Vermont Fish and Wildlife Department
Annual Report

State: Vermont **Project No**.: F-35-R-18

Grant Title: Lake Champlain Fisheries Restoration and Management

Study No. IV **Study Title:** Salmonid Management

Period Covered: July 1, 2015 to June 30, 2016

Summary of Activity:

In fall 2015, Lake Champlain salmonids were sampled by boat electrofishing in the Lamoille River, Missisquoi River, Otter Creek, and nearshore areas of Whallon Bay and Willsboro Bay; a trapnet was also deployed in Hatchery Cove. Fish capture facilities on the Winooski River and Hatchery Brook were operated in fall 2015 to monitor landlocked Atlantic salmon runs, and again in spring 2016 to monitor steelhead rainbow trout runs. Exploratory sampling in spring 2016 was attempted in three smaller tributaries with steelhead runs using backpack electrofishing. The sampling activities yielded collections of 2,108 salmon, 1,110 lake trout, 70 steelhead, and 29 brown trout.

Landlocked Atlantic salmon fry are stocked annually in the Huntington River (tributary to the Winooski River) and fall fingerlings are stocked in the Winooski River. Electrofishing surveys were conducted in the Huntington River system and seven other Winooski River tributaries to assess these stocking efforts. Salmon parr were found only in the Huntington River mainstem. A rotary screw trap was fished in the Huntington River spring 2016 to capture out-migrating salmon smolts. The trap operated for 39 days and captured 15 smolts.

Two landlocked Atlantic salmon stocking evaluations initiated in 2012 were continued. The first evaluation compares the performance of two groups of smolts stocked in 2012-2014 in the Winooski River, which were reared under different water temperature regimes at the Eisenhower National Fish Hatchery; a third experimental group of salmon reared at Vermont's Ed Weed Fish Culture Station was also stocked in 2013 and 2014. Preliminary results suggest stronger returns from salmon reared in the ambient temperature stream water. The second evaluation compares the performance of Sebago strain salmon smolts produced from domestic broodstock and feral broodstock at the Ed Weed Fish Culture Station, and stocked in the Lamoille River, Missisquoi River, Inland Sea, and Hatchery Cove since 2012. Preliminary results show far greater numbers of feral origin salmon returning in spawning runs than those of domestic origin.

Another evaluation compares the performance of the Chambers Creek and Lake Memphremagog strains of steelhead rainbow trout stocked since 2012. Preliminary results show inconsistent rates of return of each strain over the period.

Details on the above activities are presented in the following reports.

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Lake Champlain Salmonid Assessments

Procedures

Lake Champlain salmonid populations are monitored annually to assess stocking, population structure, response to sea lamprey control (F-35-R, Study VIII), and to provide broodstock for hatchery production. Salmonid sampling in FY16 was conducted by electrofishing, trapnet, and permanent fish capture facilities

Electrofishing Surveys

River runs of landlocked Atlantic salmon *Salmo salar* were sampled by boat electrofishing with pulsed DC current (MBS-1DP-COF2-RLY unit, ETS Electrofishing, LLC, Verona WI) in October and November, 2015 in the Lamoille River, Missisquoi River and Otter Creek (Figure 1).

Nearshore concentrations of salmon, steelhead rainbow trout *Oncorhynchus mykiss*, and brown trout *Salmo trutta*, as well as lake trout *Salvelinus namaycush* spawning concentrations were sampled in November, 2015 by nighttime boat electrofishing in Whallon Bay and Willsboro Bay, New York (Figure 1). The nearshore sampling was conducted in cooperation with the New York State Department of Environmental Conservation and the U.S. Fish and Wildlife Service.

Exploratory electrofishing was attempted in March and April 2016, in the LaPlatte River, Lewis Creek and Mill River (Figure 1) to assess steelhead runs. Sampling was conducted using ABP-2 backpack electrofishing units (ETS Electrofishing, LLC, Verona WI) with pulsed DC current.

Trapnet Survey

A trapnet was set in Hatchery Cove (Figures 1 and 2) on November 3, 2015, fished for two consecutive nights, and was tended both mornings to collect spawning lake trout and other salmonids. The trapnet crib measured 6’ × 6’ × 11’4” and was made of 380-18 black knotted polypropylene twine. Mesh size measured 1 ¾-inch stretched. The trapnet had 2 attached 6’ ×

25’ wings set on a 45° angle to the lead line. The lead line was 6’ × 150’ long with 2 ½-inch stretched mesh made from twine of the same type and weight as the rest of the trapnet.

Salmonid Capture Facilities

Fish capture facilities were utilized to monitor salmonids returning to Hatchery Brook and the Winooski River, (Figure 1).

The Winooski One Hydroelectric Station trap and truck fish passage facility on the Winooski River was operated in Fall 2015 and Spring 2016. Details on salmonid monitoring at this facility and other salmonid investigations in the Winooski River watershed are presented in the following report *Winooski River Fish Lift and Salmon Investigations*.

A permanent concrete trap was constructed in 2014 at the Ed Weed Fish Culture Station outfall into Hatchery Brook. The construction was funded by State Wildlife Grant T-1-7, Job 5.05. Valves are installed at the outfall above the trap to allow diversion of the hatchery discharge either through the trap when it was open and operating, or directly into Hatchery Brook when the trap was closed. The trap was operated from September 15 through November 13, 2015 for the salmon run, and from March 15 through April 29, 2016 for the steelhead run. During the fall operation period, all salmonids captured in the trap were processed for biological data and selected mature salmon were held at the hatchery as broodstock. Captured salmon that were not taken to the hatchery, as well as other captured species, were trucked to a lakeshore release point at the Fish and Wildlife Department’s Vantines Access Area, about 2.5 miles north of the outlet of Hatchery Brook. During spring operation, the trap captured relatively low numbers of steelhead, which were processed and released back into Hatchery Brook.

Biological Data Collection

Salmonids collected by electrofishing and the capture facilities were measured for total length (TL) in mm and weight to the nearest 10 g, and sex/maturity, fin clips, and sea lamprey *Petromyzon marinus* attack data were recorded. Scale samples were taken from salmon, steelhead, and brown trout for age determination, and those collected in the Vermont tributaries were also tagged with serially numbered Floy anchor tags. Weights were limited to approximately 50 lake trout of each sex from Whallon Bay electrofishing sample, and some salmon collected in nearshore and tributary sampling were not weighed.

Salmonids captured in the trapnet at Hatchery Cove were processed in a similar manner, with the following exceptions. They were sedated prior to processing using Aqui-S®20E under INAD Study # 11-741-15-171F. A minimum of 100 male and 100 green female lake trout were weighed. Salmonids collected from the trapnet were not tagged, but a lower caudal punch was applied to all fish processed, and any additional fish which were counted but not processed received an upper caudal punch.

Sea lamprey attacks on salmonids were categorized using the standard classification system from Ebener, et al. (2006). Stage A1 (fresh wounds) and A2-A3 (healing wounds) were used in the wounding rate calculations. Sea lamprey control and salmonid restoration objectives include

wounding rate targets of 25 wounds per 100 lake trout in the 533-633 mm TL size class, and 15 wounds per 100 salmon in the 432-533 mm TL size class (USFWS et al. 2001). The wounding rate calculations include pooled data for both lake trout and salmon collected in all fall assessments.

Virtually all fish collected were released alive, aside from a portion of the broodstock salmon transferred to the Ed Weed Fish Culture Station, which were sacrificed for disease testing.

Salmonid scale samples each were cleaned with water and a soft toothbrush, mounted between glass slides, and read with a microfiche reader. Two readers independently read all scale samples and lake-year ages were assigned. If the two readers agreed, that age was assigned. If there was disagreement, a third reader would read the slide. If two of the three readers agreed, that age was assigned. An age was not assigned if all three readers had different ages.

Results

Salmonid sampling methods and sampling frequency at each area are summarized in Table 1. Tables 2 summarize numbers and average lengths of salmonids collected in each sampling area and season. Same-year recaptures of tagged salmonids at each sampling area and season are summarized in Table 3.

Landlocked Atlantic Salmon

Tributary electrofishing surveys in fall 2015 resulted in collections of 143 salmon in the Lamoille River, 54 salmon in Otter Creek, and 27 salmon in the Missisquoi River (Table 2). Annual salmon smolt stocking was initiated in the Missisquoi River in 2011, and 2015 was the second consecutive year that returning salmon were detected there.

A total of 1,494 salmon were collected in the Hatchery Brook trap (Table 2), which is more than double the number (n=721) collected in the trap's first year of operation in 2014. A total of 206 spawning adult Sebago strain salmon from Hatchery Brook (120 females and 86 males) were held as broodstock at the Ed Weed Fish Culture Station. Individuals of the Sebago strain are identified by fin clips. Ed Weed FCS staff spawned 66 pairs. All of the spawned males were sacrificed for disease testing, while ovarian fluid samples from the spawned females were taken for testing prior to being released back to Lake Champlain. Eight salmon died in captivity and the remaining salmon were released alive back into Lake Champlain.

The unprecedented numbers of salmon collected in Hatchery Brook in 2015 included a peak of 245 new fish and 68 recaptures in the trap on November 2 (Table 4). The crew spent 8.5 hours to fully process all of those fish. Due to the extra time spent and the very large sample size amassing, we decided to limit collection of weight data and scale samples to the first 50 new salmon from the trap on each subsequent sampling day, and just tag and record length and lamprey wound data on the rest of them. This change in procedure substantially decreased processing time for the rest of the sampling season. A comparison of a subsample of up to the first 50 salmon on each day of sampling versus the full season sample revealed little difference in length frequency (Figure 3). Further analysis shows a similar relationship when the daily

subsample is reduced to a maximum of 30 fish (Figure 4). Future salmon sampling at Hatchery Brook will utilize the 30 fish per day maximum for full processing, which will still provide adequate sample sizes for aging and weight/condition factor analyses. Additional salmon selected for hatchery broodstock may also be weighed and have scale samples collected.

Length frequencies of salmon samples from the three Main Lake tributaries (Hatchery Brook, Winooski River, and) differed somewhat, with fish from Otter Creek and the Winooski River tending to be larger than fish from Hatchery Brook (Figure 5). Lamoille River and Missisquoi River salmon were relatively similar in length frequency (Figure 6). Salmon collected from Hatchery Brook, the Winooski River, and the Lamoille River continue to be dominated by age 1-lake-year fish, and trends in the proportion of 1-lake-year fish from 2011 through 2015 were similar among the three tributaries (Figure 7).

Male and female age 1-lake-year salmon from the Lamoille River averaged 508 and 485 mm TL, respectively; males and females from Hatchery Brook tended to be larger at age-1-lake year, averaging 543 and 527 mm, respectively (Table 5). A summary of average length and Fulton's condition factor (K) for age 1-lake-year male salmon from Hatchery Brook and the Lamoille River is shown for the years 2011 through 2015 in Table 6. There is a trend of increasing condition through the first four years, with a slight decline in 2015. Winooski River salmon assessment results are discussed in more detail in the report that follows.

Nearshore electrofishing surveys resulted in collection of 126 salmon in Willsboro Bay and 66 salmon in Whallon Bay (Table 2). One of the salmon collected in Willsboro Bay on November 17, 2015 was recaptured after being tagged at Hatchery Brook and released on November 6, 2015. Length frequency distributions of salmon collected at the two nearshore sampling areas were similar (Figure 8).

Lake Trout

Nearshore electrofishing in Whallon Bay yielded 332 lake trout (Table 2); Lake trout were not targeted in Willsboro Bay. The average TL of Whallon Bay lake trout was 684 mm for males and 700 mm for females (Table 2); lengths ranged from 545 to 755 mm for males and 554 to 858 mm for females (Figure 9).

A total of 778 lake trout were captured in 2 nights of trapnet sampling in Hatchery Cove, with 443 collected the first day and 335 collected on the second day (Table 7). The average TL of males was 633 mm and females averaged 679 mm (Table 2); lengths ranged from 424 to 797 mm for males and 540 to 785 mm for females (Figure 10). Approximately 94 lake trout collected in the trapnet were provided after processing to University of Vermont researchers to collect gametes for an egg and fry thiamine analysis study; all of those fish were released alive.

Fulton condition factors for three length classes of Lake Champlain lake trout ranged from 0.85 to 0.93 for males and 0.95 to 0.98 for females (Table 8).

Fourteen of the 1,107 lake trout with fin clip data recorded (1.3 percent) were not marked with a fin clip. This proportion of unmarked lake trout is within normal hatchery fin clipping error rates.

Sea Lamprey Wounding Rates

The 2015 sea lamprey wounding rate on 533-633 mm TL lake trout decreased to 27 wounds per 100 fish, from 30 wounds per 100 fish in 2014 (Figure 11). Wounding rates on larger lake trout size classes also continued to decline in 2015, to overall lower levels than were observed at the end of the experimental sea lamprey control program 1998 (Figure 12). The 2015 lakewide salmon wounding rate rose slightly to 19 wounds per 100 fish for the 432-533 mm TL class, after meeting the management objective of 15 wounds per 100 fish in 2014 (Figure 11). The wounding rate increased to 18 wounds per 100 fish for Main Lake basin salmon, and declined to 25 wounds per 100 fish for pooled Inland Sea/Malletts Bay salmon (Figure 13).

Angler Tag Returns

Anglers reported recaptures of 34 tagged Lake Champlain salmonids from July 2015 through June 2016. Fish from each of the seven Lake Champlain tributaries where salmonids were originally tagged were represented in the angler tag returns. Eight recaptured salmon and two steelhead were tagged at the Winooski River fish lift; details on these fish are discussed in more detail in the report that follows. Details on the remaining 19 salmon, three steelhead, and two brown trout recaptured by anglers are summarized in Table 9.

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Acknowledgment: This project was conducted in partnership with staff from the US Fish and Wildlife Service working under the Lake Champlain Special Designation Act.

References

Ebener, M.P., E.L. King, Jr., and T.A. Edsall. 2006. Application of a dichotomous key to the classification of sea lamprey attack marks on Great Lakes fish. Great Lakes Fisheries Commission Misc. Publication 2006-02. Ann Arbor, MI. 21pp.

U. S. Fish and Wildlife Service, Vermont Department of Fish and Wildlife, and New York State Department of Environmental Conservation. 2001. A long-term program of sea lamprey control in Lake Champlain. Final Supplemental Environmental Impact Statement FES# 01-27. Lake Champlain Fish and Wildlife Management Cooperative. 356 pp. plus appendices.

Table 1. Cooperative Lake Champlain salmonid sampling areas and sampling frequencies in fall 2015 and spring 2016.

Sampling Area	Sampling Method	Sampling Period	Number Days Sampled
Hatchery Brook	Fish trap	September 15 - November 13, 2015	21
		March 15 - April 29, 2016	8
Hatchery Cove	Trapnet	November 3-5, 2015	2
Lamoille River	Boat Electrofishing	October 2 - November 12, 2015	11
LaPlatte River	Backpack Electrofishing	March 21, 2016	1
Lewis Creek	Backpack Electrofishing	April 6 - 18, 2016	2
Mill River	Backpack Electrofishing	March 16 - April 15, 2016	2
Missisquoi River	Boat Electrofishing	October 21 - November 10, 2015	3
Otter Creek	Boat Electrofishing	October 6 - November 10, 2015	5
Whallon Bay	Boat Electrofishing	November 9-24, 2015	3
Willsboro Bay	Boat Electrofishing	November 17-18, 2015	2
Winooski River	Fish Lift	September 15 - November 13, 2015[a]	60
		March 15 - April 25, 2016	41

[a] The Winooski River fish lift was also operated for four days between July 24 and August 28, 2015.

Table 2. Cooperative Lake Champlain salmonid sampling summary, fall 2015 and spring 2016. All areas were sampled in fall 2015, unless otherwise noted. Average total length (TL) is in mm.

Species	Sampling Area	Number Collected[a]	Males Ave. TL (n)	Females Ave. TL(n)	Juvenile or unknown Ave. TL(n)
Landlocked Atlantic Salmon					
	Hatchery Brook	1,494[b]	540 (814)	521 (673)	493 (2)
	Hatchery Cove	74[c]	535 (20)	530 (30)	-
	Lamoille River	143	507 (71)	486 (71)	465 (1)
	Missisquoi River	28[d]	479 (18)	516 (9)	360 (1)
	Otter Creek	54	566 (37)	551 (17)	-
	Whallon Bay	66[e]	485 (1)	581 (2)	525 (63)
	Willsboro Bay	126[f]	556 (4)	526 (2)	469 (120)
	Winooski River	124[g]	562 (64)	549 (58)	570 (2)
	Total	2,108			
Lake Trout					
	Hatchery Cove	778	619 (419)	670 (358)	750 (1)
	Whallon Bay	332	684 (127)	700 (197)	644 (8)
	Total	1,110			
Steelhead Rainbow Trout					
	Hatchery Brook	1	-	-	402 (1)
	Hatchery Brook (Spring 2016)	33	468 (26)	530 (6)	-
	LaPlatte River (Spring 2016)	2	479 (2)	-	-
	Lewis Creek (Spring 2016)	0	-	-	-
	Mill River (Spring 2016)	2	531 (2)	-	-
	Whallon Bay	1	-	-	432 (1)
	Winooski River	8	-	-	478 (8)
	Winooski River (Spring 2016)	23	496 (14)	598 (9)	-
	Total	70			
Brown Trout					
	Hatchery Brook	15	443 (7)	498 (8)	-
	Otter Creek	3	370 (1)	584 (2)	-
	Willsboro Bay	4	-	-	417 (4)
	Winooski River	3	433 \ (3)	-	-
	Total	29			

[a] Number of fish collected excludes same-year recaptures, except where noted below.

[b] Number of salmon collected in Hatchery Brook includes one previously tagged in the Lamoille River in fall 2015, one previously tagged in the Winooski River in summer 2015, and three previously tagged by USFWS in the Boquet River in fall 2015.

[c] Number of salmon collected in Hatchery Cove includes 24 previously tagged in Hatchery Brook in fall 2015, and one previously tagged by USFWS in the Boquet River in fall 2015.

[d] Number of salmon collected in the Missiquoi River includes one previously tagged in Hatchery Brook in fall 2015.

[e] Number of salmon collected in Whallon Bay includes one that was previously tagged by USFWS in the Boquet River in fall 2015.

[f] Number of salmon collected in Willsboro Bay includes one previously tagged in Hatchery Brook in fall 2015.

[g] Thirteen salmon collected in the Winooski River fish lift between July 24 and August 28, 2015 are not included in above tally.

Table 3. Tagged Lake Champlain salmonids recaptured in field sampling in 2015-16, by sampling area and season. Number of recaptures does not necessarily represent individual fish since many were recaptured more than once.

Species	Sampling Area	Season	Same Year Recaptures	Previous Year Recaptures
Landlocked Atlantic Salmon				
	Hatchery Brook	Fall 2015	707	2
	Lamoille River	Fall 2015	31	0
	Missisquoi River	Fall 2015	2	0
	Otter Creek	Fall 2015	4	0
	Winooski River	Fall 2015	6	1
Steelhead Rainbow Trout				
	Hatchery Brook	Fall 2015	0	0
	Hatchery Brook	Spring 2016	16	1
	LaPlatte River	Spring 2016	0	0
	Lewis Creek	Spring 2016	0	0
	Mill River	Spring 2016	0	0
	Winooski River	Fall 2015	0	0
	Winooski River	Spring 2016	0	5
Brown Trout				
	Hatchery Brook	Fall 2015	4	0
	Otter Creek	Fall 2015	0	0
	Winooski River	Fall 2015	0	0

Table 4. Daily numbers of salmonids collected (new fish and same-year recaptures) in the Hatchery Brook return trap, fall 2015.

	Landlocked Salmon		Brown Trout		Steelhead	
Date	New	Recaptures	New	Recaptures	New	Recaptures
September 18	10	-	0	-	0	-
September 22	4	1	0	-	0	0
September 25	2	0	0	-	0	0
October 1	2	1	0	-	0	0
October 5	1	0	0	-	0	0
October 7	11	1	1	0	1	0
October 9	22	2	0	0	0	0
October 12	9	1	2	0	0	0
October 16	56	16	2	0	0	0
October 19	20	3	0	0	0	0
October 21	25	9	1	0	0	0
October 23	79	27	4	1	0	0
October 26	126	36	1	1	0	0
October 28	101	30	1	0	0	0
October 30	150	56	0	2	0	0
November 2	245	68	1	0	0	0
November 4	162	58	0	0	0	0
November 6	170	91	0	0	0	0
November 9	119	86	1	0	0	0
November 11	87	111	1	0	0	0
November 13	93	110	0	0	0	0
TOTAL	**1494**	**707**	**15**	**4**	**1**	**0**

Table 5. Average total length (mm ± 1 standard deviation) at age (lake years) of male and female landlocked Atlantic salmon collected at Hatchery Brook, Lamoille River, and Otter Creek in 2015. Sample size in parentheses.

Area	Sex	Lake Age 0	Lake Age 1	Lake Age 2
Hatchery Brook	Male	461 ± 28.1 (24)	543 ± 45.4 (289)	620 ± 15.0 (8)
	Female	459 ± 25.6 (30)	527 ± 38.2 (233)	595 ± 31.7 (10)
Lamoille River	Male	382 ± 68.6 (2)	508 ± 47.6 (57)	559 ± 92.6 (2)
	Female	446 ± 45.1 (3)	485 ± 32.6 (54)	686 ± 75.0 (2)

Table 6. Average total lengths (mm ± 1 standard deviation) and Fulton's condition factor (K ± 1 standard deviation) of lake age 1 male landlocked Atlantic salmon collected at Hatchery Brook and the Lamoille River, 2011 – 2015. Sample size in parentheses

Area	Year	Average TL	K
Hatchery Brook	2015	543 ± 45 (289)	0.93 ± 0.09 (287)
	2014	540 ± 56 (181)	0.99 ± 0.10 (144)
	2013	535 ± 48 (143)	0.98 ± 0.10 (105)
	2012	559 ± 45 (148)	0.92 ± 0.11 (137)
	2011	513 ± 34 (168)	0.88 ± 0.14 (143)
Lamoille River	2015	508 ± 48 (57)	0.96 ± 0.08 (57)
	2014	517 ± 51 (56)	0.98 ± 0.10 (56)
	2013	519 ± 45 (54)	0.90 ± 0.11 (48)
	2012	528 ± 54 (17)	0.87 ± 0.09 (17)
	2011	508 ± 29 (32)	0.88 ± 0.14 (29)

Table 7. Total number of lake trout and other salmonids captured each day of trap netting in Hatchery Cove, November, 2015.

Date	Lake Trout	Landlocked Atlantic Salmon	Steelhead Rainbow Trout	Water Temperature (°F)
November 4	443	30	1	50
November 5	335	44	0	52
Total	778	74	1	

Table 8. Fulton's condition factor (K) ± one SD for three length classes of male and female lake trout collected in Lake Champlain in November, 2015. Ripe and spent females are excluded from the analysis.

