LAKE CHAMPLAIN FISH AND WILDLIFE MANAGEMENT COOPERATIVE

FISHERIES TECHNICAL COMMITTEE

2021 ANNUAL REPORT

Approved at Lake Champlain Fish and Wildlife Management Meeting

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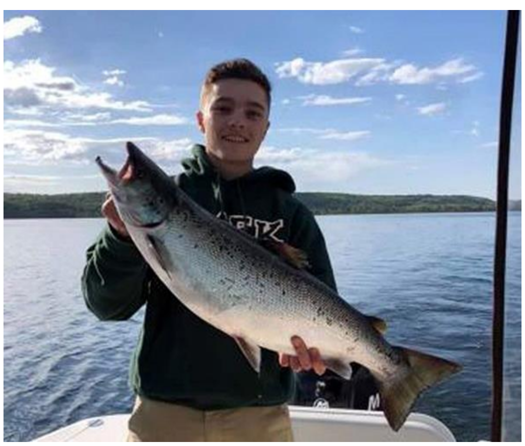

Atlantic salmon caught by an angler on Lake Champlain in April.

Atlantic salmon smolts being stocked into the net pens at the Plattsburgh Boat Basin, near the mouth of the Saranac River.

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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 2021. Landlocked Atlantic salmon (salmon) were the focal species, accounting for 60% of the 528,983 smolts equivalents stocked into the lake and tributaries. Highlights from native salmonid management include:

- Thirteen of 16 established fisheries indicators met target goals.
- Sea lamprey wounding rate for Atlantic salmon in the main lake was below the target level in 2021! The wounding rate for lake trout in the main lake remained above the target level.
- Salmon returns were similar to last year at the Hatchery Brook trap and at the Winooski fish lift. Returns at the Lamoille River were good. Sampling resumed at Otter creek, but no salmon were collected.
- Whallon and Willsboro bays salmon catches were down slightly compared to recent years (94 vs 164 in 2020).
- Condition factor for Atlantic salmon and lake trout were both within the desired range in 2021.

No lampricide treatments were conducted in the Basin during 2021 as part of the regional alignment plan. Trapping of adult sea lamprey resumed in the Lake Champlain Basin in 2021, targeting 7 tributaries. Due to the continued closure of the US – Canada Border, sea lamprey larval surveys were not done in the Pike River or Morpion Stream in Quebec in 2021. Sea lamprey wounding rates on Atlantic salmon decreased to 6.1 wounds per 100 fish, finally dropping below the target of 15 wounds per 100 fish. Wounding rates on lake trout increased from 40.8 in 2020 to 44.8 in 2021; the rate is still well above the target of 25 wounds per 100 fish.

Round goby are an Aquatic Invasive Species of fish that is approaching Lake Champlain from both the north and south ends of the lake. The Lake Champlain AIS Task Force is developing a Rapid Response Implementation Plan to prevent the round goby from migrating into the NYS Champlain Canal system and establishing self-sustaining populations in the system, including Lake Champlain.

Monitoring efforts continued for muskellunge, bass, walleye, and yellow perch.

The NYSDEC sauger restoration plan will be placed on hold while focusing efforts on other major projects within the Lake Champlain watershed. When time permits, the proposed plan will be revisited.

Research efforts in the lake and tributaries included: parentage-based tagging of Atlantic Salmon, radio telemetry of trap and trucked salmon, and characterizing evolutionary potential of salmon to respond to thiamine deficiency.

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Introduction

Management of the fishery resources of Lake Champlain is coordinated by the Lake Champlain Fisheries Technical Committee (FTC), which is a workgroup of the Lake Champlain Fish and Wildlife Management Cooperative. Members and advisors of the FTC include staff from Vermont Fish and Wildlife Department (VTFWD), 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 (VTCFWRU), Quebec Ministry of Forestry, Wildlife and Parks (MFFP), 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 2021. 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 FTC was established in 2014 with the goal of maintaining balanced and robust fish populations that provide a fishery for salmonids. The working group has 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.

The working group reviewed relevant fisheries indicators that are part of annual monitoring efforts (Fisheries Technical Committee 2019). A suite of indicators was identified to monitor salmon and lake trout fisheries and restoration of natural populations. The period from 2011 to 2017 was identified as the “desired state” for salmon and lake trout in Lake Champlain. This time period was selected based on the effectiveness of sea lamprey control efforts, stability and quality of the fishery, and evidence of natural reproduction for both species. In an effort to maintain the desired state, target goals were developed for all indicators. Thresholds for target goals were set at 25th and 75th percentile bounds for indicators over the seven-year desired state period. These target goals may change if there are long-term changes to the Lake Champlain fishery but will not be adjusted annually.

In 2021, four of the 16 indicators fell out-of-bounds of the established thresholds (Table 1 and 2). Pre-stock smolt percentage was slightly lower than target level for the second year in a row. Median total length of lake age-0 salmon was 369 mm and below the lower threshold of 390 mm. Sea lamprey wounding for lake trout was above the target threshold for the fifth year in a row while salmon wounding rate was below the threshold of <15 wounds/100 fish for the first time in four years. The lake trout wounding rate of 44.8 wounds per 100 fish is still well above the target of 25.

The FTC is in the process of exploring additional indicators of salmonid status. These include additional sampling to estimate abundance of wild lake trout, evaluating methods to characterize forage fish abundance, exploring alternative measures of sea lamprey impacts on salmonids and options to tag / mark all stocked salmonids. In addition, adaptive management experiments are underway to improve survival of salmon smolts stocked in the lake and increase adult returns to rivers; these studies include evaluating alternative stocking methods and performance of a low thiamine tolerant broodstock. Finally, additional exploration of the existing indicators and their potential interactions is being evaluated, for example assessment on potential relationship between salmon size at stocking and size at lake age-0.

Table 1. Indicators and their thresholds for annually evaluating the state of landlocked Atlantic salmon, lake trout, walleye, and fish health in Lake Champlain. The median is the middle value of all values calculated. Condition factor describes the relative “plumpness” or “fatness” based on fish length and weight.

Species and Indicators	**Thresholds or desired ranges**	**2021 Value**	**N**
Landlocked Atlantic Salmon			
Pre-stock smolt size percentage > 150 mm	≥90 %	85.6 %	2,500
Median Condition Factor – Lake Age 0	1.00 – 1.19	1.01	63
Median Condition Factor – Lake Age 1	0.86 – 1.01	0.95	223
Median Total Length – Lake Age 0	390 – 427 mm	369 mm	63
Median Total Length – Lake Age 1	494 – 562 mm	534 mm	437
Sea Lamprey Wounding Rate (lake-wide)	<15 wounds per 100	6.1	244
Median Weight of top 10 salmon from Lake Champlain International Fishing Derby	2.86 – 3.68 kg	3.60 kg	10
Median Condition Factor from Lake Champlain International Fishing Derby	1.01 – 1.22	1.14	40
Lake Trout			
Median Condition factor - Males	0.84 – 0.94	0.88	336
Sea Lamprey Wounding Rate (main lake)	<25 wounds per 100	44.8	210
Wild Lake Trout - Proportion Unclipped	≥15 %	14.5 %	110
Median weight top 10 Lake Trout from Lake Champlain International Fishing Derby	5.65 – 6.42 kg	5.93 kg	10
Median Condition Factor from Lake Champlain International Fishing Derby	0.93 – 1.09	0.96	153
Salmonid Stocking			
Number of salmonids stocked annually	512,000	528,983	
Landlocked Atlantic salmon	304,000	314,891	
Lake trout	82,000	83,819	
Steelhead trout	58,000	58,991	
Brown trout	68,000	71,282	
Walleye			
Median Condition Factor walleye Males 350.5 – 475 mm	0.90 – 0.98	0.99 & 1.05	60
Health Testing Results	Detection of new disease	No detection	246

Table 2. Indicators for annually evaluating the status of landlocked Atlantic salmon, lake trout, and walleye, and fish health in Lake Champlain. Condition factor describes the relative "plumpness" or "fatness" based on fish length and weight. Status colors: Green: Within desired ranges or threshold targets; Yellow: Outside targets; direction of yellow arrow indicates if above or below the threshold; Red: Outside targets for three consecutive years.

Species and Indicators	**2019 Status**	**2020 Status**	**2021 Status**	**2021Value**
Landlocked Atlantic Salmon				
Pre-stock smolt size percentage	🟢	⬇	⬇	88.0 %
Median Condition Factor – Lake Age 0	🟢	⬆	🟢	1.01
Median Condition Factor – Lake Age 1	🟢	🟢	🟢	0.95
Median Total Length – Lake Age 0	⬆	🟢	⬇	369 mm
Median Total Length – Lake Age 1	🟢	⬆	🟢	534 mm
Sea Lamprey Wounding (lake-wide)	🛑	🛑	🟢	6.1
Median Weight of top 10 salmon in Lake Champlain Inter. Derby	⬇	🟢	🟢	3.6 kg
Median Condition Factor salmon in Lake Champlain Inter. Derby	🟢	🟢	🟢	1.14
Lake Trout				
Median Condition Factor - Males	🟢	🟢	🟢	0.88
Sea Lamprey Wounding (Main-lake)	🛑	🛑	🛑	44.8
Wild Lake Trout - Proportion Unclipped	🟢	🟢	🟢	14.5 %
Median Weight of top 10 lake trout in Lake Champlain Inter. Derby	🟢	🟢	🟢	5.93 kg
Median Condition Factor lake trout in Lake Champlain Inter. Derby	🟢	🟢	🟢	0.96
Salmonid Stocking				
Number of salmonids stocked annually	🛑	🟢	🟢	528,983
Walleye				
Walleye Median Condition Factor (Males 350 –475 mm)	🟢	NS	⬆	0.99&1.05
Other				
Fish Health Testing Results	🟢	🟢	🟢	ND

Stocking Reduction for Lake Trout (Salmonid Working Group)

The Salmonid Working Group recommended a reduction in Lake Trout stocking for Lake Champlain in 2020 to be implemented starting in 2022. This recommendation was approved by the FTC Management Committee (FTC 2020a).

During discussions among a subset of the Salmonid Working Group regarding lake trout, an opportunity was identified to eliminate NYSDEC lake trout stocking beginning in 2022. This represents 33% of the total lake trout stocked and all agreed would be a good starting point. This reduction will continue indefinitely. New York will resume stocking if recruitment indices indicate increased stocking is necessary to sustain the fishery. As part of this recommendation, we assume stocking numbers of other salmonids will remain within their target numbers (i.e., no increase to make up for reduced lake trout stocking). It is recommended that population assessments continue to monitor the impact of the stocking reduction.

Some unknowns with this approach are the lack of understanding of how the NY and VT stockings may differ in overall survival rates and movement patterns within the lake. However, just cutting NY fish but keeping VT stocking steady helps create a good study to assess contribution from VT. All agreed this could be a good opportunity for both management and research goals.

Stocking Summary (Balk, Shanahan)

Salmonid stockings in Lake Champlain during 2021 included approximately: 315,000 landlocked Atlantic salmon (smolt equivalents); 59,000 steelhead (smolt equivalents); 84,000 lake trout; and 71,000 brown trout (Table 3). The list includes landlocked Atlantic salmon and steelhead that were stocked in the tributaries to the lake. Also listed in Table 3 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 3. Numbers (in smolt equivalents) of salmonids stocked in Lake Champlain during 2021, and stocking targets for the lake.

Species	Main Lake		Mallett's Bay/Inland Sea		Total number stocked in 2021
	Target	2021	Target	2021	
Landlocked salmon	227,000	257,891	77,000	57,000	314,891
Lake trout	82,000	83,819	0		83,819
Steelhead	53,000	53,991	5,000	5,000	58,991
Brown trout	38,000	38,282	30,000	33,000	71,282
Total	400,000	433,983	112,000	95,000	528,983

Pre-stocking Landlocked Salmon Assessments (Pientka)

To undergo the parr to smolt transformation a fish is typically greater than or equal to150 mm total length. Overall, 85.6% of the salmon stocked in the spring of 2021 exceeded that threshold. There was a difference for each hatchery. For Ed Weed Fish Culture Station (FCS) 100% of fish exceeded the threshold Ed Weed Fish

Culture Station (FCS). Eisenhower NFH the percentage was lower at 71.8% exceeding that threshold (Table 4). In 2021 the Adirondack Hatchery did not produce or stock any smolts.

Table 4. 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 2012-2021.

