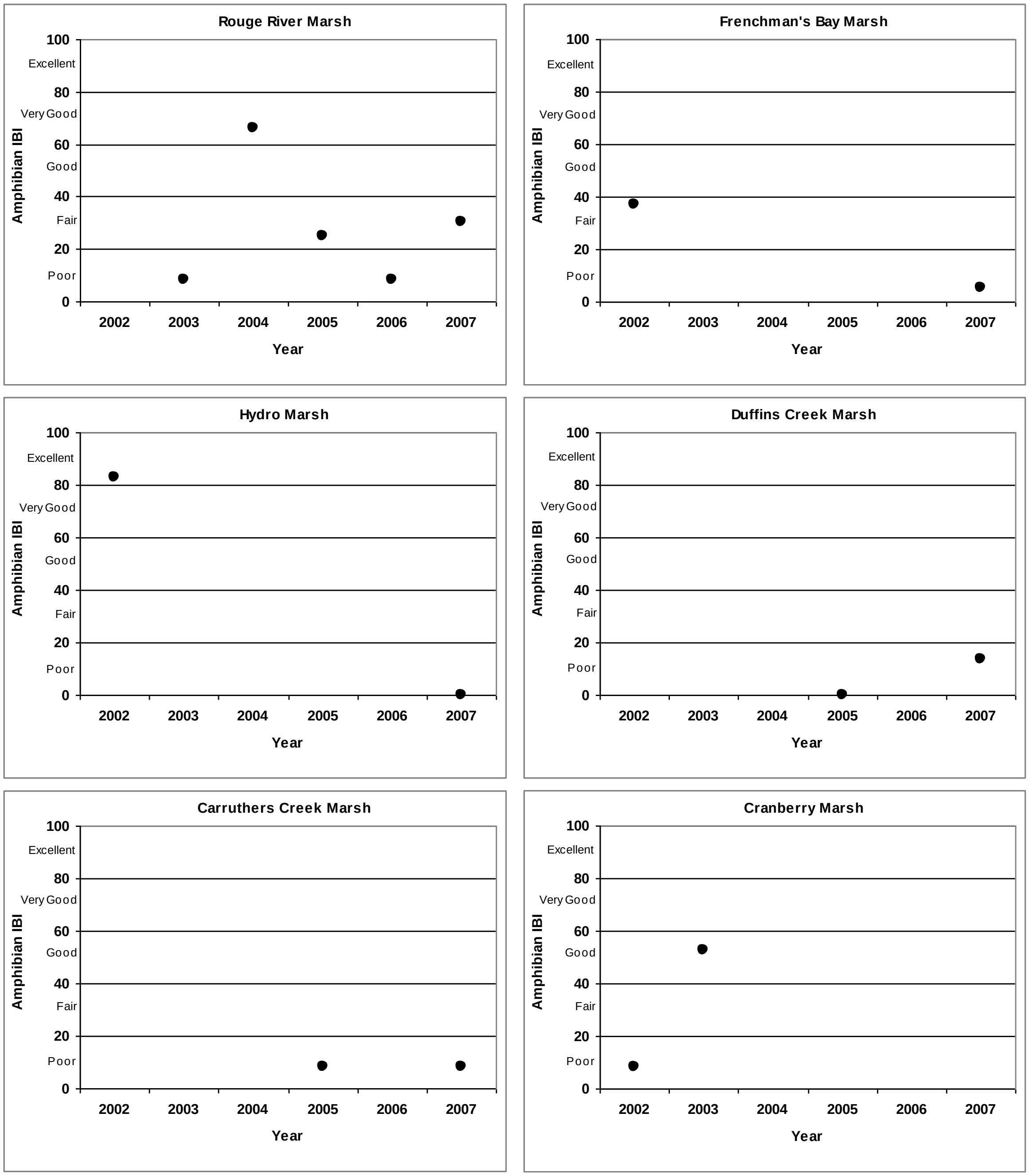
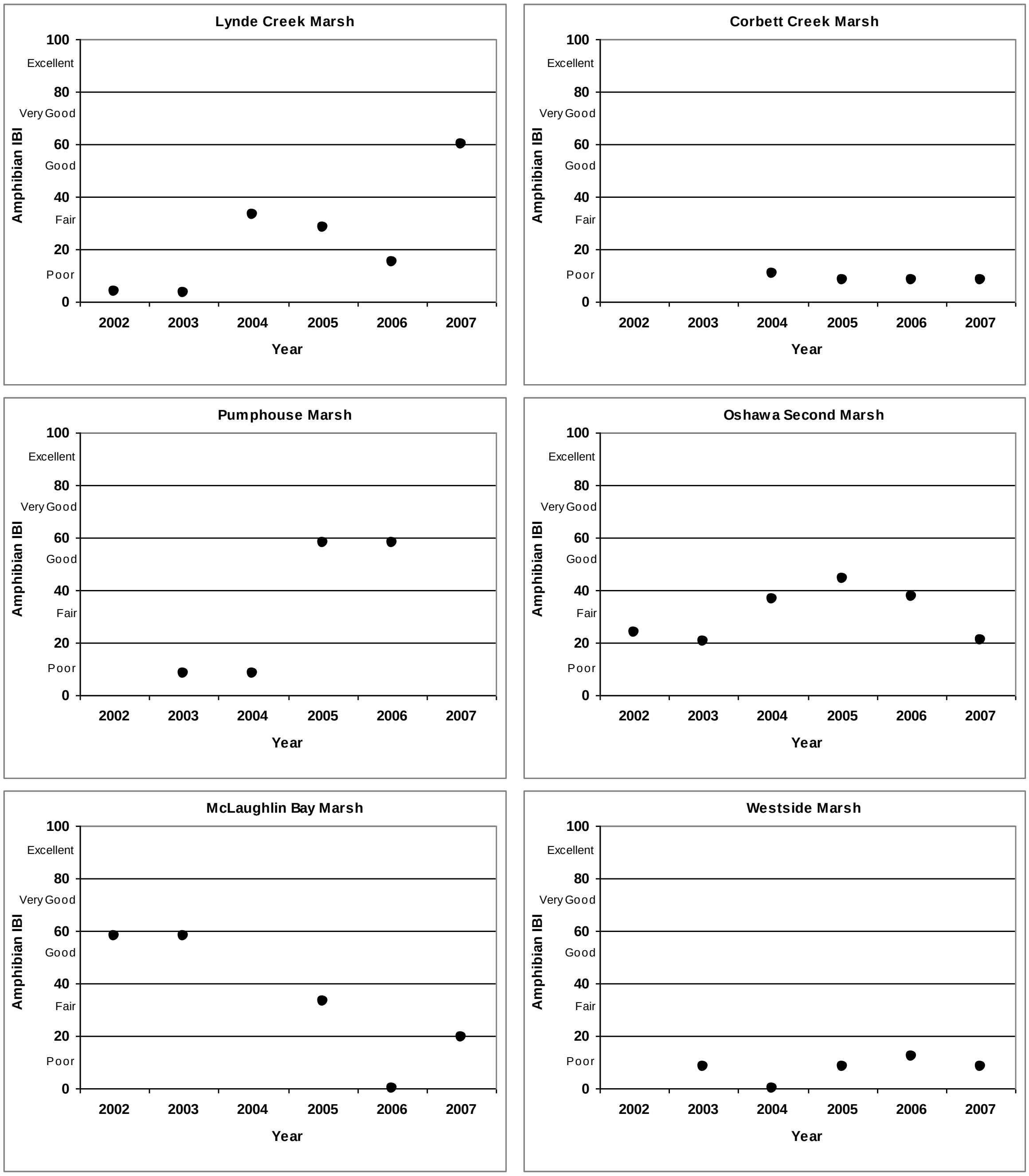


