REPORT ON ATLANTIC SALMON SMOLT SAMPLING EFFORTS AT MOORE DAM, SPRING 2010

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Final

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EXECUTIVE SUMMARY

The Fifteen Mile Falls Project is a three development hydroelectric project on the upper Connecticut River owned by TransCanada Hydro Northeast, Inc. (TransCanada) and licensed by the Federal Energy Regulatory Commission (FERC, Project No. 2077). The three developments comprising the Project are Moore, Comerford, and McIndoes. The Moore Development is the uppermost of the three located at river mile 283 near the town of Littleton in Grafton County, NH on the west side of the river and Caledonia County, VT on the east side. Having received notification from the Connecticut River Atlantic Salmon Commission (CRASC) of Atlantic salmon (*Salmo salar)* stocking above the Moore Reservoir, TransCanada is required by license to install permanent downstream fish passage at the Moore and Comerford Developments. TransCanada requested and received FERC approval to evaluate the timing and season of stream-reared smolt passage prior to submitting a passage plan for permanent downstream passage. TransCanada constructed an inclined-plane sampler and collection tank in the skimmer gate of the Moore Dam in 2004 as the mechanism to conduct the evaluation.

Since installation, the sampler and collection tank have been monitored annually for seasonal timing and duration of the stream-reared Atlantic salmon smolt migration. In addition, and with FERC and resource agency approval, the effectiveness of the sampler as a downstream passage route has been studied and a series of modifications made to improve its effectiveness. In this seventh year, current inducers were scheduled to be installed in the forebay perpendicular to the centerline of the sampler entrance, and their efficiency assessed with a mark-recapture study using hatchery-reared Atlantic salmon smolts. However, installation of the current inducers was delayed until 11 June, near the end of the smolt migration period. TransCanada decided to continue with the mark-recapture study, though with modifications, because the fish had been reserved for the study, and it was possible the results would provide some valuable information. Hatchery-reared smolts were tagged and released into the reservoir before and after the current inducers were operational, and smolts recaptured in the sampler were enumerated.

The sampler was operated from 14 April to 19 June 2010. Collected salmon were enumerated and live smolts were transported to, and released below the McIndoes Development. A summary of the 2010 results follows.

<u>Stream-reared smolts</u>

- Between 15 April and 19 June, 3,214 stream-reared smolts were collected; the greatest number of smolts collected in one day (N=272) occurred on 21 May. Over 60% of the catch was collected in a two week period between 13 – 27 May.
- There was a strong modality to the passage distribution, peaking in mid-late May. Peak passage days appeared to follow peaking flow days and gradually increasing water temperature (Figures 4-1 and 4-7).
- On most days, the sampler was checked and fish removed from the collection tank three times, in the morning (06:21 – 08:45), afternoon (10:20 – 14:50) and evening (15:02 – 19:18). Catch-per-unit-effort (CPUE) was highest (2.48 smolts/h, SD=2.01) during the morning collection, and lowest (0.55 smolts/h, SD=1.18) during the afternoon collection (Table 4-1). Overall CPUE was 2.07 smolts/h (SD=4.55).
- Mortality was 0.8%, the lowest to date. Low mortality was likely due to three factors, 1) the reservoir remained slightly below normal elevation, reducing debris load in the reservoir, 2) the effectiveness of the trash boom at limiting debris build-up on the sampler, and 3)reduced handling of smolts during collection and transport to the McIndoes Development.

<u>Hatchery-reared smolts</u>

- Due to delays, the current inducer fish guidance system was not installed until 11 June, near the end of the smolt migration period.

- Control fish (N=333) were released on 10 May, before the current inducer fish guidance system was installed, 66 (19.8%) were collected in the sampler after an 8-day monitoring period.
- Test fish (N=408) were released on 11 June, after the current inducer fish guidance system was installed, 58 (14.2%) were collected in the sampler after an 8-day monitoring period.
- Gill samples were collected from 12 hatchery fish on 10 June and analyzed for Na/K-ATPase activity. Results suggest that test fish released on 11 June had or were in the process of reverting to parr.
- Tag-recapture results suggest the current inducer fish guidance system did not improve passage to the fish sampler; however, the late release date for test fish was expected to strongly influence the results. Results of the Na/K-ATPase analysis confirms that results for the test fish are invalid because these fish had reverted to parr before release.
- Further evaluation of the current inducer fish guidance system should be conducted.

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

ºC	degree Celsius
CFD	computational flow dynamics
cfs	cubic foot per second
CPUE	catch-per-unit-effort
CRASC	Connecticut River Atlantic Salmon Commission
FERC	Federal Energy Regulatory Commission
FMF	Fifteen Mile Falls
ft	foot
gal	gallon
h	hour
mi	mile
msl	mean sea level
NH	New Hampshire
NHFG	New Hampshire Fish and Game Department
Sample event	Brief period of time when water conveyed from the Moore Dam sampler to the collection tank was shut-off and fish were retrieved from the collection tank for processing.
Sample period	Time between sample events when the sampler was operating.
smolts/h	smolts per hour
TransCanada	TransCanada Hydro Northeast, Inc.
TL	total length
VT	Vermont
VTDFW	Vermont Department of Fish and Wildlife
USFWS	United States Fish and Wildlife Service
USGenNE	USGen New England, Inc.
USGS	United States Geological Survey

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fry smoltify in approximately two years, salmon fry stocking numbers from 2003-2008 are compared with 2005-2010 production estimates and the number of smolts collected in the sampler.

1.0 INTRODUCTION

The Fifteen Mile Falls Project (FMF) (FERC Project No. 2077) is a three development hydroelectric project on the upper Connecticut River (Figure 1-1) owned by TransCanada Hydro Northeast, Inc. (TransCanada). The Federal Energy Regulatory Commission (FERC) approved a transfer of ownership to TransCanada from USGen New England on 24 January 2004. The three developments comprising the project are Moore, Comerford, and McIndoes. Moore Dam, the upper most development, is located near the town of Littleton in Grafton County, NH and Caledonia County, VT (Figure 1-2).