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	44,322
	2015	175	300	92.3	45,000	41,550
	2016	180	400	93.8	45,000	42,188
	2017	167	400	85.8	45,000	38,610
	2018	172	400	90.3	45,000	40,635
	2019	183	100	94.0	12,730	11,966
	2020	167	200	85.5	45,000	38,475
	2021	**NA**	**NA**	**NA**	**0**	**0**
Ed Weed FCS (VTFWD)	2012	196	999	99.7	155,289	154,823
	2013	191	1,100	99.6	165,459	164,857
	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
	2018	191	900	99.7	139,128	138,711
	2019	181	900	99.7	139,411	138,993
	2020	182	900	99.7	158,663	158,187
	2021	**188**	**900**	**100**	**149,595**	**149,595**
Eisenhower (USFWS)	2012	188	900	96.8	104,706	101,332
	2013	206	1,100	98.8	69,992	69,165
	2014	170	1,000	84.8	76,160	64,584
	2015	163	1,300	82.7	102,430	84,702
	2016	155	1,223	66.6	102,697	68,353
	2017	161	1,800	80.7	113,947	91,955
	2018	153	1,431	67.1	85,510	57,377
	2019	165	1,100	91.7	69,651	63,870
	2020	158	1,500	68.7	90,835	62,404
	2021	**157**	**1,600**	**71.8**	**157,196**	**112,867**
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	91.0	318,975	290,113
	2018	168	2,731	87.8	269,638	236,723
	2019	173	2,100	96.9	221,792	214,829
	2020	167	2,600	88.0	294,498	259,066
	2021	**175**	**2,500**	**85.6**	**306,791**	**262,462**

River-run Salmon Restoration

Fish Passage (Simard)

Winooski One Dam Fish Lift – In 2021, a total of 11 steelhead and 51 landlocked Atlantic salmon were trapped at the Winooski One fish passage facility in the spring and fall, respectively (Figure 1). The lift was also periodically operated during summer months. On two days in late July, 14 salmon were lifted, one of which was recaptured in the fall. All salmon lifted in the summer were released downstream. Of the salmon lifted, 26 were female, 23 were male, and two were immature. Fin clips and scales were used to age all 51 of the lifted salmon indicating 38 (74.5%) were lake age-1 and nine (17.6%) were lake age-2. Four salmon (7.8%), including the two immature fish, were lake-age 0 having been released into the Winooski River in the spring of 2021. Three of these had AD-LV marks indicating they were released below the Essex 19 dam while the fourth had an AD-LV-CWT mark indicating it was stocked below Winooski One. Two additional steelhead were lifted during the fall season. All steelhead were released directly above the Winooski One dam while salmon were transported above the next two dams and released in the Winooski River in Richmond.

Overall, spring steelhead return rates remained very low. Approximately 20,000 steelhead are stocked into the Winooski River each year. However, other than three slightly higher return years in 2011, 2013, and 2015, no more than 23 steelhead have returned to the lift in a given year since 2000 with most years not exceeding 15 fish. While landlocked Atlantic salmon return rates increased slightly relative to 2020, returns remained very low down from a peak return of 189 adults observed in 2011. Landlocked Atlantic salmon smolt stocking locations were adjusted in 2020 with the 44,000 stocked smolts being split between release locations below Essex 19 and Winooski One to assess whether stocking further upstream would increase return rates. While four of these salmon did return in the fall of 2021, most are expected to return as lake-age 1 in fall, 2022. This stocking will continue through 2024 with assessments continuing until 2025.

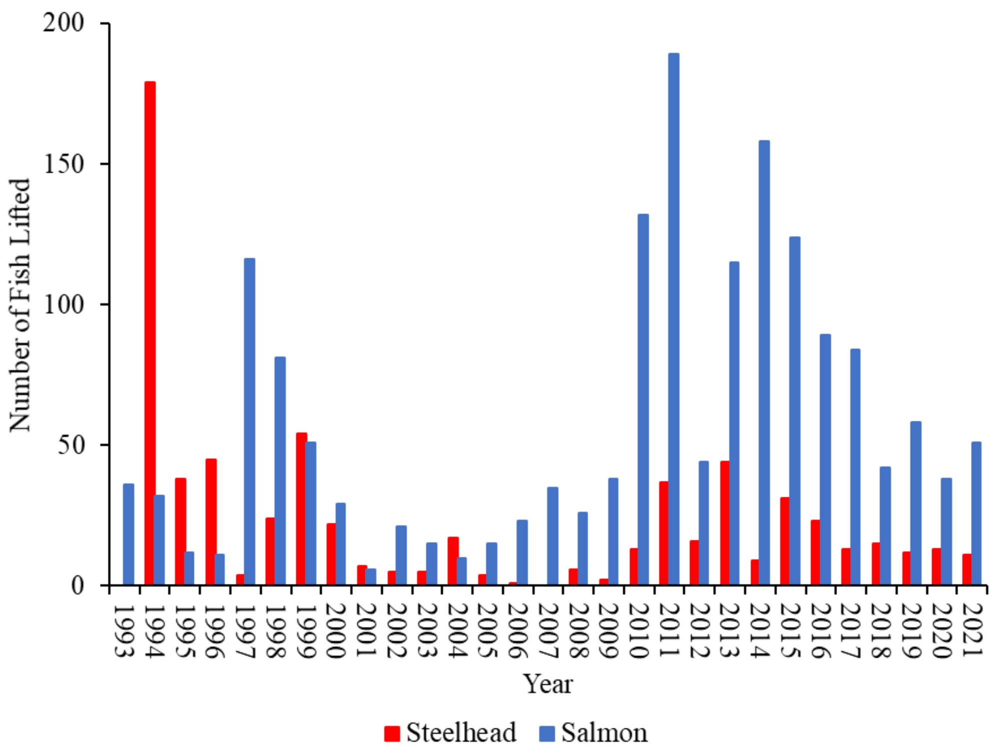

Figure 1: Number of steelhead trout (spring season) and landlocked Atlantic salmon (fall season) lifted at the Winooski One fish passage facility, 1993-2021.

Downstream smolt migration and survival in the Winooski River (Heim, Withers, Ardren, Simard, Castro-Santos)

These data have not been through peer review and should be viewed as provisional and subject to revision.

Background: In 2021, a study began to assess a new stocking location for Atlantic salmon smolts in the Winooski River, VT. The new site is located roughly 30 km upstream from the river mouth, whereas the traditional stocking site is about 15 km upstream (in the tailrace of Winooski One Dam). The incentive for this experiment is to determine if stocking further upstream in the river improves smolt imprinting and adult return rates relative to the traditional site downstream. This study is also comparing two different genetic broodstock that are held at White River National Fish Hatchery. One broodstock is a result of selective breeding to produce fish hypothesized to have a tolerance to thiamine deficiency (henceforth Low TT) and the other is managed to maintain a high level of genetic diversity (MAX). Smolts from four release groups (**Table 1**) were stocked in 2021 and will account for most adult salmon returning to the Winooski River in the Fall of 2022. The same four groups will be released from 2022 – 2024 and the performance of each release group estimated by comparing smolt-adult return rates.

Because the fish stocked at the upstream site must navigate a longer distance and successfully migrate past two hydroelectric dams, it was important to also measure survival from each location to the lake. While stocking upstream might improve imprinting and adult return rate, fewer fish from this group might survive to reach the lake. Understanding the relative improvement in imprinting thus requires accounting for differential to-lake survival. Therefore, a telemetry study was conducted in spring 2021 with the following objectives:

1. Estimate to-lake survival of fish from each of these four stocking groups
2. Estimate route specific survival at Gorge dam and Winooski Dam

For this report, initial results are presented for objective 1 without statistical modelling and results for the two broodstock are combined. Ultimately a Cormack-Jolly-Seber model will be used to address objective 1, which will provide reach specific estimates of survival as well as cumulative survival of smolts from their release site to the river. This method will also account for other factors contributing to observed data including imperfect detection probability and individual fish characteristics (e.g., length, weight, broodstock). The second objective will be addressed with a time-to-event modelling framework.

Progress and initial results: On April 5 and 6, 2021, we surgically implanted radio transmitters into 195 fish with transmitters split evenly among four release groups (W1D – Max, W1D – Low TT, E19 – Max, E19 – Low TT) and released them into hatchery raceways at D.D. Eisenhower National Fish Hatchery. By April 12th (the day before stocking, 1 week after transmitters were implanted), 21 radio tagged fish tagged fish had died (10.7% mortality) within the hatchery raceways. These transmitters were recovered and implanted into new fish on April 12th to balance sample sizes among experimental groups and the two surgeons implanting transmitters. On April 13th (the day fish were stocked), 5 additional mortalities were discovered, and these transmitters were removed from the study. The final numbers of fish released with transmitters was 190 (Table 5).

Table 5. Stocking numbers and information for Winooski River on April 13th, 2021, including the number from each genetic strain (Brood), stocking location (WD1 = Winooski One Dam, E19 = downstream of Essex 19 dam), time stocked, and the number from each group that were implanted with radio transmitters.

Brood	Location	Time	N stocked	N radio tagged	Radio tagged fish TL (sd)
MAX	WD1	13:55	11104	48	169 (12.2)
Low TT	WD1	11:30	11879	48	179 (12.8)
MAX	E19	12:11	11772	45	171 (11.3)
Low TT	E19	10:48	12587	49	172 (12.3)

On April 13th, 2021, a total of 47,341 smolts were stocked into the Winooski River with five stocking truck trips leaving from D.D. Eisenhower. Radio tagged fish were loaded into stocking trucks at D.D. Eisenhower, from this point on they were handled and treated exactly as all other smolts. This equates to 22,982 at the Winooski One Dam location and 24,359 at the Essex 19 dam location.

Radio tagged salmon were monitored at an array of 16 radio telemetry stations that continuously scanned for the presence of the transmitters. Results are presented with genetic strains grouped within stocking locations to provide an overall perspective on difference related to the two stocking sites.

In total, 139 radio tagged smolts (73% of those released) initiated migration with fish stocked at the Essex 19 site initiating migration at a higher proportion than those stocked at Winooski One (Table 6). Initiation of migration is defined as a valid detection downstream of the release location. For fish released at Winooski One, this was usually a detection at the antenna located at the Winooski wastewater treatment plant (1 km downstream of release site). For fish released at Essex 19, initiation was determined by arrival at Gorge Dam (8.2 km downstream of release site).

A total of 64 fish successfully migrated to the lake (34% of total released, 46% of those that initiated migration). A greater proportion of fish released at Winooski One entered the lake than those released at Essex 19 (Table 6).

Table 6. Migration to Lake Champlain by Atlantic smolts stocked at two locations in the Winooski River. Percentages are expressed in relation to total released.

Location	***Released***	***Initiate migration***	***Reached lake***
Winooski One	*96*	*61 (64%)*	*38 (40%)*
Essex 19	*94*	*78 (83%)*	*26 (28%)*

Fish rapidly migrated downstream after release on April 13th. By April 23, just ten days after fish were released, 88% of the observed to-lake migration had already occurred. After April 23, only 7 fish entered the lake. Fish spent an average of 7.53 days migrating to the lake (max = 36.4, min = 1.4). This calculation is the time difference between release and the first time the fish was detected at the river mouth. Fish released at the Essex 19 location took slightly longer to reach the lake (mean 9.16 days) than fish released at Winooski One (mean = 6.44 days).

To investigate avian predation as a potential source of smolt mortality, Four Brothers Islands were visited on three occasions (5/18/2021, 6/2/2021, 6/17/2021) to search for fish that may have been consumed by birds. These islands host a large nesting colony of Double Crested Cormorants (*Nannopterum auritum*) and Ring-Billed Gulls (*Larus delawarensis*). We detected 24 of the 190 tags released at the islands (12.6% of total released) (Figure 2). Of these 24 fish, 9 fish were from Winooski One stocking group and 15 fish were from the Essex 19 stocking group. Initial analysis shows that some of these smolts had migrated to the lake, and thus at least some predation is occurring at the mouth of the river.

