



# Nearshore fish community assessment on Lake Ontario and the St. Lawrence River: A trap net-based index of biotic integrity



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## ABSTRACT

An index of biotic integrity (IBI) based on an Ontario provincial standard nearshore community index netting (NSCIN) protocol was developed to assess nearshore fish communities and ecosystem health in the Lake Ontario/St. Lawrence River ecoregion. The IBI was based on 11 individual metrics representing aspects of fish assemblage integrity: taxonomic richness, habitat guilds, trophic guilds, and overall abundance and biomass. Thirteen geographic areas were sampled and grouped into three habitat types: sheltered embayments, exposed embayments, and riverine. IBI values were higher for sheltered embayments (mean IBI = 71, excluding Hamilton Harbour) than for exposed embayments (62, excluding Toronto Harbour) and riverine areas (64). The IBI accurately reflected anticipated contemporary differences in ecosystem health among geographic areas as well as historical changes within the Bay of Quinte. Two designated areas of concern (AOCs) where remedial action plans (RAP) are ongoing, Hamilton Harbour, a sheltered embayment, and Toronto Harbour, a more exposed area, had lowest IBI values (45 and 47, respectively). IBI values on Bay of Quinte and Lake St. Francis AOCs, where RAPs are nearing completion, were very similar to IBI values from less affected embayments and nearshore areas within their respective habitat types. Upper and middle Bay of Quinte IBIs increased from 47.3 and 45.9, respectively, to 71.8 and 69.2 over a 45-year time period (1969–2013) consistent with previously documented major ecosystem change.

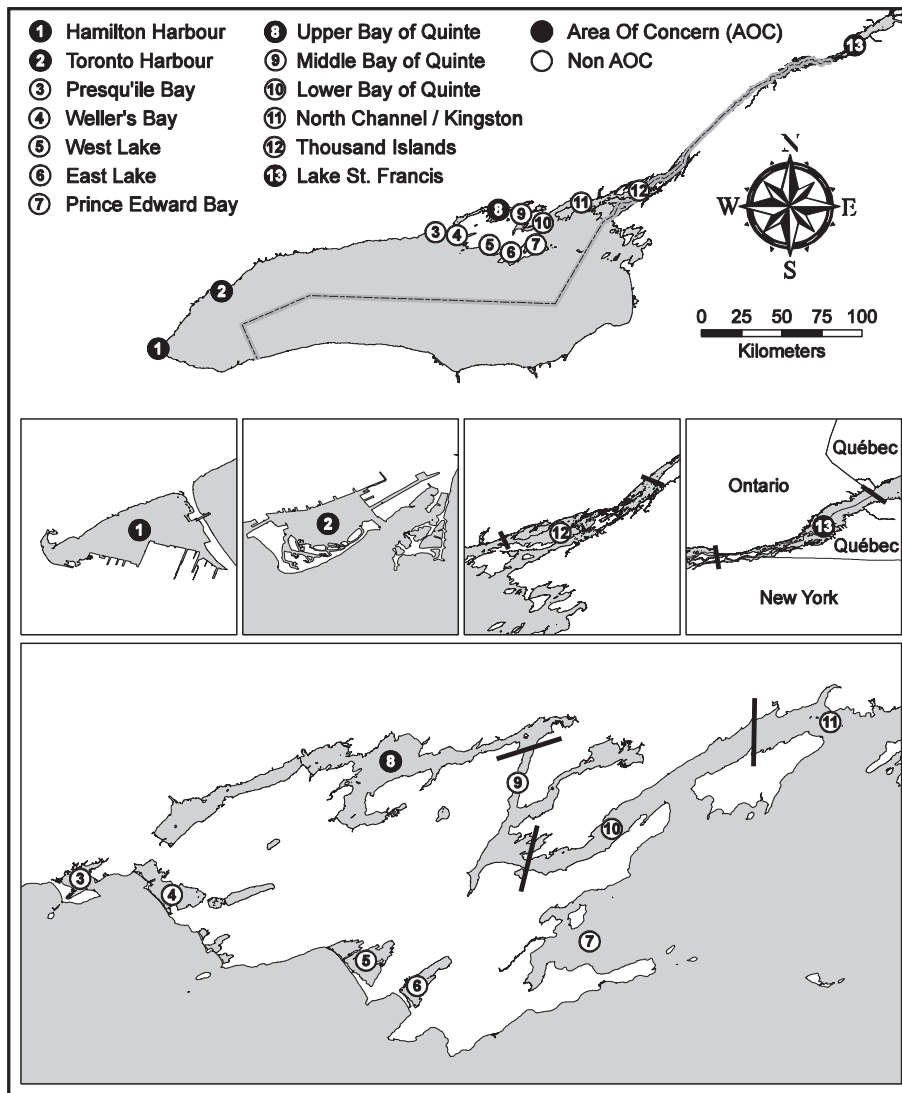
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## Introduction

Lake Ontario and the St. Lawrence River afford vast and complex nearshore aquatic habitats. These habitats are affected to some degree by human activities, and as such vary from relatively unimpaired to severely degraded. Four areas in Ontario waters are designated nearshore areas of concern (AOCs; <http://www.ec.gc.ca/raps-pas/>) and have beneficial use impairments that include degraded fish populations. These areas are Hamilton Harbour and Toronto Harbour in western Lake Ontario, the Bay of Quinte in eastern Lake Ontario, and Lake St. Francis, at Cornwall, on the St. Lawrence River. Efforts to remediate these AOCs are facilitated by multi-jurisdictional remedial action plans (RAP) and are ongoing on Hamilton Harbour and Toronto Harbour and nearing completion on the Bay of Quinte and Lake St. Francis. The Bay of Quinte in particular represents a well-studied area that affords a unique opportunity to measure ecosystem response to major human-induced disturbance (eutrophication), invasive species (dreissenid mussel-induced impacts), and remediation including point-source nutrient control over an extended time period (e.g. more than five decades; AEHMS, 2011; AEHMS, 2012; Minns et al., 1986).

