LAKE CHAMPLAIN FISH AND WILDLIFE MANAGEMENT COOPERATIVE

FISHERIES TECHNICAL COMMITTEE

2017 ANNUAL REPORT

September 10, 2018

Juvenile lake sturgeon,
Lake Champlain, October 2017

Landlocked Atlantic salmon captured
in Boquet River for transport upstream.

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Executive Summary

Restoration efforts for native salmonids continued to be the primary focus of the Lake Champlain Fisheries Technical Committee (FTC) in 2017. Landlocked Atlantic salmon (salmon) and lake trout were focal species accounting for 75% of 556,127smolt / yearlings stocked into the lake and tributaries. Highlights from native salmonid management include:

- Deep water sampling for juvenile lake trout identified wild lake trout ranging in age from young of year to three years old. This is the first evidence of wild lake trout surviving to these older age classes since restoration programs were established in the 1970s.
- Successful natural reproduction of salmon was documented in the Boquet River for the first time in over 100 years.
- Sea lamprey wounding rates for salmon remained near target levels.
- Sea lamprey wounding rates increased significantly for lake trout.
- Salmon runs declined in 2017 with lowest return to Hatchery Brook since 2006.
- Condition factor of salmon and lake trout remained high.
- Two Lake Champlain salmon broodstocks were established at White River NFH.

There were no lampricide treatments conducted in 2017 resulting from a new four-year geographically-based treatment schedule. Trapping efforts at 9 locations during the spring spawning run captured 492 adult sea lamprey, a 43% increase from 2016. Sea lamprey salmon wounding rates in 2017 remained near the target of 15 wounds per 100 fish. However, lake trout sea lamprey wounding rates increased from 42 in 2016 to 63 in 2017 and remain well above the target of 25 wounds per 100 fish. Lampricide treatments are currently scheduled for the 12 locations in New York during the fall of 2018.

A working group of the FTC began the process of updating the Strategic Plan for Lake Champlain Fisheries. Monitoring efforts continued for American eel, muskellunge, bass, walleye, and yellow perch. NYSDEC and USFWS continued development of a sauger restoration plan. Research efforts in the lake and tributaries included: using acoustic telemetry and sonar methods to monitor sturgeon movement patterns; characterizing impacts of thiamine deficiency on salmonids, evaluation of broodstock sources for salmon and steelhead; and genetic studies on lake white fish and slimy sculpin.

Introduction

Management of the fishery resources of Lake Champlain is coordinated by the Lake Champlain Fisheries Technical Committee, which is a workgroup of the Lake Champlain Fish and Wildlife Management Cooperative. Members and advisors of the Fisheries Technical Committee includes staff from the Vermont Department of Fish and Wildlife (VTDFW), New York State Department of Environmental Conservation (NYSDEC), U.S. Fish and Wildlife Service (USFWS), University of Vermont (UVM), Vermont Cooperative Fish and Wildlife Research Unit (VCFWRU), Quebec Ministry of Natural Resources, Lake Champlain Sea Grant, and other universities.

This report briefly summarizes fisheries management and research activities carried out on Lake Champlain and its tributaries during 2017. The names of project leaders are listed after section headings and their affiliation can be found on the FTC Membership list at the end of this document (Appendix 1).

SALMONIDS

Salmonid Assessment Program for Lake Champlain (Salmonid Working Group)

A workgroup of the Lake Champlain Fisheries Technical Committee was established in 2014 with the goal of maintaining balanced and robust fish populations that provide a fishery for salmonids. The working group had five objectives: (1) Evaluate status of salmonid populations; (2) Evaluate the salmonid fishery; (3) Evaluate salmonid hatchery production; (4) Evaluate fish health status and impact of aquatic nuisance species; and (5) Identify potential management actions.

Lake Champlain is a complex, dynamic system that will continue to undergo unpredictable changes into the future. While a large number of indicators could be developed to assess any salmonid population and fishery there are limited resources available in the Lake Champlain Basin for additional assessment efforts or a large scale expansion of current efforts. Developing a suite of indicators to guide management actions, such as stocking decisions, will require an adaptive approach. While information from the recommended assessment program may help guide the decision-making process there will still be uncertainty in the predictions.

The working group has developed a list of indicators and is in the final stage of setting management action thresholds. For example, if indicators identify major declines in salmonid survival, condition (K) or growth rates management agencies may make changes to harvest regulations or stocking rates to maintain acceptable growth rates for salmonids.

Stocking Summary (Shanahan)

Salmonid stockings in Lake Champlain during 2017 included approximately: 340,000 landlocked Atlantic salmon (smolt equivalents); 69,000 steelhead (smolt equivalents); 78,000 lake trout; and 69,000 brown trout (Table 1). The list includes landlocked Atlantic salmon and steelhead that were stocked in the tributaries to the lake. Also listed in Table 1 are the stocking targets for each species. Stocking numbers are presented as "stocking equivalents." Salmonids are stocked at varying sizes, from recently hatched fry that spend two years in the tributaries before migrating to the lake, to smolts and yearlings that are ready to begin life in the lake at the time of stocking. The numbers stocked are adjusted to stocking (smolt/yearling) equivalents to better represent the effective numbers stocked.

Table 1. Numbers (in stocking equivalents) of salmonids stocked in Lake Champlain during 2017, and stocking targets for the lake.

	Main Lake		Malletts Bay/Inland Sea		Total number stocked in 2017
Species	Target	2017	Target	2017	
Landlocked salmon	227,000	257,006	77,000	83,003	340,009
Lake trout	82,000	78,050	0	0	78,050
Steelhead	53,000	63,831	5,000	5,000	68,831
Brown trout	38,000	35,511	40,000	33,726	69,237
Total	400,000	434,398	122,000	121,729	556,127

Pre-stocking Landlocked Salmon Assessments (Staats)

In the spring of 2017, landlocked salmon yearlings from Eisenhower NFH, Ed Weed Fish Culture Station, and Adirondack Fish Hatchery were assessed as part of a long-term monitoring database needed for managers to better understand the percentage of stocked fish that are viable smolts. Many hatchery programs that rear one-year old smolts have developed a size threshold for classifying a stocked fish as a smolt. Fish that do not reach this size threshold are expected to remain as parr and will not undergo the parr-smolt transformation that year. Biologists working with anadromous Connecticut River salmon have established a smolt threshold of greater than or equal to 150 mm total length. In 2017, over 99% of fish exceeded the 150 mm size threshold for Ed Weed hatchery while at least 80% of fish exceeded the size threshold for Eisenhower NFH and Adirondack hatcheries (Table 2).

Table 2. Pre-stocking assessment of yearling landlocked Atlantic salmon stocked in Lake Champlain. Total number of yearling salmon stocked and the number that reached the viable smolt size (greater than or equal to 150 mm total length) are reported for stocking years from 2012-2017.

Hatchery (agency)	Year	Mean Size (mm)	Numbered Sampled	% Viable Smolts	Total Stocked	Viable Smolts Stocked
Adirondack (NYSDEC)	2012	150	400	54.8	45,000	24,638
	2013	163	400	83.0	45,000	37,350
	2014	174	399	90.0	49,260	44,334
	2015	175	300	92.3	45,000	41,535
	2016	180	400	93.8	45,000	42,210
	2017	167	400	85.8	45,000	38,610
Ed Weed (VTDFW)	2012	196	999	99.7	155,289	154,823
	2013	191	1,100	99.6	165,459	164,797
	2014	188	999	99.2	146,290	145,119
	2015	181	1,000	95.3	163,827	156,127
	2016	177	1,000	96.4	149,419	144,040
	2017	190	1,100	99.7	160,028	159,548
Eisenhower (USFWS)	2012	188	900	96.8	104,706	101,355
	2013	206	1,100	98.8	69,992	69,152
	2014	170	1,000	84.8	76,160	64,584
	2015	163	1,300	82.7	102,430	84,710
	2016	155	1,223	66.6	102,697	68,396
	2017	161	1,800	80.7	113,947	91,955
Overall	2012	185	2,299	92.1	304,995	280,792
	2013	193	2,600	96.8	280,451	271,372
	2014	178	2,398	93.5	271,710	254,024
	2015	171	2,600	90.7	311,257	282,379
	2016	167	2,623	85.7	297,116	254,580
	2017	171	3,300	87.6	318,975	290,113
Target Stocking Number						304,000

Fish Passage

Winooski One Dam Fish Lift (Staats)

Winooski River Fish Lift – In 2017 a total of 13 steelhead rainbow trout and 84 landlocked Atlantic salmon were trapped at the Winooski One fish passage facility in the spring and fall, respectively (Figure 1). Of the salmon lifted in the fall, there were 49 male and 40 females processed. Mean length of lake-age 1 males decreased slightly from 2016 while condition factor (K) increased (Figure 2). Steelhead were released directly above the Winooski dam while salmon were transported above the next two dams and released in the upper Winooski River. In addition to the above, eleven steelhead were also lifted in the fall and 29 salmon were trapped in July and August (but released back below the dam).

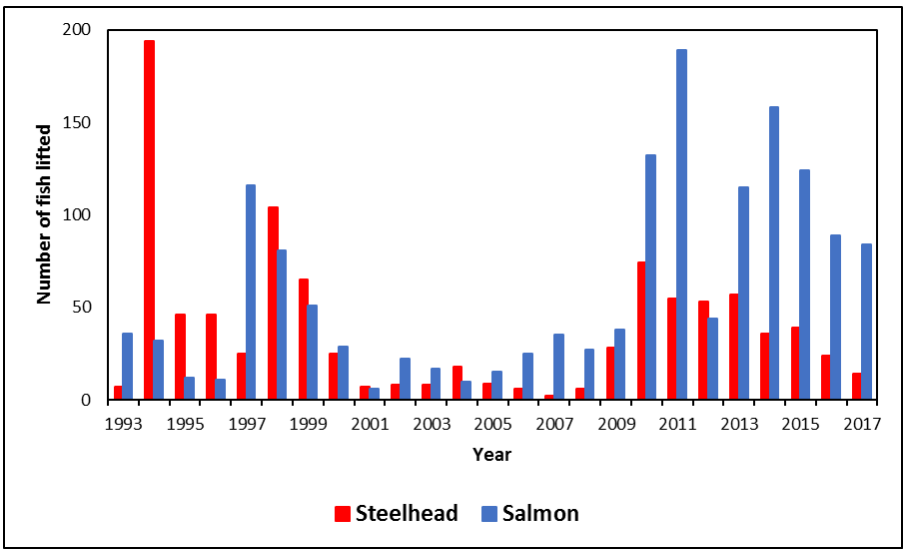

Figure 1. Summary of steelhead rainbow trout (spring season) and landlocked Atlantic salmon (fall season) lifted at the Winooski One fish passage facility, 1993 – 2017.

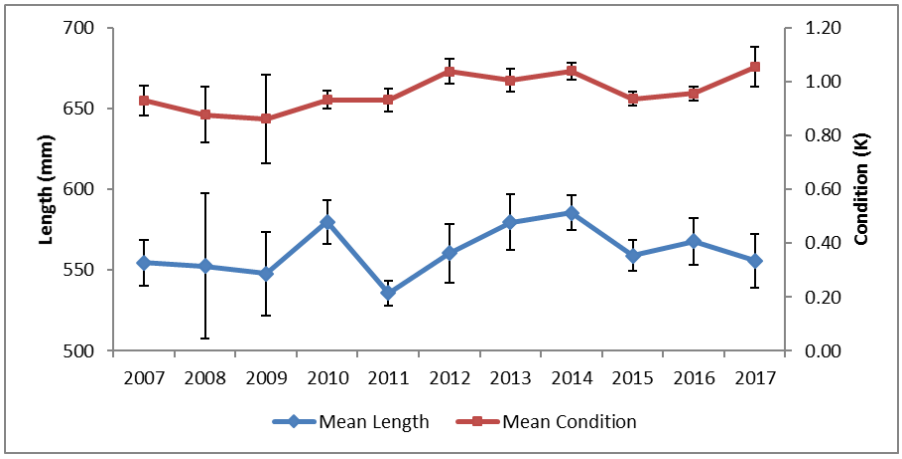

Figure 2. Comparison of mean total length (± 95 % CI) and K (± 95 % CI) of lake age 1 male landlocked Atlantic salmon collected at the Winooski One fish passage facility, 2007 – 2017.

