Photo: Barbara and Gerard Guimond

SEBAGO LAKE State of the Lake 2008 REPORT

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Sebago Lake...

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Photo: Mark Wazowski

But the lake is not invincible. What is becoming apparent on a global scale is even more true locally – humans have the capacity to overwhelm nature.

Sebago Lake has served as the drinking water supply for the citizens of Greater Portland since 1869. Today, it provides drinking water to almost 200,000 residents in 11 communities. Add to that number all the people who travel to Greater Portland to work, eat, or receive medical care, and you begin to get a sense of how many of Maine's 1.2 million people benefit from the lake as a water supply source.

But that's just part of the story. Hundreds of thousands more live or vacation in the Sebago Lake watershed, own or work at a lake-dependent business such as a marina or campground, or simply come to enjoy the lake. Taking all these users into account, it's hard to imagine that there are many natural resources in Maine as important as this one.

And what a lake it is. It covers almost 30,000 acres and is surrounded by a watershed that stretches over 300,000 acres. The watershed extends generally to the northwest of the lake into largely rural communities, so it is mostly wooded – the ideal condition for water quality. The lake is underlain by granite, which results in very soft water with few dissolved minerals. Further, much of the lake shoreline is made of glacial till, as evidenced by the many boulders at or near the shore. Till is relatively resistant to erosion. And the lake is deeper than any in New England – 305 feet at the deepest part of Big Bay – and holds almost a trillion gallons of water. The people of Greater Portland use about 22 million gallons of water per day – which means there is enough water in the lake right now to meet existing demand for more than 100 years!

Photo: Barbara and Gerard Guimond

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Photo: Curtis O'Donnell

Photo: Jay Crowley

But the lake is not invincible. What is becoming apparent on a global scale is even more true locally – humans have the capacity to overwhelm nature. There are more people than ever before around the lake. And just about every human action – cutting trees, building roads and buildings, working and playing - has the potential to impact water quality. Water quality trends since 1990 are toward lower water quality.

As the type and pace of activity changes, the need to minimize its impact grows as well. Today, however, activity in the Sebago Lake watershed is not managed or even monitored by any single entity. Instead, each town in the watershed regulates activity within its borders. Without one entity overseeing lake stewardship, conflicting decisions can result in adverse impacts on the lake we share.

This is the third "State of the Lake" report prepared by the Portland Water District. This report updates a series of measures of water quality, fisheries, land development, invasive species, lake level, and boating that were included in earlier reports. These are not the only measures of "the state of the lake" but they are some that are relatively straightforward. Although it's only been five years since the first report was published - a blink of an eye in Sebago Lake's 10,000 year history - the sets of data may provide the first glimpse of developing trends.

For copies of past reports or to comment on this report or the lake in general, contact us at **sebagolake@pwd.org**

Water Quality

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Water tests indicate an increase in the amount of chlorophyll and phosphorus in Sebago Lake since 1990.

Photo: Beth De Simon Photography

The quality of water in Sebago Lake is important to all who use the lake, own property near it or drink from it. As part of a continuing effort to evaluate lake water quality, PWD has been monitoring the lake and watershed for decades. The monitoring program includes sampling of tributaries, nearshore locations, deep basins, and many locations around the water intakes in Lower Bay. PWD monitors dissolved oxygen, total phosphorus, chlorophyll-*a*, fecal coliform bacteria, macro-invertebrate insects, zooplankton, algae, MtBE, turbidity, conductivity, and water transparency. Monitoring these parameters allows changes in water quality to be detected before they impact the quality of water consumed by our customers.

Lake Productivity

There are many ways to classify a lake. The most common is to determine how productive it is - or how much growth (algae, plants, animals, etc.) it supports. The productivity of a lake is dependant on many factors including rate of nutrient input, climate, lake geology, watershed topography, lake size & shape and human influence. All lakes have different levels of productivity and generally the lower the better. Less productive lakes (such as Sebago) are clear, cold, highly oxygenated, support environmentally sensitive organisms (ex. salmon, trout & mayflies) and are suitable for a drinking water supply. More productive lakes are murky, warm, exhibit low oxygen levels and only support environmentally tolerant organisms (pickerel, perch & mosquitoes). Three ways to assess lake productivity are water clarity, chlorophyll-*a*, and total phosphorous.