The FERC issued a license renewal for continued operation of the Moore Development on 8 April 2002. Article 410 of the license required that within 180 days of being notified by the NH Fish and Game Department (NHFG), the Vermont Department of Fish and Wildlife (VTDFW), and the U.S. Fish and Wildlife Service (USFWS) that an Atlantic salmon (*Salmo salar*) stocking program had been initiated upstream from the Moore Reservoir and that such passage facilities are needed at the developments, the licensee must file, for FERC approval, a plan for the construction, operation, and maintenance of permanent downstream fish passage facilities at the Moore and Comerford developments. TransCanada received a request from the Connecticut River Atlantic Salmon Restoration Commission (CRASC) on 4 November 2002, to install downstream passage facilities at the two developments. In a letter to FERC dated 18 September 2003, TransCanada indicated there was a lack of sufficient information to adequately provide and construct such facilities and therefore requested a deadline extension for filing a plan in response to the CRASC letter. TransCanada filed a plan on 15 December 2003, which met FERC approval through the Commission Order issued 18 March 2004. In the Order, FERC approved a two-year study plan to evaluate the timing and season of smolt passage before filing a fish passage plan. TransCanada proposed to evaluate and characterize smolt downstream passage by constructing an inclined-plane sampler and collection tank in the skimmer gate of the Moore Dam. NHDES, as part of its 401 Water Quality Certificate, also approved the extension on the passage plan requirement but only authorized a one-year extension, noting that additional extensions could be sought by TransCanada.

Consultation with agencies resulted in a plan of study for a minimum two-year evaluation, with the second year contingent upon approval from the agencies. The first year of study was conducted in 2004 and evaluations have continued through 2010 with agency approval granted prior to each year of study. The primary goals each year have been to qualify the seasonal timing of the downstream migration of stream-reared Atlantic salmon smolts and to quantify the number passing the development. These goals were met during each year of study except the first. In 2004 the sampler was not opened until mid-May when construction was completed. Daily passage numbers through June suggested that the migratory run started before the mid-May opening.

A secondary goal has been to manipulate and evaluate the attractiveness of the sampler as a downstream passage route for Atlantic salmon smolts, including assessing smolt behavior in the vicinity of the skimmer gate entrance. Mark-recapture techniques were used in 2004, 2005, 2006 and 2010. Radio telemetry tracking also was conducted in 2005 and acoustic telemetry was used in 2007 to assess behavior near the skimmer gate. Hatchery-reared Atlantic salmon smolts were used as proxy to stream-reared fish in each year except 2007. In 2007, a sub-set of stream-reared smotls removed from the sampler collection tank were used in lieu of hatchery fish because the hatchery fish were suspected of having reverted to parr.

This year current inducers were scheduled to be installed in the forebay to create flow patterns intended to direct smolts to the sluice gate entrance. Previous telemetry studies showed that while a majority of tagged smolts approached the Moore Dam and skimmer gate, many wandered near the dam but never enter the skimmer gate. This suggested that surface flow strength or direction was not sufficient for smolts to cue to the skimmer gate entrance. Computational fluid dynamics (CFD) modeling of the forebay suggested that surface currents could be created to guide smolts to the skimmer gate. The current inducers were installed, but late in the smolt migration season. The effectiveness of the current inducers was tested using two groups of hatchery-reared Atlantic salmon smolts that were tagged, released in the reservoir and recaptured in the sampler. A control group was released before the current inducers were installed and a test group was released after the current inducers were installed.

2.0 PROJECT DESCRIPTION

2.1 Moore Development

The Moore Development is located at river-mile 283.5 on the Connecticut River and includes an 11-mi-long reservoir with a surface area of 3,490 acres and 223,722-acre-ft of gross storage at a normal maximum operating level of 809 ft msl. The earthen and concrete gravity dam is 2,920 ft long, 178 ft high, and consists of a 373-ft-long concrete spillway with a 15-ft-wide by 20-ft-high sluice gate, four stanchion bays, three Tainter gate bays and a powerhouse with four Francis type turbine-generator units. The turbines have a combined power rating of 225,600 hp under a design head of 150 ft and a combined rated discharge of 13,300 cfs (FERC 2002). Maximum head and turbine discharge are 158 ft and 18,300 cfs, respectively and runner speed of the turbines is 128 revolutions per minute (NEP 1996).

The Moore Development operates as a daily peaking station and passes discharge directly into the Comerford Development reservoir. Elevation changes in Moore Reservoir average approximately 1 ft per day and generally have approached the normal operating level (~el. 804 – 806 ft msl) by mid-May (NEP 1996). This year the elevation was maintained slightly lower than in previous years due to investigations and maintenance work conducted on the earthen embankment portion of the dam. The license provides for 320-cfs-year-round minimum flows (NEP 1997).

2.2 Moore Dam Skimmer Gate and Sampler

An inclined-plane sampler was installed at the skimmer gate during early 2004 and has since been monitored for salmon smolt passage (Normandeau Associates, Inc. 2005, 2006, 2007, 2008, 2009). The inclined plane sampler was 14.5 ft wide and consisted of two sections connected on a pivot (Figure 2-1). The front section, connected to the dam horizontally, was approximately 9 ft long by 14.5 ft wide; the elevation was adjustable but the plane surface was not and remained horizontal at all times. The rear section was approximately 21 ft long by 14.5 ft wide and pivoted at its junction with the front section. The angle of the rear section to the front section was adjustable to optimize the amount of dewatering as flow passed over the screen. The surface of both sections was designed to dewater the discharge through the skimmer gate, and was made of 1.25-in by 0.375-in aluminum bars placed parallel to one another to create a gap (Figure 2-2). The gap width was originally set at 3/16 in 2004 and was not changed. A flow guidance structure was built on top of the front section screen to facilitate even flow and proper velocity across the downstream end of the screen (Figure 2-2).

At the end of the inclined plane screen is an angled, fabricated metal trough with solid sides that connects to a 12-in-diameter discharge pipe (Figure 2-2). The discharge pipe conveys water from the trough to the collection tank. The collection tank is a 4-ft deep, 8-ft by 4-ft-rectangular open-topped metal box. Perforations around top sections of the tank and an adjustable drainage valve at the bottom provided circulating water through the tank and a pre-determined water depth. A 55-gal drum affixed to a monorail system was available to transport fish from the collection tank to a processing area on the headworks of the dam (Figure 2-2).

Modifications were made to the sampler prior to 2005 and 2006 passage seasons to improve the effectiveness and efficiency of the sampler to attract and pass salmon smolts. Modifications made prior to the 2005 monitoring season were as follows:

- The sampler discharge pipe was moved from the wall to the floor of the trough, reducing the amount of time fish spent in the trough; and,

- A fixed netting structure was added to two sides of the collection tank and additional netting added mid-season to keep fish from jumping out of the collection tank or splashing out when conveyed through the pipe.

Changes made prior to the 2006 monitoring season included:

- A 14.5 ft by 25 ft wooden attraction flow shelf was submerged approximately five feet below the water surface at the entrance of the skimmer gate to extend the flow-net range into the forebay (Figure 2-3); and,
- A specially designed trash boom was anchored around the skimmer gate entrance to deflect large debris from the sampler (Figure 2-3).

