LAKE CHAMPLAIN FISH AND WILDLIFE MANAGEMENT COOPERATIVE

FISHERIES TECHNICAL COMMITTEE

2016 ANNUAL REPORT

Approved by Cooperative Policy Committee, August 23, 2017

Natural-origin juvenile lake trout (Burlington Bay) and landlocked Atlantic salmon (Winooski River) identified for the first time in over 100 years!

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Executive Summary

Restoration efforts for native salmonids continued to be the primary focus of the Lake Champlain Fisheries Technical Committee in 2016. Landlocked Atlantic salmon (salmon) and lake trout were focal species accounting for 75% of 519,715 smolt / yearlings stocked into the lake and tributaries. Highlights from native salmonid management include:

- Salmon runs declined from record highs observed in 2015. Abnormally low lake levels and river flows, along with elevated water temperatures through much of the period may have limited tributary returns.
- Fall nearshore sampling identified an increase in salmon age and size structure.
- Successful natural reproduction of salmon was documented in the upper Winooski River.
- Deep water sampling for juvenile lake trout identified wild lake trout ranging in age from young of year to two 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.
- Winter and open water angler creel surveys were conducted in Lake Champlain to estimate fishing pressure, total catch and harvest of fish species, and other fishery characteristics.
- The feral Lake Champlain salmon broodstock from Hatchery Brook continued to produce more returning adults than the traditional captive broodstock.

Lampricide treatments were completed on four tributaries in 2016 with a total of 18.8 miles of stream treated in New York and Vermont. Trapping efforts at 9 locations during the spring spawning run captured 344 adult sea lamprey. Sea lamprey wounding rates in 2016 remain lower than the average rates observed during the 1990's experimental sea lamprey control program for salmon, on par for lake trout, but remained above program objectives for both lake trout and salmon. Sea lamprey wounding rates for walleye sampled in the Missisquoi River were less than the target rate of 2 wounds per 100 fish. No lampricide treatments are currently scheduled for 2017.

Monitoring efforts included: muskellunge, bass, walleye, and yellow perch populations. Research efforts included; using acoustic telemetry methods to monitor movement patterns of lake trout and sturgeon; characterizing impacts of thymine deficiency on salmonids, evaluation of broodstock sources for salmon and steelhead; and experimentation with fish rearing practices and stocking strategies to enhance salmon survival and adult returns to spawning tributaries.

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), US 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 during 2016. The names of Project Leaders are listed after section headings and their affiliation can be found on the Fisheries Technical Committee Membership list at the end of this document (Appendix 1). More details on specific projects can be obtained by contacting project leaders.

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; (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 draft list of indicators and is seeking input from the FTC before finalizing the list. Once input is received the working group will draft a report by spring of 2017 detailing each indicator. Management action thresholds for indicators will be developed after the available information on Lake Champlain is summarized and available literature is reviewed. 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. A summary of these indicators will be included in the 2017 Lake Champlain Annual Report prepared by the Fisheries Technical Committee.

Stocking Summary (Shanahan)

Salmonid stockings in Lake Champlain during 2016 included approximately: 306,000 landlocked Atlantic salmon (smolt equivalents); 64,000 steelhead (smolt equivalents); 86,000 lake trout; and 64,000 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 2016, and stocking targets for the lake.

	Main Lake		Malletts Bay/Inland Sea		Total number stocked in 2016
Species	Target	2016	Target	2016	
Landlocked salmon	227,000	230,403	77,000	75,643	306,046
Lake trout	82,000	86,107	0	0	86,107
Steelhead	53,000	58,691	5,000	5,000	63,691
Brown trout	38,000	35,210	40,000	28,661	63,871
Total	400,000	410,411	122,000	109,304	519,715

Fish Passage (Staats) –

Winooski River Fish Lift - A total of 89 adult landlocked Atlantic salmon and 24 steelhead rainbow trout were trapped at the Winooski One fish passage facility in 2016 (Figure 1). Of the salmon lifted in the fall, there were 49 male and 40 females processed. Mean length and condition factor (K) of lake-age 1 males increased slightly from 2015 (Figure 2). Steelhead were released directly above the Winooski dam while salmon were transported above the next two dams and released salmon redds were found in the upper Winooski River as well as the Huntington River.

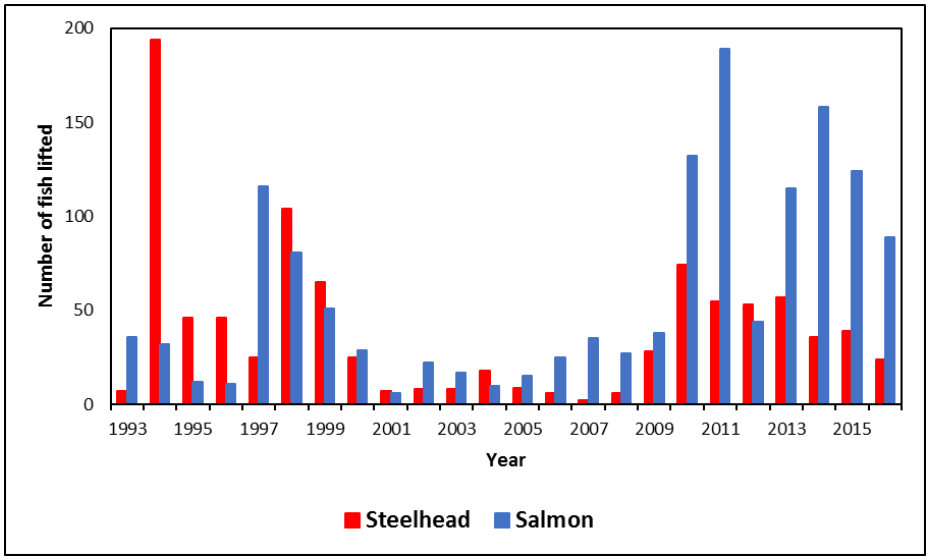


Figure 1. Summary of steelhead rainbow trout and landlocked Atlantic salmon lifted at the Winooski One fish passage facility, 1993 – 2016.

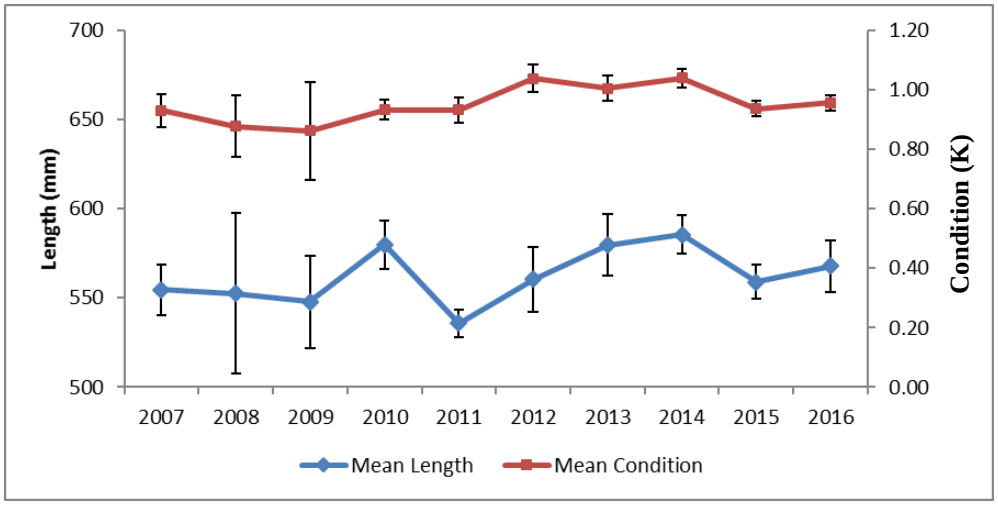


Figure 2. Comparison of mean total length (± 95 % CI) and K (± 95 % CI) of lake age 1 male landlocked Atlantic salmon collected at the Winooski One fish passage facility, 2007 – 2016.

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 third 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 during March and April, 2016 with limited success. Sampling yielded only two steelhead in Mill River, Georgia; two steelhead in LaPlatte River, Shelburne; and none in Lewis Creek, Ferrisburgh. Sampling was challenging at times due to high spring runoff flows.

Fall nearshore salmonid sampling was focused on traditional sites in Willsboro and Whallon bays. Sampling in 2016 was delayed and condensed due to delays in the sea lamprey control schedule. Catches in the Whallon Bay and Willsboro Bay areas consisted of 88 lake trout, 234 salmon, 1 steelhead, and 1 brown trout. Whallon and Willsboro bay salmon catches were up from 2015, but on par with recent years. Again in 2016 over half of the salmon sample was made up of fish greater than 500 mm indicating the presence of older age classes of salmon in the lake (Figure 3).

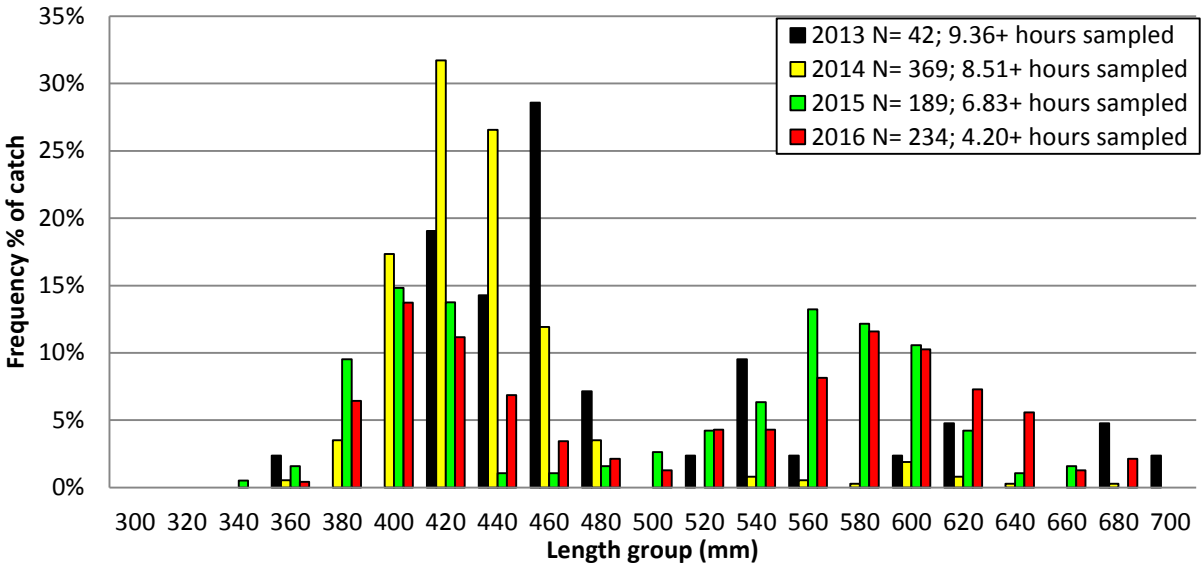


Figure 3. Length frequency distributions of landlocked Atlantic salmon collected from Willsboro and Whallon bays by electrofishing, 2013-2016.

