R-WD-20-08

New Hampshire Lake Trend Report: Status and trends of water quality indicators

Moores Pond, Tamworth, NH

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

June 2020

R-WD-20-08

New Hampshire Lake Trend Report: Status and trends of water quality indicators

New Hampshire Department of Environmental Services
PO Box 95
Concord, NH 03302-3509
(603) 271-8865

Robert R. Scott
Commissioner

Clarke Freise
Assistant Commissioner

Thomas O'Donovan
Water Division Director

Ted Diers
Watershed Bureau Administrator

Prepared by
Kirsten Nelson, Aquatic Ecologist
and
David Neils, Chief Water Pollution Biologist

June 2020

Table of Contents

Maps, Tables, Figures, Appendices

MAPS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

New Hampshire's surface waters are vital natural resources that provide habitat for aquatic life, recreational opportunities, tourism, and economic benefits. The New Hampshire Department of Environmental Services (NHDES) is responsible for monitoring and reporting on the condition of the state's surface waters. The Water Monitoring Strategy, published by NHDES in 2016, details the agency's approach for monitoring the condition of the state's inland surface waters. One component of this strategy is to provide regular reports on the status and trends of water quality conditions.

In this report, 150 lakes and ponds contributed ≥ 10 years of data from 1991 to 2018 (Appendices A and B). A majority of the data were contributed by the Volunteer Lake Assessment Program (VLAP), but in some cases data from additional programs were utilized to evaluate waterbody condition. Data were analyzed to examine current conditions, long-term trends and short-term changes for individual waterbodies. Trophic class and regional trends were also examined.

The findings of the analyses were as follows:

- The percentage of monitored beaches issued a fecal bacteria advisory and the number of days an advisory was in place significantly increased from 2003 to 2018.

- Chlorophyll-a concentration had no trends by trophic class; however, approximately 10% of individual waterbodies had significant decreases in both long-term and short-term analyses. Significant increases in both the short-term and long-term analyses were rare, occurring in approximately 3% of waterbodies.

- The number of cyanobacteria advisories issued increased from 2003 to 2018; however, the number of days' advisories were in place each year was highly variable with no overall trend.

- Aquatic invasive species infestations have increased from 2000 to 2018. The overall acreage of invasive infestations and herbicide use has remained constant; however, the number of times alternative controls are used, such as hand pulling, has increased.

- Long-term analyses found water clarity significantly decreased (worsened) in mesotrophic and oligotrophic waterbodies.

- Specific conductance and alkalinity significantly increased over the long-term in mesotrophic and eutrophic waterbodies. Analyses of short-term changes indicate that both parameters are rapidly shifting, as nearly 80% of investigated waterbodies had increasing specific conductance and 75% had increasing alkalinity over the past ten years. Of the waterbodies that had significant short-term increases in alkalinity, 85.5% also had significantly increasing specific conductance in the same time frame.

- Total phosphorus significantly increased over the long-term in eutrophic waterbodies, but was unchanged in mesotrophic and oligotrophic waterbodies. Individual waterbody analyses for both the long and short-term analyses indicated approximately 4% of waterbodies experienced an increase and approximately 6-7% experienced a decrease in total phosphorus.

- Long-term pH analyses did not find any significant changes by trophic class. For individual waterbodies, long-term and short-term analyses indicated pH levels have significantly increased (improved) in more than 10% and 20% of waterbodies, respectively.

- Dissolved oxygen (at one meter below the surface) decreased in approximately 15% of waterbodies over the long-term, with a significant overall decrease for mesotrophic waterbodies.

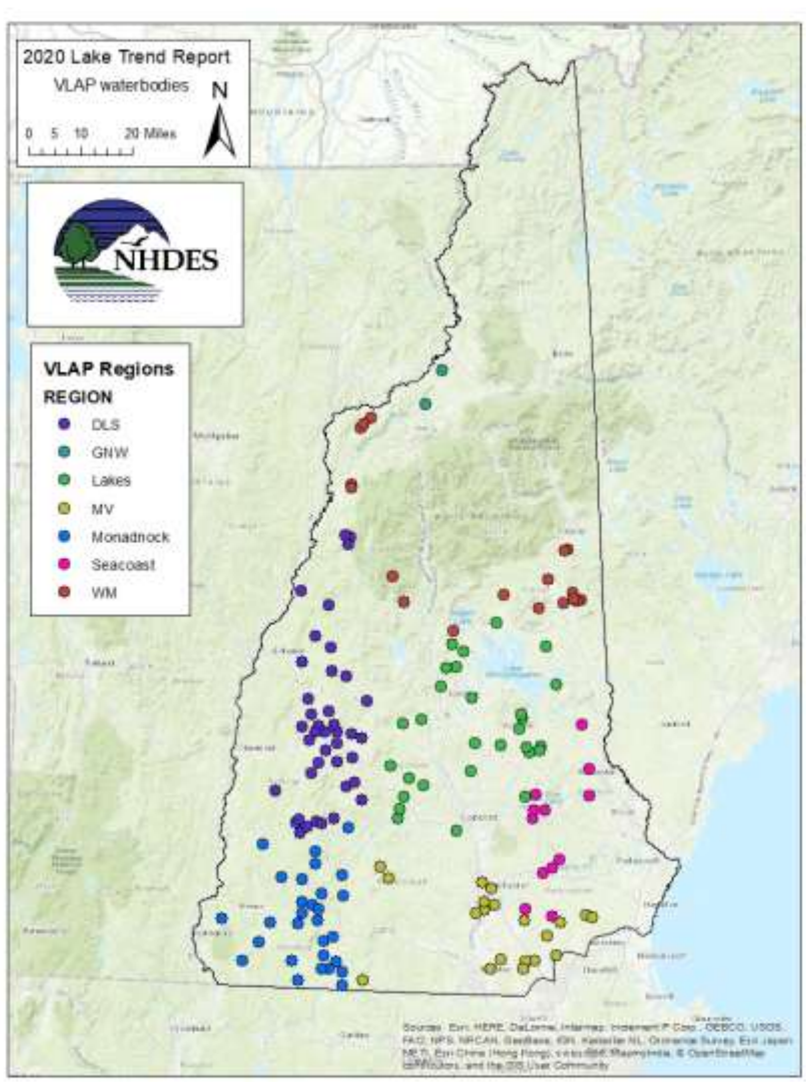
- Ice-out on lakes is occurring significantly earlier in the year.

- Water temperature (at one meter below the surface) significantly increased in mesotrophic and oligotrophic waterbodies over the long-term.

1. INTRODUCTION

There are just over 800 lakes and ponds greater than or equal to ten acres in New Hampshire. They serve as vital ecological resources providing habitat to aquatic organisms and wildlife. They also provide water for drinking, attract tourism, support economic uses, and offer recreational opportunities such as swimming, boating, and fishing. In 2016, the New Hampshire Department of Environmental Services (NHDES) published its Water Monitoring Strategy (2016 NHDES Water Monitoring Strategy) outlining the agency's approach for monitoring New Hampshire's inland surface waters through 2026. One of the primary components of the strategy is to report on the status and trends of the state's waterbodies using indicators of water quality conditions.

Map 1. VLAP waterbodies included in the 2020 lake trend report by region.



The purpose of this report is to evaluate the current status and long-term trends of conditions of lakes and ponds that have been repetitively sampled on a yearly basis. A majority of the water quality data comes directly from the Volunteer Lake Assessment Program (VLAP). Data for invasive aquatic plants, beaches, and cyanobacteria blooms originates from other NHDES monitoring programs. This is a first-of-its-kind report and is scheduled to be produced in five-year increments in order to provide regular updates on water quality conditions. The current reporting period targeted data from 1991 to 2018 where data were available.

1.1 The Volunteer Lake Assessment Program (VLAP)

VLAP is a cooperative program between NHDES, lake residents, and lake associations. Approximately 500 volunteers monitor water quality at 170 lakes throughout New Hampshire through VLAP. Volunteers collect high-quality data on their local waterbodies and educate watershed residents. Volunteers are trained by NHDES to collect lake water quality data, survey the surrounding watershed, and sample the streams and rivers that are tributaries to the lake. Each of the participating lakes must be visited by a NHDES biologist on a biennial basis. This visit provides an opportunity to discuss water quality concerns and receive recommendations on potential remediation activities. Also, the event allows NHDES biologists to perform audit of field sampling techniques to evaluate the volunteers' ability to collect quality data, as well as collect information on additional water quality parameters as necessary. Volunteers then sample on their own for the remaining summer months. Depending on capacity, volunteer groups sample one to three times per summer.

To further encourage volunteer monitoring, NHDES maintains partnerships with the Lake Sunapee Protective Association (LSPA) and Colby Sawyer College (CSC) in New London, NH, to operate a VLAP satellite laboratory. The satellite laboratory serves as a convenient location for volunteers to borrow sampling equipment and deliver water samples for analysis especially for volunteers in the Dartmouth Lake Sunapee (DLS) region. Plymouth State University (PSU) in Plymouth, NH, also serves as a sample and equipment exchange location.

VLAP operates under an Environmental Protection Agency (EPA)-approved Quality Assurance Project Plan (QAPP) that ensures the data collected by volunteers are of high quality and meet state and federal quality assurance goals. The data gathered by the volunteers are analyzed by a NHDES biologists and compiled into annual reports for individual waterbodies. The high quality data gathered through VLAP also helps NHDES to conduct statewide surface water quality assessments that are submitted to the EPA as a requirement of the Clean Water Act. The most recently available VLAP reports, as well as other lake reports, are available online at NHDES's New Hampshire Lake Information Mapper.

VLAP also classifies waterbodies by region. There are seven regions in New Hampshire: Dartmouth Lake Sunapee (DLS), Great North Woods (GNW), Lakes, Merrimack Valley (MV), Monadnock, Seacoast and White Mountain (WM; Map 1).

1.2 Indicators of Condition

Trend monitoring for lakes and ponds focused on data records of select water quality parameters, or indicators, in order to track changes in water quality condition over time. The indicators chosen for inclusion help measure the condition of the aquatic community as well as common water quality stressors (Table 1).

Table 1. Water quality indicators for the NHDES 2020 lake trend report.

Indicator Parameter	Primary or Accessory Indicator	Parameter Description
Bacteria	Primary	A measure of the concentration of *E. coli*, a common bacterium that is present in the fecal material of warm-blooded animals.
Chlorophyll-a	Primary	A photosynthetic pigment found in plants that serves as a measure of the abundance of suspended algae.
Cyanobacteria	Primary	Photosynthetic bacteria that are capable of producing toxic blooms. Occurs naturally in waterbodies, but can increase in abundance with excessive nutrients.
Invasive Aquatic Plants	Primary	Non-native species that are a threat to ecological, aesthetic, recreational and economic values of freshwater resources.
pH	Primary	A measure of the water's acidity. In addition to natural processes, the pH of surface water is affected by the precipitation of acidic compounds, such as sulfuric or nitric acid, released into the atmosphere as a result of industrial processes.
Secchi Disk Transparency	Primary	A measure of the clarity of the water.
Specific Conductance	Primary	A measurement of the water's ability to conduct electricity. Compounds such as road salts, fertilizers and other chemical compounds increase the specific conductance of water.
Total Phosphorus	Primary	Typically, the limiting nutrient for aquatic plants and algae in NH lakes. Total phosphorus concentration controls, in part, the amount of plant and algae growth, which relates to trophic status. Sources of total phosphorus are natural, such as background weathering and leaf litter, or anthropogenic, such as stormwater run-off, septic system inputs, or lawn fertilizers.
Alkalinity	Accessory	A measure of a waterbody's ability to resist acidic inputs, a.k.a. buffering capacity.
Dissolved Oxygen (1-meter below surface)	Accessory	The concentration of oxygen in water used by plants and animals. Low or highly variable dissolved oxygen concentrations can result from excessive biological activity such as decomposition of organic material.
Ice in/out records	Accessory	Period of time a waterbody is covered in ice.

Water Temperature (1-meter below surface)	Accessory	Aquatic communities are adapted to specific water temperature conditions. Water temperatures can be affected by air temperature, water clarity and global climate patterns.

Anthropogenic activity within a watershed is known to influence water quality. Road salting, stormwater run-off, fertilizer use, impervious surfaces, septic systems and landscape modification can influence indicators of waterbody condition. To better understand how indicators differ, waterbodies were examined individually as well as grouped by trophic status and region.

For each primary indicator, a specific set of questions and measures were included in the 2016 Water Monitoring Strategy to guide data analysis. For most indicators, the questions were designed around three major points of emphasis, and a fourth was added for this report to address regional trends:

1) **What are current conditions with respect to statewide data?**
2) **Are trends stable, improving, or worsening over the long term?**
3) **How do current conditions compare with data from the recent past?**
4) **Do waterbody trends differ by region?**

The current reporting period targeted data from 1991 to 2018 where data were available. To address question 3, comparing current data to data from the recent past, the data were further truncated. Current data were defined as data collected from 2014 – 2018. Data from the recent past were defined as data collected from 2009 – 2013. See Section 2.2 for more details.

1.3 Lake Productivity

Trophic status is a measurement of a waterbody's overall productivity. Oligotrophic, mesotrophic and eutrophic are the most common trophic classifications. Oligotrophic lakes are nutrient-poor, with few plants and very clear water. Eutrophic lakes are highly productive, with lots of plants and/or algae and less clear water. Mesotrophic lakes are in-between. Under typical conditions, a waterbody slowly becomes more productive over long periods of time. However, in a process called cultural eutrophication, human activities can lead to the premature aging (i.e. increased productivity) of a lake or pond through elevated nutrient inputs.

NHDES has been surveying the trophic status of New Hampshire's waterbodies under the Lake Trophic Survey Program since 1975. Trophic status is determined using a ranking system of chlorophyll-a concentration, aquatic vegetation density, Secchi depth and dissolved oxygen levels. In many cases, waterbodies have been evaluated more than once over the duration of the program. A shifting of trophic status in the time frame of the Lake Trophic Survey Program's inception is indicative of cultural eutrophication. For that reason, waterbodies were grouped based on their best available trophic classification for this report.

1.4 Changing Landscapes

In 2016, the New Hampshire Office of Energy and Planning projected that New Hampshire's total population is projected to increase by approximately 83,000 people from 2020 to 2040 (State and County Population Projections 2016). Population growth is expected to be highest across southern New Hampshire, with the landscape changing primarily due to residential development (NH EPSCoR Fact Sheet 4). With increasing population comes increasing demands and stressors on our waterbodies. Impervious surfaces (e.g. roadways or rooftops) and habitat loss increase with more development, as do road salting, stormwater run-off, nutrient loads and erosion. Development impacts can be mitigated, however, by protecting vegetative buffers and corridors, managing stormwater and using best management practices.

Overarching these projections are long-term influences. Between 1895 and 2011, air temperature in the Northeast increased by almost 2° F and annual precipitation increased by approximately five inches (Kunkel et al. 2013). The Northeast has experienced a greater increase in extreme precipitation than any other region in the United States; between 1958 and 2010, the Northeast experienced > 70% increase in the amount of precipitation that falls during very heavy events (Groisman et al. 2013). The Northeast is also undergoing a recovery from acid rain, as limitations on sulfur dioxide emissions, implemented with the 1970 and 1990 federal Clean Air Act, have sparked a partial and ongoing recovery from acidic inputs (Driscoll et al. 2001; Strock et al. 2014).

Multiple anthropogenic influences occurring simultaneously on our land and waterscapes can make determining the causes of changing water quality indicators difficult. For instance, both the recovery from acid rain and the increased application of road salt have been linked to increases in pH and alkalinity (Kaushal et al. 2018). In another example, both climate change and acid rain recovery have been linked to a darkening of surface waters in the Northeast, in a phenomenon called "lake browning" (Meyer-Jacob et al. 2019). For many water quality parameters, it is likely that water quality indicators are influenced by multiple factors.

2.0 STUDY DETAILS AND ANALYSIS

2.1 Data collection

This report focused on waterbodies with long-term datasets to analyze trends over time. In general, waterbodies were required to have a minimum of 10 years of data from 1991 – 2018 to be included in the analyses. Water quality parameters included in analyses were collected between June 1 and September 15. The majority of waterbody data was provided by VLAP, with additional inputs from the Exotic Species and Beach Programs. All data, with the exception of ice in/out data, were collected following an EPA-approved QAPP and reviewed by NHDES staff for quality and accuracy. Only data meeting quality assurance measures were used in the analysis.

2.2 Data analysis

In order to address an indicator's current condition for each waterbody with respect to statewide data, a statewide frequency distribution was created for each trophic class, and a waterbody's "proximity" – or position on the distribution – known as the percentile, was determined on the respective statewide distribution. The statewide frequency distributions were not restricted to VLAP waterbodies; rather, they included all available data from lakes and ponds by trophic class from 1991 through 2018 regardless of whether they were sampled as part of the VLAP program. In addition, a median of the statewide frequency distributions by trophic class was calculated. A tally was kept of the VLAP lakes that had a percentile greater than the 75^{th} or less than the 25^{th} of their respective statewide frequency distributions, as those ranges indicated a waterbody had notably high or low values. A concentration or lack of waterbodies in either range also helped indicate whether the VLAP lakes were over or under represented in the high or low ranges of each parameter.

For long-term trends, data were analyzed by calculating annual medians for individual waterbodies as well as by assigned trophic class and testing for a trend using a Mann Kendall trend test and corresponding Sen slope. The majority of parameters were analyzed using the trend package in R; however, for total phosphorus, which had waterbodies with records below a detection limit, analysis was conducted using the NADA package in R, which accounts for non-detects. Results from individual waterbodies were also grouped by VLAP region. The dataset used for examining trends by trophic class was smaller than the dataset used to examine trends by individual waterbody because each trophic class needed data from at least five unique waterbodies in any given year to be included in the analysis. Data from a minimum of five unique waterbodies was stipulated to prevent a single waterbody from having too strong of an influence on the trend line. The Mann Kendall trend test indicates whether a trend exists and if that trend is positive or negative. When the Mann Kendall test detects a trend, the magnitude of that trend can be estimated by calculating a Sen slope (a.k.a. Theil or Theil-Sen slope). The Sen slope is the median slope joining all pairs of observations, or the best fit of a line to sample points on a plane. A confidence interval for the Sen slope may be determined as the interval containing 95% of the estimated slopes. Significance was declared at $p < 0.05$, or in other words, when there was a less than a 5% chance that an observed trend was occurring randomly.

Short-term changes in conditions focused on data from 2009-2018. The analysis of changes in conditions over a period of approximately ten years (two distinct 5-year blocks of time) documents abrupt shifts in water quality conditions which may be tied to dramatic changes in environmental conditions or human stressors. For each individual waterbody, the “previous” (2009-2013) and “current” (2014-2018) groups of data, designated Group 1 and Group 2 respectively, were compared. To be included in the analysis, a waterbody needed to have at least one data point for each year of each group. Comparisons between time periods were performed for each waterbody using a non-parametric Wilcoxon Rank Sum Test, a.k.a. Mann-Whitney U Test, which tests if a significant difference ($p < 0.05$) between Group 1 and Group 2 occurred. The majority of parameters were analyzed using base R programming; however, for total phosphorus, which had waterbodies with records below a detection limit, analysis was conducted using the NADA package in R, which accounts for non-detects.

Long-term trend results for individual VLAP waterbodies were examined by their corresponding VLAP region. This investigation was conducted to identify notable differences among regions in parameter trends. Different regions may face different anthropogenic stressors (e.g. stresses of population growth versus agriculture) as well as have different geology, temperature, slopes, or vegetation community.

A table of VLAP waterbodies and their assigned region is included in this report in Appendix A. All percentile, long-term trend, and short-term change results for each waterbody is located in Appendix B.

3.0 RESULTS FOR PRIMARY INDICATORS

3.1 Bacteria

Primary contact recreation refers to suitability of surface water for swimming with respect to pathogen concentrations. Waters with high pathogen inputs can be a human health risk. Pathogens that cause diseases, such as gastroenteritis or Giardiasis, can be carried in the feces of humans, waterfowl, livestock, and domestic animals. The pathogens are transferred to public bathing areas when the feces of an infected warm-blooded animal enter a waterbody from nearby farms, septic systems, wildlife, storm drains or unknown sources.

New Hampshire freshwater beach areas are assessed for primary contact recreation by measuring the concentration of *E. coli*, a common indicator bacterium that is present in the fecal material of warm-blooded animals. If a beach area exceeds state water quality criteria (two or more samples ≥ 88 counts / 100 mL or one sample ≥ 158 counts / 100 mL), then an advisory is posted.

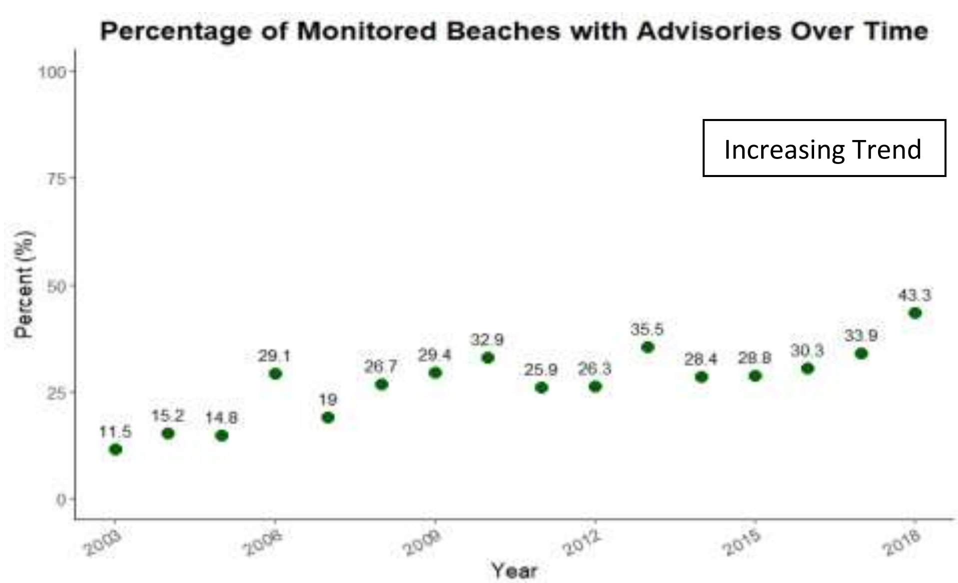
3.1.1 Long-term trend in percentage of beach advisories

A review of the data to date with respect to tracking the number of beaches with advisories includes records back as far as 1990s; however, the analysis examined beach advisories from 2003-2018, the period of time in which NHDES has the highest confidence in data collected.

MEASURE(S) OF CONDITION: The percentage of beaches with stable, increasing, or decreasing trends in fecal bacteria advisories over time. Since the number of beaches monitored varied over time only the percentage of total beaches to beaches with advisories was considered. An increasing trend would indicate that a greater percentage of beaches experienced a bacterial advisory over time, whereas a decreasing trend would indicate a lesser percentage of beaches had an advisory over time.

OUTCOME(S): From 2003 to 2018, there was a significant increase in the percentage of beaches with an advisory over time ($p < 0.001$; Figure 1).

Figure 1. Percentage of monitored beaches with a fecal bacteria advisory, 2003 – 2018.



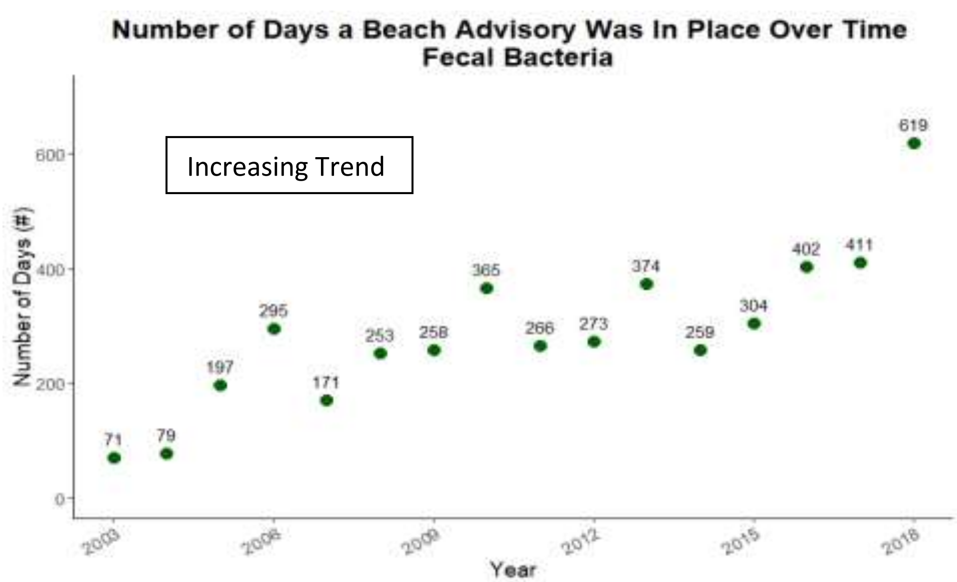
3.1.2 Long-term trend in beach advisory days

When beach advisories are issued, follow-up bacteria samples are collected, usually on a daily basis, until bacteria levels drop below the criteria indicating the water is safe for swimming. Thus, an advisory could last a single day or a number of weeks, depending on sample effort, the source of fecal bacteria that triggered the advisory, and the persistence of that source. The number of days a fecal bacteria advisory was in place was examined from 2003-2018.

MEASURE(S) OF CONDITION: The stable, increasing, or decreasing number of total days' fecal bacteria advisories were in place over time. While the number of beaches monitored varied over time, the number of advisory days gives a reasonable indication of the cumulative number of days lost to bathing due to fecal bacteria advisories. An increasing trend would indicate that a fecal bacteria advisory was in place a greater number of days and the condition was worsening, whereas a decreasing trend would indicate fewer swim days are lost to advisories and the condition was improving.

OUTCOME(S): From 2003 to 2018, there was a significant increase in the number of days a fecal bacteria beach advisory was in place ($p < 0.001$; Figure 2).

Figure 2. Number of days a fecal bacteria beach advisory was in place over time, 2003 – 2018.



3.2 Chlorophyll-a

Chlorophyll-a is a pigment found in plants and serves as an indicator of the abundance of suspended algae in a waterbody. Natural production rates of algae are affected by various factors such as light availability, temperature, and the underlying geology and soil characteristics that supply nutrients. Increases in algal production rates are most often associated with anthropogenic drivers such as nutrient loading from fertilizers, excessive soil erosion, stormwater run-off, pet waste and wastewater. Where waterbody productivity is increased beyond its natural rate, water quality conditions often decline. For example, in situations where there are dense and prolonged algal blooms, decreases in dissolved oxygen can result due to increased microbial decomposition of organic material.

For New Hampshire lakes and ponds, trophic class determines what is considered an acceptable level of chlorophyll-a concentration. Oligotrophic waterbodies are expected to be at or below 3.3 µg/L, mesotrophic waterbodies at or below 5.0 µg/L, and eutrophic waterbodies at or below 11.0 µg/L. A waterbody above its acceptable chlorophyll-a concentration may be considered impaired, and chlorophyll-a concentrations above 15.0 µg/L, no matter the trophic classification, are considered an excess of algal growth that interfere with recreational activities (CALM 2018).

3.2.1 Current Condition

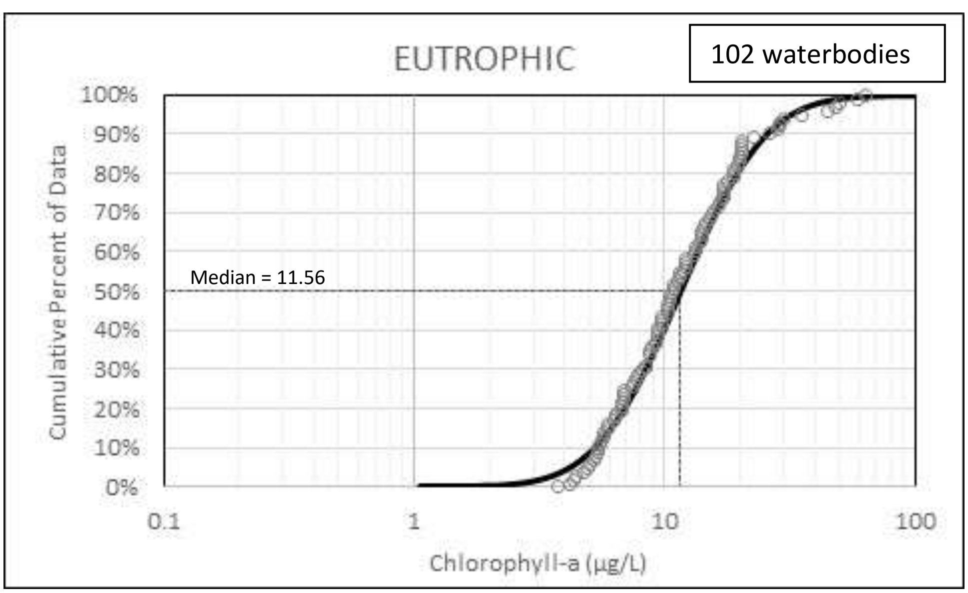
Statewide chlorophyll-a distributions were summarized from all available lake and pond data collected by various programs from 1991 to 2018. Data were used to build frequency distributions by trophic class (Section 2.2; Figure 3). Medians from 216 oligotrophic, 312 mesotrophic, and 102 eutrophic waterbodies were used to construct each respective distribution (Figure 3). Eutrophic waterbodies had a chlorophyll-a median of 11.56 µg/L, with the 25^{th} percentile at 7.64 µg/L and the 75^{th} percentile at 17.51 µg/L. The mesotrophic waterbody statewide distribution had a chlorophyll-a median of 4.55 µg/L, with the 25^{th} percentile at 3.15 µg/L and the 75^{th} percentile at 6.59 µg/L. The oligotrophic waterbody statewide distribution had a chlorophyll-a median of 2.51 µg/L, with the 25^{th} percentile at 1.76 µg/L and the 75^{th} percentile at 3.58 µg/L.

MEASURE(S) OF CONDITION: The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median chlorophyll-a level below the 25^{th} percentile of the statewide distribution of chlorophyll-a data by trophic class. Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median chlorophyll-a level above the 75^{th} percentile of statewide distribution of chlorophyll-a data by trophic class.

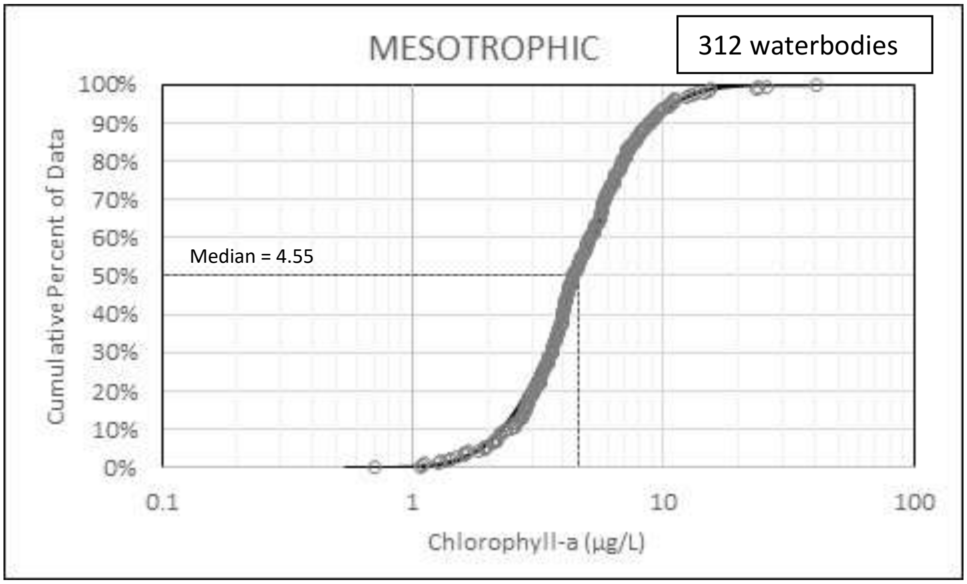
OUTCOME(S): For eutrophic waterbodies, four of ten (40%) were below the 25^{th} percentile and zero (0%) were above the 75^{th} percentile. For mesotrophic waterbodies, seven of seventy-one (9.9%) were below the 25^{th} percentile and ten (14.1%) were above the 75^{th} percentile. For oligotrophic waterbodies, fourteen of sixty-nine (20.3%) were below the 25^{th} percentile and fourteen (20.3%) were above the 75^{th} percentile.

Figure 3. Statewide data distribution for chlorophyll-a by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018. Dotted black line = Trophic median.

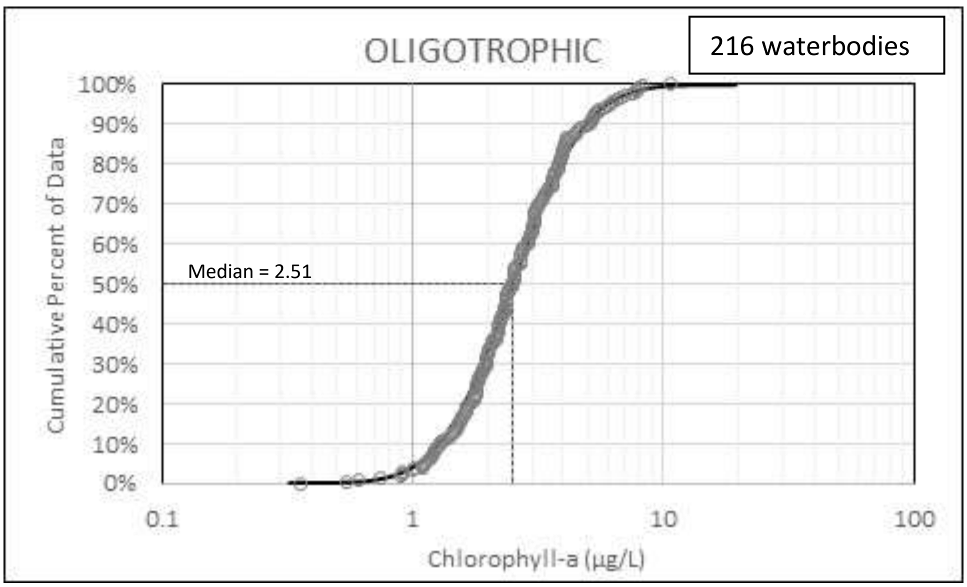
A.



B.



C.



3.2.2 Long-term trend

An initial query of VLAP chlorophyll-a data produced a data file of 13,055 records. The dataset was refined by removing invalidated or blank data records and restricting years to 1991-2018. Only records from the deepest location in the waterbody, which best represents whole lake conditions, and from June 1 through September 15 were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with fewer than ten years of data were removed from the dataset. The final dataset contained 8,433 records. Annual medians by individual waterbody and trophic class were calculated.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in chlorophyll-a, as individual waterbody and collectively by trophic class. An increasing trend line indicates that algal biomass is increasing in a waterbody or trophic class (worsening condition). A decreasing trend indicates that algal biomass is decreasing in a waterbody or trophic class (improving condition). Long term increases or decrease in chlorophyll-a concentrations are usually related to nutrient inputs.