In 2009 a guide net was installed in the forebay in an effort to improve guidance of Atlantic salmon smolts into the sampler. The guide net was installed again for the 2010 season. TransCanada installed the net perpendicular to the centerline of the sampler entrance. The net was constructed of 3/8-inch diagonal knotless nylon mesh, and was 25-ft deep by 100-ft long. The net was installed just upstream of the sampler entrance, extending perpendicularly into the reservoir (Figure 2-4). The net was deployed approximately 2 ft below the water's surface to avoid the majority of surface debris and attached to the trash boom at the upstream end of the net. The downstream end of the net was set just upstream of the attraction flow shelf (Figures 2-4).

This year, two overhead lights were installed near the fish sampler. One, a 400w high pressure sodium light, was positioned on the face of the dam to project light into the forebay at the entrance to the fish sampler, the other, a 400w metal halide flood light was located on the ceiling of the fish sampler entry way to illuminate the tunnel-like passage area.

A targeted discharge not-to-exceed 500 cfs for downstream passage onto the fish sampler has been in place since 2004 and continued in 2010. Discharge rate was maintained by manually adjusting the skimmer gate to within approximately one-foot of pond elevation changes.

3.0 MATERIALS AND METHODS

3.1 Moore Dam Sampler

The sampler was monitored during each day of operation. A sampling event entailed raising the lower screen section, allowing the collection tank to drain, and dip-netting all fish out of the tank. After all fish were removed, the lower screen section was lowered to allow flow to the collection tank. Fish were put in 5-gal buckets half filled with water and carried to the processing area located on the headworks of the dam, or transported to the headworks via the monorail system and a 55-gal drum half filled with water. As in past years, the physical condition of each salmon smolt was noted in accordance with a coding system developed for the evaluation (Table 3-1). Smolts were handled as little as possible and were only handled individually after the tagged hatchery fish were released. Individual hadling was often necessary to determine if a fish was tagged. Therefore, only gross physical condition observations were made. All live salmon were transported below the FMF Project and released in the tailwaters of the McIndoes development. Scale samples were taken from stream-reared salmon smolts that died during the evaluation. Resident fish removed from the collection tank were identified to species, enumerated, surveyed for gross injuries, and returned to Moore Reservoir.

During each sampling event, operation conditions such as pond elevation, skimmer gate position, position of the upper sampler section, and the station operator's expectation of pond fluctuation before the next collection were recorded. Sampling period (period of time the sampler was operating between sampling events) also was recorded. Adjustments to the lower sampler section were made by Normandeau personnel when necessary. Adjustments to the skimmer gate, upper sampler section, and collection tank platform, were made by TransCanada employees. Fluctuation in the reservoir elevation of approximately 1 ft necessitated a gate adjustment, after which, the upper sampler, lower sampler, and collection tank platform were adjusted accordingly.

3.2 Current Inducers

TransCanada contracted Lakeside Engineering to install a current inducer fish guidance system in the forebay of the Moore Development. Preliminary sizing and location of the current inducers required to create guiding currents to the bypass was based on a CFD model of the site with turbine flows, created by Alden Labs. Lakeside Engineering provided flow curves for different available current inducers which were input into the model in order to determine their suitability. From this model, TransCanada decided to install a total of five (5) near-dam current inducer units. Four units were installed along the dam (units 1 through 4, starting on the NH side), and one unit was installed 75 ft upstream of the skimmer gate entrance (unit 5) (Figure3-1). Units 2, 3 and 5 were 4 HP units, and units 1 and 4 were 15 HP units. After the sampler was closed for the season, TransCanada decided to augment the 5 units with 2 additional units (units 6 and 7) further upstream to create a larger influence field. Design and installation specifications for the current inducer fish guidance system are provided in Lakeside Engineering's report to TransCanada (Lakeside Engineering 2010).

The effectiveness of the current inducer system was to be evaluated by mark-recapture methods. Four release groups of up to 250 tagged hatchery smolts were to be released after the current inducers were installed. The ratio of the number of tagged smolts collected to the number of tagged smolts released was to be used as a measure of bypass effectiveness, with those data assessed relative to the ratio of tagged smolts collected in previous years (i.e., the number of smolts passed with current inducers vs. the number of smolts passed without current inducers). However, installation of the current inducers was delayed, necessitating revision to the study plan. Proposed revisions were discussed with USFWS, VTDFW and NHFGD. The final plan, pending installation of the inducers by the week of 7 June, was to release half of the hatchery smolts before the current inducers were installed (control fish) and the other half after installation (test fish). The number of control fish passed, within a defined period of time, would be compared with the number of test fish passed within the same period of time. All parties acknowledged that hatchery smolts released late in the season, particularly the test fish released after the current inducers were installed, might not respond to emigration cues in the same way that early run smolts respond, and that some of the late released smolts might revert to parr. The current inducers were installed and running by 13:30 on 11 June. Therefore, the revised study plan was followed. All tagged fish collected from the sampler were enumerated and released below the McIndoes development.

The parr/smolt status of the test fish was examined by Dr. Steve McCormick of the Conte Anadromous Fish Research Center. Gill biopsy's were collected from 12 hatchery fish on 10 June and packed in dry ice for transport from the hatchery to the Conte Lab. Dr. McCormick analyzed the samples for Na/K-ATPase enzyme activity.

3.3 Hatchery-Reared Fish Procurement Tagging and Release

Hatchery-reared fish were obtained from the USFWS Dwight D. Eisenhower National Fish Hatchery in Pittsford, VT. Smolts were handled as little as possible to minimize stress related to tagging. Smolts were selected for size (>140 mm total length, TL), anesthetized in a 40 mg/L solution of buffered tricane-methanesulfonate (MS-222) and measured for total length (mm). Fish were tagged with Northwest Marine Technology, Inc. colored visual implant elastomer (VIE) behind each eye. Control fish were tagged with red VIE and test fish were tagged with yellow VIE.

Hatchery fish were transported in 180-gal-aerated tanks, to circular holding tanks on the headworks of the Moore Development. After transport, fish were acclimated to within 2°C of Moore reservoir ambient water temperature at a rate of approximately 2°C per hour. Water from Moore Reservoir flowed continuously through three 200-gal holding tanks via a submersible pump and garden hoses. Aeration, in addition to continuous flow, was achieved by placing the garden hose discharge above the surface of the water, creating a waterfall effect. Smolts were held at least overnight to acclimate before tagging and were tagged on site. Tagged fish were released between 20 (test fish) and 50 (control fish) hours after tagging.

The first group of 200 smolts transported from the hatchery were acclimated to ambient water temperature, and put into two holding tanks on the dam. The next morning 119 fish were found dead in the tanks. Mortality was likely the result of low dissolved oxygen (DO), however it was unclear why DO had dropped low enough to kill the fish. Water temperature was relatively low, about 12.4°C. Aerators were added to each holding tank for the remainder of the study.

