Historical Trend Analysis

Kezar Lake & Ponds

Oxford County, Maine

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Prepared for
Kezar Lake Association

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INTRODUCTION

Analyzing trends of measured parameters over a long-term sampling period provides critical insight into the function and health of a waterbody. Using data from the State of Maine Water Quality data base, which includes data collected by the Maine Department of Environmental Protection (DEP), Maine Volunteer Lake Monitoring Program (VLMP) volunteers, and consultants, 40 years of data were analyzed for Kezar Lake and six nearby ponds within the Kezar Lake watershed in Lovell and Stoneham, ME. With the addition of Kezar Lake to Maine's List of Priority Waterbodies in 2005, understanding long-term historical trends in the Kezar Lake watershed is important for maintaining and improving water quality in Kezar Lake and nearby ponds. By identifying these key long-term processes within a particular waterbody, local mangers, residents, and lake associations can work together to develop manageable goals for the protection of their lakes.

<u>Water Quality Parameters</u>

The historical trend analysis for Kezar Lake and nearby ponds utilized data for several key water quality parameters, including water clarity, chlorophyll-a (Chl-a), color, total phosphorus (TP), and dissolved oxygen (DO), alkalinity and pH.

<u>Trophic State Indicators</u>

Water clarity (via Secchi disk transparency (SDT) readings), TP, and Chl-a are trophic state indicators, or indicators of biological productivity in lake ecosystems. The combination of these parameters helps determine the extent of and effects of eutrophication in lakes. In Maine, unproductive lakes have below average TP and Chl-a, and SDTs of greater than 7 m. Moderately productive lakes have average TP and Chl-a, and SDTs of 4-7 m. Productive lakes generally have higher than average TP and Chl-a, and SDTs of 4 m or less.

SDT is a vertical measure of water transparency (the ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Measuring SDT is one of the most useful ways to determine whether a lake is changing from year to year. Changes in transparency may be due to increased or decreased algal growth, or the amount of dissolved or particulate materials in a lake, resulting from human disturbance or other impacts to the lake watershed area. Factors that affect transparency include algae, water color, and sediment. Since algae are usually the most common factor, transparency is an indirect measure of algal populations. Transparency values in Maine vary from 0.5 m to 15.5 m with an average of 4.8 m. Generally, a transparency of 2 m or less indicates a water quality problem and possible algal bloom conditions.

TP refers to the total concentration of phosphorus found in the water, including organic and inorganic forms. TP is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits plant growth in freshwater ecosystems. Anoxia (low dissolved oxygen) can release phosphorus bound to sediments into the water column, thereby increasing the amount of available phosphorus. Humans can also add phosphorus to lakes through stormwater runoff, lawn or garden fertilizers, and leaky or poorly maintained septic tanks. As TP increases within a system, the amount of algae also increases, and may lead to nuisance algal blooms and low water clarity. In Maine lakes, TP varies from 1 to 158 ppb with an average of 12 ppb.

Chl-a is a measurement of the green pigment found in all plants, including microscopic plants such as algae. It is used as an estimate of algal biomass as higher Chl-a equates to greater amount of algae in a lake. Chl-a in Maine lakes ranges from 0.7 to 182 ppb with an average of 5.3 ppb.

Dissolved Oxygen and Temperature Profiles

DO and water temperature profiles have been collected at the deepest part of each waterbody. DO is the concentration of oxygen dissolved in the water, and is vital to fish, algae, macrophytes, and chemical reactions that support lake functioning. Too little oxygen (known as anoxia) severely reduces the diversity and abundance of aquatic communities. DO levels in lake water are influenced by a number of factors, including water temperature, concentration of algae and other plants in the water, and the amount of nutrients and organic matter flowing into the lake as runoff from the watershed. DO concentrations can change dramatically with lake depth as oxygen is produced in the top portion of a lake (where sunlight drives photosynthesis) and oxygen is consumed near the bottom of a lake (where organic matter accumulates and decomposes). In stratified lakes, such as Kezar Lake, this difference may be dramatic with high oxygen near the surface and virtually no oxygen near the bottom. A common problem in Maine lakes is the depletion of oxygen in the deepest part of the lake throughout the summer months. This occurs when thermal stratification prevents the oxygenated surface water from mixing with water deep in the lake. As a result, oxygen in deeper areas can become depleted. DO levels below 5 ppm can stress some species of cold water fish, and over time reduce habitat for sensitive cold water species.

Additional Parameters

In addition to the above parameters, natural color, total alkalinity, and pH were also measured. Color is the influence of suspended and dissolved particles in the water as measured by Standard Platinum Units (SPU). A variety of sources contribute to the types and amount of suspended material in lake water, including weathered geologic material, vegetation cover, and land use activity. Colored lakes have an SPU greater than 25 and cause diminished transparency readings and increased TP. However, this does not necessarily mean such lakes are more productive. Therefore, Chl-a is the best indicator of productivity in colored lakes. In Maine lakes, color varies from 2 to 481 SPU with an average of 28 SPU.

Alkalinity is a measure of the buffering capacity of a lake, or the capacity of water to neutralize acids. It is a measure of naturally-available bicarbonate, carbonate, and hydroxide ions in the water, which is largely determined by the geology of soils and rocks surrounding the lake. Alkalinity is important to aquatic life because it buffers against changes in pH that could have drastic effects on animals and plants. pH is the standard measure of the acidity or alkalinity of a solution on a scale of 0-14. Most aquatic species require a pH between 6.5 and 8. As the pH of a lake declines, particularly below 6, the reproductive capacity of fish populations can be greatly impacted as the availability of nutrients and metals changes. pH is influenced by bedrock, acid rain deposition, wastewater discharge, and natural carbon dioxide fluctuations.

Threats to Water Quality

As presented in the 2010 Kezar Lake Watershed Survey Report, threats to the water quality of Kezar Lake and nearby ponds include sediment and nutrients from existing and future development, aging septic systems, and roads in the watershed. All of these land uses have the potential to deliver phosphorus, the limiting nutrient in freshwater systems, via stormwater runoff to streams and lakes in the watershed. Stormwater runoff from rain and snowmelt picks up soil, nutrients, and other pollutants as it flows over land and washes into the lake. Soil erosion from driveways, roads, ditches, pathways, and beaches are the largest source of phosphorus to Maine lakes.

The Kezar Lake Association has also identified pH and alkalinity within Kezar Lake as a potential cause of fish population demise. Fish species found in Kezar Lake include landlocked alewife and salmon, large and smallmouth bass, white perch, chain pickerel, rainbow smelt, and lake trout. As mentioned above, as the pH of a lake declines, particularly below 6, the reproductive capacity of fish populations can be greatly impacted as the availability of nutrients and metals changes. Algae blooms can exacerbate this effect by causing the pH to rise (become basic) via photosynthesis and decline (become acid) via decomposition. As described above, alkalinity is the buffering capacity of a waterbody or the ability of a waterbody to neutralize acids and stabilize pH. According to the US EPA alkalinity classification of lakes and ponds, Kezar Lake and ponds, which range from 2.5 to 8 mg/L for alkalinity, fall in the endangered and highly sensitized categories. Without a high buffering capacity, these waterbodies are subject to both natural and anthropogenic swings in pH values, which can jeopardize the health of freshwater fish species.

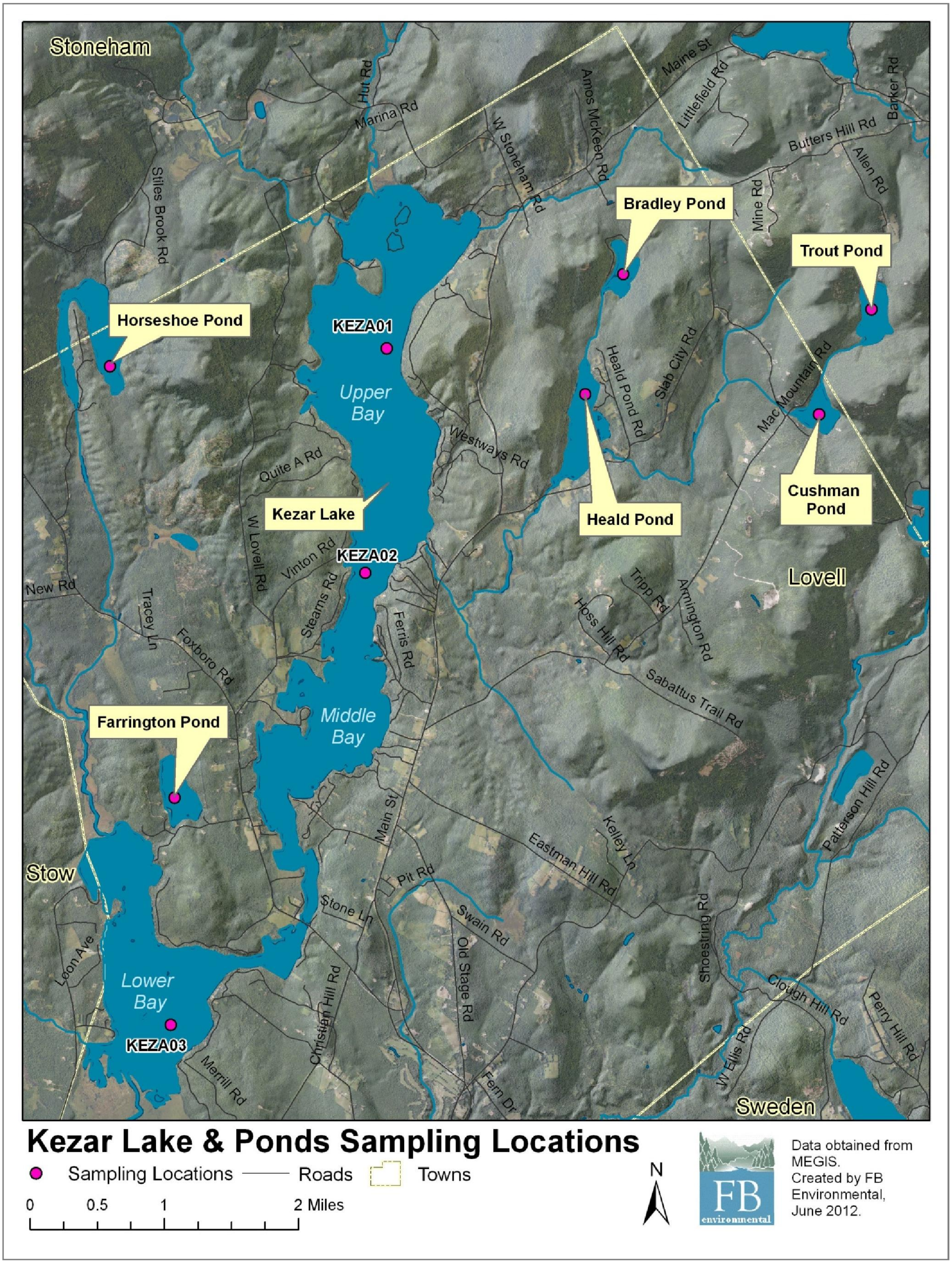
These specific threats to the water quality of Kezar Lake and nearby ponds will be further addressed in the analysis of each waterbody, and will be incorporated in any recommended goals and next steps for the watershed community.

ANALYSIS METHODS

Water quality data from multiple sources were combined into a common spreadsheet for each waterbody, sorted by station and date for Quality Assurance/Quality Control (QA/QC), and checked for any duplicate samples. Minimum, maximum, and average (mean) values were determined for each parameter for each station on each lake or pond over three time periods: 1) All data, 2) Historic data (2001 and earlier) and Recent data (2002 to present). A seasonal analysis was also conducted to compare all reported data for each station with seasonal data (May 15 through October 15). In most cases, the elimination of non-growing season samples did not greatly affect calculations (±0.3). Therefore, for purposes of this analysis, all samples were included. Figures are based on average (mean) annual values for reach water quality parameter. These averages include both grab and core samples for color, alkalinity and pH. Overall TP values (minimum, maximum, and mean) were based on epilimnetic core (EC) samples, however, bottom grab, surface grab, and profile grab samples were also included in figures for interest.

As mentioned previously, water quality data for Kezar Lakes and nearby ponds has been collected by various sources including ME DEP, volunteers and consultants for over 40 years. Historical calculations included all data from the ME DEP lake data base through 2011. This data has been through a thorough QA/QC review by ME DEP on an annual basis. Since data collection was not conducted every year, there are many years that only SDT data are available. All core sampling was conducted in accordance with standard methods and procedures for lake monitoring established by DEP, US EPA, and VLMP. This procedure includes collecting an integrated epilimnetic core at the deep hole of each lake or pond. With this method, a core of water is collected from the water surface to the upper part of the thermocline. Sampling results reflect the "average" concentration for each of the measured parameters.

Figure 1. Kezar Lake & Ponds Sampling Locations



KEZAR LAKE

Watershed: Saco River

Town: Lovell, ME

County: Oxford

Surface Area (acres): 2,665 (4.16 sq.mi)

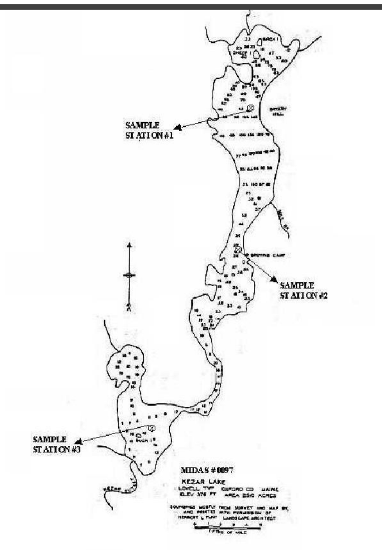
Watershed Area (acres): 35,732 (56 sq.mi)

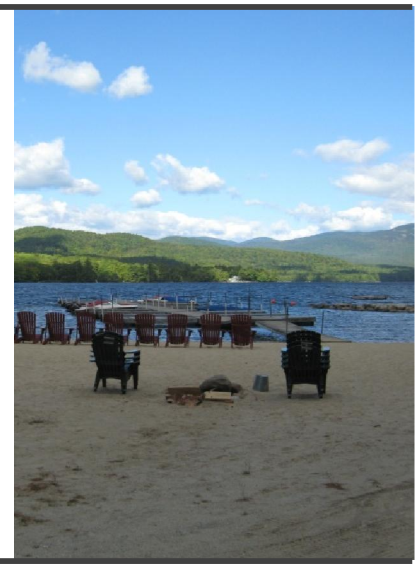
Perimeter (miles): 33.9

Mean Depth (feet): 34

Max Depth (feet): 155

Stations: 1 (Upper), 2 (Middle), 3 (Lower)





Description of Waterbody

Kezar Lake (Midas #0097) is a non-colored waterbody located in the Town of Lovell, Oxford County, Maine. The lake stretches 9 miles from north to south, covering 2,665 acres (4.16 square miles) and has a maximum depth of 155 feet (FBE recorded 162 feet on 9/19/2011 at the upper basin) and a mean depth of 34 feet. Kezar Lake lies within the larger Saco River watershed. The Kezar Lake subwatershed encompasses nine smaller ponds and numerous streams, covering 35,732 acres (56 square miles) in the Towns of Lovell, Stoneham, and Stow, Maine. These waterbodies are home to a variety of fish, including landlocked salmon, large and small-mouth bass, lake trout, white perch, pickerel, and smelt. Kezar Lake itself is a mixed warm- and cold-water fishery. Water quality data has been collected at three in-lake locations known as the upper basin (Station 1), middle basin (Station 2), and lower basin (Station 3) (Figure 1). The following trophic state summary (as of 2001) for each basin was provided by LakesofMaine.org, an online information collaboration between ME DEP, Maine VLMP, and the University of Maine.

Upper Basin (Station 1)

Water quality monitoring data for Kezar Lake's upper basin (Station 1) has been collected since 1970, and includes 27 years of TP (including 22 years of epicore samples), 22 years of Chl-a, 22 years of color data, 27 years of alkalinity, 31 years of DO and temperature profiles, and 40 years of SDT (Table 2). The water quality of Kezar Lake's upper basin is considered to be excellent based on measures of SDT, TP, and Chl-a. The potential for nuisance algae blooms is very low. The potential for TP to leave bottom sediments and become available to algae in the water column (internal loading) is very low. DO profiles show little to no DO depletion in deep areas of the lake.

Middle Basin (Station 2)

Water quality monitoring data for Kezar Lake's middle basin (Station 2) has been collected since 1976, and includes 7 years of TP (including 7 years of epicore samples), 4 years of Chl-a, 4 years of color data, 4 years of alkalinity, 7 years of DO and temperature profiles, and 32 years of SDT (Table 2). The water quality of Kezar Lake's middle basin is considered to be excellent based on measures of SDT and TP. The potential for nuisance algae blooms is low. The potential for TP to leave bottom sediments and become available to algae in the water column (internal loading) is low. Water quality appears to be stable. DO profiles show little to no DO depletion in deep areas of the lake.

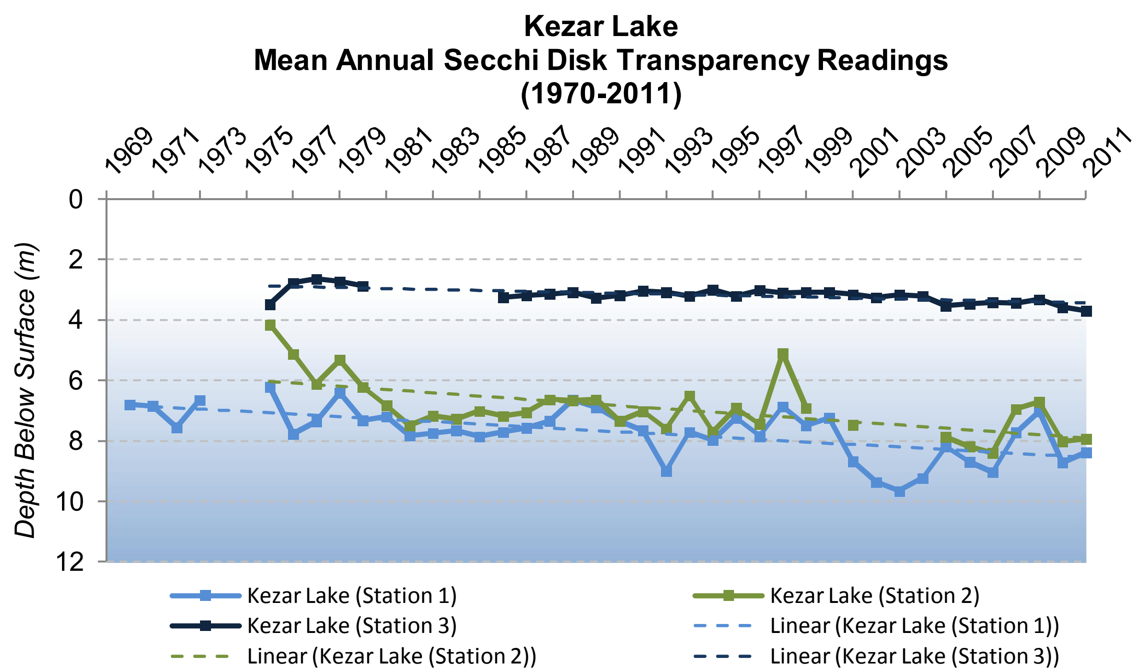
Lower Basin (Station 3)

Water quality monitoring data for Kezar Lake's lower basin (Station 3) has been collected since 1976, and includes 22 years of TP (including 22 years of epicore samples), 21 years of Chl-a, 19 years of color data, 21 years of alkalinity, 26 years of DO and temperature profiles, and 31 years of SDT (Table 1). The water quality of Kezar Lake's lower basin is considered to be below average based on measures of SDT, TP, and Chl-a. The potential for nuisance algae blooms is moderate. DO profiles show indeterminate DO depletion in deep areas of the basin. The potential for TP to leave bottom sediments and become available to algae in the water column (internal loading) is also indeterminate.

