LAKE ERIE CANADIAN NEARSHORE
Assessment

2018 RESULTS REPORT

Canada

Cat. No.: En164-71/2-2018E-PDF
ISBN: 978-0-660-39156-4
EC21052,01

Environment and Climate Change Canada
Public Inquiries Centre
12th Floor, Fontaine Building
200 Sacre-Coeur Boulevard
Gatineau QC K1A 0H3
Telephone: 819-938-3860
Toll Free: 1-800-668-6767 (in Canada only)
Email: ec.enviroinfo.ec@canada.ca

Cover photo: © Getty image

Aussi disponible en français

Table of Contents

This document supports Canadian commitments in the Lakewide Management Annex of the Great Lakes Water Quality Agreement of 2012 to provide an overall assessment of nearshore waters.

For information on Great Lakes Areas of Concern or the State of the Great Lakes, refer to https://www.canada.ca/en/environment-climate-change/services/great-lakes-protection.html

Environment and Climate Change Canada would like to thank the individuals and agencies who provided data, advice and reviews of this document. The Lake Erie Canadian Nearshore Assessment would not have been possible without contributions from the Ontario Ministry of Environment, Conservation and Parks, the Ontario Ministry of Natural Resources and Forestry, Swim Drink Fish Canada, the National Oceanic and Atmospheric Administration, Michigan Tech Research Institute, Dr. Lee Grapentine (ECCC), Peter Zuzek and Kevin Grootendorst (Zuzek Inc.) and various ECCC program staff.

Introduction

The Great Lakes, with their 16,000 kilometres of coastline, connecting river systems and watersheds are the world's largest freshwater ecosystem and socially, economically and environmentally significant to the region, the nation and the planet. While efforts to restore and protect the Great Lakes have been largely successful over the last 50 years, water quality and ecosystem health in many nearshore areas continues to be degraded. At numerous places along the Great Lakes nearshore, conditions are degraded due to a variety of human-induced, climate-induced and invasive species-induced stressors. Human activities in the landscape have a more direct influence on nearshore water quality than on offshore water quality.[1] Nearshore water quality may serve as a sentinel for the longer-term trajectory of offshore water quality and lake-wide condition.[2] Management of the nearshore is challenging because it is a complex, highly variable environment in which tributary inflows and open water processes vary spatially and across daily, seasonal and annual temporal scales. In addition, Great Lakes nearshore areas are especially vulnerable to the effects of climate change and impacts can result in loss of biodiversity of aquatic species and fundamental changes to ecosystem character, distribution, structure and function. Human-induced stressors on ecosystems further limit their ability to adapt and recover.

Although significant investment has been made in localized monitoring, assessment and restoration, the lack of a comprehensive assessment of the overall state of nearshore waters has meant that there was not a robust mechanism for identifying cumulative stress on nearshore ecosystems nor a way to identify and prioritize areas in need of remediation or protection. Action is needed to address stresses and threats in nearshore areas, as they are the source of drinking water for most communities within the basin, are the areas of the lakes where most human recreation (e.g. swimming, boating, fishing, wildlife viewing) occurs and are the critical ecological link between watersheds and the open waters of the Great Lakes.

Nearshore Framework

As envisioned by the updated Canada-U.S. Great Lakes Water Quality Agreement (GLWQA) of 2012, Canada is implementing a "Nearshore Framework" that provides for an overall assessment of the state of the nearshore waters of the Great Lakes. The Nearshore Framework is a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stress. It is intended to inform and promote action at all levels in order to restore and protect the ecological health of Great Lakes nearshore areas.

The purpose of the Nearshore Framework is to address ongoing and emerging challenges to the nearshore waters of the Great Lakes, where restoration, protection and prevention activities are critical to improving and sustaining the ecological health of Great Lakes coastal areas and supporting attendant social, cultural, recreational and economic benefits. Nearshore assessments and communication of results provide the basis for determining factors and cumulative effects that are causing stress or threatening areas of high ecological value. Continued and strengthened coordination and collaboration are needed to manage and protect our nearshore waters and to prevent and minimize water quality and ecosystem impacts which may result from chemical, physical, or biological stresses within the Great Lakes Basin. The

[1] Yurista, P.M., Kelly, J.R., Cotter, A.M., Miller, S.E., and Van Alstine, J.D. 2015. Lake Michigan: Nearshore variability and a nearshore-offshore distinction in water quality. Journal of Great Lakes Research. 41:111-122.

[2] Yurista, P.M., Kelly, J.R. and Scharold, J.V. 2016 Great Lakes nearshore-offshore: distinct water quality regions. Journal of Great Lakes Research. 42: 375-385.

Nearshore Framework will support action for nearshore areas under stress and protection for nearshore areas of high quality by communicating results, establishing priorities and engaging organizations and entities that are developing and implementing prevention, restoration and protection strategies.

The scope of the Nearshore Framework includes the nearshore waters and embayments along the coast of the Canadian Great Lakes, the lakes' connecting river systems and the St. Lawrence River. The GLWQA recognizes the interconnectedness of the Great Lakes basin watersheds where material and water flow from problem areas into the lakes and connecting channels. The Nearshore Framework aims to consider this relationship between the zone of influence and zone of impact and the nearshore is generally defined as the area of the Great Lakes and connecting rivers near the coast where waters are subject to direct influences from watersheds, while recognizing that there are also offshore influences.

This report provides a synthesis of the results for the 2018 Lake Erie and Connecting Channels Nearshore Assessment; for a detailed methodology of the Overall Assessment of Nearshore Waters, including descriptions of assessment categories and measures and data sources refer to the *Canadian Great Lakes Nearshore Assessment Detailed Methodology*.

Regional Unit Delineation

The first Phase in the Nearshore Assessment is the classification of the nearshore into Regional Units based on ecosystem type. Slow changing variables such as depth, substrate, river mouth boundaries, wave energy density and high water conditions were used for delineating the offshore, onshore and lateral boundaries of ecologically relevant units.

Offshore boundary

With a maximum depth of approximately 64 metres, Lake Erie is the shallowest Great Lake. A gradient exists from the shallow western basin, where the average depth is 7 metres, to the eastern basin where the average depth is deeper, at 24 metres (Figure 1). Based on this profile, a depth of 15 metres was selected as the offshore boundary. The Great Lakes Aquatic Habitat Framework (GLAHF) lakewide bathymetry raster dataset[3] was converted into 1 metre contour lines, and the 15 metre line was used to create a seamless offshore boundary.

Onshore boundary

The onshore boundary for the Regional Units was defined by a high water mark. Historical monthly mean lake levels from Environment and Climate Change Canada's coordinated network of gauges for Lake Erie[4] were reviewed and the maximum monthly mean from 1918 to 2013 was found to be 1.54 metres above Chart Datum.

[3] Great Lakes Aquatic Habitat Framework (GLAHF) – Geomorphology – Lake Bottom: https://www.glahf.org/data/

[4] Environment and Climate Change Canada. *Historical Monthly and Yearly Mean Water Level 1918-2016* http://www.tides.gc.ca/C&A/network_means-eng.html

On Lake Erie, Chart Datum is 173.5 metres, making the maximum monthly mean 175.04 metres (173.5 [Chart Datum] + 1.54 [Maximum Monthly Mean]). The static lake level only reached the 175 metre IGLD'85 contour once in 95 years, so it was selected to delineate the onshore extent of Regional Unit boundaries. Although the lake surface can exceed this elevation due to wave effect and storm surge, the focus here is the static 'non-storm' lake surface.

To define the 175 metre contour, the 2015 South Western Ontario Ortho-Photography (SWOOP) Digital Elevation Model (DEM)[5] was acquired from the Ontario Ministry of Natural Resources and Forestry (OMNRF). Using GIS, the 175 metre elevation contour was extracted from the DEM and the line was manually edited to remove irregularities generated during extraction (e.g. self-intersection, overlap etc.); the 2015 SWOOP imagery was consulted and an approximate map scale of 1:2,000 was used to remove self intersecting loops and to smooth jagged lines.

Figure 1. Lake Erie Bathymetry (from the Great Lakes Aquatic Habitat Framework) showing a west to east gradient in depth (shallower in western basin); 15 m depth was used to delineate the offshore boundary for Regional Units

In areas with coastal wetlands, a visual inspection of the SWOOP imagery and Google Earth was undertaken to determine whether the wetland was hydrologically connected to Lake Erie or a connecting channel. The coastal wetland polygon used for this assessment was the OMNRF Great Lakes Shoreline Ecosystem Land Classification[6] dataset, which is an inventory of Lake Erie shoreline (2 km inland) ecosystems that incorporate standard delineation processes at the ecosite scale (1:10,000). If a wetland was assessed as being hydrologically connected, the wetland boundary became the onshore extent of the Regional Unit instead of the 175 metre contour. Professional judgement was exercised to create a representative, continuous onshore boundary.

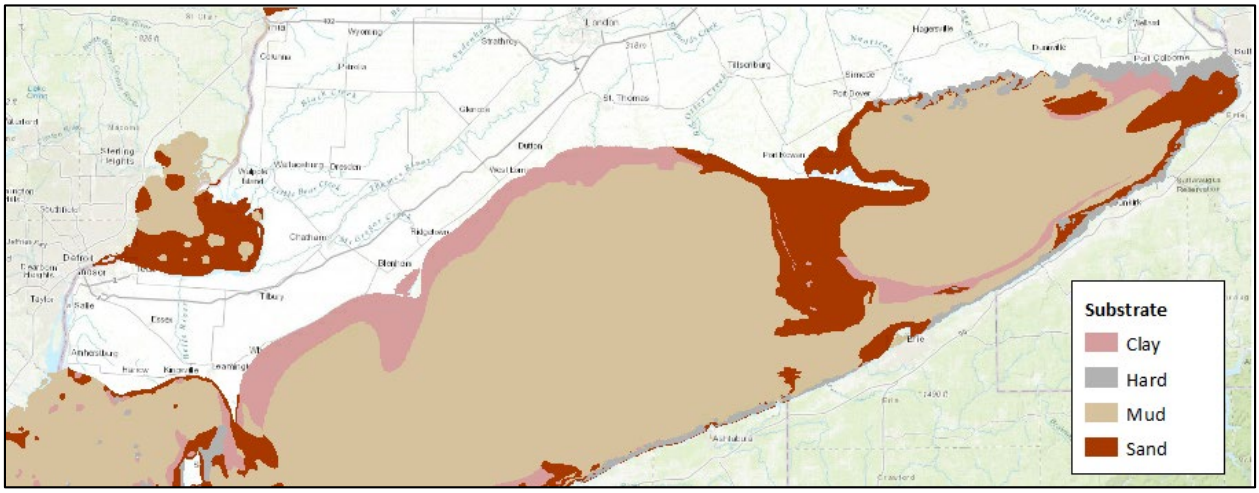
[5] Ontario Ministry of Natural Resources and Forestry. *Ontario Digital Elevation Model (Imagery-Derived).* https://geohub.lio.gov.on.ca/datasets/mnrf::ontario-digital-elevation-model-imagery-derived

[6] Ontario Ministry of Natural Resources and Forestry. *Great Lakes Shoreline Ecosystem Inventory V 1.0 – Lake Erie.* https://geohub.lio.gov.on.ca/datasets/great-lakes-shoreline-ecosystem-inventory-v-1-0-lake-erie

Lateral boundary

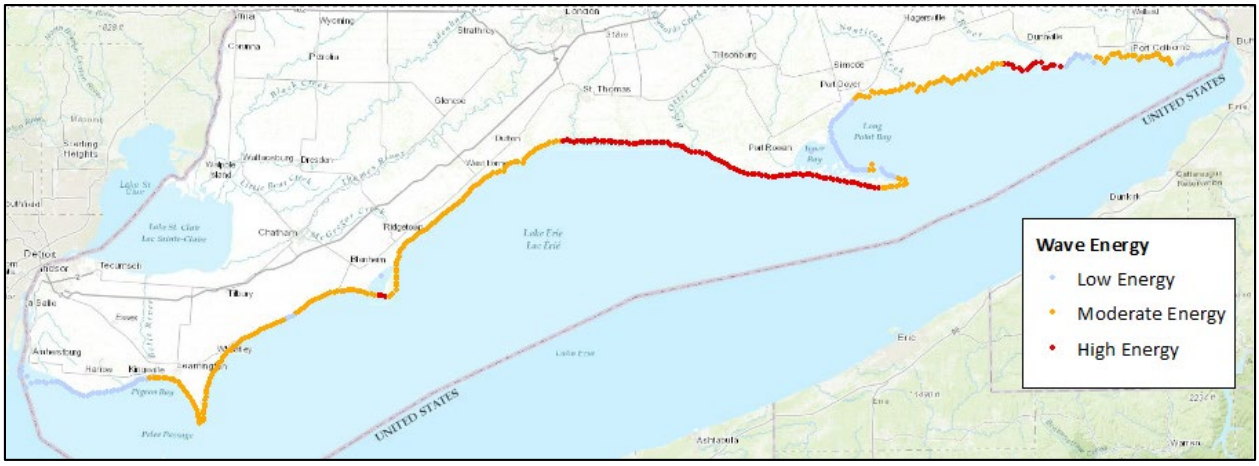
Regional Unit alongshore boundaries were generated by assessing substrate data, shoreline morphology and wave energy. The nearshore areas of Lake Erie and its connecting channel are not homogeneous; variations in substrate and wave energy result in spatially explicit characteristics that were used to delineate Regional Units. The orientation and morphology of the shoreline can impact the presence (or absence) of coastal features. For example at Port Dover, where the southwest-northeast shoreline orientation changes to an east-west orientation, the substrate transitions from sand to hard bottom (Figure 2). The exposed bedrock along the north shore of the eastern basin has a strong influence on shoreline characteristics, which include successive series of headlands and embayments. Point Abino, between Port Colborne and Fort Erie, is a prominent headland controlled by the bedrock outcrop, which shelters the calm and shallow water at Crystal Beach.

