Journal of Great Lakes Research 41 (2015) 136–144

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

Characterizing daily water-level fluctuation intensity and water quality relationships with plant communities in Lake Ontario coastal wetlands

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ARTICLE INFO

Article history:
Received 19 June 2014
Accepted 1 December 2014
Available online 20 January 2015

Communicated by Anett Trebitz

Keywords:
Lake Ontario
Coastal wetlands
Fluctuation intensity
Vegetation zonation
Hydrogeomorphic type
Water quality

ABSTRACT

Seasonal and multi-year water-level fluctuations in the Laurentian Great Lakes maintain wetland vegetation diversity and wildlife habitat value, but little is known about the relationship between daily water-level fluctuations (wind tides and seiches) and plant community attributes. We used portable water-level loggers to determine mean daily fluctuation intensity (FI) at different timescales in selected Lake Ontario wetlands of various hydrogeomorphic types. Among years, FI varied across sites but was more consistent within sites and was significantly higher in open embayments than in drowned rivermouths or protected embayments. Of the time-scales considered (15, 30, 60, and 120 min), 15-minute intervals gave the best resolution in FI among wetlands. We examined associations between FI and vegetation coverage of seven guilds: submerged and rooted floating-leaved vegetation (SAV), free-floating, non-persistent emergent (NPE), *Typha* spp., meadow marsh (MM), shrub, and upland at 20-cm elevation increments along transects from approximately 0.8 m deep to 1.2 m upland while accounting for poor water quality, which is known to decrease vegetation coverage. Wetlands with higher conductivity had less SAV, free-floating, and NPE coverage, while wetlands with high turbidity had marginally less SAV and *Typha* spp., but more free-floating coverage. Wetlands with higher FIs had more NPE vegetation in shallow depths and more MM but less shrub and upland coverage at elevations above the long-term average water level, suggesting that FI is a hydrologic factor in vegetation establishment. These results can be used for modeling Lake Ontario plant communities and support adaptive management monitoring following a water-level regulation change.

Introduction

Water levels in the Laurentian Great Lakes have naturally fluctuated in both magnitude and frequency over a range of time scales from years to hundreds of years (Wilcox et al., 2007). Seasonal and multi-year water-level fluctuations also occur as a function of annual water budgets. These fluctuations influence the dominance and spatial extent of species comprising coastal wetland vegetation communities (Keddy and Reznicek, 1986), effectively maintaining plant community diversity (Keough et al., 1999; Wilcox and Meeker, 1991; Wilcox et al., 1992, 2002). The dampening of seasonal fluctuations by the regulation of Lake Ontario water levels via the Moses-Saunders Dam in the St. Lawrence River has been linked to the loss of plant community diversity (Wilcox et al., 1992; Wilcox and Meeker, 1995) and the expansion of *Typha* spp. stands in coastal wetlands (Wilcox et al., 2008). The proliferation of monotypic taxa at the expense of plant diversity may provide less habitat value to wildlife resulting in reduced marsh bird abundance and species richness (Chin et al., 2014; Meyer et al., 2010: Steen et al., 2006).

While the occurrence and ecological implications of seasonal and multi-year water-level fluctuations in Great Lakes coastal wetlands have garnered much attention (Chin et al., 2014; DesGranges et al., 2006; Timmermans et al., 2008; Webb, 2008; Wilcox et al., 2005), particularly in Lake Ontario with the anticipated change to the current water-level regulation plan (Wilcox and Xie, 2007; Wilcox et al., 2008), other natural water-level fluctuations occur in Lake Ontario over much shorter time-scales that may affect the ecology of coastal wetlands (Trebitz, 2006). The frequency and magnitude of small-scale water-level fluctuations from wind tides and seiches have been characterized using hourly data from permanent water-level gauging stations in Lake Ontario, but due to considerable spatial variability among within-lake basin gauging stations, the use of portable water-level loggers was recommended to understand site-specific coastal wetland water-level dynamics better (Trebitz, 2006). The first purpose of this study was to gather water-level information from portable water-level loggers at several coastal wetlands across Lake Ontario and characterize the daily fluctuation intensity following Trebitz (2006). Water-level data from portable loggers and Canadian gauging stations were

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http://dx.doi.org/10.1016/j.jglr.2014.12.019

available at 15-minute intervals, and insight into the differences in fluctuation intensity calculated at various timescales is provided.

The dampening of long-term water-level fluctuations in Lake Ontario has been linked to changes in the general extent of wetland plant communities in coastal wetlands, yet within open and protected embayment wetlands, considerable variation in plant community extent persists (Wilcox et al., 2008). It is not known how daily fluctuation intensity is affected by wetland hydrogeomorphic type or if fluctuation intensity is related to plant community extent. The second purpose of this study was to determine if fluctuation intensities are different among hydrogeomorphic types and to examine the relationship between fluctuation intensity and vegetation community coverage at discrete elevations in selected Lake Ontario wetlands.

Submerged vegetation coverage is known to decrease proportionately with water quality in Lake Ontario wetlands (Grabas et al., 2012). The third purpose of this study is to examine the relationship between water quality and the coverage of vegetation communities that are submerged for at least part of the growing season (i.e., submerged, rooted floating-leaved, and emergent taxa).