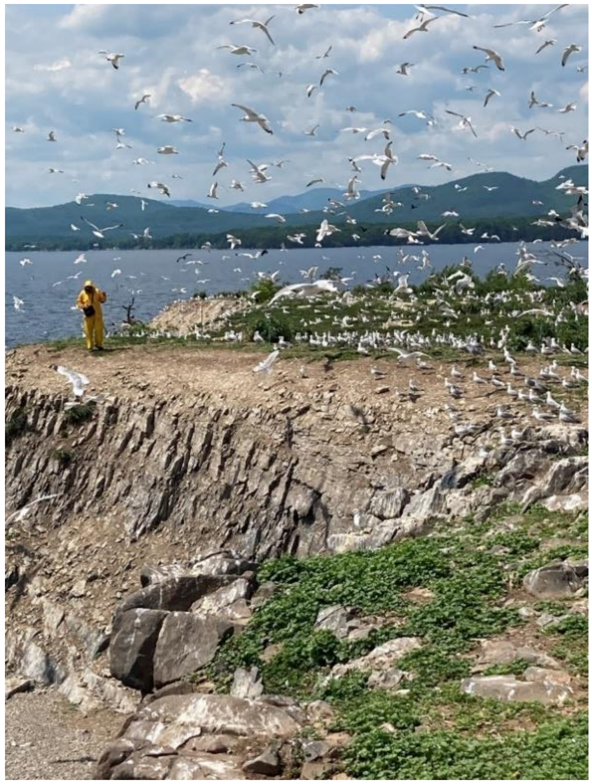

Figure 2. Tracking island C (one of Four Brothers Islands) to identify radio tagged smolts subject to avian predation in the Winooski River.

Ongoing assessment of smolt passage: Initial results of the smolt migration study in 2021 prompted a second year of study in 2022. At D.D. Eisenhower from 3/28 – 3/30 (2022) 162 fish were surgically implanted with radio transmitters and monitored for 1 week prior to release. We observed no mortalities in this group, and 90 were released at the upstream site at Essex 19 and 72 were released at the downstream site at Winooski One dam (4/5 and 4/6). Detections of these fish at telemetry stations are still being collected to assess survival of these fish, and two trips have been made to Four Brothers Islands to scan for transmitters. Results of 2021 and 2022 study will be finalized and reported in the 2022 annual report.

Radio Telemetry of Trap and Trucked Salmon in the Winooski River (Withers)

Since 2018, the USFWS in cooperation with USGS and VTFWD has been conducting a radio telemetry study on adult Atlantic salmon trapped at the Winooski One Dam and transported upstream above three dams into suitable spawning habitat (Withers 2020). The purpose of the study is to determine 1) the efficacy of the trap and transport program (fallback rate over Essex #19 dam and out of suitable habitat prior to spawning) and 2) overwintering behavior and timing of out-migration. A total of 161 Atlantic salmon were anesthetized and tagged with radio transmitters (number of tagged Atlantic salmon 2018: 21, 2019: 54, 2020: 39, and 2021: 48). Following their release, fish were monitored continuously by 14 stationary radio telemetry receivers deployed between the river mouth and Bolton Dam and weekly via mobile tracking events (Figure 3). The fourteen fixed radio telemetry receivers have provided excellent temporal resolution while mobile tracking has provided much more spatial resolution, identifying fish occupying habitat between the receivers.

Major Findings: Preliminary results suggest between 18% and 27% tagged Atlantic salmon could be classified as “fallback” salmon inter-annually (i.e., migrated 24 km downstream past Essex #19 prior to spawning). These fallback salmon are not able to migrate back upstream to suitable spawning habitat without falling back over two additional dams and being recaptured at the Winooski One dam fish lift. We also observed inter-annual out-migration over the course of the winter ranged between 10% and 17%, some of which occurred outside of the designated operation window of the downstream passage fishway at Essex #19. Data from 2021 are still being collected.

Figure 3. Radio tagging Atlantic salmon (left image), Sigma Eight Inc. radio telemetry transmitter (center image), and Sigma Eight Inc. radio telemetry receiver in the Winooski River.

Boquet River Atlantic Salmon Redd, Juvenile, and Habitat Surveys (Withers)

<u>Redd and Wild Fry Surveys (Withers, Heim, Balk, Scarfo, Ross, Ardren)</u>

Since the removal of the Willsboro Dam in 2015, production of Atlantic salmon redds and fry within the North Branch of the Boquet River has remained low (Table 7). Challenges associated with upstream fish passage at the Willsboro cascades, siltation, and early mortality syndrome caused by thiamine deficiency are thought to be contributing factors to low redd and fry survival and production. Adult Atlantic salmon broodstock that were genetically selected for thiamine tolerance were released in the North Branch of the Boquet River in 2020 and 2021 in an attempt to increase fry production, improve imprinting, and potentially survival to subsequent life stages (Figure 4). One-hundred and ninety-five broodstock were released in 2020 and 168 were released in 2021. To evaluate this alternative stocking strategy, we conducted fall redd surveys to quantify redd production and map redd locations as well as electrofishing surveys the subsequent springs to capture emerging fry. We took tissue samples from captured fry in order to determine their origin. Once the genetic samples have been processed for captured fry and broodstock, we will be able to determine the contribution the broodstock had to the surviving fry through fry parentage assignment.

Preliminary findings: The majority of redds produced in 2020 and 2021 were found near broodstock outplanting sites and suspected to be created by broodstock or a combination of broodstock and feral Atlantic salmon. The number of redds found within the North Branch in 2020 and 2021, and fry found in the spring of 2021, were greater than numbers reported in recent years suggesting broodstock are contributing to Atlantic salmon production.

Future work: Tissue samples from captured fry and outplanted broodstock are currently being processed. Once results are available, we will be able to assign fry parentage and determine the outplanted broodstock contribution.

Table 7. Number of Atlantic salmon redds and fry in the north branch and just downstream of the Willsboro cascades in the Boquet River since 2014. We survey 20 kilometers of river in the North Branch and 0.5 kilometers just below the Willsboro Cascades. Numbers presented in parentheses represent the number of redds or fry found per kilometer.

Year	Redds		Fry	
	North Branch	Willsboro Cascades	North Branch	Willsboro Cascades
2014	0 (0)	30 (60)	--	--
2015	2 (0.1)	198 (396)	--	--
2016	90 (4.5)	68 (136)	--	--
2017	32 (1.6)	9 (18)	85 (4.25)	--
2018	24 (1.2)	160 (320)	0 (0)	--
2019	3 (0.15)	1 (2)	48 (2.4)	--
2020	56 (2.8)	126 (252)	0 (0)	--
2021	41 (2.05)	40 (80)	162 (8.1)	--

Figure 4. Broodstock Atlantic salmon (left image) being released and captured Atlantic salmon fry (right image) in the North Branch of the Boquet River.

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

Annual fall boat electrofishing surveys for salmonids were conducted in larger Vermont tributaries and nearshore areas in New York. A fish trap was operated at Hatchery Brook (Ed Weed FCS discharge stream) during spring and fall to capture returning salmonids in spawning runs. 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.

The focus of fall nearshore salmonid sampling was on traditional sites in Willsboro and Whallon bays. Sampling took place throughout most of November in 2021. Catches in the Whallon Bay and Willsboro Bay areas consisted of 332 lake trout and 94 salmon. Whallon and Willsboro Bay salmon catches were down slightly compared to recent years (Figure 5). While some older, larger fish were collected the catch was dominated by smaller salmon that were stocked in spring of 2021.

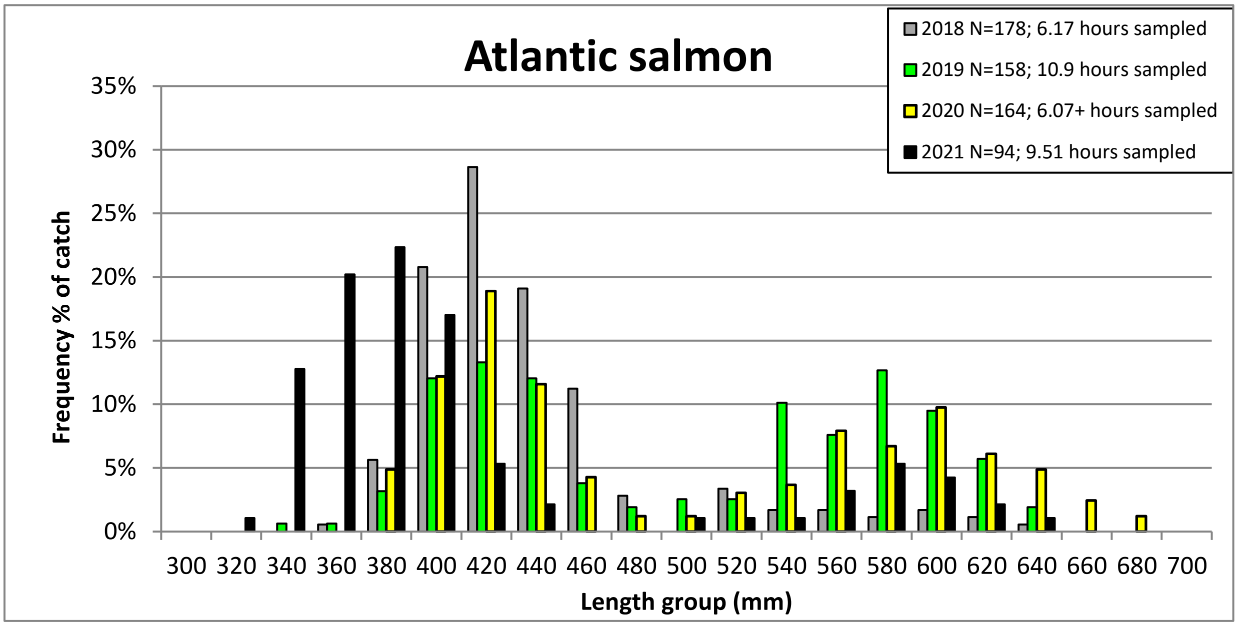

Figure 5. Length frequency distributions of landlocked Atlantic salmon collected from Willsboro and Whallon bays by electrofishing, 2017-2021.

In 2021, the Hatchery Brook trap was operated March 15-May 15, and September 15-November 29. Typically, the trap is only operated until November 15th but due to late run the operation continued. The Twenty-one steelhead were captured and processed in Hatchery Brook during the spring season. In the fall, 421 salmon, 14 brown trout, and 24 steelhead were captured in the trap and processed.

Electrofishing yielded collections of 137 salmon in eleven trips to the Lamoille River. Three electrofishing trips occurred on Otter Creek, but no salmon were collected. Seven electrofishing trips occurred to Missisquoi River, and 13 salmon were collected. Numbers of salmon collected in the fall 2021 tributary runs were good for Hatchery Brook and Lamoille River, but they started late.

A total of 150 adult salmon pairs were spawned at Ed Weed FCS. Thirty of the males were lethally sampled for disease testing. Eleven males and one female salmon died during the process, and the remainder were released alive in Lake Champlain.

Length frequency distributions of Hatchery Brook and Lamoille River salmon appeared to have more larger fish compared to previous years. Hatchery Brook peaked at 550 mm and Lamoille at 525 mm (Figure 6). Age distributions of salmon from these two sites are generally similar to past years. Lake age 1 made up a high percentage of the catch in 2021. Lake age 2 were just under 10 percent of the catch (Figure 7).

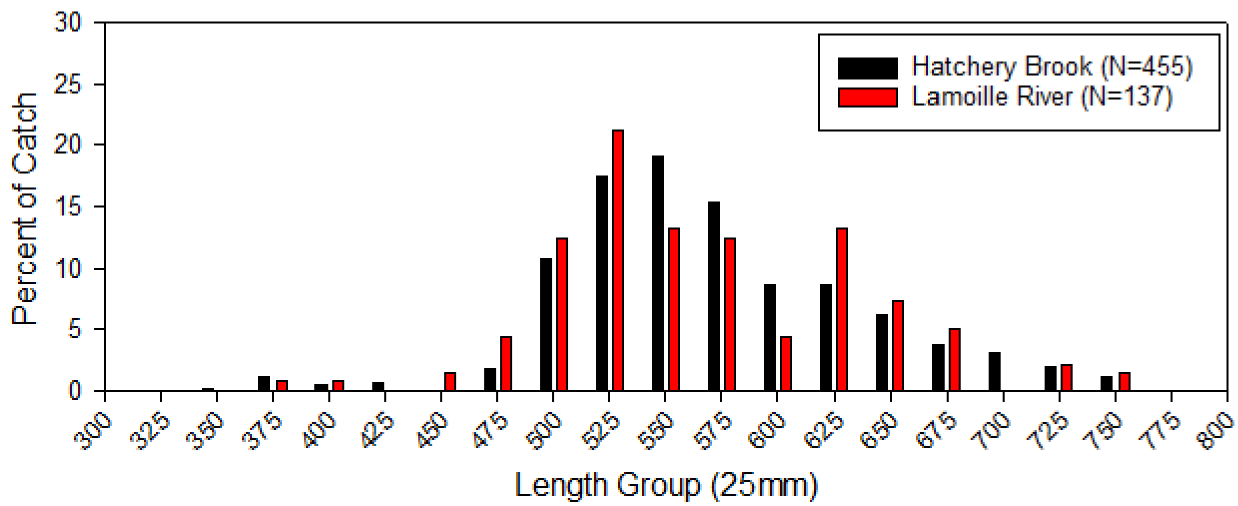

Figure 6. Length frequency distributions of landlocked Atlantic salmon collected from fall spawning runs in Hatchery Brook and Lamoille River in 2021.