In 2016, the Hatchery Brook trap was operated March 15-April 29 in the spring, and September 15-November 10 in the fall. The trap captured 33 steelhead during the spring season. In the fall, 374 salmon were captured and processed, far less than the record 1,494 salmon collected in Hatchery Brook in 2015. The fall trap catch also included 85 brown trout and one steelhead. The brown trout catch was the greatest in Hatchery Brook since fall 2000.

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 55 salmon in 5 days of electrofishing in the Lamoille River, 16 salmon in six trips to Otter Creek; and 17 salmon in five trips to the Missisquoi River.

A total of 204 adult salmon from Hatchery Brook along with 25 salmon collected in the Lamoille River and one from Hatchery Cove were retained for use as broodstock at Ed Weed FCS; 75 females and 58 males were spawned. All of the males and one female used for egg production were lethally sampled for disease testing. Twelve of the females that were spawned died following egg take and at least 69 of the salmon not spawned died in captivity; the remainder were released alive in Lake Champlain. Elevated lake water temperatures near Hatchery Brook apparently caused additional stress to salmon collected. Many of them had visible external fungal infections upon collection from the trap, which is usually a very rare occurrence.

Length frequency distributions of Hatchery Brook and Lamoille River salmon differed markedly from 2015 to 2016. Hatchery Brook salmon tended to be smaller in 2016 than in 2015, while Lamoille River salmon tended to be larger in 2016 than in 2015 (Figure 4). Aging of salmon scale samples is ongoing to enable determination of the roles of age distribution and growth rates on the spatial and temporal size structure differences.

A trap net was set in Hatchery Cove for one night in early November to sample the lake trout spawning concentration. The set yielded 323 lake trout, three salmon, and one brown 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 5. Condition factors (K) of male lake trout collected lake-wide from 2001 through 2016 are presented Table 2.

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.

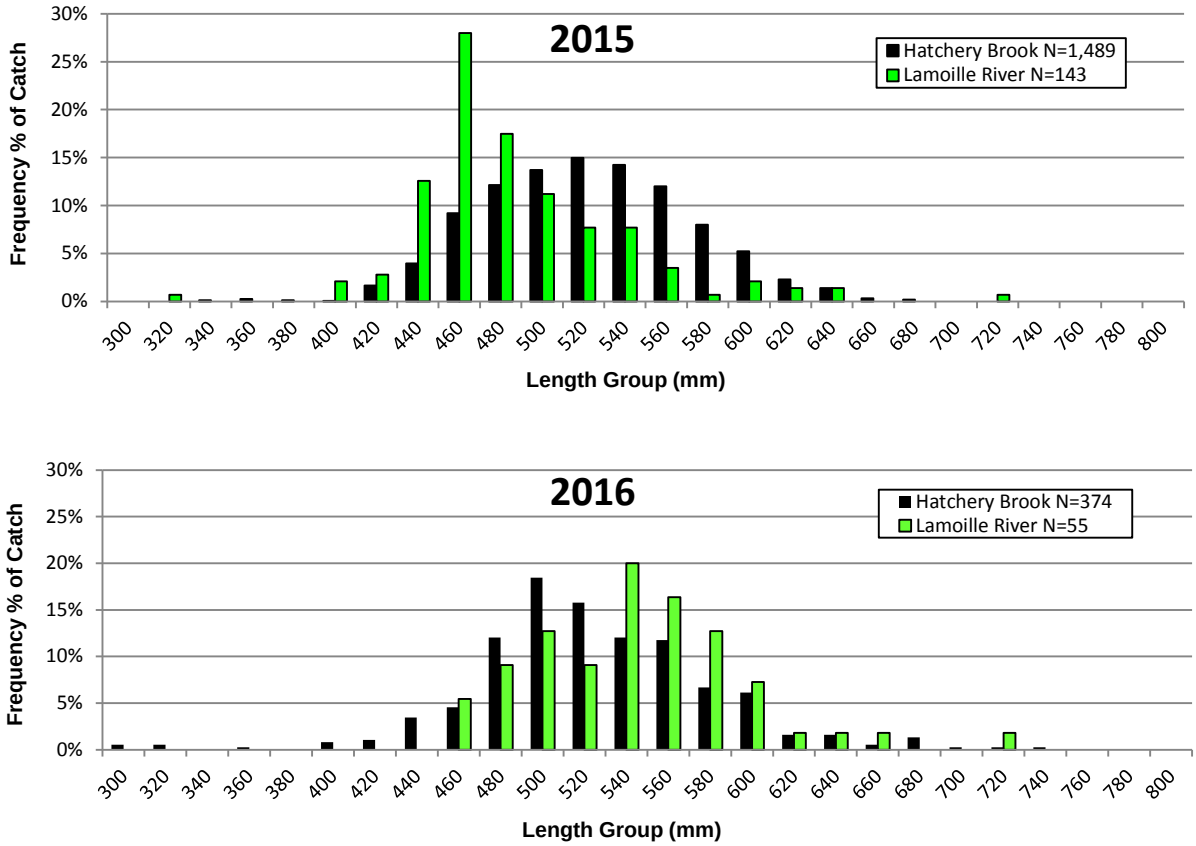
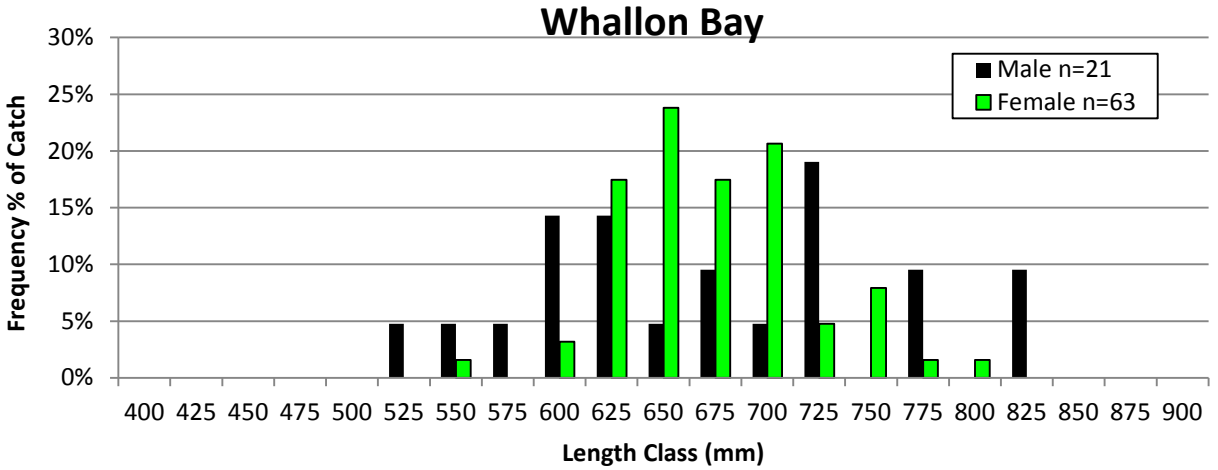


Figure 4. Length frequency distributions of landlocked Atlantic salmon collected from fall spawning runs in Hatchery Brook and Lamoille River in 2015 and 2016.



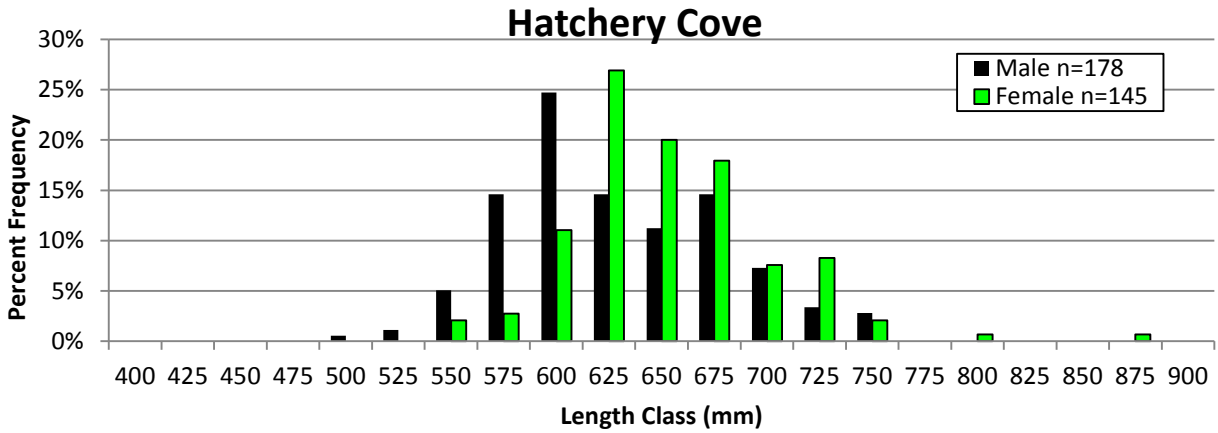


Figure 5. Length frequency distributions of male and female lake trout collected by trap net in Hatchery Cove and by electrofishing in Whallon Bay, November 2016.

Table 2. Estimated mean Fulton's condition factor (K) ± 95 % confidence interval (CI) for male lake trout collected in Lake Champlain in fall, 2011-2016.

