Toronto and Region Remedial Action Plan

Preliminary Assessment of the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI) Along the Toronto and Region Waterfront

August 2015

Foreword

This report was commissioned by the Toronto and Region Remedial Action Plan (RAP) team and provides a preliminary assessment of the ‘Eutrophication or Undesirable Algae’ Beneficial Use Impairment (BUI) in the Toronto and Region Area of Concern (AOC). The Toronto and Region was designated a Great Lakes AOC in 1987. Eutrophication or Undesirable Algae was listed as a BUI within the Toronto and Region AOC based on the then current water quality data that showed high levels of total phosphorus, and the presence of Cladophora along the western waterfront.

This preliminary assessment follows the methodology of the ‘*Interim BUI Delisting Blueprint for Eutrophication or Undesirable Algae*’ published on the RAP website (www.torontorap.ca) on March 13, 2015. The assessment provided in this report is based on the most recently available water quality data collected within the AOC nearshore by the Ontario Ministry of the Environment and Climate Change and Environment Canada. The parameters evaluated in this preliminary assessment support a lack of eutrophic conditions along the waterfront, likely driven by physical mixing conditions in the nearshore which prevent the development of large standing crops of algae, despite continual nutrient inputs. Because of the high P loadings from point and non-point sources, there is an inherent risk that eutrophic conditions could develop in the Toronto and Region nearshore given proper conditions. Continued nutrient loadings from the Greater Toronto Area (GTA) to the western basin of Lake Ontario remain a concern and excessive Cladophora growth and beds continue to occur. The eutrophication issue at a regional scale requires further consideration outside the geographic scope of the Toronto and Region AOC.

Actions taken within the AOC and regionally will continue to be implemented under the Great Lakes Water Quality Agreement (GLWQA) through the Lake Ontario Lakewide Action and Management Plan (LAMP) and other mechanisms. The implementation of major infrastructure projects within the City of Toronto, such as the Don River and Central Waterfront Project, improvements to wastewater treatment plants (WWTPs) (such as the City of Toronto’s proposed new Ashbridges Bay WWTP Outfall), and the Don River Naturalization are integral to reducing nutrient inputs to the nearshore and to delisting the Toronto and Region AOC. These actions along with results from ongoing monitoring in the Toronto and Region AOC will be considered prior to making a final decision on re-designating the Eutrophication or Undesirable Algae BUI for the Toronto and Region AOC. The current goal is for a decision on re-designating this BUI to be made by 2020. The public will be provided with an opportunity to provide input prior to a final decision on re-designation.

A progress report is scheduled to be released in 2016 which will report on all of the actions undertaken by the RAP Team within the past five years that have contributed to the restoration of environmental conditions within the Toronto and Region AOC.

Executive Summary

Toronto and Region was designated as a Great Lakes Area of Concern (AOC) in 1987 due to significant degradation of environmental quality and impairment of beneficial uses, including the impairment of Eutrophication or Undesirable Algae. Considerable progress has been made within the AOC to abate the impacts of human activities and development on water quality. Despite this progress, inputs from combined sewer overflows (stormwater mixed with sewage) and storm sewers, following heavy rain or snowmelt, continue to degrade water quality in the lower portions of the Don and Humber Rivers, and along the central waterfront.

The Toronto and Region AOC is currently in the process of completing remedial actions and monitoring the recovery of environmental conditions in the AOC. This report presents an assessment of the most recently available water quality data (1993–2013) collected by the Ontario Ministry of the Environment and Climate Change and Environment Canada at long-term monitoring stations located along the Toronto and Region waterfront to assess the status of the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI). Spatial and temporal trends of spring total phosphorus (TP) concentrations (often the limiting nutrient in algal growth) were evaluated as an indication of the nutrient stores available for algae and phytoplankton growth over the subsequent growing season. Summer chlorophyll *a* (chl *a*) concentrations and secchi disc depth (SD) were also evaluated to assess resultant algal biomass and water clarity. Carlson's Trophic State Index measurements were used as an additional line-of-evidence to interrelate the three parameters (TP, chl *a*, SD) and provide an indication of potential factors driving algal biomass and water quality conditions in the AOC waterfront.

Overall, the parameters included in this assessment support a lack of impairment of the Eutrophication or Undesirable Algae BUI in the Toronto and Region waterfront, within the context of the Remedial Action Plan (RAP). Current conditions are indicative of a variable mesotrophic environment throughout the Toronto and Region waterfront with zones of higher impact restricted to areas in close proximity to source inputs and during wet weather events. The parameters included in this assessment support a lack of eutrophic conditions along the waterfront, likely driven by physical mixing conditions in the nearshore which prevent the development of large standing crops of algae, despite continual nutrient inputs. Because of the high P loadings from point and non-point sources, there is an inherent risk that eutrophic

conditions could develop in the Toronto and Region nearshore given proper conditions. The implementation of major infrastructure projects such as the Don River and Central Waterfront Project, improvements to wastewater treatment plants (WWTPs) (such as the City of Toronto's proposed new Ashbridges Bay WWTP Outfall), and the Don River Naturalization are integral to reducing nutrient inputs to the nearshore and to delisting the Toronto and Region AOC. Collectively, these projects will significantly improve water quality and reduce the risk of developing eutrophic conditions along the waterfront, and improve aquatic habitat for fish and wildlife.

Excess Cladophora growth continues to be observed along the western waterfront within the AOC. Despite improvements on a local scale, Dreissenid mussel colonization and the resultant concentration of phosphorus (P) near the lake bed, has led to a resurgence of Cladophora growth on a regional scale. This benthification has had the net effect of making the nearshore area increasingly sensitive to current P inputs; continued nutrient loadings from the GTA to the western basin of Lake Ontario remains a concern. As Cladophora growth and beds occur at a regional scale, they require further consideration outside the scope of the Toronto and Region RAP. Actions should continue to be taken within the AOC to contribute to the Lake Ontario Lakewide Action and Management Plan and the Nearshore Framework as specified in Annex 2 of the GLWQA. For example, these actions could include further research to understand the linkage between P loadings to the Lake Ontario nearshore and the presence and density of Cladophora beds, as well as involvement in a coordinated plan to reduce P inputs to western Lake Ontario in order to mitigate regional scale problems associated with excessive growth of Cladophora.

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1. Introduction

Toronto and Region was designated as one of the 43 Great Lakes Areas of Concern (AOC) in 1987, under the Great Lakes Water Quality Agreement (GLWQA). AOCs are areas at which water quality and ecosystem health were considered to be severely degraded as a result of locally sourced pollution caused by human activities. A Remedial Action Plan (RAP) was developed for each AOC to guide restoration and protection efforts with the ultimate goal of restoring the local beneficial use impairments (BUIs) and delisting the AOC. The Toronto and Region AOC is currently in the process of completing remedial actions and monitoring the recovery of environmental conditions in the AOC. Due to the implementation of remedial and management actions over the last 28 years, the Toronto and Region RAP steering committee has set a goal of completing the remaining priority actions to restore environmental conditions by 2020 in order to move toward delisting the AOC.

Monitoring has been conducted throughout the AOC to measure changes in water quality in response to remedial actions. Conditions throughout the watersheds have been reported regularly (*e.g.,* Boyd *et al*., 1999; TRCA, 1998, 2003); however, reporting of the status of water quality along the central waterfront, especially the area surrounding the Toronto Harbour, has been intermittent and has been identified as a need by the Toronto and Region RAP steering committee. To address this need the Toronto and Region RAP steering committee has undertaken a preliminary assessment of the Eutrophication or Undesirable Algae BUI. The assessment herein provides an evaluation of water quality monitoring data to assess the status of the Toronto and Region waterfront with respect to the Eutrophication or Undesirable Algae BUI. This assessment focuses on water quality conditions for the "waters of the Great Lakes" in accordance with the terms of the 2012 Protocol of the GLWQA (IJC, 2012); water quality in the AOC watersheds were only considered if there was a direct link to eutrophication impacts on the Toronto and Region waterfront.

2. Background

2.1. Description of the Toronto and Region Area of Concern (AOC)

The Toronto and Region AOC extends along the northern shoreline of Lake Ontario from the Rouge River in the east to Etobicoke Creek in the west, and includes an area of 2000 km^2 along the Toronto waterfront and within six watersheds (Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek and Rouge River) (Figure 1). The drainage basins of these watersheds, many of which originate from the southern slopes of the Oak Ridges Moraine, result in rural landscape throughout more than 40% of the AOC. In contrast, the AOC also includes the City of Toronto, which is one of the most densely urbanized areas in the Great Lakes with a population of 2.8 million.

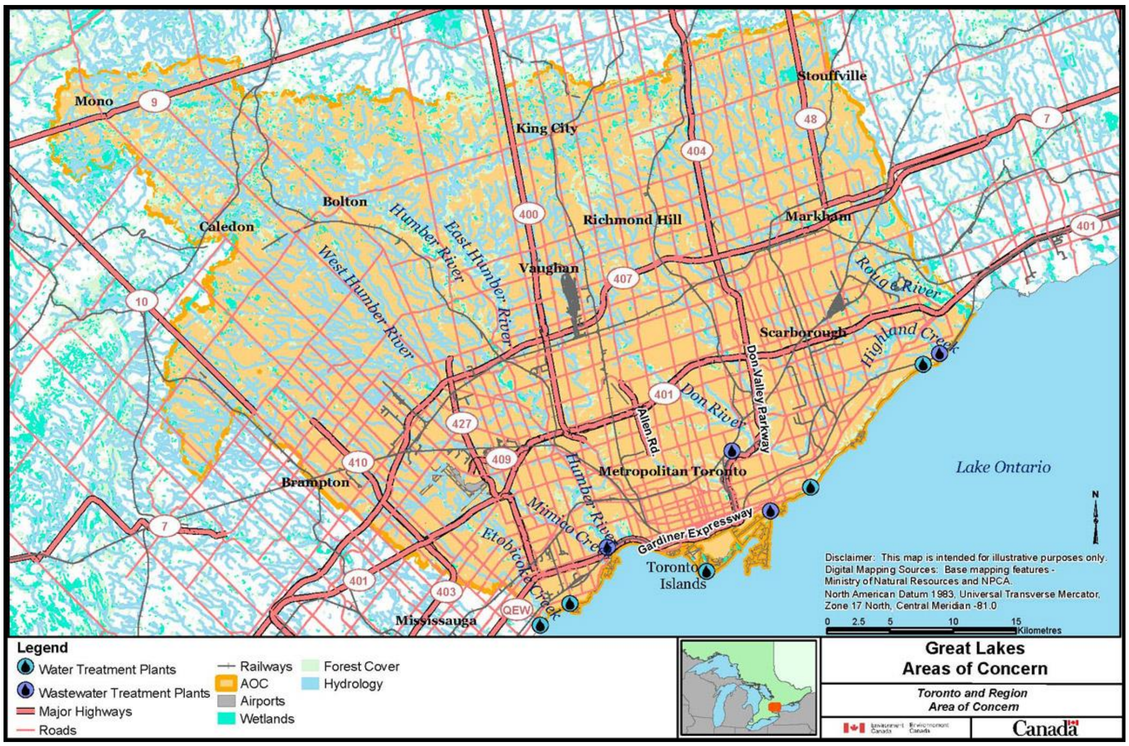

Figure 1 Map showing the boundary of the Toronto and Region Area of Concern (AOC) from Etobicoke Creek in the west to the Rouge River in the east.

Between the shoreline and the open waters of Lake Ontario is a transitional zone termed the "nearshore" which is influenced by land-based (natural and anthropogenic) inputs as well as the physical, chemical, and biological characteristics of the offshore waters (*i.e.*, open lake) of Lake Ontario. The physical processes affecting water quality in Lake Ontario at the Toronto and

Region waterfront (*i.e.*, nearshore) include lake circulation, wind-driven currents, eddies (circular currents of water), thermal stratification (the formation of a density barrier in the water column due to drastic changes in water temperature with depth), and frequent upwelling and downwelling (onshore circulation of offshore waters) events. These processes vary greatly spatially and temporally but play an important role in understanding water quality in the nearshore. In general, circulation along the Toronto and Region waterfront is toward the west in the summer and toward the east in winter (Toronto and Region RAP Team, 1989). Along the north shore of Lake Ontario, upwelling/downwelling events occur approximately every 10-12 days during the summer (Howell *et al.*, 2012b). Because the shoreline comprises various habitats, with different physical and limnological features, some areas tend to be sheltered from the full energy of open lake currents and wind-driven effects, which reduces water flow and can result in localized degraded water and sediment quality when a source of nutrients or contaminants is present.

Humber Bay forms an embayment along the western shoreline of the AOC, with some of the most urbanized tributaries (*e.g.*, Mimico Creek) within the AOC discharging into this area. Toronto Harbour, along the central waterfront, is best characterized as a sheltered embayment. The harbour is comprised of the Inner and Outer Harbours, which are separated by the Toronto Islands (Figure 2, inset). The Don River enters the Inner Harbour via the Keating Channel – a concrete channel that connects to the Don River at a 90º angle in the north east corner of the harbour. Water exchange in the Inner Harbour with Lake Ontario occurs through the East and West Gaps. The predominant flow tends to enter from the West Gap, flowing toward the ship canal and East Gap, resulting in an average residence time (of the water) of less than 3 weeks for the Inner Harbour (Kohli, 1978; Haffner et al., 1983). The eastern waterfront in the AOC consists of relatively straight stretches of shoreline and tends to be affected to a greater extent by lake circulation.

2.2. Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI)

Eutrophication refers to nutrient enrichment of a body of water. An overabundance of nutrients can lead to excessive algal growth, the decomposition of which can lead to dissolved oxygen (DO) depletion and subsequent fish kills and foul odour. The International Joint

Commission (IJC) provided the following definition for the Eutrophication or Undesirable Algae BUI: "When there are persistent water quality problems (*e.g.*, DO depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, *etc*.) attributed to cultural eutrophication (IJC, 1991)." Historically nutrient enrichment observed in the Toronto and Region AOC was attributed to anthropogenic influences from local industrial, agricultural and municipal sources which contributed high concentrations of phosphorus to tributary and nearshore waters (Toronto and Region RAP Team, 1989). Phosphorus is an essential nutrient for all living organisms but tends to be the first nutrient to limit algal growth. Phosphorus can enter the lake through point sources, such as wastewater treatment plant (WWTP) discharges, and non-point sources, including stormwater and agricultural runoff. The loading rate (amount entering the lake per given time period) of phosphorus is affected by a variety of factors, including land use, geology, and human activities. Low nitrogen (N) to phosphorus (P) ratios can further aggravate eutrophication by favouring Cyanobacteria species (Schindler, 1977; Smith, 1983). Cyanobacteria blooms can contribute to the release of toxins that may taint drinking water and pose a serious human health concern. In the nearshore zones, excess nutrient concentrations combined with suitable substrate have led to benthic algal blooms in some areas. Of particular note in Lake Ontario, is the overabundance of the filamentous green macroalga *Cladophora glomerata*.