Sex	Length Class (mm)	N	K
Male	533-633	65	0.90 ± 0.07
	634-735	54	0.93 ± 0.09
	>735	10	0.85 ± 0.08
	Combined	129	0.91 ± 0.08
Female	533-633	19	0.95 ± 0.09
	634-735	95	0.98 ± 0.10
	>735	36	0.96 ± 0.09
	Combined	150	0.97 ± 0.10

Table 9. Summary of tagged Lake Champlain salmonids recaptured and reported by anglers, July 1, 2015 through June 30, 2016.

Species	Date Caught	Location Caught	Kept or Released	Date Tagged	Location Tagged
Salmon	July 23, 2015	Sloop Island	Kept	November 12, 2014	Otter Creek
Salmon	August 16, 2015	Westport, NY	Kept	November 10, 2014	Lamoille River
Salmon	October 20, 2015	Hatchery Cove	Released	October 19, 2015	Hatchery Brook
Salmon	October 24, 2015	Lamoille River	Kept	October 20, 2015	Lamoille River
Salmon	November 8, 2015	Lamoille River	Released	October 30, 2015	Lamoille River
Salmon	November 10, 2015	Hatchery Cove	Kept	October 23, 2015	Hatchery Brook
Salmon	November 11, 2015	Otter Creek	Released	November 10, 2015	Otter Creek
Salmon	November 12, 2015	Otter Creek	Released	November 10, 2015	Otter Creek
Salmon	November 15, 2015	Otter Creek	Kept	October 22, 2015	Otter Creek
Brown Trout	November 22, 2015	Saranac River	Released	October 9, 2015	Hatchery Brook
Salmon	January 31, 2016	Keeler Bay	Kept	October 20, 2015	Lamoille River
Salmon	February 5, 2016	Whallon Bay	Kept	October 28, 2015	Hatchery Brook
Steelhead	March 22, 2016	LaPlatte River	Released	March 21, 2016	LaPlatte River
Salmon	April 2, 2016	Port Henry, NY	Kept	November 10, 2015	Otter Creek
Salmon	April 11, 2016	Keeler Bay	Released	November 10, 2015	Missisquoi River
Steelhead	April 29, 2016	Mill River	Released	March 16, 2016	Mill River
Steelhead	April 29, 2016	Mill River	Released	March 16, 2016	Mill River
Salmon	May 5, 2016	Champlain Bridge	Kept	October 19, 2015	Hatchery Brook
Salmon	May 21, 2016	Inner Malletts Bay	Kept	October 23, 2015	Lamoille River
Salmon	May 29, 2016	Inland Sea	Kept	October 21, 2015	Missisquoi River
Salmon	June 19, 2016	Westport, NY	Kept	October 28, 2015	Hatchery Brook
Salmon	June 22, 2016	Inland Sea	Kept	November 9, 2015	Lamoille River
Brown Trout	June 30, 2016	Treadwell Bay	Kept	October 16, 2015	Hatchery Brook
Salmon	June, 2016	St Albans Bay	Kept	November 9, 2015	Lamoille River

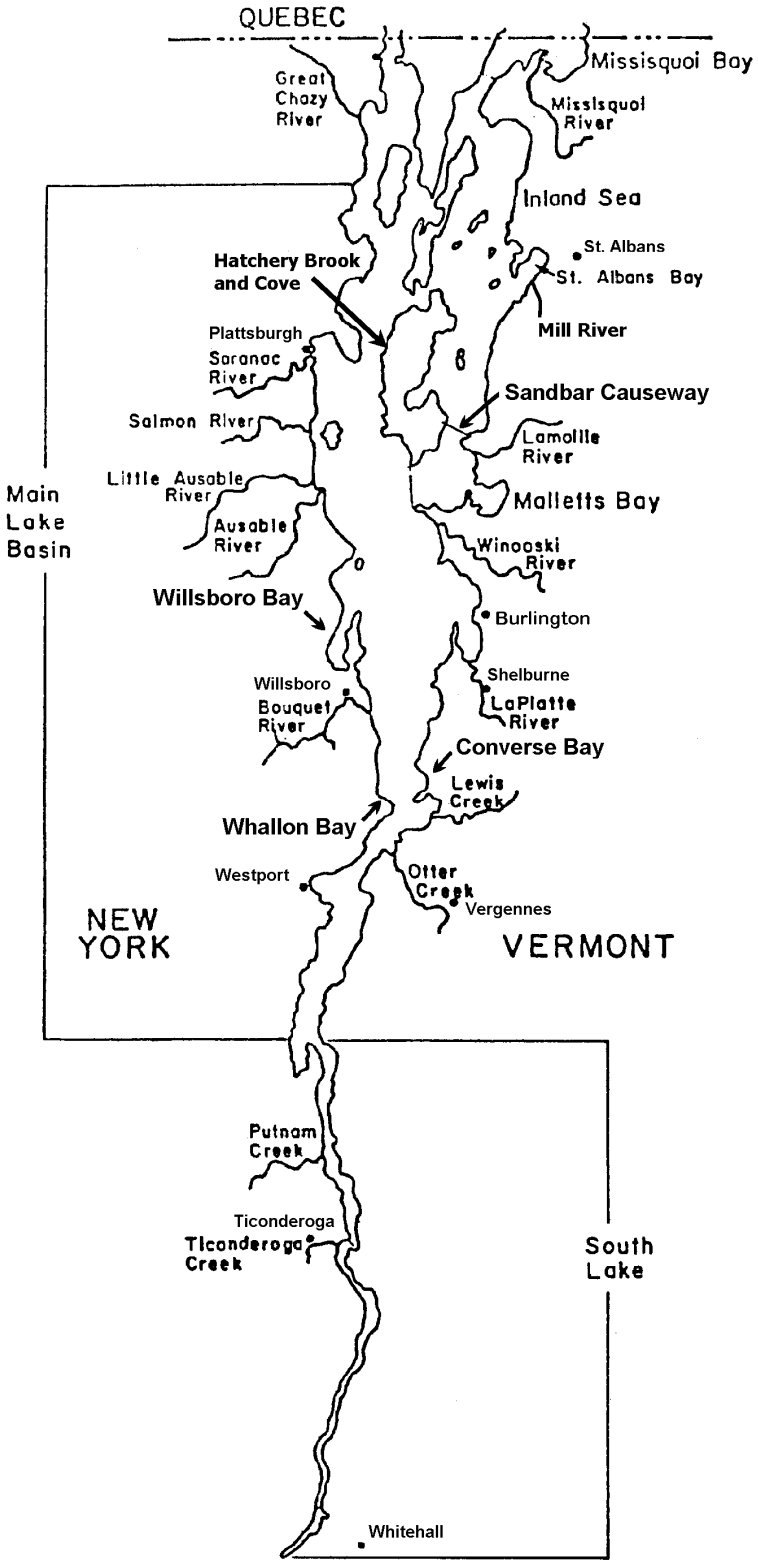

Figure 1. Lake Champlain, showing major lake basins, tributaries and salmonid sampling areas.

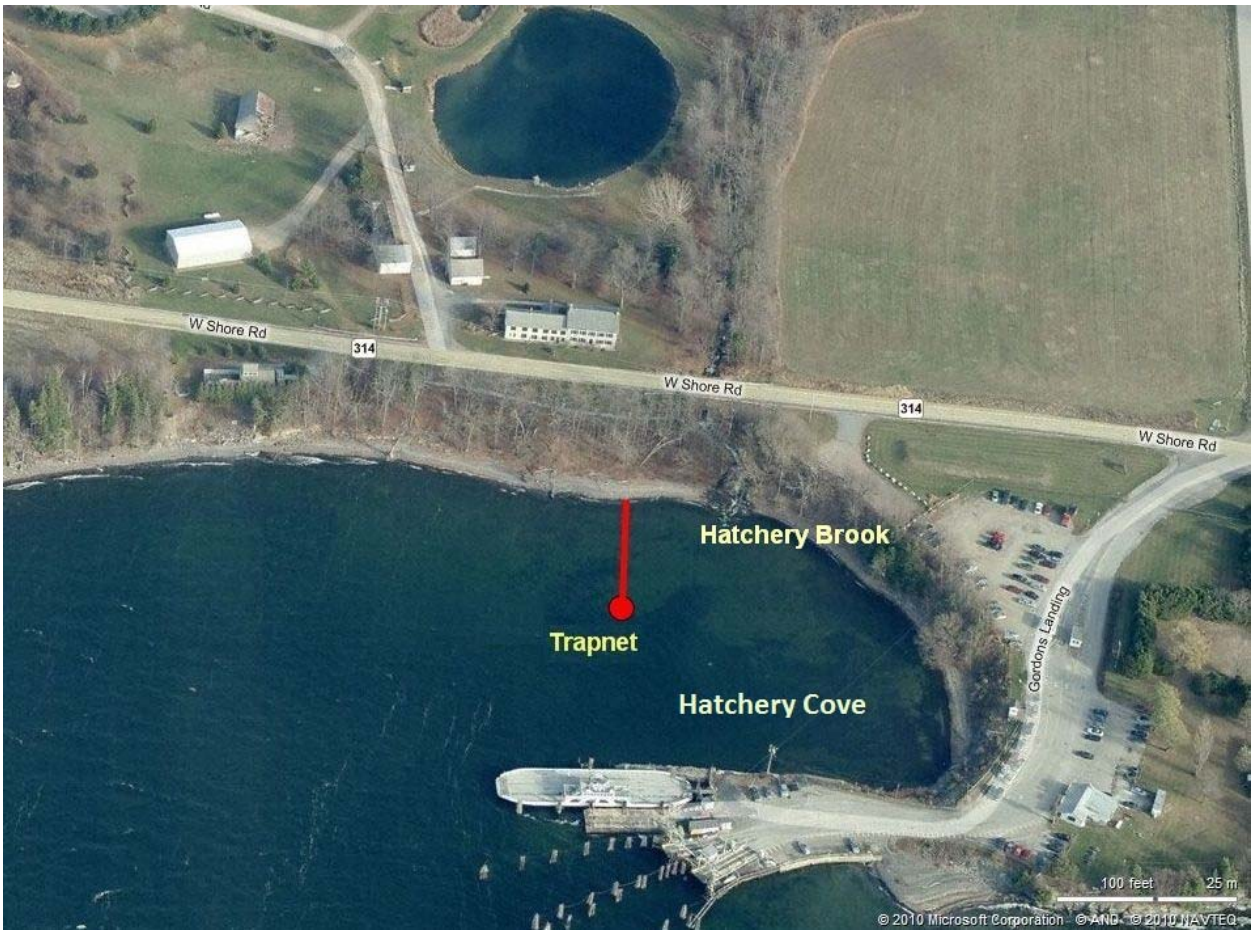

Figure 2. Hatchery Brook and Hatchery Cove, showing the location of the trapnet set in 2014.

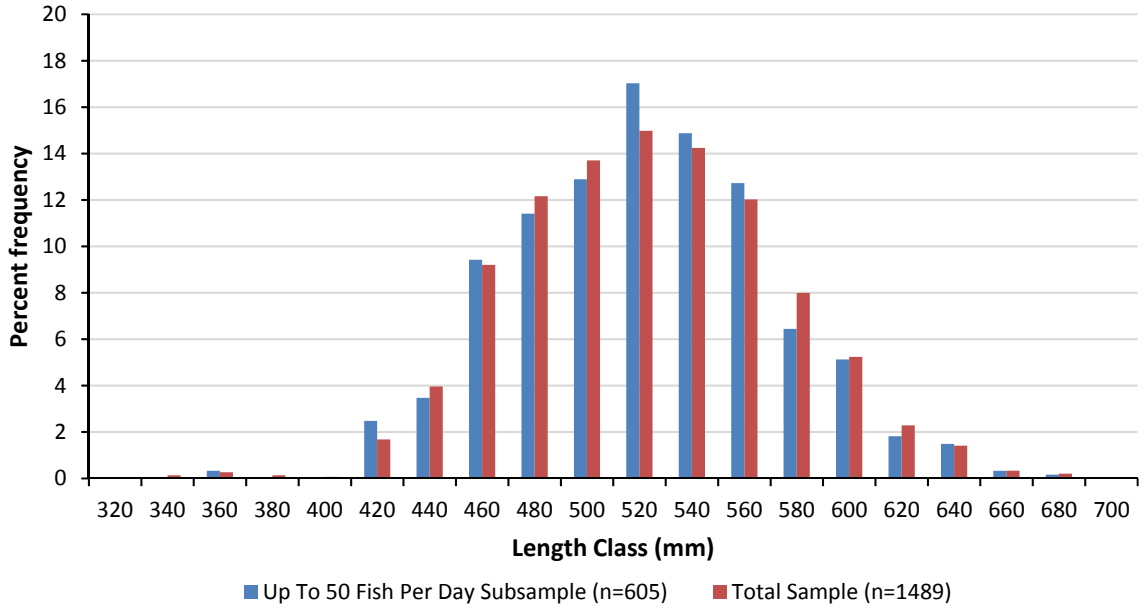

Figure 3. Length frequency distributions of landlocked Atlantic salmon collected from Hatchery Brook, fall 2015, comparing a subsample of up to the first 50 fish processed each day with the total sample.

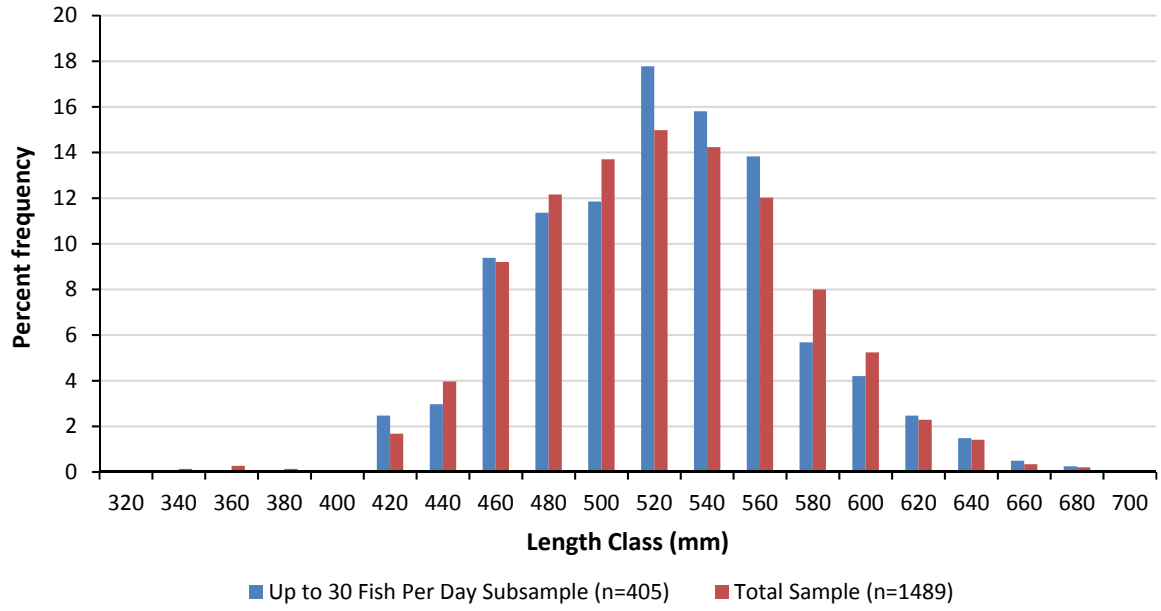

Figure 4. Length frequency distributions of landlocked Atlantic salmon collected from Hatchery Brook, fall 2015, comparing a subsample of up to the first 30 fish processed each day with the total sample.

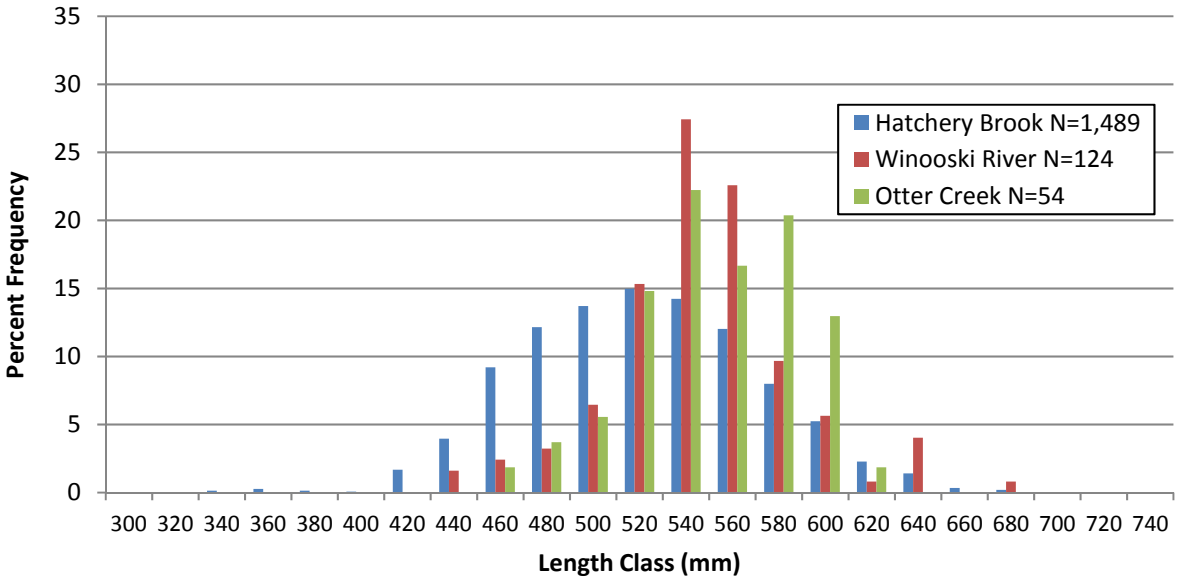

Figure 5. Length frequency distribution of landlocked Atlantic salmon collected in Hatchery Brook, Winooski River, and Otter Creek, fall 2015.

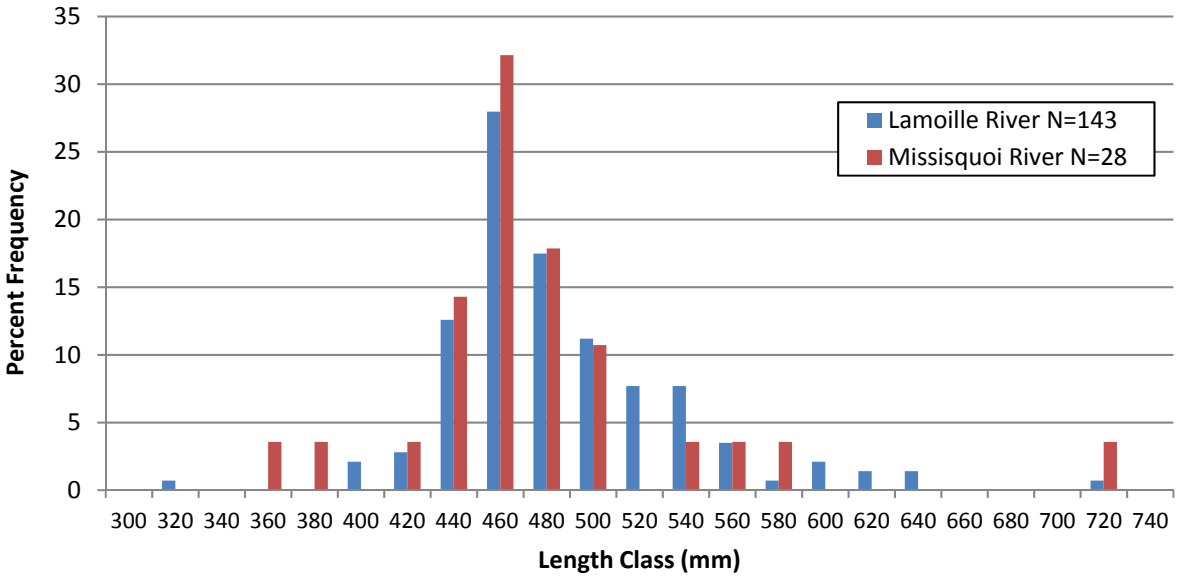

Figure 6. Length frequency distribution of landlocked Atlantic salmon collected in the Lamoille River and Missisquoi River, fall 2015.

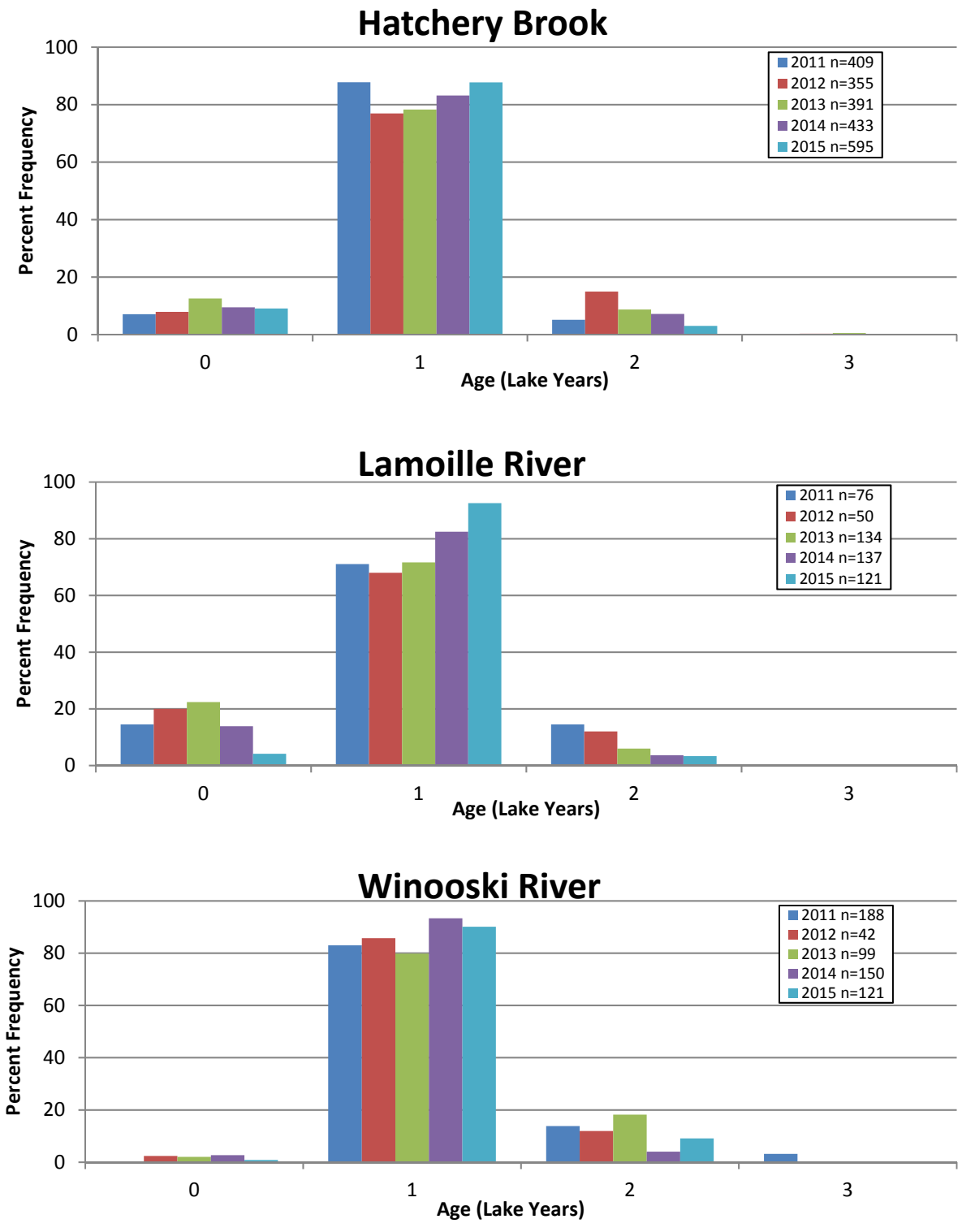

Figure 7. Age distributions (lake years) of landlocked Atlantic salmon from Hatchery Brook, Lamoille River and Winooski River, 2011-2015.

