STATE OF THE LAKE

AND ECOSYSTEM INDICATORS REPORT - 2008

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 (USEPA) and other federal agencies, the New England Interstate Water Pollution Control Commission, and local government leaders, businesses, and citizen groups.

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 USEPA appropriation under the Federal Clean Water Act. Visit www.lcbp.org to learn more.

FIGURE 1 | THE LAKE CHAMPLAIN BASIN OR WATERSHED

COVER: The Missisquoi River delta in spring 2008.

CREDITS: BACKGROUND, LCBP. INSETS LEFT TO RIGHT: LCBP, LAKE CHAMPLAIN MARITIME MUSEUM, RUBENSTEIN ECOSYSTEM SCIENCE LAB, FRIENDS OF THE WINOOSKI, USFWS AND NYSDEC.

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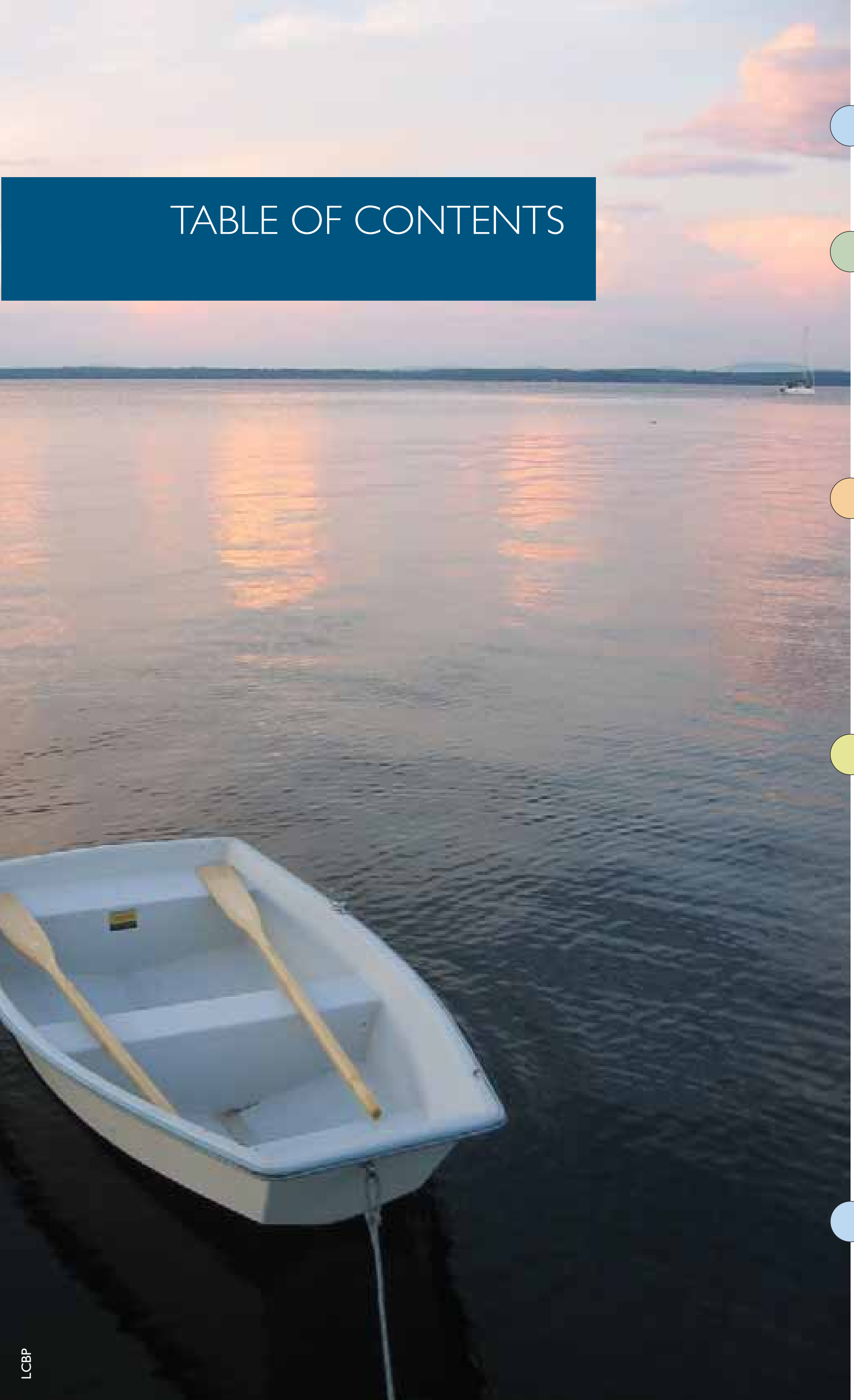
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2008
ECOSYSTEM INDICATORS SCORECARD
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WHAT IS THE **STATE OF THE LAKE** REPORT?

The Lake Champlain Basin Program (LCBP) periodically produces a *State of the Lake* report about the water quality, fisheries, wetlands, wildlife, recreation, and cultural resources of the Lake Champlain Basin. The primary purpose of this report is to inform residents about the Lake's health and provide them with a better understanding of both the problems and solutions, as well as the serious challenges that lie ahead.

LCBP

CROWN POINT'S historic bridge across Lake Champlain links New York and Vermont.

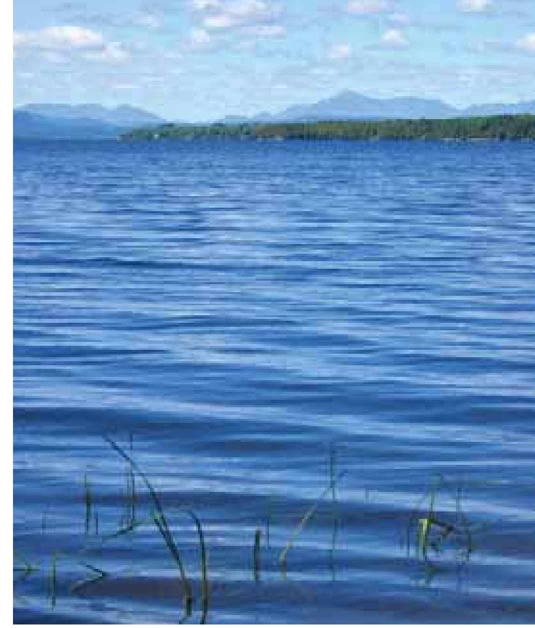
This report also is prepared for our US Senators, Patrick Leahy and Bernie Sanders (VT); Charles Schumer and Hillary Clinton (NY) and US Representatives, John McHugh, and Kirsten Gillibrand (NY) and Peter Welch (VT) who have supported Lake Champlain management through Congressional authorizations, major federal appropriations and guidance. It also is an important update for Governor David Paterson of New York, Governor Jim Douglas of Vermont, and Jean Charest, Premier of Québec, Canada, who have made vital commitments to implement *Opportunities for Action* (OFA). The *State of the Lake and Ecosystem Indicators* report provides an account of the stewardship challenges and the efforts of all partners to date for the Regional Administrators of the US Environmental Protection Agency and the other federal partners that have endorsed the implementation of OFA, and provided support for the program.

Through the seventeen year history of the LCBP, a large network of public leaders has worked together in a collaborative, nonpartisan tradition to confront cross-boundary and regional lake problems in this large watershed. Planning and implementation efforts have involved nonprofit organizations, scientists, business organizations, and the public.

This 2008 *State of the Lake* report has been expanded to include ecosystem indicators and a scorecard. An indicator provides information about the condition of the ecosystem with a set of measures that represent or "indicate" its overall state. Ecosystem indicators have been used in the Chesapeake Bay, the Great Lakes and many other watersheds. The indicators in this report were chosen with the guidance of dozens of scientists and state, provincial and federal technical experts. Please refer to the last page for the listing of the key partners.

The LCBP has adopted the Pressure-State-Response or PSR indicators framework for its indicators (figure 2). This approach has been used by many organizations around the world. In this framework, the central focus is the condition of the ecosystem or its "State." To understand why this condition exists, we also track human activities that can exert "Pressures," which can result in complex, long-term and cumulative impacts on the ecosystem. These pressures result in changes in the "State" of the ecosystem and its natural resources. Changes in the state of the environment often elicit a management "Response," such as new environmental policies or management actions. With proper management, pressures can be reduced to bring about a more desirable state of the Lake. The status of the "State" indicators also provides the basis for the scorecard on page sixteen.

Since both citizens and managers are concerned most with the "State of the Lake," in this report, the State is discussed first, related Pressures are then addressed, followed by relevant management Responses.



THE ADIRONDACK MOUNTAINS from the Northeast Arm of Lake Champlain.

PHOTOS: LCBP & USGS

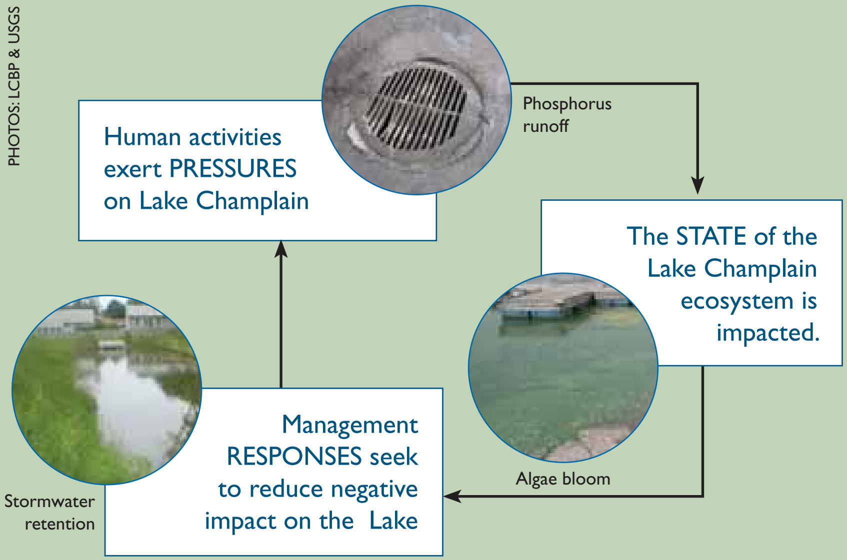
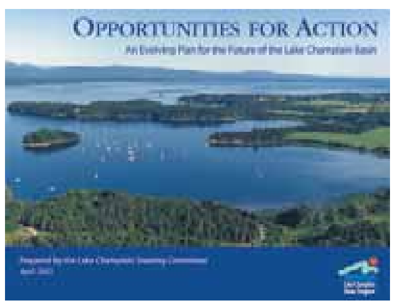


FIGURE 2 | THE PRESSURE-STATE-RESPONSE MODEL, USING URBAN RUNOFF AS AN EXAMPLE

THE LAKE CHAMPLAIN MANAGEMENT PLAN



Opportunities for Action (2003) is a management plan endorsed by the governments of New York, Vermont and Québec and by the US Environmental Protection Agency to implement a vision for a clean lake and a strong economy. The plan, developed by the Lake Champlain Basin Program (LCBP) partners after years of public input, envisions a Lake Champlain that supports multiple uses—including a healthy ecosystem and drinking water supply, wildlife habitat, recreation, and commerce. These diverse uses must be balanced to minimize stresses on any part of the Lake system. The LCBP recognizes that maintaining a vital economy which values the preservation of the agricultural sector is an integral part of the balanced management of the Lake Champlain Basin. Implementing a comprehensive management plan will ensure that the Lake and its Basin will be protected, restored and maintained so that future generations will enjoy its full benefits. The plan can be read online at www.lcbp.org.

COLLABORATION AROUND THE BASIN

Countless partners, from large federal agencies to volunteer and nonprofit watershed groups, are working hard to do their part to reduce phosphorus and other forms of pollution. Because the Lake crosses state and international borders, the LCBP was designated as the coordinating body to facilitate strategic planning across those boundaries. The comprehensive management plan, *Opportunities for Action* (OFA), provides a common road map for Vermont, New York and Québec to clean up Lake Champlain and to encourage a healthy regional economy. Each jurisdiction has developed its own implementation approach to protect and restore the Lake.

Vermont established the Clean and Clear program in 2003 and subsequently developed the Center for Clean and Clear which features a strong partnership between the Agency of Natural Resources (VTANR) and the Agency of Agriculture. The Center's initiative is to reduce phosphorus loads in the Vermont sector of the Basin, as a means of implementing the bi-state Lake Champlain Phosphorus TMDL. In New York, the Department of Environmental Conservation (NYSDEC) works with the Department of Agriculture and Markets and the State Soil and Water Conservation Districts to reduce phosphorus loads, and brings funds from the New York Environmental Bond Act to bear on infrastructure improvements. The Québec Ministry of Sustainable Development, Environment and Parks (QC MDDEP) works with other agencies, the Corporation Bassin Versant Baie Missisquoi and local farm clubs to implement its agreement with Vermont and the actions in the *2003-2009 Missisquoi Bay Action Plan*.

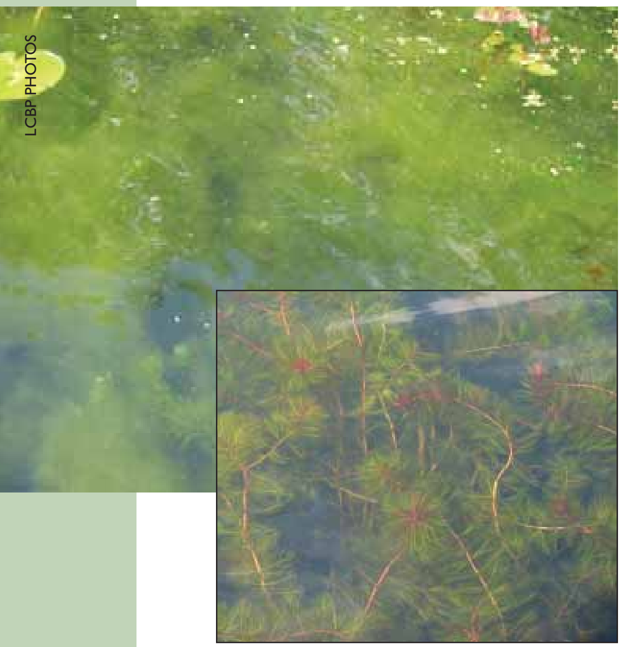
LCBP

THE LCBP works with many partners, including citizen groups and agricultural agencies to implement the annual farm award.

In addition, the LCBP collaborates through a Memorandum of Understanding with nine US federal agencies committed to Lake Champlain's cleanup through the implementation of OFA. The US Environmental Protection Agency (USEPA), Natural Resource Conservation Service (NRCS), US Army Corps of Engineers (USACE), US Geological Survey (USGS), and National Oceanic and Atmospheric Administration (NOAA) all work to implement the phosphorus pollution actions in OFA. Similarly, Lake Champlain Sea Grant, US Fish and Wildlife Service (USFWS), National Park Service and the US Forest Service bring unique research, stewardship and implementation skills to the partnership.

Public meetings and the Citizen Advisory Committees (CACs) from each jurisdiction provide public input into LCBP programs.

ARE **PHOSPHORUS LEVELS** TOO HIGH IN THE LAKE?