Lake Clarity

With an average water clarity of 33 feet, Sebago Lake is one of the clearest lakes in Maine **(Figure 1)**. However, water clarity in Sebago Lake has been declining in all three bays since 1990 **(Table 1)**, not a positive trend.

Big Bay	Lower Bay	Jordan Bay
-0.11 meters/yr.	-0.10 meters/yr.	-0.15 meters/yr.

Table 1. Rate of Change in Sebago Lake Water Transparency Since 1990

Chlorophyll-*a*

The most direct measure of lake productivity is the amount of chlorophyll-*a*. chlorophyll-*a* is the pigment in algae cells which turns sunlight into carbohydrate for food. This complex green molecule in algae is the same substance found in terrestrial plants.

Chlorophyll-*a* values depend on lake geology, watershed conditions, lake size & volume, weather conditions and human

Macroinvertebrate insect collection on the Crooked River

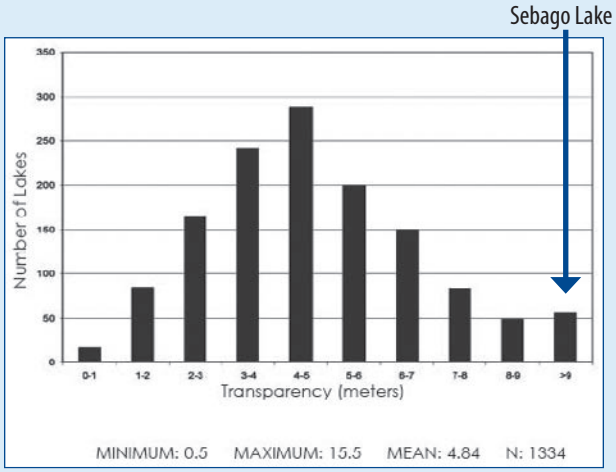


Figure 1. Transparency of Maine Lakes

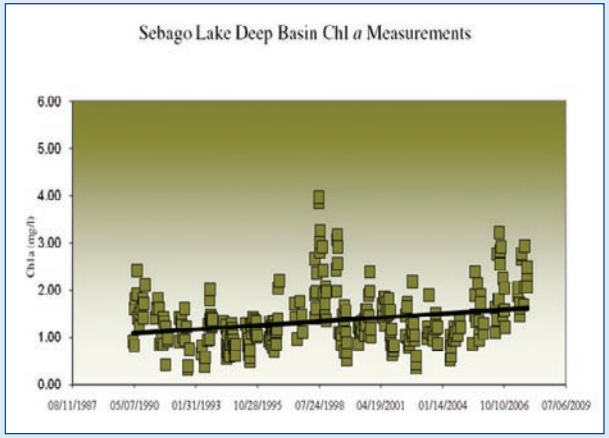


Figure 2. Sebago Lake Deep Basin Chl-*a* Measurements

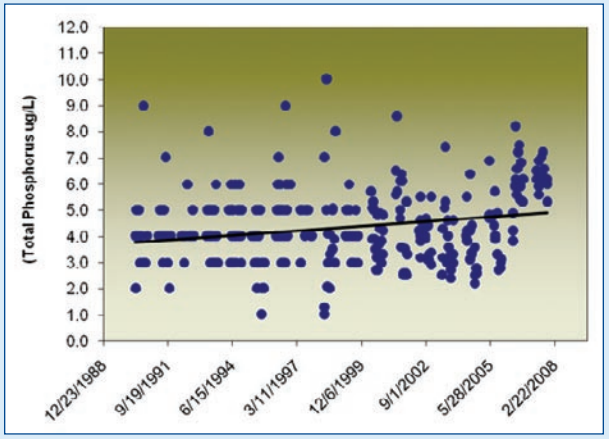


Figure 3. Sebago Lake Deep Basin Total Phosphorus Measurements

impacts. The biggest human impact to our lakes comes from storm water and soil erosion. Every time it rains, water washes over developed areas and pollutes waterways with soil. The same nutrients in the soil that feed the plants on land also feed the algae in the water.