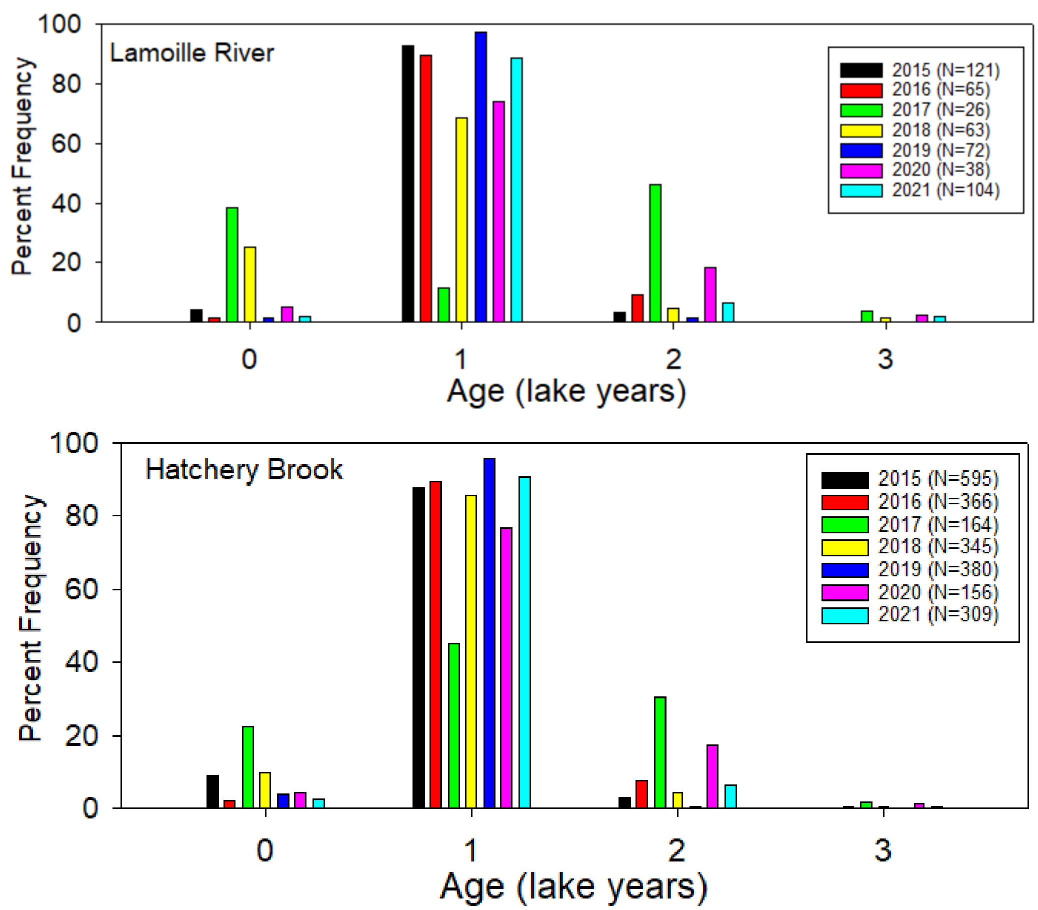

Figure 7. Age distributions (lake years) of landlocked Atlantic salmon from Lamoille River and Hatchery Brook, 2015-2021.

A trap net was deployed in Hatchery Cove for two overnight sets in early November to sample the lake trout spawning concentration; it yielded 420 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 8.

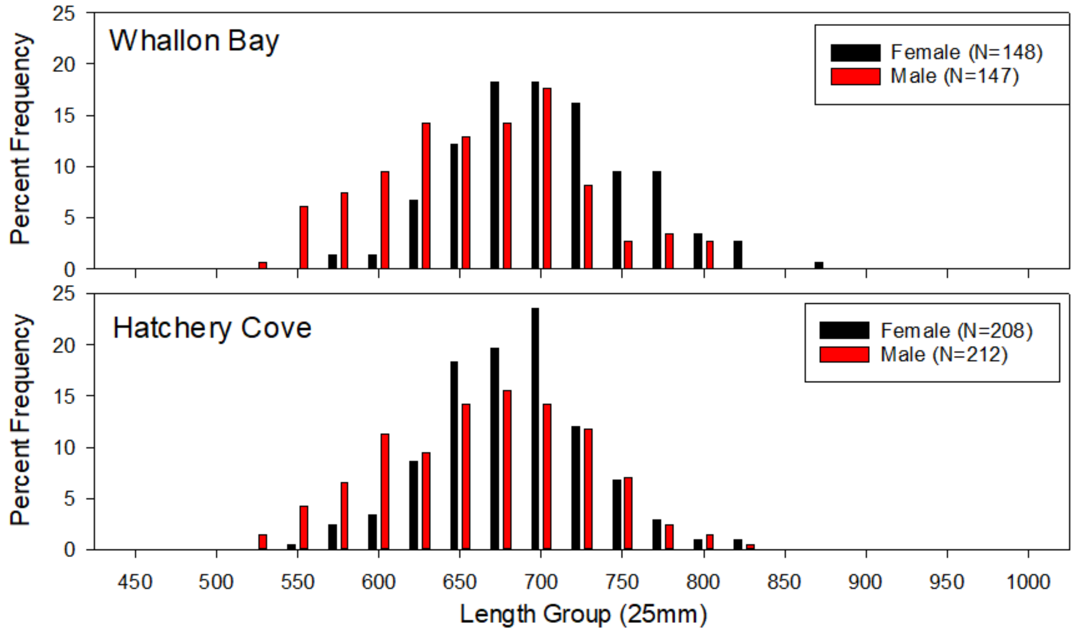

Figure 8. Length frequency distributions of male and female lake trout collected by trap net in Hatchery Cove and by electrofishing in Whallon Bay, November 2021.

Feral Atlantic Salmon Broodstock Egg Take at Ed Weed FCS (Kelsey, Blaker)

Utilizing feral broodstock for smolt production at Ed Weed FCS began in 1998. The enhanced performance of Atlantic salmon smolts derived from eggs obtained from feral broodstock has been documented by previous evaluations conducted on Lake Champlain. Adult broodstock are primarily sourced at a fish trap on the outfall of Ed Weed FCS, with some adults also being sourced during fall sampling assessments on the Lamoille River. The broodstock are individually sampled for length and weight. Each fish receives a floy tag and then transported to an isolation holding area at the facility exclusively designed for biosecure spawning.

Spawning is conducted using single paired random mating. Year class crossing (identified by size) is applied to the greatest extent possible. Strict biosecurity protocols are applied throughout the spawning events, currently using day spawn isolation techniques. Fertilized eggs are water hardened disinfected in a 50ppm iodophor solution for thirty minutes, followed by a 10,000ppm bath of thiamine mononitrate for one hour. This egg bath technique was developed in collaboration with the USGS Tunison Laboratory in 2013 as a more effective and efficient way to treat for thiamine deficiency complex (TDC) when compared to bath treatments of newly hatched sac fry. All eggs collected are held in isolation until receiving fish health diagnostic clearance before transferring to the early rearing production incubation room.

A total of 519,508 eggs were collected from five egg takes between November 4th – 19th. 150 pairs were spawned with an average fecundity of 3,463 per female. The average eye up percentage for the five takes combined was 68%. These eyed eggs will be used to produce smolts at Ed Weed FCS for direct lake entry and tributary stockings in the Lake Champlain basin.

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

Two Lake Champlain broodstocks of landlocked Atlantic salmon have been established at White River NFH. Both broodstocks were founded with feral fish from Hatchery Brook collected during the 2016, 2017, and 2018 fall spawning runs. In 2019, these two broodstocks became the primary broodstocks for Eisenhower NFH, serve as backup broodstocks for Ed Weed Fish Culture Station and are 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 used an applied "Evolutionary Rescue" approach to develop a TDC-tolerant broodstock that a recent study showed had adaptive genetic variation needed to adapt to low thiamine conditions in Lake Champlain. However, the strong selection in the TDC-tolerant broodstock may have also caused for unintended reduction in fitness of other traits and increased levels of inbreeding. Because of these concerns, we also established a max-diversity broodstock founded by surviving families supplemented with thiamine. This max-diversity broodstock is managed to maximize genetic diversity (i.e., large effective population size) but did not undergo selection for tolerance to TDC. A total of 114 unique families foundered these broodstocks, 91% of the families survived with thiamine supplementation and founded the max-diversity broodstock and 43% of the families survived without thiamine supplementation and founded the TDC Tolerant broodstock.

A total of 840,419 TDC eggs and 897,967 max-diversity eggs were taken for the 2021-year class with 57% and 64% eye up respectively. Average fecundity was 3,480 and 4,645 per female for the 2018 and 2017 broodstock respectively. Eyed eggs were transferred from White River NFH to Dwight D. Eisenhower NFH where they will be reared to the smolt stage and stocked into Lake Champlain tributaries. Applied research projects have been started to evaluate the performance of smolts stocked from these two broodstocks over the next 9 years. Performance indicators to be monitored include return to the fishery, length at age, smolt-adult return, and reproductive success.

Within-year-class crosses of the 2017 and 2018 were used to establish the 2021 year-class for each future broodstock. Number of unique families used to establish the 2021-year class was 260 for each the TDC-tolerant broodstock and max-diversity broodstock.

Sea Lamprey

Trapping and Barriers (Allaire)

After Covid 19 shut down all trapping operations in the Lake Champlain Basin in 2020, we were able to resume trapping (except in Quebec) in 2021.

Adult sea lamprey were trapped in 7 tributaries to Lake Champlain during the spring of 2021 to prevent or limit reproductive success (Table 8). We also placed a trap in Putnam Creek, not blocking the entire stream, to see if we could catch a number of adults with minimal effort.

We caught our first lamprey of the season in Malletts Creek on April 9th. We caught a total of 26 lamprey during the week of April 12th – 16th and expected to see numbers increase from there but they never did. That week ended up being our highest weekly total. We collected 40 lamprey in April, 64 in May, and just 6 in June. With a total of just 110 adults captured for the entire season we saw record low numbers at many trap sites including 0 in Bever Brook, 3 in Pond Brook, 3 in Trout Brook, and 66 in Malletts Creek. With just 3.6" of rain in April, 1.4" in May, and about 2" in June it was a very dry spring. With the low flows and trap improvements we saw higher trapping efficiencies (% of days that we were successful at blocking all upstream migration), but this did not lead to higher trapping catch totals.

Table 8. Results of spawning phase sea lamprey trapping in 2021.

Date Trap Set	State / Province	Stream	Date Trap Removed	% of Days Trap Operational	5 Year Avg. (2015 - 2019)	# of Lamprey Captured (2021)	% Change From 5 Year Avg.
4/5/21	NY	Beaver Brook	6/21/21	94.0%	63	0	-100%
4/6/21	VT	Trout Brook	6/21/21	NA	26	3	-88.5%
3/31/21	VT	Malletts Creek	6/21/21	76.0%	153	66	-56.9%
3/22/21	VT	Pond Brook	6/21/21	98.9%	80	3	-96.3%
3/23/21	VT	Sunderland Brook	6/21/21	96.7%	31	7	-77.4%
4/13/21	NY	Mullen Brook	6/21/21	75.4%	38	28	-26.3%
5/6/21	NY	Putnam Creek	6/21/21	NA	NA	3	NA
				TOTAL		**110**	

Larval Assessment Surveys (Allaire)

Pre-treatment

Streams are typically surveyed the year prior to a scheduled lampricide treatment to determine if a treatment is needed. New York tributaries including the Boquet River, Ausable River, Little Ausable River, Salmon River, Saranac River, Rea Brook, Little Chazy River, and Great Chazy River were all surveyed in 2021 to determine if a fall 2022 lampricide treatment would be needed. From these surveys, it was determined that lampricide treatments are needed in all but Rea Brook and the Little Chazy River. Larval population in both Rea Brook and the Little Chazy River, that received first ever lampricide treatments in the fall of 2018, appear to have been slow to recolonize. Targeted surveys will be done in those streams in 2022 before making a final determination if a lampricide treatment will be needed or not.

