Monitoring of Lake Ontario coastal wetland habitat in support of Adaptive Management

Summary Report - 2019 Vegetation Sampling

Submitted to

Great Lakes – St. Lawrence River Adaptive Management Committee

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Executive Summary

In the summer of 2019, 16 coastal wetlands were surveyed by the Canadian Wildlife Service - Ontario Region (CWS-ON) along the Canadian shore of Lake Ontario to provide wetland vegetation data referenced to elevation to support the International Joint Commission's Great Lakes-St. Lawrence River Adaptive Management (GLAM) Committee in validating model outputs of aquatic ecosystem impacts from changes in water-level regulation. This project provides a means to track meadow marsh extent and understand how it relates to water-level fluctuations, and to assess the performance of IJC's Plan 2014 in terms of vegetation response. The results of this study will add to the coastal wetland monitoring dataset, which contains nine previous years of data collected by CWS-ON under this protocol.

For the third consecutive year, 16 wetlands were surveyed to allow for a direct comparison of vegetative cover under varying water-level conditions. These sites were selected to be representative of wetlands in Lake Ontario, with four wetlands from each hydrogeomorphic type (dynamic barrier beach, open embayment, protected embayment, and drowned river mouth). Wetland vegetation was surveyed using an existing approach developed by CWS-ON using real-time kinematic (RTK) GPS.

To quantify disturbance, basic water quality information was collected at each wetland. In general, the water quality information collected indicates that the sites surveyed vary in disturbance from Very Degraded (Jordan Station) to Very Good (12 O'Clock Point, Blessington Creek, Hay Bay North, Huyck's Bay, Parrott's Bay, South Bay, Wesleyville). In addition, portable water level loggers were deployed in each site to capture local water-level fluctuations at 15-minute intervals.

As recommended at the GLAM committee wetland experts meeting in 2017, regular monitoring should continue in order to develop a strong dataset to evaluate wetland conditions in the coming years as Plan 2014 begins to take effect. Moving forward, CWS-ON sees this approach to monitoring wetland vegetation as a standard for continued monitoring efforts on Lake Ontario and basin-wide. However, sustained financial support is urgently needed to ensure that these data continue to be collected. This approach requires trained and experienced personnel in addition to specialized equipment. The support received in 2019-20 allowed the program to continue baseline activity and does not reflect the entire costs associated with the program.

Background

In the summer of 2019, 16 coastal wetlands were surveyed along the north shore of Lake Ontario to provide wetland vegetation data referenced to elevation to support the modelling of aquatic ecosystems following recent changes in water-level regulation. With the acceptance of this report, all deliverables have been completed, which includes the completion of field data collection, survey data processing (data entry and quality-checking), and the completion of reporting to outline project findings. The entire dataset (2009-2019) are housed in a database developed and maintained by CWS-ON.

Status of Deliverables

Deliverable		Due date	Status
1.	Complete field surveys for 16 Lake Ontario wetlands on the Canadian shoreline	September 2019	Complete
2.	Field data is input into existing database, post-processed, and reviewed	October 2019	Complete
3.	Data is analyzed and summarized; key findings are presented in Final Summary Report	March 2020	Complete

Field Surveys

Vegetation Surveys

Vegetation monitoring followed Grabas and Rokitnicki-Wojcik (2015). CWS-ON monitored vegetation using this approach at 26 wetlands from 2009-2015, selecting eight sites each year with many of the sites being revisited. In 2017, 16 sites were selected to be representative of wetlands in Lake Ontario by hydrogeomorphic type, geography, and level of disturbance (Figure 1). Four sites from each hydrogeomorphic (HGM) type were selected: dynamic barrier beach (BB), open embayment (OE), protected embayment (PE), and drowned river mouth (DRM). The same 16 sites were revisited in 2018 and 2019. Based on the allocation of field staff, survey time, and technological resources, we were able to survey six transects at each site. An earlier power analysis of several years' data (not shown here) indicated that differences in species composition and vegetation zonation can be adequately captured by six transects. By expanding the range of sites, the resulting dataset is more robust for the purpose of assessing wetland condition across the Canadian side of Lake Ontario.