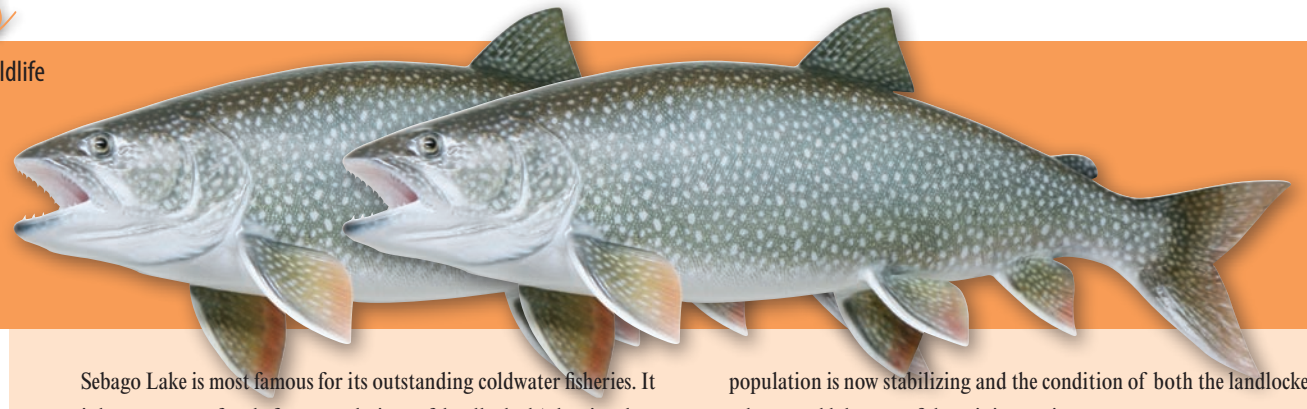
Water tests indicate an increase in the amount of chlorophyll-*a* in Sebago Lake since 1990 **(Figure 2)**. Though this may be a temporary phenomenon, it bears continued monitoring. Because of the many factors that influence chlorophyll-*a* concentrations, lakes experience seasonal and annual variations in concentration.

Total Phosphorus

Phosphorus is one of the major nutrients needed for plant growth in lakes, including algae. It is generally present in small amounts in Maine lakes and is often the limiting factor for algal growth, meaning algae has more than enough of everything it needs to multiply and grow except for phosphorous. In Sebago Lake, phosphorus concentrations have increased since 1990 **(Figure 3)**. This increase in phosphorous is consistent with the increase in chlorophyll-*a* described in the previous section since more phosphorous would be expected to result in increased algae. Storm water runoff and other sources of soil particles can contribute to the increase in phosphorous. Though the amount of phosphorus in Sebago Lake remains low compared to other Maine lakes, this increase since 1990 is a negative trend that will be monitored into the future.

Fisheries

Information in this section from Maine Inland Fisheries and Wildlife



Sebago Lake is most famous for its outstanding coldwater fisheries. It is home to one of only four populations of landlocked Atlantic salmon indigenous to Maine. The introduction of lake trout by the Maine Department of Inland Fisheries and Wildlife (MDIFW) in the early 1970s was intended to provide additional opportunity for anglers. It appears, however, that the growth of the lake trout population has contributed to a decline in the population of rainbow smelt. Since smelt are the primary forage species for salmon, the result has been a decline in the growth, size quality (size in proportion to robustness), and abundance of landlocked salmon. By the early 1990s, both the salmon and lake trout populations were showing signs of reduced growth and size.

Over the years, MDIFW has undertaken numerous initiatives to restore the balance of predator and prey. For example, salmon stocking was reduced from 8,000 fish in 1994 to 1,000 fish per year in 2002. Conservative salmon stocking practices continue. In addition, regulation changes were made to increase lake trout harvest opportunity. In 1994, daily catch limits were increased from 3 to 6 lake trout. The winter line limit was also increased in 2004 to 5 lines per person. MDIFW partnered with the Windham Rotary to establish a lake trout ice fishing derby. In an effort to increase the smelt population, MDIFW partnered with the Sebago Lake Anglers Association and the Southern Maine Community College on an experimental sea-run smelt egg transfer project, though the actual success of this experimental project is uncertain. MDIFW believes the once increasing lake trout population is now stabilizing and the condition of both the landlocked salmon and lake trout fishery is improving.

Figure 4 shows the abundance of forage fish (including smelt) measured by hydroacoustic surveys. These data and observations of smelt spawning runs and anecdotal lake angler reports indicate the smelt population is recovering.