Post-treatment

Post-treatment larval surveys were conducted in Vermont tributaries that were treated with lampricide in the fall of 2020. This included the LaPlatte River, Winooski River, Lamoille River, and the Missisquoi River. Compared to pre-treatment larval surveys, post-treatment larval surveys showed that lampricide treatments had been successful ($\geq$ 95%) at reducing sea lamprey larval densities in the LaPlatte River (96.8%), Lamoille River (100%), and the Missisquoi River (100%). The Winooski River treatment was only slightly less effective at reducing sea lamprey larval densities (85.1%). We learn from each and every treatment, carefully review treatment data, and discuss ways to improve treatment efficiency and effective for future treatments.

Deltas

Delta surveys are typically conducted the same year as a scheduled delta treatment to limit the time for larvae to relocate between surveys and treatments. No delta treatments were scheduled in the fall of 2021 and no delta surveys were done in 2021.

Other

Due to the closure of the US – Canada Border, sea lamprey larval surveys were not done in the Pike River or Morpion Stream in Quebec in 2021. These tributaries had been surveyed annually between 2014 and 2019 to monitor changes in larval densities and determine the effectiveness of the Morpion Barrier. While it is unfortunate that we were not able to operate the barrier again in 2021, we are hoping to resume operation in the spring of 2022.

Detection Sampling (Allaire)

In 2021, staff visited 44 tributaries in New York at 49 locations that have historically been either "negative" for the presence of sea lamprey larvae or where sea lamprey larvae may have previously been found at densities that did not warrant control efforts.

No new sea lamprey larval populations were found. In the LaChute River we continue to find silver lamprey but have not found any sea lamprey larvae.

Lampricide Control (Smith)

No lampricide treatments were scheduled in 2021 as part of our regional alignment plan. The 2021 sea lamprey treatment map can be found in Appendix 2 and a treatment history and schedule of future treatments is presented in Appendix 3.

Wounding Rates (Pientka, Smith)

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 two wounds per 100 walleye.

Sea lamprey wounding rates calculated for 533-633 mm TL lake trout collected in fall 2021 increased slightly to 44.8 wounds per 100 fish (n=210), which remains well above the program objective (Figure 9). The 2021 wounding rate estimate for salmon in the 432-533 TL interval decreased greatly to 6.1 wounds per 100 fish (n=244), (Figure 9).

The salmon wounding rate (6.1) is one of the lowest observed rates and meets our control objective of less than 15 wounds per 100 (Figure 9). The wounding rate on lake trout in 2021 remains above our management target. The wounding rate index as a metric to gauge sea lamprey abundance has received increased scrutiny in recent years in the Great Lakes and Lake Champlain. The number of different variables that affect the index are difficult to individually quantify and can lead to misleading interpretations. This issue has led to investigations into new approaches in the Great Lakes that more accurately measure sea lamprey abundance. We are coordinating with our partners there and are in the process of developing a new adult assessment metric that will better inform us on the response of the lamprey population to our control efforts.

The sea lamprey wounding rate assessment for walleye (534 - 634 mm TL) was planned for the Winooski River in 2021. Sampling was planned for Lamoille River in 2020 but due to Covid that sampling was pushed to 2021. Walleye sea lamprey wounding rate for both Winooski River (5.7 wounds per 100, n=122) and Lamoille River (3.97 wounds per 100, n=78) exceeded target.

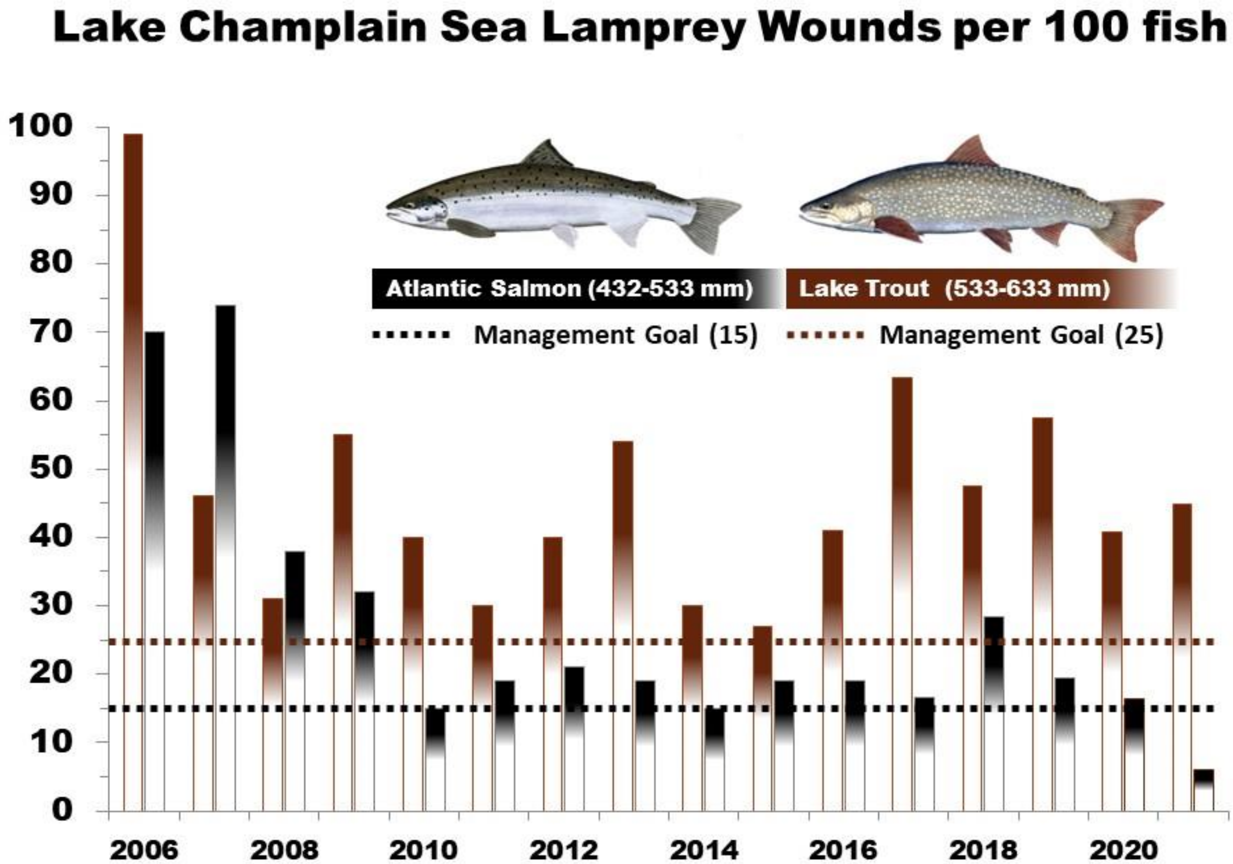

Figure 9. Type A1-A3 sea lamprey wounds (fresh and healing) per 100 lake trout (533-633 mm TL) and per 100 salmon (432-533 mm TL) from fall sampling.

Percidae

Yellow Perch (Pientka)

Experimental gillnets are set overnight at multiple locations in Vermont annually, 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 2021, the sampling occurred between July 5th and July 13th.

Yellow perch catch per overnight set (CPUE) in 2021 were compared to the multiyear average CPUE for 2009 to 2020 (Figure 10). Yellow perch CPUE in Malletts and Missisquoi Bays were slightly higher than multiyear average. Shelburne and St. Albans Bays were slightly below the multiyear average. Sampling will continue in 2022.

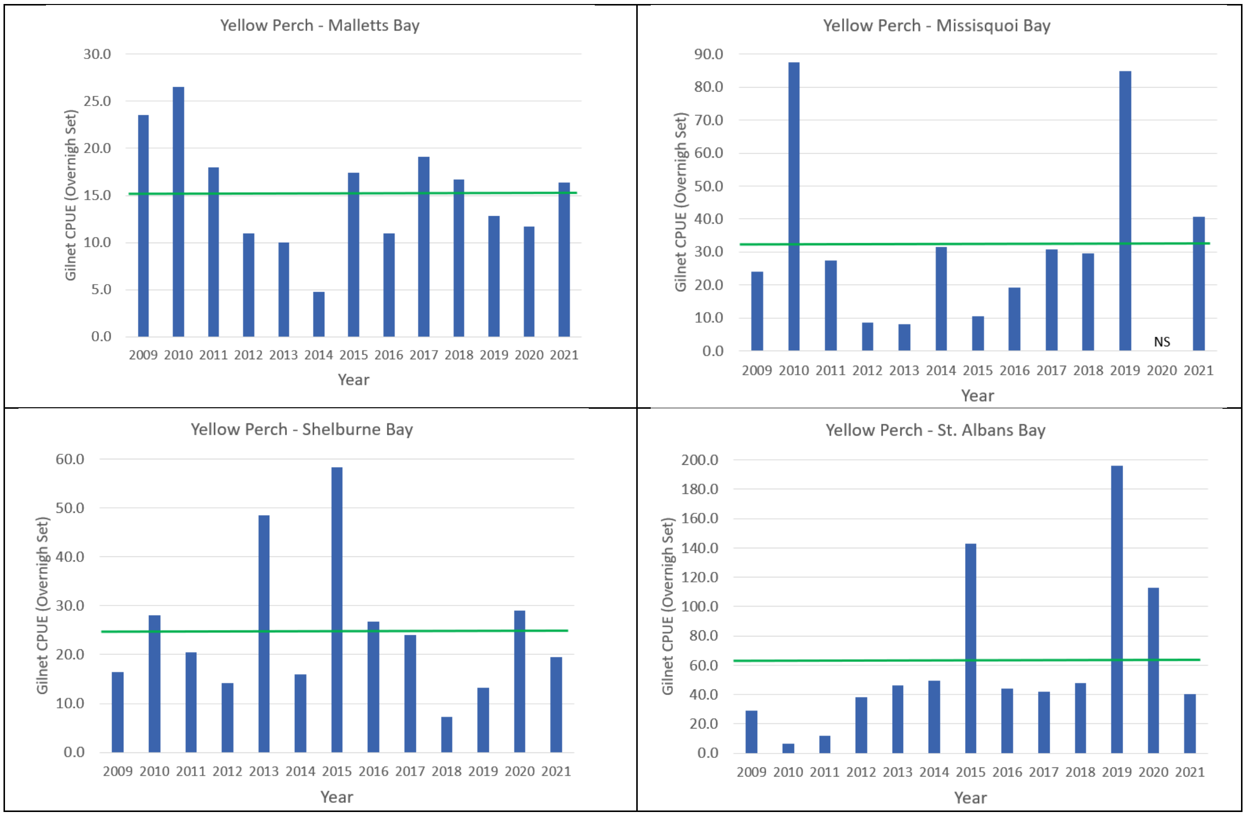

Figure 10. Yellow Perch CPUE for 2009-2021 at four Lake Champlain locations (note different y-axis scale). NS=not sampled. Green line represents the multiyear average CPUE for 2009 to 2020.

Walleye (Pientka, Good)

Walleye management activities in 2021 on Lake Champlain included monitoring adult walleye returning to spawn in the Winooski and Lamoille Rivers (VT). The Winooski 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.

On Lamoille River 122 (108 males, 14 females) were collected. Two hundred and forty-eight walleye (199 males, 48 females) were collected from the Winooski River. Twenty-three females and 45 males from Winooski River walleye were spawned resulting in 3.03 million eggs which were hatched at the Ed Weed FCS in Vermont. Fingerlings were reared in the hatchery's intensive culture system and in one pond managed by the Lake Champlain Walleye Association. All fry and fingerlings were marked with oxytetracycline (OTC) prior to stocking. Twenty-nine age-3 males were collected for evaluation of the contribution of stocked fish to the spawning run in the Winooski River. All 3-year-old males examined were found to be of hatchery origin, as indicated by the presence of an OTC mark on the otoliths.