Figure 2. Substrate types in Lake Erie (from the Great Lakes Aquatic Habitat Framework)



Wave energy also has a significant influence on the coastline. On a lakewide scale, gradients in wave energy influence the magnitude and directionality of longshore sediment transport, erosion and deposition patterns that shape the nearshore. The deposition environment that created the Long Point sand spit over thousands of years, for example, is a product of a decreasing gradient in the longshore sediment transport rate. In addition, exposure to wave energy is a major factor in the presence or absence of submerged/emerged aquatic vegetation as high wave exposure may result in the absence of aquatic vegetation. Wave energy also influences sediment characteristics along the coast, with sheltered environments typically featuring fine grained sediment and open coast areas featuring sand sized substrate and/or coarser materials.

Figure 3. Results of the wave energy density analysis on Lake Erie (Low Energy is less than 100,000 Joules/m2; High Energy is over 300,000 Joules/m2)



Due to its influence on nearshore processes, wave energy was included as a physical variable in the alongshore boundary delineation. Average annual wave energy density for April and May was calculated at the 5 metre depth contour around Lake Erie, at 1 km increments (Figure 3). The input wave conditions were generated by a historical wind-wave hind cast on Lake Erie, and then transformed to the 5 metre depth accounting for lake bottom contours and linear wave theory. The results of the wave energy reveal additional patterns with other physical variables. All of Long Point Bay, for example, is classified as a low wave energy environment. Given the shoreline orientation relative to the wind direction and incident waves, the sand spit shelters the inner and outer bays and accounts for why the area features one of the largest wetland complexes in the Great Lakes region. East of Long Point Bay, the nearshore is exposed to wave heights upwards of 5 metres, which may explain why there are little to no lacustrine wetlands except for in the sheltered confines of the Grand River mouth.

Overlaying these slow-changing variables resulted in classification of 15 Regional Units, and six different ecosystem types (Table 1/Figure 4).

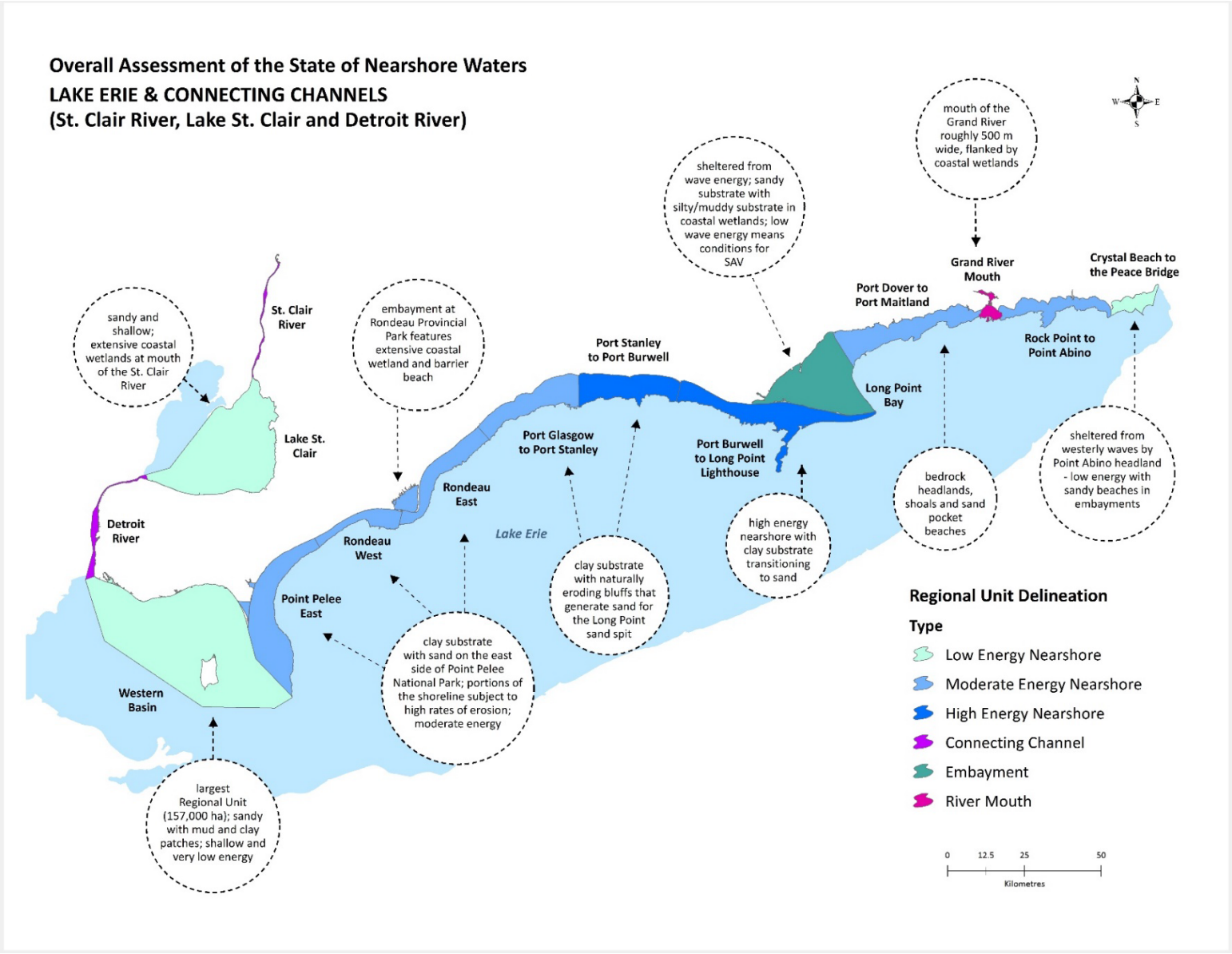
Table 1. Fifteen Regional Units were delineated in the first phase of the Nearshore Framework

Regional Unit Name and Ecosystem Type	Size	Substrate (GLAHF)	Wave Energy (Zuzek Inc.)	Description
CONNECTING CHANNEL				
ST. CLAIR RIVER (LE01)	1,800 ha	Silt	NA	Largest freshwater delta, fans out into Lake St. Clair
DETROIT RIVER (LE03)	5,000 ha	No data	NA	Sand and mud substrate at the north and south ends of the river; high energy environment
SHELTERED EMBAYMENT				
LONG POINT BAY (LE11)	48,900 ha	Sand	Low energy	Margins of the bay feature silty/muddy substrate, particularly in areas with

				lacustrine wetlands; low wave energy enables conditions conducive for submerged and emergent aquatic vegetation establishment
RIVERMOUTH				
GRAND RIVER MOUTH (LE13)	3,200 ha	Sand	High energy	Largest river draining into Lake Erie; mouth of the river approximately 500 m wide and flanked by extensive coastal wetland complex; size of the rivermouth and wetland complex as well as distinctive sandy substrate provide ecological justification to delineate the mouth of the Grand River as a Regional Unit; sandy bottom contrasts sharply with adjacent Regional Units which feature exposed bedrock
LOW ENERGY NEARSHORE				
LAKE ST. CLAIR (LE02)	87,000 ha	Sand	Low energy	Shallow (maximum depth approximately 6 m) with extensive coastal wetlands at the mouth of the St. Clair River
WESTERN BASIN (LE04)	157,000 ha	Sandy with mud and clay patches	Low energy	Shallow, very low energy; influenced by the Detroit River inflow; historically, alongshore transport of sediment from the Western Basin supplied Point Pelee
CRYSTAL BEACH TO THE PEACE BRIDGE (LE15)	6,600 ha	Rock	Low energy	Point Abino headland shelters the area from westerly waves (resulting in low energy environment; bedrock dominates the headlands, with sandy beaches present in embayments
MODERATE ENERGY NEARSHORE				
POINT PELEE EAST (LE05)	43,200 ha	Clay	Moderate energy	Clay substrate with sand on the east side of Point Pelee National Park; portions of the shoreline are subject to high rates of erosion, especially along Point Pelee
RONDEAU WEST (LE06)	10,900 ha	Clay	Moderate energy	Nearshore backed by eroding bluffs that contribute new sediment to the coast; much of the sediment is trapped by a large jetty in Erieau, restricting sediment supply east towards Rondeau Provincial Park
RONDEAU EAST (LE07)	23,900 ha	Clay	Moderate to high energy	Higher energy at Rondeau barrier beach; western and central portion features high bluffs and a large embayment in the west at Rondeau Provincial Park features an extensive coastal wetland with a barrier beach
PORT DOVER TO PORT MAITLAND (LE12)	29,900 ha	Rock	Moderate energy	Energy increases towards Port Maitland; shoreline and substrate dominated by bedrock headlands, shoals and sand pocket beaches

ROCK POINT TO POINT ABINO (LE14)	15,400 ha	Rock	Moderate energy	Shoreline has distinct headlands and embayments that are interspersed with rocky substrates and sandy beaches; the Welland Canal entrance at Port Colborne features shipping infrastructure
HIGH ENERGY NEARSHORE				
PORT GLASGOW TO PORT STANLEY (LE08)	25,100 ha	Clay	High energy	Naturally eroding bluffs along the shore generate sediment which is transported east to the tip of the Long Point sand spit
PORT STANLEY TO PORT BURWELL (LE09)	25,100 ha	Clay and sand	High energy	Clay transitions to sand west of Port Burwell; Regional Unit is defined by two large jettied river mouths (Kettle Creek at Port Stanley and Big Otter Creek at Port Burwell)
PORT BURWELL TO LONG POINT LIGHTHOUSE (LE10)	35,100 ha	Sand	High energy	Sand substrate with eroding bluffs in the west; the deposition and growth of the Long Point sand split over thousands of years created the sheltered condition in Long Point Bay and the presence of extensive coastal wetlands in the lee of the spit; high energy in the west and along the spit, with decreasing energy towards the Long Point lighthouse

Figure 4. Fifteen Regional Units were delineated in the nearshore of Lake Erie, St. Clair River, Lake St. Clair and Detroit River



2018 Lake Erie Canadian Nearshore Assessment

In 2018, Environment and Climate Change Canada (ECCC) undertook the overall assessment of the state of nearshore waters in Lake Erie and Connecting Channels. This report summarizes the findings of cumulative stress across Lake Erie and the St. Clair River, Lake St. Clair and Detroit River nearshore.

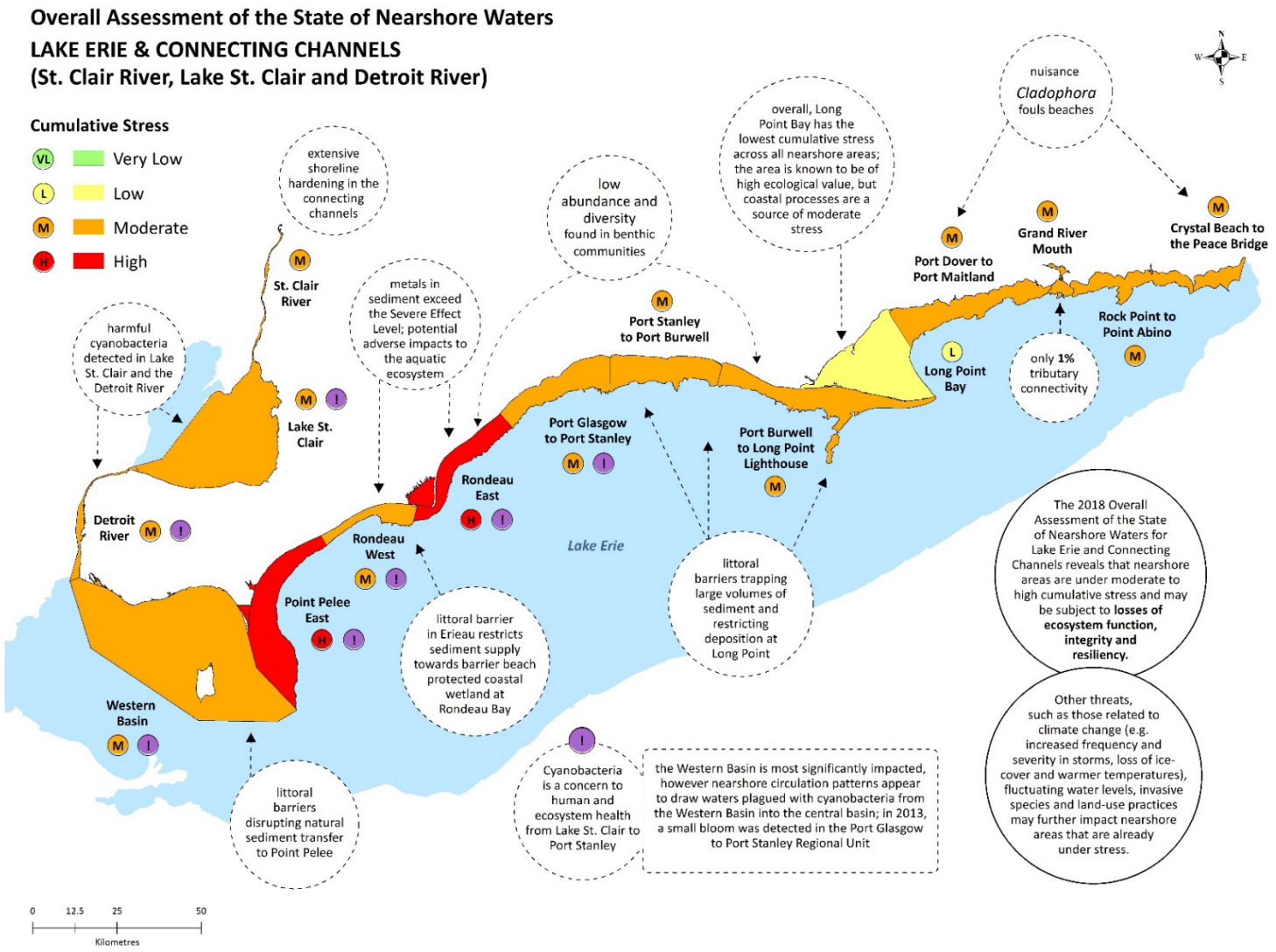
The assessment consists of 12 measures grouped into four evidence categories that were developed with consideration of the GLWQA General Objectives and specific requirements of the Nearshore Framework. Each of the measures in a category is assigned as "low," "moderate" or "high" stress on the nearshore of each Regional Unit, and then rolled up into an overall level of stress for each category using a Weight of Evidence approach. The four category scores are subsequently combined into an overall cumulative stress for each Regional Unit. Key findings from the assessment are presented in Figure 5 and summarized below. The Canadian portion of Lake Erie and Connecting Channels were delineated into 15 Regional Units with six classifications based on slow-changing physical parameters (e.g. bathymetry, substrate, wave energy density and physical features) (Figure 4). Overall, Lake Erie's nearshore areas are under moderate to high stress. A gradient exists across the north shore, with highest stress in the west-central (Point Pelee East and Rondeau East Regional Units) and lower stress in the east. Areas of known ecological value, such as Point Pelee, Rondeau Bay and Long Point are threatened by cumulative stress in nearshore areas. Cyanobacteria blooms impact the western portion of Lake Erie and were detected as far east as the Port Glasgow to Port Stanley Regional Unit in 2013. Disruption of natural coastal processes was found to be a lakewide trend, compromising the integrity, function and resilience of nearshore areas. In many areas, the cumulative impact of shoreline alteration and armouring – confounded with climate change (e.g. high water levels and increased storm intensity) – are causing significant stress on nearshore ecosystems and leading to loss of natural resiliency to flooding and erosion.

