Detroit River and St. Clair River Areas of Concern: Coastal Wetland Habitat Assessment Report

June 2012






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Executive Summary

The purpose of this document is to report on data collected in 2011 at selected coastal wetlands in the Detroit River Area of Concern (AOC), Area 1A of the St. Clair River AOC, and non-AOC wetlands along Lake St. Clair in order to assess the condition of coastal wetland habitat and biotic communities over time. Geophysical condition is assessed by calculating the Water Quality Index score and biotic condition is assessed using Index of Biotic Integrity scores for specific biotic communities; submerged aquatic vegetation, aquatic macroinvertebrates and breeding marsh birds at select wetlands in each AOC and non-AOC.

Water Quality Index Scores ranged from “highly degraded” to “good” and are typically “moderately degraded”. Water quality was consistent among AOCs and non-AOCs and indicates impacted conditions. The submerged aquatic vegetation (SAV) community Index of Biotic Integrity (IBI) rank ranged from “fair” to “excellent” and is typically “very good”. Similar to water quality, SAV IBI scores were consistent among the regions. The breeding marsh bird community Index of Biotic Integrity (Bird-IBI) rank ranged from “poor” to “excellent” and exhibits marked differences among AOCs and non-AOCs. The Detroit River AOC is typically “fair”, whereas the non-AOC and St. Clair River AOC are typically “excellent”. This highlights a major difference in wildlife population condition in the region. The aquatic macroinvertebrate community IBI (Invert-IBI) rank ranged from “fair” to “very good” and is typically “good”. Similar to marsh birds, aquatic macroinvertebrate community condition is slightly poorer in the Detroit River AOC than either the non-AOC or St. Clair River AOC. This report augments the baseline data collected during recent sampling using the same standardized methods. These baseline data will continue to aid in the understanding of the natural variation and condition of these wetlands over time and aid in the development of quantifiable delisting criteria.

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1.0 Introduction

In 1987, the International Joint Commission (IJC) identified the Detroit River and St. Clair River as two of 42 Great Lakes Areas of Concern (AOC) because they "*failed to meet the general or specific objectives of the Great Lakes Water Quality Agreement (GLWQA) where such failure has caused or is likely to cause impairment of beneficial uses or of the area's ability to support aquatic life*". Failure to meet the GLWQA in the Detroit River stemmed from contamination of sediment, point source pollution from urban and industrial sources, and non-point source inputs from surrounding watershed land uses. With respect to wildlife, concerns included changes in fish and wildlife community structure, loss of habitats, water and sediment quality impacts on biota, and exotic species. The St. Clair River was identified for failure to meet the GLWQA due to contaminant levels and the loss and degradation of aquatic habitat.

A standardized common set of impairments called Beneficial Use Impairments (BUIs) were created by the International Joint Commission (IJC) and cover a wide range of environmental and ecological concerns and aim to include a number of stakeholders into the delisting process.

This report covers impairments as they pertain to wildlife namely; BUI #3, *Degradation of fish and wildlife populations* and BUI #14 *Loss of fish and wildlife habitat*. Coastal wetlands provide a number of services including wildlife habitat and are therefore an important component of AOC remediation effort. Past reporting has presented standardized methods for assessing the geophysical and biotic condition of wetlands. This report provides a continuation of this sampling to build upon baseline data with sampling conducted in 2011 at 12 select coastal wetlands within the Huron-Erie Corridor (HEC; Figure 1, Figure 2). This allows for comparison among both AOCs and non-AOC wetlands within Lake St. Clair, and adds to a growing body of data within the region to aid in monitoring the long-term conditions and develop specific and quantifiable delisting criteria for these AOCs.

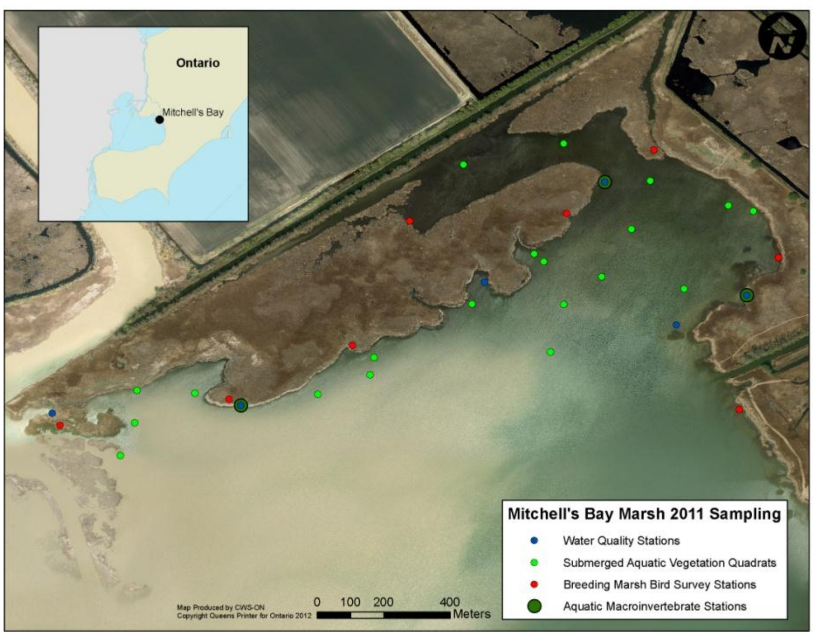

Figure 1. Representative wetland sampled in 2011 including all stations sampled for water quality, breeding marsh birds, submerged aquatic vegetation, and aquatic macroinvertebrates.

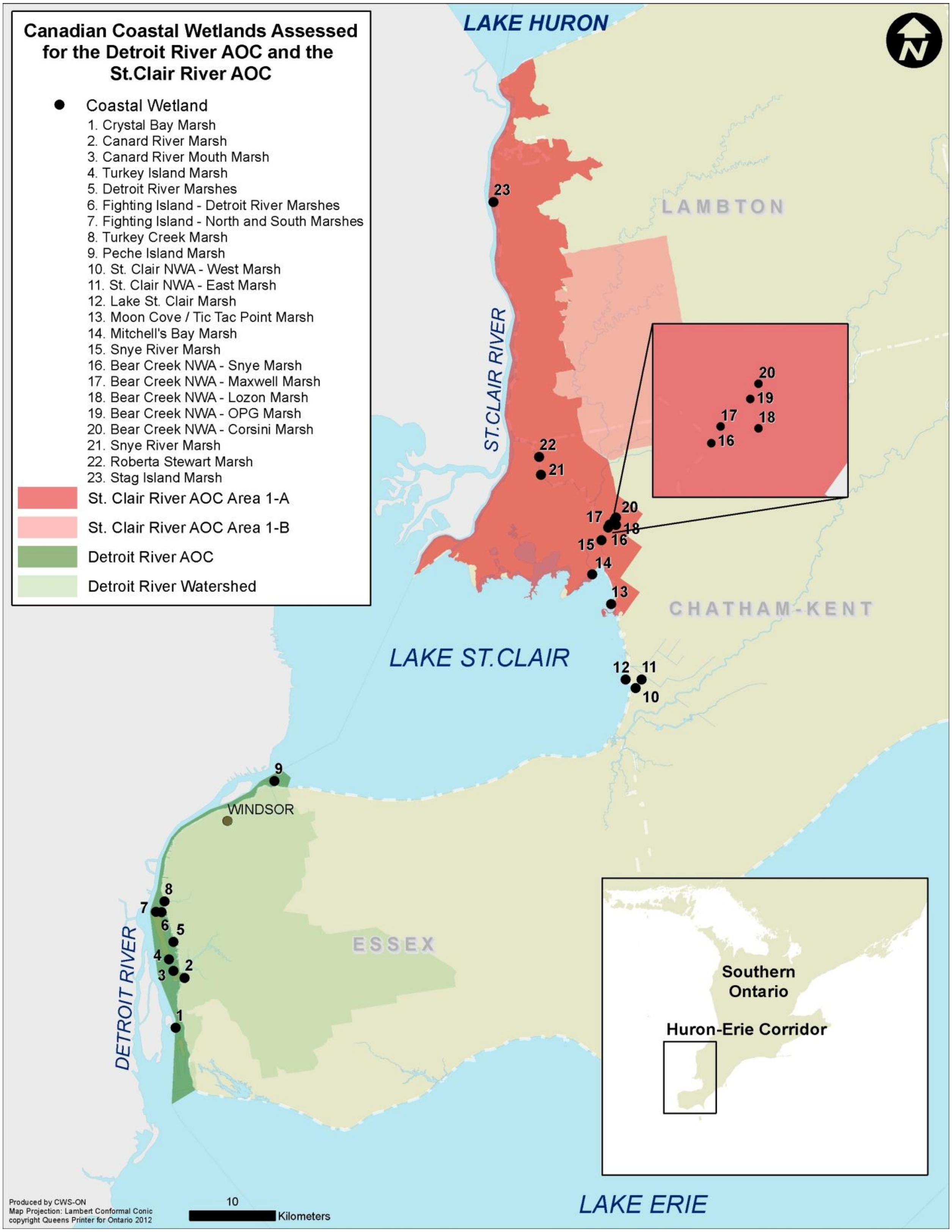

Figure 2. Coastal wetlands sampled from 2006 to 2011 in the Detroit River AOC, Lake St. Clair, and St. Clair River AOC.