Sauger (Fiorentino)

NYSDEC is assessing options for sauger restoration in Lake Champlain and has drafted a Lake Champlain Sauger Restoration Plan. The plan has been reviewed by the FTC sauger working group and was presented to the full FTC in July 2019 for final input. A major component of the plan is establishing a sauger hatchery program to restore the species to Lake Champlain with a focus on the South Lake region. The plan suggested using broodstock from the upper Mississippi River. The FTC sought approval from Quebec to use the Mississippi River stock but has received no reply in the last 2 years. The sauger restoration plan is currently on hold while NYSDEC is focusing on other major projects within the Lake Champlain watershed. When time permits the proposed plan will be revisited.

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 2021, Vermont issued 132 permits for bass tournaments on Lake Champlain, down from 150 the previous year. Both major U.S. professional bass fishing tournament series, Bassmaster (B.A.S.S) and Forrest L. Wood (FLW) Outdoors, hold regular events on the lake. Event results from these organizations indicate that tournament catches have remained very consistent since the first professional tournament was held on Lake Champlain in 1997 (Figure 11).

Electrofishing surveys were conducted on Vermont waters of northern Lake Champlain in the spring of 2021. Eight transects were sampled at two different sites. A total of 2.7 hours of electrofishing was completed and 12 largemouth bass and 111 smallmouth bass were collected. Largemouth bass ranged in size from 358 to 517 mm total length and smallmouth bass ranged in size from 196 to 504 mm TL.

No bass surveys were conducted on southern Lake Champlain in 2021.

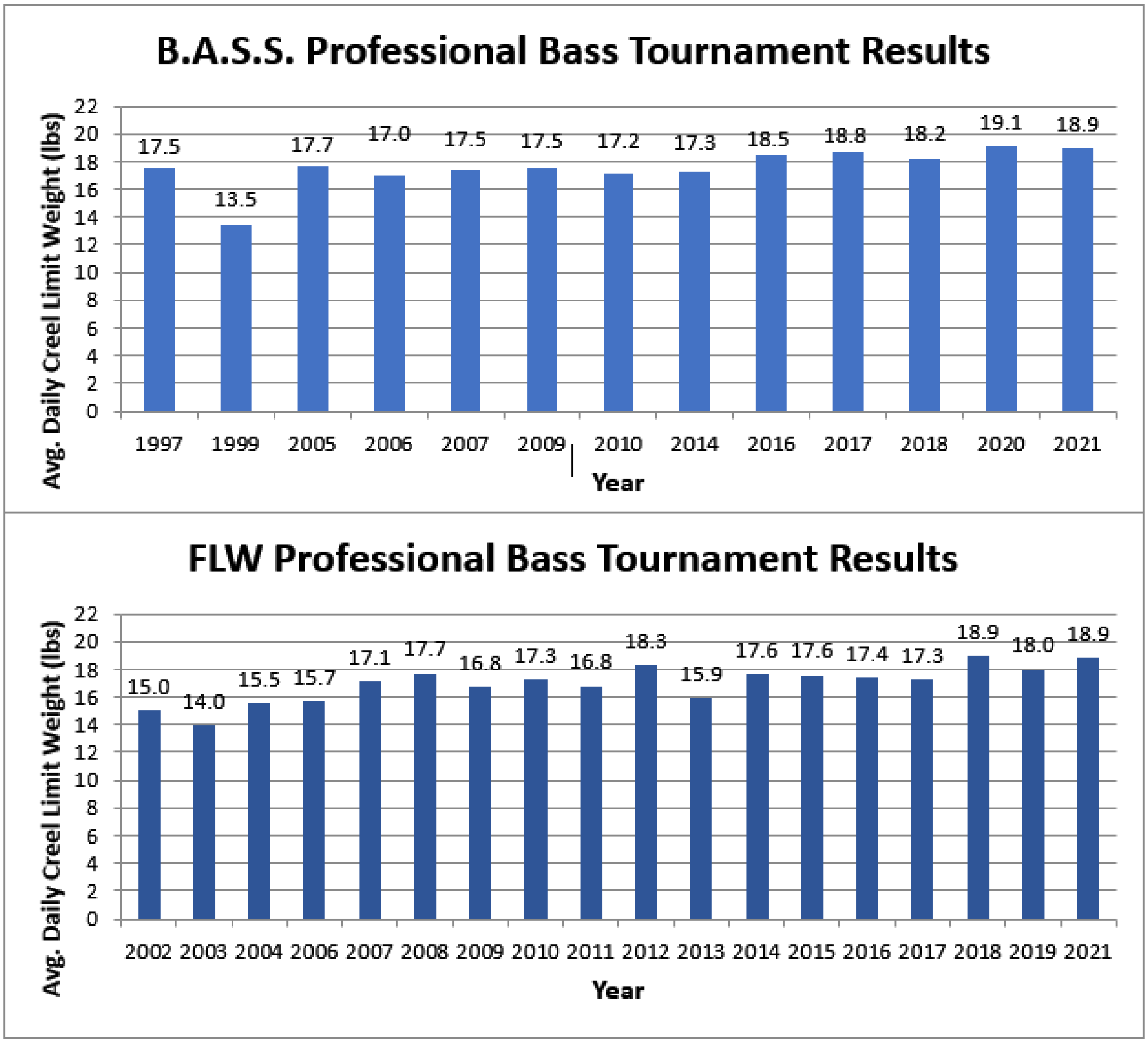

Figure 11. Average daily creel limit weights for the Top 10 anglers each year for two Professional-level tournament series held on Lake Champlain since 1997.

Esocids

Muskellunge (Good)

Due to unanticipated hatchery losses, VTFWD has been unable to secure summer Muskellunge fingerlings from the NYSDEC Chautauqua Hatchery for stocking the Missisquoi River for the last four years. Muskellunge fall fingerlings (1,150) were stocked into the Great Chazy River by NYSDEC Chateaugay hatchery in 2021 (Table 9).

In 2021, VTFWD conducted electrofishing surveys for fall young-of-year muskellunge on the upper Missisquoi River above Swanton Dam. One muskellunge was collected that measured 14.6-inches (371mm). Due to the lack of stocking in 2021, this fish was wild-produced and was the first documented evidence that muskellunge have begun spawning in the upper river and that there has been success and survival from these efforts. The same fall electrofishing surveys were conducted on the upper river in 2019 and 2020 as well, but no Age-0 fall YOY muskie were collected.

Table 9. Muskellunge stocking numbers for Lake Champlain, 2008-2021.

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	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	2,340	2,000
2018-2021	0			0	0
TOTAL	**54,960**			**43,460**	**11,500**

Similar fall surveys have been conducted on the lower river during recent non-stocking years, but no young-of-year muskellunge have been collected there. However, one wild-produced fish was caught in the lower river during a non-stocking year two years ago as incidental by-catch during spring walleye spawning surveys.

Northern Pike (Good)

Ice-out spring trap netting was conducted in southern Lake Champlain to characterize Northern Pike size structure (Figure 12). Four distinct sites were netted over a two-week period, repeating specific sites surveyed in 2009 and 2010. Nets were set for a total of 382.7 hours or 16 net nights. A total of 4,905 fish and 25 different fish species were caught. There were 375 unique Northern Pike captured; 85 were male and 290 were female. There were eight Northern pike recaptured during the two-week sampling period.

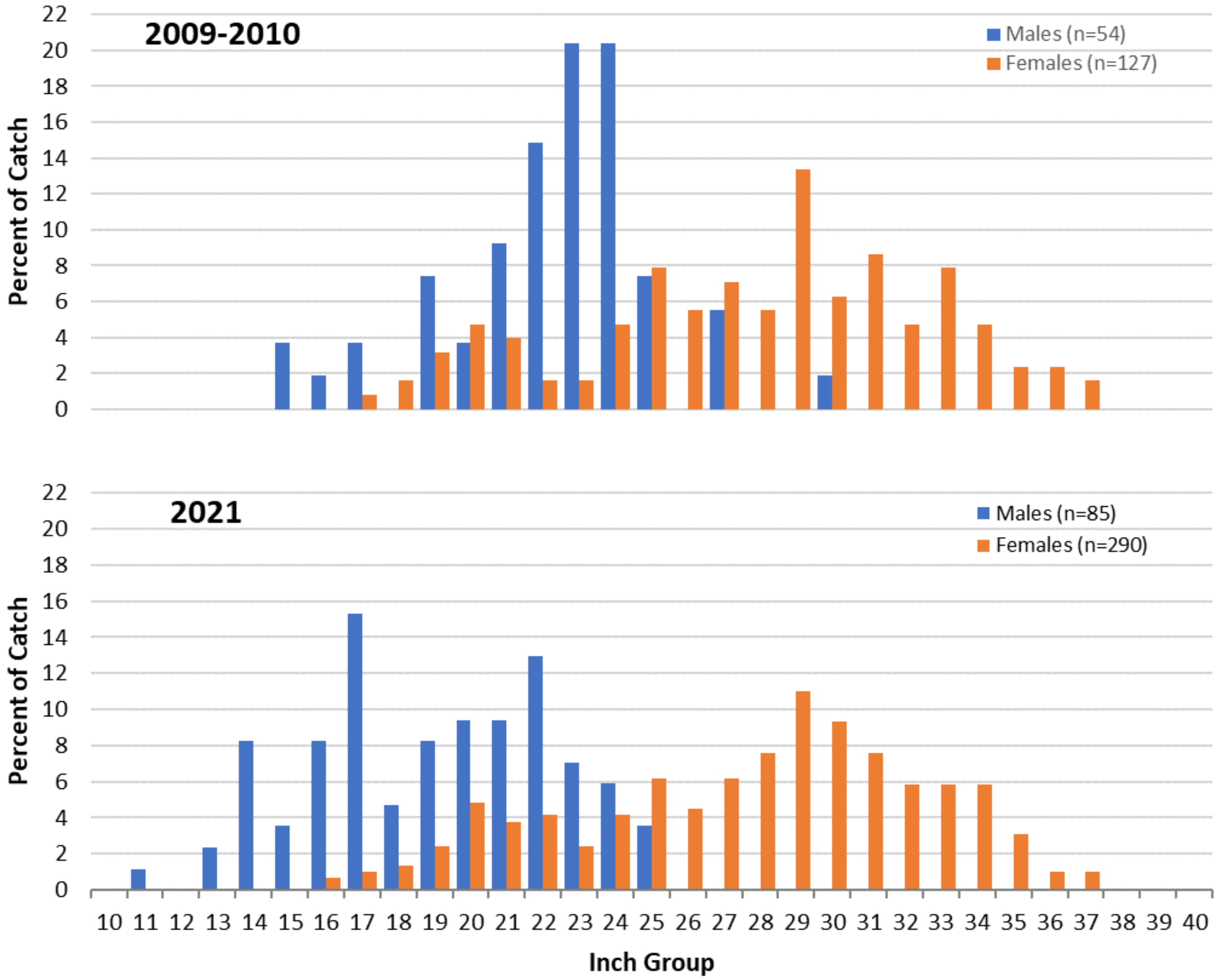

Figure 12. A comparison of male and female Northern Pike length distribution at four sites on southern Lake Champlain sampled in 2009-2010 and repeated in 2021.

Anguillids

No sampling was done in 2021.

Acipenseridae

Lake Sturgeon (Murphy, Simard)

Sampling for lake sturgeon occurred on the Missisquoi River on May 12 and 13 using a boat electroshocker in the reaches below the Swanton Dam downstream along Rt 78. No lake sturgeon were observed.

Additional sampling for lake sturgeon occurred in September and October in the Inland Sea of Lake Champlain between North Hero and the Alburgh bridge using large-mesh gillnets. One lake sturgeon (858 mm TL; 3,000 g) was captured, PIT tagged, and surgically implanted with a V16 acoustic tag before being released.

In collaboration with the University of Vermont, eleven acoustic receivers were deployed in locations in Lake Champlain and the Winooski, Lamoille, and Missisquoi rivers to monitor lake sturgeon movements. Data from these receivers has not yet been downloaded or reviewed. Manual tracking of the tagged sturgeon from the Inland Sea was also conducted. The tagged sturgeon was located on four occasions in October up to 6 km away from the release location.

Public outreach at fishing areas along spawning tributaries also continued to inform anglers of the presence of lake sturgeon, the endangered status of the species, and proper handling techniques if a lake sturgeon is caught.

Recreational Fishery Monitoring

Angler Surveys (Pientka, Balk)

No angler surveys were conducted by VTFWD in 2021.

NYSDEC conducted the first year of a two year angler survey on Lake Champlain, beginning with an ice fishing angler survey in January (Balk 2020a), followed by an open-water angler survey that started in April (Balk 2020b). Reports will be published annually to the DEC website [https://www.dec.ny.gov/outdoor/7730.html]. Overall, anglers are very receptive to the interview process and happy that we are doing this survey.