Vegetation was monitored along six transects at each of 20cm elevation increments beginning at 74.0m and ending at 76.0m referenced to the International Great Lakes Datum 1985 (IGLD85) (Figure 2). Elevation was determined using a real-time kinematic GPS system. At each targeted elevation, all species were identified and percent cover of each species was estimated within a 1m x 0.5m quadrat. Species information was summarized into vegetation guilds present in Great Lakes coastal wetlands as identified in Grabas and Rokitnicki-Wojcik (2015). Under ideal conditions, 11 quadrats are sampled along each transect. However, most wetlands have a combination of robust shrub and tree cover at upper elevations that interferes with GPS connectivity, or an aquatic basin shallower than 74.0m. Therefore, we are unable to survey the maximum number of quadrats (66) at most sites (Table 1), which is an indication of the morphometric, topographic, and vegetative characteristics of the site and not related to any qualitative measures of condition.

Table 1: Summary of transects completed along wetland elevation gradient in the summer of 2019.

Wetland Name	# Quadrats	% of Maximum Quadrats	Min Elevation Surveyed	Max Elevation Surveyed
12 O'Clock Point	43	65.15%	74.0	76.0
Bayside	40	60.61%	74.0	75.4
Blessington Creek	57	86.36%	74.0	75.8
Button Bay	58	87.88%	74.0	75.8
Corbett Creek	37	56.06%	74.4	75.6
Greater Cataraqui Creek	51	77.27%	74.0	75.6
Hay Bay North	58	87.88%	74.0	76.0
Hay Bay South	59	89.39%	74.0	76.0
Huyck's Bay	54	81.82%	74.0	76.0
Jordan Station	56	84.85%	74.0	76.0
Parrott's Bay	42	63.64%	74.0	76.0
Popham Bay	39	59.09%	74.6	75.8
Presqu'ile Bay	54	81.82%	74.0	75.8
Robinson Cove	58	87.88%	74.0	76.0
South Bay	58	87.88%	74.0	76.0
Wesleyville	35	53.03%	74.6	75.6

Water Quality Data

Basic water quality information was collected using a multiprobe (YSI 6600 V2 or Hydrolab MS5) at each wetland for the following parameters: turbidity (NTU), specific conductance (µS/cm), pH and temperature (ºC). Measurements were collected at six stations to align with the outermost aquatic vegetation point from each transect. These data were screened for outliers and the mean values for each of the four parameters were used to calculate an overall Water Quality Index score (WQI; Chow-Fraser 2006; Table 2). The WQI is an indicator of human-induced land use alterations, and can be used as an indication of wetland disturbance, with higher values indicating better water quality.

Table 2: Summary water quality data for each of the wetlands sampled. Mean parameter values are presented. The Water Quality Index (WQI) score is shaded based on the qualitative descriptors outlined in Chow-Fraser (2006).

Wetland Name	Turbidity (NTU)	Specific Conductance (µS/cm)	Temperature (°C)	pH	WQI
12 O'Clock Point	1.2	353.7	17.50	7.50	1.08
Bayside	1.3	242.7	22.11	8.92	0.92
Blessington Creek	0.8	390.7	22.09	7.68	1.01
Button Bay	3.1	386.1	20.93	8.65	0.15
Corbett Creek	2.3	1403.1	18.11	6.87	-0.20
Greater Cataraqui Creek	4.9	250.8	21.53	8.76	0.18

Hay Bay North	1.0	366.6	19.72	8.10	1.02
Hay Bay South	1.7	246.7	21.63	8.53	0.81
Huyck's Bay	1.1	229.2	20.75	8.53	1.17
Jordan Station	13.0	877.3	21.23	8.11	-1.21
Parrott's Bay	0.7	294.8	21.26	8.80	1.17
Popham Bay	2.1	298.5	22.80	8.57	0.54
Presqu'ile Bay	1.8	289.0	21.13	8.22	0.74
Robinson Cove	4.2	261.3	19.98	7.63	0.42
South Bay	1.1	295.3	18.47	8.12	1.09
Wesleyville	0.9	441.3	17.99	7.09	1.08