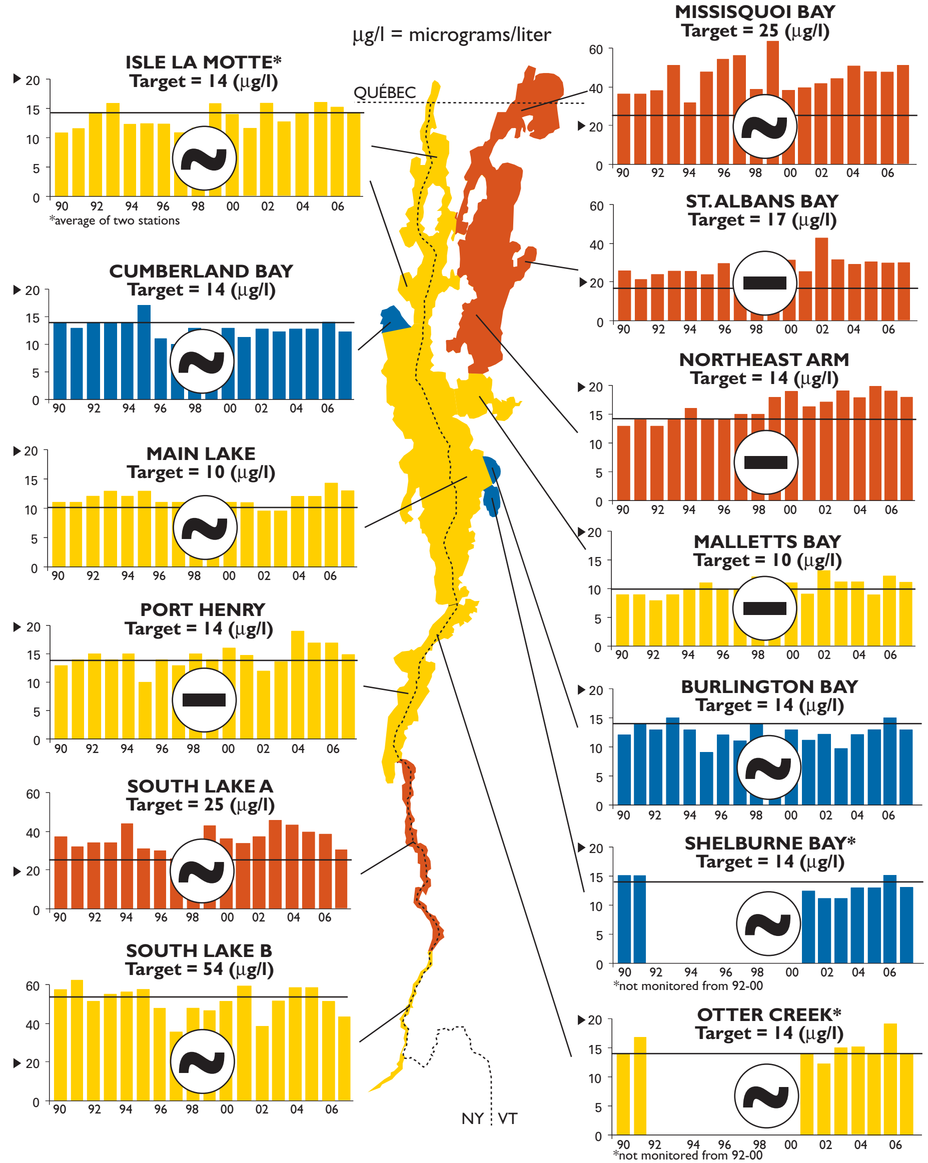


EXCESSIVE PHOSPHORUS promotes the growth of algae and aquatic plants in the Lake.

Yes, phosphorus levels are still too high in most parts of Lake Champlain. Missisquoi Bay, South Lake and the Northeast Arm continue to exceed the established targets. However, the Main Lake and Malletts Bay are at or near targets.

The target phosphorus levels in Lake Champlain are specified in water quality standards agreed to by New York, Vermont and Québec and incorporated in a Total Maximum Daily Load (TMDL) plan. The plan was developed by Vermont and New York in 2002 to meet the requirements of the USEPA and the Clean Water Act. Phosphorus is an essential nutrient that, when in excess, negatively impacts water quality by promoting too much plant and algae growth. When this occurs, other aquatic organisms are impacted by the reduced sunlight and the lower oxygen levels that develop as the organic material decomposes. Dense plant mats and algae blooms also interfere with the recreational use and enjoyment of the Lake (see sidebar).

The LCBP has funded long-term monitoring of phosphorus and other water quality indicators since 1992.



STATUS		TREND	
GOOD	Met target at least 4 times in the past 5 years	+	Improving: phosphorus is decreasing
FAIR	Met target 1-3 times in the past 5 years	~	No trend: neither improving nor deteriorating
POOR	Never met target in the past 5 years	−	Deteriorating: phosphorus is increasing

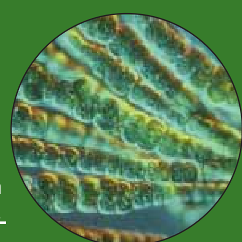
NOTE: The trend data is based on a long-term statistical analysis of the years 1990-2007.
DATA SOURCE: LCBP/Vermont ANR Lake Champlain Long-Term Monitoring Program.

FIGURE 3 | PHOSPHORUS CONCENTRATIONS IN LAKE CHAMPLAIN, STATUS AND TRENDS

Monitoring data identify phosphorus levels and trends in the Lake over time. In Figure 3, segments that have failed to meet targets in the last five years are shown in red, segments that almost always meet targets are blue, and those in yellow sometimes meet targets but are not consistent. Long-term trends show how phosphorus concentrations have changed since monitoring began in 1991. Those segments that are deteriorating over time because of increasing phosphorus levels are shown with a minus sign. Most segments have no statistically significant trend, as shown by the tilde and no segments are improving. While long-term trends are important because they smooth out the effects of short-term variations, data over the past few years suggests recent short-term improvements in phosphorus concentrations in a few segments and increasing concentrations in others.

Phosphorus from the surrounding landscape is carried to the Lake primarily by rivers and smaller tributaries. Figure 4 shows the phosphorus load to each of the lake segments in 2007 from wastewater treatment plants (WWTPs) and the average phosphorus load between 2000 and 2006 from nonpoint sources (based on monitored tributary data). WWTP loads have steadily decreased since 1990. Although some facilities are not yet meeting individual allocation goals, almost all lake segments meet TMDL targets for discharges. One exception, the Port Henry (NY) watershed, is expected to meet targets soon, since a new treatment plant was built in 2007. Trends for WWTP loads are improving (shown by a plus sign) both lake-wide (figure 8, page 9) and in each of the five major lake segments. Nonpoint source loads significantly exceed targets in at least four of the five major

THE LINK BETWEEN PHOSPHORUS AND BLUE-GREEN ALGAE



VTDEC

CYANOBACTERIA

Blue-green algae or cyanobacteria are part of the phytoplankton community in Lake Champlain (the microscopic plant portion of the food web). While cyanobacteria obtain energy through photosynthesis like green plants, it is otherwise a very primitive organism that has existed for billions of years. Despite the fact that they occur worldwide, the factors that drive nuisance cyanobacteria blooms are not fully understood. Weather patterns (including wind and cloud cover), water temperature, and changes to the food web from invasive species may all play a part. However, an important component in fueling blooms is nutrients. Both phosphorus and nitrogen, and possibly the ratio between the two, appear to create favorable conditions for blooms. More research is needed to clarify the role of both nitrogen and phosphorus in cyanobacteria blooms. Managing sources of phosphorus and other nutrients in the Basin will help to reduce the frequency of cyanobacteria blooms.

FIGURE 4 | PHOSPHORUS LOADS TO LAKE FROM NONPOINT SOURCES AND WASTEWATER PLANTS (WWTPs) IN METRIC TONS/YEAR

LAKE SEGMENT WATERSHED	NONPOINT		WWTPs		TOTAL		*Reduction*
	Load	Target	Load	Target	Load	Target	*Needed**
Main Lake (VT)	138.9	51.3	9.5	25.3	148.4	76.6	*71.8*
Main Lake (NY)	66.7	29.5	2.8	4.2	69.5	33.7	*35.8*
Otter Creek (VT)	123.3	44.1	3.8	12.0	127.1	56.1	*71.0*
Isle La Motte (NY)	32.7	18.9	2.2	3.4	34.9	22.3	*12.6*
Isle La Motte (VT)	⊘	0.2	0.0	0.1	⊘	0.3	⊘
Shelburne Bay (VT)	9.5	10.0	0.6	2.0	10.0	12.0	*0*
Burlington Bay (VT)	⊘	1.4	2.8	4.4	⊘	5.8	⊘
Port Henry (VT)	⊘	0.1	0.0	0.0	⊘	0.1	⊘
Port Henry (NY)	⊘	2.5	1.7	0.9	⊘	3.4	⊘
Cumberland Bay (NY)	19.9	8.1	14.8	17.1	34.7	25.2	9.5
MAIN LAKE TOTALS	**391.0**	**166.0**	**38.1**	**69.5**	**424.6**	**235.5**	***189.1***
MISSISQUOI BAY TOTALS*	**198.7**	**93.0**	**2.6**	**4.2**	**202.3**	**97.2**	***105.1***
South Lake B (NY/VT)	91.1	41.2	1.9	3.5	93.0	44.7	*48.3*
South Lake A (NY)	⊘	3.3	5.6	7.9	⊘	11.2	⊘
South Lake A (VT)	⊘	0.4	0.0	0.2	⊘	0.6	⊘
SOUTH LAKE TOTALS	**91.1**	**44.9**	**7.6**	**11.6**	**93.0**	**56.5**	**36.5**
MALLETTS BAY TOTALS	**54.8**	**25.4**	**2.0**	**3.2**	**56.8**	**28.6**	**28.2**
Northeast Arm (VT)	⊘	1.2	0.0	0.0	⊘	1.2	⊘
St. Albans Bay (VT)	⊘	5.2	0.9	2.8	⊘	8.0	⊘
NORTHEAST ARM TOTALS	⊘	**6.4**	**0.9**	**2.8**	⊘	**9.2**	⊘

NONPOINT STATUS

- GOOD — Average load met TMDL target
- FAIR — Average load exceeded target by less than 25%
- POOR — Average load exceeded TMDL target by greater than 25%

WWTPs STATUS

- GOOD — Load met TMDL target
- FAIR — Load exceeded target by less than 10%
- POOR — Load exceeded TMDL target by greater than 10%

⊘ Data not available (No tributaries monitored in segment during 2000-2006, or less than 75% of area monitored.)

NOTES: Nonpoint loads are averaged over water years 2000-2006; wastewater loads are for calendar year 2007. Nonpoint load estimates include extrapolations for unmonitored portions of lake segment watersheds. South Lake B (VT/NY) and Missisquoi Bay (VT/QC) segments were combined because of shared tributaries. The Missisquoi Bay WWTP load and target are for VT only. The reduction needed is an approximation.
DATA SOURCE: Longterm monitoring program (LCBP, VTANR, NYSDEC).

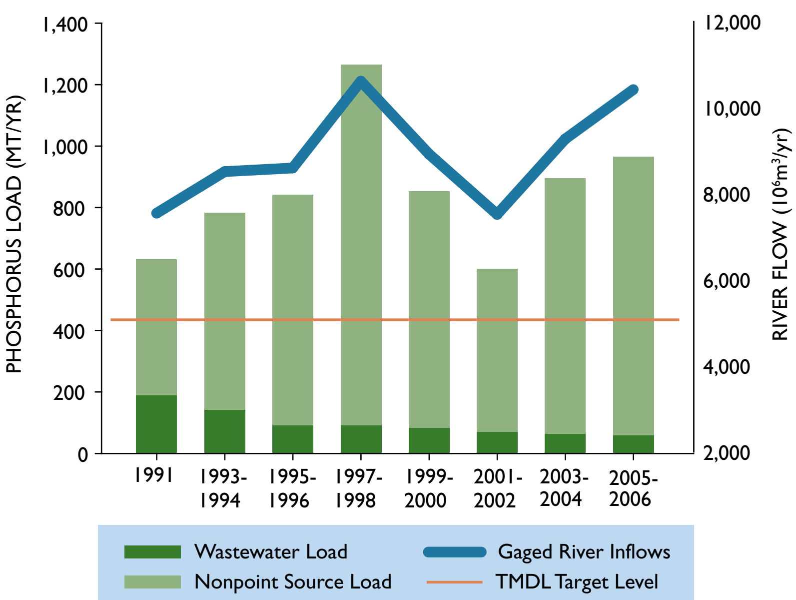
See pages 12-15 for information about human health concerns and cyanobacteria.

lake segments. No data is available for the Northeast Arm because no tributaries are currently monitored in that watershed. Funding for a new stream gauge for a St. Albans Bay tributary was recently provided by the LCBP, so data will be available in the future.

Nonpoint source loads are directly associated with greater amounts of precipitation and runoff during the last several years (figure 5). This is an important factor when considering phosphorus loading trends. If natural variations in stream flow caused by precipitation are considered in a long-term statistical analysis (1990-2006), twelve of the eighteen monitored tributaries have no significant trend (neither improving nor deteriorating) in flow-adjusted phosphorus load. Three tributaries are improving: the Winooski River, LaPlatte River and Otter Creek, and two are deteriorating: Lewis Creek and Putnam Creek. This reflects the combined effects of nonpoint and WWTP loads to tributaries. Data was not available for the same time period in Québec, but the flow-adjusted phosphorus contribution from the Pike River was decreasing as of 2004.

Other factors that contribute to higher nonpoint source loads include the conversion of agricultural and forest land to developed land, inadequate implementation of Best Management Practices (BMPs) on farms and in urban areas, and stream erosion (see Wetlands and Rivers, page 11). Although nonpoint loads greatly exceed TMDL targets, it is important to note that in-Lake concentrations (figure 3) have not increased by the same proportion. This is partially due to the fact that during high flow years the Lake volume is expanded, providing increased capacity to assimilate more phosphorus load.

FIGURE 5 | TOTAL PHOSPHORUS LOAD TO LAKE CHAMPLAIN COMPARED TO RIVER FLOW



DATA SOURCE: LCBP/Vermont ANR Lake Champlain Long-Term Monitoring Program.

SPRING FLOODING where sediment-laden Dead Creek joins Otter Creek in April 2008.

WHAT **CONTRIBUTES PHOSPHORUS TO THE LAKE** AND **ITS TRIBUTARIES**?

FRIENDS OF THE WINOOSKI

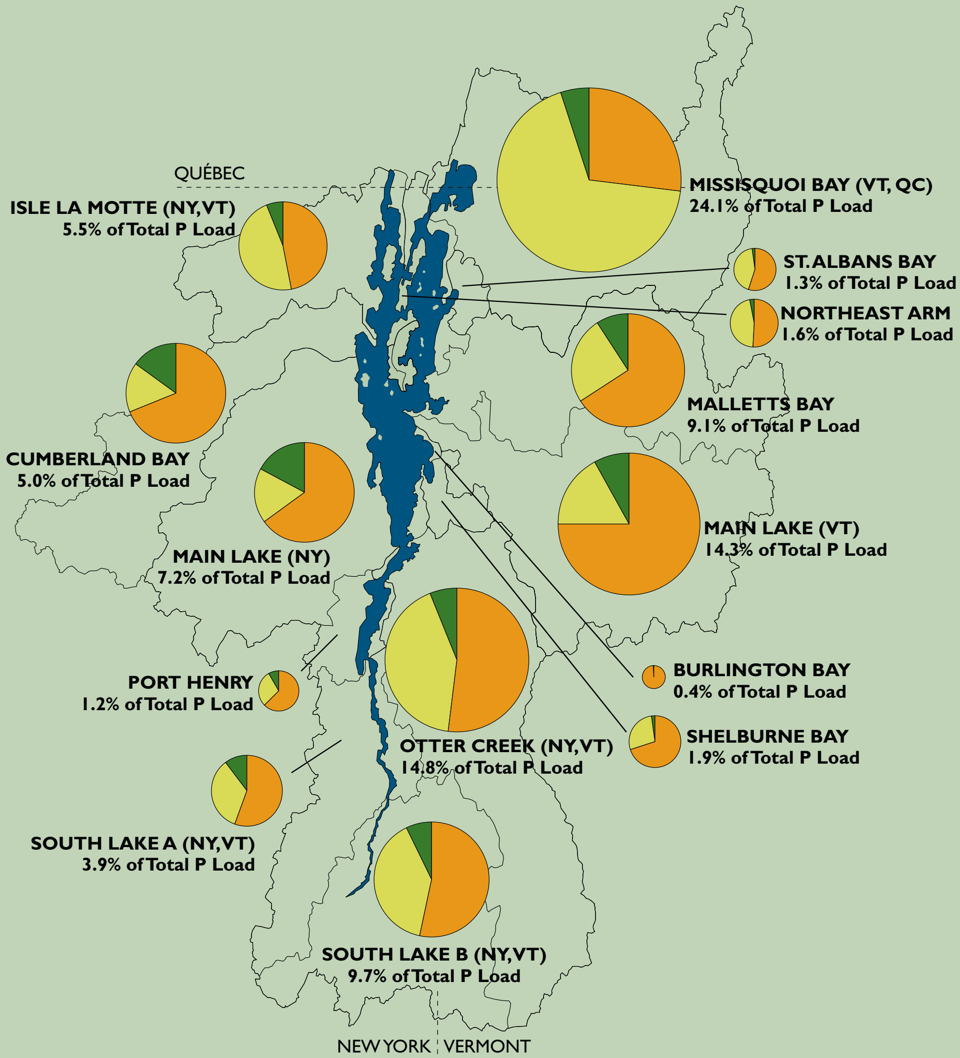
VOLUNTEERS FROM THE FRIENDS OF THE WINOOSKI planting trees along the river to reduce the flow of phosphorus to the Lake.

Point sources, mainly wastewater treatment plants, and nonpoint source runoff from the landscape contribute phosphorus to the Lake. Runoff includes fertilizers, manure, sediments, and human and pet waste.