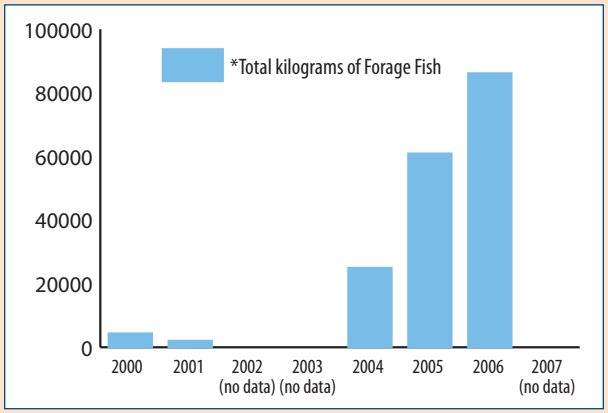


Figure 4. Total kilograms of Forage Fish

Sebago Lake Management Plan

As part of the Classic Salmon Initiative, MDIFW has developed a draft salmon management plan to improve salmon size quality. In 2008, MDIFW embraced a proposal by the Sebago Lake Anglers Association that extended open water fishing season for lake trout from October 1 to

Table 2. Mean Condition K

Mean Condition (K)		
Year	Salmon	Lake Trout
1988	0.94	
1989	0.9	
1990	0.92	
1991	0.87	
1992	0.85	0.917
1993	0.8	0.828
1994	0.8	0.78
1995	0.74	0.783
1996	0.91	0.77
1997	0.86	0.831
1998	0.93	0.965
1999	0.8	0.917
2000	0.83	0.809
2001	0.79	0.769
2002	0.9	NA
2003	0.89	0.798
2004	0.89	0.863
2005	0.97	NA
2006	0.88	0.88
2007	0.87	0.89

December 30. Another proposal currently being considered by MDIFW would modify the size and bag limit on lake trout in an effort to focus the harvest on younger lake trout to biologically limit population growth. Studies have shown that removing larger fish from long standing lake trout populations has caused their populations to increase dramatically. If the proposal is ultimately enacted and has the desired effect, anglers would have fewer lake trout to catch but they would be of much larger size quality. In addition, the salmon fishery would be enhanced by a greater abundance of smelt.

Salmon

Annual monitoring of adult salmon that enter the Jordan River Fish Collection Facility each November indicates a steady improvement in salmon growth since 2001. The mean length and weight of three-year old male salmon observed in 2007 **(Figure 5)** was lower than the previous two years but still above size quality standards established by MDIFW as a benchmark to which anglers would like to see the fishery restored. Although salmon have been generally longer and heavier in the last 7 years, their relative plumpness or condition ("K" value) has been relatively unchanged for the last 4 years with the exception of a spike in 2005. As measured on a scale of 0 to 1, K values between 0.95 and 1 reflect salmon in excellent condition **(Table 2)**. K values in this range can only be achieved where there is a healthy balance between smelt forage and predators.

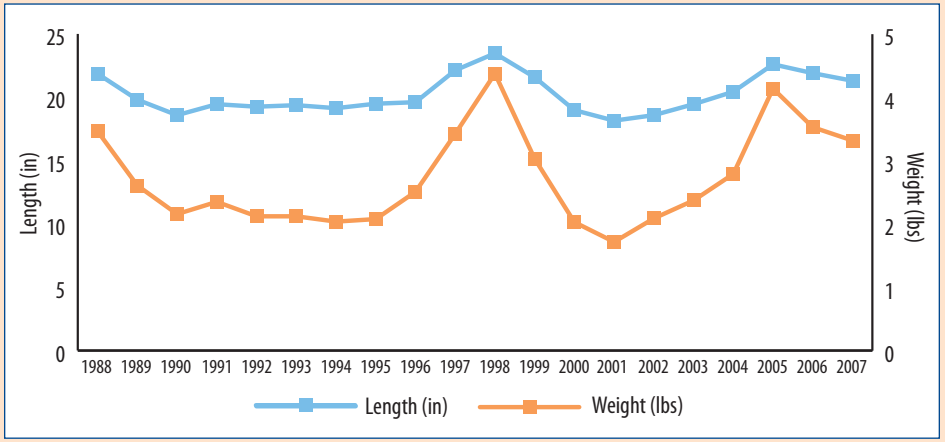


Figure 5. Mean Length and Weight for Age 3 Male Landlocked Salmon, Jordan River 1988-2007