OUTCOME(S): One hundred fifty VLAP lakes and ponds were examined for individual trends in chlorophyll-a concentration. Out of the 150 waterbodies, 10 were eutrophic, 71 were mesotrophic, and 69 were oligotrophic. These waterbodies had a minimum of ten and a maximum of 28 years of data spanning from 1991 to 2018.

Overall, 83.3% of the individual waterbodies analyzed had no trend (stable) in chlorophyll-a concentration, with 3.3% experiencing an increase in chlorophyll-a and 13.3% experiencing a decrease (Table 2). There were no significant trends by trophic class (Figures 4, 5).

Table 2. Number of VLAP waterbodies with increasing, decreasing, or no trend in chlorophyll-a concentration.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	10	7	2	1	*70.0%*	*20.0%*	*10.0%*
MESOTROPHIC	71	62	1	8	*87.3%*	*1.4%*	*11.3%*
OLIGOTROPHIC	69	56	2	11	*81.2%*	*2.9%*	*15.9%*
ALL	**150**	**125**	**5**	**20**	***83.3%***	***3.3%***	***13.3%***

Figure 4. Sen slope estimates (± 5%) of chlorophyll-a trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of chlorophyll-a trends by trophic class (Significance at $p < 0.05$) were $p = 0.77$ for eutrophic, 0.45 for mesotrophic, and 0.07 for oligotrophic waterbodies. Trophic trend analysis was performed on ten eutrophic waterbodies from 1997 - 2018, and 71 mesotrophic and 69 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five unique waterbodies in a given year.

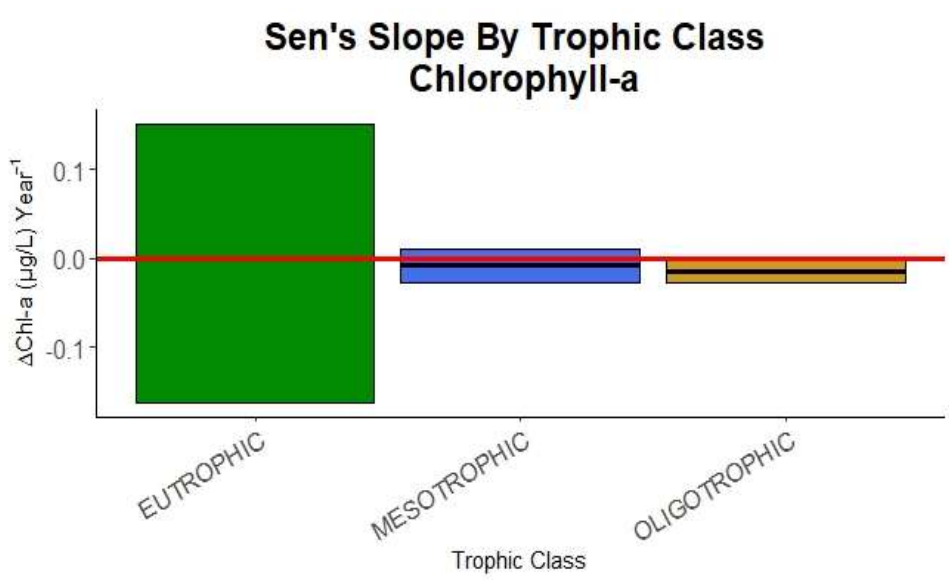
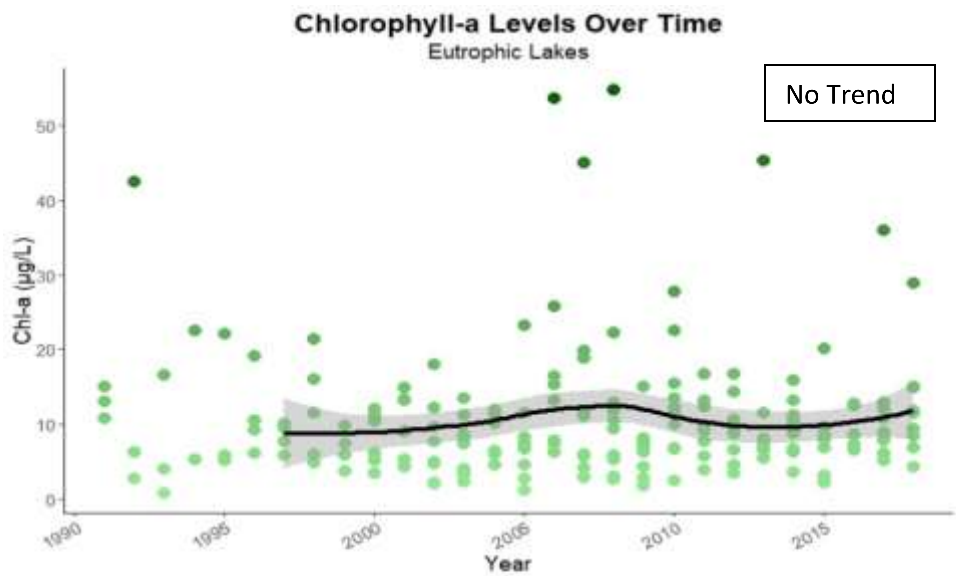
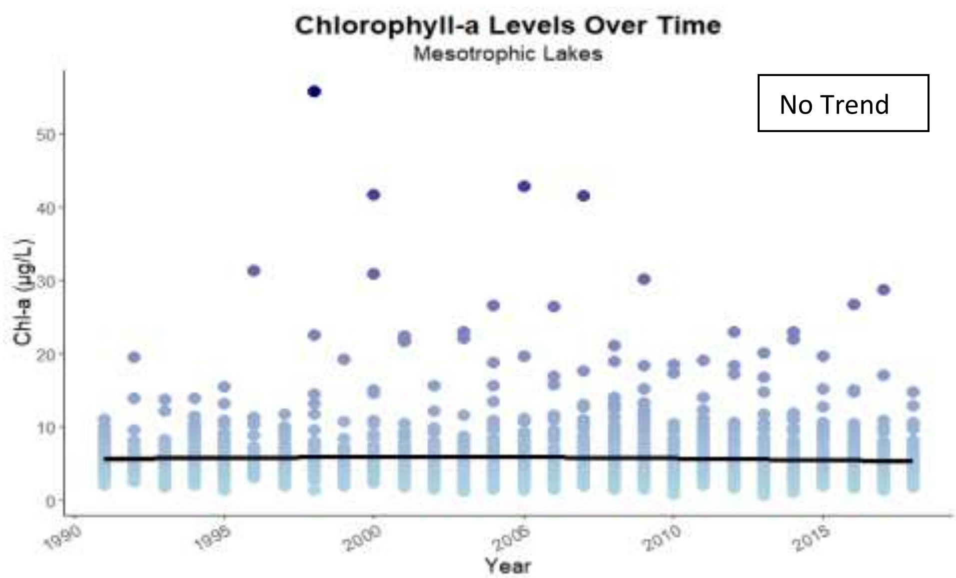


Figure 5. Annual median chlorophyll-a values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction. For eutrophic lakes, trend analysis occurred from 1997 to 2018. For mesotrophic and oligotrophic lakes, trend analysis occurred from 1991 to 2018. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis.

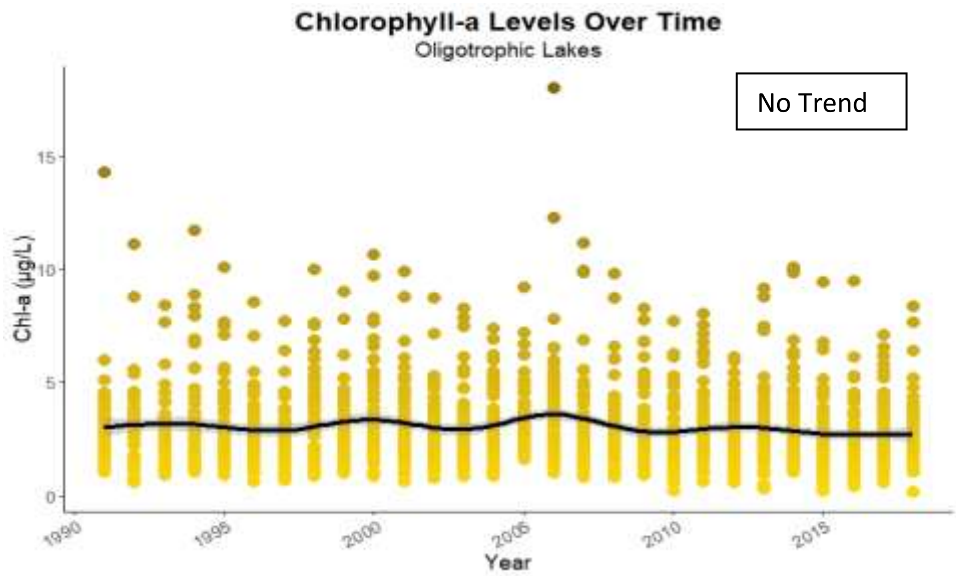
A.



B.



C.



3.2.3 Short-term change

To examine potentially rapid changes in chlorophyll-a concentration, the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 2,917 records for 116 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher or similar chlorophyll-a concentrations in the current five years compared to the previous reporting period.

OUTCOME(S): Out of the 116 waterbodies investigated, 16 waterbodies or 13.8% has significantly different concentrations in the previous time period compared to the current time period, with 12 or 10.3% having a significant decrease (current < previous) and four or 3.4% having a significant increase (current > previous) in chlorophyll-a. One hundred or 86.2% of waterbodies examined had no significant change in chlorophyll-a concentrations.

3.2.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies within each VLAP region with stable, increasing, and decreasing trends in chlorophyll-a.

OUTCOME(S): For individual waterbody trends, the most stable regions were Dartmouth Lake Sunapee and Great North Woods (no trend in >90% waterbodies); however, Great North Woods was composed of only two waterbodies (Table 3). The Lakes Region saw the largest decrease in chlorophyll-a concentration values (6 waterbodies [20.7%]; Table 3). All regions with the exceptions of Dartmouth Lake Sunapee and Great North Woods had one waterbody with increasing chlorophyll-a concentration (Table 3).

Table 3. Number of VLAP waterbodies with increasing, decreasing, or no trend in chlorophyll-a concentration by region. Only waterbodies with a minimum of ten years of data from 1991 – 2018 were included in the analysis.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	39	37	0	2	*94.9%*	*0.0%*	*5.1%*
GNW	2	2	0	0	*100.0%*	*0.0%*	*0.0%*
Lakes	29	22	1	6	*75.9%*	*3.4%*	*20.7%*
Monadnock	30	24	1	5	*80.0%*	*3.3%*	*16.7%*
MV	20	16	1	3	*80.0%*	*5.0%*	*15.0%*
Seacoast	12	9	1	2	*75.0%*	*8.3%*	*16.7%*
WM	18	15	1	2	*83.3%*	*5.6%*	*11.1%*
ALL	**150**	**125**	**5**	**20**	***83.3%***	***3.3%***	***13.3%***

3.3 Cyanobacteria

Cyanobacteria are photosynthetic bacteria found naturally in lakes, streams and ponds. Cyanobacteria are a natural part of our waterbodies and do not usually cause recreational or aesthetic problems. However, changes in waterbody condition can trigger excess cyanobacteria growth, resulting in a bloom. These blooms are generally associated with warm water temperatures, calm surface conditions, and excess nutrients; however, recent research is finding cyanobacteria abundance may also increase with climate-driven temperature increases, increases in dissolved organic matter transported to waterbodies from forests and stratification patterns (Creed et al. 2018; Paerl and Otten 2013). While some cyanobacteria blooms are merely unsightly, occasionally toxins are created, rendering the cyanobacteria bloom dangerous to humans, pets and livestock. The drivers for why toxins vary in their presence and severity is not well understood. The first reports of toxic cyanobacteria in New Hampshire occurred in the 1960s and 1970s. While most human health impacts have resulted from ingestion of contaminated water, cases of illnesses have also been attributed to swimming in cyanobacteria-laden waters.

NHDES takes an active role in monitoring the incidence and extent of cyanobacteria blooms in lakes and ponds. When a potential bloom is reported, either the observer or NHDES staff collect one or more samples to bring to the Jody Conner Limnology Center (JCLC) for identification. A cyanobacteria bloom is confirmed if the cell count of cyanobacteria is ≥ 70,000 cells/mL water. This count is an overall estimate of cyanobacteria density. When this occurs, an advisory for the waterbody is issued and appropriate officials are notified. The waterbody is sampled repeatedly and the advisory remains in place until samples indicate that a bloom is no longer present.

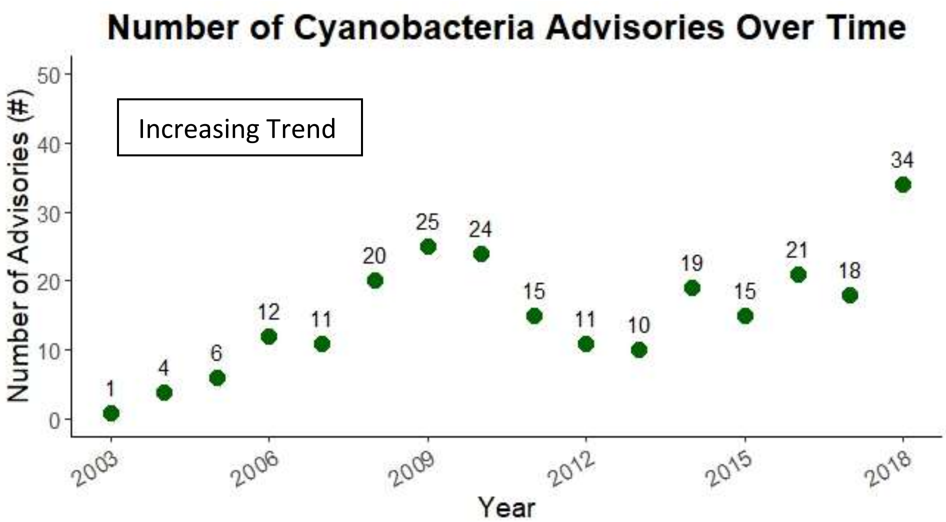
3.3.1 Long-term trend in cyanobacteria advisories

Cyanobacteria blooms have been noted for decades; however, there was no official program or method of reporting in place for many years. NHDES is most confident in its reports of cyanobacteria blooms going back to 2003; therefore, this report will focus on records from 2003-2018. It is important to note, however, that as the public has become more aware of cyanobacteria blooms, their likelihood of reporting them to NHDES has also increased. An advisory is issued whenever a cyanobacteria bloom is identified; if a waterbody has two separate cyanobacteria blooms in a year, two separate advisories will be issued.

MEASURE(S) OF CONDITION: A stable, increasing, or decreasing trend in the number of cyanobacteria advisories from 2003 to 2018.

OUTCOME(S): Since 2003, the number of cyanobacteria advisories have significantly increased (p = 0.01; Figure 6).

Figure 6. Number of cyanobacteria advisories, 2003 – 2018.



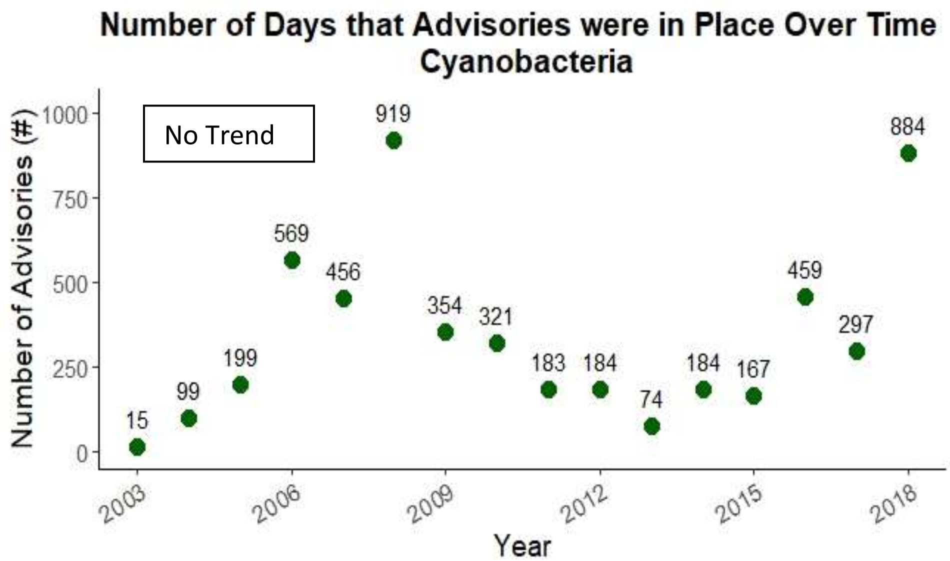
3.3.2 Long-term trend in cyanobacteria advisory days

Each cyanobacteria bloom is unique. A bloom may last for only a few hours to weeks at a time. Their location in the water column, in the area of the waterbody, the toxicity and the concentration vary by bloom. An advisory can be issued for one day or several weeks, depending on the nature of the bloom. This analysis investigates the number of days that advisories were in place from 2003 to 2018 (Section 2.2).

MEASURE(S) OF CONDITION: A stable, increasing, or decreasing trend in days that cyanobacteria advisories were in place from 2003 to 2018.

OUTCOME(S): Since 2003, the number of days that cyanobacteria advisories were in place has remained stable (p = 0.59; Figure 7).

Figure 7. Number of days that cyanobacteria advisories were in place, 2003 – 2018.



3.4 Invasive aquatic species

Invasive aquatic plants pose a threat to the ecological, aesthetic, recreational and economic values of freshwater resources (lakes, ponds, rivers and streams) primarily by forming dense growths or monocultures in areas of waterbodies that are important for aquatic habitat and recreational use. Infestations of invasive aquatic plants occur commonly by way of plant fragments that become attached to aquatic recreational equipment, such as boats, motors, and trailers and can spread from waterbody to waterbody through transient boating activities.

A total of 113 infestations in 89 waterbodies have been documented. Species present include variable milfoil, Eurasian milfoil, fanwort, water chestnut, Brazilian elodea, curly-leaf pondweed and European naiad. NHDES performs roughly 80 surveys annually to identify new infestations or track existing infestations. Invasive plant species control methods include herbicide treatments and alternative methods such as suction harvesting, hand pulling and benthic barriers.

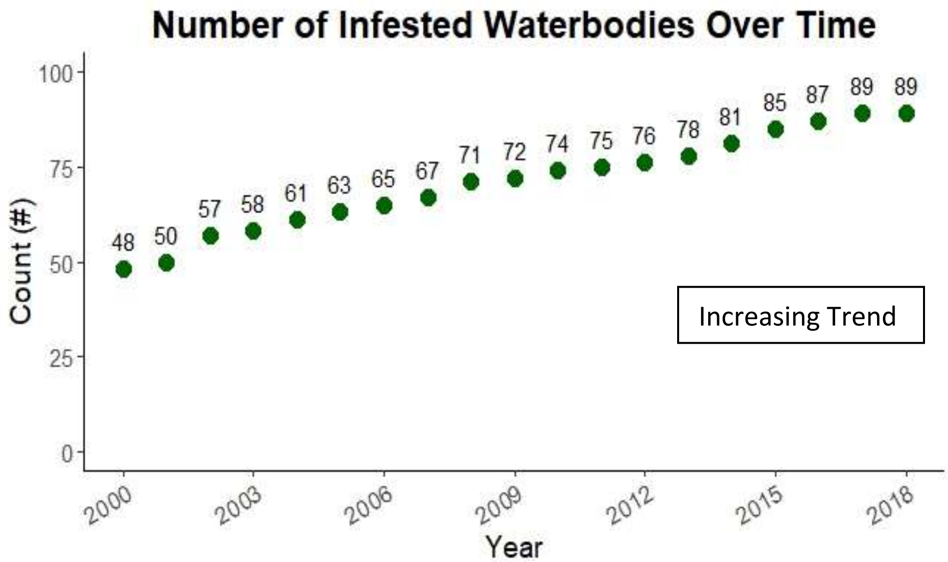
3.4.1 Long-term trend in infested waterbodies

A review of the data to date with respect to tracking the extent of invasive aquatic plant infestations includes records back as far as 1992. These records, however, were generated using a variety of inconsistent methods up until 2000. In 2000, data collection was standardized by using GPS and GIS technologies to geo-reference infested areas on individual waterbodies. For consistency, this analysis examined infestations from 2000 – 2018 (Section 2.2).

MEASURE(S) OF CONDITION: The number of New Hampshire waterbodies that are infested with an aquatic invasive species annually, 2000 - 2018.

OUTCOME(S): Since 2000, the number of infested waterbodies has significantly increased from 48 to 89 waterbodies ($p < 0.0001$; Figure 8).

Figure 8. Number of New Hampshire waterbodies with an aquatic invasive species infestation, 2000 – 2018.



3.4.2 Short-term change in acreage

To examine the potential rapid change in aquatic invasive species acreage, the total acreage of invasive species infestations was calculated annually, and the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). Total acreage of invasive species infestations ranged from 1,698 – 1,957 acres in the most recent five-year dataset and from 1,507 – 1,876 acres in the previous five-year dataset.

MEASURE(S) OF CONDITION: Whether infested acreage increased, decreased, or remained the same between the current reporting period compared to the previous.

OUTCOME(S): There was no significant difference between the current versus previous time periods (p = 0.15), indicating that the total infested acreage has not changed dramatically.

3.4.3 Short-term change in herbicide use

To examine the potential rapid change in herbicide use, the total acreage of herbicide application was calculated annually, and the most recent five years of data (2014– 2018) included in this report was compared to the previous five-year dataset (2009 – 2013; Section 2.2). The total acreage of herbicide application ranged from 504-970 acres in the current five-year dataset and from 396-869 acres in the previous five-year dataset.

MEASURE(S) OF CONDITION: Whether the acreage of herbicide application increased, decreased, or remained the same between the current reporting period compared to the previous.

OUTCOME(S): There was no significant difference between the current versus previous time periods (p = 0.84), indicating that the total area treated with herbicide has not changed dramatically.

3.4.4 Short-term change in alternative control methods

Alternative control methods are alternatives to herbicide application and can include suction harvesting, hand pulling, or benthic barriers. Often alternative methods are used when infestations are limited to small area or, conversely, if an invasive species is widespread but in low densities; therefore, calculating acreage is not practical. Instead, to examine the potential rapid change in use of alternative methods, the number of times alternative control methods were used each year was calculated, and the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). Alternative methods were used 50 – 55 times in the current time period and 32 – 45 times in the previous time period.

MEASURE(S) OF CONDITION: Whether the number of times alternative methods were used increased, decreased, or remained the same between the current reporting period compared to the previous.

OUTCOME(S): The number of times alternative control methods significantly increased in the current time period when compared to the previous ($p = 0.008$). The increase in the use of alternative control methods was driven by increased usage of diver-assisted suction harvesting (DASH), which was employed 32 – 39 times a year in the current period versus 16 – 22 times a year in the previous period.

3.5 pH

The pH of surface water is influenced by the geologic, vegetative and physical landscape characteristics within the watershed, as well as by local land use history and atmospheric deposition patterns. A pH range between 6.5 and 8.0 is best for aquatic life, and above or below this range may result in significant negative impacts to the aquatic community. The ability of water to resist acidification, measured as alkalinity, is a key component to protecting a waterbody from being affected by acidifying pollutants. Waters that have low alkalinity are particularly susceptible to, and lack the ability to be resistant to or resilient from acidification. Acid precipitation, as a result of fossil fuel combustion, is a well-documented phenomenon in the northeastern United States that causes significant negative impacts to surface waters (Driscoll et al. 2001). Recent studies have found some indications of recovery with significant reductions in acidifying compounds such as sulfate and nitrates (Strock et al. 2014, NHDES 2015).

3.5.1 Current Condition

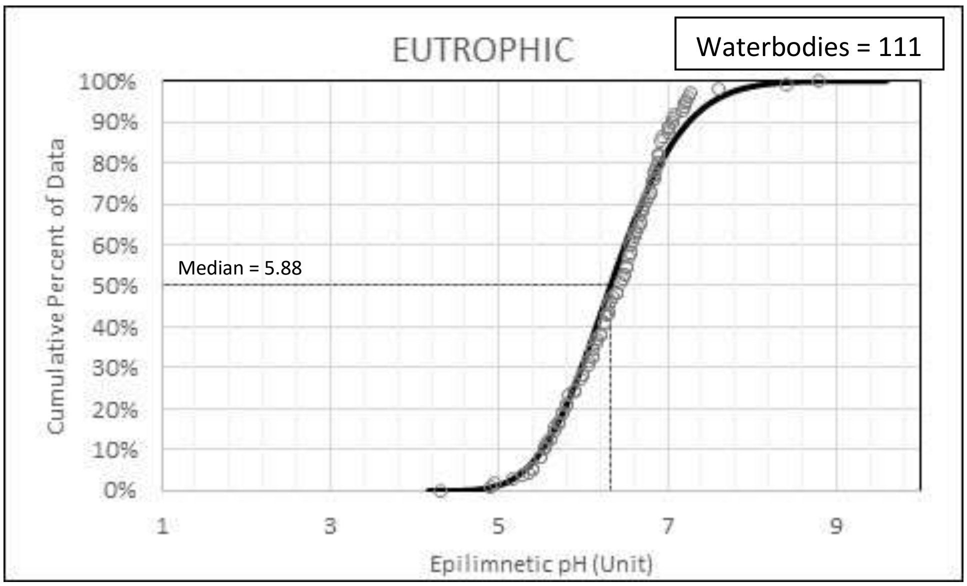
Statewide pH distributions were summarized from all available lake and pond data collected by various programs from 1991 to 2018. Data were used to build frequency distributions by trophic class (Section 2.2; Figure 9). Medians from 218 oligotrophic, 319 mesotrophic, and 111 eutrophic waterbodies were used to construct each respective distribution (Figure 9). According to the standard distributions, statewide eutrophic waterbodies had a pH median of 6.32 units, with the 25th percentile at 5.88 units and the 75th percentile at 6.79 units. The statewide frequency distribution for mesotrophic waterbodies had a pH median of 6.49 units, with the 25th percentile at 6.11 units and the 75th percentile at 6.91 units. Oligotrophic waterbodies had statewide frequency distribution with a pH median of 6.55 units, a 25th percentile of 6.18 units and a75th percentile of 6.95 units.

MEASURE(S) OF CONDITION: The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median pH level below the 25th percentile of the statewide frequency distribution of pH data by trophic class. The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median pH level above the 75th percentile of statewide distribution of pH data by trophic class.

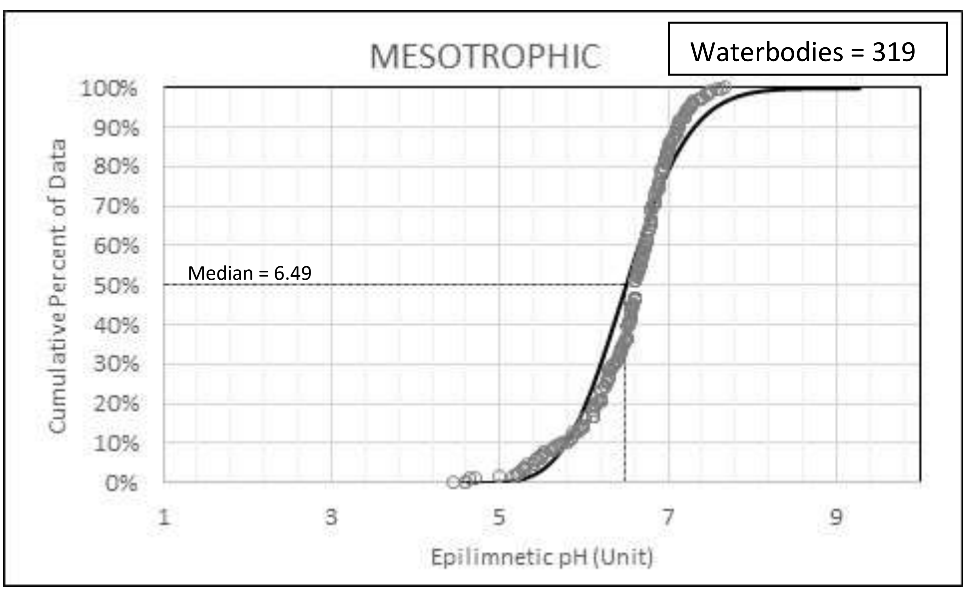
OUTCOME(S): For eutrophic waterbodies, four out of ten (40%) were above the 75th percentile and zero (0%) were below the 25th percentile. For mesotrophic waterbodies, 21 of 71 (30%) were above the 75th percentile and three (4.2%) were below the 25th percentile. For oligotrophic waterbodies, 13 of 69 (18.8%) were above the 75th percentile and four (5.8%) were below the 25th percentile.

Figure 9. Statewide frequency distribution for pH by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018.

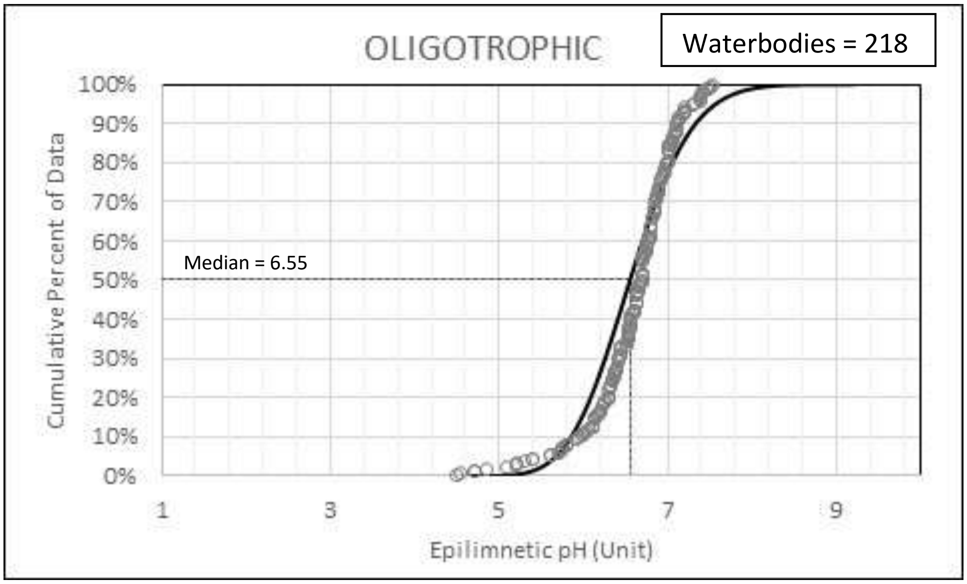
A.



B.



C.



3.5.2 Long-term trend

An initial Environmental Monitoring Database query of VLAP pH data produced a data file of 35,511 records. The dataset was refined by removing invalidated or blank data records and restricting years to 1991 – 2018. Only records from the epilimnion, or topmost layer of the water column, collected at the deepest location in the waterbody, which best represents whole lake conditions, and from June 1 through September 15 were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with fewer than ten years of data were removed from the dataset. Annual medians by individual waterbody and trophic class were calculated. The final dataset contained 8,185 records.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in pH, by individual waterbody and trophic class.

OUTCOME(S): One-hundred-fifty VLAP lakes and ponds were examined for trends in pH. Out of the 150 waterbodies, 10 were eutrophic, 71 were mesotrophic, and 69 were oligotrophic. These waterbodies had a minimum of ten and a maximum of 28 years of data spanning from 1991 to 2018.

Overall, 82% of the waterbodies analyzed had no trend in pH, with 12.7% experiencing an increase in pH and 5.3% experiencing a decrease (Table 4, Figure 10). There were no significant trends by trophic class (Figures 10, 11).

Table 4. Number of VLAP waterbodies with increasing, decreasing, or no trend in pH.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	10	9	0	1	*90.0%*	*0.0%*	*10.0%*
MESOTROPHIC	71	57	8	6	*80.3%*	*11.3%*	*8.5%*
OLIGOTROPHIC	69	57	11	1	*82.6%*	*15.9%*	*1.4%*
ALL	**150**	**123**	**19**	**8**	***82.0%***	***12.7%***	***5.3%***

Figure 10. Sen slope estimates (± 5%) of pH trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of pH trends by trophic class (significance at $p < 0.05$) were $p = 0.73$ for eutrophic, 0.71 for mesotrophic, and 0.81 for oligotrophic waterbodies. Trophic trend analysis was performed on 10 eutrophic waterbodies from 1997 -2018, and 71 mesotrophic and 69 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five unique waterbodies in a given year.