2.0 Purpose of This Report

The purpose of this document is to report on the condition of coastal wetlands to assess the quality of coastal wetlands over time in the Detroit River and St. Clair River Areas of Concern (AOC). Habitat and biotic community data were collected in coastal wetlands within the Detroit River AOC, Area 1A of the St. Clair River AOC, and in non-AOC sites along Lake St. Clair (Figure 2). The focus of this report is the current conditions of wetlands from 2011 surveys and where available, the trends from earlier sampling.

A brief introduction and condensed methodologies are provided within each section. For more details about the Detroit River and St. Clair River AOCs, wildlife related Beneficial Use Impairments, coastal wetland study sites, and methods used for sampling and reporting, refer to Environment Canada – Canadian Wildlife Service (2008, 2009; herein EC–CWS) and Green et al. (2010).

3.0 Water Quality

Methodology

Water quality was measured using both *in situ* probes and chemical analyses. *In situ* water quality determination included 4 parameters (pH, conductivity [μS/cm], temperature [°C], and turbidity [NTU]) and was collected using a Hydrolab MS5™ or Yellow Springs Institute (YSI) 6600V2™ multiprobe at mid depth of the water column adjacent to emergent vegetation. Multiprobe sampling was conducted at all water quality stations (typically 6 per wetland) and every measure was taken to resample past stations. The 4 parameters measured are used to calculate the Water Quality Index (WQI; Equation 1), a tool for determining coastal wetland water quality in the Great Lakes (Chow-Fraser 2006).

Equation 1:

$$WQI = (-1.367148 * \log TURB) - (1.577380 * \log COND) - (1.628048 * \log TEMP) - (2.371337 * \log pH) + 9.2663224$$

where TURB = turbidity, COND = conductivity, and TEMP = temperature

Water samples for three additional nutrient parameters (Table 1) were collected at 4 of the 6 stations at each wetland and include: Total Nitrate Nitrogen (TNN), Total Ammonia Nitrogen (TAN), and Total Phosphorus (TP). TNN and TAN were analyzed in a field lab within 5 hours of sampling using colorimetry (Hach DR890 Colorimeter); and samples for TP were acidified and later analyzed by Environment Canada's National Laboratory for Environmental Testing (NLET; Burlington, Ontario).

Table 1. Water quality parameters measured in coastal wetlands including parameter relationships with increased disturbance.

Parameter	Units	Relationship with Increased Disturbance
In Situ		
Turbidity	NTU	↑ turbidity from algae, suspended sediments, and bioturbation
Conductivity	μS/cm	↑ conductivity from agricultural, industrial, urban inputs
Temperature	°C	↑ temperature from industrial/urban runoff and riparian vegetation removal
pH	pH	Changes in pH from photosynthesis affects nutrient availability
Nutrient		
Total Nitrate Nitrogen	mg/L	↑ nitrates from agricultural/urban runoff and wastewater and industrial discharge
Total Ammonia Nitrogen	mg/L	↑ ammonia from agricultural and industrial wastes; and sewage and septic leachate
Total Phosphorus	μg/L	↑ phosphorus from agricultural runoff, urban stormwater, and industrial discharge

Ranking Water Quality

The WQI was developed as a relative ranking tool to report on coastal wetland water quality in the Great Lakes Basin. WQI scores fit into six categories which correspond with values ranging from -3 to +3 (Table 2).

Table 2. Water Quality Index (WQI) score and associated category based on Chow-Fraser (2006).

WQI Score	Qualitative Descriptor
+3 to +2	Excellent
+2 to +1	Very good
+1 to 0	Good
0 to -1	Moderately degraded
-1 to -2	Very degraded
-2 to -3	Highly degraded

Results

Coastal wetlands in the Huron-Erie Corridor show signs of both degradation and good health with the majority of sites classified as “moderately degraded” (Table 3). More specifically, wetlands in the Detroit River AOC vary from “very degraded” to “good” but are typically degraded to some extent. Wetlands in Lake St. Clair (non-AOC) vary from “very degraded” to “moderately degraded” but are typically moderately degraded. Wetlands in the St. Clair River AOC vary from “highly degraded” to “good” but are typically moderately degraded (Table 3). Impaired water quality from the WQI is typically the result of elevated conductivity and turbidity and this is consistent among the bodies of water sampled (Table 4).

In general, over the time period sampled there are no clear trends in water quality across the region (Table 3). Some sites had similar WQI scores over multiple years such as Canard River Marsh, Turkey Creek Marsh, and St. Clair NWA – Bear Creek Unit (herein called Bear Creek NWA) - Maxwell Marsh. Other sites showed improvements in water quality over the sample period such as Detroit River Marshes, Lake St. Clair Marshes, Mitchell’s Bay Marsh, and Snye

River Marsh. Some sites showed variation in WQI score but remained within the same or adjacent descriptors (e.g., Moderately Degraded at Bear Creek NWA – OPG Marsh).

Table 3. Water Quality Index (WQI) Score and Rank for selected coastal wetlands in the Detroit River and St. Clair River Areas of Concern (AOC) and non-AOC sites in Lake St. Clair.

				WQI			
Wetland by AOC	**2004**	**2006**	**2007**	**2008**	**2011**	**Mean**	**Descriptor***
Detroit River							
Crystal Bay	-	-	-	0.20	-	**0.20**	Good
Canard River Marsh	-	-1.72	-	-	-1.77	**-1.75**	Very Degraded
Canard River Mouth Marsh	-	-0.76	-	-0.10	-	**-0.43**	Moderately Degraded
Turkey Island Marsh	-	-0.79	-	-0.32	-	**-0.55**	Moderately Degraded
Detroit River Marshes	-	-0.09	-	-0.35	0.49	**0.02**	Good
Fighting Island – Detroit River Marsh	-	-	-	-0.47	-	**-0.47**	Moderately Degraded
Fighting Island – North and South Marshes	-	-	-	-0.09	-	**-0.09**	Moderately Degraded
Turkey Creek Marsh	-	-1.07	-	-0.88	-1.08	**-1.01**	Very Degraded
Peche Island Marsh	-	-	-	0.13	0.75	**0.44**	Good
Non-AOC							
Lake St. Clair Marshes	-2.05	-	-	-1.86	0.42	**-1.16**	Very Degraded
St. Clair NWA – East Marsh	-0.49	-	-	0.21	-0.01	**-0.10**	Moderately Degraded
St. Clair NWA – West Marsh	-0.59	-	0.25	-0.09	-	**-0.14**	Moderately Degraded
St. Clair River							
Tic Tac Point / Moon Cove Marsh	-	-1.01	-	-0.23	-0.17	**-0.47**	Moderately Degraded
Mitchell's Bay Marsh	-0.74	-0.84	-	-0.26	0.16	**-0.42**	Moderately Degraded
Bear Creek NWA – Maxwell Marsh	-	-	0.04	-	-0.08	**-0.02**	Moderately Degraded
Bear Creek NWA – Lozon Marsh	-	-1.09	-0.04	-	-	**-0.57**	Moderately Degraded
Bear Creek NWA – OPG Marsh	-	-0.86	-0.16	-0.04	-0.14	**-0.30**	Moderately Degraded
Bear Creek NWA – Snye Marsh	-	-1.26	-0.09	-0.86	-	**-0.74**	Moderately Degraded
Bear Creek NWA – Corsini Marsh	-	-	-	-2.16	-	**-2.16**	Highly Degraded
Snye River South Marsh	-	-	-	-0.94	-	**-0.94**	Moderately Degraded
Snye River Marsh	-	-0.83	-	0.39	0.58	**0.05**	Good
Roberta Stewart Marsh	-	-1.03	-0.37	-1.43	-	**-0.94**	Moderately Degraded
Stag Island Marsh	-	-	-	-	0.90	**0.90**	Good

* based upon mean WQI value for years sampled

Similarly, there were no consistent patterns among the levels of ammonium-nitrogen, nitrate-nitrogen, dissolved oxygen, and total phosphorus (Table 5). Dissolved oxygen was not measured in 2011 and is not described in this report. In general, low levels of ammonia were measured during sampling events among wetlands and regions, and across years sampled. Nitrate levels are variable among wetlands, regions, and years sampled. Nitrate levels in the Detroit River are slightly elevated from 2011 sampling but are quite high (>1mg/L) from 2008 sampling especially at Canard River Marsh. Levels in the non-AOC and St. Clair River AOC sites are low (≤ 0.1mg/L) for 2011 and show some variation from previous sampling.