A **Weight of Evidence** approach was used to develop a structured decision making processes for the overall assessment. Weight of Evidence is a process for systematic and transparent integration of multiple datasets where "weight" (+ or ++) is assigned to each assessment measure based on a categorical rating of three factors: relevance, strength and reliability. Categories and measures include:

- Coastal Processes: Shoreline Hardening (+), Littoral Barriers (+), Tributary Connectivity (+)
- Contaminants in Water & Sediment: Water Quality (+), Sediment Quality (++), Benthic Community (++)
- Nuisance & Harmful Algae: *Cladophora* (+), Cyanobacteria (++), Dissolved Oxygen/Hypoxia (+)
- Human Use: Beach Postings (+), Fish Consumption (+), Treated Drinking Water (+)

For details on the assessment methodology, see the *Canadian Great Lakes Nearshore Assessment Detailed Methodology*.

Figure 5. Results of the 2018 Overall Assessment of the State of Nearshore Waters in Lake Erie & Connecting Channels



Coastal Processes

Map of category results in Figure 7, individual measure descriptions below.

Shoreline Hardening

Low Stress	<25% of the total length of shoreline in a Regional Unit is hardened
Moderate Stress	25-50% of the total length of shoreline in a Regional Unit is hardened
High Stress	>50% of the total length of shoreline in a Regional Unit is hardened

Thresholds based on best professional judgement.

Approximately 40% of the total length of the Lake Erie and Connecting Channels shoreline is hardened. The longest stretches of natural shoreline are at ecological features such as the St. Clair River Delta (Lake St. Clair Regional Unit), Big Creek Marsh (Western Basin Regional Unit) and Long Point (Long Point Bay Regional Unit). The shoreline in the central basin, in the Port Glasgow to Port Stanley, Port Stanley to Port Burwell and Port Burwell to Long Point Lighthouse Regional Units retain the highest amount of natural shoreline. Together, this shoreline is approximately 150 km and less than 1% is hardened.

Shoreline hardening is most extensive along the Huron-Erie Corridor. In the St. Clair River and Detroit River Regional Units, 90% and 84% of the shoreline, respectively, is no longer natural. The Detroit River is modified by industry and shoreline hardening is prevalent even along the Detroit River Marshes. The shoreline remains natural along the Lake St. Clair Marshes, but most of the southern extent of the Lake St. Clair Regional Unit is hardened. Collectively, just under 50% of the 400 km of shoreline in the Huron-Erie Corridor has been hardened.

Along the eastern end of the lake, from Port Dover to the Peace Bridge, shoreline hardening is also quite extensive. In the Port Dover to Port Maitland Regional Unit, 61% of the shoreline is hardened and the longest stretch of natural shoreline is just over 3 km (with the exception of the sheltered shoreline at Selkirk Provincial Park, which is approximately 4.5 km of natural shoreline). The Rock Point to Point Abino and Crystal Beach to the Peace Bridge Regional Units are similar, in that the majority of the shoreline is hardened and the areas that remain natural are small, piecemeal sections. Although the Grand River Mouth is the smallest Regional Unit in area, it extends up the river to Dunnville and has approximately 50 km of shoreline. The mouth of the river is characterized by coastal wetlands, yet approximately 26% of the shoreline is hardened.

Overall, shoreline hardening in Lake Erie and the Connecting Channel is a source of moderate or high stress. The nearshore provides a unique set of conditions and processes that together meet the life-stage requirements of aquatic species and biological communities. When a shoreline is hardened it can alter sediment, accelerate erosion or deplete coastal areas in need of sediment replenishment. These coastal processes also play a significant role in determining the distribution and health of fish populations through impacts to their habitat including migration corridors, spawning grounds, nursery and feeding areas. Hardening of the shoreline can reduce coastal resilience; in the absence of natural vegetation or features like coastal wetlands, the shoreline may no longer adapt to rising and falling water levels, leading to physical reductions of available aquatic habitat.

Littoral Barriers

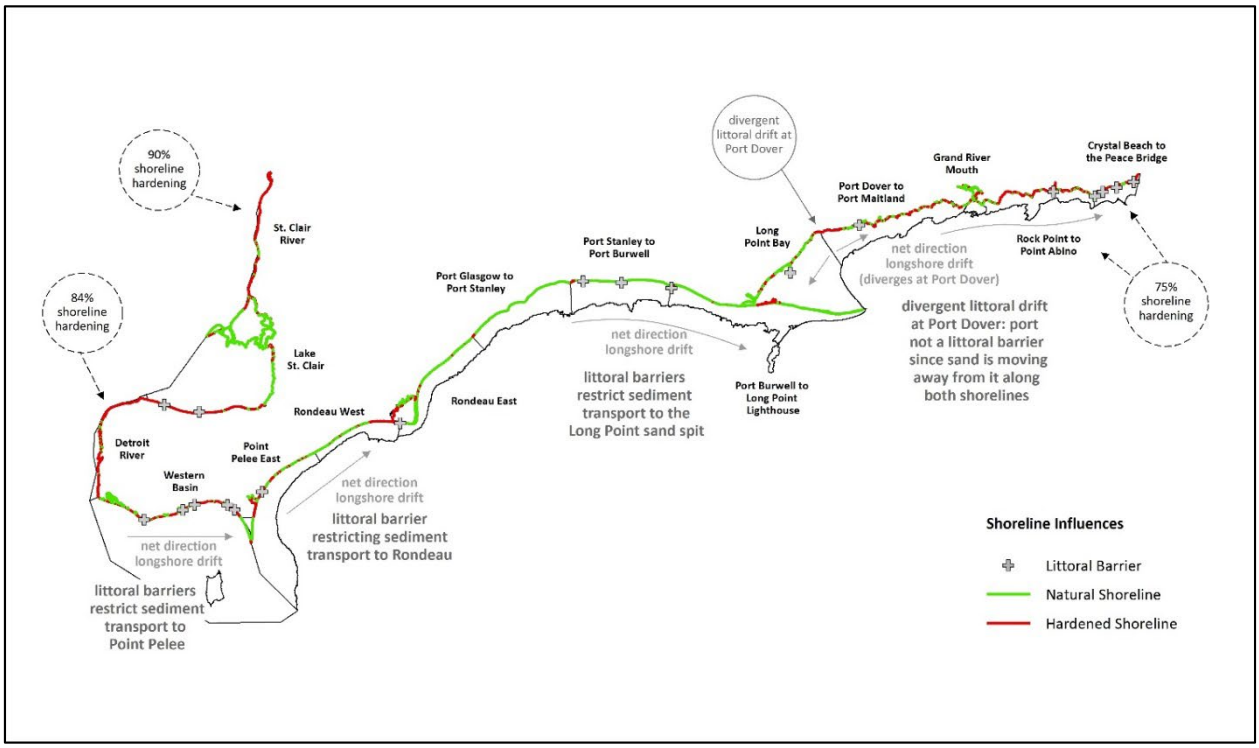
Low Stress	0 littoral barriers
Moderate Stress	1 littoral barrier
High Stress	>1 littoral barriers

Thresholds based on best professional judgement.

Littoral barriers are defined here as shore perpendicular features that are greater than 100 metres in length and that disrupt the natural movement of sediment (littoral drift). Littoral drift is the natural movement of sand and gravel in the nearshore and in areas where this is an important physical process, the presence of littoral barriers can impede natural coastal processes related to sediment dynamics. In a resilient coastal system, there should be no littoral barriers and processes related to sediment supply and deposition should not be restricted. In a resilient coastal system, sediment is supplied to the littoral "cell" through a source such as cliff erosion or coastal dunes and then transported alongshore through wave action where it is either deposited or lost offshore. In Lake Erie, coastal processes related to sediment drift have led to the formation of significant features like Point Pelee, Rondeau Bay and Long Point as well as sandy beaches.

There are 12 Regional Units where littoral drift is an important physical process; the only Regional Units where it is not are in the Connecting Channel (St. Clair River and Detroit River) and in the Grand River Mouth. Four Regional Units are under high stress from the presence of at least two littoral barriers and six are under moderate stress from the presence of a single littoral barrier (Figure 6).

Figure 6. Shoreline hardening and littoral barriers impact Coastal Processes



The Western Basin Regional Unit has five littoral barriers, the most of any Regional Unit. The direction of net longshore sediment transport is west to east and the presence of shore perpendicular structures at Colchester, Cedar Creek, Kingsville, Leamington and Sturgeon Creek are affecting natural sediment dynamics. Much of the sediment from the Western Basin would, under natural processes, move east and be deposited at Point Pelee but the littoral barriers in both the Western Basin and Point Pelee East Regional Units may be disrupting this. The jetty in Erieau restricts sediment supply towards Rondeau Provincial Park where naturally, coastal processes transport sediment towards the barrier protected coastal wetland. Rondeau Bay has been estimated to have lost more than 160 hectares of coastal wetland since 1955 due to erosion of the barrier beach and it is expected to experience further losses due to high water levels and storm events. The eastern and central portion of the Rondeau East Regional Unit features high bluffs with minimal shoreline hardening. Within the Port Glasgow to Port Stanley Regional Unit there are naturally eroding bluffs that generate sediment for the Long Point sand spit, but the presence of a littoral barrier is disrupting natural sediment flow. Large jettied river mouths trap significant volumes of sand and modify the nearshore substrate from Port Stanley to Port Burwell, and the pier at Port Burwell traps longshore transport of sediment to Long Point. Behind the Long Point sand spit is the largest coastal wetland in Lake Erie, however the sand spit is being starved of sediment that is needed for beach replenishment due to the Port Burwell jetty which holds back an estimated 12 million cubic metres of sand.

Tributary Connectivity

Low Stress	>75% of the total length of tributaries (excluding upstream of a waterfall) are connected to the Regional Unit
Moderate Stress	25-75% of the total length of tributaries (excluding upstream of a waterfall) are connected to the Regional Unit
High Stress	<25% of the total length of tributaries (excluding upstream of a waterfall) are connected to the Regional Unit

Thresholds based on the State of the Great Lakes Sub-indicator report for Aquatic Habitat Connectivity using Ontario Ministry of Natural Resources and Forestry Hydro Network data.

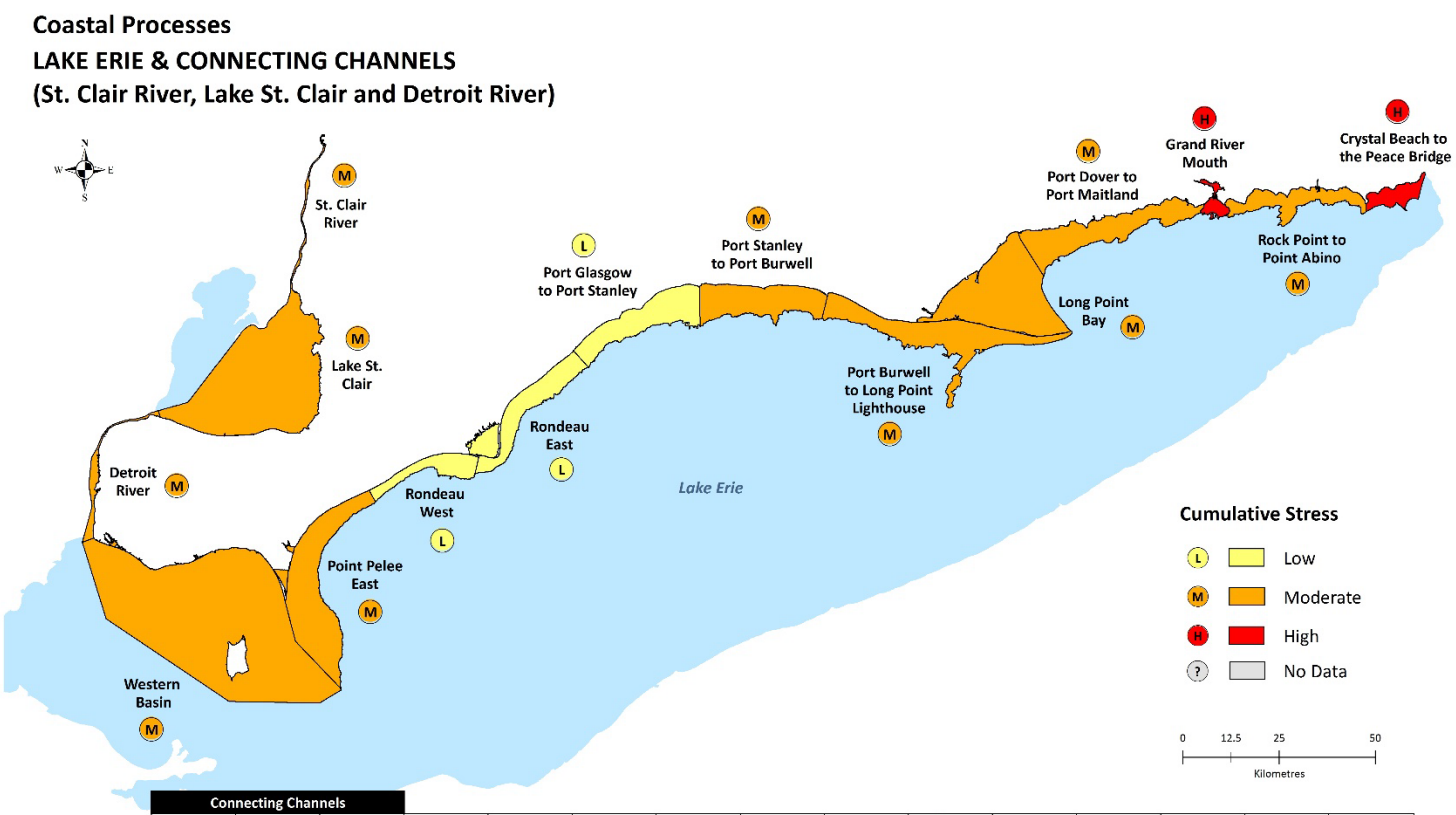
Across Lake Erie, tributary connectivity is a source of low to moderate stress on the nearshore. Six Regional Units (Detroit River, Point Pelee East, Rondeau West, Rondeau East, Rock Point to Point Abino and Crystal Beach to the Peace Bridge) have 100% of their tributaries connected to the nearshore; no dams are impeding connectivity. The Port Glasgow to Port Stanley Regional Unit has a very small portion of its tributaries upstream of a dam, but 99% of the total length of tributaries are connected. In the Western Basin Regional Unit there is a dam at the mouth of the Big Creek Marshes that is impeding connectivity for roughly 60 km of tributaries. Within the Long Point Bay Regional Unit, seven barriers are impeding connectivity for approximately 63% of the tributaries, primarily along Big Creek and many of the creeks feeding into it.