Northern Pike

In the spring of 2003 an illegal introduction of the voracious and non-native northern pike was discovered in the Songo River, just upstream of its confluence with Sebago Lake. Since then, multiple confirmed northern pike have been harvested by anglers in Sebago. In 2005, a 13 pound female northern pike laden with eggs was harvested in the Lower Bay of Sebago. Just this year an angler landed a 17 pound, 41-inch northern pike in Kettle Cove. Pike will prey upon smelt as well as salmon. According to MDIFW, "Pike have established themselves in Sebago and are spawning. Because Sebago is so large with numerous inlets, there's virtually nothing that can be done at this point to limit the expansion of this new invader which threatens salmon recovery and fishery management efforts."

Development

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Shorefront property in Maine is highly coveted. Since improper development of shorefront properties can impact lake water quality, comprehensive shoreland zoning regulations have been enacted in every town in the state. More recently, the state has adopted an erosion control law that recognizes that improperly managed development anywhere in a watershed can impact water quality. In general, state and local regulations are more restrictive for properties closer to bodies of water than those further away. Maine's Erosion and Sedimentation Control Law requires that erosion control measures be in place before an activity begins, and remain in place and functional until the site is permanently stabilized. The law further requires that all chronically eroding sites in watersheds most-at-risk (including the Sebago Lake watershed) must be stabilized. Examples of chronic erosion problems include camp roads that wash out each spring, culverts with erosion at the inlet or outlet, and ditches showing major rills and gullies.

Building Permits Issued in Shorefront Towns During 2007

The Sebago Lake watershed includes all or parts of 24 towns and covers approximately 300,000 acres (450 square miles). Water from this entire land area eventually reaches Sebago Lake, some directly and some indirectly (after flowing into and then out of other lakes such as Brandy Pond). There are seven towns that have Sebago Lake frontage: Standish, Sebago, Naples, Casco, Raymond, Windham, and Frye Island. Because of their proximity, development of watershed properties in these towns has the greatest potential to impact Sebago Lake. The total Sebago Lake watershed land area in these seven towns is 86,440 acres, ranging from 862 acres in Frye Island to 20,452 acres in Naples.

In an effort to evaluate the rate of watershed development in these towns in 2007, building permits on file at the town offices were reviewed and compared to 2002 and 2004. Numbers of building permits in **Figure 6** reflect those permits in the Sebago Lake watershed for new construction or improvements with an estimated value equal to or greater than $50,000. These totals give an indication of the numbers of previously undeveloped properties which were developed in each year. Most towns have seen fewer building permits in 2007 as compared with 2004. This is not surprising in light of economic trends. The town of Naples saw the largest decrease from 106 in 2004 to 59 in 2007.

Septic System Construction Permits, 1997-2007

In 1913, the Maine Legislature granted the PWD authority to regulate the disposal of drainage and waste from structures located within 200 feet of the high water line of Sebago Lake. In practice this means that a new or replacement septic system, or the seasonal conversion or expansion of an existing septic system, may not be undertaken without a permit from PWD. The number of permits granted each year is a measure of the rate of development in the most critical part of the lake watershed, the shoreland zone. **Table 3** shows new septic systems installed during the period 1997-2007. In 2007 ten new septic systems were installed within 200 feet of Sebago Lake, which is fewer than the average annual number for the previous ten years (17.6). The last time ten or fewer new systems were installed was 1997.

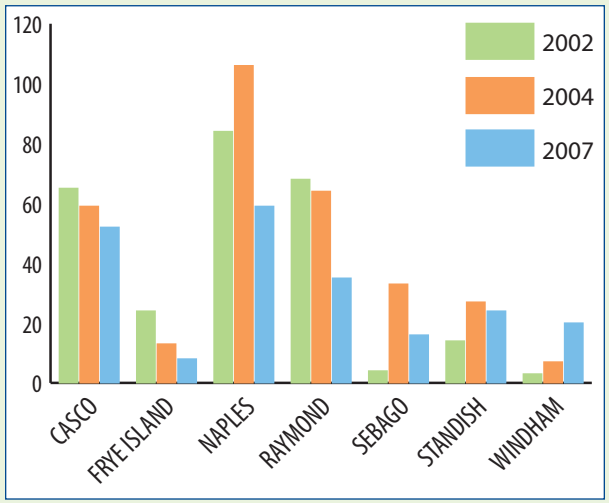


Figure 6. Building Permits for New Construction

New Septic Systems Within 200 Feet of Sebago Lake										
1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
10	15	20	29	16	21	15	20	15	15	10