Ice fishing angler survey

In 2021, 224 interviews were conducted from January 1 through March 21. Anglers fished for an estimated 14,676 hours overall on the four bays surveyed, with most effort on the weekends. Effort included 5,663 hours on King’s Bay, 343 hours on Willsboro Bay, 2,319 hours on Bulwagga Bay, and 6,351 hours on South Bay. We anticipated yellow perch being the primary target species for the Lake Champlain ice fishery and it was targeted by 50% of the anglers interviewed (Table 10). Perch were the primary target at three of the four bays, the exception being South Bay where anglers targeted a variety of species.

Table 10. Species or species group targeted, listed by rank with percent of anglers targeting them during the 2021 Lake Champlain ice fishing season.

Target species	Rank	Percent
perch	1	50
anything	2	15
northern pike	3	11
crappie	4	11
sunfish	5	7
walleye	6	3
lake trout	7	2
largemouth bass	8	0
pickerel	9	0

Interviewed anglers caught 1,616 fish and harvested 52% of them. The catch and harvest rates for all bays over the ice fishing period were 0.45 and 0.24 fish per angler hour, respectively. Northern pike effort was high (9,973 hours), nearly as much as for perch, but catch rate was low (0.01 fish/hour) and harvest was nonexistent.

Open-water angler survey

In 2021, 548 interviews were conducted from April 1 through October 31. Analysis of the data is in progress. We anticipated black bass being the primary target species for the Lake Champlain open-water fishery and they were, with smallmouth and largemouth bass combined for 52%. We expected the open-water targets to focus on black bass and the coldwater species found in the main lake. The top open-water targets were black bass, Atlantic salmon, lake trout and anything (Table 11).

Table 11. Species or species group targeted, listed by rank with percent of anglers targeting them during the 2021 Lake Champlain open-water fishing season.

Target species	Rank	Percent
smallmouth bass	1	31
largemouth bass	2	21
Atlantic salmon	3	11
lake trout	4	10
anything	5	9
yellow perch	6	5
walleye	7	3
northern pike	8	3
bass	9	1
black crappie	10	1
channel catfish	11	1
bowfin	12	1

The creel clerks measured 90 fish; 41% of them were lake trout. The lake trout measured were between 406-749 mm total length (16 to 29.5 inches), all over the Lake Champlain minimum of 15 inches (Figure 13).

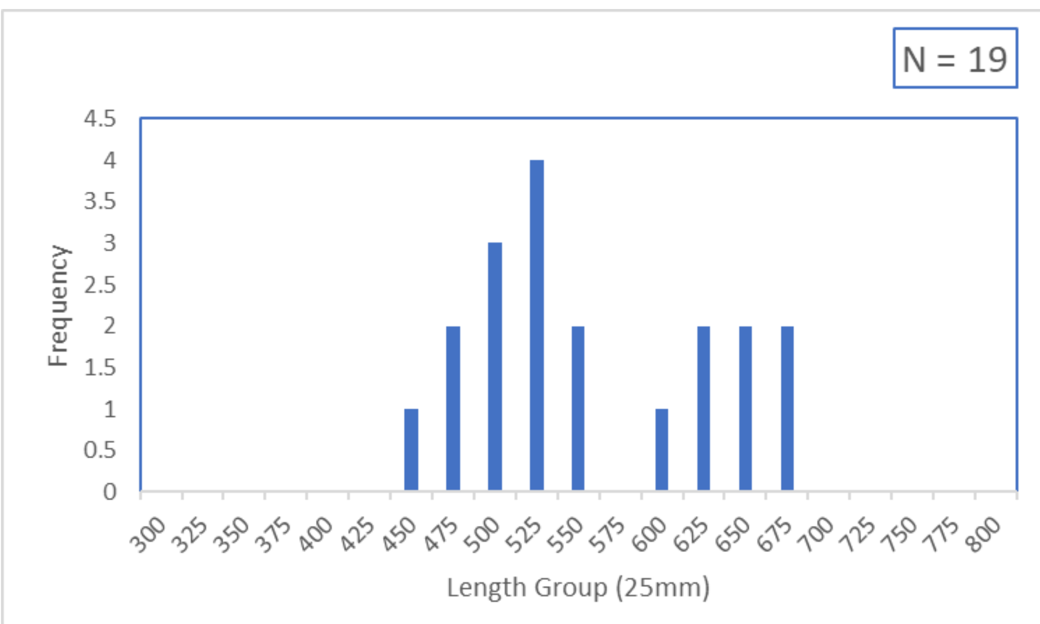

Figure 13. Length frequency of lake trout harvested from Lake Champlain during the 2021 open-water fishing season.

Atlantic salmon measured ranged between 444-671 mm, or about 17.3 to 26.4 inches, all over the Lake Champlain minimum of 15 inches (Figure 14).

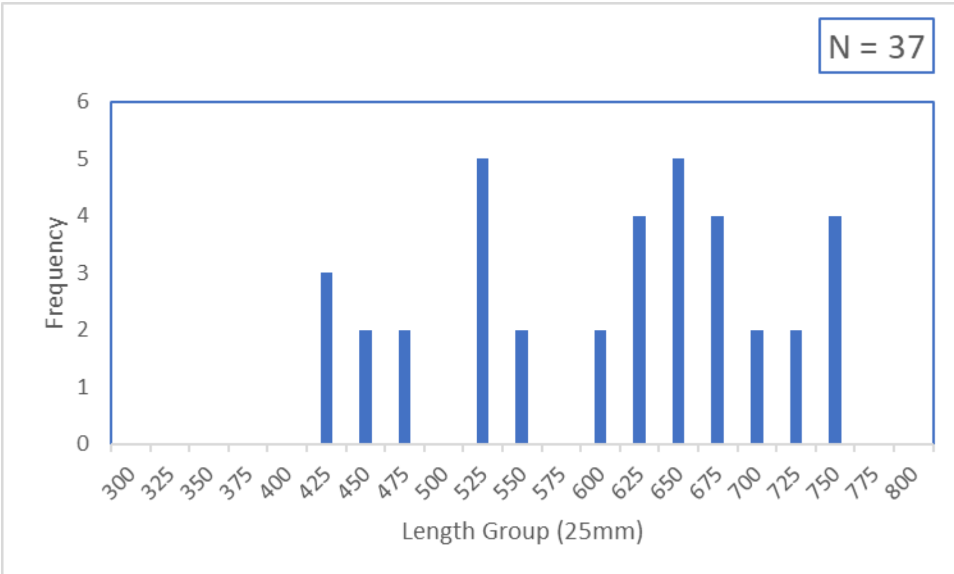

Figure 14. Length frequency of Atlantic salmon harvested from Lake Champlain during the 2021 open-water fishing season.

Fish Health (Jones, Balk, Garceau)

NYSDEC sent 10 adult Atlantic salmon collected in the fall to the Hale Creek fish health lab for testing. Results may not be available by the time this report is finalized and if they are not, the results will be included in the 2022 report.

Walleye Fish Health Inspection: Adult walleye broodstock were collected from the Winooski River and transferred to a bio-secure isolation station at the Ed Weed FCS where they were spawned. Eggs were water hardened in iodine at 50-ppm iodine solution for 30 minutes and then placed in a quarantine unite until associated fish health inspection laboratory work was completed. On April 16, through April 18, 2021, lethal samples were collected from 10 adult males and 21 males being held for OTC analysis. Non-lethal ovarian fluid samples were collected from 23 gamete contributing adult females. Tests were conducted for viral and bacterial fish pathogens of concern to include IPN, IHN, VHS, OMV, AS and YR, (Table 12). All fish sampled tested negative (Table 13). Lymphocystis (virus) was presumptively identified on the skin. Muscle tissue was visually examined for the *Heterosporis sp*. parasite which was not observed.

Wild Landlocked Atlantic Salmon Inspection: Sebago strain landlocked Atlantic salmon, originating from Lake Champlain, were captured from the Ed Weed FCS discharge stream (Hatchery Brook) and from the Lamoille River. Fish were transferred to the EW isolation station where they were spawned. Eggs were water hardened in iodine at 50-ppm solution for 30 minutes and then placed in a quarantine unite until associated fish health inspection laboratory work was completed. On November 4, through November 22, 2021, a total of 31 salmon (30 male and 1 female) were lethally sampled for viral and bacterial pathogens of concern (IPN, IHN, VHS, OMV, BKD, ER, AS and AQ), (Table 10). Non-lethal, ovarian fluid samples were collected from 161 females and tested for IPN, IHN, VHS, OMV, BKD and AQ. All fish sampled tested negative (Table 13).

Table 12. Summary of pathogen abbreviations.

Pathogen	Abbreviation	Pathogen	Abbreviation
Infectious Pancreatic Necrosis	IPN	Spring Viremia Carp Virus	SVCV
Infectious Hematopoietic Necrosis	IHN	Furunculosis	AS
Viral Hemorrhagic Septicemia	VHS	Enteric Redmouth Disease	YR
Largemouth Bass Virus	LMBV	Oncorhynchus Masou Virus	OMV
Renibacterium salmoninarum	BKD	Aquareovirus A	AQ
Epizootic Epitheliotropic Disease Virus	EEDV	Namaycush Herpesvirus	NamHV

Table 13. Summary of Disease Testing in Lake Champlain Feral Broodstock

Date	Sp.	# Test	IPN	IHN	VHS	LMB	BKD	SVCV	AS	YR	OMV	AQ	EEDV	NamHV
4/16/21 to 4/18/21	WAL	31 lethal	NEG	NEG	NEG	N/A	N/A	N/A	NEG	NEG	NEG	N/A	N/A	N/A
4/16/21 to 4/18/21	WAL	23 O/F	NEG	NEG	NEG	N/A	N/A	N/A	NEG	NEG	NEG	N/A	N/A	N/A
11/4/21 to 11/22/21	LAS	31 lethal	NEG	NEG	NEG	N/A	NEG	N/A	NEG	NEG	NEG	NEG	N/A	N/A
11/4/21 to 11/22/21	LAS	161 O/F	NEG	NEG	NEG	N/A	NEG	N/A	N/A	N/A	NEG	NEG	N/A	N/A

Species Key: WAL – Walleye LAS - Landlocked Atlantic Salmon LAT- Lake Trout
Results: POS - Positive NEG – Negative N/A – Not Tested For O/F : Nonlethal Ovarian fluid

Disease Testing for USFWS's Natural Fish Population Survey: Two Lake Champlain locations were sampled in 2021 and samples were forwarded to the USFWS Lamar Fish Health Center to be included in the USFWS's Natural Fish Population Survey. On April 27, 2021, samples were collected from Lake Champlain (Carmans Marsh) located in Swanton, VT. Testing encompassed six fish species for a total of 113 fish sampled. Pathogens tested for included: VHS, IHN, IPN, LMBV, SVCV, AS, and YR. No pathogens were detected in this sample (Table 14). Common parasites detected include yellow grub, blackspot, white grub, redworm and bass tapeworm.

On May 10, 2021, samples were collected from Lake Champlain (Larrabee's Point/East Creek) located in Shoreham, VT. Testing encompassed eight fish species for a total of 108 fish sampled. Largemouth bass virus was detected in largemouth bass (Table 14). Common parasites detected include yellow grub, blackspot, white grub and redworm. A single brown bullhead was documented with melanism on the skin surface.

Table 14. Summary of Lake Champlain Disease Testing for USFWS's Natural Fish Population Survey.

Date	Location	Sp.	# Test	IPN	IHN	VHS	LMBV	BKD	SVCV	AS	YR	OMV
4/27/2021	C. Marsh	LGM	7	NEG	NEG	NEG	NEG	N/A	NEG	NEG	NEG	NEG
4/27/2021	C. Marsh	SMB	2	NEG	NEG	NEG	NEG	N/A	NEG	NEG	NEG	NEG
4/27/2021	C. Marsh	YP	30	NEG	NEG	NEG	NEG	N/A	NEG	NEG	NEG	NEG
4/27/2021	C. Marsh	PMS	30	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
4/27/2021	C. Marsh	BLG	20	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
4/27/2021	C. Marsh	GLS	24	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	CMC	10	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	FWD	5	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	TCH	5	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	LGM	13	NEG	NEG	NEG	**POS**	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	ALW	15	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	SMB	5	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	PMS	25	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
5/10/2021	Lara. Pt.	YP	30	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG

Species Key: LMB - Largemouth bass, SMB - Smallmouth bass, YP-Yellow perch, PMS - Pumpkinseed, BLG - Bluegill, GLS - Golden shiner, CMC- Common carp, FWD - Freshwater drum, TCH - Tench,
ALW - Alewife

Results: POS - Positive NEG - Negative N/A - Not Tested For

Fish Kill's: No fish kills were reported or investigated in calendar year 2021.