Tagged fish were released in the reservoir approximately in line with the fishway entrance and just outside of the boat barrier; approximately 450 ft upstream of the skimmer gate entrance (Figure 3-1). Fish were lowered from the headworks of the dam in 5-gal buckets down to an awaiting boat carrying two plastic containers filled with approximately 20 gal of water. Up to 10 fish were lowered in the 5 gal buckets, and up to 25 fish were placed in the containers for transport to the release site.

Control fish (N=333; 334 were tagged, one died before release) were released at 15:30 on 10 May. Test fish (N=416) were released four weeks later, on 11 June, approximately 1.5 h before the current inducers were operating. Eight (8) of the test fish were removed from the collection tank before the current inducers began operating and were therefore removed from analysis, resulting in a total of 408 test fish.

3.4 Environmental Conditions and Station Operations

Water temperature was monitored at three stations: Moore Reservoir near the entrance to the Moore Dam skimmer gate, Connecticut River near Gilman, VT, and Israel River, a tributary to the Connecticut River, near Lancaster NH (Figure 1-2). Temperature was recorded from 16 April through 19 June, with Onset TidbiT™ temperature loggers. Each station had a redundant logger; loggers were placed approximately 3 and 6 ft below the water surface in the Moore Reservoir and approximately 3 ft below the surface at the Connecticut River and Israel River monitoring stations. Temperature was recorded every 15 minutes.

Provisional stream flow data were downloaded from the U.S. Geological Survey (USGS) national water information web site for gauge number 01131500, Connecticut River near Dalton, NH. These data were used to describe stream flow into the reservoir during the study period. Operations data, including flow through the skimmer gate, and unit generation and discharge, were provided by TransCanada.

3.5 Data Collection and Analysis

The number of stream-reared and hatchery-reared smolts removed from the collection tank was tallied for each day. Collections were made at least two times a day, morning and evening, and often in the afternoon as well. Catch-per-unit-effort (CPUE) was calculated for stream-reared smolts for each of the three collection categories and for daily collections. Recapture rate was determined for test and control tagged hatchery-reared smolts.

Temperature data were downloaded at the end of the study and raw data from each logger compiled, checked for gross inaccuracies, averaged for mean, maximum and minimum daily temperature, and graphed. Operations data, including flow through the skimmer gate, and unit generation and flow, were provided by TransCanada. Percent of flow to the skimmer gate (and therefore onto the sampler) relative to total station discharge was calculated.

4.0 RESULTS

4.1 Sampler Operation

The Moore sampler began operating at 14:00 on 14 April and was closed at 10:20 on 19 June 2010. The skimmer gate was closed for seven hours on 9 June (11:00 - 16:00) when installation of the current inducers required work on the water. Other short-term skimmer gate closings (> 1 h) occurred when the height of the skimmer gate was adjusted to adjust for reservoir height. The sampler operated for 1,575.8 h.

Beginning on 15 April, sampling periods, defined as the period of time the sampler operated between fish removal from the collection tank, ranged from 1.2 h to 16.7 h, and averaged 8.9 h. After the sampler was opened on 14 April, it ran for 24 h before a collection was made. The sampler collection tank was checked 175 times and fish collected in the tank were processed an average of 2.7 times per day between 14 April and 19 June (ranging from 1 to 3 times per day) (Appendix Table 1). Debris load was relatively light this year and did not cause problems with sampler operation.

4.2 Salmon Smolt Collection

Stream-reared Atlantic salmon smolts were collected on 65 of the 66 days the sampler operated and in 117 (67%) of the 175 sampling events. The greatest number of stream-reared smolts taken in one collection event was 216 in the 20 May morning collection. The seasonal distribution of the smolt migration was modal in pattern, with an additional small spike in numbers at the end of the passage season (Figure 4-1). Over 60% of the catch was collected in a two week period between 13 – 27 May. Peak collection days generally occurred shortly after a flow peak. The greatest number of stream-reared smolts collected in the sampler to date occurred this year. The number of stream-reared smolts collected in previous years was: 2004=240 (the sampler was opened late in the migration season this first year); 2005=1,404; 2006=2,473; 2007=1,029; 2008=691; 2009=3183.

For analysis of CPUE, sample periods were divided into three categories based on when collections were made. The three categories were Morning (collections made between 6:21 and 8:45h), Afternoon (10:20 – 15:50h), and Evening (15:02 – 19:18h). Therefore, fish collected in the Morning were those that entered the sampler between the time the sampler was set in the evening and the time the collection was made in the morning, and so on. The first sampling period of the season was a 24 h event and was not included in the analysis of CPUE by category.

Of 1,551.8 h of sampling, 55.1% were represented in the Morning collection, 31.4% in the Evening collection, and 13.5% in the Afternoon collection. CPUE for stream-reared salmon smolts was highest for the Morning collection at 2.48 smolts/h (SD=2.01), and lowest for the Afternoon collection (0.55 smolts/h, SD=0.19) (Table 4-1). CPUE for stream-reared salmon smolts for the season was 2.07 smolts/h.

Smolts were examined for gross injuries as they were netted from the collection tank, and when they were transported from the buckets to the holding tank, the holding tank to the transport tank, and the transport tank to the river. Of the 3,214 smolts collected, 95.8% (3,079) had no observable injuries, 2.92% (94) showed obvious descaling, 0.12% (4) had contusions, 0.03% (1) had lacerations, 0.28% (9) were moribund, and 0.84% (27) died (Table 4-2).

Length and age data were collected beginning in 2005 from smolt mortalities. Length data from stream-reared smolts collected between 2005 and 2010 show two distinct frequency distributions within each sample year, suggesting two age classes of smolts passing the sampler (Figure 4-2). Analysis of scale samples collected in these years show a prominent age-2 cohort with a smaller cohort of age-3 smolts; six fish collected in 2005 were age-4 (Table 4-3). In 2008 the subset of fish aged were dominated by the age-3 cohort (60%), with age-2 cohorts (40%) completing the sample. However, all but one of the age-3 fish were collected the morning after the sampler was opened, biasing the age sample to early migrants that may have been holdovers from the previous year. This year all of the fish aged were age-2 smolts. Length-at-age distributions for the years 2005 through

2010 show distinct length-age relationships in some years (e.g., 2005, possibly 2008 and 2009) but not in others (e.g., 2007) (Figure 4-3).

4.3 Current Inducer Evaluation

The current inducer fish guidance system was installed the week of 7 June, near the end of the smolt migration period. The fish sampler was shut down for 5 hours on 9 June for on-the-water installation activity, and the guidance system was operating by 13:30 on 11 June.