Year	K	95% CI	n
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

Pre-stocking Landlocked Salmon Assessments (Ardren) –

In the spring of 2016, 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 2016, at least 90% of fish exceeded the 150 mm size threshold for Ed Weed and Adirondack hatcheries while 83% of fish exceeded the size threshold for Eisenhower NFH (Figure 6).

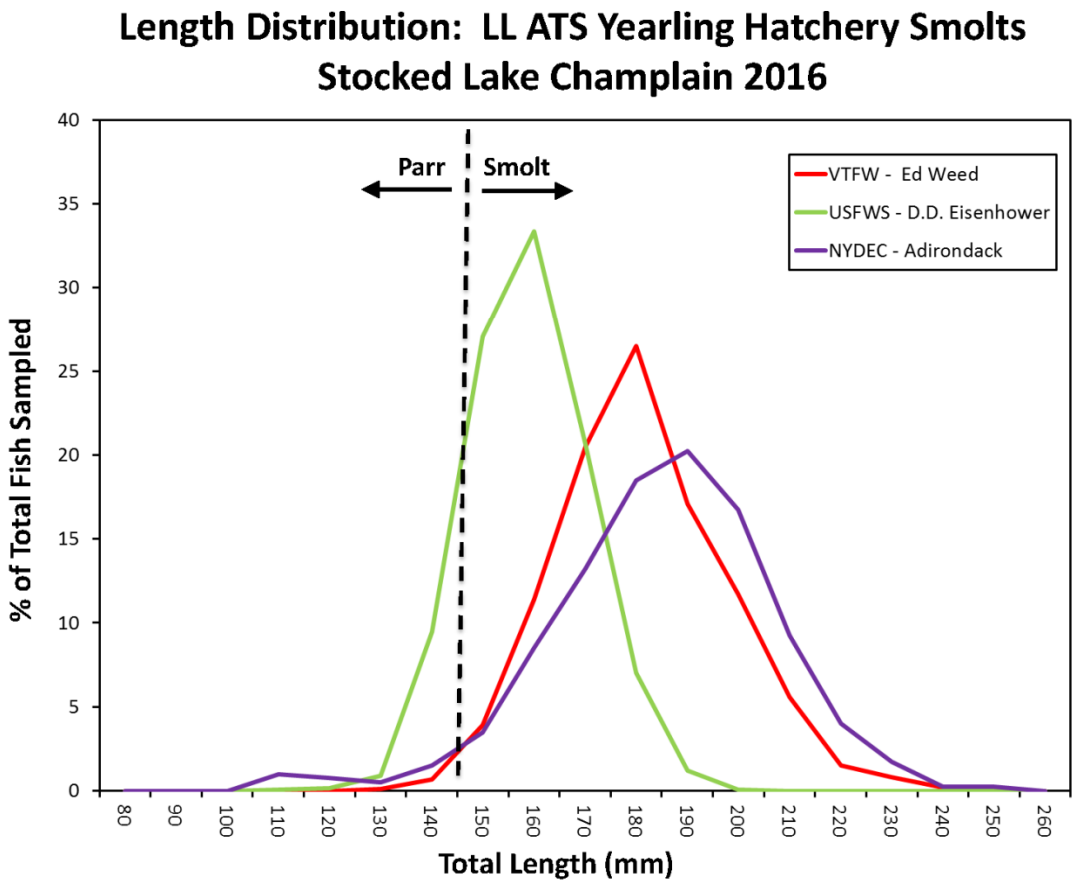


Figure 6. Total length distribution of hatchery-reared yearling landlocked Atlantic salmon stocked into the Lake Champlain Basin from three hatcheries in 2016.

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 is ongoing. 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 2016 consistently show increasingly greater returns of feral offspring relative to domestic offspring each year (Figure 7). Evaluation sampling will continue through 2017.

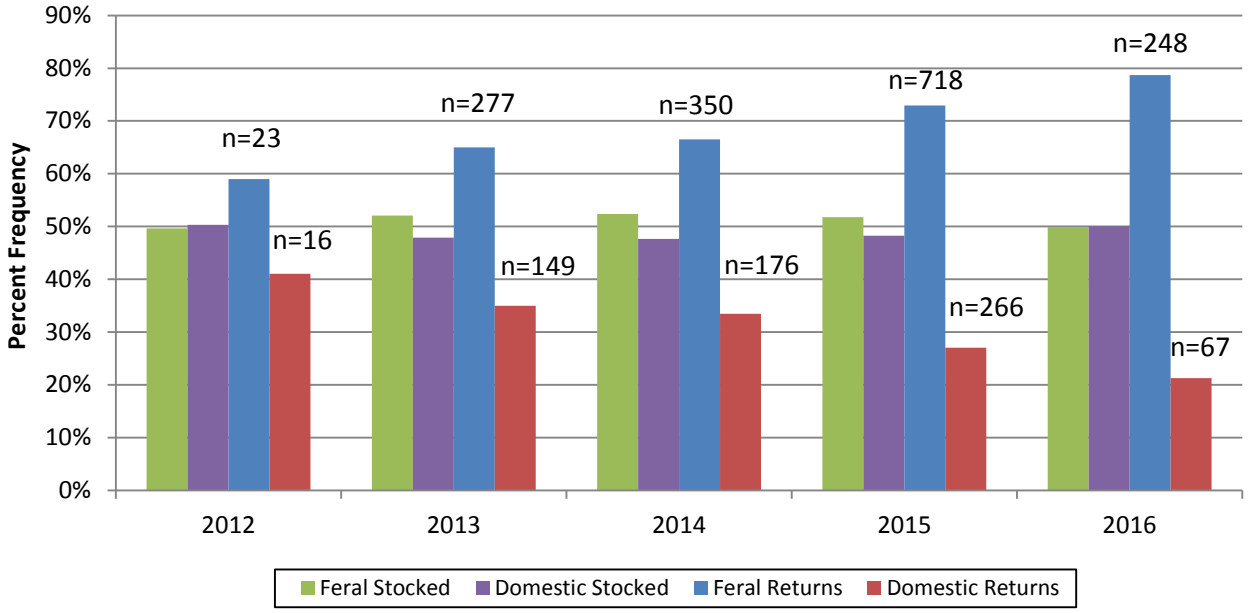


Figure 7. Returns of landlocked salmon stocked in Lake Champlain, produced from feral and domestic broodstock, 2012-2016.

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 2016 in Lewis Creek, LaPlatte River, Winooski River, Hatchery Cove, and Mill River. Annual numbers of each strain stocked averaged 31,375 (53.4%) Chambers Creek and 28,489 (46.6%) Memphremagog.

Steelhead returns from each strain were recorded in annual fall and spring nearshore, tributary, and fishway assessments. Results through fall 2016 show inconsistent overall steelhead returns from year to year, with the Chambers Creek strain returning at greater rates than the Memphremagog strain in three of the five years, however, returns were low in fall 2016 (Figure 8). Evaluation sampling will continue through fall 2017-spring 2018.

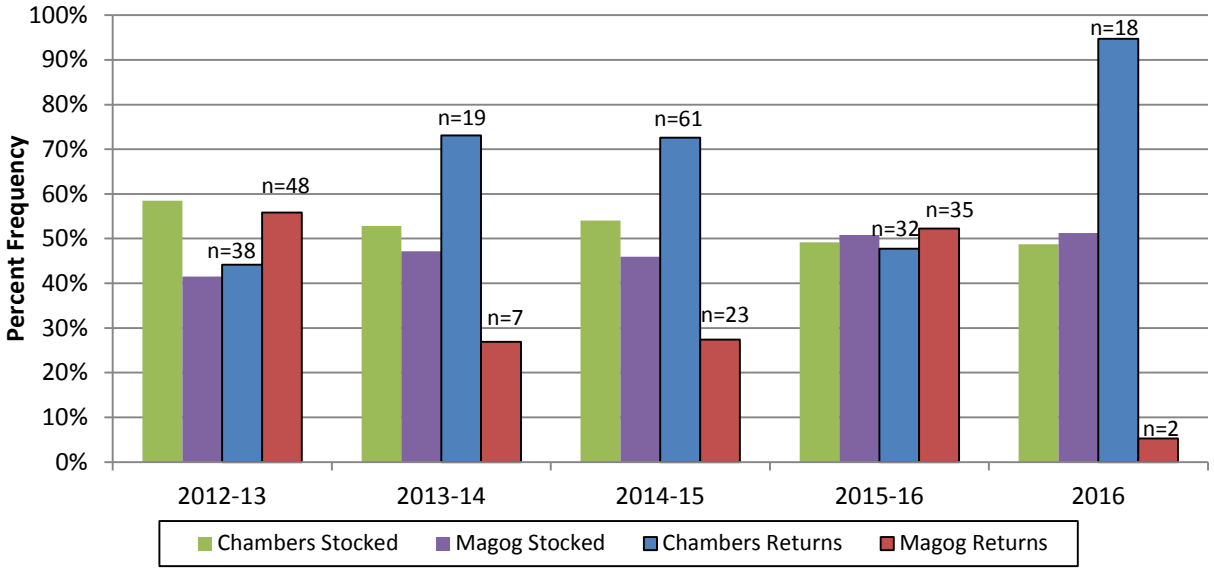


Figure 8. Returns of Chambers Creek and Lake Memphremagog strain steelhead stocked in Lake Champlain, 2012-2016. Each data group of returns represents corresponding fall and following spring sampling periods, except from the 2016 group which is the fall period only.

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.

Pre-treatment Larval Assessment Sampling (Allaire)

No lampricide treatments are currently scheduled for 2017, so no pre-treatment surveys were conducted in 2016. Lamprey larval surveys were conducted in the Pike River and in Morpion stream. 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 3). If we are successful at preventing sea lamprey from spawning in Morpion Stream, we should see a continued decrease in larval densities.

Table 3. Sea lamprey larval densities in the Pike River and Morpion Stream.