In the mid-20th century it was recognized that eutrophication posed a major threat to water quality in the Great Lakes (Beeton, 1965). As a result of nuisance levels of algal growth related to excess nutrient concentrations from WWTP discharges and the use of high phosphate detergents, Canada and the United States signed the GLWQA in 1972 (IJC, 1972). The GLWQA was expanded in 1978 to include a broader goal of protecting the Great Lakes ecosystems (IJC, 1978) and has subsequently been updated to reflect priority actions to address the current state of water quality in the Great Lakes (IJC, 1987; 2012). A decline in phosphorus concentrations and algal biomass along the Toronto and Region waterfront was observed from the late 1970s to mid-1980s, corresponding with the removal of phosphates from detergents (Painter and Kamaitis, 1987). Despite this improvement, phosphorus concentrations frequently exceeded water quality guidelines across the waterfront during the 1980s (Toronto and Region RAP Team, 1989). Eutrophication remains an important focus of water quality management efforts in the Great Lakes today. In Ontario, a Provincial Water Quality Objective (PWQO) for total phosphorus

(TP) concentrations was set at 20 µg/l over the ice-free period (10 µg/l in naturally low phosphorus lakes) in order to avoid abundance of nuisance algae. The PWQO, established in 1979 using a trophic classification scheme developed by Dillon and Rigler (1975), specifies that the objective is meant to be used as a guideline and should be supplemented with site-specific studies (CCME, 2004). The GLWQA recognizes the importance of managing eutrophication and has set interim substance objectives for TP and chlorophyll *a* (chl *a*) concentrations in the open waters of the Great Lakes. In Lake Ontario, the interim objectives for TP (10 µg/l) and chl *a* (2.6 µg/l) concentrations were developed with the goal of reaching a meso-oligotrophic state in the open lake (IJC, 1978). The 2012 GLWQA Protocol further recognizes the importance of refining the interim objectives for open waters and developing targets specific to the nearshore waters, including embayment and tributary discharge for each Great Lake and establishing load reduction targets for priority watersheds that have significant localized impact on the waters of the Great Lakes (IJC, 2012).

Significant progress has been made on restoring the Eutrophication or Undesirable Algae BUI since the designation of Toronto and Region as an AOC in 1987. Stormwater infrastructure improvements, as well as wet weather flow projects and dry weather flow reduction measures have contributed to a further decline in nutrient concentrations along the waterfront. Furthermore, TP concentrations in the open lake have declined to levels suggestive of more oligotrophic conditions (Dove 2009; Dove *et al.*, 2015). However, inputs from combined sewer overflows (*i.e.*, stormwater mixed with sewage) and storm sewers following heavy rainfall or snowmelt continue to degrade water quality in the lower portions of the Don and Humber Rivers, and along the central waterfront. Excess Cladophora growth continues to be observed along the western waterfront. The introduction of aquatic invasive species (*e.g.*, Dreissenid mussels and round gobies), changes in agricultural production systems, increased urbanization and climate change have also imposed complex environmental challenges.

A trophic evaluation of the Toronto and Region nearshore was used in this assessment to inform the status of eutrophication. To provide an indication of the trophic state of the Toronto and Region waterfront, Carlson's Trophic State Index (TSI) was applied to secchi disc depth (SD), chl *a* and TP data. Although originally developed for inland lakes and reservoirs, it provides an indication of conditions that may be driving water quality conditions and phytoplankton biomass (Carlson, 1977) thus providing a further line of evidence for this assessment. These parameters were then categorized using a trophic classification scheme (Table 1) developed by Carlson and Simpson (1996) to inform the current state of the AOC nearshore.

Table 1 Trophic classification scheme for oligotrophic, mesotrophic and eutrophic trophic states as defined by Carlson and Simpson (1996) using spring total phosphorus (TP), summer chlorophyll *a* (chl *a*), summer secchi disc depth (SD) and trophic state index (TSI) parameters.

Trophic State	Total Phosphorus (μg/l)	Chlorophyll a (μg/l)	Secchi Depth (m)	Trophic State Index (TSI)	Attributes
Oligotrophic	<6	<0.95	>8	<30	Clear water; oxygen throughout the year in hypolimnion
	6-12	0.95-2.6	8-4	30-40	Hypolimnion of shallower lakes may become anoxic
Mesotrophic	12-24	2.6-7.3	4-2	40-50	Moderately clear; increasing probability of summer hypolimnetic anoxia
Eutrophic	24-48	7.3-20	2-1	50-60	Anoxic hypolimnia; macrophyte problems possible
	48-96	20-56	0.5-1	60-70	Blue-green algae dominate, algal scums and macrophyte problems

2.2.1. Environmental Conditions and Problem Definition (Stage 1 RAP, 1989)

The Stage 1 RAP report identified the Beneficial Use ‘Eutrophication or Undesirable Algae’ as impaired (Table 2). The impaired designation was based on water quality data collected from 1976–1983 (Poulton and Griffiths, 1986; Griffiths, 1988) with phosphorus concentrations frequently exceeding the PWQO of 20 μg/l across the waterfront. In addition, nuisance growth of Cladophora was observed along the western waterfront. Water quality monitoring identified Humber Bay and the Toronto Inner Harbour (*i.e.*, Inner Harbour) as the most degraded areas along the AOC waterfront due to the poor dispersion characteristics in these areas, compared to the open shoreline along the eastern waterfront where lake circulation reduced the effects of high nutrient loadings (Toronto and Region RAP Team, 1989).

Table 2 Eutrophication or Undesirable Algae was identified as impaired in the Stage 1 Remedial Action Plan (RAP) for the Toronto and Region Area of Concern (AOC) (Toronto and Region RAP Team, 1989).

Potential Impaired Use	Status
viii) Eutrophication or Undesirable Algae	*Impaired* – Phosphorus often exceeds Provincial Water Quality Guideline of 20 µg/l across the waterfront. Algal and weed problems are restricted to the western shoreline because of lack of suitable substrate and wave action in other areas.

The Stage 1 RAP report (1989) evaluated water quality throughout three primary areas in the nearshore: Central, Western and Eastern Waterfront. Within the Central Waterfront (*i.e.*, Toronto Harbour) five water quality zones were identified, using cluster analysis for conventional pollutants. In decreasing order of impairment, these were:

i. Keating Channel
ii. Northeast corner of the Inner Harbour (adjacent to Keating Channel)
iii. Remainder of Inner Harbour
iv. Outer Harbour and East & West Gaps
v. Offshore waters

Similarly, the Western Waterfront was separated into three distinct water quality zones:

1. Immediate vicinity of Humber [WWTP] outfall, Mimico Creek & Humber River outlets
2. Intermediate, localized area of impact less than 1 km wide above major sources of input
3. Offshore

Compared to the nearshore, much higher concentrations of TP were historically reported in the watersheds within the AOC. Mean TP concentrations of 258 µg/l and 113 µg/l were measured in Highland Creek during 1979 and 1981, respectively (Toronto and Region RAP Team, 1989). High TP levels were also reported in the Rouge River, with a distinct downward trend since the mid-1970s. Sources of nutrients to the waterfront include rural non-point sources, dry weather seepage (from storm sewers), urban stormwater runoff, combined sewer overflows (CSOs) and WWTP discharges.

2.2.2. Moving Forward (1994–2010)

The governments of Canada and Ontario, together with community stakeholders, undertook a detailed review of environmental goals and remedial actions needed to restore, protect and monitor environmental quality within the AOC. The Stage 2 RAP Report "Clean

Waters, Clear Choices" identified 53 recommended remedial actions to protect ecosystem health and remove the AOC designation (Toronto and Region RAP Team, 1994). Specific targets related to the Eutrophication or Undesirable Algae BUI included:

Control stormwater quality and quantity:

- The quality of stormwater run-off is protected and enhanced.
- In cold water fisheries areas, sufficient stormwater controls are established to control runoff from rainfall events of at least 25 mm daily precipitation; buffer zones of 30 m or more separate developed lands from receiving streams and lakes; temperature impacts should be mitigated.
- In warm water fisheries areas, sufficient stormwater controls are established to control runoff from rainfall events of at least 25 mm daily precipitation; buffer zones of 15 m or more separate developed from receiving streams and lakes.

Virtual elimination of combined sewer overflows:

- 90% of the wet weather flow in the combined sewer system is controlled.
- The controlled volume of the combined sewage receives treatment at least equivalent to primary treatment plus disinfection (that is, treatment equivalent to 50% biochemical oxygen demand removal and 70% total suspended solids removal).

Control quality of sanitary discharge:

- Sanitary sewage receives secondary treatment with phosphorus removal and disinfection and produces non-toxic and non-mutagenic effluent with the following characteristics:
  a. Biochemical Oxygen Demand: 25 mg/l
  b. Total Suspended Solids: 25 mg/l
  c. Total Phosphorus: 0.5 mg/l

The recommended remedial actions to address the Eutrophication or Undesirable Algae BUI have been, or are currently being, implemented within the AOC (Table 3) and any changes to water quality resulting from these restoration and protection efforts are being measured. RAP progress reports were issued in 1998 & 1999 (Clean Waters, Clear Choices Progress Reports), 2001 (Clean Waters, Healthy Habitats) and 2007 (Moving Forward). In 2010, an update on the Status of Beneficial Use Impairments in the Toronto and Region AOC was published (EC & MOE, 2010). The update identified Eutrophication or Undesirable Algae as impaired and listed remaining remedial actions to be completed (Table 3).

Table 3 Toronto and Region Area of Concern (AOC) Status of Beneficial Use Impairments (September 2010) update on the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI)

Status: ***Impaired*** While levels of phosphorus along the waterfront frequently meet provincial guidelines, levels of phosphorus in the watershed frequently exceed provincial guidelines. Algal growth continues to be a problem along the western part of the waterfront.	
Completed Actions (Agency Lead)	**Remaining Actions (Agency lead)**
▪ Decreased phosphorous loading into waterways through improvements to the stormwater infrastructure, including targeted combined sewer separation projects; installation of new infrastructure; evaluation and demonstration of sustainable technologies; and ensuring best management practices on construction sites (City of Toronto). ▪ Addressed concerns about eutrophication through wet weather flow projects and dry weather flow reduction measures (City of Toronto).	▪ Maintain efforts in the rural areas to implement best management practices through Environmental Farm Plans and the Rural Clean Water Program (TRCA/MOECC). ▪ Continue wet weather flow projects and dry weather flow reduction measures (City of Toronto). ▪ Ensure stormwater management facilities in the upper reaches of the watersheds are operating properly (City of Toronto). ▪ Implement low impact development guidelines at new development sites (TRCA). ▪ Implement the Don and Waterfront Trunk Interceptor Capacity and Combined Sewer Overflow Control and Treatment Strategy (City of Toronto).

2.2.3. Current Status (Objectives of this Report)

The present evaluation provides a thorough review and analysis of the most recently available (1993–2013) water quality data in the Toronto and Region waterfront to assess the status of the Eutrophication or Undesirable Algae BUI. Water quality parameters will be evaluated to assess the various aspects of eutrophication including nutrient stressors (*i.e.*, phosphorus), as well as biological (*i.e.*, chlorophyll) and environmental (*i.e.*, SD, DO) responses.

The key objectives of this evaluation are to:

- Develop and provide guidance on the evaluation of the status of the Eutrophication or Undesirable Algae BUI along the Toronto and Region waterfront.
- Conduct a thorough review and analysis of eutrophication related water quality data and monitoring information for the Toronto and Region waterfront.
- Provide clarity on the status of Eutrophication or Undesirable Algae along the Toronto and Region waterfront.
- Provide recommendations for future actions to address Eutrophication or Undesirable Algae which would result in local or regional improvements in water quality and environmental benefits within the AOC.
- Provide recommendations for required long-term monitoring of the status of eutrophication in the AOC.

3. Methodology & Data Sources

Evaluation of the status of beneficial uses is typically conducted by comparing monitoring data against specific delisting criteria developed by the RAP team that, if achieved, would ensure long-term protection of water quality in the AOC. However, as the Toronto and Region RAP does not have specific target concentrations for parameters related to eutrophication, a weight-of-evidence approach that relies on multiple lines-of-evidence was used to inform the evaluation of the Eutrophication or Undesirable Algae BUI in the Toronto and Region waterfront. This assessment examines the most recently available (1993–2013) data collected along the waterfront for five key water quality parameters: TP, Chl *a*, DO and SD. Data analyzed in this assessment were collected by the Ontario Ministry of the Environment and Climate Change (MOECC) and Environment Canada (EC), as described below.

Long-term trends in spring (April–May) TP concentrations were assessed as an indication of the nutrient stores available for algae and phytoplankton growth over the subsequent growing seasons. Long-term summer (July-August) Chl *a* concentrations and SD were assessed as an indication of resultant algal biomass and water clarity. The relationship between nutrients and response variables to trophic state has been investigated through the use of the Carlson Trophic State Index (TSI). The index assumes that algal biomass is the basis for trophic state classification and uses linear regression models to interrelate three variables: SD, chl *a*, and TP to independently estimate algal biomass:

$$\text{TSI (SD)} = 60 - 14.4 \ln(\text{SD}) \qquad (1)$$

$$\text{TSI (CHL)} = 9.81 \ln(\text{CHL}) + 30.6 \qquad (2)$$

$$\text{TSI (TP)} = 14.42 \ln(\text{TP}) + 4.15 \qquad (3)$$

3.1. MOECC Lake Ontario Nearshore Index Stations

The MOECC has a network of fixed-point monitoring stations, termed “Index Stations”, located throughout the Great Lakes (Figure 2). The purpose of these stations is to provide information regarding where, and how, ambient water quality conditions are changing over time, as well as identifying the onset of anomalous conditions, through periodic monitoring. The program monitors select indicators from three broad categories:

1. Concentrations of selected contaminants, focusing on persistent and bioaccumulative contaminants (both legacy and current-use) in surficial sediment and in suspended particulate material, as indicators of the level of contaminants present in the aquatic environment.
2. The composition of benthic invertebrates living in bottom sediments, used as biological indicators of trophic status and general environmental conditions.
3. Various physical measurements, including thermal and optical profiles of the water column, and physical characterization of the lake bottom, used as indicators of habitat integrity.

Long-term trends in water quality parameters were assessed using data from fixed-point MOECC Index Stations along the AOC nearshore (Figure 2). Water quality sampling has been conducted at the Index Stations generally every 3 years from 1994 to 2012 (the most recent data available at the time of this assessment), with samples collected approximately 3 times per sampling year (spring, summer, fall). The Index Stations located in Humber Bay (Station 2047) and Toronto (Inner) Harbour (Station 1364), are of most interest and the focus of this assessment because of their location and availability of a long-term monitoring data set. Water quality parameters were also measured at the Etobicoke Creek Index Station (Station 3508) from 2006 to 2012. The Etobicoke Creek Station is located along the western boundary of the AOC, just offshore of Etobicoke Creek.

During each survey, replicate (n = 3) epilimnetic-integrated water samples (or surface-integrated if no thermocline was present) were collected, along with a single grab water sample collected approximately 1 m above the sediment bed. Secchi disc depth was also measured during each survey, and DO data was collected via a depth-profile using an AMT sonde. Water samples were analyzed at the MOECC Resources Road laboratory using standard MOECC methods for surface waters (Chow *et al.*, 2010) for a variety of parameters – key to this assessment are TP (MOECC method TOTNUT3367), and chl *a* (CHL3169).