Table 3. New Septic Systems Within 200 ft. of Sebago Lake

Lake Level

Photo: Jay Crowley

The Portland Water District (PWD) has filed two lake level recommendations with FERC. Both are designed to decrease the likelihood of high-water storm events.

Sebago Lake outlets through the Presumpscot River to Casco Bay. A dam was first built at the outlet of the lake around 1827. The existing Eel Weir dam was built to its present height in 1884 by the Presumpscot Water Power Company and is managed today by the South Africa Pulp and Paper Company (SAPPI) which owns S.D. Warren Co. The level of the lake has historically been managed over an average 5-foot range from just above the spillway crest in the spring to lower levels in the fall and winter. Because the dam is used to generate hydroelectric power, the Federal Energy Regulatory Commission (FERC) licenses the operation of the dam. The dam license was issued in 1984 and expired in 2004. S. D. Warren Co. is presently operating under the old license agreement while the Maine Department of Environmental Protection (DEP) is considering minimum flow requirements for the Presumpscot River and other environmental concerns before authorizing a new permit.

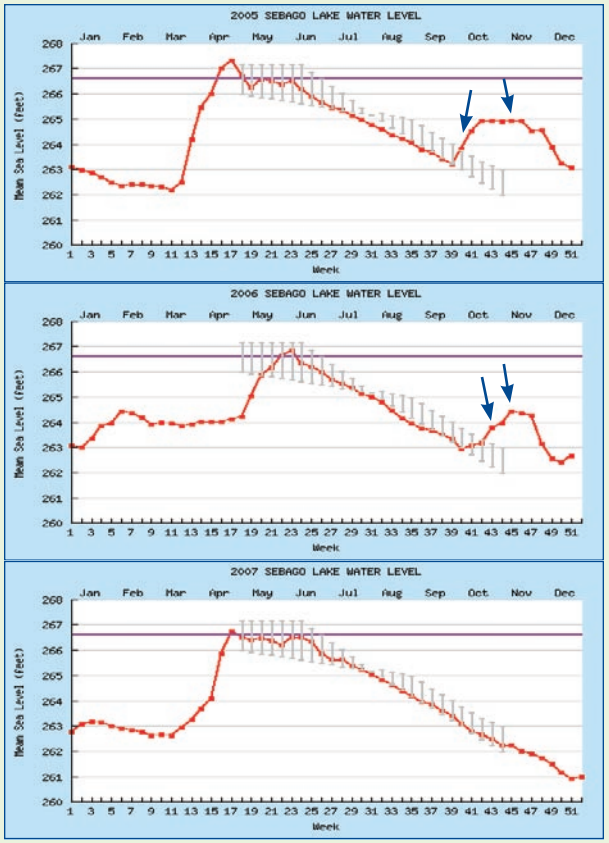
Since April 1997, management of the level of the lake has been governed by a compromise agreement crafted by the DEP, the Department of Conservation, and the Department of Inland Fisheries and Wildlife, and accepted by many stakeholder groups associated with Sebago Lake. In short, the plan calls for maintaining the lake level within a range of values for each week between May 1 and November 1. In addition, the plan establishes target lake level elevations on May 1 at 266.65 feet above mean sea level (msl), on August 1 at 265.17 feet msl, and on November 1 at 262.5 ±0.5 feet msl. The plan also calls for lowering the lake to an elevation at or below 261.0 feet msl between November 1 and January 1 twice every nine years. These "low water" years attempt to mimic the historical lake level pattern and build back shorelines that may have eroded during higher water years.

Figure 7 includes lake level graphs for the years 2005-07. The graphs include vertical bars that indicate the lake level ranges permitted each week from May to November according to the Compromise Plan. The red line on each graph indicates the actual daily water level measured by a lake level gauge. Arrows on the graphs show periods during which the level exceed the permitted range. The graphs show that the lake level went above the permitted range for a number of weeks in the spring and fall of 2005 and the fall of 2006 following significant rain events. In 2007, however, the lake was in the approved range every week.