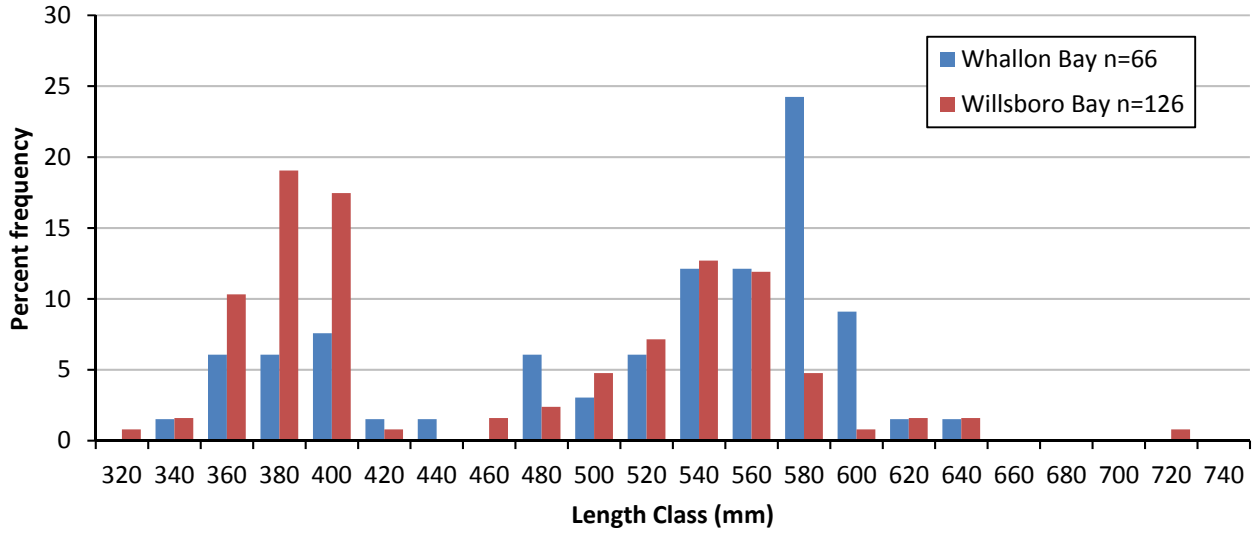

Figure 8. Length frequency distribution of landlocked Atlantic salmon collected by nearshore electrofishing in Whallon Bay and Willsboro Bay, November 2015.

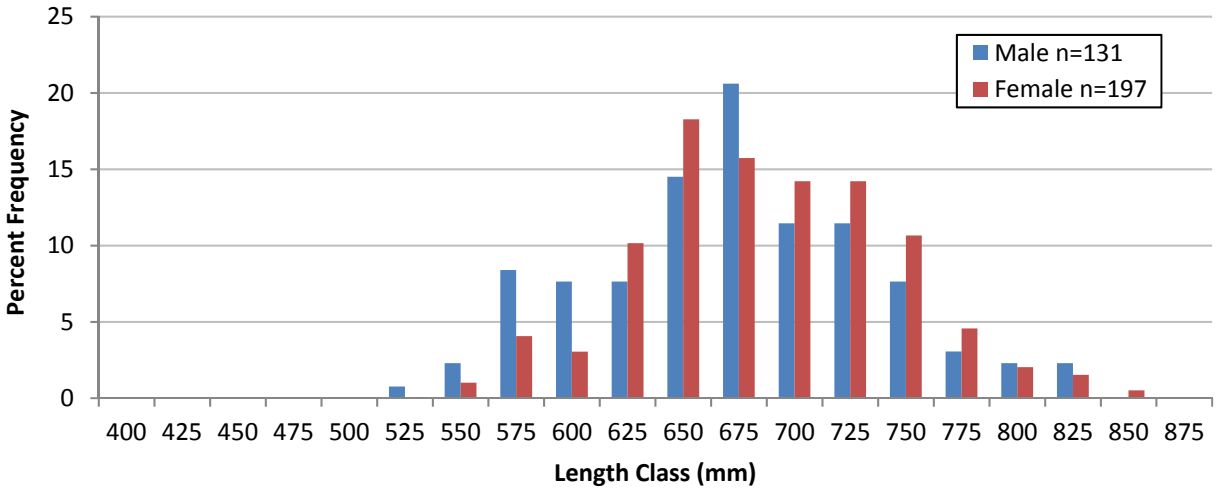

Figure 9. Length frequency distribution of male and female lake trout collected by electrofishing in Whallon Bay, November 2015.

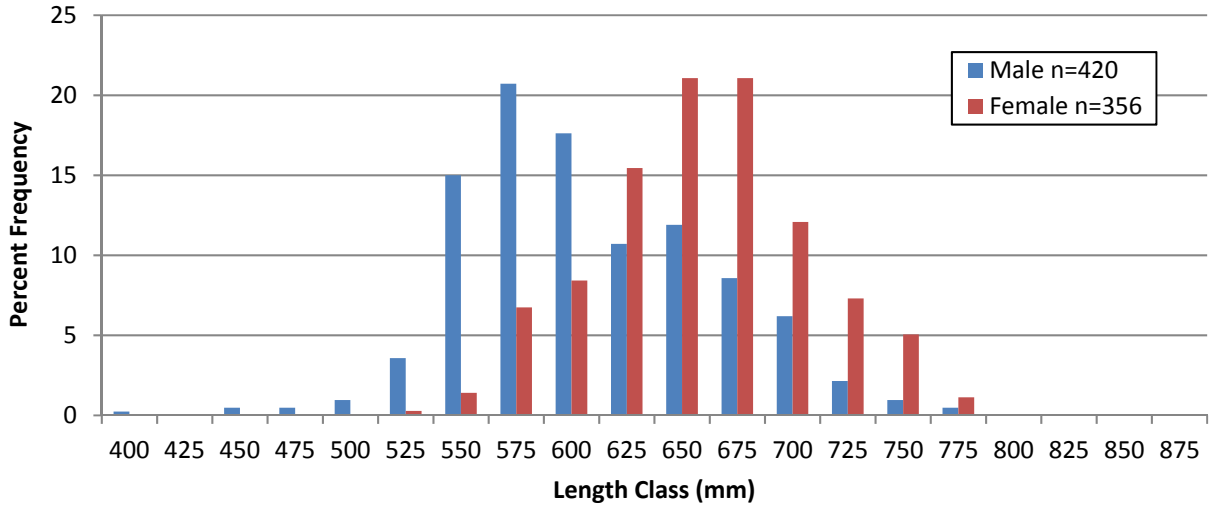

Figure 10. Length frequency distribution of male and female lake trout collected by trapnet in Hatchery Cove, combined, November 2015.

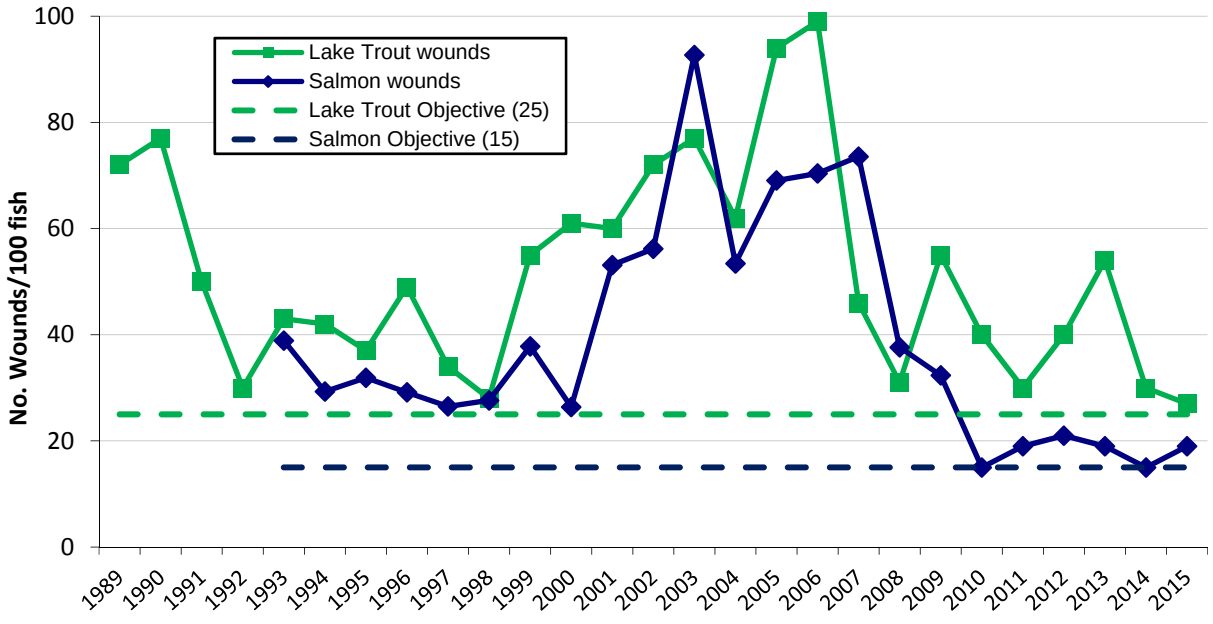

Figure 11. Sea lamprey wounding rates on 533-633 mm TL lake trout and 432-533 mm TL landlocked Atlantic salmon from Lake Champlain, 1989-2015.

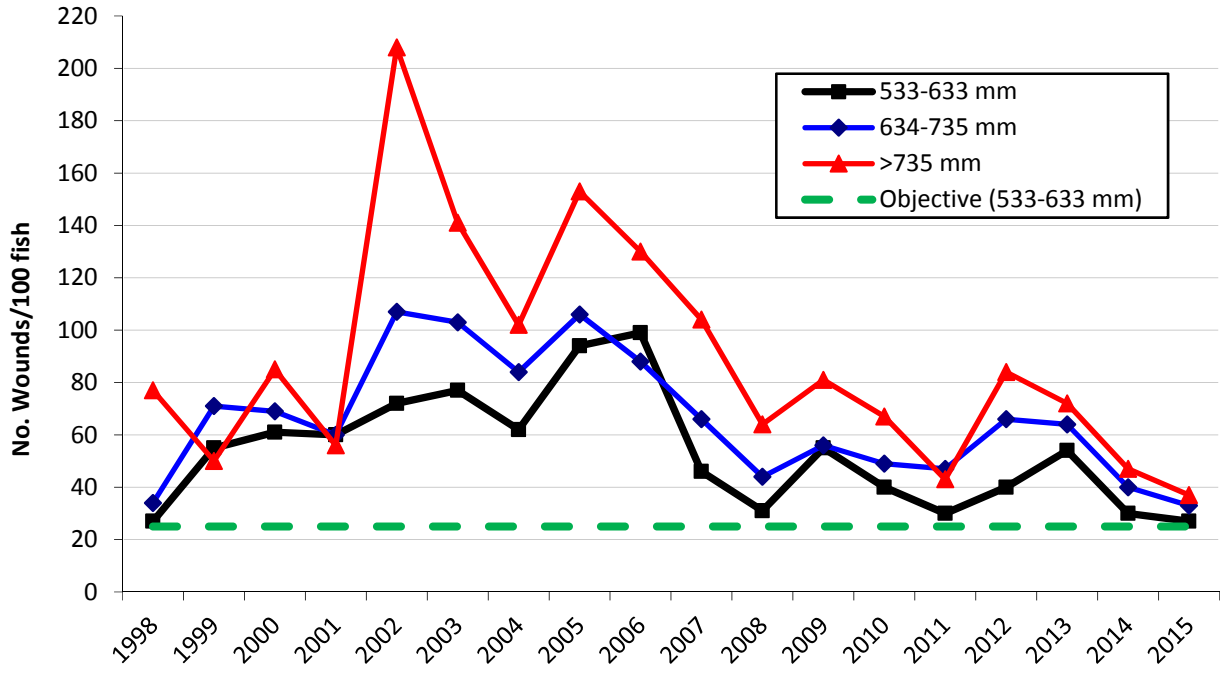

Figure 12. Sea lamprey wounding rates on three length classes (TL) of lake trout from Lake Champlain, 1998-2015.

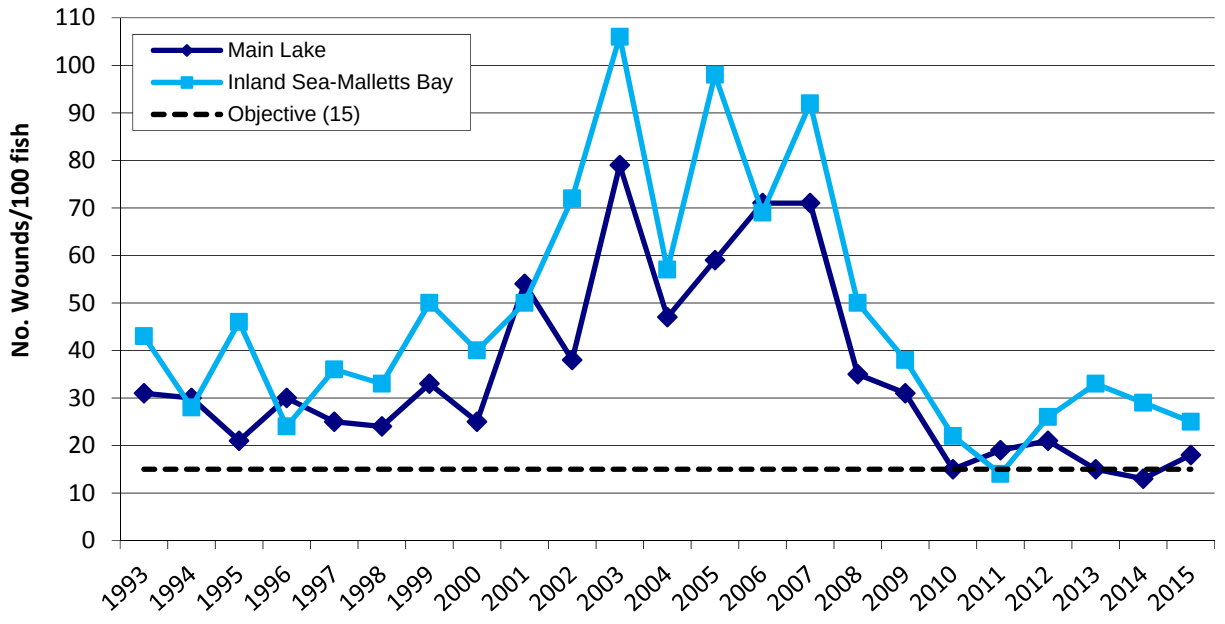

Figure 13. Sea lamprey wounding rates on 432-533 mm TL landlocked Atlantic salmon from the Main Lake and Inland Sea/Malletts Bay basins of Lake Champlain, 1993-2015.

Vermont Fish and Wildlife Department
Annual Report

State: Vermont **Project No**.: F-35-R-18

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Study No. IV **Study Title:** Salmonid Management

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Winooski River Fish Lift and Salmon Investigations

Introduction

On November 3, 1988 the City of Burlington Electric Department and the Winooski One Partnership was issued a Federal Energy Regulatory Commission (FERC) License to construct, operate, and maintain the Chase Mill Hydroelectric Project No. 2756. This hydroelectric facility is located on the Winooski River at the Winooski Falls in the City of Winooski, Vermont, approximately 16.5 kilometers (km) upstream of Lake Champlain (Figure 1). The project was completed in 1993 and consists of three large generating units with a capacity of producing 7.5 megawatts.

The installation and operation of a fish passage facility was a requirement of licensing. FERC license article 408 states "The licensee, after consultation with the Vermont Department of Fish and Wildlife (VTDFW) and the U.S. Fish and Wildlife Service (USFWS) shall develop plans for a trap and truck facility immediately downstream of the project dam to ensure upstream fish passage past the project dam". Winooski One is also required to operate in an "instantaneous run-of-river mode" (article 405) which provides protection of fish downstream of the dam.

The Winooski One project is the first upstream barrier on the Winooski River. Two more hydroelectric facilities owned by the Green Mountain Power Corporation, Gorge #18, 2.8 km upstream of Winooski One, and Essex #19, 13.2 km upstream, are additional barriers to fish migration. Favorable salmonid habitat is accessible upstream of Essex #19 dam for approximately 33.5 km to Green Mountain Power's Bolton Falls dam.

The Winooski One fish lift has allowed fisheries managers the opportunity to restore wild migratory salmonid populations and fisheries in the lower Winooski River that have been restricted by barriers built on the river. The lift has enabled migrating Lake Champlain landlocked Atlantic salmon *Salmo salar* and steelhead rainbow trout *Oncorhynchus mykiss*

access to critical spawning and nursery habitat above the Winooski One hydroelectric station. The goals of the project are:

1. To create a quality stream fishery for lake-run steelhead rainbow trout and landlocked Atlantic salmon in the Winooski River.

2. To encourage natural reproduction of Lake Champlain landlocked Atlantic salmon in the Winooski River watershed.

Fish Lift Monitoring

Objective: To move migratory landlocked Atlantic salmon and steelhead rainbow trout above the first dam on the Winooski River.

Procedures

The fish lift was scheduled to operate in the spring (March 15 – May 15) and in the fall (September 15 – November 15). Power company personnel activated the lift 1-3 times a day (0800 hr, 1300 hr, and 1600 hr). Lift frequency was determined based on the numbers of fish being lifted. Lifted fish were emptied into a sorting tank where targeted species were separated from the other catch. A daily log was kept of the number of lifts, time, species numbers, flows, water temperature, and general weather.

Targeted species were saved for processing by state or federal biologists while other catch was released back downstream. Biological data recorded from fish collected include length, weight, sex (when possible), scales for age analysis, fin erosion and sea lamprey attacks. Fish were tagged with a serially numbered floy-type tag (yellow for salmon, red for steelhead) under the dorsal fin to determine movements and contribution to the fishery, and the release site recorded.

In addition to the biological information collected at the lift, an hourly flow history was provided by United States Geological Survey as well as the power company for the fish lift period. Hourly temperature data at the lift was also recorded by the power company.

Findings

<u>Fall lift season</u>

The fish lift operated continuously from September 15 thru November 13, 2015 (Figure 2). A total of 124 adult salmon were recorded (Table 1). A total of 122 salmon were transported and released upstream above the Essex 19 dam (Figure 1). There were 64 male and 57 female salmon processed at the lift (sex was not identified for 2 salmon). One hundred and nine of the 121 salmon aged had spent one year in the lake (1-lake-year). Mean total lengths of male and female 1-lake-year salmon were 559 and 545 millimeters (mm), respectively (Table 2). Eleven

salmon were 2-lake-year fish with mean TL's of 589 mm for males and 604 mm for females. Table 3 summarizes mean length and Fulton's condition factor (K) for 1-lake-year male salmon, 2007-2015.

The lift was also checked prior to the regular lifting season to monitor earlier running salmon. Lifting occurred in July when 8 salmon were tagged on the 23rd and one on July 24. In August, two salmon tagged in July were again lifted on August 12th and two new salmon were trapped on August 28.

In addition to the salmon, 8 steelhead were lifted in the fall, 2015 (Table 1). There were three Chambers Creek strain (left ventral fin removed or LV clip), three Lake Memphremagog strain (right ventral or RV clip), and two no-clip steelhead processed. Two fish were 0-lake-year fish (i.e. stocked in the spring) with the rest being 1-lake-year. Mean total length of the Chambers Creek and Memphremagog steelhead were 482 mm and 400 mm, respectively (Table 4).

Spring lift season

The fish lift operated for 41 days from March 15 through April 25, 2016; there were no days during the period where high flows prevented operation of the lift. Twenty-three adult steelhead rainbow trout were trapped (Table 1); these included seven Chambers Creek strain, 14 Lake Memphremagog strain, one ADRV clipped fish, and one no-clip steelhead processed (Table 4). Aged fish were distributed nearly equally between 1 and 2-lake-year fish (Table 5).

Lamprey wounding rates

Sea lamprey attacks on salmonids were categorized using the standard classification system from Ebener, et al. (2006). Stage A1 (fresh wounds) and A2-A3 (healing wounds) were used in the wounding rate calculations. The goal of the Lake Champlain sea lamprey control program is to achieve or surpass the fish population, recreational fishery and economic benefits realized during the 1990-97 experimental sea lamprey control program (Fisheries Technical Committee 2001). To this end, a lamprey wounding rate objective of 15 wounds per 100 fish was established for landlocked salmon in the 432-533 mm length class. In 2015, 28 salmon fell within this length class with a calculated lamprey wounding rate of 11 wounds per 100 fish (Table 6).

Evaluation of Salmon Spawning

Objectives: To determine if salmon transported and released upstream resulted in redd construction and spawning activity.

Procedures

In 2015 the Winooski River watershed was divided into four sampling groups, A-D, from the fish release site on the Winooski River upstream to Bolton Dam (Table 7, Figure 3). Groups B and C include parts of the Winooski River as well as tributaries. Each group consisted of

several sampling locations and were surveyed once per week starting with Group B on Monday. However, the Huntington River (in Group B) was to be surveyed twice per week – Monday with group B and Friday alone. Tributaries were surveyed from their mouth to the first upstream barrier. At each location the surveyor would walk the accessible portions of the river searching for evidence of redd construction and/or salmon. Redds found were marked by GPS and a painted rock placed within to prevent double counting. An average water depth was estimated by measuring water depth on the left, right and upstream edge of redd. Sampling began in early October and continued into December as time permitted.

Findings

Sampling began on October 8 with the last sampling event occurring on December 1, 2015. A total of 41 redds were recorded with the majority being located in the Huntington River (Table 8, Figure 4). Many of the redds on the Huntington River were located near the confluence with the Winooski River. The peak period of redd construction occurred in early November (Figure 5). A total of 15 redds were found on the Winooski River with the majority being near the town of Richmond (Figure 6). Eight salmon were seen during the survey (6 in the Winooski River and 2 on the Huntington River)
The average redd depth in the Huntington river was 28 cm and 45 cm in the Winooski River. Due to scheduling issues with other projects not all sampling areas were checked.