Table 1. Years of available data by parameter for Kezar Lake

LAKE	SDT	DO	COLOR	ALKALINITY	CHLA	TP (ALL)	TP (EPICORE)
Kezar Lake (Station 1)	40	31	22	27	22	27	22
Kezar Lake (Station 2)	32	7	4	4	4	7	7
Kezar Lake (Station 3)	31	26	19	21	21	22	22

Water Quality Measures for Kezar Lake



Kezar Lake-01	All Years (1970-2011)	Historical (1970-2001)	Recent (2002-2011)
Minimum SDT (m)	4.6	4.6	5.5
Mean SDT (m)	7.6	7.4	8.8
Maximum SDT (m)	11.6	11.2	11.6

**Hit bottom 0 out of 310 readings (0%)*

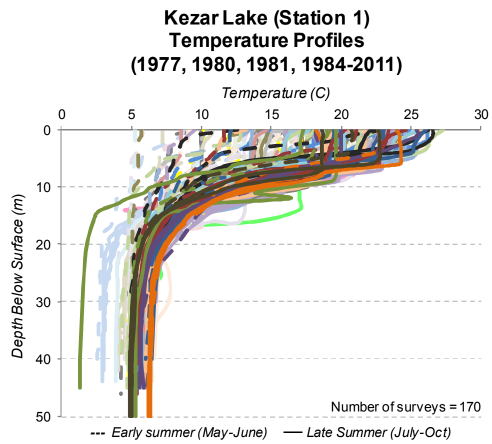
Kezar Lake-02	All Years (1976-2011)	Historical (1976-2001)	Recent (2002-2011)
Minimum SDT (m)	3.0	3.0	5.2
Mean SDT (m)	6.9	6.7	7.8
Maximum SDT (m)	9.2	8.5	9.2

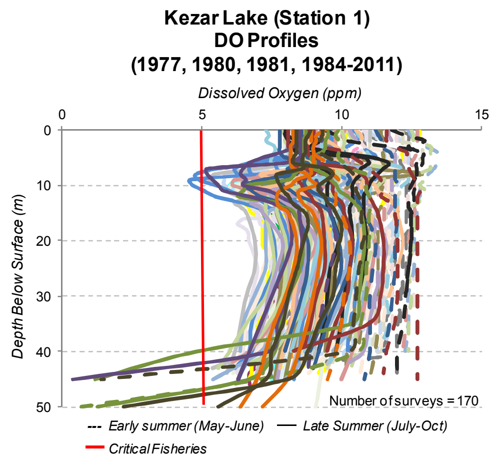
**Hit bottom 33 out of 190 readings (17%)*

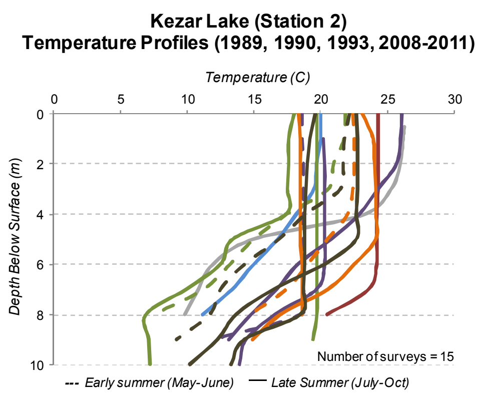
Kezar Lake-03	All Years (1976-2011)	Historical (1976-2001)	Recent (2002-2011)
Minimum SDT (m)	1.9	1.9	2.4
Mean SDT (m)	3.2	3.0	3.4
Maximum SDT (m)	4.8	4.8	4.1

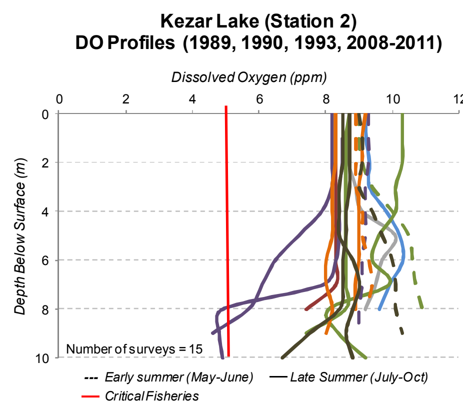
**Hit bottom 183 out of 189 readings (97%)*

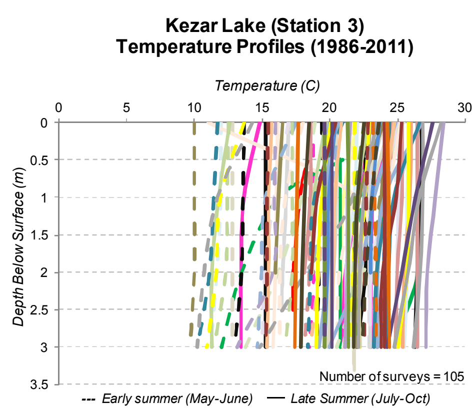
At Kezar Lake (Station 1), SDT ranged from 4.6 m to 11.6 m from 1970 to 2011 with an average of 7.6 m. Recent years (since 2002) and the general SDT trend show more than 1 m improvement in SDT (recent 8.8 m compared to historical 7.4 m). At Kezar Lake (Station 2), SDT ranged from 3.0 to 9.2 m from 1976 to 2011 with an average of 6.9 m. Similar to Station 1, recent years (since 2002) and the general SDT trend show a more than 1 m improvement in SDT (recent 7.8 m compared to historical 6.7 m). At Kezar Lake (Station 3), SDT ranged from 1.9 to 4.8 m from 1976 to 2011 with an average of 3.2 m. When compared to the other basins, water clarity in the lower basin may be misrepresented due to its shallow nature. In most cases, the Secchi disk touched bottom before disappearing from view, indicating that the water is clear to depth. As such, TP and Chl-a are better water quality measures for the lower basin.

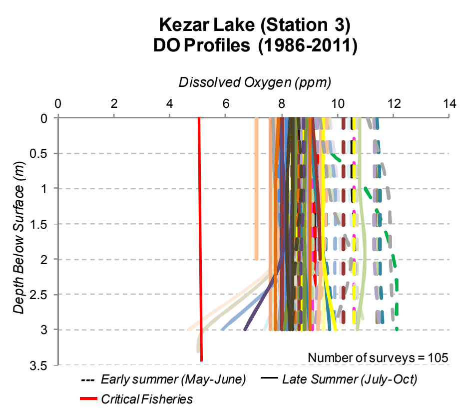






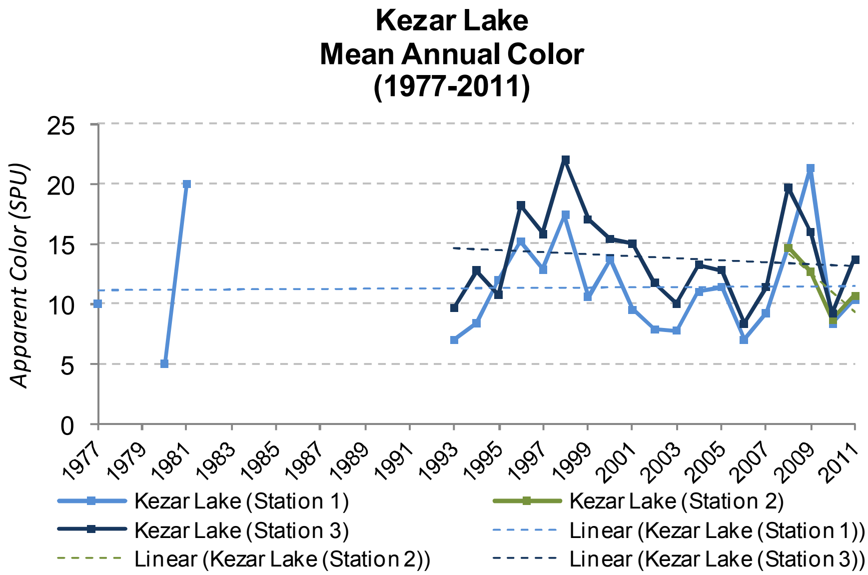






Historic profiles at Station 1 show temperature stratification during the late summer months (July, August and September) as compared to the early summer months (May, June). Historic profiles at Station 2 show some temperature stratification during the year. Historic profiles at Station 3 show little to no temperature stratification during the late summer months (July, August and September) due to the basin's shallow depth. Formation of the metalimnion or thermocline has generally occurred between 5 and 11 meters below the surface at Station 1, and between 5 and 9 meters below the surface at Station 2. A thermocline cannot develop due to the shallow depth at Station 3. Epicore samples are taken approximately 1 meter above the bottom.

Historic profiles at Stations 1 and 2 show some DO depletion in deep areas of the lake beginning in June through late September. Late summer profiles at Station 1 in 1998 and Station 2 in 2009 show DO depletion (less than 5 ppm) within 8 to 10 m below the surface. This is an example of the beginning stages of fall turnover where the oxygen-depleted, nutrient-rich waters from the bottom (hypolimnion) begin mixing with the oxygen-rich, nutrient-depleted waters from the surface (epilimnion). Late summer profiles in 1990 and 1996 at Station 3 show DO depletion (less than 5 ppm) at the bottom. Oxygen levels below 5 parts per million (ppm) stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species.



Kezar Lake-01	All Years (1977-2011)	Historical (1977-2001)	Recent (2002-2011)
Minimum Color (SPU)	2	4	2
Mean Color (SPU)	11	12	10
Maximum Color (SPU)	39	24	39

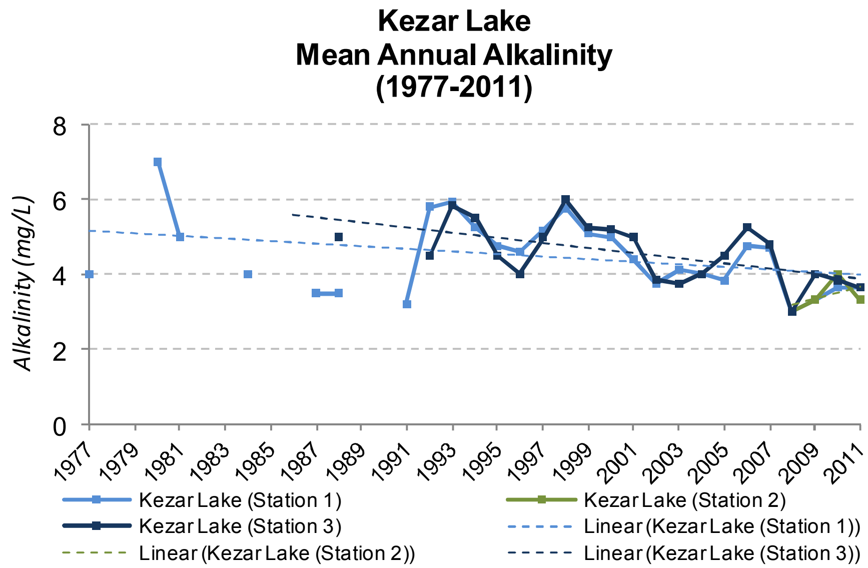
Kezar Lake-02	All Years (2008-2011)	Historical (2008-2011)	Recent (2008-2011)
Minimum Color (SPU)	8	8	8
Mean Color (SPU)	12	12	12
Maximum Color (SPU)	18	18	18

Kezar Lake-03	All Years (1993-2011)	Historical (1993-2001)	Recent (2002-2011)
Minimum Color (SPU)	4	5	4
Mean Color (SPU)	14	15	12
Maximum Color (SPU)	33	33	24

At the upper basin (Station 1), color ranged from 2 to 39 SPU from 1977 to 2011 with an average of 11 SPU. Comparing the last 10 years of data to historical data (prior to 2001), Kezar Lake's upper basin has become less colored by 2 SPU. Overall, mean annual color has remained stable. Historically, the maximum value for color was below 24 SPU. In August 2009, this value increased dramatically to 39. Color may have increased from stormwater runoff during high precipitation events in 2009. The area received 37 inches of rain from June to September.

At the middle basin (Station 2), color ranged from 8 to 18 SPU from 2008 to 2011 with an average of 12 SPU. Since water quality data for color has only been collected in the last 4 years, a historical and recent data comparison could not be made. However, recent trends show a decrease in mean annual color at Station 2, similar to Stations 1.

At the lower basin (Station 3), color ranged from 4 to 33 SPU from 1993 to 2011 with an average of 14 SPU. A comparison of the recent data (last 10 years) to the historical mean (prior to 2001) indicates a slight decrease in color of approximately 3 SPU, meaning the lake is becoming less "colorful" and may be a sign of decreasing productivity.



Kezar Lake-01	All Years (1977-2011)	Historical (1977-2001)	Recent (2002-2011)
Minimum Alkalinity (mg/L)	2.5	3.0	2.5
Mean Alkalinity (mg/L)	4.5	4.9	4.0
Maximum Alkalinity (mg/L)	8.0	8.0	5.5

Kezar Lake-02	All Years (2008-2011)	Historical (2008-2011)	Recent (2008-2011)
Minimum Alkalinity (mg/L)	3.0	3.0	3.0
Mean Alkalinity (mg/L)	3.4	3.4	3.4
Maximum Alkalinity (mg/L)	4.0	4.0	4.0

Kezar Lake-03	All Years (1988-2011)	Historical (1988-2001)	Recent (2002-2011)
Minimum Alkalinity (mg/L)	2.7	3.5	2.7
Mean Alkalinity (mg/L)	4.6	5.0	4.1
Maximum Alkalinity (mg/L)	7.0	7.0	6.0

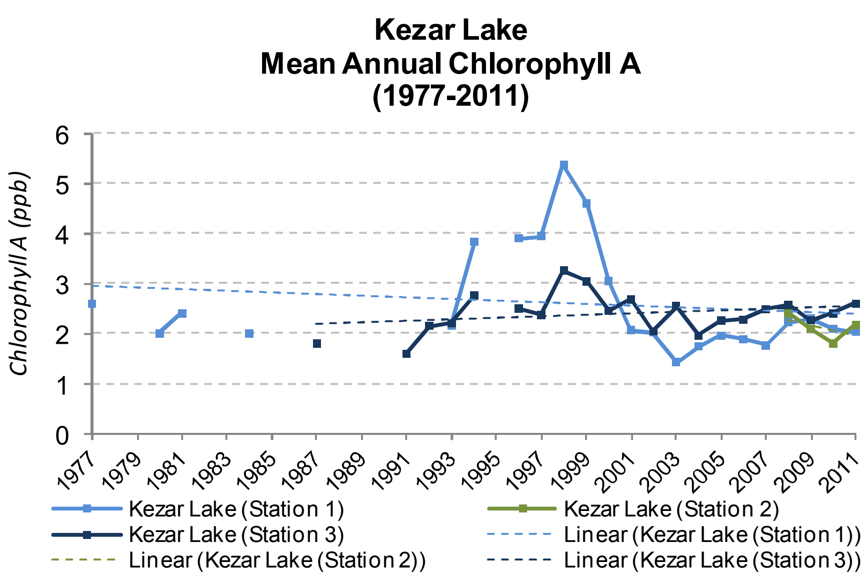
At Kezar Lake (Station 1), alkalinity ranged from 2.5 to 8.0 mg/L from 1977 to 2011 with an average of 4.5 mg/L. Recent years (since 2002) compared to the historical mean (prior to 2001) show decreasing alkalinity values by 0.9 mg/L. Results from 2008 to 2011 reveal consistently below average values for alkalinity. This may be cause for concern as Kezar Lake is already classified as highly sensitive to pH changes. Based on US EPA classification of lakes and ponds based on alkalinity, Kezar Lake falls in the "Endangered" category (2-5 mg/L). Without a strong buffering capacity, Kezar Lake is at risk to changes in water chemistry that may impact aquatic communities. This risk may be exacerbated in the future as the watershed becomes more developed.

Table 1: U.S. E.P.A. Classification[1] of lakes and ponds based on alkalinity as measured in concentration of calcium carbonate ($CaCO_3$).

U.S. E.P.A. category	Concentration of $CaCO_3$ (mg/L)
Acidified	< 1 and pH < 5
Critical	< 2
Endangered	2 – 5
Highly Sensitive	5 – 10
Sensitive	10 – 20
Not Sensitive	> 20

At Kezar Lake (Station 2), alkalinity ranged from 3.0 to 4.0 mg/L from 2008 to 2011 with an average of 3.4 mg/L. Since water quality data for alkalinity has only been collected in the last 4 years, a historical and recent data comparison could not be made.

At Kezar Lake (Station 3), alkalinity ranged from 2.7 to 7.0 mg/L from 1988 to 2011 with an average of 4.6 mg/L. The average alkalinity in recent years (since 2002) indicates a slight decline in alkalinity compared to the historical mean by 0.9 mg/L. This long-term trend may harm aquatic communities in the lower basin without a strong buffering capacity, especially since the lower basin is so shallow.



