# 2015 STATE of the LAKE

## and ECOSYSTEM INDICATORS REPORT

Lake Champlain
Basin Program

## ABOUT THE LAKE CHAMPLAIN BASIN PROGRAM

The Lake Champlain Basin Program (LCBP) was created by the Lake Champlain Special Designation Act of 1990. Our mission is to coordinate the implementation of the Lake Champlain management plan, *Opportunities for Action*. Program partners include New York, Vermont, and Québec, the US Environmental Protection Agency (US EPA) and several other federal agencies, and local government leaders, businesses, and citizen groups. The New England Interstate Water Pollution Control Commission manages business operation of the LCBP on behalf of the Steering Committee.

The Lake Champlain Steering Committee leads the LCBP. Its members include many of the program partners, and the chairpersons of technical, cultural heritage and recreation, education, and citizen advisory committees. The LCBP's primary annual funding is received through a US EPA appropriation under the Federal Clean Water Act. The program also receives funding from the Great Lakes Fishery Commission and the National Park Service.

In the twenty-five years since the Lake Champlain Basin Program was created, these public partners have led a collaborative, non-partisan effort to address regional water quality and environmental challenges that cross political boundaries in a large watershed. This *State of the Lake 2015* report is an opportunity to carefully describe the condition of the Lake.

The report also is an update for our representatives in Congress—US Senators Patrick Leahy and Bernie Sanders of Vermont and Charles Schumer and Kirsten Gillibrand of New York, and Representatives Peter Welch of Vermont and Elise Stefanik of New York—who have supported management of Lake Champlain through congressional authorizations, major federal appropriations, and guidance. It is also an important update for Governor Peter Shumlin of Vermont, Governor Andrew Cuomo of New York, and Premier Philippe Couillard of Québec, who have made vital commitments to implement the Lake Champlain management plan *Opportunities for Action (OFA)*. *State of the Lake 2015* provides an account of today's stewardship challenges and management efforts to the US Environmental Protection Agency (US EPA) and other state, federal, and international partners that have endorsed *OFA* and provided support for the program.

**Visit www.lcbp.org to learn more.**

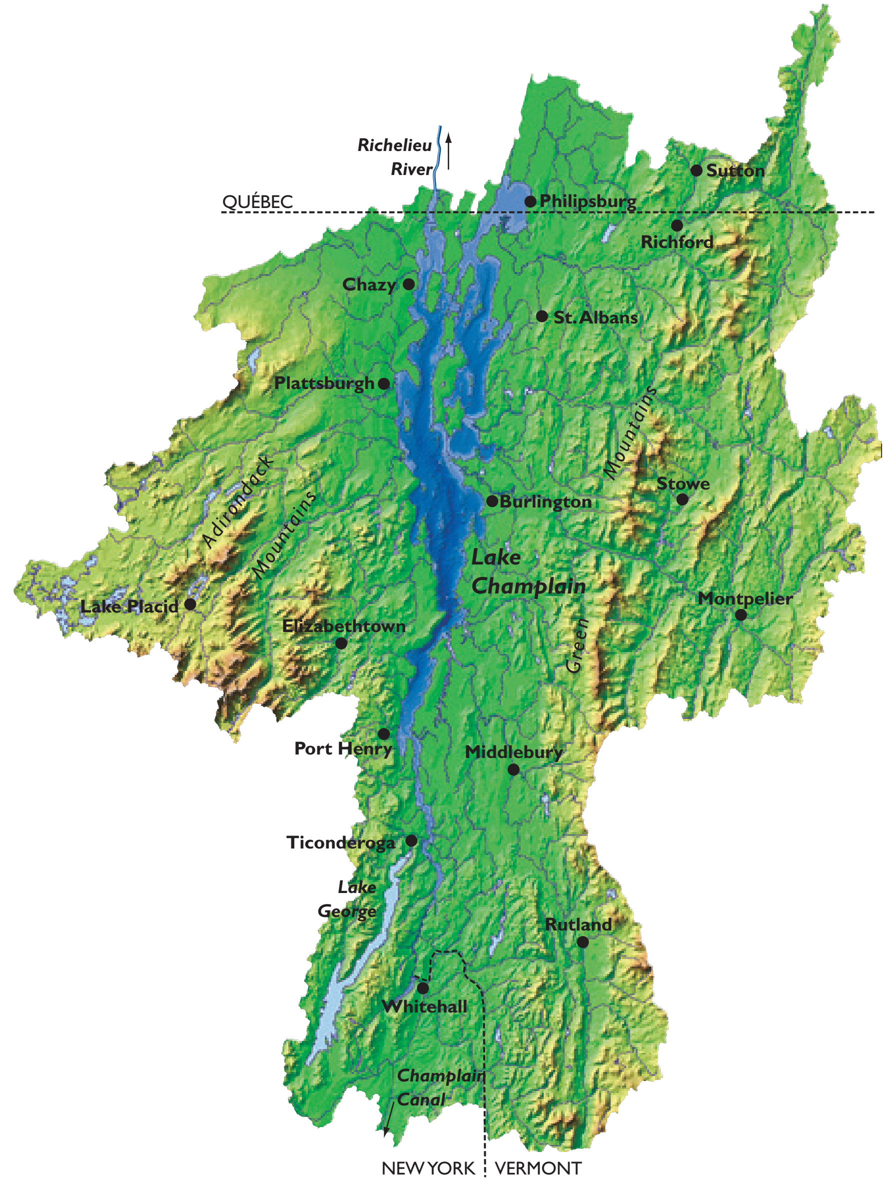


**Figure 1 | The Lake Champlain Basin**

*COVER: Burton Island State Park, Vermont. Photo by Mary Mitchell*

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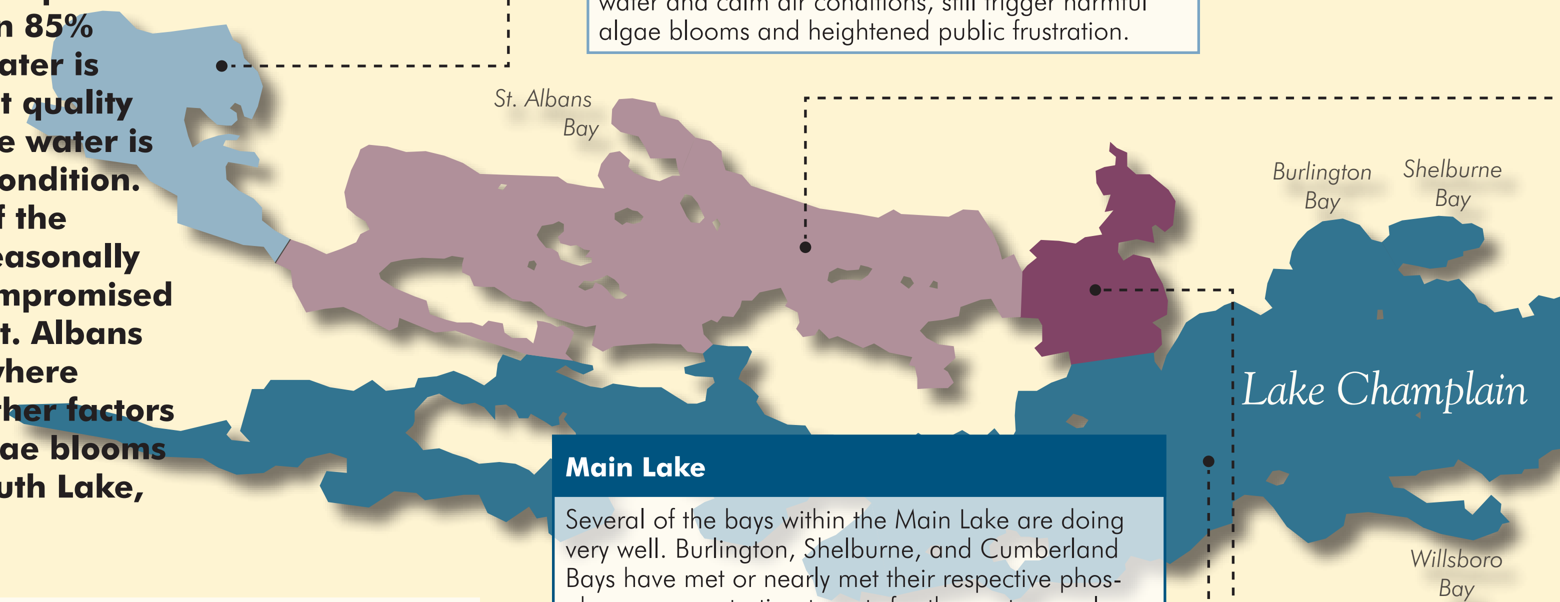
# The state of Lake Champlain:
## A Summary

**Although the water quality trends in Lake Champlain are cause for concern, it is important to know that more than 85% of Lake Champlain's water is consistently of excellent quality and another 13% of the water is usually in quite good condition. In the remaining 2% of the Lake, conditions are seasonally alarming. The most compromised parts of the Lake are St. Albans and Missisquoi Bays, where excess nutrients and other factors trigger blue-green algae blooms in summer, and the South Lake, where the water tends to be quite muddy.**




### Missisquoi Bay

The water quality of Missisquoi Bay continues to miss established targets and has deteriorated in recent decades, although the rate of deterioration appears to be slowing. Annual phosphorus concentrations, still well-above target, have been fairly stable since 2004 except for flood-related events. The amount of phosphorus entering the Bay from the Missisquoi River has decreased slightly. Excess nutrients, under warm water and calm air conditions, still trigger harmful algae blooms and heightened public frustration.

### Main Lake

Several of the bays within the Main Lake are doing very well. Burlington, Shelburne, and Cumberland Bays have met or nearly met their respective phosphorus concentration targets for the past several years. However, the phosphorus target for the Main Lake, while rigorous, is not being met, and the trend is slightly increasing. Phosphorus inputs from WWTFs are less than half of their allocation, and some tributaries do contribute less now than in 1990, but most nonpoint sources are estimated to deliver three times more than their targeted levels. Algae blooms do sometimes occur in calm warm waters near shore. Beach closures occur occasionally in Chittenden and Addison counties of Vermont and the Plattsburgh, New York area, usually due to coliform bacteria contamination. Cold- and warm-water fishery reports from this lake segment are very good.

### Too Much Phosphorus?

*Yes, phosphorus concentrations remain too high.*

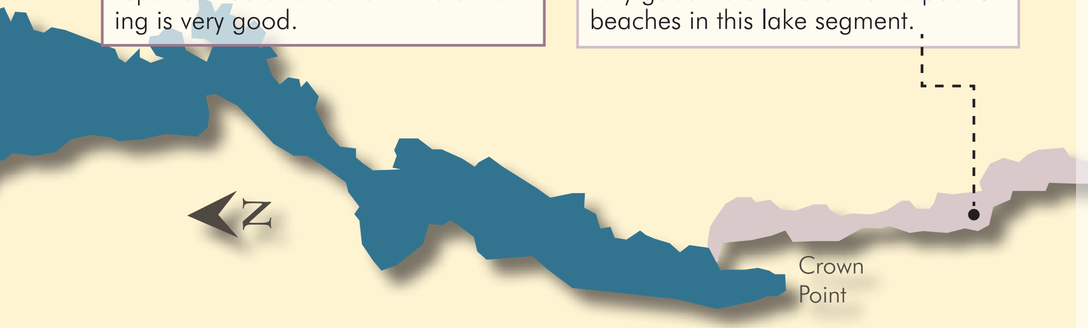
Excess phosphorus remains a concern in nearly all segments of the Lake. Reductions in phosphorus load have been observed in a few tributaries over the last decade, but these small improvements have not yet resulted in significant reductions of in-lake phosphorus concentrations. Wastewater treatment facilities are generally meeting their phosphorus effluent targets, but much work remains to reduce nutrients washing off of the landscape. Until phosphorus concentrations in the Lake are closer to the established targets, algae blooms will continue to form when weather conditions are favorable for intense growth.

### Northeast Arm

The Northeast Arm and St. Albans Bay consistently exceed their phosphorus targets and phosphorus continues to increase here. There are no major tributaries to these segments that have been monitored to provide trend information on nonpoint sources of phosphorus. The WWTFs are well below established targets. Public beaches in the St. Albans Bay Park were closed frequently from 2012 to 2014, due to both blue-green algae blooms and coliform bacteria. However, other than in St. Albans Bay, the beaches and shoreline areas in the Northeast Arm typically are in very good condition, and no beach closures in the past three years were reported. Cold- and warm-water fishing is very good.

### South Lake

South Lake has the highest phosphorus targets in Lake Champlain, reflecting the conditions that would occur naturally without human influence. South Lake B has met its target frequently since 2006 but has missed the target five times since 1996. South Lake A remains well above its target. The problems of these segments are associated primarily with phosphorus from nonpoint sources, as phosphorus coming from WWTFs is well below the target for this segment. Despite high phosphorus levels in this segment, algae blooms are infrequent in the turbid South Lake, with only one documented here since 2008. Warm-water fishing is very good here. There are no public beaches in this lake segment.




### Malletts Bay

Malletts Bay and the Main Lake have the strictest phosphorus targets among the 13 segments and the waters of Malletts Bay are deep and typically very clear. However, the phosphorus concentrations in the Bay have been slowly and steadily increasing since 1990. Malletts Bay is not significantly impacted by algae blooms. Beach closures due to coliform bacteria contamination occur occasionally each year, in the days following heavy rainfall.

## Goals of the Clean Water Act

### Swimmable Waters?

*Yes, in most of the Lake, most of the time the water is good for swimming.*

Lake Champlain has many beautiful beaches but access is sometimes restricted by beach closures. Elevated bacteria counts continue to cause beach closures, especially near urban areas where inadequate sewerage systems sometimes overflow during heavy rain events. The frequency of these closures should be reduced as sewerage issues are resolved around the Basin. Coliform bacterial contamination mostly results from wildlife and pet waste. Fortunately, closures due to bacterial contamination during the past several years have been infrequent and brief. Some beaches are also closed periodically as a result of blue-green algae blooms.

### Edible Fish?

*Yes, most Lake Champlain fish generally are safe to eat, but consult the fish consumption advisories to learn the details.*

Management of the fish population in the Lake Champlain Basin has been mostly successful in recent years - fishing has never been better in human memory. Sea lamprey control has achieved acceptable rates of wounding of Atlantic salmon, although this has been at the cost of introducing lampricides into our waterways and the Lake. Fish consumption advisories for mercury remain for many species, but mercury concentrations in walleye and lake trout have dropped 50% in the past 15 years.

### Drinkable Water?

*Yes, Lake Champlain is a source of very high quality drinking water, though only treated water is recommended for consumption.*

Relatively simple treatment is the norm for public water supplies in the Lake Champlain Basin, and the finished water is of very good quality. Public water suppliers very rarely need to shut down distribution due to source water quality.

## What does *State of the Lake 2015* report present?

The release of the *2015 State of the Lake and Ecosystems Indicators Report* comes at a time when interest in and concern for water quality and ecosystem integrity in the Lake Champlain Basin are at an all-time high. Lake Champlain stewardship has been the focus of renewed investment in funding and legislation for watershed management in all sectors. Public concern for the future of the Lake also is at a peak and public commentary about lake issues has been energetic, enthusiastic and, at times, angry. A growing number of citizens is recognizing that the condition of Lake Champlain—the *State of the Lake*—requires a serious revitalization of management and a basinwide public commitment to reduce pollution. With public concern growing and far-reaching legislative initiatives and improved enforcement capacity established, it's timely for the LCBP to provide the most recent available information on the condition of Lake Champlain.

The previous edition of the *State of the Lake* report, published in 2012, came on the heels of the historic flooding of the previous year. The impacts of the record-breaking spring flooding of 2011, and Tropical Storm Irene later in the summer, were just beginning to be understood at that time. In the three years since that last report, much new data has been collected. Scientists have gained a better understanding of the water quality and ecological impacts of the floods, and resource managers and policy makers have made strides in enacting public policy to prepare for and mitigate the environmental and economic effects of future flood events.

The state, or condition, of the lake ecosystem—the focus of this report—is one of the primary components of the Pressure-State-Response framework adopted by the LCBP for assessing and managing Basin resources. To understand why this condition (or State) exists, we track human activities that can exert "Pressures," which can result in complex, long-term, and cumulative ecosystem impacts. Changes to the "State" that result from these "Pressures" often elicit a management "Response," such as new environmental policies or management actions. Proper resource management can reduce pressures to bring about a more desirable "State" of the Lake.

The *State of the Lake* report uses an Ecosystem Indicators Scorecard (pages 18-19) to provide information about the condition of the ecosystem with a set of measures that represent, or indicate, its overall state. These indicators address the key priorities or goals of the Lake Champlain management plan *Opportunities for Action*. The indicators were chosen with the guidance of dozens of scientists and state, provincial, and federal technical experts, as the best indicators for which there are adequate data to evaluate.

This hard-copy document provides an accessible summary of many complex conditions and issues that characterize the state of the Lake. More detailed information and citations for the scientific literature and technical reports that form the basis of the document are available in an online version of the *2015 State of the Lake* at sol.lcbp.org.

ELISSA GAROFALO

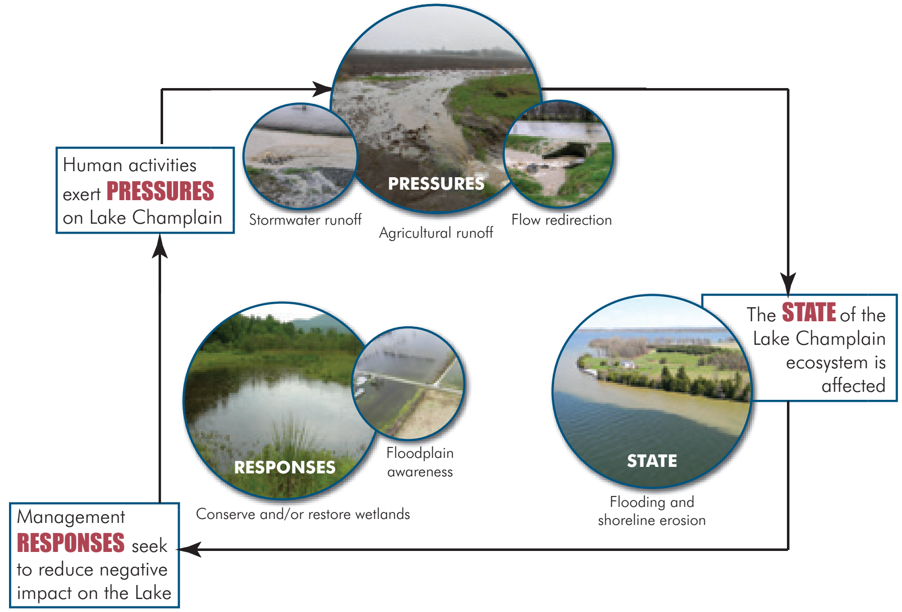



**Figure 2 | The Pressure-State-Response model, using flooding as an example**

## Qu’est-ce que le rapport de 2015 sur l’état du lac souligne?

La publication en 2015 du rapport *State of the Lake and Ecosystems Indicators* arrive à point car les inquiétudes sont réelles en ce qui à trait à la qualité de l’eau et à l’intégrité des écosystèmes sur le basin du lac Champlain. De par des investissements renouvelés et de récentes législations, le parrainage de la qualité des eaux du lac Champlain est de nouveau à l’avant-plan. L’inquiétude du public sur le future du lac est aussi à son comble. Plusieurs commentaires énergétiques, enthousiastes et quelquefois virulents furent soulignés par le public. Un nombre croissant de citoyens reconnait en effet que la condition des eaux du lac Champlain requière une sérieuse revitalisation de sa gestion avec promesse de réduction de la pollution. Ce présent rapport publié par le Lake Champlain Basin Program (LCBP) s’accouple à merveille avec les pressions du public et la mise en vigueur des récentes initiatives législatives à grand portée.

L’édition antérieure de ce rapport fut publiée en 2012, un an après les inondations record de 2011. L’impact de ce désastre combiné à la tempête tropicale Irène survenue plus tard en cet été venait juste d’être évalué. Dans les trois années qui suivirent, plusieurs nouvelles données furent recueillies. Les scientifiques furent en mesure d’acquérir une meilleure connaissance sur le traumatisme écologique et l’impact sur la qualité de l’eau causés par ces drames de la nature. Les gestionnaires et responsables politiques ont fait progresser très rapidement les initiatives publiques afin de se préparer pour alléger l’impact environnemental et économique des inondations futures.