Two groups of tagged fish were released to test the effectiveness of the current inducers. A control group of 333 red VIE tagged fish was released on 10 May, and a test group of 408 yellow VIE tagged fish was released on 11 June (Table 4-4). The monitoring period for each group was 8 days. This was the number of days that test fish were available for passage (i.e., release date to close of the sampler). Of the 333 control fish released, 66 (19.8%) entered the fish sampler within the monitoring period. Of the 408 test fish released, 58 (14.2%) entered the fish sampler within the monitoring period.

While these results suggest the current inducer fish guidance system did not improve passage to the fish sampler, the late release date of the test smolts was expected to strongly influence the results. Control fish were released in the middle of the smolt emigration season, while test fish were released near the end of the season. Control fish were released during the peak of the 2010 emigration. By the end of the control fish monitoring period (i.e., 18 May) 41% of the stream-reared smolts had passed into the fish sampler; during the control fish monitoring period (10 – 18 May), 29% of the stream-reared smolts entered the fish sampler. The percent of stream-reared smolts collected during the test fish monitoring period (11 - 19 June) was the same as the percent of test fish collected (14.2%).

Gill samples were collected from 12 hatchery fish on 10 June and analyzed for Na/K-ATPase activity. These fish were representative of the current inducer test fish released just a day later. The results ranged from 2.43 – 4.36 µmol ADP/mg protein/hour. These are low values more typical of parr (normally 2-4 µmol ADP/mg protein/hour) than smolts (normally 6-14 µmol ADP/mg protein/hour). These data confirm that the results of the mark-recapture study are invalid.

Independent of the current inducer fish guidance system study, the return rate (48%) for of all control fish, i.e., those collected from the date of release to the close of the sampler (10 May – 19 June) is on the high end of return rates for tagged fish released in previous years (Table 4-5).

Plotting daily passage numbers of tagged fish against average daily water temperature and average daily flow suggests a pattern of passage similar to stream-reared smolts (Figure 4-4). Tagged smolt passage numbers, like stream-reared smolt passage numbers, appeared to be more influenced by flow than temperature. Tagged smolt passage numbers peaked shortly after flows peaked.

4.4 Water Temperature, River Flow, and Station Discharge

Water temperature recorded on the redundant thermistors deployed at the Connecticut River monitoring station at Gilman, VT (Gilman monitoring station) and Israel River monitoring station were similar; therefore, the data from redundant thermistors for corresponding 15 minute increments were averaged. Water temperature recorded on the two thermistors deployed in the Moore Reservoir was slightly different and therefore reported separately.

Mean daily water temperature was generally greater at the Moore Reservoir monitoring station than at the Gilman and Israel River monitoring stations, and generally lower at the Israel River monitoring station compared to the Moore Reservoir and Gilman monitoring stations; however, temperature regime at the Gilman and Israel monitoring stations was similar (Figures 4-5, 4-6 and see Figure 4-1). Water temperature (15-min readings) ranged from 2.3 to 25.3°C at the Israel River monitoring station, from 4.2 to 22.3°C at the Gilman monitoring station and 6.4 to 24.2°C at the Moore Reservoir monitoring station.

Average daily discharge from the Moore Development closely followed average daily inflow recorded at the Dalton, NH USGS gauge station (Figure 4-7). The sampler opened for the season as flows were coming down from a high of over 12,000 cfs. During the study period, approximately four peak inflow and discharge events occurred, each was followed by brief or extended increases in the number of stream-reared smolts collected. Over the two week period of 13-27 May when over 60% of the stream-reared smolts were collected, flow through the reservoir was slowly falling from an inflow peak of 6,850 cfs on 9 May to 1,300 cfs on 1 June. No spill events occurred during the assessment period.

The proportion of flow through the skimmer gate, relative to total station discharge, ranged from 3.59 to 100% (mean = 49.98%) and was most often 5-10%, and 100% of total station discharge (Figure 4-8A). High proportional flows through the skimmer gate occurred when there was little or no turbine discharge, and low proportional flows to the skimmer gate occurred when turbine discharge was high. Averaged hourly proportional flow to the skimmer gate demonstrated the stations daily peaking operation. Proportional flow to the skimmer gate was higher during night hours when flow to the turbines was low (Figure 4-8B). Averaged daily proportion of flow to the skimmer gate was small early in the season when inflow and discharge was high, and increased by the end of the season when inflow and discharge decreased (Figures 4-8B and 4-7). Daily CPUE for smolts did not appear to be directly affected by proportion of flow to the skimmer gate over a seasonal scale (Figure 4-8C).

4.5 Resident Species

Over 1,300 resident fish representing 16 species were collected in the sampler (Table 4-6). The most abundant species collected were yellow perch (*Perca flavescens*, 30%) rock bass (*Ambloplites rupestris*, 28%) and brown trout (*Salmo trutta*, 21%).

5.0 DISCUSSION

The purpose of this evaluation was to obtain information on the timing and abundance of the stream-reared Atlantic salmon smolt migration past the Moore Dam and conduct a preliminary assessment of the effectiveness of a current inducer fish guidance system installed in the forebay to guide smolts to the entrance of the fish sampler. These objectives were achieved. TransCanada was requested by the agencies to open the sampler as early as possible to provide passage for smolts that may be in the reservoir early. The sampler was opened on the afternoon of 14 April, following ice-off, when pond elevation could be brought up high enough to provide adequate flow through the sampler and after the trash boom, boat barrier and guide net were installed. On 9 June the fish sampler was shut down for five hours to allow safe access for workers installing the current inducers.

The salmon smolt migration was clearly modal this year, similar to patterns observed in 2005 and 2007 (Normandeau Associates 2006, 2008). As in 2007 and 2009, peak passage this year seemed to follow flow more closely than water temperature, as compared to 2008 when water temperature appeared to influence passage. A two-week period of peak passage began after inflow peaked just below 7,000 cfs, and gradually fell to below 2,000 cfs.

As in previous years, smolts that passed early in the season were larger than those that passed three to four weeks later. These were probably age-3 fish, and may be holdovers (i.e., smolts that do not pass the dam in the first year of migration, and holdover in the reservoir to pass the following year). The age of the larger fish collected early in the season is suggested by scale samples taken from 11 smolts that died one day after the fish sampler was opened in 2009. Scale analysis identified them as age-3 smolts.