Evaluation of Salmon Fry, Fall Fingerling and Smolt Stocking

Objective: To establish runs of adult landlocked Atlantic salmon that will provide a stream fishery as well as encourage natural reproduction.

Procedures

In 2010 the USFWS initiated a 3-year salmon river-run project which entailed collecting genetic samples from the brood stock salmon providing the progeny used to stock the Winooski River watershed. The progeny were reared at the Dwight D. Eisenhower National Fish Hatchery in Chittenden, Vermont and received one of four different stocking treatments.

1. **Fry Stocking** - Salmon were stocked as fry in the Huntington River. Stocking years 2011-2013.

2. **Fall Fingerling Stocking** - Salmon were stocked as fall fingerlings in the main stem of the Winooski River. Fingerlings were adipose clipped (AD). Stocking years 2011-2013

3. **Smolt Stocking Control** (Winooski control) - Salmon were stocked as smolts after being cultured in well water with constant water temperature of about 8 degrees Celsius. Smolts had their left ventral fin removed (LV clipped). Stocking years 2012-2014.

4. **Smolt Stocking Experimental** (Winooski experimental) - Salmon were stocked as smolts after being raised in well water then moved to raceways supplied by Furnace

Brook water approximately four months prior to stocking. Furnace Brook water temperature varied naturally with the season. Smolts were LV clipped. Stocking years 2012-2014.

An additional treatment (5) was the stocking of smolts from the State of Vermont's Ed Weed Fish Culture Station in Grand Isle, Vermont in 2013 and 2014. These fish had a right ventral (RV) clip as well as being nose-tagged with a coded wire tag (CWT).

Figure 7 compares water temperatures of each of the three salmon smolt treatments (Winooski control, Winooski experimental and Ed Weed) prior to stocking. Water temperature of the Huntington River is also included as well as the time when the majority of wild smolts (from fry stocking) are captured at the smolt trap.

The subsequent collection of genetic samples from returning adult salmon at the fish lift will confirm their stocking history. A more detailed description of these procedures and results for this study will be included in a future report.

Findings

Stocking numbers

Salmon smolts --- A total of 32,970 Sebago strain salmon smolts were stocked in the Winooski River in spring, 2016 (Table 9). The salmon lots had mean lengths ranging from 156 – 190 mm and were reared at State of Vermont's Ed Weed Fish Culture Station in Grand Isle, Vermont. Salmon received a right ventral fin clip (RV) and were stocked on March 23 and March 31.

Salmon Fingerlings --- On November 5, 2015, 8,456 fingerling salmon were stocked in the Huntington River (Table 10). These fingerlings have been stocked in the main stem Winooski but the fry stocked in the Huntington in spring 2015 were decimated due to the June floods. These fish came from the Dwight D. Eisenhower National Fish Hatchery and averaged 116 mm total length. All fingerlings received an adipose fin clip for future identification.

Salmon fry --- No salmon fry were stocked in 2016. It was decided to replace the fry stocking of the Huntington River with fall fingerling stocking which will begin in fall, 2016.

Steelhead smolts --- A total of 21,000 steelhead rainbow trout were stocked in the Winooski River in 2016 (Table 11). These fish came from the Ed Weed Fish Culture Station. Equal numbers of the Chambers Creek (LV clipped) and Lake Memphremagog strains (RV clipped) were stocked at the Winooski One dam and at the fishing access near the mouth of the river. The fish were stocked on March 23 and March 31.

Adult returns by fin clip

During the fall 2015 fish lift season 63 returning adult salmon had an LV clip; 44 fish had an RV clip; and 9 fish had no clip (Table 12). Thirty-three of the RV clipped salmon scanned

positive for a CWT. The majority (93%) of both the clipped and non-clipped salmon were 1-lake-year fish. In addition to the above, three AD, three ADLV and 2 ADRV clipped salmon were trapped.

Genetic samples were collected from adult salmon in 2013, 2014 and 2015. Preliminary analysis of the 204 LV clipped salmon indicates that 63 percent were Winooski experimental smolts and only 18 percent were Winooski control smolts (Table 13). A total of 85 RV clipped adult salmon were trapped at the lift with 66 percent also having a coded wire tag indicating they were stocked as smolts in the Winooski river. A total of 32 unclipped salmon were checked over the three years with 56 percent originating from fry stocking.

Winooski River and Tributary Habitat Assessment

Objective: To assess present salmonid habitat within the Winooski River watershed.

Procedures

No habitat assessment was conducted in 2015. However, temperature data was collected for the Winooski River and several tributaries using temperature loggers from Onset Instruments, (Pocasset, MA); model HOBO Water Temp Pro v2. Temperature loggers were programmed to record every hour. Temperature data was summarized (May – October) for each stream based on temperature preferences of either salmon (Winooski, Huntington and Mill Brook) or brook trout *Salvelinus fontinalis* (all other streams). Temperature preferences (in Celsius degrees) were categorized as below optimal, optimal, upper range, or above range. The following optimal and upper range temperature categories were chosen for each species: Salmon optimal—**12.8-20**, upper range —**20.1-24**; brook trout optimal —**12.8-14.4**, upper range —**14.5-22**. These temperatures were chosen based on the literature and conversations with fish culture biologists (Stanley and Trial 1995; Raleigh 1982; Henry Bouchard, USFWS, personal communication).

Findings

Figure 8 summarizes water temperature data in the Winooski River and several tributaries. Recorded water temperatures during the months of May through October fell within the optimal range for salmon 30 percent of the time in the Winooski River; 50 percent in the Huntington River and 62 percent in Mill Brook. The Winooski River had the greatest percent of time (7%) the temperature was above the upper range. However, the Winooski logger was lost in June and replaced in July, thus the Winooski data is abbreviated. Temperatures in the other tributaries fell within optimal for brook trout 18 to 24 percent of the time for the period but never were above the upper range.

Winooski River Tributary Salmonid Assessment

Objective: To assess present natural reproduction of resident salmonids, survival of stocked salmon fry and/or fingerlings and spawning success of lifted adult salmonids.

Procedures

Salmon fry and fingerling stocking

No fry stocking occurred in 2016. Fingerlings were stocked in fall, 2015 as discussed above.

Salmon parr and trout sampling

The subsequent status of juvenile salmon stocked as fry and other salmonid populations were evaluated during August and September, 2015. Salmon and trout were sampled on the Huntington River, including four of its tributaries, and eight other Winooski River tributaries.

Sampling accessibility and general habitat characteristics determined site selection. Tributary stations varied in length from approximately 100 to 175 meters. Sampling was accomplished by electrofishing with a ABP-2 backpack electrofishing unit (ETS Electrofishing, LLC, Verona WI).

Population size was estimated using a maximum weighted likelihood modification of the Zippin removal method (Carl and Strub 1978). Multiple sampling runs (usually 3) were conducted at each station until the last run collected no more than 20 percent of the total trout collected in the previous runs. This ensured that allowable coefficient of variation values resulted from calculated population estimates.

Captured salmon and trout were identified, measured, weighed. A scale sample was taken from some salmon. Scale samples from these and salmon captured in the out-migration study (see Salmon Smolt Out-Migration below) as well as length-frequency analysis were used to assign ages to salmon. Young-of-year (YOY) fish were weighed collectively.

Findings

Salmon fry and fingerling stocking

No fry were stocked in 2016. Fry stocked in 2015 were placed upstream of the gorge, a barrier to fish migration, in addition to OTC marking, to further differentiate them physically from naturally produced fry in the lower portion of the river. A total of 8,456 fingerlings were stocked in the upper Huntington River (above the gorge) in ~1,844 salmon units (~4.6 fish per unit).

Salmon parr sampling

Only one young-of-year salmon parr was found in the Huntington River in 2015. This salmon was found at the lower of the 2 index stations. The low survival of stocked salmon fry is presumed the result of flooding which occurred in June, 2015 (Figure 9). However, several age-1 salmon were collected at both locations. Density of age-1 salmon found at the lower sampling

location was 0.2 fish per salmon unit and 0.8 at the upper sampling location (Table 14, Figure 10). Survival estimates for salmon fry stocked in 2015 as well as 2014 are presented in Table 15.

Multiple attempts were made to collect additional YOY salmon above the gorge to confirm presence of OTC marks and compare to the one parr collected in the lower Huntington. Additional sampling below the gorge was conducted to try to catch more YOY salmon as well. Five salmon parr were collected above the gorge but no others were found below. OTC marks were found on 4 of the 5 salmon collected above the gorge (the 5th was destroyed during processing)(Figure 11). No OTC mark was distinguishable on the otolith of the parr found below the gorge suggesting this was a wild salmon.

A total of 489 trout were collected from 14 Winooski River tributaries during the 2015 sampling effort. Table 16 summarizes population estimates and biomass for the tributaries sampled in 2015. Brook trout made up 69 percent of the fish collected followed by rainbow trout (22%) and brown trout (9%) (Figure 12). Figure 13 illustrates the variability of rainbow trout population estimates over time for three tributaries sampled.

Salmon Smolt Out-Migration

Objective: (1) describe timing and rates of migration, (2) assessing in-river migration factors, (3) evaluating inter-year variability in magnitude of out-migration.

Procedures

In spring 2004, the first attempt at capturing salmon smolts stocked as fry out-migrating to Lake Champlain was conducted utilizing a rotary screw trap. This trap was placed in the lower Huntington River, performed well and a total of 57 salmon were captured. In 2007 a new trap was purchased from E.G. Solutions of Corvallis, Oregon. The new trap has a larger fish capturing cone (2.4 meters diameter vs. the old traps cone of 1.8 meters).

In 2015 the rotary screw trap was deployed in the Huntington River at river kilometer 0.5. The trap consists of two 8-meter floating pontoons between which a revolving mesh–covered cone is suspended. The large end of the cone (2.4 m diameter) is facing upstream and an internal screw built into the cones center axle rotates the cone as the water current exerts pressure on it. Downstream migrating fish that enter the cone are passed to the end of the cone and collected in a live box. The trap was tied to the shore and positioned in the upstream end of a pool at the end of a shallow riffle that funneled much of the flow into the cone.

Discharge in the Huntington River was monitored daily with a staff gauge placed near the trap location. Stream temperature was monitored using a temperature logger from Onset Instruments, (Pocasset, MA), model HOBO Water Temp Pro v2. The temperature logger was programmed to record every hour.

The trap was checked at least once per day in the morning. Captured salmon were measured for total length, weighed and a scale sample taken for age verification. Salmon were marked by punching a 3.5 mm (1/8 inch) hole in the tail to help identify potential re-captures.

After processing, salmon were placed in a cage 400 meters upstream and held from 8-24 hours before being released in order to estimate trap efficiency (see below).

Rotary screw traps sample only a portion of the cross-sectional area of the stream. For this reason, numbers of migrants were estimated by the trap-efficiency method. Trap efficiency was calculated by releasing marked salmon upstream of the trap. The estimated number of migrants was calculated by the following formula:

Efficiency = Recaptured marked salmon / Marked fish released

The total number of fish migrating past the trap site was then estimated by:

Number of fish = unmarked fish caught / Efficiency

Findings

The trap was deployed on April 18 and fished until May 29, 2016 (Table 17). The trap fished 39 days during the period and captured 15 salmon smolts. Trapping conditions were excellent during most of April and May with only 2 days missed due to excessive flows but low flow conditions in late May ended the sampling. High flows in June, 2015 had changed the river bed at the site depositing gravel in the hole where the trap typically fishes. Furthermore, the flow through the riffle upstream was more evenly distributed across the width of the river amounting to less of a focused flow into the trap cone. The majority of smolts (13 of 15) were captured between May 12 and May 29 (Figure 14). This is similar to previous year's out-migration when about 80 percent of the smolts were captured during the last two weeks of May.

With few salmon captured, calculating trap efficiency and estimating numbers of out-migrants is challenging so the following estimates should be viewed cautiously. Trap efficiency for the entire period of trapping was 0.077 and calculated from the recapture of 1 out of 13 marked and released smolts. About 195 salmon smolts passed the trapping site based on the estimated trap efficiency and a total of 15 unmarked salmon captured. Table 17 compares the 2016 trapping efforts to previous years trapping.

Eight of the trapped smolts had an adipose clip indicating they were stocked as fall fingerlings. Analysis of scale samples did indeed confirm all but one were 1-year olds. Mean length of these smolts was 130 mm (SD=4) and ranged from 124-135 mm (Table 18). Wild smolts (those originating from fry stocking) were mostly 2-years old and would have originated from the 2014 stocking of 62,000 fry in the Huntington River (Table 17). Mean length of these smolts was 152 mm (SD=21) and ranged from 123-185 mm. One three-year wild old salmon was also trapped (216 mm) and one fish was not aged (131 mm).

Angler Exploitation

Objective: To estimate angler fishing effort and catch of returning salmonids.

Procedures

Angler exploitation was measured by angler tag returns and volunteer reporting on angler creel survey forms posted at the Winooski One fish lift.

Findings

Eight salmon and three steelhead tagged at the Winooski One fish lift were reported caught by anglers between July 1, 2015 and June 30, 2016 (Table 19). Six of the salmon were originally tagged and moved upstream of the Winooski One dam in fall 2015. The other two salmon caught was originally tagged and released upstream in fall 2014. Three of the tagged fish were reported caught in Lake Champlain; one in the Lamoille River; one in the Saranac River, NY; and the remaining three salmon were caught in the Winooski River - Salmon Hole below the Winooski One Dam for two salmon, and the Richmond, VT area for one salmon (Table 19). The salmon caught in Richmond was tagged in Fall, 2015 and caught in April, 2016 which is interesting because it had not exited the river yet. This fish also had no fin clip suggesting it may have been fry stocked.

There were 10 entries on the volunteer angler survey forms between September 28, 2015 and November 10, 2015. Based on information provided by anglers, it took approximately 3.9 hours of fishing effort to catch either a salmon or steelhead during this period. Only five salmon were reported to have been caught in 19.75 hours of fishing effort below the Winooski One dam. No steelhead were reported caught by anglers.

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

Year	Spring		Fall	
	Steelhead	Salmon	Salmon	Steelhead
1993	NA	0	36	7
1994	179	0	32	15
1995	38	0	12	8
1996	45	0	11	1
1997	4	0	116	21
1998	24	0	81	80
1999	54	0	51	11
2000	22	0	29	3
2001	7	0	6	0
2002	5	1	21	3
2003	5	2	15	3
2004	17	0	10	1
2005	4	0	15	5
2006	1	2	23	5
2007	0	0	35	2
2008	6	1	26	0
2009	2	0	38	26
2010	13	3	132	61
2011	37	0	189	18
2012	16	0	44	37
2013	44	0	115	13
2014	9	0	158	27
2015	31	0	124	8
2016	23	0	na	na

Table 2. Summary of mean total lengths of aged landlocked Atlantic salmon collected at the Winooski One fish passage facility, fall 2015. All lengths in millimeters ± one standard deviation. Number of fish in parenthesis.

Sex	Lake Age 0	Lake Age 1+	Lake Age 2+	Lake Age 3+	Total
Landlocked Atlantic Salmon					
Male	---	559 ± 36 (58)	589 ± 36 (6)	---	64
Female	466 (1)	545 ± 36 (51)	604 ± 62 (5)	---	57
Total	1	109	11	---	121

Table 3. Summary of mean total lengths (± one SD) and condition factor (K) (± one SD) of lake age 1 male landlocked Atlantic salmon collected at the Winooski One fish passage facility, 2007 – 2015.

Year	Mean Length	Number	Condition	Number
2007	555 ± 29	16	0.93 ± .11	16
2008	553 ± 51	5	0.88 ± .12	5
2009	548 ± 46	12	0.86 ± .28	11
2010	580 ± 42	38	0.93 ± .10	38
2011	536 ± 33	69	0.93 ± .19	68
2012	560 ± 35	14	1.04 ± .09	14
2013	580 ± 52	35	1.01 ± .13	35
2014	586 ± 45	69	1.04 ± .13	69
2015	559 ± 36	58	0.94 ± .10	58

Table 4. Summary of mean total lengths of steelhead rainbow trout by strain collected at the Winooski One fish passage facility, fall 2015 and spring, 2016. All lengths in millimeters.

Strain (Clip)	Number	Mean Length	Standard Deviation
Fall 2015			
No Clip	2	587	81
Chambers Creek (LV)	3	482	88
Lake Memphremagog (RV)	3	400	11
Spring 2016			
No Clip	1	530	na
Chambers Creek (LV)	7	547	103
Lake Memphremagog (RV)	14	525	64
RV/AD	1	618	na

Table 5. Summary of mean total lengths of aged steelhead rainbow trout by strain collected at the Winooski One fish passage facility, spring 2016. All lengths in millimeters ± one standard deviation. Number of fish in parenthesis.

Sex	Lake Age 1	Lake Age 2	Total
Chambers Creek			
Male	442 ± 9 (2)	500 ± 63 (2)	4
Female	---	649 ± 32 (3)	3
Total	2	5	7
Memphremagog			
Male	496 ± 63 (7)	514 (1)	8
Female	566 ± 27 (2)	618 (1)	3
Total	9	2	11

Table 6. Summary of sea lamprey attacks on Landlocked Atlantic salmon in the 432-533 mm length class lifted at the Winooski One fish lift, 1993 - 2015.

Year	Number of Salmon	Stage A1 wounds	Stage A2&A3 wounds	Stage A4 wounds	Total wounds (A1-A3)	Wounds/ 100 fish
1993	14	0	4	9	4	28.6
1994	10	0	3	7	3	30.0
1995	3	0	0	4	0	0
1996	6	0	0	2	0	0
1997	112	4	21	30	25	22.3
1998	15	0	1	5	1	6.7
1999	14	3	7	9	10	71.4
2000	6	0	4	3	4	66.7
2001	4	1	2	2	3	75.0
2002	7	0	3	10	3	42.8
2003	3	2	3	8	5	166.6
2004	4	0	0	6	0	0
2005	7	7	4	9	11	157.1
2006	16	4	18	29	22	137.5
2007	10	2	5	13	7	70.0
2008	11	0	9	12	9	81.8
2009	12	0	10	14	10	83.3
2010	20	1	8	15	9	45.0
2011	96	4	26	73	30	31.3
2012	13	1	9	8	8	76.9
2013	21	1	3	12	4	19.0
2014	36	2	3	28	5	13.9
2015	28	1	2	16	3	10.7

Table 7. List of salmon redd sampling locations on the Winooski River and tributaries. Also included is number of times each location was sampled in 2015.

Group	River	Location	Code	Times Sampled
A	Winooski River	Fish release site	WR-1	2
A	Winooski River	Railroad bridge	WR-3	
A	Winooski River	Richmond Rt 2 Bridge	WR-4	
A	Winooski River	Johnnie Brook Rd Lower	WR-5	
A	Winooski River	Johnnie Brook Rd Upper	WR-6	
A	Winooski River	Richmond recreation fields	WR-7	3
A	Winooski River	Cementery Island	WR-8	2
A	Winooski River	Cochran Ski Area	WR-9	1
A	Winooski River	Richmond canoe access	WR-10	
B	Winooski River	Horse farm island	WR-11	
B	Winooski River	Huntington River mouth	WR-12	3
B	Huntington River	Huntington River	HR-1	8
B	Winooski River	Preston Brook mouth	WR-17	2
B	Preston Brook	Below bridge	PB-2	1
B	Preston Brook	Above bridge	PB-1	
B	Gleason Brook	Gleason Brook	GB-1	
B	Winooski River	Railroad trestle/Ridley mouth	WR-24	2
B	Ridley Brook	Below bridge	RB-2	2
B	Ridley Brook	Above bridge	RB-1	1
B	Winooski River	Bolton Dam islands	WR-25	1
C	Mill Brook	Below bridge	MB-2	3
C	Mill Brook	Above bridge	MB-1	
C	Winooski River	Mill Brook Mouth	WR-2	1
C	Johnnie Brook	Johnnie Brook	JNY-1	
C	Snipe Island Brook	Snipe Island Brook	SIB-1	
C	Winooski River	Snipe Island Mouth	WR-11	
C	Duck Brook	Duck Brook	DB-1	
C	Joiner Brook	Below bridge	JB-2	1
C	Joiner Brook	Above bridge	JB-1	
C	Winooski River	Pinneo Brook Island	WR-21	1
C	Pinneo Brook	Pinneo Brook	PIN-1	
D	Winooski River	Duxbury Rd first corner	WR-13	2
D	Winooski River	Duxbury Rd red house	WR-14	1
D	Winooski River	Long Trail bridge	WR-15	2
D	Winooski River	Temp logger corner	WR-16	
D	Winooski River	Bolton island	WR-18	1
D	Winooski River	Town line island	WR-19	2
D	Winooski River	High road island	WR-20	
D	Winooski River	Fishing Island - lower	WR-22	2
D	Winooski River	Fishing Island - upper	WR-23	1

Table 8. Summary of new redds found by date and stream during fall, 2015.

Date	Stream					
	Winooski River	**Huntington River**	**Mill Brook**	**Preston Brook**	**Ridley Brook**	**Joiner Brook**
October 8	0	0		0	0	
October 21	0					
October 28		0	0			
November 5	11	9				
November 6	1		0			
November 9		4				
November 10	3				0	0
November 12	0	7	3			
December 1		3				
Total Redds	**15**	**23**	**3**	**0**	**0**	**0**

Table 9. Summary of recent landlocked Atlantic salmon smolt stocking in the Winooski River, 2010 – 2016. Stockings are typically split between the boat access near the river mouth and below the Winooski One dam. Sources include the State of Vermont's Ed Weed Fish Culture Station and Dwight D. Eisenhower National Fish Hatchery.

Year Stocked	Stocking Location	Number Stocked	Size (mm)	Source[1]	Total Stocked	Clip
2010	W. One	15,466	178 - 192	Ed Weed	31,169	RV
	Mouth	15,703				
2011	W. One	15700	178 - 203	Ed Weed	31,710	RV
	Mouth	16010				
2012	W. One	8,711	194	Eisenhower (well)	35,308	LV
	W. One	7,803	174	Eisenhower (brk)		LV
	Mouth	8,313	194	Eisenhower (well)		LV
	Mouth	10,481	174	Eisenhower (brk)		LV
2013	W. One	7,387	197	Eisenhower (well)	29,577	LV
	W. One	7,757	180	Eisenhower (brk)		LV
	Mouth	4,563	178	Eisenhower (brk)		LV
	Mouth	2,370	194	Ed Weed		RV/CWT
	W. One	7,500	194	Ed Weed		RV/CWT
2014	W. One	10,863	200	Eisenhower (well)	36,417	LV
	W. One	15,554	175	Eisenhower (brk)		LV
	W. One	10,000	204	Ed Weed		RV/CWT
2015	W. One	15,688	184	Ed Weed	31,388	RV
	Mouth	15,700	192			
2016	W. One	15,700	190	Ed Weed	32,970	RV
	Mouth	12,377	156			
	Mouth	4,893	180			

[1] Eisenhower - Well = salmon cultured in well water at nearly constant temperature (~8.0 degrees). Brk = salmon cultured in Furnace Brook water with variable temperature.