Qualitative Descriptors:	Highly Degraded	Very Degraded	Moderately Degraded	Good	Very Good	Excellent
WQI Score Range:	-3 to -2	-2 to -1	-1 to 0	0 to 1	1 to 2	2 to 3

Local Water Level Data

Wetland water levels were measured at the time of survey using the RTK GPS and tied back to water-level readings from loggers that were deployed in April to record levels at 15 minute increments during the growing season (as described in Grabas and Rokitnicki-Wojcik 2015). The water level dataset can be made available to the GLAM committee should it be requested.

Fluctuation intensity (FI) is an integrated measure of the magnitude and frequency of daily water-level changes (mostly from wind tides and seiches) experienced in a wetland and is calculated as the back-transformed logarithmic mean of one-half the sum of daily water-level increments every 15 minutes. (Grabas and Rokitnicki-Wojcik, 2015). These values vary among sites depending on the site's characteristics and hydrogeomorphic type (HGM), as sites that are more protected are less influenced by lake-level fluctuations. CWS has collected water level data for multiple years at many sites, and noted that fluctuations at the site level do not vary greatly among years.

Table 3: Water levels at time of survey and fluctuation intensities from May – November WL data.

Wetland Name	Type	Date sampled	Water level during survey (m IGLD)	Fluctuation intensity (FI)
12 O'Clock Point	PE	10/09/2019	75.30	15.4
Bayside	OE	11/09/2019	75.23	18.72
Blessington Creek	DRM	11/09/2019	75.33	16.41
Button Bay	OE	18/09/2019	75.18	101.1
Corbett Creek	BB	09/09/2019	75.49	14.98
Greater Cataraqui Creek	DRM	18/09/2019	75.18	30.53
Hay Bay North	DRM	17/09/2019	75.18	N/A*
Hay Bay South	OE	17/09/2019	75.17	65.19
Huyck's Bay	BB	10/09/2019	75.47	N/A*
Jordan Station	DRM	20/09/2019	75.24	24.61
Parrott's Bay	PE	19/09/2019	75.15	46.46

Popham Bay	BB	16/09/2019	75.23	24.09
Presqu'ile Bay	PE	19/09/2019	75.16	50.62
Robinson Cove	PE	12/09/2019	75.20	16.92
South Bay	OE	13/09/2019	75.18	132.09
Wesleyville	BB	09/09/2019	75.75	N/A*