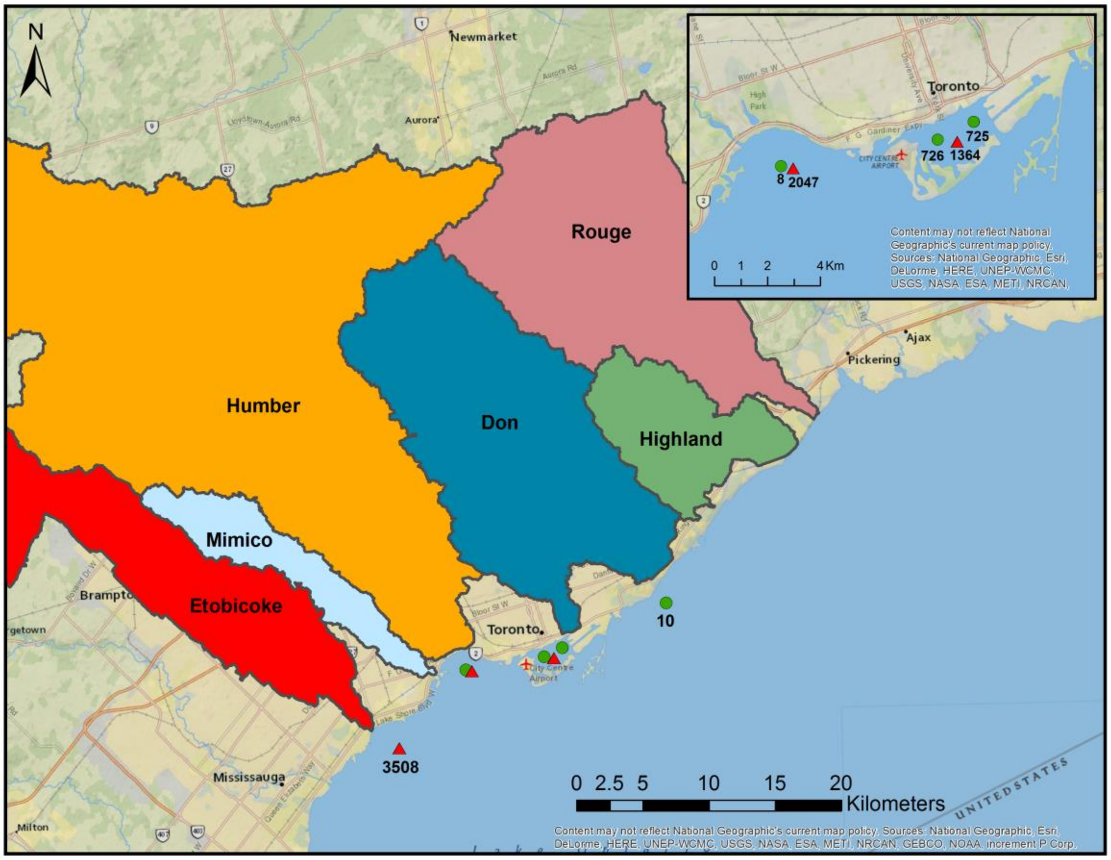

Figure 2 Map of Toronto and Region waterfront, showing the location of MOECC Index (red triangles) and EC nearshore (green circles) sampling stations used for this assessment. Stations are shown in the context of the Area of Concern (AOC) watersheds from Etobicoke Creek in the west to the Rouge River in the east. A close up of the Central Toronto waterfront (*i.e.,* Humber Bay and Toronto Harbour) is also provided (inset, upper right).

3.2. MOECC Activities for the 2008 Lake Ontario Binational Monitoring Year Cooperative Science and Monitoring Initiative (CSMI)

In 2008 the Ontario MOECC participated in a binational study of the nearshore zone of Lake Ontario. The nearshore was defined as the lake area extending from approximately 3 m depth to 5 km offshore and was sub-divided into 7 study polygons along the Canadian shoreline of Lake Ontario (Howell *et al.*, 2012a, 2012b). This study provided good spatial coverage of the Toronto and Region waterfront, including sampling polygons throughout the Greater Toronto Area (GTA).

Five surveys were conducted from April through October 2008, targeting a range of conditions:

- Survey 1 (April–May): Thermal bar narrow; runoff levels moderate to high; pre Cladophora growth; nearshore spatial variability high.
- Survey 2 (June): Low to moderate runoff levels; high Cladophora growth rates; nearshore biological activity increasing; onshore-offshore circulation increasing.
- Survey 3 (late July–early August): Runoff levels low; Cladophora growth rates declining and shoreline accumulation beginning; whole lake warming complete and thermal stratification developed; more intensive onshore-offshore circulation.
- Survey 4 (late August – September): Runoff levels low; Cladophora biomass on lake bed reduced and shore fouling ongoing; usual period for onshore transport of cyanobacteria metabolites to nearshore via downwelling events nutrient drawdown by biological activity near seasonal lows.
- Survey 5 (October): Moderate to high runoff levels; nearshore cooling beginning; high wind events and physical disturbance more frequent; Cladophora biomass on lakebed low; biological activity declining; generally more unpredictable and extreme conditions.

Detailed methodology and results of this study, except for the Toronto Centre polygon, were featured in a special edition of the Journal of Great Lakes Research (Howell *et al.*, 2012a; 2012b). To briefly summarize, near-continuous water quality and physical measurements were taken over a defined survey track within each polygon using a shipboard flow-through system connected to a series of sensors (water intake ~1.5 m below surface; readings logged every ~5–10 m). Depth profile information was collected at multiple locations along the track. Discrete surface water samples were collected and analyzed for various water quality parameters at the MOECC Resources Road laboratory, using standard MOECC methods as previously described. For the purposes of this assessment, a comparison of water quality parameters related to eutrophication were assessed to identify spatial variability within surveys; spatial variability between surveys; and temporal variability among surveys. Data presented in this evaluation include the GTA Centre, Toronto Centre, and GTA East study polygons (Figure 3). Discrete surface water chemistry samples for spring (survey 1, April–May) TP concentration, summer (surveys 3 & 4, July–August) chl *a* concentration and SD were used to assess trophic state throughout the Toronto and Region nearshore and compare to known ranges from the Carlson and Simpson (1996) trophic classification scheme.

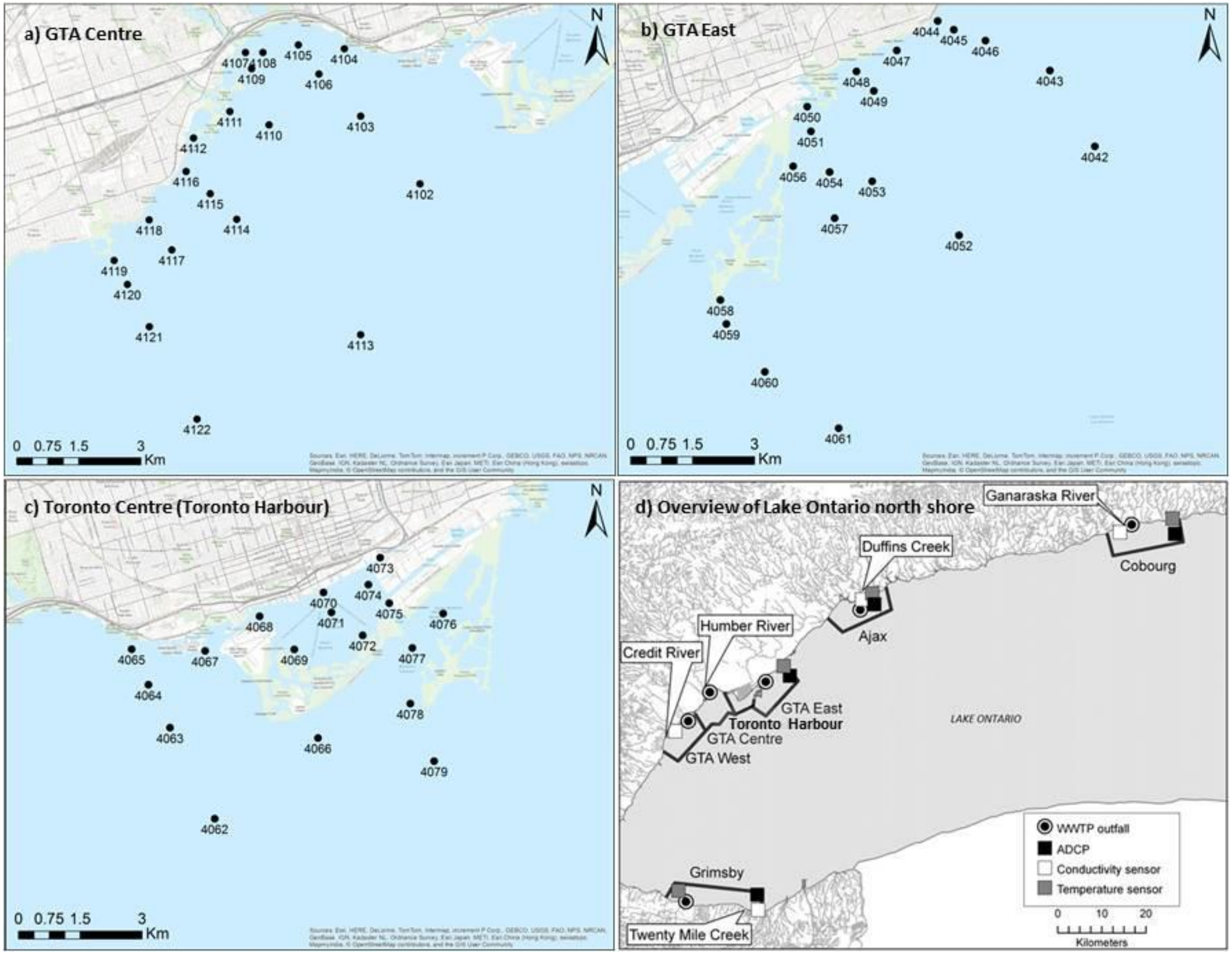

Figure 3 Map of AOC nearshore showing location of the MOECC 2008 Lake Ontario CSMI survey polygons (modified from Howell et al., 2012b). Point-chemistry sampling stations are shown for a) GTA Centre, b) GTA East, c) Toronto Centre (Toronto Harbour) and d) overview of sampling along the north shore of Lake Ontario.

3.3. Environment Canada Great Lakes Surveillance Program

Environment Canada's Great Lakes Surveillance has been conducting water quality monitoring since 1966. Ship-based monitoring cruises are conducted to measure physical, chemical and (some) biological parameters, and includes nutrients, major ions, trace metals and organic contaminants. The surveillance and monitoring is delivered as part of Canada's commitment to the Canada-United States GLWQA. As part of the program, Lake Ontario is sampled approximately every 2 years (since 1998), with one spring (April–May) and one summer (mid-August) cruise conducted during sampling years. The entire lake is assessed; here we include a summary of water quality measured at four nearshore stations within the Toronto and Region AOC boundary (Figure 2). Detailed methodology and an assessment of long-term offshore nutrient trends are reported by Dove *et al.* (2009) and Dove and Chapra (2015), respectively.

This assessment focuses on water quality parameters related to eutrophication collected from the Toronto and Region waterfront since 1993. Spring and summer cruises were conducted in 1993, followed by a period from 1994 through 1997 when no surveillance cruises were conducted and a large gap exists in the water quality record. Spring surveillance cruises have been conducted during 12 of the 16 years since that time, and summer cruises have been conducted during nine of the years. Toronto Harbour stations were added to the network in 2001. Key to this assessment are surface (1 m) concentrations of TP measured during spring cruises, as well as summer SD measurements and integrated depth (surface to 20 m depth, or 2 m above bottom) chl *a* concentrations.

4. BUI Assessment and Evaluation

4.1. Dissolved Oxygen

Dissolved oxygen provides a measure of how much oxygen is dissolved in the water, which can help inform water quality. Concentration of DO in surface water is temperature dependent (cold water can hold more DO than warm water). In lakes, natural variation in DO concentration occurs seasonally, as well as daily. Oxygen is produced by photosynthesis, which requires ample light conditions and therefore only occurs during the day; however, it is consumed during respiration and decomposition processes which occur 24 hrs a day. This process results in daily variations in DO concentrations, with a steady decline observed throughout the day with the lowest levels occurring just before dawn. Oxygen can also enter lakes through inflowing rivers and from air through wind mixing. During spring turnover the water column is typically near 100% saturation (for both oligotrophic and eutrophic systems). In summer and fall when water temperature is high and water bodies may become stratified, DO concentration is lower. DO depletion (anoxia) of bottom waters can be indicative of eutrophication due to decaying algae, however, the presence of other oxygen demanding substances in the water can have the same effect on DO concentrations. Dissolved oxygen concentration guidelines for the protection of aquatic life were developed to reflect the habitat needs of fish and therefore not necessarily indicative of an oxygen deficit due directly to eutrophication. DO concentrations within the Toronto and Region nearshore were evaluated for this assessment as an indicator of general water quality. If DO concentrations were to be considered impaired, additional lines-of-evidence would need to be assessed to determine whether nutrient-driven processes are contributing to the cause of low DO.

Reduced oxygen levels have been shown to cause lethal and sub-lethal effects in fish and other aquatic organisms. Water quality guidelines for DO are designed to protect both cold-water and warm-water biota. Cold water fishes include all of the trout, salmon, and whitefishes, along with smaller prey species such as Alewife, and are typically found where water temperature does not exceed 19ºC. Warm water fishes such as largemouth bass, sunfish and catfish are more tolerant of higher temperatures and can be found where maximum water temperatures often exceed 25ºC. The PWQO for DO concentrations was developed to span a range of ambient temperature: a minimum DO of 5 $mg{\cdot}L^{-1}$ at 25ºC at the upper end of the range, and 8 $mg{\cdot}L^{-1}$ at 0ºC at the lower end of the range (MOEE, 1994). The Canadian Water Quality Guideline (CWQG) similarly, has more than one guideline based on both temperature and life-stage. The CWQG for the lowest acceptable DO concentration are 6 and 5.5 $mg{\cdot}L^{-1}$ for early and other life stages, respectively, in warm-water ecosystems, and 9.5 and 6.5 $mg{\cdot}L^{-1}$ for early and other life stages, respectively, in cold-water ecosystems (CCME, 1999).

Since DO guidelines are based on the nature of the biological community present in a particular area, choice of an appropriate guidelines is dependent on the desire to protect warm-water or cold-water biota. The Toronto and Region waterfront supports a diversity of fish, therefore the cold-water DO guidelines allow for a more conservative approach. Dissolved oxygen concentrations measured in surface water at EC surveillance stations throughout the Toronto and Region waterfront indicated DO levels were consistently above both the PWQO and CWQG for all life-stages (based on guidelines for cold-water and warm-water ecosystems) from 1993 to 2013 (Figure 4). DO concentrations were lower during summer sampling dates as compared to other times during the year. This is consistent with the expectation that the water column is well mixed (and therefore well oxygenated) during the spring, and tends to stratify during the summer which may result in lower DO levels in the hypolimnion. DO concentrations measured at waterfront monitoring stations during the summer were above the CWQG for "other life stages" during all sampling dates and locations except for the Toronto East station in summer 2010 (Figure 4b). The Toronto East station is located in close proximity to the Ashbridges Bay WWTP effluent outfall and it is possible that oxygen demanding substances other than decaying algae were responsible for the observed oxygen depletion. DO concentrations were also measured throughout the water column during summer 2012 (the most recent data available) at the MOECC Index Stations (Toronto Harbour, Humber Bay, Etobicoke) (Figure 5). DO levels were above the CWQG for warm-water ecosystems as well as the guidelines for "other life stages" in cold-water ecosystems at all stations and depths measured. DO concentrations were below the minimum DO guideline for early life stages in cold-water ecosystems at the Toronto Harbour stations, as well as multiple depths at the Etobicoke and Humber Bay stations. Because of the location of these stations and timing of sampling, it is not expected that DO levels below this guideline (but above the guideline for other life stages) would impact biota.