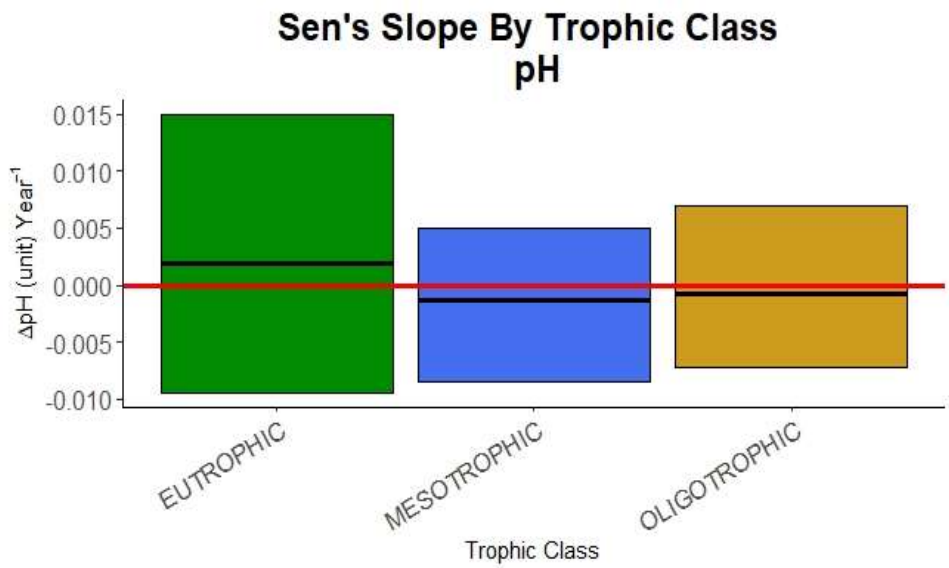
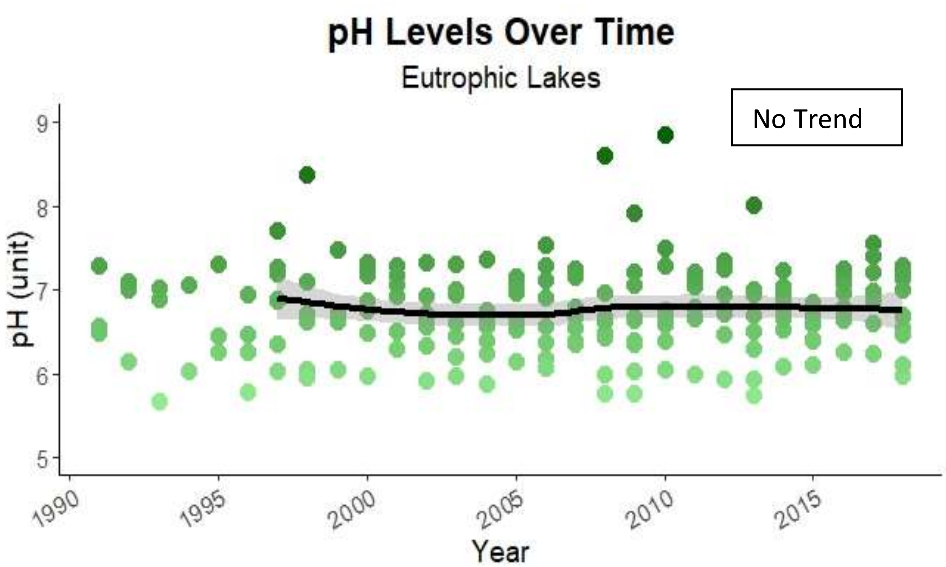
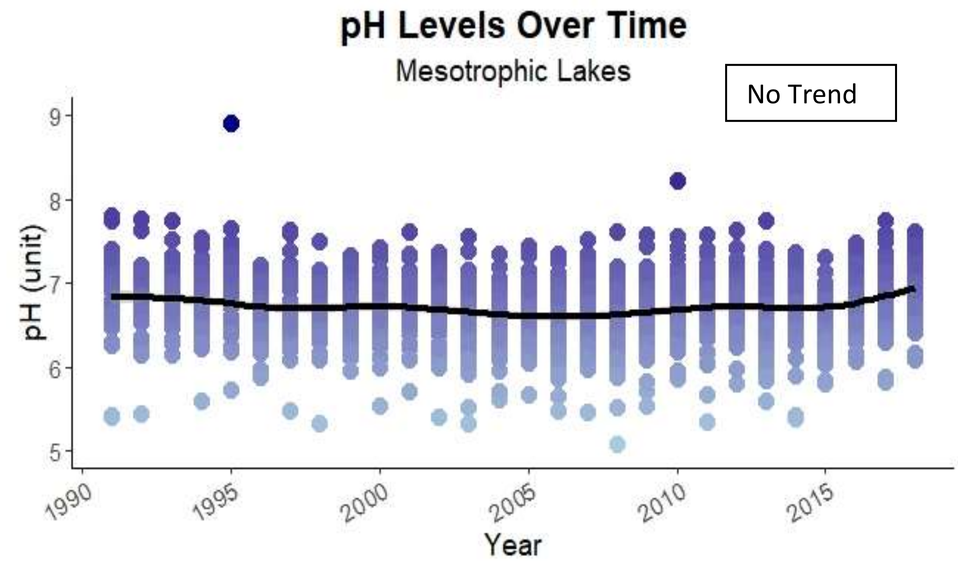


Figure 11. Annual median pH values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction. For eutrophic lakes, trend analysis occurred from 1997 to 2018. For mesotrophic and oligotrophic lakes, trend analysis occurred from 1991 to 2018. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis.

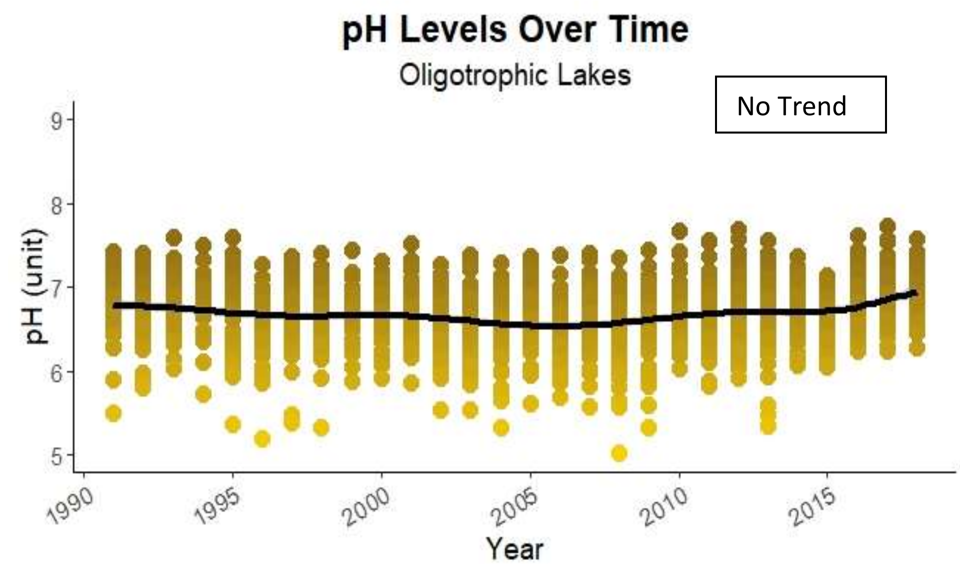
A.



B.



C.



3.5.3 Short-term change

To examine these potential rapid changes in pH, the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 2,622 records from 108 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher, or similar pH levels in the current five years compared to the previous reporting period.

OUTCOME(S): Out of the 108 waterbodies investigated, 29 waterbodies or 26.9% has significantly different populations from the previous and current groups of data. Of the waterbodies with significant differences, four or 3.7% had lower pH in the current data group as compared to the previous. Twenty-five or 23.2% of the waterbodies with a significant difference had higher pH in the current time period as compared to the previous.

3.5.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies within each region with stable, increasing, or decreasing trends in pH.

OUTCOME(S): The Dartmouth Lake Sunapee region had the greatest number of waterbodies with increasing pH (6 waterbodies [15.4%]), followed by the Monadnock (4 waterbodies [13.3%]) and then White Mountain (3 waterbodies [16.7%]) regions (Table 5). The Dartmouth Lake Sunapee region had the greatest number of waterbodies with decreasing trends as well (3 waterbodies [7.7%]; Table 5).

Table 5. Number of VLAP waterbodies with increasing, decreasing, or no trend in pH by region.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	39	30	6	3	*76.9%*	*15.4%*	*7.7%*
GNW	2	2	0	0	*100.0%*	*0.0%*	*0.0%*
Lakes	29	25	2	2	*86.2%*	*6.9%*	*6.9%*
Monadnock	30	25	4	1	*83.3%*	*13.3%*	*3.3%*
MV	20	16	2	2	*80.0%*	*10.0%*	*10.0%*
Seacoast	12	10	2	0	*83.3%*	*16.7%*	*0.0%*
WM	18	15	3	0	*83.3%*	*16.7%*	*0.0%*
ALL	**150**	**123**	**19**	**8**	***82.0%***	***12.7%***	***5.3%***

3.6 Secchi Depth

Secchi depth is a measure of water clarity. Water clarity is influenced by many variables, such as concentration of suspended algae, underlying geology, type and quantity of sediment deposits, watershed land use, climate change and history of exposure to acid rain. Waterbodies with high algae or fine sediment levels will have lower water clarity. Decreasing water clarity has also been documented in the Northeast as waterbodies recover from acid rain inputs and are subject to climate change. In a phenomenon known as "lake browning", significant increases in dissolved organic carbon (DOC) concentrations, which darken the color of water, have been found in some Northeastern waterbodies (Creed et al. 2018; SanClements et al. 2012). The increase in DOC is partially attributed to reductions in the acid rain-causing pollutant, sulfur dioxide. The reduction of acid deposition has increased forest soil pH, which has led to increased mobility of organic matter which allows more terrestrial DOC to move from forests to waterbodies (Creed et al. 2018; SanClements et al. 2012). Additionally, average annual precipitation and extreme storm events in Northeastern America have increased since 1958, and this increase in the volume and magnitude of precipitation increases terrestrial DOC loading to lakes (Meyer-Jacob et al. 2019; Richardson et al. 2017). Water clarity influences many processes in a waterbody, such as macrophyte growth, plankton communities, temperature, stratification and even bacteria growth. Since the trophic status of a waterbody is a description of overall productivity, Secchi depths vary for different trophic classes. Eutrophic waterbodies generally have a Secchi depth of less than 1.8 meters, mesotrophic waterbodies a Secchi depth of 1.8 to 4 meters, and oligotrophic waterbodies a Secchi depth of greater than 4 meters.

3.6.1 Current Condition

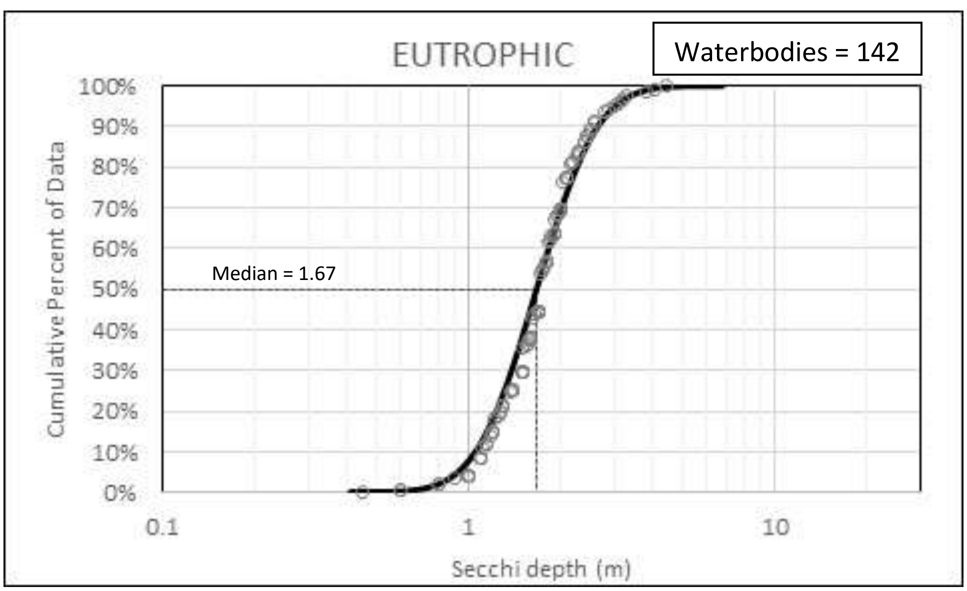
Statewide Secchi depth frequency distributions were summarized from all available lake and pond data collected by various programs from 1991 to 2018. Data were used to build statewide frequency distributions by trophic class (Section 2.2; Figure 8). Data from 235 oligotrophic, 373 mesotrophic, and 142 eutrophic waterbodies were used to construct each frequency distribution (Figure 8). Overall, eutrophic waterbodies had a Secchi depth median of 1.67 meters, with the 25th percentile at 1.31 meters and the 75th percentile at 2.13 meters. The mesotrophic waterbodies had a Secchi depth median of 2.68 meters, with the 25th percentile at 2.07 meters and the 75th percentile at 3.48 meters. Oligotrophic waterbodies had a Secchi depth median of 4.53 meters, with the 25th percentile at 3.44 meters and the 75th percentile at 5.96 meters.

MEASURE(S) OF CONDITION: Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median Secchi depth below the 25th percentile of the statewide distribution of Secchi depth data by trophic class. Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median Secchi depth above the 75th percentile of statewide distribution of Secchi depth data by trophic class.

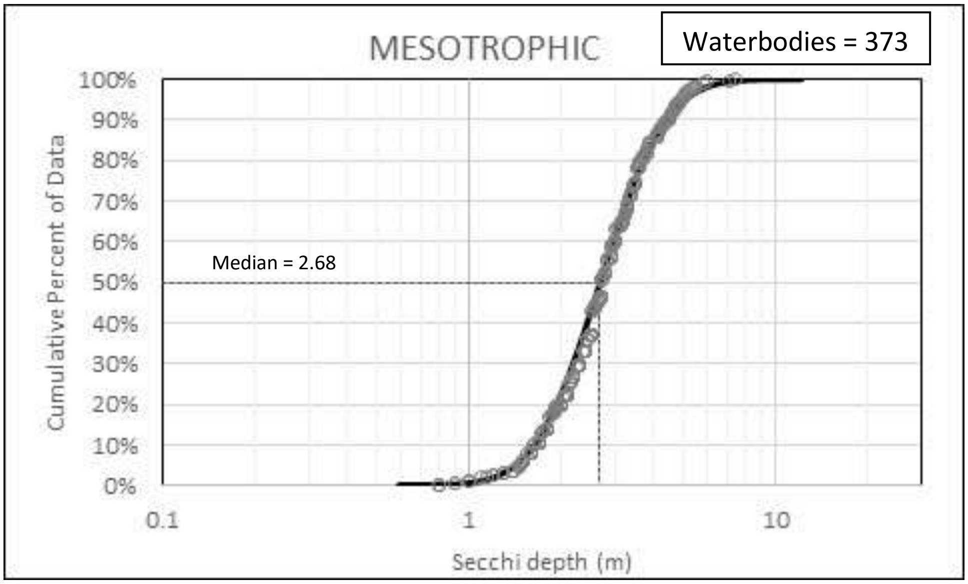
OUTCOME(S): For eutrophic waterbodies, three of ten (30%) of waterbodies were above the 75th percentile and one of ten (10%) was below the 25th percentile. For mesotrophic waterbodies, 20 of 71 (28.2%) were above the 75th percentile and nine of 71 (12.7%) were below the 25th percentile. For oligotrophic waterbodies, 15 of 68 (22.1%) were above the 75th percentile and 13 of 68 (19.1%) were below the 25th percentile.

Figure 12. Statewide data distribution for Secchi depth by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018.

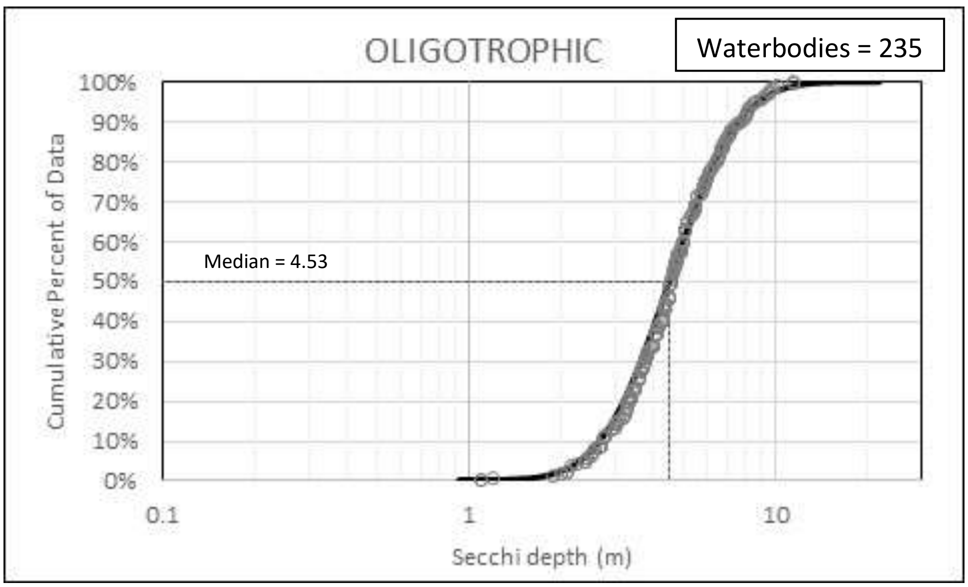
A.



B.



C.



3.6.2 Long-term trend

An initial Environmental Monitoring Database query of VLAP Secchi depth data produced a datafile of 16,225 records. The dataset was refined by removing Secchi depth data collected using a viewing scope, invalidated or blank data records, and restricting years to 1991 – 2018. Only records collected at the deepest location in the waterbody, which best represents whole lake conditions, and from June 1 through September 15 were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with multiple “Visible on Bottom (VOB)” Secchi disk readings were adjusted to the deepest recorded VOB value to standardize the readings. Waterbodies with fewer than ten years of data were removed from the dataset. Annual medians by individual waterbody and trophic class were calculated. A Mann Kendall trend test and corresponding Sen slope were calculated for each individual waterbody as well as by trophic class (Section 2.2). The final dataset contained 8,325 records.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in Secchi depth, by individual waterbody and trophic class. An increasing trend in Secchi depth indicates that light can pass deeper into the water column of a waterbody, while a decreasing trend indicates that the water is becoming less clear.

OUTCOME(S): One hundred forty-nine VLAP lakes and ponds were examined for individual Mann Kendall trends in Secchi depth. Out of the 149 waterbodies, 10 were eutrophic, 71 were mesotrophic, and 68 were oligotrophic. In total, 82% of waterbodies had a stable trend, 2% had an increasing trend, and 16% had a decreasing trend (Table 6). Mesotrophic and oligotrophic waterbodies displayed a significant decrease in Secchi depth while eutrophic waterbodies displayed no trend (Figures 13, 14).

Table 6. Number of VLAP waterbodies with increasing, decreasing, or no trend in Secchi depth levels.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	10	7	0	3	*70.0%*	*0.0%*	*30.0%*
MESOTROPHIC	71	63	1	7	*88.7%*	*1.4%*	*9.9%*
OLIGOTROPHIC	68	52	2	14	*76.5%*	*2.9%*	*20.6%*
ALL	**149**	**122**	**3**	**24**	***81.9%***	***2.0%***	***16.1%***

Figure 13. Sen slope estimates (± 5%) of Secchi depth trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of Secchi depth trends by trophic class (Significance at $p < 0.05$) were $p = 0.33$ for eutrophic, 0.0004 for mesotrophic, and 0.001 for oligotrophic waterbodies. Trophic trend analysis was performed on 10 eutrophic waterbodies from 1997 -2018, and 71 mesotrophic and 68 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five unique waterbodies in a given year.

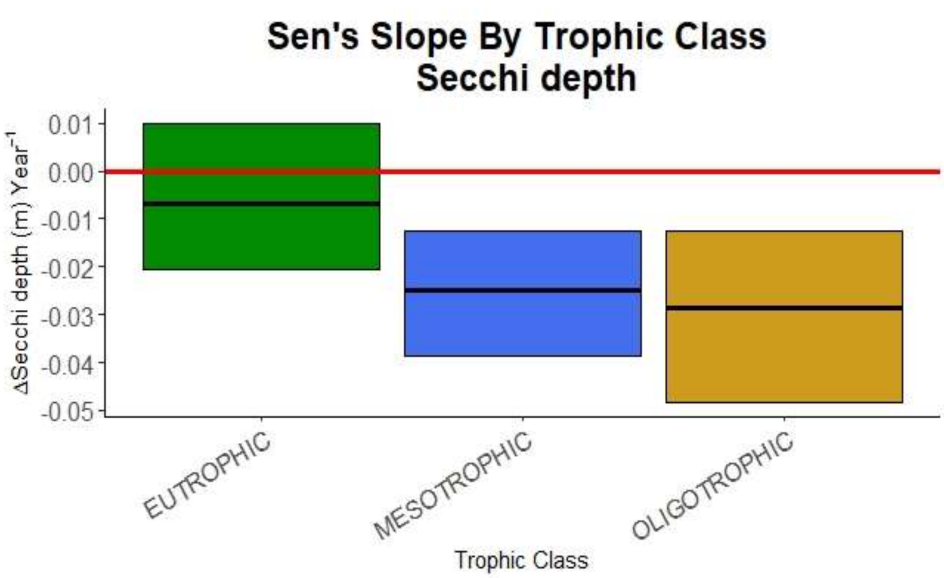
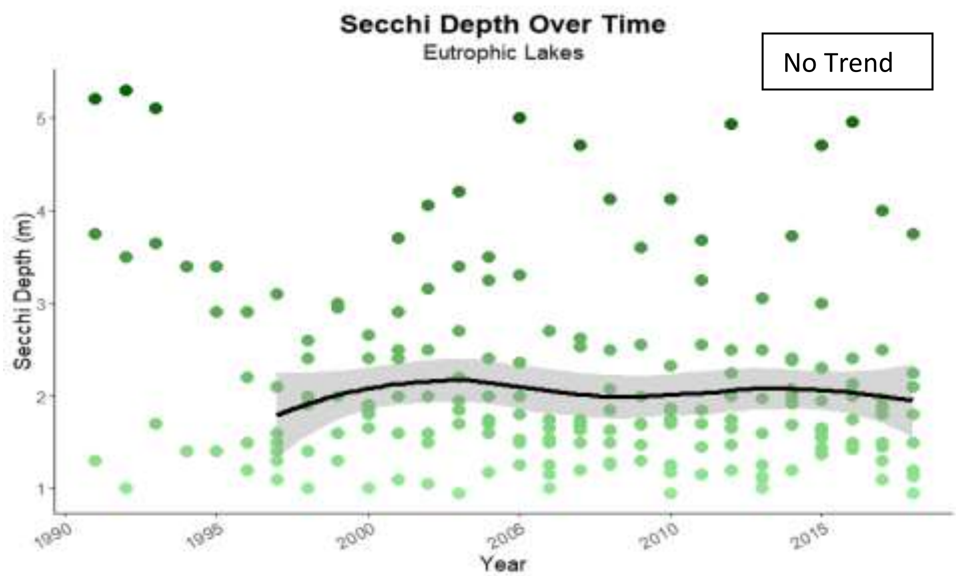
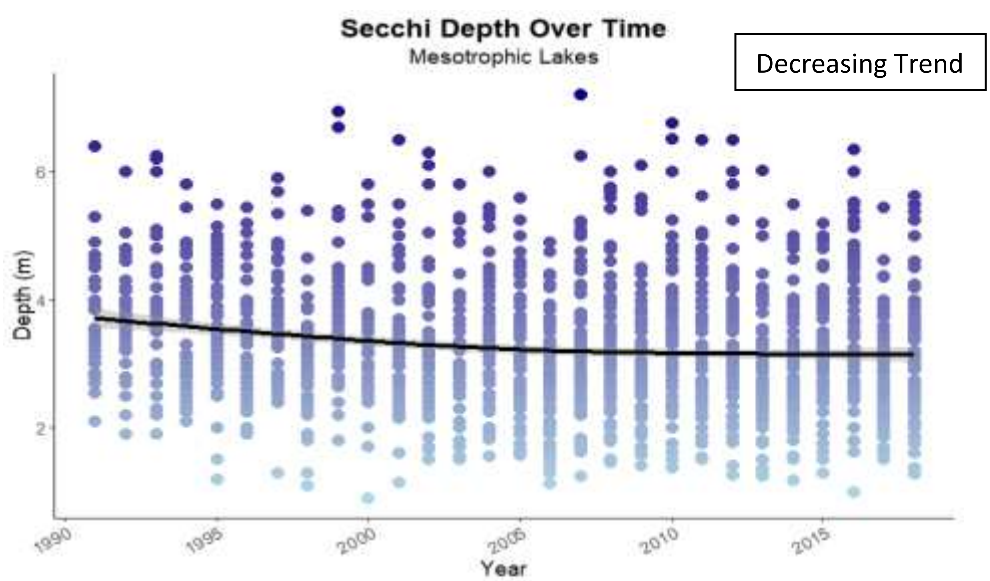


Figure 14. Annual median Secchi depth values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction. Trend analysis occurred from 1997 to 2018 for eutrophic lakes and from 1991 to 2018 for mesotrophic and oligotrophic lakes. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis.

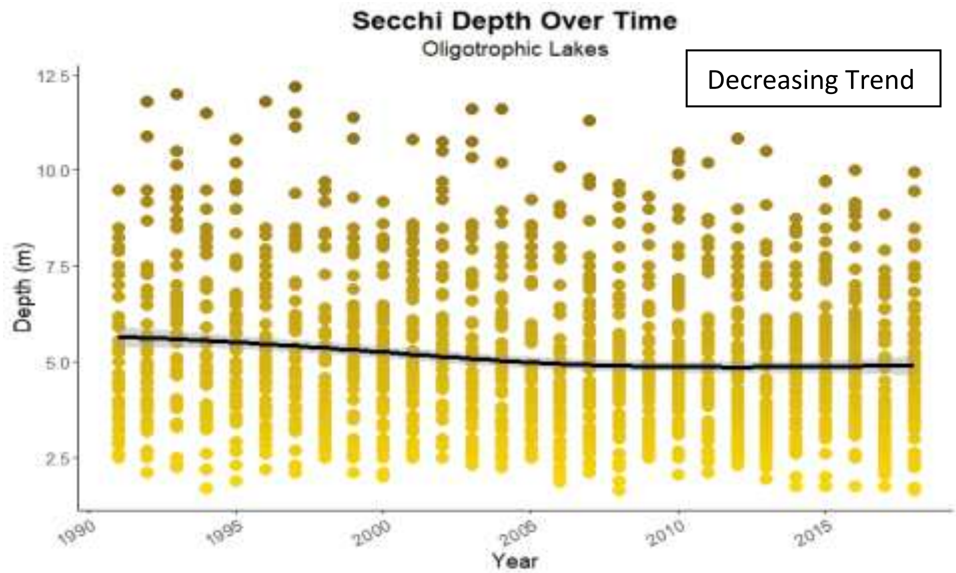
A.



B.



C.



3.6.3 Short-term change

To examine these potential rapid changes in Secchi depth, the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 2,805 records for 114 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher, or similar Secchi depth values in the current five years compared to the previous reporting period.

OUTCOME(S): Out of the 114 waterbodies investigated, 12 waterbodies or 10.5% had significantly differences between time periods. Of the 12, five waterbodies (4.4%) had lower (shallower) Secchi depth and seven waterbodies (6.1%) had higher (deeper) Secchi depths in the current time period as compared to the previous.

3.6.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies in VLAP regions with stable, increasing, and decreasing trends in Secchi depth.

OUTCOME(S): The regions with the greatest number of waterbodies with declining Secchi depth trends were Dartmouth Lake Sunapee (9 waterbodies [23.7%]), followed by White Mountain (5 waterbodies [27.8%]) and Monadnock (3 waterbodies [10%]; Table 7). Dartmouth Lake Sunapee, Monadnock, and Merrimack Valley regions all had one waterbody with an increasing Secchi depth trend (Table 7).

Table 7. Number of VLAP waterbodies with increasing, decreasing, or no trend in Secchi depth by region. Only waterbodies with a minimum of ten years of data from 1991 – 2018 were included in the analysis.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	38	28	1	9	*73.7%*	*2.6%*	*23.7%*
GNW	2	1	0	1	*50.0%*	*0.0%*	*50.0%*
Lakes	29	27	0	2	*93.1%*	*0.0%*	*6.9%*
Monadnock	30	26	1	3	*86.7%*	*3.3%*	*10.0%*
MV	20	17	1	2	*85.0%*	*5.0%*	*10.0%*
Seacoast	12	10	0	2	*83.3%*	*0.0%*	*16.7%*
WM	18	13	0	5	*72.2%*	*0.0%*	*27.8%*
ALL	**149**	**122**	**3**	**24**	***81.9%***	***2.0%***	***16.1%***

3.7 Specific Conductance

Specific conductance is a measure of water's ability to carry an electrical current and reflects the concentration of dissolved solids. Ions such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron and aluminum all contribute to specific conductance levels. These ions originate from natural (bedrock) and anthropogenic (fertilizers, road salt, stormwater run-off, septic systems, agricultural practices) sources. These ions can have secondary influences on other water quality parameters.

In New Hampshire, natural in-lake specific conductance levels are typically low (< 50 µS/cm) and reflective of the typical rock formations (granite) over which most of the lakes lie and in-flowing water travels over. Higher in-lake specific conductance levels are typically associated with urbanized watersheds that have a greater percentage of impervious cover and greater road density (Deacon et al. 2005, Dugan et al. 2017). Impervious cover and, more specifically, road density are linked to greater inputs of sodium and chloride ions as a result of road deicing (Trowbridge et al. 2010, Daley et al. 2009). In the United States, road salting became common practice in the 1940s and the volume of road salt used on our impervious surfaces has increased to over 18 million metric tons per year (Dugan et al. 2017). Elevated chloride concentrations can adversely affect water quality and aquatic life, and increasing chloride levels, due to inputs of road salt, in surface and ground water have been documented in New Hampshire (Daley et al. 2009, Trowbridge et al. 2010, Dugan et al. 2017). Recent efforts to reduce road salt usage by NHDES and UNH resulted in the launch of the NH Green SnowPro Program, which trains road salt applicators in ways to safely reduce road salt usage. Increases in specific conductance due to road salt inputs has been linked to increasing alkalinity, altered plankton communities, and enhanced thermal stratification (Dugan et al. 2017; Kaushal et al. 2018).

3.7.1 Current Condition

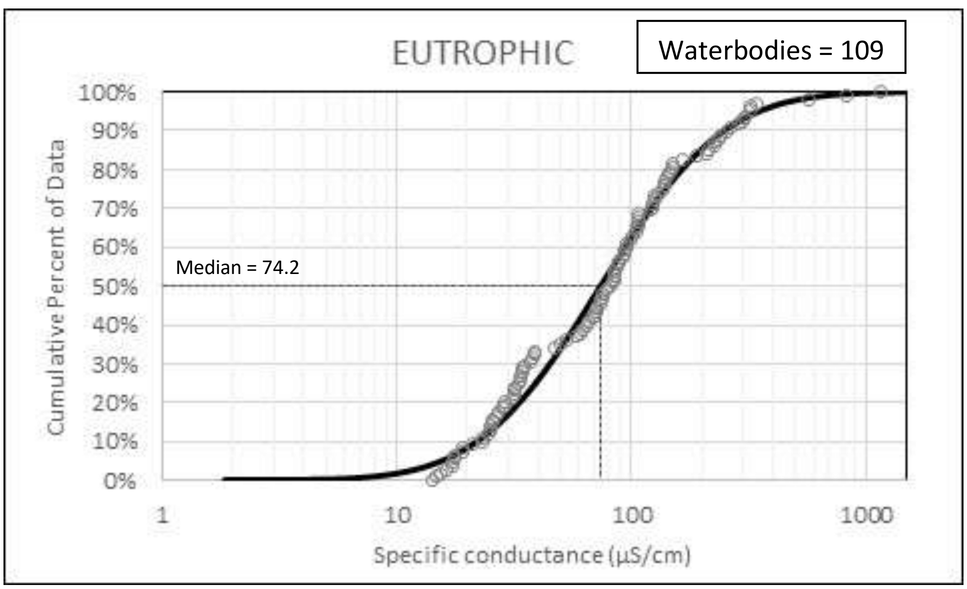
Statewide specific conductance distributions were summarized from all available lake and pond data collected by various programs from 1991 to 2018. Data were used to build statewide frequency distributions by trophic class (Section 2.2; Figure 15). Medians from 226 oligotrophic, 332 mesotrophic, and 109 eutrophic waterbodies built each respective frequency distribution (Figure 15). Eutrophic waterbodies had a specific conductance median of 74.2 µS/cm, with the 25th percentile at 39.2 µS/cm and the 75th percentile at 140.5 µS/cm. The mesotrophic waterbody statewide frequency distribution had a specific conductance median of 49.2 µS/cm, with the 25th percentile at 28 µS/cm and the 75th percentile at 86.6 µS/cm. The oligotrophic waterbody statewide frequency distribution had a specific conductance median of 40.8 µS/cm, with the 25th percentile at 25.7 µS/cm and the 75th percentile at 64.8 µS/cm.

MEASURE(S) OF CONDITION: The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median specific conductance value below the 25th percentile of the statewide distribution of specific conductance data by trophic class. Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median specific conductance value above the 75th percentile of statewide distribution of specific conductance data by trophic class.

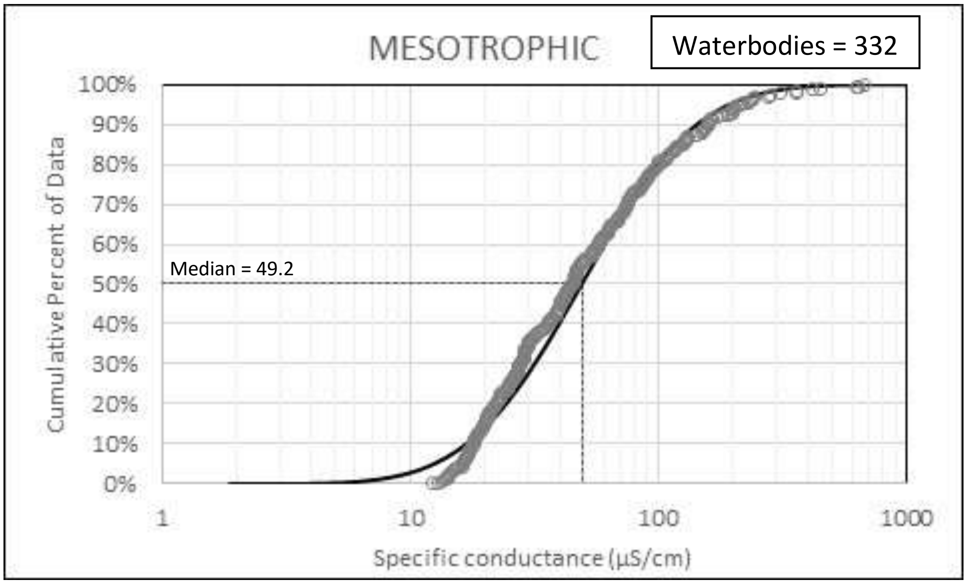
OUTCOME(S): For eutrophic waterbodies, four out of 10 (40%) were above the 75th percentile and zero were below the 25th percentile. For mesotrophic waterbodies, 27 of 71 (38%) were above the 75th percentile and 10 of 71 (14.1%) were below the 25th percentile. For oligotrophic waterbodies, 21 of 69 (30.4%) were above the 75th percentile and 11 of 69 (15.9%) were below the 25th percentile.

Figure 15. Statewide frequency distribution for specific conductance by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018.

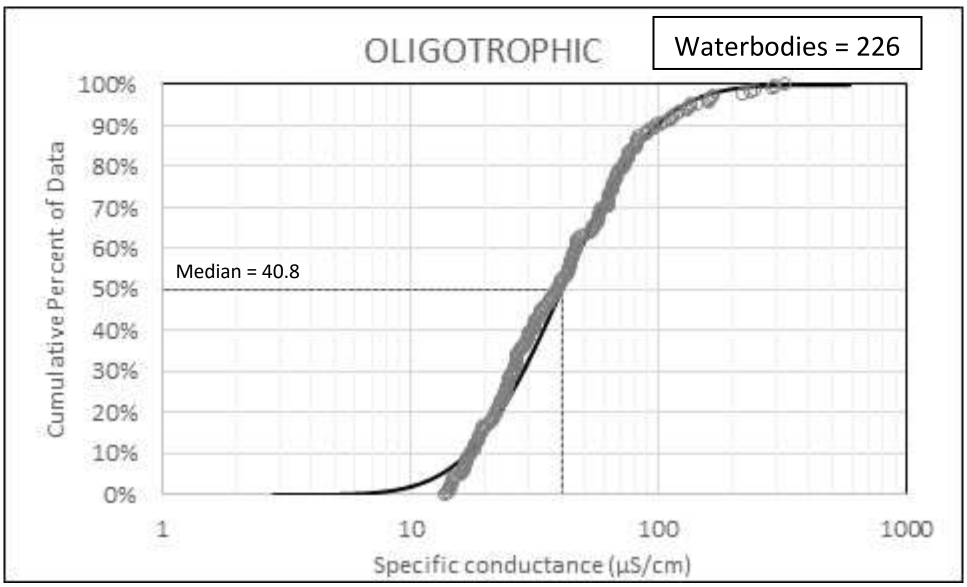
A.