Stream	Type I Larval Density (n/m^2)	Type II 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
2014 Morpion Stream	1.139	0.164
2015 Morpion Stream	1.256	0.535
2016 Morpion Stream	0.699	0.263

Post-treatment Larval Assessment Sampling (Allaire)

Post-treatment larval surveys were conducted in five Lake Champlain tributaries (Mount Hope Brook, Poultney River, Hubbardton River, Lewis Creek, and the Winooski River) that received lampricide treatments in the fall of 2015. Post-treatment surveys were also conducted in Putnam Creek and Beaver Brook to evaluate the effectiveness of lampricide treatments that were conducted in the spring of 2016 (Table 4).

Table 4. Pre-treatment and post-treatment larval densities for streams treated with lampricides during the fall of 2015 or the spring of 2016.

Stream	Pre-treatment (2014) Density (n/m^2)	Post-treatment (2016) Density (n/m^2)	Percent reduction in sea lamprey larvae density
Mount Hope Brook	0.348	0.070	79.9%
Poultney River	0.026	0.002	92.3%
Hubbardton River	0.272	0.005	98.2%
Lewis Creek	0.007	0.000	100.0%
Winooski River	0.201 (2013)	0.022	89.1%
Putnam Creek	0.814	0.501	38.5%
Beaver Brook	0.224	0.019	91.5%

Detection Sampling (Allaire)

In 2016, staff surveyed 26 tributaries in the southeastern quadrant of Lake Champlain that have historically been considered "negative" for the presence of sea lamprey. No new sea lamprey populations were identified. The Mettawee River has historically been positive for silver lamprey, but not for sea lamprey. In 2016, staff visited 3 sampling sites on the Mettawee River and collected 90 lamprey larvae. All were identified as silver lamprey.

Trapping and Barriers (Allaire)

Adult sea lamprey were trapped in 9 tributaries to Lake Champlain during the spring of 2016 to prevent or limit reproductive success (Table 5). Stone Bridge Brook (now included in treatment schedule) and the Great Chazy River (had been both trapped and treated) that were trapped in 2015 were not trapped in 2016.

Baited pots were deployed above trap sites in Malletts Creek and Trout Brook to capture sea lamprey which had made it past the downstream weir. No adult sea lamprey were caught in the pots in Trout Brook during the 2016 season. In Malletts Creek, we captured 14 adults in pots (17.9% of the 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.

We saw a decrease in the number of adults captured in 2016 at all 9 trapping sites. The total number of adults captured was just 344, which was a significant decrease from the 929 captured in 2015 at these same sites and the fewest number of adults captured since at least 2000.

Table 5. Results of adult sea lamprey trapping in 2016.

Date Trap Set	State / Province	Stream	Date Trap Removed	% of Days Trap Operational	# of Lamprey Captured **(2015)**	# of Lamprey Captured **(2016)**	% Change From 2014
4/4/16	NY	Beaver Brook	6/15/16	98.6%	235	1	-99.6%
4/14/16	VT	Trout Brook	6/16/16	94.0%	29	14	-51.7%
4/21/16	VT	Malletts Creek	6/15/16	70.9%	175	78	-55.4%
4/13/16	VT	Pond Brook	6/16/16	87.5%	72	43	-40.3%
4/22/16	NY	Rea Brook	6/16/16	87.3%	63	51	-19.0%
4/12/16	VT	Sunderland Brook	6/16/16	89.2%	60	11	-81.7
4/11/16	NY	Mullen Brook	6/15/16	92.3%	41	5	-87.8%
4/12/16	NY	McKenzie Brook	6/13/16	71.0%	6	1	-83.3%
4/20/16	QC	Morpion	6/16/16	98.2%	248	140	-43.5%
				TOTAL	**929**	**344**	-63.0%

Lampricide Control (Smith) –

Lampricide treatments were completed on four tributaries in 2016 (Table 6). Control status of Lake Champlain tributaries is presented in Appendix 2. A treatment history and schedule of future treatments is presented in Appendix 3.

Three lampricide application permits were submitted to the state of Vermont in 2016: LaPlatte River, Stone Bridge Brook, and the Missisquoi River. In July of 2016, the Vermont Department of Health changed their policy on the human health advisory threshold for TFM from 35ppb to 3ppb. That change would have forced changes to our existing monitoring plans (increased duration and area) and extending notification zones that we could not accommodate for personnel, time, resource, and safety reasons. It effectively cancelled the treatments on the Missisquoi and LaPlatte rivers for those reasons.

After a great deal of negotiation and the installation of a powdered activated charcoal (PAC) injection system at a water treatment facility, we were permitted to treat the LaPlatte River. Because no similar opportunities for mitigation or negotiation were available for the Missisquoi River, its treatment was canceled. The relative larval population contributions for the 3 rivers were LaPlatte = 84%, Stone Bridge = 6%, and Missisquoi = 10%.

Once a permit was issued for the LaPlatte River treatment, environmental challenges arose that further complicated the treatment. Flows were unseasonably low making a treatment extremely more challenging to execute than under normal flow conditions. Given 1) the discharge of the river, 2) diurnal water chemistry cycles and the time of travel for TFM in that uppers section, and 3) the status of stonecats as a Vermont state-listed species, it was a virtual certainty that treating at the proposed upstream application point would cause substantial mortality of a state species of concern. We therefore chose to treat only the bottom 1/3 of the LaPlatte River where we were confident that conditions would allow us to safely treat over stonecats and where fortunately, 2/3 of the river's larval lamprey population resided.

Given the population estimates, we can estimate that we treated about 62% of the larval lamprey that were originally proposed for treatment in Vermont in 2016. The two factors that prevented the treatment of 100% of the larvae were the policy change by the Vermont Department of Health and the presence of the Vermont state-listed stonecat in the LaPlatte River. Initiatives are underway to address both of these issues and keep them from limiting lamprey control operations in future treatments.

Table 6. Summary of 2016 lampricide applications in tributaries to Lake Champlain.

Stream or delta	Date treated	Discharge (CFS)	TFM (lbs. active ingredient)	Length treated
Putnam Creek	April 26	65	631	9.2 mi.
Beaver Brook	April 28	1.9	26	2.5 mi.
Stone Bridge Brook	November 2	3.9	45	3.6 mi.
LaPlatte River	November 14	5.0	86	3.5 mi.
		Totals:	**788**	**18.8 mi.**

Wounding Rates (Chipman, Smith) -

Sea lamprey wounding rates calculated for lake trout collected in fall 2016 increased to 41 wounds per 100 fish, from 27 wounds per 100 fish in 2015 (Figure 9). The wounding rate for Main Lake salmon collected in fall 2016 remained at the 2015 level of 18 wounds per 100 fish (Figure 10). Inland Sea-Malletts Bay salmon continued to show a higher wounding rate than Main Lake salmon, and like lake trout, was up from 2015 to 32 wounds per 100 fish (Figure 10). Both salmon and lake trout wounding rates in 2016 remained above program objectives. Salmon wounding rates in 2016 remained substantially lower than the average rates observed during the 1990's experimental sea lamprey control program, while the wounding rate on lake trout was still on par with rates achieved during the experimental program (Table 7).

The sea lamprey wounding rate for walleye (534 to 634 mm TL) collected in spring 2016 from the Missisquoi River was 0.4 wounds per 100 fish, which is below the Cooperative's lamprey wounding rate objective of 2 wounds per 100 walleye.

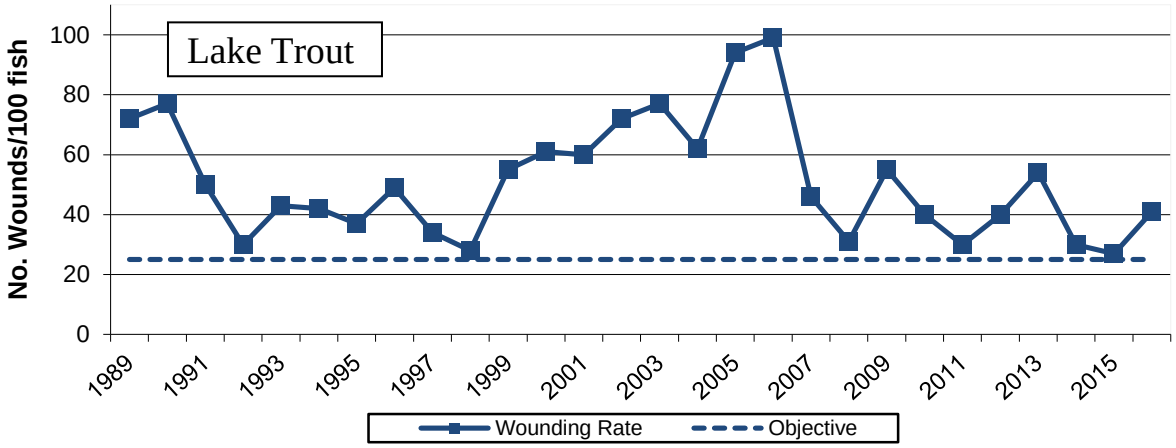


Figure 9. Type A1-A3 sea lamprey wounds (fresh and healing) per 100 lake trout (533-633 mm total length) from fall sampling in the Main Lake basin, 1989-2016. The target wounding rate of 25 wounds per 100 fish is also presented for reference (dashed line).

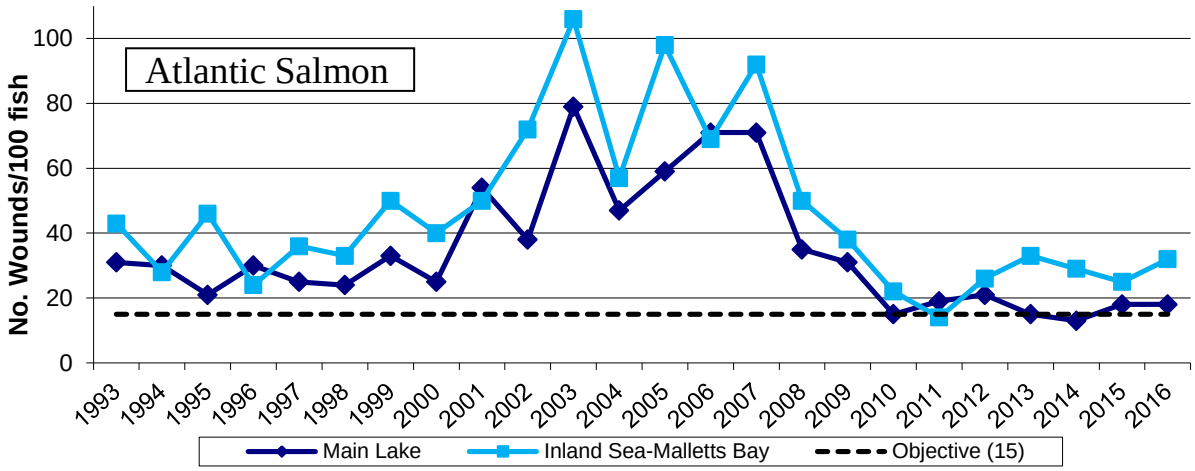


Figure 10. Type A1-A3 sea lamprey wounds (fresh and healing) per 100 salmon (432-533 mm total length) from fall sampling in the Main Lake and Inland Sea-Malletts Bay basins, 1993-2016. The target wounding rate of 15 wounds per 100 fish is also presented for reference (dashed line).