Point sources, such as industrial discharges and sewage treatment plants have been dramatically reduced and now contribute less than 10% of the total phosphorus load to the Lake. However, even though wastewater treatment permits restrict the amount of phosphorus that can be discharged, a number of large plants are currently discharging below their permitted capacity and loads may increase as new development occurs. Runoff from non-point sources contributes the remaining 90% of the total phosphorus load. This includes runoff from impervious surfaces such as roads, rooftops and other devel-opments, storm drains, fertilized lawns, eroding riverbanks, manure and other farm agricultural runoff.

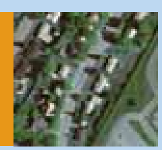
A 2007 study funded by the VTANR estimated phosphorus loads from three different types of land use in the Basin. On an acre for acre basis, developed land contributes up to four times more phosphorus than agricultural land and seven times more than forests. As popu-lation increases and other land use types

FIGURE 6 | ESTIMATED NONPOINT SOURCE PHOSPHORUS LOADING BY LAND USE TYPE

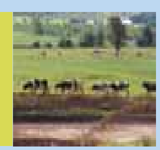


LAND USE TYPES

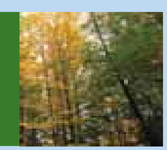
DEVELOPED
All roads, cities, suburbs, lawns and large-lot buildings.



AGRICULTURE
Crop and livestock production.



FORESTED
Areas covered primarily with trees.



NOTE: The land use data is from 2001 satellite imagery— the most recent comprehensive and complete data for this region.
DATA SOURCE: Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading. LCBP Technical Report #54. May 2007. Page 45, Table 2-11.

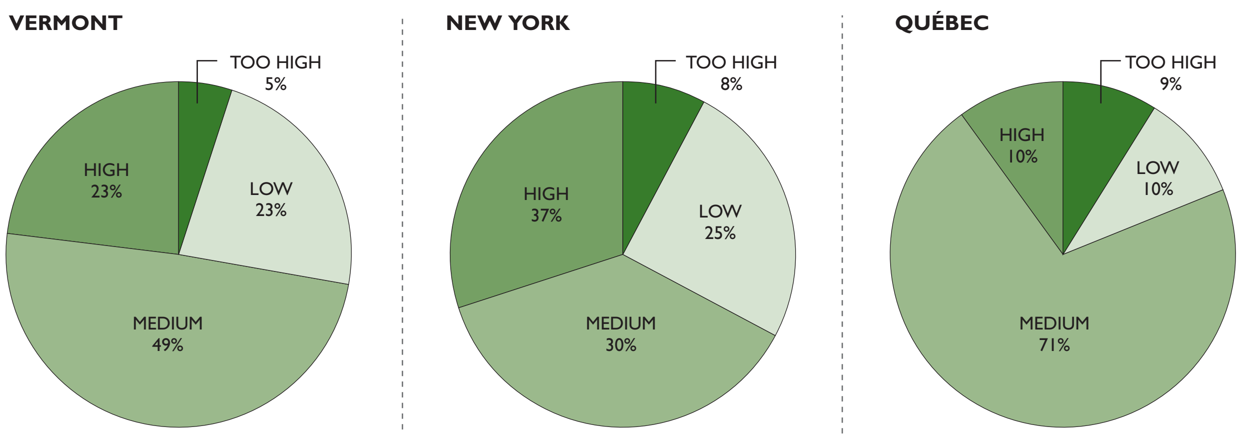
are converted to development, phosphorus loads will continue to rise unless effective management action is taken to mitigate the increased runoff.

The study estimated that in 2001, developed land contributed about 46% of the phosphorus runoff basin-wide to Lake Champlain and agricultural lands contributed about 38%. These proportions, however, vary greatly among the various sub-watersheds. For example, developed land is the largest contributor to phosphorus in Burlington Bay (99%) and Cumberland Bay (69%), but agricultural land contributes the majority of the phosphorus load to Missisquoi Bay (over 70%). Figure 6 shows the estimated loads by land use in each lake segment. The relative size of the pie chart is proportional to the overall load entering the Lake.

Some homeowners use fertilizer to promote healthy lawns. Farmers also apply manure and other fertilizers to fields to promote crop growth. These practices in urban, suburban and farm settings can increase phosphorus runoff to the Lake. As part of nutrient management planning on farms, soil samples should be taken on fields to determine the level of soil phosphorus, which has the potential make its way into the Lake when it rains. Soil tests also track the buildup of phosphorus over time. Figure 7 shows that while some farm fields have acceptable phosphorus levels (medium in Vermont and medium or high in New York), approximately 5% in Vermont, 8% in New York, and 9% in Québec are considered too high. Agricultural management practices for water quality are aimed at reducing the percent of fields in some of the high and all of the too high categories.

ROOFS, ROADS AND PARKING LOTS speed up the flow of rain, which washes pollutants into waterways and stormdrains.

FIGURE 7 | PHOSPHORUS LEVELS IN AGRICULTURAL SOILS IN THE CHAMPLAIN BASIN



NOTES: For VT, 2,873 samples were collected from the Otter Creek, Winooski, Champlain direct, Lamoille, and Missisquoi watersheds from 2003-07 and analyzed with the Modified Morgan test (phosphorus PPM). For NY, 2,614 samples were collected from Essex, Clinton and Washington Counties from 2002-06 (some land outside Basin) using Morgan extraction test (phosphorus lbs/acre). For QC, 2,863 samples were taken from Missisquoi Bay area municipalities (some land outside Basin) using a mean soil P test (Mehlich-3) for 1995-2001 (phosphorus kgs/ha). SOURCES: VT Agency of Agriculture, Cornell Nutrient Analysis Laboratory, Québec Ministry of Agriculture, Fisheries and Food and IRDA.

WHAT IS BEING DONE TO **REDUCE PHOSPHORUS** FROM ALL SOURCES?


USGS

STORMWATER RETENTION PONDS, such as this one on Englesby Brook in South Burlington slow the flow of rain and trap pollutants.

In addition to wastewater treatment plant upgrades, Best Management Practices or BMPs are used on forested, developed and agricultural lands to reduce phosphorus runoff. Some BMPs are required by law, while others are voluntary and rely on the efforts of informed and caring citizens and landowners.

Significant phosphorus reductions have been gained from WWTP improvements. In early 2008, Québec committed over $9 million for three new treatment plants in the Pike River watershed. Since 2005, upgrades have been made in Westport, Port Henry and Lake Placid, New York. In Vermont, the Lake Champlain TMDL extended phosphorus removal requirements to five aerated lagoon plants; three upgrades are complete and two are in the preliminary engineering stages. Figure 8 shows reductions and trends from WWTPs in the Basin since 1990. As of 2007, these sources (in aggregate) met TMDL requirements in each of the major lake segments.

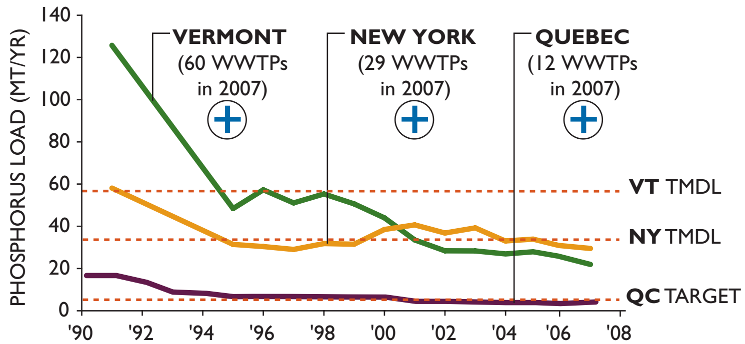
For nonpoint sources from developed land, urban BMPs such as stormwater retention ponds and ditch remediation mitigate runoff from impervious surfaces. Programs exist to help communities reduce the impacts of developed land on water quality. Some municipalities in the Basin have town plans that address water quality protection through zoning regulations, such as setbacks from streams and buffers. Several watersheds have been federally listed as impaired by stormwater, including twelve in Vermont and seven in New York. Programs are in place to require permits for new construction sites and to update expired permits in these areas. A relatively new approach to urban water quality is to create a stormwater utility, which uses revenue from user fees to maintain and improve a stormwater management system. Currently, the only stormwater utility in the Basin is in South Burlington, Vermont.

For agricultural nonpoint sources, all "Concentrated Animal Feeding Operations" (CAFO) farms in New York and all "Medium and Large Farm Operations" in Vermont must have permits. These farms are defined by the number of animals and the amount of waste

DON'T "P" ON YOUR LAWN


LCBP

In 2007, the LCBP began working with several organizations to encourage local residents to test their lawn and switch to zero-phosphorus (P) lawn fertilizer. In the first summer, more than 5,500 brochures were distributed; displays were posted at lawn and garden shows; and the campaign was covered by newspapers and television stations. More than 30 local stores have committed to selling zero-P products. The Vermont Agency of Agriculture also featured the "Don't P" slogan in its public service announcements. Learn more on www.lawntolake.org.



NOTES: The Québec target is an estimate based on the VT/QC agreement for Missisquoi Bay. DATA SOURCE: NYSDEC, VTDEC AND QC MDDEP.

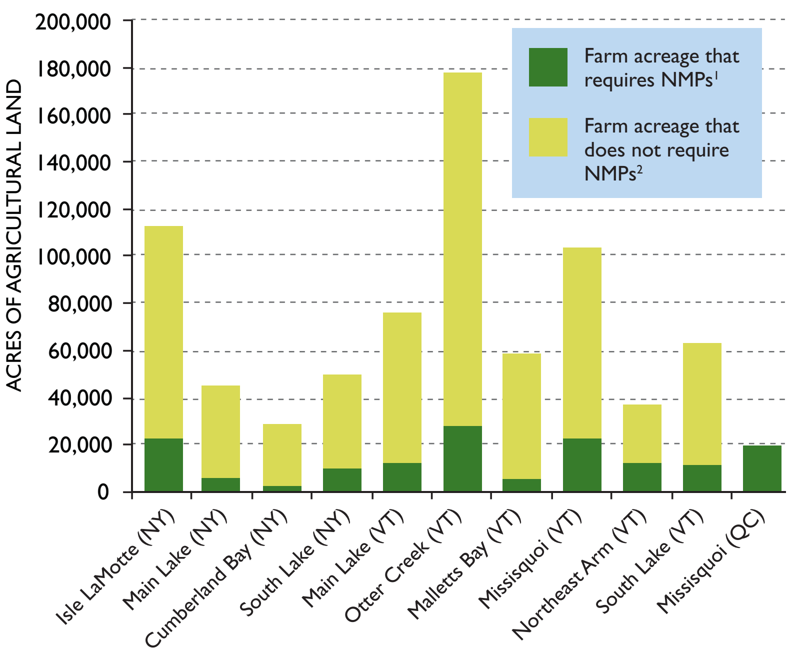
FIGURE 8 | PHOSPHORUS LOAD FROM WASTEWATER TREATMENT PLANTS TRENDS, 1990-2007

TREND (1990-2007)

Improving: phosphorus is decreasing

they generate. For example, Vermont regulations apply to farm operations with over 200 mature dairy cows. The permits require farms to develop nutrient management plans (NMPs) and prevent pollution discharge into waterways by installing BMPs such as manure pits, milk house runoff treatment and stream buffers. In Québec, virtually all farms must have a nutrient management plan. Figure 9 shows the total farm acreage and the amount of acreage that is required to have NMPs for each lake segment watershed. In addition, many small farms voluntarily have NMPs in place (see sidebar). Studies by IRDA in the Pike River watershed in Québec showed that BMPs such as cover crops, runoff control structures, buffers and incorporating manure into soil on fields results in a drop in phosphorus load from agricultural areas.

FIGURE 9 | FARM ACREAGE REQUIRING NUTRIENT MANAGEMENT PLANS (NMPs)



NOTES: 1) In NY, NMPs are required on medium and large sized "CAFO" farms. In VT, NMPs are required on medium and large farm operations (MFOs and LFOs) as of March 2008. All farms in Québec are required to have NMPs. 2) Voluntary NMPs may be in place (see sidebar). DATA SOURCES: NYS Department of Agriculture and Markets, VT Agency of Agriculture and Québec Ministry of Agriculture, Fisheries and Food.

INCENTIVES TO REDUCE POLLUTION FROM AGRICULTURAL SOURCES

Many Best Management Practices (BMPs) are aimed at reducing phosphorus pollution from farms. Because larger farms are regulated, some programs target small unregulated operations while others cover farms of all types and sizes. Federal funds from the Natural Resources Conservation Service (NRCS) help share the cost of these programs and both states supply matching funds. New York and Vermont also provide incentive grants to develop NMPs, manure storage pits and other structures, and additional pollution reduction practices.

In Québec, federal funds were awarded in 2008 to establish contiguous nine-meter agricultural buffers in the Pike River watershed and local agroenvironmental clubs provide nutrient management plans to farmers. The Champlain Watershed Improvement Coalition of New York (CWICNY) recently received over $1 million from the USEPA's Targeted Watershed Grant program to combat nonpoint source pollution, some of which will be used for agricultural BMPs. In Vermont, the Farmers' Watershed Alliance in the Missisquoi Bay area provides farmer-to-farmer education and technical assistance. The LCBP has funded a University of Vermont Extension project to work with farmers to write their own water quality plans and also is funding a project to develop voluntary NMPs on small farms in the Missisquoi watershed with International Joint Commission funds.

LCBP

MANY FARM BMPs, such as this aerator that was purchased by the Farmers' Watershed Alliance and fencing cows away from streams, can reduce phosphorus runoff.

LCBP

CLIMATE CHANGE & THE STATE OF THE LAKE

M. KLONICK

Lake Champlain is affected by many factors from outside the Basin and often beyond local control. Global climate change is expected to have a significant impact on Lake Champlain; however, the full range of potential effects is not well understood. Changes in precipitation patterns in the Northeastern US, with more and heavier rain in the late winter and spring, would increase nonpoint source runoff, carrying more nutrients, toxins and sediment to the Lake.

Since the last century, the number of days of ice cover on Lake Champlain has decreased significantly. Ice cover provides protection for some species and also helps to moderate Lake water temperature. Milder winters can impact a wide variety of organisms. Some sensitive species may not be able to adapt to temperature changes, while for others, thermal stress may increase vulnerability to pests and disease. Climate change also threatens biodiversity by changing the distribution of plant and animal habitats and may allow some invasive species to expand their range, further altering the ecosystem.

As global pressure mounts to find renewable energy sources, the demand for corn for ethanol has increased. If corn crop production is maximized, water quality may suffer from the consequences of increased field cultivation and drainage, reduction of riparian buffers and increased fertilizer use.

LCBP

WETLANDS AND RIVERS

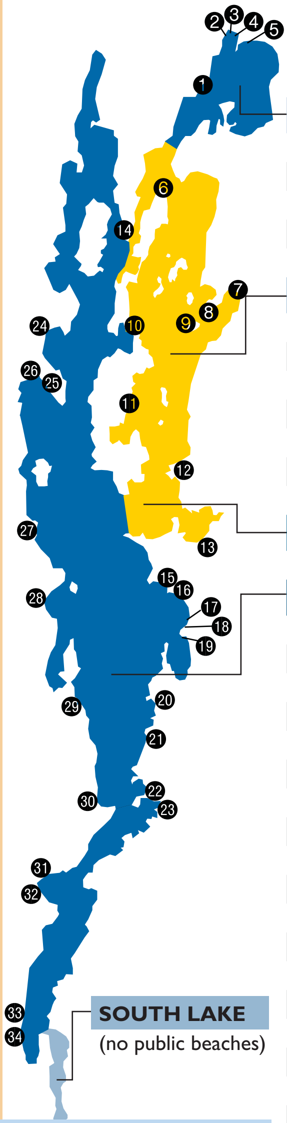
Wetlands and stable riverbanks not only provide important habitat for many species, they also slow runoff, retain and filter sediments, and naturally absorb phosphorus and other pollutants. Rivers are dynamic systems that need to be connected to their floodplains and adjacent wetlands in order to reduce pollution and provide critical habitat.

Streambank erosion and sediment transport from channelized rivers, however, can negatively impact water quality by sending nutrient laden sediment downstream to Lake Champlain—a significant source of phosphorus loading. Furthermore, poor land-use practices such as deforestation and wetland draining that occurred decades or even centuries ago has increased sediments stored in floodplains. Erosion and scouring of stream banks delivers these “old” sediments to the Lake. Research on these soils is ongoing at the University of Vermont.

The Nature Conservancy continues to partner with the LCBP, the states of Vermont and New York, the USFWS and others to identify valuable wetlands and identify funding sources to permanently protect these areas. In 2006, the VTANR developed a more detailed list of Vermont wetlands prioritized for restoration in the Lake Champlain Basin.