L’état ou la condition de l’écosystème du lac symbolise le point central de ce rapport et est l’élément primaire du plan Pression-État–Réponse adopté par le LCBP ayant pour but d’évaluer et de gérer les ressources du basin. Afin de comprendre pourquoi cette condition ou état existe, l’empreinte des activités humaines pouvant exercer des « Pressions » et ainsi créer des dénouements complexes, à long terme ou cumulatifs impactant l’écosystème est suivi fidèlement.

Un changement d’ « Etat » résultant des ces « Pressions » nécessite une « Réponse » administrative comme une nouvelle politique environnementale ou une additionnelle mesure de gestion. Une gestion de ressource compétente peut ainsi réduire les pressions vers un « État » de lac plus satisfaisant.

Le rapport sur l’état du lac utilise une série de mesures d’évaluation de l’écosystème (pages 18-19) afin de présenter de l’information quantitative et qualitatives sur les conditions de l’écosystème et de préciser l’état général du lac. Ces repères d’évaluation soulignent les priorités et buts du plan de gestion du lac Champlain: *Opportunities for Action*. Ils furent définis par un conseil de scientifiques et appuyés par des experts à l’échelle provincial, fédéral et d’état.

Ce document offre un sommaire compréhensif de plusieurs impacts et problèmes caractérisant l’état du lac. Vous trouverez plus d’information sur le rapport technique et la littérature scientifique formant la base de ce document dans la version web du rapport *2015 State of the Lake* à l’adresse suivante: sol.lcbp.org

SUE LOWE

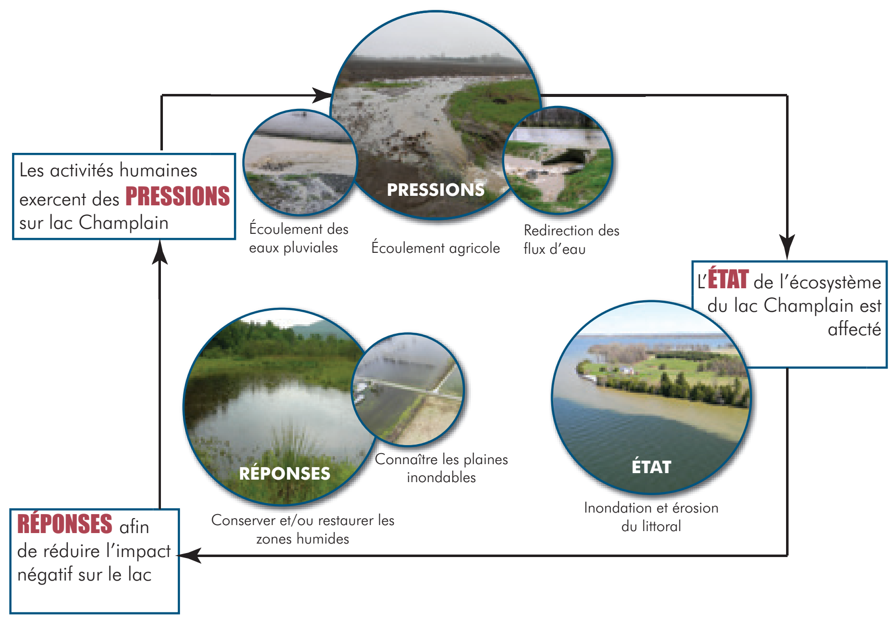



**Figure 2 | Le plan Pression-État-Réponse utilisant l’inondation comme exemple**

## How are the phosphorus levels in Lake Champlain changing?

*Phosphorus concentrations have not decreased significantly in any areas of Lake Champlain, despite reductions in the amount of phosphorus entering the Lake from several of its tributaries. Long-term trends since 1990 indicate that phosphorus concentrations in several segments continue to increase.*

Phosphorus is a nutrient that, when overabundant, has a significant impact on a lake ecosystem. This has become a problem for lakes large and small around the world, and Lake Champlain is no exception. Warmer waters are often more productive than cooler waters, supporting more plant and algae growth, including the blue-green algae that thrive on phosphorus. Consequently, shallow, warm bays in Lake Champlain are especially susceptible to problems with excess phosphorus compared to the Main Lake area, which is cold and deep, and has a relatively moderate concentration of phosphorus.

Long-term phosphorus concentrations continue to increase in the Port Henry area of the Main Lake as well as the Inland Sea (Northeast Arm), and in several bays, including Missisquoi Bay, St. Albans Bay, Shelburne Bay, and Malletts Bay (Figure 3). Phosphorus concentrations are more stable, though slightly increasing, in the Main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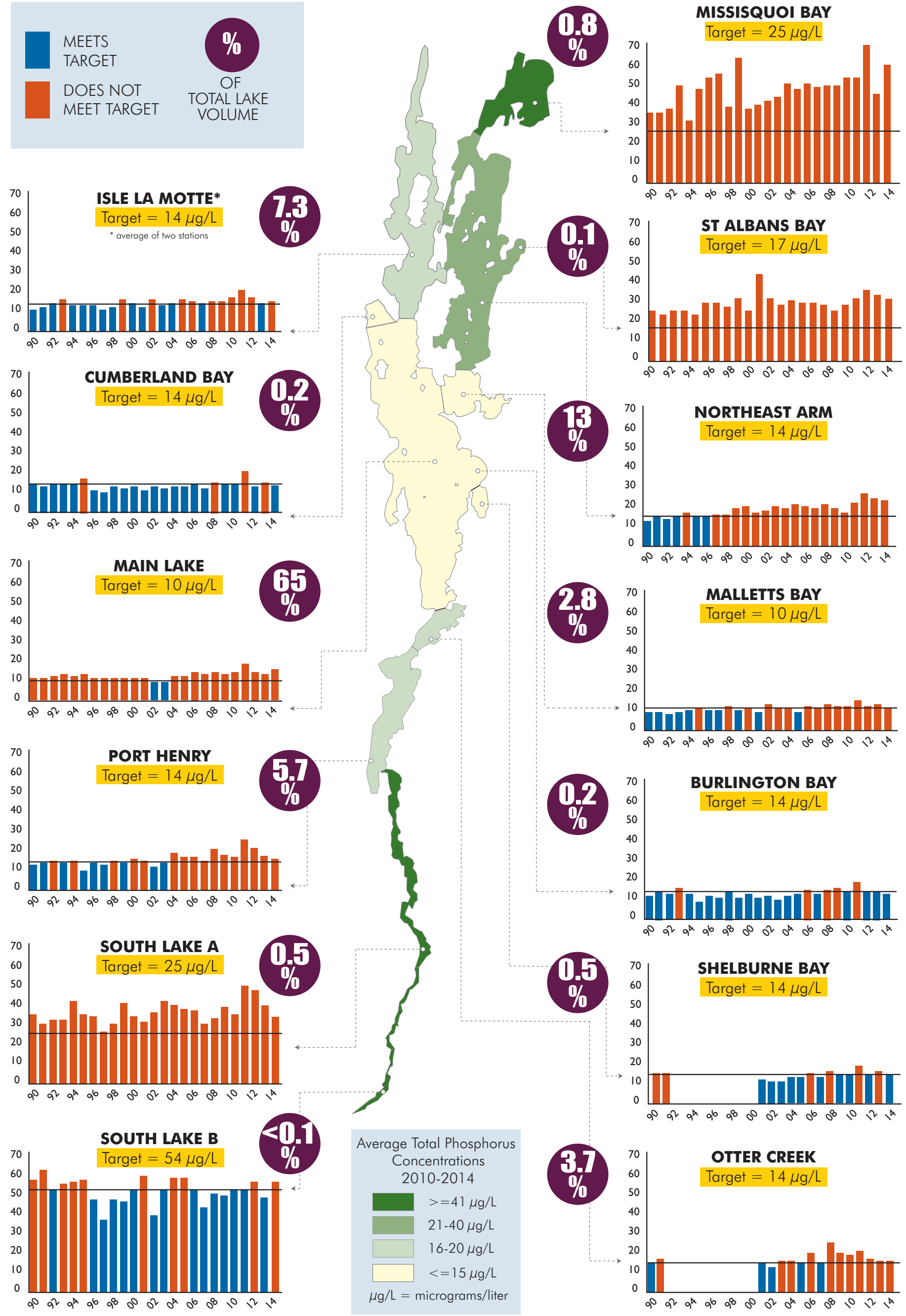
*High phosphorus levels can promote excess plant and algae growth in warm, shallow bays.*



DATA SOURCE: Long Term Monitoring Program (LCBP, VTANR, NYSDEC)

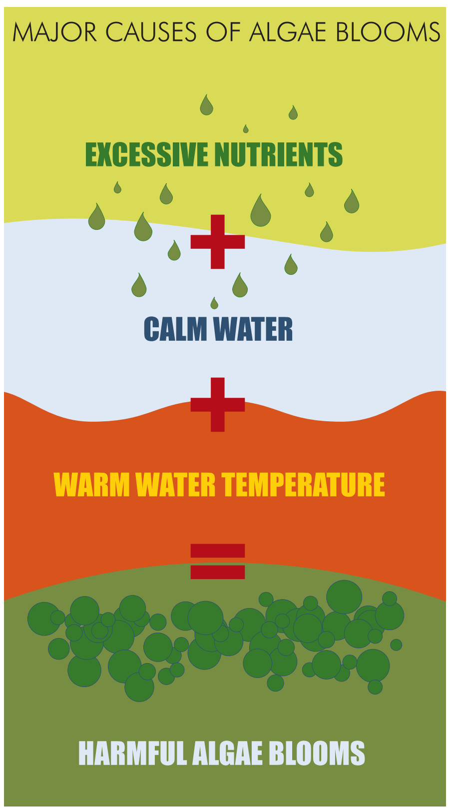
**Figure 3 | Lake Champlain phosphorus concentration by lake segment, 1990–2014**

Lake. There are no statistically significant trends in the South Lake, Otter Creek segment, Burlington Bay, or Cumberland Bay. Phosphorus concentrations are lowest in the Main Lake and in Malletts Bay, which together comprise nearly 68% of the total volume of the Lake. Concentrations are greatest at the extreme ends of the Lake, in Missisquoi Bay and South Lake, comprising, respectively, 0.8% and 0.6% of the total volume of the Lake.

Most lake management efforts are focused on phosphorus, but other nutrients, such as nitrogen, also affect water quality in Lake Champlain. Recent research, both in the Lake Champlain region and globally, has investigated the connections among phosphorus, nitrogen, and climate change impacts, such as warming surface waters, on water quality. These changes in water chemistry and temperature affect the biological integrity of the Lake, the number of species of fish, plants, and other organisms, and also can trigger harmful algae blooms (see the Human Health and Toxins section for additional information). Although excess phosphorus is a driver of blue-green algae blooms, nitrogen may affect which blooms become toxic.

The Total Maximum Daily Load (TMDL) is an important management tool that can help resource agencies determine where to focus their management efforts. TMDL is a calculation of the loading capacity—or the maximum amount of a pollutant that a body of water can be expected to handle each day, while safely meeting established water quality standards. The US Environmental Protection Agency (US EPA) is required by the Clean Water Act to use this tool for many different pollutants. In the Lake Champlain Basin, TMDLs have been developed most frequently for pathogens such as the bacteria *E. coli* or for nutrient pollution, and also for mercury, temperature, and sediments.

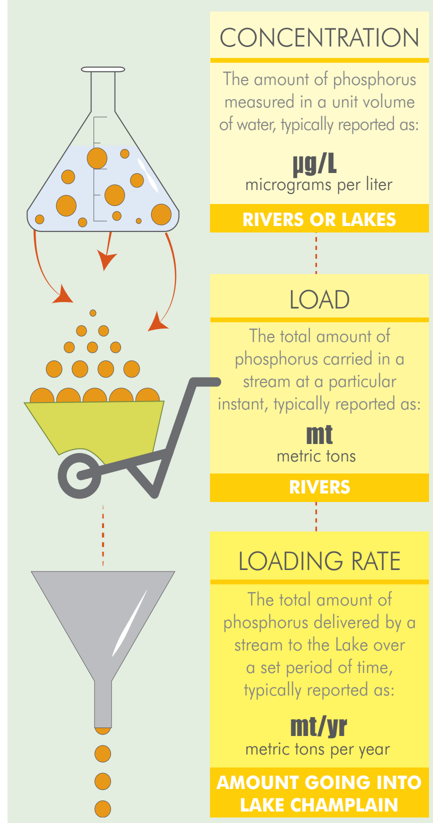
The US EPA is currently developing a new phosphorus TMDL for the Vermont portion of Lake Champlain. This will update Vermont's responsibilities under the original 2002 bi-state Lake Champlain phosphorus TMDL. The New York portion of that earlier TMDL remains in effect. The new phosphorus TMDL for Vermont will be far more comprehensive, accounting for both historic and future climate patterns in the region to project how changes in temperature and precipitation will affect the amount of phosphorus entering Lake Champlain. The new TMDL implementation plan will produce and enforce new Required Management Practices (RMPs) and other tools that farms, other businesses, residents, and communities must use to reduce pollution to the Lake.




*If we all reduce our pollution of the Lake, we will protect water quality for our children and their children.*

JEFF CASTLE

**What do "concentration" and "load" mean?**



## Where does the phosphorus in Lake Champlain come from?

*There are many sources of phosphorus and other nutrients entering Lake Champlain. For every square mile of lake area, there are 18 square miles of land area in the watershed that drains into the Lake. Activities in forested, developed, and agricultural lands all contribute nutrients and other pollutants to the Lake. While tributaries carry the largest load of nutrients from the upper portions of the watershed downstream into the Lake, properties along the lakeshore also can have a direct influence on the Lake's water quality.*

The ratio of land area in Lake Champlain's watershed—or drainage area—to the surface area of the Lake is 18 to 1. With such a large watershed supplying water to the Lake, the challenge of limiting pollution that washes off the land area and enters the Lake is greater—the watershed has a much greater effect on the water quality of the Lake than would occur with a smaller watershed ratio. For example, the Great Lakes in the Midwestern US and Canada are much larger than Lake Champlain, but their watershed ratio is much smaller (between 1.5:1 and 3.4:1). Consequently, acre for acre, the watersheds of those lakes have a much smaller impact on their water quality and there is, proportionately, a much smaller land area to manage.

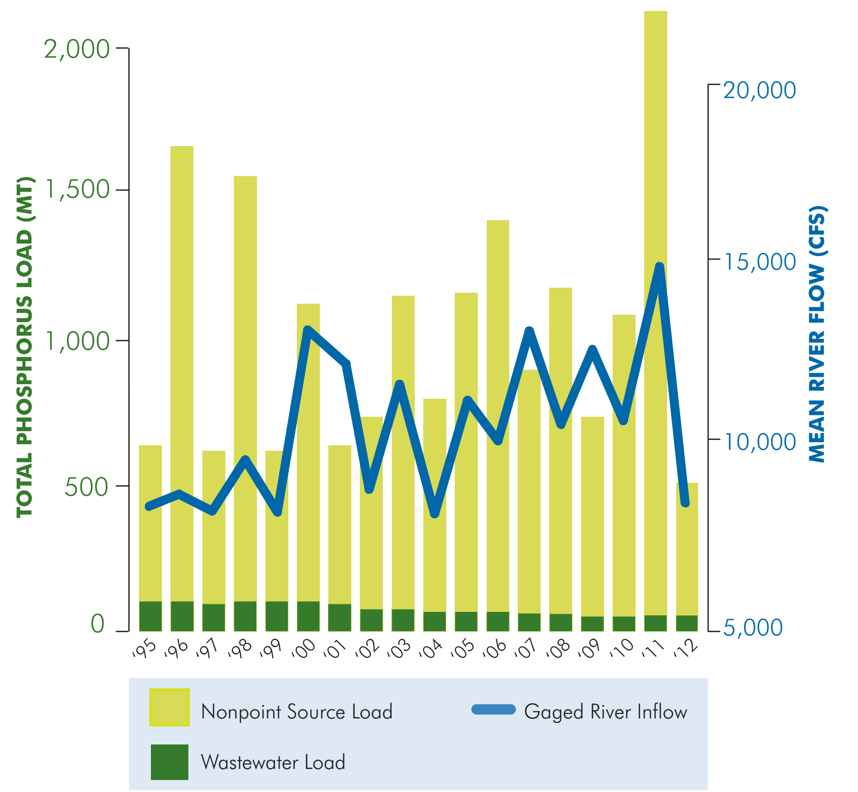
Nutrients and pollution enter Lake Champlain, its tributaries, and other water bodies within the watershed through runoff from the land, or nonpoint source pollution (Figure 4), along with discharges from wastewater treatment facilities (WWTFs) and other discrete sources (called point sources).

### Tributary Loading

The tributaries that drain into Lake Champlain from its watershed continually replenish the Lake's water supply. These tributaries also deliver pollutants, including excess phosphorus, nitrogen, and other nutrients, and toxic substances that are washed off the landscape. Not all tributaries are created equal, however. The total phosphorus load estimated to be delivered to the Lake each year from its watershed is 921 metric tons (2.03 million lbs), but some tributaries deliver substantially more pollutants than others. Management agencies in all parts of the watershed have been targeting problem areas for decades, with some successes.

Recent research by the US Geological Survey has determined that these efforts are beginning to show positive effects (Figure 5). Most notably, pollution from the LaPlatte River in Vermont has decreased as a result of improvements in nonpoint source management and upgrades to wastewater treatment facilities. Other tributaries from which the amount of phosphorus delivered to the Lake has been reduced over the past ten to twenty years include the Little Ausable, Putnam, and Mettawee rivers in New York and the Otter, Missisquoi, and Winooski rivers in Vermont.

Although phosphorus pollution loads from some tributaries, such as the Missisquoi River, have been somewhat reduced, they continue to be far higher than their targets, despite years of concentrated efforts by resource management agencies, local watershed groups and residents to curb this pollution. In some tributaries it may take decades for measurable




NOTE: All load data are actual (not flow-normalized) loads from river inflow to Lake Champlain. Total phosphorus load is represented by metric tons per year (MT). Flow is shown in cubic feet per second (CFS). DATA SOURCE: USGS, LCBP/VT ANR Lake Champlain Long-Term Monitoring Program.

**Figure 4 | River flow and total phosphorus load to Lake Champlain**

reductions in the pollution loads to occur, despite best management practices that may be employed today and in the future.

**Load from Developed Land Use**

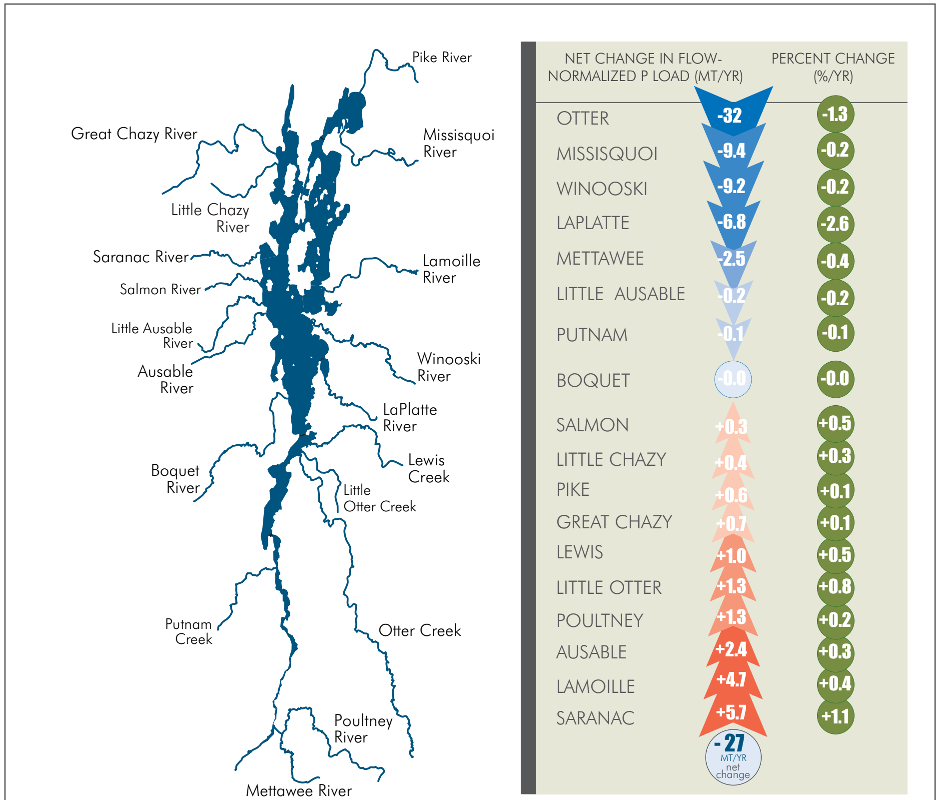
Land that has been developed can be a substantial source of nutrients and other pollutants to the Lake. Developed lands tend to have large areas with impervious surfaces, such as building rooftops and parking lots, which shed rain water very quickly and rarely provide opportunities for stormwater to infiltrate or soak into the ground. High storm flows in the rivers increase erosion of streambanks, sending more sediment and nutrients downstream toward the Lake. Flashier storm flows, with surges of large volumes of runoff from developed lands, can also increase the severity of flooding downstream, causing damage to public and private property, as demonstrated by Tropical Storm Irene in 2011. Investment in better-designed and more resilient roads, culverts, and "green infrastructure"—that reduce these storm flows—can increase the amount of water that soaks into the ground, reducing and delaying runoff to a tributary downstream.