Table 7. Sea lamprey wounding rates on Lake Champlain lake trout and Atlantic salmon during 2016, 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	2016
Lake Trout[a] (Main Lake)	25	55	38	41
Atlantic Salmon[b] (lake-wide)	15	32	31	19
Atlantic Salmon[b] (Main Lake)	15	34	27	18
Atlantic Salmon[b] (Malletts Bay-Inland Sea)	15	32	39	32

[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.

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 give insight into relative abundance. In 2016, the sampling occurred between July 5th and July 14th. Yellow perch catch per overnight set (CPUE) in 2016 was similar to past years (Figure 11). Sampling will continue in 2017.

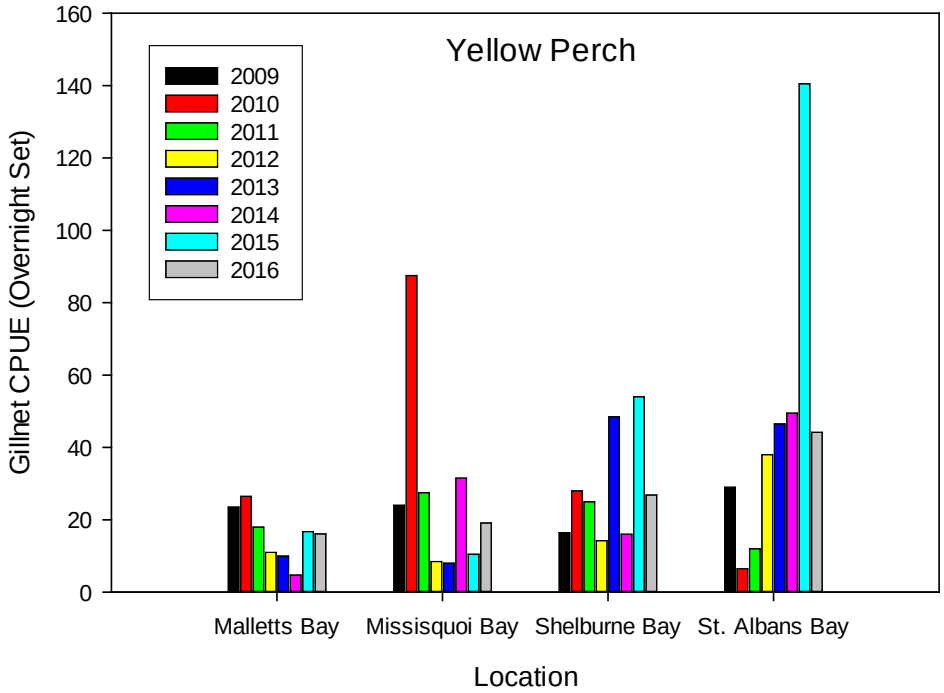


Figure 11. Yellow Perch CPUE for 2009-2016 at four Lake Champlain locations

Walleye (MacKenzie, Pientka) -

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

Four hundred and ninety-three walleye (358 males, 128 females) were collected from the Missisquoi River. Twenty-four pairs were spawned resulting in 3.74 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. Fifty age-3 males were collected for evaluation of the contribution of stocked fish to the spawning run in the Missisquoi River.

Sauger (Durfey, Ardren, Bouchard) -

A Lake Champlain sauger working group has been formed to: Establish expert opinion on status of sauger in the lake, identify restoration goals for the species, and discuss a potential conservation hatchery program at White River NFH.

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 2016, Vermont issued 130 permits for bass tournaments on Lake Champlain, up from 105 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 12). Both major U.S. professional bass fishing tournament series, Bassmaster and Forrest L. Wood (FLW) Outdoors, hold regular events on the lake.

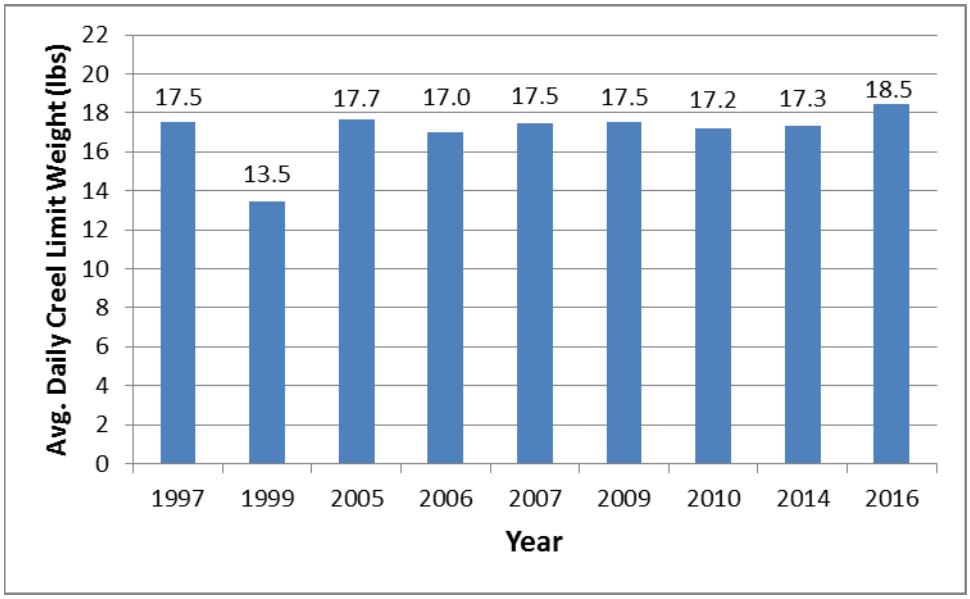


Figure 12. Average daily creel limit weights for the Top 10 anglers from 9 professional-level B.A.S.S. tournaments held on Lake Champlain since 1997.

Springtime bass sampling was conducted at 20 sites on southern Lake Champlain to target smallmouth bass when they are located nearshore and more vulnerable to electrofishing. Surveys captured 310 largemouth bass and 282 smallmouth bass in 8.7 hours of electrofishing in 2016. Largemouth bass ranged in size from 4.9 to 23.3 inches total length and smallmouth bass ranged in size from 3.4 to 20.5 inches total length.

Summertime electrofishing surveys at the same 20 standardized sampling stations captured 613 largemouth bass and 243 smallmouth bass in 7.8 hours of electrofishing in 2016. Largemouth bass ranged in size from 1.7 to 21.0 inches total length and smallmouth bass ranged in size from 4.4 to 19.5 inches total length.

Electrofishing surveys were also conducted on northern Lake Champlain in the spring of 2016. This was the second year of sampling, with the primary purpose of repeating transects sampled in 2015. Transects were evaluated as potential future standardized bass sampling sites. Two areas were selected and a total of 14 transects was sampled. A total of 5.46 hours of electrofishing was completed and 250 black bass were collected.

ESOCIDS

Muskellunge (Good, Pientka) -

NYDEC has been providing muskellunge to VTDFW since 2008 to aid reestablishing the fishery for this species in Lake Champlain. In 2016, VTDFW stocked 6,300 muskellunge into the lower Missisquoi River and Missisquoi Bay, including Campbell's Bay (Table 8). As in the previous three years, approximately 2,000 of the muskellunge were also stocked above the Swanton Dam. The location above Swanton Dam has been stocked recently because 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.

Table 8. Muskellunge stocking numbers for Lake Champlain, 2008-2016.

Date	Strain	Source	Number Stocked	Length (Inches)	Wt. (Lbs.)	Life Stage	Stocking Location
2008	Chautauqua	NYSDEC	250	6.10	4.35	Summer Fingerling	Missisquoi River & Bay
2009	Chautauqua	NYSDEC	10,000	5.04	174	Summer Fingerling	Missisquoi River & Bay
2011	Chautauqua	NYSDEC	5,150	5.00	95.5	Summer Fingerling	Missisquoi River & Bay
2012	Chautauqua	NYSDEC	8,800	5.40	185	Summer Fingerling	Missisquoi River & Bay
2013	Chautauqua	NYSDEC	7,580	5.32	155	Summer Fingerling	Lower Missisquoi R & Bay, Upper Missisquoi R. (Swanton to Highgate)
2014	Chautauqua	NYSDEC	7,000	5.24	137	Summer Fingerling	Lower Missisquoi R & Bay, Upper Missisquoi R. (Swanton to Highgate)
2015	Chautauqua	NYSDEC	5,540	4.83	85	Summer Fingerling	Lower Missisquoi R & Bay, Upper Missisquoi R.
2015	Chautauqua	NYSDEC	6,300	5.31	128	Summer Fingerling	Lower Missisquoi R & Bay, Upper Missisquoi R.

Sampling for fall young-of-year muskellunge was conducted on November 11, 2016 on the upper Missisquoi River between Swanton and Highgate dams. 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 targeting potential habitat, versus the vast areas of habitat in the lower river and bay. A total of fifteen muskellunge were captured, all from the August 2016 stocking and ranged in size from 200 mm to 251 mm (7.9" – 9.9"). No older, larger muskellunge from earlier stockings were observed, possibly because the sampling date was several weeks later than in previous years, water temperatures were much colder, and vegetative habitat was in an advanced state of decay.