Recommended Changes to the Lake Level Management Plan

The Portland Water District (PWD) has filed two lake level recommendations with FERC. Both are designed to decrease the likelihood of high-water storm events. PWD recommended a spring target level range of 266.15 feet msl to 266.65 feet msl from May 1 to the third week in June instead of the current target level of 266.65' on May 1. This would allow S.D. Warren greater flexibility during the spring fill up and would tend to err on the side of slightly lower spring water levels. The PWD has observed that storms that occur when the lake is at or above the spillway crest can cause significant erosion. This eroded material cannot be beneficial, however it remains unclear whether or not it significantly influences overall lake water quality. PWD also proposed that S.D. Warren develop a hydrologic model to better predict the influence of weather conditions on the lake level. The goal of the model is to anticipate the impact of future rain forecasts on lake level and develop a more proactive management response.

Figure 7. Sebago Lake Water Levels



Invasive Aquatic Plants

In early August 2008, Eurasian Watermilfoil was discovered in Salmon Lake, which is a headwater lake in the Belgrade Lakes chain.

Variable Leaf Milfoil photo by Dennis Roberge © 2007 Maine Volunteer Lake Monitoring Program

A healthy lake supports a diverse community of aquatic plants. The variety and density of plants varies from lake to lake and from place to place within a lake. Thousands of years of interaction between native plants, fish, insects, and other life set up stable and sustainable biological systems.

When an invasive plant species takes root, a lake's natural balance can be disrupted. Invasive plants can out-compete native plants, spread rapidly, and permeate shallow areas, adversely affecting many aspects of habitat and human use.

Invasive Species in Maine

Currently there are four species of invasive plants in Maine, including: Variable Leaf Milfoil (*Myriophyllum heterophyllum*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Hydrilla (*Hydrilla verticiallata*), and Curly-Leaf Pondweed (*Potamogeton crispus*). Variable Leaf Milfoil is the species most often referred to as "milfoil" in Maine, and it occurs in 25 waterbodies in the state. Eurasian Watermilfoil has been found in two Maine lakes and Hydrilla and Curly-Leaf Pondweed in one lake each. Variable Leaf Milfoil has been documented in Sebago Lake since the mid 1970s.

Most people know that milfoil is an invasive plant. However, not all milfoils are the same. There are at least eight different species of the "milfoil" genus (*Myriophyllum*). Five of these milfoils are native to Maine and three are not. **Figure 8** illustrates the known locations of variable leaf milfoil in Sebago Lake through 2007.

Action

The Maine DEP treated the Eurasian Watermilfoil infestation in Pleasant Hill Pond in Scarborough with the aquatic herbicide fluridone in 2005 and 2006. The DEP monitored the pond in 2007 and did not find the plant, so herbicides were not applied that year. Plants were found during a 2008 survey and fluridone was applied to the pond in late July.

The Hydrilla infestation at Pickerel Pond in Limerick has been treated annually with fluridone since 2002 because of the aggressive nature of the plant. In 2008, fluridone was applied to the pond in June and July.

Aquatic herbicides are considered a last resort for managing invasive plant infestations and their application requires a permit from the Maine DEP. There is particular concern about applying them to drinking water lakes.

In early August 2008, Eurasian Watermilfoil was discovered in Salmon Lake, which is a headwater lake in the Belgrade Lakes chain. The Maine DEP has implemented a rapid response plan which includes hand removal of the plants, surveys of the lake and its outlet stream, increased education to shorefront property owners, and increased courtesy boat inspections at the boat launch.

Various lake groups and associations manage and control some of the Variable Leaf Milfoil infestations with methods such as hand pulling and benthic barriers. These methods are labor intensive, but have been successful. Hand-pulling may only be done by those certified by the DEP to do so.

The PWD employs a summer boat launch attendant at the Standish boat launch. One of the attendant's responsibilities is to prevent plants from illegally entering or leaving the lake.