Figure D-1. Continued



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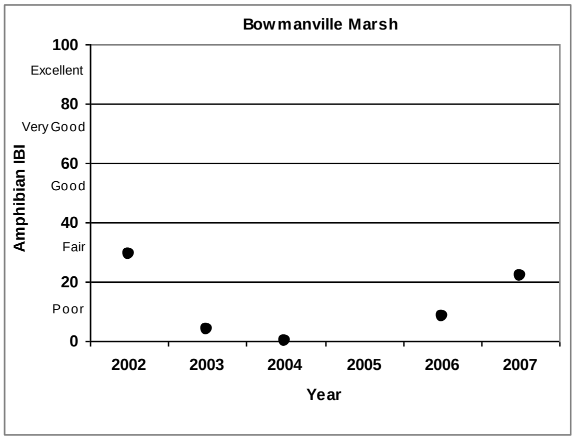
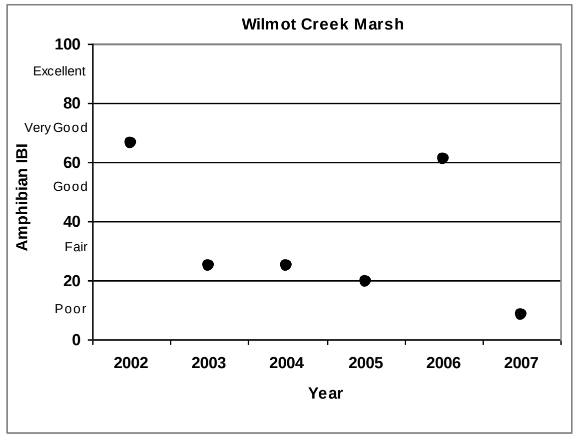




