Quality of Ontario Lakes

How has the water quality of Ontario's inland lakes changed from 2015 to 2022, as measured by total phosphorus and water clarity? What does this suggest about the productivity of Ontario's inland lakes?

2024-03-30

Introduction

Sources to add while citing: https://data.ontario.ca/dataset/ontario-lake-partner & https://files.ontario.ca/moe_mapping/downloads/metadata/opendata/Lake_Partner_Program_metadata_EN2.pdf

This report is based on two datasets sourced from the Ontario Lake Partner Program (LPP) via the Ontario Data Catalog. The LPP conducts annual assessments of water quality in inland lakes throughout Ontario, with data collected by volunteers following standardized provincial protocols. The datasets cover total phosphorus (ug / L) and water clarity measured by seechi depth (m) for numerous inland lakes in the Precambrian Shield region. Each dataset includes geospatial information, site descriptions, collection dates, and metrics pertaining to the water quality. The data was last validated on January 17, 2024 and is updated yearly. Both datasets were last updated on December 31, 2022.

Dataset Description

Variable	Types	Description
Site.ID	integer	The latitude of the lake in DMS
Township	character	The longitude of the lake in DMS
Lake.Name	character	The site ID of the sampling point
Site.Description	character	The township the lake
avg_phos_ug_l	numeric	The name of the lake
phos_is_outlier	character	The description of the sampling point
phos_date	Date	The average total phosphorus (ug / L)
secchi_depth_m	numeric	Whether total phosphorus
trans_date	Date	The date that the phosphorus sample was collected
Latitude	numeric	The depth at which the seechi disk can no longer be distinguished
Longitude	numeric	The date that the seechi disk was inserted into the lake

```r
library(ggpubr)
library(jpeg)
img=readJPEG("ontario.jpg")


ggplot(data, aes(y=Latitude, x=Longitude, col=Site.ID)) + background_image(img) +
  geom_point()
```

```
## Warning: Removed 208 rows containing missing values or values outside the scale range
## (`geom_point()`).
```
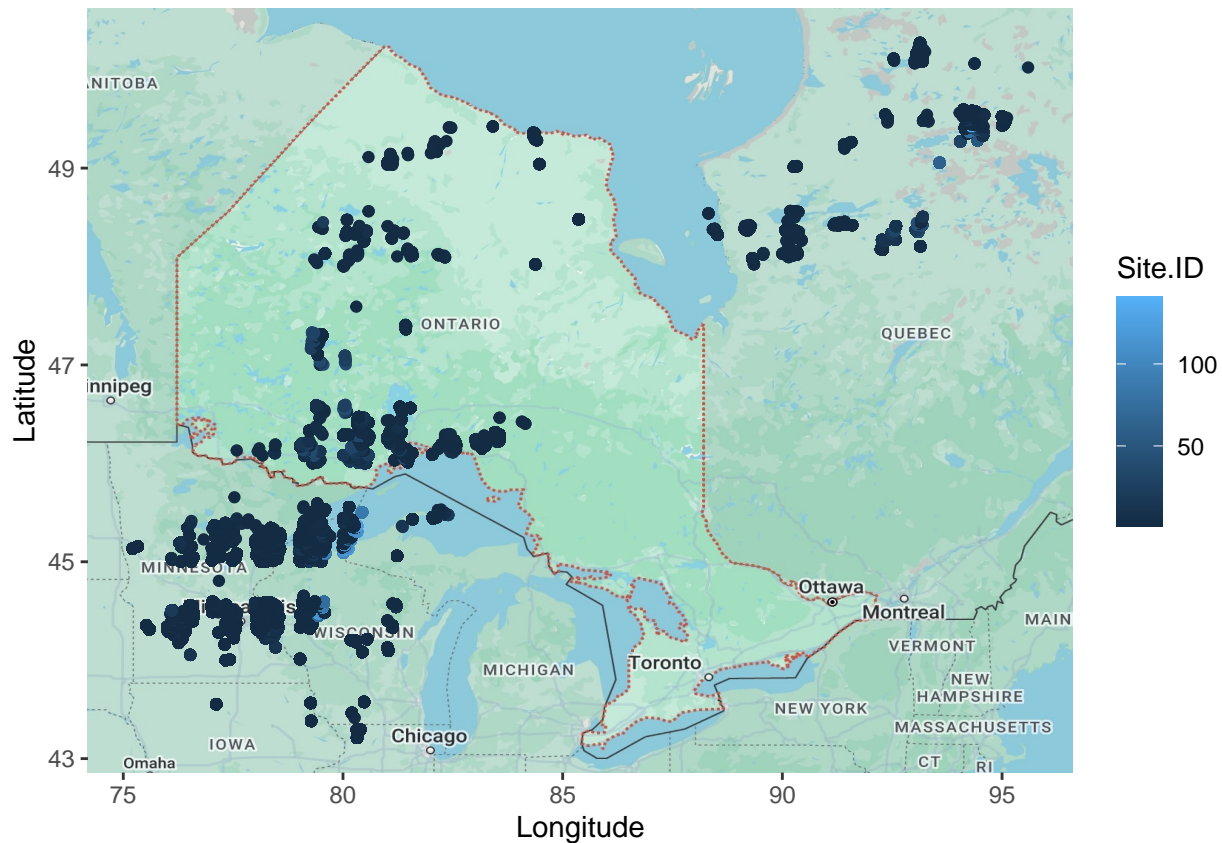
Purpose