While tributary connectivity remains high (and a low source of stress) across the majority of Regional Units, it should be noted that the combined length of these tributaries is less than half of the total that flow into Lake Erie.

The tributaries in the Lake St. Clair and Grand River Mouth Regional Units account for over half of the total length of tributaries flowing into Lake Erie but also account for the majority of disconnected tributaries. In the Lake St. Clair Regional Unit, connectivity is impeded in many of the tributaries in the Upper Thames watershed and a dam on the North Sydenham River, near Duthill, disconnects a significant portion of tributaries from the nearshore. The highest source of stress on tributary connectivity is at the Grand River, where the Dunville Dam disconnects nearly all of the river from the lake. A mere 1% of the length is downstream of the dam and connected to the nearshore. Built in 1829, the dam was originally built to regulate flow to the feeder canal for the Welland Canal; today, it's used to regulate the level of the Grand River at Port Maitland.

Of the approximately 20,000 km of tributaries that flow into Lake Erie and the Huron-Erie Corridor, around 65%, are upstream of a dam and disconnected from the nearshore. These barriers that limit tributary connectivity can have adverse impacts on the health of aquatic ecosystems by limiting access of fishes to spawning and nursery habitats, affecting nutrient flows and riparian and coastal processes. Although road crossings have not been included in this assessment, there have been several regional initiatives to identify and mitigate culverts that act as barriers and in future assessments they could be considered.

Figure 7. Results of the Coastal Processes category (N/A means that the measure does not apply in the Regional Unit)



	Connecting Channels														
	St. Clair River	Lake St. Clair	Detroit River	Western Basin	Point Pelee East	Rondeau West	Rondeau East	Port Glasgow to Port Stanley	Port Stanley to Port Burwell	Port Burwell to Long Point Lighthouse	Long Point Bay	Port Dover to Port Maitland	Grand River Mouth	Rock Point to Point Abino	Crystal Beach to the Peace Bridge
Shoreline Hardening	90%	29%	84%	43%	39%	35%	24%	5%	10%	10%	22%	61%	26%	76%	75%
Littoral Barriers	N/A	2	N/A	5	1	0	1	0	3	1	1	1	N/A	1	4
Tributary Connectivity	86%	55%	100%	78%	100%	100%	100%	99%	75%	66%	37%	91%	1%	100%	100%

Contaminants in Water & Sediment

Map of category results in Figure 8, individual measure descriptions below.

Water Quality

Low Stress	0 exceedances
Moderate Stress	1 or 2 exceedances
High Stress	>2 exceedances

Thresholds based on Provincial and Federal Guidelines and best professional judgement using data from the Ontario Ministry of Environment, Conservation and Parks Great Lakes Nearshore Water Chemistry.

Across Lake Erie water quality is generally a source of low stress. The MECP Great Lakes Water Chemistry data was assessed for any exceedances in published guidelines, and mercury was the only contaminant found to exceed guidelines (Canadian Water Quality Guidelines). Mercury was found in excess of the guidelines on one sampling day in the Western Basin and Rondeau West Regional Units. In each case, the exceedance was recorded in 2010. Outside these two Regional Units there were no exceedances of any contaminant.

Although mercury occurs naturally, it also enters aquatic ecosystems through anthropogenic emission, re-emissions and discharges and is a source of stress in the nearshore because of potential acute or chronic impacts on aquatic organisms that depend on water for some part of their life cycle.

Sediment Quality

Low Stress	• PCBs < No Effect Level • Organochlorine pesticides & PAHs < Lowest Effect Levels • Metals < Probable or Severe Effect Levels
Moderate Stress	• PCBs > No Effect Level OR, • Organochlorine pesticides & PAHs > Lowest Effect Levels but < Severe Effect Levels OR, • Metals > Probable Effect Levels but < Severe Effect Levels
High Stress	• Any contaminant > Severe Effect Levels

Thresholds based on Provincial and Federal Guidelines and best professional judgement using data from the Ontario Ministry of Environment, Conservation and Parks Great Lakes Nearshore Sediment Chemistry (2007, 2010, 2014, 2016).

Provincial long-term sensing sites were monitored for sediment quality in Lake Erie in 2007, 2010, 2014 and 2016. The monitoring stations were not all visited each year but each station

had results for at least one sampling year. For many Regional Units, the level of stress was determined from a single sampling site. Sediment quality in the nearshore is highly variable and sampling locations may not represent conditions for the entire Regional Unit area. Three Regional Units have "No Score" as there is currently no monitoring station within the Unit. The data was compiled by Regional Unit for all sampling years and compared to Provincial and Federal Sediment Quality Guidelines (Table 2).

Across most of Lake Erie, sediment quality is scored as low or moderate stress. Although a number of Regional Units have metals detected above Provincial LELs (lowest effect levels), this generally reflects background conditions and are not at levels of concern. Moderate stress in four Regional Units is caused by PCB levels above the Provincial No Effect Level indicating potential for bioaccumulation in the food chain. Two Regional Units (Rondeau East and Rondeau West) were found to be of High Stress due to the presence of metals (Arsenic, Iron and Manganese) above the Severe Effect Level. This indicates that contaminant levels are high enough to negatively impact sediment dwelling organisms and pose a risk to the aquatic ecosystem.

While overall ambient sediment quality is good in the St. Clair River, it should be noted that it is a Great Lakes Area of Concern (AOC) with localized contaminated sediment at Sarnia. Three priority sediment zones contaminated with mercury are the subject of current management planning and action.

Table 2. Number of contaminants that exceeded Federal or Provincial guidelines within each Regional Unit, for each category of contaminant. As a rule, LEL<PEL<SEL, so if the contaminant exceeds the PEL is also exceeds the LEL, and if it exceeds the SEL it exceeds the LEL and PEL

Regional Unit	**Metals**			**PCBs**	**Organochlorine Pesticides**			**Polycyclic Aromatic Hydrocarbons**			**Score**
	LEL	PEL	SEL	NEL	LEL	PEL	SEL	LEL	PEL	SEL	
St. Clair River											Low
Lake St Clair				1							Moderate
Detroit River				1							Moderate
Western Basin Nearshore	3			1				3			Moderate
Point Pelee East	No Data										
Rondeau West	3		3								High
Rondeau East	2		3								High
Port Glasgow to Port Stanley	2										Low
Port Stanley to Port Burwell	2										Low

Port Burwell to Long Point Lighthouse	No Data										
Long Point Bay											Low
Port Dover to Port Maitland											Low
Grand River Mouth	5										Low
Rock Point to Point Abino	No Data										
Crystal Beach to the Peace Bridge				1							Moderate

Benthic Community

Low Stress	Benthic community is condition is functional and of high diversity (top 67th percentile of scores)
Moderate Stress	Benthic community is condition is degraded but functional (33rd to 67th percentile of scores)
High Stress	Benthic community is condition is severely degraded and not functional (bottom 33rd percentile of scores)

Thresholds based on statistical analysis using data from the Erie Comprehensive Collaborative Study of 2004.

Benthic community composition can vary substantially due to natural habitat conditions and human stressors, but the general health of an ecosystem may be reflected in the benthic community. Across Lake Erie, benthic community quality varies (Table 3).

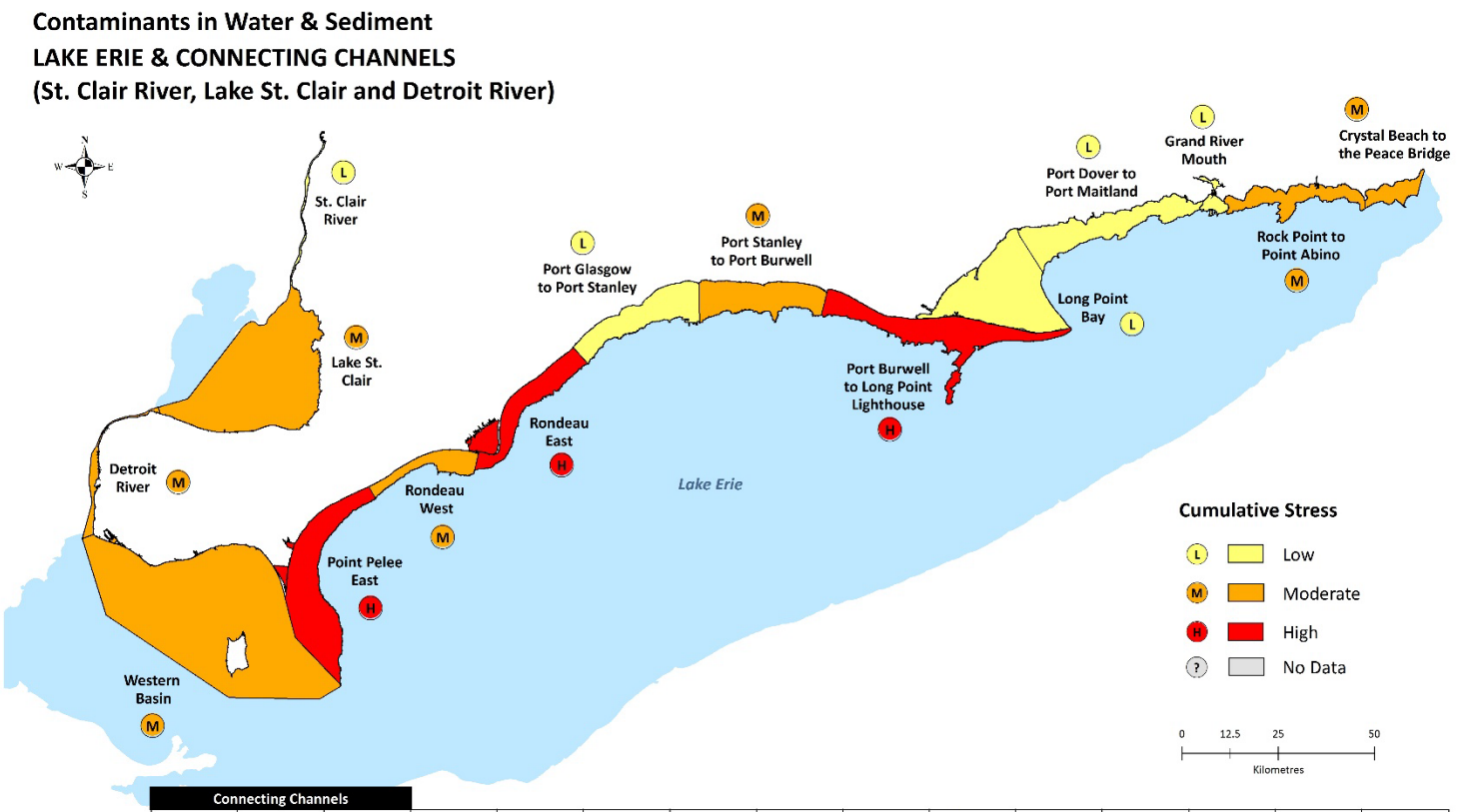
In the Point Pelee East, Rondeau East, Port Stanley to Port Burwell and Port Burwell to Long Point Lighthouse Regional Units, benthic community is a source of high stress as the relative condition of benthic invertebrate communities was low. The Western Basin, Port Glasgow to Port Stanley and Rock Point to Point Abino Regional Units were assessed as having average benthic community quality. Generally, this means that the benthic communities at these sites had a lower total benthos, lower taxon richness and higher tolerance score.

Sites in the Rondeau West, Long Point Bay and Port Dover to Port Maitland Regional Units were assessed as being in the top percentile of the range of quality across all sites. In these Regional Units, benthic community is a source of low stress. See Appendix A for details on the statistical analysis used to assess Benthic Community.