The MDDEP and their partners in Québec have protected over 2,200 acres on 15 sites in the Missisquoi Bay watershed since 2002. Local watershed and sportsmen groups are also important partners, developing working relationships with wetland and streambank landowners interested in reducing erosion and improving wildlife habitat. These groups also provide volunteers to complete streambank plantings and bank stabilization projects. The Vermont River Management Program addresses the planning, protection and restoration of riverbanks to ensure natural floodplain processes that encourage river stability. The Vermont Rapid Geomorphic Assessment protocol is a national model that is being adopted by local watershed groups in Vermont and New York.

FIGURE 10 | DAYS OF PUBLIC BEACH CLOSURES DUE TO COLIFORM BACTERIA



	MISSISQUOI BAY	2006	2007	BACTERIA TESTING
1	Plage Miller	▲	0	no testing
2	Plage Champlain	▲	0	no testing
3	Plage Kirkland	▲	0	1-4 times/season
4	Plage Venise	▲	0	no testing
5	Plage Missisquoi	▲	0	no testing
	NORTHEAST ARM	**2006**	**2007**	
6	North Hero State Park	1	3	1 time/week
7	St. Albans Town Beach	▲	3	1 time/week
8	Kill Kare State Park	1	3	1 time/week
9	Burton Island State Park	0	0	1 time/week
10	Knight Point State Park	2	1	1 time/week
11	Grand Isle State Park	0	0	1 time/week
12	Sand Bar State Park	2	3	1 time/week
	MALLETTS BAY	**2006**	**2007**	
13	Bayside Beach	0	7	2 times/week
	MAIN LAKE	**2006**	**2007**	
14	Alburg Dunes State Park	0	2	2 times/week
15	Leddy Beach	0	0	2 times/week
16	North Beach	0	0	2 times/week
17	Blanchard Beach	◆	0	2 times/week
18	Cove Beach	0	0	2 times/week
19	Red Rocks Park Beach	2	1	2 times/week
20	Shelburne Town Beach	4	1	2 times/week
21	Charlotte Town Beach	0	0	1 time/week
22	Kingsland Bay State Park	NA	1	1 time/week
23	Ferrisburgh Town Beach	0	0	no testing
24	Point Au Roche State Park	0	0	1 time/week
25	Cumberland Bay State Park	1	2	1 time/week
26	Plattsburgh Municipal Beach	1	1	2 times/month
27	Ausable Point State Beach	0	0	1 time/season
28	Port Douglas Beach	0	0	1 time/month
29	Noblewood Park Beach	◆	0	1 times/season
30	Essex Town Beach	◆	◆	(not open)
31	Westport Beach	◆	◆	(not open)
32	Ballard Park Beach	0	0	1 time/season
33	Port Henry Municipal Beach	0	0	1 time/season
34	Bulwagga Bay Beach	0	0	1 time/season

NOTES: Public beach closure data was collected for the summer season, June through Labor Day. ▲ = In 2006, all Missisquoi Bay beaches were closed all season and St. Albans Town Beach was closed twice due to blue-green algae (cyanobacteria). ◆ = Beach was not officially open or was closed for reasons other than bacteria and blue-green algae for the entire season. NA = No data available.

LAKE SEGMENT STATUS FOR 2007

GOOD Any beach in the segment is closed between 0-2 days

FAIR Any beach in the segment is closed between 3-7 days

POOR Any beach in the segment is closed 8 days or more

LAKE SEGMENT TREND

No trend data is available

IS IT **SAFE TO SWIM** IN LAKE CHAMPLAIN?

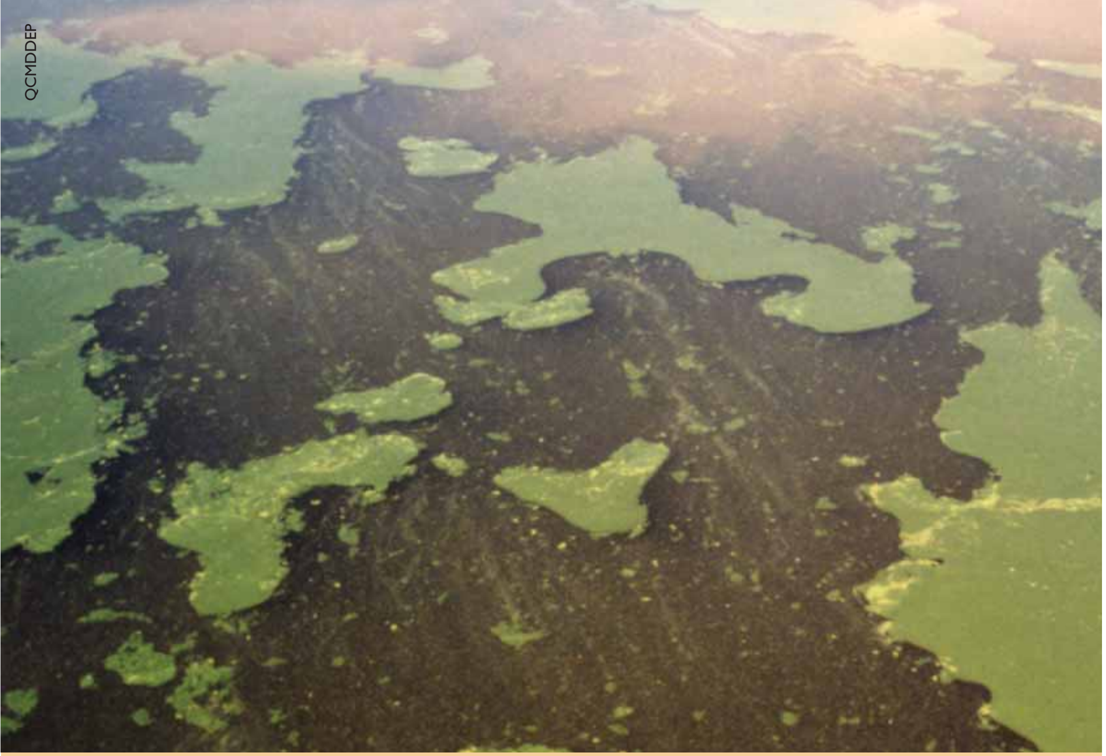
The Lake's water quality is usually safe for swimming and pathogens are often not high enough to warrant closing public beaches. Cyanobacteria (blue-green algae) blooms, however, periodically pose a risk in some areas. People using unmonitored areas, especially near river mouths and stormwater discharges are advised to avoid swimming after rainstorms.

The most widespread human health risk for swimming worldwide is pathogen contamination. Pathogens are disease-causing agents, such as bacteria, viruses and parasites that can create gastrointestinal illness when ingested. Public beaches on Lake Champlain are tested for coliform bacteria because it is an indicator that human or animal waste is in the water.

Although New York, Vermont and Québec use different standards for closing beaches, Figure 10 shows that in 2007 there were relatively few public beach closures due to pathogens and all segments were scored either good or fair. Surveys of Lake users determined that more than seven days of closures on average is unacceptable, and this criterion was used to determine the *poor* ranking.

LCBP

ALBURG DUNES STATE PARK



QCMDDEP

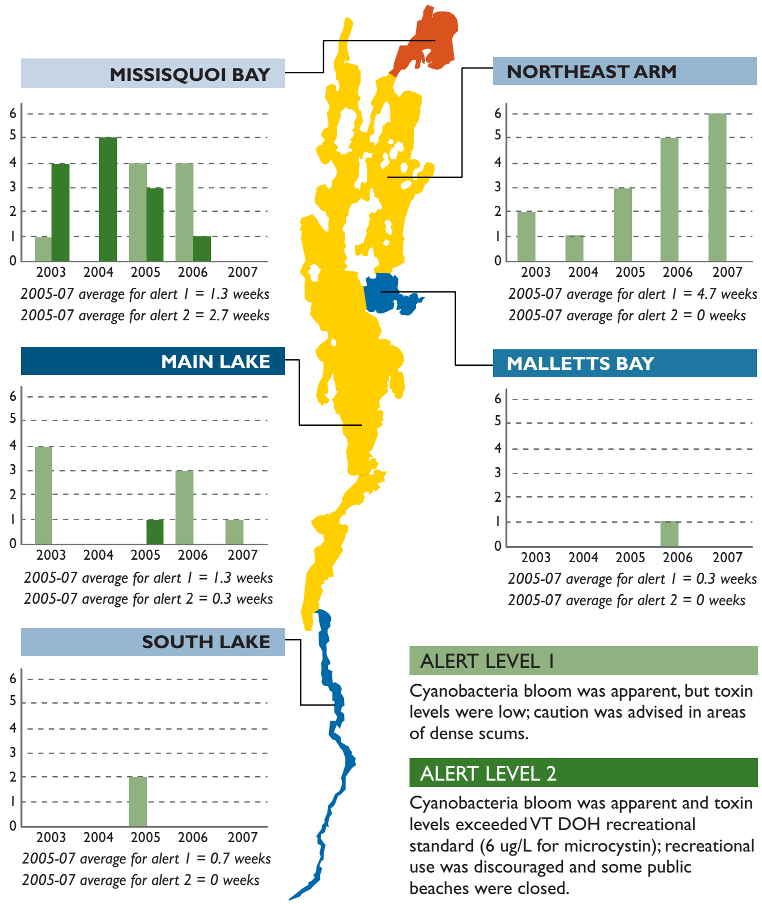
A DENSE CYANOBACTERIA bloom on Missisquoi Bay.

The survey also determined that users were negatively impacted by three or more days of closure, which determined the split between *good* and *fair* rankings. When beaches do close it is often after a heavy rain, when pollutants from the landscape wash into rivers and the Lake. Therefore, it is suggested that swimmers avoid areas near river mouths and stormwater outfalls after rainstorms.

Cyanobacteria, commonly known as blue-green algae, are a normal part of Lake Champlain biology. High densities of blue green algae, called blooms or scums have increased worldwide in recent years and nuisance blooms were recognized as a problem in the Lake in the late 1990s. When blue-green algae densities are high, the algae can produce toxins that cause gastrointestinal problems, skin irritation, and other symptoms. Blooms have occurred most frequently in Missisquoi Bay, St. Albans Bay and several smaller northeastern bays. Most of the Lake, however, has never had dense blooms or high levels of toxins.

Figure 11 shows the number of weeks of algae blooms by lake segment from 2003-2007 for June through September. Although cyanobacteria blooms forced Québec beaches to close all season in 2006, closures or dense blooms did not occur there in 2007 until September. When ranked for the average number of alerts for the past three years (2005-2007), however, Missisquoi Bay receives a poor status. All other segments are either fair or good.

FIGURE 11 | WEEKS OF CYANOBACTERIA (BLUE-GREEN ALGAE) BLOOMS AT ALERT LEVELS



ALERT LEVEL 1

Cyanobacteria bloom was apparent, but toxin levels were low; caution was advised in areas of dense scums.

ALERT LEVEL 2

Cyanobacteria bloom was apparent and toxin levels exceeded VT DOH recreational standard (6 ug/L for microcystin); recreational use was discouraged and some public beaches were closed.

LAKE SEGMENT STATUS*

GOOD The segment averaged less than one week at alert levels 1 or 2.

FAIR The segment averaged more than one week at alert level 1 and less than one week at alert level 2.

POOR The segment averaged more than one week at alert level 2.

*Averages were calculated for 2005-07 for the months of June - September.

LAKE SEGMENT TREND

No trend data is available

NOTE: Missisquoi Bay data is for locations in Vermont only.
DATA SOURCE: UVM Rubenstein Ecosystem Science Laboratory cyanobacteria monitoring and evaluation program and LCBP Technical Report #s 51,52,53,and 55.

WHAT CAUSES **PATHOGEN** AND **CYANOBACTERIA** PROBLEMS?

Coliform bacteria can come from both developed and agricultural land, and are produced by both people and wildlife. Cyanobacteria blooms are influenced by many factors—especially excess nutrients.

STORMWATER RUNOFF CONTROLS along Englesby Brook allowed Burlington to reopen Blanchard Beach in 2007.

Combined sewer overflows, storm drains and failing septic systems contribute bacteria to waterways in both urban and rural areas. However, information on where and how often these problems occur throughout the Basin is difficult to acquire. Wildlife and pet waste are also sources of contamination. Livestock that have access to waterways, and manure spread on farm fields before a rainstorm, can send pathogens downstream to the Lake as well.

Levels of nutrients such as phosphorus and nitrogen are important causes of cyanobacteria blooms. Sources are the same as those described earlier in the phosphorus chapter (see page 5). Cyanobacteria blooms also are affected by competition from other organisms, water temperature, wind, sunlight, and other factors that are difficult, if not impossible, to control. In fact strong winds can blow surface scums around on the surface of the Lake, making it difficult to predict where problems may occur for lake users, or to identify their origins.

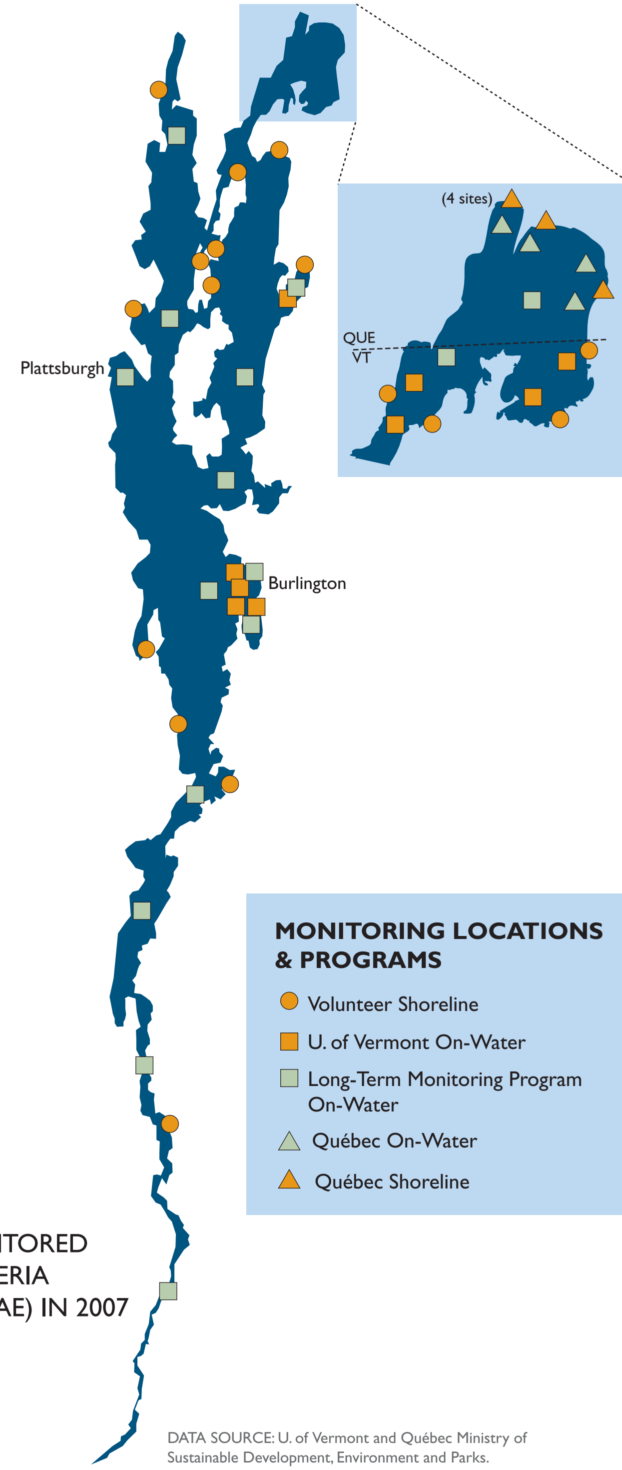


FIGURE 12 |
LOCATIONS MONITORED FOR CYANOBACTERIA (BLUE-GREEN ALGAE) IN 2007

DATA SOURCE: U. of Vermont and Québec Ministry of Sustainable Development, Environment and Parks.

WHAT'S BEING DONE TO **REDUCE BEACH CLOSURES** AND **ALERT THE PUBLIC**?

QCMDDEP

CYANOBACTERIA have been monitored in Lake Champlain since 2000.

State parks and municipal public beaches are monitored for pathogens and warnings are posted when needed. For cyanobacteria, an alert system was developed in 2001 in Québec and 2002 in Vermont and New York to warn the public about the location of blooms and the presence of harmful toxins.