This report aims to address the research question:

How has the water quality of Ontario's inland lakes changed from 2015 to 2022, as measured by total phosphorus and water clarity? What does this suggest about the productivity of Ontario's inland lakes?

By answering this question, this report ultimately aims to provide insight on where the government of Ontario can best address its conservation efforts and understand the trend of productivity of Ontario's inland lakes.

Background

Source (https://foca.on.ca/wp-content/uploads/2012/05/Guide-to-Interpreting-TP-and-Secchi-Data-Complete.pdf)
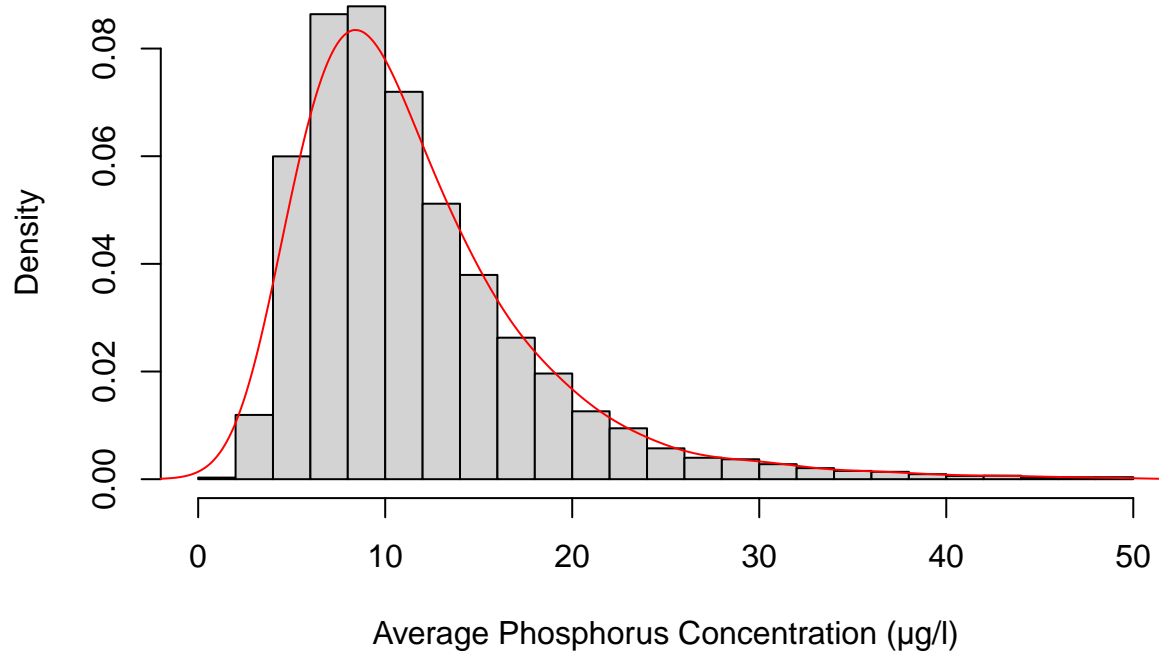
Water quality, as measured by phosphorus levels and secchi depth, has a major influence on the biodiversity of inland lakes and freshwater streams.