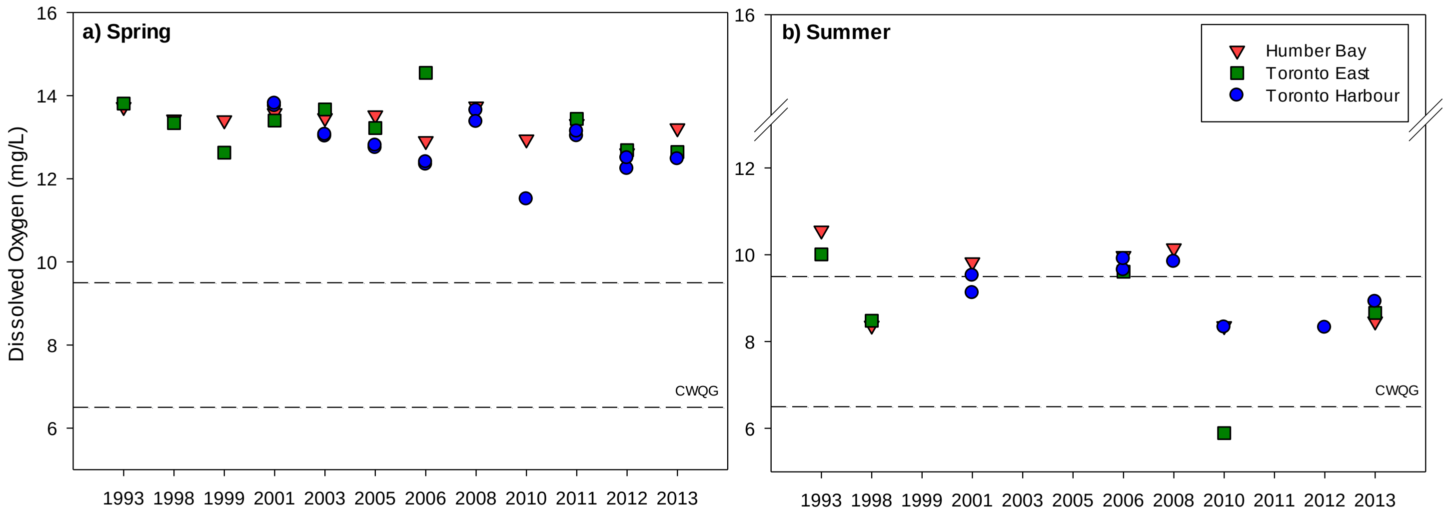

Figure 4 Surface dissolved oxygen concentration (mg/l) measured during a) spring and b) summer from EC surveillance stations located in Humber Bay (red triangles), Toronto Harbour (blue circles) and Toronto East (green squares) during 1993–2013. The Canadian Water Quality Guidelines (CWQG) for cold-water ecosystems are represented by the dotted lines at 9.5 mg·L^{-1} (early life stages) and 6.5 mg·L^{-1} (other life stages) (CCME, 1999).

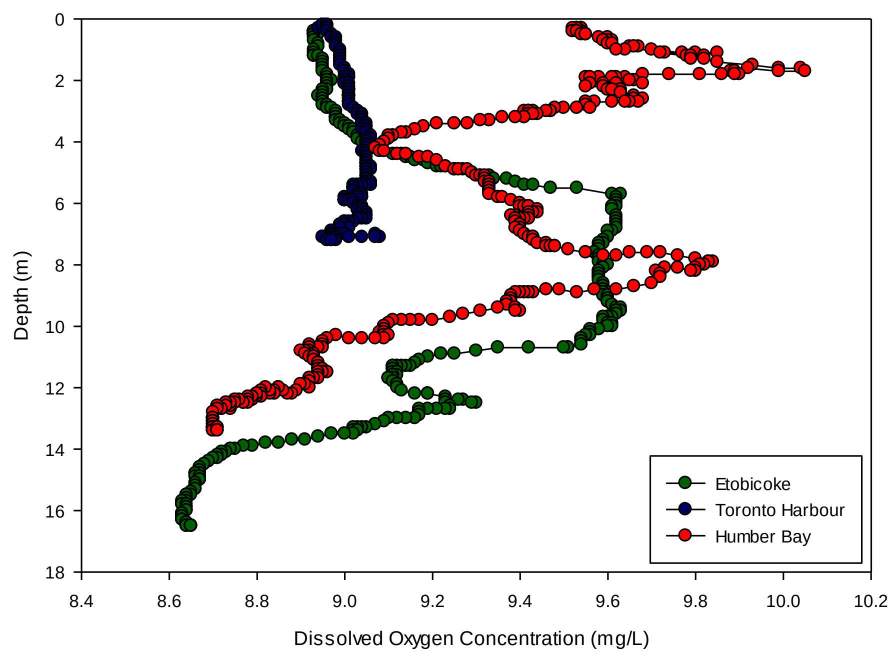

Figure 5 Dissolved oxygen concentration measured throughout the water column during summer 2012 at three MOECC Index Stations: Etobicoke (green), Toronto Harbour (blue) and Humber Bay (red). Depths are reported as meters below the surface, with an inverse y-axis so that the surface (0 m) is at the top of the graph.

4.2. Total Phosphorus

The Stage 1 RAP document reported a decrease in TP values from the late 1960s or early 1970s to the mid-1980s throughout the AOC nearshore, including Toronto Inner Harbour (130 µg/l down to 27 µg/l), and Ashbridges Bay (28 µg/l down to 17 µg/l). Offshore of Highland Creek, mean TP concentrations of 19 µg/l were reported in the mid-1980s. A decline in the number of exceedances of the PWQO for TP (20 µg/l) was also reported throughout the AOC. This decline in phosphorus concentration is largely attributable to increased phosphorus removal at WWTPs and more stringent federal guidelines on the use of phosphorus in detergents that were introduced in the 1970s. Although largely a whole-lake effect, reduced loadings from several WWTPs, including the Lakeview, Humber Bay, Ashbridges Bay (previously "Main"), North Toronto, Highland Creek, and potentially Duffin Creek Treatment Plants, as well as the Don River, Humber River and Etobicoke Creek, have contributed to a decrease in TP concentrations on a local scale.

Historically, the highest mean annual TP concentrations in the AOC have been in the Inner Harbour, with the major contribution from Don River loadings (which includes the North Toronto Treatment Plant), as well as storm and combined sewer discharges (Toronto and Region RAP Team, 1989). High phosphorus loading from the Ashbridges Bay and Highland Creek WWTPs were also reported along the eastern waterfront. The Stage 1 RAP estimated that annual TP loads discharged along the eastern waterfront accounted for 50% of the total loadings to the AOC waterfront in the mid-1980s (Toronto and Region RAP Team, 1989). However, due to the nature of the open coast along the eastern shore (*i.e.,* a lack of embayments and harbours) the area tends to be less prone to water quality problems, compared to the partially-enclosed Inner Harbour.

4.2.1. Long-term Trends at Nearshore Monitoring Stations

Spring TP concentrations ranged from 2–54 µg/l throughout the entire AOC waterfront with the greatest variability observed in the Inner Harbour (6–54 µg/l). Despite the large variability in TP concentrations, the majority of samples fell below the PWQO of 20 µg/l, suggesting that some of the variability may be due to the snapshot nature of the long-term monitoring data, whereby the time of sampling (*e.g.,* after a rain event) can have a large influence on water quality. The nearshore spring TP measured at the MOECC Index Stations (median of 3 integrated-depth samples) and EC Surveillance Stations (surface concentration, median of 2 stations for Inner Harbour) are shown in Figure 6. There was no clear long-term trend at any of the stations. The highest concentrations were consistently measured at the Inner Harbour station. In general, median spring TP concentrations fell within the mesotrophic (12–24 µg/l) to oligotrophic (<6–12 µg/l) ranges (Table 1), with the exception of Toronto Inner Harbour during spring 2000 (median TP 52 µg/l). It should be noted that on May 12, 2000 – 4 days prior to sampling at the MOECC Index Station – there was a large rain storm which saw 67.8 mm of rain fall over the City of Toronto, resulting in flooding of multiple waterways throughout the region. This was the same rainstorm that contributed to *Escherichia coli* (*E. coli*) bacteria contamination of the water supply in Walkerton, a small community in Southern Ontario. Thus, this survey is largely influenced by high levels of runoff relative to surveys conducted during other years which reflect more ambient conditions. When samples collected during May 2000 are removed from the dataset, spring TP concentrations in the Toronto Inner Harbour range from 6–22 µg/l.

4.2.2. Spatial Variability: 2008 Nearshore Survey

The spatial variability of spring surface TP concentrations measured throughout the AOC nearshore in May 2008 are shown in Figure 7. The highest median TP concentrations were measured in the Inner Harbour (14 µg/l, median of 8 replicates) and Outer Harbour (15 µg/l, median of 2 replicates). The overall spatial variability in TP concentration was low, with no statistically significant difference between study polygons. The greatest range of spring TP concentrations were reported for GTA Centre (5–34 µg/l, with outliers of 53 µg/l and 80 µg/l),[1,2] Inner Harbour (8–43 µg/l) and GTA East stations (6–30 µg/l, with one outlier of 162 µg/l)[2].

[1] Spring TP concentrations of 5 µg/L and 6 µg/L measured at stations in the GTA Centre polygon were identified as outliers on the box plots but were reported in the data range because the concentrations are at the low end of the analytical range

[2] Values greater or less than two times the quartile range from the mean

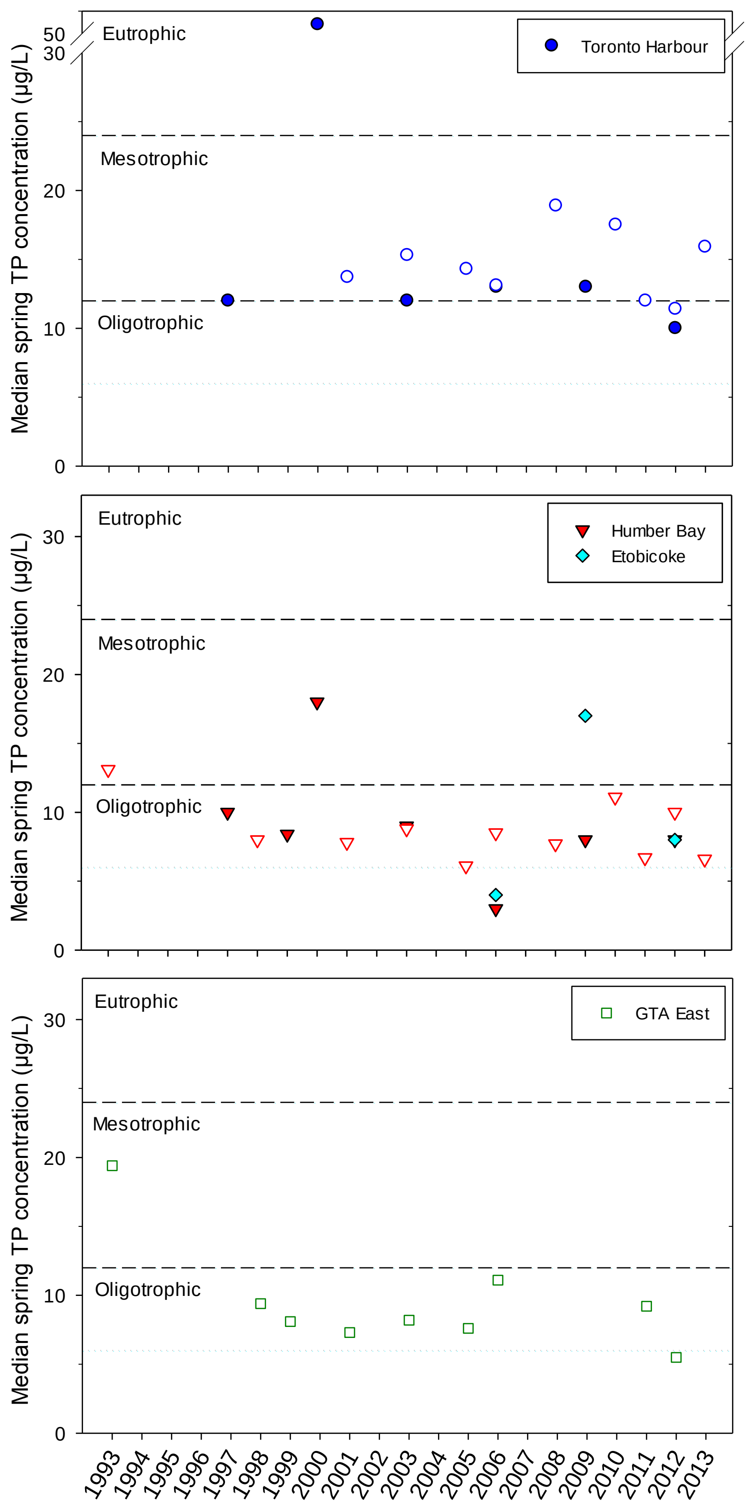

Figure 6 Median spring total phosphorus (TP) concentrations (µg/l) measured at MOECC Index (solid symbols) and EC Surveillance (open symbols) Stations located within the Toronto and Region waterfront: Etobicoke (light blue diamonds), Humber Bay (red triangles), Toronto Harbour (dark blue circles), and GTA East (dark green squares). Dotted lines represent trophic ranges for spring total phosphorus as reported by Carlson and Simpson (1996).

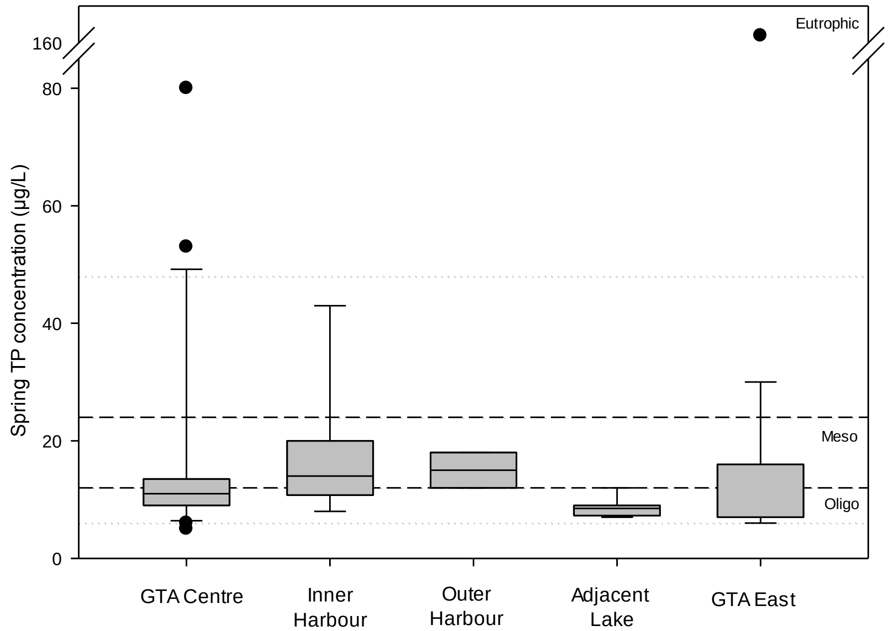

Figure 7 Box plot comparing spring, surface total phosphorus (TP) concentration (µg/l) measured throughout five areas within the Toronto and Region waterfront during 2008. The solid line within each box represents the median[3]; the lower and upper ends of the boxes are the 25th and 75th percentiles, respectively; whiskers show the minimum and maximum values; and dots represent outliers[2]. Dotted lines represent trophic ranges as reported by Carlson and Simpson (1996).