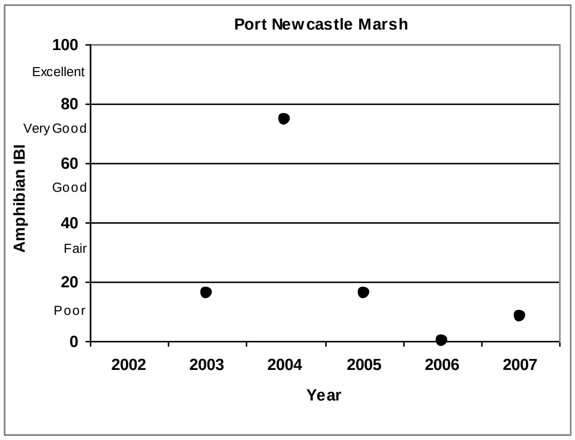


Table D-3. Mean standardized amphibian community metrics and IBIs for Durham Region coastal wetlands from 2002-2007, where available. Metrics used in the calculation of the IBI include: mean total species richness across survey stations in a wetland (rTOT), mean species richness of woodland associated amphibian species across survey stations in a wetland (rWOOD) and probability of detection of woodland associated amphibian species across survey stations in a wetland (pWOOD). Wetlands are ordered vertically from west to east.

Durham Region Wetland	Years	rTOT	rWOOD	pWOOD	Amphibian IBI
Rouge River Marsh	2003-2007	3.25	1.67	3.33	27.51
Frenchman's Bay Marsh	2002, 2007	2.65	1.25	2.50	21.31
Hydro Marsh	2002, 2007	2.44	5.00	5.00	41.47
Duffins Creek Marsh	2005, 2007	2.04	0.00	0.00	6.78
Carruthers Creek Marsh	2005, 2007	2.44	0.00	0.00	8.13
Cranberry Marsh	2002, 2003	3.26	2.50	3.34	30.29
Lynde Creek Marsh	2002-2007	1.91	1.75	3.50	23.87
Corbett Creek Marsh	2004-2007	2.64	0.00	0.00	8.81
Pumphouse Marsh	2003-2006	2.44	2.50	5.00	33.13
Oshawa Second Marsh	2002-2007	2.57	2.31	4.33	30.70
McLaughlin Bay Marsh	2002, 2003, 2005-2007	1.63	2.83	5.67	33.75
Westside Marsh	2003-2007	2.20	0.00	0.00	7.32
Bowmanville Marsh	2002-2004, 2006, 2007	1.30	0.83	1.67	12.67
Wilmot Creek Marsh	2002-2007	2.71	2.50	5.00	34.04
Port Newcastle Marsh	2003-2007	3.90	1.00	2.00	23.01
Grand Mean		**2.49**	**1.61**	**2.76**	**22.85**
± SD		**0.66**	**1.40**	**2.06**	**11.51**

Table D-4. Mean standardized amphibian community metrics and IBIs for Lake Ontario coastal wetlands from 2002-2007, where available. Metrics used in the calculation of the IBI include: mean total species richness across survey stations in a wetland (rTOT), mean species richness of woodland associated amphibian species across survey stations in a wetland (rWOOD) and probability of detection of woodland associated amphibian species across survey stations in a wetland (pWOOD). Wetlands are ordered vertically from west to east.