Although public beaches are monitored for potential pathogens, individual towns have different protocols. Some monitor once a week, whereas others monitor more or less frequently (figure 10, page 12). In all cases, the states and the province have set similar standards for closures based on risk to the public.

Several management practices can be used to reduce pathogens entering the Lake. These include fencing livestock out of water bodies, proper disposal of pet waste, repair of failing septic systems, and stormwater management in urban areas.

Programs exist to share the cost of some of these practices. For example, state, federal and provincial funding exists for farmers to fence livestock away from streams and provide alternate water sources for farm animals. Some municipalities have ordinances to encourage picking up pet waste. And

LCBP

BAYSIDE BEACH in Colchester had more closures than usual due to pathogens in 2007, yet had zero closures in 2006.

in all areas around the Lake, homeowners must have a properly functioning septic system, although problems are often discovered only when properties are bought and sold. In Québec, most municipalities in the Missisquoi Bay watershed survey landowners to assess compliance with local regulations.

Cyanobacteria have been monitored in Lake Champlain since 2000 and a tiered alert system is implemented by the University of Vermont and funded in part by the LCBP. This information is used by the Vermont Department of Health to warn the public about blooms and toxins. The MDDEP in Québec also tests for toxins regularly and its health department issues advisories and closes beaches. As shown in figure 12, 49 on-water and shoreline sites were monitored in 2007 by a combination of state and provincial agencies, the University of Vermont and Lake Champlain Committee volunteers.

Only a few traces (well below health guidelines) of the cyanobacteria toxin microcystin have been found in treated drinking water. In reponse, the State of Vermont and the Lake Champlain Coalition of Water Suppliers have developed a process for testing and managing algae toxins in the water supply system in Vermont. Québec has developed a protocol for drinking water as well. Camps and homes that draw untreated water directly from the Lake must be vigilant in watching for blooms to reduce their risk of illness. No one should drink untreated Lake water.

2008 ECOSYSTEM INDICATORS SCORECARD

The 2008 Ecosystem Indicators Scorecard assesses the health of Lake Champlain by 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. All segments have different physical characteristics and land uses in their surrounding watersheds that influence the health of the segment.

For this report, the status of nine ecosystem indicators are scored as either good, fair, or poor for each major lake segment. Two issues, sea lamprey wounds and aquatic nuisance species arrivals, are scored for the entire Lake, since data was not available by segment. To learn more about each indicator and the criteria used to determine the scores, please refer to the page numbers noted after each issue.

In five issue areas, trends are also presented. As new data is complied over time, future editions of the scorecard will include trends for additional indicators.

As more indicators are developed and as data is collected by the many agencies working on Lake Champlain and evaluated by the LCBP, they will be included in future editions. A long-term goal for the scorecard is to track and score pressures to the Lake's ecosystem and management responses. For more information about the science behind developing indicators please refer to LCBP Technical Report #46, *Ecosystem Indicators and an Environmental Scorecard for the Lake Champlain Basin Program* (available on www.lcbp.org).

STATUS	
(blue circle)	GOOD
(yellow circle)	FAIR
(orange circle)	POOR
⊘	NO STATUS DATA IS AVAILABLE

TREND	
+	IMPROVING
~	NO TREND (neither improving nor deteriorating)
−	DETERIORATING
⊘	NO TREND DATA IS AVAILABLE

INDICATORS by LAKE SEGMENT

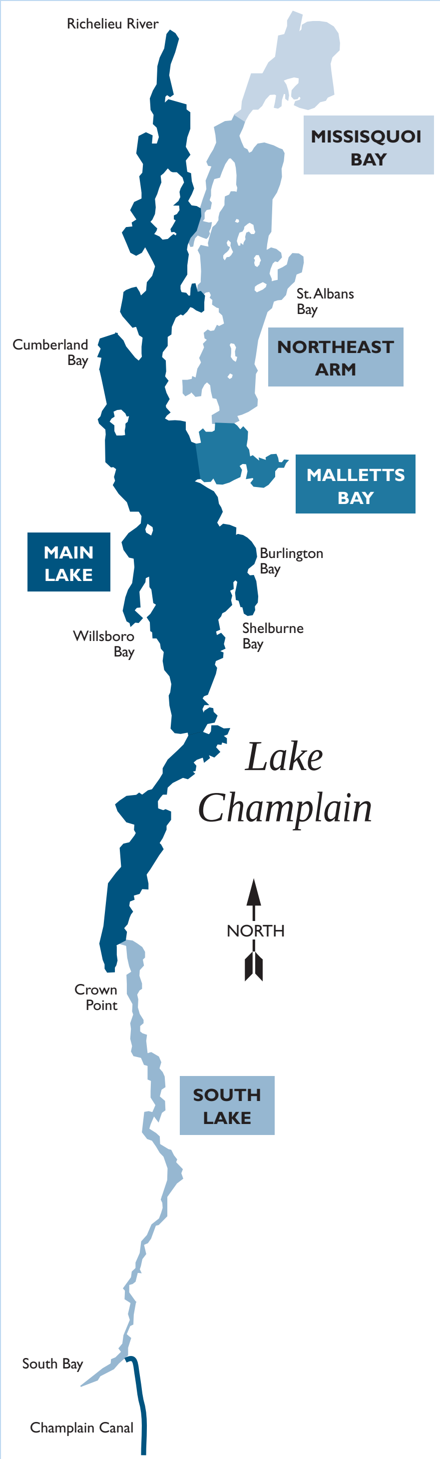
		MISSISQUOI BAY		NORTHEAST ARM	
		STATUS	TREND	STATUS	TREND
PHOSPHORUS & ALGAE	Phosphorus in Lake (p. 4)	Poor	~	Poor	−
	Nonpoint source loading to Lake (p. 5-6)	Poor	~ *	⊘	⊘ *
	Wastewater plant loading to Lake (p. 5&9)	Good	+	Good	+
		* NPS trends were only available for the Missisquoi River, which showed no trend. See page 6 for Pike River information.		* There are no monitored tributaries in the NE Arm.	
HUMAN HEALTH & TOXINS	Beach closures from bacteria (p. 12)	Good	⊘	Fair	⊘
	Blue-green algae blooms (p. 13)	Poor	⊘	Fair	⊘
	Fish advisories for toxins (p. 18)	Fair	⊘	Fair	⊘
BIODIVERSITY & AQUATIC INVASIVE SPECIES	Sea lamprey wounds+ (p. 25)	Poor	~	Poor	~
	Aquatic nuisance species arrivals+ (p. 27)	Good	⊘	Good	⊘
	Water chestnut infestations (p. 30)	Fair	−	Good	⊘

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

NYSDEC & LCBP PHOTOS

MISSISQUOI BAY is shallow, with a maximum depth of about 15 ft (5m), and warm water. It exceeds phosphorus targets and has had blue-green algae blooms in some summers. Agricultural land in sub-basin is a major source of phosphorus.

THE NORTHEAST ARM or "Inland Sea" has extensive agricultural land and urban growth that results in nonpoint source phosphorus concerns and periodic blue-green algae blooms. The waters are an important bass fishery.



INDICATORS by LAKE SEGMENT

MALLETTS BAY STATUS	MALLETTS BAY TREND	MAIN LAKE STATUS	MAIN LAKE TREND	SOUTH LAKE STATUS	SOUTH LAKE TREND		
Yellow	−	Yellow	~	Orange	~	Phosphorus in Lake (p. 4)	PHOSPHORUS & ALGAE
Orange	~*	Orange	~*	Orange	~*	Nonpoint source loading to Lake (p. 5-6)	
Blue	+	Blue	+	Blue	+	Wastewater plant loading to Lake (p. 5&9)	
*The Lamoille River has no trend for NPS load.		*The Winooski R., Laplatte R. and Otter Creek have improved, Lewis Creek has deteriorated and 8 tributaries have no NPS load trend.		*Putnam Creek is deteriorating while the Poultney and Mettawee Rivers have no trend for NPS load to the Lake.			
Yellow	⊘	Blue	⊘	⊘*	⊘	Beach closures from bacteria (p. 12)	HUMAN HEALTH & TOXINS
Blue	⊘	Yellow	⊘	Blue	⊘	Blue-green algae blooms (p. 13)	
Yellow	⊘	Yellow ▲	⊘	Yellow	⊘	Fish advisories for toxins (p. 18)	
		▲ Cumberland Bay, NY has an additional fish advisory due to PCBs, which gives it a poor ranking.		*The South Lake has no monitored public beaches.			
Orange	~	Orange	~	Orange	~	Sea lamprey wounds⁺ (p. 25)	BIODIVERSITY & AQUATIC INVASIVE SPECIES
Blue	⊘	Blue	⊘	Blue	⊘	Aquatic nuisance species arrivals⁺ (p. 27)	
Blue	⊘	Yellow*	+	Orange	+	Water chestnut infestations (p. 30)	
		*Water chestnuts are hand-pulled between Little Otter Creek and Crown Point; the rest of the Main Lake has no infestation.					

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

LCBP PHOTOS

MALLETTS BAY has deep cold water (up to 100 ft / 32m). Although its phosphorus target is low, increased runoff from developed land is a concern. The bay is popular for boating and fishing activities.

THE MAIN LAKE contains 81% of the Lake's water including the deepest, coldest water (up to 400 ft /129m). Population growth and mixed land use dominate the Vermont side and urban runoff is a concern. The New York side is more forested.

THE SOUTH LAKE includes all the waters south of the Crown Point Bridge. The segment is shallow and narrow, and phosphorus levels are high. Water chestnut and Eurasian watermilfoil interfere with recreation. The segment is popular for bass fishing.


LCBP

FISHING is a year-round activity on Lake Champlain.

CAN I **EAT THE FISH** FROM LAKE CHAMPLAIN?

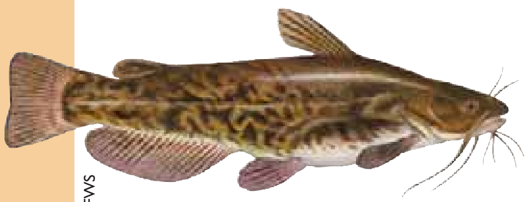
Yes, but fish consumption advisories have been issued by Vermont, New York and Québec due to concentrations of mercury and PCBs in fish. These advisories should be followed when eating fish from the Lake.

Mercury and polychlorinated biphenols (PCBs) are toxins that persist in the environment and bioaccumulate in fish and other wildlife over time. Consuming fish containing high concentrations of mercury, PCBs or other toxins may cause birth defects, cancer or other illnesses in humans. Elevated concentrations of these contaminants in the environment also can affect aquatic animals. Fish consumption advisories due to mercury contamination are posted for most northeastern waterbodies, including Lake Champlain.

Advisories for fish consumption due to mercury have been issued by all three jurisdictions. PCBs in fish have lead to advisories for yellow perch, brown bullhead, and American eel in Cumberland Bay, NY, and for large lake trout lakewide (see figure 13). The Vermont and New York fish advisories include

FISH ADVISORY STATUS

The fish advisories are used to score how the lake is doing with regard to toxins in fish for each major lake segment. If there were no advisory for a segment, it would be ranked *good*. If there was only a lakewide contaminate advisory that affected the segment, it was ranked *fair*. If there was an additional advisory specific to the segment or area in the segment, as well as the lakewide advisory, it was ranked *poor*. See pages 16-17 for scores.


USFWS

BROWN BULLHEAD sampled from Cumberland Bay after the PCB cleanup showed significant reductions in toxin levels. The advisory remains in place, however.

FIGURE 13 | LAKE CHAMPLAIN FISH CONSUMPTION ADVISORIES in number of meals per month *(1 meal = 8 oz. or 230 grams of fish)*

	VERMONT		NEW YORK		QUEBEC*	
FISH SPECIES	**Women/Child[A]**	**All Others**	**Women/Child[B]**	**All Others**	**Women/Child**	**All Others**
Brown Bullhead	5	no advisory	0	in Cumberland Bay: 0*	8	8
Pumpkinseed	5	no advisory	0	4	no advisory	no advisory
Walleye	0	1	0	> 19" (48cm): 1*	8 < 20" / 4 > 20" (50cm)	8 < 20" / 4 > 20" (50cm)
Lake Trout	1	3	0	4	no advisory	no advisory
Lake Trout >25" (63cm)	0 (incl. child <15)*	1*	0	1*	no advisory	no advisory
Trout: Brook/Brown/Rainbow	3-4	no advisory	0	4	no advisory	no advisory
Chain Pickerel	1	3	0	4	no advisory	no advisory
American Eel	1	3	0	in Cumberland Bay: 1*	no advisory	no advisory
Largemouth Bass	2	6	0	4	8	8
Smallmouth Bass	1	3	0	4	8	8
Northern Pike	2	6	0	4	8	8
Yellow Perch <10" (25cm)	3-4	no advisory	0	in Cumberland Bay: 1*	8	8
Yellow Perch >10" (25cm)	2-3	6	0	in Cumberland Bay: 1*	8	8
White Perch	no advisory	no advisory	no advisory	no advisory	8	8
White Sucker	no advisory	no advisory	no advisory	no advisory	8	8
Redhorse Sucker	no advisory	no advisory	no advisory	no advisory	8 < 14" / 4 > 16" (40cm)	8 < 14" / 4 > 16" (40cm)
All Other Fish Species	2-3	9	0	4	no advisory	no advisory

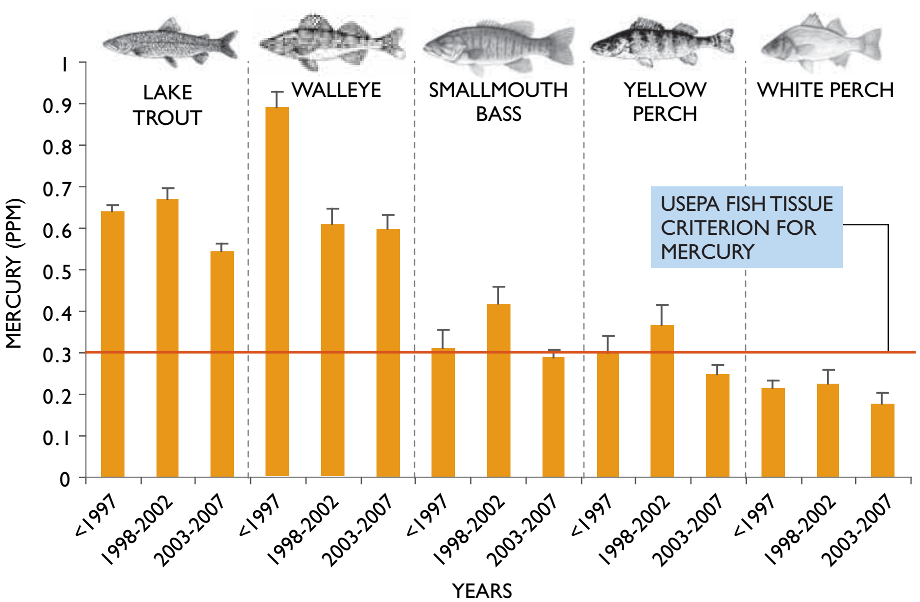
* = Advisory specific to Lake Champlain. All other advisories are state-wide in NY and VT. The QC advisories are all specific to Missisquoi Bay. A = The VT advisory applies to women of childbearing age, particularly pregnant women, women planning to get pregnant and breast feeding mothers, and children age six or younger. B = The NY advisory applies to women of childbearing age, infants and children under the age of 15.
SOURCES: NYS Department of Health, 2007-2008; VT Department of Health, 2007, QC Department of Health, April 2006.

both state-wide and local advisories specific to Lake Champlain, whereas the Québec advisory is specific to the Québec waters of Missisquoi Bay. Special advisories are issued for women of childbearing age and children. Fetuses are sensitive to the toxins consumed by the mother, and children are at high risk due to their developing systems.

Mercury and PCBs are monitored and managed in the Basin. VTANR, NYSDEC and the QC MDDEP monitor toxin concentrations in various fish species to develop fish advisories. Figure 14 shows mercury in parts per million in fish tissue for five fish species in Lake Champlain. Walleye and lake trout have the highest mercury concentrations because they are long-lived large predator fish. In general, younger and smaller fish contain lower mercury levels. A level of 0.3 ppm is the criterion set by the USEPA for mercury in fish tissue.

The PCB-related advisories are the result of high PCB concentrations in sediments near Wilcox Dock in Cumberland Bay, an area remediated by the NYSDEC in 2001. Subsequent monitoring has indicated a significant decline in PCBs in both sediment and water. They also have declined in the fish, although a specific fish advisory for PCBs remains in effect for Cumberland Bay.