We sampled fish communities in the four AOCs and in a variety of other areas that spanned the range of nearshore habitat types found among the AOCs (2001–2013; Fig. 1, Table 1). The nearshore habitat types range from sheltered embayments – relatively protected from the open waters of Lake Ontario proper – to exposed embayments and nearshore areas heavily influenced by the open waters of the lake and vast riverine reaches on the St. Lawrence River. An Ontario provincial standard method known as nearshore community index netting (NSCIN; Lester et al., 1996; Stirling, 1999) was used to evaluate relative aquatic ecosystem health in these nearshore areas. In this paper, we develop an index of biotic integrity (IBI) based on fish community data collected during our standard trap net sampling. IBIs for fish assemblages have been widely used to provide biological assessment of aquatic ecosystem health using standardized fish catch data (see review by Beck and Hatch, 2009). For example, Minns et al. (1994) developed an IBI for Great Lakes AOCs based on standardized boat electrofishing. IBIs consist of individual metrics that represent aspects of fish assemblage integrity such as taxonomic richness, habitat guilds, trophic guilds, and overall abundance and biomass (Whittier et al., 2001). Observed ranges in IBI values reflect integrated effects of major factors influencing fish assemblages including water quality, physical habitat supply, invasive species, and trophic structure—especially piscivore abundance (Minns et al., 1994).

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**Fig. 1.** Map of NSCIN sampling areas on Lake Ontario ( $n = 11$ ) and the St. Lawrence River ( $n = 2$ ). Upper panel: Lake Ontario and the St. Lawrence River with filled circles indicating designated Great Lakes Areas of Concern (AOCs); middle panel: four magnified maps of, from left to right, Hamilton Harbour, Toronto Harbour, Thousand Islands, and Lake St. Francis; lower panel: northeastern Lake Ontario and the Bay of Quinte sampling areas. Solid lines depict borders between upper, middle, and lower Bay of Quinte, North Channel/ Kingston, Thousand Islands, and Lake St. Francis.

**Table 1**

Sampling areas (arranged in Table geographically from west to east). Habitat type designations for sheltered and exposed embayment classifications based on relative exposure to Lake Ontario following [Bowly and Hoyle \(in press\)](#). For each area, the range and number of years sampled (in parentheses), the total number of trap net samples ( $N$ ), and the number of fish species caught are given. Areas of concern (AOCs) are indicated.

Sampling area	Habitat type	Range and number of years sampled	$N$	Number of fish species
Hamilton Harbour (AOC)	Sheltered	2006–2012 (4)	91	36
Toronto Harbour (AOC)	Exposed	2006–2012 (4)	96	25
Presqu'ile Bay	Exposed	2008 (1)	12	18
Weller's Bay	Sheltered	2001–2008 (2)	30	18
West Lake	Sheltered	2001–2013 (3)	48	20
East Lake	Sheltered	2007–2013 (2)	34	17
Prince Edward Bay	Exposed	2009–2013 (2)	51	21
Upper Bay of Quinte (AOC)	Sheltered	2001–2013 (12)	432	29
Middle Bay of Quinte	Sheltered	2002–2011 (6)	174	27
Lower Bay of Quinte	Transitional	2002–2011 (6)	53	22
North Channel/Kingston	Transitional	2009 (1)	25	18
Thousand Islands	River	2009 (1)	36	20
Lake St. Francis (AOC)	River	2007–2008 (2)	72	24

Our objective was to develop an IBI based on standard NSCIN trap net sampling that considers complexities among major habitat types ([Beck and Hatch, 2009](#); [Whittier et al., 2001](#)) – especially the degree of exposure to the open waters of Lake Ontario – to aid in the evaluation of contemporary aquatic ecosystem health in Lake Ontario and St. Lawrence River nearshore areas. [Bowly and Hoyle \(in press\)](#) found that the degree of exposure to Lake Ontario influenced fish community composition and species abundance differences among embayments. We expect our IBI would reflect contrasting ecosystem status in known degraded areas (i.e., Hamilton Harbour and Toronto Harbour AOCs), in AOCs nearing completion of remediation efforts, and in less disturbed (cf. [Stoddard et al., 2006](#)) reference embayments and nearshore areas in Lake Ontario and the St. Lawrence River. We acknowledge that our “reference” areas are not pristine habitats but they do support functional native fish communities and significant fisheries ([Stewart et al., 2013](#)) and thereby provide an appropriate context within which to set realistic expectations for degraded area remediation. To validate the ability of the IBI to reflect ecosystem status, we also applied the contemporary-based IBI in retrospect to a historic trap net data series on the Bay of Quinte. Major ecosystem time stanzas, reflecting human and invasive species-induced disturbance and remediation, are

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