Downstream passage at Winooski River Essex 19 Dam (Ardren, Staats, Pientka)

The USFWS and VTDFW have been consulting with Green Mountain Power (GMP) and its consultant, Kleinschmidt Associates regarding the application for Low Impact Hydropower Institute (LIHI) Certification for Essex 19 dam on the Winooski River (Figure 3). After the initial site visit on September 23, 2016, GMP made some recommended repairs, temporary modifications to the plunge pool, and conducted field testing of the downstream fish passage systems. The field testing was conducted on August 22, 2017 and staff from the USFWS and VTDFW were present to observe and assist. The Service also recommended that GMP prepare standard operating procedures (SOP) for the downstream fish passage facility.

The USFWS and VTDFW made the following recommendations to GMP after initial inspection of the facility on September 23, 2016:
1. Repair Outboard-side Downstream Gate Actuator/Stem to Ensure Proper Functioning
2. Grind Off/Remove Angle Iron Stub Welded to Downstream Bypass Entrance Walls
3. Re-Seat and Secure Floor Diffuser on Downstream Bypass Supplementary Water Supply
4. Ensure Both Gates Operate in Fully Open/Fully Closed Position (or modify the lip of the gate to approximate broad-crested weir geometry)
5. Repair Bent Turbine Intake Rack to Meet 1" Clear Spacing Requirements
6. Slotted Weir Impounding Plunge Pool May Require Chute/Floor to Ensure Safe Plunge
7. Modify Plunge Pool and/or Downstream Chute to Provide Safe Movement Downstream

Items 1-3 and 5 have been addressed. Items 4, 6 and 7 are currently undergoing field testing to find the best solution. Once all modifications are made to the downstream fish passage structure and operating procedures, GMP will need to verify the effectiveness of the system. We recommend pursuing downstream passage effectiveness studies through LIHI first and if that is not successful, using the relicensing process - the project's FERC license is due to expire in 2025.

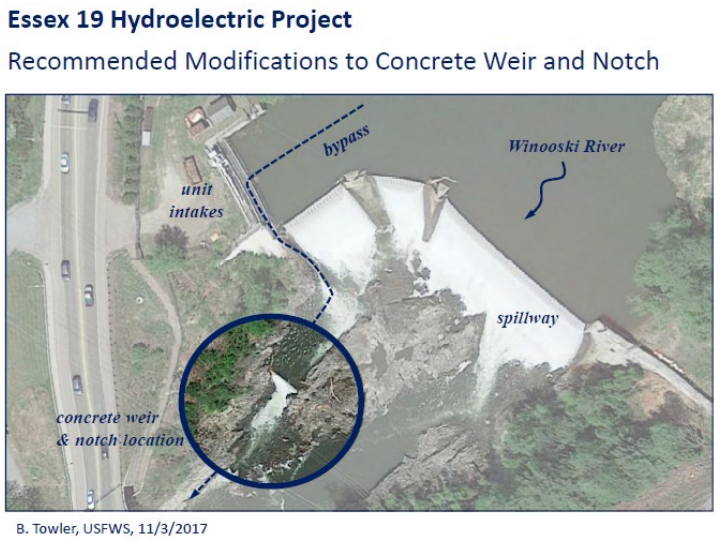

Figure 3. Aerial view of Essex 19 Dam on Winooski River. Areas associated with downstream fish passage for landlocked Atlantic salmon smolts are highlighted in blue text and the plunge pool and weir associated with the passage is highlighted with a circle.

Spring and Fall Nearshore and Tributary Assessments (Chipman, Smith)

Exploratory spring backpack electrofishing surveys were conducted in wadable areas of mid-sized Lake Champlain tributaries in Vermont to assess steelhead rainbow trout returns. Annual fall boat electrofishing surveys for salmonids were conducted in larger Vermont tributaries and nearshore areas in New York. A fish trap was operated for the fourth year at Hatchery Brook (Ed Weed Fish Culture Station discharge stream) during spring and fall to capture returning salmonids in spawning runs; salmonids in Hatchery Brook were collected by electrofishing and dip netting in previous years. A trap net was deployed in Hatchery Cove to collect spawning lake trout. These sampling efforts allow for the collection of biological data including total length, weight, sex, and age information as well as lamprey wounding data. Salmonids collected in Vermont tributaries were tagged with serially numbered Floy anchor tags prior to release. The data are utilized in hatchery product and fishery evaluations, and to monitor sea lamprey control progress through time. Numbers of fish reported below do not include same-year recaptures.

Spring steelhead sampling by electrofishing was attempted in Mill River, Georgia, Vermont during April 2017. Only one adult steelhead was collected. Sampling was not attempted in other tributaries due to high spring runoff flows.

The focus of fall nearshore salmonid sampling was on traditional sites in Willsboro and Whallon bays. Warm temperatures delayed the near-shore sampling into mid to late November. Catches in the Whallon Bay and Willsboro Bay areas consisted of 259 lake trout, 163 salmon, 1 steelhead, and 1 brown trout. Whallon and Willsboro bay salmon catches were down slightly from recent years. In 2017, over half of the salmon sample was made up of fish that are in their first year in the lake, which are generally less than 480 mm TL: very few age 1 lake year salmon, generally between 480 and 560 mm, were collected (Figure 4).

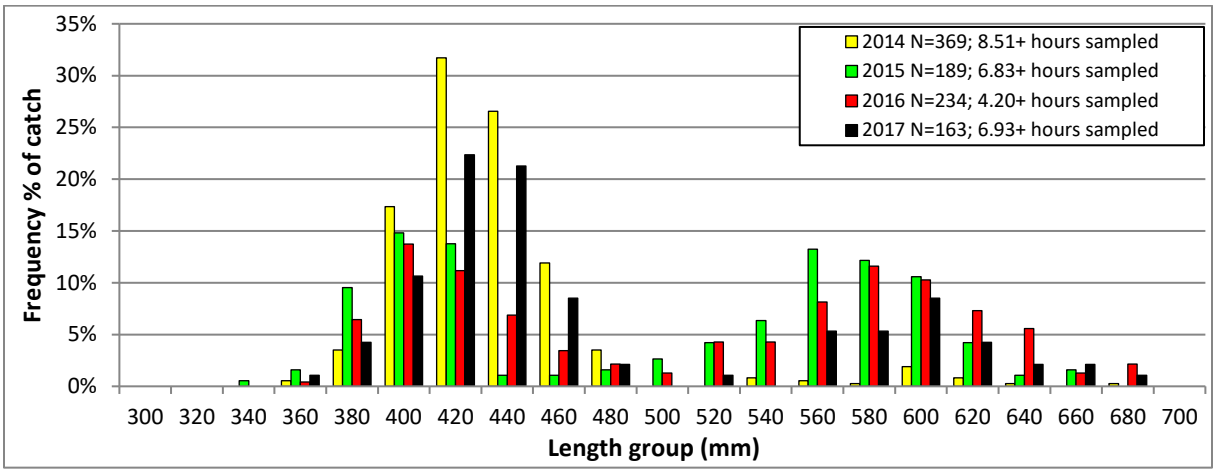

Figure 4. Length frequency distributions of landlocked Atlantic salmon collected from Willsboro and Whallon bays by electrofishing, 2014-2017.

In 2017, the Hatchery Brook trap was operated March 15-May 1, and September 15-November 17. The trap captured 19 steelhead during the spring season. In the fall, 164 salmon were captured and processed, which is the lowest number of salmon collected in Hatchery Brook since 2006. The fall trap

collection also included 41 brown trout and five steelhead.

Salmon runs were also relatively low in other Vermont tributaries, compared to recent years. Abnormally low lake levels and river flows, along with elevated water temperatures through much of the period may have limited tributary returns. Sampling crews collected 28 salmon in nine trips to the Lamoille River, 11 salmon in six trips to Otter Creek; and 10 salmon in six trips to the Missisquoi River.

A total of 122 adult salmon from Hatchery Brook, along with 16 from the Lamoille River, 4 from the Missisquoi River, and 1 from Otter Creek were retained for use as broodstock at Ed Weed FCS. All of the 57 pairs of salmon spawned were lethally sampled for disease testing; 22 salmon that were not spawned died in captivity, and the remainder were released alive in Lake Champlain.

Length frequency distributions of Hatchery Brook and Lamoille River salmon showed few fish in the 480 to 560 mm size classes (generally age 1 lake year) in 2017, compared to a more usual peak of abundance in those size classes in 2016 (Figure 5). Age distributions of salmon from these two sites also show a large decline of the Age 1 lake year cohort in 2017, compared to recent years (Figure 6). Mean lengths at age and condition factors for age 1 lake year salmon returning to Hatchery Brook and the Lamoille River in 2010 through 2017 are presented in Table 3. The relatively high condition factor (K=1.02) of Hatchery Brook salmon in 2017 (Table 3), may be related to the low relative density of this cohort (Figure 6).

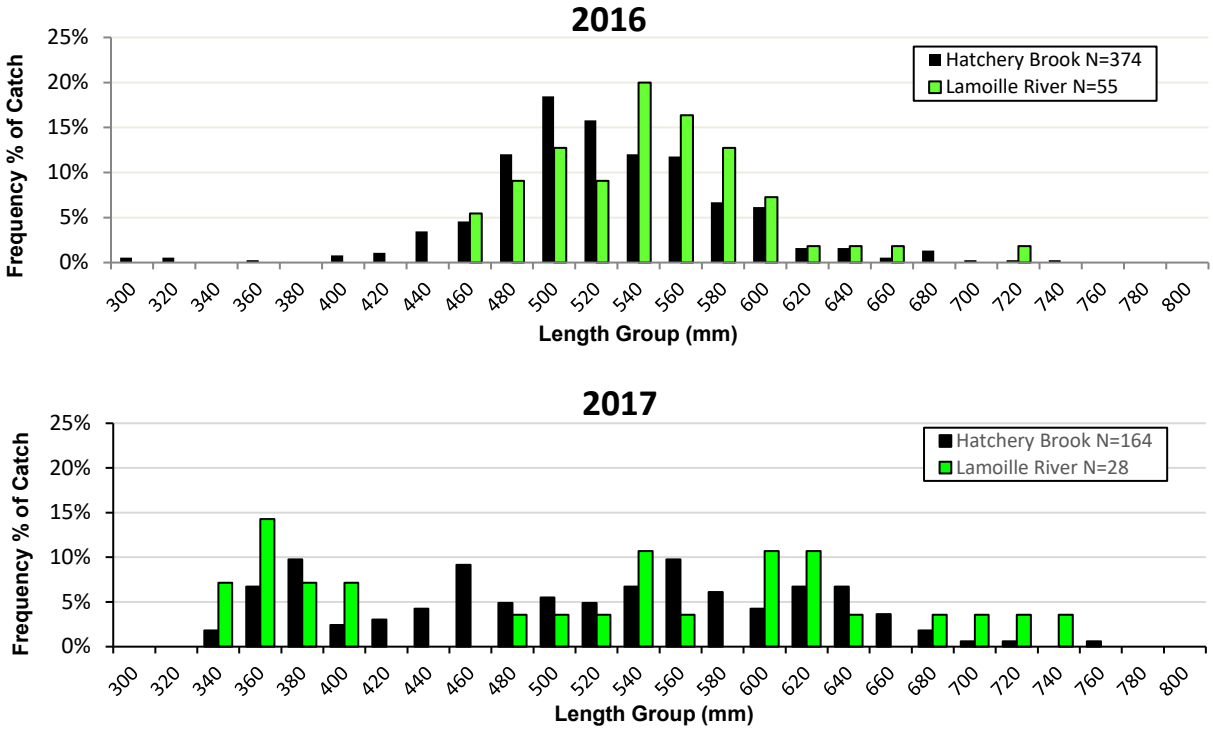

Figure 5. Length frequency distributions of landlocked Atlantic salmon collected from fall spawning runs in Hatchery Brook and Lamoille River in 2016 and 2017.