Approximately 16% (147 metric tons or 323,610 lbs) of the phosphorus delivered to Lake Champlain each year comes from developed lands in the watershed. This is phosphorus delivered to the Lake from nonpoint sources in developed areas, such as parking lots, roofs, and lawns. Of the 147 metric tons, 112 mt are estimated to come from the Vermont portion of the developed lands in the watershed, 28 mt from New York, and less than 8 mt from Québec.

Phosphorus pollution of the Lake from wastewater treatment facilities is a small fraction of the problem of phosphorus in the watershed, amounting to only 4% of the total phosphorus load to the Lake. Total loads from wastewater treatment facilities in each jurisdiction (New York, Vermont, and Québec) have been at or below their respective targets since 2004 or earlier (Figure 6). Regulations banning phosphorus in detergents have greatly reduced the amount of phosphorus entering treatment facilities, further reducing the amount of phosphorus they need to remove from their effluent stream.

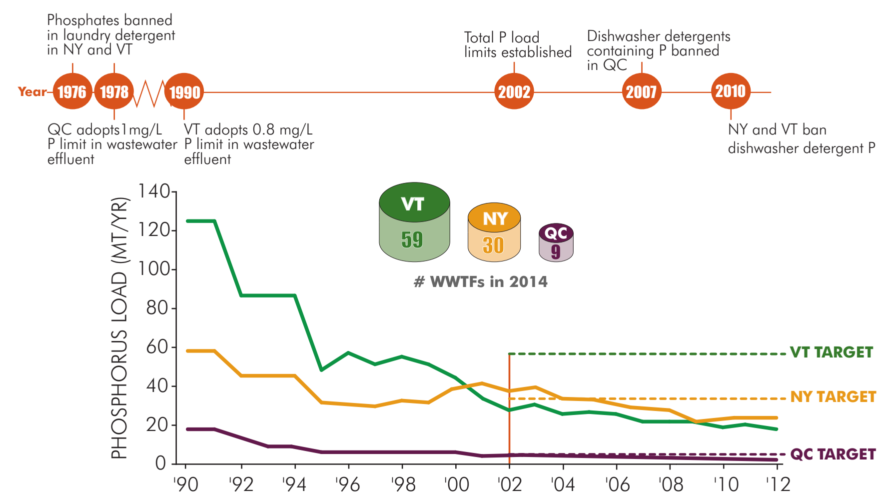
**Load from Agricultural Land Use**

Agriculture is an important part of the identity of the Lake Champlain region, but it also has a very significant effect on the water quality of the Lake. Many farming practices, both conventional and organic, require application of fertilizer to increase crop productivity. Cattle and other animal-based farms generate large




NOTE: Data are from gaged tributaries, which represent 74% of the total area in the Lake Champlain Basin. The total phosphorus load in 1990 was 786 mt compared to 744 mt in 2010 and 757 mt in 2012, representing a -27 mt net change post-2011 flood events.
DATA SOURCE: L. Medalie, USGS (2012).

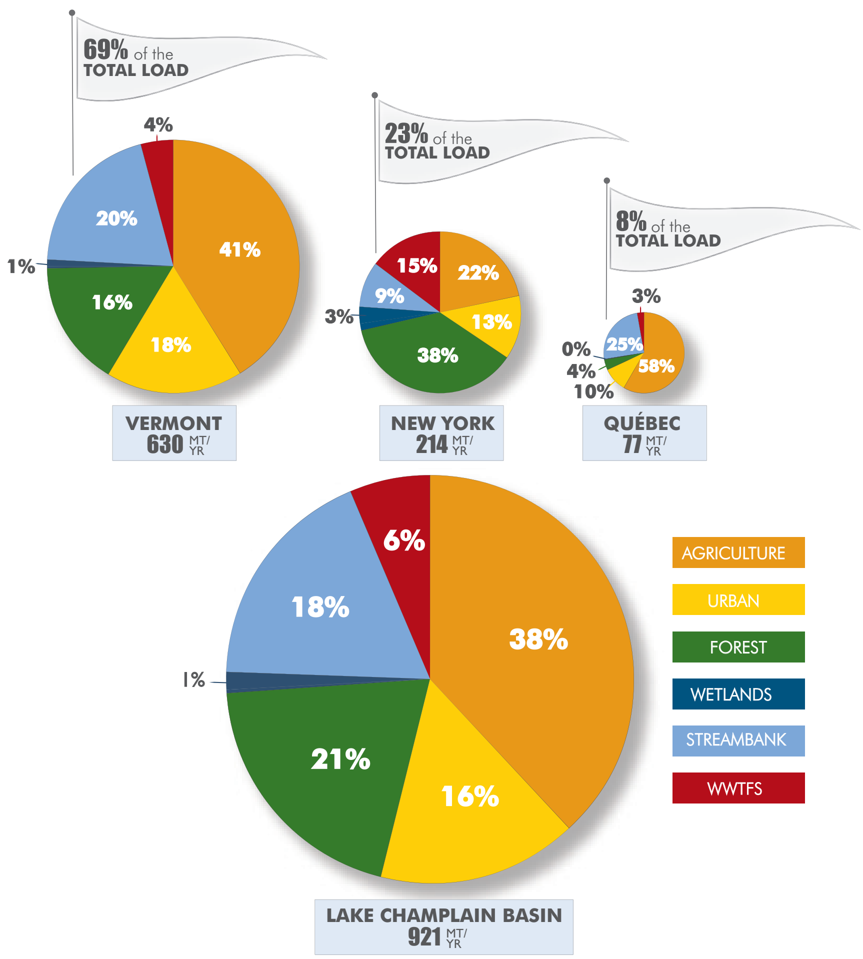
**Figure 5 | Changes in tributary total phosphorus loading, 1990–2012**




NOTES: The Québec target is an estimate based on the 2002 VT/QC agreement for Missisquoi Bay. The New York target is from the current 2002 TMDL. Vermont's target was based on the same 2002 TMDL and is currently under revision.
DATA SOURCE: NYSDEC, VTDEC AND QC MDDELCC.

**Figure 6 | Phosphorus load from wastewater treatment facilities, 1990–2012**

amounts of manure that must be disposed of carefully. Runoff and erosion from barnyards, laneways to pastures, and animal congregation areas can carry excessive pollution into nearby waterways. Frequently farmers spread manure on their fields to recycle those nutrients back into their crops and pastures. Most conventional farms also rely in part on commercial fertilizers and feed additives imported to the Basin. A portion of these nutrients is inevitably washed off the land and into a waterway before soaking into the ground.




NOTE: Grass/Shrub was included in the analysis but excluded from this graphic due to the comparatively low percentage of phosphorus.
DATA SOURCE: Tetra Tech, 2015.

**Figure 7 | Phosphorus loading to Lake Champlain by land use**

The fraction of this phosphorus pollution that comes directly from agriculture is estimated to be about 352 metric tons (775,000 lbs) per year, or 38% of the total estimated amount of phosphorus entering the Lake (Figure 7).

### Streambank Sediments

Recent research has shown that in the Lake Champlain watershed, the erosion of streambanks contributes an estimated 18%, or 165 metric tons (365,600 lbs) of phosphorus to the Lake. In Vermont, 20% of the phosphorus load is estimated to come from streambanks, more than 24% of the load in Québec, and 9% from New York. The New York load is likely lower because of the greater amount of forest in this part of the watershed, which helps protect streambanks from erosion. The streambank contribution estimate is separate from the phosphorus that already is in the stream as wash-off from the land. Significant erosion of streambanks occurs most often when stream corridors or the adjacent lowlands are altered to accommodate some land use activity such as construction of a culvert for a town road, the cultivation of farmlands right to the edge of a river, or any streamside disturbance that removes or prevents a vegetated woody buffer.

Streambanks lacking vigorous woody plant growth can be very susceptible to erosion, especially in a time of flooding. When streambanks are eroded and sediments collapse into the steam, changing flow patterns result, potentially causing further erosion of streambanks downstream, and ultimately releasing yet more sediment and nutrients into the waters flowing toward the lake. Collapsed streambanks at the edge of agricultural fields may be especially rich in nutrients, including phosphorus, because of their history as fertilized land. The preconditions that increase the vulnerability of lowland terrain to significant streambank erosion result from both historical and contemporary agricultural practices and developed land use practices in these sensitive areas throughout the Basin.

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*Cultivated land is a significant source of nutrients during floods.*

## What is being done to reduce phosphorus in the Lake?

*Lake Champlain has been the focus of renewed investments in watershed management practices by the US federal government, the state and provincial governments, and municipalities. Outreach programs now are delivered to new audiences—and to old audiences in new ways—to change personal and business behaviors and habits in all parts of society to reduce pollution of Lake Champlain.*

Farmers, resource management agencies, and local watershed organizations have long recognized the nutrient pollution problem from farms in the watershed. In the last few years, many groups have formed new partnership agreements to share information, target financial resources, and optimize time in order to better manage the worst problem areas in the watershed. New computing tools (such as Critical Source Analyses) allow resource managers to identify and assess critical locations likely to be contributing large amounts of phosphorus load, and to identify best management practices to reduce or remove that problem.

Meanwhile, federal and state agencies have recognized the need to assist farmers to reduce phosphorus pollution. In 2014 alone, more than $60 million in new federal funding was directed to the Lake Champlain watershed to help reduce phosphorus pollution from agricultural operations. States are developing improved rules to tighten regulation of farms of all sizes as well, including increased oversight of small farms, strengthening required agricultural practices such as livestock exclusion from streams, and removal of current use property tax reductions for farms that do not comply.

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*Management practices must improve in order to reduce phosphorus levels.*

In 2014, the State of Vermont passed a law to better protect shoreline areas from development and to increase their resistance to erosion. The resulting new rules promote more riparian vegetation that protects the lakeshore from wave action during periods of high water levels and improves the diversity of aquatic habitats near the waters' edge. In 2015, Vermont passed a new water quality law that created a "Clean Water Fund" and will further increase requirements and enforcement of water quality regulations on agriculture and urban lands, as well as education and outreach programming.

Fertilizers sold in retail stores and by large agricultural feed and fertilizers suppliers are major contributors of nonpoint source phosphorus pollution in Lake Champlain. Under the new water quality law in Vermont, commercial phosphorus fertilizers sold to the public for non-agricultural use will be subject to a new tax (there is no new tax on agricultural fertilizers). The "Don't P on Your Lawn" campaign initiated in 2010 targeted retail sale of fertilizers through workshops and public service announcements. Additionally, the Lawn to Lake Workgroup developed signs for retail stores in Vermont in 2011 at storeowners' request. Legislation enacted in both New York and Vermont bans the retail sale of phosphorus-containing fertilizer for use on established lawns, unless a soil test indicates the need for additional phosphorus.

### What *YOU* can do

**Test Your Turf:** Test your lawn and garden soil before you fertilize. You may need less than you think or none at all.

**Healthy Soil, Healthy Lawn:** Foster soil health in your lawn and garden rather than relying on lawn care products that import more nutrients into the watershed.

**Let It Grow:** When mowing, set the blade high. Tall grass is healthier and grows deeper roots, helping it to outcompete weeds.

**Leave It on the Lawn:** Use your grass clippings as mulch on your lawn. This recycles nutrients and decreases the need for watering.

**Rein In the Rain:** Redirect your gutter downspouts to the lawn, plant a rain garden, or install a rain barrel.

**Wash Cars on the Lawn:** Wash your car on the grass instead of the driveway to help prevent detergents from washing into the Lake; or take your car to a carwash where the water is treated after use.

**Shore Up the Water's Edge:** Plant native vegetation along shorelines and riverbanks to hold soil in place and reduce erosion.

## Is it safe to swim in Lake Champlain?

*In most areas of Lake Champlain, the water quality is usually very safe for recreational use, including swimming. At certain times of the year, however, harmful algae blooms may develop, causing localized recreational health hazards. Occasionally, following a heavy rainstorm, unhealthy levels of coliform bacteria may be present in the waters near beaches for a few days, which creates localized recreation concerns.*

Although most of Lake Champlain is normally safe for swimming, some shallow areas frequently develop unhealthy conditions. In recent years the waters in some areas, particularly in St. Albans Bay and several areas of Missisquoi Bay, have developed conditions that caused the beaches to be closed to swimmers. Of the 35 public beaches on Lake Champlain, 23 were closed two or fewer times between 2012 and 2014. When a public beach is closed for health concerns, it is typically for risk of exposure to coliform bacteria or to toxins produced by harmful algae blooms (Figure 8).

In Lake Champlain, elevated levels of coliform bacteria typically occur after heavy rainstorms, which wash sediment, pollutants, and bacteria into the Lake. Very heavy rainstorms may cause municipal sewers to overflow, sending untreated sewage directly into the Lake. These events are called Combined Sewer Overflows (CSOs). CSOs occur in towns and cities with stormwater systems that are connected to the sewer system. Ideally, a municipality should have two separate systems, one to carry sewage to a wastewater treatment facility and another to handle stormwater independently. Constructing and maintaining separate systems can be very costly, so municipalities often try to find other ways to reduce stormwater flows in their sewer systems, but leave the systems combined. Public beaches along Lake Champlain were closed on more than 30 occasions between 2012 and 2014 as a result of elevated coliform bacteria levels.

Blooms of cyanobacteria, or blue-green algae, sometimes (but not always) produce toxins that are harmful to humans and other animals. Short-term exposure to these toxins can lead to minor skin irritation and stomach issues, and longer-term exposure (for example the ingestion of water that is high in algae toxins) can result in damage to the liver or the central nervous system. Although there are no records of serious human health effects known from algae in Lake Champlain, the risk of exposure makes it prudent to close beaches in areas when and where heavy algae blooms are observed. Public beaches on Lake Champlain closed more than 25 times between 2012 and 2014 as a result of harmful algae blooms.


NOTE: The number in each circle represents the number of individual closures, but each closure may have been for more than one consecutive day. * Québec beaches are **no longer officially monitored** for blue-green algae. Though a bloom may occur, closures are voluntary.
DATA SOURCES: Town Offices, VT ANR, UVM, NYS DOH, MDDELCC

**Figure 8 | Public beach closures on Lake Champlain, 2012–2014**

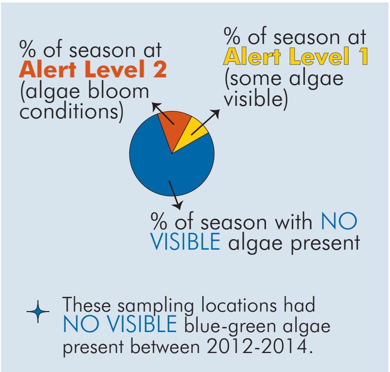
## What is the problem with cyanobacteria blooms in Lake Champlain?

*Harmful algae blooms occasionally occur in Lake Champlain during warm, calm summer weather. The cyanobacteria that cause these blooms sometimes release toxins into the water that are harmful to humans and other animals. Some sections of the Lake are more susceptible to these blooms than others.*

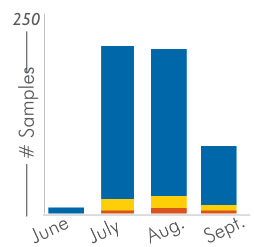
Harmful algae blooms first attracted attention in Lake Champlain in 1999, when two dogs died after exposure to the toxins created under bloom conditions. In response to that event, LCBP funded and has maintained a monitoring program to detect and report harmful algae bloom conditions in the Lake. The monitoring program, which identifies three levels of algae conditions, has served as a model for other water bodies in the US and globally. By 2014, the program had transitioned largely toward a reporting program, a lakewide system of trained volunteers operated by the Lake Champlain Committee. Testing is done by the Vermont Department of Environmental Conservation, and risk assessment by the Vermont Department of Health. Certified harmful algae bloom observations from around the Lake are posted on an interactive webpage maintained by the VT Department of Health. The current program is designed to inform the public with reliable and timely information.

Harmful algae blooms most frequently occur in Lake Champlain from mid-July through August. They are typically found in the shallower, warmer bays of Lake Champlain, including Missisquoi and St. Albans bays, although they occasionally are observed in other Lake areas (Figure 9). The cyanobacteria monitoring program on Lake Champlain identifies lake conditions as one of three categories: *Generally Safe,* where normal levels of blue-green algae may be present, but not in bloom conditions that might create toxins; *Low Alert* (Alert Level 1), where algae have been observed at moderate densities; or *High Alert* (Alert Level 2), where algae scums have been observed in the water or toxins are present at high levels.