B.



C.



3.7.2 Long-term trend

An initial Environmental Monitoring Database query of VLAP specific conductance data produced a datafile of 35,327 records. The dataset was refined by removing invalidated or blank data records, restricting years to 1991 – 2018, and targeting samples collected in the epilimnion or topmost layer in the water column. Only records collected at the deepest location in the waterbody, which best represents whole lake conditions, and from June 1 through September 15 were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with fewer than ten years of data were removed from the dataset. Two data point outliers were removed. Annual medians by individual waterbody and trophic class were calculated. A Mann Kendall trend test and corresponding Sen slope were calculated for each individual waterbody as well as by trophic class (Section 2.2). The final dataset contained 8,184 records.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in specific conductance, by individual waterbody and trophic class. An increasing trend in specific conductance indicates anthropogenic influences, such as exposure to road salt. A decreasing trend suggests decreases in pollutants, such as a decrease in sulfate.

OUTCOME(S): One-hundred-fifty VLAP lakes and ponds were examined for individual Mann Kendall trends in specific conductance levels. Out of the 150 waterbodies, 10 were eutrophic, 71 were mesotrophic, and 69 were oligotrophic. These waterbodies had a minimum of ten and a maximum of 28 years of data spanning from 1991 to 2018.

Overall, 50.7% of the waterbodies analyzed had no trend in specific conductance levels, with 41.3% experiencing an increase in specific conductance levels and 8.0% experiencing a decrease (Table 8). As a group, eutrophic and mesotrophic waterbodies displayed a significant increase in specific conductance while oligotrophic waterbodies displayed no trend (Figures 16, 17).

Table 8. Number of VLAP waterbodies with increasing, decreasing, or no trend in specific conductance levels.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	10	5	5	0	*50.0%*	*50.0%*	*0.0%*
MESOTROPHIC	71	38	29	4	*53.5%*	*40.8%*	*5.6%*
OLIGOTROPHIC	69	33	28	8	*47.8%*	*40.6%*	*11.6%*
ALL	**150**	**76**	**62**	**12**	***50.7%***	***41.3%***	***8.0%***

Figure 16. Sen slope estimates (± 5%) of specific conductance trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of specific conductance trends by trophic class (significance at $p < 0.05$) were $p < 0.001$ for eutrophic, < 0.001 for mesotrophic, and 0.44 for oligotrophic waterbodies. Trophic trend analysis was performed on ten eutrophic waterbodies from 1997 -2018, and 71 mesotrophic and 69 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five unique waterbodies in a given year.

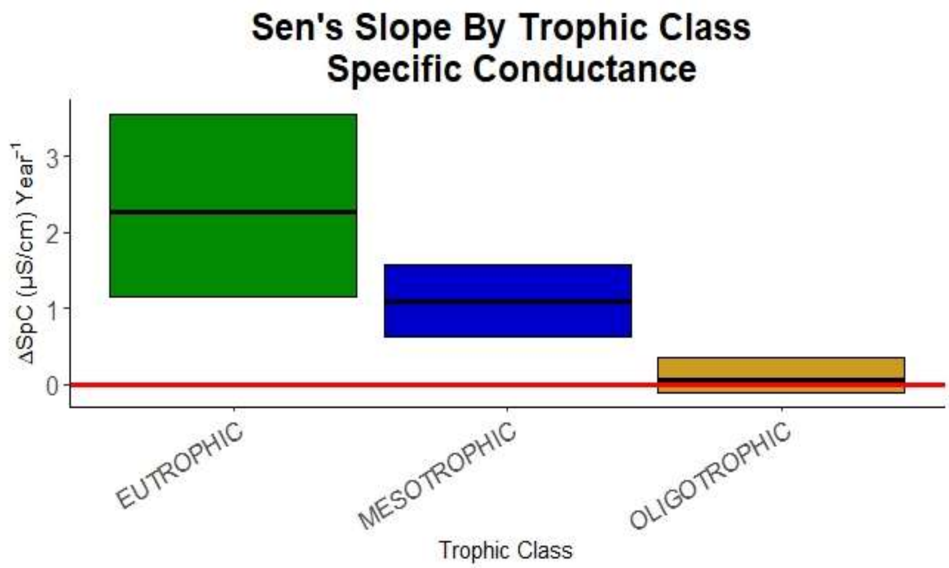
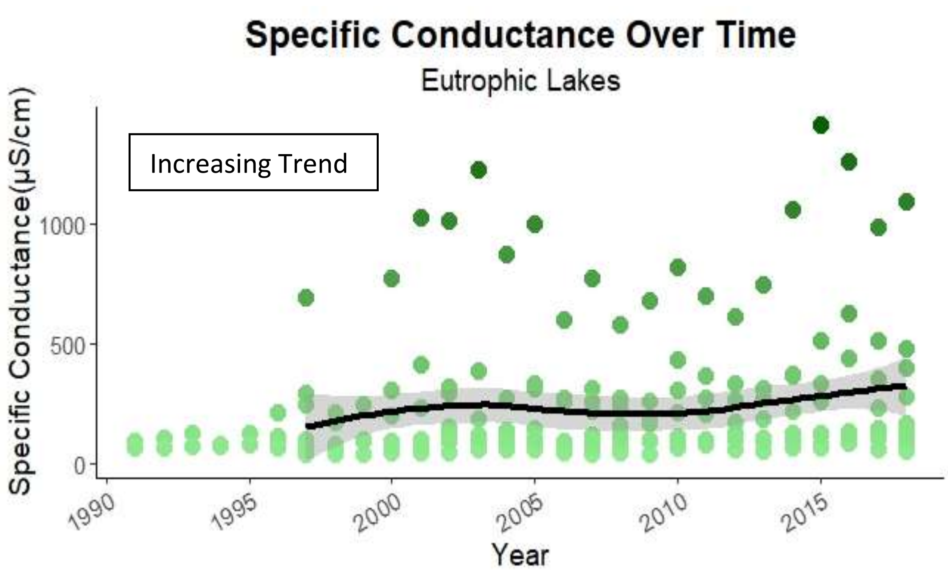
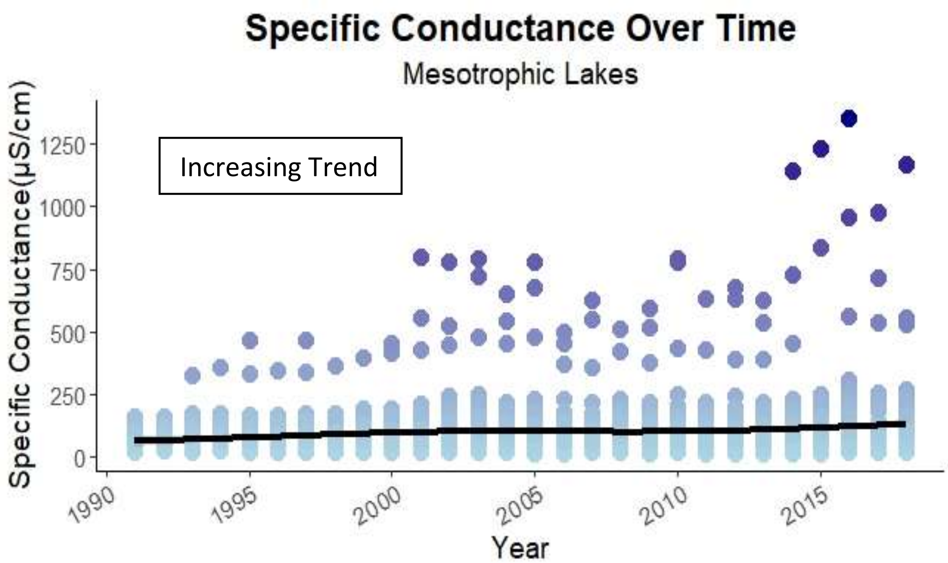


Figure 17. Annual median specific conductance values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction. For eutrophic lakes, trend analysis occurred from 1997 to 2018. For mesotrophic and oligotrophic lakes, trend analysis occurred from 1991 to 2018. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis.

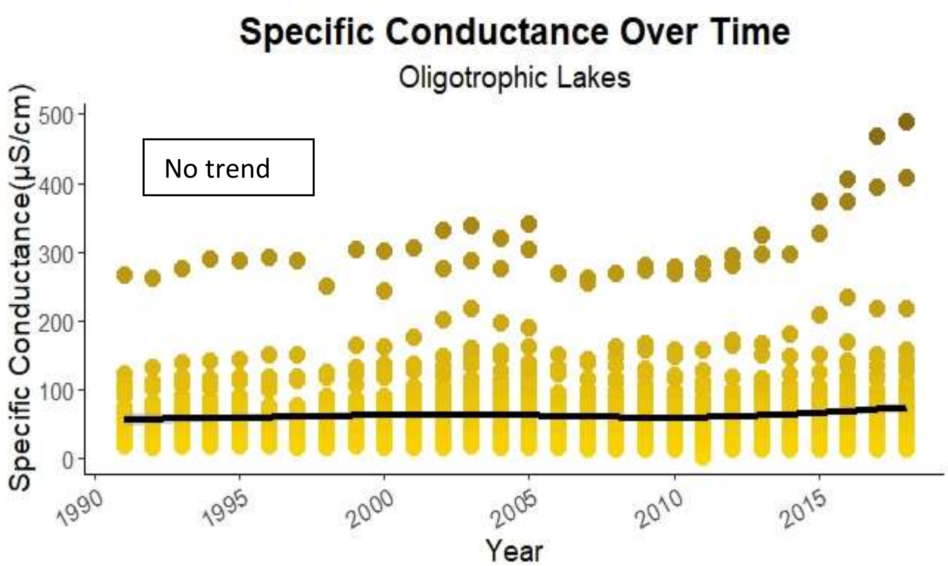
A.



B.



C.



3.7.3 Short-term change

To examine potentially rapid changes in specific conductance, the most recent five years of data (2014–2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 2,941 records from 119 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher, or similar specific conductance values in the current five years compared to the previous reporting period.

OUTCOME(S): Out of the 119 waterbodies investigated, 95 waterbodies or 79.8% had significantly different specific conductance in the previous compared current time periods. Of the waterbodies with significant differences, 95 or 100% had higher specific conductance in the current time period as compared to the previous.

3.7.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies within each VLAP region with stable, increasing, and decreasing trends in specific conductance.

OUTCOME(S): The Lakes region had the greatest number of waterbodies with increasing specific conductance trends (16 waterbodies [55.2%]), followed by Merrimack Valley (13 waterbodies [65%]) and Dartmouth Lake Sunapee (12 waterbodies [30.8%]; Table 9). The Great North Woods and Seacoast regions also had at least half of their waterbodies with increasing specific conductance levels; however, Great North Woods was composed of only two waterbodies (Table 9). The Monadnock region had the most waterbodies with decreasing specific conductance levels (7 waterbodies [23.3%]; Table 9).

Table 9. Number of VLAP waterbodies with increasing, decreasing, or no trend in specific conductance by region. Only waterbodies with a minimum of ten years of data from 1991 – 2018 were included in the analysis.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	39	23	12	4	*59.0%*	*30.8%*	*10.3%*
GNW	2	1	1	0	*50.0%*	*50.0%*	*0.0%*
Lakes	29	12	16	1	*41.4%*	*55.2%*	*3.4%*
Monadnock	30	14	9	7	*46.7%*	*30.0%*	*23.3%*
MV	20	7	13	0	*35.0%*	*65.0%*	*0.0%*
Seacoast	12	6	6	0	*50.0%*	*50.0%*	*0.0%*
WM	18	13	5	0	*72.2%*	*27.8%*	*0.0%*
ALL	**150**	**76**	**62**	**12**	***50.7%***	***41.3%***	***8.0%***

3.8 Total Phosphorus

Total phosphorus is a measure of all the phosphorus forms present in the water, including inorganic and organic forms. It is typically the limiting nutrient for aquatic plants and algae in NH lakes and directly relates to a waterbody's trophic status. Excessive amounts of phosphorus may impair the aesthetics and recreational use of waterbody by causing increased rooted plant growth and algal blooms. Sources of total phosphorus come from natural (background weathering, leaf litter) or anthropogenic (stormwater run-off, siltation, septic system inputs, lawn fertilizers) sources. Natural total phosphorus levels vary depending on trophic status. Oligotrophic water bodies are expected to have total phosphorus below 8 µg/L, mesotrophic waterbodies ≤ 12 µg/L, and eutrophic waterbodies ≤ 28 µg/L (CALM 2018).

3.8.1 Current Condition

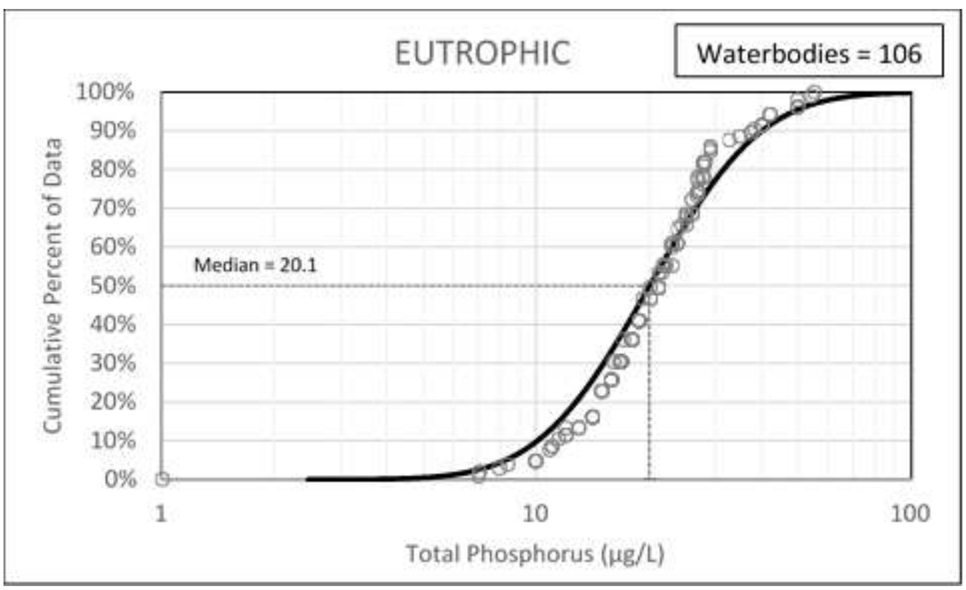
Statewide total phosphorus frequency distributions were summarized from all available lake and pond data collected by various programs from 1991 to 2018. Data were used to build frequency distributions by trophic class (Section 2.2; Figure 18). Data from 213 oligotrophic, 305 mesotrophic, and 106 eutrophic waterbodies were used to construct each frequency distribution (Figure 18). Overall, eutrophic waterbodies had a total phosphorus median of 20.1 µg/L, with the 25th percentile at 14 µg/L and the 75th percentile at 28.9 µg/L. The mesotrophic waterbodies had total phosphorus median of 11.4 µg/L, with the 25th percentile at 8.3 µg/L and the 75th percentile at 15.7 µg/L. Five (1.3%) mesotrophic waterbodies had a median total phosphorus concentration below detection limit (5 µg/L). Oligotrophic waterbodies had a total phosphorus median of 6.7 µg/L, with the 25th percentile at 4.5 µg/L and the 75th percentile at 10.1 µg/L. Twenty-seven (12.2%) oligotrophic waterbodies had a median total phosphorus concentration below detection limit (5 µg/L).

MEASURE(S) OF CONDITION: Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median total phosphorus value below the 25th percentile of the statewide distribution of total phosphorus data by trophic class. Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median total phosphorus value above the 75th percentile of statewide distribution of total phosphorus data by trophic class.

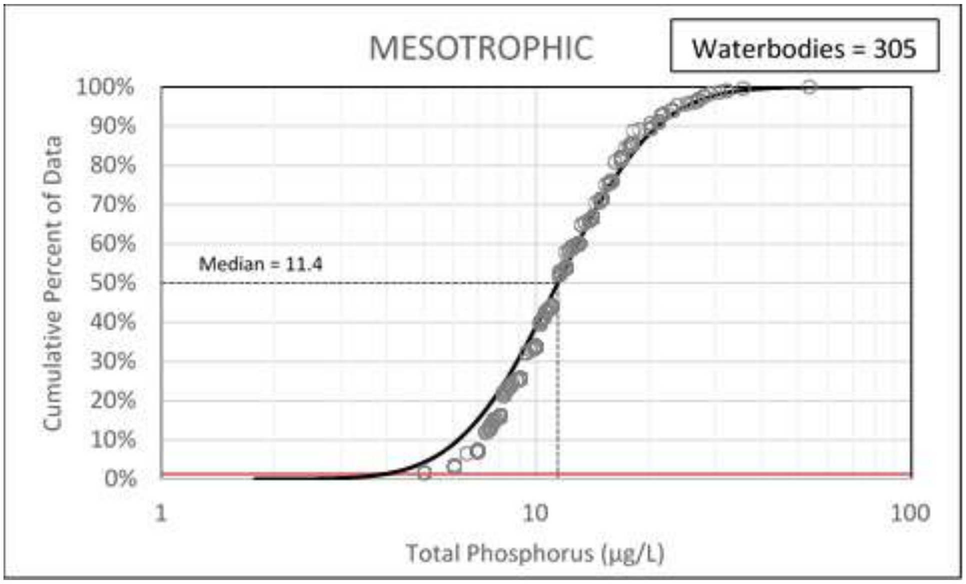
OUTCOME(S): For eutrophic waterbodies, one out of 10 (10%) were below the 25th percentile and no waterbodies were above the 75th percentile. For mesotrophic waterbodies, 23 of 71 (32.4%) were below the 25th percentile and 6 of 71 (8.5%) were above the 75th percentile. For oligotrophic waterbodies, 4 out of 69 (5.8%) were below the 25th percentile and 5 out of 69 (7.25%) were above the 75th percentile.

Figure 18. Statewide data distribution for total phosphorus by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018. The cumulative percentage of waterbodies below the detection limit of 5 µg/L is indicated by a solid red line.

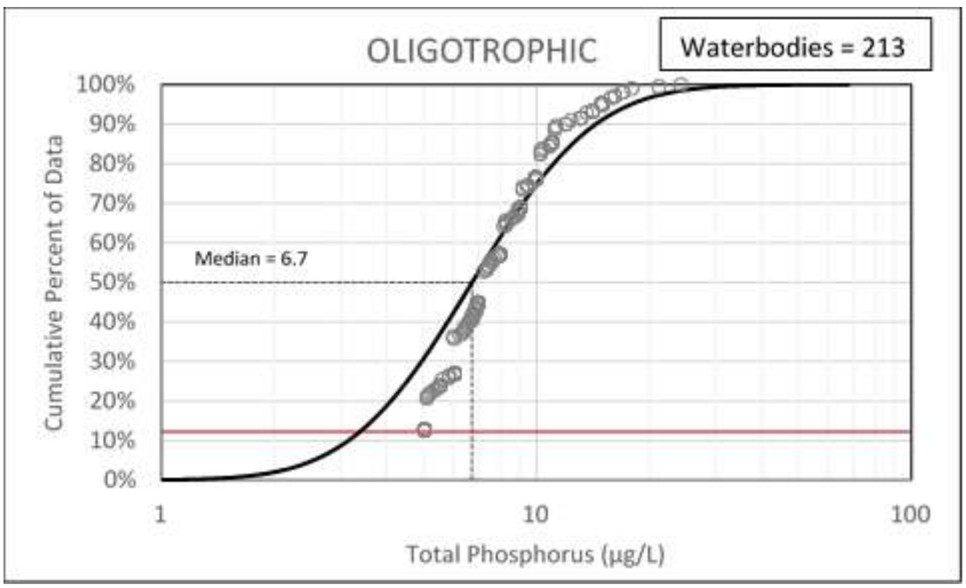
A.



B.



C.



3.8.2 Long-term trend

An initial Environmental Monitoring Database query of VLAP total phosphorus data produced a datafile of 31,679 records. The dataset was refined by removing invalidated or blank data records, restricting years to 1991 – 2018, and targeting samples collected in the epilimnion or topmost layer in the water column. Only records collected at the deepest location in the waterbody, which best represents whole lake conditions, and from June 1 through September 15 were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with fewer than 10 years of data were removed from the dataset. Annual medians by individual waterbody and trophic class were calculated. Annual medians that were below the detection limit (5 µg/L) were noted and included in the analysis using the NADA package in R. A Mann Kendall trend test and corresponding Sen slope were calculated for each individual waterbody as well as by trophic class (Section 2.2). The final dataset contained 8,186 records.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in total phosphorus, by individual waterbody and trophic class. An increasing trend in total phosphorus indicates anthropogenic influences, such as exposure to fertilizers or septic inputs. A decreasing trend suggests decreases in nutrients.

OUTCOME(S): One-hundred-fifty VLAP lakes and ponds were examined for individual Mann Kendall trends in total phosphorus levels. Out of the 150 waterbodies, 10 were eutrophic, 71 were mesotrophic, and 69 were oligotrophic. These waterbodies had a minimum of ten and a maximum of 28 years of data spanning from 1991 to 2018.

Overall, 88.6% of the waterbodies analyzed had no trend in total phosphorus levels, with 4.0% experiencing an increase in total phosphorus levels and 7.3% experiencing a decrease (Table 10). As a group, eutrophic waterbodies displayed a significant increase in total phosphorus while mesotrophic and oligotrophic waterbodies displayed no trend (Figures 19, 20).

Table 10. Number of VLAP waterbodies with increasing, decreasing, or no trend in total phosphorus levels.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	10	7	1	2	*70.0%*	*10.0%*	*20.0%*
MESOTROPHIC	71	65	3	3	*91.5%*	*4.2%*	*4.2%*
OLIGOTROPHIC	69	61	2	6	*88.4%*	*2.9%*	*8.7%*
ALL	**150**	**133**	**6**	**11**	***88.7%***	***4.0%***	***7.3%***

Figure 19. Sen slope estimates (± 5%) of total phosphorus trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of total phosphorus trends by trophic class (Significance at $p < 0.05$) were $p < 0.01$ for eutrophic, 0.94 for mesotrophic, and 0.29 for oligotrophic waterbodies. Trend analysis was performed on ten eutrophic waterbodies from 1997 -2018, and 71 mesotrophic and 69 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five waterbodies each year.

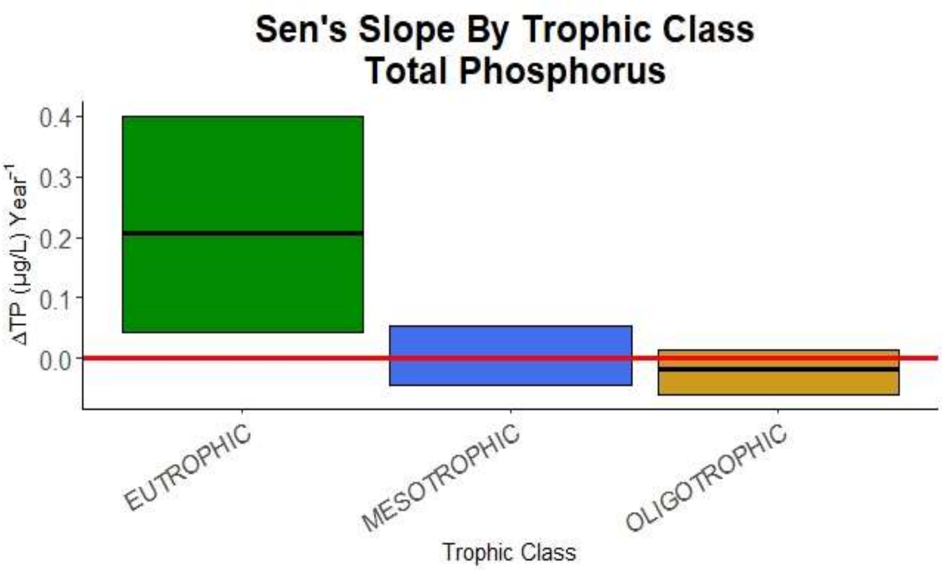
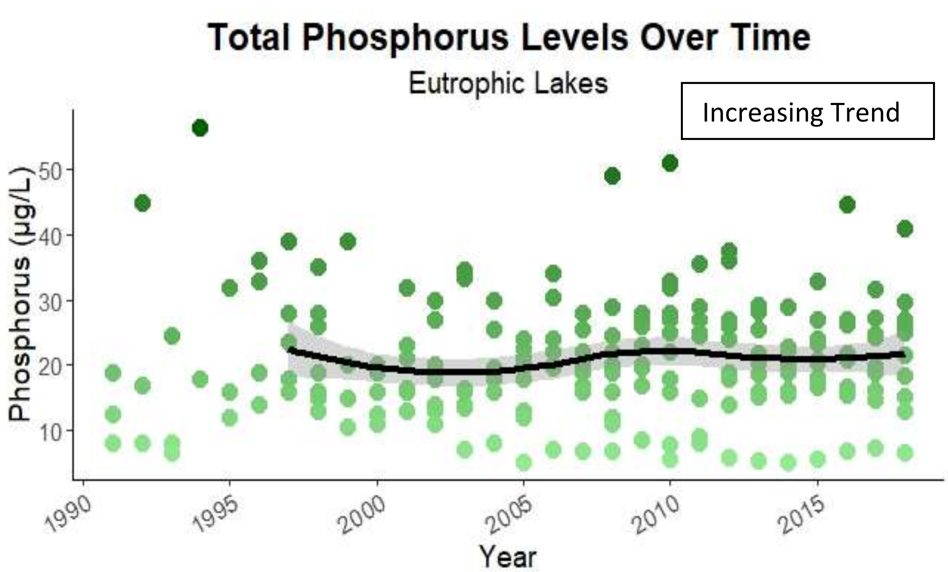
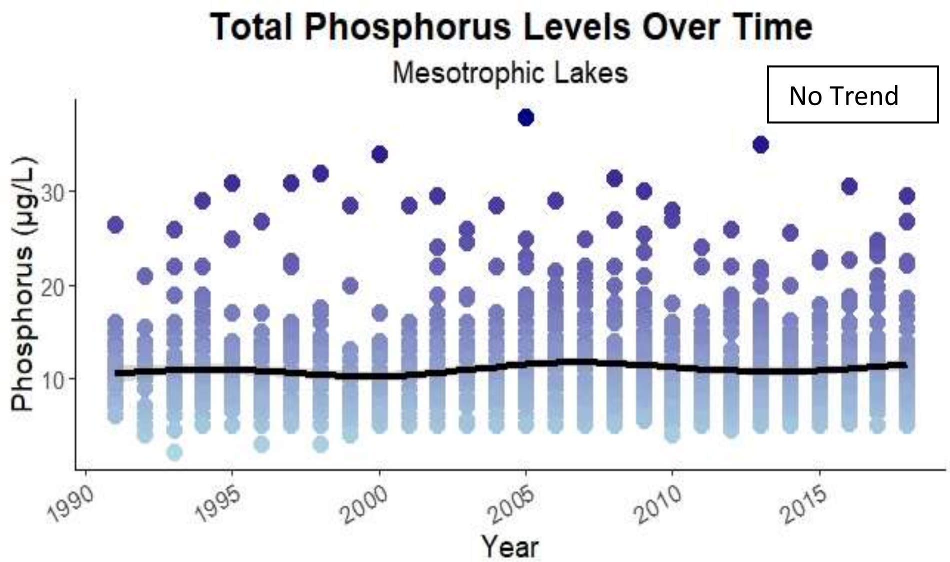


Figure 20. Annual median total phosphorus values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Plots include non-detect records, displayed at their detection limit value. A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction. For eutrophic lakes, trend analysis occurred from 1997 to 2018. For mesotrophic and oligotrophic lakes, trend analysis occurred from 1991 to 2018. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis.

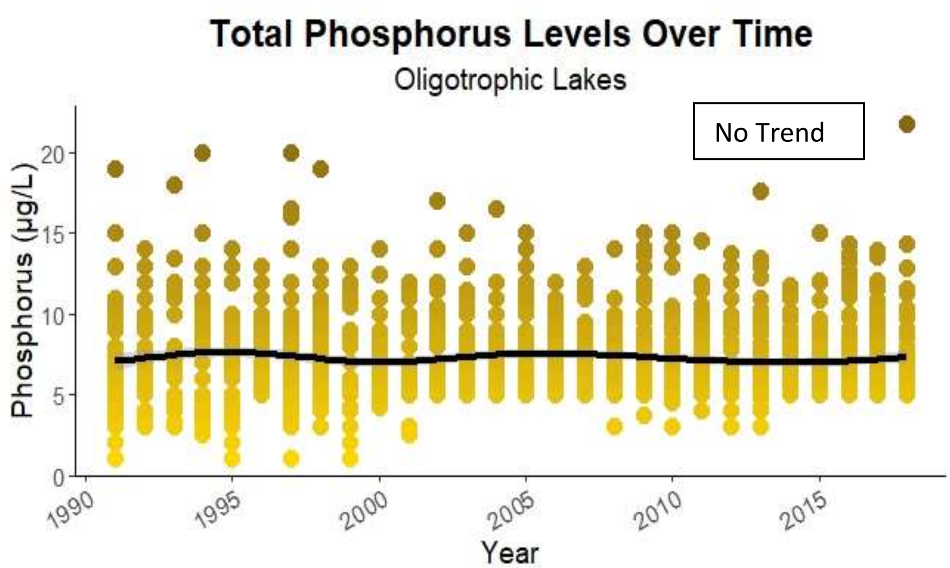
A.



B.



C.



3.8.3 Short-term change

To examine these potential rapid changes in total phosphorus, the most recent five years of data (2014–2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 2,952 records for 119 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher or similar total phosphorus values in the current five years compared to the previous reporting period.

OUTCOME(S): Out of the 119 waterbodies investigated, 12 waterbodies (10.1%) had significantly different total phosphorus concentrations in the previous time period compared to the current. Of the waterbodies with significant differences, seven (5.9%) had lower total phosphorus in the current time period as compared to the previous. Five (4.2%) of the waterbodies with significant differences had higher total phosphorus in the current time period compared to the previous.

3.8.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies within each VLAP region with stable, increasing and decreasing trends in total phosphorus.

OUTCOME(S): The Lakes region (3 waterbodies [10.3%]) had the most individual waterbodies with decreasing total phosphorus trends (Table 11). The Monadnock (2 waterbodies [6.7%]) and Merrimack Valley (2 waterbodies [10%]) regions had the most individual waterbodies with increasing total phosphorus trends (Table 11).

Table 11. Number of VLAP waterbodies with increasing, decreasing, or no trend in total phosphorus by region. Only waterbodies with a minimum of ten years of data from 1991 – 2018 were included in the analysis.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	39	37	0	2	*94.9%*	*0.0%*	*5.1%*
GNW	2	2	0	0	*100.0%*	*0.0%*	*0.0%*
Lakes	29	25	1	3	*86.2%*	*3.4%*	*10.3%*
Monadnock	30	26	2	2	*86.7%*	*6.7%*	*6.7%*
MV	20	17	2	1	*85.0%*	*10.0%*	*5.0%*
Seacoast	12	10	0	2	*83.3%*	*0.0%*	*16.7%*
WM	18	16	1	1	*88.9%*	*5.6%*	*5.6%*
ALL	**150**	**133**	**6**	**11**	***88.7%***	***4.0%***	***7.3%***

4.0 RESULTS FOR ACCESSORY INDICATORS

4.1 Alkalinity

Acid Neutralizing Capacity (ANC), also known as alkalinity or buffering capacity, describes the ability of a solution to resist changes in pH by neutralizing acidic inputs. Historically, acidifying compounds, such as sulfur dioxide, were generated from the burning of coal for electricity, and the prevailing wind patterns caused the deposition of acidifying compounds (i.e. acid rain) in the Northeast from the Midwest. Additionally, New Hampshire's natural geology is mostly granitic bedrock, which lacks the buffering properties that help protect waterbodies from acid inputs. The combined influence of anthropogenically generated pollutants and natural geology left New Hampshire's waterbodies with particularly low alkalinity levels. The 1970 and 1990 federal Clean Air Act limited the emission of acidifying pollutants, which is thought to have initiated a gradual and ongoing recovery of alkalinity (Strock et al. 2014). Simultaneously, salt, through the sodium ion, also contributes to increases in alkalinity. Since the 1940s, salt has been used to deice roadways and parking lots in New England (Trowbridge et al. 2010). The input of salt, primarily from road salt but also from water softeners and septic systems, appears to be artificially increasing alkalinity levels (Kaushal et al. 2018).

4.1.1 Current Condition

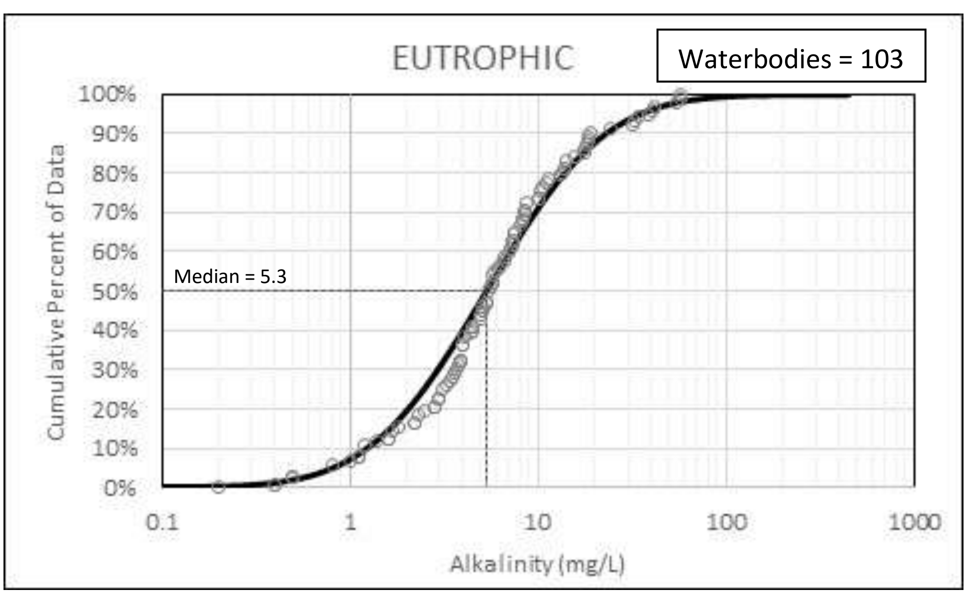
Statewide alkalinity frequency distributions were developed from all available lake and pond data collected by various programs from 1991 to 2018. The data were used to build frequency distributions by trophic class (Section 2.2; Figure 21). Medians from 206 oligotrophic, 300 mesotrophic, and 103 eutrophic waterbodies were used to construct each respective frequency distribution (Figure 21). Two mesotrophic and two oligotrophic waterbodies were not included due to zero or negative values. Eutrophic waterbodies had an alkalinity median of 5.3 mg/L, with the 25th percentile at 2.5 mg/L and the 75th percentile at 11.5 mg/L. The mesotrophic waterbody statewide distribution had an alkalinity median of 4.8 mg/L, with the 25th percentile at 2.5 mg/L and the 75th percentile at 9.1 mg/L. The oligotrophic waterbody statewide distribution had an alkalinity median of 3.8 mg/L, with the 25th percentile at 2.0 mg/L and the 75th percentile at 7.1 mg/L.