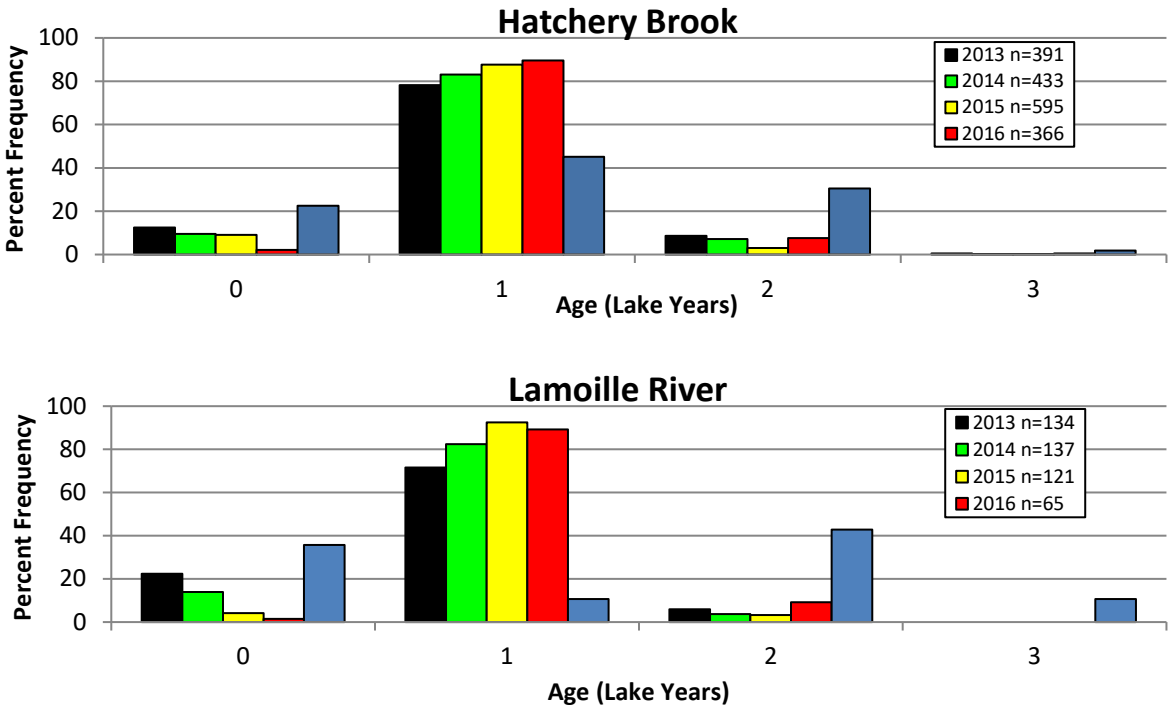

Figure 6. Age distributions (lake years) of landlocked Atlantic salmon from Hatchery Brook and Lamoille River, Lamoille River and Winooski River, 2013-2017.

Table 3. Estimated mean total length (TL, mm) ± 95 % confidence interval (CI) and Fulton's condition factor (K) ± 95 % CI of lake age 1 male landlocked Atlantic salmon collected at Hatchery Brook and the Lamoille River, fall 2010-2017.

Area	Year	TL	95% CI	n	K	95% CI	n
Hatchery Brook	2017	528	17	41	1.02	0.03	41
	2016	538	6	192	0.90	0.02	183
	2015	543	5	289	0.93	0.01	287
	2014	540	8	181	0.99	0.02	144
	2013	535	8	143	0.98	0.02	105
	2012	559	7	148	0.92	0.02	137
	2011	513	5	168	0.88	0.02	143
	2010	535	9	120	0.96	0.03	120
Lamoille River	2017	516	-	1	0.85	-	1
	2016	540	15	33	0.90	0.04	31
	2015	508	13	57	0.96	0.02	57
	2014	517	14	56	0.98	0.03	56
	2013	519	12	54	0.90	0.03	48
	2012	528	28	17	0.87	0.05	17
	2011	508	10	32	0.88	0.05	29
	2010	529	24	14	0.88	0.06	14

A trap net was set in Hatchery Cove for one night in early November to sample the lake trout spawning concentration. The set yielded 427 lake trout. Length frequency distributions of male and female lake trout collected by trap net in Hatchery Cove and by electrofishing in Whallon Bay are presented in Figure 7. Condition factors (K) of male lake trout collected lake-wide from 2010 through 2017 are presented Table 4.

A workgroup of the Fisheries Technical Committee continued work on development of a plan with metrics to assess salmonid stocking rates. Salmonid sampling data will be used to identify potential indicators of fish condition and abundance.

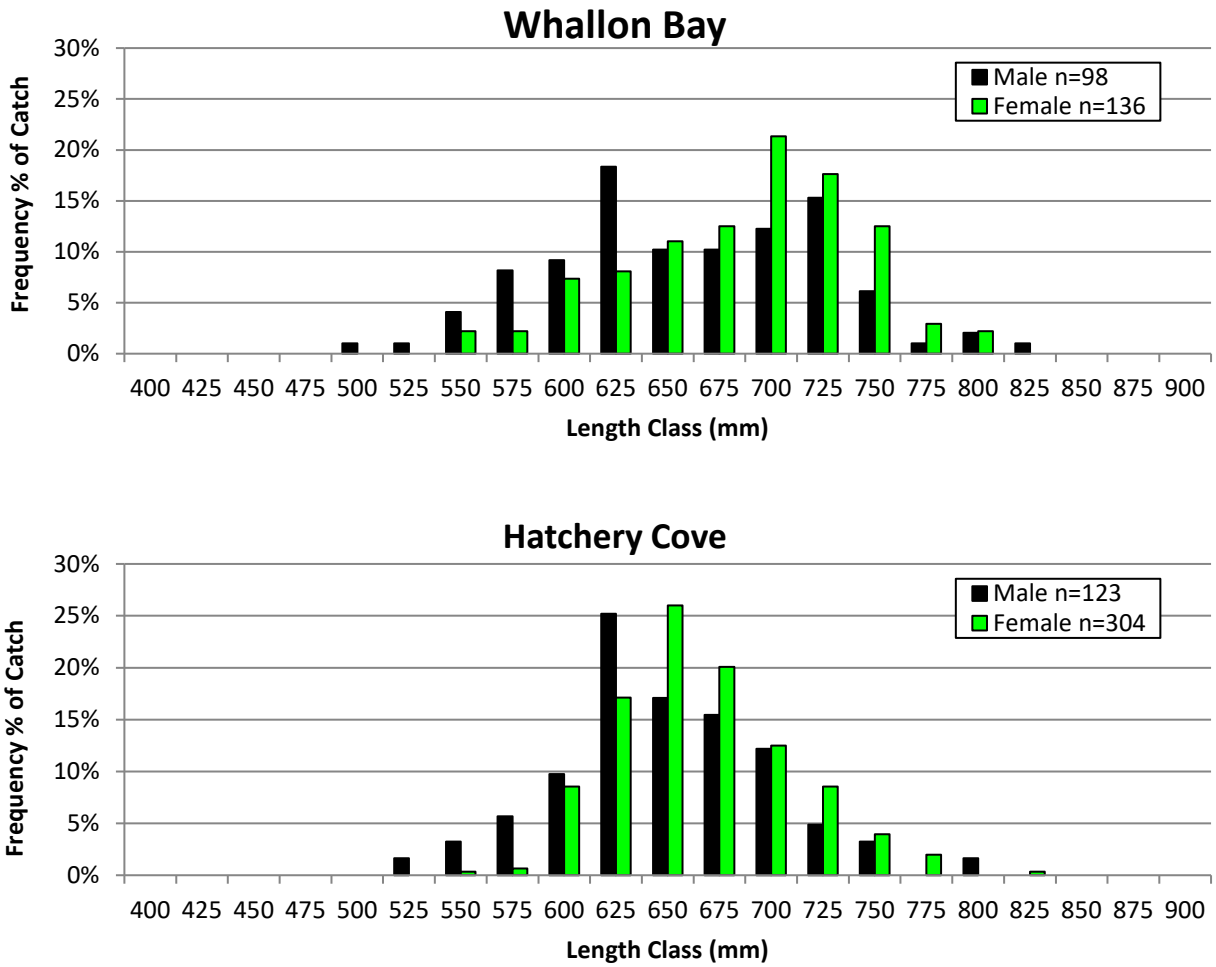

Figure 7. Length frequency distributions of male and female lake trout collected by trap net in Hatchery Cove and by electrofishing in Whallon Bay, November 2017.

Table 4. Estimated mean Fulton's condition factor (K) ± 95 % confidence interval (CI) for male lake trout collected in Lake Champlain in fall sampling, 2010-2017.

Year	K	95% CI	n
2017	0.91	0.01	124
2016	0.88	0.01	123
2015	0.91	0.01	129
2014	0.96	0.02	193
2013	0.91	0.01	182
2012	0.87	0.01	248
2011	0.86	0.01	123
2010	0.93	0.01	234

Landlocked Salmon Brood Source Evaluation (Chipman)

An experiment to compare the performance of stocked Sebago strain salmon smolts produced from domestic broodstock and feral broodstock was completed. Fish from each experimental group were reared under identical conditions at the Ed Weed Fish Culture Station and marked prior to stocking with fin clips specific to each group. Equal numbers of yearling smolts of each group were planned to be stocked annually from 2012 through 2016 in the Lamoille River, Missisquoi River, Inland Sea, and Hatchery Cove. Annual numbers of each group stocked averaged 40,752 (51.0%) feral and 39,218 (49.0%) domestic.

Returns of salmon from each brood source were recorded in annual fall nearshore, tributary, and fishway assessments. Results through 2017 consistently show greater returns of feral offspring relative to domestic offspring each year (Figure 8).

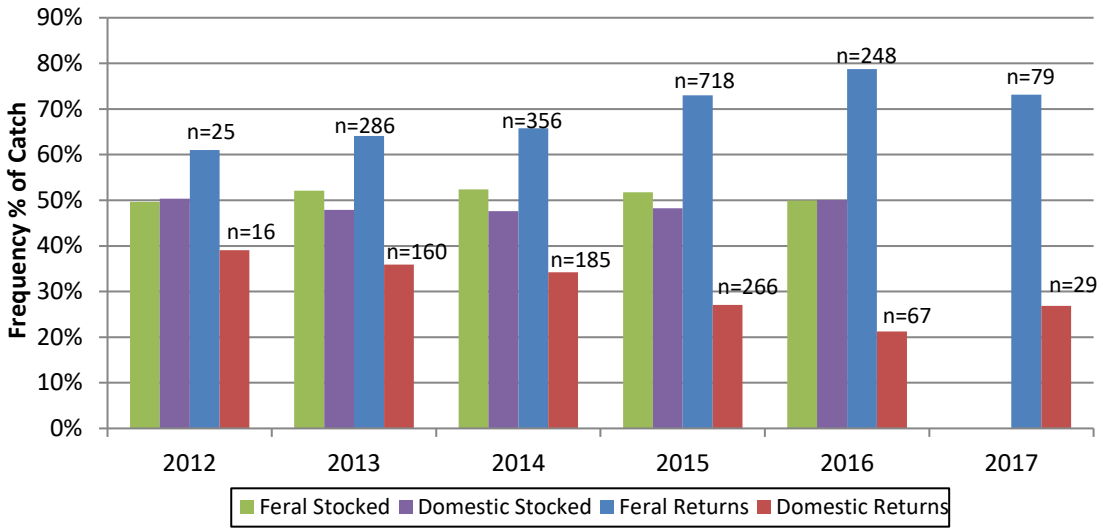

Figure 8. Returns of landlocked salmon stocked in Lake Champlain, produced from feral and domestic broodstock, 2012-2017.

Steelhead Strain Evaluation (Chipman)

An experiment to compare the performance of Chambers Creek strain and Lake Memphremagog strain steelhead rainbow trout is ongoing. Fish of each strain were reared under identical conditions at the Ed Weed Fish Culture Station and marked prior to stocking with fin clips specific to each group. Equal numbers of yearling smolts of each strain were planned to be stocked annually from 2012 through 2017 in Lewis Creek, LaPlatte River, Winooski River, Hatchery Cove, and Mill River. Annual numbers of each strain stocked averaged 31,462 (51.3%) Chambers Creek and 28,897 (48.7%) Memphremagog.