FIGURE 14 | MERCURY IN LAKE CHAMPLAIN FISH BY INDICATOR SPECIES



NOTE: The values are mean mercury concentrations, normalized to the average length of the fish. Bars show standard errors.
DATA SOURCE: Vermont Agency of Natural Resources.

// PRESSURE INDICATORS //

WHAT ARE THE SOURCES OF MERCURY?

Mercury is a naturally occurring element, but human activities have greatly increased the amount released into the environment.

Mercury is the most widespread contaminant of concern in Lake Champlain. Atmospheric deposition of mercury, to both the Lake and its surrounding watershed, is a major source of this contamination. This mercury originates largely from coal-fired power plants and waste incinerators outside the Basin. Other sources include wastewater treatment effluent and losses from landfills containing improperly disposed of mercury bearing products. Products containing mercury include gauges, thermometers, thermostats, batteries, and fluorescent light bulbs.

A 2006 assessment by the Ecosystems Research Group of Norwich, VT, Dartmouth College, USGS and VTANR indicated that most of the mercury (59%) enters the Lake from the surrounding watershed. Sources of this mercury include atmospheric deposition that is then washed down to the Lake, leachate from landfills, and wastewater treatment effluent discharged to tributaries. Atmospheric deposition directly to the Lake's surface accounts for 40% of the mercury entering Lake Champlain.

A CORE OF SEDIMENT from the Lake bottom is taken to test for mercury and other toxins.

The remaining 1% is from wastewater treatment effluent that is discharged directly to the Lake.

In the environment, mercury moves freely between air, water and soil. It can be converted from its inorganic elemental form to a more toxic organic form called methylmercury. Methylmercury bioaccumulates through the aquatic food chain and is the main form of mercury found in fish.

WHAT IS BEING DONE TO **REDUCE MERCURY POLLUTION**?

Hazardous waste and recycling programs are in place to encourage the proper disposal of mercury-bearing products. In 2007, a regional mercury Total Maximum Daily Load (TMDL) was approved to reduce contamination in the Northeast.

LCBP

THE ROVER, a free service of the Chittenden Solid Waste District, collects all household hazardous waste. Of the paint collected, 70% is recycled into "Local Color" brand house paints.

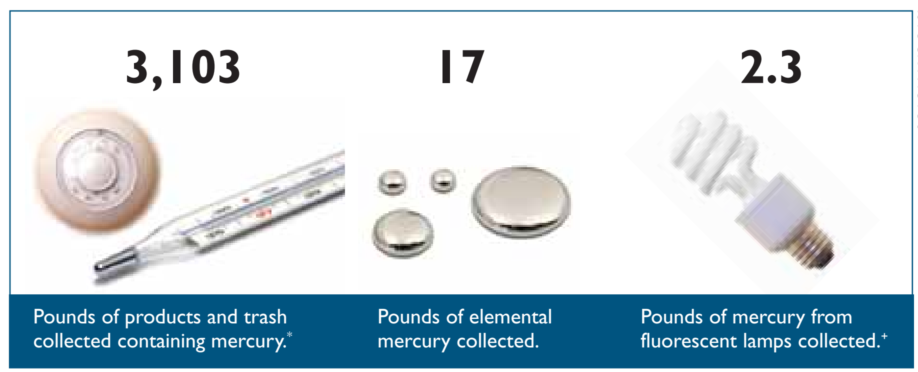
Additional regulations have been enacted to prevent mercury from being released into the environment, such as consumer product labeling laws and requirements for recycling of amalgam and mercury-contaminated dental wastes in Vermont and New York. Both states have banned the sale of many mercury-added products including novelties and thermometers.

Hazardous waste collection programs in both Vermont and New York encourage proper disposal and recycling to prevent the release of additional mercury into the environment. In Vermont, municipal solid waste districts and other local programs in the Basin collect hazardous waste, including mercury bearing products. Over 3,000 pounds of mercury-bearing products, 17 pounds of elemental mercury and 2.3 pounds of mercury from fluorescent bulbs were collected in 2006 (figure 15). New York's Clean Sweep program and county solid waste departments provide environmentally safe collection and disposal of hazardous wastes, including mercury. Exchange programs for mercury-bearing products, including thermometers, thermostats and dairy manometers, also have been successful in eliminating local sources.

Reducing atmospheric sources of mercury is being pursued through the regional mercury TMDL for the northeast states, which was approved by the USEPA in 2007. The goal of the TMDL is to reduce mercury emissions both in and beyond the region to reduce the deposition of atmospheric mercury. According to the TMDL, a 98% reduction in human-generated atmospheric deposition is required to reduce mercury levels in fish to acceptable levels.

Over the long-term, the speed of ecosystem recovery that is anticipated based on current regional and national mercury emission controls may be reduced by the ever-increasing "global pool" of mercury. The global pool of atmospheric mercury continues to grow due to increasing emissions from China, India, and other developing nations with large fossil fuel reserves.

FIGURE 15 | MUNICIPAL MERCURY COLLECTION IN LAKE CHAMPLAIN BASIN TOWNS IN VERMONT, 2006



ISTOCK PHOTOS

NOTES: *Includes the weight of mercury and non-mercury containing components. +Estimated.
DATA SOURCE: Vermont Agency of Natural Resources, MercVT Program.

ARE THERE OTHER TOXINS OF CONCERN?

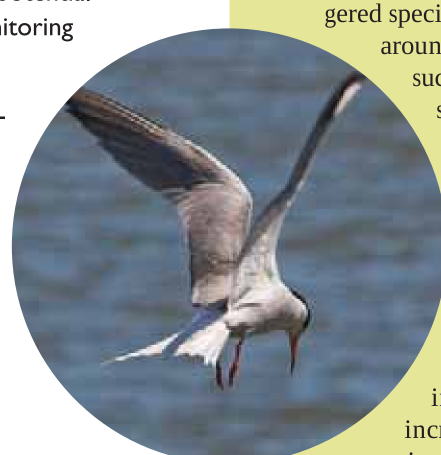
New chemicals are constantly being produced for domestic, agricultural and industrial purposes, and more sophisticated measurement techniques allow these potentially harmful substances to be detected in the environment. These "new generation contaminants" include pesticides, pharmaceutical products, detergents, fire retardants, and cosmetics. Road salt is also a concern, as concentrations in Lake Champlain are increasing.

ISTOCK PHOTO

A 2006 study by the USGS indicated many new generation contaminants are present in low levels in Lake Champlain Basin waterways. The study sampled for contaminants in wastewater treatment plants, combined sewer overflows, streams, and the Lake. Over 70 different chemicals were detected, including fire retardants, plasticizers, pesticides, fragrances, stimulants, and detergents, but few were detected in the samples taken directly from the Lake.

These new generation chemicals are typically found at very low concentrations and in complex mixtures. More research is needed to understand the extent of the potential contamination and to develop methods for measuring and monitoring the environmental impacts of these contaminants.

The LCBP Toxics Management Workgroup is currently developing a comprehensive toxic substance management strategy. Toxic substances of concern have been identified and the appropriate preventative measures to reduce threats to the ecosystem and human health are being determined.



COMMON TERN

PHOTO BY THERMOS

LAKE CHAMPLAIN BIODIVERSITY

S.PARREN/VTFWD

SPINY SOFTSHELL TURTLE

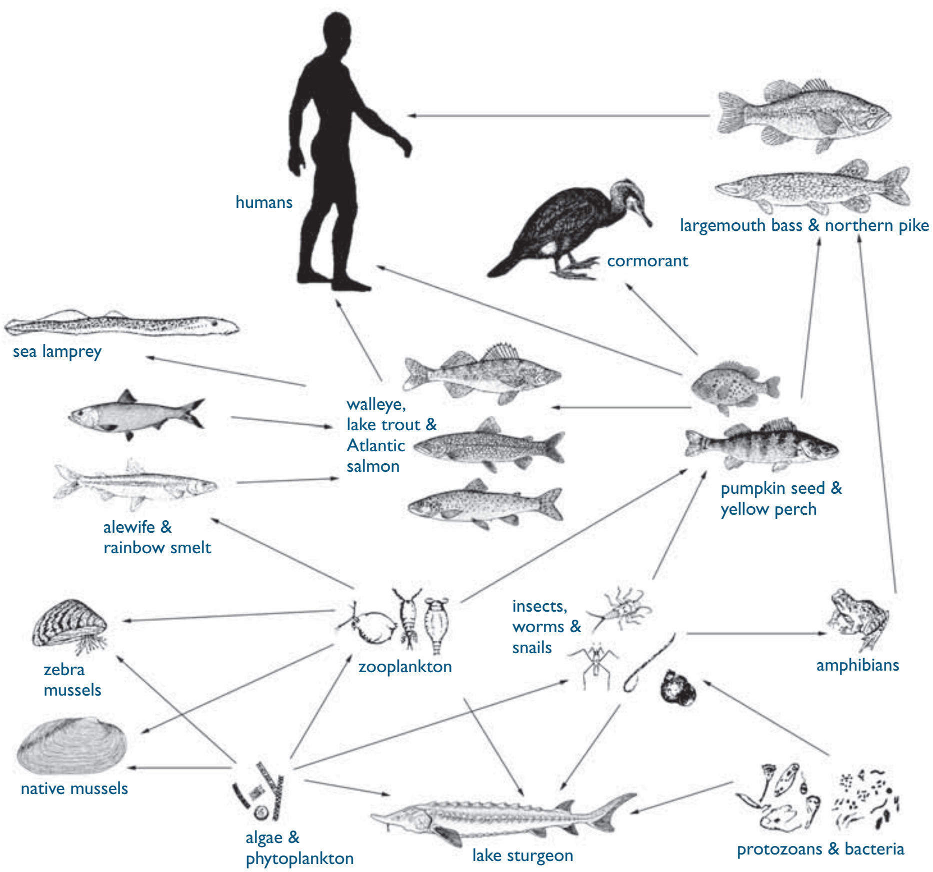
Lake Champlain is a large freshwater ecosystem with a rich diversity of native plants, fish, birds and other wildlife. Preliminary information from the soon-to-be-released Vermont Breeding Bird Atlas indicates changing patterns. Since 1981, 17 more species of breeding birds have been discovered in Vermont, including bald eagles, great egrets, and sandhill cranes. A record number of bald eagles (84) were observed on Lake Champlain during a 2008 survey by New York biologists; evidence of progress in the restoration efforts by federal and state agencies. At the same time, several birds are in decline, such as the eastern meadowlark, common nighthawk, and several species of northern warblers.

Other rare, threatened and endangered species are still in peril around the Basin. Species such as the pink heel splitter (a native mussel), common tern, lake sturgeon, and spiny softshell turtle are all part of the complex web of life. While the number of species in the Lake ecosystem is increasing, some of this increase is from invasive species that can harm native plants and animals (see page 27).

The Nature Conservancy published a report on Lake Champlain's biodiversity in 2006 and established a program to coordinate biodiversity protection. Threats identified include poorly planned development, loss of stream buffers, dams, undersized culverts, invasive species and climate change. These pressures have led to habitat fragmentation or degradation, which negatively affects biodiversity. Smart growth, riparian buffer protection, eco-friendly culverts, and invasive species spread prevention can help address these threats.

Several cooperative initiatives and cost-share programs support biodiversity protection in the Basin. Federal, state and provincial agencies, as well as nonprofit organizations and research cooperatives coordinate their efforts through the Lake Champlain Ecosystem Team. The USFWS Partners for Fish and Wildlife Program, Vermont and New York Landowner Incentive Program (LIP), and NRCS Wildlife Habitat Incentives Program (WHIP) and Environmental Quality Incentives Program (EQIP) are available to help private landowners improve wildlife habitat and stabilize streambanks.

WHAT DO WE KNOW ABOUT THE LAKE'S LOWER **FOOD WEB OF PLANKTON**?



Food energy moves in the direction of the arrows.

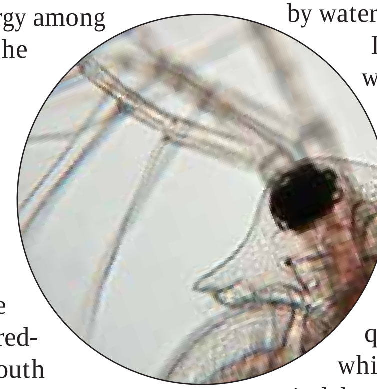
FIGURE 16 | LAKE CHAMPLAIN FOOD WEB

Lake Champlain's food web links all its inhabitants, from microscopic plankton to fish, birds and other wildlife. Its structure and function affects water quality, human health, toxins, and habitat diversity.

The food web shows the complex feeding relationships among species in Lake Champlain. In figure 16, each species is connected to those they consume and the arrows indicate the transfer of energy among species. At the base of the web, sometimes called the "lower food web," are the most numerous and simplest organisms, primarily phytoplankton and zooplankton. Complex predator-prey relationships lead to the top of the food web—predator fish such as largemouth bass, northern pike, lake trout, and salmon—and people who fish for these species and others. Forage fish, such as smelt and smaller perch, link the plankton community and the predator fish. Most fish, including predatory fish, feed directly on the plankton community when they are young.

Recent changes in the phytoplankton community have been observed with the increasing dominance of cyanobacteria (blue-green algae) in parts of the Lake. Both the specific cause and the impact of this change are currently unknown. However, a change in the lower food web can trigger ripple effects up to the top, since all levels are connected. For instance, changes in phytoplankton may cause zooplankton to change, which may in turn affect forage fish.

Aquatic plant communities have changed, particularly in the South Lake, as a result of invasive plants such as water chestnut and Eurasian watermilfoil. These invaders out-compete native plants and now dominate some habitats. While invasive plants provide habitat for some species, they have replaced native plants. Research suggests these invaders change the character of the Lake ecosystem significantly and are disruptive to the food web relied upon by waterfowl and other wildlife.



Invasive zebra mussels were first discovered in Lake Champlain in 1993. They now are found in every Lake segment and have changed the Lake's food web. As filter feeders, they consume large quantities of plankton, which has lead to an increase in lake water clarity in shallow water. While the clearer water may be appreciated by swimmers, it allows more sunlight to penetrate deep waters, thus promoting aquatic plant growth. Zebra mussels also have caused a decline in native mussel populations by growing on their shells, which suffocates them, and competing with them for food. Like invasive aquatic plants, zebra mussels are not an ideal food source, although some fish eat them.

THE ZOOPLANKTON DAPHNIA (above) are an important food source in the Lake.

PHOTO: F. GELLER-GRIMM

HOW ARE **ALEWIVES AND OTHER INVASIVE FISH** CHANGING THE FOOD WEB?


M. WATZIN

WHITE PERCH shown with the daphnia, a zooplankton, that it consumed.


NYSDEC

A DIE-OFF OF ALEWIVES on the New York shoreline from April 2008.

Invasive species, including alewives and white perch, are changing the diversity of the Lake's fish. These changes impact both the upper food web of sport fish such as trout and salmon and the lower food web of plankton.

Over 80 fish species live in Lake Champlain, including 15 non-native species. Although not all of these fish are problematic, alewife and white perch, two invasive forage fish, are significant threats to native fish and biodiversity. While the impact of these invasive species develops over time, evidence suggests they already are changing the Lake ecosystem.

White perch, which entered the South Lake in 1984, have slowly expanded north, and are now found lake-wide. As opportunistic feeders, white perch limit the availability of food for other species, including native yellow perch. White perch also prey on eggs of other fish species, which reduces the populations of their competitors. These impacts affect the lower food web and may lead to an increase in algal growth.

Alewives were discovered in Lake Champlain in 2003. They were observed in a yearly forage fish trawl survey by Vermont Fish and Wildlife Department (VTFWD) and USFWS in 2006. The number caught in the survey increased in 2007. In the winter and spring of 2008, widespread alewife die-offs occurred in the Lake, confirming that large numbers are now present. Although alewives typically undergo periodic mass mortality events in all freshwater systems, the specific cause of the mass die-offs remain unclear. Potential causes include food limitation, low water temperature, or rapid temperature fluctuations.

The full impacts of alewives on Lake Champlain are yet to be realized. Alewives compete with native fish for food, consume native fish eggs and larvae, and alter the plankton population as they selectively feed on large zooplankton. An alewife-dominated diet also would cause reproductive problems for lake trout and Atlantic salmon due to vitamin deficiency.


USFWS

ALEWIFE

WHAT IS BEING DONE TO UNDERSTAND THE **CHANGES TO THE FOOD WEB**?