MEASURE(S) OF CONDITION: Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median alkalinity value below the 25th percentile of the statewide distribution of alkalinity data by trophic class. Number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median alkalinity value above the 75th percentile of statewide distribution of alkalinity data by trophic class.

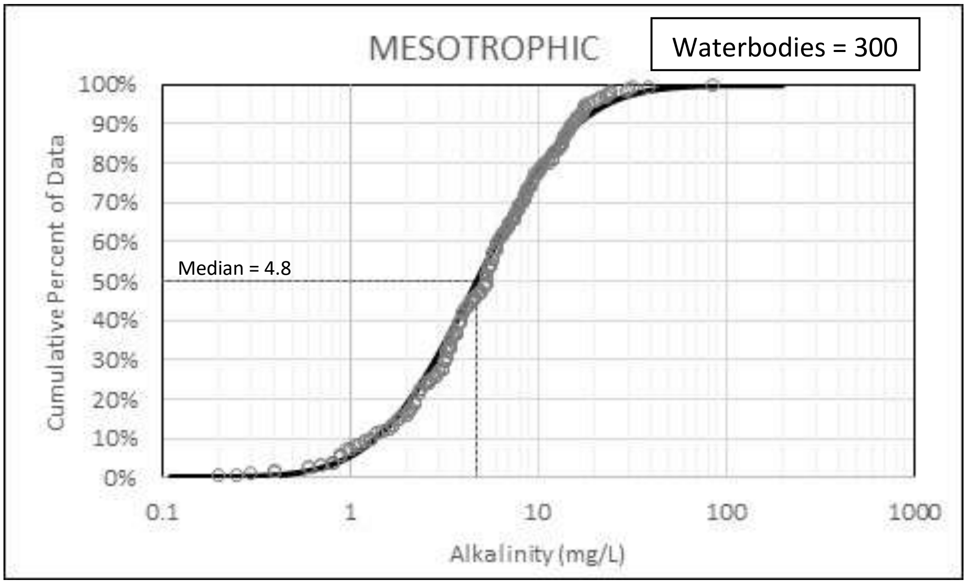
OUTCOME(S): For eutrophic waterbodies, one out of eight (12.5%) was below the 25th percentile and four out of eight (50%) were above the 75th percentile. For mesotrophic waterbodies, nine out of 70 (12.9%) were below the 25th percentile and 19 out of 70 (27.1%) were above the 75th percentile. For oligotrophic waterbodies, 14 out of 69 (20.3%) were below the 25th percentile and 13 out of 69 (18.8%) were above 75th percentile.

Figure 21. Statewide data distribution for alkalinity by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018.

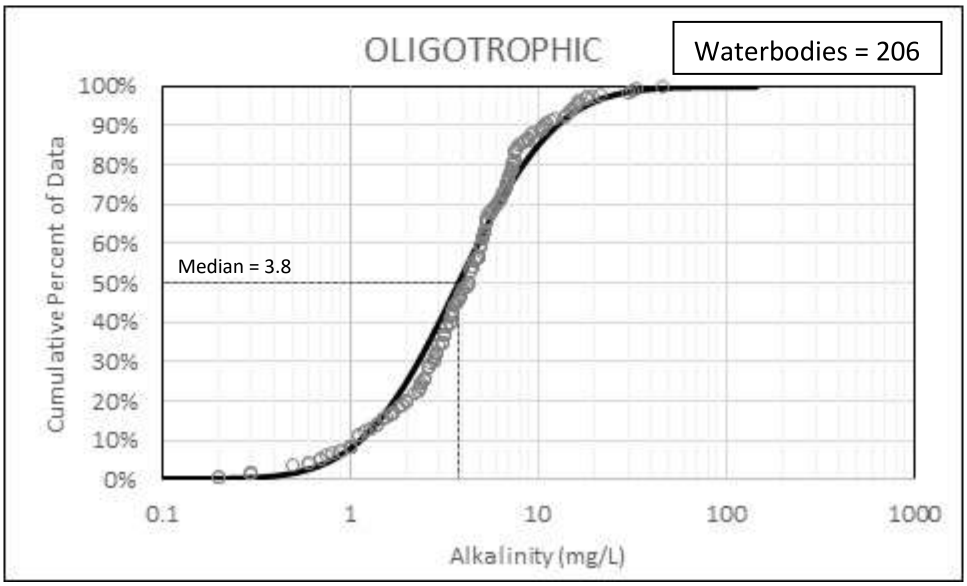
A.



B.



C.



4.1.2 Long-term trend

An initial Environmental Monitoring Database query of VLAP alkalinity data produced a datafile of 16,826 records. The dataset was refined by removing invalidated or blank data records, restricting years to 1991 – 2018, and targeting samples collected in the epilimnion or topmost layer in the water column. Only records collected at the deepest location in the waterbody, which best represents whole lake conditions, and from June 1 through September 15 were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with fewer than 10 years of data were removed from the dataset. Annual medians by individual waterbody and trophic class were calculated. A Mann Kendall trend test and corresponding Sen slope were calculated for each individual waterbody as well as by trophic class (Section 2.2). The final dataset contained 7,906 records.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in alkalinity, by individual waterbody and trophic class. An increasing trend in alkalinity could indicate recover from acidic inputs; however, it may also reflect increases in salt input. A decreasing trend suggests acidifying compounds (e.g. sulfate) are entering the waterbody.

OUTCOME(S): One-hundred-forty-seven VLAP lakes and ponds were examined for individual Mann Kendall trends in alkalinity levels. Out of the 147 waterbodies, 8 were eutrophic, 70 were mesotrophic, and 69 were oligotrophic. These waterbodies had a minimum of ten and a maximum of 28 years of data spanning from 1991 to 2018.

Overall, 40.8% of the waterbodies analyzed had no trend in alkalinity, with 58.5% experiencing an increase in alkalinity and 0.7% experiencing a decrease (Table 12). Eutrophic and mesotrophic waterbodies displayed significant increases in alkalinity while oligotrophic waterbodies did not have a trend (Figures 22, 23).

Table 12. Number of VLAP waterbodies with increasing, decreasing, or no trend in alkalinity.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	8	5	3	0	*62.5%*	*37.5%*	*0.0%*
MESOTROPHIC	70	29	40	1	*41.4%*	*57.1%*	*1.4%*
OLIGOTROPHIC	69	26	43	0	*37.7%*	*62.3%*	*0.0%*
ALL	**147**	**60**	**86**	**1**	***40.8%***	***58.5%***	***0.7%***

Figure 22. Sen slope estimates (± 5%) of alkalinity trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of alkalinity trends by trophic class (Significance at $p < 0.05$) were $p < 0.0001$ for eutrophic, < 0.01 for mesotrophic, and 0.22 for oligotrophic waterbodies. Trophic trend analysis was performed on eight eutrophic waterbodies from 1997 -2018, and 70 mesotrophic and 69 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five unique waterbodies in a given year.

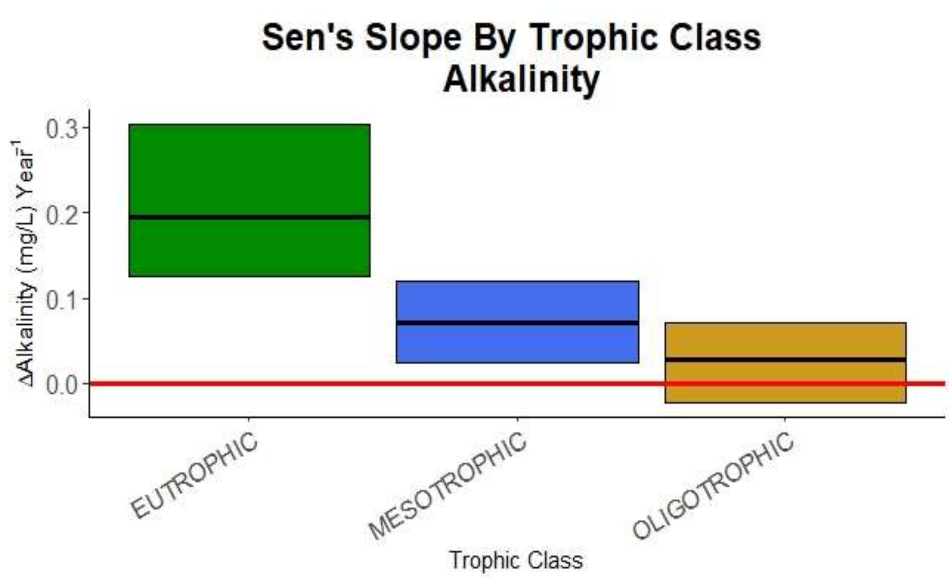
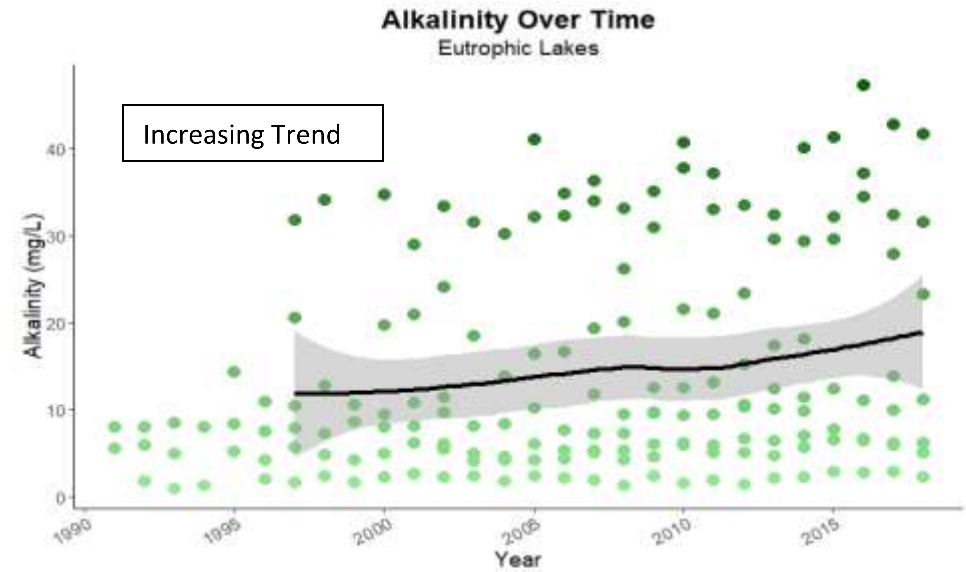
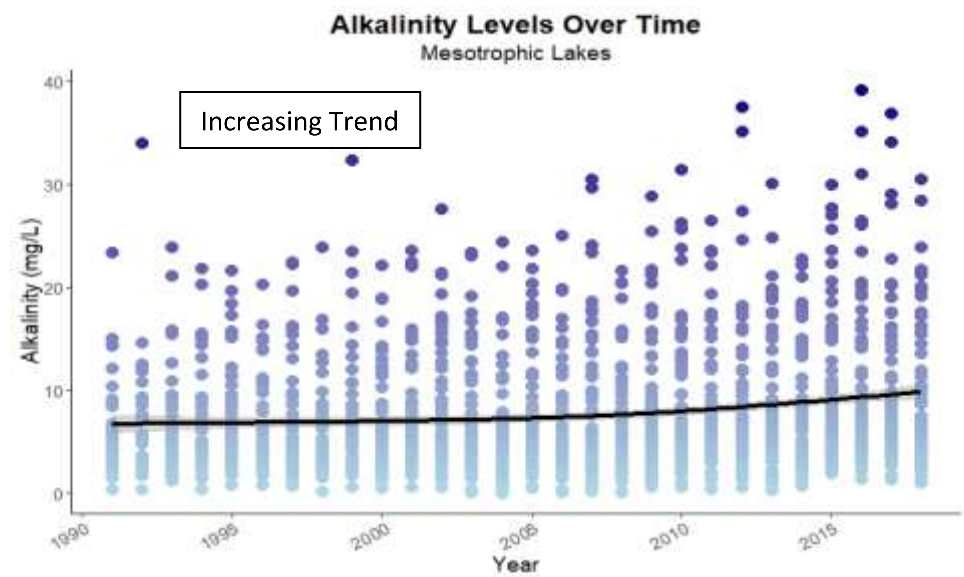


Figure 23. Annual median alkalinity values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction. For eutrophic lakes, trend analysis occurred from 1997 to 2018. For mesotrophic and oligotrophic lakes, trend analysis occurred from 1991 to 2018. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis.

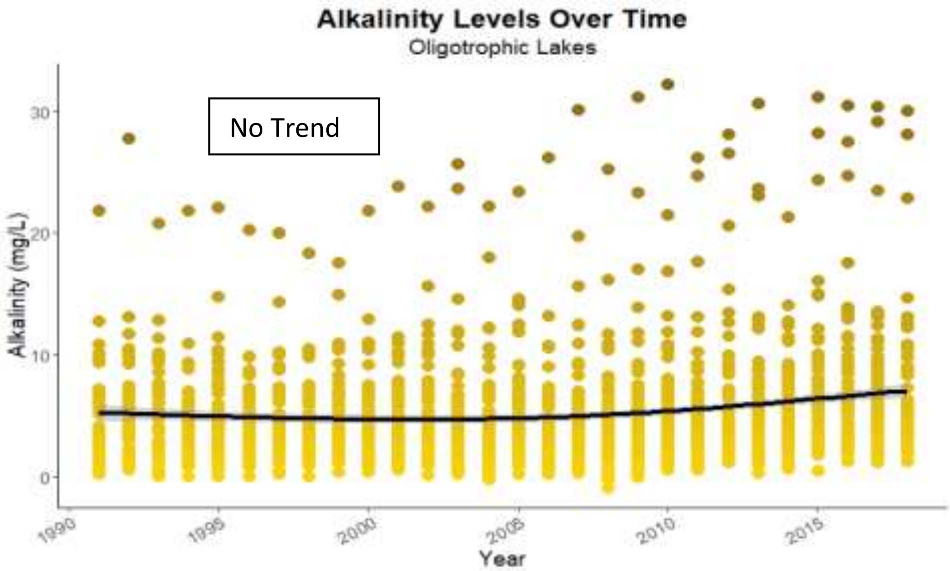
A.



B.



C.



4.1.3 Short-term change

To examine these potential rapid changes in alkalinity, the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 2,438 records for 103 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher or similar alkalinity values in the current five-year time period compared to the previous five-year period.

OUTCOME(S): Out of the 103 waterbodies investigated, 76 waterbodies or 73.8% has significantly different alkalinity levels in the previous time period compared to current time period. Of the waterbodies with significant differences, all 76 (100%) had higher alkalinity in the current time period as compared to the previous time period.

4.1.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies within each VLAP region with stable, increasing, and decreasing trends in alkalinity.

OUTCOME(S): The Dartmouth Lake Sunapee (23 waterbodies [59%]) and Monadnock (17 waterbodies [56.7%]) regions had the highest number of waterbodies with an increasing trend (Table 13). Great North Woods (2 waterbodies [100%]), Merrimack Valley (13 waterbodies [68.4%]) and Seacoast (10 waterbodies [90.9%]) all had increasing alkalinity in greater than half of their waterbodies (Table 13). The only waterbody that had a decreasing trend was located in the Monadnock region (Table 13).

Table 13. Number of VLAP waterbodies with increasing, decreasing, or no trend in alkalinity by region. Only waterbodies with a minimum of ten years of data from 1991 – 2018 were included in the analysis.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	39	16	23	0	*41.0%*	*59.0%*	*0.0%*
GNW	2	0	2	0	*0.0%*	*100.0%*	*0.0%*
Lakes	28	15	13	0	*53.6%*	*46.4%*	*0.0%*
Monadnock	30	12	17	1	*40.0%*	*56.7%*	*3.3%*
MV	19	6	13	0	*31.6%*	*68.4%*	*0.0%*
Seacoast	11	1	10	0	*9.1%*	*90.9%*	*0.0%*
WM	18	10	8	0	*55.6%*	*44.4%*	*0.0%*
ALL	**147**	**60**	**86**	**1**	***40.8%***	***58.5%***	***0.7%***

4.2 Dissolved Oxygen

Dissolved oxygen is a measure of how much oxygen is in the water column and available to aquatic organisms. Levels of dissolved oxygen are influenced by many factors, such as temperature, algae and vascular plant growth, decomposition, stratification, lake morphology, dissolved mineral concentration and time of day. For the majority of New Hampshire's lakes and ponds, a dissolved oxygen level of < 5 mg/L in the epilimnion (top water layer) is considered detrimental for aquatic life (2018 CALM). Dissolved oxygen is typically lowest in early morning, as photosynthesis has paused due to lack of light while decomposition continues. Excessive algal or plant growth, and the subsequent decomposition, can cause large fluctuations in dissolved oxygen, with high values during the day but low values at night. Additionally, the solubility of oxygen decreases as temperature or salinity increases.

4.2.1 Current Condition

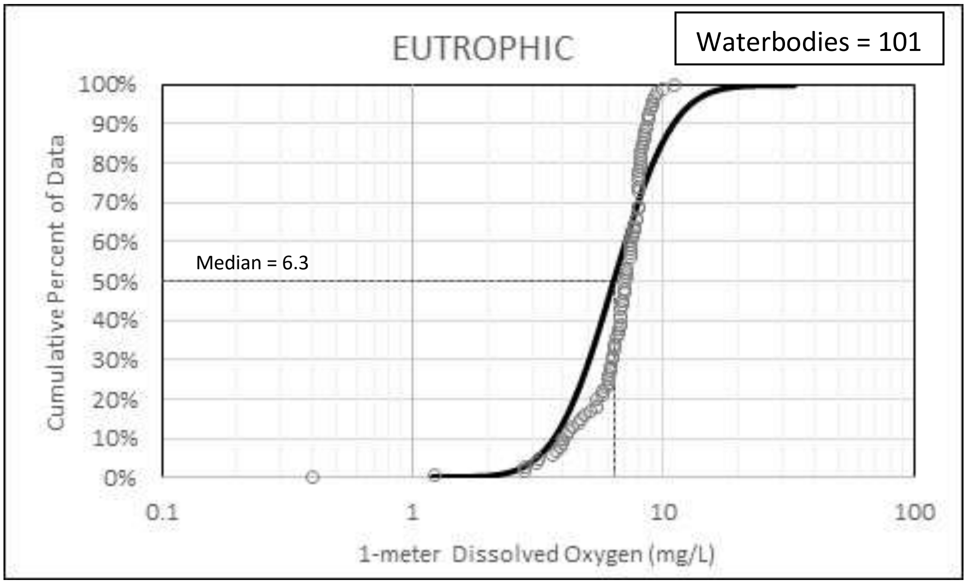
Statewide dissolved oxygen distributions were summarized from all available lake and pond data collected by various programs from 1991 to 2018. Data were used to build frequency distributions by trophic class (Section 2.2; Figure 24). Only data from one meter (± 0.1) below the surface at deep spot locations were examined. Medians from 204 oligotrophic, 300 mesotrophic, and 101 eutrophic waterbodies were used to construct each distribution (Figure 24). Eutrophic waterbodies had a 1-meter dissolved oxygen median of 6.3 mg/L, with the 25th percentile at 4.8 mg/L and the 75th percentile at 8.5 mg/L. Mesotrophic waterbodies had a 1-meter dissolved oxygen median of 7.9 mg/L, with the 25th percentile at 7.3 mg/L and the 75th percentile at 8.5 mg/L. Oligotrophic waterbodies had a 1-meter dissolved oxygen median of 8.2 mg/L, with the 25th percentile at 7.8 mg/L and the 75th percentile at 8.6 mg/L.

MEASURE(S) OF CONDITION: The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median 1-meter dissolved oxygen value below the 25th percentile of the statewide distribution for each respective trophic class. The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median 1-meter dissolved oxygen value above the 75th percentile of statewide distribution for each respective trophic class.

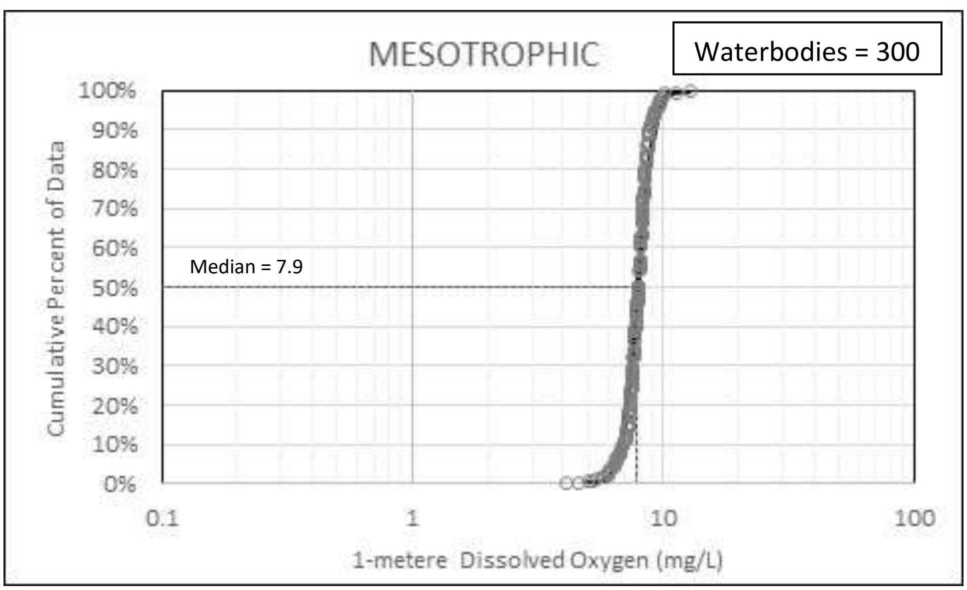
OUTCOME(S): For eutrophic waterbodies, eight waterbodies were examined and none were below the 25th percentile or above the 75th percentile. For mesotrophic waterbodies, 5 out of 69 (7.3%) were below the 25th percentile and 3 out of 69 (4.4%) were above the 75th percentile. For oligotrophic waterbodies, 8 out of 68 (11.8%) were below the 25th percentile and 3 out of 68 (4.4%) were above 75th percentile.

Figure 24. Statewide data distribution for dissolved oyxgen by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018.

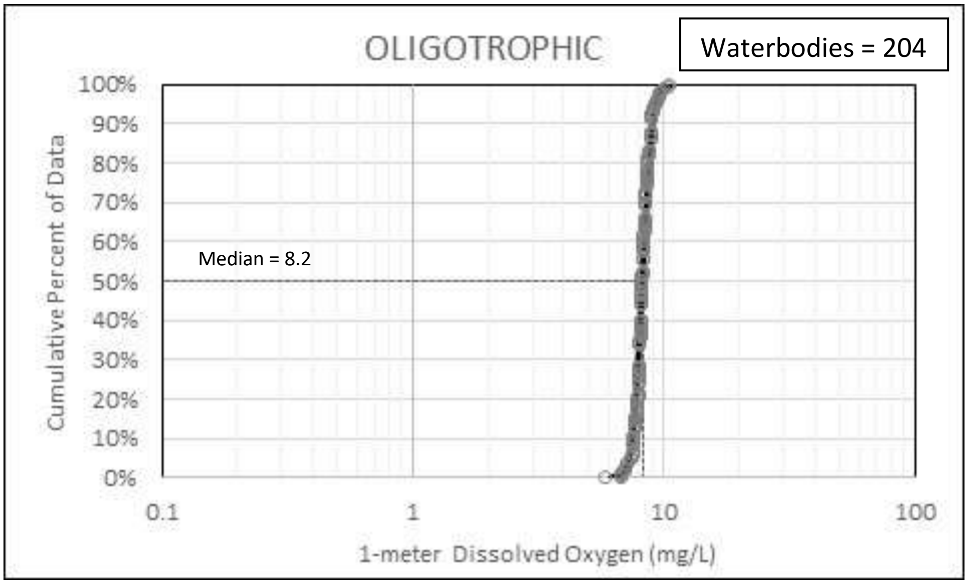
A.



B.



C.



4.2.2 Long-term trend

An initial Environmental Monitoring Database query of VLAP dissolved oxygen data produced a datafile of 110,258 records. The dataset was refined by removing invalidated or blank data records, restricting years to 1991 – 2018, and targeting samples collected from 1 (±0.1) meter below the surface. Only records collected at the deep site location in the waterbody, which best represents whole lake conditions, and from June 1 through September 15 were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with fewer than ten years of data were removed from the dataset. Annual medians by individual waterbody and trophic class were calculated. A Mann Kendall trend test and corresponding Sen slope were calculated for each individual waterbody as well as by trophic class (Section 2.2). The final dataset contained 3,657 records.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in 1-meter dissolved oxygen, by individual waterbody and trophic class. An increasing trend in 1-meter dissolved oxygen could indicate increases in algal production, cooler water, or a decrease in dissolved minerals. A decreasing trend could signal increasing decomposition, warmer water, or increasing dissolved minerals.

OUTCOME(S): One-hundred-forty-five VLAP lakes and ponds were examined for individual Mann Kendall trends in dissolved oxygen levels. Out of the 145 waterbodies, 8 were eutrophic, 69 were mesotrophic, and 68 were oligotrophic. These waterbodies had a minimum of ten and a maximum of 28 years of data spanning from 1991 to 2018.

Overall, 82.8% of the waterbodies analyzed had no trend in dissolved oxygen at 1-meter, with 1.4% experiencing an increase in dissolved oxygen and 15.9% experiencing a decrease (Table 14). By trophic class, mesotrophic waterbodies had a significant decrease in dissolved oxygen at 1-meter below the surface (Figures 25, 26). Eutrophic and oligotrophic waterbodies did not display a trend (Figures 25, 26).

Table 14. Number of VLAP waterbodies with increasing, decreasing, or no trend in dissolved oxygen at 1-meter depth.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	8	7	0	1	*87.5%*	*0.0%*	*12.5%*
MESOTROPHIC	69	54	1	14	*78.3%*	*1.4%*	*20.3%*
OLIGOTROPHIC	68	59	1	8	*86.8%*	*1.5%*	*11.8%*
ALL	**145**	**120**	**2**	**23**	***82.8%***	***1.4%***	***15.9%***

Figure 25. Sen slope estimates (± 5%) of dissolved oxygen trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of dissolved oxygen at 1-meter trends by trophic class (Significance at $p < 0.05$) were $p = 0.76$ for eutrophic, 0.04 for mesotrophic, and 0.12 for oligotrophic waterbodies. Trend analysis was performed on 69 mesotrophic and 68 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five unique waterbodies each year; therefore, the trend analysis on eutrophic waterbodies included 1997, 2001 – 2014, and 2016 – 2018.

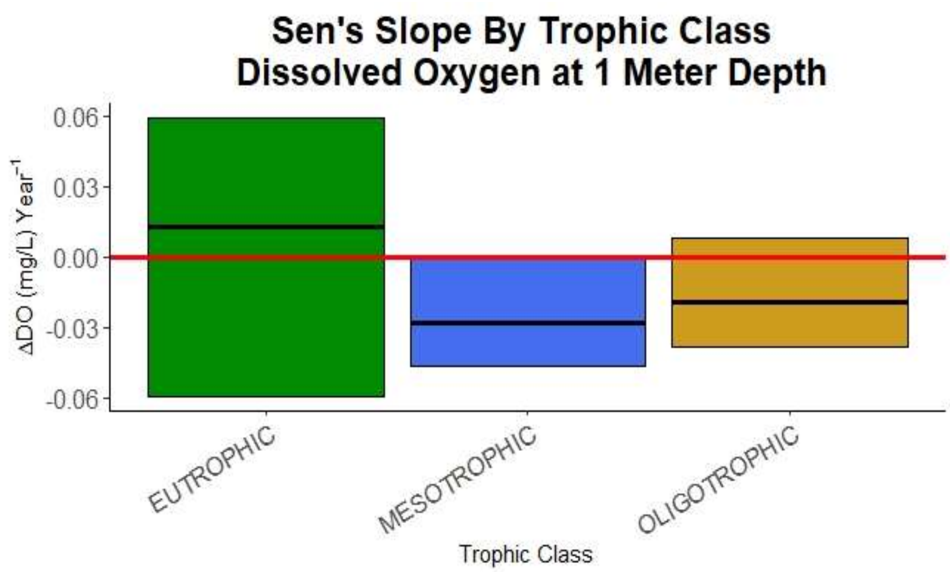
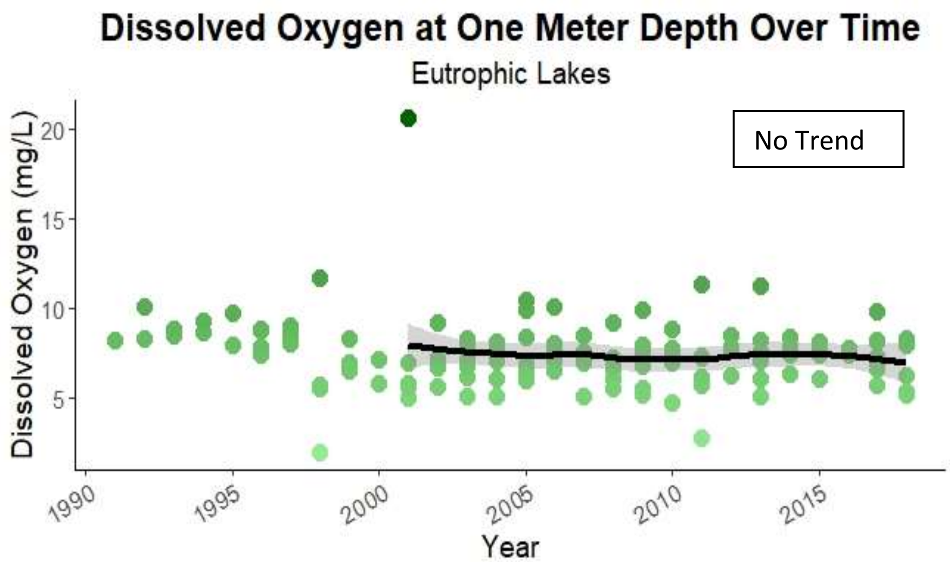
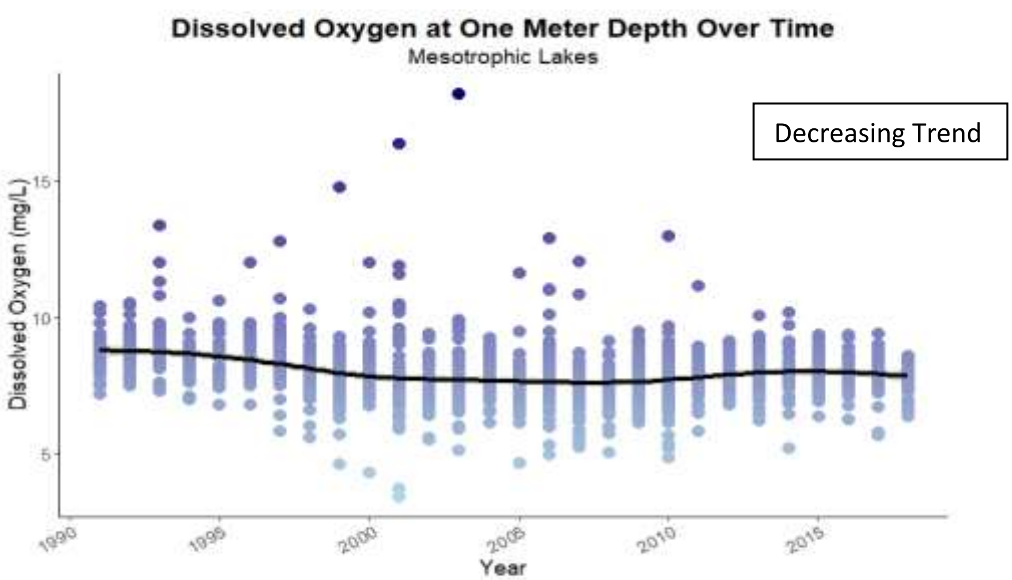


Figure 26. Annual median dissolved oxygen at 1-meter depth values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction for mesotrophic and oligotrophic waterbodies. For mesotrophic and oligotrophic lakes, trend analysis occurred from 1991 to 2018. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis. For eutrophic lakes, trend analysis occurred from 1997, 2001 – 2014, and 2016 – 2018.

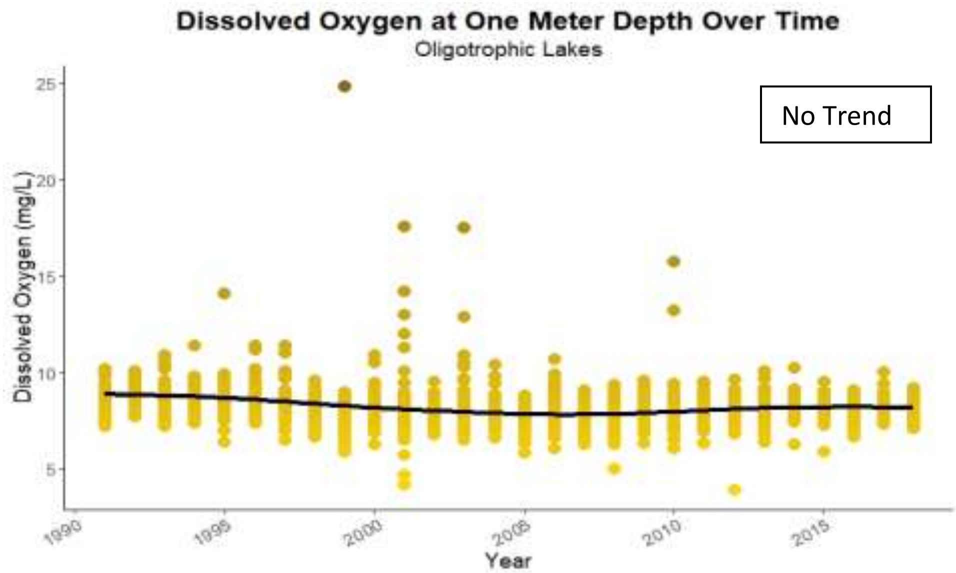
A.