Kezar Lake-01	All Years (1977-2011)	Historical (1977-2001)	Recent (2002-2011)
Minimum Chl-a (ppb)	0.8	1.4	0.8
Mean Chl-a (ppb)	2.8	3.5	1.9
Maximum Chl-a (ppb)	9.5	9.5	3.2

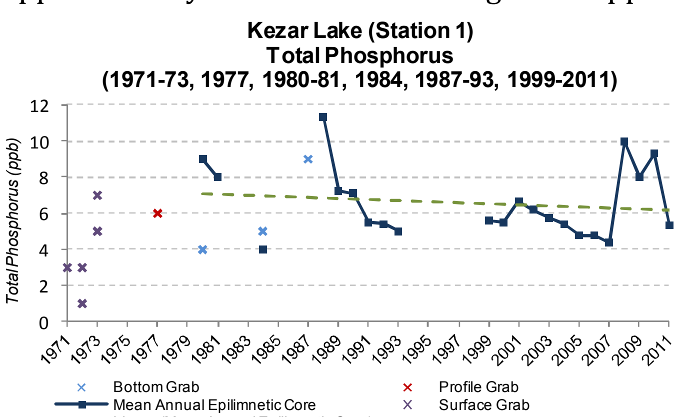
Kezar Lake-02	All Years (2008-2011)	Historical (2008-2011)	Recent (2008-2011)
Minimum Chl-a (ppb)	1.7	1.7	1.7
Mean Chl-a (ppb)	2.1	2.1	2.1
Maximum Chl-a (ppb)	2.8	2.8	2.8

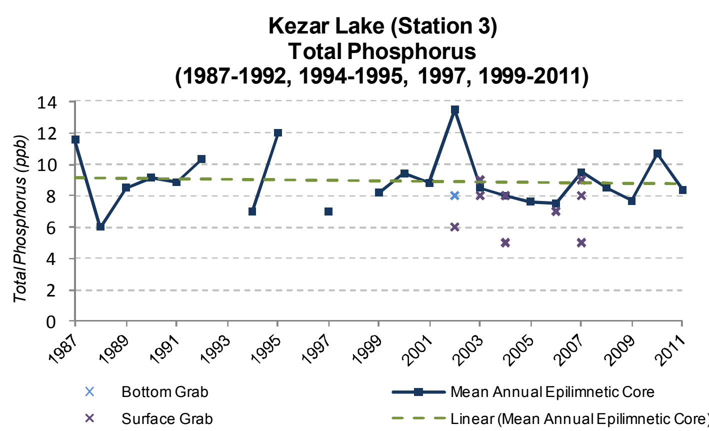
Kezar Lake-03	All Years (1987-2011)	Historical (1987-2001)	Recent (2002-2011)
Minimum Chl-a (ppb)	0.8	0.8	0.9
Mean Chl-a (ppb)	2.4	2.5	2.3
Maximum Chl-a (ppb)	6.2	6.2	4.6

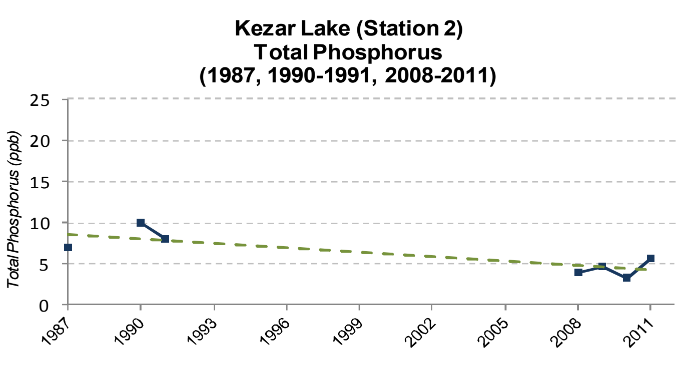
At Kezar Lake (Station 1), Chl-a ranged from 0.8 to 9.5 ppb from 1977 to 2011 with an average of 2.8 ppb. Recent years (since 2002) compared to the historical mean (prior to 2001) show decreasing Chl-a values by 1.6 ppb. Results from 2001 to 2011 reveal consistently below average Chl-a counts. The highest annual mean for Chl-a was recorded in 1998, corresponding with DO depletion 10 m below the surface.

At Kezar Lake (Station 2), Chl-a ranged from 1.7 to 2.8 ppb from 2008 to 2011 with an average of 2.1 ppb. Since water quality data for Chl-a has only been collected in the last 4 years, a historical and recent data comparison could not be made. However, recent trends show a decrease in mean annual Chl-a at Station 2. This corresponds well with observed increasing clarity and decreasing color.

At Kezar Lake (Station 3), Chl-a ranged from 0.8 to 6.2 ppb from 1987 to 2011 with an average of 2.4 ppb. Similar to Station 1, recent years (since 2002) compared to the historical mean (prior to 2001) show decreasing Chl-a values by 0.2 ppb. The lower basin is more at risk to algal growth than other areas of the lake because it is shallow and clear, so sunlight can penetrate to the bottom of the lake, and algae can thrive throughout the profile. Even so, Chl-a concentrations are approximately half the Maine average of 5.3 ppb.







Kezar Lake-01	All Years (1971-2011)	Historical (1971-2001)	Recent (2002-2011)
Minimum TP Epicore (ppb)	3	3	3
Mean TP Epicore (ppb)	6	7	6
Maximum TP Epicore (ppb)	19	13	19
Mean TP Bottom Grab	6	-	-
Mean TP Surface Grab	4	-	-
Mean TP Profile Grab	6	-	-

Kezar Lake-02	All Years (1987-2011)	Historical (1987-2001)	Recent (2002-2011)
Minimum TP Epicore (ppb)	2	7	2
Mean TP Epicore (ppb)	5*	8	5*
Maximum TP Epicore (ppb)	10*	10	6*
Mean TP Bottom Grab	-	-	-
Mean TP Surface Grab	-	-	-
Mean TP Profile Grab	-	-	-

** Max 2008 TP sample of 41 ppb not included due to possible lab or sampling error*

Kezar Lake-03	All Years (1987-2011)	Historical (1987-2001)	Recent (2002-2011)
Minimum TP Epicore (ppb)	6	6	6
Mean TP Epicore (ppb)	9	9	9
Maximum TP Epicore (ppb)	29*	29*	14
Mean TP Bottom Grab	8	-	-
Mean TP Surface Grab	7	-	-
Mean TP Profile Grab	-	-	-

**Max TP value of 29 ppb taken on May 9, 1987 outside seasonal sampling period*

At Kezar Lake (Station 1), TP ranged from 3 to 19 ppb from 1971 to 2011 with an average of 6 ppb. Recent years (since 2002) compared to the historical mean indicates a decrease in TP by 1 ppb. TP increased above the historical average from 2007 to 2010, which may be attributed to above average seasonal rainfall for the area.

At Kezar Lake (Station 2), TP ranged from 2 to 10 ppb from 1987 to 2011 with an average of 5 ppb. Very little historical water quality data is available for TP at Station 2; however, with the exception of a significant spike in TP in 2008, TP has decreased in recent years (since 2002) compared to the historical mean by 3 ppb. Since there is no larger data set to compare these large fluctuations to, the 41 ppb observed on 8/21/2008 may be due to a lab or sampling error. Rainfall is unlikely since 2009 samples were below average even during the higher precipitation year. Further monitoring is needed to determine the appropriate trend for TP at Station 2.

At Kezar Lake (Station 3), TP ranged from 6 to 29 ppb from 1987 to 2011 with an average of 9 ppb. Recent years (since 2002) compared to the historical mean indicate a stable TP trend. The maximum TP value (29 ppb) recorded on May 9, 1987 was taken outside of the seasonal sampling period (May 15 – Oct 15) and may be attributed to seasonal variables such as heavy spring runoff or spring turnover.

Summary for Kezar Lake

Secchi Disk Transparency

- 1 m improvement in SDT at Stations 1 and 2
- Stable trend at Station 3; lower average SDT due to shallow depth- 97% of readings were clear to depth (hit bottom)

Dissolved Oxygen Profiles

- Little to no DO depletion at all three stations
- Relatively unstratified DO profiles indicate less productive trophic state

Color

- Color has remained relatively stable with decreases in recent years (since 2002) at Stations 1 and 3
- High color values correspond to high precipitation years, most likely from runoff volumes
- Minimal data at Station 2 makes historical and recent comparisons difficult, but data years mimic Stations 1 and 3

Alkalinity

- Declining alkalinity values at Stations 1 and 3 by 0.9 mg/L when comparing historical (2001 and prior) to recent (since 2002) annual averages
- Kezar Lake's already low alkalinity means it is more at risk for fluxes in pH
- Minimal data at Station 2 makes historical and recent comparisons difficult, but data years mimic Stations 1 and 3

Chlorophyll-a

- All stations had consistently below average Chl-a values since 2001
- All stations exhibit decreasing Chl-a values

Total Phosphorus

- Decreasing TP values at Stations 1 and 2
- Highest average TP at Station 3 (9 ppb), but historical trend is stable
- Station 3 may be more at risk to internal loading due to shallow depth

HORSESHOE POND

Watershed: Saco River

Town: Lovell and Stoneham, ME

County: Oxford

Surface Area (acres): 136 (0.2 sq.mi)

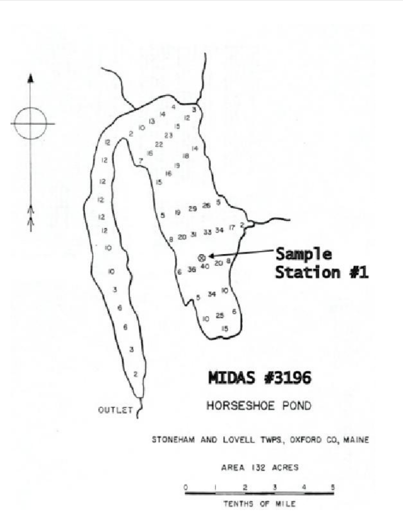
Watershed Area (acres): 1,050 (1.64 sq.mi)

Perimeter (miles): 3.9

Mean Depth (feet): 12

Max Depth (feet): 40

Stations: 1 (deep hole)



Description of Waterbody

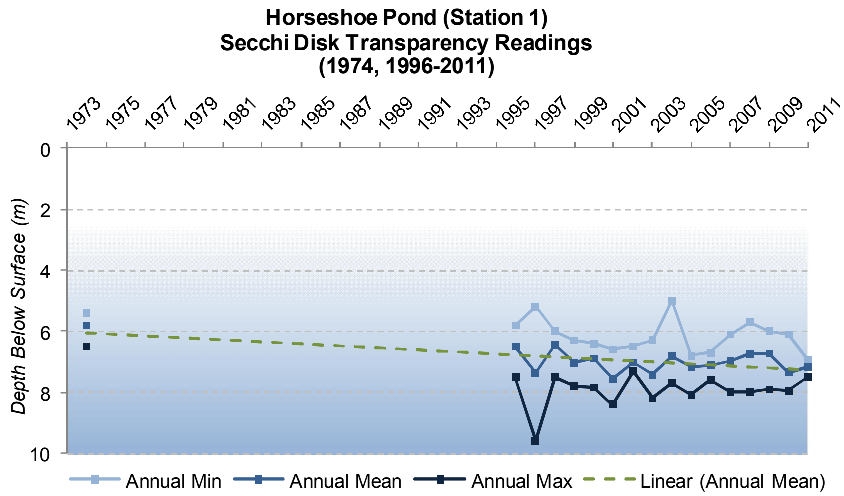
Horseshoe Pond (Midas #3196) is a non-colored waterbody located in the Towns of Lovell and Stoneham, Oxford County, Maine. Covering 136 acres (0.2 square miles) with a maximum depth of 40 feet, the pond drains into Moose Pond, which in turn drains into Kezar Lake. Horseshoe Pond lies within the larger Saco River watershed and Kezar Lake subwatershed. Horseshoe Pond is a mixed warm- and cold-water fishery, and is home to a variety of fish, including brown trout, brook trout, smelt, smallmouth bass, yellow perch, chain pickerel, white sucker, minnow, and golden shiner. Brook trout and brown trout require annual stockings due to little natural reproductive activity and forage on smelts, golden shiners, and insects. The following trophic state summary (as of 2001) for the deep basin was provided by LakeofMaine.org, an online information collaboration between ME DEP, Maine VLMP, and the University of Maine.

Water quality monitoring data for Horseshoe Pond's deep hole (Station 1) has been collected since 1974, and includes 11 years of TP (including 10 years of epicore samples), 12 years of Chl-a, 12 years of color data, 12 years of alkalinity, 15 years of DO and temperature profiles, and 17 years of SDT (Figure 1; Table 2). The water quality of Horseshoe Pond is considered to be slightly above average based on measures of SDT, TP, and Chl-a. The potential for nuisance algae blooms is low. The potential for TP to leave bottom sediments and become available to algae in the water column (internal loading) is moderate. DO profiles show moderate DO depletion in deep areas (below 25-30 feet) of the lake.

Table 2. Years of available data by parameter for Horseshoe Pond

LAKE	SDT	DO	COLOR	ALKALINITY	CHLA	TP (ALL)	TP (EPICORE)
Horseshoe Pond (deep hole)	17	15	12	12	12	11	10

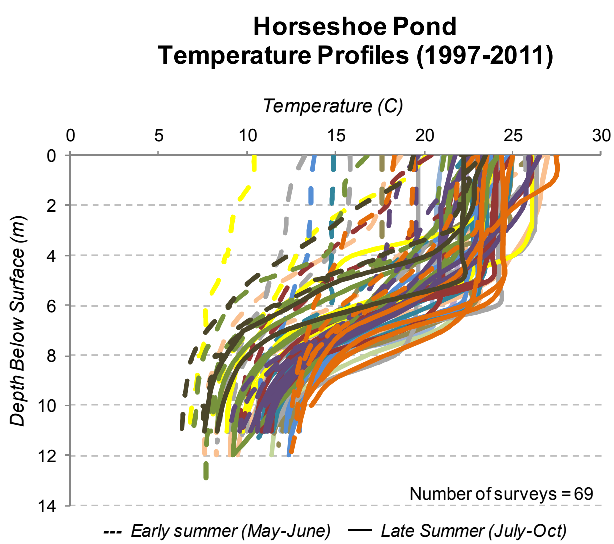
Water Quality Measures for Horseshoe Pond (Station 1)

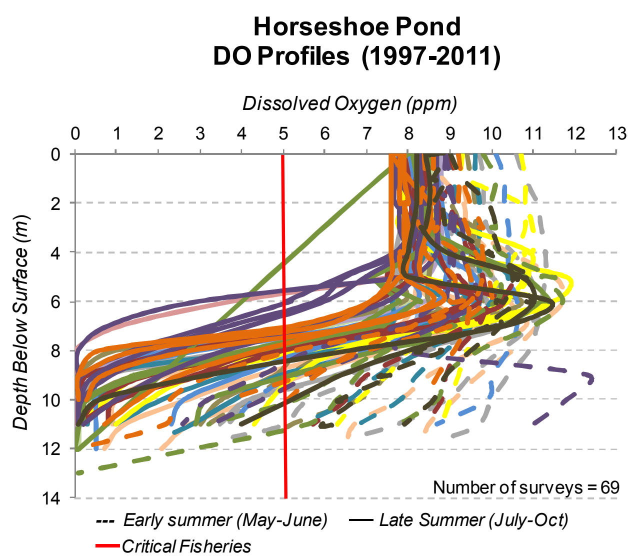


	All Years (1974-2011)	Historical (1974-2001)	Recent (2002-2011)
Minimum SDT (m)	5.0	5.2	5.0
Mean SDT (m)	7.0	6.9	7.1
Maximum SDT (m)	9.6	9.6	8.2

**Hit bottom 0 out of 101 readings (0%)*

SDT ranged from 5.0 m to 9.6 m from 1974 to 2011 with an average of 7.0 m. Recent years (since 2002) compared to the historical mean show 0.2 m improvement in SDT, although the maximum SDT recorded has decreased by 1.4 m.

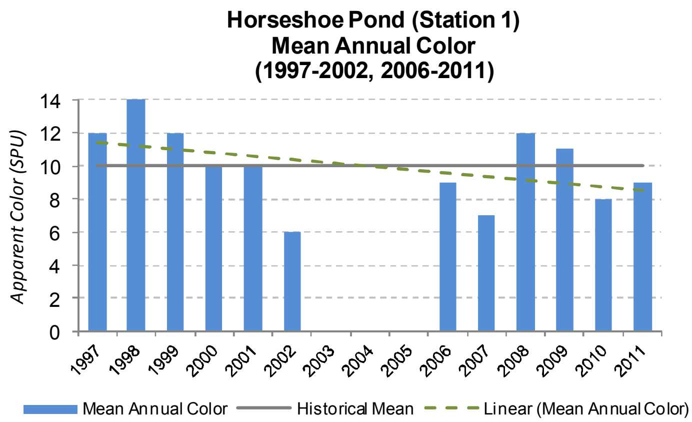




Historic profiles show temperature stratification during the late summer months (July, August and September) as compared to the early summer months (May, June). Formation of the metalimnion or thermocline has generally occurred at 7 meters below the surface.

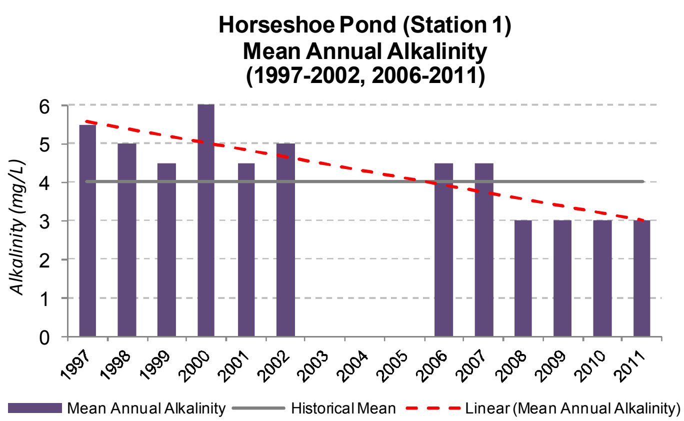
Historic profiles show DO depletion in deep areas of the lake beginning in June through September. Late summer profiles in most years show DO depletion (less than 5 ppm) within 6 to

12 m below the surface. Oxygen levels below 5 part per million (ppm) stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species.