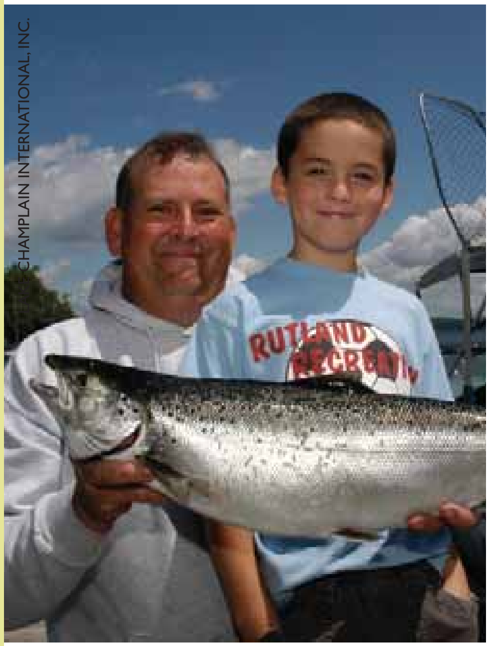
Some fish populations in Lake Champlain are monitored to inform management actions.

Plankton are monitored through the long term monitoring program conducted by New York and Vermont and funded by the LCBP. The VTFWD and the USFWS monitor forage fish in open waters through a yearly trawl survey of five locations in the lake and a more comprehensive hydro-acoustic, or fish finder, survey. These populations are monitored because smelt, currently the main open water forage fish species, are an important food source for salmonids (lake trout and Atlantic salmon) and are also part of an important winter recreational fishery. The hydro-acoustic survey will improve the ability to determine salmonid stocking rates based on the availability of forage fish. Monitoring also will help researchers learn more about population trends for both smelt and alewife.

WHAT IS KNOWN ABOUT THE **HEALTH OF THE LAKE'S SPORT FISH**?

Many efforts are underway to maintain healthy sport fish populations that support the Lake's recreational fisheries. A healthy fishery can provide tremendous social, economic and environmental benefits.

CHAMPLAIN INTERNATIONAL, INC.



FISHING DERBIES are important to the economy of many lakeside communities.

Lake Champlain fisheries management is coordinated by the Lake Champlain Fish and Wildlife Management Cooperative, a partnership of the NYSDEC, VTFWD and the USFWS. Activities include assessing landlocked Atlantic salmon, lake trout and brown trout, walleye and northern pike populations. Several fish species also are evaluated for sea lamprey wounds. As part of these assessments, the Winooski River and Boquet River fish passageways are monitored. Fish lifts on these rivers enable migrating salmon and trout to access spawning and nursery habitats above the dams. The data are used to evaluate the fish movements and stocking programs.

The great majority of the salmonids in the Lake have been cultivated and released in annual stocking programs. Researchers from the University of Vermont have determined that lake trout naturally spawn at multiple sites, but their young do not survive to contribute to the population. Several native fish prey heavily on juvenile lake trout, but it does not appear to be the only reason the fish are not surviving to adulthood.

An angler catch diary program and fishing tournaments also provide information on fisheries trends. Recent angler catches of Atlantic salmon have been dominated by smaller, young fish. Sea lamprey predation seems the most likely cause for the reduced catch of larger, older salmon (see page 25).

Bass are another important recreational fishery in the Lake, which is often called one of the top ten bass fisheries in the United States. Bass populations are not actively assessed or stocked like Atlantic salmon and trout.

Lake whitefish once supported a thriving commercial fishery in Lake Champlain. Commercial fishing records in Missisquoi Bay through the early 2000s indicate a steady decline in catch since the mid 1970s. Research on lake whitefish indicates this species is not reproducing in their historic spawning areas in the South Lake and Missisquoi Bay. However, adults and larvae recently have been found near Grand Isle.

FISHERIES BIOLOGISTS from Québec showing educators how to seine for fish on Missisquoi Bay.

LCBP

HOW ARE **SEA LAMPREY** HARMING THE LAKE'S SPORT FISH?

Sea lamprey are parasitic fish that prey heavily on the Lake's sport fish. They are managed to reduce their population size and their impacts on other fish.

Although many factors may be impacting the fish in Lake Champlain, including habitat changes and the effects of climate change, one well-known threat is the parasitic sea lamprey. Although believed to be a native species, sea lamprey populations are currently excessive and problematic. Sea lamprey weaken and kill other fish by feeding on their body fluids. They are monitored through fish wound sampling programs, angler surveys and larval sampling.

The status of the problems caused by sea lamprey is determined by the average number of wounds per 100 fish on lake trout and Atlantic salmon (figure 17) in the Main Lake and on walleye in four tributaries. Wounding rates of 25 wounds per 100 lake trout and 15 wounds per 100 salmon have been set as targets. Wounding rates presently greatly exceed targets, though in 2007 an improvement in wounding rates was observed. Lake trout had an average of 46 wounds per 100 fish and salmon had and average of 71 wounds per 100 fish. This data and reports from other surveys and anglers indicate that sea lamprey greatly impact Lake Champlain fisheries and the recreational fishing economy.

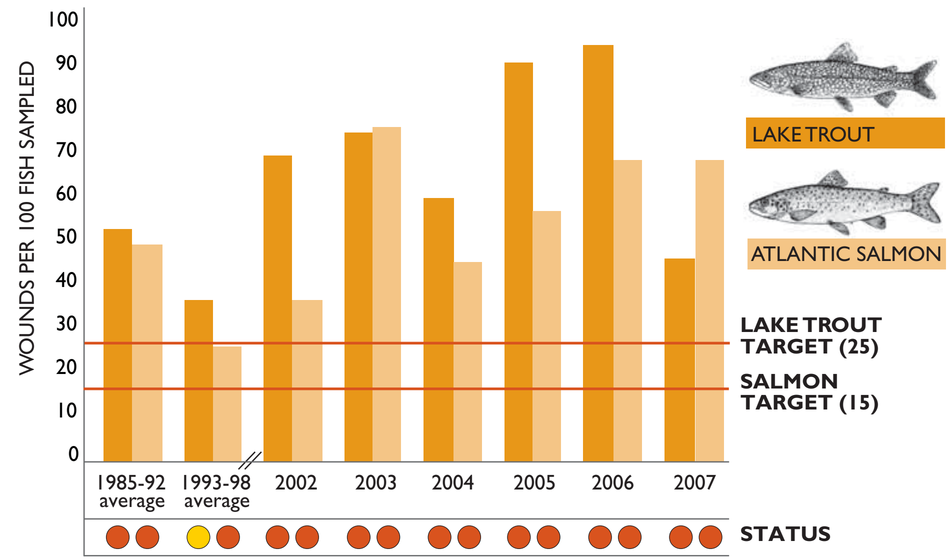
SEA LAMPREY attach to fish using their mouth, which acts like a suction cup.

ECHO LEAHY CENTER

USFWS

ATLANTIC SALMON

FIGURE 17 | SEA LAMPREY WOUNDING RATES ON LAKE TROUT AND ATLANTIC SALMON IN LAKE CHAMPLAIN



LAKE WIDE STATUS BY YEAR

GOOD Meets target for lake trout (25 wounds per 100 fish sampled) and salmon (15 wounds per 100 fish sampled)

FAIR Within 50% of meeting target for lake trout and salmon

POOR Exceeds target by more than 50% for lake trout and salmon

LAKEWIDE TREND

No trend: neither improving nor deteriorating from 2002-2007

NOTES: Lake trout were 533-633mm (21-25 in) in length. Salmon were 432-533 mm (17-21in) in length. 1982-92 was pre-control and experimental control was during 1993-98.
DATA SOURCE: Lake Champlain Fish and Wildlife Management Cooperative.

WHAT IS BEING DONE TO **SUPPORT FISHERIES AND CONTROL SEA LAMPREY**?

Stocking programs have been established with the long-term goal of restoring salmonid populations in Lake Champlain and management efforts are conducted to control lamprey.

The natural populations of lake trout and salmon collapsed prior to the 1900s. VTFWD, NYSDEC and USFWS have developed extensive fish culture and stocking programs to reestablish spawning populations in Lake Champlain and to maintain a healthy recreational fishery. The programs stock rainbow, lake and brown trout, and Atlantic salmon. However, this fishery has not been developing as well as expected, probably due to sea lamprey parasitism.

Following an 8-year experimental program that showed promising results, a long-term sea lamprey control program was initiated in 2002 due to the severity of lamprey impacts on the fisheries and ecosystem. The control program goal is to achieve the target wounding rates shown in figure 17 (page 25).

Sea lamprey spawn in 31 streams and four deltas of Lake Champlain. As of 2007, the populations in 18 streams and two deltas are being controlled by several methods. Additional streams are scheduled for control in the next few years. Control programs using lampricides target young lamprey populations in the streams before they mature and move to the Lake. Alternative (non-chemical) treatments include trapping lamprey and building physical barriers that prohibit adults from passing upstream to spawn. A sea lamprey barrier is scheduled for construction on the Morpion River in Québec in 2008.

Efforts are underway to enhance the Lake's walleye population. The VTFWD works with the Lake Champlain Walleye Association annually to stock walleye by collecting eggs and rearing them to eventually be released as fry. The USFWS and NYSDEC also work with the Walleye Association in the South Bay.

Fisheries management also includes regulating the harvest of fish. The Lake Champlain fisheries management goal is to protect fish as a resource for recreational fishing, as well as to protect and restore natural fish populations that are vital components of the ecosystem.

CORMORANTS AND WATER BIRDS

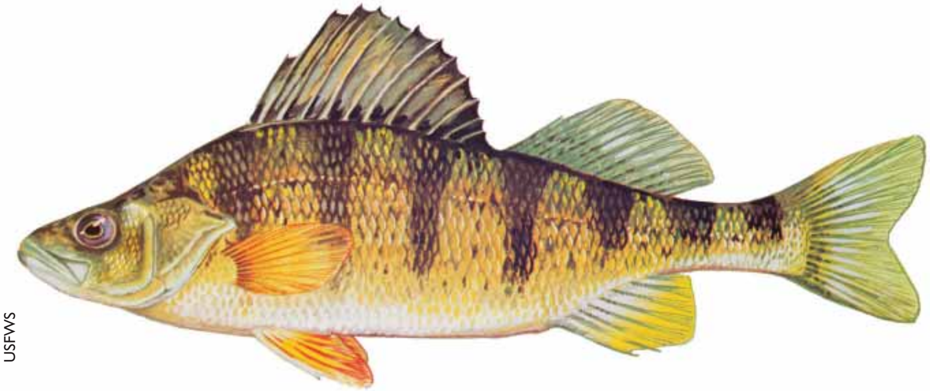

USFWS

Since 1981, when double-crested cormorants were first spotted on Lake Champlain, the population has grown to over four thousand nesting pairs. While cormorants are protected by the Federal Migratory Species Act, many people consider them a nuisance to fish and other birds. The majority nest in a few locations, including Young Island, Four Brothers Islands, and the Missisquoi National Wildlife Refuge.

Research has shown that cormorants consume about a pound of fish daily. Although they can temporarily disrupt local fishing in their feeding grounds, they do not commonly eat salmon, trout, bass and other popular sport fish in the Lake. A 2001 Lake Champlain Sea Grant study found that most of a cormorant's diet consists of yellow perch, rainbow smelt and sunfish.

In 2003, the USFWS ruled that cormorant management in Lake Champlain was allowed in areas where they damage fish, vegetation, and other birds. Methods used to reduce cormorants and protect other nesting birds include egg oiling, destruction of eggs and nests, lethal control of adults, harassment, and grid netting island areas to deter nesting. Populations on the islands fluctuate with the intensity of management efforts.

Cormorants impact other birds by occupying nesting areas, and their droppings have defoliated island vegetation, altering the habitat for birds such as the common tern, black crowned night heron, cattle egret, and great blue heron. Management is helping, however. Caspian tern nesting pairs have risen from one in 2001 to 50 in 2007 and the common tern has also benefited.


USFWS

YELLOW PERCH (left) and a CORMORANT (above).

HOW MANY **AQUATIC INVASIVE SPECIES LIVE** IN THE LAKE?

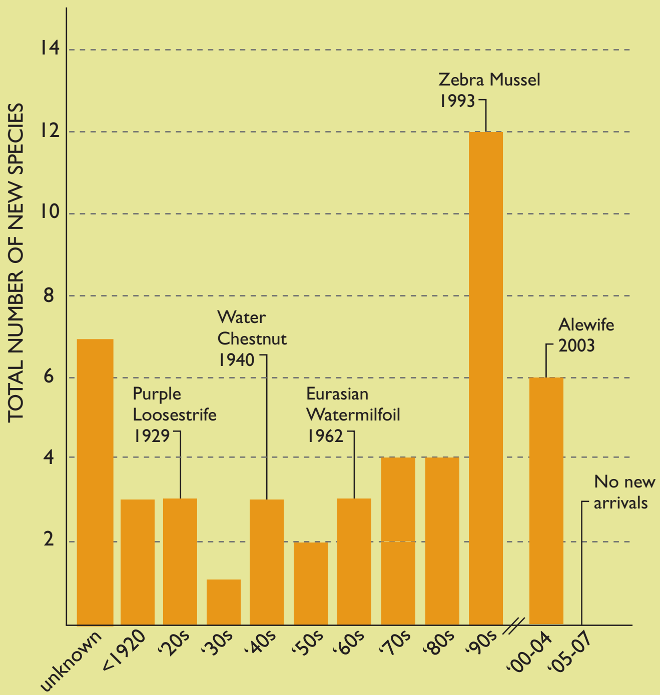

SEA GRANT

In spring 2008, there were 48 known aquatic invasive species in Lake Champlain. The main pathways of introduction included unauthorized fish stocking, bait fish release, and passage through the canals.

Aquatic invasive species are nonnative plants, animals, and pathogens that cause economic and environmental harm. The number of invasive species introduced into Lake Champlain has increased dramatically in recent decades. From the 1920s to 1980s, roughly three new species entered the Lake each decade. During the 1990s, however, twelve invasive species were discovered (see figure 18). Since 2000, six new invasive species (tench, largemouth bass virus, slender-leaved naiad, Chinese mystery snail, lymphosarcoma disease that affects muskellunge and northern pike, and alewife) have entered the Lake. While alewives were illegally introduced in Lake St. Catherine in 1997, they were not found in Lake Champlain until 2003.

Aquatic invasive species frequently out-compete native species for food and habitat, and they can affect the Lake's food web by imposing pressures from both the top down and the bottom up. In parts of the watershed, invasive plants such as water chestnut and Eurasian watermilfoil choke waterways and limit recreational use, displace native species, and lower water oxygen levels during decomposition. Invasive zebra mussels clog water intake pipes for industrial and domestic water supplies, cut the feet of swimmers and encrust boat motors, dock equipment and historic shipwrecks.

FIGURE 18 | AQUATIC INVASIVE SPECIES ARRIVALS TO LAKE CHAMPLAIN



NOTE: The data includes the arrival decade or first reported sighting of the species.
DATA SOURCE: Ellen Marsden, U. of Vermont.

STATUS OF AQUATIC INVASIVE SPECIES ARRIVALS

The arrival of new species in Lake Champlain is one indicator of its health. The *Lake Champlain Basin Aquatic Nuisance Species Management Plan* identifies invasive species that have not yet arrived according to their potential economic and environmental impacts. Using the plan's ranking, the indicator evaluates both the number of introductions and the degree of their invasiveness over the past three years.

While there was a dramatic increase in invasions over the past several decades, no new species have been introduced to Lake Champlain within the last three years, which results in a *good* ranking. If an invasive species that is not of high priority arrives within three years, a *fair* ranking would be given (see information on high priority species on page 28). The state of invasive species would be *poor* if more than one species arrived, or if any high priority species arrived within a three year period.


M. MALCHOFF

ZEBRA MUSSELS (left) were found in Lake Champlain in 1993 and tench (above) was reported in 2002.

WHICH **AQUATIC INVASIVE SPECIES** THREATEN THE LAKE?

ROUND GOBY, QUAGGA MUSSEL AND HYDRILLA threaten the Lake (top to bottom).

While it is not possible to predict which species will next invade Lake Champlain, there are many “waiting on the doorstep” in the Great Lakes and the Hudson River watersheds.

Lake Champlain has fewer invasive species than adjacent waterbodies. Currently there are 48 known aquatic invasive species in Lake Champlain, while there are 184 in the Great Lakes, 87 in the St. Lawrence River, and 91 in the Hudson River (figure 19). Lake Champlain’s proximity and connectivity to these infested waterways is a concern. Human activities are also a cause of intentional or unintentional invasive species introductions. These activities include private fish stocking, accidental and bait bucket release, canal passage, aquarium dumping, ballast water exchange, and transport of plants and animals on boats, trailers and other recreational equipment.