Water temperature in Moore Reservoir was much more moderated then temperature fluctuations recorded at the monitoring stations in the Israel River and Connecticut River near Gilman. Water temperature reached 10°C at all monitoring stations about a week after the fish sampler was opened and then dropped for a few days before gradually increasing. Two dips in water temperature at the Israel River and Gilman stations early in the season (4/28 and 5/10) reflected a brief drop in passage numbers at the fish sampler. Peak passage occurred as average daily water temperature in the Israel River increased from 5.4 to 21.7°C.

The number of smolts passing the sampler this year was greater than in previous years. Smolts entering the Moore sampler are the product of salmon fry stocked in tributaries above the Moore Dam by NHFGD and VTDFW. The majority of fry mature to the smolt stage and begin migrating two years after stocking. Index streams above the Moore Dam are sampled by the NHFGD and VTDFW and data are used to develop smolt production estimates for the upcoming migration season. These two variables were compared with the number of smolts collected at the Moore sampler during the years 2005-2010 (2004 was not included because the sampler was opened late in the season) using Pearson's correlation coefficient. Because fry smoltify in approximately two years, fry stocking numbers from 2003-2008 were compared with the number of smolts collected in the sampler from 2005-2010 (Table 5-1, Figure 5-1). No statistical correlation was found for the relationship between the number of fry stocked and the number of smolts collected in the sampler (R=0.01, P= 0.99) or for the relationship between the estimated production number and the number of smolts collected at the sampler (R=0.65, P=0.16). However, considering the low power (number of years) and relatively high R-value for the relationship between the estimated production number and the number of smolts collected at the sampler, a biological correlation may exist. Over the six years, production estimates increased gradually each year from 2005 to 2007, fell slightly in 2008, increased significantly in 2009 and fell back to approximately the 2007 value in 2010. The number of fry stocked from 2003 to 2007 increased slightly to a peak in 2004, dropped to the lowest value in 2006 and increased in 2007 and 2008.

All of the 28 fish aged through scale analysis were determined to be age-2. These fish were collected over the full migration season, suggesting that the majority of the run was age-2 smolts. This coincides with data from previous years, except 2008, that indicates the proportion of age-2 fish is increasing over time. In 2008, 55% of the aged fish were collected on the first day of operation, all were age-3 and were probably smolts that migrated down to the reservoir in 2007 but did not pass the dam until 2008. An annual increase in the proportion of age-2 smolts passing the Project may be due to the availability of passage; fewer smolts migrating to the reservoir in the spring and holding over through the winter.

Percent mortality (0.8%) was the lowest to date. A light debris load entering the sampler contributed to the low mortality figure. The debris load this year was likely a result of the reservoir elevation being maintained about a foot lower than in previous years, due to investigations and maintenance work conducted on the earthen embankment portion of the dam. This, and reduced handling of smolts during collection and transport. For a couple of days before the sampler was closed, smolts entered the sampler in large numbers, as many as 194 on 18 June. Though the fish were transported to the release site immediately after being collected from the fish sampler, they were stressed and lethargic when released. High water temperature combined with the abundance of smolts in the collection tank was cause for concern, especially considering the condition of the fish after being transported to the release site. This and the fact that fish passage structures downstream had been closed earlier in the week prompting a decision to close the fish sampler for the season.

A delay in the installation of the current inducer fish guidance system resulted in the release of test fish well after the majority of stream-reared smolts had entered the fish sampler. Blood tests from a sub-set of the late release fish (collected from fish at the hatchery) indicated the test fish had revered to parr prior to release. Therefore, test results (19.8% passage of control fish, and 14.2% passage of test fish) are inconclusive for the purpose of evaluating the effectiveness of the current inducer fish guidance system. Further evaluation of the current inducer fish guidance system should be conducted.

5.1 Conclusions

Based on the results of the last five years of study, the following conclusions can be made:

- The inclined plane sampler is effective at collecting fish that pass over the skimmer gate, providing a non-turbine emigration route past the station for salmon that are stocked above the Moore Reservoir.
- This year the sampler was opened approximately two weeks earlier than in past years and was used by smolts that may have been holdovers from last year.
- Survival improved after installation of a debris boom in 2006, and by conducting sampling events three times per day, early morning, afternoon, and evening. Less handling and minimal holding time on site after retrieval from the collection tank are also likely contributors to survival.
- Investigation of the effectiveness of a current inducer fish guidance system was unsuccessful due to the late timing of its installation. Further study should be initiated early in the season next year.

6.0 LITERATURE CITED

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Normandeau Associates Inc. 2009. Atlantic salmon smolt report on fish sampling effort at Moore Dam, spring 2009. Report prepared for TransCanada Hydro Northeast, Inc., Concord, NH.

Tables

Table 3-1. Codes used to document condition of salmon smolts collected in the Moore sampler, spring 2010.

Code Number	Condition
1	No observed injuries or descaling
2	Minor descaling (<10%)
3	Moderate descaling (10-25%)
4	Major descaling (>25%)
5	Eye injury
6	Contusion on body
7	Lacerations or other open wounds likely caused by sampler
8	Moribund
9	Dead

Table 4-1. Number of collections made at the sampler, effort, and catch-per-unit-effort (smolts/h) for stream-reared Atlantic salmon smolts collected at the Moore sampler, spring 2010. Collections were generally made three times per day: morning, afternoon, and evening.

		Effort				
Time Category	**No. of Collections**	**Hours (sum)**	**Range (h)**	**Mean**	**SD**	**Time of Day Collections Made**
Morning (evening set, morning collection)	65	855.68	11.52 - 16.83	13.16	0.88	6:21 - 8:45
Afternoon (morning set, afternoon collection)	40	209.07	1.75 - 7.80	5.23	0.90	10:20 - 14:50
Evening (afternoon set, evening collection)	69	487.08	1.17 - 11.93	7.06	2.65	15:02 - 18:18

	SR Smolts			CPUE			
Time Category	**Number**	**Mean**	**SD**	**Overall CPUE**	**Mean**	**SD**	**SE**
Morning	2129	32.75	39.72	2.48	2.47	2.01	0.37
Afternoon	116	2.90	4.79	0.55	0.62	1.18	0.19
Evening	967	14.01	40.17	1.98	2.26	6.48	0.78

Table 4-2. Physical condition and potential cause of mortality for stream-reared salmon smolts collected in the Moore sampler, spring 2010. For the last four conditions listed, fish were noted to have either that condition only, or that condition and one or more of the previous listed conditions.

	Stream-Reared		Hatchery	
Condition	**Number**	**Percent**	**Number**	**Percent**
No injuries	3,079	95.80	224	98.68
Descaling	94	2.92	0	0.00
Eye injury	0	0.00	0	0.00
Contusions, and …	4	0.12	0	0.00
Lacerations, and …	1	0.03	0	0.00
Moribund, and …	9	0.28	0	0.00
Dead, and …	27	0.84	3	1.32

Table 4-3. Number of stream-reared Atlantic salmon smolts collected at the Moore sampler from 2005 through 2010, and the number, percent, and range in total length (mm) of a sub-set of smolts that were aged using scale analysis.