In the vast majority of Ontario's inland lakes, phosphorus is the element that controls the growth of algae. As such total phosphorus concentrations (µg/L) are most aptly used to assess lake nutrient status. Limnologists place lakes into three categories based on their total phosphorus concentrations: oligotrophic (less than 10 µg/L), mesotrophic (10-20 µg/L TP), and eutrophic (over 20 µg/L). Oligotrophic lakes are low in nutrients and rarely have algal blooms. Mesotrophic lakes vary in characteristics and may experience moderate blooms. Eutrophic lakes have high nutrient levels and often suffer from persistent algal blooms.

A basic graph to give the reader some sense into how our data is structured

Option 1A

Distribution of Average Phosphorus Concentration

Source: https://hallshawklakes.ca/featured/secchi-readings/#:~:text=Secchi%20Reading%20and%20Lake%20Nutrient,enrich

Secchi disks are black and white disks used to ascertain water clarity by lowering it into the water and measuring the point at which black and white can no longer be distinguished. Readings of over 5 meters indicate oligotrophic conditions, depths of 3.0 to 4.9 meters suggest mesotrophic conditions and readings less than 2.9 meters signify eutrophic lakes, with higher nutrient levels.

Table 2

```
## `summarise()` has grouped output by 'Year'. You can override using the
## `.groups` argument.
```

Year	Eutrophic	Mesotrophic	Oligotrophic
2015	2.027140	3.803148	6.072994
2016	2.118546	3.833635	6.171241
2017	2.070776	3.813988	6.168022
2018	2.070520	3.817491	6.039375
2019	2.069596	3.815862	6.142789
2020	2.007616	3.917175	6.007801
2021	2.084981	3.865085	6.187396
2022	2.079520	3.848938	6.488841

In an effort to ascertain the proportion of inland lakes whose secchi depth readings indicate eutrophic conditions (less than or equal to 2.9 metres), a one-sample proportion test will be conducted with a confidence

interval of 95% and a sample size of 1000. The 25th and 75th percentiles of these proportions will be calculated using bootstrapping to gain a more holistic view of the proportion's variability.

```
##
##  1-sample proportions test with continuity correction
##
## data:  sum(sample$secchi_depth_m <= 2.9) out of 1000, null probability 0.5
## X-squared = 247.01, df = 1, p-value < 2.2e-16
## alternative hypothesis: true p is not equal to 0.5
## 95 percent confidence interval:
##  0.2246334 0.2793077
## sample estimates:
##     p
## 0.251
```

From this, it can be determined that the proportion of inland lakes that exhibit eutrophic conditions is estimated to be 0.254, with a 95% confidence interval ranging from 0.225164 and 0.2824012. Since the p-value < 2.2e-16, there is strong evidence against the null hypothesis. This suggests that the proportion of lakes that exhibit eutrophic conditions is significantly different than the null proportion of 0.5.

```
##   Quantile   Value
## 1      25% 0.24275
## 2      75% 0.25900
```

The 25th percentile and 75th percentile of the bootstrapped proportions of eutrophic inland lakes are estimated to be 0.245 and 0.264, respectively. This suggests **HELP**, so it can be concluded that roughly a quarter of Ontario's inland lakes have high nutrient levels and often suffer from persistent algal blooms.