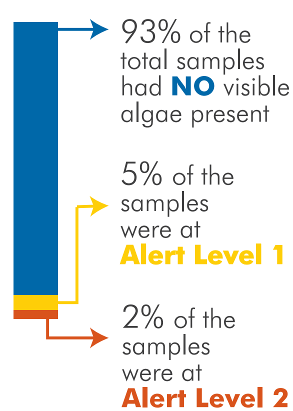
### HOW TO INTERPRET THIS MAP

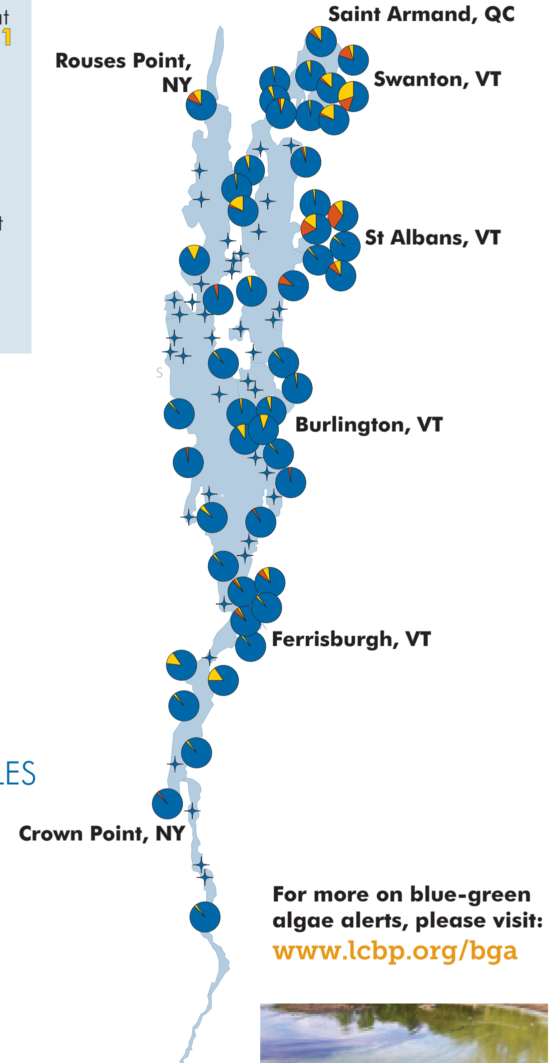



### THE SAMPLING SEASON




### 2012-2014 TOTAL SAMPLES




**For more on blue-green algae alerts, please visit:**
**www.lcbp.org/bga**


MARY WATZIN

DATA SOURCES: US-only monitoring programs, VT ANR, LCC

**Figure 9 | Blue-green algae alerts, 2012-2014**

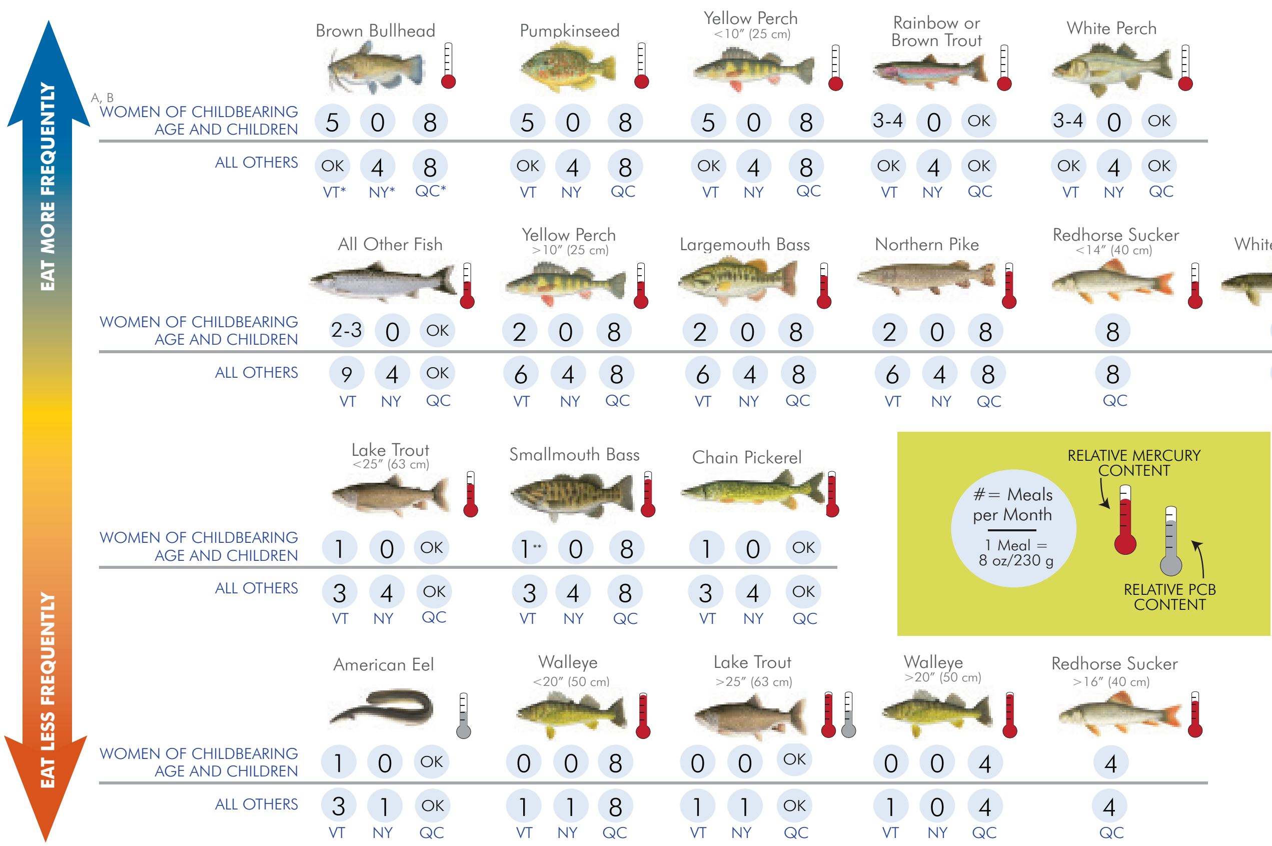
## Can I eat the fish from Lake Champlain?

*The Lake Champlain watershed offers many opportunities to catch your own healthy fish meal. Trout, salmon, bass, and perch may be found in the Lake or in tributary streams. However, it is important to be aware of consumption advisories for some species of fish found in the watershed.*

Fish can be an important part of a healthy diet, and a great way to eat local food in the Lake Champlain watershed. However, similar to the case of many seafoods, there are consumption advisories in place for fish caught in Lake Champlain and its tributaries. New York, Québec, and Vermont have each determined safe consumption levels for their jurisdictions, designed to provide guidance to consumers about safely eating fish from the watershed.

Most fish consumption advisories exist because of the amount of mercury found in the flesh of the species listed. Figure 10 illustrates the advisories for New York, Québec, and Vermont for many Lake Champlain species. Generally, smaller fish such as yellow perch have less mercury than larger sport fish, and younger fish have less than older fish. Lake trout and walleye are higher in the food chain; they consume many smaller fish over time, and bioaccumulate contaminants found in their prey. As a result, advisories are less restrictive for yellow perch than for lake trout, meaning the advisory suggests consumption of more meals of yellow perch than of lake trout is safe in a one-month period.

National and local efforts to reduce mercury pollution have been successful over the past two decades. Mercury concentrations in fish tissues, particularly in walleye and lake trout, have significantly decreased over the past several years (Figure 11), allowing some consumption advisories to be relaxed.




A = The VT advisory applies to women of childbearing age, particularly pregnant women, women planning to get pregnant and breastfeeding mothers, as well as children age six or younger.

B = The NY advisory applies to women of childbearing age, infants and children under the age of 15.

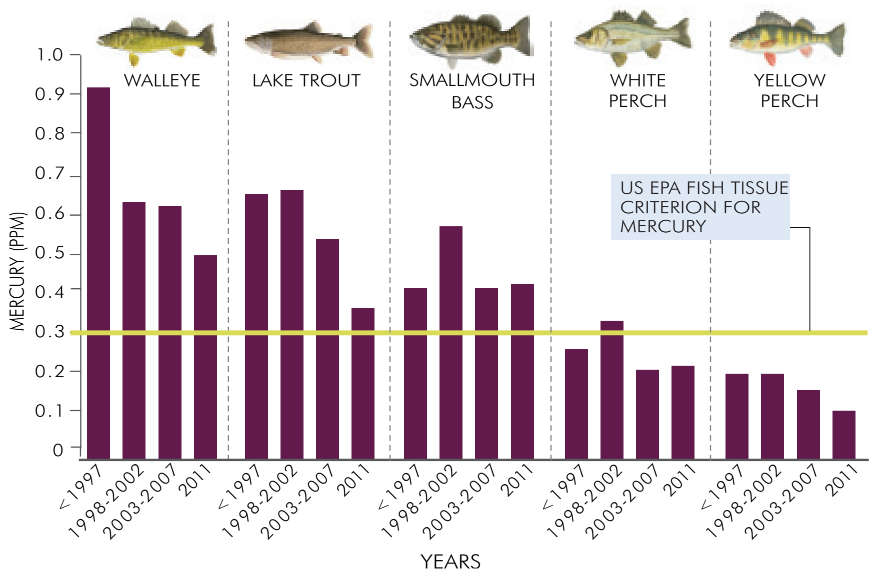
* All VT advisories are state-wide. Lake trout and walleye advisories in NY are specific to Lake Champlain; the American eel advisory is specific to Cumberland Bay. The QC advisories are all specific to Missisquoi Bay.

** smallmouth bass >19" (48 cm) consumption limited to 0 meals per month in women and children in VT. If there is no number, there is no advisory for that jurisdiction. If there is an "OK", the fish falls into the general advisory for that jurisdiction.

SOURCES: NY Department of Health, 2014; VT Department of Health, 2013; QC Department of Health, April 2006

Fish illustrations © Flick Ford and NYSDEC (redhorse sucker, white sucker, and American eel).

**Figure 10 | Lake Champlain fish consumption advisories**




NOTE: The values are mean mercury concentrations, normalized to the average length of the fish.
DATA SOURCES: Vermont Agency of Natural Resources; 2011 data from Biodiversity Research Institute.
Fish illustrations © Flick Ford.

**Figure 11 | Mercury in Lake Champlain fish by indicator species**

## What *YOU* can do

**Go Natural:** Reduce or eliminate application of pesticides and herbicides on your lawn and in your gardens. Choose less toxic alternatives for pest control.

**Clean Green:** Use less toxic cleaners. Not all household chemicals are removed by wastewater treatment. Use personal care products that do not contain plastic microbeads.

**Take It Back:** Never flush unused pharmaceuticals. Return them to the pharmacy or find authorized drug collection locations in your area.

**Don't Trash Toxics:** Take toxic waste to a hazardous waste drop-off center. This includes electronics, motor oil, paint, adhesives, pesticides, herbicides, and mercury-bearing items like non-digital thermometers and compact fluorescent light bulbs (CFLs).

**Look for Leaks:** Keep cars, boats and other machinery in good working order to eliminate oil and fluid leaks.

**Pick Up after Pets:** Dispose of pet waste in the garbage. The droppings of dogs and other pets contain harmful bacteria that can cause beach closings.

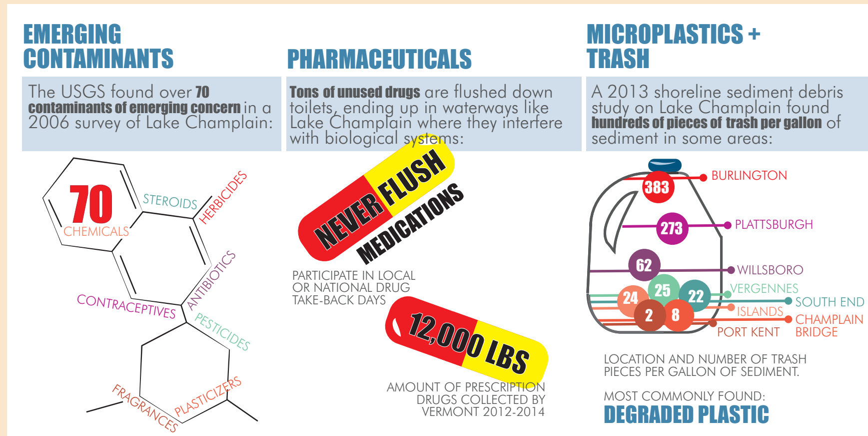
# POLLUTANTS OF CONCERN in LAKE CHAMPLAIN

### Mercury

Mercury (Hg) is a highly toxic metal that can cause severe health effects at low levels in both the aquatic and terrestrial ecosystems. It is also a persistent pollutant that bioaccumulates through the food chain. Older, predatory species, such as large lake trout and walleye, can have high levels of mercury and should be consumed sparingly. The biggest source of mercury in the Lake Champlain watershed actually comes from the sky as air pollution from coal-burning utilities, municipal waste incineration, and industries to the west of the watershed. Mercury also enters the ecosystem through the improper disposal of household products. Flourescent light bulbs, batteries, and thermometers contain mercury and should be handled carefully. Check out your state health department for information on proper disposal.

### Microbeads

Microbeads are tiny (<5 mm) plastic particles added to over 100 different health and beauty products sold in the United States. Every day, these particles are washed down drains and end up in our lakes, rivers and ponds where unsuspecting fish and birds ingest them. Recent surveys have shown that microbeads escape wastewater treatment facilities, including those operating on Lake Champlain, due to their microscopic size. Now, legislative efforts in both Vermont and New York have banned the sale and distribution of products containing microbeads in an effort to curb plastics pollution in surface waters across the region.



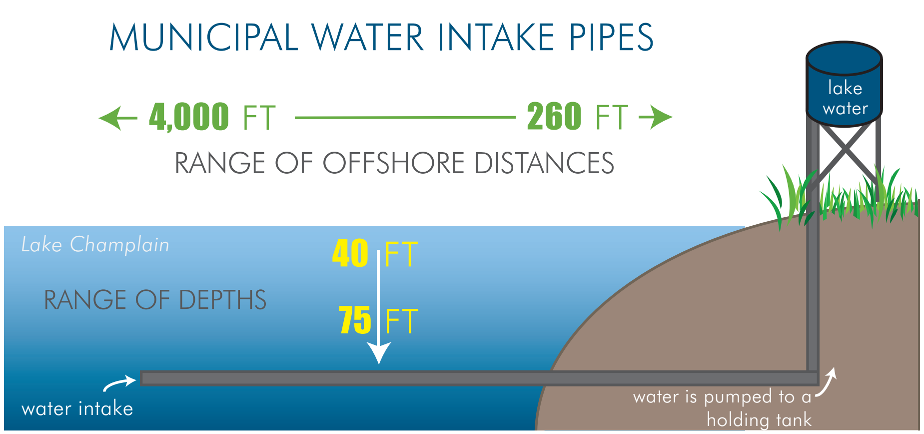
## Is Lake Champlain a safe drinking water source?

*Many communities around Lake Champlain use the Lake as a source of drinking water. Overall, Lake Champlain can be an excellent drinking water source with appropriate treatment measures in place.*

Roughly 20 million gallons of water are pumped from the Lake each day to supply drinking water to about 145,000 people (or about 20% of the Basin's population). Almost all of these people obtain their water from the 100 public water suppliers that are monitored and regulated by the states of New York and Vermont and the Province of Québec. About 35 large systems are community or publicly owned water supplies; the remaining public-private supplies include motels, trailer parks, restaurants, and other businesses. Although some shoreline residences and seasonal dwellings still draw untreated drinking water directly from the Lake, this approach to water supply is not recommended.

The US Safe Drinking Water Act (SDWA) requires public water systems to monitor 84 potential contaminants in drinking water. Vermont has 73 water supply systems, New York has 26, and Québec has one in the Lake Champlain watershed. The City of Burlington, Vermont and the Champlain Water District, which serves many cities and towns within Chittenden County, Vermont, are among the largest water suppliers in the Basin.

Most of the Plattsburgh, New York area uses ground water for drinking water, and relies on a reservoir outside the city. The US EPA's Safe Drinking Water Information System contains information about public water systems around the country and also lists violations of EPA's drinking water regulations.





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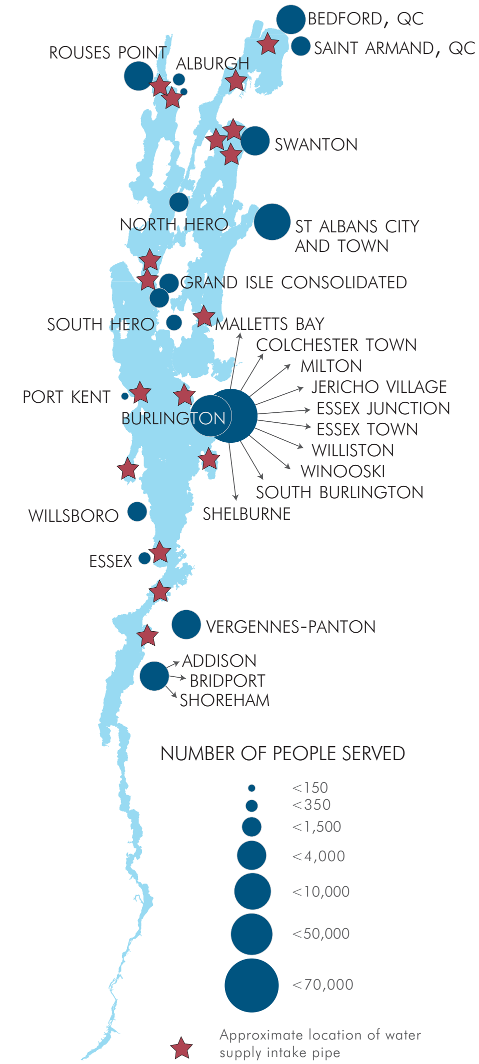



**Figure 12 | Lake Champlain as a public water supply**

## WHY TREAT THE WATER?

**BACTERIA**
All water is tested and treated for sanitary bacteria and other harmful viruses and pathogens.

**CONTAMINANTS**
At least 84 contaminants are tested for and treated in municipal water systems. If levels are concerning, the public is notified.

**BLUE-GREEN ALGAE**
Microcystin and anatoxin levels are monitored when conditions merit at some water intake locations.

**PHARMACEUTICALS**
Personal care products are rarely monitored in municipal water supplies.

# LAKE CHAMPLAIN DRINKING WATER BY THE NUMBERS

**145,000** PEOPLE GET PUBLIC DRINKING WATER FROM LAKE CHAMPLAIN

**20 MILLION** GALLONS PER DAY ARE PUMPED OUT OF LAKE CHAMPLAIN FOR DRINKING WATER

**4** MUNICIPALITIES IN NY

**28** MUNICIPALITIES IN VT

**2** MUNICIPALITIES IN QC

GET DRINKING WATER FROM LAKE CHAMPLAIN

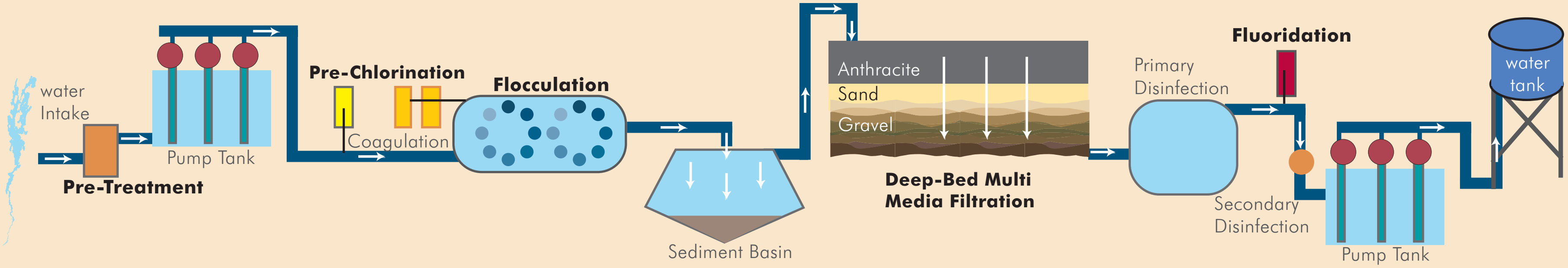
**84** POTENTIAL CONTAMINANTS ARE MONITORED IN MUNICIPAL DRINKING WATER

## OTHER SOURCES OF DRINKING WATER IN THE BASIN

- PRIVATE & MUNICIPAL WELLS (GROUNDWATER)
- MAN-MADE RESERVOIRS
- NATURAL RIVERS AND LAKES, TREATED
- DIRECT UNTREATED LAKE WATER **(NOT ADVISED)**

LCBP

## TYPICAL DRINKING WATER TREATMENT PROCESS



# Ecosystems Indicators Scorecard 2015

The 2015 Ecosystem Indicators Scorecard describes the health of Lake Champlain in each of its five major lake segments: Missisquoi Bay, Northeast Arm, Malletts Bay, Main Lake, and South Lake. These segments have been used by scientists since the 1970s to describe the major regions of the Lake. The surrounding watersheds of these segments have different physical characteristics and land use that influences the health of the segment.

For the 2015 report, the scorecard provides updated information on the nine original ecosystem indicators presented in the previous reports, reflecting the most current data available for each of these indicators. The indicators have been grouped to report on three overarching issues: phosphorus contamination, human health and toxins, and biodiversity. Three indicators have been developed for each issue; it is these nine indicators that are used to comprehensively characterize the state of Lake Champlain in this document. Each indicator is scored as good, fair, or poor for each major lake segment. A more detailed explanation of each indicator and the criteria used to determine the scores are presented in the relevant sections of this report. Please refer to the page numbers noted after each issue on the scorecard for more information. Trends for each of the indicators also are presented for individual lake segments. The trends are an assessment of whether each condition is improving, staying the same, or declining as of 2015. The trends are typically evaluated for the duration of the available data—more than 20 years in the case of water chemistry monitoring. The status of each indicator also is presented, based on an evaluation of recent data. Status information is related to specific criteria, or targets, that have been established by resource managers in the Basin.

| STATUS |
|---|
| GOOD |
| FAIR |
| POOR |
| NO STATUS DATA AVAILABLE |

| TREND |
|---|
| IMPROVING |
| NO TREND (neither improving nor deteriorating) |
| DETERIORATING |
| NO TREND DATA AVAILABLE |

## INDICATORS by LAKE SEGMENT

| | | MISSISQUOI BAY | | NORTHEAST ARM | |
|---|---|---|---|---|---|
| | | STATUS | TREND | STATUS | TREND |
| PHOSPHORUS | Phosphorus in Lake (p. 6) | Poor | No trend | Poor | Deteriorating |
| | Nonpoint source loading to Lake (p. 9) | Poor | Improving | No status data available | No trend data available* |
| | Wastewater facility loading° (p. 9) | Good | No trend data available | Good | No trend data available |
| HUMAN HEALTH & TOXINS | Beach closures (p. 12) | Good | No trend data available* | Fair | Improving |
| | Cyanobacteria blooms (p. 13) | Poor | No trend | Poor | Deteriorating |
| | Fish advisories for toxins⁺ (p. 14) | Fair | No trend | Fair | No trend |
| BIODIVERSITY & AQUATIC INVASIVE SPECIES | Sea lamprey wounds⁺ (p. 24) | Fair | Improving | Fair | Improving |
| | Aquatic invasive species arrivals (p. 25) | Fair | No trend | Fair | Deteriorating |
| | Water chestnut infestations (p. 30) | Fair | No trend | Good | No trend |

* There are no monitored tributaries in the NE Arm.