Table 10. Summary of landlocked Atlantic salmon fall fingerling stocking in the main stem of the Winooski River, 2009 – 2015. Sources include the State of Vermont's Ed Weed Fish Culture Station (2009-2010) and Dwight D. Eisenhower National Fish Hatchery (2011-2015).

Year	Number	Mean size (mm)	Clip
Winooski River			
2009	30,000	115	No clip
2010	33,000	114	No clip
2011	39,000	105	Adipose
2012	20,000	102	Adipose
2013	13,800	93	Adipose
2014	8,860	93	Adipose
Huntington River			
2015	8,456	116	Adipose

Table 11. Summary of recent steelhead rainbow trout smolt stocking in the Winooski River, 2009 – 2016. All steelhead are raised at State of Vermont's Ed Weed Fish Culture Station.

Year Stocked	Stocking Location	Number Stocked	Size (mm)	Strain	Total Stocked	Clip
2009	Mouth W. One	10,000 10,000	211	Chambers	20,000	AD
2010	Mouth W. One	10,410 10,270	203	Chambers	10,680	None
2011	Mouth W. One	11,876 9,000	203	Chambers	20,876	None
2012	W. One W. One Mouth Mouth	5900 5776 5900 4100	201 182 201 182	Chambers Magog Chambers Magog	21,676	LV RV LV RV
2013	W. One W. One Mouth Mouth	5,000 5,000 5,000 5,000	200 171 203 171	Chambers Magog Chambers Magog	20,000	LV RV LV RV
2014	W. One W. One	10,000 10,000	206 161-171	Chambers Magog	20,000	LV RV
2015	W. One W. One Mouth Mouth	5,000 5,000 5,000 5,000	202 175 196 171	Chambers Magog Chambers Magog	20,000	LV RV LV RV
2016	W. One W. One Mouth Mouth	5000 5000 5500 5500	198 163 198 163	Chambers Magog Chambers Magog	21,000	LV RV LV RV

Table 12. Comparison of returning fin clipped and non-clipped landlocked Atlantic salmon lifted at the Winooski One fish passage facility, 2009 - 2015.

Clip	2009	2010	2011	2012	2013	2014	2015
No Clip	7	46	32	18	24	23	9
Right Ventral	31	85	155	25	12	41	44
Left Ventral	0	0	2	1	72	81	63
Adipose	0	0	0	0	2	9	3
Right Pectoral	0	0	0	0	1	0	0
ADLV	0	0	0	0	4	4	3
ADRV	0	0	0	0	0	0	2
Not checked	0	1	0	0	0	0	0
Total Lifted	38	132	189	44	115	158	124

Table 13. Preliminary results of genetic testing for origin of salmon trapped at the Winooski One fish passage facility, 2013 – 2015.

Fin clip and origin	Year			Total (%)
	2013	2014	2015	
Left ventral salmon checked	62	79	63	204
Well water	13	18	5	36 (18)
Furnace Brook water	39	37	52	128 (63)
Right ventral salmon checked	na	41	44	85
Coded wire tagged	na	23	33	56 (66)
No Clipped salmon checked	17	23	9	32
Fry stocked	0	15	3	18 (56)

Table 14. Population estimates (with standard error) and calculated densities by age class for landlocked Atlantic salmon collected in Winooski River tributaries in 2015.

Tributary	Age group	Sample Size	Population Estimate	Density (no./unit)	95% C.I.
Huntington 0.9 km	0+ 1+	1* 6	1 ± 0.00 6 ± 0.47	0.03 0.2	0.03 – 0.03 0.2 – 0.2
Huntington 8.7 km	0+ 1+	0 19	--- 20 ± 2.1	--- 0.8	--- 0.7 – 0.9

***** Wild salmon collected

Table 15. Population densities and survival estimates by age groups for the 2014 and 2015 age class of landlocked Atlantic salmon in Winooski River tributaries.

Tributary	Density (no./salmon unit)			Survival (percent)			Fry/0+ Survival 95% C.I.
	Fry	0+	1+	Fry/0+	0+/1+	Fry/1+	
2014 Year Class							
Huntington 0.9 km	31	4.0	0.2	12.9	5.0	0.6	11.9 – 13.9
Huntington 8.7 km	31	4.2	0.8	13.5	19.0	2.6	12.6 – 14.5
2015 Year Class							
Huntington 0.9 km	32	0	na	0.0	na	na	0
Huntington 8.7 km	32	0	na	0.0	na	na	0

Table 16. Population estimates for salmon and trout collected in Winooski River tributaries in 2015.

LEGEND

Stream – Name of tributary; may be followed by river kilometer from mouth of stream
Elev. – Elevation (feet)
Date – Day, month
Len. – Survey section length (feet)
Width – Average stream width (feet)

Species –

RBT = Rainbow trout
BNT = Brown trout
BKT = Brook trout
LLS = Landlocked Atlantic salmon

Class – Size/age class

YOY – young-of-year
<6 – yearling or older trout measuring less than 6.0 inches total length
6-9.9 - yearling or older trout measuring between 6.0 and 9.9 inches total length
10 - yearling or older trout measuring between 10.0 and 11.9 inches total length
12+ - yearling or older trout measuring greater than 11.9 inches total length
1+ and 2+ - Salmon age class

Num – Number of fish collected
Est. – Population estimate
LOCI/UPCI – Upper and Lower 95% confidence interval expressed as a percentage of the population estimate

Popmi – Population estimate expressed as number per mile
Popkm - Population estimate expressed as number per kilometer

MnWt – Mean weight of fish (grams)
Lbac – Estimated pounds per acre
Kghec – Estimated kilograms per hectare

Table 16. Population estimates for salmon and trout collected in Winooski River tributaries in 2015

Stream	Elev.	Date	Len	Width	Species	Class	Num	Est.	LOCI	UPCI	Popmi	Popkm	Mn Wt	Lbac	Kghec
Huntington 8.7 km	590	25-Aug	420	66.5	RBT	10-12	1	1	0.0	0.0	10	6	208.0	0.56	0.63
					BNT	6-10	1	1	0.0	0.0	13	8	70.0	0.24	0.27
						12+	1	1	0.0	0.0	13	8	515.0	1.77	1.98
							2	2			26	16		2.01	2.25
					BKT	<6	1	1	0.0	143.8	13	8	41.0	0.14	0.16
						6-10	1	1	0.0	397.3	13	8	55.0	0.19	0.21
						10-12	1	1	0.0	0.0	13	8	147.0	0.51	0.57
							3	3			39	24		0.84	0.94
					LLS	1+	19	20	5.0	20.7	251	156	21.0	1.44	1.62
					TOTALS		**25**	**25**			**326**	**202**		**4.86**	**5.44**
Huntington 0.9 km	310	25-Aug	790	50	RBT	<6	2	2	0.0	98.0	13	8	23.5	0.11	0.13
						6-10	3	3	0.0	48.7	20	12	61.7	0.45	0.50
							5	5			33	30		0.56	0.63
					BNT	YOY	1	1	0.0	0.0	7	4	2.0	0.01	0.01
						6-10	1	1	0.0	0.0	7	4	57.0	0.14	0.16
							2	2			14	8		0.15	0.17
					LLS	YOY	1	1	0.0	0.0	7	4	4.0	0.01	0.01
						1+	6	6	0.0	15.4	40	25	19.3	0.28	0.32
							7	7			47	29		0.29	0.33
					TOTALS		**14**	**14**			**94**	**67**		**1.00**	**1.13**

Table 16. (cont.)

Stream	Elev.	Date	Len	Width	Species	Class	Num	Est.	LOCI	UPCI	Popmi	Popkm	Mn Wt	Lbac	Kghec
Mill Brook	300	24-Aug	394	29	RBT	<6	24	24	0.0	9.6	322	200	24.3	4.90	5.49
						6-10	11	11	0.0	6.8	147	92	47.9	4.43	4.96
							35	35			469	292		9.33	10.45
					BNT	YOY	3	3	0.0	0.0	40	25	5.0	0.13	0.14
						6-10	2	2	0.0	101.7	27	17	72.0	1.21	1.36
						12+	1	1	0.0	0.0	13	8	422.0	3.55	3.98
							6	6			80	50		4.89	5.48
					BKT	YOY	1	1	0.0	0.0	13	8	3.0	0.03	0.03
						<6	1	1	0.0	0.0	13	8	33.0	0.28	0.31
						6-10	1	1	0.0	143.8	13	8	105.0	0.88	0.99
							3	3			39	24		1.19	1.33
					TOTALS		**44**	**44**			**588**	**366**		**15.41**	**17.26**
Pinneo Brook	370	18-Aug	355	12.3	BNT	YOY	1	1	0.0	0.0	15	9	3.0	0.07	0.07
					BKT	YOY	5	5	0.0	20.7	74	46	2.4	0.26	0.30
						<6	1	1	0.0	0.0	15	9	19.0	0.42	0.47
							6	6			89	55		0.68	0.77
					TOTALS		**7**	**7**			**104**	**64**		**0.75**	**0.84**
Cobb Brook	775	20-Aug	372	14.8	BKT	YOY	11	11	0.0	22.6	156	97	3.0	0.58	0.65
						<6	3	3	0.0	17.4	43	26	18.7	0.98	1.09
							14	14			199	123		1.56	1.74
					TOTALS		**14**	**14**			**199**	**123**		**1.56**	**1.74**

Table 16. (cont.)

Stream	Elev.	Date	Len	Width	Species	Class	Num	Est.	LOCI	UPCI	Popmi	Popkm	Mn Wt	Lbac	Kghec
Preston Brook	365	17-Aug	384	18.4	RBT	<6	7	7	0.0	9.2	96	60	23.0	2.19	2.45
						6-10	3	3	0.0	17.4	41	26	43.0	1.75	1.97
							10	10			137	86		3.94	4.42
					BNT	YOY	1	1	0.0	0.0	14	9	3.0	0.04	0.05
						<6	1	1	0.0	143.8	14	9	22.0	0.30	0.34
							2	2			28	18		0.34	0.39
					BKT	YOY	3	3	0.0	17.4	41	26	3.0	0.12	0.14
						6-10	1	1	0.0	0.0	14	9	48.0	0.65	0.73
							4	4			55	35		0.77	0.87
					TOTALS		**16**	**16**			**220**	**139**		**5.05**	**5.68**
Ridley Brook	360	17-Aug	379	19.1	RBT	YOY	2	2	0.0	240.0	28	17	1.5	0.04	0.04
						<6	1	1	0.0	0.0	14	9	15.0	0.20	0.22
						12+	1	1	0.0	0.0	14	9	296.0	3.93	4.40
							4	4			56	35		4.17	4.66
					BNT	10-12	1	1	0.0	0.0	14	9	182.0	2.41	2.71
						12+	1	1	0.0	0.0	14	9	340.0	4.51	5.06
							2	2			28	18		6.92	7.77
					BKT	YOY	1	1	0.0	0.0	14	9	2.0	0.03	0.03
					LLS	1+	2	2	0.0	0.0	28	17	23.0	0.61	0.68
					TOTALS		**9**	**9**			**126**	**79**		**11.73**	**13.14**

Table 16. (cont.)

Stream	Elev.	Date	Len	Width	Species	Class	Num	Est.	LOCI	UPCI	Popmi	Popkm	Mn Wt	Lbac	Kghec
Snipe Island Brook	300	26-Aug	507	12	RBT	YOY	19	19	0.0	9.6	198	123	3.9	1.18	1.33
						<6	6	6	0.0	45.1	62	39	26.8	2.54	2.85
						6-10	4	4	0.0	47.5	42	26	40.8	2.57	2.88
							29	29			302	188		6.30	7.06
					BNT	YOY	5	5	0.0	0.0	52	32	2.6	0.21	0.23
						6-10	1	1	0.0	143.8	10	6	119.0	1.88	2.11
						10-12	1	1	0.0	143.8	10	6	366.0	5.78	6.48
							7	7			72	44		7.86	8.81
					BKT	YOY	4	4	0.0	0.0	42	26	3.3	0.21	0.23
						<6	2	2	0.0	0.0	21	13	23.5	0.74	0.83
						6-10	1	1	0.0	0.0	10	6	45.0	0.71	0.80
							7	7			73	45		1.66	1.86
					TOTALS		**43**	**43**			**447**	**277**		**15.82**	**17.73**
Interchange Brook	335	29-Aug	399	8.8	BKT	YOY	5	5	0.0	20.7	66	41	4.6	0.63	0.71
						<6	2	2	0.0	98.0	26	16	22.5	1.23	1.38
						6-10	2	2	0.0	0.0	26	16	54.5	2.98	3.34
							9	9			118	73		4.84	5.43
					TOTALS		**9**	**9**			**118**	**73**		**4.84**	**5.43**
Beaver Meadow	1135	19-Aug	411	10	BKT	YOY	37	37	0.0	3.7	475	295	2.3	2.01	2.25
						<6	35	35	0.0	3.0	450	279	15.8	12.94	14.51
						6-10	3	3	0.0	17.4	39	24	37.3	2.62	2.93
							75	75			964	598		17.57	19.69
					TOTALS		**75**	**75**			**964**	**598**		**17.57**	**19.69**

Table 16. (cont.)

Stream	Elev.	Date	Len	Width	Species	Class	Num	Est.	LOCI	UPCI	Popmi	Popkm	Mn Wt	Lbac	Kghec
Duck Brook	320	26-Aug	333	8.7	RBT	YOY	3	3	0.0	46.3	48	30	8.7	0.86	0.97
						<6	11	11	0.0	3.9	174	108	17.4	6.33	7.10
							14	14			222	138		7.19	8.07
					BNT	YOY	5	5	0.0	64.3	79	49	4.0	0.66	0.74
						<6	2	2	0.0	0.0	32	20	18.0	1.19	1.34
							7	7			111	69		1.86	2.08
					BKT	YOY	2	2	0.0	37.7	32	20	3.0	0.20	0.22
						<6	2	2	0.0	37.7	32	20	28.5	1.89	2.12
						6-10	1	1	0.0	0.0	16	10	95.0	3.15	3.53
							5	5			80	50		5.24	5.87
					TOTALS		**26**	**26**			**413**	**257**		**14.29**	**16.02**
Texas Brook	605	13-Aug	289	18.8	BNT	YOY	5	5	0.0	20.7	91	57	3.2	0.28	0.32
						<6	1	1	0.0	339.5	18	11	22.0	0.39	0.44
						6-10	1	1	0.0	0.0	18	11	41.0	0.72	0.81
							7	7			127	79		1.40	1.57
					BKT	YOY	2	2	0.0	0.0	37	23	3.5	0.12	0.14
						<6	3	3	0.0	48.7	55	34	25.0	1.33	1.49
							5	5			92	57		1.45	1.62
					LLS	1+	5	5	0.0	20.7	91	57	20.8	1.84	2.06
					TOTALS		**17**	**17**			**310**	**193**		**4.69**	**5.25**
Bakers Brook	1075	19-Aug	370	8.4	BKT	YOY	83	95	12.6	15.5	1356	842	2.3	6.68	7.49
						<6	61	63	3.2	6.9	899	559	15.0	29.13	32.66
						6-10	2	2	0.0	0.0	29	18	47.0	2.90	3.26
							146	160			2284	1419		38.71	43.40
					TOTALS		**146**	**160**			**2284**	**1419**		**38.71**	**43.40**

Table 16. (cont.)

Stream	Elev.	Date	Len	Width	Species	Class	Num	Est.	LOCI	UPCI	Popmi	Popkm	Mn Wt	Lbac	Kghec
Joiner Brook	350	18-Aug	323	19.7	RBT	YOY	1	1	0.0	0.0	16	10	7.0	0.11	0.12
						<6	4	4	0.0	30.0	65	41	25.3	1.52	1.71
						6-10	3	3	0.0	0.0	49	30	50.0	2.26	2.54
							8	8			131	81		3.89	4.37
					BNT	YOY	1	1	0.0	0.0	16	10	3.0	0.05	0.05
						6-10	3	3	0.0	48.7	49	30	59.7	2.70	3.03
							4	4			65	40		2.75	3.08
					BKT	<6	1	1	0.0	0.0	16	10	28.0	0.42	0.47
						6-10	5	5	0.0	0.0	82	51	104.2	7.86	8.81
							6	6			98	61		8.28	9.28
					TOTALS		**18**	**18**			**294**	**182**		**14.92**	**16.73**
Huntington Hanksville	1145	31-Aug	320	13.1	BNT	<6	1	1	0.0	0.0	17	10	31.0	0.71	0.80
						6-10	1	1	0.0	0.0	17	10	141.0	3.23	3.62
							2	2			34	20		3.94	4.42
					BKT	YOY	20	22	9.1	27.9	363	226	3.6	1.79	2.01
						<6	11	11	0.0	4.6	182	113	21.0	5.29	5.93
						6-10	1	1	0.0	0.0	17	10	46.0	1.05	1.18
							32	32			562	349		8.13	9.12
					TOTALS		**34**	**34**			**596**	**369**		**12.07**	**13.54**

Table 16. (cont.)

Stream	Elev.	Date	Len	Width	Species	Class	Num	Est.	LOCI	UPCI	Popmi	Popkm	Mn Wt	Lbac	Kghec
Brush Brook	820	20-Aug	479	21.1	BNT	<6	1	1	0.0	0.0	11	7	35.0	0.33	0.37
						10-12	1	1	0.0	0.0	11	7	203.0	1.93	2.16
							2	2			22	14		2.26	2.53
					BKT	YOY	6	6	0.0	32.7	66	41	3.2	0.18	0.20
						<6	10	10	0.0	8.2	110	68	19.3	1.83	2.06
						6-10	3	3	0.0	0.0	33	21	53.3	1.52	1.70
							19	19			209	130		3.53	3.96
					LLS	1+	5	5	0.0	17.4	55	34	20.6	0.98	1.10
					TOTALS		**26**	**26**			**286**	**178**		**6.77**	**7.59**

Table 17. Summary of out-migrating smolt trapping on the Huntington River and fry stocking, 2004 – 2016.

Year	Start Date	End date	Days Fished	First fish	Number new, unmarked Trapped	Number Marked and released[1]	Number Recaptured	Estimate	Trap style[2]	Fry stocked
2016	April 18	May 29	39	May 2	15	13	1	195	New	0
2015	April 28	June 8	34	April 30	137	144	14	1,412	New	57,100
2014	April 29	June 11	31	May 8	24	na	na	na	New	62,064
2013	April 23	June 6	28	Apr 26	82	na	na	na	New	47,500
2012	Mar 30	June 8	37	May 6	79	na	na	na	New	25,896
2011	May 9	May 26	10	May 10	43	na	2	na	New	110,000
2010	April 19	June 1	41	Apr 26	205	214	16	2,733	New	98,000
2009	April 16	June 12	52	May 2	76	88	16	418	New	102,000
2008	April 24	June 13	49	May 6	360	412	66	2,250	New	89,955
2007	May 1	June 15	44	May 9	288	276	19	4,174	New	89,955
2006	April 11	June 9	49	May 3	60	39	0	Nd	Old	66,074
2005	April 14	June 9	49	Apr 21	126	135[3]	6	2,864	Old	67,200
2004	May 6	June 4	25	May 12	57	0	na	na	Old	74,480

1 Includes recaptured smolts released again.
2 The old trap had a 1.8 meter diameter; the new trap has a 2.4 m diameter.
3 Includes 35 hatchery smolts.

Table 18. Summary of mean total lengths (mm) and weights (grams) of aged landlocked Atlantic salmon collected in the rotary screw trap in 2016. All measurements include ± one standard deviation and range.

Age	**Number**	**Mean Length** (range)	**Mean Weight** (range)
1	7 (AD clip)	130 ± 4.4 (124 – 135)	16 ± 2.1 (13 – 20)
2	6 (1 AD Clip)	152 ± 20.7 (123– 185)	29 ± 13.4 (14 – 53)
3	1	216	72

Table 19. Summary of Winooski One-tagged landlocked Atlantic salmon and steelhead rainbow trout recaptured and reported by anglers, July 1, 2015 through June 30, 2016.

Species	**Sex**	**Fin Clip**	**Date Caught**	**Location**	**Year/Season Tagged**
Salmon	Male	LV	November 13, 2015	Lamoille River	2015 / Fall
Salmon	Female	RV	November 15, 2015	Winooski River-Salmon Hole	2014 / Fall
Salmon	Male	RV	November 24, 2015	Winooski River-Salmon Hole	2015 / Fall
Steelhead	Male	LV	November 25, 2015	Winooski River-Salmon Hole	2014 / Fall
Salmon	Male	LV	December 17, 2015	Saranac River – Plattsburgh, NY	2015 / Fall
Steelhead	Unknown	RV	February 8, 2016	Winooski River-Salmon Hole	2015 / Fall
Salmon	Male	LV	April 17, 2016	Lake Champlain – Bulwagga Bay	2014 / Fall
Salmon	Female	No Clip	April 22, 2016	Winooski River-Richmond, VT	2015 / Fall
Steelhead	Female	RV	May 27, 2016	Lake Champlain-Port Kent, NY	2016 / Spring
Salmon	Male	LV	June 4, 2016	Lake Champlain-Valcour Island	2015 / Fall
Salmon	Female	LV	June 16, 2016	Lake Champlain-Westport, NY	2015 / Fall

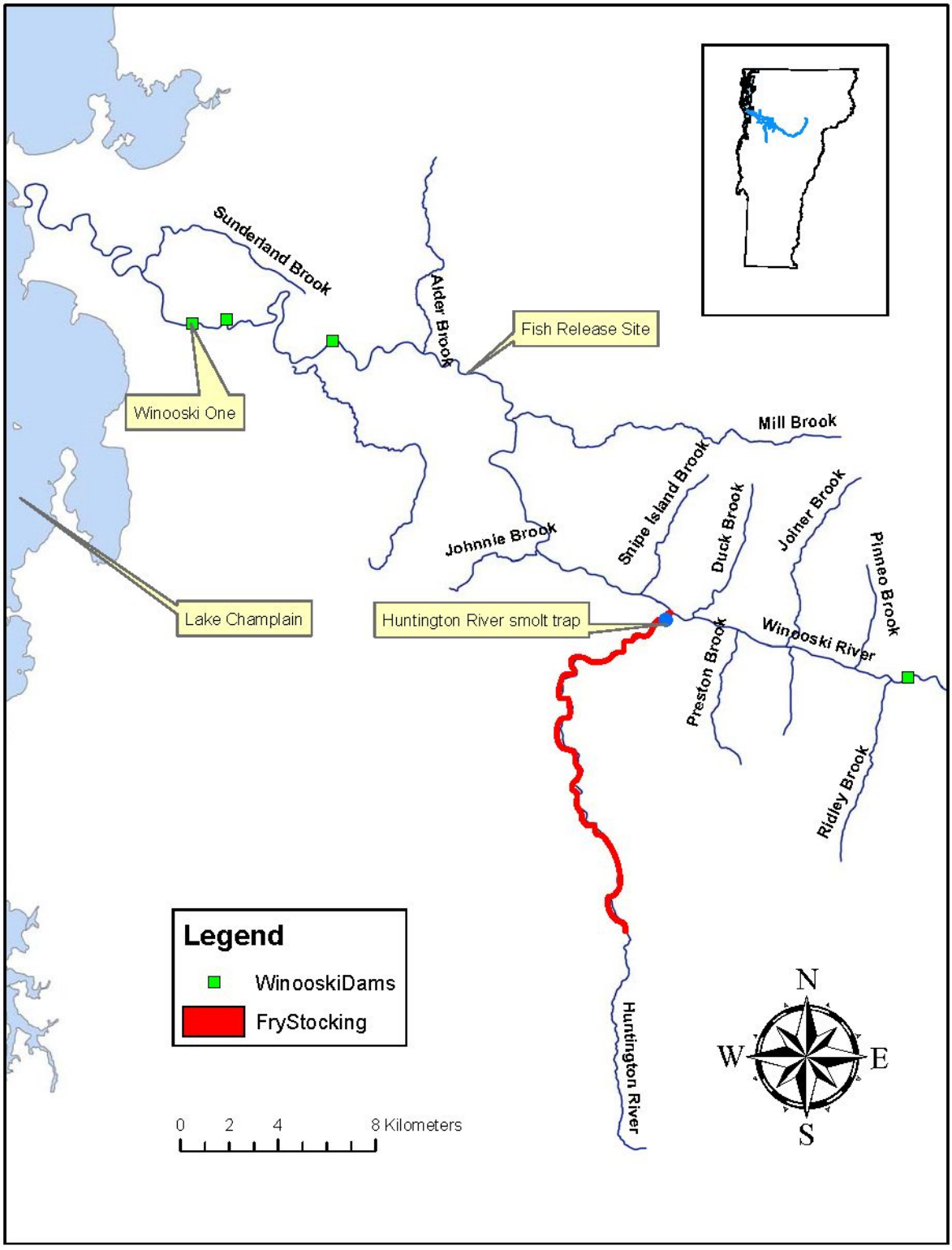

Figure 1. Map of lower Winooski River drainage showing Winooski One Dam, the fish release site, named tributaries, and fry stocking areas.