Overall, TP levels tend to be above the Provincial Water Quality Objectives (PWQO) limit of 30µg/L with few wetlands at or below this threshold. Wetlands in the Detroit River typically had lower levels of phosphorus than in the non-AOC sites and the St. Clair River AOC sites. Of note from 2011 sampling are Canard River Marsh having a high phosphorus level (174 µg/L) and Turkey Creek Marsh, Peche Island Marsh, St. Clair NWA East Marsh, and Bear Creek NWA-

OPG Marsh for having intermediate levels of phosphorus. Water analyzed from 2007 samples exhibit abnormally high levels of phosphorus which may indicate analytical errors and/or contamination.

Table 4. Mean water quality parameters and Water Quality Index (WQI) Scores for selected coastal wetlands in the Detroit River and St. Clair River Areas of Concern (AOC) and non-AOC sites in Lake St. Clair.

	Conductivity ($\mu S \bullet cm^{-1}$)				Turbidity (NTU)				Temperature (^{O}C)				pH				WQI Score			
Wetland Name	**2006**	**2007**	**2008**	**2011**	**2006**	**2007**	**2008**	**2011**	**2006**	**2007**	**2008**	**2011**	**2006**	**2007**	**2008**	**2011**	**2006**	**2007**	**2008**	**2011**
Detroit River																				
Crystal Bay	-	-	220.3	-	-	-	4.0	-	-	-	25.76	-	-	-	8.91	-	-	-	0.20	-
Canard River Marsh	-	-	452.5	522.7	-	-	50.7	43.1	-	-	28.0	29.60	-	-	7.79	7.79	-	-	-1.72	-1.77
Canard River Mouth Marsh	213.3	-	234.7	-	22.0	-	7.5	-	25.27	-	24.40	-	8.73	-	8.29	-	-0.76	-	-0.10	-
Turkey Island Marsh	218.3	-	219.1	-	25.6	-	10.4	-	23.37	-	24.18	-	8.56	-	8.84	-	-0.79	-	-0.32	-
Detroit River Marshes	202.3	-	237.2	215.1	27.8	-	14.5	3.1	24.94	-	21.15	26.19	9.15	-	7.84	7.85	-0.90	-	-0.35	0.49
Fighting Island – Detroit River Marsh	-	-	222.0	-	-	-	14.7	-	-	-	25.35	-	-	-	8.11	-	-	-	-0.47	-
Fighting Island – North and South Marshes	-	-	413.6	-	-	-	4.8	-	-	-	23.8	-	-	-	7.36	-	-	-	-0.09	-
Turkey Creek Marsh	312.3	-	304.3	477.7	26.4	-	16.4	14.6	23.87	-	25.92	27.18	8.59	-	9.00	8.39	-1.07	-	-0.88	-1.08
Peche Island Marsh	-	-	218.1	217.2	-	-	5.2	2.3	-	-	25.50	23.79	-	-	8.28	7.71	-	-	0.13	0.75
Non-AOC																				
Lake St. Clair Marshes	470.3	354.7	436.9	249.8	93.7	2.3	57.3	2.3	23.17	28.58	29.47	28.00	8.31	-	8.24	8.56	-2.05	-	-1.86	0.42
St. Clair NWA – East Marsh	374.3	421.9	326.5	347.4	9.6	5.1	4.1	4.4	24.44	24.41	23.42	27.75	7.62	-	7.12	7.26	-0.49	-	0.21	-0.01
St. Clair NWA – West Marsh	353.3	427.6	348.6	-	12.4	2.9	5.1	-	24.48	18.20	28.27	-	7.56	8.38	7.03	-	-0.59	0.25	-0.09	-
St. Clair River																				
Tic Tac Point / Moon Cove Marsh	213.3	199.3	217.3	223.2	32.7	17.7	7.9	6.3	26.04	20.34	26.59	29.48	8.69	-	9.01	8.83	-1.01	-	-0.23	-0.17
Mitchell's Bay Marsh	266.8	219.5	254.0	221.2	23.0	8.8	10.1	4.5	24.94	22.91	23.08	27.2	8.01	-	8.01	8.24	-0.84	-	-0.26	0.16
Bear Creek NWA – Maxwell Marsh	-	373.5		323.3	-	4.4	-	7.3	-	21.97	-	22.09		7.78	-	7.09	-	0.04	-	-0.08
Bear Creek NWA – Lozon Marsh	350.3	381.3		-	31.4	5.5	-	-	22.68	20.05	-	-	7.57	7.71	-	-	-1.09	-0.04	-	-
Bear Creek NWA – OPG Marsh	307.0	352.2	384.9	237.3	18.8	5.5	4.5	7.9	26.82	22.84	25.01	25.18	8.00	8.34	7.36	8.09	-0.86	-0.16	-0.04	-0.14
Bear Creek NWA – Snye Marsh	524.0	451.6	362.1	-	23.3	3.6	17.9	-	24.31	24.71	26.37	-	7.78	8.04	7.45	-	-1.26	-0.09	-0.86	-
Bear Creek NWA – Corsini Marsh	-		685.7	-	-	-	65.9	-	-	-	27.62	-	-	-	7.87	-	-	-	-2.16	-
Snye River South Marsh	-		245.7	-	-	-	26.9	-	-	-	25.07	-	-	-	8.51	-	-	-	-0.94	-
Snye River Marsh	221.3	278.3	221.1	204.7	27.0	3.5	4.4	2.7	26.64	24.16	23.67	26.7	7.81	-	7.42	7.92	-0.83	-	0.39	0.58
Roberta Stewart Marsh	318.0	412.8	412.8	-	24.8	5.6	27.9	-	25.17	23.29	29.86	-	8.19	8.99	8.42	-	-1.03	-0.37	-1.43	-
Stag Island Marsh	-	-	-	276.6	-	-	-	1.2	-	-	-	24.92	-	-	-	7.84	-	-	-	0.90

Table 5. Additional water quality parameters collected for selected coastal wetlands in the Detroit River and St. Clair River Areas of Concern (AOC) and non-AOC sites in Lake St. Clair.