Lake Sturgeon (MacKenzie) –

Sampling for lake sturgeon returning to spawn in the Lamoille and Winooski rivers in Spring 2016 resulted in the capture of 14 sturgeon in the Winooski River and one each in the Lamoille River and Otter Creek. Two of the sturgeon captured in the Winooski were recaptures from 2015. Total lengths ranged from 46.5 inches to 63.6 inches. Sea lamprey wounding rates were significantly lower than those observed from 1998 to 2002.

Acoustic tags were surgically implanted in 9 sturgeon captured in the Winooski River and in each of the sturgeon captured in Otter Creek and the Lamoille River. Sturgeon movements were monitored in Lake Champlain with a portable acoustic receiver and stationary receivers set in spawning tributaries and the Winooski Delta. All 19 sturgeon tagged with acoustic tags from the Winooski River were located near or on the Winooski River delta on multiple occasions. The sturgeon tagged in Otter Creek spent the summer in Town Farm Bay but was not located in the fall. The sturgeon tagged in the Lamoille River appears to be overwintering in Malletts Bay.

Lake sturgeon tagged in the Winooski River were distributed across the delta during the summer (Figure 13) but congregated in a smaller area for the winter (Figure 14). One fish left the delta in late June but returned in October. The sturgeon detections in Malletts Bay were for the only sturgeon tagged in the Lamoille River (Figures 13-14).

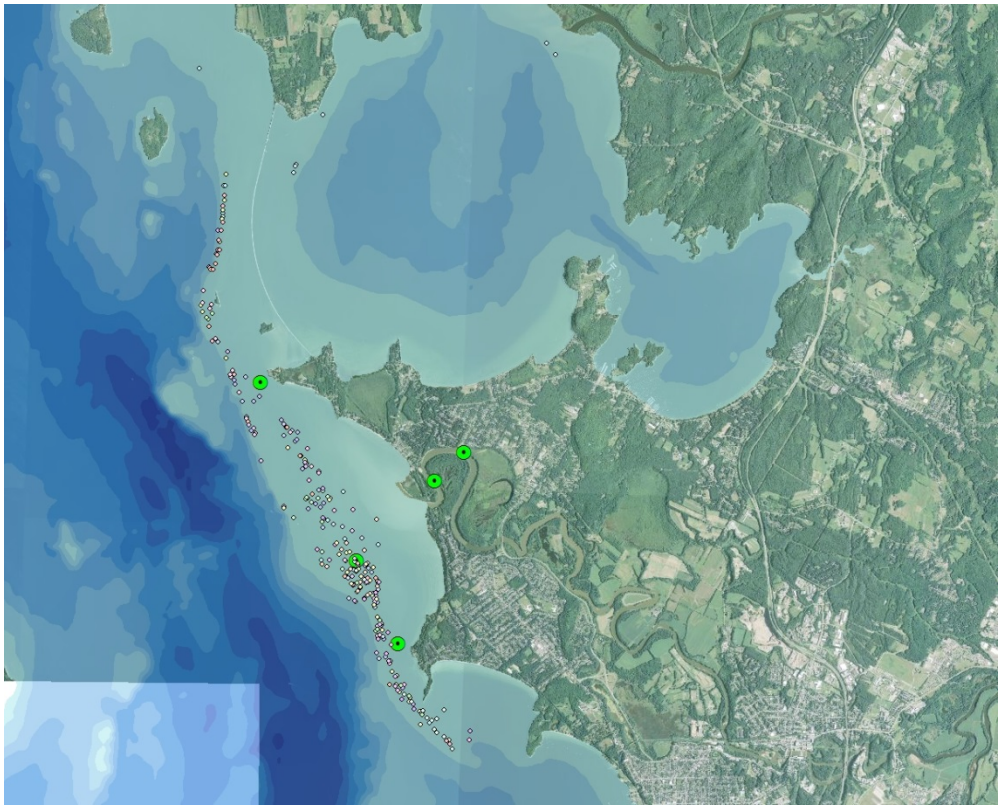


Figure 13. Lake sturgeon locations on the Winooski Delta as determined by acoustic tracking, 2016 (Green circles indicate stationary receiver locations)

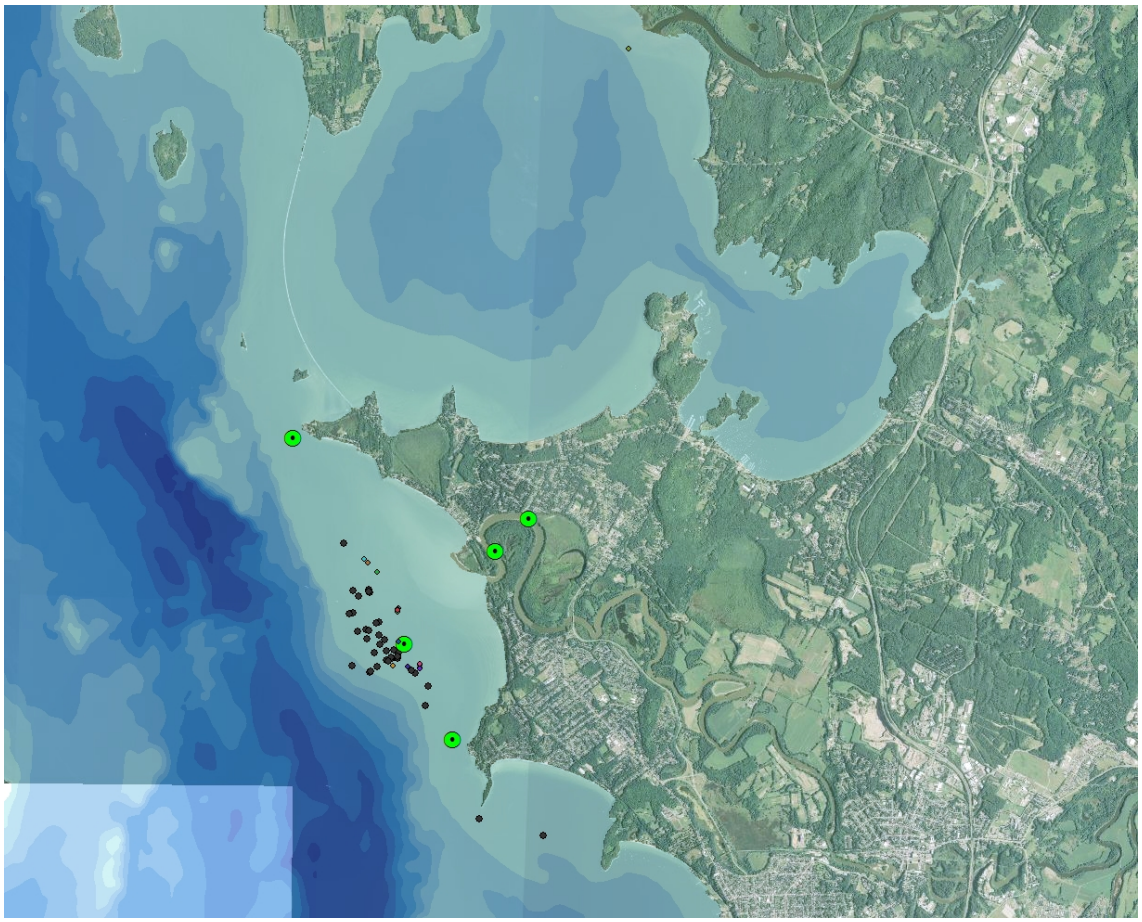


Figure 14. Lake sturgeon locations on the Winooski Delta as determined by acoustic tracking, November and December, 2015 and 2016 (Green circles indicate stationary receiver locations)

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 2016 and numbers of eels collected or observed were similar or greater relative to sampling efforts in 2014 (Table 9). Eels collected ranged in size from 336 mm to 742 mm. Mean length was 543 mm (SD = 84, n =158) and mean weight was 329 grams (SD = 176). Except for 2007, the average size of eel collected has increased each year and 2016 was no different. Mean total length of eels collected in 2016 was significantly larger than collected in 2014 (508 mm, SD = 81, n = 82).

Table 9. 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
2005	600,000	----	----	----	----	----
2006	1,000,000	----	----	----	----	----
2007	425,500	0	0	----	0	1
2008	746,000	----	----	----	----	----
2010	0	1	1	----	25	14
2012	0	1	2	----	57	21
2014	0	12	17	----	54	---
2016	0	18	31	41	58	10

RECREATIONAL FISHERY MONITORING

Angler Surveys (Pientka, Chipman, Ardren, Eisenhauer)-

Winter and open water angler creel surveys were conducted in selected areas of Lake Champlain to estimate fishing pressure, total catch and harvest of fish species, and other fishery characteristics. In addition, a fall salmon creel was conducted in the Boquet River.

During the winter of 2016 roving ice angler surveys were completed on portions of the Inland Sea and Mallets Bay (Figure 15). While the proposed start of the winter creel survey was January 1, warmer winter temperatures delayed the start date and resulted in an earlier end date. Start dates ranged from January 6th to February 14th for different areas sampled. End dates were more consistent between March 6 and 9th, 2016. A total of 990 angler interviews were completed and 2,584 fish were measured during the winter surveys. Yellow Perch was the most frequently targeted species by interviewed ice anglers. Northern pike were the second most targeted species.

Data analysis from the 2015 Main Lake open water angler survey was completed. A total of 1,182 parties (2,446 anglers) were interviewed. Salmonids were the most frequently targeted species (68% of interviewed parties), followed by bass (14%). Anglers expended an estimated 253,532 angler hours during the survey period, and catches of 19 fish species were recorded. The sport fish catch was dominated by smallmouth bass (estimated 51,825 caught and 4,195 harvested), lake trout (estimated 31,220 caught and 7,170 harvested), and landlocked salmon (estimated 29,217 caught and 10,668 harvested). Yellow perch was the dominant panfish species (estimated 145,279 caught and 81,260 harvested) seen during the survey.

An open water roving angler survey was completed on the Inland Sea April 9 (shortly after ice-out) to October 9, 2016 (Figure 15). A total of 1,055 parties (2,091 anglers) were interviewed. Bass were the most frequently targeted species (33% of interviewed parties), followed by salmonids (29%). Data processing for the 2016 angler surveys is underway and major findings will be presented in the 2017 annual report.