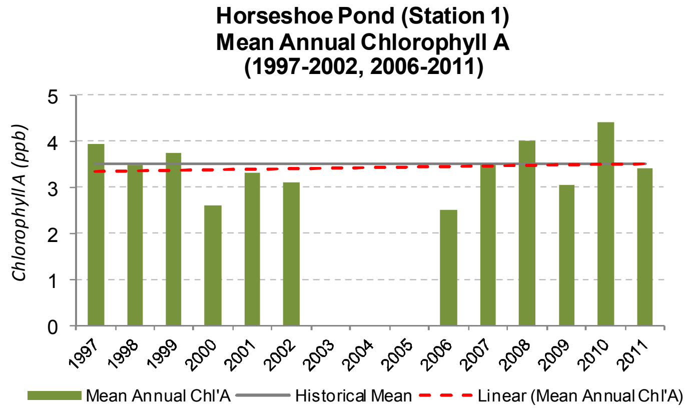
	All Years (1997-2011)	Historical (1997-2001)	Recent (2002-2011)
Minimum Color (SPU)	6	10	6
Mean Color (SPU)	10	12	9
Maximum Color (SPU)	15	14	15

Color ranged from 6 to 15 SPU from 1997 to 2011 with an average of 10 SPU. Within the last 10 years, Horseshoe Pond has become less colored by 3 SPU, which may be an indicator of decreasing productivity.



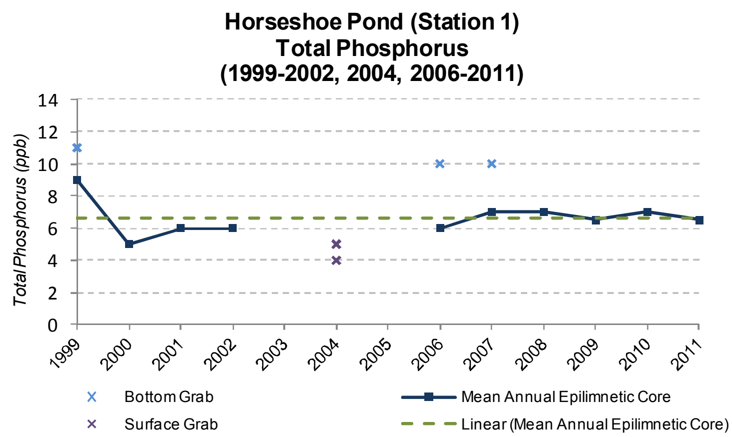
	All Years (1997-2011)	Historical (1997-2001)	Recent (2002-2011)
Minimum Alkalinity (mg/L)	3.0	4.5	3.0
Mean Alkalinity (mg/L)	4.0	5.1	3.5
Maximum Alkalinity (mg/L)	6.0	60.0	5.0

Alkalinity ranged from 3.0 to 6.0 mg/L from 1997 to 2011 with a historical average of 4.0 mg/L. Recent years (since 2002) compared to the historical mean show decreasing alkalinity values by 1.6 mg/L. Results from 2008 to 2011 reveal consistently below average values for alkalinity. This may be a cause for concern as Horseshoe Pond is already classified as highly sensitive to pH changes. Without a strong buffering capacity, Horseshoe Pond is at risk to changes in water chemistry that may impact aquatic communities. This risk may be exacerbated in the future as the watershed becomes more developed.



	All Years (1997-2011)	Historical (1997-2001)	Recent (2002-2011)
Minimum Chl-a (ppb)	2.5	2.6	2.5
Mean Chl-a (ppb)	3.5	3.4	3.5
Maximum Chl-a (ppb)	5.0	3.9	5.0

Chl-a ranged from 2.5 to 5.0 ppb from 1997 to 2011 with an average of 3.5 ppb. Recent years (since 2002) compared to the historical mean show relatively stable Chl-a values, with only 0.01 ppb increase. Recent maximum values increased from 3.9 to 5.0 ppb. Even so, Chl-a remains below average compared to average Maine lake Chl-a values with no major annual spikes.



	All Years (1999-2011)	Historical (1999-2001)	Recent (2002-2011)
Minimum TP Epicore (ppb)	5	5	5
Mean TP Epicore (ppb)	7	7	7
Maximum TP Epicore (ppb)	9	9	8
Mean TP Bottom Grab	13	-	-
Mean TP Surface Grab	5	-	-
Mean TP Profile Grab	-	-	-

TP ranged from 5 to 9 ppb from 1999 to 2011 with an average of 7 ppb. TP at Horseshoe Pond has remained stable since 2000, with a decrease in maximum TP by 1 ppb. Bottom grab samples collected in 2006 and 2007 were slightly higher, most likely due to natural sediment TP accumulation near the bottom.

FARRINGTON POND

Watershed: Saco River

Town: Lovell, ME

County: Oxford

Surface Area (acres): 57 (0.09 sq.mi)

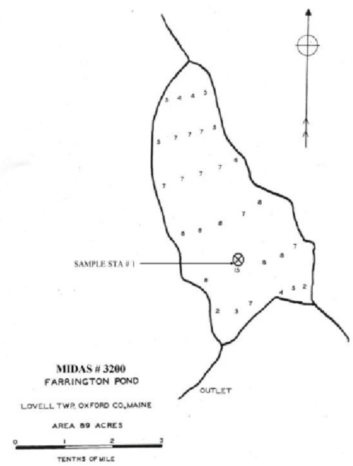
Watershed Area (acres): 339 (0.53 sq.mi)

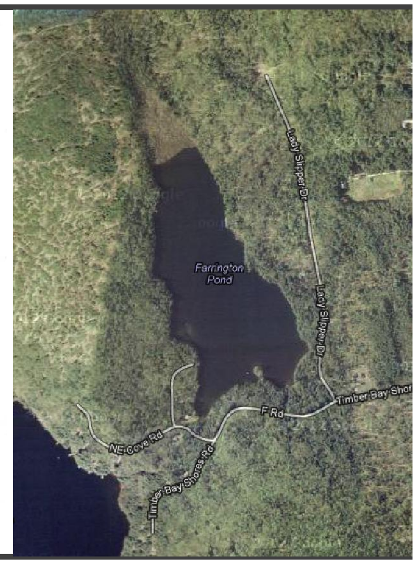
Perimeter (miles): 1.4

Mean Depth (feet): 5

Max Depth (feet): 15

Stations: 1 (deep hole)





Description of Waterbody

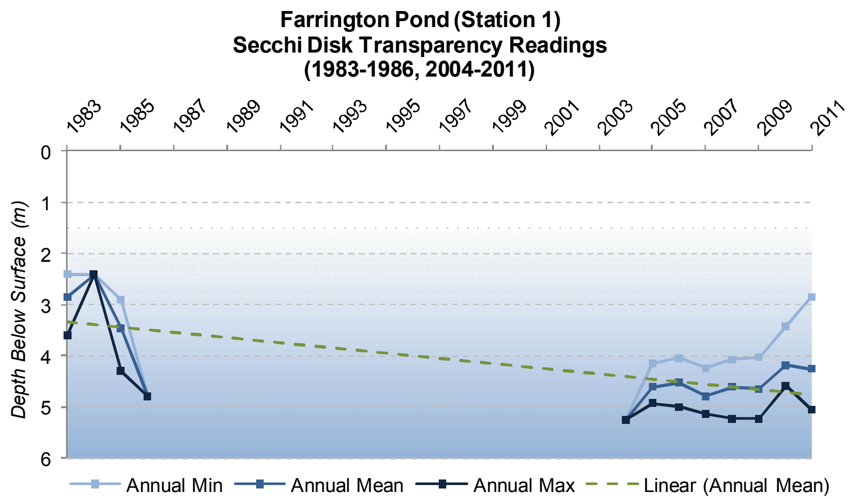
Farrington Pond (Midas #3200) is a non-colored waterbody located in the Town of Lovell, Oxford County, Maine. Covering 57 acres (0.09 square miles) with a maximum depth of 15 feet, the pond drains directly into Kezar Lake. Farrington Pond lies within the larger Saco River watershed and Kezar Lake subwatershed. Farrington Pond is a warm water fishery, and is home to a variety of fish. The following trophic state summary (as of 2001) for the deep basin was provided by LakeofMaine.org, an online information collaboration between ME DEP, Maine VLMP, and the University of Maine.

Water quality monitoring data for Farrington Pond's deep hole (Station 1) has been collected since 1983, and includes 10 years of TP (including 10 years of epicore samples), 9 years of Chl-a, 10 years of color data, 10 years of alkalinity, 10 years of DO and temperature profiles, and 12 years of SDT (Figure 1; Table 3). The water quality of Farrington Pond is considered to be average based on measures of SDT, TP, and Chl-a. The potential for nuisance algae blooms is moderate. The potential for TP to leave bottom sediments and become available to algae in the water column (internal loading) is moderate due to the shallow nature of the pond and the ability of wind to cause sediments to mix into the water column. DO profiles show low DO depletion in deep areas of the lake.

Table 3. Years of available data per parameter for Farrington Pond

LAKE	SDT	DO	COLOR	ALKALINITY	CHLA	TP (ALL)	TP (EPICORE)
Farrington Pond (deep hole)	12	10	10	10	9	10	10

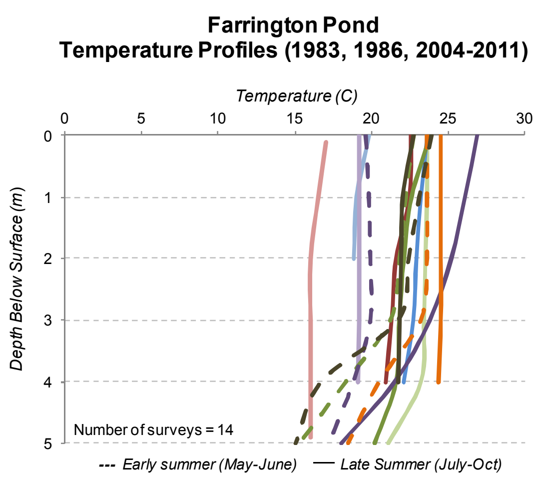
Water Quality Measures for Farrington Pond (Station 1)

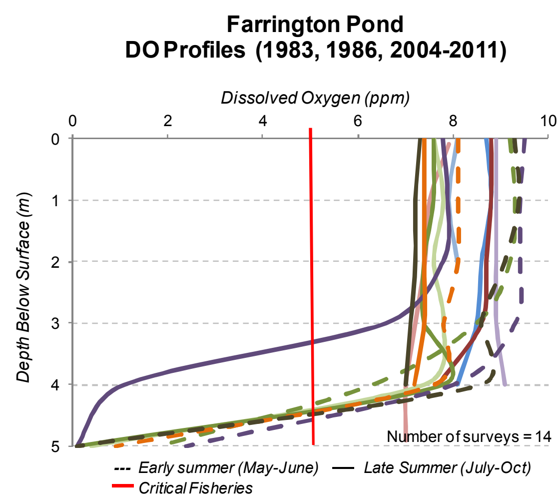


	All Years (1983-2011)	Historical (1983-2001)	Recent (2002-2011)
Minimum SDT (m)	2.4	2.4	2.9
Mean SDT (m)	4.4	3.3	4.5
Maximum SDT (m)	5.3	4.8	5.3

**Hit bottom 31 out of 99 readings (31%)*

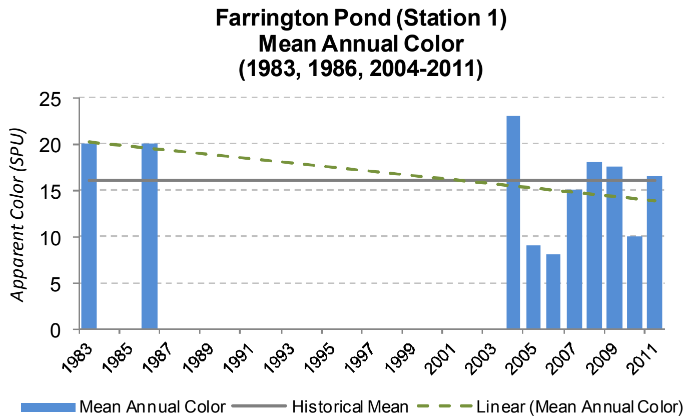
SDT ranged from 2.4 m to 5.3 m from 1983 to 2011 with an average of 4.4 m. Recent years (since 2002) compared to the historical mean show 1.2 m improvement in SDT. However, a large sampling gap exists between the early 1980's and late 2000's, which may not show the actual variability in water clarity at Farrington Pond. Readings within the last 5 years indicate declining water clarity, approaching 2 m in 2011, similar to measurements collected in the early 1980's.





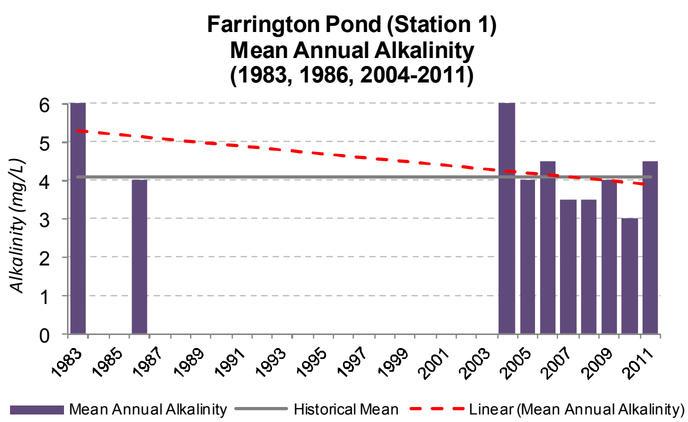
Historic profiles show little to no temperature stratification during the late summer months (July, August and September). A thermocline cannot develop due to the shallow depth at Farrington Pond. Epicore samples are taken approximately 1 meter above the bottom.

Historic profiles show moderate DO depletion (less than 5 ppm) from 2009-2011 below 3 m depth. Oxygen levels below 5 ppm stress certain fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive species.



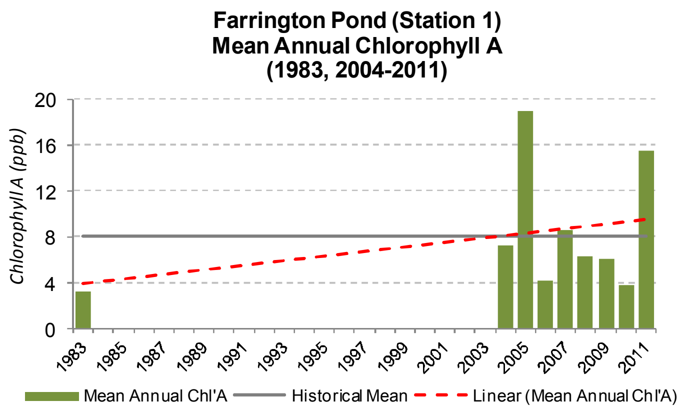
	All Years (1983-2011)	Historical (1983-2001)	Recent (2002-2011)
Minimum Color (SPU)	6	20	6
Mean Color (SPU)	16	20	15
Maximum Color (SPU)	23	20	23

Color ranged from 6 to 23 SPU from 1983 to 2011 with an average of 16 SPU. Since water quality data for color has only been collected for 10 years over a span of 28 years, it is difficult to compare historical and recent trends. However, recent trends (since 2002) compared to the historical mean show a decrease in annual color by 5 SPU, meaning the lake is becoming less "colorful" and may be a sign of decreasing productivity.



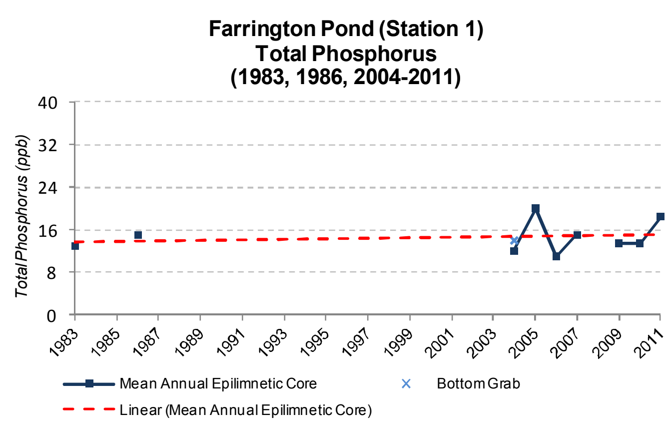
	All Years (1983-2011)	Historical (1983-2001)	Recent (2002-2011)
Minimum Alkalinity (mg/L)	3.0	4.0	3.0
Mean Alkalinity (mg/L)	4.1	5.0	4.0
Maximum Alkalinity (mg/L)	6.0	6.0	6.0

Alkalinity ranged from 3.0 to 6.0 mg/L from 1983 to 2011 with an average of 4.1 mg/L. Since water quality data for alkalinity has only been collected for 10 years over a span of 28 years, it is difficult to compare historical and recent trends. However, recent trends (since 2002) compared to the historical data show a decrease in average annual alkalinity, making the pond more susceptible to pH fluctuations.



	All Years (1983-2011)	Historical (1983-2001)	Recent (2002-2011)
Minimum Chl-a (ppb)	1.2	3.3	1.2
Mean Chl-a (ppb)	8.1	3.3	8.5
Maximum Chl-a (ppb)	26.0	3.3	26.0

Chl-a ranged from 1.2 to 26 ppb from 1983 to 2011 with an average of 8.1 ppb. Samples taken in 2005 and 2011 exceeded the historical average for Farrington Pond, most likely due to a potential algae bloom. A historical and recent data comparison could not be made due to a lack of historical data (prior to 2001). The State of Maine Chl-a criteria for freshwater lakes is 8 ppb. Recent years (since 2002) have averaged 8.5 with a maximum value of 26 ppb. With Farrington Pond's average Chl-a exceeding the established threshold, the potential for algal blooms is moderate to high. Farrington Pond has the highest average annual Chl-a values of all the waterbodies in the watershed.



	All Years (1983-2011)	Historical (1983-2001)	Recent (2002-2011)
Minimum TP Epicore (ppb)	11	13	11
Mean TP Epicore (ppb)	15	14	15
Maximum TP Epicore (ppb)	25*	15	25*
Mean TP Bottom Grab	14	-	-
Mean TP Surface Grab	-	-	-
Mean TP Profile Grab	-	-	-

** Max 2008 TP sample of 39 ppb not included due to possible lab or sampling error*

TP ranged from 11 to 25 ppb from 1983 to 2011 with an average of 15 ppb. Little historical water quality data is available for TP at Farrington Pond; however, the general trend for TP has remained unchanged to slightly increasing by 1 ppb. Since there is no larger data set to compare these fluctuations to, the 39 ppb observed on 8/21/2008 may be due to a lab or sampling error. Rainfall is unlikely since 2008 samples were average even during the higher precipitation year. Further monitoring is needed to determine the appropriate trend for TP at Farrington Pond. Farrington Pond is particularly sensitive to sediment suspension from either the anchor or the Secchi disk during sampling events. For this reason, Secchi readings are taken last. High TP readings may be the result of re-suspension of bottom sediments caused by dropping the anchor. Even so, mean TP values at Farrington are at the DEP established threshold of 15 ppb. TP values above 15 ppb are at increased risk for algal blooms. Farrington Pond has the highest annual average TP of all the waterbodies in the Kezar Lake watershed.