* No trend data available because MDDELCC no longer monitors and closes beaches for BGA.

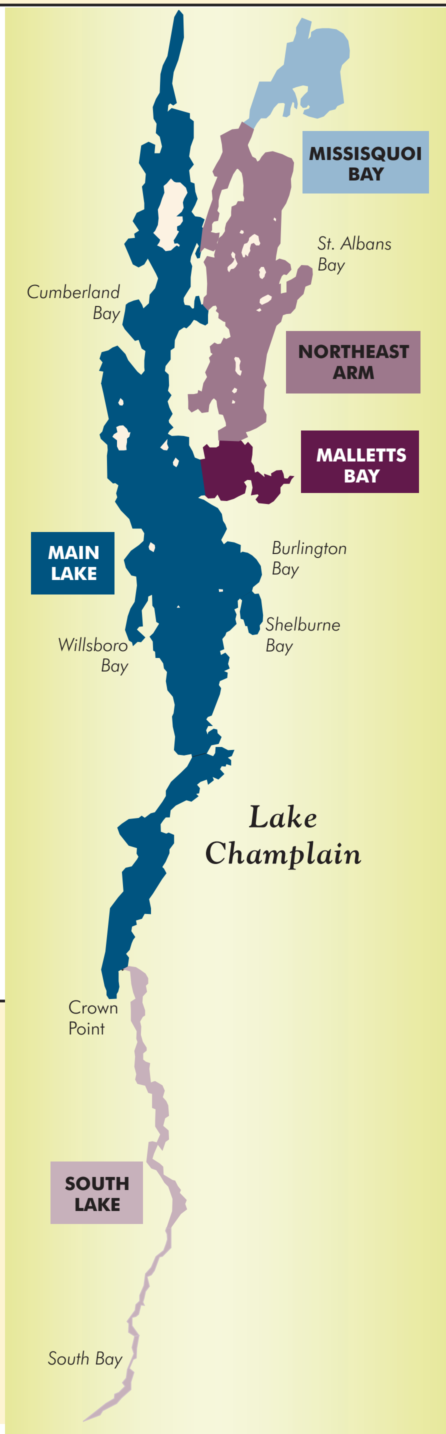
*° No post-2012 data available.*

*⁺ These indicators are lake-wide; therefore, scores are the same across all lake segments.*

LCBP PHOTOS

Missisquoi Bay

Northeast Arm




# INDICATORS by LAKE SEGMENT

| | | MALLETTS BAY Status | MALLETTS BAY Trend | MAIN LAKE Status | MAIN LAKE Trend | SOUTH LAKE Status | SOUTH LAKE Trend |
|---|---|---|---|---|---|---|---|
| Phosphorus in Lake (p. 6) | PHOSPHORUS | orange ● | ~ | orange ● | ~ | orange ● | ~ |
| Nonpoint source loading to Lake (p. 9) | PHOSPHORUS | orange ● | thumbs down | orange ● | thumbs up | orange ● | thumbs up |
| Wastewater facility loading° (p. 9) | PHOSPHORUS | blue ● | ⊘ | blue ● | ⊘ | blue ● | ⊘ |
| Beach closures (p. 12) | HUMAN HEALTH & TOXINS | yellow ● | ~ | yellow ● | thumbs down | ⊘* | ⊘ |
| Cyanobacteria blooms (p. 13) | HUMAN HEALTH & TOXINS | blue ● | ~ | yellow ● | thumbs down | blue ● | ~ |
| Fish advisories for toxins+ (p. 14) | HUMAN HEALTH & TOXINS | yellow ● | ~ | yellow ● | ~ | yellow ● | ~ |
| Sea lamprey wounds+ (p. 24) | BIODIVERSITY & AQUATIC INVASIVE SPECIES | yellow ● | thumbs up | yellow ● | thumbs up | yellow ● | thumbs up |
| Aquatic nuisance species arrivals (p. 25) | BIODIVERSITY & AQUATIC INVASIVE SPECIES | yellow ● | thumbs down | yellow ● | thumbs down | yellow ● | thumbs down |
| Water chestnut infestations (p. 30) | BIODIVERSITY & AQUATIC INVASIVE SPECIES | blue ● | ~ | yellow ●* | thumbs up | orange ● | thumbs up |

* The South Lake has no monitored public beaches.

* Water chestnut is hand-pulled between Little Otter Creek and Crown Point; the rest of the Main Lake has no infestation.

° *No post-2012 data available.*

+ *These indicators are lake-wide; therefore, scores are the same across all lake segments.*

**Malletts Bay**

**Main Lake**

**South Lake**

## How does a **healthy ecosystem** protect Lake Champlain?

*A healthy Lake Champlain ecosystem relies on clean water, but also requires intact, functional fish and wildlife habitat. Efforts to reduce habitat fragmentation and maintain habitat diversity include removing barriers to fish and wildlife passage, restoring and protecting wetlands, shorelines, and river banks, and preventing the introduction of aquatic invasive species. These efforts are also critically important in protecting water quality.*

The Lake Champlain ecosystem contains all forms of life in and around the Lake, together with their habitats, which include the quality and temperature of the water and the local climate. The Lake's biological diversity refers to the large number and variety of native species of plants, animals, and microorganisms, in a variety of habitats within the ecosystem. Over the course of many thousands of years, a complex, dynamic, and relatively stable web of life that relies on many habitat types has been established in the Lake (Figure 13).

Lake Champlain is experiencing environmental, biological, and chemical stresses that influence the ecosystem and are causing the character of the Lake to change. Seasonal temperature and precipitation patterns are changing toward warmer and wetter conditions. Changes in the landscape, especially from development and agriculture, negatively affect the Lake by altering water quality and the related food web, directly affecting the wildlife, fish, plants, and other organisms that live in the Lake and its watershed. Increasing concentrations of phosphorus and decreasing frequency of lake-wide winter ice exert additional stress on the Lake ecosystem and its native species.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*Riparian restoration projects improve wildlife habitat and help protect water quality.*

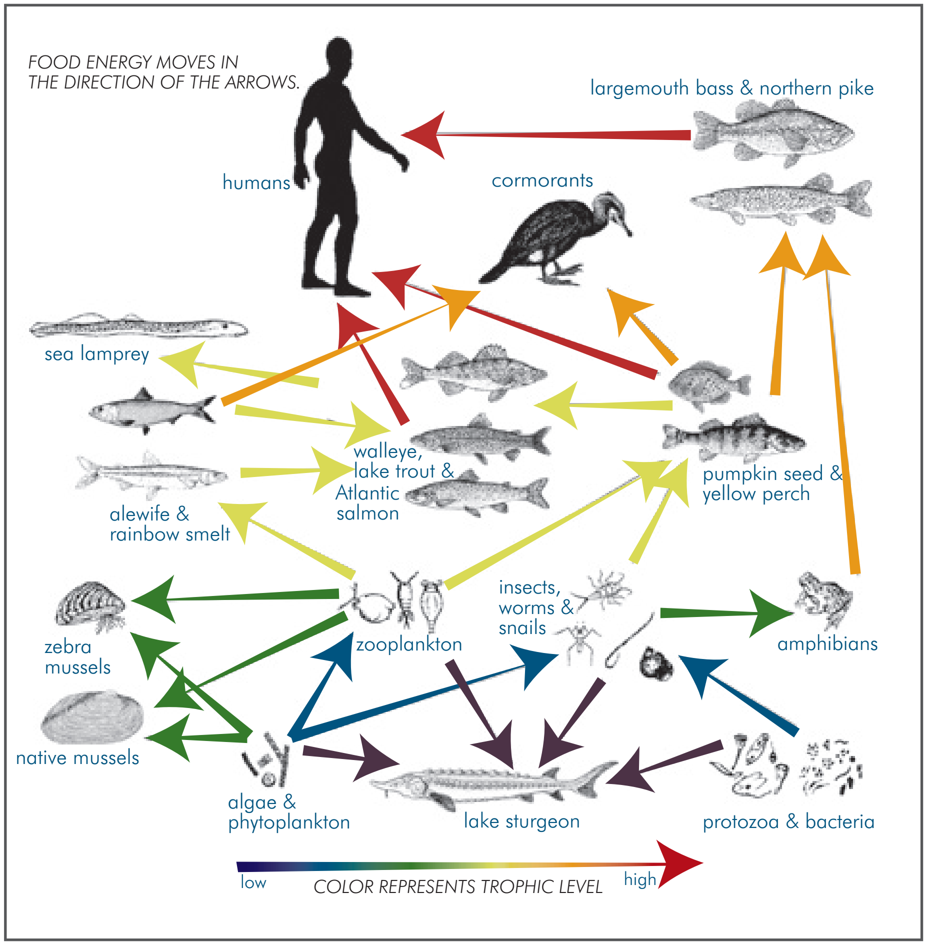
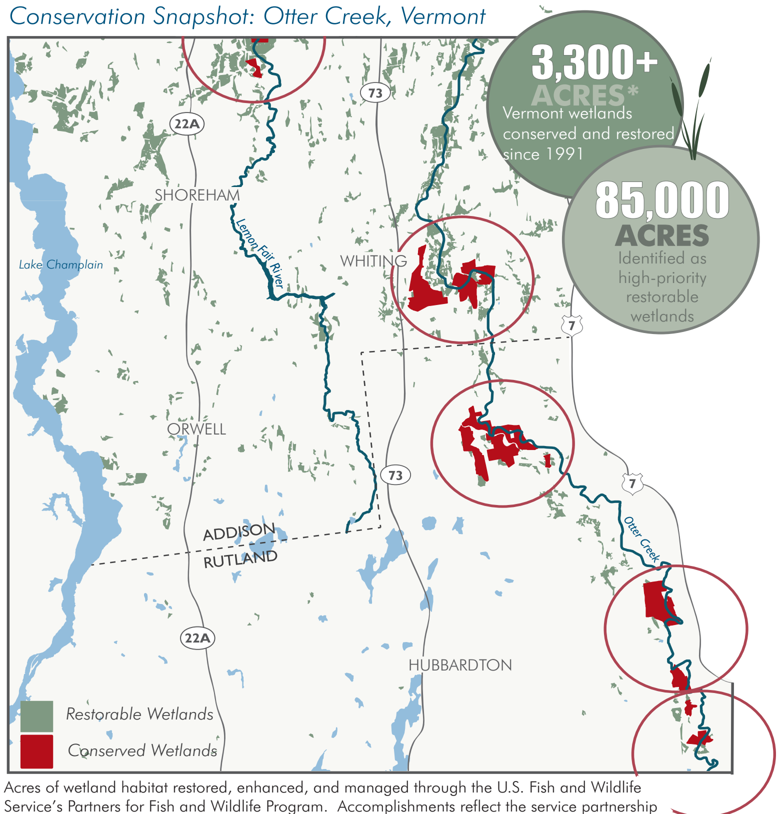



**Figure 13 | Lake Champlain food web**




Acres of wetland habitat restored, enhanced, and managed through the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program. Accomplishments reflect the service partnership with local landowners, other federal (NRCS-WRP Program) and state agencies, and numerous other non-governmental conservation groups.

DATA SOURCE: US Fish and Wildlife Service, NRCS

*3,300 acres = 1,335 hectares; 85,000 acres = 34,400 hectares.

**Figure 14 | Wetland conservation in the Lake Champlain Basin**

LCBP

*Wetlands provide habitat for wildlife while protecting water quality by filtering nutrients and pollutants.*

Certain types of habitats that support the biodiversity of the Lake ecosystem are also critically important in protecting water quality in the Lake. Wetlands and riparian areas provide nursery habitat, water storage, nutrients, and food for fish and wildlife. They also protect water quality by temporarily storing flood waters, filtering sediments and nutrients, and buffering river banks during high flows. In Vermont, over 3,300 acres of wetlands have been conserved since 1991, thanks to a strong partnership between the US Fish and Wildlife Service, USDA Natural Resource Conservation Service, private land owners, and other organizations working toward this goal (Figure 14). These groups are working to restore as many as 85,000 acres of wetlands in Vermont.

Development, especially roads and culverts, can create barriers between aquatic animals and important parts of their habitat, especially during the breeding season. Vermont and New York now have guidelines for improving aquatic organism passage (AOP) when culvert or bridge work is underway. Fishery and other resource managers are working with municipalities to install culverts and bridges with a greater capacity to handle large volumes of flood water, which will reduce erosion and allow aquatic organisms to reach spawning areas. Identifying, mapping, and assessing culverts at the watershed level can help resource managers and watershed organizations determine which stream crossings are most in need of improved AOP.

## How is the Lake Champlain **food web** changing?

*Introductions of non-native species to Lake Champlain continue to change the Lake's food web. In the last 20 years, the invasions of zebra mussel and alewife have altered plankton populations. These invasions have contributed to changing algae populations at the lower levels of the food web, and have affected the reproduction rates of some sport fish at the upper levels. The more recent arrival of spiny waterflea will cause further changes to the food web.*

In Lake Champlain, the invasive zebra mussel was first discovered in 1993. Within a few years, it had displaced several native mussel species on the Lake bottom in many areas by encrusting and suffocating them. In 2003, alewife first arrived in the Lake. Data collected by the Vermont Department of Fish and Wildlife and the U.S. Fish and Wildlife Service have shown a significant reduction in native smelt populations in several parts of Lake Champlain in the years since alewife became established, suggesting that alewife are outcompeting and displacing smelt (Figure 15).

New invasive species continue to arrive both in the Lake and in the terrestrial watershed, in many cases outcompeting and displacing native species by using resources previously available to the native species. In 2014 the spiny waterflea, a tiny invasive crustacean, was discovered throughout most of Lake Champlain, and this new species is expected to cause further alterations of the base of the food web over time.

These seemingly small changes in the food web in some areas of the Lake can have significant repercussions to biodiversity across the whole ecosystem. It takes many years of research to show the impacts from some of the 50 non-native species on the native species. The cumulative effects of non-native species on the Lake Champlain ecosystem are unknown and difficult to measure, though they undoubtedly occur.

LCBP

*Zebra mussels continue to be a nuisance in many areas of the lake.*

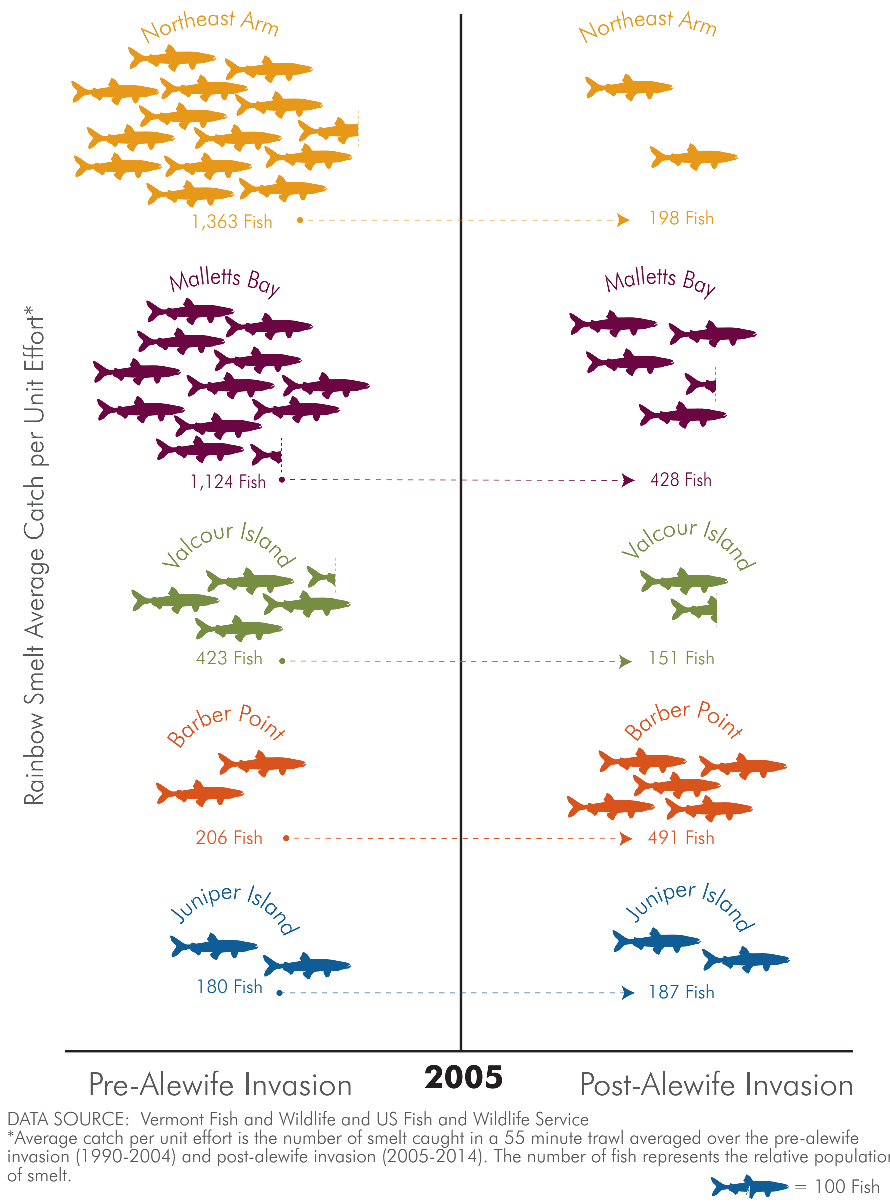



**Figure 15 | Change in Lake Champlain smelt populations, 1990–2014**

## How are the populations of Lake Champlain's sport fish changing?

*Greater numbers of larger and healthier sport fish have been caught in recent years on Lake Champlain, compared to the 1980s and '90s, and there has been a reduction in the frequency of sea lamprey wounds. Atlantic salmon runs in Lake Champlain tributaries continue to increase each year. Weigh-ins at bass tournaments for several years have demonstrated a strong and healthy bass fishery in the Lake.*

Lake Champlain is home to over 80 species of fish and is known particularly for its salmonid, bass, and walleye fisheries. Fishing tournaments on Lake Champlain have increased in number and popularity, ranging from local fishing club tournaments and derbies to professional fishing competitions. Anglers visiting Lake Champlain come from all over the country to participate in these competitions and to enjoy fishing on the Lake. Although solid ice coverage across the Lake is now less frequent than in previous decades, winter weather always brings ice to the bays and near-shore areas that are more protected from the wind, providing good ice fishing.


LCBP

*Anglers of all ages are enjoying a thriving sport fishery on Lake Champlain.*

Non-native fish species in Lake Champlain have increased in number over the last decade, and include alewife, tench, white perch and rudd, as well as some of the more popular introduced species such as rainbow and brown trout. Some of these species (alewife in particular) are problematic, outcompeting native forage fish that have traditionally comprised the diet of fishes higher up the food chain, including our most popular sport fishes. As trout and salmon start to rely more on alewife as a food source, they ingest greater quantities of the enzyme thiaminase, which has been shown in other lakes to cause a thiamine deficiency in eggs and fry, known as Early Mortality Syndrome. Since the arrival of alewife in Lake Champlain, salmonid eggs from the Lake that are used for rearing hatchery fish are checked annually for possible thiamine deficiency and are treated with a thiamine supplement.

