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## Breeding birds and anurans of dynamic coastal wetlands in Green Bay, Lake Michigan

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### ABSTRACT

Breeding birds and anurans (frogs and toads) in coastal wetlands of Green Bay, Lake Michigan vary dynamically with changing water levels, habitat type, and geography. We describe species assemblages over a seven-year period (2011–2017) beginning with historic low water levels followed by an increase in average lake level of 0.85 m. In general, species richness and abundance of marsh-obligate species responded positively to increasing water levels, although several species of shallow wetlands (sandhill crane, sedge wren, swamp sparrow, and American toad) showed the opposite trend. Anuran assemblages were more diverse in the middle and upper bay, coinciding with a well-established nutrient gradient from the hypereutrophic lower bay to more oligotrophic waters of the upper bay. Three marsh-obligate bird species (black tern, sandhill crane, and sedge wren) were significantly more abundant in the middle or upper bay while sora, American coot, and common gallinule were more abundant in the eutrophic lower bay. Our findings have several important implications for conservation. Inland wetlands near the coast (including diked wetlands) might play a key ecological role by providing refugia for some species during low water years. However, the importance of shallow coastal wetlands and near-shore gradients of wetland habitat might be overlooked during low water years; when high water returns, these areas can become extremely productive and species-rich.

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### Introduction

Coastal wetlands in the Laurentian Great Lakes region support rich and dynamic assemblages of plants and animals that are adapted to both short- and long-term variability in habitat conditions. Seiches, seasonal precipitation, storms, and basin-wide climatic factors can cause Great Lakes water levels to fluctuate by several centimeters across days or weeks to more than a meter across years or decades. Within this constantly changing coastal environment, diverse assemblages of birds (Epstein et al., 2002; Ewert et al., 2012; Price et al., 1995; Tozer, 2013, 2016a) and anurans (frogs and toads; Harding, 1997; Price et al., 2007, 2005; Tozer, 2013, 2016b) utilize Great Lakes coastal wetlands as both breeding and migratory habitat.

Widespread anthropogenic changes, such as urban development (Danz et al., 2007; Radeloff et al., 2005) and the spread of invasive species (Frieswyk and Zedler, 2007; Robichaud and Rooney, 2017; Tulbure et al., 2007), have led to the loss of quality Great Lakes coastal wetland habitat for breeding birds and anurans (Knutson et al., 1999; Robichaud and Rooney, 2017). Coastal wetlands within the bay of

Green Bay, Lake Michigan (hereafter called Green Bay) are no exception, particularly in the southern half of Green Bay where a large fraction of the pre-settlement wetlands have been destroyed or degraded (Bosley, 1978; Epstein et al., 2002; Tulbure et al., 2007). Both natural water level fluctuations and human-induced changes in hydrology affect coastal wetland plant communities (Frieswyk and Zedler, 2007; Grabas and Rokitnicki-Wojcik, 2015) and ultimately influence the habitat of bird and anuran assemblages. Within the past two decades, published studies have examined factors that influence spatial and temporal variability in bird and anuran communities in Great Lakes coastal wetlands (Desgranges et al., 2006; Hanowski et al., 2007; Price et al., 2005; Steen et al., 2006; Tozer, 2016b), though none of these have focused specifically on Green Bay. With a few exceptions (e.g., Hecnar, 2004; Price et al., 2007, 2005; Tozer, 2013, 2016b), anurans are a particularly understudied group in Great Lakes coastal wetlands, including Green Bay. Hanowski et al. (2007) explored differences in coastal wetland breeding bird communities across ecoprovinces in the U.S. portion of Great Lakes, but they did not account for changing water levels or include anuran species in their comparisons. Many important coastal wetland bird species (e.g., herons, egrets, bitterns) feed regularly on tadpoles and adult anurans, so the ecological connection between these two taxonomic groups may be an important feature of Great Lakes coastal wetland communities.

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We investigated how breeding bird and anuran communities are differentiated in space and time among Green Bay coastal wetlands. Our analysis is based on 2011–2017 point count data that we collected as part of the Great Lakes Coastal Wetland Monitoring Program (CWMP; Uzarski et al., 2017). Results document variation in wetland bird and anuran communities associated with different lake levels, sub-regions within Green Bay, and hydromorphic wetland type. To our knowledge, this is one of the first attempts to understand Green Bay bird and anuran communities during the transition from extremely low to relatively high lake levels.