B.



C.



4.2.3 Short-term change

To examine these potential rapid changes in dissolved oxygen at 1-meter depth, the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 2,438 records for 103 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher, or similar dissolved oxygen at 1-meter values in the current five years compared to the previous reporting period.

OUTCOME(S): Out of the 36 waterbodies investigated, five waterbodies (13.9%) had significantly different dissolved oxygen concentrations when the previous and current time periods were compared. Of the waterbodies with significant differences, all five waterbodies had higher dissolved oxygen concentrations at 1-meter depth in the current data group as compared to the previous. None of the waterbodies with a significant difference had lower dissolved oxygen concentrations in the current time period as compared to the previous.

4.2.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies within each VLAP region with stable, increasing, and decreasing trends in dissolved oxygen at 1-meter depth.

OUTCOME(S): The Dartmouth Lake Sunapee (7 waterbodies [18.4%]) and Monadnock (8 waterbodies [26.7%]) regions had the greatest number of waterbodies with decreasing trends in dissolved oxygen (Table 15). The Seacoast and White Mountain regions each had one waterbody with an increasing trend (Table 15).

Table 15. Number of VLAP waterbodies with increasing, decreasing, or no trend in 1-meter dissolved oxygen by region. Only waterbodies with a minimum of 10 years of data from 1991 – 2018 were included in the analysis.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	38	31	0	7	*81.6%*	*0.0%*	*18.4%*
GNW	2	1	0	1	*50.0%*	*0.0%*	*50.0%*
Lakes	28	25	0	3	*89.3%*	*0.0%*	*10.7%*
Monadnock	30	22	0	8	*73.3%*	*0.0%*	*26.7%*
MV	19	16	0	3	*84.2%*	*0.0%*	*15.8%*
Seacoast	10	9	1	0	*90.0%*	*10.0%*	*0.0%*
WM	18	16	1	1	*88.9%*	*5.6%*	*5.6%*
ALL	**145**	**120**	**2**	**23**	***82.8%***	***1.4%***	***15.9%***

4.3 Ice in/ Ice out Records

Surfaces of waterbodies in New Hampshire typically freeze during winter months. When ice covered, dissolved oxygen can drop, temperature remains low and aquatic communities are isolated. When the ice melts in the spring, temperature begins to rise, stratification is initiated, gaseous exchange is possible, plankton communities multiply and aquatic plants begin growing. Recording ice-in and ice-out dates year after year creates a valuable dataset. These data help track long-term climatological trends, assist in interpreting short-term seasonal lake conditions and help determine total days of ice cover on lakes. Since the specific day of ice-in and ice-out can vary widely from year to year, keeping a long-term dataset over many years using the same criteria is crucial. A record of the day of ice-in and ice-out that extends for decades allows scientists to break through the "noise" of the dataset and determine trends.

Analyzing long-term ice-out records at many New England lakes has found that the day of ice-out is changing. New England lakes are experiencing, on average, earlier ice-out (Creed et al. 2018; Hayhoe et al. 2006; Hodgkins et al. 2002). Ice-out is largely determined by air temperature, but can also be influenced by snow cover, cloudiness and wind (Hodgkins 2013). Earlier ice-out is associated with the changing climate (Hayhoe et al. 2006). The occurrence of ice-out earlier in the year has recreational, economic and environmental implications. Thinner ice and fewer days of ice cover reduce the time period for winter recreational activities on our lakes, which, in turn, negatively effects winter tourism activity. Environmentally, earlier ice-out allows lake water to begin warming sooner, stimulating plant and algal growth. Earlier ice-out will result in hotter summer water temperatures, lower water levels due to increased evaporation, and prolonged summer lake stratification, which may lead to longer periods and/or greater areas of depleted oxygen in lake bottom waters. These changes are favorable for more rapid eutrophication (i.e. aging) of waterbodies and cyanobacteria growth.

In 2011, VLAP began asking individuals and lake associations for historical ice-in and ice-out records after realizing that a central statewide repository for this information did not exist. Since then, VLAP has acquired records from 118 New Hampshire lakes. Ice-out can be defined in different ways. Some groups declare ice-out when the ice has melted and broken up enough to navigate a boat from one end of a lake to the other; others wait until a lake is entirely ice-free. The most important aspect for keeping a record is consistency in how the ice-in/ ice-out records are generated.

4.3.1 Long-term trend

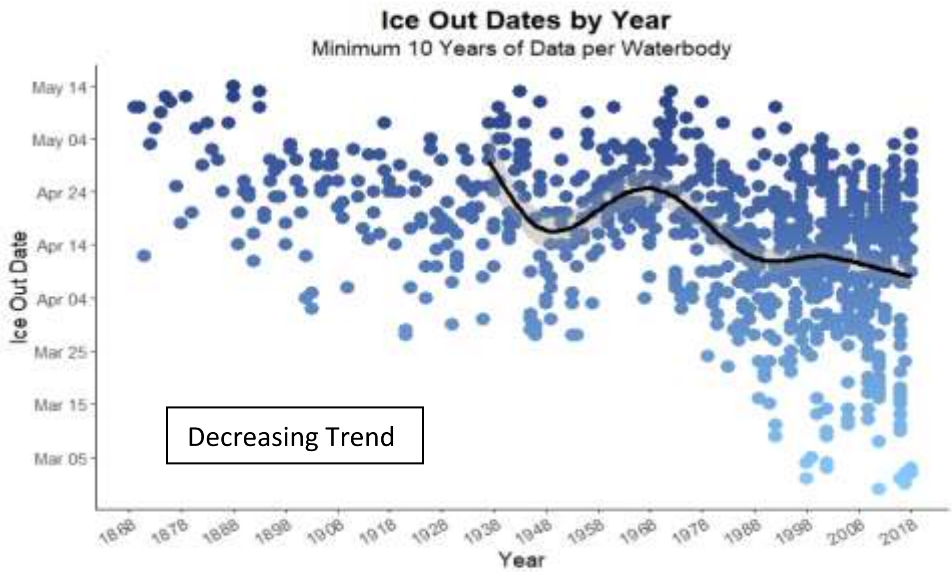
Due to the long period of time needed to determine a trend in ice-in or ice-out, the ice dataset was not limited to the 1991 – 2018 period stipulated in other sections of this report. For many lake groups, this is a new form of data collection, and records extend back only a few years. Additionally, as these data are more difficult to acquire, waterbodies that do not participate in VLAP were also included if their data were available (e.g. Lake Winnipesaukee). A Mann Kendall trend test and Sen slope were calculated for each individual waterbody that had a minimum of 10 years of ice-out records available as well as for all waterbodies combined (Section 2.2). Ice-out records for waterbodies ranged from a minimum of ten to a maximum of 148 years spanning from 1869 to 2018. The final ice-out dataset contained 1,047 records for 31 waterbodies. For ice-in data, only four waterbodies had a minimum of ten records; therefore, only ice-out data were examined.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing, and decreasing trends in ice-out records. An increasing trend in ice-out indicates increases that ice is leaving a waterbody later in the year and ice coverage is longer. A decreasing trend in ice-out indicates that ice is leaving a waterbody sooner and ice coverage is shorter.

OUTCOME(S): Out of the 31 waterbodies, five or 16.1% of the waterbodies had significantly decreasing (earlier in the year) ice-out days. None of the waterbodies had increasing (later in the year) ice-out days. All waterbodies with a significant trend had a minimum of 75 years of data, indicating the importance of long term record collection.

With all dates combined together, a decreasing trend (earlier in the year) was documented from 1937 to 2018($p < 0.005$; Figure 27). Trend analysis stipulated an annual minimum of five unique waterbodies to prevent any one waterbody from having too much influence.

Figure 27. Annual ice-out days by individual waterbody (solid circles) over time. Waterbodies had a minimum of ten years of ice-out data to be included in the plot. A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included from 1937 to 2018, the period of trend analysis, to display overall data direction. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis.



4.4 Water Temperature

Water temperature influences many variables, including but not limited to dissolved oxygen concentration, metabolic rates, nutrient cycling, photosynthesis, water density and stratification, and aquatic community structure and species abundance. Water temperature can be influenced by the duration of ice cover, air temperature, weather, water clarity, lake depth and mixing regime. Recent studies have documented increases in lake surface water temperature in northeastern North America (O'Reilley et al. 2015; Richardson et al. 2017). These increases are happening as climate patterns are changing and waterbody color is darkening simultaneously (Secchi Depth - Section 3.3; Creed et al. 2018; Meyer-Jacob et al. 2019).

4.4.1 Current Condition

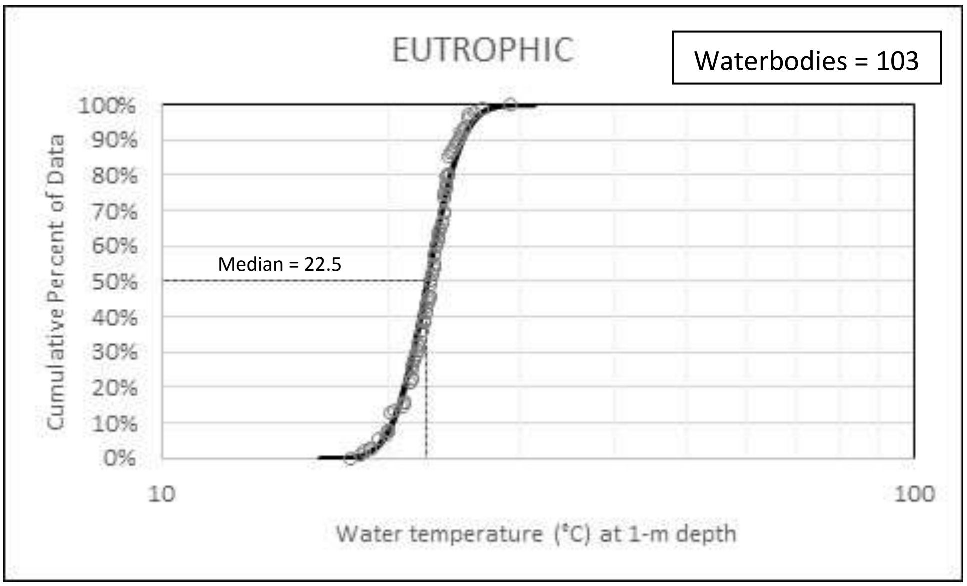
Statewide temperature distributions were summarized from all available lake and pond data collected by various programs from 1991 to 2018. Data were used to construct frequency distributions by trophic class (Section 2.2; Figure 28). Only data from one meter (± 0.1) below the surface and from deep spot locations were analyzed. Medians from 213 oligotrophic, 309 mesotrophic, and 103 eutrophic waterbodies built each respective frequency distribution (Figure 28). Eutrophic waterbodies had a 1-meter temperature median of 22.5°C, with the 25th percentile at 21.3°C and the 75th percentile at 23.9°C. Mesotrophic waterbodies had a 1-meter temperature median of 22.8°C, with the 25th percentile at 21.4°C and the 75th percentile at 24.3°C. Oligotrophic waterbodies had a 1-meter temperature median of 23.0°C, with the 25th percentile at 21.5°C and the 75th percentile at 24.6°C.

MEASURE(S) OF CONDITION: The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median 1-meter temperature value below the 25th percentile of the respective statewide distribution by trophic class. The number of VLAP waterbodies with ≥ 10 years of data from 1991-2018 with a median 1-meter temperature value above the 75th percentile of respective statewide distribution by trophic class.

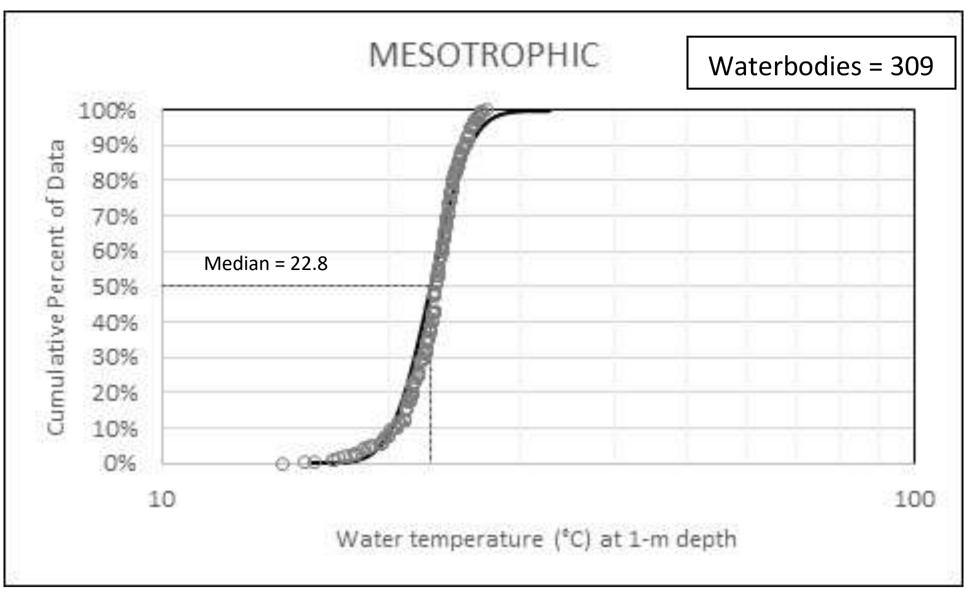
OUTCOME(S): None of the eight eutrophic waterbodies investigated were below the 25th percentile or above the 75th percentile. For mesotrophic waterbodies, 5 out of 68 (7.4%) were below the 25th percentile and 12 out of 68 (17.7%) were above the 75th percentile. For oligotrophic waterbodies, 3 of 68 (4.4%) were below the 25th percentile and 2 of 68 (2.9%) were above the 75th percentile.

Figure 28. Statewide data distribution for temperature by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). Curved black line = standard normal distribution of statewide data, 1991-2018. Hollow gray circles = individual lake medians, 1991-2018.

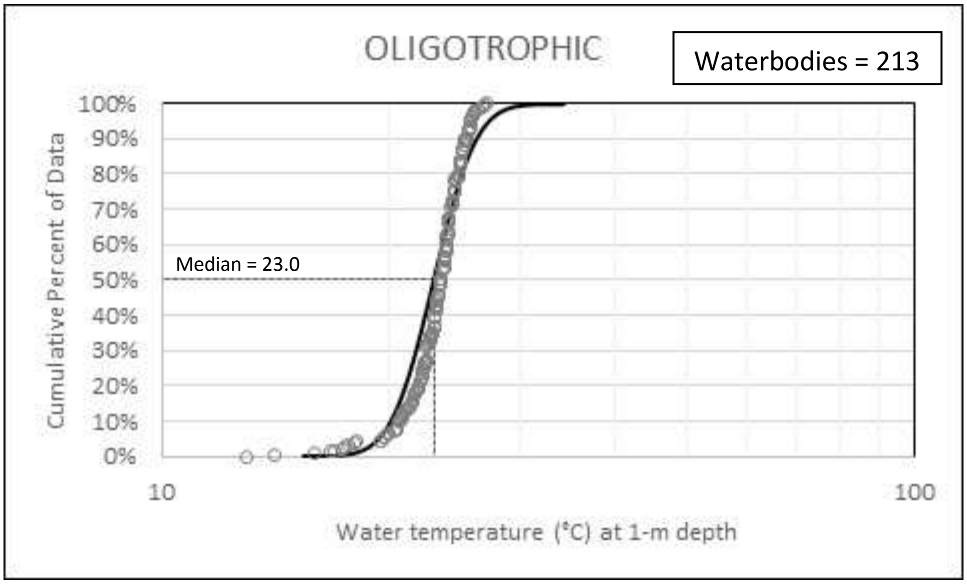
A.



B.



C.



4.4.2 Long-term trend

An initial Environmental Monitoring Database query of VLAP temperature data produced a datafile of 66,441 records. The dataset was refined by removing invalidated or blank data records, restricting years to 1991 – 2018, and targeting samples collected from 1 (±0.1) meter below the surface. Only records collected at the deepest location in the waterbody, which best represents whole lake conditions, and from June 1st through September 15th were included. Daily averages were calculated to account for quality controlled duplicate or replicate sampling. Waterbodies with fewer than ten years of data were removed from the dataset. One outlier was removed. Annual medians by individual waterbody and trophic class were calculated. A Mann Kendall trend test and corresponding Sen slope were calculated for each individual waterbody as well as by trophic class (Section 2.2). The final dataset contained 3,737 records.

MEASURE(S) OF CONDITION: The number and percentage of waterbodies with stable, increasing and decreasing trends in 1-meter temperature, by individual waterbody and trophic class.

OUTCOME(S): One-hundred-forty-four VLAP lakes and ponds were examined for individual Mann Kendall trends in temperature. Out of the 144 waterbodies, 8 were eutrophic, 68 were mesotrophic, and 68 were oligotrophic. These waterbodies had a minimum of ten and a maximum of 28 years of data spanning from 1991 to 2018.

Overall, 80.6% of the waterbodies analyzed had no trend in temperature at 1-meter, with 1.4% experiencing a decrease in temperature and 18.1% experiencing an increase (Table 16). By trophic class, mesotrophic and oligotrophic waterbodies had a significant increase in water temperature at 1-meter below the surface (Figures 29, 30). Eutrophic waterbodies did not display a trend (Figures 29, 30).

Table 16. Number of VLAP waterbodies with increasing, decreasing, or no trend in temperature at 1-meter depth.

Trophic Class	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
EUTROPHIC	8	5	2	1	*62.5%*	*25.0%*	*12.5%*
MESOTROPHIC	68	56	12	0	*82.4%*	*17.6%*	*0.0%*
OLIGOTROPHIC	68	55	12	1	*80.9%*	*17.6%*	*1.5%*
ALL	**144**	**116**	**26**	**2**	***80.6%***	***18.1%***	***1.4%***

Figure 29. Sen slope estimates (± 5%) of temperature trends by trophic class. Data ranges that cross zero, as marked by the red line, do not have a significant trend. Probability values (p-value) of temperature at 1-meter trends by trophic class (Significance at $p < 0.05$) were $p = 0.73$ for eutrophic, < 0.01 for mesotrophic, and 0.02 for oligotrophic waterbodies. Trend analysis was performed on 68 mesotrophic and 68 oligotrophic waterbodies from 1991 – 2018. Trend analyses stipulated that each trophic category had data from at least five unique waterbodies each year; therefore, the trend analysis on eutrophic waterbodies included 1997 and 2001 – 2018.

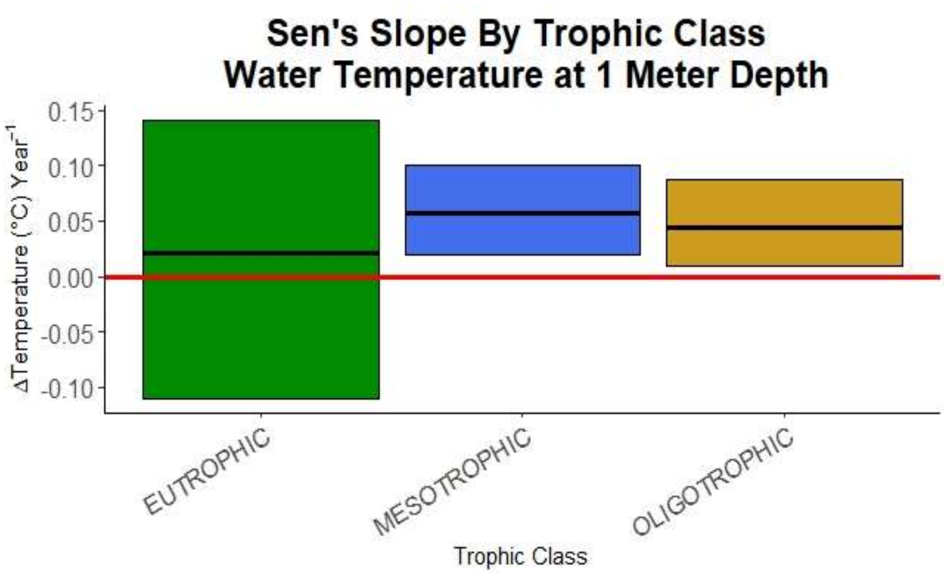
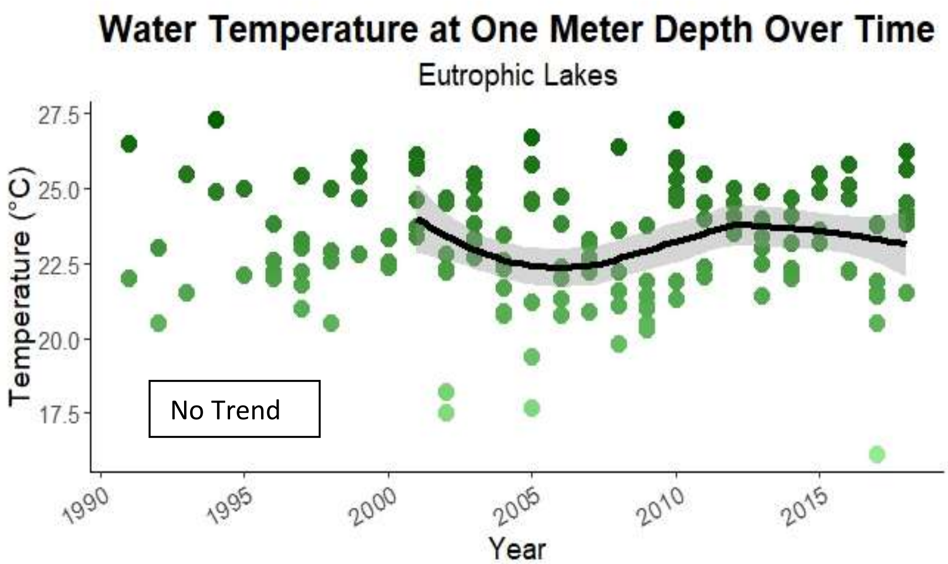
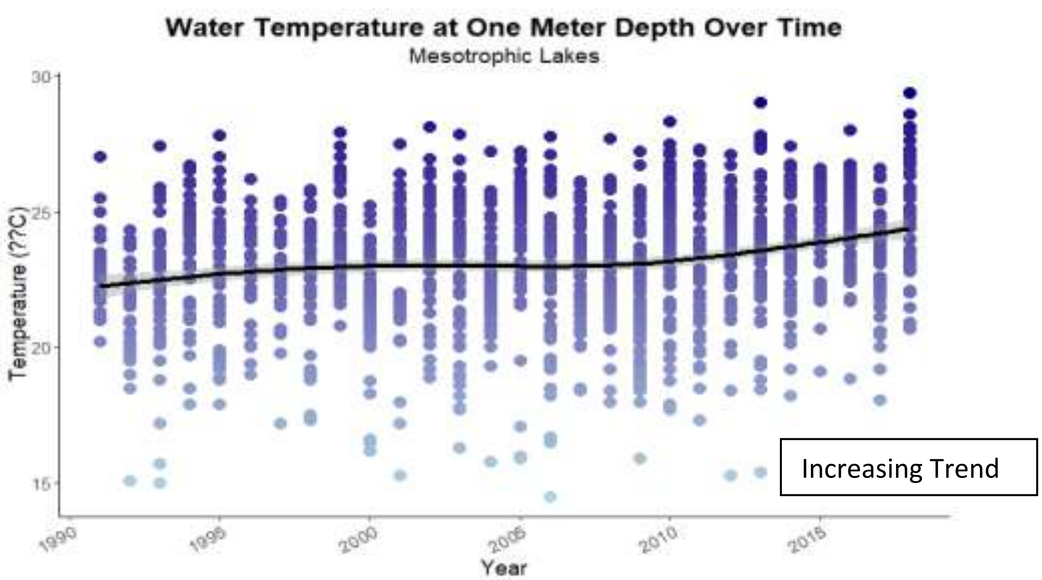


Figure 30. Annual median temperature at 1-meter depth values by individual waterbody (solid circles) over time by trophic class (A. Eutrophic; B. Mesotrophic; C. Oligotrophic). A smoothing curve (black line) with a 95% confidence interval (gray shaded area) is included over the period of trend analysis to display the overall data direction for mesotrophic and oligotrophic waterbodies. For mesotrophic and oligotrophic lakes, trend analysis occurred from 1991 to 2018. Data from a minimum of five independent waterbodies per year were necessary to conduct trend analysis. For eutrophic lakes, trend analysis occurred from 1997 and 2001 – 2018.

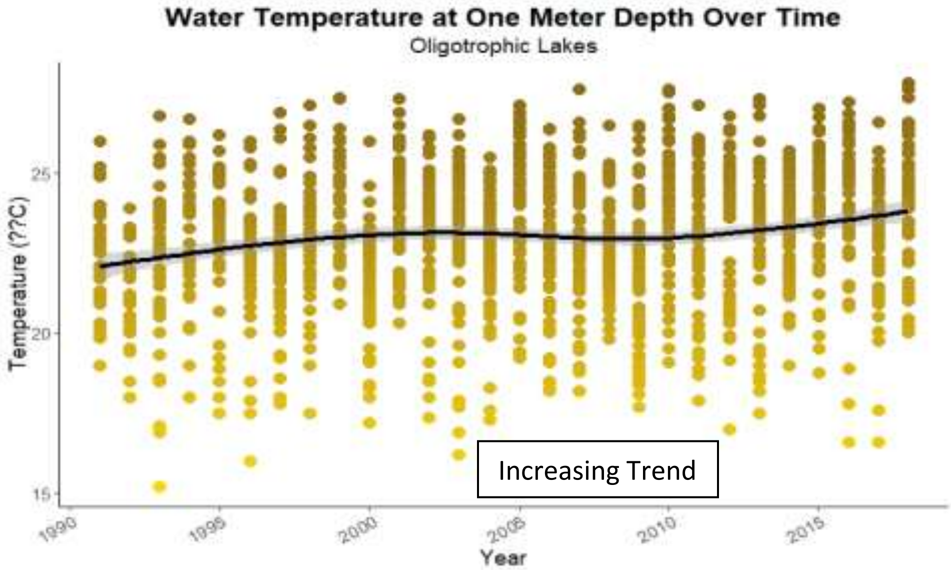
A.



B.



C.



4.4.3 Short-term change

To examine these potential rapid changes in temperature at 1-meter depth, the most recent five years of data (2014– 2018) included in this report were compared to the previous five-year dataset (2009 – 2013; Section 2.2). The final dataset contained 642 records for 41 waterbodies.

MEASURE(S) OF CONDITION: The percentage of VLAP waterbodies that have lower, higher or similar temperature at 1-meter values in the current five years compared to the previous reporting period.

OUTCOME(S): Out of the 41 waterbodies investigated, two waterbodies or 4.9% has significantly different water temperatures in the previous time period compared to the current time period. Upon further investigation, both waterbodies with significant differences had higher temperature at 1-meter depth in the current time period as compared to the previous.

4.4.4 Regional trends

MEASURE(S) OF CONDITION: The number and percentage of waterbodies within each VLAP region with stable, increasing, and decreasing trends in temperature at 1-meter depth.

OUTCOME(S): The Dartmouth Lake Sunapee region had the greatest number of waterbodies with increasing trends in temperature at 1-meter depth (9 waterbodies [24.3%]), followed by the Lakes (6 waterbodies [22.2%]) and Monadnock (6 waterbodies [20.0%]) regions (Table 17). The Dartmouth Lake Sunapee and Monadnock regions were the only regions to have a waterbody with a decreasing trend (Table 17).

Table 17. Number of VLAP waterbodies with increasing, decreasing, or no trend in 1-meter temperature by region. Only waterbodies with a minimum of 10 years of data from 1991 – 2018 were included in the analysis.

Region	Number of Waterbodies	Count			*Percent*		
		No trend	Increasing	Decreasing	*No trend*	*Increasing*	*Decreasing*
DLS	37	27	9	1	*73.0%*	*24.3%*	*2.7%*
GNW	2	2	0	0	*100.0%*	*0.0%*	*0.0%*
Lakes	27	20	6	1	*74.1%*	*22.2%*	*3.7%*
Monadnock	30	24	6	0	*80.0%*	*20.0%*	*0.0%*
MV	19	18	1	0	*94.7%*	*5.3%*	*0.0%*
Seacoast	11	8	3	0	*72.7%*	*27.3%*	*0.0%*
WM	18	17	1	0	*94.4%*	*5.6%*	*0.0%*
ALL	**144**	**116**	**26**	**2**	***80.6%***	***18.1%***	***1.4%***

5.0 SUMMARY OF CONDITIONS

- The percentage of monitored beaches issued a fecal bacteria advisory and the number of days an advisory was in place significantly increased from 2003 to 2018.

The reason for this increase is unclear. Possible explanations include warmer water temperature, more people using beaches, increased waterfowl populations, or increased stormwater run-off.

- Total phosphorus significantly increased overall in eutrophic waterbodies, but was unchanged in mesotrophic and oligotrophic waterbodies. Individual waterbody analyses indicated approximately 4% of waterbodies increased in total phosphorus in the long or short-term while approximately 6-% decreased. The Lakes and Monadnock regions had the most waterbodies with decreasing trends.

As the most common limiting nutrient in New Hampshire lakes, changes in total phosphorus concentration can have cascading effects throughout a waterbody. Increases in total phosphorus are associated with increased productivity and can fuel cyanobacteria blooms. Changes in total phosphorus levels are waterbody-specific and reflect land use practices in each watershed. Increases are associated with anthropogenic activities such as stormwater run-off, impervious surfaces, and vegetation loss, while decreases may reflect better management practices, such as leaving vegetation buffers intact, reducing fertilizer use, or regularly pumping septic systems.

New Hampshire's Shoreland Water Quality Protection Act (SWQPA) provides instruction on best management practices for phosphorus. The SWQPA prohibits fertilizer use within 25 feet of public waters, and from 25 to 250 feet, only slow or controlled release fertilizer may be used. Additionally, native vegetation within 50 feet of public waters may not be converted to lawn, and from 50 to 150 feet, at least 25% of native vegetation must be left intact. More information on SWQPA and best management practices can be found here.

- The number of cyanobacteria advisories have increased from 2003 to 2018, but the number of days an advisory is in place is highly variable with no overall trend.

Increased awareness of cyanobacteria and sample effort may have led to the increase in the number of advisories issued; however, an increasing number of blooms may also be occurring. Reoccurring cyanobacteria blooms may reflect legacy nutrient loads to the waterbody, which are nutrients that entered the waterbody in year or even decades prior. Under anoxic (no oxygen) conditions at the bottom of the waterbody, these legacy nutrients can re-suspend in the water column and fuel cyanobacteria blooms.

- Invasive aquatic plant species infestations have increased from 2000 to 2018. The overall acreage of invasive infestations and herbicide use has remained constant; however, the number of times alternative controls are used annually has increased.

Once an invasive aquatic plant species has invaded a waterbody, it is extremely difficult to remove entirely. Control efforts help waterbodies where invasives have been introduced by keeping water-travel corridors open, reducing chance of spreading, and keeping recreation enjoyable. Variable milfoil (Myriophyllum heterophyllum) is the most common aquatic invasive species in New Hampshire lakes and ponds, currently found in more than 75 waterbodies.

- Water clarity, as measured by Secchi depth, decreased in more than 15% of lakes, with mesotrophic and oligotrophic waterbodies significantly decreasing as a group. The highest number of waterbodies with decreasing trends were in the Dartmouth Lake Sunapee region, followed by the White Mountain region.

- Chlorophyll-a concentration had no trends by trophic class; however, approximately 10% of waterbodies had significant decreases in both long-term and short-term analyses. Significant increases in both the short-term and long-term investigations were rare, occurring in approximately 3% of waterbodies.

Declining Secchi depths are a recent phenomenon noted in the Northeast known as “lake browning”. It is thought that dissolved organic carbon (DOC) is increasing in lakes and ponds is partially due to recovery from acid rain. The reduction of acid-causing pollutants has been found to mobilize organic matter from forests to waterbodies. However, the increases in DOC may also be due to the more severe storms and increased rain that the Northeast has experienced in recent decades. Wetter weather and flashier storms are more likely to flush out organic matter from forests. It is likely a combination of both acid rain recovery and changing climate that are causing the shift.

Decreases in chlorophyll-a concentrations could be linked to the darker water, as less sunlight can pass through the water column.

- From 1991 to 2018, specific conductance significantly increased in over 40% of lakes, and, as a group, mesotrophic and eutrophic waterbodies had an overall significant increase. Analyses of short-term changes indicate that specific conductance is rapidly shifting, as nearly 80% of investigated waterbodies significantly increased in specific conductance over the past 10 years. The regions with the highest number of waterbodies with increasing trends were the Lakes region, followed by Merrimack Valley and then Dartmouth Lake Sunapee. The Great North Woods, Lakes, Merrimack Valley and Seacoast regions had increasing specific conductance in ≥ 50 % of their waterbodies. The Monadnock region had the greatest number of waterbodies with a decreasing trend.

- Alkalinity increased in nearly 60% of lakes from 1991 to 2018, with significant increases in mesotrophic and eutrophic classes. Short-term change analysis found that almost 75% of waterbodies increased in alkalinity over the past 10 years. The Monadnock region had the largest number of waterbodies with increasing alkalinity, followed by Dartmouth Lake Sunapee region. Of the 76 waterbodies that had significant short-term increases in alkalinity, 65 waterbodies (85.5%) also had significantly increasing specific conductance in the same time frame.

New Hampshire's surface water tends to have low specific conductance (< 50 µS/cm). While specific conductance can be naturally high or low based on geology, the increasing long-term trend in over 40% of lakes and ponds is alarming. The most likely driver of this change is salt – specifically road salt, and to a lesser extent, water softeners. The short-term change analysis revealed that waterbodies are shifting rapidly, with almost three-fourths of waterbodies experiencing an increase in the last ten years.

The long-term increases in alkalinity in more than half the lakes are likely due to two factors. First, our lakes and ponds are recovering from acid rain. The decline in acid-causing pollutants should allow waterbodies to regain positive ions from weathering, which would increase alkalinity. However, increases in alkalinity may also be tied to the increases in specific conductance. Salt is composed of chloride and sodium, and sodium is a positive ion. An influx of salt, and consequently sodium, has been found to increase alkalinity. Our short-term analysis found that nearly 75% of the waterbodies in this study had significant increases in alkalinity in the last ten years, which is more rapid than would be expected for acid rain recovery and coincided with waterbodies that also had increasing specific conductance.