There was a great degree of intra-station variability in mean TP concentrations measured during each of the five sampling surveys conducted between late April or early May and October 2008 (Figure 8). The highest single TP concentration was reported in the GTA East survey area, with concentrations reaching 370 µg/l during October 2008. A review of the raw data indicates the high TP measured in the GTA East polygon is driven by data collected from one station, located in close proximity to the Ashbridges Bay WWTP effluent outfall (43°38'54.19"N, 79°18'38.76"W). At the Inner and Outer Harbours the highest TP concentrations were measured during the second survey, conducted on June 17, 2008, with mean TP of 40 µg/l and 31 µg/l, respectively. Targeted conditions for this sampling date included "low to moderate runoff," however, this survey had the greatest amount of rainfall within 1 week prior to sampling (39.5 mm measured at the Toronto City Centre weather station), compared to the other 4 survey dates.

[3] Median TP concentration for GTA East polygon (7 µg/L) falls along the lower end of the box (25th percentile line)

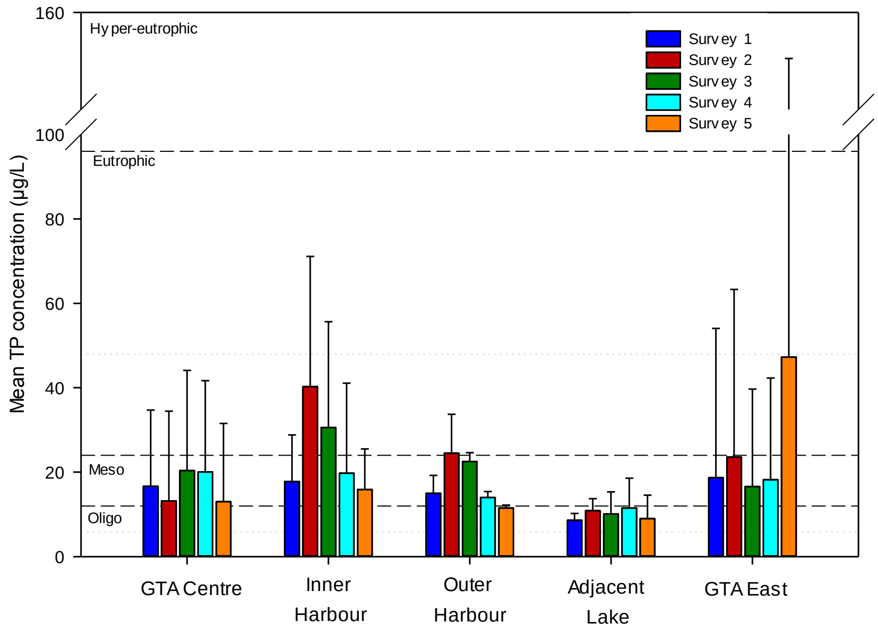

Figure 8 Mean surface total phosphorus (TP) concentration (µg/l) measured along the Toronto and Region nearshore. Five MOECC sampling surveys were conducted between late April or early May and October 2008. Dotted lines represent trophic ranges as reported by Carlson and Simpson (1996).

4.3. Chlorophyll a

Chlorophyll *a* concentrations are measured as a proxy for algal density to indicate the level of biological response to nutrients. In order to best understand the relationship between phosphorus concentrations and algal growth, chl *a* concentrations are presented as median summer values, since algal production during spring and fall overturn tend to be limited by temperature and light.

4.3.1. Long-term Trends at Nearshore Monitoring Stations

The long-term trends of median nearshore summer chl *a* concentrations measured at the MOECC Index (median of 3 integrated-depth samples) and EC Surveillance (integrated-depth samples, median of 2 stations for Inner Harbour) stations are shown in Figure 9. The highest concentrations were measured in Toronto Harbour (7.8 µg/l & 8.5 µg/l during 2006 and 2009, respectively) and Humber Bay (5.2 µg/l during 2009), with no significant long-term trend at any of the nearshore stations. In general, median summer chl *a* concentrations were representative of mesotrophic (2.6–7.3 µg/l, Table 1) or oligotrophic (<0.95–2.6 µg/l, Table 1) conditions, with the exception of Toronto Harbour during summer 2000 and 2009, which fell within the eutrophic (>7.3 µg/l) range. During the summer of 2012, median chl *a* concentrations at all three Index Stations within the AOC nearshore were indicative of oligotrophic conditions. In the Toronto Inner Harbour, chl *a* concentrations measured during spring 2013 were slightly elevated but remained at the lower mesotrophic range.

4.3.2. Spatial Variability: 2008 Nearshore Survey

The spatial variability of summer surface chl *a* concentrations measured in 2008 throughout the AOC nearshore are shown in Figure 10. In general, median summer chl *a* concentrations were representative of mesotrophic or oligotrophic conditions. The highest median concentrations were measured in the Inner Harbour (4.8 µg/l) and GTA Centre (4.1 µg/l), with a higher degree of intra-polygon variability observed for the GTA Centre samples (2.2–43 µg/l) (Figure 10). Median summer chl *a* concentration differed between sub-areas (Kruskal-Wallis test, $H = 37.140$, $P < 0.001$, d.f. = 4). Post-hoc testing was performed using Dunn's method for multiple comparisons, it was determined that median summer chl *a* concentration in the Inner Harbour was significantly different ($p < 0.05$) than those measured in Adjacent Lake and GTA East samples. Median summer chl *a* concentration measured in the GTA Centre polygon, on the other hand, was significantly different from levels measured in the GTA East polygon, but not from other areas.

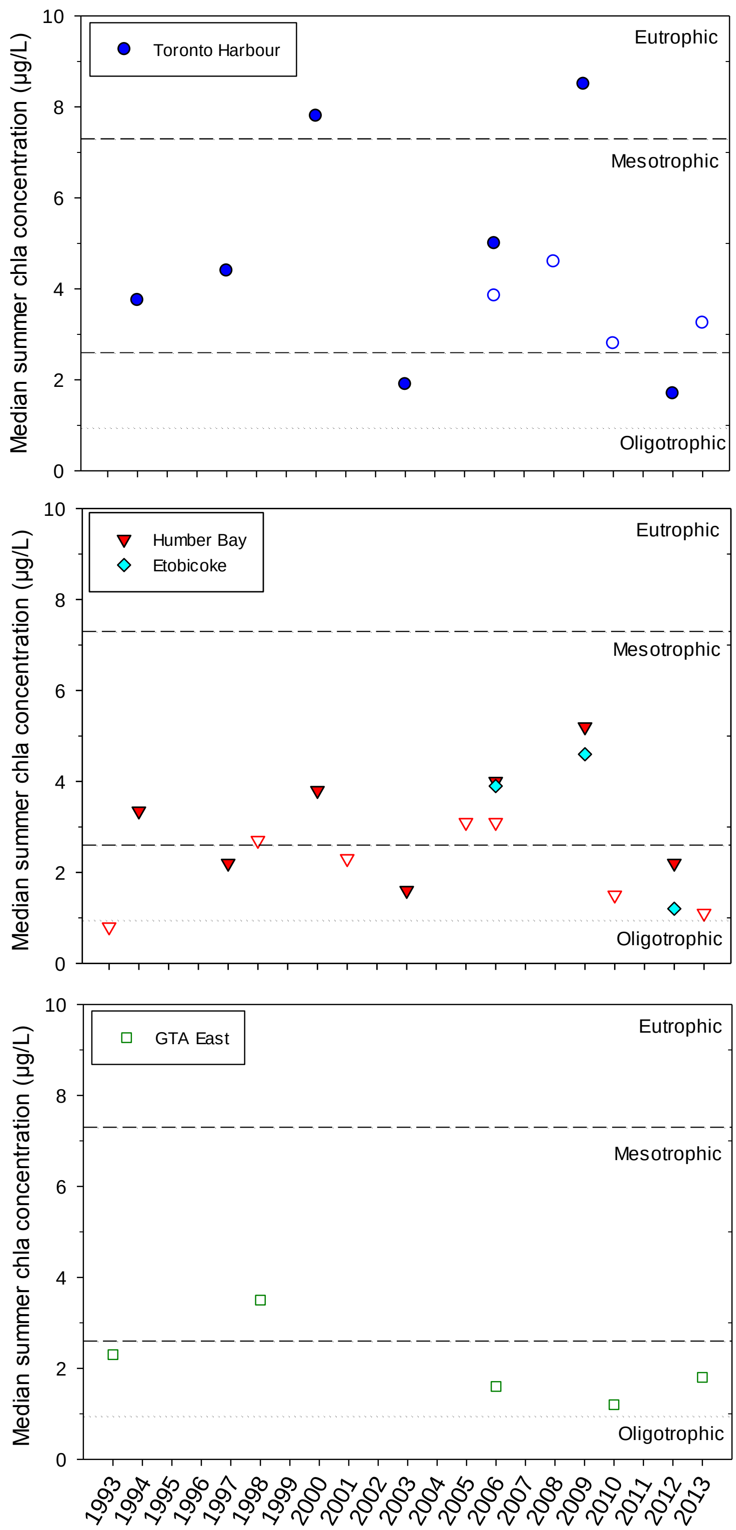

Figure 9 Median summer chlorophyll *a* (chl *a*) concentrations (µg/L) measured at MOECC Index (solid symbols) and EC Surveillance (open symbols) stations located within of the Toronto and Region waterfront: Etobicoke (light blue diamonds), Humber Bay (red triangles), Toronto Harbour (dark blue circles), and GTA East (dark green squares). Dotted lines represent trophic ranges for spring total phosphorus as reported by Carlson and Simpson (1996).

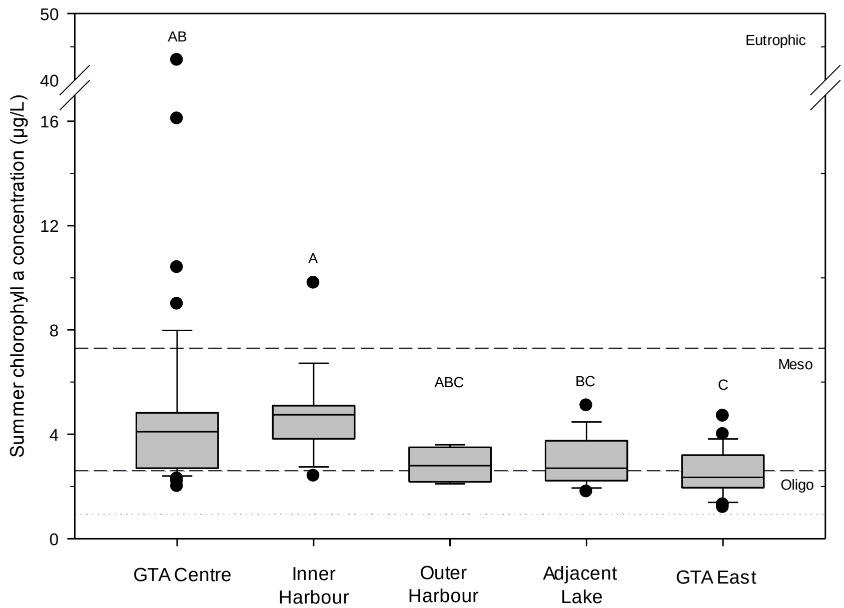

Figure 10 Box plot comparing summer surface chlorophyll *a* (chl *a*) concentration (µg/L) measured throughout five areas within the Toronto and Region nearshore in 2008. The solid line within each box represents the median; the lower and upper ends of the boxes are the 25th and 75th percentiles, respectively; whiskers show the minimum and maximum values; dots represent outliers[2] and letters indicate significant differences between sub-areas. Dotted lines represent trophic state classification scheme for as reported by Carlson and Simpson (1996).

4.4. Secchi Disc Depth

Secchi disc depth is measured as a proxy for water clarity – another indicator of a biological effect due to eutrophication. Although this method is easy and inexpensive to measure, it is important to note that SD can have a wide degree of error due to differences in field staff estimating SD, amount of sunlight present during measurement, *etc.* Additionally, SD can be driven by factors other than algal turbidity, particularly during wet weather events. High total suspended solids (TSS) concentrations (seston) can cause low water transparency. Although TSS may be important to consider for other ecosystem effects (*e.g.*, direct impacts on biota), TSS-related impacts are outside the scope of this eutrophication assessment. Despite this, SD is generally a reliable tool for long-term monitoring (particularly with large sample sizes).

4.4.1. Long-term Trends at Nearshore Monitoring Stations

The long-term trends of summer SD measured at the MOECC Index Stations are shown in Figure 11. In general, one SD was reported for each sampling seasons, however, where more than one reading was available data are reported as mean values. There was no significant long-term trend at any of the sampling stations throughout the nearshore. In general, mean summer SD falls within the mesotrophic (2–4 m) or oligotrophic (>4 m) range. The lowest SD measurements were reported during summer 2009 at the Etobicoke (<0.5 m) and Toronto Harbour (<1 m) stations. This may be related to high TSS concentrations due to stormwater runoff, rather than a direct result of algal biomass, since the summer of 2009 saw an above average amount of precipitation, including a large flooding event in July. This is consistent with high TP concentrations (not shown) measured at the Toronto Harbour Index Station in summer 2009.

4.4.2. Spatial Variability: 2008 Nearshore Survey

Summer secchi disc depths are presented in Figure 12 for each polygon during five sampling surveys conducted throughout 2008. Values are presented as mean SD for each survey and sub-area. The largest SD were observed during spring (dark blue) and fall (orange) at all stations – likely related to the mixing with clear water from Lake Ontario during spring/fall turnover periods. Summer SD generally fell within the mesotrophic or oligotrophic ranges, with the exception of depths measured in the Inner (1.2 m) and Outer (1.4 m) Harbours during June 2008 (red circle and square, respectively, Figure 12), which had SD measurements reported within the eutrophic (0.5–2 m) range.