*Water level loggers could not be retrieved in Fall 2019

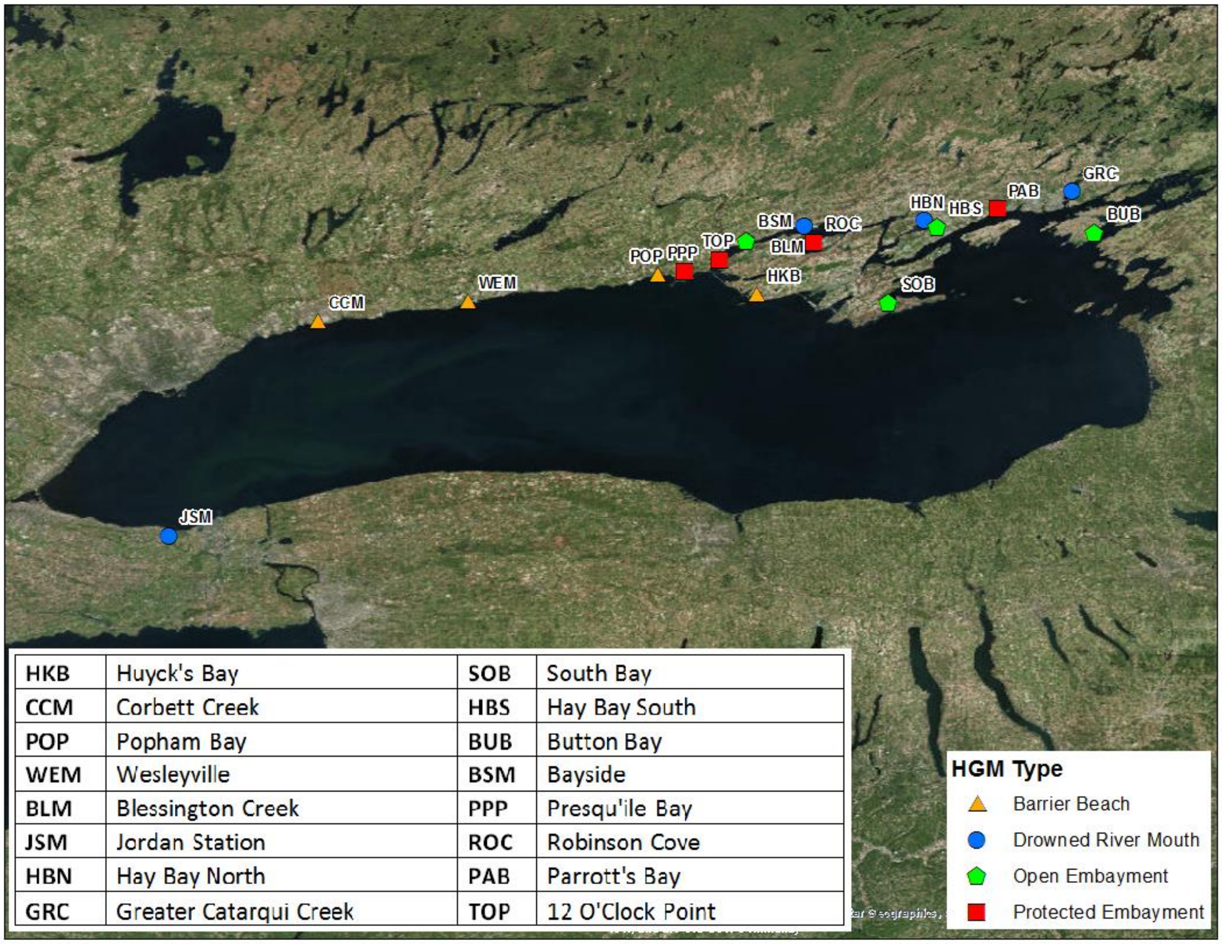

Figure 1: Wetland study sites surveyed by CWS-ON in 2019.

Summary of 2019 Results

Water levels

Lake Ontario water levels in 2019 surpassed the historical highs recorded in 2017, peaking at 75.92m IGLD in mid-June (IJC, 2019). In 2018, Lake Ontario water levels were fairly close to the historical monthly averages during the growing season (Figure 2). With a large portion of the meadow marsh community flooded during the 2017 growing season (maximum of 75.81m IGLD reached in June), vegetative cover had decreased considerably. The 2018 data provided an indication of how these species responded when they were able to grow unhindered by flooding. The return of high water levels in 2019 provided the opportunity to monitor the cumulative vegetative response to multiple extreme high water years over a short (3 year) period.