Several species of fish continue to be stocked regularly into Lake Champlain, including lake trout and Atlantic salmon. This fish cultivation and stocking program is especially important because natural lake trout and Atlantic salmon do not currently have enough reproductive success to sustain their Lake Champlain populations. Researchers are investigating causes of poor survival of young salmonids, and are monitoring movement of these species throughout the Lake to better inform restoration efforts.

### Cormorants on Lake Champlain

Double-crested cormorants are a colonial native water bird species considered by many to be a nuisance on Lake Champlain. Their population was heavily depleted nationwide in the mid-1900s by DDT and habitat loss, but has bounced back in recent decades as a result of the expansion of the catfish farming industry in the southeastern United States and federal regulations enacted in 1972 to protect migratory species.

Public perception of the cormorant population is that it is too high in Lake Champlain and other regions, despite a lack of scientific research demonstrating significant aquatic ecosystem impacts. Many anglers on Lake Champlain are concerned that cormorants are depleting the yellow perch population, although there have not been any studies documenting these effects. However, the cormorant population on Lake Champlain has caused extensive defoliation on several islands where they breed, which has reduced the nesting habitat for other birds like the common tern, black-crowned night heron, cattle egret, great egret, snowy egret, and great blue heron.

Cormorant populations have been managed by the state fish and wildlife agencies and the US Fish and Wildlife Service for many years, in collaboration with non-government organizations such as The Nature Conservancy and Audubon. Control efforts on Lake Champlain have historically consisted of shooting and hazing adults, and oiling eggs to reduce breeding success. A Lake Champlain colonial nesting bird management plan is being developed to help guide management of cormorants on Lake Champlain.

## What is the impact of sea lamprey on trout and salmon?

*The impact of sea lamprey on trout and salmon populations in Lake Champlain has diminished in the last ten years. The sea lamprey control program has effectively reduced sea lamprey wounding of Atlantic salmon to near target levels consistently since 2010.*

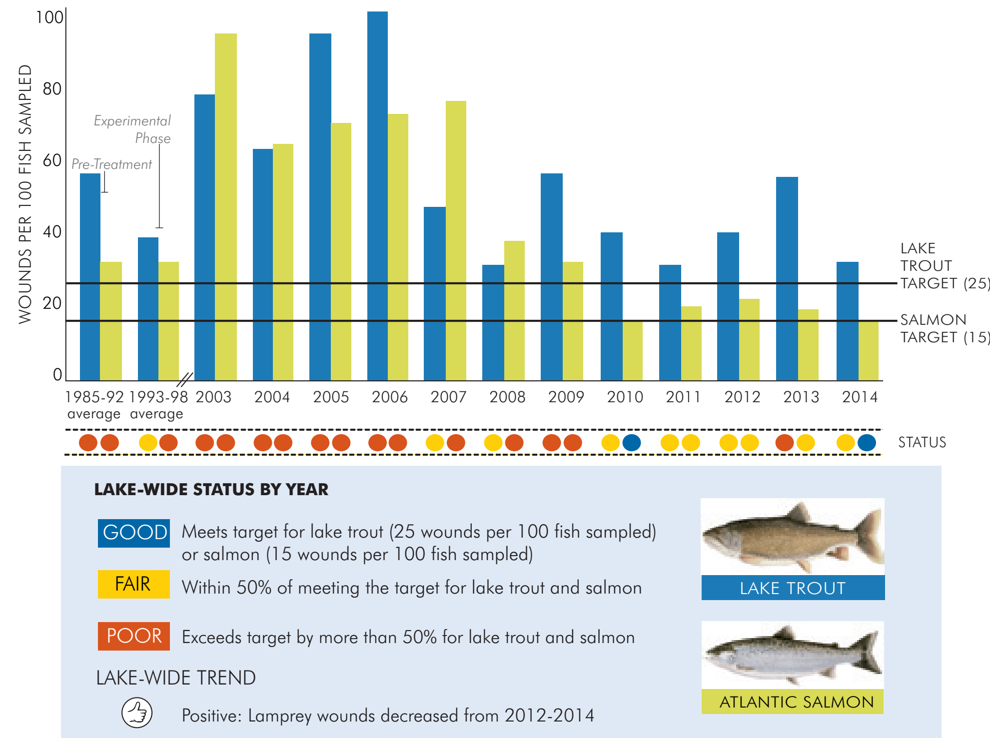
Fishery biologists continue to try to determine whether parasitic sea lamprey are a native nuisance or invasive nuisance species but, in either case, overall management of sea lamprey is not likely to change. There is strong evidence and broad agreement that the parasitic sea lamprey has had a significant negative impact on salmon and trout. Fortunately, sea lamprey management has been very effective (Figure 16).

In its parasitic phase, the sea lamprey attaches its mouth to its prey and feeds on the blood and body fluids of its host. However, before it reaches this phase in its life cycle, the sea lamprey lives in streams as a larval filter feeder for about four years. It is in this earlier phase of its life cycle that sea lamprey are most vulnerable to control measures.

The sea lamprey control program on Lake Champlain uses several strategies to reduce the number of larval sea lamprey in streams. Methods to control and reduce sea lamprey populations in the Lake's tributaries include the use of barriers to spawning habitat, spawning traps, and pesticides applied at strategic times and places. Highly specialized pesticides ("lampricides") have been used to control larval sea lamprey before they transform into their parasitic phase and migrate to the Lake to prey on trout and salmon.

A partnership among the US FWS, the Province of Québec, and local residents developed an innovative new method for controlling sea lamprey. In 2014, a seasonal spawning barrier was constructed on Morpion Stream, a tributary to the Pike River in the Missisquoi River basin in Québec, with funds provided by the US FWS and the Great Lakes Fishery Commission. The temporary barrier is installed early each spring and removed in early summer, to prevent sea lamprey from migrating up the Morpion Stream to spawning habitat. The design allows other fishes to continue their migration, and eliminates the need for chemical control of this tributary for sea lamprey.

As with most pesticides, there are non-target impacts from the use of lampricides. Some endangered or threatened species, including lake sturgeon, channel and Eastern sand darters, stonecats, mudpuppies, mussels, and a native lamprey species also are susceptible to lampricide treatments. The US FWS is required to ensure that there will be a minimal effect on populations of non-target species, particularly for those that are threatened or endangered. Human health risks also are minimized as much as possible. Residents within the treatment areas are notified before lampricide treatments occur and are provided with drinking water when necessary. Recreation advisories are posted in the affected areas for the duration of potential effect on water supplies.




NOTES: Lake trout were 533-633mm (21-25 in) in length. Salmon were 432-533 mm (17-21 in) in length. The pre-control period was 1985-92, and experimental control period was 1993-98. Previous versions of this graphic were limited to data from the Main Lake. This graphic contains Lake-wide data.
DATA SOURCE: Lake Champlain Fisheries Technical Committee
Fish illustrations © Flick Ford

**Figure 16 | Sea Lamprey wounding rates in Lake Champlain**

## What new **aquatic invasive species** have populated the Lake?

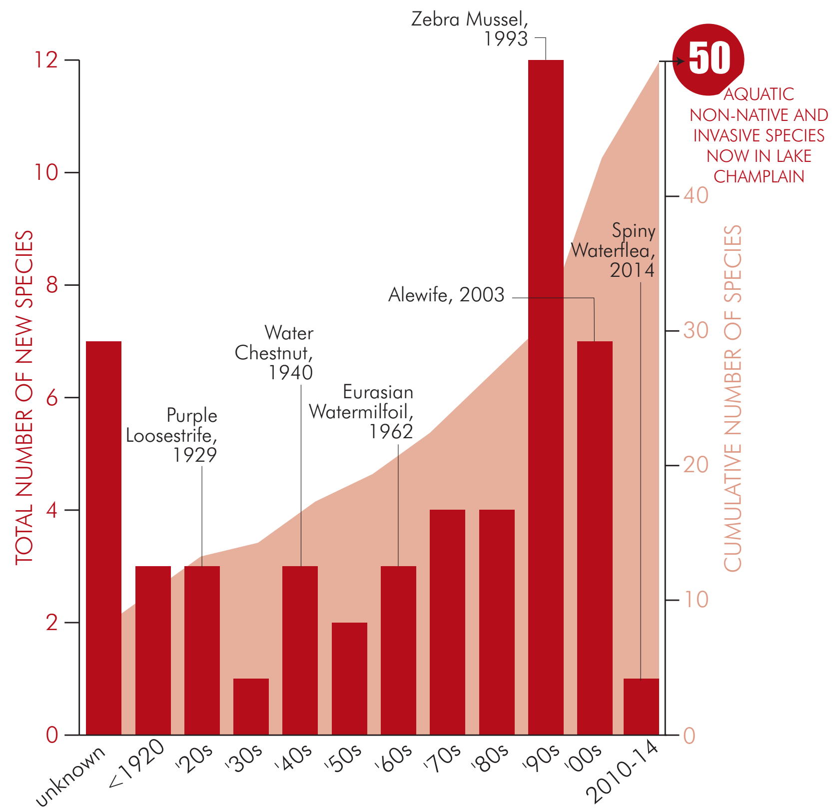
*Spiny waterflea (SWF), the most recent aquatic invasive species to arrive in the Lake, was detected in late summer 2014. It is thought to be the only new invader since variable-leaved milfoil was found in southern Lake Champlain in 2009.*

As of 2014, Lake Champlain is home to 50 known non-native and invasive species (Figure 17). Aquatic invasive species (AIS) are non-native species that cause harm to the aquatic environment, economy, or human health. AIS include aquatic plants, animals, and pathogens, and they may be transported intentionally or unintentionally to the Basin mostly by people. Once AIS are introduced to Lake Champlain they are very difficult to manage and have the potential to spread to other water bodies.

Spiny waterflea (SWF), a small invasive crustacean (not an actual flea) was detected in Lake Champlain by the LCBP Long Term Biological Water Quality Monitoring Program in August 2014 and spread throughout much of the Lake by September. Native to northern Europe and Asia, spiny waterflea hitchhiked in ballast water to the Great Lakes in the 1980s and has recently spread to inland

EMILY DEBOLT

*Spiny waterfleas are not harmful to humans, but have altered the food web of lakes in the region.*

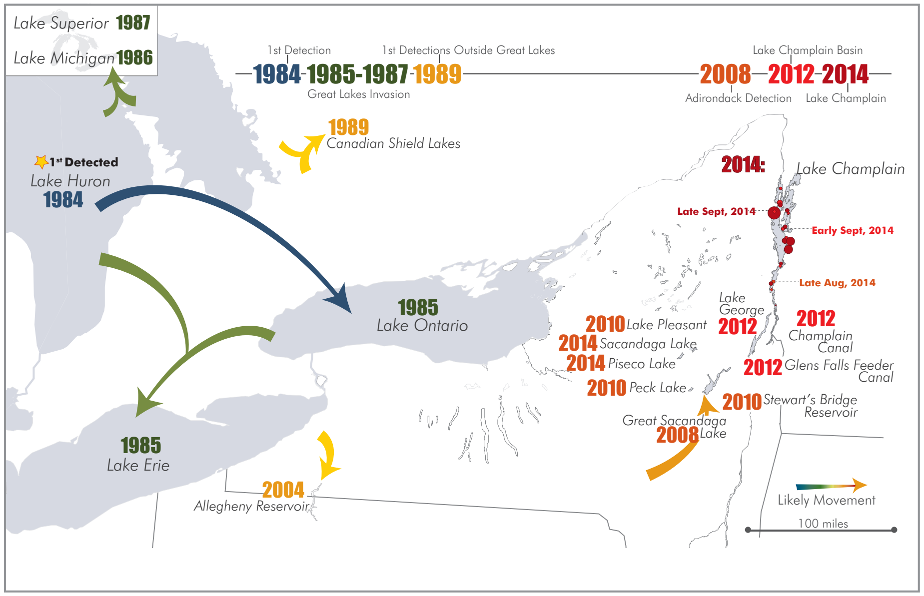



NOTE: Data reflect the decade of arrival or first reported sighting of the species.
DATA SOURCE: Ellen Marsden, University of Vermont

**Figure 17 | Aquatic non-native and invasive species arrivals in Lake Champlain**

lakes in the Adirondacks (Figure 18). Spiny waterflea have long barbed tails that make up 70% of their body length and can get caught in the stomachs of fish that eat them. This species is a visual predator and feeds on zooplankton and smaller crustaceans such as *Daphnia*; changes in the food web of other northeastern lakes have been documented after SWF introduction. They prefer cold, deep water and are a nuisance to anglers because they can accumulate on downriggers and foul fishing lines and other fishing gear. Researchers are carefully gathering data to evaluate their effect on Lake Champlain.

The discovery of the spiny waterflea in Lake Champlain prompted the Lake Champlain Basin Aquatic




NOTE: Detection dates are the first recorded sightings of the species. The entire geographic spread of Spiny Waterflea also includes areas north, south and west of the Great Lakes.
DATA SOURCES USGS, NYS DEC, Lake Champlain Research Institute

**Figure 18 | Spiny waterflea movement to Lake Champlain**

Invasive Species Rapid Response Task Force to evaluate the new infestation. The task force is an appointed group of Lake Champlain Basin experts from New York, Vermont, and Québec that is dedicated to responding quickly to any new invasive species in the Basin.

The task force reviewed the technical feasibility of steps to prevent the spiny waterflea from spreading from Lake Champlain to other inland water bodies in the Basin. Although there are no known methods to control or eradicate spiny waterfleas once they have been detected in a water body, vigorous efforts to contain and prevent the species spread within the watershed are underway. Lake Champlain researchers were surprised at the apparent rate of population growth and spread when, by September 2014, they were detected at multiple lake stations in large numbers. Research shows that the most effective way to prevent the spread of all life stages of the spiny waterflea is to dry your boat, trailer, and equipment (including fishing line and anchors) completely, after boating in a body of water infested with spiny waterfleas and before launching in a different body of water.


UNIVERSITY OF FLORIDA


LCBP


LAKE GEORGE ASSOCIATION


USFWS

*Hydrilla, quagga mussel, round goby, and Asian clam (clockwise from top left) are the most threatening invasive species "on the doorstep" of Lake Champlain.*

## What *YOU* can do

**Clean:** Inspect and remove plants, animals, and mud from gear and equipment, including waders, ropes, anchors, and fishing gear before leaving water access area.

**Drain:** Remove all water from your boat, motor, bilge, live well, and bait containers before leaving water access area.

**Dry:** Keep your boat and trailer in the sun for at least five days or wash with hot water or a car wash if you use it sooner.

**Don't Dump Bait:** Never release unwanted aquatic bait, dead or alive, into any water body.

**Be Species Smart:** Use only non-invasive plants and animals in gardens, ornamental ponds, and aquaria. Never release unwanted plants or animals into the wild.

## What aquatic invasive species outside the Basin pose a threat?

*The invasive plant hydrilla (found in Cayuga Lake and the Erie Canal), quagga mussels (found in the Great Lakes and the Erie Canal), round goby (found in the Erie Canal and the St. Lawrence and Richelieu rivers), and the Asian clam (found in Lake George and the Champlain Canal) are four of the most threatening invasive species "on the doorstep" of Lake Champlain.*

Invasive plants, animals, and pathogens can move across the landscape and enter Lake Champlain in a number of ways. Primary pathways include aquarium plant and pet dumping, water garden escape (especially during significant tropical storms like Irene), hitchhiking on boats, trailers, and other recreational equipment, live bait release, intentional stocking, and canal passage. Other waterways in the region surrounding Lake Champlain are home to many potential invaders (Figure 19).

Hydrilla is a submerged aquatic invasive plant that grows prolifically in dense mats and is considered more invasive than Eurasian water milfoil, a well-known and established invasive species in Lake Champlain. Hydrilla is believed to be native to Korea, but has now become established in the Cayuga Lake Inlet and Erie Canal in New York, threatening to spread towards Lake Champlain.

Quagga mussels are an aquatic invasive mollusk, first discovered in Lake Erie in 1991, where they are thought to have arrived in ballast water from the Ukraine. The quagga mussel has been referred to as the evil twin of the zebra mussel because it is able to reproduce more prolifically and is adapted to live in deeper water. The species was most likely spread overland by hitchhiking on vessels and equipment. It has caused billions of dollars in damage to aquaducts, hydroelectric dams, and irrigation systems in other parts of the country. Quagga mussels are now present in the Erie Canal and expanding their range eastward, toward Lake Champlain. They have been intercepted by the boat launch steward program on Lake George. If quagga mussels arrive in Lake Champlain, they could threaten the accessibility of deep-water historic shipwrecks that have escaped zebra mussel damage, as well as compete with zebra mussels and native mussels in shallow water.

Round goby are small invasive fish that have spread through the dumping of bait buckets and passage through canals, after their introduction to the Great Lakes from ballast water in the St. Clair River in 1990. Round goby are aggressive eaters that consume the eggs of native fish species and sport fish. The species is presently found both in the Erie Canal and in the Richelieu River.

Asian clams are present in the Champlain Canal and in Lake George, New York, both of which are connected to Lake Champlain. Asian clams are small bivalves with distinctive ridges on their shells. Asian clams are hermaphrodites, so it only takes one clam for reproduction to occur. They are filter feeders that foul water intake pipes and irrigation systems. They reproduce prolifically and displace native species. Asian clams have been successfully overwintering in the cold waters of Lake George. After they die, their shells may persist for years, providing a growing substrate for zebra mussels.


DATA SOURCE: UVM, LCBP, Lake Champlain Sea Grant, Great Lakes Environmental Research Laboratory, Lafontaine and Costan 2002, and Strayer 2012. Lake Champlain data current as of 2015.

**Figure 19 | Non-native and aquatic invasive species threats to Lake Champlain from connected waterways**

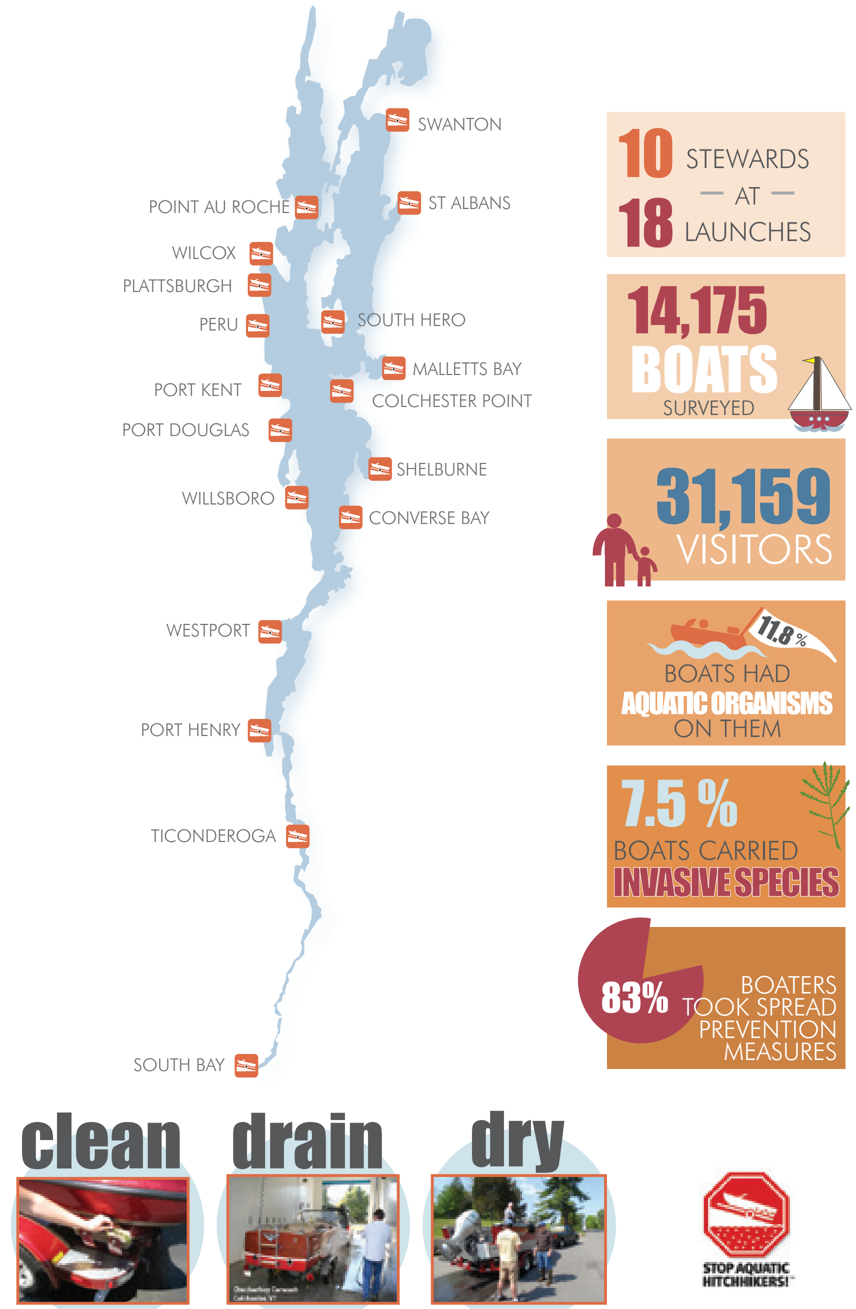
## What effect are management actions having on the **arrival and spread** of aquatic invasive species?