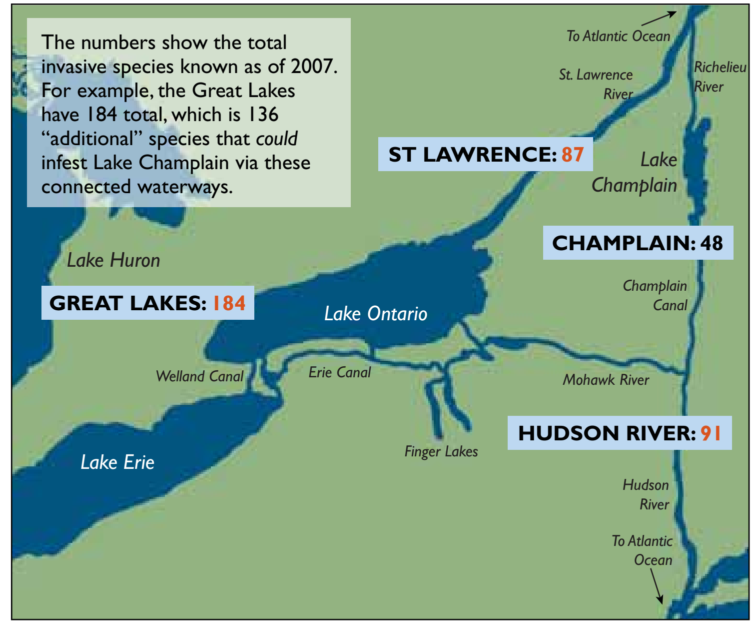
Several species that are not yet here are of special concern because their impacts could be widespread and severe, both economically and ecologically. The *Lake Champlain Basin Aquatic Nuisance Species Management Plan* lists hydrilla, round goby, Eurasian ruffe, quagga mussel, spiny waterflea, and fishhook waterflea as high priority species. The arrival of one of these species with a three-year period would rank the state of aquatic invasions as *poor*.

Round goby are a small bottom-dwelling fish that have spread rapidly through ballast water, bait buckets, and natural expansion. They are a significant threat because they are aggressive eaters, consuming the eggs of native species such as lake trout. They also tend to displace native species.

Quagga mussels have impacts similar to zebra mussels, but have a higher tolerance for cold, deep water and could inhabit more Lake habitat. They could enter by “hitch-hiking” a ride on a boat traveling through canals or on trailers and recreational equipment.

Hydrilla is a popular aquarium plant that is often misidentified as a native species. It can spread rapidly, and if it enters Lake Champlain, dense mats would displace many native species, clog water intakes, and impede recreation. Hydrilla could enter on a boat or trailer. It is illegal to possess or release it in Vermont.

Fish pathogens, including Viral Hemorrhagic Septicemia (VHS) that has spread through the Great Lakes, also are of concern because they could significantly impact native fish populations. They can be transferred by infected fish and by water around the fish.



DATA SOURCE: Updated from Mark Malchoff, Lake Champlain Sea Grant; Ellen Marsden, U. of Vermont.

FIGURE 19 | AQUATIC INVASIVE SPECIES THREATS TO LAKE CHAMPLAIN FROM CONNECTED WATERWAYS

PHOTOS: ERIC ENGBRETSON/USFWS, USGS, L. MERHOFF/U. OF CONNECTICUT

WHAT IS BEING DONE TO **PREVENT AND MANAGE NEW INVASIONS**?

Once invasive species are present they are very difficult and costly or even impossible to remove. Management relies on early detection and rapid response, spread prevention, and public education.

AN LCBP LAKE STEWARD discusses invasive species with a local boater.

People who use Lake Champlain can reduce the spread of invasive species by taking prevention measures, such as checking, cleaning, and drying boats and recreational equipment, and properly disposing bait. The LCBP, in cooperation with partners, has initiated a steward program to provide education about aquatic invasive species spread prevention at boat launches.

Both states have volunteer monitoring programs to identify and report sightings of new species.

Detecting new invasions quickly and rapidly responding to them to contain the spread is more cost effective than managing or eradicating an established species. A rapid response management plan is being developed by the LCBP to establish the process for Vermont, New York, and Québec to address new invasions. The LCBP and partners also developed the *Lake Champlain Basin Aquatic Nuisance Species Management Plan* approved by the National Aquatic Nuisance Species Task Force in 2000 and updated in 2005. LCBP committees plan invasive species spread prevention, develop rapid response strategies and provide education programs.

In response to the threat of fish pathogens entering the Lake, both Vermont and New York have enacted new baitfish regulations. The regulations restrict the use of baitfish to certain water bodies and prohibit the transport of fish from one water body to another. Both wild and hatchery raised fish are also tested for fish pathogens.

VTDEC staff search the Missisquoi NWR for water chestnuts.

YOU CAN HELP THE LAKE!

The state of the Lake depends on our individual actions. Here are a few things you can do:

DON'T "P" ON YOUR LAWN: Only use phosphorus-free (P-free) fertilizers and have your soil tested.

MAKE A DISH-WASH SWITCH: Most automatic dishwashing detergents still contain phosphorus. Switch to a phosphate-free version.

LOOK FOR LEAKS: Leaking oil, antifreeze and gas can pollute the Lake—keep your engines tuned and recycle your oil.

LEAVE IT ON THE LAWN: Let your mowed grass clippings serve as mulch on your lawn. This adds nutrients and decreases the need for watering.

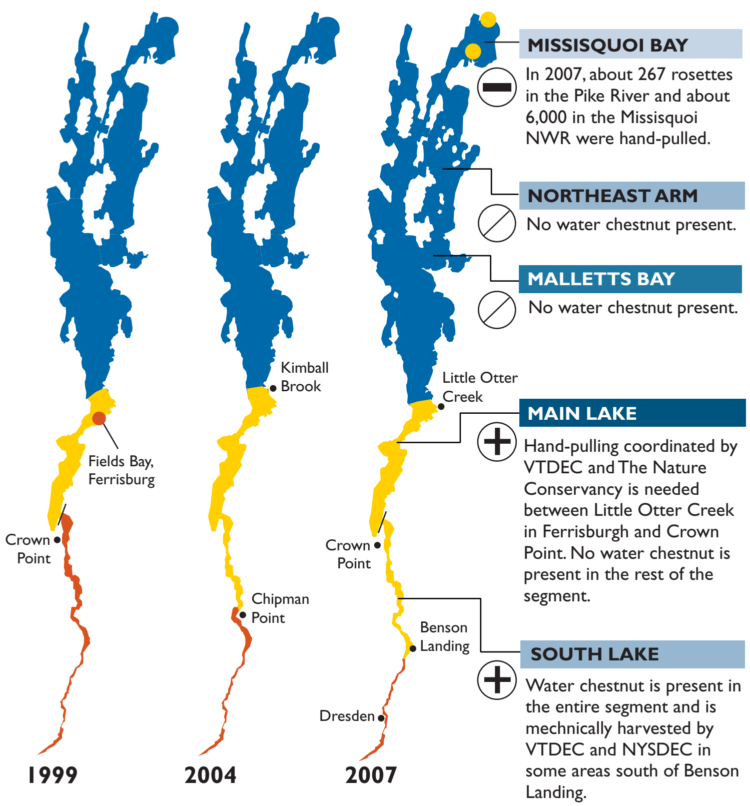
CHECK THE SEPTIC: If not properly maintained, your septic system may pollute the Lake with harmful *E. coli* bacteria.

INSPECT YOUR BOAT: Remove all mud, plants and animals from your boat and trailer between launches to keep invasive species from spreading.

SCOOP THE POOP: Pick up pet waste and throw it in the trash or toilet to keep it from washing into the Lake.

GET INVOLVED: Volunteer with a local watershed group and attend public meetings about water issues—turn your love of the Lake into action!

FIGURE 20 | STATUS OF WATER CHESTNUT INFESTATIONS ON LAKE CHAMPLAIN



STATUS

- **GOOD** — No water chestnut present and no management needed
- **FAIR** — Water chestnut present with less than 25% coverage (typically managed by hand-pulling)
- **POOR** — Water chestnut present with greater than 25% coverage (typically managed by mechanical harvesting) in an area covering greater than 10% of the segment

TREND

- (+) Improving: water chestnut is decreasing
- (~) No trend: neither improving nor deteriorating
- (−) Deteriorating: water chestnut is increasing
- (/) No trend data is available

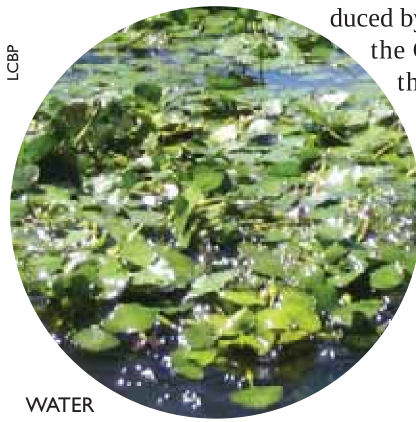
DATA SOURCES: VTDEC, NYSDEC, QC MDDEP.

IS WATER CHESTNUT STILL A PROBLEM?

The invasive water chestnut has displaced native aquatic plants and is of little food value to wildlife. It was first documented in southern Lake Champlain in the 1940s and it is believed to have been introduced by vessels traveling up the Champlain Canal from the Hudson River.

In the South Lake segment, water chestnut forms dense mats, limits boat traffic and recreational use, and crowds out native plants. It is also found in lower densities in the Main Lake (figure 20). Fortunately, aggressive management in Vermont, New York and Québec has significantly limited its local range.

In 2006, water chestnut was found in the USFWS Missisquoi National Wildlife Refuge in Swanton, VT. All three jurisdictions worked together quickly to survey the area and remove about 12,000 plants by hand. In 2007, only 6,000 plants were found and they were removed. This recent infestation demonstrates the important of early detection and rapid response actions and effective management.



LCBP

WATER CHESTNUT

WHAT IS BEING DONE TO MANAGE IT?

Since water chestnut produces seeds that remain viable for up to twelve years, it must be controlled before the seeds drop to the Lake bottom. Both mechanical harvesting and hand pulling has been used since the 1960s for control. The local range of the plant has fluctuated in close correspondence with funding levels over the past few decades. Aggressive management of water chestnut began in 1998. Nearly $500,000 has been spent every year since to successfully control it.

The management program is supported by the USACE, USEPA and LCBP and is implemented by Vermont, New York, The Nature Conservancy, and many volunteers. Figure 20 shows progress made since 1999. In 2007 mechanical harvesting was only needed south of Benson Landing for the first time in 27 years. The remaining parts of the South Lake and Main Lake up to Little Otter Creek in Ferrisburgh requires hand harvesting of localized mats and scattered plants. The Québec Ministry of Natural Resources and Wildlife supports control efforts in the Missisquoi Bay watershed, including the Pike River.

CULTURAL HERITAGE, RECREATION AND THE STATE OF THE LAKE

LCMM

THE MARITIME MUSEUM'S CANAL SCHOONER *LOIS MCCLURE* will travel to Québec City in 2008 to help celebrate the anniversary of the city's 1608 founding and herald Lake Champlain's 2009 Quadricentennial.

Over the past 15 years, the LCBP has worked with its partners to promote the Basin as a sustainable tourism destination and build a greater stewardship ethic among recreational users. More recreation opportunities, such as the reciprocal fishing license, lead to increased commitment to Lake stewardship.

One of the many negative impacts of zebra mussels is the destruction of the Lake's historic shipwrecks. This threat led to an eight-year underwater survey of 300 square miles of the Lake by the Lake Champlain Maritime Museum (LCMM). More than 75 shipwrecks were found, some of which could be added as dive sites to the Lake Champlain Underwater Historic Preserves System. Projects like this enhance the links between the cultural and natural worlds and lead to a better understanding of Lake issues.

The LCBP has provided more than $1 million in grants to cultural heritage, recreation and public access projects since 1992. Efforts like Lake Champlain Bikeways, the Birding Trail, the Lake Champlain Committee Paddlers' Trail, and the LCBP Wayside Exhibit Program (with 150 interpretive signs to date) enhance recreational experiences, build the connection between our appreciation of and caring for the Lake, and contribute to the regional economy.

THE FIRST-EVER bi-state and international stamp cancelation was coordinated by the LCBP to kick off the Champlain Quadricentennial.

LCBP PHOTO

Scenic byways in New York and Vermont link recreation and historic sites in shoreline communities. The array of resources in the Basin—including Fort Ticonderoga's exceptional historical interpretation, Shelburne Museum's world-class folk art collection, and the dozens of historical society museums that tell their own unique stories—is outstanding.

The year 2009 will mark the 400th anniversary of Samuel de Champlain's arrival to the region. Champlain's journals give us the first written description of the Lake, the surrounding landscape and its native peoples. The LCBP is working closely with quadricentennial commissions in Vermont, New York and Québec to develop projects linking the two states and the province. This coordination supports citizens who are working to thematically enhance, or "quadricize" local events, festivals, and recreational programs. This year, the LCBP will offer $50,000 in special grants that support these efforts.

While the Quadricentennial highlights the commonalties between US and Québec cultures, 2009 is just a starting point. The Champlain Valley National Heritage Partnership (CVNHP) was designated by the US Congress in 2006, in part, to interpret and promote the history of the waterways; form stronger bonds between the US and Canada; and promote the international aspects of the Champlain Valley. The LCBP will distribute $100,000 in CVNHP grants in 2008.

A BIKE FERRY operated by Local Motion provides riders with a unique opportunity to experience the Lake.

LOCAL MOTION

EDUCATION PROGRAMS AND LOCAL INVOLVEMENT

Local citizens increasingly show a sophisticated understanding of the Lake's complicated ecosystem. Many groups are working aggressively to solve local problems, such as invasive species infestations and stream bank erosion. As these groups share their knowledge and solutions, all are gaining in effectiveness.

The more than 30 local watershed groups in the Basin are especially effective in finding landowners to plant trees along tributaries. The Missisquoi River Basin Association and the Friends of the Winooski recently reached their 10th anniversaries, a testimony to the commitment of their many volunteers. Together with conservation districts and land trusts, these groups continue to conserve prime farmland, protect wildlife habitat and implement water quality improvement projects.

Many effective outreach efforts reflect changes in human behavior over time, some of which are now measurable within the watershed. For example, in two St. Albans neighborhoods, data from Lake Champlain Sea Grant showed that homeowners were willing to change their landscaping practices after an extensive local watershed campaign was conducted. This data helped to inform the "Don't 'P' on Your Lawn" campaign (see page 9).

In the past three years, more than 140 educators received training through the LCBP-supported Champlain Basin Education Initiative. These teachers will share their knowledge with nearly 10,000 students in the next three years alone. Education partners provide on-site school programs and offer many field trips.

Other audiences include anglers, paddlers, municipalities, and farmers. Fishing organizations, including Lake Champlain International and Trout Unlimited, provide aquatic invasive species information and phosphorus reduction outreach, providing access to more than 20,000 anglers each year. Trout Unlimited volunteers also assisted with the Adopt-A-Salmon program in thirteen Adirondack schools in 2007 and provided technical assistance on streambank stabilization projects.

Several organizations assist farmers with nonpoint source pollution reduction. The Farmers' Watershed Alliance and Québec agroenvironmental clubs in the Missisquoi Basin and the Champlain Watershed Improvement Coalition of New York are examples (see page 10).

The LCBP Resource Room within ECHO at the Leahy Center received 100,000 visitors during its first five years, many of whom seek additional information about the Lake and volunteer opportunities. The South Lake Visitor Center, created by the Poultney Mettowee NRCD provides a new venue for residents to learn about the ecosystem. More than 30,000 visitors stepped aboard the LCMM's *Lois McClure* canal boat in 2007 as she traveled 1,000 miles through the Champlain and Erie Canals, sharing regional cultural history and environmental messages.

JEFF CLARKE/ECHO

ECHO LAKE AQUARIUM AND SCIENCE CENTER at the Leahy Center for Lake Champlain is celebrating its 5th anniversary this summer, having welcomed 750,000 guests since opening.

LCBP PHOTO

LCBP EDUCATION staff teaching local students about watersheds and polluted runoff.

VYCC

THE LCBP HAS AWARDED more than $3 million in local grants and funded more than 50 research projects since 1992. Work on the Poultney River is shown on the left. Additional support to communities has been provided through the Watershed Environmental Assistance Program, in cooperation with the US Army Corps of Engineers.

VISIT **WWW.LCBP.ORG** TO LEARN LOTS MORE ABOUT THE LAKE AND LINK TO OTHER LAKE GROUPS!

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VISIT **WWW.LCBP.ORG/LCSTATE.HTM** TO LEARN MORE ABOUT THIS REPORT AND TO OBTAIN REFERENCES.

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LCBP

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REQUESTED