Lake Ontario Wetland	Years	rTOT	rWOOD	pWOOD	Amphibian IBI
Port Britain Marsh	2002	6.10	5.00	10.00	70.33
Presqu'ile Bay Marsh					
Huyck's Bay Marsh	2002	4.88	10.00	10.00	82.93
Sawguin Creek Central Marsh	2006, 2007	10.00	7.00	10.00	90.00
Belleville Marsh	2003, 2004, 2007	2.44	0.83	1.67	16.46
Blessington Creek Marsh	2006	4.88	5.00	10.00	66.27
Robinson's Cove Marsh	2002, 2003, 2007	3.25	1.67	3.33	27.51
Big Island East Marsh	2002, 2003, 2005, 2007	8.42	10.00	10.00	94.73
South Bay Marsh	2002	8.54	10.00	10.00	95.13
Hay Bay South Marsh	2002, 2007	6.10	5.00	10.00	70.34
Parrott's Bay Marsh	2002-2005	5.19	7.50	10.00	75.62
Grand Mean		**5.98**	**6.20**	**8.50**	**68.93**
±SD		**2.40**	**3.32**	**3.19**	**26.91**

APPENDIX E

Table E-1. Number of replicate samples of aquatic macroinvertebrates in Lake Ontario wetlands from 2002-2007. Durham Region coastal wetlands are shaded.

Wetland Name	2002	2003	2004	2005	2006	2007
Rouge River Marsh		3	6	3	3	3
Frenchman's Bay Marsh	3	3	6	3	3	3
Hydro Marsh		3	6	3	3	3
Duffins Creek Marsh		3	6	3	3	3
Carruthers Creek Marsh		3	6	3	3	3
Cranberry Marsh		3	6	3	3	
Lynde Creek Marsh	3	3	6	3	3	3
Whitby Harbour Marsh						1
Corbett Creek Marsh		3	6	3	3	3
Pumphouse Marsh		3	6	3	3	
Oshawa Second Marsh		3		3	3	3
McLaughlin Bay Marsh		3	6	3	3	3
Westside Marsh		3	6	3	3	3
Bowmanville Marsh		3	6	3	3	3
Wilmot Creek Marsh		3	6	3	3	3
Port Newcastle Marsh		3	6	3	3	3
Jordan Station Marsh		3				
Port Britain Marsh	3	3				
Presqu'ile Bay Marsh	9	3				
Dead Creek Marsh					3	3
Huyck's Bay Marsh	6	3	6			
12 O'Clock Point Marsh					3	
Carrying Place Marsh					3	3
Blessington Creek Marsh				3	3	3
Sawguin Creek Central Marsh				3	3	3
Sawguin Creek Ditched Marsh					3	3
Sawguin Creek North Marsh					3	3
Robinson's Cove Marsh	6	3		3	3	3
Lower Salmon River Marsh					3	
Big Island West Marsh				3	3	3
Big Island East Marsh				3	3	3
Marysville Creek Marsh					3	
Solmesville East Marsh					3	
Lower Sucker Creek Marsh					3	3
Lower Sucker Creek East Marsh					3	
Airport Creek Marsh					3	3
Forester's Island Marsh					3	
South Bay Marsh	3	3				
Big Sand Bay Marsh		3	6			
Carnachan Bay Marsh						3
Lower Napanee River Marsh					3	3
Hay Bay North Marsh	3	3	6	3	3	3
Hay Bay South Marsh		3		3	3	3
Amherst Island Diked Marsh			6			

Table E-1. Continued

Wetland Name	2002	2003	2004	2005	2006	2007
Amherst Island Undiked Marsh			6			
Parrott's Bay Marsh	3	3	6	3		
Button Bay Marsh	6	3				
Bayfield Bay Marsh	3	3				

Figure E-1. Macroinvertebrate community IBI temporal trends for 15 Durham Region coastal wetlands from 2002-2007, where available, and associated conditions as identified in EC and CLOCA (2004). Results of Mann-Kendall tests with S statistics, where significant, are shown. The macroinvertebrate IBI score for Whitby Harbour Marsh (49.64) is not plotted.