Steelhead returns from each strain were recorded in annual fall and spring nearshore, tributary, and fishway assessments. Results through fall 2017 show inconsistent overall steelhead returns from year to year, with the Chambers Creek strain returning at greater rates than the Memphremagog strain in four of the six years (Figure 9). Analysis by season shows little to no difference in spring returns of the two strains over three of the five years; however, consistently greater fall returns of the Chambers Creek strain were observed (Figure 10). Evaluation sampling will continue through spring 2018.

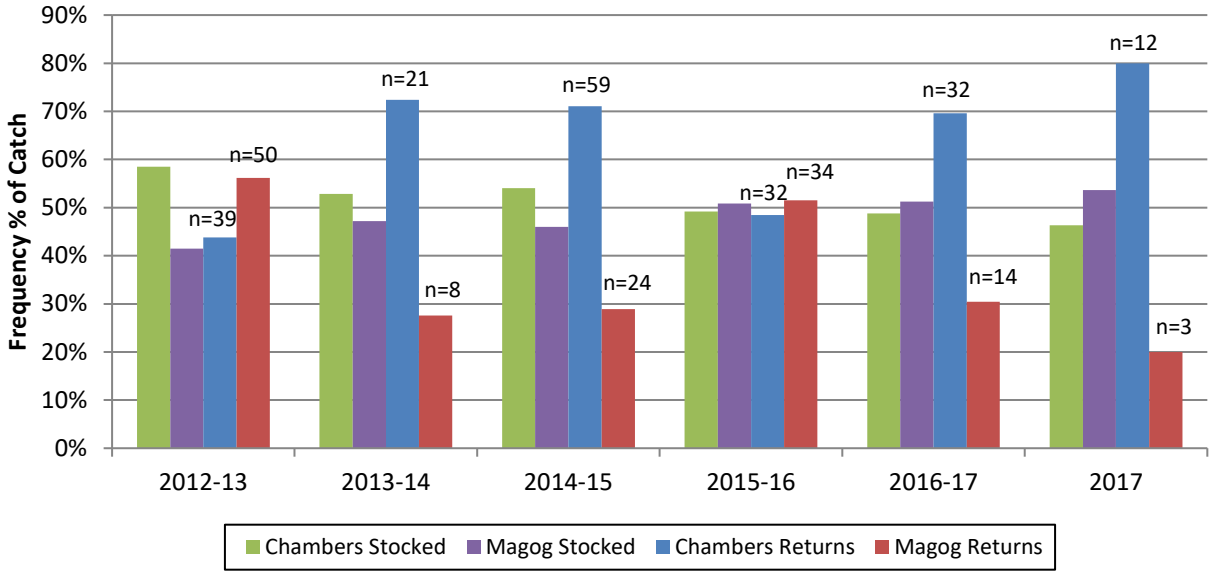

Figure 9. Returns of Chambers Creek and Lake Memphremagog strain steelhead stocked in Lake Champlain, 2012-2017. Each group of returns represents corresponding fall and following spring sampling periods, except from the 2017 group which is the fall period only.

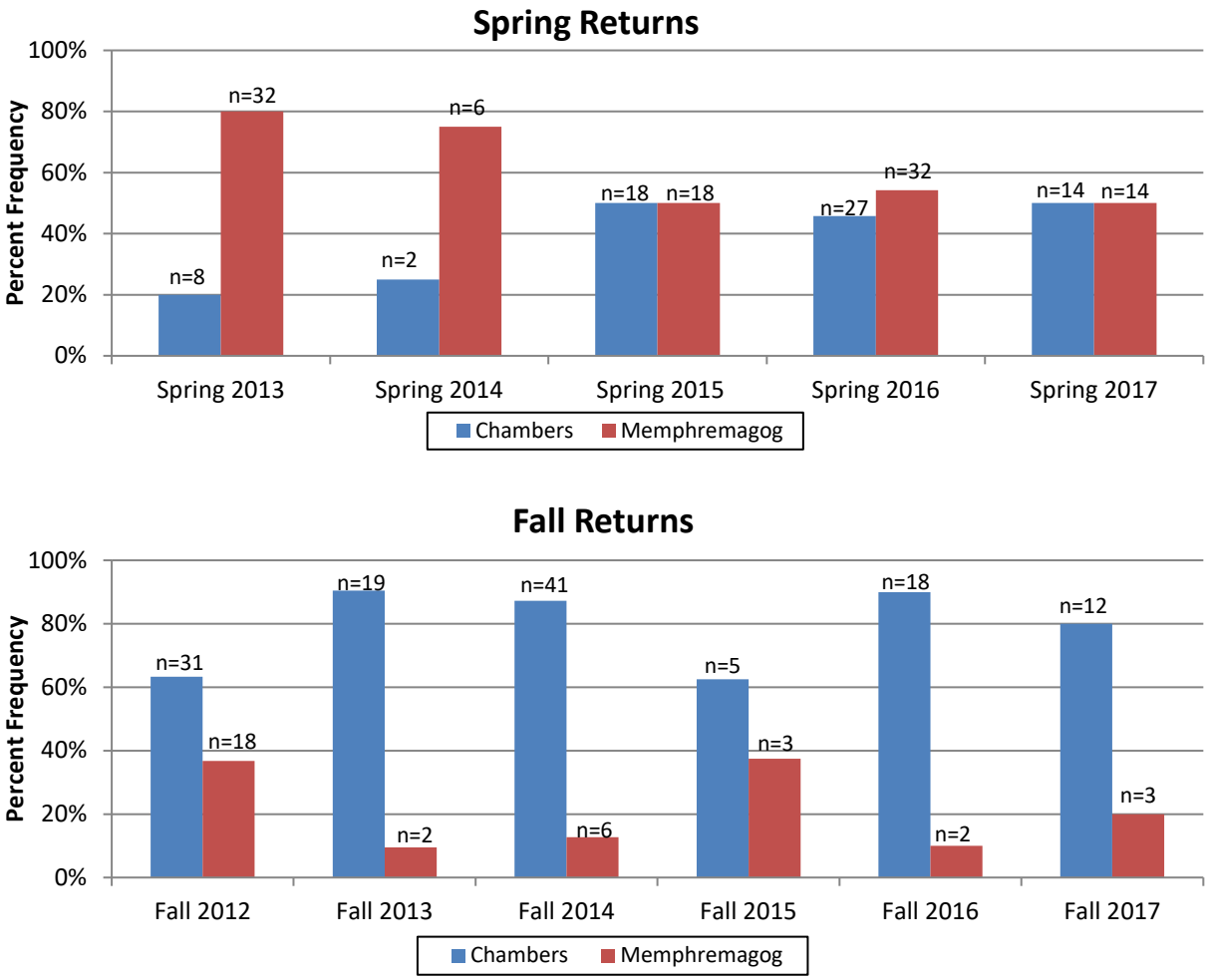

Figure 10. Spring and fall returns of Chambers Creek and Lake Memphremagog strain steelhead stocked in Lake Champlain, 2012-2017.

Atlantic Salmon Broodstock Development at White River NFH (Ardren, Bouchard)

Two Lake Champlain broodstocks of landlocked Atlantic salmon are being established at White River NFH. Both broodstocks are being founded with feral fish from Hatchery Brook collected during the 2016, 2017, 2018 and possibly 2019 fall spawning runs. By 2020, these two broodstocks will be primary broodstocks for Eisenhower NFH, serve as backup broodstocks for Ed Weed FCS and potential broodstock sources for Lake Ontario restoration efforts.

Atlantic salmon in Lake Champlain have critically low levels of thiamine caused by foraging on non-native alewife. Thiamine deficiency complex (TDC) has impacted salmon survival at early life stages and migration performance of adults. We are using "Evolutionary Rescue" to develop a TDC Tolerant broodstock that we anticipate will have increased survival and reproductive success in Lake Champlain. The Evolutionary Rescue process is accomplished by splitting eggs from all families into two groups that are supplemented and not supplemented with thiamine immediately after fertilization. Families that survive in the hatchery without thiamine supplementation will be founders of the TDC Tolerant broodstock. However, the strong selection in the TDC Tolerant broodstock could also cause for unintended reduction in fitness of other traits and increased levels of inbreeding. Because of these concerns, we are also maintaining a Max Diversity broodstock founded by surviving families supplemented with thiamine. This Max Diversity broodstock will be managed to maximize genetic diversity (i.e., large effective population size) but will not undergo selection for tolerance to TDC.

In 2016 we collected 17 unique families, all families survived when supplemented with thiamine while only five families survived when not supplemented with thiamine. In 2017 we collected 50 unique families, 43 families survived when supplemented with thiamine while only 16 families survived when not supplemented with thiamine. Median egg thiamine levels were higher for families that survived without thiamine supplementation in 2016 and 2017 (Figure 11). Most females in 2016 and 2017 had egg thiamine levels below predicted survival threshold. To date, 21 of 67 (31%) families survived without thiamine supplementation and founded the TDC Tolerant broodstock vs. 60 of 67 (90%) families survived with thiamine supplementation and founded the Max diversity broodstock.

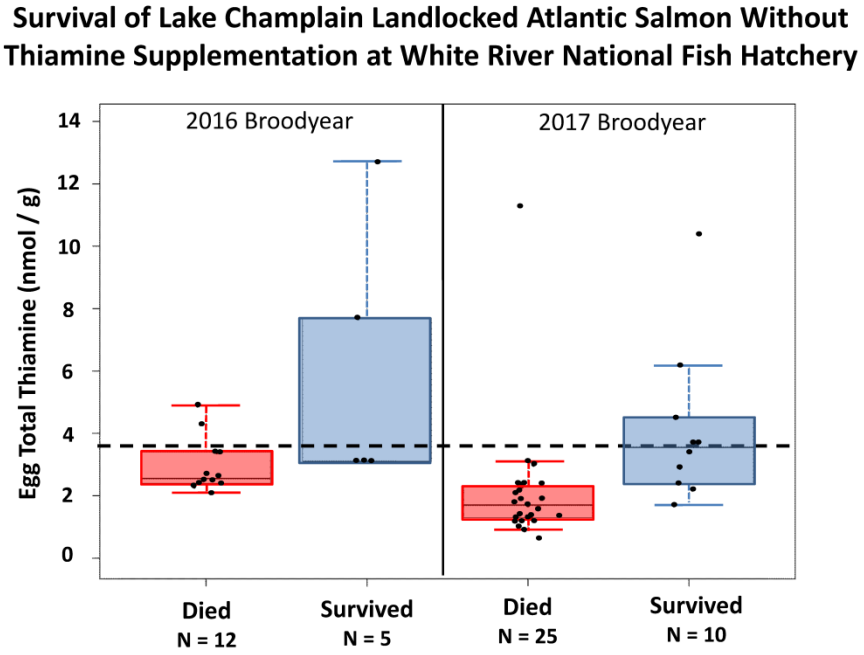

Figure 11. Total thiamine concentration of eggs from female landlocked Atlantic salmon used to establish Lake Champlain broodstocks at White River NFH in 2016 and 2017. Samples are grouped by survival status to the first feeding stage at the hatchery. Predicted threshold for survival of 3.8 nmol /g is shown by dashed line. Due to a shortage of eggs in the 2017 broodyear, we examined a subsample of eggs from 35 of 50 females used for broodstock.

SEA LAMPREY

The objective of the sea lamprey control program is to achieve and maintain wounding rates at or below 25 wounds per 100 lake trout, 15 wounds per 100 landlocked Atlantic salmon (salmon), and 2 wounds per 100 walleye.

Sea Lamprey Control Permitting (Young)

In response to a 2016 policy change by the Vermont Department of Health, it became necessary to undertake a toxicity study for use in establishing human health protection threshold values for the lampricide TFM. A lab in Maryland was contracted through Steve Lantz of USGS in LaCrosse, Wisconsin and our partners in the Great Lake Fishery Commission. The study will begin in March 2018 with a completion date in September. All aspects of the study have been developed in conjunction with the Vermont Department of Health to ensure the results satisfy state requirements. Results are anticipated to provide the Sea Lamprey Control Program with the information needed to apply for and receive permits authorizing the use of TFM on 3 Vermont rivers scheduled for treatment in 2019.

The Federal NEPA and New York SEQR processes were completed in 2017 to allow for sea lamprey control in two new New York tributaries (ie. Little Chazy and Rea Brook).