*Boat launch steward and greeter programs have helped to prevent the introduction and spread of invasive species by intercepting invasives at points of arrival and departure from water bodies. New regulations are helping to make these programs more common and effective. AIS removal efforts, such as those for water chestnut and Asian clam, have also helped to control the spread of invasives that have already arrived.*

In 2007, LCBP initiated the Lake Champlain Boat Launch Steward program. This program stations stewards at public boat launches around the Lake, where they survey launch users and inspect their boats for the presence of invasive species when they are being launched or retrieved from the Lake. Stewards reduce the chance of introducing new species by intercepting them as they are about to enter a water body, and also educate the public about the threats posed by invasive species and the importance of cleaning boats and gear before launching into and when leaving the water body. The 2014 effort was the most far-reaching yet, with more than 31,000 visitors reached (Figure 20).


LCBP

*Boat launch stewards on Lake Champlain share the Clean, Drain, Dry message with visitors from as far away as Texas and Colorado.*




DATA SOURCE: LCBP. Data from 2014 LCBP Boat Launch Steward interactions with visitors at NYS DEC Access Areas and VT Fish and Wildlife Access Areas.

**Figure 20 | Lake Champlain Boat Launch Steward highlights, 2014**

The Boat Launch Steward program also provides an important perspective on the Lake's place in the movement of aquatic invasive species at regional and national scales. Survey data reveal that boats are trailered from as far away as Colorado and Texas. The top ten water bodies most recently visited are all in northeastern North America; the Hudson River is the water body most frequently visited in the two weeks prior to launching in Lake Champlain (Figure 21). The geographic range of visitors to the Basin, and the number of potential invaders from a variety of ecosystems, underscores the importance and effectiveness of steward and greeter programs.

Recent legislation and regulatory programs have helped to make AIS spread prevention a cornerstone of natural resource management in the Basin. New York now requires all boats, trailers, and gear to be cleaned and drained prior to launching at state access points. Additional rules prohibit sales, transportation, or introduction of certain species in New York. Similarly, Vermont has banned the transportation of aquatic plants on boats and trailers. In response to the 2009 discovery of Asian clams in Lake George and the widespread concern it raised, the Lake George Park Commission implemented a pilot mandatory boat wash and decontamination program on Lake George, the first of its kind in New York State and in the northeast region.

Following the discovery of Asian clam in Lake George in 2009, a group of partners quickly banded together to collaboratively develop a management strategy. The strategy has evolved to include research, monitoring, and intensive efforts to control the clams using benthic barrier mats and other eradication methods. Management has been very effective, but the detection of juvenile clams

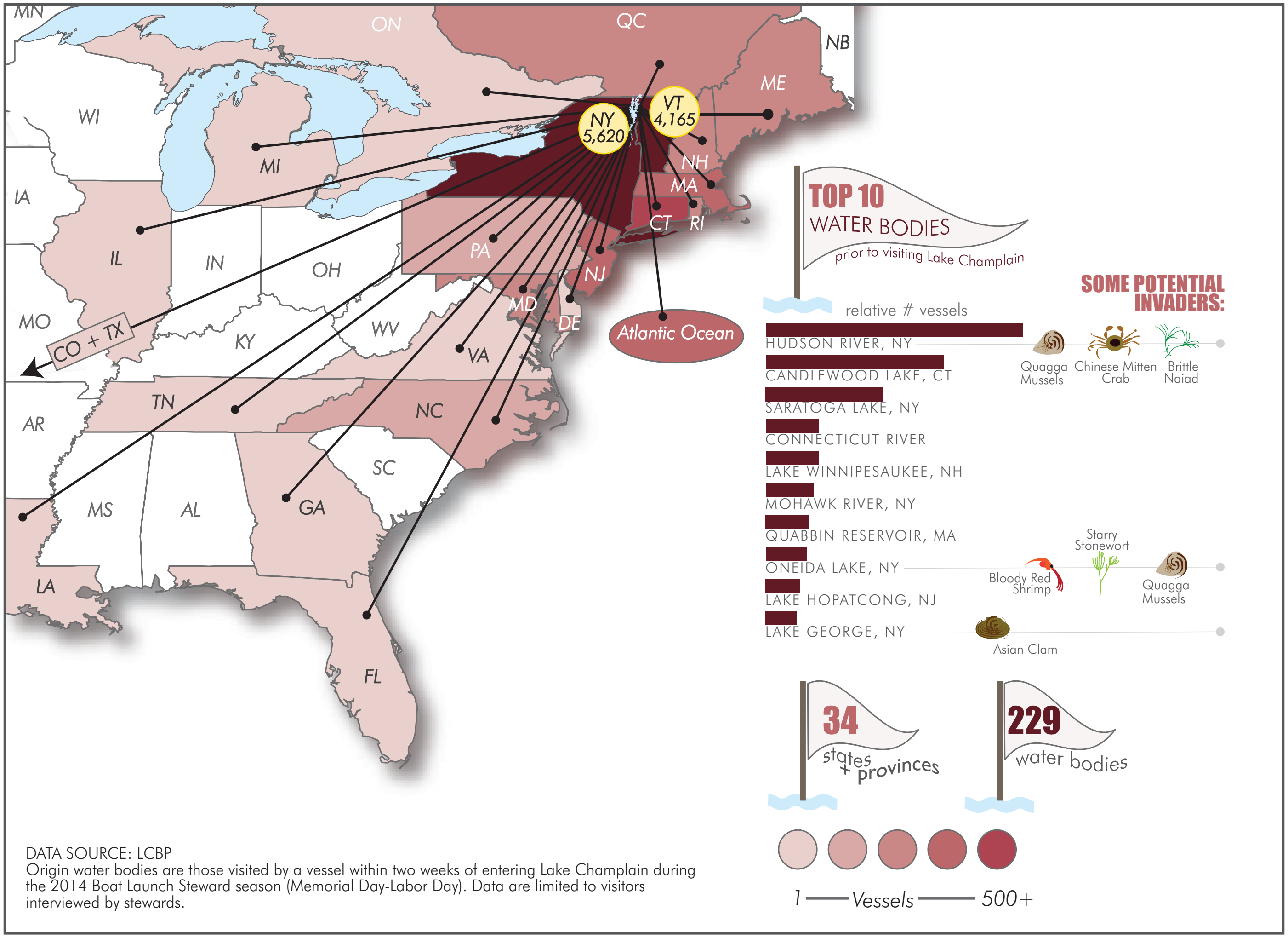



**Figure 21 | Origins of vessels launched into Lake Champlain, 2014**

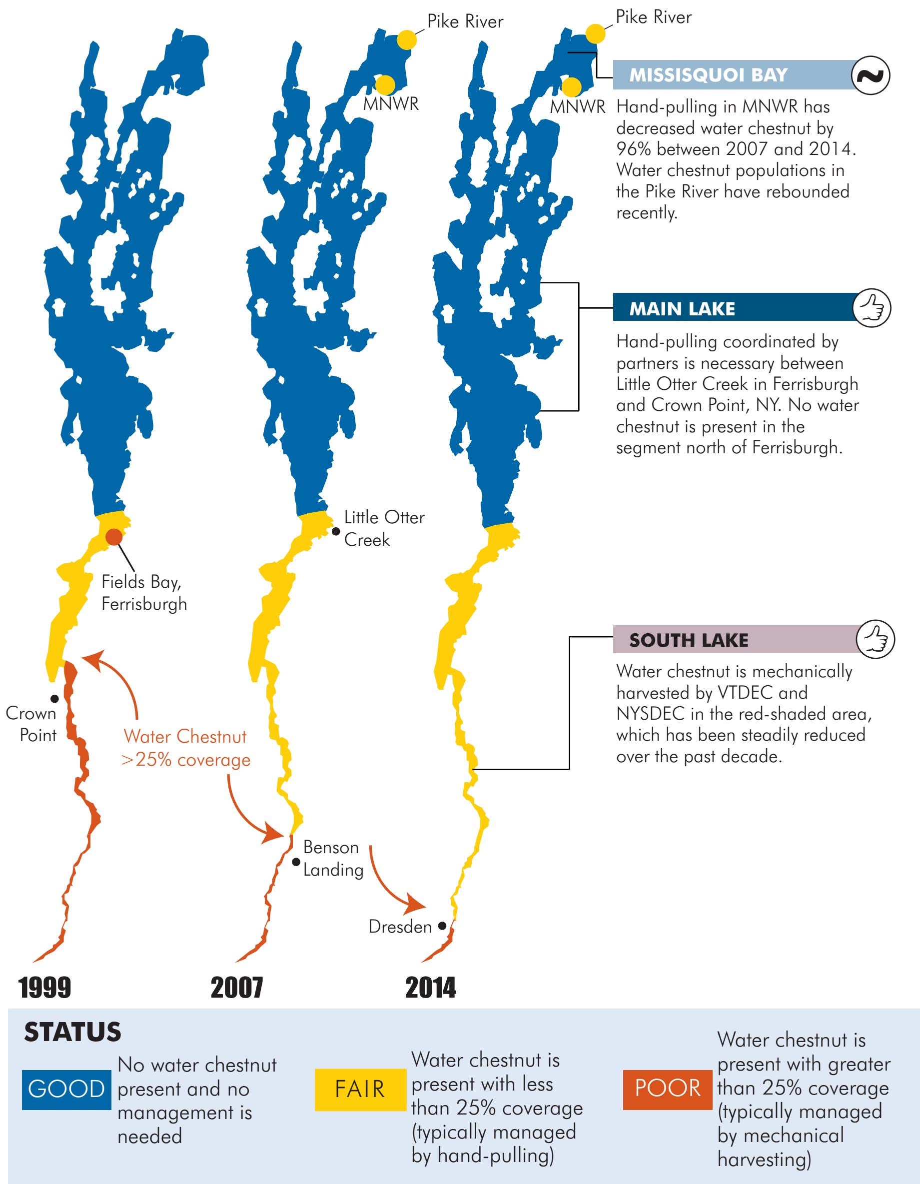
NYSDEC

*The State of New York now requires all gear to be clean and drained prior to launching at state access points.*

has been challenging. In the past few years, Asian clams have spread to several Lake George locations that are surveyed and managed where possible.

Lake Champlain's water chestnut control program is a long-standing success story that remains dependent on steady funding and support from state, federal, and local partners. Water chestnut is a floating invasive plant that forms dense leafy mats. In the southern end of Lake Champlain, it limits boat traffic and recreational use, crowds out native plants, and creates oxygen-depleted zones uninhabitable for fish and other organisms. It was first documented in southern Lake Champlain in the 1940s, and was likely introduced through the Champlain Canal from a water garden escape or other population in the Hudson River.

Partners including the states of Vermont and New York, the Province of Québec, the Missisquoi National Wildlife Refuge, US Army Corps of Engineers, New York State Canal Corporation, Lake Champlain Basin Program, and The Nature Conservancy work to harvest water chestnut, mechanically and by hand, in Lake Champlain and other inland waters. These efforts continue to push back the northern extent of dense populations: from Benson in 2011 to south of the Dresden Narrows in 2014 (Figure 22). Progress also has been made in the Missisquoi National Wildlife Refuge where the water chestnut population was reduced by 96% between 2007 and 2014 by hand-pulling in shallow waters, though the Pike River population has rebounded recently.




DATA SOURCES: VTDEC, NYSDEC, QC MDDELCC

**Figure 22 | Status of water chestnut infestations in Lake Champlain**

MARTIN MIMEAULT

*Water chestnut control continues to be a success story on Lake Champlain.*

## How is climate change affecting Lake Champlain?

*Mounting evidence makes clear that the Lake Champlain Basin's climate is changing, affecting fish, wildlife, and plant communities, as well as human uses of the Lake. The type and number of fish species likely will change, as aquatic invasive species may have greater opportunity to spread. Warmer water temperatures have the potential to increase the frequency of blue-green algae blooms as well.*

Studies in the Lake Champlain Basin and neighboring regions have documented climatic trends of increasing temperature and precipitation. Climate models predict these changes are likely to continue and increase in the coming decades. Climate change has caused, and will continue to cause, changes in the Basin's ecology and water quality. Resource managers and stakeholders recognize the need for both individuals and communities to adapt to climate change. Climate adaptation strategies can help to mitigate many of the environmental, economic, and social risks resulting from climate change.

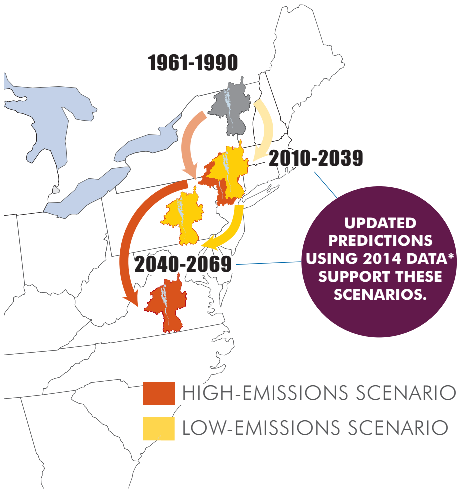
### Climate Trends

Climate trends observed in the Lake Champlain Basin are similar to those observed across the northeastern US and eastern Canada. The average temperature in Vermont has increased by 2.7 °F since 1941, and the last decade has been the warmest on record. Global climate models project continued increases in air temperatures. National and regional studies project that average air temperatures in the Basin may rise 3-6 °F by the middle of the century. By the end of the century, local temperatures may have risen by 5.5 - 8 °F, resulting in a shift to climate conditions currently experienced in the mid-Atlantic states (Figure 23).

Average Lake Champlain surface water temperatures also have increased in recent decades (Figure 24). Records from the US National Weather Service indicate that Lake Champlain

ANDREW GILBERTSON

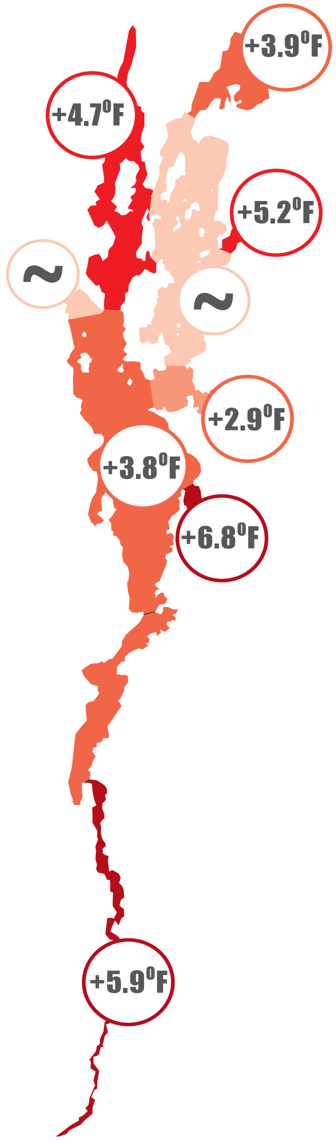
*Increased surface water temperatures affect native cold-water fish species.*




**Red arrows** track the shift in the Lake Champlain Basin's summer climate over the next 60 years if we continue under a high-emissions scenario. **Yellow arrows** track the shift under a low-emissions scenario.

DATA SOURCE: Adapted from Union of Concerned Scientists. *Sources include VCA, 2014; NEICA, 2014; IPCC, 2014; NCA, 2014

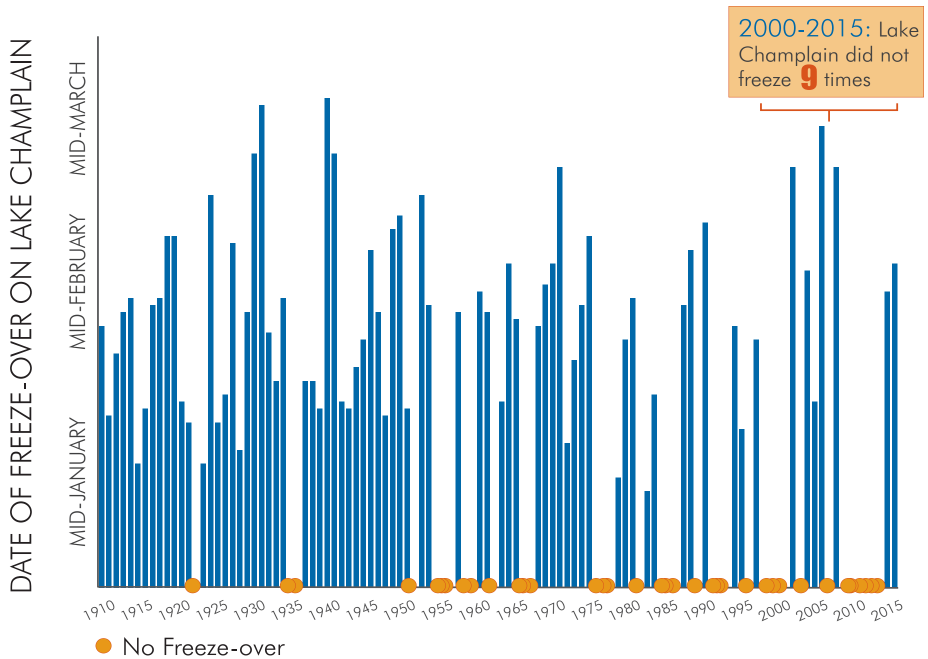
**Figure 23 | Lake Champlain Basin migrating climate**




* Data are August mean lake surface temperatures in degrees Fahrenheit.
DATA SOURCE: Smeltzer et. al., 2012

~ indicates no statistically significant trend

**Figure 24 | Mean August water surface temperature change since 1964**




DATA SOURCE: National Weather Service/U.S. Weather Bureau

**Figure 25 | Date of freeze-over on Lake Champlain, 1910–2015**

has frozen over much less often in the last 50 years than in the previous half century (Figure 25). When freeze-over does occur, it is later in the winter and ice melts earlier in the spring.

Annual precipitation in the Vermont and Québec portions of the Basin has increased by 45.8 mm per decade since 1941, and in New York, precipitation has increased by an average of 0.22% per year between 1951 and 2006. High intensity precipitation events (greater than one inch per day) are now more frequent in the Basin, and the amount of precipitation falling in the heaviest 1% of all daily rain events has increased by more than 70% between 1958 and 2010.

Although precipitation remains difficult to forecast, most studies and models suggest that a warmer climate will lead to wetter, more energetic precipitation patterns in northeastern North America. The Lake Champlain Basin can expect more rain, especially in the winter, and will experience more intense storm events.

### Consequences of Climate Change

More intense storms will result in more severe flash floods in rivers and streams. Streambank erosion and municipal combined sewer overflows are common hazards during flood events, releasing sediments, nutrients, and other pollutants that are transported to the Lake.

JUSTIN BEVINS

*By the end of the century, the region can expect more winter rain and less snow.*

## What *YOU* can do

**Plant Buffers:** Volunteer to help plant trees and shrubs along waterways with a local watershed group. Roots will hold the soil and help protect habitat and water quality downstream.

**Plant Native:** Native trees, shrubs, flowers, and ground covers flourish with less water, fertilizer, and pest control measures. Native plants also attract wildlife including birds and pollinating insects.

**Get Pervious:** Replace pavement with porous surfaces like gravel, bricks, or pervious paving. Porous surfaces reduce storm water runoff and allow pollutants to be absorbed and filtered.

**Be a Citizen Scientist:** Anyone can volunteer to help scientists with their research. There are citizen-sourced projects that observe and monitor water quality, weather, wildlife, invasive species, and much more.