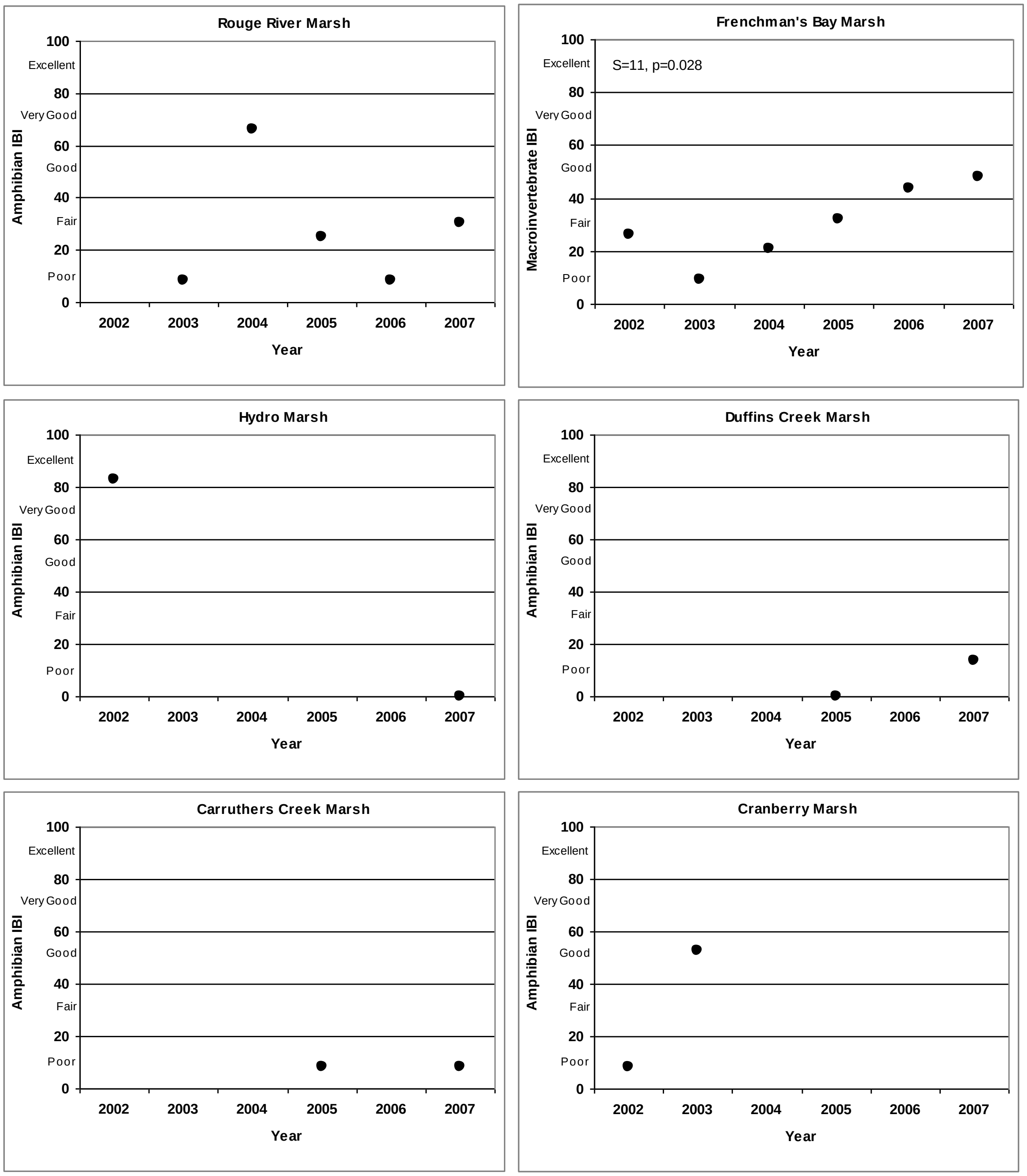
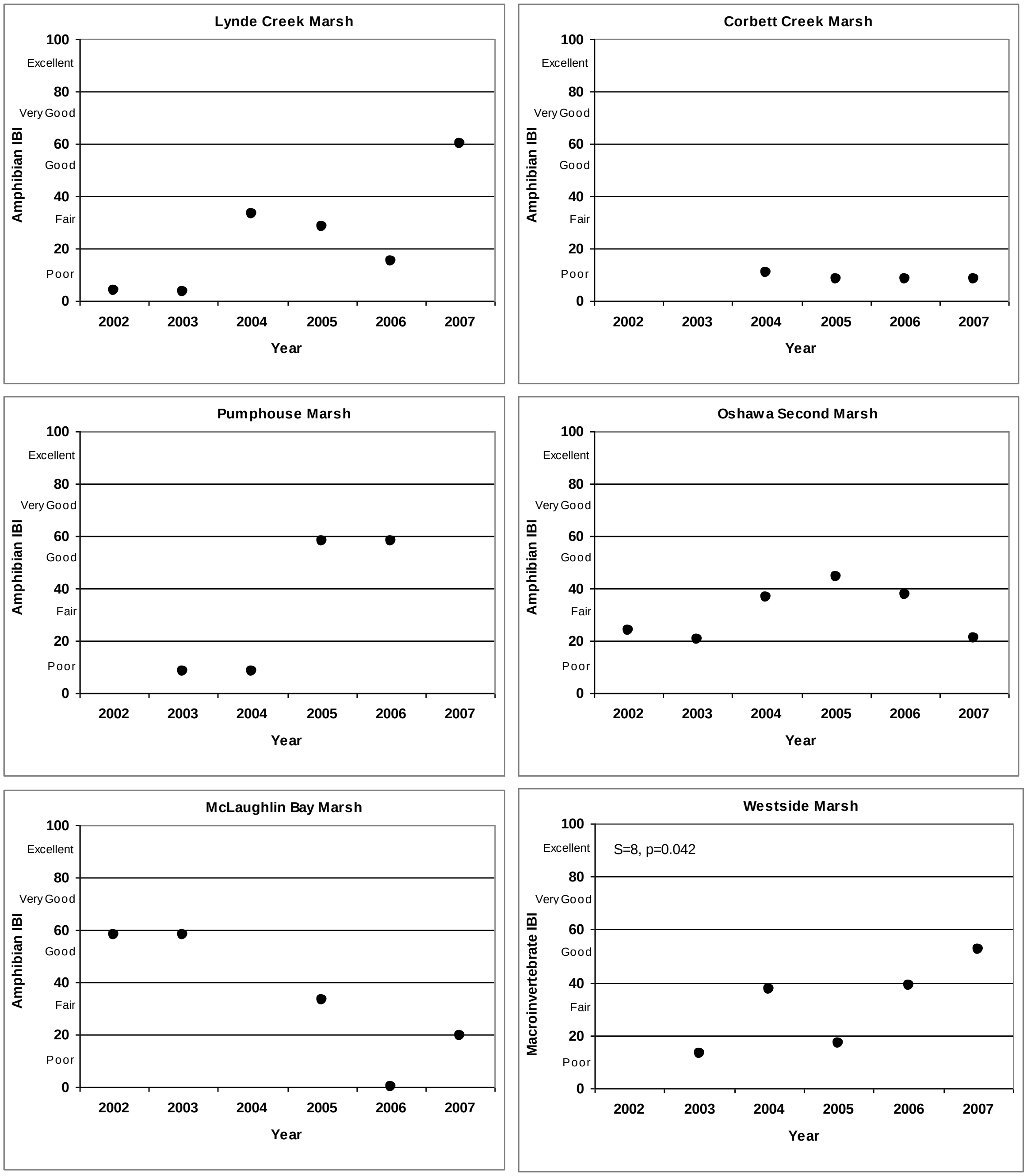