Assistance and support from the Department of Fisheries and Oceans, Canada has led to continued coordination with the Town of Shelburne, Vermont to design and construct a modification to an existing bridge abutment on the LaPlatte River. By adding an elevated lip to the Falls Road bridge base we will eliminate sea lamprey access to the upper 2/3 of the river.

Pre-treatment Larval Assessment Sampling (Allaire)

During the summer of 2017 the Boquet River, Ausable River, Little Ausable River, Salmon River, Saranac River, Rea Brook, Little Chazy River, and the Great Chazy River were all surveyed prior to possible lampricide treatments in the fall of 2018 (Table 5). Lamprey larval surveys were also conducted in the Pike River and in Morpion stream in Quebec. In 2014, the US Fish and Wildlife Service began operating an adult barrier in Morpion Stream to remove spawning phase adults. Larval surveys have been conducted annually in the Pike River and in Morpion Stream to monitor for any changes in larval density (Table 6).

Table 5. Sea lamprey larval densities during pre-treatment surveys conducted during summer of 2017.

Stream	Type I (optimal) Larval Density (n/m^2)	Type II (suboptimal) Larval Density (n/m^2)
Boquet River	0.061	0.111
Ausable River	4.277	0.373
Little Ausable River	0.456	0.256
Salmon River	0.793	0.522
Saranac River	4.600	2.800
Rea Brook	1.606	0.693
Little Chazy River	0.673	0.870
Great Chazy River (Reach 2)	1.232	0.617

Table 6. Sea lamprey larval densities in the Pike River and Morpion Stream between 2014 and 2017.

Stream	Type I (optimal) Larval Density (n/m^2)	Type II (suboptimal) Larval Density (n/m^2)
2016 Pike River – Reach 1	0.200	0.089
2014 Pike River – Reach 2	2.084	1.072
2015 Pike River – Reach 2	1.767	0.878
2016 Pike River – Reach 2	0.212	0.154
2017 Pike River – Reach 2*	0.283	0.133
2014 Morpion Stream	1.139	0.164
2015 Morpion Stream	1.256	0.535
2016 Morpion Stream	0.699	0.263
2017 Morpion Stream	0.551	0.139

* In 2017 permit conditions only allowed for sampling in the upstream portion of reach 2 of the Pike River.

Post-treatment Larval Assessment Sampling (Allaire)

Post-treatment larval surveys were conducted in two Lake Champlain tributaries (Stone Bridge Brook and the LaPlatte River) that received lampricide treatments in the fall of 2016 (Table 7).

Table 7. Pre-treatment and post-treatment larval densities for streams treated with lampricides during the fall of 2016.

Stream	Pre-treatment (2015) Density (n/m^2)	Post-treatment (2017) Density (n/m^2)	Percent reduction in sea lamprey larvae density
Stone Bridge Brook	0.030	0.000	100.0%
LaPlatte River (Reach 1)	0.762	0.021	97.2%

Detection Sampling (Allaire)

In 2017, staff visited 35 tributaries in the southwestern quadrant of Lake Champlain that have historically been considered "negative" for the presence of sea lamprey. Three new sea lamprey populations were found. All three new populations were found in the town of Westport, NY. A single sea lamprey ammocoete was collected in a small unnamed tributary just north of the state boat launch. In Hoisington Brook, just south of the state boat launch, 26 sea lamprey ammocoetes and transformers were collected. In Stacy Brook, approximately 3 miles south of Hoisington Brook, 5 sea lamprey ammocoetes were collected.

Trapping and Barriers (Allaire)

Adult sea lamprey were trapped in 9 tributaries to Lake Champlain during the spring of 2017 to prevent or limit reproductive success (Table 8). Baited pots were deployed above trap sites in Malletts Creek, Trout Brook, and the Pike River. One adult sea lamprey was caught in the pots in both Trout Brook and in the Pike River. In Malletts Creek, we captured 10 adults in pots (7.2% of the total catch). We will continue to use pots above traps to gauge the amount of escapement past trap sites and in areas where we are unable to deploy traps.

In 2017 we saw an increase in the number of adult sea lamprey captured at all but one of our trapping sites (Morpion Stream). The total number of adults captured was 492, compared to just 344 in 2016

(record low number). The percent of days that our traps were operational and blocking adults was down at all trap sites as well due to higher stream flows during the spring of 2017.

Table 8. Results of adult sea lamprey trapping in 2017.

Date Trap Set	State / Province	Stream	Date Trap Removed	% of Days Trap Operational	# of Lamprey Captured (2016)	# of Lamprey Captured (2017)	% Change From 2016
4/17/17	NY	Beaver Brook	6/26/17	91.5%	1	25	2400.0%
4/20/17	VT	Trout Brook	6/22/17	76.6%	14	35	150%
4/26/17	VT	Malletts Creek	6/22/17	22.4%	78	138	76.9%
4/17/17	VT	Pond Brook	6/22/17	71.6%	43	126	193.0%
4/19/17	NY	Rea Brook	6/26/17	75.4%	51	65	27.5%
4/18/17	VT	Sunderland Brook	6/20/17	53.1%	11	14	27.2%
4/17/17	NY	Mullen Brook	6/26/17	63.4%	5	58	1060.0%
5/10/17	QC	Pike River (pots)	6/26/17	NA	NA	1	NA
4/25/17	QC	Morpion	6/26/17	93.5%	140	30	-78.6%
				TOTAL	**343**	**492**	**43.0%**

Lampricide Control (Smith)

There were no Lampricide treatments conducted in 2017. This resulted from a new geographically based treatment schedule, which came into alignment in 2016. Control status of Lake Champlain tributaries is presented in Appendix 2. A treatment history and schedule of future treatments is presented in Appendix 3.

Wounding Rates (Chipman, Smith)

Sea lamprey wounding rates calculated for lake trout collected in 2017 increased to 63.3 wounds per 100 fish (n=150), which remains well above the program objective (Figure 12). The wounding rate for Main Lake salmon collected in 2017, however, decreased slightly again to 17 wounds per 100 fish (n= 100) (Figure 13). No lamprey wounds were recorded on Inland Sea-Malletts Bay salmon in the wounding analysis length interval in 2017, although the sample contained only 3 salmon in the target size class (Figure 13). Salmon wounding rates in 2017 remained substantially lower than the average rates observed during the 1990's experimental sea lamprey control program (Table 9). The wounding rate on lake trout was again higher in 2017 than recent years, exceeding levels seen since 2006.

The sea lamprey wounding rate for walleye (534 to 634 mm TL) collected in spring 2017 from the Poultney River was 0 wounds per 100 fish (n=57), which is below the Cooperative's lamprey wounding rate objective for walleye of 2 wounds per 100 fish. Wounding rates on walleyes in the same size class collected from the Lamoille River in spring 2017 were greater than the objective, at 5 wounds per 100 fish.

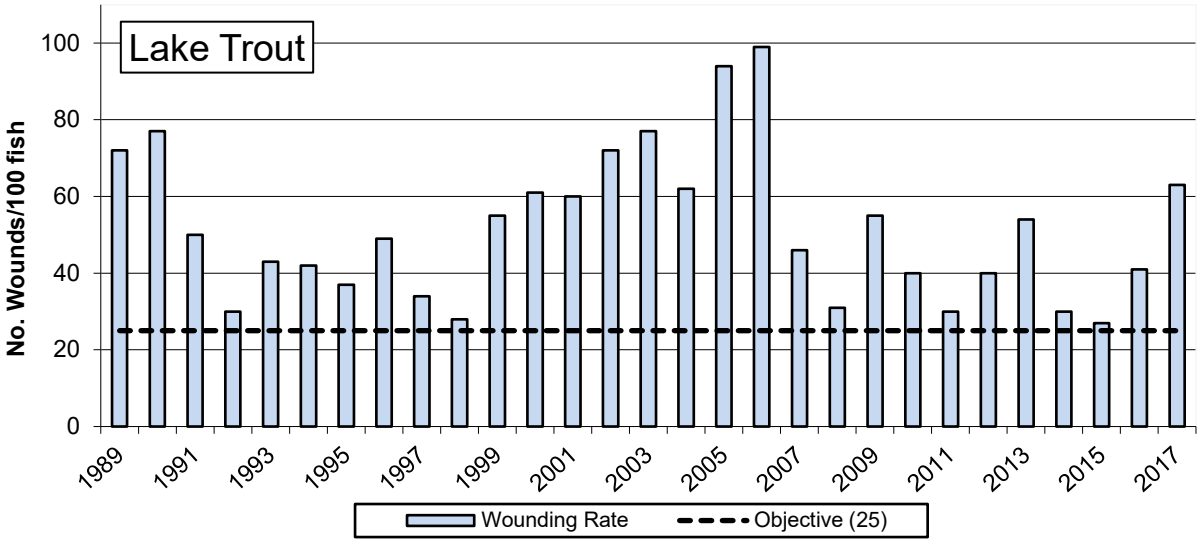

Figure 12. Type A1-A3 sea lamprey wounds (fresh and healing) per 100 lake trout (533-633 mm total length) from fall sampling in the Main Lake basin, 1989-2017. The target wounding rate of 25 wounds per 100 fish is presented for reference (dashed line).

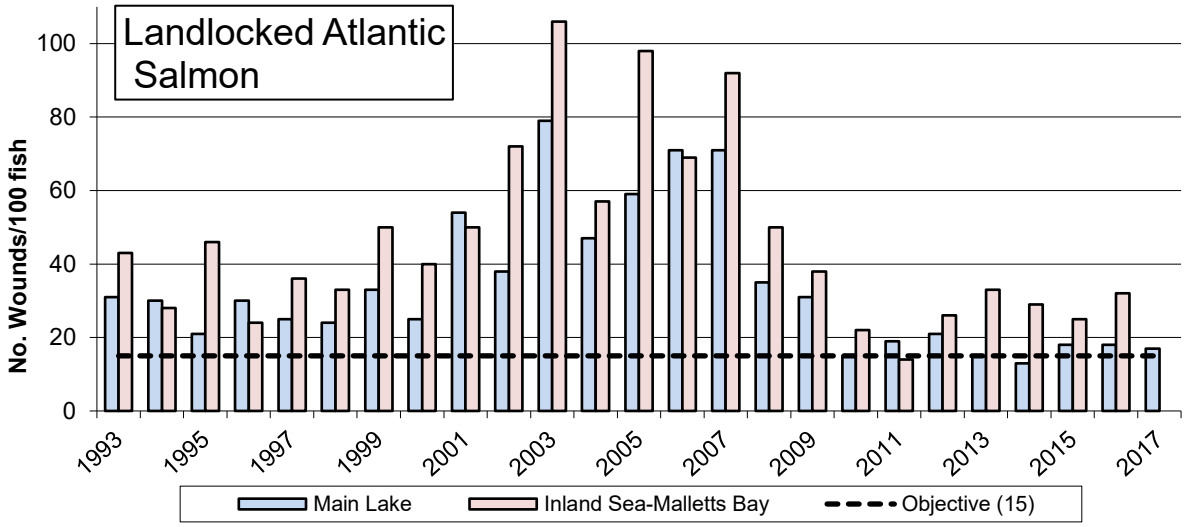

Figure 13. Type A1-A3 sea lamprey wounds (fresh and healing) per 100 salmon (432-533 mm total length) from fall sampling in the Main Lake and Inland Sea-Malletts Bay basins, 1993-2017. The target wounding rate of 15 wounds per 100 fish is also presented for reference (dashed line).

Table 9. Sea lamprey wounding rates on Lake Champlain lake trout and Atlantic salmon during 2017, compared with pre-control and eight-year experimental control program results.

	Number of type A1-A3 lamprey wounds per 100 fish			
	Objective	Pre-control	Experimental control	2017
Lake Trout[a] (Main Lake)	25	55	38	63
Atlantic Salmon[b] (lake-wide)	15	32	31	17
Atlantic Salmon[b] (Main Lake)	15	34	27	17
Atlantic Salmon[b] (Malletts Bay-Inland Sea)	15	32	39	NA[c]

[a] Lake trout in the 533-633 mm (21.0-24.9 inches) length interval. For lake trout, pre-control included 1982 - 92, while experimental control includes 1993 - 97.
[b] Salmon in the 432-533 mm (17.0-21.0 inches) length interval. For salmon, pre-control included 1985 - 92, while experimental control includes 1993 - 98.
[c] Wounding rate data for Malletts Bay-Inland Sea salmon are not available due to insufficient sample size (n=3).