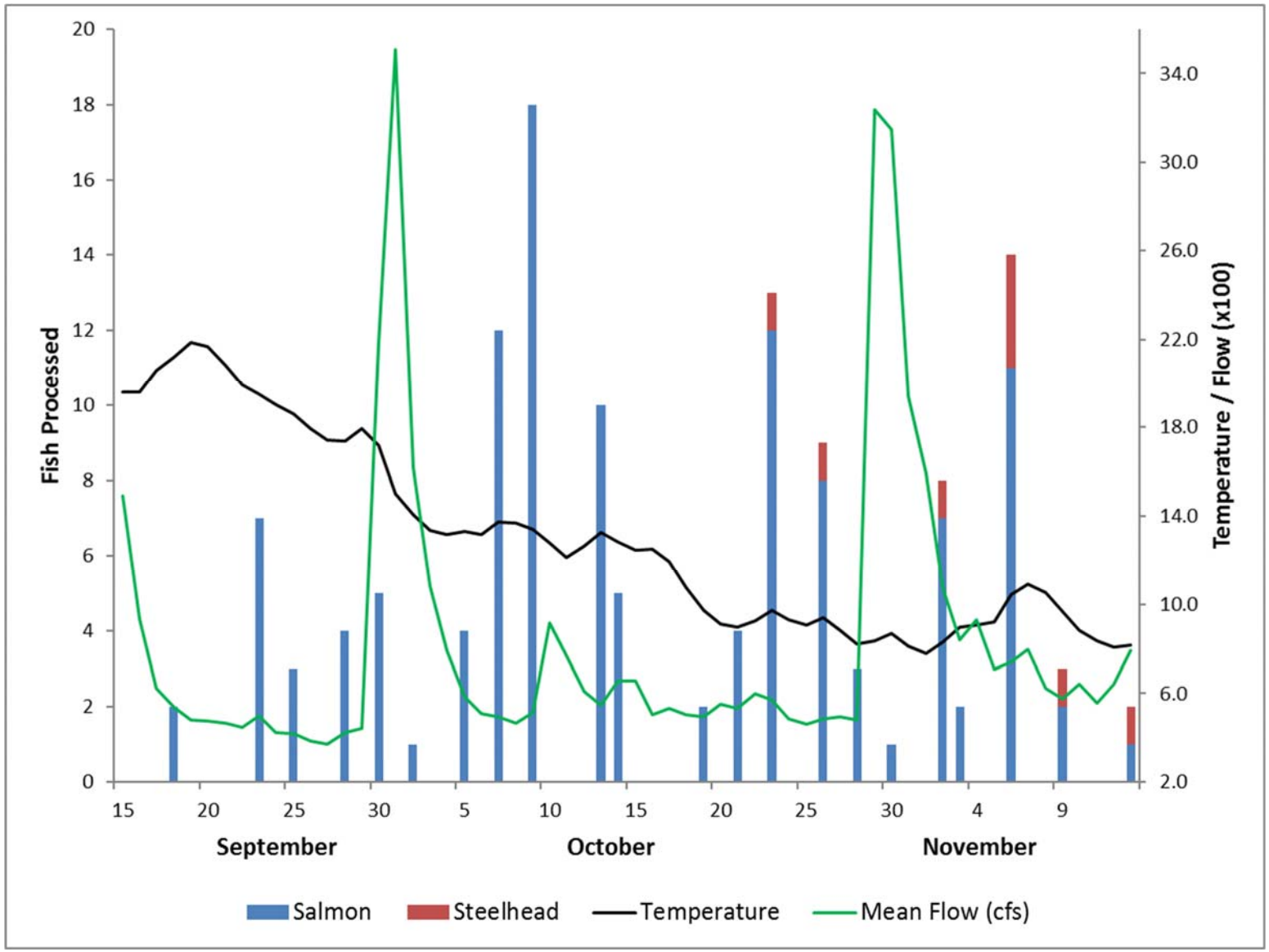

Figure 2. Numbers of new salmon and steelhead processed by date at the Winooski One fish passage facility in fall, 2015.

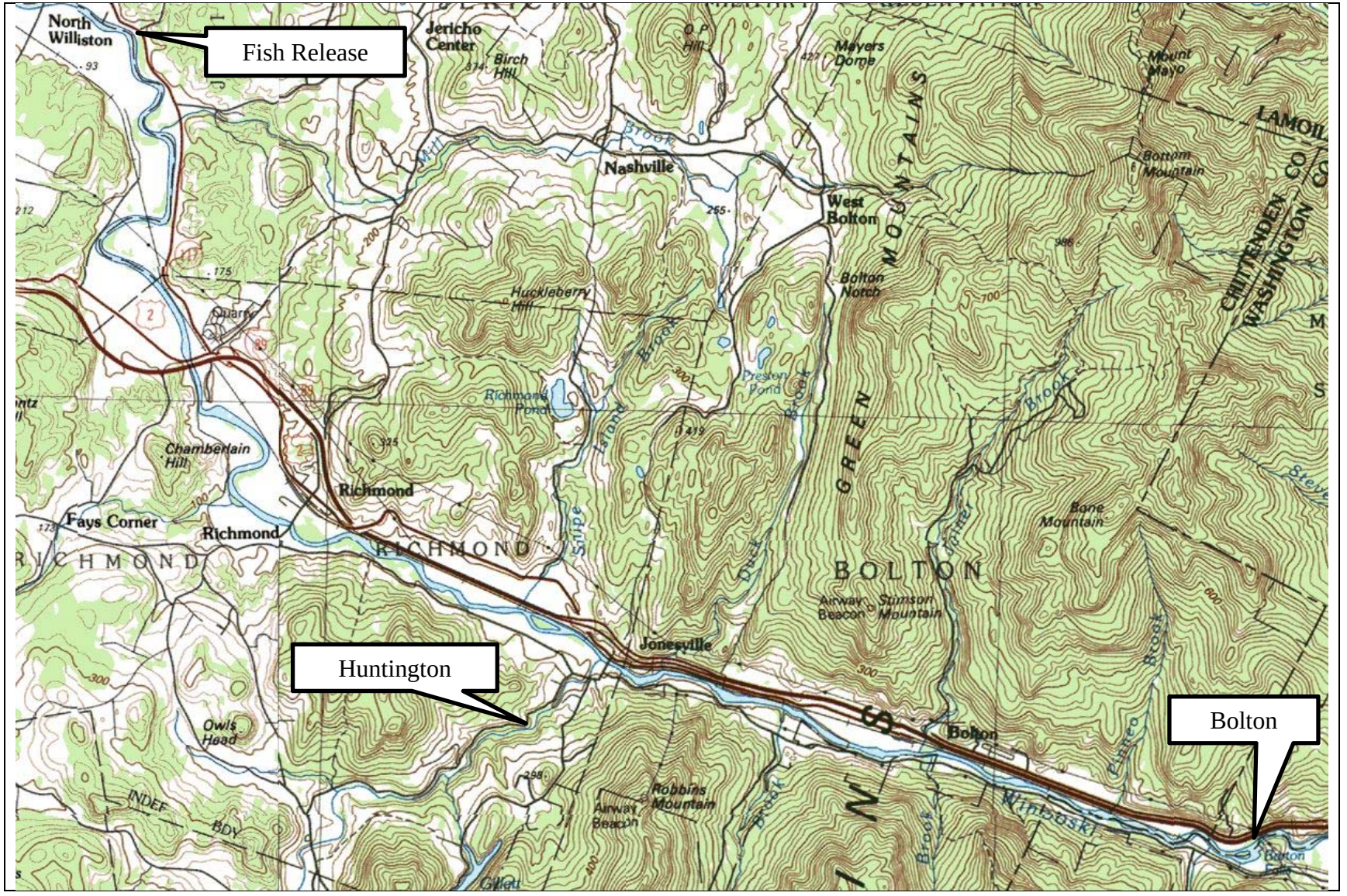

Figure 3. Section of Winooski River where salmon redd searches were conducted in 2015.

Figure 4. Lower Huntington River with salmon redd locations indicated by yellow dots.

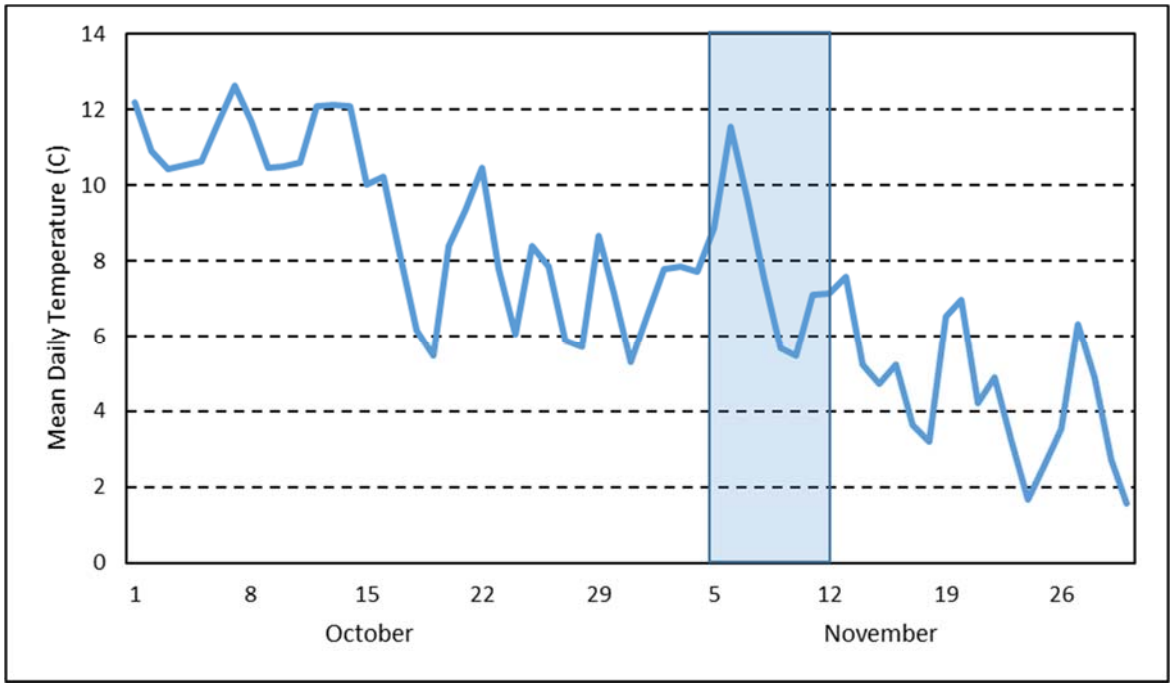

Figure 5. Mean daily water temperature of the Huntington River, October-November, 2015 with period of redd discovery highlighted.

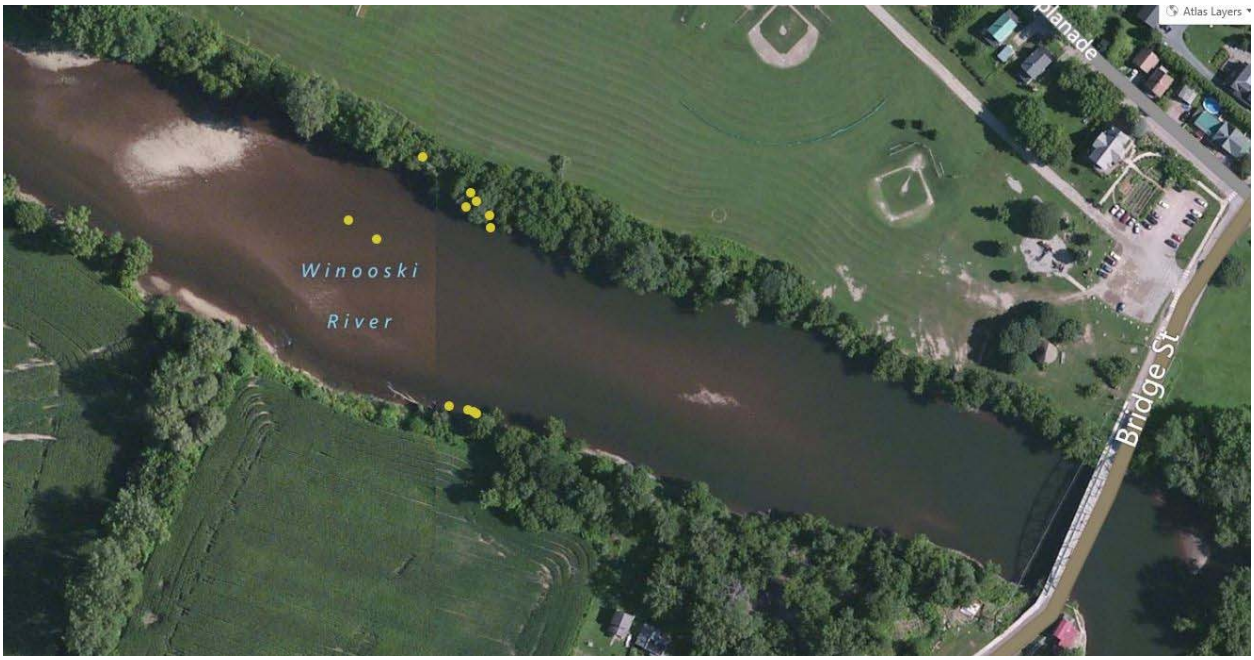

Figure 6. Winooski River in Richmond with redd locations.

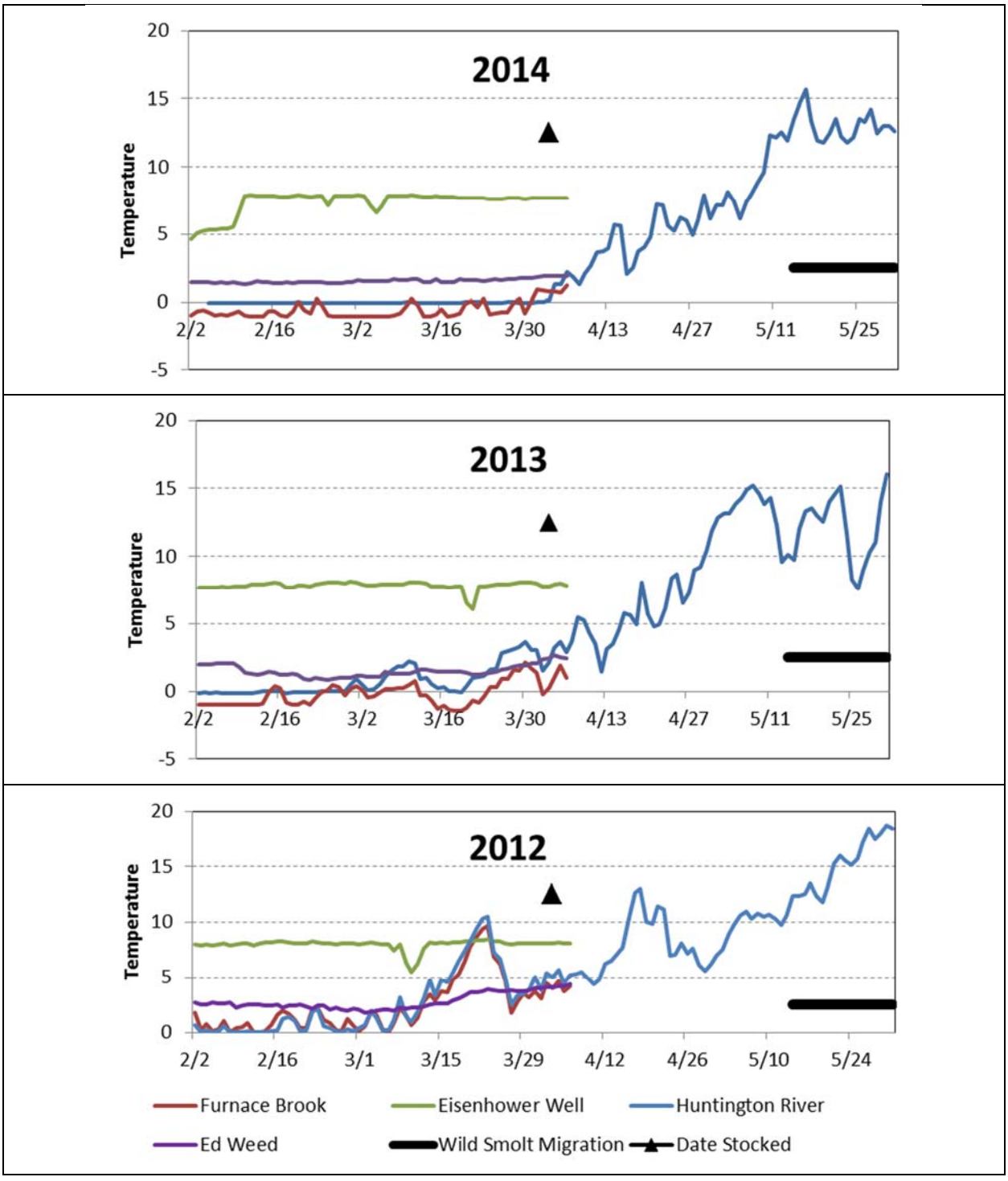

Figure 7. Comparison of mean daily water temperatures in which salmon smolts were raised before stocking. Stocking occurred April 2-4. Wild smolt migration represents that period when 75-80% of wild smolts are captured in the Huntington River smolt trap.

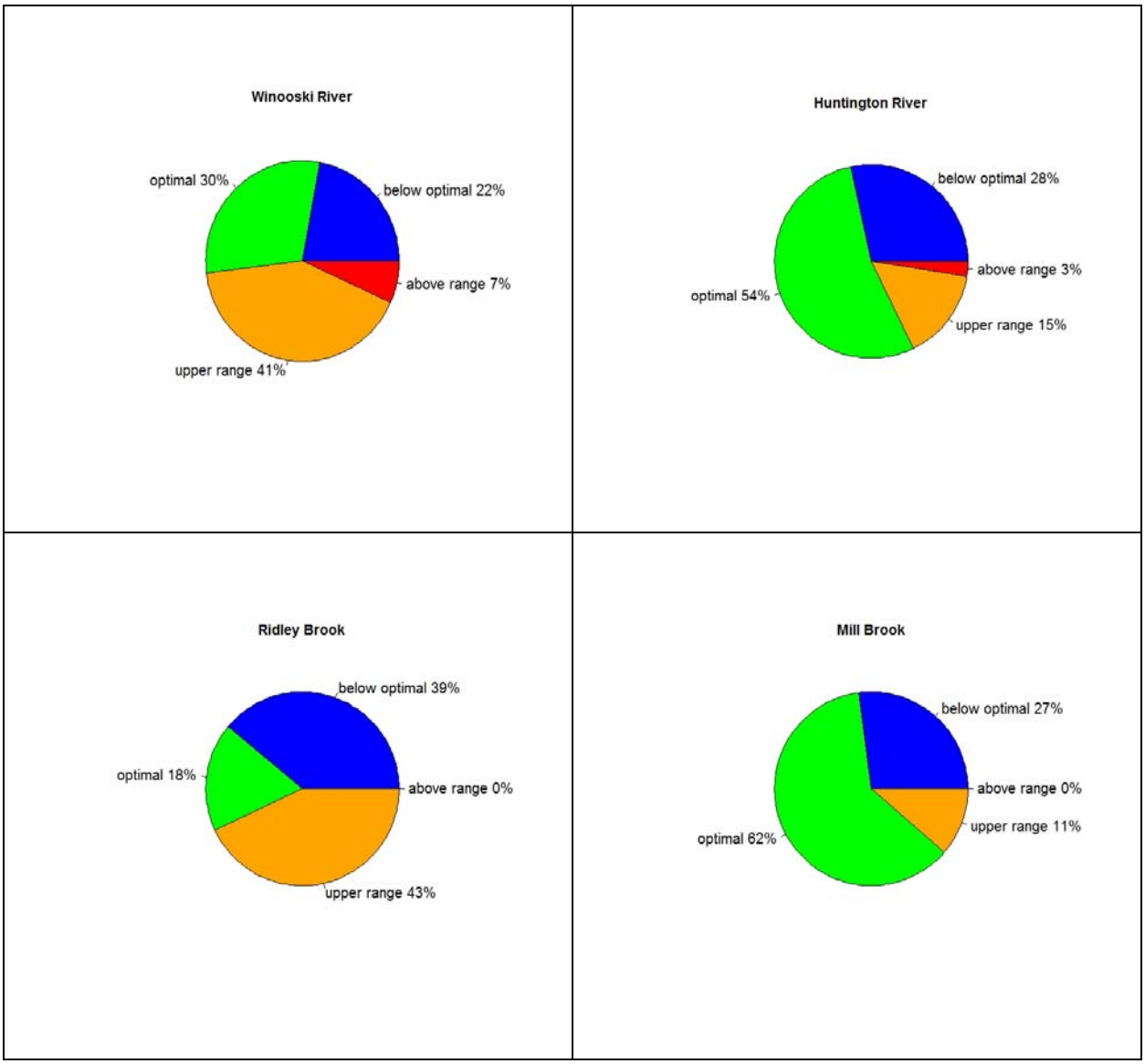

Figure 8. Summary of temperature data collected during the months of May-October in the Winooski River and tributaries in 2015. The Winooski and Huntington River and Mill Brook charts are based on salmon temperature preferences; all others based on brook trout temperature preferences. Winooski River period began July 9, 2015. See text for details.