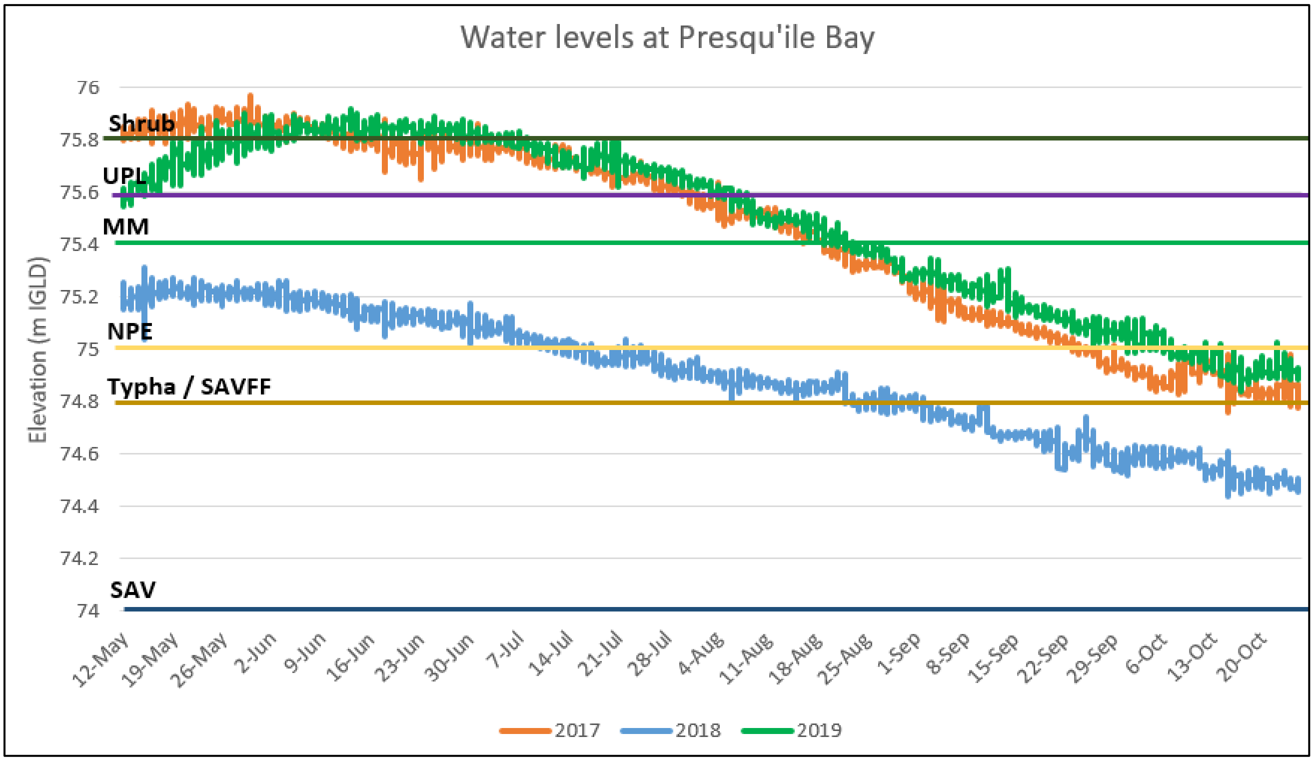

Figure 2: Local water level data captured at Presqu'ile Bay in 2017, 2018, and 2019. Horizontal lines indicate the elevation where each guild typically experiences max coverage.

Vegetation Guild Summary Data

Individual species data collected along the aquatic-upland gradient were summarized by vegetation guild and elevation. The sum of species percent cover per guild was averaged across transects to provide a measure of the abundance of a vegetation type at each elevation. During relatively stable water levels prior to 2017, there was little change in vegetation community structure. In the following years, with extreme high water levels in 2017 and 2019, we observed significant changes in cumulative percent cover, a landward expansion of the elevation range for some guilds, and a shift in where max guild coverage occurs along the elevation gradient (Figures 3 and 4). Free-floating species (e.g. *Lemna minor*) were not included in Figures 3 and 4 below because they were not expected to be influenced by changes in water levels. Non-persistent emergent species (e.g., *Sparganium eurycarpum*) were also not included because they were only observed at a limited number of wetlands.