	Dissolved Oxygen (mg/L)					Total Ammonia Nitrogen (mg/L)					Total Nitrate Nitrogen (mg/L)					Total Phosphorus (µg/L)				
Wetland Name	**2004**	**2006**	**2007**	**2008**	**2011**	**2004**	**2006**	**2007**	**2008**	**2011**	**2004**	**2006**	**2007**	**2008**	**2011**	**2004**	**2006**	**2007**	**2008**	**2011**
Detroit River																				
Crystal Bay	-	-	-	0.33	-	-	-	-	0.04	-	-	-	-	0.70	-	-	-	-	10	-
Canard River Marsh	-	-	-	0.40	-	-	-	-	0.17	0.25	-	-	-	5.00	0.50	-	-	-	170	174
Canard River Mouth Marsh	-	8.53	-	0.23	-	-	0.01	-	0.05	-	-	0.77	-	1.50	-	-	30	-	20	-
Turkey Island Marsh	-	8.63	-	10.68	-	-	0.02	-	0.02	-	-	1.30	-	1.30	-	-	30	-	20	-
Detroit River Marshes	-	10.90	-	5.86	-	-	0.02	-	0.01	0	-	0.37	-	1.37	0.15	-	30	-	20	44
Fighting Island – Detroit River Marsh	-	-	-	1.60	-	-	-	-	0.02	-	-	-	-	1.83	-	-	-	-	20	-
Fighting Island – North and South Marshes	-	-	-	0.27	-	-	-	-	0.06	-	-	-	-	1.77	-	-	-	-	120	-
Turkey Creek Marsh	-	6.78	-	4.76	-	-	0.04	-	0.02	0.08	-	0.6	-	2.27	0.18	-	30	-	20	70
Peche Island Marsh	-	-	-	9.43	-	-	-	-	0.02	0.04	-	-	-	1.07	0.25	-	-	-	40	65
Non-AOC																				
Lake St. Clair Marshes	7.51	-	10.27	8.65	-	-	-	0.04	0.05	0.02	1.30	-	0.93	-	0.05	100	-	40	80	30
St. Clair NWA – East Marsh	3.04	-	7.05	0.88	-	-	-	0.04	0.01	0.03	0.60	-	0.80	-	0.075	60	-	40	-	66
St. Clair NWA – West Marsh	3.54	-	3.21	3.82	-	-	-	0.03	0.01	-	0.57	-	0.03	-	-	30	-	80	-	-
St. Clair River																				
Tic Tac Point / Moon Cove Marsh	-	6.62	4.42	9.41	-	-	0.08	0.11	0.01	0.07	-	0.90	0.47	-	0	-	30	490	40	49
Mitchell's Bay Marsh	3.84	5.56	6.11	6.45	-	-	0.03	0.04	0.02	0.015	0.87	2.01	0.85	-	0.075	30	40	30	30	29
Bear Creek NWA – Maxwell Marsh	-	-	5.42	-	-	-	-	0.03	-	0.003	-	-	0.43	-	0.075	-	-	200	-	29
Bear Creek NWA – Lozon Marsh	-	4.64	4.24	-	-	-	0.04	0.03	-	-	-	3.33	0.23	-	-	-	270	220	-	-
Bear Creek NWA – OPG Marsh	-	6.77	5.98	2.96	-	-	0.00	0.05	0.01	0.003	-	1.00	0.10	-	0.05	-	50	280	50	67
Bear Creek NWA – Snye Marsh	-	3.45	7.28	5.13	-	-	0.04	0.03	0.01	-	-	0.93	0.37	-	-	-	40	140	40	-
Bear Creek NWA – Corsini Marsh	-	-	8.33	5.20	-	-	-	-	0.10	-	-	-	-	-	-	-	-	-	80	-
Snye River South Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
Snye River Marsh	-	6.22	6.97	5.86	-	-	0.02	0.01	0.01	0.01	-	1.3	1.07	-	0.075	-	10	20	20	36
Roberta Stewart Marsh	-	2.05	6.28	10.23	-	-	0.09	0.15	0.03	-	-	1.23	0.33	-	-	-	260	400	200	-
Stag Island Marsh	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	0.10	-	-	-	-	12

Discussion

Water Quality Index scores indicate that HEC coastal wetlands are typically "*moderately degraded*" although there are some wetlands that are "*very degraded*" and others that are "*good*" with respect to water quality. In general, AOC sites were comparable to non-AOC Lake St. Clair coastal wetlands. These data indicate that the condition of coastal wetlands in the region has been fairly consistent over time.

Southwestern Ontario was one of the most wetland-rich regions pre-European settlement and has suffered the greatest rates of wetland loss from conversion to alternate land uses (Snell 1987, DUC 2010). The remaining wetlands experience disturbance from nutrient and sediment loadings from high intensity agriculture throughout the region; and dense industry and urban centres along the Detroit and upper St. Clair rivers (Maynard and Wilcox 1997, Green et al. 2010). The ancillary water quality parameters collected (TAN, TNN, and TP) indicate non-point source pollution in the form of nitrogen derivatives and phosphorus which are consistent with agricultural and urban runoff. The more disturbed wetlands tended to be those that have the greatest connectivity to the watershed (drowned river mouths) and the least disturbed tended to be along islands in large rivers.

Vegetated riparian buffers could play a large role in the improvement of tributary water quality which would ultimately enhance wetland water quality downstream. Their nutrient and sediment sequestering qualities as well the ability to moderate water temperature would greatly benefit the region's wetlands. As suggested in past reporting, creating wetland habitat at the end of drains would greatly limit the load on wetlands downstream.

4.0 Submerged Aquatic Vegetation Community

Methodology

The submerged aquatic vegetation community (SAV) was surveyed by sampling a one-metre square quadrat at 20 random locations in the open water basin of each wetland. Quadrat locations were randomly generated in a Geographic Information System (GIS) prior to sampling. Within each quadrat, total areal coverage and species-specific coverages for submerged and floating-leaved species were recorded (see Appendix 1 for a list of SAV species).

SAV community condition is determined using an Index of Biotic Integrity (IBI). SAV species were grouped into two plant guilds based on growing tolerance (e.g., turbidity tolerant and turbidity intolerant) and native designation (EC and CLOCA 2004; Grabas et al. 2012). A Floristic Quality Index (FQI) was calculated based on a numerical score called a *Coefficient of Conservatism* (Oldham et al. 1995). This methodology takes into account a plant's tolerance to disturbance, fidelity to a natural habitat and native designation. Five metrics were shown to significantly respond to disturbance (SINT – number of turbidity-intolerant species, PINT – relative percentage of cover of turbidity-intolerant species, FQI, PCOV – total coverage, and SNAT – total number of native species). Metrics were then standardized into a range from 0 to 10 (EC and CLOCA 2004; Grabas et al. 2012). They were then added, multiplied by 10 and divided by the total number of metrics to create an IBI with scores between 0 and 100. Five classes were identified in which minimum detectable differences could be distinguished (Table 6).

Table 6. Index of biotic integrity (IBI) score and associated category based on EC-CLOCA (2004).

IBI Score	Qualitative Descriptor
81-100	Excellent
61-80	Very good
41-60	Good
21-40	Fair
0-20	Poor

Results

In general, SAV community condition in the Huron-Erie Corridor is "*very good*" (Table 7). With the exception of Canard River Marsh, Roberta Stewart Marsh, and Stag Island Marsh; wetlands scored in the "*very good*" and "*excellent*" categories. Over time, some wetlands; however, showed large variation in IBI scores and are worth noting. Canard River Mouth Marsh SAV IBI scores decreased from 95 (2006) to 63 (2008), Turkey Creek Marsh decreased from 97 (2006) to 37 (2011), and Snye River Marsh experienced a consistent decline from 94 (2006) to 46 (2011) (Table7).

Wetlands in good condition typically have greater species richness of turbidity intolerant and native taxa; high floristic quality; and high total coverage. These sites were classified as good, very good, and excellent (Table 8). Wetlands in poorer condition exhibited low richness of turbidity intolerant taxa, are less vegetated with high proportions of turbidity intolerant species. These wetlands were classified as Poor and Fair (Table 8).

Table 7. Index of Biotic Integrity (IBI) and Rank for the condition of the submerged aquatic vegetation community in selected St. Clair River Area of Concern coastal wetlands. IBI and Rank based on EC and CLOCA (2004).

Wetland by AOC	Index of Biotic Integrity					Rank (based on mean or most recent data)
	2006	2007	2008	2011	Mean	
Detroit River						
Canard River Marsh	-	-	59.29	18.96	**39.13**	Fair
Canard River Mouth Marsh	95.73	-	63.86	-	**79.80**	Very Good
Turkey Island Marsh	75.19	-	65.89	-	**70.54**	Very Good
Detroit River Marshes	95.73	-	93.20	75.28	**88.07**	Excellent
Fighting Island – Detroit River Marsh	-	-	72.67	-	**72.67**	Very Good
Fighting Island – North and South Marshes	-	-	65.05	-	**65.05**	Very Good
Turkey Creek Marsh	97.30	-	68.02	37.83	**67.72**	Very Good
Peche Island Marsh	-	-	78.67	64.38	**71.53**	Very Good
Non-AOC						
Lake St. Clair Marshes	-	-	-	71.26	**71.26**	Very Good
St. Clair NWA – East Marsh	-	-	-	71.36	**71.36**	Very Good
St. Clair NWA – West Marsh	-	-	-	-	**-**	-
St. Clair River						
Tic Tac Point / Moon Cove Marsh	82.10	90.21	60.76	75.04	**77.03**	Very Good
Mitchell's Bay Marsh	94.99	88.84	79.36	90.44	**88.41**	Excellent
Bear Creek Unit – OPG Marsh	64.84	61.48	60.00	75.66	**65.50**	Very Good
Bear Creek Unit – Lozon Marsh	74.21	79.96	-	-	**77.08**	Very Good
Bear Creek Unit – Maxwell Marsh	-	77.54	-	83.94	**80.74**	Excellent
Bear Creek Unit – Snye Marsh	84.67	79.19	73.53	-	**79.13**	Very Good
Snye River Marsh	94.62	85.74	63.10	46.41	**72.47**	Very Good
Roberta Stewart Marsh	58.24	58.80	59.84	-	**58.96**	Good
Stag Island Marsh	-	-	-	22.55	**22.55**	Fair

Table 8. SAV community IBI scores (out of 100) and standardized metrics (out of 10) for coastal wetlands sampled in 2011 in the Detroit River AOC, Lake St. Clair, and St. Clair River AOC.