HEALD POND

Watershed: Saco River

Town: Lovell, ME

County: Oxford

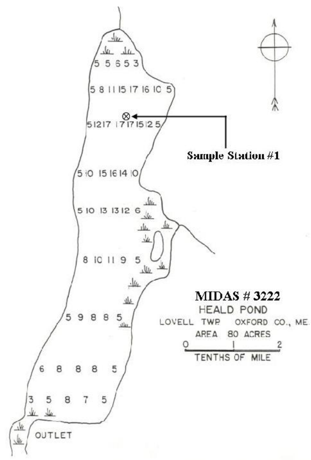
Surface Area (acres): 106 (0.17 sq.mi)

Watershed Area (acres): 2,714 (4.24 sq.mi)

Perimeter (miles): 3.4

Mean Depth (feet): Unknown

Max Depth (feet): 17



Description of Waterbody

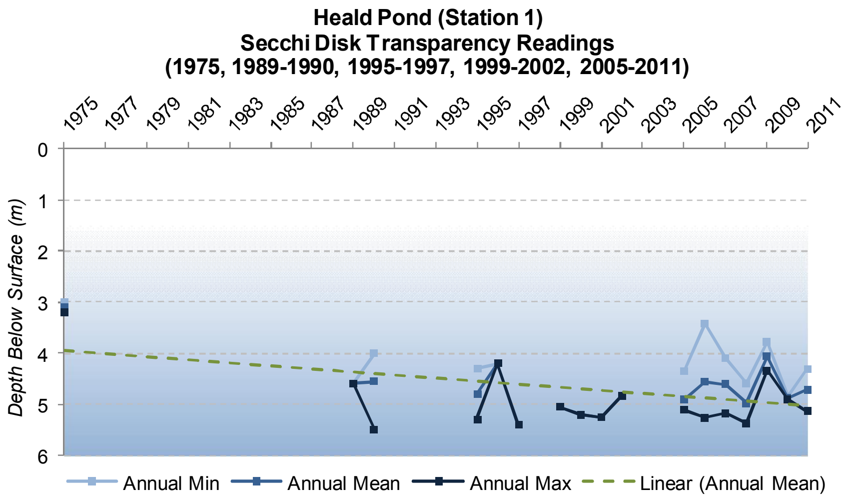
Heald Pond (Midas #3222) is a non-colored waterbody located in the Town of Lovell, Oxford County, Maine. Covering 106 acres (0.17 square miles) with a maximum depth of 17 feet (FBE measured 19 feet), the pond drains into Kezar Lake through a tributary to Boulder Brook. Heald Pond lies within the larger Saco River watershed and Kezar Lake subwatershed. Heald Pond is a warm water fishery, and is home to a variety of fish. The following trophic state summary (as of 2001) for the deep basin was provided by LakeofMaine.org, an online information collaboration between ME DEP, Maine VLMP, and the University of Maine.

Water quality monitoring data for Heald Pond's deep hole (Station 1) has been collected since 1975, and includes 11 years of TP (including 11 years of epicore samples), 11 years of Chl-a, 12 years of color data, 12 years of alkalinity, 14 years of DO and temperature profiles, and 17 years of SDT (Figure 1; Table 4). The water quality of Heald Pond is considered to be average based on measures of SDT, TP, and Chl-a. The potential for nuisance algae blooms is moderate-high. The potential for TP to leave bottom sediments and become available to algae in the water column (internal loading) is low. DO profiles show little DO depletion in deep areas of the lake.

Table 4. Years of available data per parameter for Heald Pond

LAKE	SDT	DO	COLOR	ALKALINITY	CHLA	TP (ALL)	TP (EPICORE)
Heald Pond (deep hole)	17	14	12	12	11	11	11

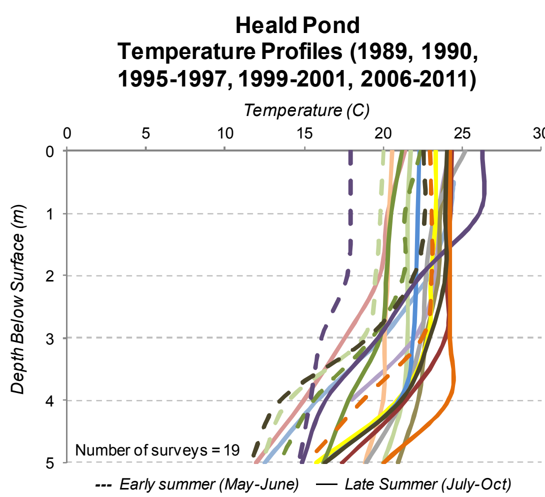
Water Quality Measures for Heald Pond (Station 1)

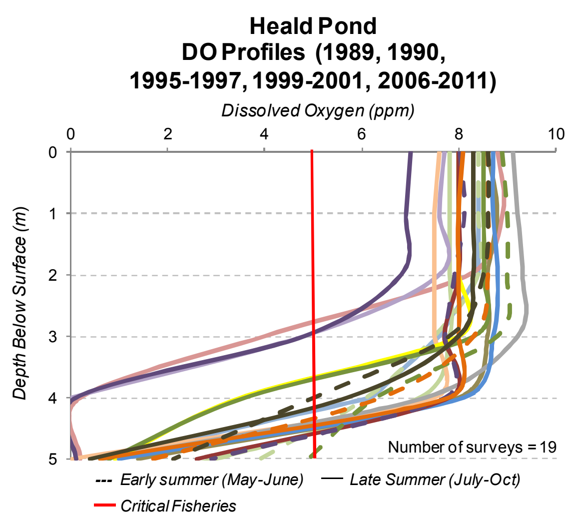


	All Years (1975-2011)	Historical (1975-2001)	Recent (2002-2011)
Minimum SDT (m)	3.0	3.0	3.4
Mean SDT (m)	4.6	4.6	4.7
Maximum SDT (m)	5.5	5.5	5.4

**Hit bottom 9 out of 41 readings (22%)*

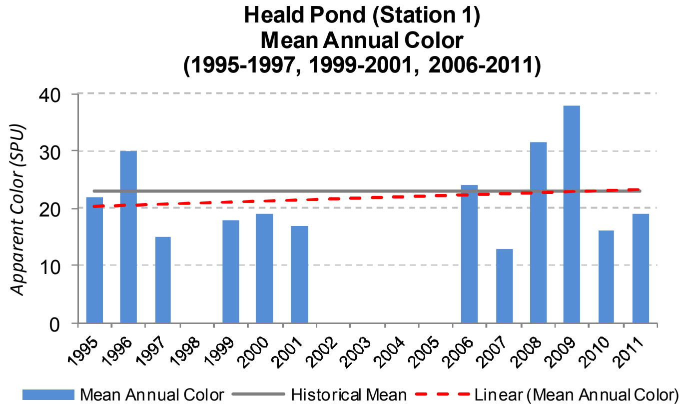
SDT ranged from 3.0 m to 5.5 m from 1975 to 2011 with an average of 4.6 m. Recent years (since 2002) compared to the historical average show slight improvement in SDT by 0.1 m. SDT readings for Heald Pond have been sporadic since 1989, leaving critical gaps in the data. Further monitoring is needed to confirm this trend.





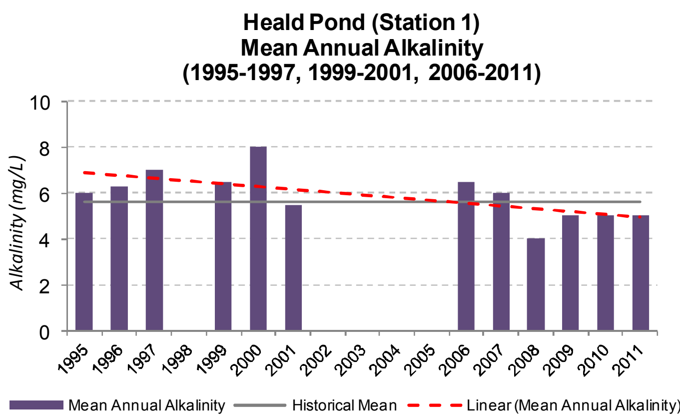
Historic profiles show little temperature stratification during the late summer months (July, August, and September). Even with its shallow depth, a short thermocline develops between 3 and 5 meters below the surface.

Historic profiles show moderate DO depletion (less than 5 ppm) in most years below 3 m depth. Oxygen levels below 5 ppm stress certain fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive species.



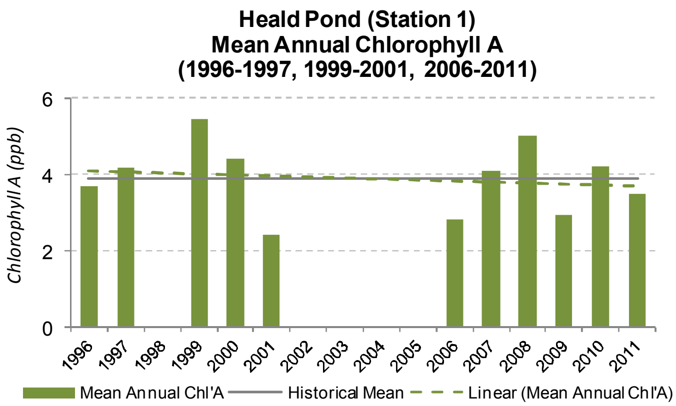
	All Years (1995-2011)	Historical (1995-2001)	Recent (2002-2011)
Minimum Color (SPU)	13	15	13
Mean Color (SPU)	23	20	25
Maximum Color (SPU)	44	30	44

Color ranged from 13 to 44 SPU from 1995 to 2011 with an average of 23 SPU. Recent years (since 2002) compared to the historical mean show an increase in color by 5 SPU. As expected, mean annual color was highest in 2009 due to increased stormwater runoff during abnormally high precipitation events that year. Heald Pond is the most colored pond in the Kezar Lake watershed, and the recent (last 10 years) average color of 25 SPU make Heald Pond a borderline 'colored' waterbody.



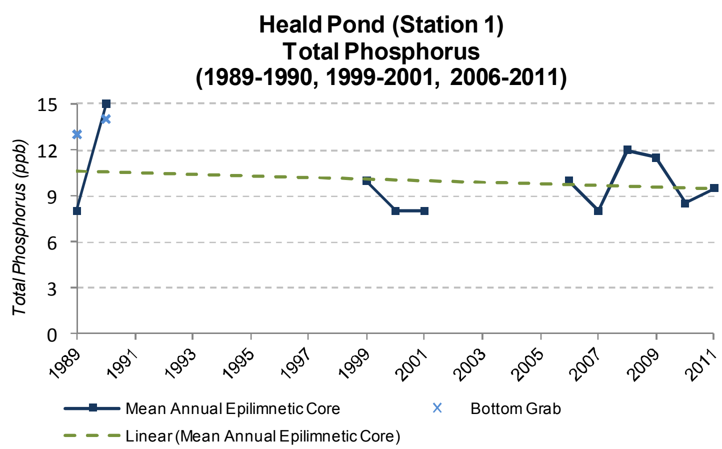
	All Years (1995-2011)	Historical (1995-2001)	Recent (2002-2011)
Minimum Alkalinity (mg/L)	4.0	5.5	4.0
Mean Alkalinity (mg/L)	5.6	6.6	5.1
Maximum Alkalinity (mg/L)	8.0	8.0	6.5

Alkalinity ranged from 4.0 to 8.0 mg/L from 1995 to 2011 with a historical average of 5.6 mg/L. Recent years (since 2002) compared to the historical mean show decreasing alkalinity values by 1.5 mg/L. Results from 2008 to 2011 reveal consistently below average values for alkalinity. This may be cause for concern as Heald Pond is already susceptible to pH fluctuations without a strong buffering capacity. However, Heald Pond remains the only waterbody in the Kezar Lake Watershed classified as 'highly sensitized;' all other waterbodies average below 5 mg/L, and are classified as endangered for alkalinity.



	All Years (1996-2011)	Historical (1996-2001)	Recent (2002-2011)
Minimum Chl-a (ppb)	2.4	2.4	2.6
Mean Chl-a (ppb)	3.9	4.0	3.8
Maximum Chl-a (ppb)	5.6	5.5	5.6

Chl-a ranged from 2.4 to 5.6 ppb from 1996 to 2011 with an average of 3.9 ppb. Recent years (since 2002) compared to the historical average indicate a slight decrease in Chl-a values by 0.2 ppb. All samples are below the DEP threshold of 8 ppb.



	All Years (1989-2011)	Historical (1989-2001)	Recent (2002-2011)
Minimum TP Epicore (ppb)	8	8	8
Mean TP Epicore (ppb)	10	10	10
Maximum TP Epicore (ppb)	15	15	13
Mean TP Bottom Grab	14	-	-
Mean TP Surface Grab	-	-	-
Mean TP Profile Grab	-	-	-

TP ranged from 8 to 15 ppb from 1989 to 2011 with an average of 10 ppb. Little historical water quality data is available for TP at Heald Pond; the general trend for TP has remained unchanged; however, the range of TP values for Heald Pond exceeds the DEP algae bloom threshold. With a mean TP value of 10 ppb, Heald Pond is highly susceptible to algal blooms. Even so, Chl-a counts have been consistently low, and water clarity remains below the 2 m DEP threshold for SDT.

CUSHMAN POND

Watershed: Saco River

Town: Lovell, ME

County: Oxford

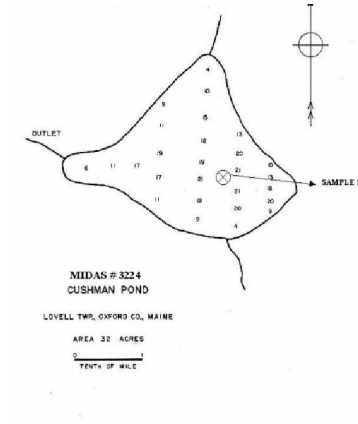
Surface Area (acres): 37 (0.06 sq.mi)

Watershed Area (acres): 0.5

Perimeter (miles): 1.2

Mean Depth (feet): 15

Max Depth (feet): 21



Description of Waterbody

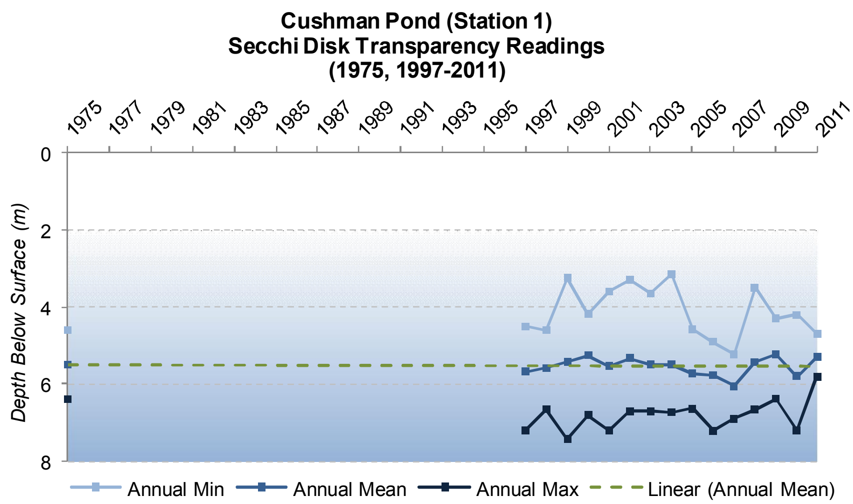
Cushman Pond (Midas #3224) is a non-colored waterbody located in the Town of Lovell, Oxford County, Maine. Covering 37 acres (0.06 square miles) with a maximum depth of 21 feet, the pond drains into Horseshoe Pond, which in turn drains into a tributary to Boulder Brook and eventually Kezar Lake. Cushman Pond lies within the larger Saco River watershed and Kezar Lake subwatershed. Cushman Pond is a cold water fishery, and is home to a variety of fish. Cushman Pond is one of the few known lakes in Maine with growths of the invasive plant Variable Milfoil. Milfoil poses a threat to fishery habitat, and action has been taken to eradicate the aggressive plant. The following trophic state summary (as of 2001) for the deep basin was provided by LakeofMaine.org, an online information collaboration between ME DEP, Maine VLMP, and the University of Maine.

Water quality monitoring data for Cushman Pond's deep hole (Station 1) has been collected since 1997, and includes 9 years of TP (including 9 years of epicore samples), 11 years of Chl-a, 11 years of color data, 11 years of alkalinity, 11 years of DO and temperature profiles, and 16 years of SDT (Figure 1; Table 5). The water quality of Cushman Pond is considered to be average based on measures of SDT, TP, and Chl-a. The potential for nuisance algae blooms is low. The potential for TP to leave bottom sediments and become available to algae in the water column (internal loading) is low. DO profiles show little DO depletion in deep areas of the lake.