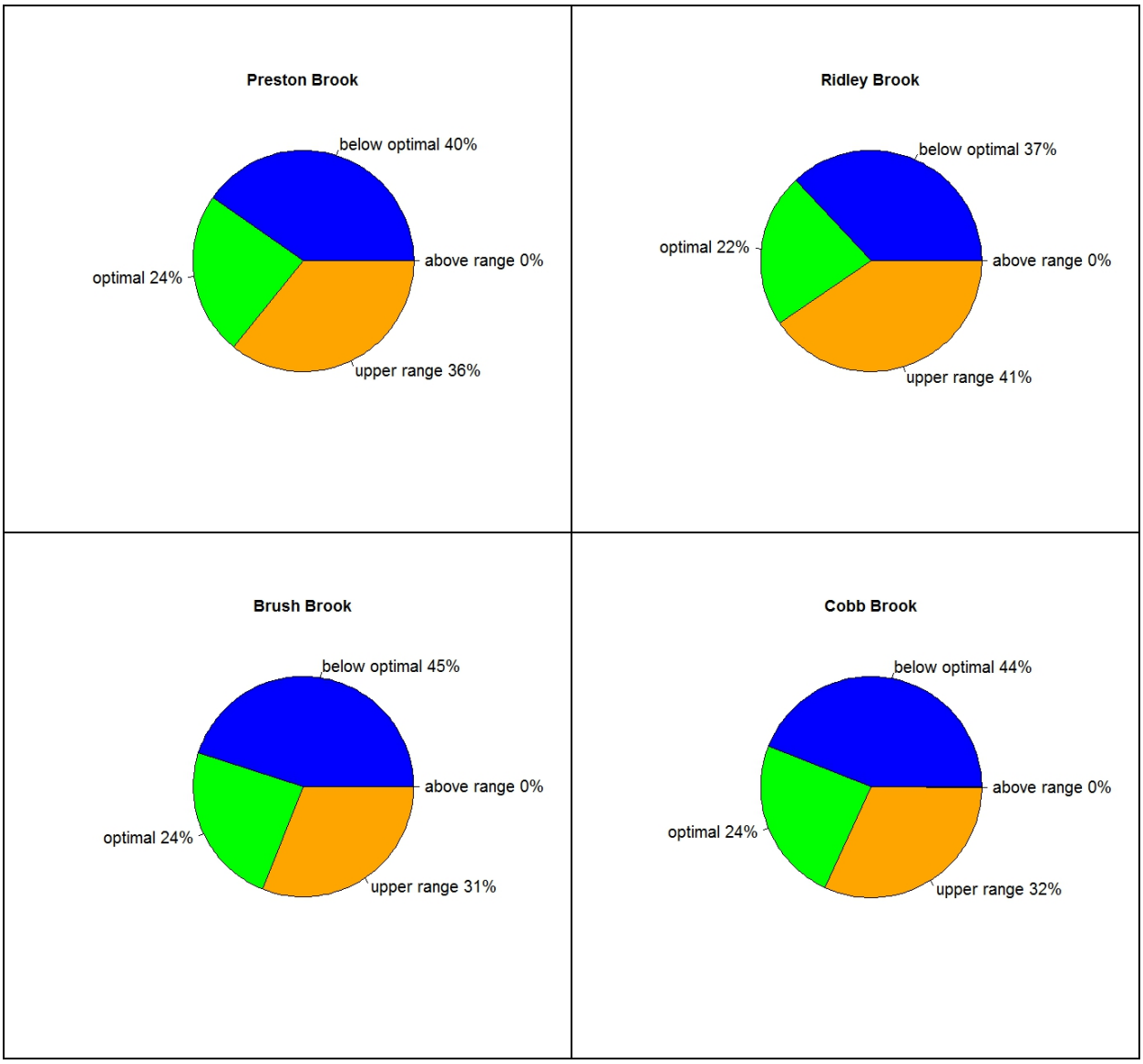

Figure 8. Continued.

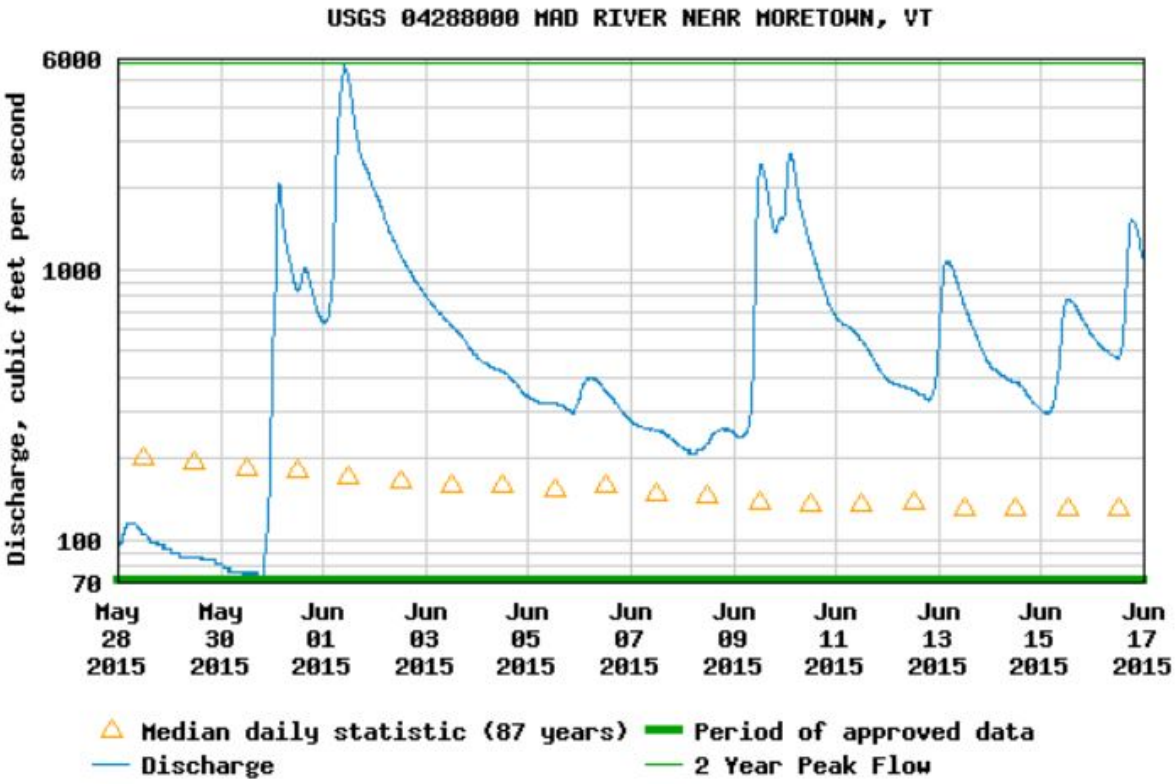

Figure 9. Hydrograph of the Mad River, a tributary to the Winooski River upstream of the Huntington River, showing high water events immediately after fry stocking on May 28, 2015.

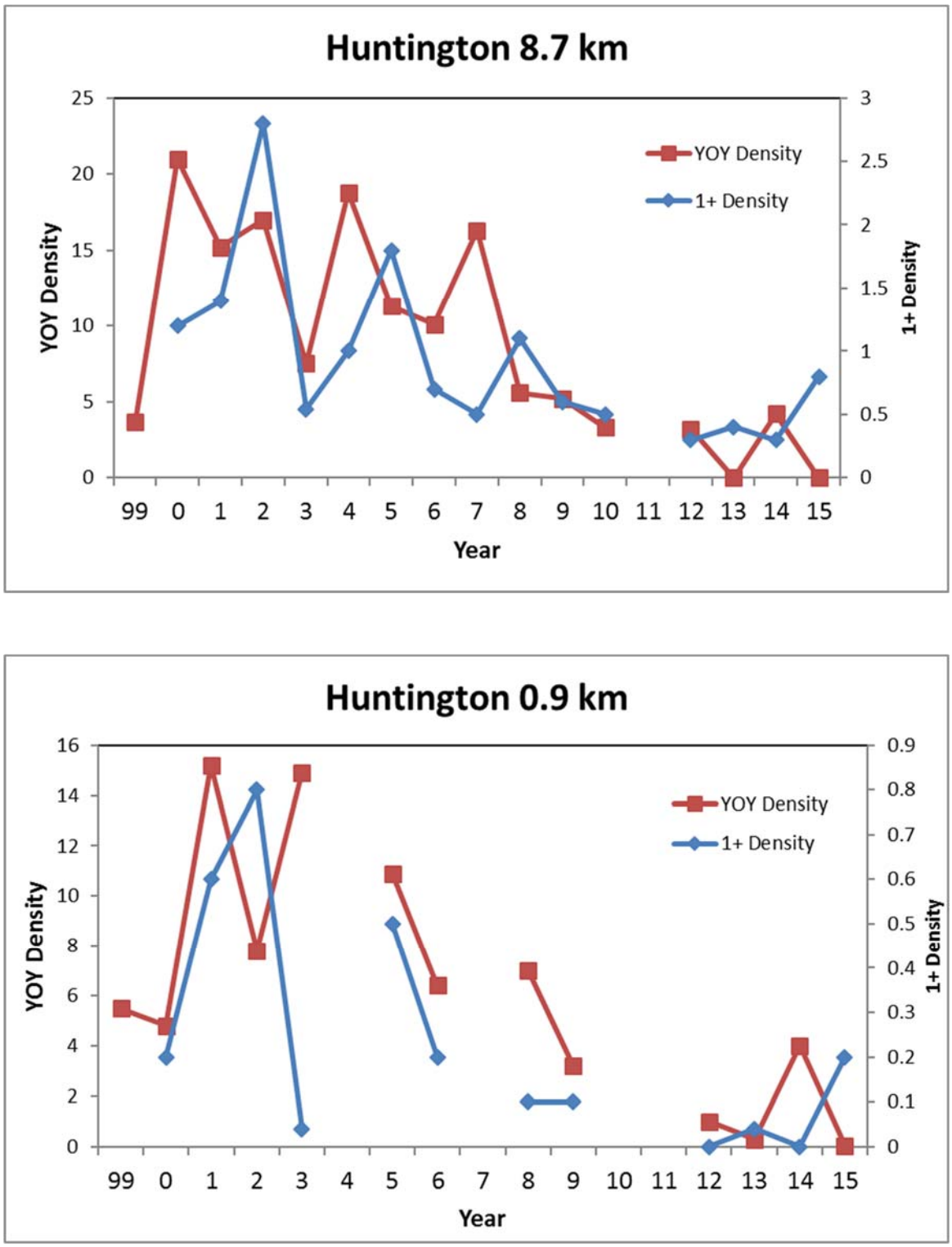

Figure 10. Summary of salmon young-of-year (YOY) and age 1+ density on the Huntington River. The 8.7 km station (2013-2015) also includes the 7.7 km station (1999-2012). Density is number of salmon per 100 square meters.

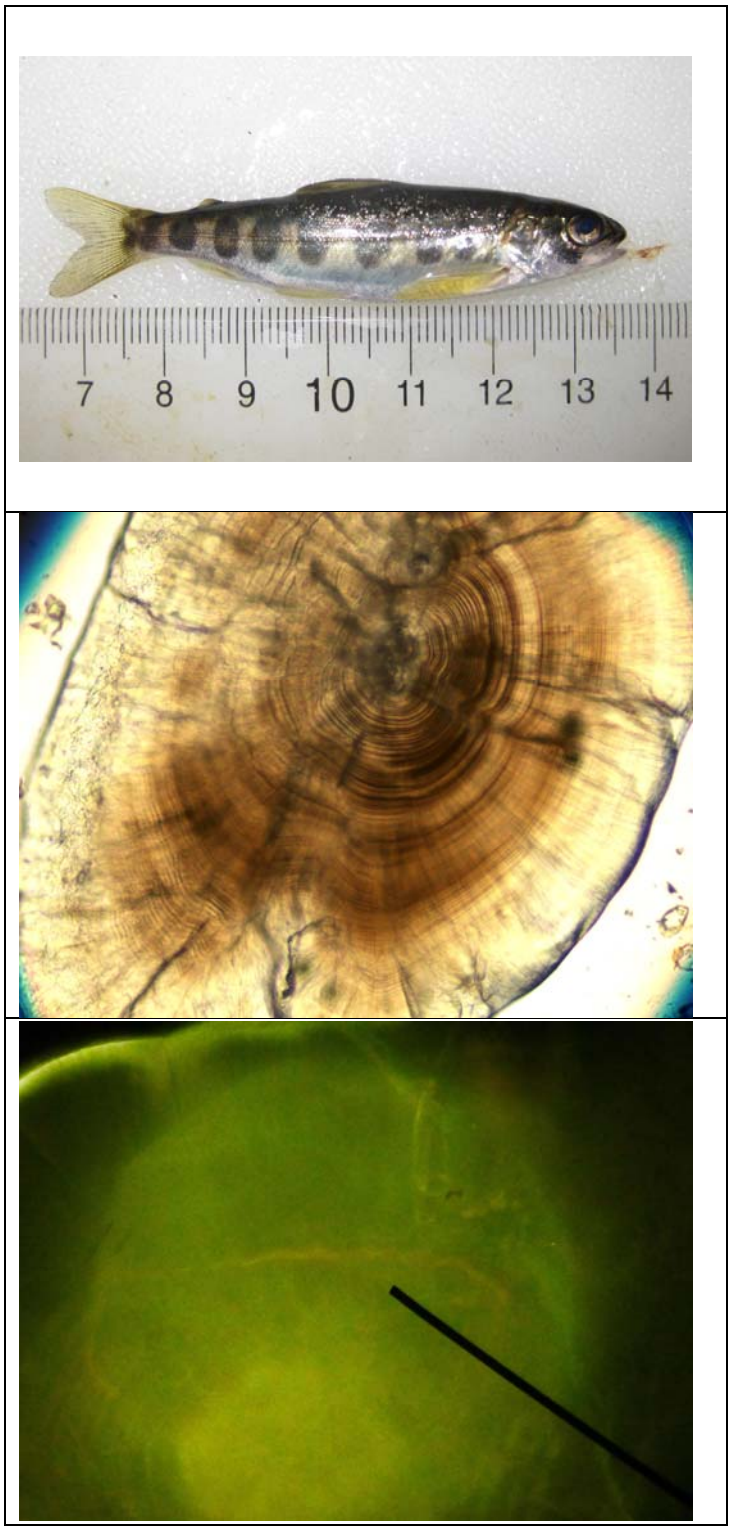

Figure 11. Top: wild salmon parr collected in the Huntington River below gorge. Middle: Prepared parr otolith for OTC check. Bottom: salmon parr otoloth under ultra violet light with OTC mark illuminated.

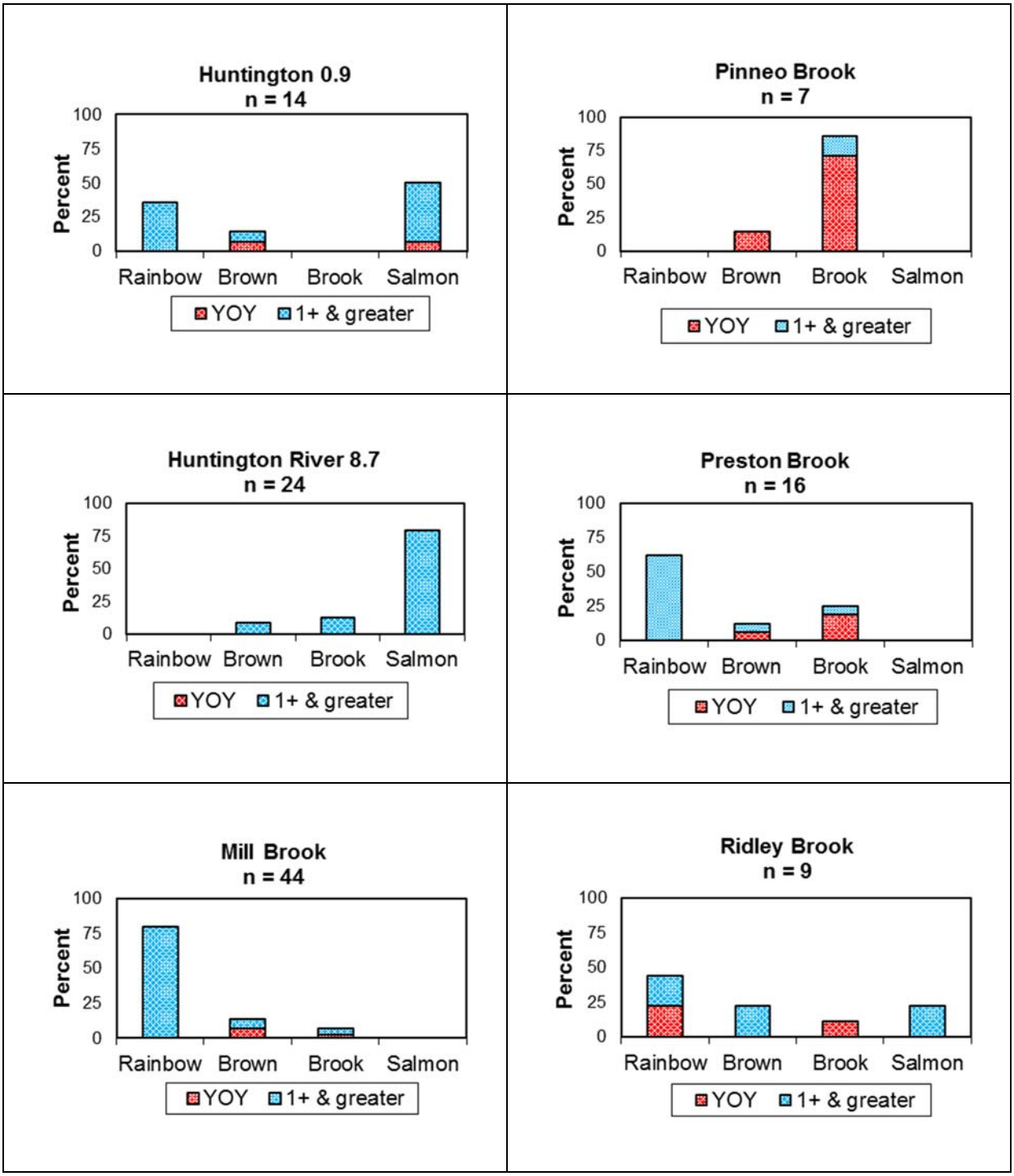

Figure 12. Percent composition of trout and salmon collected by site in 2015.

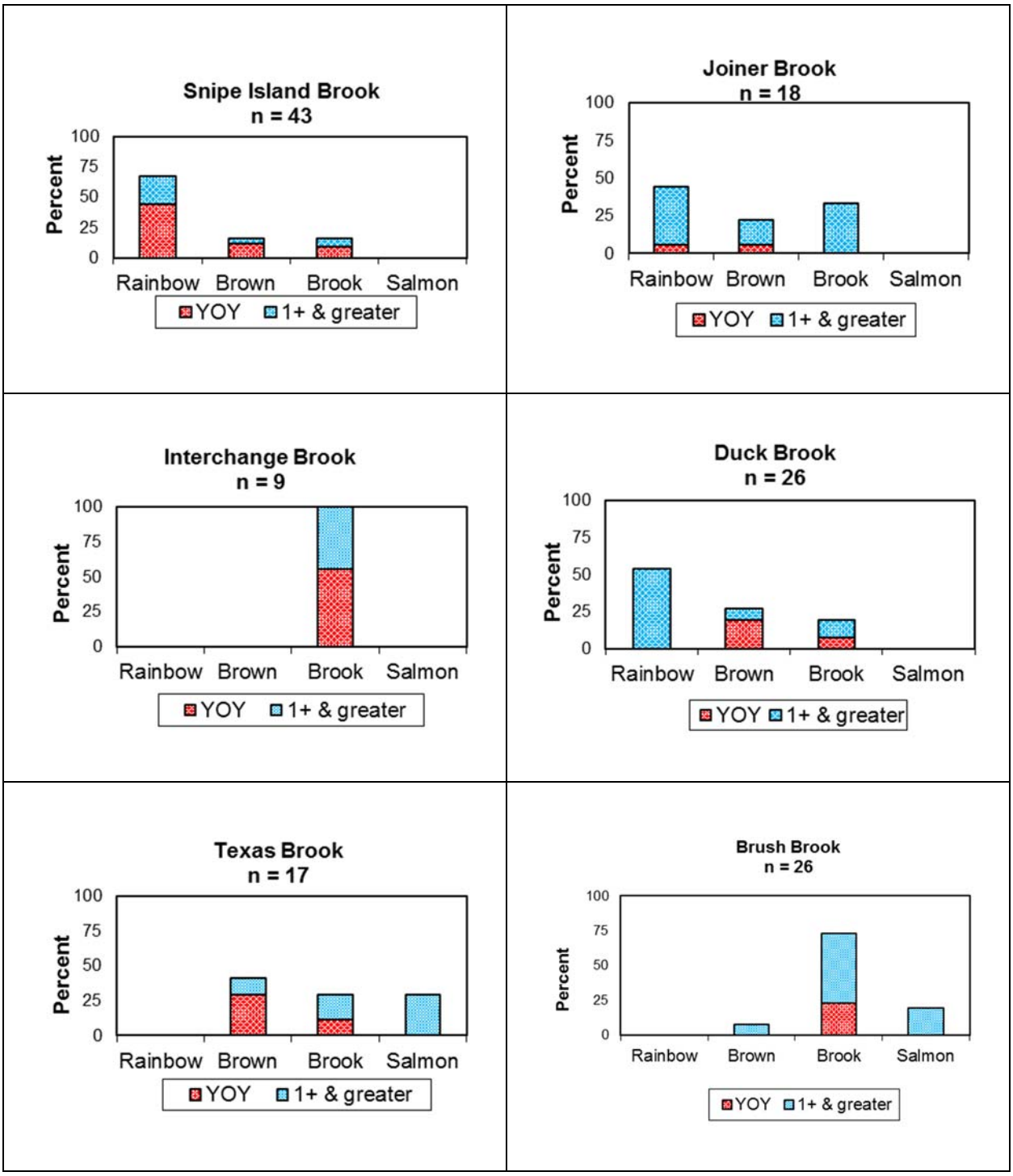

Figure 12. Continued.