	2011 Metrics					IBI
Wetland Name	**SINT**	**PINT**	**FQI**	**PCOV**	**SNAT**	**2011**
Detroit River						
Canard River Marsh	0.00	0.00	6.30	1.31	1.87	**18.96**
Detroit River Marshes	7.25	4.48	10.00	8.85	7.06	**75.28**
Turkey Creek Marsh	2.82	2.60	5.79	1.66	6.05	**37.83**
Peche Island Marsh	5.24	1.48	8.70	8.86	7.92	**64.38**
Non-AOC						
Lake St. Clair Marshes	7.25	6.71	8.54	5.64	7.49	**71.26**
St. Clair NWA – East Marsh	4.03	1.65	10.00	10.00	10.00	**71.36**
St. Clair River						
Tic Tac Point / Moon Cove Marsh	7.66	8.34	9.25	6.08	6.19	**75.04**
Mitchell's Bay Marsh	9.67	5.55	10.00	10.00	10.00	**90.44**
Bear Creek Unit – OPG Marsh	4.43	3.40	10.00	10.00	10.00	**75.66**
Bear Creek Unit – Maxwell Marsh	9.27	2.70	10.00	10.00	10.00	**83.94**
Snye River Marsh	3.63	2.87	6.27	5.25	5.18	**46.41**
Stag Island Marsh	0.81	0.19	3.96	2.72	3.60	**22.55**

SINT	Number of turbidity-intolerant species
PINT	Relative % cover of turbidity-intolerant species
FQI	Floristic Quality Index
PCOV	Total coverage
SNAT	Total number of native species

Discussion

Among the three regions sampled, average SAV IBI scores are similar and are ranked as "*very good*". Detroit River and St. Clair River AOCs show similarity in the levels of variation in SAV community condition from sites with fair to excellent communities. Similarly, several wetlands exhibit stability in SAV condition and others exhibit considerable change over time. In this report we do not illustrate consistent trends in SAV community condition and recommend that SAV community sampling continue to better understand the natural levels of variability in SAV community conditions over time to develop robust delisting criteria. Major contributors to poor SAV community health are turbid conditions impeding plant growth and the exclusion of native species by invasive species. Improvements in water quality especially turbidity, would greatly improve the condition of SAV communities and highlights the added benefits of enhancing wetland condition and connectedness of wetland functions.

5.0 Breeding Bird Community

Methodology

Breeding marsh bird communities were surveyed using a modification to the Marsh Monitoring Program protocol (Meyer et al. 2006) to report on site-level or specific AOC wetland bird communities. The primary purpose of the MMP is to assess population trends of common marsh bird species across broad geographic scales and/or long timeframes. Bird survey stations were identified using aerial photographs and set up at least 250 m apart. Only those that had at least 50% of marsh habitat (i.e., non-woody emergent plants) within the sampling radius (100m) were surveyed. Marsh bird surveys were conducted using a 15-min point count - five minutes of passive surveying followed by five minutes of call broadcasting for secretive species (e.g., Virginia Rail, Sora, Least Bittern, Common Moorhen / American Coot, and Pied-billed Grebe) followed by five minutes of passive surveying (see Appendix 2 for a list of bird species).

The GLCWC (2008) developed a method to report on the condition of marsh breeding bird communities in Great Lakes coastal wetlands using an IBI. Four metrics were used to calculate the breeding bird IBI (Bird IBI) are as follows: SAMNO (number of area-sensitive marsh-nesting obligates); PMNO (% of marsh-nesting obligates); and PNAF (% of non-aerial foragers). These metrics are expected to decrease with increasing disturbance.

Results

Overall, breeding bird community condition was dichotomous; from “fair” condition in the Detroit River AOC wetlands to “very good” and “excellent” condition elsewhere (Table 9). This separation appears to be the result of a lack of area-sensitive marsh-nesting obligates and small proportion of marsh-nesting obligates in Detroit River wetlands (Table 10). The St. Clair River AOC wetlands are approaching the condition of the non-AOC Lake St. Clair wetlands; however, Lake St. Clair coastal wetlands support some of the highest quality marsh bird communities in the Lower Great Lakes.

Table 9. Marsh breeding bird community IBI (Bird-IBI) score and rank for selected coastal wetlands in the Detroit River and St. Clair River Areas of Concern (AOC) and non-AOC sites in Lake St. Clair.

	Bird -IBI				
Wetland by AOC	**2007**	**2008**	**2011**	**Mean**	**Descriptor***
Detroit River					
Crystal Bay	-	-	-	**-**	-
Canard River Marsh	-	48.14	55.50	**51.82**	Good
Canard River Mouth Marsh	-	56.37	-	**56.37**	Good
Turkey Island Marsh	-	0.43	-	**0.43**	Poor
Detroit River Marshes	-	40.62	42.02	**41.32**	Good
Fighting Island – Detroit River Marsh	-	-	-	**-**	-
Fighting Island – North and South Marshes	-	31.26	-	**31.26**	Fair
Turkey Creek Marsh	-	35.71	40.74	**38.23**	Fair
Peche Island Marsh	-	32.03	33.33	**32.68**	Fair
Non-AOC					
Lake St. Clair Marshes	93.75	-	100	**96.89**	Excellent
St. Clair NWA – East Marsh	97.84	-	100	**98.92**	Excellent
St. Clair NWA – West Marsh	97.26	-	-	**97.26**	Excellent
St. Clair River					
Tic Tac Point / Moon Cove Marsh	62.52	-	91.44	**76.98**	Very Good
Mitchell's Bay Marsh	87.17	-	86.90	**87.04**	Excellent
Bear Creek NWA – Maxwell Marsh	54.29	-	99.30	**76.80**	Very Good
Bear Creek NWA – Lozon Marsh	86.00	-	-	**86.00**	Excellent
Bear Creek NWA – OPG Marsh	83.52	-	93.85	**88.69**	Excellent
Bear Creek NWA – Snye Marsh	90.36	-	-	**90.36**	Excellent
Bear Creek NWA – Corsini Marsh	-	-	-	**-**	-
Snye River South Marsh	-	-	-	**-**	-
Snye River Marsh	89.24	-	80.50	**84.87**	Excellent
Roberta Stewart Marsh	74.21	-	-	**74.21**	Very Good
Stag Island Marsh	-	-	67.31	**67.31**	Very Good

* based upon mean IBI value for years sampled

Table 10. Breeding bird community IBIs (out of 100) and standardized metrics (out of 10) for coastal wetlands sampled in 2011.

Wetland by AOC	SAMNO	PMNO	PNAF	2011 Bird-IBI
Detroit River				
Canard River Marsh	2.92	3.73	10.00	**55.50**
Detroit River Marshes	0.00	2.61	10.00	**42.02**
Turkey Creek Marsh	0.00	2.22	10.00	**40.74**
Peche Island Marsh	0.00	0.00	10.00	**33.33**
Non-AOC				
Lake St. Clair Marsh	10.00	10.00	10.00	**100**
St. Clair NWA – East Marsh	10.00	10.00	10.00	**100**
St. Clair River				
Moon Cove – Tic Tac Point Marsh	10.00	10.00	7.43	**91.44**
Mitchell's Bay Marsh	6.56	10.00	9.51	**86.90**
Bear Creek NWA – Maxwell Marsh	10.00	9.79	10.00	**99.30**
Bear Creek NWA – OPG Marsh	10.00	10.00	8.15	**93.85**
Snye River Marsh	5.83	10.00	8.32	**80.50**
Stag Island Marsh	8.75	1.44	10.00	**67.31**

Metrics:	SAMNO = Number of area-sensitive marsh-nesting obligates (formerly "SMAS") PMNO = Proportion of marsh-nesting obligates PNAF = Proportion of non-aerial foragers

Discussion

There is a major difference in the condition of breeding marsh bird communities between the Detroit River AOC and St. Clair River AOC. The Detroit River wetlands exhibit communities that are indicative of disturbed conditions, whereas in the St. Clair River AOC and Lake St. Clair, marsh bird communities score near or at the top of the IBI scale. These differences cannot be attributed to a single factor; however, habitat encroachment from urban development and habitat loss from shoreline hardening have resulted in the remaining coastal wetlands existing as small fringing units that do not support many area-sensitive and marsh obligate species. Larger wetlands that remain such as Canard River, are heavily impacted by watershed inputs and do not support the quality of habitat necessary for these species.