Table 5. Years of available data per parameter for Cushman Pond

LAKE	SDT	DO	COLOR	ALKALINITY	CHLA	TP (ALL)	TP (EPICORE)
Cushman Pond (deep hole)	16	11	11	11	11	9	9

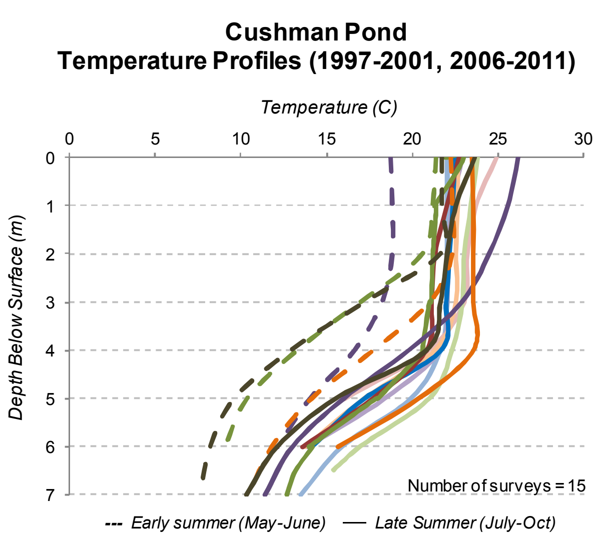
Water Quality Measures for Cushman Pond (Station 1)

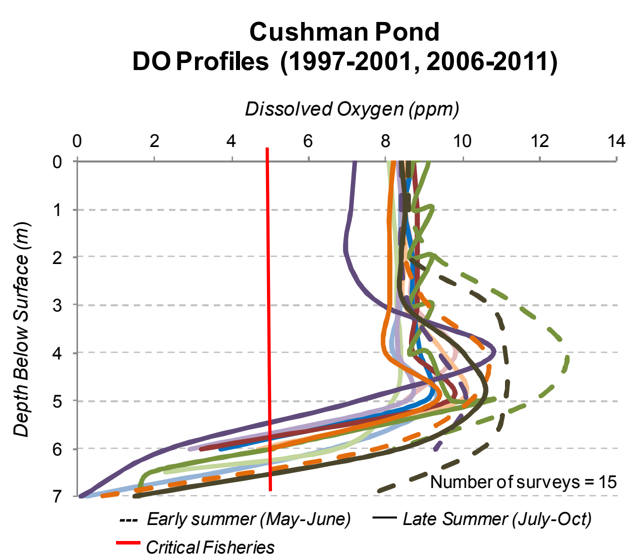


	All Years (1975-2011)	Historical (1975-2001)	Recent (2002-2011)
Minimum SDT (m)	3.2	3.3	3.2
Mean SDT (m)	5.5	5.5	5.5
Maximum SDT (m)	7.4	7.4	7.2

**Hit bottom 1 out of 136 readings (1%)*

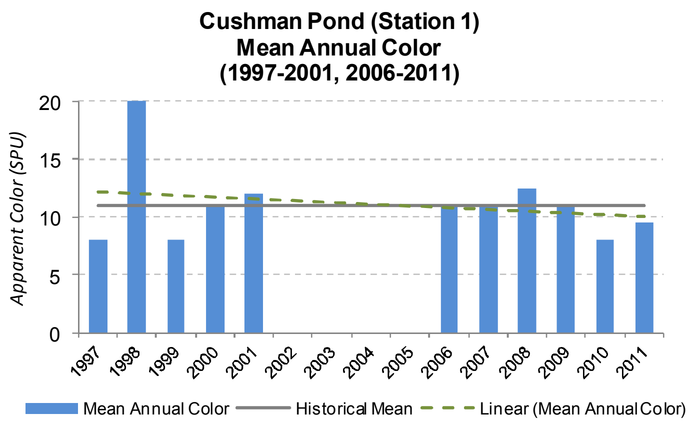
SDT ranged from 3.2 m to 7.4 m from 1975 to 2011 with an average of 5.5 m. Recent years (since 2002) compared to the historical mean show stable water clarity conditions. However, annual fluctuation between minimum and maximum readings is great (2-3 meter difference). The low clarity readings may be caused by algal blooms or increased turbidity from sediment disturbance.





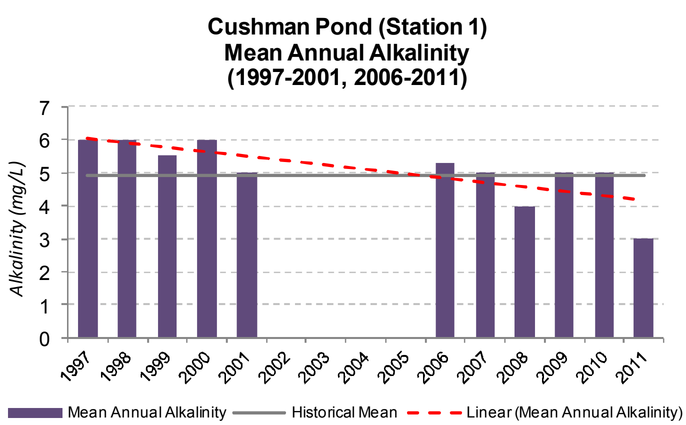
Historic profiles show some temperature stratification, particularly during the early summer months (May, June), which seems contradictory to typical spring turnover conditions. Formation of the metalimnion or thermocline has generally occurred between 3 and 6 meters below the surface.

Historic profiles show DO depletion in deep areas of the lake beginning in June through September, particularly below 5 m depth. Oxygen levels below 5 part per million (ppm) stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species.



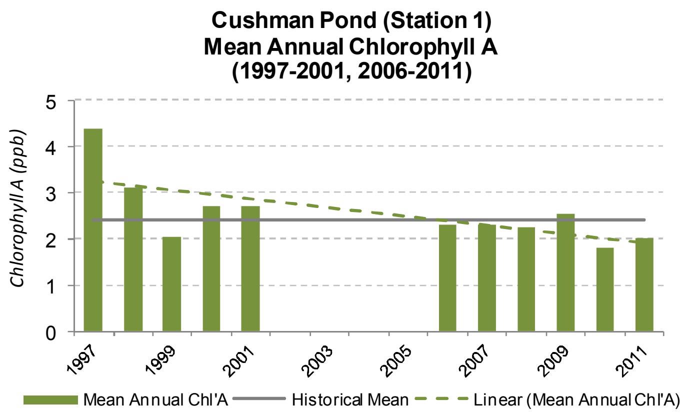
	All Years (1997-2011)	Historical (1997-2001)	Recent (2002-2011)
Minimum Color (SPU)	8	8	8
Mean Color (SPU)	11	12	10
Maximum Color (SPU)	20	20	17

Color ranged from 8 to 20 SPU from 1997 to 2011 with an average of 11 SPU. Recent years (since 2002) compared to the historical mean show a decrease in color by 2 SPU, indicating that the lake may be trending toward less productivity.



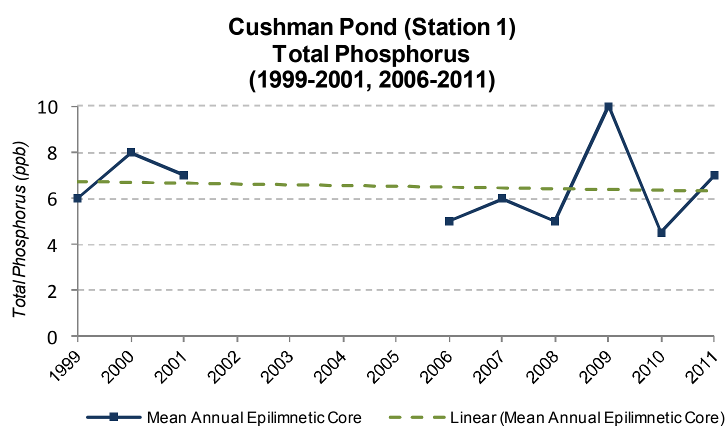
	All Years (1997-2011)	Historical (1997-2001)	Recent (2002-2011)
Minimum Alkalinity (mg/L)	1.0	5.0	1.0
Mean Alkalinity (mg/L)	4.9	5.7	4.4
Maximum Alkalinity (mg/L)	6.0	6.0	5.3

Alkalinity ranged from 1.0 to 6.0 mg/L from 1997 to 2011 with an average of 4.9 mg/L. Recent years (since 2002) compared to the historical mean show decreasing alkalinity values by 1.3 mg/L. Cushman Pond is already at high risk for pH fluctuations due to its weak buffering capacity.



	All Years (1997-2011)	Historical (1997-2001)	Recent (2002-2011)
Minimum Chl-a (ppb)	1.6	2.0	1.6
Mean Chl-a (ppb)	2.4	3.0	2.2
Maximum Chl-a (ppb)	4.4	4.4	2.8

Chl-a ranged from 1.6 to 4.4 ppb from 1997 to 2011 with an average of 2.4 ppb. Recent years (since 2002) compared to the historical mean show decreasing Chl-a values by 0.8 mg/L. Results from 2006 to 2011 reveal consistently below average Chl-a counts. The maximum recorded Chl-a value since 2002 was 2.8 ppb, which is 1.6 ppb less than the historical maximum.



	All Years (1999-2011)	Historical (1999-2001)	Recent (2002-2011)
Minimum TP Epicore (ppb)	4	6	4
Mean TP Epicore (ppb)	7	7	7
Maximum TP Epicore (ppb)	13	8	13
Mean TP Bottom Grab	-	-	-
Mean TP Surface Grab	-	-	-
Mean TP Profile Grab	-	-	-

TP ranged from 4 to 13 ppb from 1999 to 2011 with an average of 7 ppb. Recent years (since 2002) compared to the historical mean show stable TP values. TP increased above the overall average to 13 ppb in 2009, corresponding with an abnormally high precipitation year.

TROUT POND

Watershed: Saco River

Town: Stoneham, ME

County: Oxford

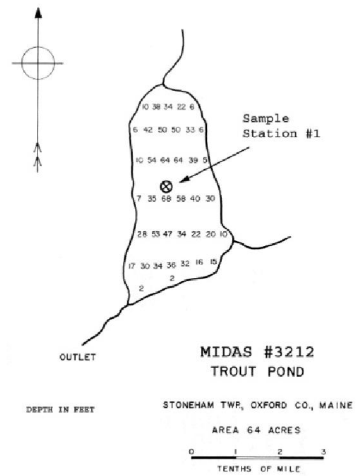
Surface Area (acres): 64 (0.1 sq.mi)

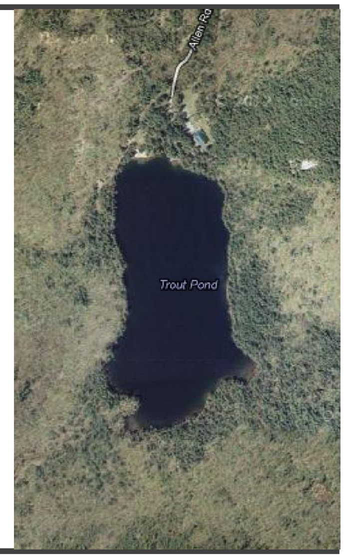
Perimeter (miles): 1.3

Mean Depth (feet): 27

Max Depth (feet): 68

Stations: 1 (deep hole)





Description of Waterbody

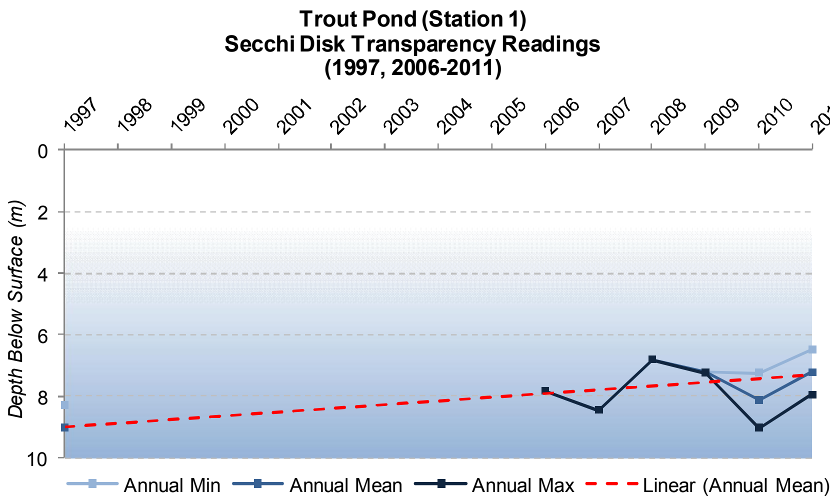
Trout Pond (Midas #3212) is a non-colored waterbody located in the Town of Stoneham, Oxford County, Maine. Covering 64 acres (0.1 square miles) with a maximum depth of 68 feet (camp employee measured 87 feet and FBE measured 73 feet), the pond drains into Cushman Pond, which in turn drains into Heald Pond, then a tributary to Boulder Brook, and eventually Kezar Lake. Trout Pond lies within the larger Saco River watershed and Kezar Lake subwatershed. Trout Pond is a cold water fishery, and is home to a variety of fish, including brook trout, splake, rainbow smelt, minnows, golden shiner, blacknose dace, and hornpout (bullhead). The only development on the lake is Camp Susan Curtis for underprivileged children. Historically, this pond was managed for coldwater gamefish, particularly brook trout in the 1950's. Annual stocking is required to maintain fishery. Splake, a hybrid between male brook trout and female lake trout, were introduced by the Maine Department of Inland Fisheries and Wildlife in 1995.

Water quality monitoring data for Trout Pond's deep hole (Station 1) has been collected since 1997, and includes 6 years of TP (including 6 years of epicore samples), 6 years of Chl-a, 6 years of color data, 6 years of alkalinity, 6 years of DO and temperature profiles, and 7 years of SDT (Figure 1; Table 6). A trophic summary provided by LakesofMaine.org, an online information collaboration between DEP, VLMP, and the University of Maine, was unavailable.

Table 6. Years of available data per parameter for Trout Pond

LAKE	SDT	DO	COLOR	ALKALINITY	CHLA	TP (ALL)	TP (EPICORE)
Trout Pond (deep hole)	7	6	6	6	6	6	6

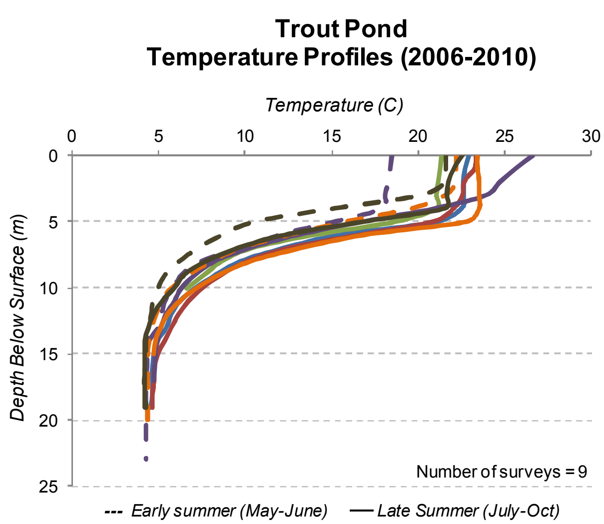
Water Quality Measures for Trout Pond (Station 1)

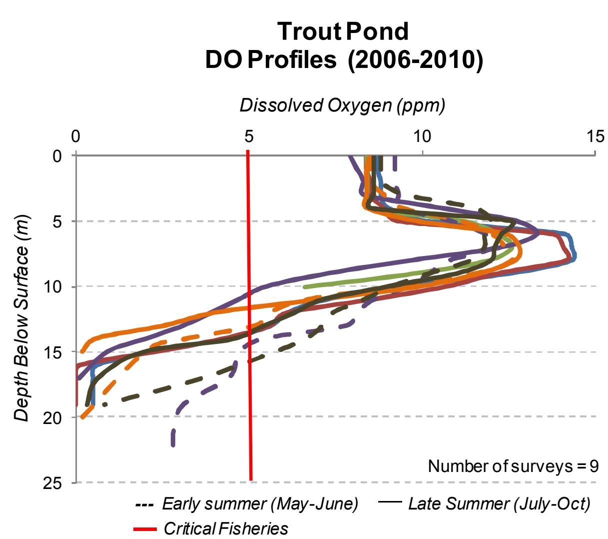


	All Years (1997-2011)	Historical (1997-2001)	Recent (2002-2011)
Minimum SDT (m)	6.5	8.3	6.5
Mean SDT (m)	8.2	9.0	7.6
Maximum SDT (m)	10.7	10.7	9.0

**Hit bottom 0 out of 16 readings (0%)*

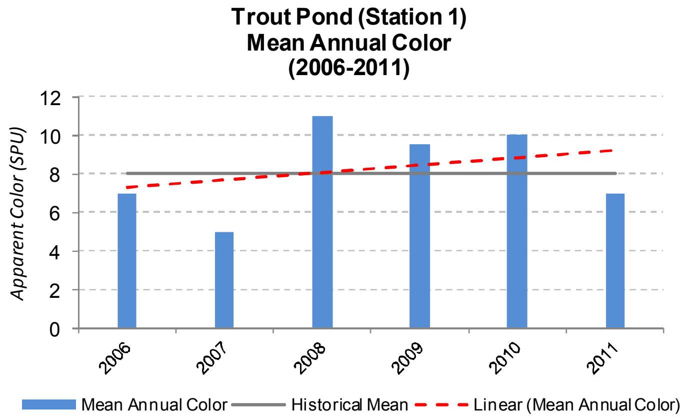
SDT ranged from 6.5 m to 10.7 m from 1997 to 2011 with an average of 8.2 m. Recent years (since 2002) compared to the historical mean show more than 1.4 m decrease in SDT. A large data gap exists from 1998 to 2005, which may reveal more annual fluctuation in SDT. Further monitoring is needed to confirm this trend. Even though Trout Brook may have declining SDT readings, Trout Brook has the highest mean SDT reading compared to the other waterbodies, including Kezar Lake.





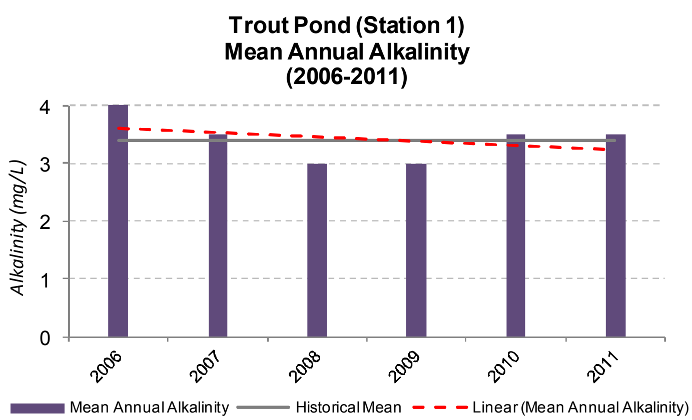
Historic profiles show temperature stratification from May to October. Formation of the metalimnion or thermocline has generally occurred between 4 and 6 meters below the surface.

Historic profiles show DO depletion in deep areas of the lake beginning in June through September, particularly below 10 m depth. Oxygen levels below 5 part per million (ppm) stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species.



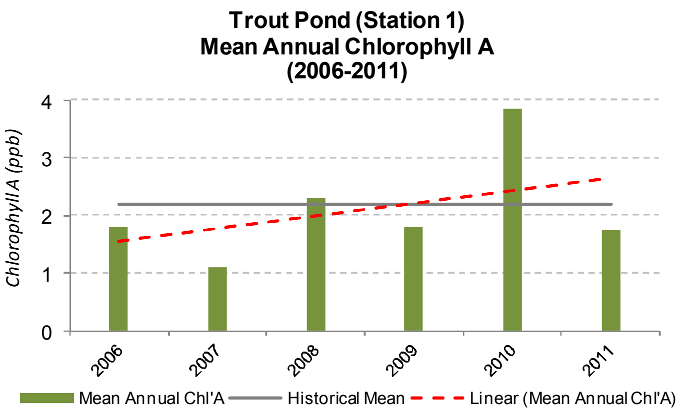
	All Years (2006-2011)
Minimum Color (SPU)	5
Mean Color (SPU)	8
Maximum Color (SPU)	13

Color ranged from 5 to 13 SPU from 2006 to 2011 with an average of 8 SPU. Since water quality data for color has only been collected in the 6 years, a historical and recent data comparison could not be made. However, recent trends show an increase in mean annual color, meaning the lake is becoming more "colored" and may be a sign of increasing productivity.