**Join In:** Join a lake or river organization. You can help clean up your watershed and advocate for public policies that will protect it.

Increased nutrient levels combined with longer periods of warmer surface water temperatures may intensify potentially toxic algae blooms. Algae blooms degrade water quality and reduce dissolved oxygen in the water, depriving fish and other aquatic life of oxygen. Toxic algae blooms also threaten human and animal health and impair recreation where they occur.

Increased surface water temperatures also affect Lake Champlain's capacity to support native cold-water fish species such as salmon and trout and cool-water fishes like walleye and northern pike. Warmer water may also alter spawning times, potentially harming the reproductive success of cool-water fishes in Lake Champlain. Simultaneously, populations of warm-water fish species like bass and invasive white perch are likely to increase.

Biological diversity also is affected by floodwaters, which increase opportunities for invasive species to spread to new areas. More winter precipitation falling as rain, rather than snow, will alter the natural fluctuations of the water levels of shallow areas and wetlands that support spring spawning of some fish and provide habitat to many amphibians.

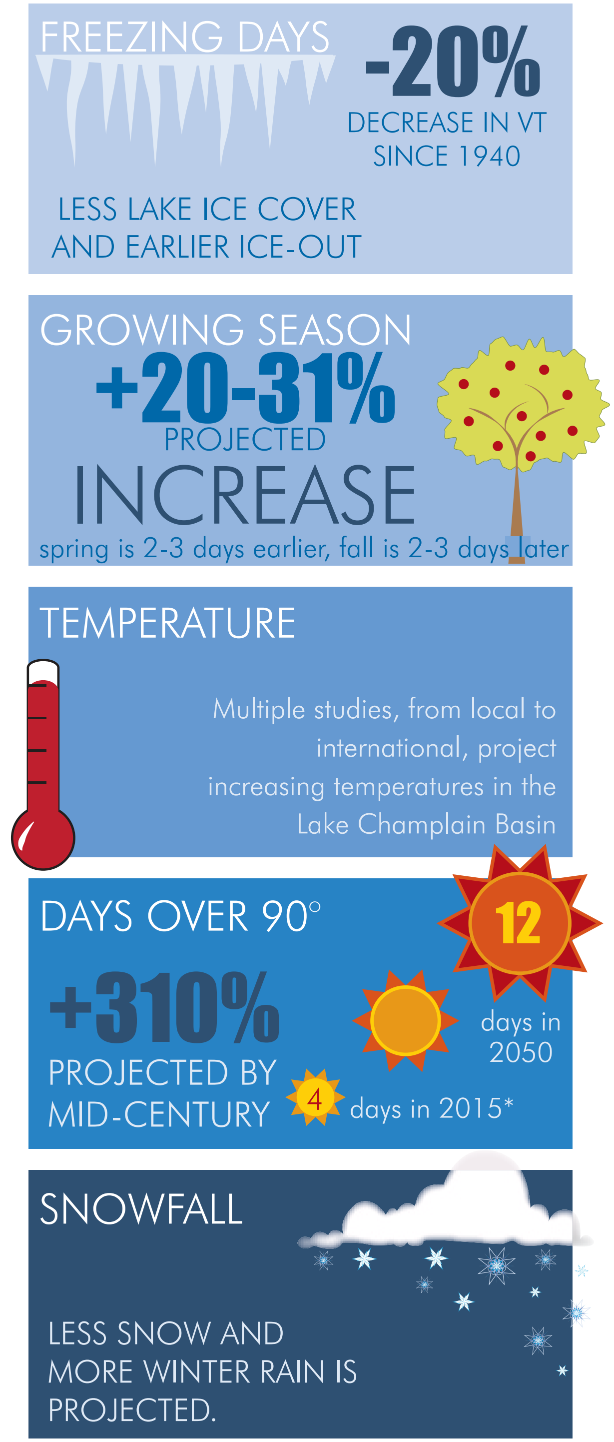
**Climate Adaptation**

Policy makers and resource managers are working to adapt to climate change by increasing the resilience of natural and human systems in the wake of intense weather events. Strategies and measures that improve the ability of these systems to absorb the impacts of severe events, and quickly recover in their aftermath, are necessary to minimize the effects of climate change.

Floodplain planning and mitigation of storm water runoff, using best management practices, will help to prevent or minimize erosion and water quality degradation. Preventing new invasive species from becoming established in the Basin is a long-term strategy to reduce climate change impacts.

### Weather, Climate, and Climate Change

Some people wonder what scientists mean by "global warming," when winter in the Lake Champlain Basin often still includes long periods of bitter low temperatures, blustery wind, snow, and ice. The temperature, wind, and precipitation observed during any particular storm event are the key components of weather—the atmospheric conditions at a point in time. An average of temperatures, wind, and precipitation over several decades presents a weather pattern over time, and this pattern is known as climate. The term "climate change" refers to a long-term shift in weather patterns at a regional scale. When changes in climate across the globe are considered collectively, the global trend is towards warmer conditions. Local weather conditions may not seem particularly unusual, but global atmospheric patterns drive local weather conditions. As temperatures increase, so do the energy and moisture contained in the atmosphere, which lead to more severe local weather at times.




NOTE: Freezing Days are below 32 °F/0 °C. Days above 90 °F=32.2 °C; *Average days above 90 °F for period of 1981-2014.
DATA SOURCES: VCA, 2014; Stager & Thill, 2010; Guilbert et al., 2014; IPCC, 2014; NCA, 2014; NEICA, NWS, 2015; 2007; TNC Climate Wizard, 2014.

## How has flooding affected the region?

*Flooding is not a new problem in the Lake Champlain watershed, but it is happening more often and more severely. The 2011 floods, with over 60 days of record-setting lake levels in the spring, followed just two months later by record flash floods from Tropical Storm Irene, left a lasting impact on both the people and ecosystems around Lake Champlain.*

Above-average snowpack coupled with heavy spring rains in 2011 led to the most severe flooding ever recorded on Lake Champlain. The Lake reached an all-time high of 103.27 feet above mean sea level in May of 2011, and remained well above the 100-foot flood stage into June of that year. The flooding damaged or destroyed more than 3,500 homes and caused $88 million in damages in Vermont, New York, and Québec. One of the hardest hit areas was along the Richelieu River, where many residents were evacuated for several weeks.

In August of 2011, Tropical Storm Irene swept through the region causing four deaths in the Lake Champlain Basin, heavy tributary flooding, and widespread infrastructure, property, and agricultural damages.


LAURA HOLLOWELL

*More intense rain storms will result in more runoff from impervious surfaces in urban areas.*

## How can we be better prepared for future floods?

*Although we can't predict when, Lake Champlain certainly will reach flood levels again. To help prevent damage both to the built and natural environments, some actions must be taken before the next major flood. Reducing construction in flood-prone areas and providing rivers with better access to their floodplains are two important steps towards flood resilience.*

Scientists have studied river dynamics for decades to better understand how rivers, shorelines, and wetlands respond to natural and human disturbances. Storms and floods can significantly alter and severely degrade these natural features. Floodplains store water and sediment at the height of the flood, and mitigate flood impacts by slowing river flow and allowing sediments and pollutants to settle outside of the normal river channel. When rivers can access their natural floodplains, as Otter Creek in the Middlebury area did following Tropical Storm Irene (Figure 26), it can significantly reduce downstream flows and resulting damage. Removing hazards from flood prone areas, increasing culvert sizes to handle higher volumes of storm water, and stabilizing eroding streambanks also help to lessen flooding impacts.

Very high lake levels due to seasonal flooding cause inundation of near-shore structures and roads and degrade shoreline areas that are ordinarily out of the reach of erosive wave action. Maintaining forested shoreline buffers where possible, limiting impervious surfaces, and making existing structures more flood-resistant where appropriate will reduce inundation, erosion, and related damage to infrastructure.

Since the 2011 floods, shoreline protection zones, floodplain hazard areas, and development standards have been redefined across the region. In municipalities, post-flood responders now have more training and better guidelines to ensure that emergency responses protect long-term ecosystem health wherever possible. The proven economic benefits of advance floodplain protection has encouraged communities to reconsider building in flood-prone areas.

New data and technologies, such as highly detailed LiDAR elevation data, have enabled far more accurate flood modeling and floodplain mapping efforts, such as that now being conducted Basin-wide by the

International Joint Commission. Stream gage data, together with improvements in weather and storm forecasts, allow residents, emergency responders, and resource managers to be better informed and prepared for the next big flood, so that both danger and damages can be minimized. Although information and preparation gaps remain, the region has made great strides towards flood resilience.


*Otter Creek floodplain*

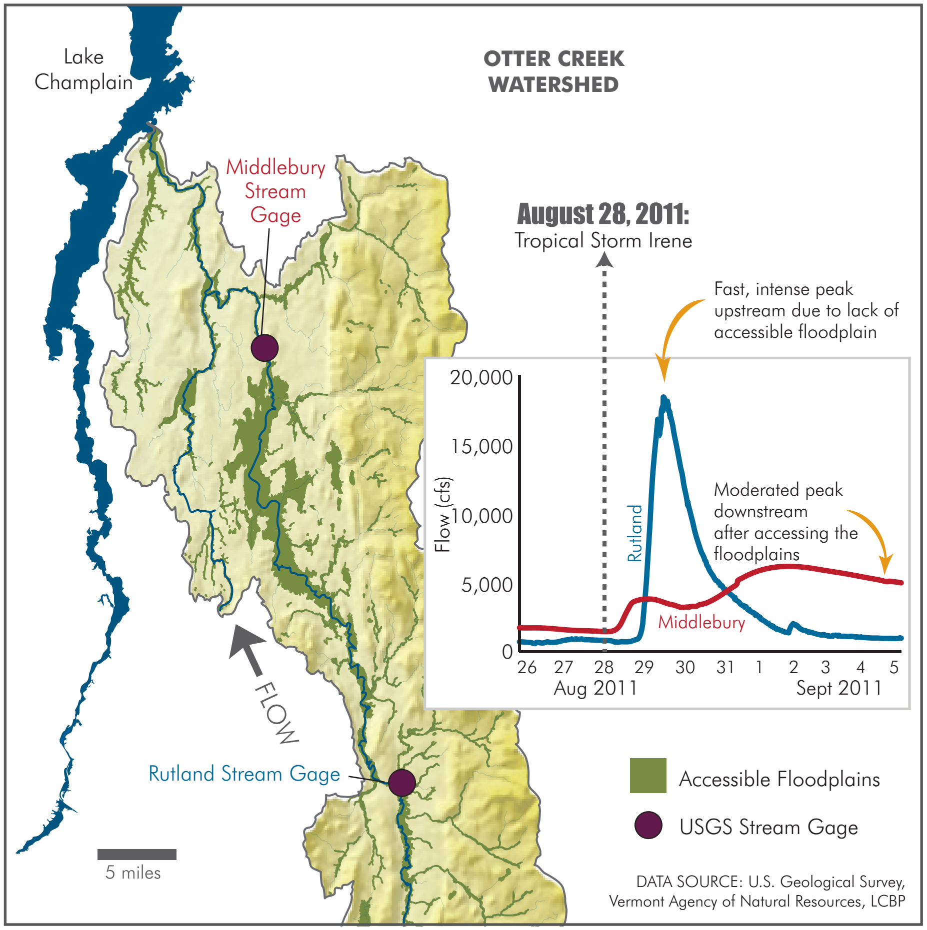



**Figure 26 | Floodplain access in Otter Creek Watershed, Tropical Storm Irene, August 28, 2011**

## Hazard Resiliency

***Oil Trains:*** Rail lines traverse both sides of Lake Champlain, including many miles of track just a few feet from the Lake's edge. The trains carry passengers, freight and, increasingly, crude oil from the Bakken shale fields. Estimates place the rate of highly volatile crude oil passing along the margins of the Lake, much of it in DOT 111 and CTC-111A tank cars ill-suited for this use, at up to 60 million gallons each week. Recent derailments and catastrophic explosion disasters in other areas have generated headlines and stories across the continent. These events highlight the need to improve the rail system, both tracks and cars, in order to reduce the risk of derailments, oil spills, and related tragic consequences.

***Outdated Infrastructure:*** The 2011 floods caused significant damage to regional infrastructure and underscored the need to update aging systems. Improvements have been made to roads and bridges in flood-prone areas by replacing washed out or badly damaged bridges and culverts with higher capacity flood-resilient structures. However, some expensive gaps remain in the flood-proofing of infrastructure for both public drinking water supply and wastewater treatment facilities in the Lake Champlain Basin. Developed areas with combined sewer overflows present a special challenge. Floodwaters in these areas sometimes exceed the capacity of storm sewer systems and are routed to wastewater treatment facilities where it is combined with sewage, exceeding the plant's capacity and resulting in a discharge of overflow into receiving waters.

***Shoreline Development:*** Increasing development pressures along the shore of Lake Champlain, coupled with significant flood damage from 2011, have raised public awareness of shoreline erosion problems. Several communities now promote more rigorous property management guidelines to improve lakeshore conservation efforts. In the interest of improved flood resilience, New York, Québec, and Vermont have updated shoreline development regulations.

***Sub-Lake Power Lines:*** Several new projects have been proposed to bury electric power lines under Lake Champlain to connect major metropolitan areas to Canadian energy hubs. One proposed line, planned for installation in the New York waters of Lake Champlain and continuing above-ground along the Hudson River, has received all necessary permits and is scheduled to be in service by the autumn of 2017. Similar transmission lines are being proposed within the Vermont waters of Lake Champlain, to carry Canadian power to the New England power grid. Assessments and reviews of these developments tend to be conducted on a case-by-case basis, but the cumulative ecosystem effects of numerous transmission line projects remains undetermined.

## How do cultural heritage and recreation **connect us** to Lake Champlain?

*The Champlain Valley possesses a trove of cultural and natural treasures that require careful stewardship so that future generations can enjoy them. The Champlain Valley National Heritage Partnership, operated by the LCBP, works to help people better understand and appreciate these resources.*

The Champlain Valley National Heritage Partnership (CVNHP) was established to preserve, protect, and interpret the historical, cultural, and recreational resources of the Champlain Valley though partnerships in New York, Québec and Vermont. Much has been accomplished since the CVNHP Management Plan was approved in May 2011. New bike routes have been established, the anniversaries of the War of 1812 and the American Civil War were commemorated, historic artifacts conserved and interpreted, several interpretive guides produced, and dozens of new wayside exhibits developed.

While much of the context of the CVNHP is focused on the region's rich history, the future conservation of the natural and cultural treasures of Lake Champlain relies on today's youth. In recent years, the focus of the CVNHP has been on programs that encourage children and young adults to better understand their community's cultural and natural heritage. In 2013, the CVNHP partnered with the National Park Service (NPS) and the Lake Champlain Maritime Museum to enhance access for underserved children to board the replica canal schooner *Lois McClure* as it traveled the interconnected waterways of the heritage area. Last year, the CVNHP awarded 11 grants for projects that involved active participation from youth in the research and interpretation of their local heritage.

LAKE CHAMPLAIN MARITIME MUSEUM

*Children aboard a Lake Champlain longboat begin their journey down Otter Creek as part of the Otter Creek Odyssey, a project funded by a 2014 CVNHP Local Heritage Grant.*

LCBP

*The Island Line Trail, once the route of the Rutland Railroad, provides a spectacular way for cyclists to experience Lake Champlain.*

These grants resulted in many noteworthy projects, including dozens of oral history documentaries made by high-school students in Bennington County. Students in Middlebury, Vermont, collected oral histories from fur trappers in a project that included the documentation and replication of vintage trapping boats. Plattsburgh youth worked with museum professionals to develop an interpretive guide for the "Old Base." Readers can learn more about other student-oriented programs on the CVNHP Facebook page.

Projects that focus on youth involvement will continue in 2015 with four new interpretive paddling routes sponsored by the CVNHP. In future years, the CVNHP will award Local Heritage grants that encourage students to explore and interpret their own communities. A generation from now, the health and integrity of the Champlain Valley's natural and cultural resources will rely on a population that appreciates, understands and values them.

Acknowledgements

**LAKE CHAMPLAIN BASIN PROGRAM TECHNICAL ADVISORY COMMITTEE**

Bill Ardren, US Fish and Wildlife Service
Kevin Behm, Addison County Regional Planning Commission
Bob Brower, NYS Department of Agriculture & Markets
Jenn Callahan, VT Agency of Transportation
Dennis Deweese, USDA, Natural Resources Conservation Service - NY
Laura DiPietro, VT Agency of Agriculture, Farms & Markets
Fred Dunlap, NYS Department of Environmental Conservation
Kevin Farrington, City of Plattsburgh
Curt Gervich, SUNY Plattsburgh
Neil Kamman, VT Agency of Natural Resources
John Kanoza, Clinton County, NY Health Department
Mark Malchoff, Lake Champlain Sea Grant
Martin Mimeault, QC Ministère du Développement durable, de l'Environnement et la Lutte contre les changements climatiques
Mario Paula, US Environmental Protection Agency, Region 2
Bernie Pientka, VT Agency of Natural Resources
Fletcher (Kip) Potter, USDA, Natural Resources Conservation Service - VT
Ed Romanowicz, SUNY Plattsburgh
Jamie Shanley, US Geological Survey
Eric Smeltzer, VT Agency of Natural Resources
Ed Snizek, Adirondack Park Agency
Jason Stockwell, University of Vermont
Jeanne Voorhees, US Environmental Protection Agency, Region 1
Michael Winslow, Lake Champlain Committee (TAC Chair)
Eric Young, Miner Institute

**SPECIAL THANKS TO:**

Students from Williston Central School, Williston, VT
Jim Fay, Champlain Water District
Liz Royer, Vermont Rural Water Association
Eric Perkins, US Environmental Protection Agency, Region 1
Brad Young, US Fish and Wildlife Service
Rachael Miller, Rozalia Project
Phillip Brett, LCBP Boat Launch Steward
Chris Smith, US Fish and Wildlife Service
Laura Medalie, US Geological Survey
Ann Bove, VT Agency of Natural Resources
Angela Shambaugh, VT Agency of Natural Resources
Dave Tilton, US Fish and Wildlife Service
*…and many others who gave input on indicators.*

The ***State of the Lake and Ecosystem Indicators Report*** was compiled by the Lake Champlain Basin Program Steering Committee and staff, with input from the researchers listed on the left and LCBP committees. The report is available online at sol.lcbp.org.

Lake Champlain Basin Program
54 West Shore Road
Grand Isle, VT 05458
(802) 372-3213
(800) 468-5227 (NY & VT)
www.lcbp.org
lcbp@lcbp.org

**STAFF SUPPORTING THE PROGRAM**

Call (802) 372-3213, unless otherwise noted
Jim Brangan - Cultural Heritage & Recreation Coordinator
Marika Dalton - Climate Change Fellow
Fred Dunlap - NY Coordinator, NYSDEC, (518) 897-1241
Colleen Hickey - Education & Outreach Coordinator
Eric Howe - Technical Coordinator
Bill Howland - Director
Kathy Jarvis - Administrative Assistant
Martin Mimeault - QC Coordinator, Québec MDDELCC, (450) 928-7607
Ryan Mitchell - Communications & Publications Coordinator
Meg Modley - Aquatic Nuisance Species Coordinator
Elizabeth Lee - Communications & Publications Associate
Mario Paula - LC Coordinator, USEPA Region 2, (212) 637-3819
Pete Stangel, VT Agency of Natural Resources
Michaela Stickney - VT Coordinator, VTANR/LCBP (802) 490-6117
Stephanie Castle - Technical Associate
Jeanne Voorhees - LC Coordinator, US EPA Region1, (617) 918-1686
Resource Room Staff: Laura Hollowell, Stephanie Larkin, Cynthia Norman (802) 864-1848

LCBP staff are employees of New England Interstate Water Pollution Control Commission

*Design: Ryan Mitchell, Elizabeth Lee, Stephanie Castle, LCBP*
*Publication Date: June 2015*
*Printed at Queen City Printers on 100% post-consumer recycled and Forest Stewardship Council certified paper.*
*The views expressed in this report do not necessarily reflect the positions of the US EPA or NEIWPCC.*

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**Visit sol.lcbp.org to read the full report, including supplemental content, and to obtain references.**

Lake Champlain
Basin Program

**Read the full *State of the Lake* report, including supplemental content, at:**

**sol.lcbp.org**