PERCIDS

Yellow Perch (Pientka)

Experimental gillnets are set overnight at multiple locations in order to monitor the Lake Champlain fish community. While these nets are not specifically targeting yellow perch, they do provide insight into relative abundance of yellow perch. In 2017, the sampling occurred between July 5th and July 17th. Yellow perch catch per overnight set (CPUE) in 2017 was similar to past years (Figure 14). Sampling will continue in 2018.

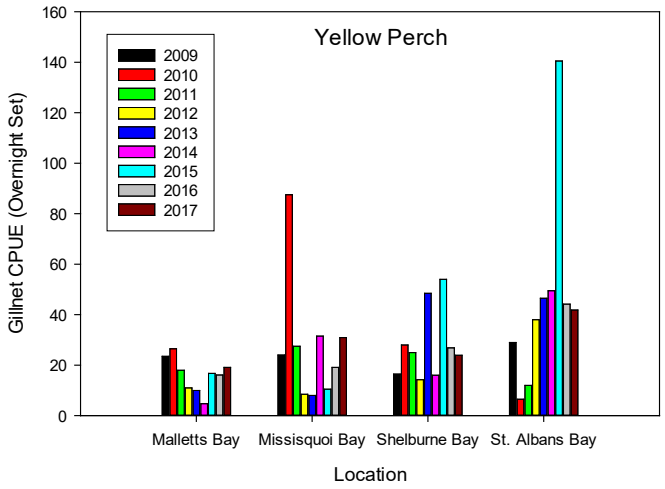

Figure 14. Yellow Perch CPUE for 2009-2017 at four Lake Champlain locations

Walleye (MacKenzie, Pientka) -

Walleye management activities on Lake Champlain included monitoring adult walleye returning to spawn in the Poultney and Lamoille rivers. The Poultney River spawning stock was used for collection of brood stock for the fish culture and stocking program, and evaluation of the contribution of stocked walleye to spawning populations.

Two hundred and thirty-four walleye (136 males, 86 females) were collected from the Poultney River. Twenty-three pairs were spawned resulting in 3.24 million eggs. Eggs were hatched at the Ed Weed Fish Culture Station (FCS) in Vermont. Fingerlings were reared in the intensive culture system located at the Ed Weed FCS and in 4 ponds managed by the Lake Champlain Walleye Association. All fry and fingerlings were marked with OTC prior to stocking. Forty eight age-3 males were collected for evaluation of the contribution of stocked fish to the spawning run in the Poultney River.

Adult walleye (n = 372) were collected during the spawning run in the Lamoille River over six days in 2017. Walleye lamprey wounding rate (2017) for the Lamoille River was above the wounding target of 2 wounds per 100 fish. Review of the length frequency distribution of the spawning population indicates the population is healthy and there is natural reproduction occurring often enough to sustain the population.

Sauger (Durfey, Ardren, Bouchard) -

NYSDEC and USFWS are assessing options for sauger restoration in Lake Champlain. NYSDEC is currently drafting a Lake Champlain Sauger Restoration Plan and is working with USFWS to assess the feasibility of establishing a sauger hatchery program at White River NFH. The Lake Champlain FTC sauger working group considered the following information and issues.

I. Status of sauger in Lake Champlain

1. Last sauger observed in Lake Champlain was a large female sampled in South Bay during 2010 walleye broodstock collections. This was the first sauger recorded from a New York water since 1994.
2. Direct sampling for sauger was done by NYSDEC via trap netting in south bay of Lake Champlain during spring of 2011 and no sauger were captured.
3. No sauger have been observed in the south lake region by Vermont Department of Fish and Wildlife during fish creel and walleye broodstock collections in the Poultney River.
4. Fishery for sauger in Lake Champlain has been closed by both NYSDEC and VTDFW.
5. Members of the subgroup made it clear that we have not sampled with enough effort to label sauger extirpated from Lake Champlain
6. All agreed that sauger are likely at extremely low abundance in Lake Champlain and increased efforts to find sauger in the south lake are not likely to be successful for finding enough fish to establish a genetically diverse broodstock for using hatchery produced fingerlings to restore the population.

II. Restoration goals for sauger in Lake Champlain.

1. Southern Lake Champlain (South Lake) is considered the best habitat for sauger. NYSDEC is focusing on South Lake for stocking program to restore sauger to the lake.
2. Stocking target set by NYSDEC is 300,000 fingerling sauger for five consecutive years. This target is based on estimate of 15,000 acres of suitable habitat in South Lake and a standard walleye stocking of rate 20 fingerlings / acre.

3. This stocking rate should also take into account that VTDFW stocks 100,000 walleye fingerlings in South Lake every third year.

III Potential broodstock sources for conservation hatchery program at White River NFH

Three potential broodstock options were discussed.

1. Genoa National Fish Hatchery broodstock collected for upper Mississippi River near La Crosse, WI.
   a. Evidence from yellow perch genetic study that Lake Champlain is a mix of fish from different glacial refugia, including Great Lakes, Atlantic, and Mississippi.
   c. Have over five years of extensive disease testing results and established biosecurity plan for transfer of fish to Genoa NFH.
   d. Both Hatcheries are willing to work with us to collect additional broodstock needed to start Lake Champlain Program.
2. St. Lawrence River – Lake St. Catherine Pierre – embryos directly to White River NFH.
   a. This source is likely closest ecological and genetics match to Lake Champlain sauger.
   b. NYSDEC is working with biologists in Quebec to determine if collection of enough fish is possible for broodstock needs and also collection of fish health samples to screen the population for possible import back into USA. NYSDEC collected sauger (n = 60) in spring 2017 and these fish had a clean fish health report from USFWS Lamar Fish Health Lab.
3. St. Lawrence River – Lake St. Catherine Pierre – eggs and sperm Fed Exed to Northern Aquaculture Demonstration Facility in Bayfield, WI. Disease tested and pellet trained broodstock provide eyed eggs to White River NFH.
   a. This is a combination of the two sources identified above.

IV. Fish Health / Biosecurity Needs

1. Transfer of fish from the wild to a hatchery increases disease risk at the hatchery. In particular, viral hemorrhagic septicemia virus (VHSv), is of serious concern.
   a. Fortunately, a recent study by USGS demonstrated that the iodophor disinfection of walleye gametes greatly reduces the risk of pathogen transfer, including VHSv, during spawning operations.
   b. 100% lethal sampling of all broodstock for fish disease testing would be required.
   c. History of disease testing for the wild population used for broodstock may be required.
2. Sauger are not native to the Connecticut River Basin where White River NFH is located.
   a. There needs to be a containment plan that does not allow sauger to escape from White River NFH.
   b. The final plan for rearing sauger at White River NFH should be presented to other states in Connecticut River Basin via CRASC Technical Committee for comment.
3. Risk assessment of stocked sauger from Lake Champlain migrating into St. Lawrence River Basin.
   a. Evaluate risk of migration occurring.
   b. Evaluate genetic risk of outbreeding depression if migration occurs.
4. A quarantine space at White River NFH would need to be developed.
   a. Biosecurity needs for this project will require a walled off area that isolated and disinfects effluent via fish health guidelines.
   b. Quarantine needs may be relaxed if disease tested fish from Northern Aquaculture Demonstration Facility in Bayfield, WI are transferred to White River NFH.

V. Next Steps

1. Need to get input from fish health staff from VT, NY and USFWS on biosecurity needs for three brood stock options identified above.
2. Complete genetics study on historic Lake Champlain sauger samples. Assess genetic relationship of historic Lake Champlain to potential broodstock sources. Also screen historical samples for evidence for hybridization with walleye. – On going with USFWS Genetics Lab – Lamar Northeast Fishery Center.
2. NYSDEC gets more information on feasibility of using St. Lawrence River – Lake St. Catherine Pierre as a broodstock source. USFWS gets more information on feasibility of using upper Mississippi River as broodstock source.
3. USFWS develops a cost estimate for rearing sauger at White River NFH for each of the three broodstock options identified above. Goal is to start program in spring of 2019 or 2020.

CENTRARCHIDS

Largemouth and Smallmouth Bass (Good, Pientka)

Angling for largemouth and smallmouth bass in Lake Champlain continues to be highly popular. The lake is widely considered to be one of the top 5 bass fishing destinations in the country, and it attracts and supports a high level of recreational and tournament-oriented fishing pressure. In 2017, Vermont issued 114 permits for bass tournaments on Lake Champlain, down from 130 the previous year. B.A.S.S. event results indicate that tournament catches have remained very consistent since the first tournament was held on Lake Champlain in 1997 (Figure 15). Both major U.S. professional bass fishing tournament series, Bassmaster and Forrest L. Wood (FLW) Outdoors, hold regular events on the lake.

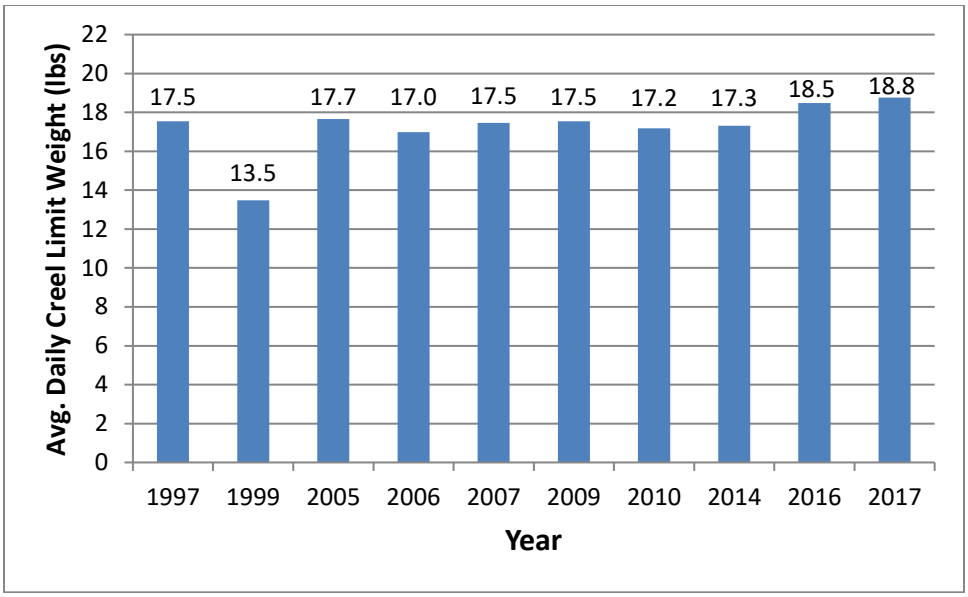

Figure 15. Average daily creel limit weights for the Top 10 anglers from 10 professional-level B.A.S.S. tournaments held on Lake Champlain since 1997.

No bass sampling was conducted on southern Lake Champlain in 2017 due to unfavorable weather and lake conditions.

Electrofishing surveys were conducted on northern Lake Champlain in the spring of 2017. A total of fifteen transects were sampled at three different sites. A total of 5.44 hours of electrofishing was completed and 179 largemouth bass and 113 smallmouth bass were collected. Largemouth bass ranged in size from 5.2 to 19.1 inches total length and smallmouth bass ranged in size from 7.2 to 20.3 inches total length.

ESOCIDS

Muskellunge (Good, Pientka)

In 2017, VTDFW stocked 4,340 muskellunge into the lower Missisquoi River and Missisquoi Bay, including Campbell's Bay (Table 10). As in the previous three years, approximately 2,000 of the muskellunge were also stocked above the Swanton Dam. The location above Swanton Dam is stocked because of several potential benefits – there is abundant forage and a relative lack of predation and competition. Muskellunge may grow readily and have good survival rates. Fish are likely to then migrate downstream into the lower river and Lake Champlain at a size where predation would be low and survival high in the Champlain fish community.

Table 10. Muskellunge stocking numbers for Lake Champlain, 2008-2017.