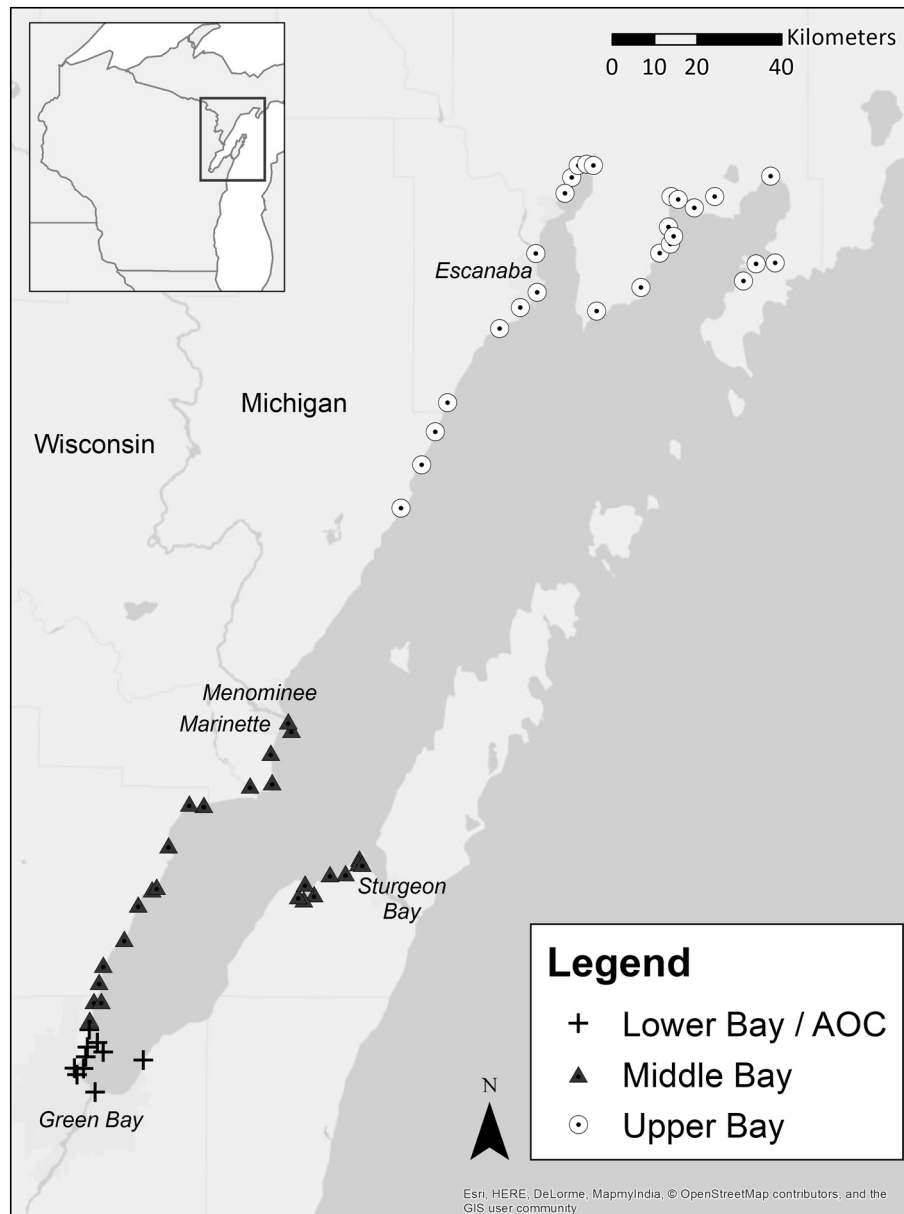
## Methods

### Study area

Located within the Laurentian Mixed Forest ecoregion, Green Bay comprises the western arm of Lake Michigan, extending from the city of

Green Bay, Wisconsin to the Upper Peninsula of Michigan, including Little and Big Bay de Noc (Fig. 1). It is nearly 190 km long and encompasses nearly 4000 km<sup>2</sup> and over 500 km of shoreline. Green Bay's coastal zone consists of a heterogeneous landscape of emergent and submergent wetlands, wet meadows, shrub carr, and upland and lowland forests, in addition to extensive human developed lands, particularly near the major urban centers of Green Bay, Sturgeon Bay, and Marinette in Wisconsin and Escanaba in Michigan.

As a part of the Great Lakes Restoration Initiative-funded CWMP, we sampled 63 Green Bay coastal wetlands that were at least 4 ha in size, dominated by open herbaceous vegetation, and hydrologically connected to and influenced by the bay (e.g., through seiche or wave action). Dominant plants of these wetlands included cattails (e.g., *Typha* spp.), bulrushes (e.g., *Schoenoplectus* spp.), sedges (e.g., *Carex* spp.), grasses (*Calamagrostis* spp.), and invasive common reed (*Phragmites australis* [Cav.] Trin. ex Steud.), reed canary grass (*Phalaris arundinacea* L.), and hybrid cattail (*Typha × glauca* Godr.). Each coastal



**Fig. 1.** Project study area in Green Bay, Lake Michigan, USA indicating Great Lakes coastal wetland sites ( $n = 63$ ) surveyed for birds (228 samples) and anurans (173 samples) between 2011 and 2017. Wetland sites were categorized into sub-regions within Green Bay: lower bay/Lower Green Bay and Fox River Area of Concern (AOC;  $n = 10$ ), middle bay ( $n = 26$ ), and upper bay ( $n = 27$ ). Map was created using ArcGIS 10.5 software (Environmental Systems Research Institute, 2016) and displays the World Light Gray Canvas basemap for reference. Wisconsin inset map sources include Esri, TomTom North America, Inc., U.S. Census Bureau, U.S. Department of Agriculture, and National Agricultural Statistics Service.

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