Table 3. Results of the Benthic Community Quality assessment; low quality sites are those in the bottom 33rd percentile of the range of quality scores across all sites and high quality sites are those in the top 67th percentile

Regional Unit	Number of Sites	Number of Low Quality Sites	Number of Moderate Quality Sites	Number of High Quality Sites	Score
St. Clair River	No Data				
Lake St. Clair	No Data				
Detroit River	No Data				
Western Basin	102	24	42	36	Moderate Stress
Point Pelee East	7	4	2	1	High Stress
Rondeau West	3	1	0	2	Low Stress
Rondeau East	6	5	1	0	High Stress
Port Glasgow to Port Stanley	5	2	2	1	Moderate Stress
Port Stanley to Port Burwell	7	4	3	0	High Stress
Port Burwell to Long Point Lighthouse	9	8	1	0	High Stress
Long Point Bay	9	0	0	9	Low Stress
Port Dover to Port Maitland	6	1	2	3	Low Stress
Grand River Mouth	No Data				
Rock Point to Point Abino	6	3	3	0	Moderate Stress
Crystal Beach to the Peace Bridge	No Data				

Figure 8. Results of the Contaminants in Water & Sediment category



	Connecting Channels														
	St. Clair River	Lake St. Clair	Detroit River	Western Basin	Point Pelee East	Rondeau West	Rondeau East	Port Glasgow to Port Stanley	Port Stanley to Port Burwell	Port Burwell to Long Point Lighthouse	Long Point Bay	Port Dover to Port Maitland	Grand River Mouth	Rock Point to Point Abino	Crystal Beach to the Peace Bridge
Water Quality	0 exceedances	0 exceedances	0 exceedances	1 mercury exceedance	No Data	1 mercury exceedance	0 exceedances	0 exceedances	0 exceedances	No Data	0 exceedances	0 exceedances	0 exceedances	No Data	0 exceedances
Benthic Community	No Data	No Data	No Data	average quality	low quality	high quality	low quality	average quality	low quality	low quality	high quality	high quality	No Data	average quality	No Data
Sediment Quality	0 exceedances	PCBs > NEL	PCBs > NEL	3 metals > LEL, PCBs > NEL & 3 PAHs > LEL	No Data	3 metals > LEL & 3 metals > SEL	2 metals > LEL & 3 metals > SEL	2 metals > LEL	2 metals > LEL	No Data	0 exceedances	0 exceedances	5 metals > LEL	No Data	PCBs > NEL

Nuisance & Harmful Algae

Map of category results in Figure 10, individual measure descriptions below.

Cyanobacteria

Low Stress	Western Basin: No cyanobacteria bloom that exceeds 20% of the Regional Unit in any 10-day composite Other Regional Units: No cyanobacteria bloom that exceeds 2% of the Regional Unit detected in any 10-day composite
Moderate Stress	Not applicable
High Stress	Western Basin: Cyanobacteria bloom exceeds 20% of the Regional Unit in any 10-day composite Other Regional Units: Cyanobacteria bloom exceeds 2% of the Regional Unit in any 10-day composite

Thresholds based on the World Health Organization cyanobacteria guidelines using satellite composites from NOAA's Harmful Algal Bloom Forecasting Branch (2012-2017).

Cyanobacteria was assessed as a source of high stress and flagged as a concern to human and ecosystem health from Lake St. Clair to the Port Glasgow to Port Stanley Regional Unit. From 2012 to 2017 the extent of cyanobacteria blooms exceeded 20% of the total area of the Western Basin Regional Unit and 2% of the other Regional Units in numerous 10-day composites.

In 2013, a HAB started in mid-summer and lasted well into October, covering close to 50% of the Western Basin Regional Unit, over 30% of the Point Pelee East Regional Unit and extended all the way to the Port Stanley to Port Burwell Regional Unit where it covered nearly 8% of its surface area. Although a relatively mild year in Canadian waters, the bloom in 2014 was concerning as it forced the closure of the City of Toledo's drinking water intakes and for residents on Pelee Island, it was encouraged they use bottled water for bathing and drinking as their water sources may have been contaminated.

In 2015 a record bloom extent was set when excessive spring rains across the region led to huge loads of phosphorus entering Lake Erie. Satellite imagery detected the bloom from the Western Basin as far east as the Port Glasgow to Port Stanley Regional Unit. There were eight composites in 2015 where the bloom exceeded 20% of the total area of the Western Basin Regional Unit and in three composites, the coverage was over 50%.

The following year (2016) was a relatively mild bloom year, however it was the first year Cyanobacteria was detected in the assessed 10-day satellite composites in Lake St. Clair and the Detroit River. Forming in the Western Basin in August and persisting through September, the 2016 bloom also extended into the Rondeau West Regional Unit, covering roughly 9% of its area.

In early July to the end of August in 2017, a bloom was detected within Lake St. Clair. August, September and October of 2017 had an extensive bloom in the Western Basin Regional Unit, where it covered well over 20% of the total area. Forming late in the bloom season, it covered upwards of 50% of the Western Basin in October. The bloom was not detected east of the Western Basin in 2017.

Cladophora

Low Stress	<20% coverage
Moderate Stress	20-35% coverage
High Stress	>35% coverage

Thresholds developed using best professional judgement using 2016-2018 satellite-derived Submerged Aquatic Vegetation (SAV) Mapping from Michigan Tech Research Institute (MTRI).

Cladophora is filamentous green algae that grows on hard substrates in all of the Great Lakes. While not toxic, it is a nuisance and can pose threats to human health. Beyond clogging water intakes and degrading fish habitat, odorous rotting mats of *Cladophora* on beaches encourage the growth of bacteria and are a factor in beach postings. The *Cladophora* measure does not apply to Regional Units that are dominated by unconsolidated substrate, highly erosive coastlines and embayments characterized by coastal wetlands nor connecting channels. In areas where coastal wetlands are prevalent, it was assumed that areas classified as either sparse or dense submerged aquatic vegetation (SAV) in the MTRI mapping may actually be wetland associated SAV and not nuisance *Cladophora.*

In areas suitable for *Cladophora* it was assessed as a moderate to high source of stress on nearshore waters (Figure 9).

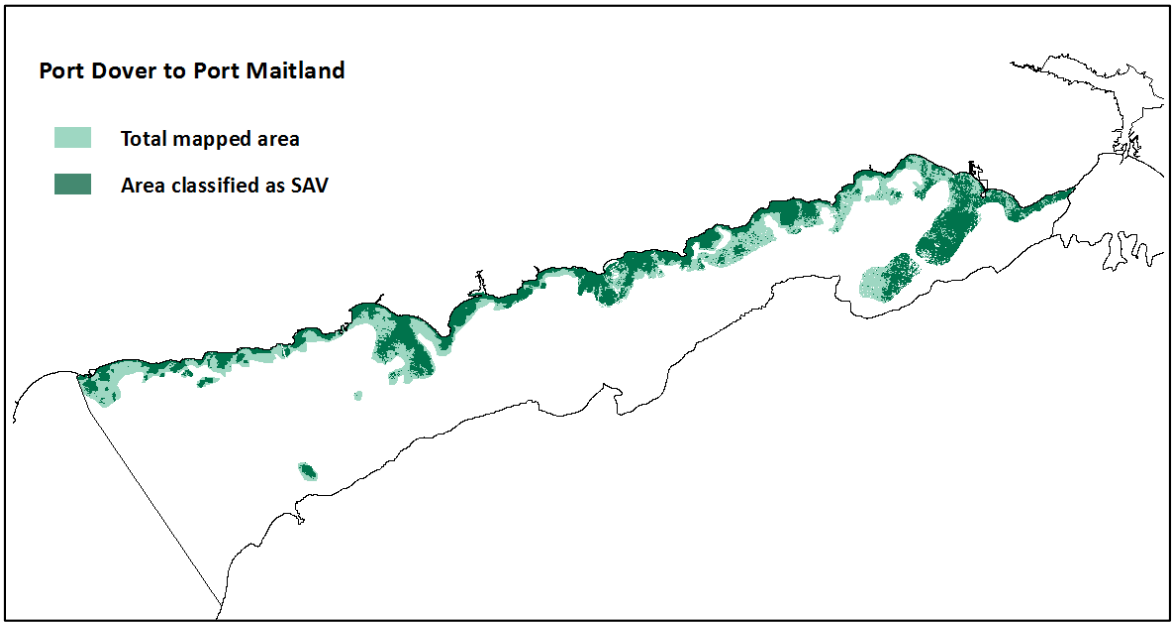
***Cladophora* vs. Submerged Aquatic Vegetation:** The best available dataset to measure the amount of *Cladophora* within the nearshore of Lake Erie is the Michigan Tech Research Institute satellite-derived Submerged Aquatic Vegetation (SAV) mapping. These maps represent the extent of SAV in the Great Lakes, acknowledging that much of it is *Cladophora*, with localized areas of vascular plants and other filamentous algae. Although the MTRI product has an overall accuracy of 83% based on comparison with ground truth data, this measure is not applicable in Regional Units where SAV is likely attributed to coastal wetlands or in other areas dominated by unconsolidated substrate.

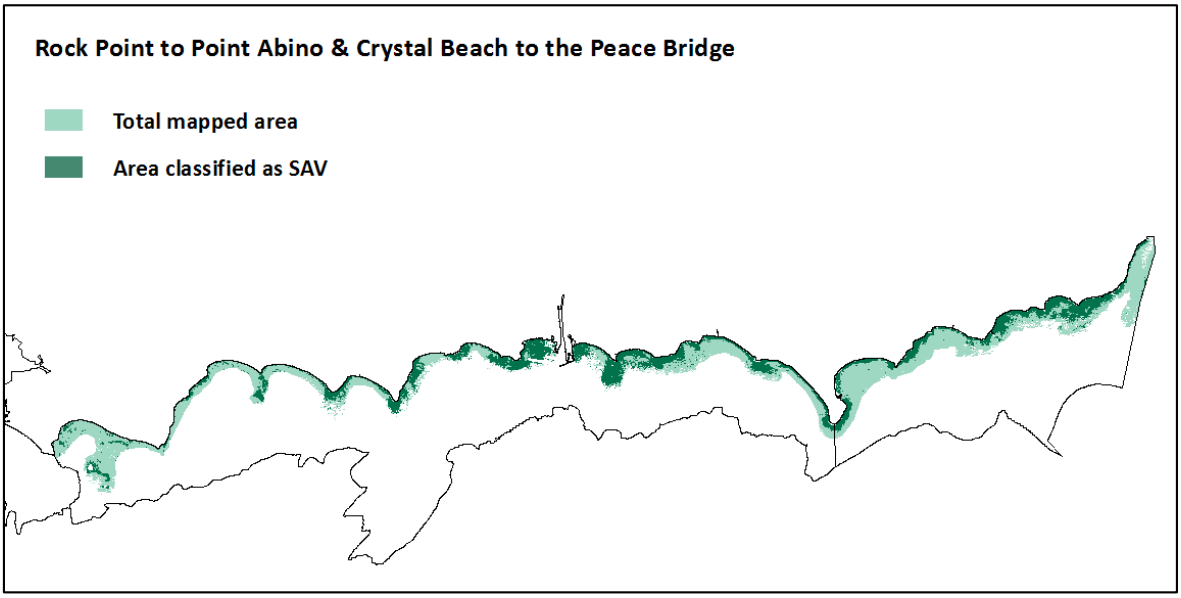
The Port Dover to Port Maitland Regional Unit is assessed as being under high stress from *Cladophora.* With 53% coverage, the extent is well over the 35% threshold for high stress. The area is characterized by limestone outcroppings and bedrock headlands that are quite suitable for *Cladophora* establishment.

In the Rock Point to Point Abino Regional Unit, the coverage was almost 38%. Similar to the Port Dover to Port Maitland Regional Unit, the area is characterized by substrate suitable for *Cladophora* establishment, such as bedrock and cobble.

Cladophora is considered a source of moderate stress in the Crystal Beach to Peace Bridge Regional Unit, where the coverage is roughly 30% of the mapped area. Wash-up of *Cladophora* is known to be extensive along this stretch of coast, which has bedrock outcroppings and areas of cobble substrate.

Figure 9. Extent of mapped area and area classified as submerged aquatic vegetation (SAV) from the MTRI satellite-derived products





Additional Research & Monitoring of Nuisance *Cladophora*

Environment and Climate Change Canada and Ontario Ministry of Environment, Conservation and Parks researchers have a number of sentinel sites to monitor *Cladophora* across the eastern basin of Lake Erie. Locations include the nearshore at the Tecumseh Reef off South Cayuga in the Port Dover to Port Maitland Regional Unit. Further east, sites are located at Rock Point, Lighthouse Point, Mohawk Road and Port Colborne within the Rock Point to Point Abino Regional Unit. The intent of the monitoring is to track spatial variation and biomass of *Cladophora* as part of long term monitoring, and to use data to support modelling algae dynamics. At each site, divers collect all *Cladophora* in one square meter; the sample is then

dried, giving a *Cladophora* biomass of grams per square meter. Sampling years included 2012 to 2017 and 2019, and range in depth between three and 18 metres. The shallow monitoring locations, three and six metres in depth, coincide the depths the satellite imagery can penetrate. The results are complimentary to those from the satellite-based imagery of submerged aquatic vegetation. The Tecumseh, Lighthouse Point, Mohawk Road and Port Colborne sites were all found to have relatively high *Cladophora* biomass, at the three and six metre depths. Rock Point was lower than the other monitoring sites, and may be due to the plume from the Grand River decreasing water clarity, limiting the ability for *Cladophora* growth. While researchers don't regularly sample the nearshore in the two easterly Regional Units, *Cladophora* wash-up has been identified as a concern by a number of local stakeholders. Along the coast between Wainfleet and Fort Erie, numerous small embayments, trap sloughed *Cladophora*, impacting the local property owners and cottage communities. Stakeholders have developed a monitoring program to track nutrient loading in tributaries and *Cladophora* wash-up along the shore. The program has been running since 2018, and includes 10 sections of the coast monitored by 20 volunteers. Significant wash-up has been noted in Lorraine Bay, also the area with the highest tributary phosphorus concentrations. The results will be shared with researchers to supplement the in-lake monitoring efforts, in attempt to understand the impact and extent that *Cladophora* is having on the communities.

Dissolved Oxygen/Hypoxia

Low Stress	All samples > 6 mg/L
Moderate Stress	1 or more samples between 2 and 6 mg/L
High Stress	1 or more samples < 2 mg/L

Thresholds adopted from the Canadian Water Quality Guidelines for the Protection of Aquatic Life using data from Environment and Climate Change Canada's Great Lakes Water Quality Monitoring and Surveillance Data (2012-2014).