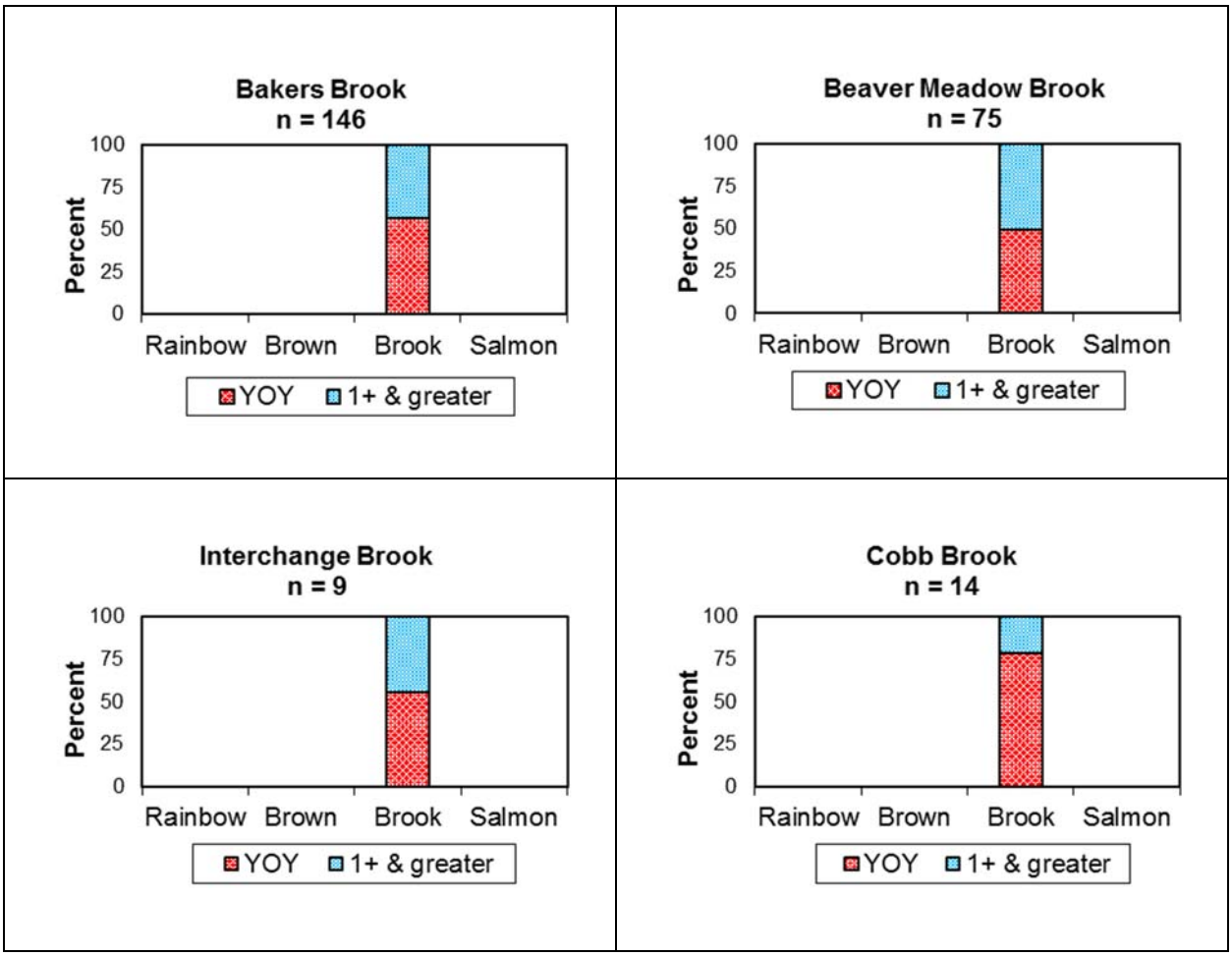

Figure 12. Continued.

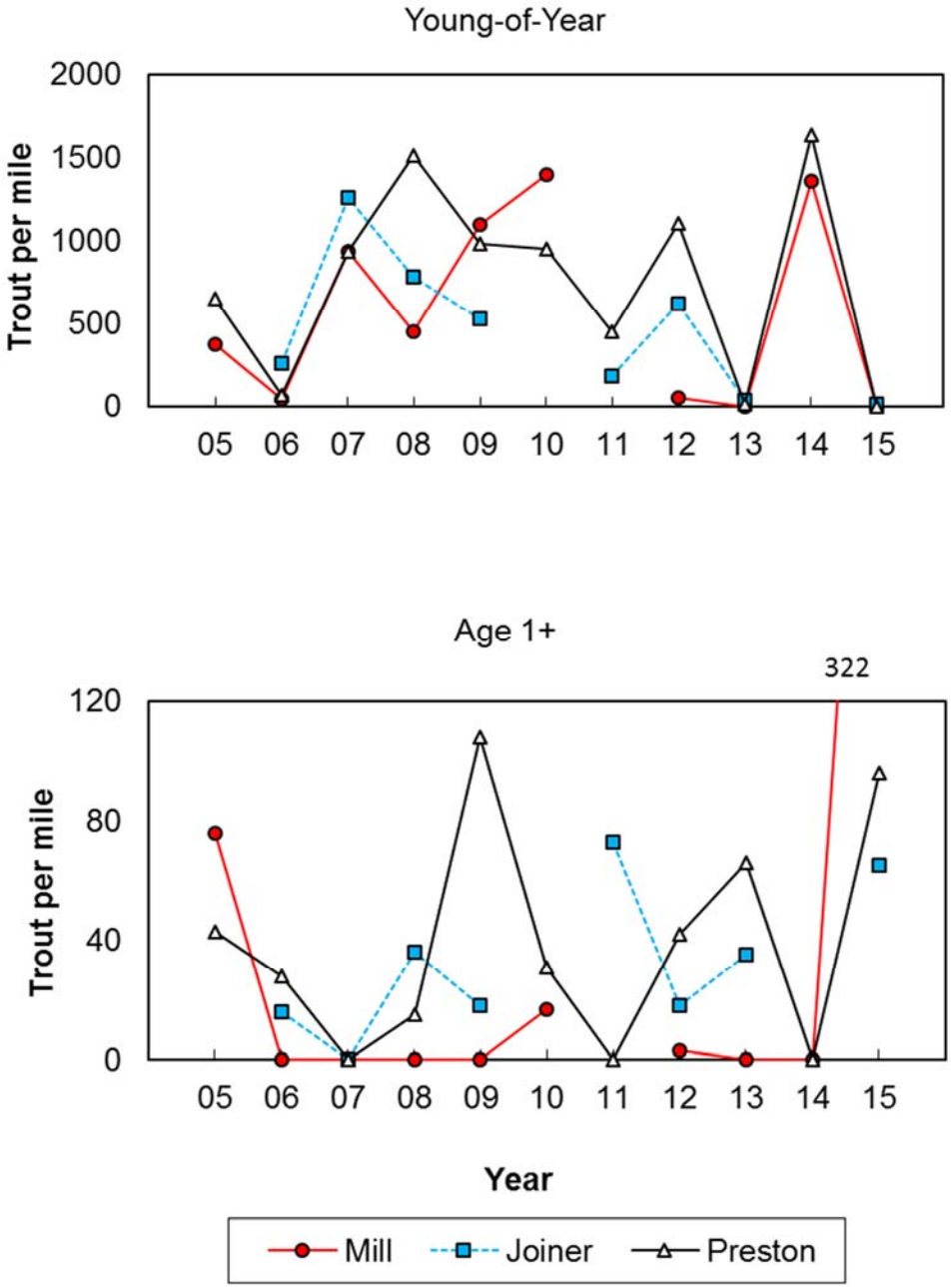

Figure 13. Estimated number per mile of young-of-year and 100-152 mm length class (age 1+) rainbow trout for Mill, Joiner, and Preston Book, 2005 – 2015.

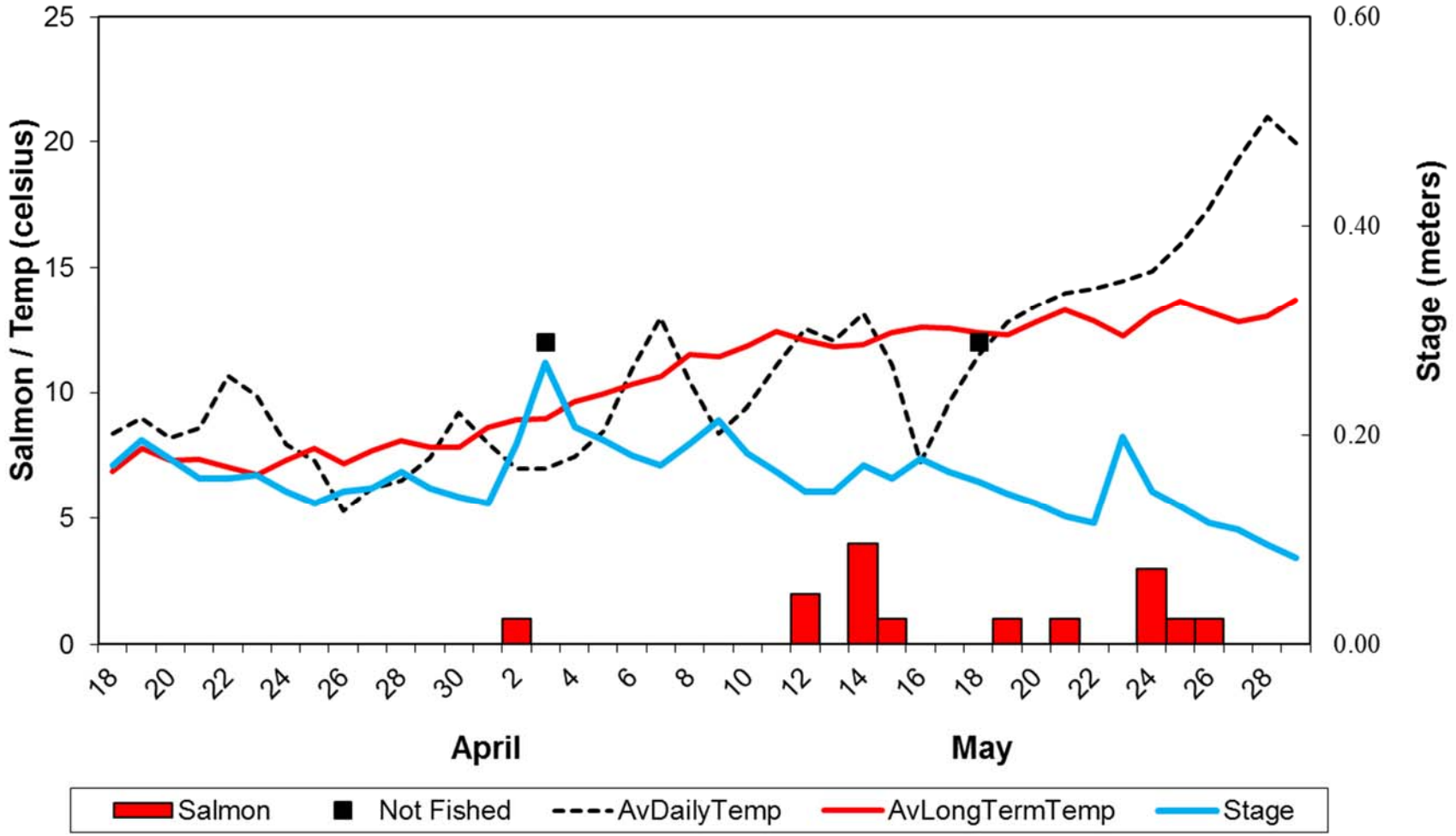

Figure 14. Comparison of stream stage, mean daily stream temperature, mean long term stream temperature (2005-2014) and number of landlocked Atlantic salmon smolts trapped in the Huntington River, 2016

Vermont Fish and Wildlife Department
Annual Report

State: Vermont **Project No**.: F-35-R-18

Grant Title: Lake Champlain Fisheries Restoration and Management

Study No. IV **Study Title:** Salmonid Management

Period Covered: July 1, 2015 to June 30, 2016

Salmon and Steelhead Stocking Evaluations

Two Lake Champlain salmonid stocking evaluations were initiated in 2012. The first evaluation compares the performance of Sebago strain salmon smolts produced from domestic broodstock and feral broodstock collected in assessment sampling. The second evaluation compares the performance of the Chambers Creek and Lake Memphremagog strains of steelhead rainbow trout. The fish were reared at the Ed Weed Fish Culture Station and marked prior to stocking with fin clips specific to each experimental group (Table 1). Stocking of yearling smolts of each species for the evaluation began in spring 2012, and continued annually through spring 2016.

Table 2 summarizes the 2012 through 2015 salmon smolt stocking for the brood source comparison. Table 3 summarizes the 2012 through 2015 steelhead smolt stocking for the strain comparison. Some preliminary findings are presented below.

Salmon from feral broodstock again dominated the 2015 samples from Hatchery Brook, Lamoille River, Missisquoi River, Winooski River, and nearshore areas (Table 4). There was little difference in average lengths of returning salmon from each brood source (Table 4). The dominance of returning salmon from feral broodstock returns has increased through the first four years of the evaluation (Figure 1).

Steelhead returns were very low in fall 2015, with only two fish collected from Hatchery Brook/Cove, and six collected from the Winooski River (Table 5). During the spring 2015 season, over twice as many returning Memphremagog strain steelhead than Chambers Creek strain were captured at the Winooski River fish lift, while the majority captured in the Hatchery Brook trap were Chambers Creek strain (Table 6). Only four steelhead were collected during exploratory sampling in the LaPlatte River and Mill River in spring 2016 (Table 6). No steelhead were collected in exploratory sampling in Lewis Creek in spring 2016. Relative returns of each strain were inconsistent over the first four years of the evaluation (Figure 2).

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August 22, 2016

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Table 1. Experimental groups of landlocked Atlantic salmon and steelhead rainbow trout and corresponding fin clips.

Species	Experimental Group	Fin Clip
Landlocked Atlantic salmon	From domestic broodstock	ADRV
	From feral broodstock	ADLV
Steelhead rainbow trout	Chambers Creek strain	LV
	Lake Memphremagog strain	RV

Table 2. Numbers stocked and average total length (TL) of landlocked Atlantic salmon smolts from domestic and feral brood stocks, 2012-2015.

			Domestic (ADRV clip)		Feral (ADLV clip)	
Year	Location		Number stocked	Ave. TL (mm)	Number stocked	Ave. TL (mm)
2012	Missisquoi River		11,030	196	11,014	203
	Inland Sea		26,400	191-196	26,521	201-208
	Lamoille River		11,000	196	11,121	201
	Hatchery Cove		8,053	196	7,090	203
		Total	56,483		55,746	
2013	Missisquoi River		6,410	191	6,770	180
	Inland Sea		8,132	191-196	9,323	180-196
	Lamoille River		6,410	191	6,770	180
	Hatchery Cove		3,205	191	3,385	180
		Total	24,157		26,248	
2014	Missisquoi River		9,344	176	11,000	181
	Inland Sea		12,950	176-181	12,950	180-181
	Lamoille River		9,039	181	10,000	181
	Hatchery Cove		5,000	181	5,987	180
		Total	36,333		39,937	
2015	Missisquoi River		10,000	180	10,000	182
	Inland Sea		14,000	177-180	16,855	182-183
	Lamoille River		10,000	177	10,000	182
	Hatchery Cove		5,000	180	5,000	182
		Total	39,000		41,855	

Table 3. Numbers stocked and average total length (TL) of Chambers Creek and Memphremagog strain steelhead smolts, 2012-2014.

			Chambers Creek (LV clip)		Lake Memphremagog (RV clip)	
Year	Location		Number stocked	Ave. TL (mm)	Number stocked	Ave. TL (mm)
2012	Mill River		2,250	203	2,250	183
	Hatchery Cove		7,080	198	4,920	180
	Winooski River		11,800	203	4,938	183
	LaPlatte River		1,500	198	1,500	183
	Lewis Creek		8,416	198	8,416	183
		Total	31,046		22,024	
2013	Mill River		2,644	201	2,500	170-178
	Hatchery Cove		6,000	201	6,000	178
	Winooski River		10,000	201-203	10,000	170-178
	LaPlatte River		1,500	201	1,500	178
	Lewis Creek		10,225	203	7,103	178
		Total	57472		27,103	
2014	Mill River		2,750	195	2,750	161
	Hatchery Cove		8,844	195-206	6,000	171
	Winooski River		10,000	199-206	10,000	166
	LaPlatte River		1,500	195	1,500	161
	Lewis Creek		9,176	195	7,218	161
		Total	32,270		27,468	
2015	Mill River		2,500	196	2,500	171
	Hatchery Cove		8,982	196-202	10,068	175
	Winooski River		10,000	196-202	10,000	171-175
	LaPlatte River		1,650	202	1,650	175
	Lewis Creek		9,000	196	9,000	171
		Total	32,132		33,218	

Table 4. Sebago strain landlocked Atlantic salmon from two different brood sources, collected during fall 2015 sampling in Hatchery Brook (including Hatchery Cove), Lamoille River, Missisquoi River, Winooski River, and nearshore areas of Whallon Bay and Willsboro Bay.

	Domestic (ADRV clip)		Feral (ADLV clip)	
Area	N	Ave. TL (mm)	N	Ave. TL (mm)
Hatchery Bk/Cove	216	512	591	511
Lamoille River	37	490	91	490
Missisquoi River	6	464	20	476
Whallon/Willsboro bays	7	556	12	526
Winooski River	2	580	4	532
Total	266	510	718	507

Table 5. Two strains of steelhead collected during fall 2015 sampling in Hatchery Brook (including Hatchery Cove) and the Winooski River.

	Chambers Creek (LV clip)		Memphremagog (RV clip)	
Area	N	Ave. TL (mm)	N	Ave. TL (mm)
Hatchery Bk/Cove	2	486	0	
Winooski River	3	657	3	664
Total	5	588	3	664

Table 6. Two strains of steelhead from spring 2016 sampling in Hatchery Brook, LaPlatte River, and Winooski River.

	Chambers Creek (LV clip)		Memphremagog (RV clip)	
Area	N	Ave. TL (mm)	N	Ave. TL (mm)
Hatchery Bk/Cove	18	478	15	469
LaPlatte River	0		2	479
Mill River	1	556	1	505
Winooski River	7	666	15	665
Total	26	532	33	560

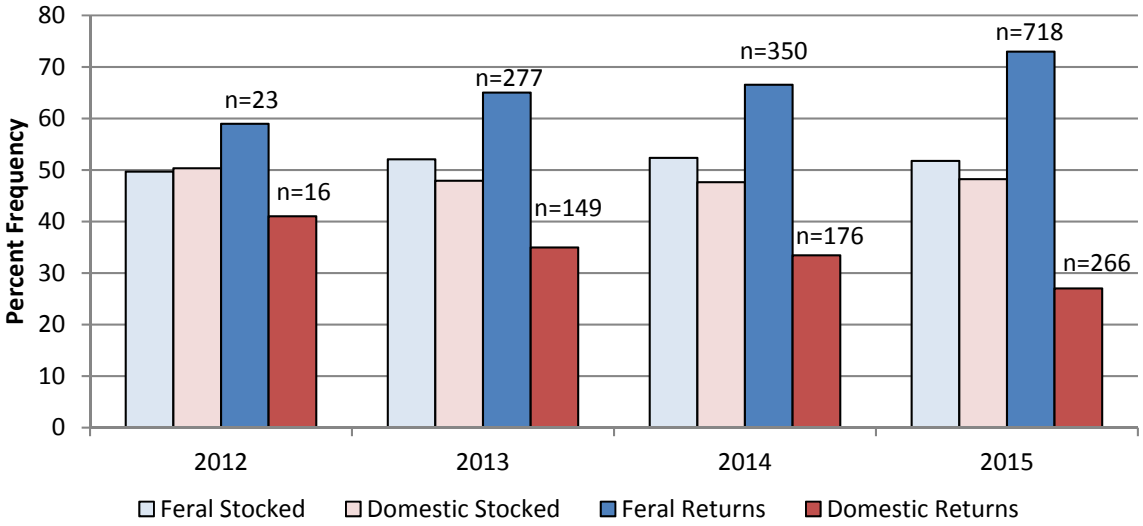

Figure 1. Percentages of Sebago strain landlocked Atlantic salmon smolts stocked from feral and domestic brood sources and percentages of adult returns by brood source, all sites combined.

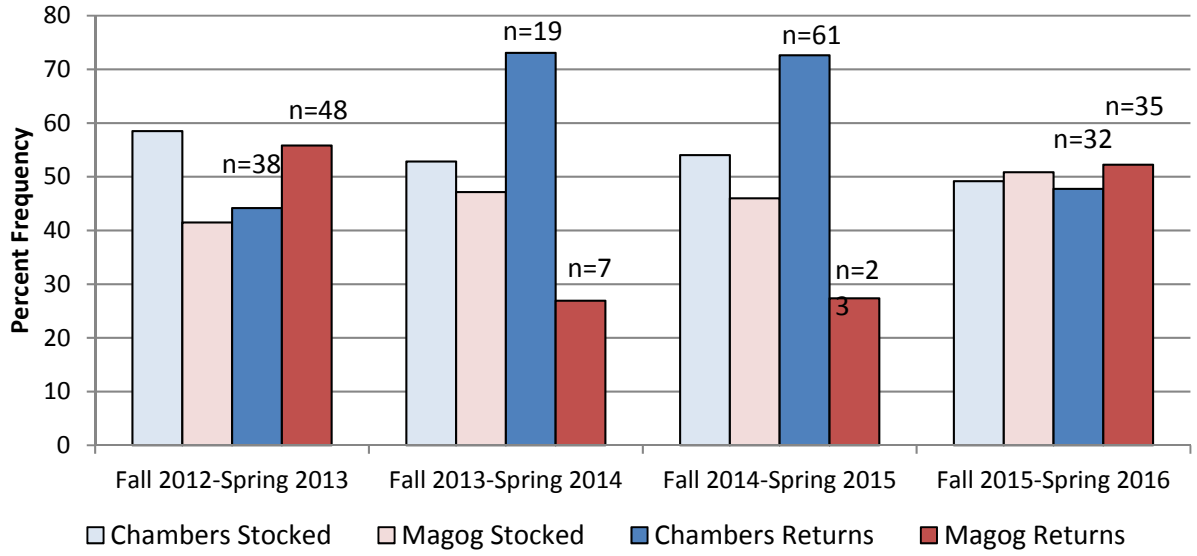

Figure 2. Percentages of Chambers Creek strain and Lake Memphremagog strain steelhead smolts stocked and percentages of adult returns by strain, all sites combined.