The wetlands remaining in the St. Clair River AOC exist in small units in the river proper but exist as a network of wetlands along the Snye River and large marshes of the St.Clair River Delta which is known to support many target guilds and species. Lake St. Clair wetlands act as a contiguous swath of wetland along a portion of the shoreline and scored extremely well and highlight the importance of the St. Clair National Wildlife Areas in providing high quality habitat for marsh birds.

6.0 Aquatic Macroinvertebrate Community

Methodology

For each wetland, three replicate sub-samples of approximately 150 nektonic and epiphytic aquatic macroinvertebrates (≥500μm) were taken by sweep-netting through the water column in the cattail-dominated or flooded common reed emergent communities. Macroinvertebrates were identified to the lowest taxonomic group possible.

Burton et al. (2008) include recommendations for an aquatic macroinvertebrate community IBI through the Great Lakes Coastal Wetland Consortium (www.glc.org/wetlands). Five metrics were used that have shown a significant association with disturbance (Table 9). Most metrics (e.g., number of Odonata genera [NODO] and percent Trichoptera [PTRI]) have been shown to decrease with disturbance while others (e.g., percent Diptera [PDIP]) have been shown to increase with disturbance (Merrit and Cummins 1996, EC and CLOCA 2004).

Results

The Macroinvertebrate IBI scores change slightly by region. The Detroit River AOC wetlands scored from “fair” to “very good” but are typically “good”. The non-AOC Lake St. Clair wetlands scored from “good” to “very good” but are typically “very good”. The St. Clair River AOC wetlands scored from “good” to “very good” but are typically “very good”. There is considerable variation in IBI scores over time with no consistent trend among wetlands. Regionally, the Detroit River wetlands scored lower than both the non-AOC and St. Clair River AOC wetlands (Table 11).The variation in IBI scores does not appear to be driven by specific metric values as variation exists among sites and regions (Table 12).

Table 11. Index of Biotic Integrity (IBI) for the condition of the aquatic macroinvertebrate community for selected coastal wetlands in the Detroit River and St. Clair River Areas of Concern (AOC) and non-AOC sites in Lake St. Clair.

	Aquatic Macroinvertebrate IBI					
Wetland by AOC	**2006**	**2007**	**2008**	**2011**	**Mean**	**Descriptor ***
Detroit River						
Canard River Marsh	-	-	31.90	44.26	**38.08**	Fair
Canard River Mouth Marsh	50.40	-	28.00	-	**39.20**	Fair
Turkey Island Marsh	65.40	-	8.90	-	**37.20**	Fair
Detroit River Marshes	54.20	-	71.40	61.19	**62.26**	Very Good
Fighting Island – Detroit River Marsh	-	-	40.30	-	**40.30**	Fair
Fighting Island – North and South Marshes	-	-	48.30	-	**48.30**	Good
Turkey Creek Marsh	60.30	-	45.00	26.60	**43.97**	Good
Peche Island Marsh	-	-	54.70	51.33	**53.02**	Good
Non-AOC						
Lake St. Clair Marshes	51.00	56.30	-	59.84	**55.71**	Good
St. Clair NWA – East Marsh	-	69.90	-	74.25	**72.08**	Very Good
St. Clair NWA – West Marsh	-	77.20	-	-	**77.20**	Very Good
St. Clair River						
Tic Tac Point / Moon Cove Marsh	68.70	73.60	57.50	69.55	**67.34**	Very Good
Mitchell's Bay Marsh	40.30	54.50	59.80	79.11	**58.43**	Good
Bear Creek Unit – OPG Marsh	48.40	69.50	52.50	65.17	**58.89**	Good
Bear Creek Unit – Lozon Marsh	46.40	85.60	-	-	**66.00**	Very Good
Bear Creek Unit – Maxwell Marsh	-	60.10	-	77.46	**68.78**	Very Good
Bear Creek Unit – Snye Marsh	44.60	65.50	49.20	-	**53.10**	Good
Snye River Marsh	68.20	86.90	72.10	47.72	**68.73**	Very Good
Roberta Stewart Marsh	50.30	65.10	54.00	-	**56.47**	Good
Stag Island Marsh	-	-	-	79.96	**79.96**	Very Good

* based upon mean IBI value for years sampled

Table 12. Aquatic Macroinvertebrate community IBIs (out of 100) and standardized metrics (out of 10) for coastal wetlands sampled in 2011.

Wetland by AOC	NETG	NFAM	NODO	PTRI	PDIP	2011 IBI
Detroit River						
Canard River Marsh	10.00	0.00	5.88	6.25	0.00	**44.26**
Detroit River Marshes	10.00	3.61	6.86	5.30	4.83	**61.19**
Turkey Creek Marsh	6.45	0.85	2.94	3.05	0.00	**26.60**
Peche Island Marsh	6.45	7.54	2.94	6.57	2.16	**51.33**
Non-AOC						
Lake St. Clair Marshes	9.68	0.00	1.96	9.00	9.28	**59.84**
St. Clair NWA – East Marsh	8.07	9.90	2.94	10.00	6.22	**74.25**
St. Clair River						
Tic Tac Point / Moon Cove Marsh	10.00	0.85	3.92	10.00	10.00	**69.55**
Mitchell’s Bay Marsh	10.00	5.18	9.80	8.28	6.29	**79.11**
Bear Creek Unit – OPG Marsh	8.07	10.00	3.92	8.47	8.28	**77.46**
Bear Creek Unit – Maxwell Marsh	8.07	7.15	3.92	5.20	8.26	**65.17**
Snye River Marsh	9.68	9.51	2.94	1.73	0.00	**47.72**
Stag Island Marsh	10.00	9.51	6.86	4.72	8.89	**79.96**

Metrics:	NETG = Number of Ephemeroptera and Trichoptera
	NFAM = Number of families
	NODO = Number of Odonata
	PTRI = Proportion of Trichoptera
	PDIP = Proportion of Diptera

Discussion

The results from the aquatic macroinvertebrate IBI highlights the importance of using a multimetric approach in IBI development as no single metric appeared to drive IBI scores. This also illustrates that, despite wetlands being characterized as being in "good" or "very good" condition, certain metrics are still negatively impacted and that disturbance remains.

The utility of using aquatic macroinvertebrates to assess coastal wetland health cannot be understated as these organisms spend a large proportion of their life cycle in water and act as an indicator of conditions on a longer scale than discrete water quality sampling. In addition, the GLCWC methodology utilized here is standardized for the Great Lakes and can be used in regional comparisons across the basin. This is important in the development of specific delisting criteria and for comparisons with non-AOC conditions. It is recommended that aquatic macroinvertebrate community monitoring continue to support the reporting on coastal wetland habitat condition in this region to fully understand variability in condition at multiple time scales.

7.0 Summary

This report describes the condition of coastal wetlands in the Huron-Erie Corridor (Detroit River AOC, Lake St. Clair, and St. Clair River AOC) with water chemistry and three separate IBIs for SAV, aquatic macroinvertebrates, and breeding bird communities. Overall, wetland condition ranged widely from highly degraded to excellent, with a large proportion of sites exhibiting evidence of being in "good" condition (Table 13).

Table 13. Summary of index scores and ranks for water quality (from -3 to +3), submerged aquatic vegetation (SAV), aquatic macroinvertebrates (Inverts), and breeding marsh bird communities (Birds) (from 0 to 100) of selected coastal wetlands in the Detroit River and St. Clair River Areas of Concern (AOC) and non-AOC sites in Lake St. Clair.