				Age-2				**Age-3**				**Age-4**			
Year	**N Smolts Collected**	**N Aged**	**% of Collected**	**N**	**% of Aged**	**Length Range**	**Mean Length**	**N**	**% of Aged**	**Length Range**	**Mean Length**	**N**	**% of Aged**	**Length Range**	**Mean Length**
2005	1,404	82	5.84%	63	76.8	152-248	199.6	13	15.9	284-340	315.8	6	7.3	325-395	344.7
2006	2,473	77	3.11%	67	87.0	162-257	193.3	10	13.0	201-310	274.7	0	-	-	-
2007	1,029	110	10.69%	101	91.8	160-340	228.1	9	8.2	187-332	256.1	0	-	-	-
2008[a]	691	20	2.89%	8	40.0	165-261	213.0	12	60.0	265-325	303.3	0	-	-	-
2009	3,183	38	1.19%	37	97.4	150-240	202.2	1	2.6	355.6	-	0	-	-	-
2010	3,214	28	0.87%	28	100.0	178-340[b]	208.2[b]	-	-	-	-	-	-	-	-

[a] Results are not representative, 55% of the aged fish were collected on the first day of operation, all were Age-3 and likely holdovers from previous year.

[b] Length data based on 27 fish, one fish was not measured

Table 4-4. Descriptive data for two groups of VIE tagged hatchery-reared Atlantic salmon smolts released in the Moore Reservoir, spring 2010. Smolts were released for the purpose of assessing the effectiveness of a current inducer fish guidance system.

VIE Color	Date Released	Number Released	Monitoring Period	Number Returned	Percent Returned
Red	5/10	333	5/10 - 5/18	66	19.82
Yellow	6/11	408	6/11 - 6/19	58	14.22

Table 4-5. Annual release and return data for Atlantic salmon smolts released above the Moore Dam in the years 2004, 2005, 2006, 2007, 2009 and 2010. Data for 2010 are not culled for study parameters; they include all fish released and all fish returned.

Year		Number Released	Number Returned	Percent Return	Release Location, as Distance from Dam
2004[a]		1386	127	9.16	forebay to 11 mi.
2005[b]		896	40	4.46	11 mi.
2006[b,c,d]		805	377	46.83	11 mi.
2007[b]		102	29	28.43	forebay -1 mi.
2009[e]		889	329	37.01	forebay -1 mi.
2010[b]	(released 5/10)	333	160	48.05	forebay - 450 ft
	(released 6/11)	416	66	15.87	forebay - 450 ft

a - Smolts from White River Hatchery
b - Smolts from Pittsford Hatchery
c - Attraction flow shelf and trash boom installed
d - Spill occurred during smolt migration season
e - Stream-reared smolts from collection tank

Table 4-6. Resident fish species and number collected in the Moore sampler between 14 April and 19 June 2010.

Common Name	Scientific Name	Number Collected	Percent of Total
Yellow perch	*Perca flavescens*	410	29.97
Rockbass	*Ambloplites rupestris*	381	27.85
Brown trout	*Salmo trutta*	282	20.61
Smallmouth bass	*Micropterus dolomieui*	172	12.57
Spottail shiner	*Notropis hudsonius*	86	6.29
Golden shiner	*Notemigonus crysoleucas*	7	0.51
Rainbow trout	*Oncorhynchus mykiss*	7	0.51
Rainbow smelt	*Osmerus mordax*	5	0.37
Black crappie	*Pomoxis nigromaculatus*	4	0.29
Northern pike	*Esox lucius*	3	0.22
White sucker	*Catostomus commersoni*	3	0.22
Common shiner	*Notropis cornutus*	2	0.15
Blacknose dace	*Rhinichthys atratulus*	2	0.15
Pumpkinseed	*Lepomis gibbosus*	2	0.15
Largemouth bass	*Micropterus salmoides*	1	0.07
Brook trout	*Salvelinus fontinalis*	1	0.07

Table 5-1. Number of salmon fry stocked above the Moore Dam, estimate of smolt production numbers from index sites above the Moore Dam and number of smolts collected in the Moore Dam sampler for the years data were available.

Year	Number of Salmon Fry Stocked Above Moore Dam[1]	Salmon Smolt Production Estimate (Number) Above Moore Dam[2]	Number of Stream-Reared Salmon Smolts Collected in the Moore Sampler[3]
1997	81,152	N/A	
1998	232,976	N/A	
1999	60,577	523	
2000	471,428	4,458	
2001	476,028	2,416	
2002	229,279	4,629	
2003	252,840	5,197	
2004	267,638	1,934	240
2005	215,022	3,758	1,404
2006	134,069	4,511	2,473
2007	155,975	5,679	1,029
2008	185,336	4,060	691
2009	189,166	10,608	3,183
2010	N/A	6,119	3,214

[1] Fry stocking numbers provided by NHFG and VTDFW.

[2] Salmon smolt production numbers provided by VTDFW.

[3] Installation of the sampler was completed in 2004, shortly after the smolt migration had begun.