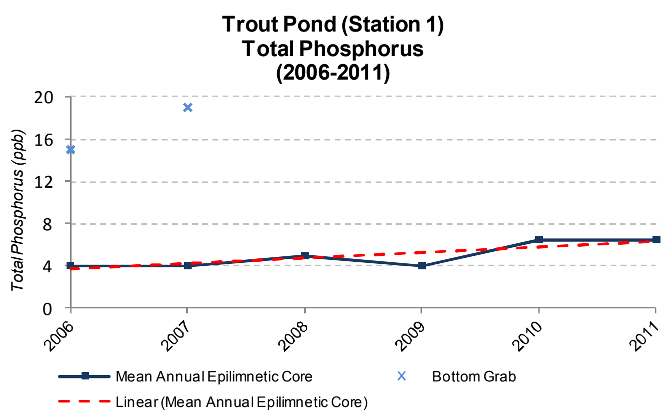
	Historical (2006-2011)
Minimum Alkalinity (mg/L)	3.0
Mean Alkalinity (mg/L)	3.4
Maximum Alkalinity (mg/L)	4.0

Alkalinity ranged from 3.0 to 4.0 mg/L from 2006 to 2011 with an average of 3.4 mg/L. Since water quality data for alkalinity has only been collected in the last 6 years, a historical and recent data comparison could not be made. However, recent trends show a decrease in average annual alkalinity, thus decreasing the buffering capacity of Trout Pond against pH fluctuations.



	Historical (2006-2011)
Minimum Chl-a (ppb)	1.0
Mean Chl-a (ppb)	2.2
Maximum Chl-a (ppb)	6.7

Chl-a ranged from 1.0 to 6.7 ppb from 2006 to 2011 with an average of 2.2 ppb. Since water quality data for Chl-a has only been collected in the last 6 years, a historical and recent data comparison could not be made. However, recent trends show an increase in mean annual Chl-a. This corresponds with decreasing water clarity and increasing color.



	Historical (2006-2011)
Minimum TP Epicore (ppb)	3
Mean TP Epicore (ppb)	5
Maximum TP Epicore (ppb)	10
Mean TP Bottom Grab	17
Mean TP Surface Grab	-
Mean TP Profile Grab	-

TP ranged from 3 to 10 ppb from 2006 to 2011 with an average of 5 ppb. Since water quality data for TP has only been collected in the last 6 years, a historical and recent data comparison could not be made. However, recent trends show an increase in mean annual TP. This increase in TP may have triggered algal growth (explains Chl-a increases), which affect water clarity.

BRADLEY POND

Watershed: Saco River

Town: Lovell, ME

County: Oxford

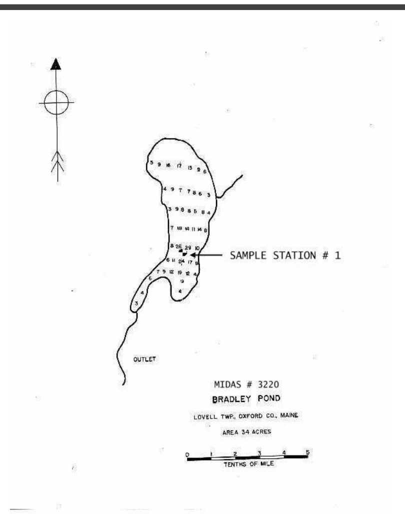
Surface Area (acres): 35 (0.05 sq.mi)

Perimeter (miles): 1.4

Mean Depth (feet): 10

Max Depth (feet): 29

Stations: 1 (deep hole)



Description of Waterbody

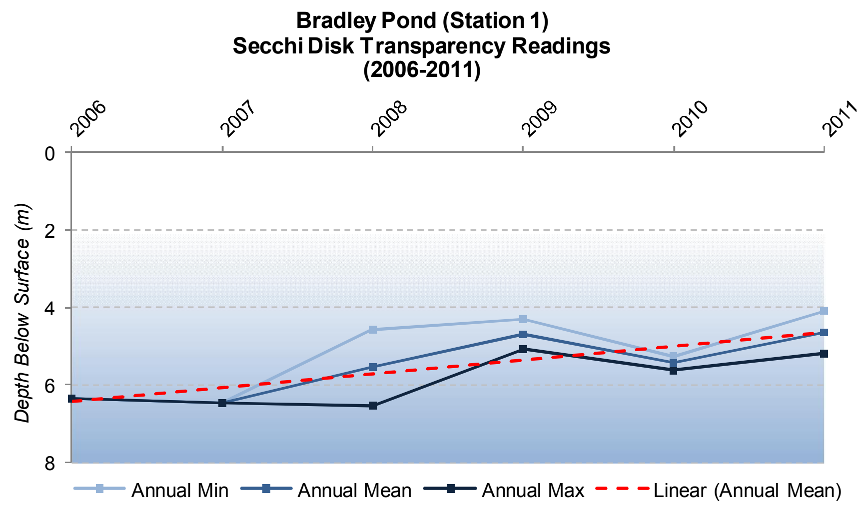
Bradley Pond (Midas #3220) is a non-colored waterbody located in the Town of Lovell, Oxford County, Maine. Covering 35 acres (0.05 square miles) with a maximum depth of 29 feet, the pond drains into Heald Pond, which in turn drains into a tributary to Boulder Brook and eventually Kezar Lake. Bradley Pond lies within the larger Saco River watershed and Kezar Lake subwatershed. Bradley Pond is a mixed warm and cold water fishery, and is home to a variety of fish, including brown trout, brook trout, largemouth bass, yellow perch, chain pickerel, minnows, golden shiner, white sucker, hornpout (bullhead), and pumpkinseed sunfish. This pond is stocked annually with brook trout and brown trout due to a lack of suitable spawning tributaries.

Water quality monitoring data for Bradley Pond's deep hole (Station 1) has been collected since 2006, and includes 6 years of TP (including 6 years of epicore samples), 6 years of Chl-a, 6 years of color data, 6 years of alkalinity, 6 years of DO and temperature profiles, and 6 years of SDT (Figure 1; Table 7). A trophic summary provided by LakesofMaine.org, an online information collaboration between DEP, VLMP, and the University of Maine, was unavailable.

Table 7. Years of available data per parameter for Bradley Pond

LAKE	SDT	DO	COLOR	ALKALINITY	CHLA	TP (ALL)	TP (EPICORE)
Bradley Pond (deep hole)	6	6	6	6	6	6	6

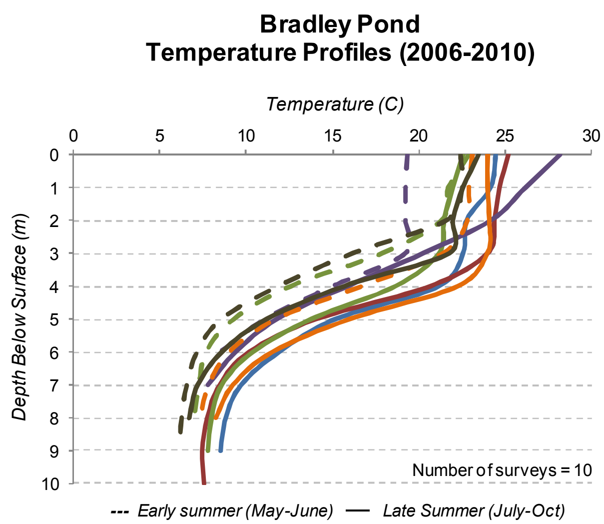
Water Quality Measures for Bradley Pond (Station 1)

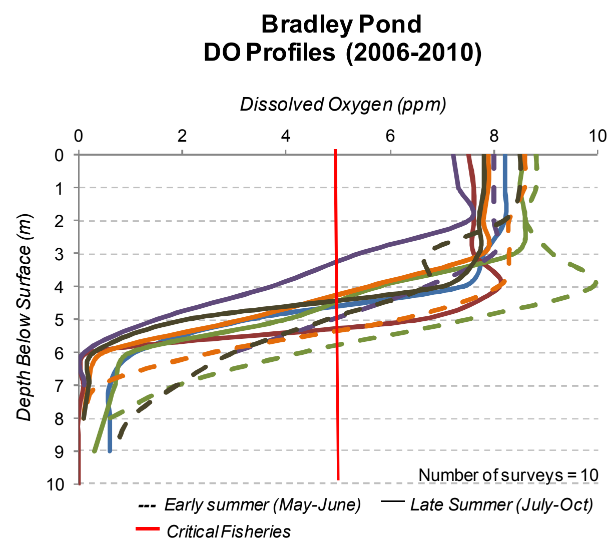


	All Years (2006-2011)
Minimum SDT (m)	4.1
Mean SDT (m)	5.3
Maximum SDT (m)	6.5

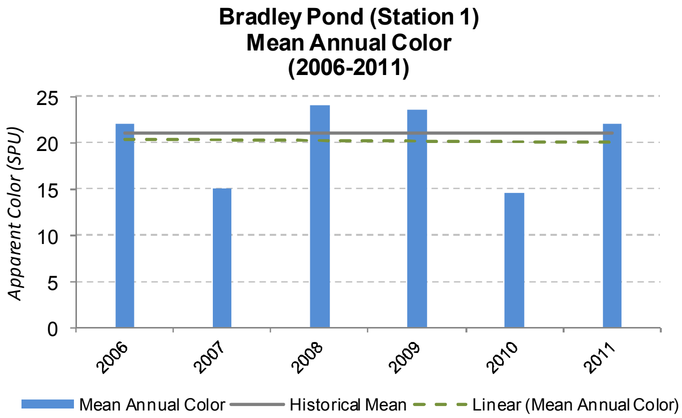
**Hit bottom 0 out of 10 readings (0%)*

SDT ranged from 4.1 m to 6.5 m from 2006 to 2011 with an average of 5.3 m. Although limited data is available for Bradley Pond, recent trends show a decrease in water clarity.



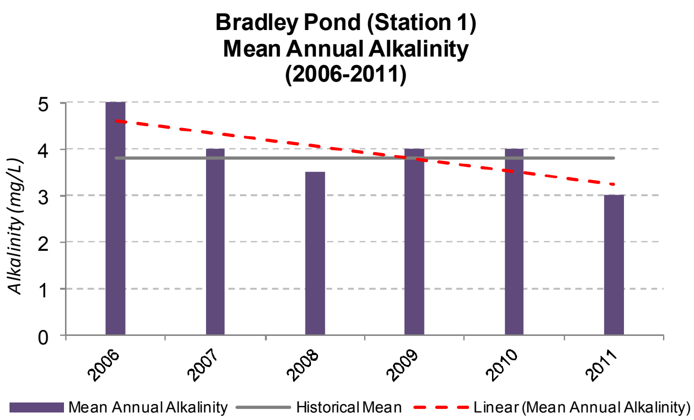


Historic profiles show temperature stratification from May to October. Formation of the metalimnion or thermocline has generally occurred between 3 and 5 meters below the surface. DO depletion occurs in deep areas of the lake beginning in June through September, particularly below 3 m below the surface. Oxygen levels below 5 part per million (ppm) stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species.



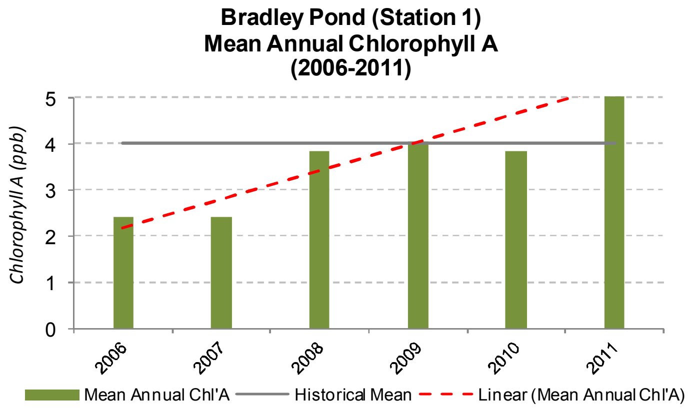
	Historical (2006-2011)
Minimum Color (SPU)	13
Mean Color (SPU)	21
Maximum Color (SPU)	29

Color ranged from 13 to 29 SPU from 2006 to 2011 with an average of 21 SPU. Since water quality data for color has only been collected in the past 6 years, a historical and recent data comparison could not be made. However, recent trends show relatively stable average annual color.



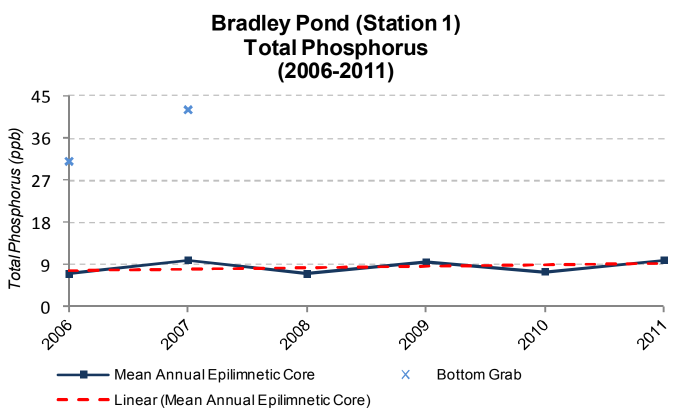
	Historical (2006-2011)
Minimum Alkalinity (mg/L)	3.0
Mean Alkalinity (mg/L)	3.8
Maximum Alkalinity (mg/L)	5.0

Alkalinity ranged from 3.0 to 5.0 mg/L from 2006 to 2011 with an average of 3.8 mg/L. Since water quality data for alkalinity has only been collected in the last 6 years, a historical and recent data comparison could not be made. However, recent trends show a decrease in mean annual alkalinity, thus decreasing the buffering capacity of Bradley Pond against pH fluctuations.



	Historical (2006-2011)
Minimum Chl-a (ppb)	2.4
Mean Chl-a (ppb)	4.0
Maximum Chl-a (ppb)	5.9

Chl-a ranged from 2.4 to 5.9 ppb from 2006 to 2011 with an average of 4.0 ppb. Since water quality data for Chl-a has only been collected in the last 6 years, a historical and recent data comparison could not be made. However, recent trends show an increase in average annual Chl-a. This corresponds with decreasing water clarity and increasing color.

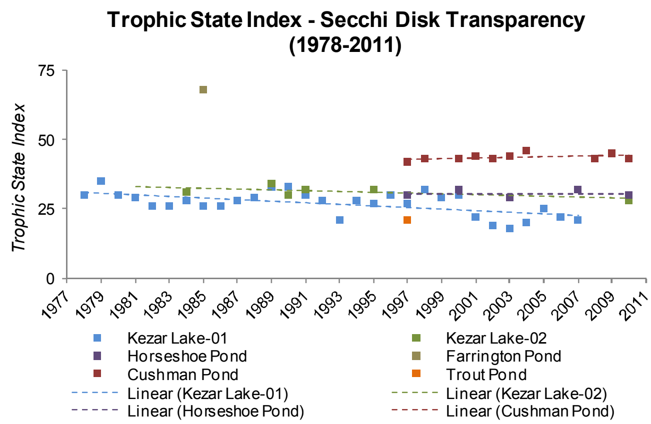


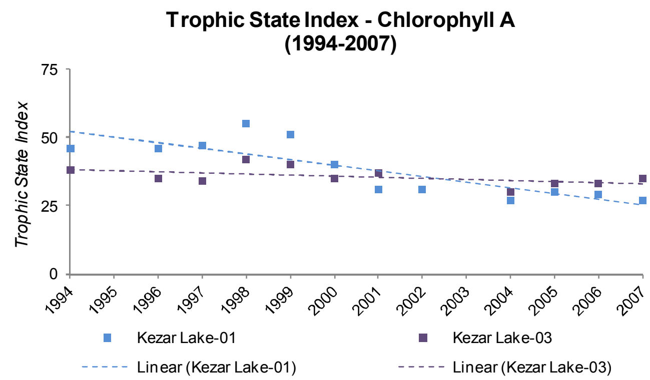
	Historical (2006-2011)
Minimum TP Epicore (ppb)	7
Mean TP Epicore (ppb)	9
Maximum TP Epicore (ppb)	12
Mean TP Bottom Grab	37
Mean TP Surface Grab	-
Mean TP Profile Grab	-

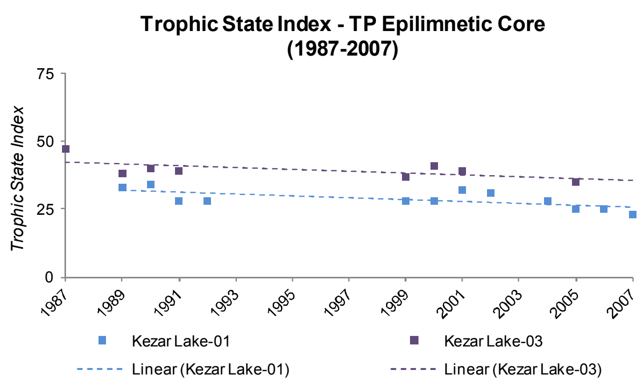
TP ranged from 7 to 12 ppb from 2006 to 2011 with an average of 9 ppb. Since water quality data for TP has only been collected in the last 6 years, a historical and recent data comparison could not be made. However, recent trends show a slight increase in mean annual TP. This increase in TP may have triggered algal growth (correlates with Chl-a increase), which affect water clarity. High bottom grab samples taken in 2006 and 2007 indicate that internal loading may be a potential cause of increasing TP and that the lake may be at risk for release of phosphorus from bottom sediments.