Date	Total Number Received	Total Wt. (Lbs)	Avg. Length (Inches)	Numbers Stocked by Location	
				Lower Missisquoi River & Bay	Above Swanton Dam
8/19/2008	250	4.35	6.1	250	0
8/19/2009	10,000	174	5.04	10,000	0
2010	0			0	0
8/18/2011	5,150	95.5	5.0	5,150	0
8/21/2012	8,800	185	5.36	8,800	0
8/26/2013	7,580	155	5.32	4,580	3,000
8/27/2014	7,000	137	5.24	5,000	2,000
8/25/2015	5,540	85	4.83	3,540	2,000
8/22/2016	6,300	128	5.31	3,800	2,500
8/21/2017	4,340	74	5.00	2,340	2,000
TOTAL	**54,960**			**43,460**	**11,500**

Sampling for fall young-of-year muskellunge was conducted on November 15, 2017 on the upper Missisquoi River between Swanton and Highgate dams to document the survival of stocked fish. Although muskellunge are also stocked below the dam and in Missisquoi Bay, the upper Missisquoi River is more conducive to collecting stocked fish because of the ease of targeting potential habitat, versus the vast areas of habitat in the lower river and bay. Sampling occurred between 9am and 1pm, targeting all potential habitat types including submerged aquatic vegetation, submerged woody structure, gravel bars and riprap areas. Water temperature was 35°F at 12:00pm, which is substantially lower than previous years (43°F, 45°F, 58°F). A total of three muskellunge were captured, all from the August 2017 stocking and ranged in size from 184mm to 220mm (7.2" – 8.7"). No older, larger muskellunge from early stockings were observed. The low capture success is likely due to the late sampling date and low water temperatures.

ANGUILLIDS

American eel (Staats)

In 1997, an eel ladder was constructed at the Richelieu River dam in Chambly, Quebec and in 2001 a fish ladder and an eel ladder were built at the St. Ours dam on the Richelieu. These facilities reopened connectivity for eel migration from the St. Lawrence River to Lake Champlain. Faune Québec, in cooperation with a commercial fishing union and Hydro-Québec, initiated an eel stocking program in 2005 in the Richelieu River to further enhance eel recruitment. In order to monitor the success of these stocking efforts and new passage facilities, Québec asked members of Fisheries Technical Committee to monitor eel in Lake Champlain.

American eel sampling was conducted in 2017 and total numbers of eels collected were greater relative to sampling efforts in 2016 (Table 11). Eels collected ranged in size from 297 mm to 761 mm. Mean length was 551 mm (SD = 83, n =204) and mean weight was 343 grams (SD = 188). Except for 2007, the average size of eel collected has increased each year and 2017 was no different. Few small eels were collected, and larger eels are becoming more abundant suggesting minimal recruitment of eels to Lake Champlain.

Table 11. Summary of American eel stocking in the upper Richelieu River and the number of eels caught in Lake Champlain by electrofishing.

Year	Number of glass eels stocked	Number of eels collected					
		Keeler Bay	Paradise Bay	Crane Point	Converse Bay	Grand Isle shoreline	Total
2005	600,000	----	----	----	----	----	---
2006	1,000,000	----	----	----	----	----	---
2007	425,500	0	0	----	0	1	1
2008	746,000	----	----	----	----	----	---
2010	0	1	1	----	25	14	41
2012	0	1	2	----	57	21	81
2014	0	12	17	----	54	---	83
2016	0	18	31	41	58	10	158
2017	0	25	13	76	74	16	204

ACIPENSERIDAE

Lake Sturgeon (MacKenzie)

Sampling for lake sturgeon returning to spawn in the Lamoille and Winooski rivers in Spring 2017 resulted in the capture of 2 adult sturgeon in the Winooski River and two in the Lamoille River. One of the sturgeon captured in the Lamoille River was first captured in 1998. Five sturgeon were captured in Malletts Bay during the fall. One of these fish was the recapture from 1998. Total lengths ranged from 45.1 inches to 67.4 inches.

Acoustic tags were surgically implanted in the 2 sturgeon captured in the Lamoille River and one of the sturgeon captured in Malletts Bay. Sturgeon movements were monitored in Lake Champlain with a portable acoustic receiver and stationary receivers set in spawning tributaries and on the deltas near the Lamoille and Winooski rivers and Otter Creek. The sturgeon tagged in Otter Creek may be overwintering on the Otter Creek delta and the sturgeon tagged in the Lamoille River and Malletts Bay are overwintering near the mouth of the Lamoille River.

RECREATIONAL FISHERY MONITORING

Angler Surveys (Pientka, Chipman)

Data analysis from the 2016 Inland Sea open water angler survey was completed. The survey was conducted from April 9 to October 9, 2016 and a total of 1,056 parties (2,092 anglers) were interviewed. Vermont residents comprised 71.9% of interviewed anglers, followed by residents of Canada (6.4%), Massachusetts (5.4%), New York (4.1%), and 24 other states and countries. Bass were the most frequently targeted species (33% of interviewed parties), followed by salmonids (29%). Anglers expended an estimated 57,390 angler hours during the survey period and catches of 20 fish species were recorded. The estimated sport fish catch was dominated by smallmouth bass (21,954 caught and 1,559 harvested), largemouth bass (13,851 caught and 983 harvested), and northern pike (estimated 5,547 caught and 276 harvested). An estimated 4,479 landlocked Atlantic salmon were caught and 1,512 were harvested. Yellow perch was the dominant panfish species (estimated 65,779 caught and 33,493 harvested), followed by pumpkinseed (estimated 41,185 caught and 33,483 harvested).

RESEARCH

Lake Trout Recruitment (J. Ellen Marsden, Steve Cluett, Brad Roy, UVM)

In 2017, we continued and expanded bottom trawling surveys for juvenile lake trout, focused on evaluating the proportion of natural recruits (unclipped fish) first detected in sizeable numbers in 2015. Twice a month from May to November we made 4-6 replicate trawls in Burlington Bay, and once in spring, summer, and fall we sampled as far north as Hazen Point, North Hero, and south to Arnold Bay. We collected a total of 1,016 lake trout of which 50% were unclipped; 75% of lake trout less than 350 mm total length were unclipped. This proportion is at least in part due to focused sampling in areas which yielded wild lake trout; wild juveniles were distributed slightly higher in depth than stocked fish. The depth and geographic data are being used to establish a standardized monitoring protocol so that annual changes in proportion of wild recruits can be assessed. Diet analysis indicates that young-of-year wild lake trout feed almost exclusively on *Mysis*, diversifying their diet to include small smelt, sculpin, and alewife by age-1.

Lack of Population Genetic Structure of Slimy Sculpin in a Large, Fragmented Lake (Peter M. Euclide, Natalie Flores, Matt Wargo, C. William Kilpatrick, J. Ellen Marsden, UVM)

Most of what is known about sculpin population structure comes from research in streams; however, slimy sculpins are also a common benthic species in deep lakes. In streams, sculpins are considered to be a relatively inactive species, moving only small distances and characteristically have high levels of genetic structure. We examined population genetic structure of slimy sculpin (*Cottus cognatus*) across multiple barriers and over distances up to 227 km in Lake Champlain (USA, Canada) and Lake Ontario (USA, Canada) to determine if lake populations of sculpin are also highly structured. We predicted that slimy sculpin populations in Lake Champlain would be structured by six causeways as well as by distance, Lake Ontario populations would be structured only by distance, and differences between the lakes would be large relative to within-lake differences. We examined microsatellite variation among 200 slimy sculpins from Lake Champlain and 48 slimy sculpins from Lake Ontario to evaluate patterns of population connectivity and structure. There was no indication of population sub-structuring within either lake but sculpin were genetically distinct between lakes. We conclude that there is a single, panmictic population of sculpin present in Lake Champlain and another potentially panmictic population in Lake Ontario, with no indication of genetic isolation by distance. Our results contrast with data from sculpin in streams, suggesting distance and habitat fragmentation exert little influence on population connectivity of benthic fish in lakes.

Genetic Structure of Lake Whitefish (*Coregonus Clupeaformis*) in Lake Champlain, Vermont 100 Years After Commercial Fishery Closure (Peter T. Euclide, C. William Kilpatrick, J. Ellen Marsden, UVM)

Commercial fishing for lake whitefish in Lake Champlain closed in 1913 due to concerns about overexploitation. However, the historic whitefish population size is unknown and harvest statistics have not been compiled. Lake trout, which were also commercially fished, disappeared from the lake by 1900; harvest may have significantly affected both species. In 2010, a growth analysis of lake whitefish found that populations were characteristic of an unexploited stock, suggesting that if the fishery had an

impact, the population has recovered. The objective of this study was to look for genetic evidence of a population bottleneck and describe the genetic diversity and population structure of lake whitefish in Lake Champlain. One hundred and fifty whitefish were collected on both sides of causeways that divide the northern portion of the lake into two basins. Fish were genotyped at 8 microsatellite loci; we evaluated genetic diversity and looked for evidence of a bottleneck by looking for heterozygosity excess with the program BOTTLENECK and running simulations under different overfishing scenarios. Based on historical data, we conducted simulations to estimate how effective population size and fishing pressure in the 1900s would have affected genetic diversity seen 100 years later. Data suggest that lake whitefish have high genetic diversity, limited evidence of population sub-structuring and show no signs of a recent bottleneck. Simulations suggest that even for a large effective population size of 10,000 individuals, a 50% - 90% reduction in population would have small impacts on diversity. These data provide a perspective on effects of a commercial fishery that was closed prior to population collapse, compared with Great Lakes whitefish populations that are currently recovering after overharvest collapsed their populations.

Role of Drainage and Barriers in the Genetic Structuring of a Tessellated Darter Population (Peter T. Euclide and J. Ellen Marsden, UVM).

While population genetic structuring is easily identified, the causes of the structure can be difficult to determine. Habitat fragmentation in aquatic systems has often been identified as a major source of increased population structure and decreased genetic diversity in fish, including benthic resident species such as darters. However, these findings are often not replicated across natural and manmade barriers and come from endangered or threatened populations where the genetic structure is likely already compromised due to small population size. To evaluate the factors involved in structuring a healthy darter metapopulation, we genotyped 506 tessellated darters from 18 sites in three different river drainages and one large lake. Sites were all in the same watershed but separated from on another by one or more of three different types of barriers: dams, natural fall lines and causeways. We found that while diversity and allele frequency varied largely by drainage, within drainage variation was minimal even across multiple barriers. No one barrier type appeared to be a stronger barrier than any other. Our results indicate that healthy populations of darters may naturally be structured by drainage, but likely have enough dispersal across barriers to retain drainage-wide homogeneity.

Development of methods to assess lake sturgeon populations in Lake Champlain (Lisa Izzo, Donna L. Parrish, Gayle Barbin Zydlewski, Joseph Zydlewski, and J. Ellen Marsden, Affiliations: USGS, Vermont Coop Unit, UMaine, Maine Coop Unit, UVM. Project officer: Chet MacKenzie, VFWD)

In 2017, a fixed-location dual-frequency identification sonar (DIDSON) was deployed downstream of the lake sturgeon spawning site in the Winooski River, VT to count upstream migrating lake sturgeon. DIDSON data were paired with data from an array of five stationary acoustic receivers that monitored the movements of tagged adult lake sturgeon that entered the river (n=10, tagged in 2015 and 2016). From 10 May to 21 June, 1,000 hours of DIDSON footage were collected and 271 sturgeon targets (fish > 1 m) were observed moving upstream. Acoustic receiver data indicated that 6 of 10 tagged sturgeon made multiple movements upstream during this period which had the potential to inflate abundance estimates obtained from fixed-location hydroacoustic equipment. Additionally, side-scan sonar was investigated as a method to estimate abundance of overwintering lake sturgeon on the Winooski River delta. Preliminary surveys in November 2016 and January 2017 were able to visualize lake sturgeon on

side-scan sonar images, with more sturgeon targets located in January (potentially due to decreased water temperature and assumed decreased fish movement). During the 2017 field season, ten juvenile lake sturgeon captured in Lake Champlain were tagged with acoustic transmitters. These fish are being monitored using an array of stationary receivers throughout Lake Champlain.