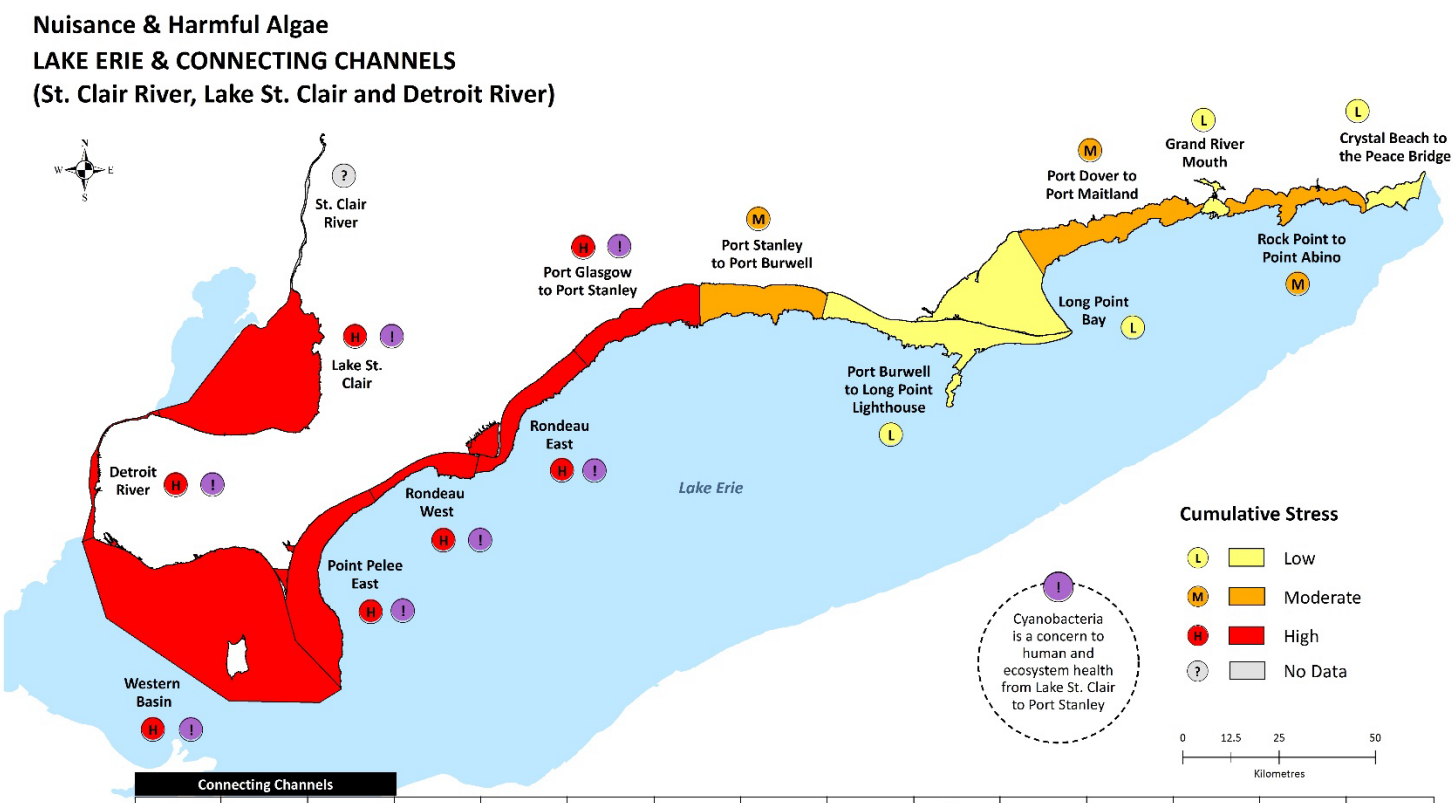
For much of Lake Erie dissolved oxygen is a source of low stress on nearshore waters. Eight Regional Units had samples with recorded concentrations above 6 mg/L (and in six Regional Units there is No Data).

Dissolved Oxygen is a source of moderate stress on the Port Stanley to Port Burwell Regional Unit where it was detected at levels below the acceptable range for aquatic life. In July 2012, the ECCC Great Lakes Water Quality Monitoring and Surveillance Program recorded concentration of 4.2 mg/L and 5 mg/L. That same year, hypoxic conditions were responsible for large numbers of dead fish washing up onto the stretch of shoreline between Erieau and Port Stanley. Dissolved oxygen concentrations were also recorded at levels below acceptable ranges in 2013.

Lake St. Clair water quality was extensively sampled in 2016 and 2017 through a partnership monitoring program between ECCC and MECP. Twelve general monitoring areas had water quality data loggers installed for continuous sampling through the ice-free season. Dissolved oxygen is one of the parameters included in the monitoring, measured as percent saturation. Samples were found to be in the acceptable range for aquatic life throughout the lake. The supplementary data collected through the partnership program was not used for the nearshore

assessment, but is worth mentioning in lieu of ECCC Great Lakes Water Quality Monitoring and Surveillance Program survey stations.

Figure 10. Results of the Nuisance & Harmful Algae Category (N/A means that the measure does not apply in the Regional Unit)



	Connecting Channels														
	St. Clair River	Lake St. Clair	Detroit River	Western Basin	Point Pelee East	Rondeau West	Rondeau East	Port Glasgow to Port Stanley	Port Stanley to Port Burwell	Port Burwell to Long Point Lighthouse	Long Point Bay	Port Dover to Port Maitland	Grand River Mouth	Rock Point to Point Abino	Crystal Beach to the Peace Bridge
Cyanobacteria	No Data	>2%	>2%	>20%	>2%	>2%	>2%	>2%	<2%	<2%	<2%	<2%	<2%	<2%	<2%
Cladophora	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	53% SAV extent	N/A	38% SAV extent	30% SAV extent
DO/ Hypoxia	N/A	No Data	N/A	within acceptable range	No Data	within acceptable range	No Data	within acceptable range	2-6 mg/L	within acceptable range	within acceptable range	within acceptable range	within acceptable range	No Data	within acceptable range

Human Use

Map of category results in Figure 12, individual measure descriptions below.

Beach Postings

Low Stress	Beaches posted 5% or less of the time during July and August 2015 & 2016
Moderate Stress	Beaches posted 5-20% of the time during July and August 2015 & 2016
High Stress	Beaches posted more than 20% of the time during July and August 2015 & 2016

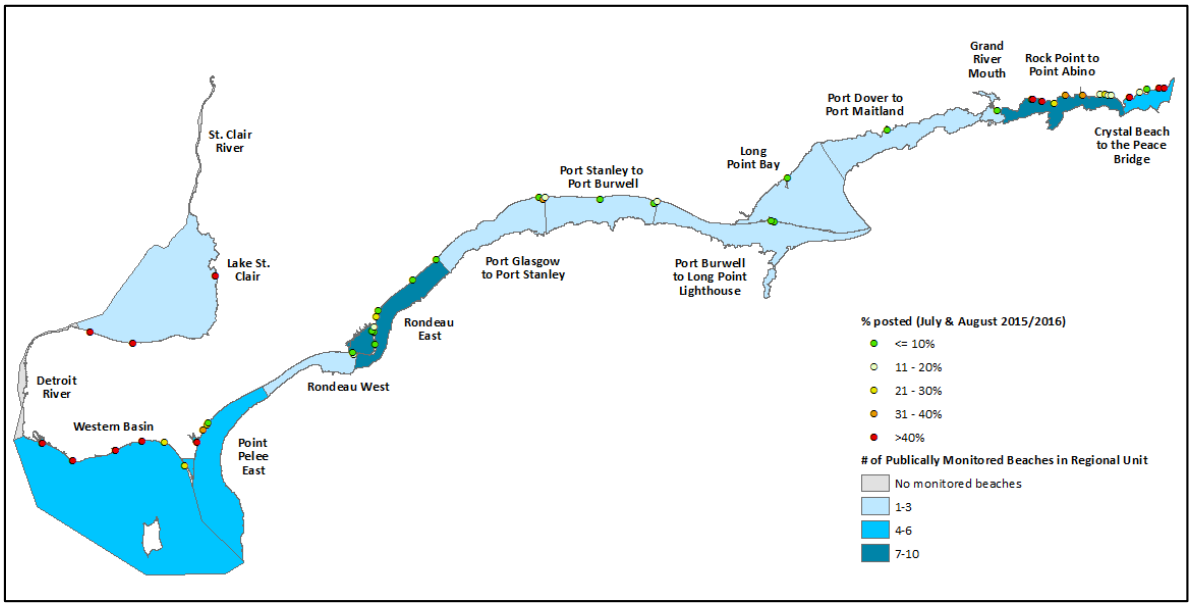
Thresholds developed using best professional judgement using data from Swim Drink Fish Canada.

This assessment included information on 50 publically monitored beaches on Lake Erie and Lake St. Clair. The Rondeau East and Rock Point to Point Abino Regional Units have the most beaches, with the Western Basin, Point Pelee East and Crystal Beach to the Peace Bridge each having from 4 to 6 beaches (see Figure 11). This may be a result of physical limitations of the lakes themselves (i.e. unsafe currents for recreational swimming or high bluffs) or the limited capacities of Health Units to monitor all locations at which people can access the lake for swimming. Regional Units with no publically monitored beaches were not scored. The only Regional Units with no monitored beaches are the St. Clair River and Detroit River.

On average, beaches were posted over 40% of the swimming season (July and August) in 2015 and 2016 in the Lake St. Clair and Western Basin Regional Units, as well as the Rock Point to Point Abino and Crystal Beach to the Peace Bridge Regional Units (Figure 11). Beaches in the central basin were posted for less of the swimming season and overall, are a lower source of stress. Most beach postings were in the Lake St. Clair Regional Unit where 3 beaches (Sand Point Beach, West Belle River Beach, and Mitchells Bay) were posted on average 66% of July and August 2015 and 2016. The second most affected Regional Unit was the Western Basin, where 6 beaches (Holiday Beach, Colchester Beach, Cedar Beach, Mettawas, Seacliff Park Beach and North West Beach Point Pelee) were posted for almost half of the 2015 and 2016 swimming season. The most eastern Regional Units, Rock Point to Point Abino and Crystal Beach to Peace Bridge were posted for approximately 30% of the swimming season, and considered to be under high stress. This stretch includes Crystal Beach which is the most used beach on Lake Erie.

The Long Point Bay Regional Unit was the only unit to have no postings in July and August 2015 and 2016. The Port Burwell to Long Point Lighthouse and Grand River Mouth Regional Units were also found to be under low stress with only 4% and 3% of July and August 2015 and 2016 postings, respectively.

Figure 11. There are 50 publically monitored beaches across Lake Erie and Connecting Channels; the number of beaches within each Regional Unit varies, as does the percent of time in July and August 2015 & 2016 that each beach was posted as unsafe for swimming



Fish Consumption

Low Stress	≥8 meals per month
Moderate Stress	1-7 meals per month
High Stress	<1 meal per month

Thresholds developed in consultation with the Ontario Ministry of Environment, Conservation and Parks using consumption advisories from the Guide to Eating Ontario Fish; average meals per month based on consumption advisories for Walleye, Smallmouth Bass and Yellow Perch.

Fish from the Great Lakes provide a diverse and accessible source of food. They can however, be a source of contaminants and a risk to human health if consumption advisories are not considered. The province of Ontario provides consumption guidance based on a combination of fish size, species, location and contaminant (e.g. Mercury and PCBs). In the nearshore waters of Lake Erie and Connecting Channels, fish species most targeted by commercial and recreational fisheries are Walleye, Yellow Perch and Smallmouth Bass. The Guide to Eating Ontario Fish[7] provides consumption advisories for specific class sizes. The size classes most representative of fish caught and kept for consumption have been used to assess the Fish Consumption measure: size classes 35-55 cm for Walleye, 20-30 cm for Yellow Perch and 20-45 cm for Smallmouth Bass.

Across Lake Erie and Connecting Channels, there is a gradient in Fish Consumption advisories with a low average number of meals per month in the west and higher average number of meals

[7] Ontario Ministry of Environment, Conservation and Parks. *Guide to Eating Ontario Fish* https://data.ontario.ca/dataset/guide-to-eating-ontario-fish-advisory-database

per month east of the Western Basin. In the St. Clair River, Lake St. Clair and Detroit River Regional Units, the average number of meals per month is 5 and in the Western Basin it is 7. These averages put them into the Moderate Stress range for Fish Consumption advisories. From the Point Pelee East to the Crystal Beach to the Peace Bridge Regional Units, the average number of meals per month is over 8, putting them into the Low Stress range for Fish Consumption advisories.

The consumption advisories vary between species as do the contaminants of concern (see Table 4). For Yellow Perch, the contaminant of concern is mercury; for Walleye and Smallmouth Bass, the contaminants of concern are mercury and PCBs. Research has shown that following adoption of regulatory measures in the 1970's, there was a gradual reduction in mercury contamination in Lake Erie fish, but that in the 1990's mercury concentrations began increasing again in most species – including in Walleye, Smallmouth Bass and Yellow Perch[8]. The cause of this trend reversal remains unclear, but scientists suggest that increases in mercury may be explained by structural shifts of the Lake Erie food web due to invasive species.

For specific information on the consumption advisories for the species assessed as part of the Fish Consumption measure, and for other fish species within the Great Lakes, please consult the Guide to Eating Ontario Fish (https://data.ontario.ca/dataset/guide-to-eating-ontario-fish-advisory-database).

Table 4. Average fish consumption advisory for species within each Regional Unit and the associated contaminant of concern

	Walleye		Yellow Perch		Smallmouth Bass		Average
Regional Unit	35-55cm	Contaminant of Concern	20-30cm	Contaminant of Concern	20-45cm	Contaminant of Concern	
St. Clair River	6	Mercury	3	Mercury	4	Mercury	4
Lake St Clair	5	Mercury	6	Mercury	6	Mercury	6
Detroit River	4	Mercury & PCBs	5	Mercury	-		5
Western Basin Nearshore	7	Mercury	12	Mercury	2	Mercury	7
Point Pelee East	7	Mercury & PCBs	20	Mercury	-		14
Rondeau West	7	Mercury & PCBs	24	Mercury	-		16
Rondeau East	7	Mercury & PCBs	15	Mercury	10	Mercury & PCBs	11
Port Glasgow to Port Stanley	7	Mercury & PCBs	24	Mercury	3		11
Port Stanley to Port Burwell	7	Mercury & PCBs	24	Mercury	3		11
Port Burwell to Long Point Lighthouse	7	Mercury & PCBs	24	Mercury	-		16
Long Point Bay	9	Mercury	14	Mercury	11	Mercury & PCBs	11

[8] Azim, M.E., A. Kumarappah, S.P. Bhavsar, S.M. Backus, and G. Arhonditsis. 2011. Detection of the spatiotemporal trends of mercury in Lake Erie fish communities: A Bayesian approach, Environ. Scie. Technol. 45(6): 2217-2226.