- From 1991 to 2018, pH levels have significantly increased in more than 10% of lakes and significantly decreased in approximately 5% of lakes. The highest number of waterbodies with increasing and decreasing long-term pH levels occurred in the Dartmouth Lake Sunapee region, which is likely due to differing activities in each watershed. Analyzing short-term changes found that more than 20% of lakes have increased pH levels in the last 10 years while less than 4% decreased.

A measure of a waterbody's acidity, pH is influenced by a number of variables including alkalinity, dissolved oxygen levels, carbon dioxide levels, pollutant levels, and water temperature. Vitally important to aquatic life, pH levels below 6.5 or above 8.0 are considered to have negative influences on aquatic organisms such as insects and fish. Approximately 84% of waterbodies with an increasing long-term trend in pH also had an increasing long-trend in alkalinity. Similarly, 80% of waterbodies that had a short-term increase in pH also had a short-term increase in alkalinity. The greater number of waterbodies with increasing trends in pH may be partially due to decreases in acid precipitation.

- Ice-out is occurring significantly earlier in the now than it did in years past. All significant trends in ice-out data were found in lakes with data at least 75 years of data indicating the value of long-term datasets.

The day of ice-out is largely determined by air temperature. Earlier ice-out has been found in New England (Hodgkins et al. 2002; Hodgkins 2013). As the day of ice-out can vary drastically from year to year, long-term datasets are imperative for breaking through the "noise" to investigate trends. Earlier ice-outs dates are likely to result in hotter summer water temperatures, lower water levels, and prolonged summer lake stratification, which may promote low dissolved oxygen levels at lake bottom and cyanobacteria.

- Dissolved oxygen at 1-meter below the surface decreased in approximately 15% of waterbodies, with a significant overall decrease for mesotrophic waterbodies from 1991 to 2018. Decreases were most abundant in the Dartmouth Lake Sunapee region, followed by the Monadnock region.

- From 1991 to 2018, water temperature at 1-meter below the surface significantly increased in approximately 18% of lakes, with the mesotrophic and oligotrophic classes as a whole significantly increasing. Short-term changes found little change (5% of waterbodies increasing). The greatest number of waterbodies with significantly increasing temperature were in the Dartmouth Lake Sunapee region, followed by the Lakes and Monadnock regions.

Increases in water temperature likely has multiple drivers: the first is that air temperature has increased by almost 2° F from 1895 to 2011, and water temperature may be responding to that increase (Kunkel et al. 2013). Earlier ice-out dates are occurring on our waterbodies (see Section 4.3), which allows lake water to begin warming and stratifying earlier. Another potential driver is that the temperature increase is in response to the increase in water color. The darker water absorbs sunlight, preventing light from penetrating deeper into the water column. Reductions in dissolved oxygen are likely a response to increasing water temperature, as warmer water holds less dissolved oxygen.

6.0 REFERENCES

6.1 Public Reports and Websites

Neils, D.E., Burack, T.S., Freise, C., Forbes, E.J. (2016) New Hampshire Department of Environmental Services Water Monitoring Strategy. R-WD-16-02.
https://www.des.nh.gov/organization/commissioner/pip/publications/wd/documents/r-wd-16-02.pdf

Nelson, K.A., Neils, D.E., Healy, D., Underhill, J., Burack, T., Dubois, K., Forbes, G., Wright, C. (2015) Acid Rain Status and Trends: New Hampshire Lakes, Ponds and Rainfall. R-WD-15-5.
https://www.des.nh.gov/organization/commissioner/pip/publications/wd/documents/r-wd-15-5.pdf

New Hampshire Department of Environmental Services Volunteer Lake Assessment Program (VLAP).
https://www.des.nh.gov/organization/divisions/water/wmb/vlap/index.htm

New Hampshire EPSCoR. Fact Sheet 4: Land Cover Scenarios.
https://www.nhepscor.org/sites/default/files/media/factsheet4_landcoverscenarios.pdf

New Hampshire Green SnowPro Program. https://www.des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/index.htm

New Hampshire Lake Information Mapper.
http://nhdes.maps.arcgis.com/apps/webappviewer/index.html?id=1f45dc20877b4b959239b8a4a60ef540

New Hampshire Office of Energy and Planning: Population Projections. State and County Population Projections – September 2016. https://www.nh.gov/osi/data-center/documents/2016-state-county-projections-final-report.pdf

Wood, M.A., Edwardson, K., O'Donovan, T.E., Freise, C., Scott, R.R. (2020). 2018 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology (CALM). R-WD-19-04.
https://www.des.nh.gov/organization/divisions/water/wmb/swqa/2018/documents/r-wd-19-04.pdf

6.2 Peer-reviewed Scientific Papers

Creed, I.F., Bergstrom, A., Trick, C.G., Grimm, N.B., Hessen, D.O., Karlsson, J., Kidd, K.A., Kritzberg, E., McKnight, D.M., Freeman, E.C., Senar, O.E., Andersson, A., Ask, J., Berggren, M., Cherif, M., Giesler, R., Hotchkiss, E.R., Kortelainen, P., Palta, M.M., Vrede, T., Weyhenmeyer, G.A. (2018). Global change-driven effects on dissolved organic matter composition: Implications for food webs of northern lakes. *Global Change Biology*, 24 (8), 3692-3714.

Daley, M.L., Potter, J.D., McDowell, W.H. (2009). Salinization of urbanizing New Hampshire streams and groundwater: effects of road salt and hydrologic variability. *Journal of the North American Benthological Society*, 28 (4), 929 – 940.

Deacon, J.R., Soule, S.A., Smith, T.E. (2005). Effects of urbanization on stream quality at selected sites in the Seacoast region in New Hampshire, 2001 – 03: U.S. Geological Survey Scientific Investigation Report 2005 – 5103, 18 p.

Driscoll, C.T., Lawrence, G.B., Bulger, A.J., Butler, T.J., Cronan, C.S., Eagar, C., Lambert, K.F., Likens, G.E., Stoddard, J.L., Weathers, K.C. (2001). Acidic Deposition in the Northeastern United States: Sources and Inputs, Ecosystem Effects, and Management Strategies: The effects of acidic deposition in the northeastern United States include the acidification of soil and water, which stresses terrestrial and aquatic biota. *BioScience*, 51 (3), 180–198.

Dugan, H.A., Bartlett, S.L., Burke, S.M., Doubek, J.P., Krivak-Tetley, F.E., Skaff, N.K., Summers, J.C., Farrell, K.J., McCullough, I.M., Morales-Williams, A.M., Roberts, D.C., Ouyang, Z., Scordo, F., Hanson, P.C., Weathers, K.C. (2017). Salting our freshwater lakes. *PNAS*, 114 (17), 4453 – 4458.

Groisman, P.Y., Knight, R.W., Zolina, O.G. (2013). Recent trends in regional and global intense precipitation patterns. *Climate Vulnerability*, R.A. Pielke, Sr., Ed., Academic Press, 25-55.

Hayhoe, K., Wake, C.P., Huntington, T.G., Luo, L., Schwartz, M.D., Sheffield, J., Wood, E., Anderson, B., Bradbury, J., DeGaetano, A., Troy, T.J., Wolfe, D. (2007). Past and future changes in climate and hydrological indicators in the U.S. Northeast. *Climate Dynamics*, 28(4), 381-407.

Hodgkins, G.A., James I.C., Huntington, T.G. (2002). Historical changes in lake ice-out dates as indicators of climate change in New England, 1850 – 2000. *International Journal of Climatology*, 22(15), 1819-1827.

Hodgkins, G.A. (2013). The importance of record length in estimating the magnitude of climate changes: an example using 175 years of lake ice-out dates in New England. *Climate Change*, 119(3-4), 705 - 718.

Kaushal, S.S., Likens, G.E., Pace, M.L., Utz, R.M., Haq, S., Gorman, J., Grese, M. (2018). Freshwater salinization syndrome on a continental scale. *PNAS*, 115(4), E574 – E583.

Kunkel, K. E., Stevens, L.E., Stevens, S.E., Sun, L., Janssen, E., Wuebbles, D., Rennells, J., DeGaetano, A., Dobson, J.G. (2013). Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 1. Climate of the Northeast U.S. NOAA Technical Report NESDIS 142-1. 87 pp., National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, D.C.

Meyer-Jacob, C., Michelutti, N., Paterson, A.M., Cumming, B.F., Keller, W., Smol, J.P. (2019) The browning and re-browning of lakes: Divergent lake-water organic carbon trends linked to acid deposition and climate change. Scientific Reports, 9, 16676. https://doi.org/10.1038/s41598-019-52912-0.

O'Reilly, C.M., Sharma, S., Gray, D.K., Hampton, S.E., Read, J.S., Rowley, R.J., Schneider, P., Lenters, J.D., McIntyre, P.B., Kraemer, B.M., Weyhenmeyer, G.A., Straile, D., Dong, B., Adrian, R., et al. (2015). Rapid and highly variable warming of lake surface waters around the globe. *Geophysical Research Letters*, 42, doi: 10.1002/2015GL066235.

Paerl, H.W. and Otten, T.G. (2013). Harmful Cyanobacterial Blooms: Causes, Consequences, and Controls. *Microbial Ecology*, 65(4), 995 – 1010.

Richardson, D.C., Melles, S.J., Pilla, R.M., Hetherington, A.L., Knoll, L.B., Williamson, C.E., Kraemer, B.M., Jackson, J.R., Long, E.C., Moore, K., Rudstam, L.G., Rusak, J.A., Saros, J.E., Sharma, S., Strock, K.E., Weathers, K.C., Wigdahl-Perry, C.R. (2017). Transparency, Geomorphology and Mixing Regime Explain Variability in Trends in Lake Temperature and Stratification across Northeastern North America (1975 – 2-14). *Water*, 9, 442.

SanClements, M.D., Oelsner, G.P., McKnight, D.M., Stoddard, J.L., Nelson, S.J. (2012). New Insights into the Source of Decadal Increases of Dissolved Organic Matter in Acid-Sensitive Lakes of the Northeastern United States. *Environmental Science & Technology*, 46, 3212 – 3219.

Strock, K.E., Nelson, S.J., Kahl, J.S., Saros, J.E., McDowell, W.H. (2014). Decadal Trends Reveal Recent Acceleration in the Rate of Recovery from Acidification in the Northeastern US. *Environmental Science & Technology*, 48, 4681 – 4689.

Trowbridge, P.R., Kahl, J.S., Sassan, D.A., Heath, D.L., Walsh, E.M. (2010). Relating Road Salt to Exceedances of the Water Quality Standard of Chloride in New Hampshire Streams. *Environmental Science & Technology*, 44 (13), 4903 – 4909.

Appendix A. VLAP waterbodies listed by name, town, waterbody ID, trophic class, and VLAP region that were included in the 2020 New Hampshire Lake Trend Report. Region code abbreviations are as follows: Dartmouth Lake Sunapee (DLS), Great North Woods (GNW), Merrimack Valley (MV), and White Mountain (WM).

WATERBODYNAME	TOWN	WATERBODY ID	TROPHIC CLASS	REGION
ARMINGTON LAKE	**PIERMONT**	NHLAK801040201-01	**OLIGOTROPHIC**	DLS
ASHUELOT POND	**WASHINGTON**	NHLAK802010101-01	**MESOTROPHIC**	DLS
BAPTIST POND	**SPRINGFIELD**	NHLAK801060402-02	**MESOTROPHIC**	DLS
BEARDS BROOK – E. WASHINGTON DAM	**WASHINGTON**	NHIMP700030204-05-01	**MESOTROPHIC**	DLS
BLAISDELL LAKE	**SUTTON**	NHLAK700030302-02	**OLIGOTROPHIC**	DLS
CANAAN STREET LAKE	**CANAAN**	NHLAK801060101-01-01	**OLIGOTROPHIC**	DLS
CHALK POND	**NEWBURY**	NHLAK801060402-03	**OLIGOTROPHIC**	DLS
CHASE POND	**WILMOT**	NHLAK700030402-01	**OLIGOTROPHIC**	DLS
CRESCENT LAKE	**ACWORTH**	NHLAK801070201-01	**MESOTROPHIC**	DLS
DUTCHMAN POND	**SPRINGFIELD**	NHLAK801060402-06	**OLIGOTROPHIC**	DLS
EASTMAN POND	**GRANTHAM**	NHLAK801060401-06	**MESOTROPHIC**	DLS
GOOSE POND	**CANAAN**	NHLAK801060103-01	**OLIGOTROPHIC**	DLS
HALFMOON POND	**WASHINGTON**	NHLAK700030201-02	**MESOTROPHIC**	DLS
ISLAND POND	**WASHINGTON**	NHLAK700030204-03	**OLIGOTROPHIC**	DLS
KEZAR LAKE	**SUTTON**	NHLAK700030303-03-01	**MESOTROPHIC**	DLS
KILTON POND	**GRAFTON**	NHLAK700010701-02-01	**OLIGOTROPHIC**	DLS
KOLELEMOOK LAKE	**SPRINGFIELD**	NHLAK801060401-08-01	**OLIGOTROPHIC**	DLS
LAKE KATHERINE	**PIERMONT**	NHLAK801040201-02	**OLIGOTROPHIC**	DLS
LAKE TARLETON	**PIERMONT**	NHLAK801040201-03	**OLIGOTROPHIC**	DLS
LEDGE POND	**SUNAPEE**	NHLAK801060402-08	**OLIGOTROPHIC**	DLS
LITTLE SUNAPEE LAKE	**NEW LONDON**	NHLAK801060402-04-01	**OLIGOTROPHIC**	DLS
LONG POND	**LEMPSTER**	NHLAK802010101-04	**OLIGOTROPHIC**	DLS
MASCOMA LAKE	**ENFIELD**	NHLAK801060105-04-01	**OLIGOTROPHIC**	DLS
MASSASECUM LAKE	**BRADFORD**	NHLAK700030302-04-01	**MESOTROPHIC**	DLS
MESSER POND	**NEW LONDON**	NHLAK700030303-04	**MESOTROPHIC**	DLS
MILLEN POND	**WASHINGTON**	NHLAK802010101-06-01	**OLIGOTROPHIC**	DLS
MOUNTAINVIEW LAKE	**SUNAPEE**	NHLAK801060402-11	**OLIGOTROPHIC**	DLS
OTTER POND	**SUNAPEE**	NHLAK801060402-12-01	**MESOTROPHIC**	DLS
PERKINS POND	**SUNAPEE**	NHLAK801060405-03	**OLIGOTROPHIC**	DLS
PLEASANT LAKE	**NEW LONDON**	NHLAK700030402-02-01	**OLIGOTROPHIC**	DLS
POST POND	**LYME**	NHLAK801040203-01-01	**MESOTROPHIC**	DLS
RAND POND	**GOSHEN**	NHLAK801060403-04-01	**OLIGOTROPHIC**	DLS
RESERVOIR POND	**DORCHESTER**	NHLAK801060101-05	**OLIGOTROPHIC**	DLS
ROCKYBOUND POND	**CROYDON**	NHLAK801060404-01	**OLIGOTROPHIC**	DLS
SPECTACLE POND	**ENFIELD**	NHLAK801060102-03	**OLIGOTROPHIC**	DLS
STOCKER POND	**GRANTHAM**	NHLAK801060401-02	**MESOTROPHIC**	DLS
SUNAPEE LAKE	**SUNAPEE**	NHLAK801060402-05-01	**OLIGOTROPHIC**	DLS

WATERBODYNAME	TOWN	WATERBODY ID	TROPHIC CLASS	REGION
TODD LAKE	**NEWBURY**	NHLAK700030301-02	**MESOTROPHIC**	DLS
WAUKEENA LAKE	**DANBURY**	NHLAK700010701-05	**MESOTROPHIC**	DLS
FOREST LAKE	**DALTON**	NHLAK801030101-02-01	**MESOTROPHIC**	GNW
MARTIN MEADOW POND	**LANCASTER**	NHLAK801030102-02	**MESOTROPHIC**	GNW
CHESTNUT POND	**EPSOM**	NHLAK700060502-03	**OLIGOTROPHIC**	Lakes
CLEMENT POND	**HOPKINTON**	NHLAK700030505-01	**MESOTROPHIC**	Lakes
CLOUGH POND	**LOUDON**	NHLAK700060202-03-01	**MESOTROPHIC**	Lakes
CRYSTAL LAKE	**GILMANTON**	NHLAK700060401-02-01	**OLIGOTROPHIC**	Lakes
DEAR MEADOW BROOK - PILLSBURY LAKE	**WEBSTER**	NHIMP700030506-01	**EUTROPHIC**	Lakes
FRENCH POND	**HENNIKER**	NHLAK700030504-02-01	**EUTROPHIC**	Lakes
HALFMOON LAKE	**ALTON**	NHLAK700060402-03	**OLIGOTROPHIC**	Lakes
HERMIT LAKE	**SANBORNTON**	NHLAK700010802-03-01	**EUTROPHIC**	Lakes
HIGHLAND LAKE	**ANDOVER**	NHLAK700010804-01-01	**MESOTROPHIC**	Lakes
HILLS POND	**ALTON**	NHLAK700060401-04	**MESOTROPHIC**	Lakes
LAKE WAUKEWAN	**MEREDITH**	NHLAK700020108-02-01	**OLIGOTROPHIC**	Lakes
LAKE WICWAS	**MEREDITH**	NHLAK700020201-04	**MESOTROPHIC**	Lakes
LAKE WINNEPOCKET	**WEBSTER**	NHLAK700030304-08	**OLIGOTROPHIC**	Lakes
LAKE WINNISQUAM	**BELMONT**	NHLAK700020201-05-01	**OLIGOTROPHIC**	Lakes
LAKE WINONA	**CENTER HARBOR**	NHLAK700020108-02-02	**MESOTROPHIC**	Lakes
LEES POND	**MOULTONBOROUGH**	NHLAK700020103-05	**MESOTROPHIC**	Lakes
LOON POND	**GILMANTON**	NHLAK700060201-01-01	**MESOTROPHIC**	Lakes
LOWER BEECH POND	**TUFTONBORO**	NHLAK600020701-02	**OLIGOTROPHIC**	Lakes
LOWER SUNCOOK POND	**BARNSTEAD**	NHLAK700060402-10-01	**OLIGOTROPHIC**	Lakes
NEW POND	**CANTERBURY**	NHLAK700060201-03	**MESOTROPHIC**	Lakes
PEMIGEWASSET LAKE	**MEREDITH**	NHLAK700010801-01	**MESOTROPHIC**	Lakes
RUST POND	**WOLFEBORO**	NHLAK700020101-07-01	**OLIGOTROPHIC**	Lakes
SUNSET LAKE	**ALTON**	NHLAK700060401-12	**OLIGOTROPHIC**	Lakes
TOM POND	**WARNER**	NHLAK700030304-05	**MESOTROPHIC**	Lakes
TUCKER POND	**SALISBURY**	NHLAK700030304-07	**MESOTROPHIC**	Lakes
TUREE POND	**BOW**	NHLAK700060301-01	**EUTROPHIC**	Lakes
UPPER SUNCOOK POND	**BARNSTEAD**	NHLAK700060402-10-02	**OLIGOTROPHIC**	Lakes
WEBSTER LAKE	**FRANKLIN**	NHLAK700010804-02-01	**MESOTROPHIC**	Lakes
WEBSTER STREAM - LOCKE LAKE	**BARNSTEAD**	NHIMP700060402-02	**MESOTROPHIC**	Lakes
CHAPMAN POND	**SULLIVAN**	NHLAK802010201-04	**MESOTROPHIC**	Monadnock
CONTENTION POND	**HILLSBOROUGH**	NHLAK700030204-02	**MESOTROPHIC**	Monadnock
CONTOOCOOK LAKE	**JAFFREY**	NHLAK700030101-03-01	**MESOTROPHIC**	Monadnock
DUBLIN POND	**DUBLIN**	NHLAK802010202-05	**OLIGOTROPHIC**	Monadnock
EMERSON POND	**RINDGE**	NHLAK802020103-04	**MESOTROPHIC**	Monadnock
FOREST LAKE	**WINCHESTER**	NHLAK802010401-01-01	**MESOTROPHIC**	Monadnock
FROST POND	**JAFFREY**	NHLAK700030102-02	**MESOTROPHIC**	Monadnock
GILMORE POND	**JAFFREY**	NHLAK700030101-05	**OLIGOTROPHIC**	Monadnock

WATERBODYNAME	TOWN	WATERBODY ID	TROPHIC CLASS	REGION
GRANITE LAKE	**STODDARD**	NHLAK802010201-05	**OLIGOTROPHIC**	Monadnock
GREGG LAKE	**ANTRIM**	NHLAK700030108-02-01	**OLIGOTROPHIC**	Monadnock
HARRISVILLE POND	**HARRISVILLE**	NHLAK700030103-05-01	**MESOTROPHIC**	Monadnock
HIGHLAND LAKE	**STODDARD**	NHLAK700030201-03	**MESOTROPHIC**	Monadnock
ISLAND POND	**STODDARD**	NHLAK700030202-02-01	**MESOTROPHIC**	Monadnock
LAKE MONOMONAC	**RINDGE**	NHLAK802020103-06	**MESOTROPHIC**	Monadnock
LAKE SKATUTAKEE	**HARRISVILLE**	NHLAK700030103-08	**MESOTROPHIC**	Monadnock
LAUREL LAKE	**FITZWILLIAM**	NHLAK802020202-02-01	**OLIGOTROPHIC**	Monadnock
NORWAY POND	**HANCOCK**	NHLAK700030107-02-01	**MESOTROPHIC**	Monadnock
NUBANUSIT LAKE	**HANCOCK**	NHLAK700030103-07	**OLIGOTROPHIC**	Monadnock
PEARLY LAKE	**RINDGE**	NHLAK802020103-08	**EUTROPHIC**	Monadnock
POOL POND	**RINDGE**	NHLAK700030101-12	**MESOTROPHIC**	Monadnock
ROCKWOOD POND	**FITZWILLIAM**	NHLAK802010303-04	**OLIGOTROPHIC**	Monadnock
RUSSELL RESERVOIR	**HARRISVILLE**	NHLAK802010202-07	**MESOTROPHIC**	Monadnock
SAND POND	**MARLOW**	NHLAK802010101-08	**OLIGOTROPHIC**	Monadnock
SILVER LAKE	**HARRISVILLE**	NHLAK802010202-09	**OLIGOTROPHIC**	Monadnock
SPOFFORD LAKE	**CHESTERFIELD**	NHLAK801070503-01-01	**OLIGOTROPHIC**	Monadnock
STONE POND	**MARLBOROUGH**	NHLAK802010303-05-01	**OLIGOTROPHIC**	Monadnock
SWANZEY LAKE	**SWANZEY**	NHLAK802010302-01-01	**OLIGOTROPHIC**	Monadnock
THORNDIKE POND	**JAFFREY**	NHLAK700030102-01-01	**OLIGOTROPHIC**	Monadnock
WARREN LAKE	**ALSTEAD**	NHLAK801070203-01	**OLIGOTROPHIC**	Monadnock
WILSON POND	**SWANZEY**	NHLAK802010303-10	**MESOTROPHIC**	Monadnock
ANGLE POND	**SANDOWN**	NHLAK700061403-01-01	**MESOTROPHIC**	MV
BEAVER LAKE	**DERRY**	NHLAK700061203-02-01	**MESOTROPHIC**	MV
CANOBIE LAKE	**SALEM**	NHLAK700061102-02	**OLIGOTROPHIC**	MV
CAPTAIN POND	**SALEM**	NHLAK700061102-03-01	**MESOTROPHIC**	MV
COBBETTS POND	**WINDHAM**	NHLAK700061204-01-01	**OLIGOTROPHIC**	MV
CRYSTAL LAKE	**MANCHESTER**	NHLAK700060703-02-01	**MESOTROPHIC**	MV
DEERING RESERVOIR	**DEERING**	NHLAK700060601-01	**OLIGOTROPHIC**	MV
DORRS POND	**MANCHESTER**	NHLAK700060802-01	**MESOTROPHIC**	MV
GREAT POND	**KINGSTON**	NHLAK700061403-06-01	**MESOTROPHIC**	MV
ISLAND POND	**DERRY**	NHLAK700061101-01-01	**OLIGOTROPHIC**	MV
NUTT POND	**MANCHESTER**	NHLAK700060803-01	**MESOTROPHIC**	MV
OTTERNICK POND	**HUDSON**	NHLAK700061206-02	**EUTROPHIC**	MV
PINE ISLAND POND	**MANCHESTER**	NHLAK700060703-04	**EUTROPHIC**	MV
PLEASANT POND	**FRANCESTOWN**	NHLAK700060604-01	**OLIGOTROPHIC**	MV
POWWOW RIVER - POWWOW POND	**KINGSTON**	NHIMP700061403-04	**MESOTROPHIC**	MV
PRATT POND	**NEW IPSWICH**	NHLAK700060901-03	**MESOTROPHIC**	MV
ROBINSON POND	**HUDSON**	NHLAK700061203-06-01	**MESOTROPHIC**	MV
ROCK POND	**WINDHAM**	NHLAK700061204-03	**MESOTROPHIC**	MV
SEBBINS POND	**BEDFORD**	NHLAK700060804-02	**MESOTROPHIC**	MV

WATERBODYNAME	TOWN	WATERBODY ID	TROPHIC CLASS	REGION
STEVENS POND	**MANCHESTER**	NHLAK700060803-02	**EUTROPHIC**	MV
AYERS POND	**BARRINGTON**	NHLAK600030607-01	**OLIGOTROPHIC**	Seacoast
BAXTER LAKE	**FARMINGTON**	NHLAK600030602-01	**MESOTROPHIC**	Seacoast
GOVERNORS LAKE	**RAYMOND**	NHLAK600030703-01	**MESOTROPHIC**	Seacoast
HARANTIS LAKE - HARANTIS LAKE DAM	**CHESTER**	NHIMP700061203-01	**EUTROPHIC**	Seacoast
HARVEY LAKE	**NORTHWOOD**	NHLAK700060502-05	**EUTROPHIC**	Seacoast
JENNESS POND	**NORTHWOOD**	NHLAK700060502-06	**OLIGOTROPHIC**	Seacoast
NORTHWOOD LAKE	**NORTHWOOD**	NHLAK700060502-08-01	**MESOTROPHIC**	Seacoast
ONWAY LAKE	**RAYMOND**	NHLAK600030703-03-01	**MESOTROPHIC**	Seacoast
PAWTUCKAWAY LAKE	**NOTTINGHAM**	NHLAK600030704-02-01	**MESOTROPHIC**	Seacoast
PHILLIPS POND	**SANDOWN**	NHLAK600030802-03-01	**MESOTROPHIC**	Seacoast
PLEASANT LAKE	**DEERFIELD**	NHLAK700060502-09-01	**OLIGOTROPHIC**	Seacoast
SUNRISE LAKE	**MIDDLETON**	NHLAK600030601-05-01	**OLIGOTROPHIC**	Seacoast
BEARCAMP POND	**SANDWICH**	NHLAK600020601-01-01	**MESOTROPHIC**	WM
BERRY BAY	**FREEDOM**	NHLAK600020804-01-01	**OLIGOTROPHIC**	WM
BIG PEA PORRIDGE POND	**MADISON**	NHLAK600020303-05	**OLIGOTROPHIC**	WM
BROAD BAY	**OSSIPEE**	NHLAK600020804-01-03	**OLIGOTROPHIC**	WM
CONNER POND	**OSSIPEE**	NHLAK600020802-02	**OLIGOTROPHIC**	WM
DODGE POND	**LYMAN**	NHLAK801030502-01	**OLIGOTROPHIC**	WM
LEAVITT BAY	**OSSIPEE**	NHLAK600020804-01-02	**OLIGOTROPHIC**	WM
LOON LAKE	**PLYMOUTH**	NHLAK700010307-01	**MESOTROPHIC**	WM
LOWER DANFORTH POND	**FREEDOM**	NHLAK600020803-01-01	**MESOTROPHIC**	WM
LOWER MOUNTAIN LAKE	**HAVERHILL**	NHLAK801030505-03	**OLIGOTROPHIC**	WM
MIDDLE PEA PORRIDGE POND	**MADISON**	NHLAK600020303-06	**OLIGOTROPHIC**	WM
MOORES POND	**TAMWORTH**	NHLAK600020604-03	**MESOTROPHIC**	WM
OSSIPEE LAKE	**OSSIPEE**	NHLAK600020802-04-01	**OLIGOTROPHIC**	WM
PARTRIDGE LAKE	**LITTLETON**	NHLAK801030502-03	**MESOTROPHIC**	WM
ROUND POND	**LYMAN**	NHLAK801030502-04	**MESOTROPHIC**	WM
STINSON LAKE	**RUMNEY**	NHLAK700010306-01	**OLIGOTROPHIC**	WM
UPPER MOUNTAIN LAKE	**HAVERHILL**	NHLAK801030505-04	**MESOTROPHIC**	WM
WHITE OAK POND	**HOLDERNESS**	NHLAK700010501-05	**MESOTROPHIC**	WM

Appendix B. Individual waterbody trends for VLAP waterbodies used in analyses for 2020 Lake Trend Report. Dark gray fill indicates that there was insufficient data to perform analysis.

Region / Lake	Town	Parameter																							
		Primary Indicator															Accessory Indicator								
		Chlorophyll-a			pH			Secchi depth			Specific Conductance			Total Phosphorus			Alkalinity			1-meter Dissolved Oxygen			1-meter Water Temperature		
		Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile
Dartmouth Lake Sunapee (DLS)																									
ARMINGTON LAKE	PIERMONT	No trend	Increase	24.8	No trend	Decrease	54.0	Decrease	No change	72.6	No trend	No change	27.4	Decrease	No change	29.1	Increase	No Change	42.1	No trend	No change	69.1	No trend	No change	15.9
ASHUELOT POND	WASHINGTON	No trend	No change	54.0	Increase	Increase	4.5	No trend	No change	57.9	Decrease	Increase	21.2	No trend	No change	46.0	No trend	Increase	1.4	Decrease		42.1	Increase		50.0
BAPTIST POND	SPRINGFIELD	No trend	No change	65.5	No trend	No change	54.0	No trend	No change	46.0	No trend	Increase	86.4	No trend	No change	30.9	No trend	Increase	50.0	No trend		50.0	Increase		34.5
BLAISDELL LAKE	SUTTON	No trend		65.5	Decrease		75.8	No trend		65.5	No trend		72.6	No trend		42.1	Increase		69.1	No trend		25.0	No trend		65.5
CANAAN STREET LAKE	CANAAN	Decrease	No change	24.8	No trend	No change	81.6	No trend	No change	50.0	Increase	Increase	72.6	No trend	No change	50.0	Increase	No Change	84.1	No trend		30.9	Increase		57.9
CHALK POND	NEWBURY	No trend	Increase	72.6	No trend		42.1	No trend	No change	21.2	Increase	Increase	54.0	No trend	No change	50.0	No trend		34.5	No trend		27.4	No trend		57.9
CHASE POND	WILMOT	No trend		78.8	No trend		65.5	No trend		11.5	No trend		72.6	No trend		72.6	No trend		75.0	No trend		27.4	No trend		61.8
CRESCENT LAKE	ACWORTH	No trend	No change	50.0	No trend	No change	50.0	Decrease	No change	65.5	No trend	Increase	38.2	No trend	Decrease	38.2	Increase	No Change	34.5	No trend		57.9	No trend		27.4
DUTCHMAN POND	SPRINGFIELD	No trend		13.6	No trend		30.9	No trend		8.1	Increase		11.5	No trend		65.5	No trend		18.4	Decrease		15.9	Increase		61.8
EASTMAN POND	GRANTHAM	No trend	No change	57.9	Decrease	No change	75.8	No trend	No change	65.5	Increase	Increase	91.9	No trend	No change	15.9	No trend		69.1	No trend		65.5	No trend		38.2
EAST WASHINGTON DAM	WASHINGTON	No trend	No change	8.1	No trend	No change	54.0	No trend	No change	13.6	No trend	No change	50.0	No trend	No change	65.5	No trend	No Change	69.1	No trend		46.0			
GOOSE POND	CANAAN	No trend	No change	42.1	No trend	Increase	69.1	No trend	No change	61.8	Increase	Increase	42.1	No trend	No change	42.1	No trend		69.1						
HALFMOON POND	WASHINGTON	No trend	No change	50.0	No trend	No change	34.5	Decrease	No change	54.0	Decrease	Increase	21.2	No trend	No change	38.2	No trend	Increase	18.4	Decrease		46.0	No trend		18.4
ISLAND POND	WASHINGTON	No trend	No change	78.8	No trend	No change	21.2	Decrease	No change	42.1	No trend	Increase	42.1	No trend	No change	42.1	Increase	Increase	8.1	No trend		34.5	No trend	No change	38.2
KEZAR LAKE	SUTTON	Decrease		65.5	No trend		65.5	No trend		50.0	Increase		88.5	No trend		54.0	No trend		57.9	No trend		57.9	Increase		38.2
KILTON POND	GRAFTON	No trend		65.5	No trend		65.5	No trend		15.9	No trend		75.8	No trend		78.8	No trend		81.6	No trend		18.4	No trend		46.0
KOLELEMOOK LAKE	SPRINGFIELD	No trend	No change	34.5	No trend	No change	65.5	Increase	No change	57.9	No trend	No change	88.5	No trend	No change	42.1	Increase	Increase	65.5	No trend		34.5	No trend		57.9
LAKE KATHERINE	PIERMONT	No trend	No change	57.9	No trend	No change	69.1	No trend	No change	34.5	No trend	No change	50.0	No trend	No change	50.0	Increase	Increase	61.8	No trend		69.1	No trend		11.5
LAKE TARLETON	PIERMONT	No trend	No change	24.8	Increase	Decrease	57.9	No trend	No change	54.0	No trend	No change	42.1	No trend	No change	29.1	Increase	Increase	46.0	No trend	No change	84.1	No trend	No change	5.5
LEDGE POND	SUNAPEE	No trend	No change	38.2	Increase	No change	27.4	No trend	No change	42.1	No trend	No change	8.1	No trend	No change	42.1	Increase	Increase	15.9	No trend		57.9	No trend		46.0
LITTLE SUNAPEE LAKE	NEW LONDON	No trend	No change	57.9	No trend	No change	61.8	Decrease	No change	42.1	No trend	No change	84.1	No trend	No change	42.1	Increase		54.0	No trend		27.4	Decrease		34.5
LONG POND	LEMPSTER	No trend	No change	9.7	Increase	Increase	4.5	Decrease	No change	93.3	Decrease		9.7	Decrease	No change	29.1	Increase	No Change	0.1	No trend	No change	46.0	No trend	No change	50.0
MASCOMA LAKE	ENFIELD	No trend	No change	57.9	No trend	No change	78.8	No trend	Increase	21.2	Increase	Increase	75.0	No trend	Decrease	69.1	No trend		84.1	Decrease	Increase	61.8	No trend	No change	46.0
MASSASECUM LAKE	BRADFORD	No trend		24.8	No trend	No change	54.0	No trend	No change	94.5	No trend	Increase	38.2	No trend	No change	8.1	Increase	Increase	34.5	Decrease		57.9	No trend		57.9
MESSER POND	NEW LONDON	No trend	No change	54.0	Increase	No change	61.8	No trend	No change	42.1	No trend	Increase	88.5	No trend	No change	54.0	Increase		61.8	No trend		34.5	No trend		46.0
MILLEN POND	WASHINGTON	No trend	No change	38.2	Increase	Increase	30.9	No trend	No change	75.8	No trend	Increase	38.2	No trend	No change	29.1	Increase	Increase	13.6	No trend		42.1	No trend		46.0
MOUNTAINVIEW LAKE	SUNAPEE	No trend	No change	72.6	No trend	No change	65.5	No trend	No change	21.2	No trend	Increase	93.3	No trend	No change	72.6	No trend		69.1	Decrease		24.2	Increase		38.2
OTTER POND	SUNAPEE	No trend	No change	27.4	No trend	No change	65.5	Decrease	No change	72.6	Increase	Increase	84.1	No trend	No change	21.2	Increase		54.0	No trend		65.5	No trend		46.0
PERKINS POND	SUNAPEE	No trend	No change	97.7	No trend	No change	69.1	No trend	Decrease	3.6	Increase	Increase	69.1	No trend	No change	78.8	Increase		65.5	No trend		42.1	No trend		61.8