Methods and materials

Data collection

Water levels

Portable water-level loggers (Solinst: Model 3001 Gold LT or Edge) were calibrated to 5-m depth, set to record a time and date-stamped water level every 15 min, and deployed in late-April through mid- to late-October each year for 2006 through 2013 in a total of 16 drowned rivermouth, open embayment, and protected embayment wetlands (Albert et al., 2005) along the Canadian shore of Lake Ontario (Fig. 1). The loggers were housed in 30-cm-long × 5-cm-diameter capped ABS piping that was vented to allow water exchange, fastened erect to a 30 cm square of steel 6 mm thick and placed on top of the sediment in water as deep as safely wadeable to ensure that they were not exposed during seasonal lows and seiche events. The steel base was necessary to ensure that the logger housing remained stationary for the duration of the deployment. Portable water-level loggers infer water level as a function of the water and air pressure above an internal pressure transducer. Barometric loggers (Solinst: Model 3001 Gold or Edge) were used to determine and subtract the air pressure component of the readings and were typically secured to trees close to the wetland shoreline. A single barometric logger could be used to correct multiple water-level loggers within a 30-km radius or within 0.30-km elevation (Solinst, 2011). Both the water-level and barometric logger deployment locations were recorded to the nearest metre with a hand-held Trimble GeoXT global positioning system (GPS). The water-level logger deployment location within each wetland remained consistent throughout years. Following logger recovery, data were downloaded and barometrically corrected, and hydrographs were examined for errors, which were removed. Errors were single readings (spikes) that deviated unreasonably (e.g., ±50 cm) compared to the contiguous data points. Water levels were referenced to International Great Lakes Datum 1985 (IGLD85) by obtaining a time-stamped water-level measurement from either the closest gauging station or using a sub-centimetre accuracy Real-Time Kinematic differential GPS system (Trimble R8 GNSS) referenced to a local benchmark during vegetation surveys described below.

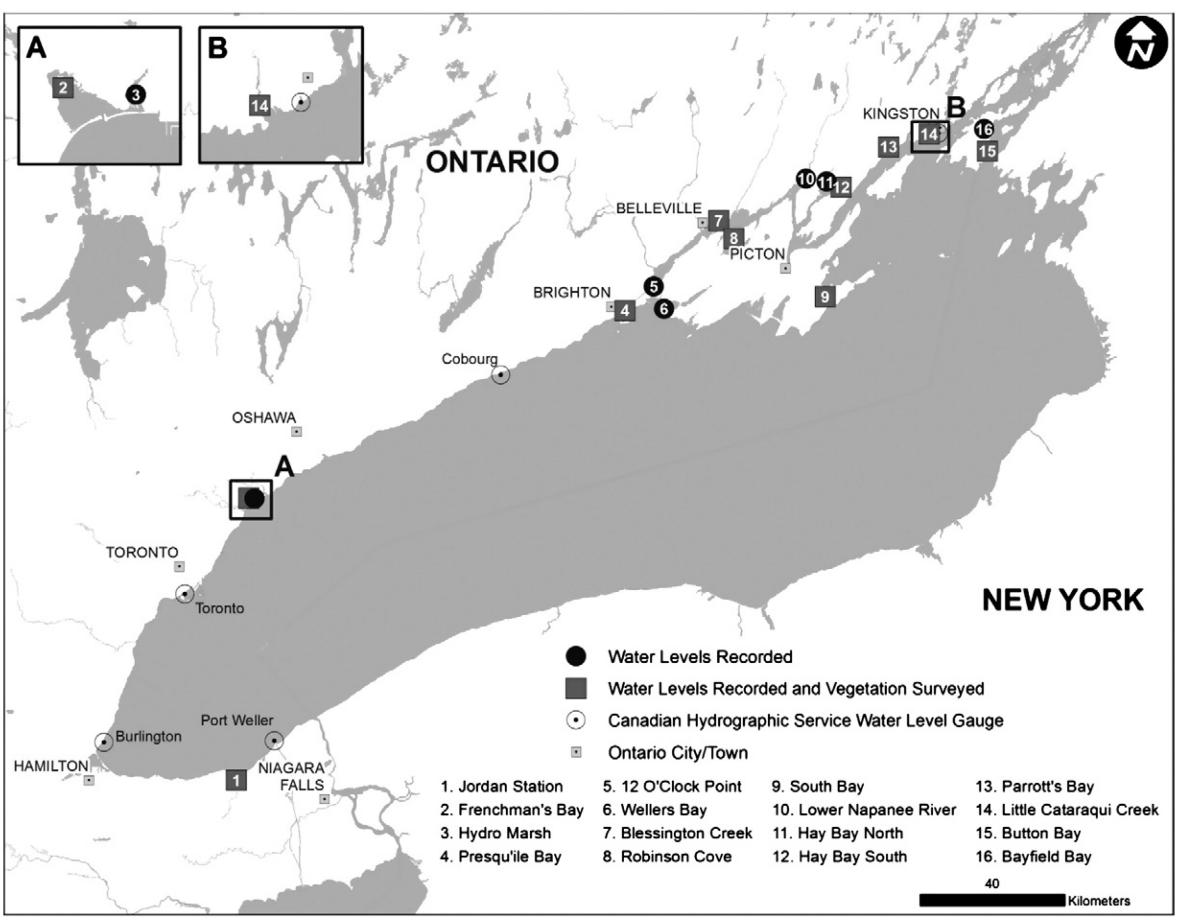

Fig. 1. Locations of gauging stations and coastal wetlands on Lake Ontario where site-specific water-level and vegetation community data collection occurred. Capital letters refer to inset maps.