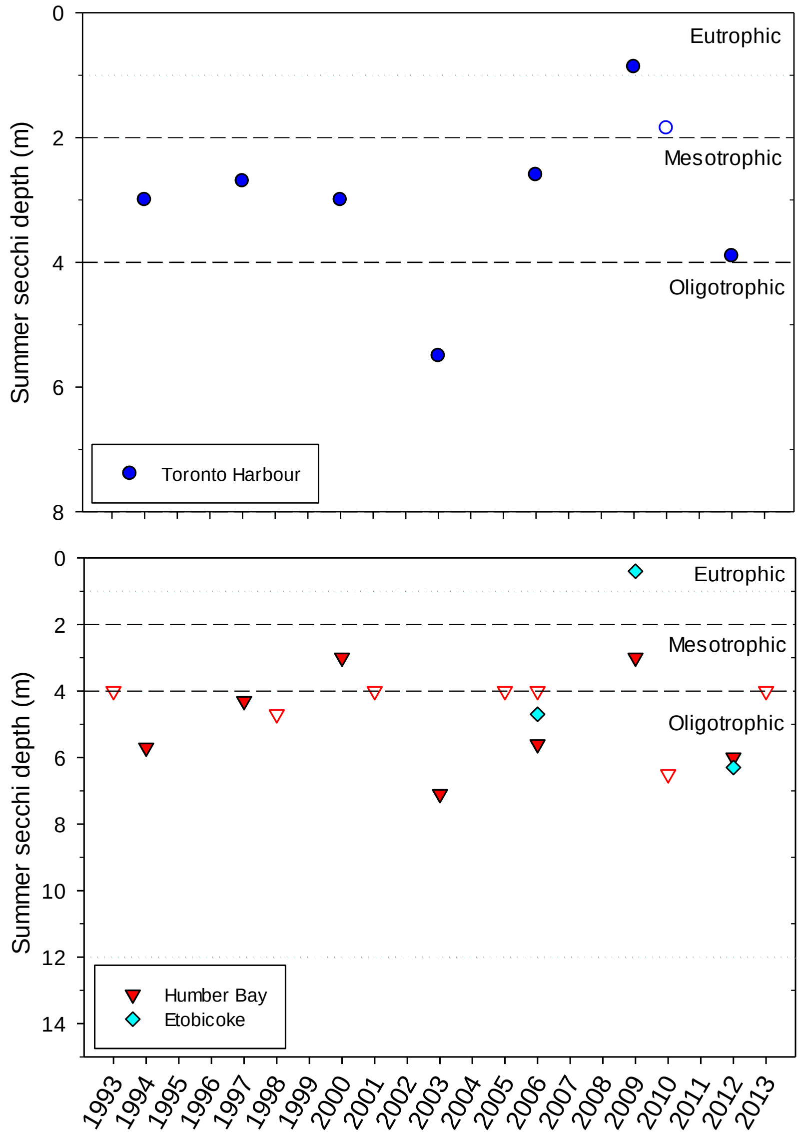

Figure 11 Summer secchi disc depth (SD) (m) measured during 1993–2013 at MOECC Index (solid symbols) and EC Surveillance (open symbols) stations located in the Toronto Harbour, Humber Bay, and Etobicoke (MOECC only) during 1993–2013. Depths are reported as meters below the surface, with an inverse y-axis so that the surface (0 m) is at the top of the graph. Dotted lines represent trophic ranges as reported by Carlson and Simpson (1996).

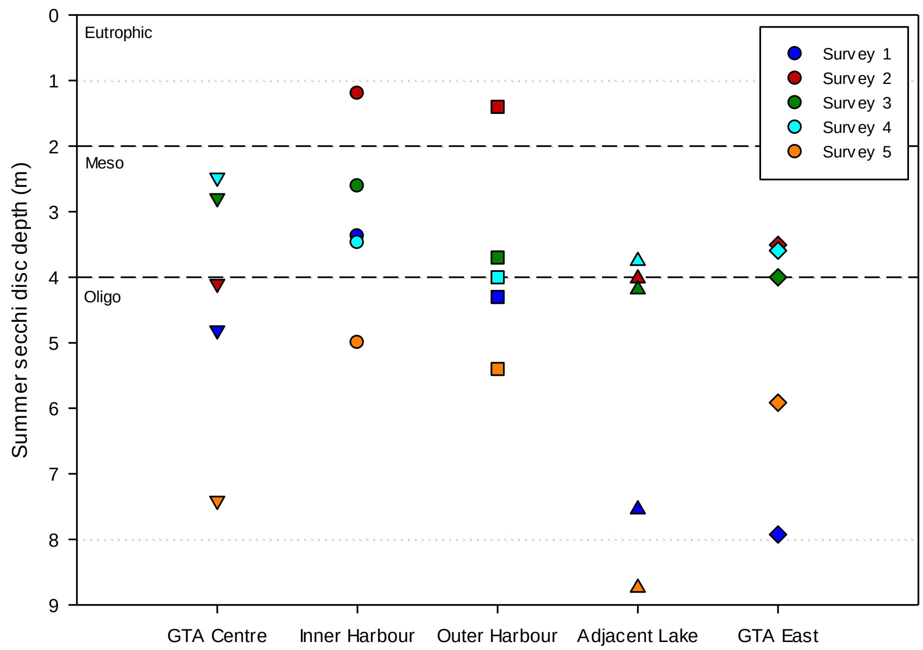

Figure 12 Mean summer secchi disc depth (SD) (m) measured throughout the Toronto and Region Area of Concern (AOC) during the 2008 MOECC nearshore survey. Secchi depth was measured during 5 sampling surveys (as indicated by colour) between April and October. Depths are reported as meters below the surface, with an inverse y-axis so that the surface (0 m) is at the top of the graph. Dotted lines represent trophic state classification scheme for as reported by Carlson and Simpson (1996).

4.5. Trophic State Index (TSI)

Trophic State Index (TSI) values were used as an additional line-of-evidence for the assessment of Eutrophication or Undesirable Algae. TSI provides an integrated measure of trophic state and can provide an indication of factors driving phytoplankton biomass and water quality conditions. If a direct relationship exists between parameters the three indices would be expected to estimate approximately the same value. Differences between TSI values suggest other factors, such as zooplankton grazing, may be at play (Carlson and Havens, 2005; Carlson and Simpson, 1996). In general, TSI values <30 are representative of oligotrophic conditions, while TSI values of 50–70 may represent eutrophic conditions. Deviations from the centre axes indicate factors other than TP and chl *a* are affecting water transparency (*i.e.*, SD) (Carlson and Havens, 2005). In general, deviations of TSI(CHL) from TSI(TP) indicate the degree of phosphorus limitation, while the degree of deviation of TSI(CHL) from TSI(SD) informs the degree of light penetration relative to the number and size of seston particles. Further, if TSI(TP) and TSI(SD) both deviate from TSI(CHL) but are themselves correlated, it is likely due to non-algal turbidity (Carlson and Havens, 2005).

4.5.1. Long-term Trends at Nearshore Monitoring Stations

TSI indices calculated using each parameter (TP, Chl *a*, SD) are presented using time plots to assess temporal variability at long-term monitoring stations throughout the Western (Figure 13), Central (Figure 14) and Eastern (Figure 15) Waterfront. TSI values for the western waterfront, calculated using parameters measured at Humber Bay monitoring stations, were consistently within the mesotrophic or oligotrophic ranges. Variability between trophic state indices measured using TP, Chl *a* and SD varied among years, with the greatest variability observed during 2005–2009. At the MOECC and EC monitoring stations located in the Toronto Inner Harbour, TSI calculations were generally indicative of mesotrophic conditions (Figure 14). TSI values suggest eutrophic conditions were present during 2000 and 2009; however, the relatively high variability between indices indicate that other factors, such as erosional runoff during wet weather events may play an important role. Toronto East measurements were not available for all three parameters during each sampling year; however, the TSI values calculated from available data suggest that oligotrophic conditions have been present along the eastern waterfront since the early 2000s.

Western Waterfront

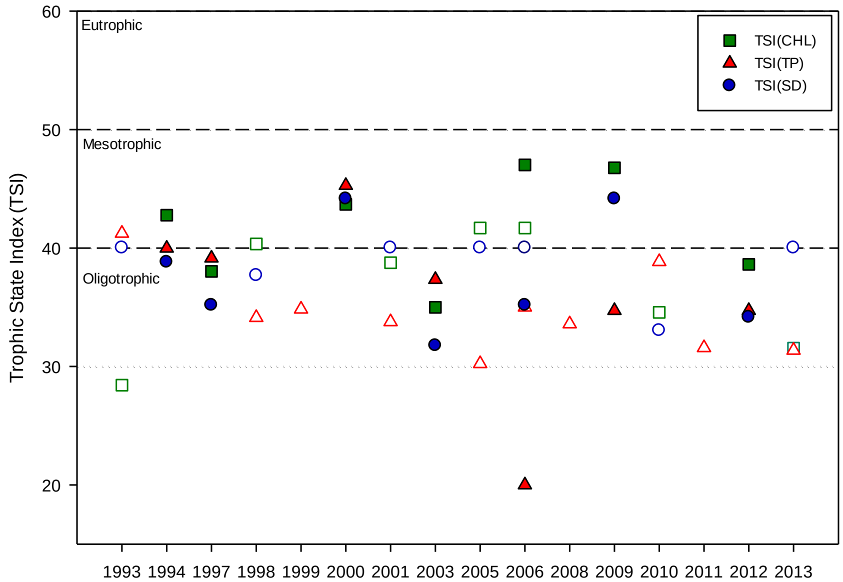

Figure 13 Time plot representing changes in Trophic State Indices (TSI) measured at MOECC (solid coloured symbols) and EC (open symbols) stations in Humber Bay. TSI values were calculated using spring total phosphorus (TP), summer chlorophyll *a* (chl *a*) and summer secchi disc depth (SD) measurements. Dotted lines represent TSI classification scheme for oligotrophic (<30), mesotrophic (30–40), and eutrophic (50–60) trophic states (Carlson & Simpson, 1996).

Central Waterfront

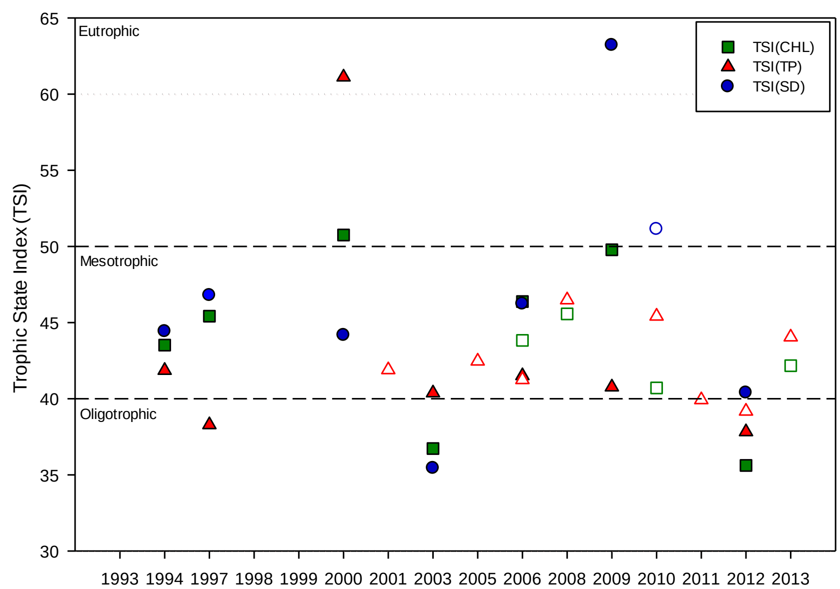

Figure 14 Time plot representing changes in Trophic State Indices (TSI) measured at MOECC (solid coloured symbols) and EC (open symbols) stations in Toronto (Inner) Harbour. TSI values were calculated using spring total phosphorus (TP), summer chlorophyll *a* (chl *a*) and summer secchi disc depth (SD) measurements. Dotted lines represent TSI classification scheme for oligotrophic (<30), mesotrophic (30–40), and eutrophic (50–60) trophic states (Carlson & Simpson, 1996).

Eastern Waterfront

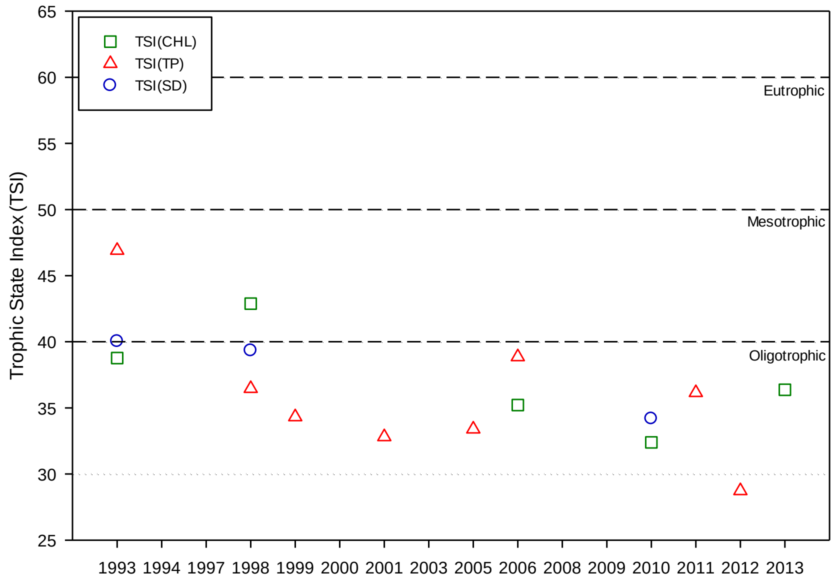

Figure 15 Time plot representing changes in Trophic State Indices (TSI) measured at the EC surveillance station in Ashbridges Bay (Toronto East). TSI values were calculated using spring total phosphorus (TP), summer chlorophyll *a* (chl *a*) and summer secchi disc depth (SD) measurements. Dotted lines represent TSI classification scheme for oligotrophic (<30), mesotrophic (30–40), and eutrophic (50–60) trophic states (Carlson & Simpson, 1996).

4.5.2. Spatial Variability

Spatial variability of TSI values throughout the Toronto and Region waterfront is presented using difference plots. TSI calculations from nearshore long-term monitoring stations sampled by MOECC (Toronto Harbour, Humber Bay) and EC (Toronto Harbour, Humber Bay, Toronto East) were calculated using median spring TP, summer chl *a* and summer SD for the most recent sampling years (1993–2013) (Figure 16a). TSI values for samples collected during the 2008 MOECC nearshore survey are presented in Figure 16b. TSI was calculated for each parameter using median values from all sites within each sub-area (Inner Harbour, Outer Harbour, Adjacent Lake, GTA Centre, GTA East). TSI values were further sub-divided by year (long-term monitoring data) or station (2008 nearshore survey) and presented according to location along the AOC waterfront (Western, Central, Eastern) in Figures 17–19.