	Mean Index Score*			
Wetland by AOC	**WQI**	**SAV-IBI**	**Bird-IBI**	**Invert-IBI**
Detroit River				
Crystal Bay	0.20	-	-	-
Canard River Marsh	-1.75	39.13	51.82	38.08
Canard River Mouth Marsh	-0.43	79.80	56.37	39.20
Turkey Island Marsh	-0.55	70.54	0.43	37.20
Detroit River Marshes	0.02	88.07	41.32	62.26
Fighting Island – Detroit River Marsh	-0.47	72.67	-	40.30
Fighting Island – North and South Marshes	-0.09	65.05	31.26	48.30
Turkey Creek Marsh	-1.01	67.72	38.23	43.97
Peche Island Marsh	0.44	71.53	32.68	53.02
Non-AOC				
Lake St. Clair Marshes	-1.16	71.26	96.89	55.71
St. Clair NWA – East Marsh	-0.10	71.36	98.92	72.08
St. Clair NWA – West Marsh	-0.14	-	97.26	77.20
St. Clair River				
Tic Tac Point / Moon Cove Marsh	-0.47	77.03	76.98	67.34
Mitchell's Bay Marsh	-0.42	88.41	87.04	58.43
Bear Creek NWA – Maxwell Marsh	-0.02	65.50	76.80	68.78
Bear Creek NWA – Lozon Marsh	-0.57	77.08	86.00	66.00
Bear Creek NWA – OPG Marsh	-0.30	80.74	88.69	58.89
Bear Creek NWA – Snye Marsh	-0.74	79.13	90.36	53.10
Bear Creek NWA – Corsini Marsh	-2.16	72.47	-	-
Snye River South Marsh	-0.94	58.96	-	-
Snye River Marsh	0.05	22.55	84.87	68.73
Roberta Stewart Marsh	-0.94	39.13	74.21	56.47
Stag Island Marsh	0.90	79.80	67.31	79.96

IBI Key:	Poor	Fair	Good	Very Good	Excellent

WQI Key	Highly Degraded	Very Degraded	Moderately Degraded	Good	Very Good	Excellent

* based upon mean index value for years sampled

Water quality was similar among AOCs and non-AOCs. In general, index scores have indicated moderate levels of degradation in the Huron-Erie Corridor. Similarly, submerged aquatic vegetation condition exhibits some variability but is consistent among waterbodies. It is however, classified as being in “good” condition with few wetlands showing signs of high levels of disturbance. Breeding marsh bird community condition exhibits a major difference between AOCs. The Detroit River AOC wetlands have poorer marsh bird community condition than both the non-AOC and St. Clair River AOC wetlands. The St. Clair River bird communities are in “very good” condition and highlight the importance of this area for bird populations. Similarly, aquatic macroinvertebrate community condition is slightly poorer in the Detroit River AOC than either the non-AOC or St. Clair River AOC and provides insight into the long-term water quality conditions of the region. This report outlines the conditions in the Huron-Erie Corridor coastal wetlands and provides key baseline monitoring data for the region.

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Appendix 1

List of submerged aquatic vegetation (SAV) species observed during 2011 surveys.

.

Common Name	Genus/Species	Native	Turbidity -Tolerant	Coefficient of Conservatism
American lotus	*Nelumbo lutea*	√		10
Arrowhead	*Sagittaria sp.*	√		
Brittlewort	*Nitella sp.*	√		
Broad-leaved Arrowhead	*Sagittaria latifolia*	√		4
Canada Waterweed	*Elodea canadensis*	√	√	4
Common Bladderwort, Spatterdock	*Utricularia vulgaris*	√		4
Common burreed	*Sparganium eurycarpum*	√		3
Common Reed (Invasive)	*Phragmites australis*	X		
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 surface	*Algae sp. (fil. surface)*	√		
Filamentous algae underwater	*Algae sp. (fil. underwater)*	√		
Flat-stemmed Pondweed	*Potamogeton zosteriformis*	√	X	5
Floating-leaved Pondweed	*Potamogeton natans*	√		5
Greater Duckweed	*Spirodela polyrhiza*	√		4
Hardstem Bulrush	*Schoenoplectus acutus*	√		6
Hybrid Cattail	*Typha x glauca*	√		3
Leafy Pondweed	*Potamogeton foliosus*	√	√	4
Lesser Duckweed	*Lemna minor*	√		2
Narrow-leaved Cattail	*Typha angustifolia*	√		3
Northern Water Milfoil	*Myriophyllum sibiricum*	√	X	6
Richardson's Pondweed	*Potamogeton richardsonii*	√		5
Sago Pondweed	*Potamogeton pectinatus*	√	√	4
Slender Naiad	*Najas flexilis*	√	X	5
Slender Pondweed	*Potamogeton pusillus*	√	√	5
Softstem Bulrush	*Schoenoplectus tabernaemontani*	√		5
Spike-Rush	*Eleocharis smallii*	√		6
Spiny Naiad	*Najas minor*	X		
Star Duckweed	*Lemna trisulca*	√		4
Stiff Arrowhead	*Sagittaria rigida*	√		6
Stonewort, Muskgrass	*Chara sp.*	√		
Tape Grass	*Vallisneria americana*	√	X	6
Variable-leaved Pondweed	*Potamogeton gramineus*	√		4
Water Star-grass	*Heteranthera dubia*	√	√	7
Watermeal	*Wolffia sp.*	√		

Common Name	Genus/Species	Native	Turbidity -Tolerant	Coefficient of Conservatism
Water-Plantain	*Alisma plantago-aquatica*	√		3
White Water Lily	*Nymphaea odorata*	√		5
Wild Rice	*Zizania palustris*	√		9
Yellow Pond Lily	*Nuphar lutea ssp. variegata*	√		4

Appendix 2

Bird species observed during 2011 surveys, grouped into metrics that were included for calculating the IBI: a) area-sensitive marsh-nesting obligate species, b) marsh-nesting obligate species, and c) non-aerial foragers.

a) Area-sensitive marsh-nesting obligate bird 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*
LEBI	least bittern	*Ixobrychus exilis*

b) Marsh-nesting obligate bird 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*
MOOT	common moorhen / American coot	*Gallinula chloropus / Fulica americana*
COSN	common snipe	*Gallinago gallinago*
FOTE	Forster's tern	*Sterna forsteri*
LEBI	least bittern	*Ixobrychus exilis*
MAWR	marsh wren	*Cistothorus palustris*
PBGR	pied-billed grebe	*Podilymbus podiceps*
SORA	sora	*Porzana carolina*
SWSP	swamp sparrow	*Melospiza georgiana*
VIRA	virginia rail	*Rallus limicola*
YHBL	yellow-headed blackbird	*Xanthocephalus xanthocephalus*

c) Non-aerial forager bird species

Code	Common Name	Species
AMGO	American goldfinch	Carduelis tristis
AMRO	American robin	Turdus migratorius
BAOR	Baltimore oriole	Icterus galbula
BHCO	brown-headed cowbird	Molothrus ater
CEDW	cedar waxwing	Bombycilla cedrorum
COGR	common grackle	Quiscalus quiscula
COSN	common snipe	Gallinago gallinago
COYE	common yellowthroat	Geothlypis trichas
EUST	European starling	Sturnus vulgaris

Code	Common Name	Species
GRCA	gray catbird	Dumetella carolinensis
MAWR	marsh wren	Cistothorus palustris
MODO	mourning dove	Zenaida macroura
NOCA	northern cardinal	Cardinalis cardinalis
NOFL	northern flicker	Colaptes auratus
RWBL	red-winged blackbird	Agelaius phoeniceus
SOSP	song sparrow	Melospiza melodia
SORA	sora	Porzana carolina
SWSP	swamp sparrow	Melospiza georgiana
VEER	veery	Catharus fuscescens
VIRA	Virginia rail	Rallus limicola
WAVI	warbling vireo	Vireo gilvus
YWAR	yellow warbler	Dendroica petechia
YBCU	yellow-billed cuckoo	Coccyzus americanus
YHBL	yellow-headed blackbird	Xanthocephalus xanthocephalus

Appendix 3

List of Aquatic Macroinvertebrate species identified to the lowest taxonomic unit possible from 2011 samples.