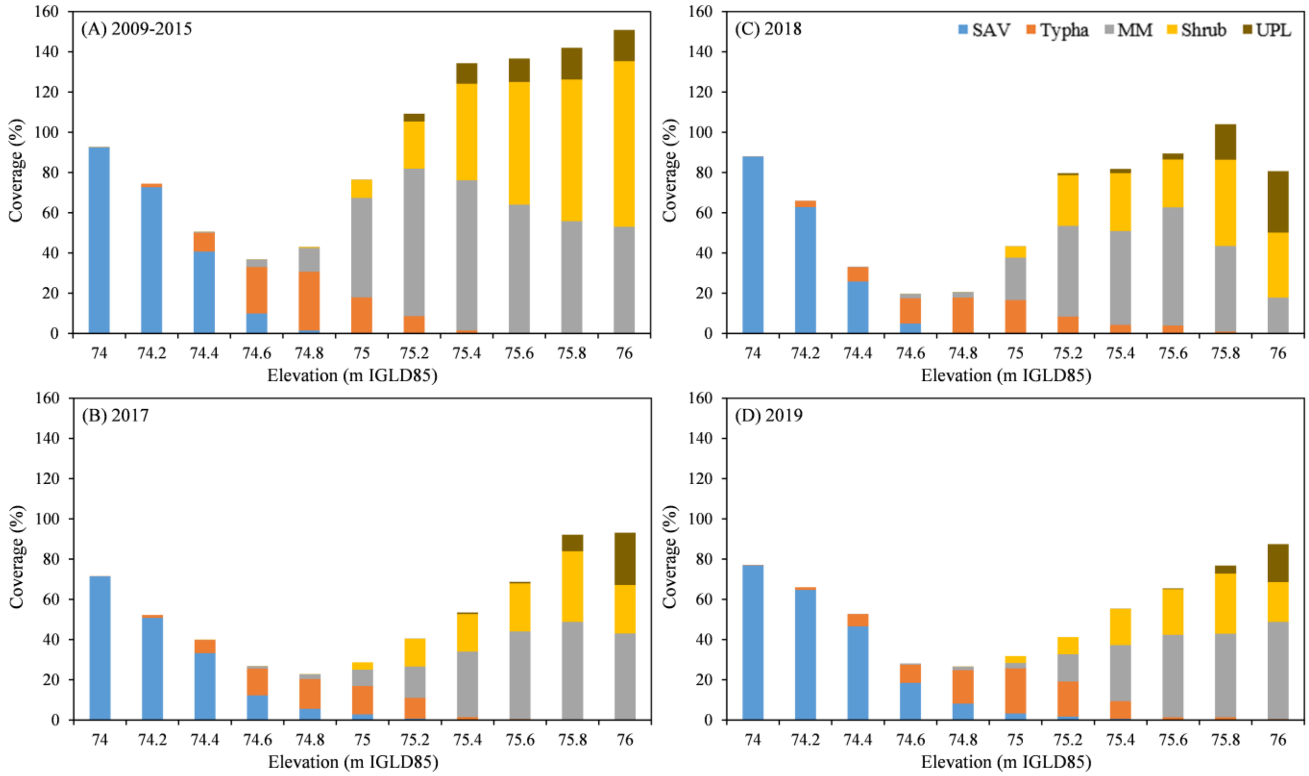

Figure 3: Cumulative coverage (percent) of vegetation guilds (submerged aquatic vegetation [SAV], *Typha*, meadow marsh [MM], shrub and upland [UPL]) at discrete elevations across the elevation gradient.

Observations by Guild

SAV (Submerged Aquatic Vegetation):
In all years, SAV coverage peaked at the deepest water elevation and decreased along the gradient towards shallow water. Coverage did not change significantly at the lower elevations; however, the range that SAV was typically present expanded upland in high water level years. Prior to 2017, SAV was present (>1%) at 74.0-74.8m. In 2019, the upper boundary increased to 75.2m, where SAV species were interspersed with *Typha*.

SAVFF (Free-floating):
SAVFF species move freely on the surface and therefore are not expected to be significantly influenced by water-level fluctuations. However, high water levels early in the growing season caused these species (e.g. frogbit, duckweed) to be pushed up to higher elevations where they were observed even after the water receded.

NPE (Non-persistent emergent):
Non-persistent emergent vegetation coverage is relatively low at all sites, and is less likely to be found at the more degraded wetlands on Lake Ontario. The range and coverage of NPE appears to be consistent among years, with some variability likely explained by changes in the site selection.