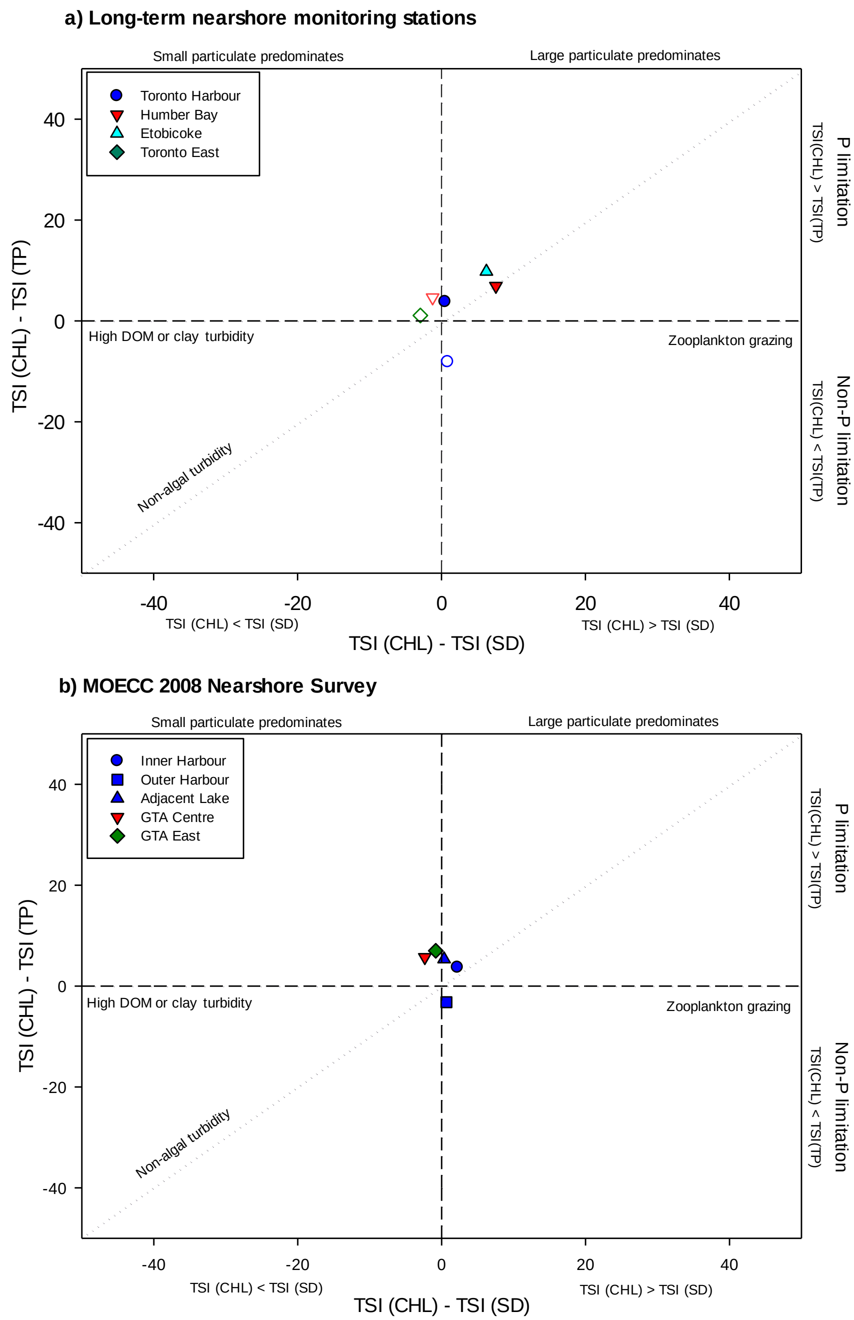

Figure 16 Difference plots of Trophic State Index (TSI) values comparing MOECC (solid coloured symbols) and EC (open symbols) values for Toronto Harbour (dark blue), GTA Centre/Humber Bay (red), Etobicoke (light blue) and Toronto East (dark green). Data are represented as TSI calculations from median values for spring total phosphorus (TP), summer chlorophyll *a* (chl a), and summer secchi depth (SD) sampled: a) between 1993 & 2013 at long-term monitoring stations and b) during 2008 MOECC nearshore surveys. Deviations from the centre axes indicate factors other than TP and Chl *a* may be affecting water transparency.

Western Waterfront

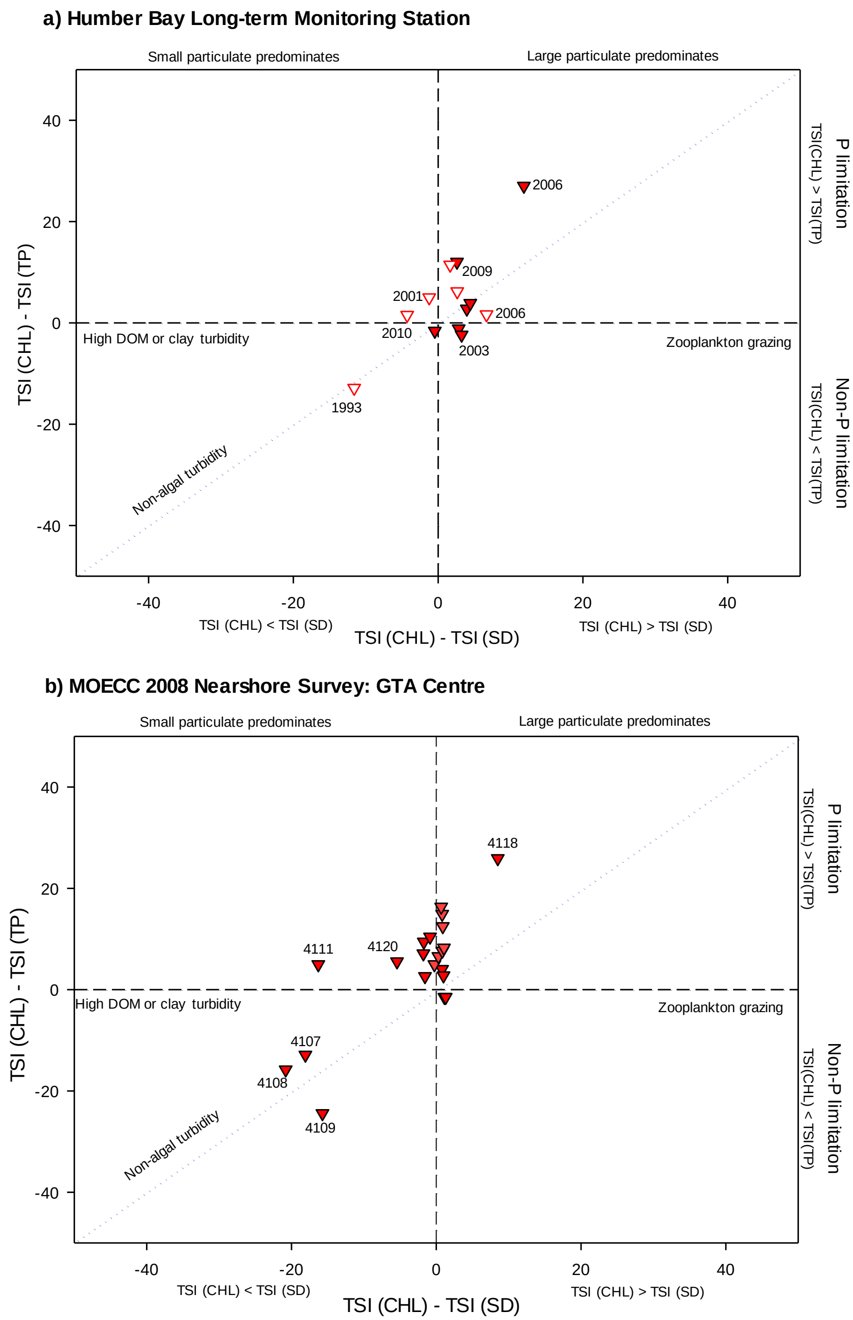

Figure 17 Difference plots of Trophic State Index (TSI) values comparing MOECC (solid coloured symbols) and EC (open symbols) values for Humber Bay (GTA Centre). Data are represented as TSI calculations for spring total phosphorus (TP), summer chlorophyll *a* (chl a), and summer secchi depth (SD) for a) individual years sampled between 1993 & 2013 at long-term monitoring stations and b) at individual stations sampled during 2008 MOECC nearshore surveys. Deviations from the centre axes indicate factors other than TP and Chl *a* may be affecting water transparency.

Central Waterfront

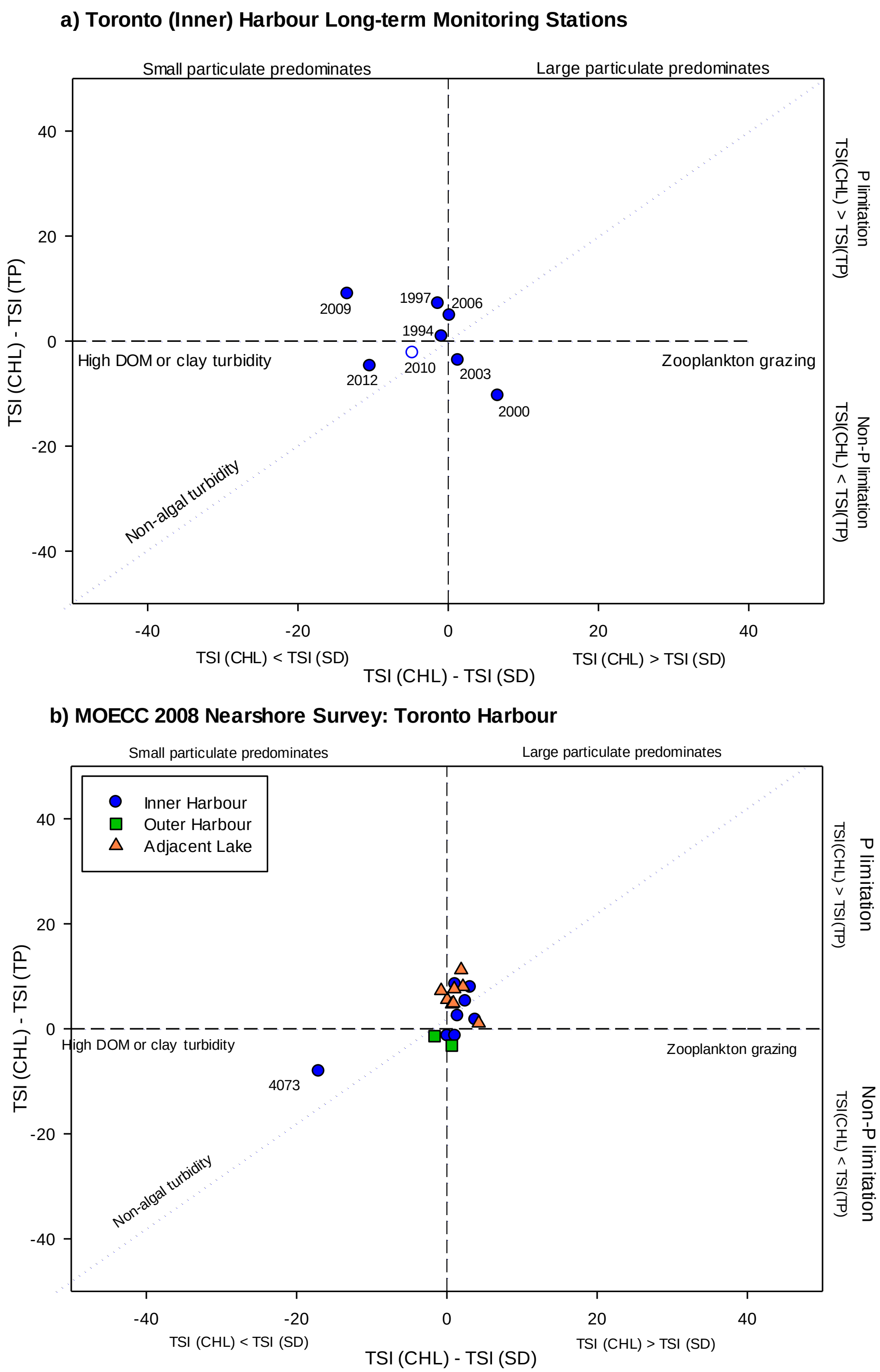

Figure 18 Difference plots of Trophic State Index (TSI) values comparing MOECC (solid coloured symbols) and EC (open symbols) values for Toronto Harbour. Data are represented as TSI calculations for spring total phosphorus (TP), summer chlorophyll *a* (chl a), and summer secchi depth (SD) for a) individual years sampled between 1993 & 2013 at long-term monitoring stations and b) at individual stations sampled during 2008 MOECC nearshore surveys. Deviations from the centre axes indicate factors other than TP and Chl *a* may be affecting water transparency.

Eastern Waterfront

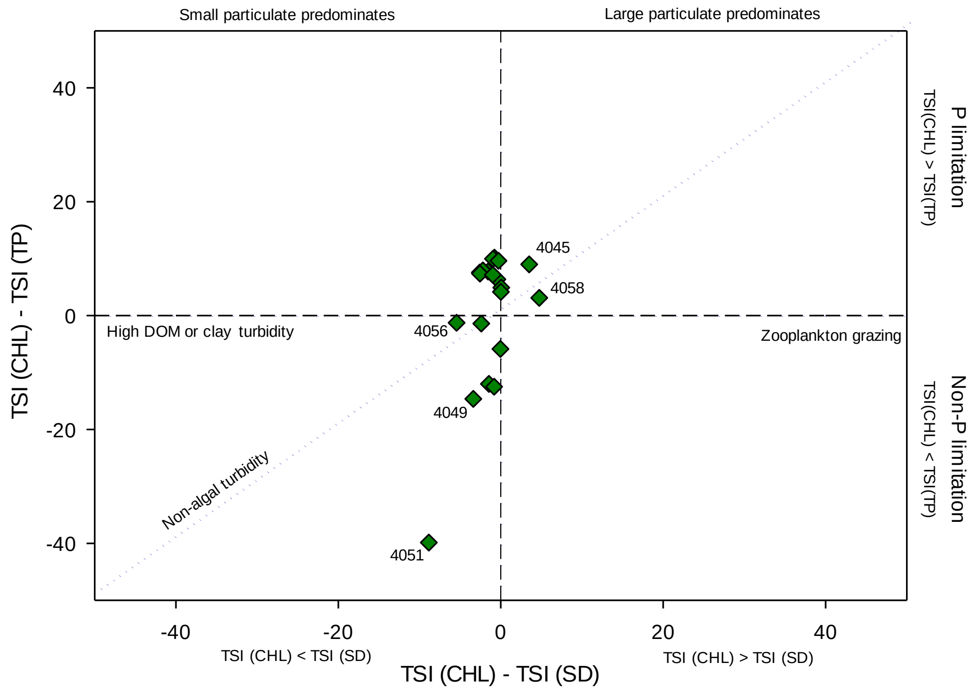

Figure 19 Difference plot of Trophic State Index (TSI) values comparing individual stations throughout the GTA East polygon sampled during the 2008 MOECC nearshore survey. Data are represented as TSI calculations for spring total phosphorus (TP), summer chlorophyll *a* (chl a), and summer secchi depth (SD). Deviations from the centre axes indicate factors other than TP and Chl *a* may be affecting water transparency.

TSI calculated using median parameter values from 1994–2012 at MOECC Index Stations suggest that the Western Waterfront (Humber Bay and Etobicoke) may experience P-limitation (Figure 16a). Upon further investigation, there was a great deal of variability in TSI values for individual sampling years in Humber Bay, although all years tended to plot in close proximity to the non-algal turbidity line clustered near the origin (Figure 17a). TSI values calculated using parameters measured at the Humber Bay (MOECC) Index Station in 2006 plotted further away from other years, in the upper right quadrant, indicating P-limitation. TSI values calculated for individual stations sampled in Humber Bay during the 2008 MOECC nearshore survey (GTA Centre, Figure 3), similarly clustered near the origin on the difference plot (Figure 17b). The stations closest to the mouth of the Humber River separated out in the bottom left quadrant, suggesting high dissolved organic matter (DOM) or clay turbidity may affect light penetration in the water column.

In the central waterfront, long-term monitoring at the MOECC (and EC in 2010) Toronto (Inner) Harbour station TSI tended to plot near the origin on the difference plot with some years suggesting slight P-limitation may be present, while other years suggest non-P limitation (Figure 18a). Of particular interest, differences in TSI during 2000 suggest non-P limitation and large particulate dominance. This is consistent with the suggestion that spring TP values measured at this station were strongly influenced by runoff from a large storm event. During the 2008 nearshore survey, TSI values for individual stations were separated into sub-areas throughout the Toronto Harbour (Inner Harbour, Outer Harbour, Adjacent Lake) in Figure 18b. All stations clustered together near the origin with the exception of station 4073 located in the Keating Channel, which connects the Don River to the Inner Harbour. For stations sampled in the GTA East polygon during the 2008 nearshore survey, the majority of stations plotted slightly above the origin along the non-algal turbidity line, while a number of TSI calculations were indicative of non-P turbidity (Figure 19). Stations nearest to the outfall for the Ashbridges Bay WWTP tended to plot lower on the TSI(CHL)-TSI(TP) axis.