A fall salmon creel was completed on the Boquet River in the area from the Willsboro Cascade downstream to the boat launch. The creel started on September 21 and concluded on November 19 with a total of 33 days sampled. A total of 147 anglers were interviewed that had residence in CA, CT, GA, MA, NH, NY, PA, RI, VT and Canada. Data analysis is underway and major findings will be presented in the 2017 annual report.

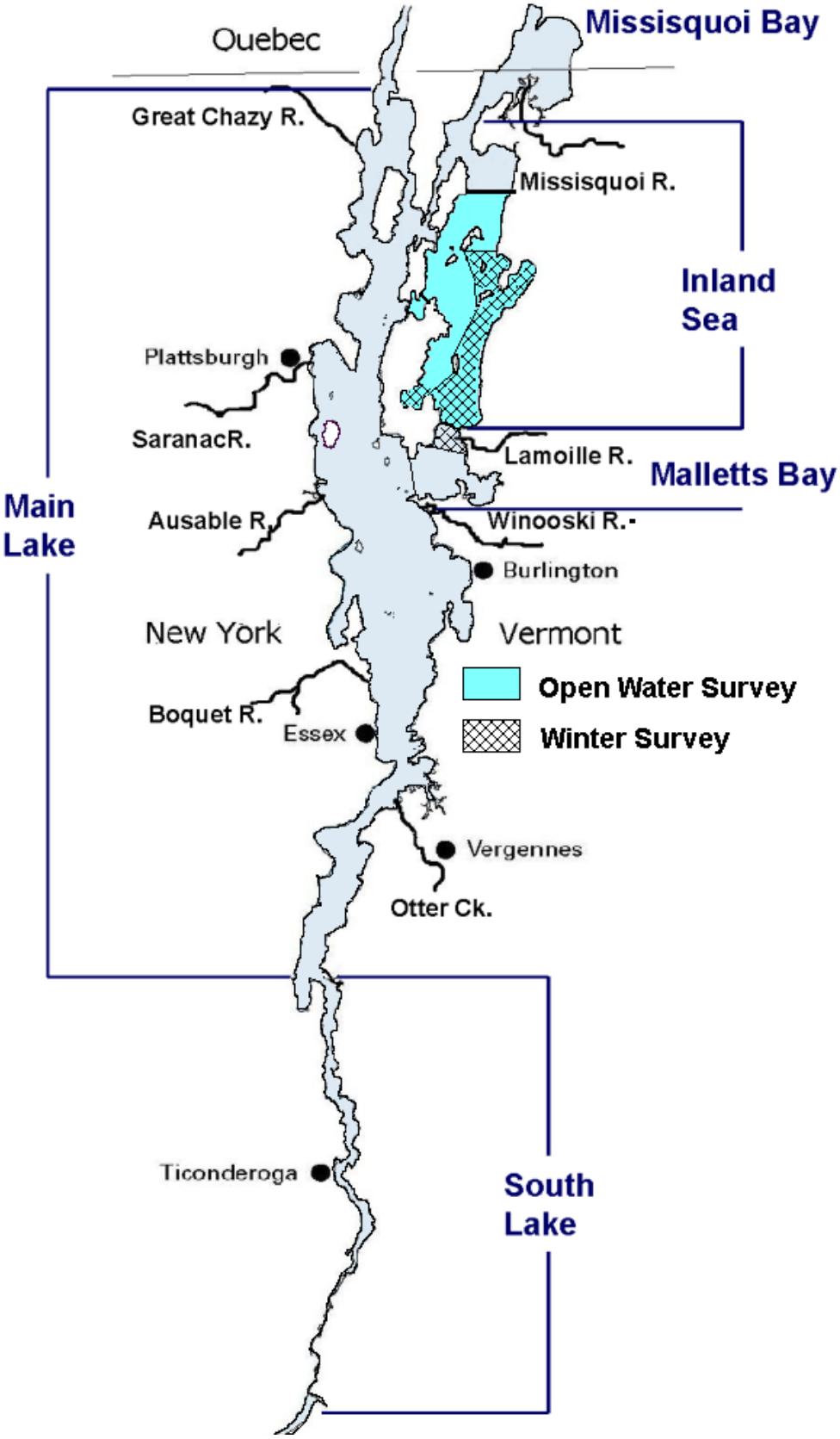


Figure 15. Lake Champlain angler survey areas in 2016.

RESEARCH

Lake trout recruitment (Ellen Marsden, Carrie Kozel, Bethany Alger, Steve Cluett, UVM)
In 2016, 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 1,215 lake trout less than 350 mm total length, of which 412 (33.9%) were unclipped. The highest catch per unit effort was found along the New York shore between the Boquet River and Whallon Bay, and in Burlington Bay. The highest percentage of unclipped fish was collected in Burlington Bay (50.5% of 656 lake trout collected). Juveniles were mostly distributed near the lower edge of the thermocline. Based on size distribution, the wild lake trout comprised three age classes (age-1, age-2, and age-3), and a fourth year class (young-of-year) appeared in the trawls in September. Stocked juveniles were the same size as wild lake trout one year older. Diet analysis of over 700 juveniles has been completed and will be used to evaluate diet overlap between hatchery and wild lake trout and assess whether changes in the forage base may in part explain the abundance of new recruits.

Evaluating Stocking Techniques for Atlantic salmon Fry (William Ardren USFWS and Eric Brunsdon, Dylan Fraser and James Grant, Concordia University)
Dispersal from nesting sites and habitat selection are essential for the fitness of young individuals and shape the distribution, growth and persistence of populations. These processes are important to consider when releasing young, hatchery-origin fishes into the wild to restore extirpated or depleted populations. By manipulating the density of released young-of-the-year (YOY) Atlantic salmon, we evaluated the effects of clumped- (releasing all the fish at one location) and dispersed-stocking (releasing the fish evenly over a complete reach) treatments on juvenile habitat use, dispersal, growth and survival. Across 14 river reaches, clump-stocked YOY density decreased and growth rate increased with distance downstream, whereas dispersed-stocked YOY densities and growth were relatively constant. Overall, density, spatial variance in density, growth and survival did not differ between these two stocking treatments, likely due to the greater-than-expected mobility of fish in clumped-stocking reaches: YOY dispersed up to 1600-m, with 41% moving over 200-m downstream. As predicted from previous work, growth rate of individual fish was density-dependent, following a negative power curve. Our results provide insights into how the growth and survival of released individuals are altered via stocking treatments, ultimately shaping their distribution and growth rate.

This research was conducted as part of Eric Brunsdon's MSc graduate thesis project at Concordia University, and has been recently published in Canadian Journal of Fisheries and Aquatic Sciences (2017). 10.1139/cjfas-2015-0488.

Novel, continuous monitoring of fine-scale movement using fixed-position radio telemetry arrays and random forest location fingerprinting (William Ardren USFWS, Theodore Castro-Santos, USGS, Dmitry Gorsky USGS, and Andrew Harbicht and Dylan Fraser, Concordia University)
Radio-tag signals from fixed-position antennas are most often used to indicate presence/absence of individuals, or to estimate individual activity levels from signal strength variation within an antenna's detection zone. The potential of such systems to provide more precise information on tag location and movement has not been explored in great detail in an ecological setting. By reversing the roles that transmitters and receivers play in localization methods common to the telecommunications industry,

we present a new telemetric tool for accurately estimating the location of tagged individuals from received signal strength values. The methods used to characterize the study area in terms of received signal strength are described, as is the random forest model used for localization. The resulting method is then validated using test data before being applied to true data collected from tagged individuals in the study site. Application of the localization method to test data withheld from the learning dataset indicated a low average error over the entire study area (< 1m) while application of the localization method to real data produced highly probable results consistent with field observations. This telemetric approach provided detailed movement data for tagged fish along a single axis (a migratory path) and is particularly useful for monitoring passage along migratory routes. The new methods applied in this study can also be expanded to include multiple axes (x, y, z) and multiple environments (aquatic and terrestrial) for remotely monitoring wildlife movement. For example, this technique is directly applicable to the study of fish passage and can provide fisheries biologists studying a wide range of species with a means of identifying: path choice by tagged fish, speeds at which tagged fish travel through areas of concern, the preferred resting areas for fish moving through high energy environments, and the number of attempts required by fish to overcome various types of barriers, among others.
This research was conducted as part of Andrew Harbicht's PhD thesis project at Concordia University, and has been recently published in Methods in Ecology and Evolution (2017) DOI: 10.1111/2041-210X.12745

The influence of vitamin B1 injections on upstream migratory ability of Atlantic salmon (William Ardren USFWS, Theodore Castro Santos USGS, and Andrew Harbicht and Dylan Fraser, Concordia University)
Thiamine deficiencies represent a major impediment to the successful restoration of Atlantic salmon to Lake Champlain. The purpose of this study is to evaluate the effects of a vitamin B1 injection into adult Atlantic salmon to determine if thiamine deficiencies impede the upstream migratory movement and rigor of salmon. Initial results suggest that, while our treatment of migrating salmon with a vitamin B1 supplement did not increase the numbers of fish that overcame the Willsboro rapids, it did reduce the time required by successful fish to climb the high-energy sections of the rapids. While this was not necessarily the outcome we had hoped for, it does show promise of vitamin B1 injections as a means of combatting dietary induced thiamine deficiencies. It is possible that in our experiment, where fish were treated immediately before encountering the rapids, thiamine absorption was incomplete at the time that many fish attempted to climb the rapids. This could explain the apparent increased energy levels observed by treated fish, but not the increased numbers of treated fish reaching the upper limit of the rapids. Administering a vitamin B1 injection to mature salmon earlier in the season may produce better results. However, follow-up experiments would be required to confirm this.
This research was conducted as part of Andrew Harbicht's PhD thesis project at Concordia University. We are currently analyzing the data produced by our treated and non-treated fish and anticipate a manuscript submission date planned for late-summer/early-fall of 2017.