Typha:
As in previous years, *Typha* coverage peaked around 75.0m. Due to the resilience of *Typha* to flooding or drought, it was expected that long periods of extreme high or low water levels would be required to significantly alter their zonation and coverage. In 2019, we saw a small but significant increase in coverage at 75.4m, indicating that conditions were wet enough in recent years to allow *Typha* to expand upland into the meadow marsh zone.

MM (Meadow marsh):
In 2017, meadow marsh guild coverage declined significantly from the pre-2017 baseline average at 74.8-75.6m. Although meadow marsh was not suppressed by flooding in 2018, the average cover for meadow marsh remained lower than pre-2017 sampling years. In 2017 and 2019, peak coverage of meadow marsh occurred at 75.8m, which suggests a landward shift compared to the peak of 75.6m in 2018.

UPL (Upland) and Shrub:
Shrub and upland species showed similar responses to extreme high water levels, as their flood tolerance is relatively low. We saw significant decline in coverage in 2017, minimal regrowth in 2018, and greater decline in coverage in 2019.

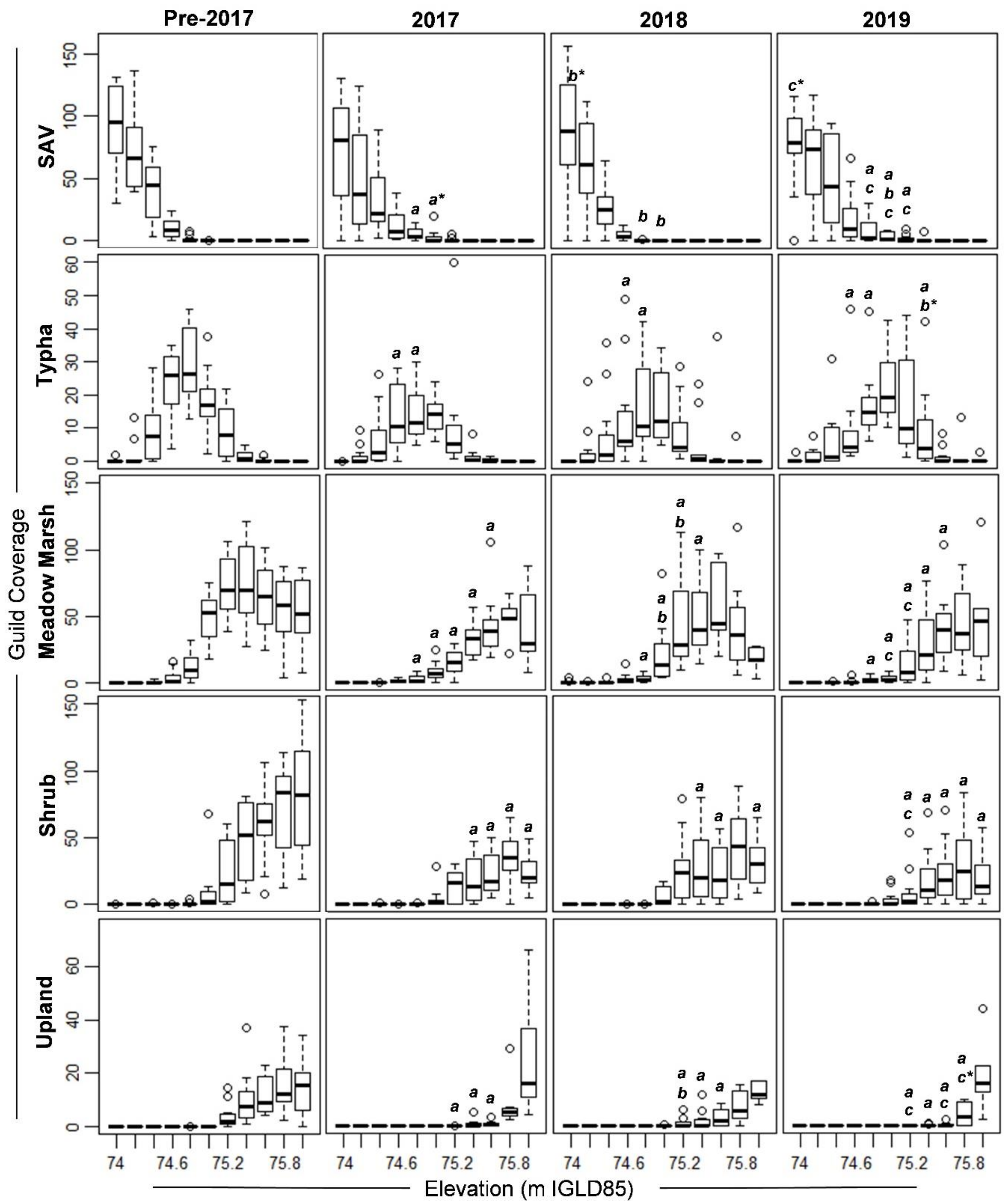

Figure 4: Guild coverages (percent) at discrete elevations for submerged aquatic vegetation (SAV), *Typha,* meadow marsh, shrub and upland vegetation communities. "Pre-2017" is the average coverage from 2009-2015 (no surveys were conducted in 2016) and represents the baseline conditions reflective of a relatively stable water-level regime. a = statistically significant difference (P < 0.05) from "pre-2017"; b = statistically significant difference from 2017; c = statistically significant difference from 2018; *= marginal statistically significant difference (0.05 < *P* < 0.1).

2009-2019 Dataset

The complete CWS-ON coastal wetlands monitoring dataset from surveys conducted from 2009-2019 will be provided to the GLAM committee. These data, along with those collected on the U.S. side of Lake Ontario, represent a great asset to the Committee in implementing an adaptive management program with field verified information.

Data collected in 2013 did not include spatial precision values due to the internal survey style used in that year. Other samples lacking precision values are included in the dataset, and based on how the surveys are conducted we feel that they should be retained for further use.