Phylum	Class	Order	Family	Genus/Species
Annelida	Clitellata	Arhynchobdellida	Erpobdellidae	
Annelida	Clitellata	Arhynchobdellida	Erpobdellidae	Erpobdella punctata
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Alboglossiphonia sp.
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Helobdella sp.
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Helobdella triserialis
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Placobdella ornata
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Placobdella sp.
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Theromyzon sp.
Annelida	Oligochaeta			
Arthropoda	Arachnida	Hydracarina		
Arthropoda	Crustacea	Amphipoda		
Arthropoda	Crustacea	Amphipoda	Crangonyctidae	Crangonyx sp.
Arthropoda	Crustacea	Amphipoda	Gammaridae	Gammarus fasciatus
Arthropoda	Crustacea	Amphipoda	Gammaridae	Gammarus pseudolimnaeus
Arthropoda	Crustacea	Amphipoda	Gammaridae	Gammarus sp.
Arthropoda	Crustacea	Amphipoda	Hyalellidae	Hyalella azteca
Arthropoda	Crustacea	Decapoda	Cambaridae	
Arthropoda	Crustacea	Decapoda	Cambaridae	Orconectes sp.
Arthropoda	Crustacea	Isopoda	Asellidae	Caecidotea sp.
Arthropoda	Insecta	Coleoptera	Carabidae	
Arthropoda	Insecta	Coleoptera	Curculionidae	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hydrovatus sp.
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus sp.
Arthropoda	Insecta	Coleoptera	Dytiscidae	Liodessus sp.
Arthropoda	Insecta	Coleoptera	Dytiscidae	Matus sp.
Arthropoda	Insecta	Coleoptera	Gyrinidae	Dineutus sp.
Arthropoda	Insecta	Coleoptera	Gyrinidae	Gyrinus sp.
Arthropoda	Insecta	Coleoptera	Haliplidae	Haliplus sp.
Arthropoda	Insecta	Coleoptera	Haliplidae	Peltodytes sp.
Arthropoda	Insecta	Coleoptera	Helophoridae	Helophorus sp.
Arthropoda	Insecta	Coleoptera	Hydrochidae	Hydrochus sp.
Arthropoda	Insecta	Coleoptera	Hydrophilidae	
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Enochrus sp.
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Paracymus sp.
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Tropisternus sp.

Phylum	Class	Order	Family	Genus/Species
Arthropoda	Insecta	Coleoptera	Noteridae	Hydrocanthus sp.
Arthropoda	Insecta	Coleoptera	Scirtidae	Elodes sp.
Arthropoda	Insecta	Diptera	Ceratopogonidae	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia/Palpomyia
Arthropoda	Insecta	Diptera	Ceretopogonidae	Ceratopogon sp.
Arthropoda	Insecta	Diptera	Chironomidae	
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae sp.
Arthropoda	Insecta	Diptera	Culicidae	
Arthropoda	Insecta	Diptera	Culicidae	Anopheles sp.
Arthropoda	Insecta	Diptera	Dolichopodidae	
Arthropoda	Insecta	Diptera	Sciomyzidae	
Arthropoda	Insecta	Diptera	Sciomyzidae	Sepedon sp.
Arthropoda	Insecta	Diptera	Stratiomyidae	Odontomyia/Hedriodiscus
Arthropoda	Insecta	Diptera	Tipulidae	Helius sp.
Arthropoda	Insecta	Ephemeroptera	Baetidae	
Arthropoda	Insecta	Ephemeroptera	Baetidae	Callibaetis sp.
Arthropoda	Insecta	Ephemeroptera	Baetidae	Centroptilum sp.
Arthropoda	Insecta	Ephemeroptera	Baetidae	Cloeon dipterum
Arthropoda	Insecta	Ephemeroptera	Baetidae	Procloeon/Centroptilum/Cloeon
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis sp.
Arthropoda	Insecta	Hemiptera	Belostomatidae	Belostoma sp.
Arthropoda	Insecta	Hemiptera	Corixidae	
Arthropoda	Insecta	Hemiptera	Corixidae	Hesperocorixa sp.
Arthropoda	Insecta	Hemiptera	Corixidae	Palmacorixa sp.
Arthropoda	Insecta	Hemiptera	Corixidae	Sigara sp.
Arthropoda	Insecta	Hemiptera	Corixidae	Trichocorixa sp.
Arthropoda	Insecta	Hemiptera	Gerridae	
Arthropoda	Insecta	Hemiptera	Gerridae	Gerris sp.
Arthropoda	Insecta	Hemiptera	Hebridae	Merragata sp.
Arthropoda	Insecta	Hemiptera	Hydrometridae	Hydrometra sp.
Arthropoda	Insecta	Hemiptera	Mesoveliidae	Mesovelia sp.
Arthropoda	Insecta	Hemiptera	Nepidae	Ranatra sp.
Arthropoda	Insecta	Hemiptera	Notonectidae	
Arthropoda	Insecta	Hemiptera	Notonectidae	Buenoa sp.
Arthropoda	Insecta	Hemiptera	Notonectidae	Notonecta sp.
Arthropoda	Insecta	Hemiptera	Pleidae	Neoplea sp.
Arthropoda	Insecta	Hemiptera	Veliidae	Microvelia sp.
Arthropoda	Insecta	Lepidoptera	Pyralidae	Acentria sp.
Arthropoda	Insecta	Lepidoptera	Pyralidae	Parapoynx sp.
Arthropoda	Insecta	Megaloptera	Corydalidae	Chauliodes sp.
Arthropoda	Insecta	Odonata	Aeshnidae	
Arthropoda	Insecta	Odonata	Aeshnidae	Aeshna sp.
Arthropoda	Insecta	Odonata	Aeshnidae	Anax sp.

Phylum	Class	Order	Family	Genus/Species
Arthropoda	Insecta	Odonata	Coenagrionidae	
Arthropoda	Insecta	Odonata	Coenagrionidae	Enallagma sp.
Arthropoda	Insecta	Odonata	Coenagrionidae	Enallagma/Coenagrion sp.
Arthropoda	Insecta	Odonata	Coenagrionidae	Ischnura sp.
Arthropoda	Insecta	Odonata	Corduliidae	
Arthropoda	Insecta	Odonata	Corduliidae	Epitheca (Epicordulia)
Arthropoda	Insecta	Odonata	Libellulidae	Leucorrhinia sp.
Arthropoda	Insecta	Odonata	Libellulidae	Sympetrum sp.
Arthropoda	Insecta	Odonata	Libellulidae/Corduliidae	
Arthropoda	Insecta	Trichoptera		
Arthropoda	Insecta	Trichoptera	Hydroptilidae	
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Agraylea sp.
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila sp.
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira sp.
Arthropoda	Insecta	Trichoptera	Leptoceridae	
Arthropoda	Insecta	Trichoptera	Leptoceridae	Leptocerus sp.
Arthropoda	Insecta	Trichoptera	Leptoceridae	Nectopsyche sp.
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis sp.
Arthropoda	Insecta	Trichoptera	Leptoceridae	Triaenodes sp.
Arthropoda	Insecta	Trichoptera	Leptoceridae	Trianodes/Ylodes
Arthropoda	Insecta	Trichoptera	Leptoceridae	Ylodes sp.
Arthropoda	Insecta	Trichoptera	Phryganeidae	Fabria sp.
Arthropoda	Insecta	Trichoptera	Polycentropodidae	
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus sp.
Cnidaria	Hydrozoa	Hydroida	Hydridae	Hydra sp.
Mollusca	Bivalvia	Veneroida	Dreisseniidae	Dreissena polymorpha
Mollusca	Bivalvia	Veneroida	Dreisseniidae	Dreissena sp
Mollusca	Bivalvia	Veneroida	Pisidiidae	
Mollusca	Gastropoda	Basommatophora	Ancylidae	
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Pseudosuccinea sp.
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Stagnicola sp.
Mollusca	Gastropoda	Basommatophora	Physidae	
Mollusca	Gastropoda	Basommatophora	Physidae	Physa sp.
Mollusca	Gastropoda	Basommatophora	Planorbidae	
Mollusca	Gastropoda	Basommatophora	Planorbidae	Armiger crista
Mollusca	Gastropoda	Basommatophora	Planorbidae	Gyraulus sp.
Mollusca	Gastropoda	Basommatophora	Planorbidae	Helisoma sp.
Mollusca	Gastropoda	Basommatophora	Planorbidae	Menetus sp.
Mollusca	Gastropoda	Basommatophora	Planorbidae	Planorbula sp.
Mollusca	Gastropoda	Basommatophora	Planorbidae	Promenetus sp.
Mollusca	Gastropoda	Mesogastropoda	Bithyniidae	Bithynia tentaculata
Mollusca	Gastropoda	Mesogastropoda	Valvatidae	Valvata sp.

Phylum	Class	Order	Family	Genus/Species
Mollusca	Gastropoda	Mesogastropoda	Valvatidae	Valvata tricarinata
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	
Mollusca	Gastropoda	Stylommatophora	Succineidae	Succinea sp.
Nematoda				
Platyhelminthes	Turbellaria	Tricladida		