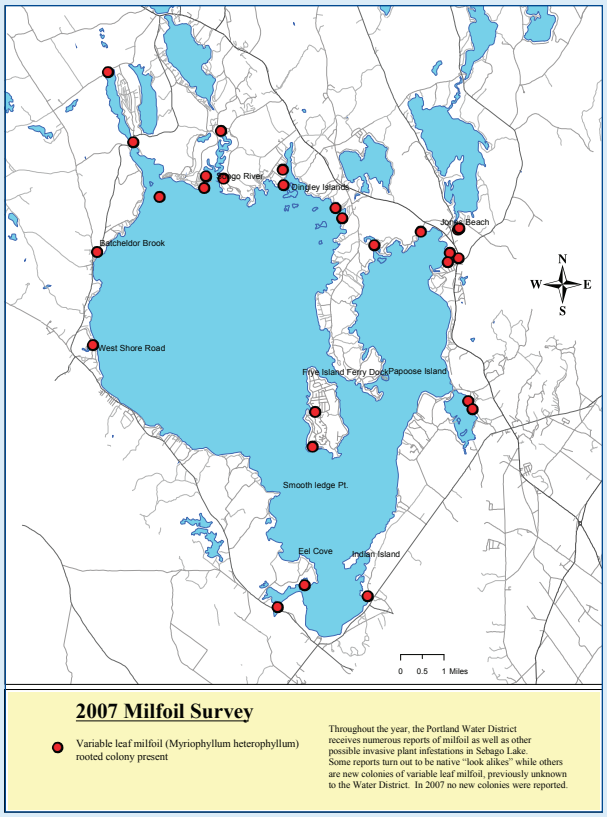


Figure 8. Confirmed Variable Leaf Milfoil Locations

Boating

There are many points of access around Sebago Lake for recreational boaters. There are four public boat launches, at least four private boat launches, and four marinas with launches. Boats can also reach the lake by passing through the Songo Locks that connect Long Lake and Brandy Pond with Sebago Lake. Boat owners with shore frontage can also access the lake directly across their own property. The majority of lake activity occurs between Memorial Day and Labor Day.

The PWD employs a boat launch attendant to monitor daily activity at the Standish Boat Launch, located at the southern end of the lake, during the summer season. The boat launch attendant educates the public about preserving and protecting the drinking water supply, ensures compliance with the no bodily contact law, and inspects boats and trailers for invasive aquatic plants. The attendant records the number of boats launched and landed. Over 90 % of the boats launched at the Standish Boat Launch during the months of June, July, and August are registered in Maine. Only about 10% are from Standish.

Sebago Lake State Park has two public boat launches: one at the day use area for the general public and one for overnight campers. Park employees counted 1,415 boats launched at the day use area in 2005 (recording period May 15 through October 15), 799 in 2006, and 1,146 in 2007 (recording period June, July, and August). They do not track launches or landings from the overnight area.

The hand-operated locks on the Songo River make it possible to travel a 42-mile waterway from Long Lake, Brandy Pond, and Songo River through the Songo Locks and into Sebago Lake. Built in 1830, Songo Locks is the only navigation lock still in service in Maine. The locks are operated by the Department of Conservation, which records the number of boats that pass through the locks each day.

Figure 9 shows 2002-2007 boat counts for the Standish Boat Launch, the Songo Locks, and the Sebago Lake State Park Day Launch.

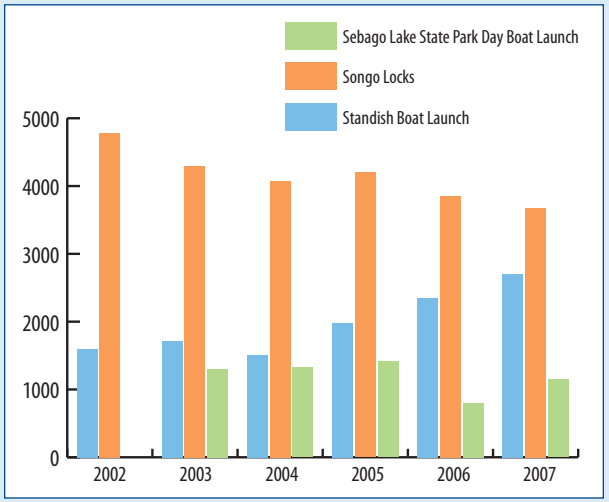


Figure 9. Boat Counts at Three Public Launches

Please note: data were not available for the State Park Day Launch for 2002 and the State Park Day Launch data for 2005 includes the months of May-Oct.

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