Habitat preferences of juvenile Atlantic salmon (Salmo salar) from a landlocked population (William Ardren USFWS, and Eric Brunsdon, Ashlee Prevost, James Grant and Dylan Fraser, Concordia University)
Restoration and conservation efforts of salmonids have increased as their populations have declined throughout their native ranges. The success of these efforts is often constrained by a lack of suitable habitat, or a lack of knowledge on habitat requirements. Understanding the link between the habitat used by a species and the habitat available can increase restoration success, and has become a key focus of habitat selection studies. In this study, we stocked 14 reaches of the Boquet River, NY, with young-of-the-year (YOY) Atlantic salmon (Salmo salar) where the species was extirpated, to examine

habitat use and preference during two life stages of early growth. YOY habitat preference differed both spatially between stocking reaches, and temporally between life stages. In early summer, YOY showed more discrete preferences for habitat variables, whereas later in summer, they tended to use a much larger range. Habitat used by YOY was also dependent on what was available and it differed between stocking reaches. Our study is one of the first to investigate the habitat use of a landlocked population at multiple life stages and has important implications for restoration programs.
This research was conducted as part of Ashlee Prevost's BSc thesis project at Concordia University. Final modifications to the paper are currently taking place before being submitted to North American Journal of Fisheries Management (2017).

Phenotypic and life history correlates of reproductive success in recolonizing adult Atlantic salmon to Lake Champlain tributaries, and their spawning habitat preferences (William Ardren and Nick Staats USFWS, Ashlee Prevost, Nicole Hill, James Grant and Dylan Fraser, Concordia University)
The main goal of this study is to achieve a greater understanding of reproductive success (RS) and to promote recolonization of the Atlantic salmon population in the Boquet and Winooski Rivers. We will specifically estimate the number of adults returning to spawning grounds in each river, process adults to obtain a measure of their specific phenotypic traits, genetically tag each adult, translocate adults into a historic spawning site to promote RS, determine the locations of spawning redds of recolonizing salmon, quantify individual RS of recolonizing salmon by sampling early juveniles produced from recolonizing salmon redds, and determine the phenotypic correlates of RS. To achieve these tasks, we sampled the lower reaches of the Boquet River (below the previous Willsboro dam) twice a week from September 21st to November 11th, 2016; the fish lift on the Winooski one dam was sampled by Nick Staats and his team from September 15th to November 11th. Boquet River: 81 adult salmon were captured, floy tagged and transported into the North Branch of the Boquet River near Reber. A total of 90 redds were identified in the North Branch and three untagged fish were spotted near the Reber release site. These fish either got over the dam without assistance or could have shed their tag. Winooski River: 89 fish were caught and processed and transported upstream above Essex 19 dam. A total of 74 redds were established among six different locations within the Winooski River system. All stream reaches with salmon reeds will be sampled for juveniles in spring/summer 2017.

Rearing and juvenile habitat of recolonizing Atlantic salmon (William Ardren USFWS, and Nicole Hill, Ashlee Prevost, James Grant and Dylan Fraser, Concordia University)
In the summer of 2016, we observed 77 young-of-year across four sites in the Winooski River basin. However, one of the two observations at the Upper Huntington site and three of the twelve observations at the Mill Brook site are questionable and may have been juvenile brown trout. The Winooski Bridge Street site was sampled multiple times throughout the season as it produced the highest number of individuals. Data from this site can be used to analyze general changes in habitat use throughout the summer as individuals increase in age and size. Water depth, water velocity at mid column and dominant substrate size were recorded at the microhabitat scale for each individual observed. Over 1000 transect points were taken across the four sites using the same habitat variables. These will be used to analyze habitat availability within each site.

To test the effects of thiamine deficiency and siltation on egg-to-fry survival in a natural environment, fertilized eggs from 16 different families were planted in Whitlock-Vibert boxes at two sites in the Winooski River system. The first site was on the Winooski main stem near Bridge Street in Richmond (Winooski Bridge Street) and the second site was on the Huntington River below the Huntington Gorge (Upper Huntington). Both corresponded to sites used for young-of-year habitat sampling.

Gametes were collected from adult Atlantic salmon from Lake Champlain. In total 32 Whitlock-Vibert boxes were planted at each site, two boxes per family, one containing eggs treated with thiamine and one untreated. There were roughly 100 eggs per box, though this varied based on the egg give for each female. The two corresponding boxes for each family were planted together in a single artificial redd. Scour chains were placed within a meter downstream of each redd in order to record scour experienced at the site. Temperature loggers were deployed near each site to monitor degree days throughout winter and early spring.

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

U.S. Fish and Wildlife Service:

B. Young, B.J. Allaire, M. Lyttle, W. Ardren (FTC Chair),
Lincoln St., Essex Junction, VT
N. Staats – Liaison to VTDFW – West St., Essex Junction, VT
S. Smith – Liaison to NYSDEC – Lincoln St., Essex Junction, VT
H. Bouchard – North Chittenden, VT

Vermont Department of Fish and Wildlife:

B. Chipman, B. Pientka - Essex Junction, VT
C. MacKenzie, S. Good – Rutland, VT
K. Kelsey – Grande Isle, VT

New York State Department of Environmental Conservation:

L. Durfey, Tom Shanahan – Ray Brook, NY
R. Fiorentino, J. Pinheiro – Warrensburg, NY

University of Vermont:

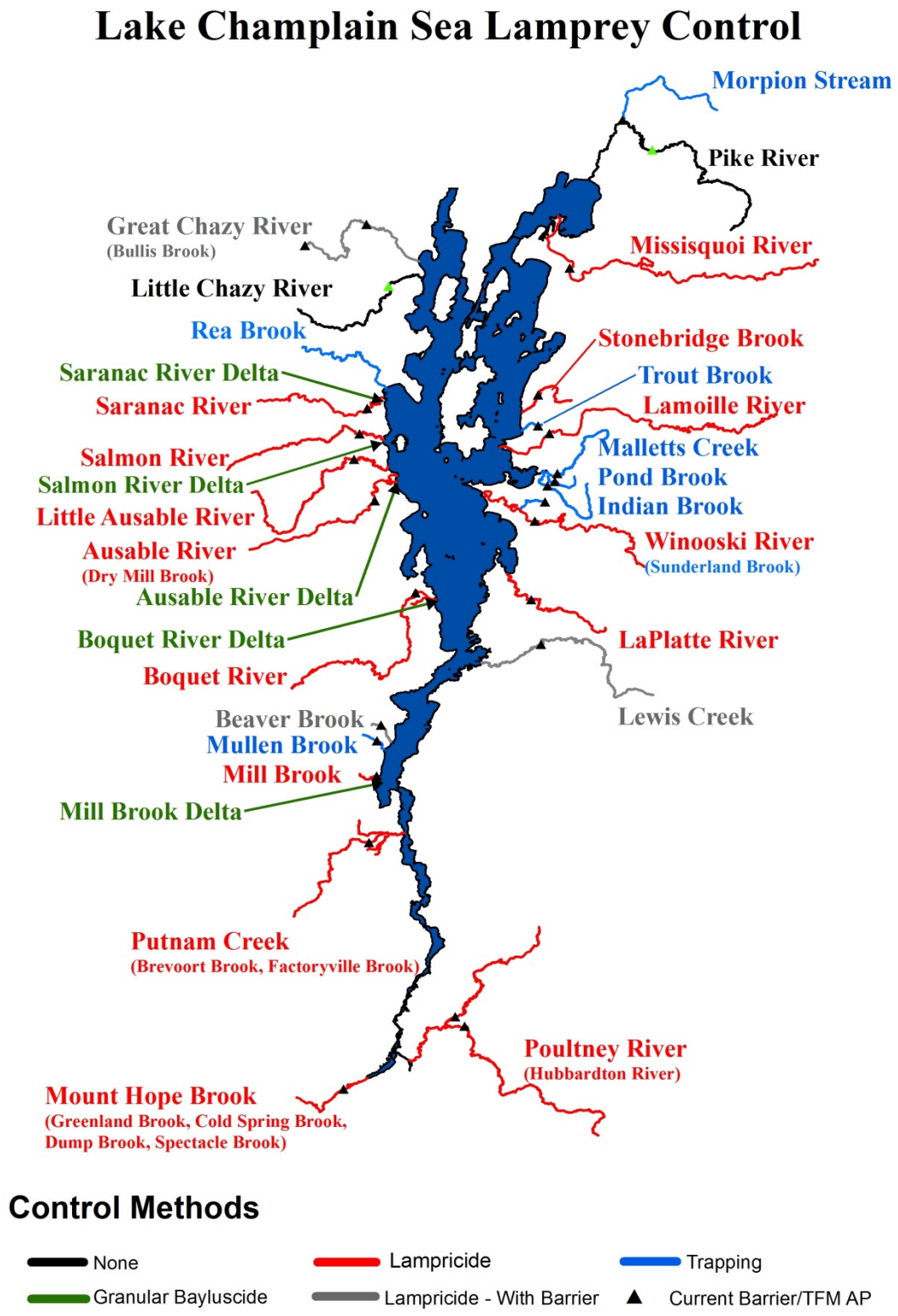
E. Marsden – Burlington, VT
A. Lochet – Burlington, VT

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 included in the sea lamprey control program and control methods planned for use on those tributaries.

Appendix 3: Schedule of completed Lake Champlain lampricide treatments 2002-2016 and projected treatments through 2021. The "T" denotes completed TFM only treatments, "B" denotes completed Granular Bayluscide, "C" denotes completed TFM + 1% Niclosamide and "P" denotes proposed treatments. Treatments did occur in some streams listed as part of the experimental control program conducted between 1990 and 2000. Note that in 2017, the geographic reorganization plan was completed by way of several off-schedule treatments. The result is 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
New York	WEST	Great Chazy River			T				T				T		T				P			
		Little Chazy River																	P			
		Rea Brook																	P			
		Saranac River												C					P			
		Saranac Delta			B				B				B		T				P			
		Salmon River	T				T				T				T				P			
		Salmon Delta													B				P			
		Little Ausable River	T				T				T				T				P			
		Ausables Delta Complex		B				B				B			B				P			
		Ausable River	T				T	T			T				T	T			P			
		Boquet River		T				T				C			C				P			
		Boquet Delta													B				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	