Port Dover to Port Maitland	9	Mercury & PCBs	20	Mercury	2	PCBs	10
Grand River Mouth	10	Mercury & PCBs	20	Mercury	3	PCBs	11
Rock Point to Point Abino	9	Mercury & PCBs	20	Mercury	2	PCBs	10
Crystal Beach to the Peace Bridge	9	Mercury & PCBs	20	Mercury	2	PCBs	10

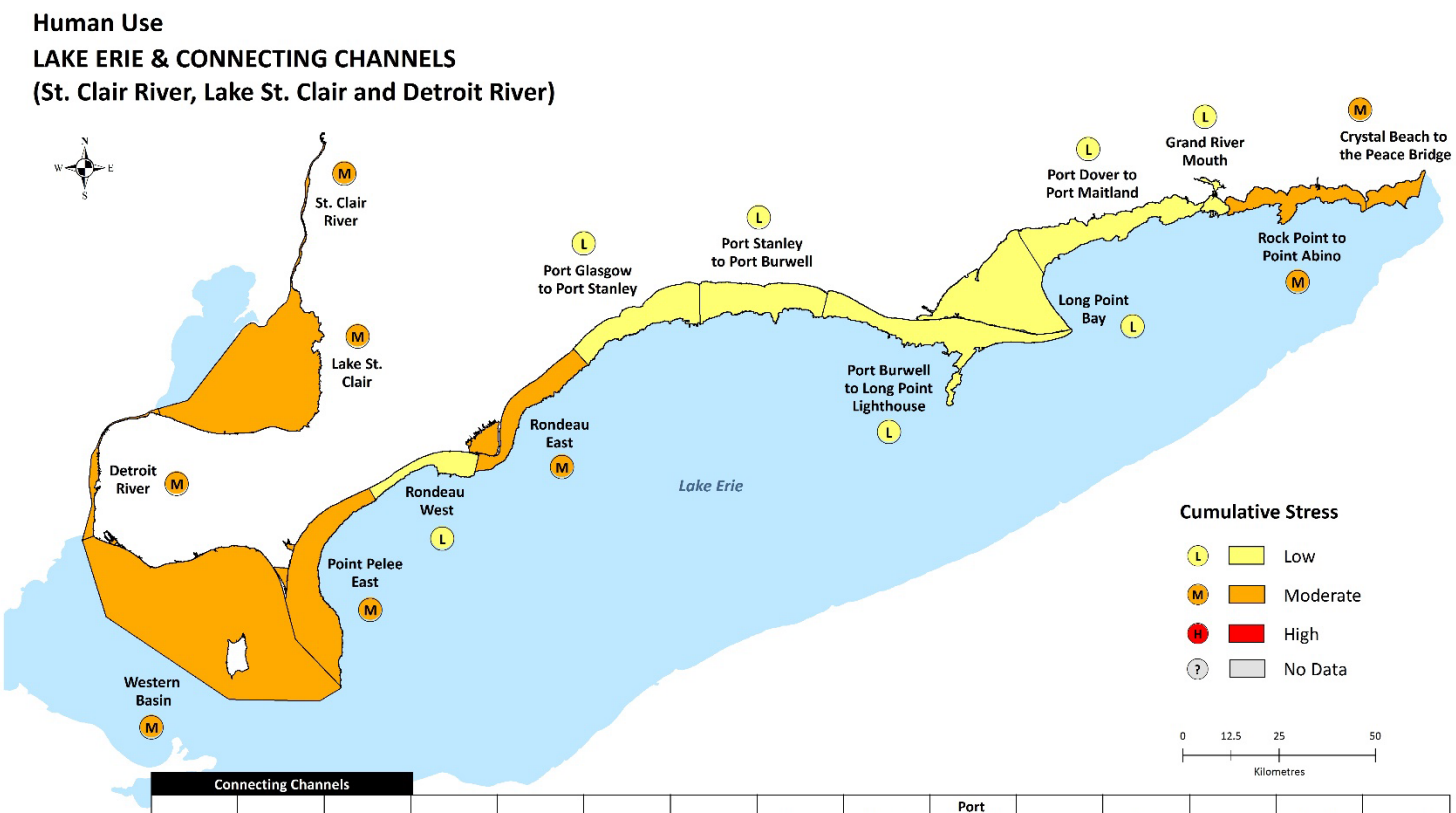
Treated Drinking Water

Low Stress	No adverse water quality incidents
Moderate Stress	Does not apply - any incident is considered a high stress
High Stress	1 or more adverse water quality incidents

Thresholds based on Ontario Drinking Water Quality Standards.

All of the Regional Units in Lake Erie and the Connecting Channels' water treatment plants had no adverse water quality incidents (AWQIs) during 2017 (Rondeau East and Port Burwell to Long Point Lighthouse Regional Units have no treatment plants). Cyanobacteria blooms are a serious water quality, human health and ecological issue affecting the western basin however, and in 2014, Pelee Island residents were warned to only drink bottled water, as private shore water systems may be compromised. Cyanobacteria detections resulted in the closure of a drinking water treatment plant in Toledo, Ohio in August of that year and affected more than 500,000 people who were advised against drinking Lake Erie water or using the lake for recreation.

Figure 12. Results of the Human Use category



	Connecting Channels														
	St. Clair River	Lake St. Clair	Detroit River	Western Basin	Point Pelee East	Rondeau West	Rondeau East	Port Glasgow to Port Stanley	Port Stanley to Port Burwell	Port Burwell to Long Point Lighthouse	Long Point Bay	Port Dover to Port Maitland	Grand River Mouth	Rock Point to Point Abino	Crystal Beach to the Peace Bridge
Beach Postings	No Beaches	66% of July & Aug	No Beaches	47% of July & Aug	27% of July & Aug	19% of July & Aug	6% of July & Aug	18% of July & Aug	10% of July & Aug	4% of July & Aug	0% of July & Aug	10% of July & Aug	3% of July & Aug	30% of July & Aug	33% of July & Aug
Fish Consumption	4 meals per month	6 meals per month	5 meals per month	7 meals per month	14 meals per month	16 meals per month	11 meals per month	11 meals per month	11 meals per month	16 meals per month	11 meals per month	10 meals per month	11 meals per month	10 meals per month	10 meals per month
Treated Drinking Water	0 AWQI	0 AWQI	0 AWQI	0 AWQI	0 AWQI	0 AWQI	No Drinking Water Plant	0 AWQI	0 AWQI	No Drinking Water Plant	0 AWQI	0 AWQI	0 AWQI	0 AWQI	0 AWQI

Data Gaps and Limitations in Nearshore Science

Data used in the assessment has been obtained from existing monitoring programs, from a range of partners, and varies in type, format and resolution. Where available, data from long-term monitoring programs is used. Various monitoring and surveying programs were considered, and key considerations in the selection of data included the spatial and temporal resolution, the amount of processing required (e.g. technical expertise, software requirements) and the availability of the data. Considerable effort was given to identify high-quality data sets. Where possible, data from remote-sensing technologies were used as they provide high spatial and temporal resolution.

The first cumulative assessment of the nearshore waters of Lake Erie and Connecting Channels demonstrated some gaps in scientific data and information on nearshore water quality, physical processes and ecological health. This includes gaps in temporal and spatial coverage of monitoring programs as well as robust information on stressor interactions. Figure 13 shows which Regional Units had data gaps and the associated measure(s) that could not be assessed. Improved understanding of nearshore health may be advanced by:

- Increased spatial and temporal resolution of nearshore monitoring;
- Advancing science on remote sensing for ecosystem health data; and
- Continued commitment to existing long term monitoring programs.

Beyond the limitation of being unable to robustly assess cumulative stress for categories with insufficient data, limitations in nearshore monitoring and data for each Category – based on lessons learned from this assessment – are briefly outlined.

Coastal Processes

The MNRF Ontario Dam Inventory was used to evaluate barrier to tributary connectivity. This database is not regularly updated to reflect new dams or restoration of existing dams. This may affect the ability to assess changes over time to the Tributary Connectivity measure.

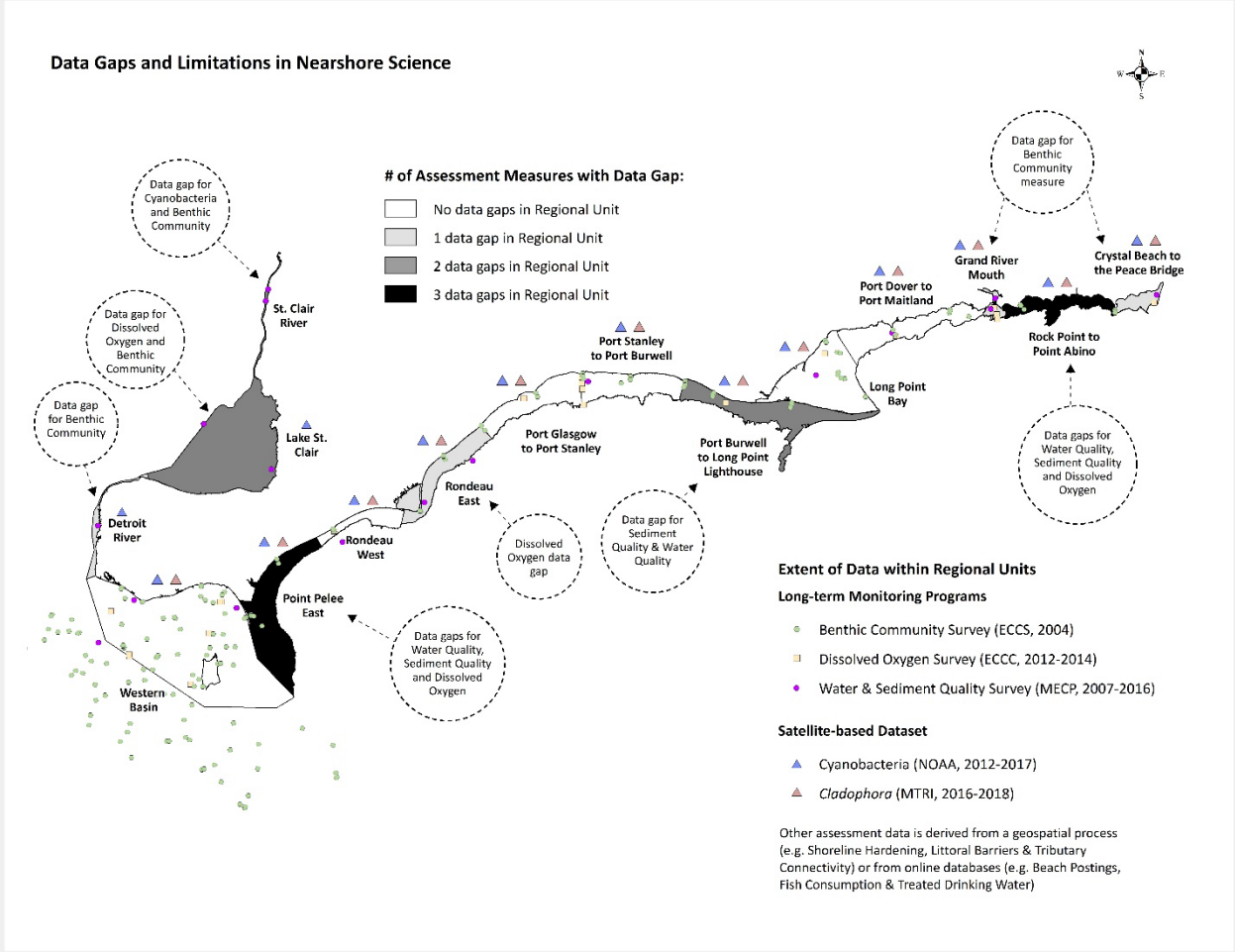
Contaminants in Water & Sediment

The overall assessment of nearshore waters relied on data collected by various ship-based sampling programs. This type of monitoring is typically limited spatially and temporally due to the size of the Great Lakes and weather that restricts sampling effort. Large research vessels typically used for this program cannot always access the nearshore waters due to depth limitations. Increasing monitoring locations would improve understanding of water and sediment quality, as well as benthic communities, at the Regional Unit scale.

Federal and provincial monitoring programs are designed to measure contaminants in all media (air, water, sediment, fish, birds and benthos) but the temporal and spatial coverage as well as the parameters measured and purpose of various monitoring programs is diverse. Despite the diversity of the various monitoring programs, there is limited data available to measure Contaminants in Water & Sediment at a scale that is regionally appropriate and offers coverage at the lake scale. Due to the geographic scale of the Great Lakes, the short weather windows for sampling and the high cost of laboratory analysis especially for organochlorine contaminants (e.g. dioxins and furans), very limited data is available to measure contaminant-related overall nearshore health. Many recent and emerging contaminants, such as Per- and polyfluoralkyl substances [PFAS], of which there are nearly 5,000 types (US FDA, 2020) are not understood

well enough to set thresholds for safety or develop analysis methods. In addition, concentrations may be so low as to avoid detection with existing laboratory equipment.

Figure 13. The number of data gaps within Regional Units varies, as does the extent of data



Increased sampling effort at existing long-term monitoring stations would improve results for both the Sediment Quality and Water Quality measures. Not only would more sites benefit the assessment by adding spatial coverage, but site selection could consider areas where depositional sediment exists thereby improving the reliability of the data to reflect ambient conditions. Further, additional site selection for benthic community sampling as well as increases in temporal and spatial coverage are critically needed to increase confidence in the overall assessment of nearshore waters.

Nuisance & Harmful Algae

The MTRI satellite based product provides an opportunity for regular, extensive mapping of the nearshore for *Cladophora*. It occurs at a temporal and spatial scale not achievable through traditional ship-based monitoring programs. The *Cladophora* product would be enhanced with

high-resolution substrate mapping. It is well documented that *Cladophora* needs to be attached for growth and this typically occurs on cobble, boulders, and bedrock substrate. By overlapping areas mapped as unconsolidated or sandy substrates, with detectable SAV, those areas could be eliminated from the product, further refining potential habitat from the observed *Cladophora* growth areas. Dreissenid mussels and their shells are also known to be suitable substrate for growth. Substrate mapping that includes dreissenid mussel beds would also refine the assessment by mapping suitable *Cladophora* growth habitat. MTRI analyzed SAV for each Great Lake between 2016 and 2018. By expanding the analysis annually, changes in extent of *Cladophora* could be detected, leading to a better understanding of inter-annual variability and growth patterns, a reduction of model uncertainty.