The influence of thiamine on mortality and behavior of newly hatched Atlantic salmon (William Ardren USFWS, and Nicole Hill, Ashlee Prevost, James Grant and Dylan Fraser, Concordia University)

To further our understanding of the influence of Early Mortality Syndrome on Atlantic salmon, recruitment behavioral experiments were conducted on salmon larvae at the White River Fish Hatchery in the Spring of 2017. The effects of egg thiamine level (ETL) on the mortality and behavior of larvae were studied to: (i) determine if there was a clear threshold for ETL above which EMS did not occur; (ii) determine if mortality in individuals that did not receive thiamine treatment decreased with increasing ETL, (iii) determine if there were any behavioral differences between treated and untreated individuals at the sac fry stage, and (iv) to look for sublethal effects in surviving individuals at the button up stage. To do so, eggs were collected from 17 females during the 2016 spawning run and divided into two groups, one which received thiamine treatment and the other one being left untreated. The ETL was determined for each family and mortality recorded from hatch to the first feeding stage (button up). Behavioral assays were preformed both before (sac fry) and at the button up life stage to explore differences in stimulus response between thiamine treated and untreated individuals, and families with varying ranges of ETL. This work is currently ongoing with final results anticipated in the spring of 2018.

Effect of dam removal on the quantity and quality of spawning habitat available for a reintroduced Atlantic salmon population (William Ardren USFWS, and Nicole Hill, Jessamine

Trueman, Ashlee Prevost, James Grant and Dylan Fraser, Concordia University)
To facilitate migration of a reintroduced Atlantic salmon to historic spawning grounds, the Willsboro dam was removed from the Boquet River in the Lake Champlain basin in August 2015. As part of an ongoing monitoring effort, Atlantic salmon redd surveys were conducted below the former dam site in 2014, 2016, and 2017, and in historic spawning grounds farther upstream in 2016 and 2017. Microhabitat data were collected at each redd to quantify the quality of habitat used by spawning individuals and explore differences in habitat preference and variability between the two sites. When compared to literature data, used habitat was of good quality above the former dam, with suitability scores of over 0.65 in both years. In 2016, salmon used a narrower range of habitats upstream of the former dam than below it, likely due to mitigation of the density dependent pressures experienced in this lower site. After dam removal, the mean and variance in depth and substrate size at redds decreased in the lower site, leading to an increase in habitat suitability. The removal of the Willsboro dam has increased access to suitable spawning habitat on the Boquet River by improving habitat quality downstream and facilitating migration to higher quality, historic spawning grounds upstream. This is a promising first step towards the reestablishment of a naturally reproducing population in the Lake Champlain basin.

Patterns of reproductive success among reintroduced Atlantic salmon in two Lake Champlain tributaries (William Ardren USFWS, and Ashlee Prevost, Nicole Hill, James Grant and Dylan Fraser, Concordia University)

Reintroduction programs are increasingly implemented to regenerate self-sustaining salmon populations. The extent to which returning adults successfully produce surviving offspring and knowledge of the genetic makeup of those offspring are useful for informing reintroduction efforts. We investigated the patterns of reproductive success among returning Atlantic salmon reintroduced as juveniles in two tributaries of Lake Champlain, by combining redd surveys and DNA parentage analysis. Tissue samples collected from returning adults and their offspring produced in the wild (young-of-the-year) were genotyped using microsatellite loci. Our results suggest that a low proportion of returning adults produced surviving offspring in either tributary (range 4-12%, or 11-15 of 124 and 3-4 of 81 returning adults, respectively) and that reproductive success was variable, especially amongst males. These results demonstrate that adults can naturally and successfully reproduce in both of the studied tributaries (Winooski River, Boquet River). Nevertheless, a larger number of breeders would need to produce offspring in subsequent years to demographically augment the reintroduced population whilst avoiding short-term issues associated with low genetic diversity and inbreeding. This study is one of only several in the literature to quantify and document reproductive success of reintroduced salmon in a natural environment, and provides relevant data for assessing recolonization and reestablishment potential in the focal tributaries.

Homing and imprinting cues for landlocked Atlantic salmon
(David Minkoff - Boston University and USFWS, Andy Dittman - NOAA-Seattle, Karl Kaiser - Texas A&M University, Jelle Atema - Boston University, William Ardren – USFWS)

Indigenous populations of Atlantic salmon (*Salmo salar*) in Lake Champlain were extirpated by 1838. Re-introduction efforts from 1973-present include annual stocking from hatcheries to support a recreational fishing industry, yet the number of wild spawning (river-run) salmon remains low. Current management plans emphasize the need to restore self-sustaining populations, however the reasons for the dearth of river- run salmon remain uncertain. Our research focuses on the timing and mechanisms of *S. salar* imprinting and homing, with potential implications for hatchery protocols for rearing salmon targeted for restoration. The focus of our studies includes: 1. Investigation of the relative concentrations and temporal stability of dissolved, free amino acids (DFAA) in salmon stream sites in Vermont, New York and Maine during known period of downstream (Spring) and spawning (Autumn) migrations to determine if DFAAs can be candidate odors for imprinting on natal stream chemistry. 2. Developing a weekly time- series of relative concentrations of thyroxine (T4) hormone during different stages of development to establish the time windows of thyroxin surges in Atlantic salmon that may correspond with odor imprinting periods hypothesized to occur both in parr-smolt and hatchling-emergence stages of development.

Impacts of thiamine deficiency on metabolic pathways and genetic influences on disease outcomes in Atlantic salmon
(Avril Harder and Mark Christie - Purdue University, William Ardren - USFWS)

A prerequisite for the reestablishment of a self-sustaining Atlantic salmon population in Lake Champlain is a sufficient number of individuals capable of natural reproduction without thiamine

treatments. If tolerance to low available thiamine has a heritable genetic basis, it may be possible to create a supplemental breeding program that allows for the natural selection of such individuals in the wild. Support has been found for the hypothesis that strains of Atlantic salmon that co-occur with alewife have adapted to diets low in available thiamine, suggesting the possibility for a response to selection.

To identify the effects of thiamine deficiency and supplementation on metabolic pathways, we crossed 10 pairs of thiamine-deficient Atlantic salmon and treated half of the eggs in each family with thiamine, leaving the remaining eggs untreated. We used RNAseq to identify genes differentially expressed between the experimental and control groups across all 10 families and describe mRNA sequence variation associated with family-level differences in fry survivorship. Survivorship was corroborated as a measure of TDC susceptibility by a novel behavioral assay designed to detect signs of thiamine deficiency. Analysis of RNAseq data is ongoing, and our results will help determine if and how Lake Champlain Atlantic salmon may be adapting to a diet high in alewife and low in available thiamine. If an association is detected between susceptibility to thiamine deficiency and particular patterns of gene expression or genetic variation, it may indicate that Atlantic salmon are able to respond to selection and, after several generations, to reproduce without supplemental thiamine.

2017 Scientific Publications

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Appendix 1. Members and Advisors of the Lake Champlain Fish and Wildlife Management Cooperative, Fisheries Technical Committee

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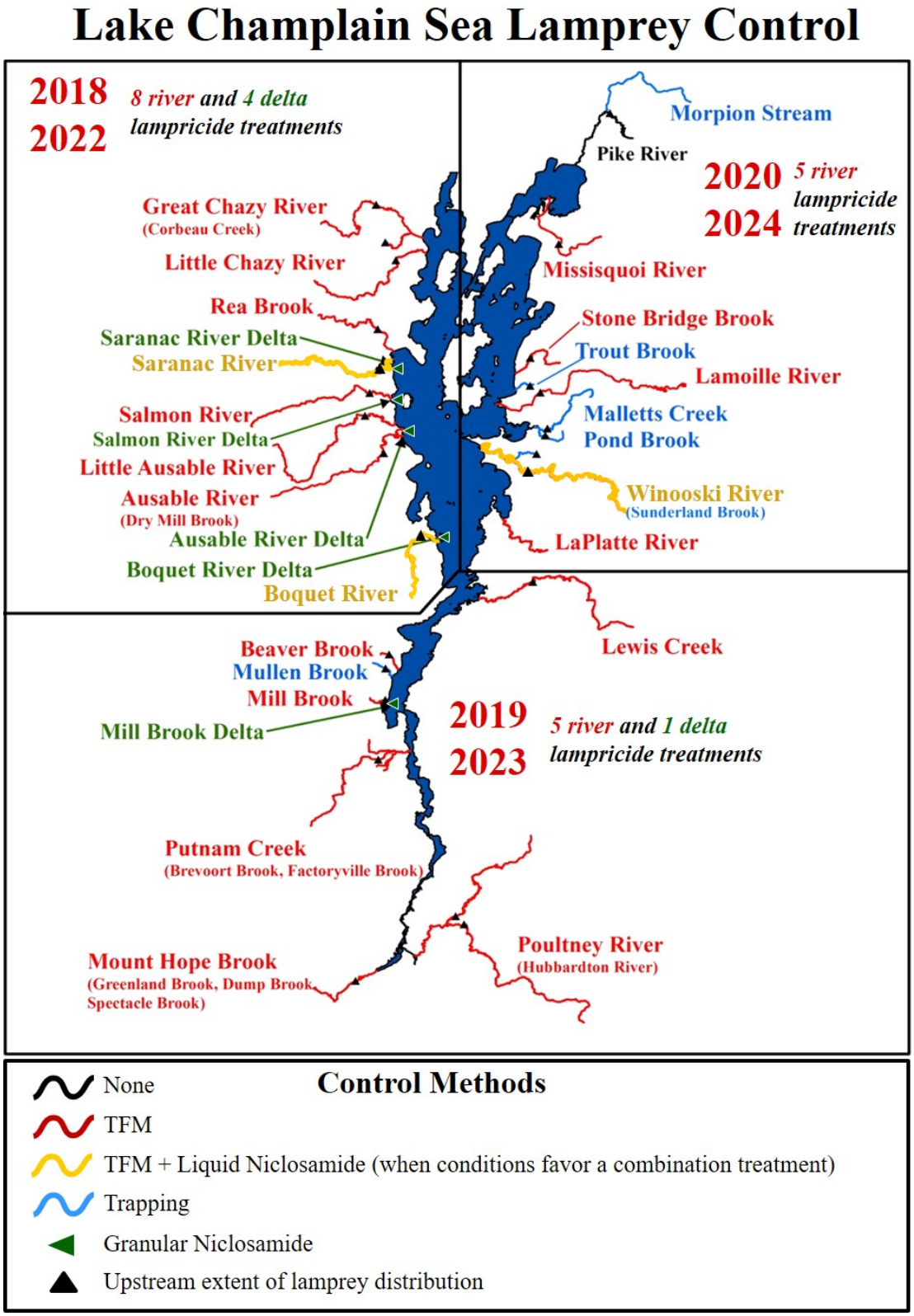

Appendix 2: Map of Lake Champlain tributaries with lamprey populations and the site-specific methods used to control them.

Appendix 3: Schedule of completed Lake Champlain lampricide treatments 2002-2017 and projected treatments through 2022. The "T" denotes completed TFM-only treatments, "B" denotes completed Granular Bayluscide delta treatments, "C" denotes completed TFM + 1% Niclosamide treatments and "P" denotes pending treatments. Treatments conducted during the experimental control program between 1990 and 2000 are not shown. The geographic reorganization plan was completed in 2017 resulting in the temporal and geographical alignment of treatments in the Lake Champlain Basin and a new cycle of treatments in 3 out of every 4 years.

			02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
New York	WEST	Great Chazy River			T				T				T		T				P				P
		Little Chazy River																	P				P
		Rea Brook																	P				P
		Saranac River												C					P				P
		Saranac Delta			B				B				B		T				P				P
		Salmon River	T				T				T				T				P				P
		Salmon Delta													B				P				P
		Little Ausable River	T				T				T				T				P				P
		Ausables Delta Complex		B				B				B			B				P				P
		Ausable River	T				T	T			T				T	T			P				P
		Boquet River		T				T				C			C				P				P
		Boquet Delta													B				P				P
	SOUTH	Beaver Brook		T				T									T			P			
		Mill Brook							T				T							P			
		Mill Delta							B				B							P			
		Putnam Creek	T				T				T			T			T			P			
		Mt. Hope Brook			T				T				T			T				P			
----		Poultney/Hubbardton rivers						T				T				T				P			
		Lewis Creek	T				T				T				T	T				P			
Vermont	EAST	LaPlatte River															T				P		
		Winooski River			T				T				T			T					P		
		Stonebridge Brook												T			T				P		
		Lamoille River								T				T							P		
		Missisquoi River							T				T								P		