Figure E-1. Continued



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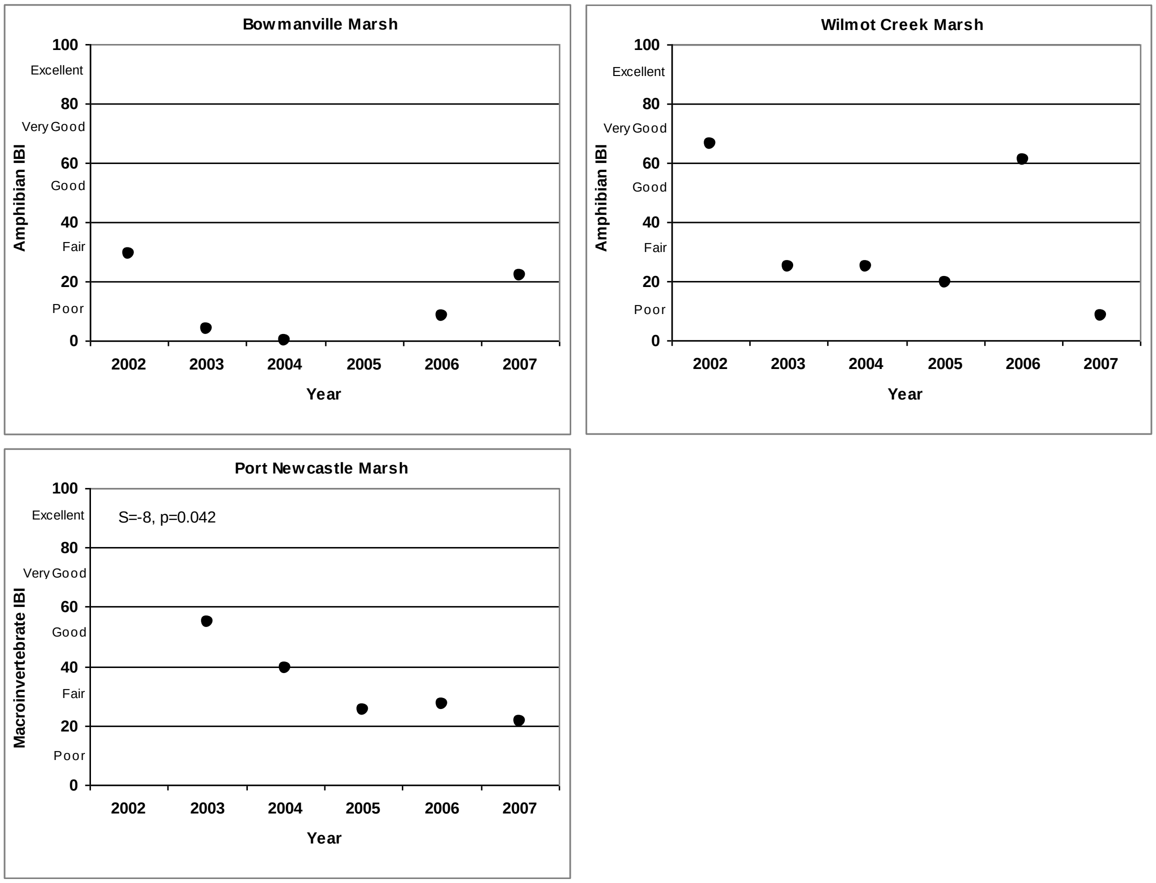