Data that do not have coordinates associated with them have been included in the dataset but have been flagged in a table should it be decided that they be removed. These flagged samples represent <1% of the dataset.

The updated data were output in the same manner as the dataset provided for the previous IWI project completed by CWS-ON in 2018:

- Raw Data
  - raw quadrat level data
- Summarized Data
  - crosstab summary of quadrat data by guild
  - summarized data by guild and by target elevation
- Sample Sizes
  - sample size by wetland for a given year
- Geospatial data
  - shapefile of sampling locations
- QA/QC
  - table of flagged quadrats (missing coordinate and elevation data but have been included in tables above)

Each data table includes a metadata tab that provide a brief description of the data.

Future Considerations

Although we have already seen significant changes in wetland vegetation in response to high water levels in 2017 and 2019, the effects may become more apparent in the following years. As we are in the early years of Plan 2014, ongoing implementation of this well-established approach to monitoring wetland vegetation will continue to provide valuable information to the GLAM Committee. A recent bulletin from the US Army Corps of Engineers reported that Great Lakes water levels in January 2020 are higher than last year at this time, and the forecast predicts that levels will continue to be well above average for the next six months (USACE, 2020). Should lake levels reach extreme highs or lows in the future, it would be especially important to detect changes to coastal wetland vegetation communities to provide information on Plan 2014 performance and inform vegetation modelling.

CWS-ON is limited by budgetary restrictions and sustained financial support is required for ensuring that these data continue to be collected. This approach requires trained and experienced personnel in addition to specialized equipment. The support received in 2019-20 allowed monitoring to continue and does not reflect the entire cost associated with this long-term program.

Literature Cited

Chow-Fraser, P. 2006. Development of the Water Quality Index (WQI) to assess effects of basin-wide land-use alteration on coastal marshes of the Laurentian Great Lakes. In: Coastal Wetlands of the Laurentian Great Lakes: Health, Habitat and Indicators. Eds. Simon, T.P. and Stewart, P.M. Authorhouse, Bloomington, Indiana.

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