Research

Lake Trout Population Dynamics (Benjamin Marcy-Quay, J. Ellen Marsden, UVM)
Objective: assess the relative performance (growth and survival) of the two stocking strategies used by New York and Vermont, as well as the parental population underlying recruitment, using next-generation genetics to determine the origin of stocked fish and the size and structure of the parental population contributing to wild recruitment. Genetic samples have been collected for most aspects of the analyses, preliminary data have been collected, analysis is underway.

Lake Trout Recruitment (J. Ellen Marsden, Matt Futia, Ben Marcy-Quay UVM)
Assessment of wild lake trout (Salvelinus namaycush) recruitment continued in 2021. We caught 260 lake trout in 2021, of which 46.5% were wild fish. The proportion of wild fish was highest in the Burlington Bay area (56.8%). Among juveniles, 48.3% were wild whereas among adults 29.1% were wild. Comparison of the diet of adult stocked and wild fish is in progress.

Lake Champlain food web model (Jason D. Stockwell, J. Ellen Marsden, Justin Lesser, Rosalie Bruel, UVM)
We are completing and balancing a food-web model for Lake Champlain Use of the model will inform our understanding of the effects of the invasion of alewife on native species (especially lake trout and rainbow smelt), quantify routes of energy and nutrient transfer between littoral and pelagic communities, and design ecosystem-based management approaches.

Lake Champlain forage fish/carbon project (Jason D. Stockwell, J. Ellen Marsden, Ariana M. Chiapella, UVM)
Objective: describe the carbon (i.e., energy) pathways of Lake Champlain's forage fish community, to anticipate the potential effects of quagga mussels on the lake's fishery. All components of the forage fish food web have been sampled and are being analyzed for stable nitrogen and carbon isotopes. We are constructing a lakewide assessment of the carbon contained in zebra mussels in anticipation of changes that will occur if/when quagga mussels invade the lake.

Lake trout habitat use in Lake Champlain (Matt Futia, J. Ellen Marsden, UVM)
Objectives: Compare seasonal three-dimensional habitat use by stocked and wild lake trout using acoustic telemetry; compare seasonal diet composition using stomach content and fatty acid analyses; identify off-shore spawning sites.

Forage Fish Survey (J. Ellen Marsden, Jason Stockwell, Shelby Scarfo, UVM)
Objective: design and begin implementation of a survey to assess abundance and biomass of cold-water forage fish (focused on rainbow smelt, alewife, slimy sculpin, and trout-perch). The survey will integrate annual assessment of wild juvenile lake trout abundance relative to stocked lake trout.

Rapid detection of Atlantic salmon and trout in the Boquet and Ausable Rivers using environmental DNA
(Carrianne Pershyn, Liz Metzger, Ausable River Association, Jonah Withers, USFWS, Taylor Wilcox, USFS)
We are utilizing environmental DNA (eDNA) for rapid Detection of Atlantic salmon (Salmo salar) and Brook trout (Salvelinus fontinalis) in the Boquet River, NY. In 2021, more than 25 km of river were sampled for salmonid distribution and to test the efficacy of eDNA sampling to accurately indicate spawning success of Atlantic Salmon. The project helps measure the success of the Lake Champlain Atlantic salmon restoration program and recent restoration projects to increase access for spawning adult salmon in Lake Champlain tributaries.

Conservation of the Lamoille River Mudpuppy (*Necturus maculosus*) Population Using Translocation and Monitoring (Mark Ferguson, VT Department of Fish & Wildlife)
Objective: Trap and relocate mudpuppies in the Lamoille River to establish a novel population upstream of Arrowhead Mountain Lake, and track a subset of these individuals using radio telemetry to study their movements post-relocation. The 2022 trapping season was completed with a total of 114 mudpuppies trapped below Peterson dam and released at the relocation site. Six of these received internal radio transmitters and their movements will be tracked in 2022 and potentially into 2023, dependent on battery life. Small tissue samples (tail fin clip) were collected from all individuals to accommodate future genetic study.

2021 Scientific Publications

Bruel, R., J. E. Marsden, B. Pientka, N. Staats, T. Mihuc, J. D. Stockwell. 2021. Rainbow smelt population responses to species invasions and change in environmental condition. J. Great Lakes Res. 47:1171-1181

Johnson, J.A., K. Kelsey, and R. Summerfelt. 2021. Walleye larviculture in water reuse aquaculture systems. Pages 141-190 in J.C. Bruner and R.L. DeBruyne, editors. Yellow Perch, Walleye, and Sauger: Aspects of Ecology, Management, and Culture. Springer.

Marsden, J. E., M. Schumacher, PD Wilkins, B. Marcy-Quay, C. Kozel, B. Alger, K. Rokosz. 2022. Diet of wild and stocked juvenile lake trout in Lake Champlain. J. Great Lakes Res.

Wilkins, P.D. and J. E. Marsden. 2021. Spatial and seasonal comparisons of growth of wild and stocked juvenile lake trout in Lake Champlain. J. Great Lakes Res. 47:204-212

Wilkins, P.D. and J. E. Marsden. 2021. Seasonal depth distribution of wild and stocked juvenile lake trout in Lake Champlain. J. Great Lakes Res. 47:252-258

Young, B.; Allaire, BJ; Smith, S. 2021. Achieving sea lamprey control in Lake Champlain. Fishes, 6(1), pp. 115-129. https://doi.org/10.3390/fishes6010002

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Balk, N. 2020. Lake Champlain Open-water Fishing Creel Survey Plan. NYSDEC. Region 5 Fisheries.

Lake Champlain Fisheries Technical Committee (FTC). 2019. Protocol for Summarizing Indicators of Lake Champlain Salmonid Status. Lake Champlain Fisheries Technical Committee Salmonid Working Group. 24 pages.

Lake Champlain Fisheries Technical Committee (FTC). 2020a. Lake Champlain Lake Trout Stocking Reduction Recommendation. Salmonid Working Group. Approved November 24, 2020.

Withers, J. 2020. Utilizing radio telemetry to elucidate barrier passage efficiency and impacts on upstream movement, spatial distribution, and habitat use of spawning Landlocked Atlantic Salmon, Salmo salar, in the Boquet River. USFWS.

Appendices

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

U.S. Fish and Wildlife Service:
W. Ardren , B. Young, B.J. Allaire, Essex Junction, VT
S. Smith – Liaison to NYSDEC – Essex Junction, VT
H. Bouchard, retired in 2021; replaced by Shane Hanlon – North Chittenden, VT

Vermont Fish and Wildlife Department:
B. Pientka, L. Simard **-** Essex Junction, VT
M. Murphy, S. Good – Rutland, VT
K. Kelsey – Grande Isle, VT

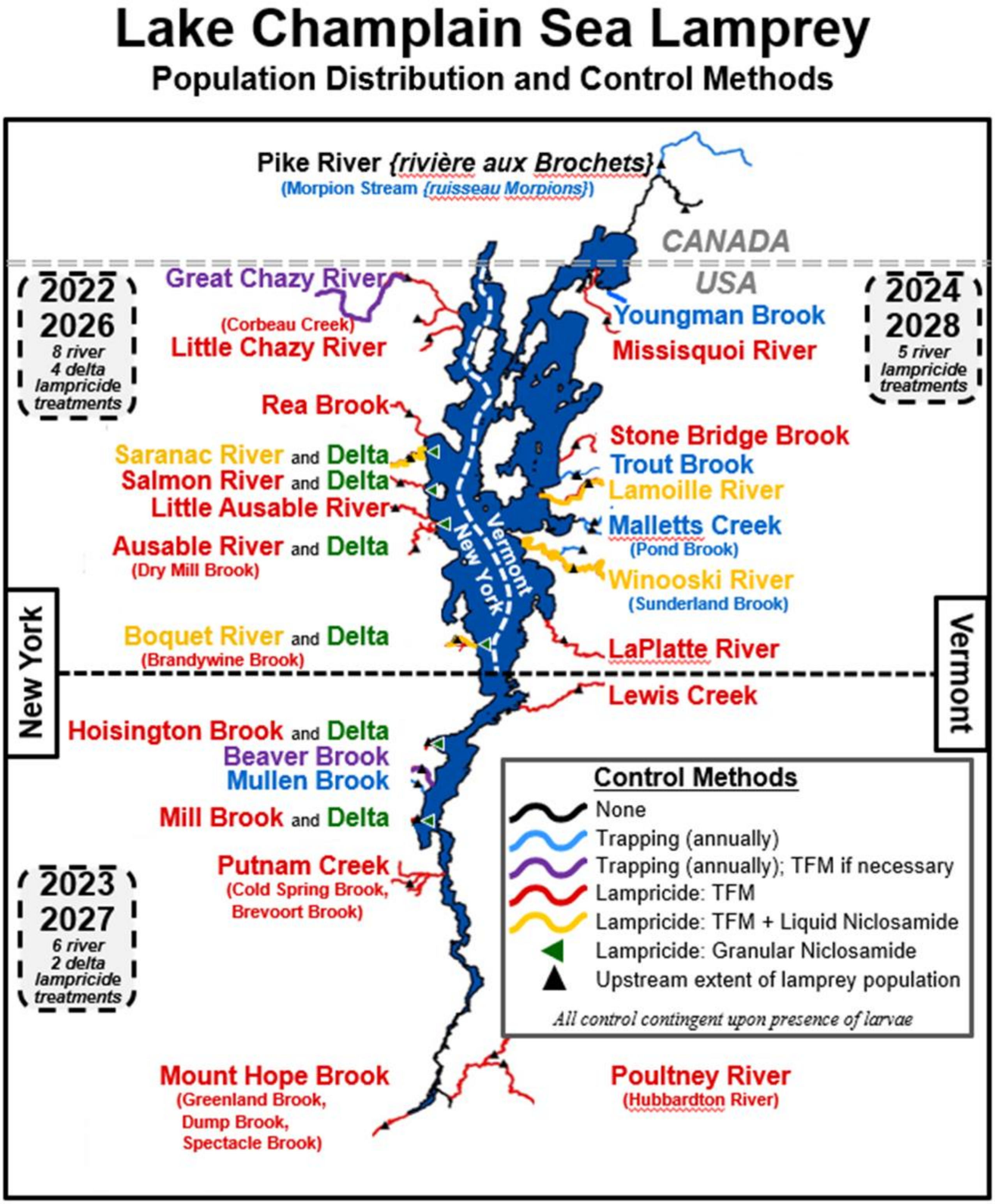
New York State Department of Environmental Conservation:
R. Fiorentino, T. Shanahan, N. Balk (FTC Chair) – Ray Brook, NY

University of Vermont:
J.E. Marsden – Burlington, VT

Vermont Cooperative Fish and Wildlife Research Unit (USGS):
D. Parrish – Burlington, VT

Lake Champlain Sea Grant:
M. Malchoff – Plattsburgh, NY

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



Appendix 3. Schedule of completed and projected Lake Champlain lampricide treatments.
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. Treatment histories from the experimental control program (1990-2000) and the long-term program from 2001-2009 are available in earlier annual reports. 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.

			10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
New York	WEST	Great Chazy River			T		T				T				P		
		Little Chazy River									T				P		
		Rea Brook									T				P		
		Saranac River				C					C				P		
		Saranac Delta			B		T				B				P		
		Salmon River	T				T				T				P		
		Salmon Delta					B				B				P		
		Little Ausable River	T				T				T				P		
		Ausable Delta Complex		B			B				B				P		
		Ausable River	T				T	T			T				P		
		Boquet River		C			C				C				P		
		Boquet Delta					B								P		
	SOUTH	Hoisington Brook										T				P	
		Beaver Brook							T							P	
		Mill Brook			T							T				P	
		Mill Delta			B											P	
		Putnam Creek	T			T			T			T				P	
		Mt. Hope Brook			T			T				T				P	
- -- -		Poultney/Hubbardton rivers		T				T				T				P	
		Lewis Creek	T				T	T				T				P	
Vermont	EAST	LaPlatte River							T				T				P
		Winooski River			T			T					T				P
		Stonebridge Brook				T			T								P
		Lamoille River				T							T				P
		Missisquoi River			T								T				P