Table E-2. Mean standardized aquatic macroinvertebrate community metrics and IBIs for Durham Region coastal wetlands from 2002-2007, where available. Metrics used in the calculation of the IBI include: number of Ephemeroptera and Trichoptera in a wetland (NEGT), number of macroinvertebrate families found within a wetland (NFAM), percentage of Crustacea and Mollusca (PCRM), percentage of Trichoptera within a wetland (PTRI), and percentage of Diptera within a wetland (PDIP). Asterisks specify the results of temporal trend analyses based on raw data for the parameter of interest, whereby "**" denotes a significant trend ($p<0.05$) and "*" denotes a marginally-significant trend ($p<0.1$); arrows denote the direction of trend. Wetlands are ordered vertically from west to east.

Durham Region Wetland	Years	NETG	NFAM	PCRM	PTRI	PDIP	Macroinvertebrate IBI
Rouge River Marsh	2003-2007	8.50	5.86	1.36	3.24	5.88	49.67
Frenchman's Bay Marsh	2002-2007	2.64	2.35	5.28	0.96	3.77↓*	30.01
Hydro Marsh	2003-2007	1.33	2.24	1.33	0.16	1.19↓**	12.53
Duffins Creek Marsh	2003-2007	3.17	5.94	3.51	1.72	7.08↓**	42.85
Carruthers Creek Marsh	2003-2007	2.50	6.62	4.64	0.21	5.46↓**	38.88
Cranberry Marsh	2003-2006	1.88	1.02	7.26	0.00	9.25↓**	38.80
Lynde Creek Marsh	2002-2007	2.50	4.85	3.72	0.42	5.85	34.68
Corbett Creek Marsh	2003-2007	1.83	6.54	5.77	0.00	6.03↓**	40.35
Pumphouse Marsh	2003-2006	4.79	5.58	4.00	0.29	8.45	46.21
Oshawa Second Marsh	2003, 2005-2007	4.17	4.82	5.41	1.60	6.50	44.98
McLaughlin Bay Marsh	2003-2007	4.00	1.27	2.70	4.22	5.47	35.34
Westside Marsh	2003-2007	3.17↑**	2.37	5.08	0.82	4.46	31.79
Bowmanville Marsh	2003-2007	3.33	5.11	2.58	0.24	3.00↓**	28.52
Wilmot Creek Marsh	2003-2007	3.50	2.77	5.98	0.31	8.16	41.44
Port Newcastle Marsh	2003-2007	5.00	4.57	2.04	2.47	2.76	33.68
Grand Mean		**3.13**	**4.00**	**4.24**	**0.96**	**5.53**	**35.72**
± SD		**1.75**	**1.93**	**1.79**	**1.30**	**2.24**	**9.04**

Table E-3. Mean standardized aquatic macroinvertebrate community metrics and IBIs for Lake Ontario coastal wetlands from 2002-2007, where available. Metrics used in the calculation of the IBI include: number of Ephemeroptera and Trichoptera in a wetland (NEGT), number of macroinvertebrate families found within a wetland (NFAM), percentage of Crustacea and Mollusca (PCRM), percentage of Trichoptera within a wetland (PTRI), and percentage of Diptera within a wetland (PDIP). Wetlands are ordered vertically from west to east.