5. Discussion

The goal of the Toronto and Region RAP is to restore beneficial uses through local management actions that restore and protect environmental quality within the AOC. Nutrients are an important component of healthy aquatic ecosystems. Aquatic plants provide habitat for fish and other organisms and are dependent on nutrients and light for growth. The penetration of light in the water column can be affected by excessive algae. Controlling algae levels can be achieved through limiting TP concentrations. Increased TP levels can result in increased algal biomass, which in turn may lead to decreased hypolimnetic oxygen, decreases in water clarity and changes in algal species composition. The overall RAP goal of achieving a mesotrophic to oligotrophic state (*i.e.*, not eutrophic) throughout the Toronto and Region nearshore was established to ensure a healthy ecosystem while protecting water quality through a reduction in nutrient concentrations and resultant algal biomass.

5.1. Nutrients

Total phosphorus concentrations have been declining throughout the Great Lakes since the 1970s as a result of remedial actions including legislative changes to reduce phosphorus loadings from WWTP effluent and other point sources (Dove & Chapra, 2015). Within the AOC, additional actions have been implemented to control loadings associated with human development and activities. Improvements to stormwater infrastructure, as well as wet weather flow projects and dry weather flow reduction measures have contributed to a decline in nutrient concentrations along the waterfront. Toronto Inner Harbour and Ashbridges Bay (Toronto East) continue to have the highest mean spring TP concentrations (18 and 19 µg/l, respectively, in 2008) (Figure 8). The degree of variability in TP concentrations can be strongly influenced by time of sampling and location within the nearshore. The 2008 nearshore survey illustrated a large degree of spatial and seasonal variability in nearshore nutrients along the Toronto and Region waterfront (Figure 8). Howell *et al.* (2012a) reported that variability of TP in the GTA nearshore was significantly related to shore-proximity variables (*i.e.*, lake depth or distance from shore) and that a high proportion of TP was composed of particulate-bound P. This is consistent with variability in TP observed throughout the Toronto and Region waterfront, with higher concentrations in close proximity to point and non-point sources such as the Don River. Within the Toronto Centre polygon alone, a higher (although not significant) degree of variability in spring TP was observed throughout the Inner Harbour, compared to the Outer Harbour and Adjacent Lake (Figure 7).

Despite the high variability, the majority of TP measurements reported throughout the Toronto and Region nearshore during spring 2008 were indicative of mesotrophic or oligotrophic conditions. Exceedance of the PWQO was reported for all areas except for stations located within the Outer Harbour and Adjacent Lake sub-areas. The highest observed TP concentrations during the 2008 nearshore study were measured in the GTA East polygon at the station located in close proximity to the Ashbridges Bay Treatment Plant (ABTP) effluent outfall (43°38'54.19"N, 79°18'38.76"W). In the 1990s the City of Toronto investigated various options for meeting future wastewater treatment needs at the WWTP. As a result, in 2008 the MOECC approved an environmental assessment for improvements to the ABTP which included a larger capacity outfall pipe that would extend approximately 3.7 km into Lake Ontario (replacing the current 1 km long pipe). In 2014, the City of Toronto undertook a conceptual design study for a new outfall pipe at the ABTP (Ch2M-Hill, 2014). The 75th percentile of total phosphorus concentrations in the Ashbridges Bay area of Lake Ontario over the period of 1995 to 2011 (7 ug/l) was used to establish mixing zone criteria for the new ABTP outfall, and for far-field water quality modelling. Once complete, this project will result in a reduction in TP concentrations in the nearshore, as well as at fiducial markers at beaches along the eastern waterfront, and the shoreline along Tommy Thompson Park (i.e., the Leslie St. Spit), and will also decrease the size of the effluent mixing zone.

Long-term monitoring at each of the four Index Stations located within the AOC boundary found median spring TP concentrations <20 µg/l during all years except 2000 at the Inner Harbour station (Figure 6). It is likely that TP levels measured at the Inner Harbour station during 2000 were influenced by high stormwater runoff from a large rainstorm that occurred 4 days prior to sampling and saw 67.8 mm of rain fall over the City of Toronto, and resulted in flooding of multiple waterways. Although this is an important part of the water quality story, and emphasizes the large impact that wet weather events can have on water quality, it is not necessarily indicative of a long-term trend. Median TP concentrations have otherwise remained within the mesotrophic (12–24 µg/l, Table 1) classification range, and generally below the PWQO throughout the Toronto and Region waterfront. Long-term monitoring data from MOECC and EC sampling programs indicate that the greatest temporal variability in nutrients is in the Toronto Inner Harbour (compared to the western and eastern waterfront). Spring TP concentrations measured in the Inner Harbour ranged from 6–22 µg/l over the period of 1993–2013 (excluding median TP of 52 µg/l measured after the 2000 rainstorm). Along the western and eastern shoreline, spring TP concentration was indicative of oligotrophic (<6–12 µg/l) conditions for the majority of years sampled.

Spring TP concentrations throughout the waterfront generally indicate variable mesotrophic conditions with zones of high impact restricted to areas in close proximity to source inputs, and during wet weather events. Knowledge of physical processes affecting the open lake and tributaries play an important role in understanding nearshore water quality. During higher flow events (such as the May 2000 storm) it is expected that TP will increase with erosional runoff, and concentrations will likely exceed the PQWO, especially in highly urbanized areas.

Elevated TP concentrations due to non-point sources are generally more difficult to control, however, where practicable can be addressed through local management actions, such as the Rural Clean Water Program and Environmental Farm Plan. Improved municipal stormwater management will further address point and non-point source nutrient loadings. The City of Toronto has conducted several studies to assess expected improvements in nearshore water quality following implementation of proposed infrastructure projects, including the Wet Weather Flow Master Plan (City of Toronto, 2003), Don and Central Waterfront project (MMM, 2011), ABTP Outfall Concept Design Study (Ch2M- Hill, 2014) and the Ashbridges Bay Erosion Control project study (TRCA & City of Toronto, 2014). Collectively, these projects will significantly improve nutrient loadings and overall water quality along the Toronto waterfront.

5.2. Algal Biomass

Spring TP concentrations provide an indication of the nutrient stores available for algae and phytoplankton growth. Summer chl *a* concentrations and SD were assessed as an indication of resultant algal biomass and water clarity over the subsequent growing season. In 2008, summer chl *a* concentrations were generally indicative of mesotrophic (2.6–7.3 µg/l, Table 1) or oligotrophic (<0.95–2.6 µg/l, Table 1) conditions throughout the AOC nearshore, although a large degree of variability was observed within and between sub-areas. Median summer chl *a* concentrations measured in 2008 indicated that there were significant differences between Toronto Inner Harbour and GTA Centre compared to GTA East (Figure 10). In addition, chl *a* concentrations in the Inner Harbour were significantly different than adjacent lake stations. Overall, the highest variability and median concentrations of chl *a* were measured in the Inner Harbour and GTA Centre (Figure 10). Maximum chl *a* concentrations were measured in the Outer Harbour, Adjacent Lake and GTA East areas, however, all measurements were well below (<6 µg/l) levels indicative of eutrophication.

The long-term record of chlorophyll *a* concentrations along the Toronto and Region nearshore showed no significant trend from 1993–2013 (Figure 9). In general, median summer chl *a* concentrations were indicative of mesotrophic or oligotrophic conditions throughout this period, with the exception of Toronto Inner Harbour during 2000 and 2009 which fell within the eutrophic (>7.3 µg/l, Table 1) range. However, the most recent (2010–2013) summer chl *a* concentrations were within the lower end of the mesotrophic range in the Inner Harbour, and within the oligotrophic classification along the western and eastern waterfront. Total phosphorus is generally a good indicator of chlorophyll concentration in lakes, however large variation in the relationship can be associated with regional, morphometric and physical-chemical features (Stemberger *et al.*, 2001). Despite summer chl *a* concentrations measured on the higher end of the mesotrophic range during 2006 and 2009, spring TP concentrations during this time were <10 µg/l in Humber Bay and < 15 µg/l in Toronto Harbour.

Summer chl *a* concentrations were generally indicative of mesotrophic or oligotrophic conditions throughout the Toronto and Region nearshore. Chlorophyll *a* concentrations in exceedance of the mesotrophic classification were not related to harmful algal blooms. Furthermore, there have been no hypolimnetic oxygen deficits reported throughout the waterfront (Figure 4), nor have persistent water clarity problems been observed (Figure 11). Increasing levels of benthic algae (particularly Cladophora) have been reported in the littoral zone of the lower Great Lakes over the past decade (Auer *et al.*, 2010; Higgins *et al.*, 2008). Cladophora biomass can accumulate in areas where hard substrate and sufficient light and nutrients are available to promote production. The current persistence/resurgence of Cladophora observed along the western shoreline of the Toronto and Region AOC cannot be explained by deteriorating water quality conditions in terms of TP concentration in the nearshore.

Further research is needed to determine the factors driving Cladophora growth in the Lake Ontario nearshore; however, current observations suggest that it is likely a regional (*i.e.*, western Lake Ontario) issue, and therefore may be beyond the scope of the RAP. Evidence suggests that the resurgence in growth of Cladophora on a regional scale has been strongly influenced by Dreissenid mussel colonization and that the resulting “nearshore shunt” (a benthic process within the coastal zone of Lake Ontario) (Hecky *et al.* 2004) of nutrients has promoted this growth by concentrating phosphorous near the lake bed and increasing water clarity. This benthification has had the net effect of making the nearshore area increasingly sensitive to current P inputs in the sense that there has been a significant increase in Cladophora growth in the absence of any corresponding significant increase in P loadings. Although this regional phenomenon only manifests itself in the western shoreline of the AOC, the tributaries and WWTPs within the AOC boundaries undoubtedly represent a significant source of P to the western portion of the lake. According to recent loading estimates the six tributaries and three WWTPs that discharge to the lake within the AOC boundaries account for total P loads of approximately 500 tonnes per year (Makarwicz *et al.* 2012). This suggests that although the regional problem extends well beyond the direct scope of the Toronto and Region AOC, the RAP agencies will need to be involved as part of any coordinated regional response involving remedial actions to diminish P loadings to western Lake Ontario.

5.3. Trophic State

Trophic state describes the biological condition of a waterbody. Although the exact division of variables to describe trophic ranges depends on the particular classification scheme being used, the trophic state that they describe has attributes of production that remain constant. The trophic state of the nearshore was evaluated using various water quality parameters (*i.e.*, TP, chl *a*, SD). Although each of these parameters can be classified as oligotrophic, mesotrophic and eutrophic, the changes between states often does not occur in sharply defined places, nor do they occur at the same time for all parameters. Although not developed specifically for the Great Lakes, the Carlson TSI provides a reasonable basis for generally assessing the relative significance of TP, chl a, and SD results (in particular for areas that are fairly enclosed, such as the Inner Harbour).

Trophic state index was evaluated for the Toronto and Region nearshore by combining spring TP with summer chl *a* concentration and summer SD. TSI values for Humber Bay (Figure 13) and Toronto East (Figure 15) were indicative of mesotrophic (40–50, Table 1) or oligotrophic (<30–40, Table 1) conditions for all years sampled between 1993 and 2013. There was no clear long-term trend in TSI for the Toronto Inner Harbour (Figure 14); however values were generally indicative of mesotrophic conditions, except for TSI(TP) and TSI(CHL) during 2000, as well as TSI(SD) during 2009. The high variability between indices during these years indicates that factors other than algal biomass (for example, erosional runoff during wet weather events) may be driving TSI calculations. As previously discussed, TP measurements during spring 2000 were influenced by a large storm event. In addition, 2009 was a relatively wet year with 811 mm of rainfall at the Toronto Pearson International Airport weather station. Recent years (2010–2013), on the other hand, suggestf mesotrophic or oligotrophic conditions exist throughout the Toronto and Region waterfront.

Difference plots of TSI values suggest that the nearshore waters throughout the AOC are phosphorus limited to some extent, with the majority of values falling in close proximity to the origin and along the non-algal turbidity line (Figures 16–19). Because non-algal particulate matter tends to attenuate light and may be associated with phosphorus, this may interfere with chlorophyll predictions from TP and SD. Throughout each of the 3 regions (Western, Central, Eastern) along the waterfront, sampling locations located in close proximity to a significant point or non-point source such a WWTP effluent discharge (GTA East) or a large river mouth (*i.e.*, Humber River and Don River) tended to plot close to the origin or in the bottom left quadrant, suggesting non-P limitation and possibly high DOM or clay turbidity.

TSI calculations provided an additional line-of-evidence to assess trophic state of the nearshore. Results were consistent with the evaluation of water quality parameters related to eutrophication which suggested variable mesotrophic conditions throughout the waterfront. In addition, trophic state indices provided some insight into factors driving phytoplankton biomass and water quality conditions, particularly for locations in close proximity to source inputs.

6. Conclusion

There have been no reported hypolimnetic oxygen deficits throughout the AOC, nor have persistent water clarity problems been observed. Nutrient concentrations throughout the Toronto and Region waterfront generally indicate variable mesotrophic conditions with zones of high impact restricted to areas in close proximity to source inputs, except during wet weather events. High TP concentrations have been measured on occasion throughout the Inner Harbour, however values are generally very low. Further, the short residence time of water in the Toronto Harbour and frequency of upwelling events prevent the development of large standing crops of algae, despite continual nutrient inputs.

Several lines-of-evidence support a conclusion of a lack of impairment for the Eutrophication or Undesirable Algae BUI in the Toronto and Region waterfront, within the context of the RAP:

- DO concentrations throughout the waterfront remain above the CWQG for cold-water biota. For observations that were below the guideline of 9.2 mg/l for early-life stages, impact on biota was not expected.
- TP concentrations throughout the waterfront are generally indicate variable mesotrophic conditions with zones of high impact restricted to areas in close proximity to source inputs, except during wet weather events.
- Chl a concentrations are generally indicative of mesotrophic or oligotrophic conditions throughout the nearshore. Summer chl a concentrations in exceedance of the mesotrophic range were not related to harmful algal blooms.
- Secchi disc depths measured throughout the nearshore indicate that there are not persistent water clarity problems due to excessive algal biomass throughout the AOC waterfront.
- TSI values are indicative of variable mesotrophic conditions throughout the waterfront, and suggest factors other than algal biomass may be driving chl a and water quality conditions in certain locations close to source inputs.

In summary there is no evidence that eutrophication in the Toronto and Region AOC waterfront should be considered impaired. In order to meet the broader goals for the GLWQA, recommendations should be made to continue to improve wet weather flows, and point- and non-point- source inputs, which would reduce impacts and improve habitat in the nearshore. Further, actions should continue to be taken within the AOC to contribute to the Lake Ontario Lakewide Action and Management Plan and the Nearshore Framework as specified in Annex 2 of the GLWQA. For example, these actions could include further research to understand the linkage between P loadings to the Lake Ontario nearshore and the presence and density of Cladophora beds, as well as involvement in a coordinated plan to reduce P inputs to western Lake Ontario in order to mitigate regional scale problems associated with excessive growth of Cladophora.

The implementation of major infrastructure projects such as the Don River and Central Waterfront Project, improvements to wastewater treatment plants (such as the City of Toronto's proposed new ABTP Outfall) and the Don River Naturalization are integral to reducing nutrient inputs to the nearshore and to delisting the Toronto and Region AOC. Collectively, these projects will significantly improve water quality and reduce the risk of developing eutrophic conditions along the Toronto waterfront, and improve aquatic habitat for fish and wildlife.

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