TROPHIC STATE INDICES

Maine DEP defines trophic state as the ability of a waterbody to produce algae and other aquatic plants. The trophic state of a waterbody is a function of its nutrient content, and the Maine Trophic State Index (TSI) is estimated using average Chl-a, TP, and SDT. This trophic classification system accounts for lake water color, particularly for lakes with color less than 30 SPU. In most cases, the TSI of these waterbodies, particularly Kezar Lake (Stations 1, 2, and 3), is decreasing or unchanging, meaning the lake systems are becoming less productive. However, Cushman and Farrington Ponds have increasing or high TSI values, which may be of concern. Long-term trends showed some DO depletion and decreasing alkalinity, but most parameters are stable or improving. Farrington Pond has high Chl-a values that may account for the high TSI. No or limited data is available to calculate and compare the TSI for Bradley and Trout Ponds.

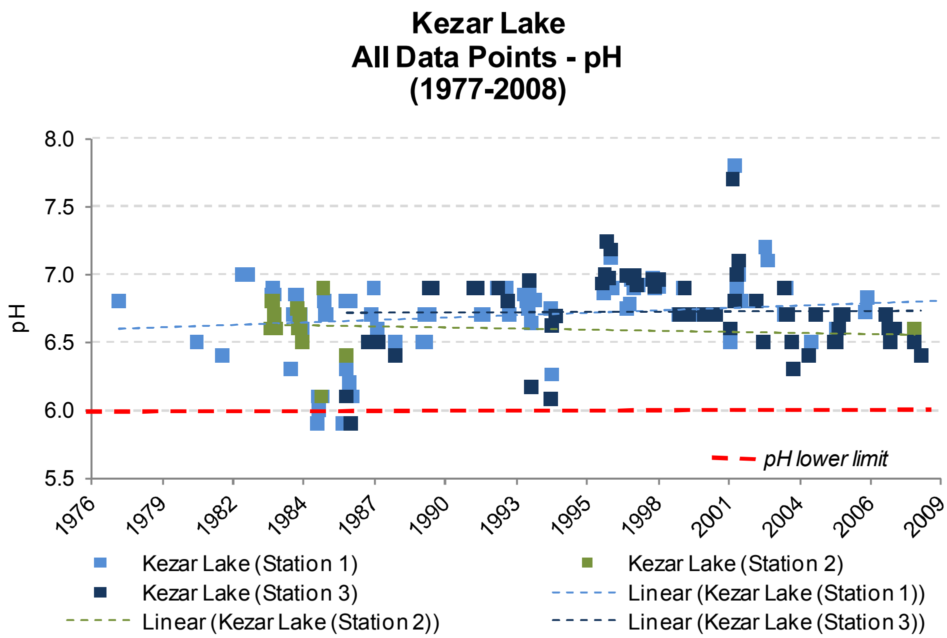






pH ANALYSIS

Due to concerns presented by KLWA about loss of sport fish and crayfish populations in Kezar Lake, and because the results of this analysis indicate a trend of decreasing alkalinity across all waterbodies in the Kezar Lake watershed, a closer examination of fluctuations in pH was conducted. There is natural variation in pH in lakes due to carbon dioxide fluctuations. Consumption of carbon dioxide reduces the acidity of water and increases pH, while the production of carbon dioxide (during the high growing season or daylight hours) increases the acidity of water and decreases pH. Changes in pH can increase the solubility and thereby the availability of phosphorus for plant growth. Less productive lakes tend to range between 6.5 and 7.5 for pH. A pH less than 6 can be toxic to fish and may account for some loss in fish populations observed in Kezar Lake.



Kezar Lake-01	All Years (1977-2008)	Historical (1977-2001)	Recent (2002-2011)
Minimum pH	5.9	5.9	6.3
Mean pH	6.7	6.7	6.7
Maximum pH	7.8	7.8	7.2

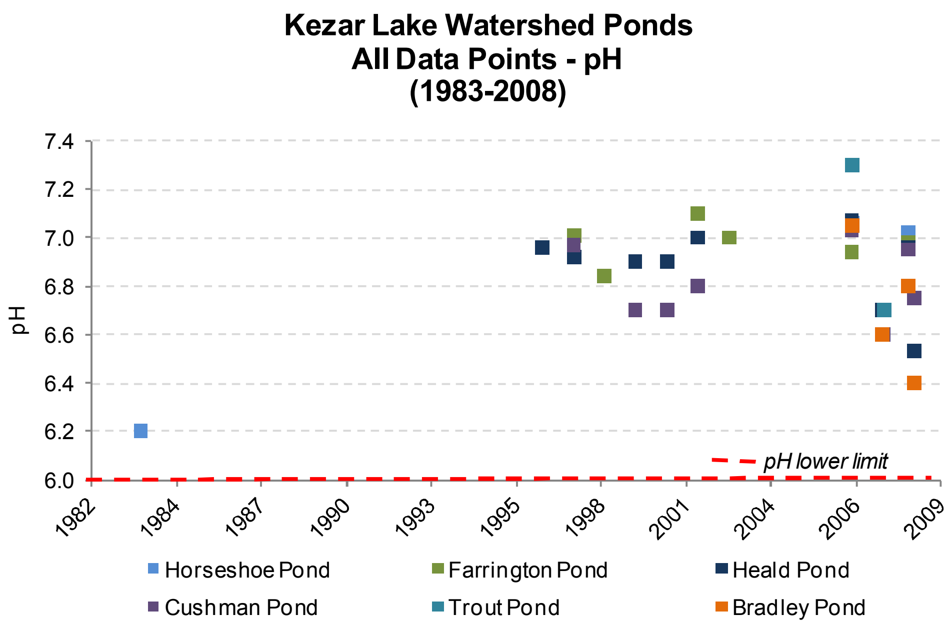
Kezar Lake-02	All Years (1983-2011)	Historical (1983-2001)	Recent (2008-2011)
Minimum pH	6.1	6.1	6.6
Mean pH	6.6	6.6	6.6
Maximum pH	6.9	6.9	6.6

Kezar Lake-03	All Years (1986-2011)	Historical (1986-2001)	Recent (2002-2011)
Minimum pH	5.9	5.9	6.3
Mean pH	6.7	6.9	6.6
Maximum pH	7.7	7.7	6.9

At Kezar Lake (Station 1), pH ranged from 5.9 to 7.8 with an average of 6.7. Recent years (since 2002) compared to the historical mean show stable pH. Station 1 fell below the optimal range (6.0 to 8.5) from 1984 to 1986, but has remained above 6.0 in recent years.

At Kezar Lake (Station 2), pH ranged from 6.1 to 6.9 with an average of 6.6. Since water quality data for pH is limited at Station 2, a historical and recent data comparison could not be made (only one data point was available for recent years. However, trends show relatively stable pH.

At Kezar Lake (Station 3), pH ranged from 5.9 to 7.7 with an average of 6.7. Recent years (since 2002) compared to the historical mean show a decrease in pH by 0.3. Station 3 seems to have a greater range or fluctuation in pH; this may be due to its shallow depth and being more susceptible to inputs. Station 3 fell below the optimal range (6.0 to 8.5) in 1986, but has remained above 6.0 in recent years.



Horseshoe Pond	All Years (1997-2008)	Historical (1997-2001)	Recent (2002-2011)
Minimum pH	6.6	6.7	6.6
Mean pH	6.9	6.9	6.9
Maximum pH	7.1	7.1	7.0

Farrington Pond	All Years (1983-2008)	Historical (1983-2001)	Recent (2002-2011)
Minimum pH	6.2	6.2	6.7
Mean pH	6.7	6.2	6.9
Maximum pH	7.1	6.2	7.1

Heald Pond	All Years (1995-2008)	Historical (1995-2001)	Recent (2002-2011)
Minimum pH	6.5	6.9	6.5
Mean pH	6.9	6.9	6.8
Maximum pH	7.1	7.0	7.1

Cushman Pond	All Years (1997-2008)	Historical (1997-2001)	Recent (2002-2011)
Minimum pH	6.6	6.7	6.6
Mean pH	6.8	6.8	6.8
Maximum pH	7.0	7.0	7.0

Trout Pond	All Years (2006-2007)	Historical (2006-2007)	Recent (2002-2011)
Minimum pH	6.7	NA	NA
Mean pH	7.0	NA	NA
Maximum pH	7.3	NA	NA

Bradley Pond	All Years (2006-2008)	Historical (2006-2008)	Recent (2002-2011)
Minimum pH	6.4	NA	NA
Mean pH	6.7	NA	NA
Maximum pH	7.1	NA	NA

Overall, the range of pH for the watershed ponds was smaller with less fluctuation than seen at Kezar Lake. However, significantly less data was available for the ponds and long-term trends are difficult to interpret based on these limited findings. pH appears to be decreasing at all the ponds beginning in 2006.

Changes in the Clean Air Act in 1990 helped reduce sulfur dioxide from burning coal that drifts into the atmosphere and lowers the pH of rainwater. In Maine, the average pH of rainwater is 4.8 (USEPA, 2003). When this acidic rain falls to the ground, it leaches calcium from the soil, depriving plants of a key nutrient. This may have implications for fish that need calcium, and for mollusks such as mussels and possibly crayfish that need calcium to make their shells.

A study of 100 acidic lakes in Maine indicated that the effects of acid rain remains relatively unchanged in Maine despite improvements in other states and a more than 20% reduction in sulfate in precipitation (USEPA, 2003). It's believed that Maine may not have seen much improvement compared to other states because the state has higher levels of natural acidity. Watersheds that are rich in granite, such as the Kezar Lake watershed, and contain fewer acid-neutralizing ions (low alkalinity) may have a predisposition to acidification.

The National Lakes Assessment (USEPA, 2009) indicates that lake acidification is not a widespread problem across the nation, and yet, acidification on a smaller scale, *i.e.*, "hot spots," do occur. While only a relatively small proportion of lakes may be impacted by acidification, the effects of acidification in the impacted lakes, and the contribution of acidity to other stressors, can be severe in specific geographic regions.

Further study is needed to assess the trends that indicate a decrease in alkalinity in Kezar Lake and all of the ponds in the watershed and this relationship to low pH, reported fish and crayfish declines and acid rain. More long-term data is needed to confirm this trend. Interested watershed stakeholders should consider conducting a study to determine the sources of low alkalinity and pH and whether the trend is in fact influencing the local sport fishery.

SUMMARY

The following summarizes major trends and observations made from the water quality data analysis for Kezar Lake and six area ponds. Overall averages for each waterbody by water quality parameter are provided in Table 8. Parameters with declining trends are indicated with a (*).

Table 8. Summary of mean water quality parameters for Kezar Lake and ponds

Lake/Pond-Station (MIDAS)	Mean SDT	Mean Color	Mean TP (Epicore)	Mean Alkalinity	Mean Chl-a	DO Trends
Kezar Lake-01 (0097)	7.6	11	6	4.5*	2.8	Late/early summer anoxia (>40m)
Kezar Lake-02 (0097)	6.9	12	5	3.4	2.1	Late summer anoxia (>8m)
Kezar Lake-03 (0097)	3.2	14	9	4.6*	2.4*	No anoxia observed
Horseshoe Pond-01 (3196)	7.0	10	7	4.0*	3.5*	Late/early summer anoxia (>5m)
Farrington Pond-01 (3200)	4.4	16	15*	4.1*	8.1*	Late/early summer anoxia (>3m)
Heald Pond-01 (3222)	4.6	23*	10	5.6*	3.9	Late/early summer anoxia (>3m)
Cushman Pond-01 (3224)	5.5	11	7	4.9*	2.4	Late/early summer anoxia (>6m)
Trout Pond-01 (3212)	8.2*	8*	5*	3.4*	2.2*	Late/early summer anoxia (>10m)
Bradley Pond-01 (3220)	5.3*	21*	9*	3.8*	4.0*	Late/early summer anoxia (>3m)

**Indicates declining trend over time*

Kezar Lake (Upper, Middle, Lower Basins)

- SDT improved by more than 1 m at Stations 1 and 2; Station 3 has remained stable since 97% of SDT readings hit bottom.
- Little to no DO depletion at all three stations. As expected, some DO depletion was typically seen at Stations 1 and 2 during the hottest summer months (July, August) in the hypolimnion.
- Color remained relatively stable at Stations 1 and 3; high color values correspond with high precipitation years; Station 2 mimics data trends at Stations 1 and 3.
- Alkalinity decreased at Stations 1 and 3 by 0.9 mg/L and remains within the endangered category established by EPA; Station 2 mimics data trends at Stations 1 and 3, but was the only station that didn't exhibit decreasing alkalinity over time. Continuing declines in alkalinity should be examined closely since it is a parameter that can help buffer against changes in pH. Both pH and alkalinity can negatively affect fish populations at low levels.
- Chlorophyll-a has decreased over time at Stations 1 and 2, and since 2001 has been consistently below average at all stations; Station 3 exhibited a slight increase in Chl-a.

- Total phosphorus decreased at Stations 1 and 2 and remained stable at Station 3; high TP values within the data set at Station 3 may indicate that internal loading is a factor due to its shallow depth, or that bottom sediments are highly susceptible to re-suspension during sampling events.
- Stations 1 and 3 fell below the optimal range (6.0 to 8.5) for pH in the 1980's and showed some fluctuations in pH between years that may impact aquatic communities; data for pH is only available through 2008.

Ponds (Horseshoe, Farrington, Heald, Cushman, Trout, and Bradley)

Careful interpretation of pond data needs to be considered due to lack of long-term data. Trends are better suited to long-term data sets (>10 years). The ponds in the Kezar Lake watershed have less than this recommendation, and therefore, any interpretation should be considered premature for assigning long-term trends to these waterbodies. Natural fluctuations are common over the short-term due to variability in weather, or other factors, such as one-time perturbations from land use changes in any given year.

- SDT improved by 0.2 m at Horseshoe Pond, 1.2 m at Farrington Pond, and 0.1 m at Heald Pond. Minimum values at Farrington Pond are approaching 2 m and may be cause for concern for algal blooms. SDT at Cushman Pond is stable, but annual range is high (2-3 m difference). Trout and Bradley Ponds may be misrepresented due to lack of long-term data, but both indicate decreasing trends in SDT over the short-term.
- DO depletion was observed below 6 m at Horseshoe Pond, below 3 m at Farrington Pond, below 3 m at Heald Pond, below 5 m at Cushman Pond, below 10 m at Trout Pond, and below 3 m at Bradley Pond. There was little temperature stratification at Farrington and Heald Ponds.
- Color decreased by 3 SPU at Horseshoe Pond, 5 SPU at Farrington Pond, and 2 SPU at Cushman Pond. The maximum color value at Farrington Pond increased by 3 SPU; lack of historical data may be problematic for comparison. Heald Pond had the highest color followed by Bradley, both of which are borderline colored waterbodies. Trout and Bradley may be misrepresented due to lack of data, but Trout Brook showed increasing color trend.
- Alkalinity decreased by 1.6 mg/L at Horseshoe Pond, 1 mg/L at Farrington Pond, 1.5 mg/L at Heald Pond, and 1.3 mg/L at Cushman Pond. Trout and Bradley Ponds may be misrepresented due to lack of data, but both have decreasing trends in alkalinity.
- Chl-a increased by 0.01 ppb at Horseshoe Pond and the maximum increased by 1.1 ppb. A historical comparison could not be made for Farrington Pond due to inaccurate representation of limited historical data, but the average exceeds DEP threshold of 8 ppb. Chl-a decreased by 0.2 ppb at Heald Pond, and 0.8 ppb at Cushman Pond. Trout and Bradley may be misrepresented due to lack of data, but both have increasing trends in Chl-a that fall below the DEP threshold of 8 ppb.
- TP data at Farrington, Trout, and Bradley Ponds may be misrepresented due to lack of data; however, Farrington Pond's mean TP value is highest of all the waterbodies and is at the DEP threshold for TP (15 ppb). Trout and Bradley Ponds had a slight increase in TP, but fall below the DEP threshold. High bottom grabs at Bradley Pond indicate internal loading may be a potential cause of increased TP. Horseshoe and Cushman Ponds have stable TP values. A high of 13 ppb at Cushman Pond in 2009 may correspond with the high precipitation that year. Heald Pond had a high mean TP, second to Farrington, but remains stable at 10 ppb.

Kezar Lake remains one of Maine's cleanest and clearest lakes with above average water quality and clarity. Improvements in clarity, chlorophyll-a and total phosphorus may be linked to declining alkalinity and low pH in these lakes since acidic lakes are less productive by nature. Continuing to monitor all three basins of the lake will help identify long and short-term trends and maintain Kezar Lake's water quality in the future.

There are similar trends across the six ponds in the watershed (with a few exceptions) including short-term improvements in water clarity, color, total phosphorus and chlorophyll-a and a decrease in alkalinity; however, each pond is unique and is impacted by different land use patterns. The shallow nature and smaller area of the ponds as compared to Kezar Lake make them more susceptible to watershed pollutant inputs. Like Kezar Lake, a major trend is decreasing alkalinity, which should be monitored closely over the next 5-10 years.

RECOMMEDATIONS

1. Continue monitoring in order to complete a more accurate long-term trend analysis. Analyses of some parameters were difficult due to limited data or large data gaps.
    a. *Limited data was available for the ponds, particularly Trout and Bradley Ponds. These waterbodies should continue to be monitored in order to complete a more accurate long-term trend analysis.*
    b. *Significant data gaps can also mask true water quality trends. Parameters with major data gaps include: SDT at Horseshoe, Farrington, Heald, and Cushman Ponds, TP at Farrington Pond, Heald Pond, Cushman Pond, and Kezar Lake-02, and color, alkalinity, and Chl-a at Farrington Pond.*
2. Conduct historical trend analysis of Kezar Lake and area ponds on a 5-year schedule. Since the lack of long-term data for the ponds favors large annual variation as a result of natural or anthropogenic impacts.
3. Continue to actively involve residents in the protection of waterbodies in the Kezar Lake watershed, particularly as development around the lake increases, weather patterns change lake system dynamics, and invasive species threaten lake health.
4. Include pH in future lake and stream monitoring to gain a better understanding of the impact that decreasing alkalinity will have on these waterbodies. Alkalinity in lakes is influenced by several sources, including calcium carbonate dissolved from limestone rock, salt inputs, plant activity (carbon dioxide fluctuations), acid rain, vehicle emissions and wastewater discharges. Stormwater runoff can also carry lime that is applied to lawns or agricultural fields and increase pH, while decaying organic matter can decrease pH. Kezar Lake is underlain primarily by granite bedrock, which has very little natural base compared to limestone. Kezar Lake lies within the highly sensitized zone for acid rain in the northeast region. It may be beneficial to conduct a study on acid rain deposition in the region to see if that is truly the primary cause of declining alkalinity and low pH in the watershed. If low pH proves to be negatively affecting the health of fish and crayfish populations in the lake, more research into management solutions may be appropriate to help increase the buffering capacity of these waterbodies.

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