Lake Ontario Wetland	Years	NETG	NFAM	PCRM	PTRI	PDIP	Macroinvertebrate IBI
Jordan Station Marsh	2003	5.00	0.00	0.77	3.92	0.00	19.37
Port Britain Marsh	2002, 2003	0.00	2.59	4.87	0.00	0.70	16.30
Presqu'ile Bay Marsh	2002, 2003	8.33	4.64	4.41	6.29	5.84	59.01
Dead Creek Marsh	2006, 2007	6.67	10.00	1.28	4.36	7.98	60.57
Huyck's Bay Marsh	2002-2004	3.89	5.84	8.67	1.80	9.07	58.52
12 O'Clock Point Marsh	2006	6.67	4.10	1.49	0.00	8.27	41.05
Carrying Place Marsh	2006, 2007	8.33	7.34	2.64	5.11	8.50	63.84
Blessington Creek Marsh	2005-2007	7.22	5.18	6.40	4.31	9.08	64.37
Sawguin Creek North Marsh	2006, 2007	4.17	6.98	4.80	1.49	7.21	49.29
Sawguin Creek Central Marsh	2005-2007	6.11	5.95	3.93	3.74	8.35	56.16
Sawguin Creek Ditched Marsh	2006, 2007	5.00	6.26	4.29	0.65	5.92	44.24
Robinson's Cove Marsh	2002, 2003, 2005-2007	5.83	3.42	8.45	3.25	9.77	61.45
Lower Salmon River Marsh	2006	10.00	5.18	10.00	10.00	10.00	90.36
Big Island East Marsh	2005-2007	5.00	6.19	1.17	2.24	6.93	43.08
Big Island West Marsh	2005-2007	6.67	4.58	5.00	3.53	8.15	55.86
Marysville Creek Marsh	2006	3.33	5.54	10.00	0.00	10.00	57.75
Solmesville East Marsh	2006	6.67	8.78	9.97	0.97	10.00	72.77
Lower Sucker Creek Marsh	2006, 2007	4.17	6.51	6.75	0.00	9.68	54.21
Lower Sucker Creek East Marsh	2006	8.33	0.00	10.00	3.10	10.00	62.86
Airport Creek Marsh	2006, 2007	8.33	9.21	5.11	5.29	8.59	73.07
Forester's Island Marsh	2006	10.00	0.00	10.00	2.23	10.00	64.46
South Bay Marsh	2002, 2003	10.00	4.64	8.56	10.00	5.52	77.43
Big Sand Bay Marsh	2003, 2004	6.25	8.06	2.74	0.58	8.02	51.29
Carnachan Bay Marsh	2007	3.33	5.54	9.60	0.00	9.66	56.27
Lower Napanee River Marsh	2006, 2007	8.33	7.70	5.25	5.99	9.42	73.40
Hay Bay North Marsh	2002-2007	8.75	6.08	7.89	6.28	8.66	75.30

Table E-3. Continued

Lake Ontario Wetland	Year	NEGT	NFAM	PCRM	PTRI	PDIP	Macroinvertebrate IBI
Hay Bay South Marsh	2003, 2005-2007	7.50	4.34	8.08	7.77	9.90	75.15
Amherst Island Undiked Marsh	2004	2.50	1.40	3.62	0.00	8.77	32.57
Amherst Island Diked Marsh	2004	1.67	2.48	10.00	0.00	8.37	45.04
Parrott's Bay Marsh	2002-2005	6.67	6.76	8.68	1.38	7.79	62.55
Button Bay Marsh	2002, 2003	1.67	2.30	10.00	1.16	6.59	43.43
Bayfield Bay Marsh	2002, 2003	6.67	0.00	10.00	10.00	9.36	72.06
Grand Mean		**6.03**	**4.92**	**6.39**	**3.30**	**8.00**	**57.28**
± SD		**2.56**	**2.73**	**3.15**	**3.12**	**2.39**	**16.23**