Cladophora is known to impact ecosystem health by growing on and smothering fish spawning reefs, and providing growth opportunities for bacteria such as botulism. While *Cladophora* is a problem to ecosystem health, it is also a nuisance to people who use and/or depend on the social and economic benefits derived from the shoreline and nearshore waters. Moreover, it has been noted by researchers that local patches of Cladophora growth, may not supply the Cladophora that is washing up, it may be transported from other areas. From a human use perspective, sloughed material is having an impact by fouling area beaches, clogging water intakes and reducing property values along the coast. Researching the transport and deposition of sloughed *Cladophora* has been identified as an important gap to be filled to enable targeting nutrient reduction efforts. Citizen scientists along the Niagara portion of Lake Erie's coast are surveying *Cladophora* wash-up throughout the summer months, to help researchers understand where and when *Cladophora* is causing problems locally. There is interest in expanding this community based monitoring to Lake Ontario. Incorporating this data into the *Cladophora* measure, may provide a more robust nearshore assessment in the future.

Supplementation of in-situ *Cladophora* sentinel site data and validation of satellite-based SAV interpretation has the potential to be improved using new remote sensing technology. The United States Geological Survey is currently investigating the utility of underwater, robot-deployed computer vision system capable of automatically classifying habitat types and mapping *Cladophora* biomass. An autonomous underwater vehicle, equipped with stereo cameras, captures images of the lake-bed, including *Cladophora*. Artificial intelligence models will be developed to automate the classification and prediction of *Cladophora* biomass using images of the lake-bed.

Locally, additional sentinel site monitoring could provide more insight, as ECCC & MECP monitoring records go back to the previous decade, and at that time, only moderate quantities of *Cladophora* were detected in the nearshore. In-lake sentinel site monitoring is a gap along the Welland Canal section of the nearshore.

Hypoxia is typically a late spring issue along the Leamington stretch of coast, and then becomes an offshore, lake bed water quality issue later in the summer. Traditional ship based sampling programs, are limited in the spatial and temporal coverage of the data collected, they do not typically align with the regional units of the overall assessment of nearshore waters, nor are they in the right location (or sample the right depth) of the lake, to capture hypoxic waters. As a lake turnover can happen with little warning, it would be a rare occasion to have the water quality-monitoring program on the lake, in the right location at the right time. The Overall Assessment of Nearshore Waters should investigate the use of NOAA's hypoxia monitoring data and determine if it may be suitable to fill data gaps.

Human Use

Not all areas accessible for swimming are regularly monitored for recreational water quality. There are some locations where people swim but at which Health Units do not monitor due to limited capacity. Health Units weigh multiple factors to decide where to best allot their resources to maximize the benefit to beach goers. Increasing the number of locations that are monitored would allow for a more thorough understanding of beach water quality at a Regional Unit scale. The number of sampling days per season varies between health units with some units sampling daily and others bi-weekly. In some cases the beaches will remain posted unsafe until the next sampling event even though the poor conditions may not have persisted for the whole time between sampling. More frequent sampling would allow for a more accurate count of the days that the water was unsafe for swimming since the duration of postings would be more reflective of actual conditions. There is potential to use modelling tools to predict beach water quality at a higher spatial and temporal scale to better understand where and when the nearshore is safe for swimming.

Next Steps

The Overall Assessment of Lake Erie and Connecting Channels Nearshore Waters will be repeated to monitor change over time. Areas of high ecological value and other habitat factors will be integrated to complete the comprehensive assessment. Results are included in the 2019-2023 Lakewide Action and Management Plan (LAMP) and provided to communities and stakeholders for collaboration on identification of management priorities and to take action by protecting areas of high ecological value that are or may become subject to stress. The Lake Erie Lakewide Partnership and the Canada-Ontario Agreement partners may support collaboration opportunities under the Nearshore Framework.

Identified data gaps, such as the need to increase spatial and temporal resolution of nearshore monitoring and the need to support advancements in remote sensing will be considered in the Cooperative Science and Monitoring priority setting exercise for each lake (a component of the Lakewide Management process). Progress continues on the Nearshore Framework to complete a cumulative assessment for each of the Canadian Great Lakes nearshore as respective LAMPs are developed.

In 2022, the Overall Assessment of the State of Canadian Nearshore Waters – including results from Superior, Huron, Erie and Ontario – will be the first cumulative assessment of the Canadian Great Lakes nearshore waters.

Appendix A

Benthic Community

Provided by Lee Grapentine (2018)
Environment and Climate Change Canada

In Lake Erie there are few locations that are not potentially disturbed due to exposure to moderate or high levels of human stressors. In addition, habitat conditions, including those used to define Regional Units, strongly affect benthic communities. Therefore, identifying appropriate reference conditions for Lake Erie benthos and characterizing their range of variability is a challenge.

The most extensive survey of benthic invertebrates in Lake Erie suitable for the Nearshore Framework assessment was conducted for the Erie Comprehensive Collaborative Study (ECCS) in 2004. Data from the survey were obtained from Jan Ciborowski (University of Windsor at the time, now University of Calgary) on February 19th, 2018. In this survey, 280 sites were sampled by Ponar grab (soft bottom) or airlift (hard bottom) during late summer for a benthic community assessment. Data from the survey include densities (number per m^2) of 53 benthic taxa identified to lowest taxonomic level possible. There is also some habitat and general water quality data for most locations, but these were not used in the classification analysis.

As an alternative to using reference sites for the assessments of sites and Regional Units, benthic communities were characterized in terms of total benthos (density of all macroinvertebrates per unit area), taxon richness (number of benthic taxa in the area) and average tolerance to disturbance of the individuals present at a site. Sites with higher tolerance scores have, on the balance, a more tolerant benthic community compared to sites with lower tolerance scores. These values were calculated from taxon tolerance values obtained from the literature and the densities of the various taxa at a site.

Using the ECCS 2004 survey data on densities of 53 taxa, benthic community quality was assessed by:

- Conducting a Principal Components Analysis (PCA) on the 3 benthos descriptors -- total benthos, lowest level taxon richness and site sensitivity score (= -1 × site tolerance score) (Figure A-1);
- Based on the first 2 axes from the PCA, calculating a gradient (multiplying PC1 x PC2 after first ranging the axes from 0 to 1) aligned with increasing total benthos, increasing taxon richness and increasing sensitivity of site individuals (= decreasing tolerance) (Figure A-2);
- Calculating 33rd and 67th percentiles of the gradient values to divide the range of values into thirds, which defined low, moderate and high quality of the benthic communities (Figure A-3); and
- Counting the numbers of sites in each quality category each Regional Unit (Table A-1).

The category that divided the sites in half was identified to characterize the “median” quality of the Regional Unit. This procedure produces a relative measure of quality for the lake sites, and doesn’t account for any effects of habitat conditions.

Figure A-1. Results of Principal Components Analysis on the 3 benthos descriptors – total benthos, lowest level taxon richness and site sensitivity score

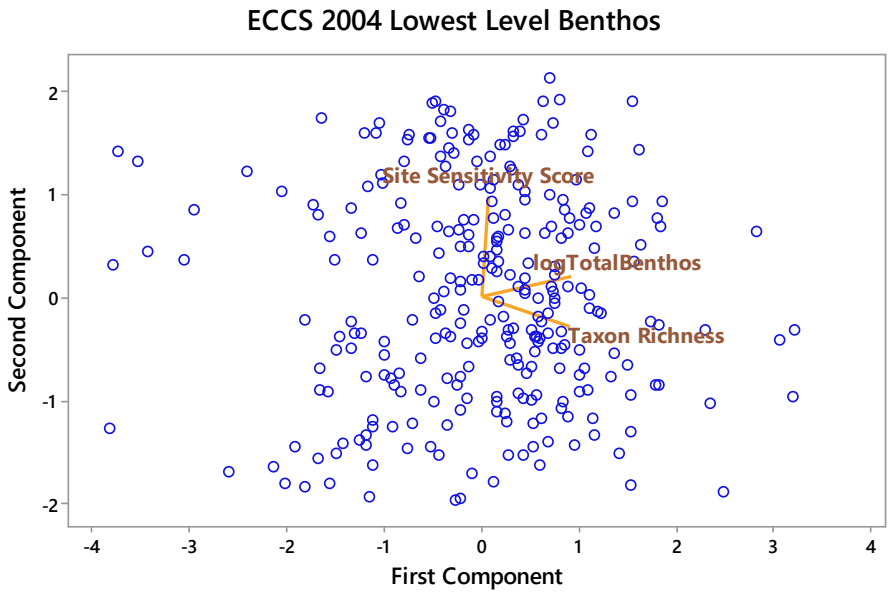


Figure A-2. A gradient was calculated aligned with increasing total benthos, increasing taxon richness and increasing sensitivity of site individuals

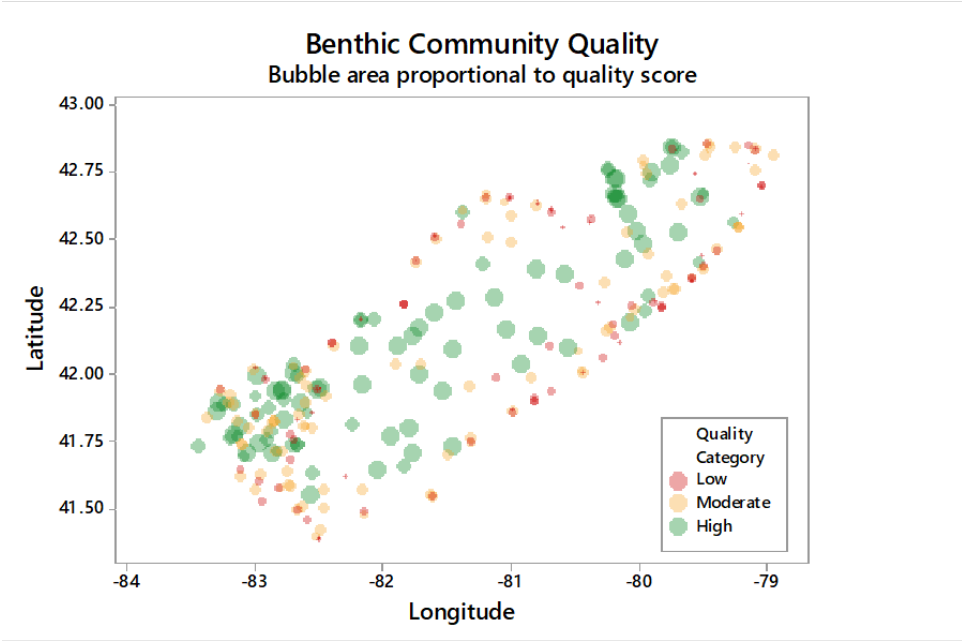


Figure A-3. The range of quality scores were divided into thirds, and used to define low, moderate and high quality of benthic communities

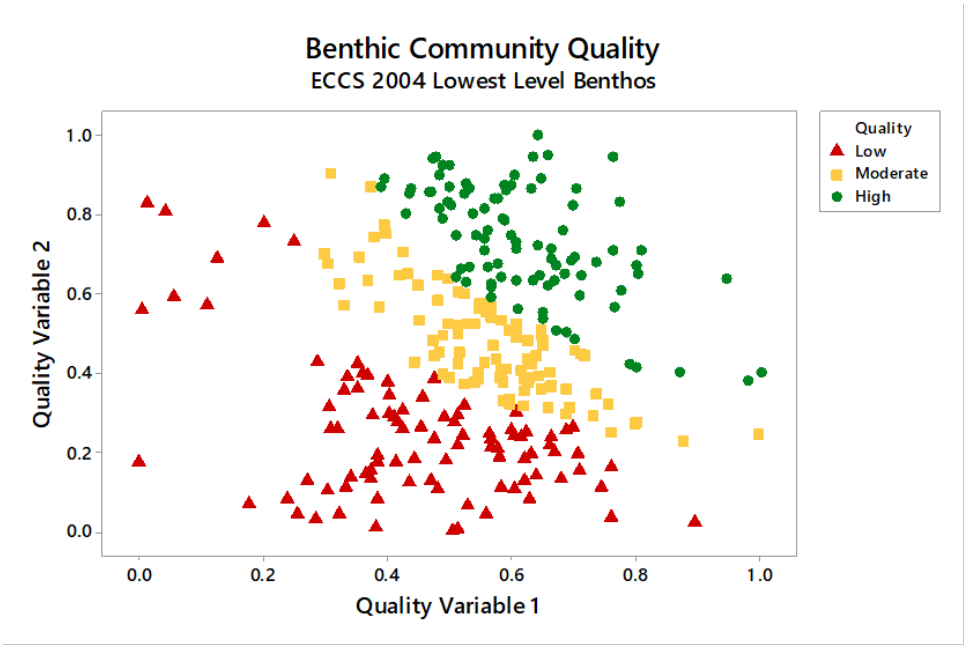


Table A-1. Results of the Benthic Community Quality assessment; low quality sites are those in the bottom 33rd percentile of the range of quality scores across all sites and high quality sites are those in the top 67th percentile

Regional Unit	Number of Sites	Number of Low Quality Sites	Number of Moderate Quality Sites	Number of High Quality Sites	Score
St. Clair River	No Data				
Lake St. Clair	No Data				
Detroit River	No Data				
Western Basin	102	24	42	36	Moderate Stress
Point Pelee East	7	4	2	1	High Stress
Rondeau West	3	1	0	2	Low Stress
Rondeau East	6	5	1	0	High Stress
Port Glasgow to Port Stanley	5	2	2	1	Moderate Stress
Port Stanley to Port Burwell	7	4	3	0	High Stress
Port Burwell to Long Point Lighthouse	9	8	1	0	High Stress
Long Point Bay	9	0	0	9	Low Stress
Port Dover to Port Maitland	6	1	2	3	Low Stress
Grand River Mouth	No Data				
Rock Point to Point Abino	6	3	3	0	Moderate Stress

Crystal Beach to the Peace Bridge	No Data