Region / Lake	Town	Parameter																							
		Primary Indicator															Accessory Indicator								
		Chlorophyll-a			pH			Secchi depth			Specific Conductance			Total Phosphorus			Alkalinity			1-meter Dissolved Oxygen			1-meter Water Temperature		
		Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile
PLEASANT LAKE	NEW LONDON	No trend	No change	46.0	No trend	No change	61.8	Decrease	No change	75.8	No trend	Increase	57.9	No trend	No change	29.1	Increase		54.0	No trend	Increase	46.0	No trend	No change	54.0
POST POND	LYME	No trend	No change	46.0	No trend		91.9	No trend	No change	90.3	No trend	No change	69.1	No trend	No change	18.4	Increase	No Change	93.3	No trend	No change	69.1	No trend	No change	65.5
RAND POND	GOSHEN	No trend	No change	42.1	No trend	Increase	72.6	No trend	No change	42.1	No trend	Increase	78.8	No trend	Decrease	57.9	Increase		74.2	No trend		38.2	No trend		42.1
RESERVOIR POND	DORCHESTER	No trend		75.8	No trend		50.0	No trend	No change	27.4	No trend		9.7	No trend		34.5	No trend		34.5	No trend	No change	34.5	No trend	No change	54.0
ROCKYBOUND POND	CROYDON	No trend	No change	50.0	No trend	No change	75.8	Decrease	No change	57.9	Increase	No change	69.1	No trend	Decrease	50.0	No trend		75.8	No trend		42.1	Increase		38.2
SPECTACLE POND	ENFIELD	No trend	No change	57.9	No trend	No change	75.0	No trend		21.2	Increase	Increase	46.0	No trend	No change	54.0	Increase		69.1	No trend	No change	34.5	No trend	No change	57.9
STOCKER POND	GRANTHAM	No trend	No change	46.0	No trend	No change	75.8	No trend	No change	42.1	Increase	Increase	91.9	No trend	No change	25.0	Increase		84.1	No trend		38.2	Increase		54.0
SUNAPEE LAKE	SUNAPEE	No trend	No change	21.2	No trend	Increase	61.8				Increase	Increase	84.1	No trend	No change	29.1	Increase		54.0	Decrease	No change	75.0	No trend	No change	27.4
TODD LAKE	NEWBURY	No trend	No change	38.2	Decrease	No change	69.1	No trend	No change	50.0	No trend	Increase	50.0	No trend	No change	54.0	No trend		61.8	No trend		46.0	No trend		46.0
WAUKEENA LAKE	DANBURY	No trend		54.0	No trend	No change	42.1	No trend	No change	54.0	No trend	No change	15.9	No trend	No change	24.2	Increase	No Change	34.5	No trend		38.2	Increase		75.8
Great North Woods (GNW)																									
FOREST LAKE	DALTON	No trend		46.0	No trend		75.8	Decrease		78.8	No trend		42.1	No trend		21.18554	Increase		69.1	Decrease		46.0	No trend		57.9
MARTIN MEADOW POND	LANCASTER	No trend		54.0	No trend	No change	84.1	No trend	No change	57.9	Increase	Increase	75.8	No trend	No change	38.208858	Increase	No Change	88.5	No trend	No change	61.8	No trend	No change	57.9
Lakes																									
CHESTNUT POND	EPSOM	Decrease	Decrease	65.5	Increase	No change	54.0	No trend	No change	50.0	No trend	Increase	38.2	No trend	No change	61.8	Increase	Increase	54.0	No trend		13.6	No trend		50.0
CLEMENT POND	HOPKINTON	No trend	No change	42.1	Decrease	No change	78.8	No trend	No change	75.8	Increase	Increase	38.2	No trend	No change	25.0	No trend	Increase	69.1	No trend		61.8	No trend		54.0
CLOUGH POND	LOUDON	No trend	No change	57.9	No trend	Increase	75.8	No trend	No change	90.3	Increase	Increase	65.5	No trend	Increase	18.4	Increase	Increase	57.9	No trend	No change	57.9	No trend	No change	78.8
CRYSTAL LAKE	GILMANTON	Decrease	No change	75.8	No trend	Increase	57.9	No trend	No change	54.0	No trend	Increase	30.9	No trend	No change	57.9	Increase	Increase	50.0	No trend	Increase	38.2	No trend	No change	65.5
FRENCH POND	HENNIKER	Increase		46.0	No trend		86.4	Decrease		90.3	Increase		54.0	No trend		27.4	Increase		61.8	No trend		72.6	Decrease		69.1
HALFMOON LAKE	ALTON	Decrease	No change	72.6	No trend	No change	57.9	No trend	No change	30.9	Increase	Increase	65.5	No trend	No change	65.5	No trend	Increase	54.0	Decrease		9.7	No trend		61.8
HERMIT LAKE	SANBORNTON	No trend	No change	8.1	No trend	No change	65.5	No trend	No change	99.4	No trend	Increase	69.1	Decrease	No change	2.3	No trend	No Change	46.0	No trend	No change	69.1	Increase	No change	72.6
HIGHLAND LAKE	ANDOVER	No trend	Decrease	30.9	No trend		69.1	No trend	Increase	90.3	No trend	Increase	38.2	No trend	No change	18.4	Increase	Increase	54.0	Decrease		61.8	Increase		69.1
HILLS POND	ALTON	No trend	No change	65.5	No trend		57.9	No trend	No change	72.6	No trend		27.4	No trend		27.4	No trend		42.1	No trend	No change	42.1	No trend	No change	69.1
LAKE WAUKEWAN	MEREDITH	No trend	No change	34.5	No trend	No change	72.6	No trend	No change	81.6	Increase	Increase	88.5	No trend	No change	29.1	Increase	Increase	74.2	No trend		65.5	No trend		50.0
LAKE WICWAS	MEREDITH	No trend	No change	34.5	No trend		54.0	No trend	No change	88.5	Increase	Increase	57.9	No trend	No change	13.6	No trend	Increase	50.0	No trend	No change	46.0	No trend	No change	61.8
LAKE WINNEPOCKET	WEBSTER	No trend	No change	61.8	No trend	Increase	69.1	No trend	No change	72.6	Decrease	No change	57.9	No trend	No change	42.1	Increase	Increase	69.1	No trend		42.1	No trend		61.8
LAKE WINNISQUAM	BELMONT	No trend	Decrease	30.9	No trend		75.8	No trend	No change	88.5	Increase	Increase	84.1	Decrease	No change	42.1	Increase	Increase	75.8	No trend		42.1	No trend		57.9
LAKE WINONA	CENTER HARBOR	No trend	No change	38.2	No trend	No change	69.1	No trend	No change	96.4	Increase	Increase	57.9	No trend	No change	9.7	No trend	No Change	54.0	No trend		57.9	No trend		61.8
LEES POND	MOULTONBORO	No trend	No change	50.0	No trend	No change	75.8	No trend	No change	57.9	Increase	Increase	54.0	No trend	No change	50.0	No trend	No Change	78.8	No trend		57.9	No trend		42.1
LOCKE LAKE	BARNSTEAD	No trend		72.6	No trend		54.0	No trend		21.2	Increase		61.8	No trend		90.3	Increase		42.1	No trend		27.4			
LOON POND	GILMANTON	No trend	No change	13.6	No trend	No change	69.1	No trend	No change	94.5	Increase	Increase	75.8	No trend	No change	13.6	Increase	Increase	54.0	No trend		65.5	Increase		50.0

Region / Lake	Town	Parameter																							
		Primary Indicator																Accessory Indicator							
		Chlorophyll-a			pH			Secchi depth			Specific Conductance			Total Phosphorus			Alkalinity			1-meter Dissolved Oxygen			1-meter Water Temperature		
		Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile
LOWER BEECH POND	TUFTONBORO	Decrease	Decrease	42.1	No trend		50.0	No trend	No change	57.9	Increase	Increase	34.5	No trend	No change	30.9	No trend	Increase	42.1	No trend		27.4	No trend		50.0
LOWER SUNCOOK POND	BARNSTEAD	No trend		61.8	No trend		65.5	No trend		24.2	Increase		50.0	No trend		72.6	No trend		57.9	No trend		21.2	Increase		69.1
NEW POND	CANTERBURY	No trend	No change	57.9	Increase	No change	61.8	No trend	No change	21.2	Increase	Increase	61.8	No trend	No change	61.8	Increase	Increase	57.9	No trend		4.5	No trend		72.6
PEMIGEWASSET LAKE	MEREDITH	No trend	Decrease	30.9	No trend	No change	57.9	No trend	No change	84.1	No trend	No change	46.0	No trend	No change	18.4	Increase		42.1	No trend		42.1	Increase		81.6
PILLSBURY LAKE	WEBSTER	No trend		6.7	No trend		65.5	No trend		54.0	No trend		50.0	No trend		30.9									
RUST POND	WOLFEBORO	No trend	No change	54.0	No trend		86.4	No trend	No change	54.0	Increase	Increase	69.1	Decrease	No change	46.0	Increase	Increase	86.4	No trend		84.1	No trend		38.2
SUNSET LAKE	ALTON	Decrease		72.6	No trend		54.0	No trend		72.6	No trend		27.4	No trend		29.1	No trend		42.1	No trend		30.9	No trend		65.5
TOM POND	WARNER	No trend	No change	84.1	Decrease	Increase	75.0	No trend	No change	54.0	No trend	No change	81.6	No trend	No change	38.2	No trend	Increase	78.8	No trend		84.1	No trend		50.0
TUCKER POND	SALISBURY	Decrease		34.5	No trend		57.9	No trend		81.6	No trend		25.0	No trend		30.9	No trend		42.1	Decrease		46.0	No trend		65.5
TUREE POND	BOW	No trend		8.1	No trend		69.1	No trend		38.2	No trend		86.4	Increase		46.0	No trend		75.0	No trend		42.1	No trend		46.0
UPPER SUNCOOK POND	BARNSTEAD	No trend		61.8	No trend		61.8	No trend		27.4	Increase		54.0	No trend		72.6	No trend		57.9	No trend		34.5	Increase		65.5
WEBSTER LAKE	FRANKLIN	No trend	No change	34.5	No trend	No change	72.6	Decrease	No change	84.1	No trend	Increase	46.0	No trend	No change	38.2	No trend	Increase	57.9	No trend		61.8	No trend		69.1
Monadnock																									
CHAPMAN POND	SULLIVAN	Decrease	Decrease	38.2	No trend	No change	11.5	No trend	No change	18.4	No trend	Increase	42.1	No trend	No change	61.8	Increase	No Change	8.1	No trend	No change	8.1	No trend	No change	46.0
CONTENTION POND	HILLSBOROUGH	No trend	No change	18.4	No trend		54.0	No trend	No change	75.8	No trend	No change	15.9	No trend	Decrease	18.4	No trend	No Change	38.2	No trend	No change	50.0	No trend	No change	57.9
CONTOOCOOK LAKE	JAFFREY	Decrease	No change	46.0	No trend		46.0	No trend	No change	50.0	Increase	Increase	65.5	No trend	No change	50.0	No trend	Increase	34.5	No trend		65.5	No trend		25.0
DUBLIN POND	DUBLIN	No trend		11.5	No trend		69.1	No trend	No change	84.1	No trend	Increase	81.6	No trend	No change	4.5	Increase	Increase	57.9	No trend	No change	46.0	No trend	No change	34.5
EMERSON POND	RINDGE	No trend	No change	69.1	Increase	No change	50.0	No trend	No change	42.1	Increase	Increase	75.8	No trend	No change	38.2	Increase	Increase	38.2	No trend		46.0	No trend		61.8
FOREST LAKE	WINCHESTER	No trend		84.1	Decrease	No change	72.6	Increase		65.5	Decrease	No change	61.8	No trend	No change	38.2	Decrease	Increase	69.1	Decrease		75.8	No trend		65.5
FROST POND	JAFFREY	No trend		50.0	No trend		54.0	No trend		50.0	No trend		15.9	No trend		42.1	Increase		34.5	No trend		50.0	Increase		75.8
GILMORE POND	JAFFREY	No trend	No change	21.2	No trend	Increase	42.1	No trend	Decrease	91.9	Increase	No change	96.4	No trend	No change	42.1	Increase	Increase	21.2	No trend	No change	54.0	No trend	Increase	38.2
GRANITE LAKE	STODDARD	No trend	No change	6.7	No trend	No change	34.5	No trend	No change	91.9	No trend	Increase	72.6	No trend	No change	18.4	Increase	Increase	18.4	Decrease		46.0	Increase		54.0
GREGG LAKE	ANTRIM	No trend		78.8	No trend		46.0	Decrease		46.0	Decrease		18.4	No trend		50.0	No trend		24.2	No trend		46.0	No trend		54.0
HARRISVILLE POND	HARRISVILLE	No trend	No change	54.0	No trend	No change	34.5	No trend		84.1	No trend	Increase	18.4	No trend	No change	13.6	No trend	Increase	13.6	Decrease	No change	54.0	Increase	No change	42.1
HIGHLAND LAKE	STODDARD	Decrease	Increase	50.0	No trend	Increase	27.4	No trend	No change	50.0	Decrease	Increase	27.4	No trend	No change	42.1	No trend	Increase	15.9	No trend		46.0	No trend		30.9
ISLAND POND	STODDARD	No trend	No change	61.8	No trend	Increase	30.9	No trend		57.9	No trend	Increase	27.4	No trend	No change	42.1	No trend	Increase	18.4	Decrease		21.2	No trend	No change	42.1
LAKE MONOMONAC	RINDGE	No trend		61.8	No trend		34.5	Decrease		46.0	Increase		69.1	No trend		42.1	Increase		15.9	Decrease		57.9	No trend		46.0
LAKE SKATUTAKEE	HARRISVILLE	No trend	No change	46.0	No trend	Increase	46.0	No trend	No change	57.9	No trend	Increase	34.5	Decrease	No change	38.2	Increase	Increase	21.2	No trend		50.0	No trend		42.1
LAUREL LAKE	FITZWILLIAM	No trend	No change	57.9	No trend	Increase	50.0	No trend	No change	69.1	No trend	Increase	57.9	No trend	No change	42.1	Increase	Increase	30.9	No trend		69.1	No trend		46.0
NORWAY POND	HANCOCK	No trend	No change	50.0	No trend	No change	54.0	No trend	No change	72.6	No trend	Increase	38.2	No trend	No change	38.2	Increase	Increase	42.1	No trend		34.5	No trend		61.8
NUBANUSIT LAKE	HANCOCK	Decrease	No change	4.5	No trend	Increase	30.9	No trend		97.7	Decrease	No change	9.7	No trend	No change	29.1	No trend	Increase	6.7	Decrease		42.1	No trend		42.1
PEARLY LAKE	RINDGE	Decrease	No change	46.0	No trend	Increase	34.5	No trend	No change	15.9	Increase	Increase	57.9	Decrease	No change	69.1	No trend	Increase	21.2	Decrease		54.0	Increase		61.8

Region Lake	Town	Parameter																							
		Primary Indicator															Accessory Indicator								
		Chlorophyll-a			pH			Secchi depth			Specific Conductance			Total Phosphorus			Alkalinity			1-meter Dissolved Oxygen			1-meter Water Temperature		
		Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile
POOL POND	RINDGE	No trend		30.9	No trend	No change	50.0	No trend	No change	54.0	Increase		91.9	Increase	No change	42.1	Increase	No Change	42.1	Decrease		34.5	No trend		50.0
ROCKWOOD POND	FITZWILLIAM	No trend	No change	65.5	Increase	No change	15.9	No trend	No change	34.5	Decrease	No change	34.5	No trend	No change	57.9	No trend	No Change	6.7	No trend	No change	13.6	No trend	No change	65.5
RUSSELL RESERVOIR	HARRISVILLE	No trend		46.0	Increase		34.5	No trend		21.2	No trend		38.2	No trend		50.0	Increase		25.0	No trend		34.5	No trend		15.9
SAND POND	MARLOW	Increase	No change	27.4	Increase	No change	18.4	No trend	No change	91.9	Decrease	No change	13.6	No trend	No change	29.1	Increase		6.7	No trend		54.0	Increase		27.4
SILVER LAKE	HARRISVILLE	No trend	No change	18.4	No trend	Increase	34.5	No trend	No change	91.9	Decrease	Increase	21.2	No trend	No change	5.5	No trend	Increase	13.6	No trend		65.5	No trend		30.9
SPOFFORD LAKE	CHESTERFIELD	No trend	Decrease	21.2	No trend	No change	75.8	No trend	Increase	93.3	Increase	Increase	93.3	No trend	No change	34.5	Increase	Increase	75.8	No trend		42.1	No trend		61.8
STONE POND	MARLBOROUGH	No trend	No change	50.0	No trend	Increase	42.1	No trend	No change	65.5	No trend	Increase	21.2	No trend		34.5	No trend	Increase	24.2	No trend		46.0	No trend		50.0
SWANZEY LAKE	SWANZEY	No trend	No change	61.8	No trend	Increase	69.1	No trend	No change	46.0	Increase	No change	54.0	No trend	Increase	42.1	Increase	Increase	69.1	No trend		38.2	No trend		65.5
THORNDIKE POND	JAFFREY	No trend	No change	78.8	No trend	No change	38.2	No trend	No change	27.4	No trend	Increase	38.2	No trend	No change	57.9	No trend	Increase	27.4	No trend	No change	42.1	No trend	No change	34.5
WARREN LAKE	ALSTEAD	No trend	No change	95.5	No trend	Increase	50.0	Decrease	Decrease	8.1	No trend	Increase	69.1	Increase	No change	78.8	Increase	No Change	50.0	No trend		38.2	No trend		54.0
WILSON POND	SWANZEY	No trend	No change	27.4	No trend	No change	61.8	No trend	No change	57.9	Increase	Increase	78.8	No trend	No change	65.5	Increase	Increase	61.8	No trend		42.1	No trend		72.6
Merrimack Valley (MV)																									
ANGLE POND	SANDOWN	No trend	No change	38.2	Increase	No change	84.1	No trend	No change	65.5	No trend	Increase	94.5	No trend	No change	54.0	Increase	Increase	90.3	No trend		42.1	No trend		81.6
BEAVER LAKE	DERRY	No trend	No change	69.1	No trend	No change	86.4	Decrease	No change	72.6	Increase	Increase	91.9	No trend	No change	57.9	Increase	Increase	90.3	No trend		46.0	No trend		54.0
CANOBIE LAKE	SALEM	Decrease	No change	38.2	No trend	No change	88.5	Increase	No change	65.5	Increase	Increase	99.9	No trend	No change	57.9	Increase	Increase	94.5	No trend		42.1	No trend		84.1
CAPTAIN POND	SALEM	No trend	No change	72.6	No trend	No change	81.6	No trend	No change	27.4	No trend	Increase	95.5	No trend	No change	78.8	Increase	Increase	88.5	No trend		27.4	No trend		78.8
COBBETTS POND	WINDHAM	No trend	No change	84.1	No trend		90.3	No trend	No change	30.9	Increase		99.9	Increase		75.8	Increase		97.1	No trend	No change	46.0	No trend	No change	61.8
CRYSTAL LAKE	MANCHESTER	Decrease		38.2	No trend		84.1	No trend		84.1	Increase		99.4	No trend		54.0	No trend		90.3	No trend	No change	57.9	Increase	No change	84.1
DEERING RESERVOIR	DEERING	No trend	Decrease	50.0	No trend	Increase	65.5	No trend	No change	72.6	No trend	Increase	75.8	No trend	No change	46.0	No trend	Increase	61.8	Decrease		27.4	No trend		50.0
DORRS POND	MANCHESTER	Decrease	No change	91.9	No trend	No change	81.6	No trend	Decrease	5.5	No trend	Increase	99.9	No trend	No change	95.5	No trend	No Change	94.5	No trend	No change	5.5	No trend	No change	46.0
GREAT POND	KINGSTON	No trend	No change	38.2	No trend	No change	72.6	No trend	Increase	57.9	Increase	Increase	91.9	No trend	No change	38.2	Increase	Increase	75.0	Decrease		46.0	No trend		65.5
ISLAND POND	DERRY	No trend	No change	88.5	No trend		78.8	No trend	No change	34.5	Increase	Increase	97.7	No trend	No change	65.5	Increase	Increase	88.5	No trend		27.4	No trend	No change	69.1
NUTT POND	MANCHESTER	No trend	Increase	81.6	No trend	No change	81.6	No trend	Decrease	57.9	Increase	Increase	99.9	Decrease	No change	75.8	Increase	Increase	90.3	No trend	No change	42.1	No trend	No change	69.1
OTTERNICK POND	HUDSON	No trend	No change	30.9	No trend	No change	86.4	Decrease	No change	69.1	Increase	Increase	91.9	No trend	No change	69.1	Increase	Increase	95.5	No trend		34.5			
PINE ISLAND POND	MANCHESTER	No trend	No change	34.5	No trend	No change	81.6	No trend	No change	50.0	Increase	Increase	94.5	No trend	No change	57.9	No trend	Increase	86.4	No trend		54.0	No trend	No change	69.1
PLEASANT POND	FRANCESTOWN	No trend	No change	57.9	No trend	No change	46.0	No trend	No change	46.0	Increase	Increase	27.4	No trend	Increase	65.5	Increase	Increase	38.2	No trend		11.5	No trend		69.1
POWWOW POND	KINGSTON	No trend		50.0	No trend		57.9	No trend		11.5	Increase		91.9	No trend		65.5							No trend		78.8
PRATT POND	NEW IPSWICH	Increase	No change	11.5	Increase	Increase	25.0	No trend		61.8	No trend	Increase	11.5	Increase	No change	18.4	Increase	Increase	4.5	No trend		38.2	No trend		81.6
ROBINSON POND	HUDSON	No trend	No change	93.3	No trend	No change	78.8	No trend	No change	50.0	No trend	Increase	94.5	No trend	No change	69.1	Increase	No Change	84.1	No trend		25.0	No trend		46.0
ROCK POND	WINDHAM	No trend	No change	27.4	No trend	No change	84.1	No trend	No change	91.9	Increase	Increase	81.6	No trend	No change	21.2	No trend	Increase	81.6	No trend		61.8	No trend		69.1
SEBBINS POND	BEDFORD	No trend	No change	98.2	Decrease	No change	81.6	No trend	No change	50.0	Increase	Increase	95.5	No trend	No change	65.5	Increase	Increase	86.4	Decrease		96.4	No trend		25.0

Region / Lake	Town	Parameter																							
		Primary Indicator																Accessory Indicator							
		Chlorophyll-a			pH			Secchi depth			Specific Conductance			Total Phosphorus			Alkalinity			1-meter Dissolved Oxygen			1-meter Water Temperature		
		Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile
STEVENS POND	MANCHESTER	No trend	No change	21.2	Decrease	Decrease	88.5	No trend	No change	86.4	No trend	Increase	99.5	No trend	No change	57.9	No trend	No Change	93.3	No trend	No change	54.0	No trend	No change	50.0
Seacoast																									
AYERS POND	BARRINGTON	Decrease	Decrease	57.9	No trend	No change	46.0	No trend	No change	54.0	Increase	Increase	75.0	No trend	No change	54.0	No trend	Increase	30.9	No trend		38.2	No trend		72.6
BAXTER LAKE	FARMINGTON	No trend		38.2	No trend		42.1	No trend		46.0	Increase		50.0	No trend		54.0	Increase		27.4	No trend		42.1	No trend		75.0
GOVERNORS LAKE	RAYMOND	Decrease		78.8	No trend		61.8	No trend		18.4	Increase		84.1	No trend		88.5	Increase		65.5	No trend		34.5	No trend		78.8
HARANTIS LAKE	CHESTER	Increase		30.9	No trend		50.0	No trend		42.1	Increase		27.4	No trend		34.5							No trend		46.0
HARVEY LAKE	NORTHWOOD	No trend	No change	30.9	No trend	No change	65.5	Decrease	No change	57.9	No trend	Increase	57.9	No trend	No change	38.2	Increase	Increase	50.0	No trend		61.8	No trend		72.6
JENNESS POND	NORTHWOOD	No trend	Decrease	61.8	Increase	No change	38.2	Decrease	No change	34.5	No trend	Increase	75.8	No trend	No change	54.0	Increase	No Change	27.4	No trend		54.0	No trend		50.0
NORTHWOOD LAKE	NORTHWOOD	No trend	No change	42.1	No trend	No change	54.0	No trend	No change	57.9	No trend	Increase	69.1	No trend		46.0	Increase	Increase	34.5	No trend		38.2	No trend		65.5
ONWAY LAKE	RAYMOND	No trend	No change	30.9	No trend	No change	65.5	No trend	No change	50.0	No trend	Increase	91.9	No trend	No change	42.1	Increase	No Change	65.5	Increase	No change	21.2	Increase	No change	88.5
PAWTUCKAWAY LAKE	NOTTINGHAM	No trend	No change	50.0	No trend	Increase	57.9	No trend		65.5	No trend	Increase	42.1	No trend	No change	50.0	Increase	Increase	46.0	No trend		54.0	No trend		72.6
PHILLIPS POND	SANDOWN	No trend	Decrease	61.8	No trend	Decrease	65.5	No trend	Increase	13.6	Increase	Increase	95.5	No trend	Decrease	75.8	Increase	No Change	84.1						
PLEASANT LAKE	DEERFIELD	No trend	No change	38.2	Increase	Increase	34.5	No trend	No change	78.8	No trend	Increase	75.8	Decrease	No change	34.5	Increase	Increase	15.9	No trend		65.5	Increase		38.2
SUNRISE LAKE	MIDDLETON	No trend		91.9	No trend		57.9	No trend		6.7	Increase		72.6	Decrease		65.5	Increase		54.0	No trend		30.9	Increase		65.5
White Mountain (WM)																									
BEARCAMP POND	SANDWICH	No trend	No change	54.0	No trend	No change	50.0	No trend	No change	69.1	No trend	Increase	15.9	No trend	No change	25.0	No trend	Increase	38.2	Decrease		50.0	No trend		61.8
BERRY BAY	FREEDOM	No trend	No change	42.1	No trend	No change	54.0	No trend	No change	46.0	No trend	Increase	54.0	No trend	No change	50.0	Increase	Increase	61.8	No trend	No change	50.0	No trend	No change	72.6
BIG PEA PORRIDGE POND	MADISON	No trend	Decrease	30.9	Increase		54.0	Decrease	Increase	46.0	Increase	Increase	57.9	No trend	No change	42.1	Increase	Increase	46.0	No trend		27.4	No trend		65.5
BROAD BAY	OSSIPEE	Decrease	No change	42.1	No trend	No change	57.9	Decrease	No change	46.0	Increase	Increase	46.0	No trend	Decrease	50.0	No trend	Increase	61.8	No trend	Increase	50.0	No trend	No change	65.5
CONNER POND	OSSIPEE	Decrease	No change	2.3	Increase	No change	46.0	No trend	No change	97.7	No trend	No change	9.7	No trend	No change	4.5	Increase	Increase	34.5	Increase	No change	46.0	No trend	No change	50.0
DODGE POND	LYMAN	No trend		88.5	No trend		91.9	No trend		9.7	No trend		81.6	No trend		78.8	No trend		98.6	No trend		38.2	No trend		75.0
LEAVITT BAY	OSSIPEE	No trend	No change	38.2	No trend	No change	57.9	Decrease	No change	42.1	Increase	Increase	50.0	No trend	No change	50.0	No trend	Increase	61.8	No trend	Increase	46.0	No trend	No change	69.1
LOON LAKE	PLYMOUTH	No trend	No change	27.4	No trend	No change	61.8	No trend	No change	81.6	No trend	No change	18.4	No trend	Increase	21.2	Increase	No Change	38.2	No trend		54.0	No trend		50.0
LOWER DANFORTH POND	FREEDOM	No trend	No change	38.2	No trend	No change	65.5	No trend		78.8	No trend	Increase	54.0	No trend	No change	21.2	No trend	Increase	69.1	No trend	No change	69.1	No trend	Increase	65.5
LOWER MOUNTAIN LAKE	HAVERHILL	No trend	No change	81.6	No trend	No change	81.6	No trend	No change	21.2	No trend	Increase	81.6	No trend	No change	57.9	No trend	No Change	88.5	No trend	No change	42.1	No trend	No change	61.8
MIDDLE PEA PORRIDGE POND	MADISON	No trend	No change	42.1	No trend	No change	50.0	No trend	Increase	46.0	Increase	Increase	65.5	No trend	No change	42.1	Increase	Increase	50.0	No trend		27.4	No trend		61.8
MOORES POND	TAMWORTH	No trend		18.4	No trend	No change	54.0	No trend	No change	81.6	No trend	Increase	54.0	No trend	No change	3.6	No trend	No Change	46.0	No trend	No change	69.1	No trend	No change	21.2
OSSIPEE LAKE	OSSIPEE	No trend	No change	30.9	No trend	No change	61.8	Decrease		54.0	No trend	Increase	54.0	No trend	No change	50.0	Increase	Increase	61.8	No trend	No change	61.8	No trend	No change	50.0
PARTRIDGE LAKE	LITTLETON	No trend	No change	61.8	No trend		93.3	No trend	No change	93.3	No trend	No change	65.5	No trend	Increase	30.9	No trend	No Change	94.5	No trend		69.1	No trend		57.9
ROUND POND	LYMAN	No trend		72.6	Increase		88.5	No trend		42.1	No trend		69.1	Increase		57.9	No trend		97.1	No trend		25.0	No trend		61.8
STINSON LAKE	RUMNEY	Increase	No change	18.4	No trend	No change	46.0	Decrease	No change	86.4	No trend	Increase	15.9	No trend	No change	29.1	Increase	Increase	27.4	No trend		61.8	Increase		30.9

Region Lake	Town	Parameter																							
		Primary Indicator															Accessory Indicator								
		Chlorophyll-a			pH			Secchi depth			Specific Conductance			Total Phosphorus			Alkalinity			1-meter Dissolved Oxygen			1-meter Water Temperature		
		Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile	Long term	Short term	Percentile
UPPER MOUNTAIN LAKE	**HAVERHILL**	No trend	No change	57.9	No trend	No change	78.8	No trend	No change	42.1	No trend	No change	75.8	No trend	No change	38.2	No trend	No Change	86.4	No trend	No change	65.5	No trend	No change	46.0
WHITE OAK POND	**HOLDERNESS**	No trend	No change	46.0	No trend	No change	69.1	No trend	No change	72.6	**Increase**	**Increase**	46.0	**Decrease**	No change	21.2	**Increase**	**Increase**	54.0	No trend		42.1	No trend		54.0

Appendix C. Lake name, town, trophic class, trend results and number of years of data for waterbodies used in ice-out trend analysis.

Lake	Town	Trophic Class	Ice-out Trend	Number of Years
BRADLEY LAKE	**ANDOVER**	OLIGOTROPHIC	No Trend	10
CANAAN STREET LAKE	**CANAAN**	OLIGOTROPHIC	Decreasing	94
CANOBIE LAKE	**SALEM**	OLIGOTROPHIC	No Trend	11
CLOUGH POND	**LOUDON**	MESOTROPHIC	No Trend	32
COBBETTS POND	**WINDHAM**	OLIGOTROPHIC	No Trend	24
CRESCENT LAKE	**ACWORTH**	MESOTROPHIC	No Trend	21
DUBLIN POND	**DUBLIN**	OLIGOTROPHIC	No Trend	29
GOOSE POND	**CANAAN**	OLIGOTROPHIC	No Trend	15
ISLAND POND	**WASHINGTON**	OLIGOTROPHIC	No Trend	15
KEZAR LAKE	**SUTTON**	MESOTROPHIC	No Trend	25
KILTON POND	**GRAFTON**	OLIGOTROPHIC	No Trend	13
LAKE TARLETON	**PIERMONT**	OLIGOTROPHIC	No Trend	12
MESSER POND	**NEW LONDON**	MESOTROPHIC	No Trend	19
LAKE MONOMONAC	**RINDGE**	MESOTROPHIC	No Trend	10
OSSIPEE LAKE	**OSSIPEE**	OLIGOTROPHIC	No Trend	11
OTTERNICK POND	**HUDSON**	EUTROPHIC	No Trend	30
OTTER POND	**SUNAPEE**	MESOTROPHIC	No Trend	35
PARTRIDGE LAKE	**LITTLETON**	MESOTROPHIC	No Trend	21
PERKINS POND	**SUNAPEE**	OLIGOTROPHIC	No Trend	24
PINE RIVER POND	**WAKEFIELD**	MESOTROPHIC	No Trend	13
PLEASANT LAKE	**DEERFIELD**	OLIGOTROPHIC	No Trend	14
PLEASANT LAKE	**NEW LONDON**	OLIGOTROPHIC	No Trend	28
ROBINSON POND	**HUDSON**	MESOTROPHIC	No Trend	29
SPOFFORD LAKE	**CHESTERFIELD**	OLIGOTROPHIC	Decreasing	75
STINSON LAKE	**RUMNEY**	OLIGOTROPHIC	Decreasing	82
SUNAPEE LAKE	**SUNAPEE**	OLIGOTROPHIC	Decreasing	148
WAUKEENA LAKE	**DANBURY**	MESOTROPHIC	No Trend	15
LAKE WAUKEWAN	**MEREDITH**	OLIGOTROPHIC	No Trend	15
LAKE WICWAS	**MEREDITH**	MESOTROPHIC	No Trend	20
LAKE WINNEPOCKET	**WEBSTER**	OLIGOTROPHIC	No Trend	25
LAKE WINNIPESAUKEE	**MULTIPLE**	OLIGOTROPHIC	Decreasing	132