Figures

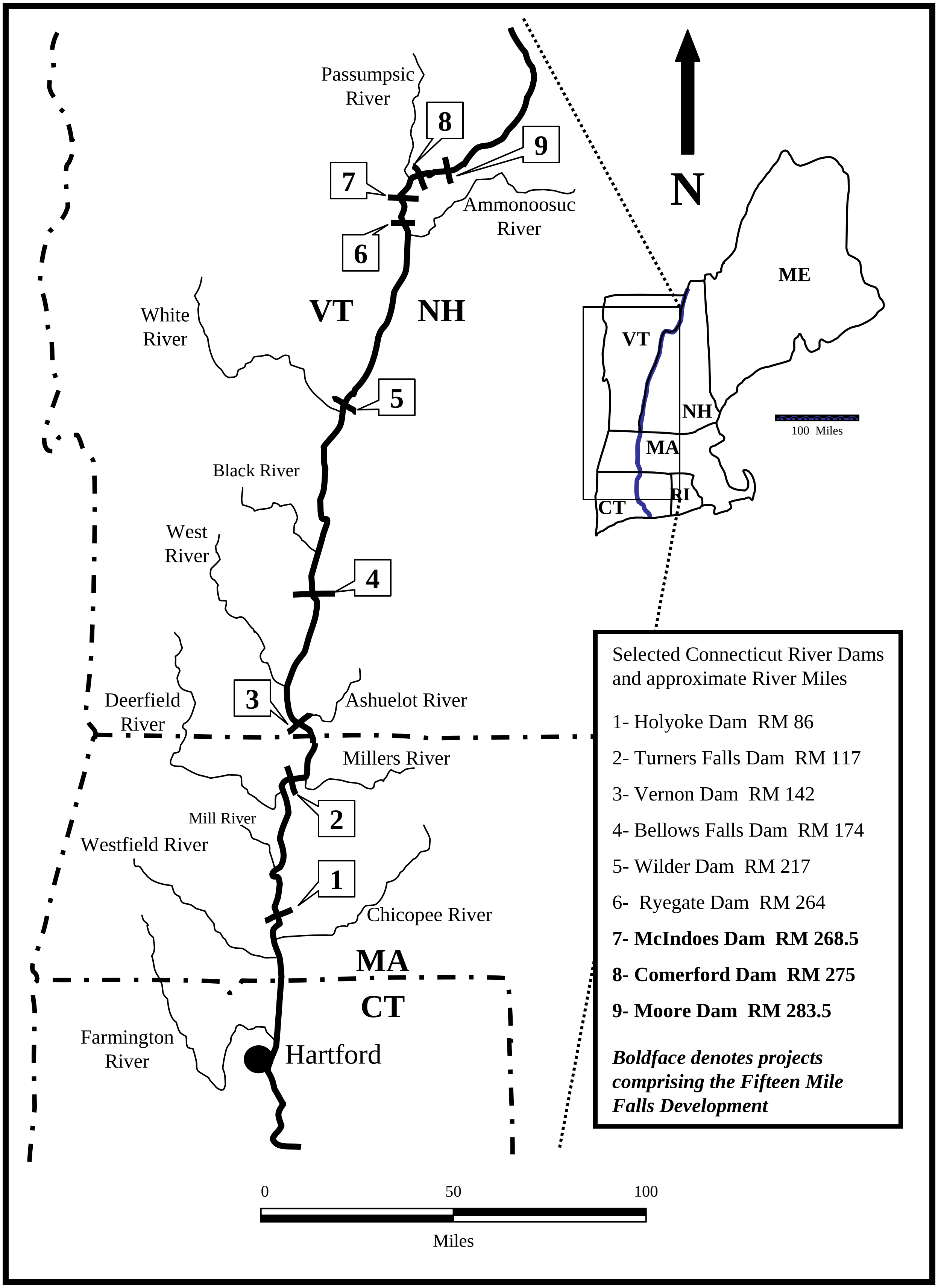


Figure 1-1. Location of the Fifteen Mile Falls Project on the Connecticut River.

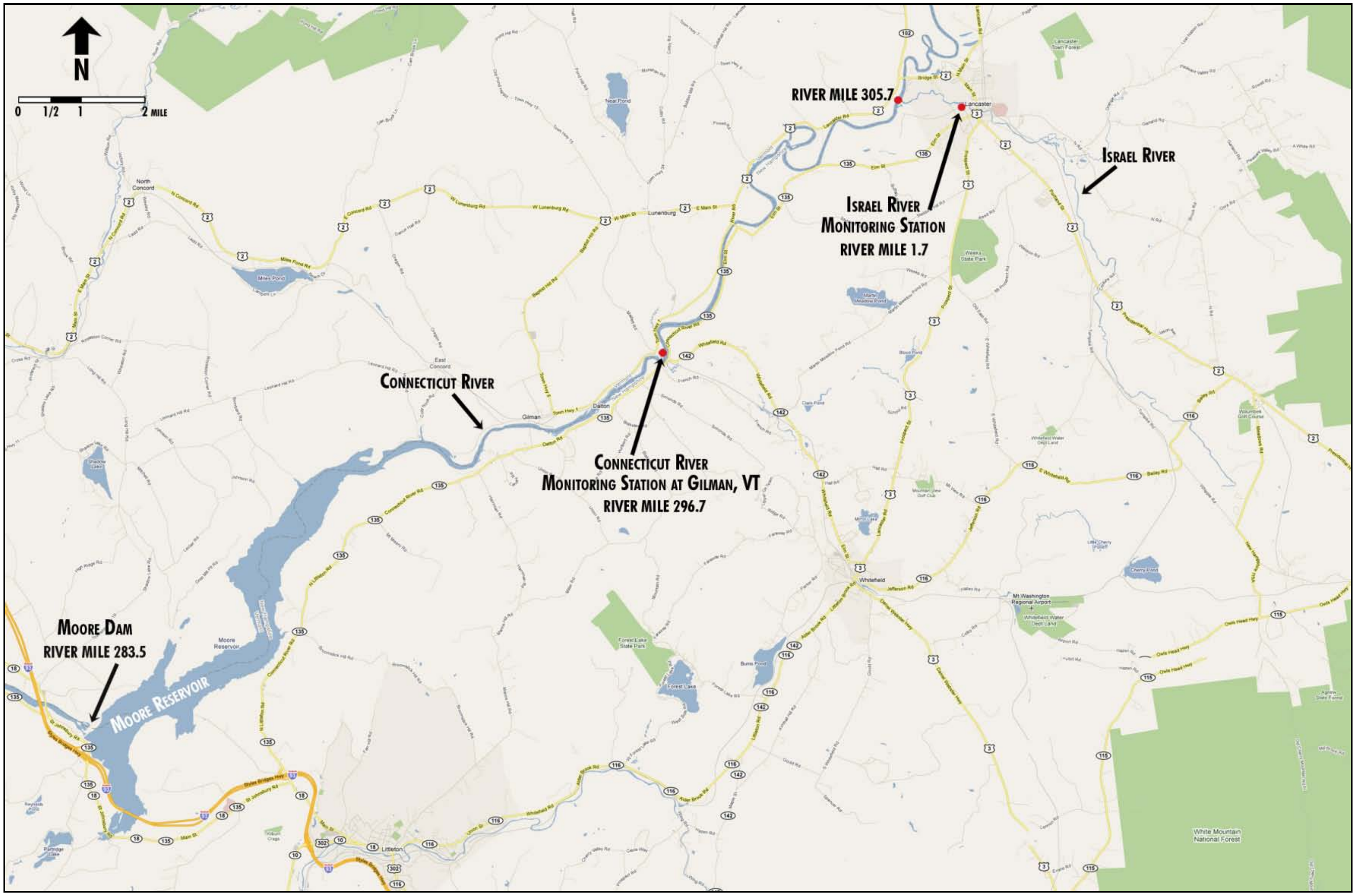


Figure 1-2. Location map showing the Moore Dam and three water temperature monitoring stations: Moore Reservoir, Connecticut River at Gilman, VT and Israel River.

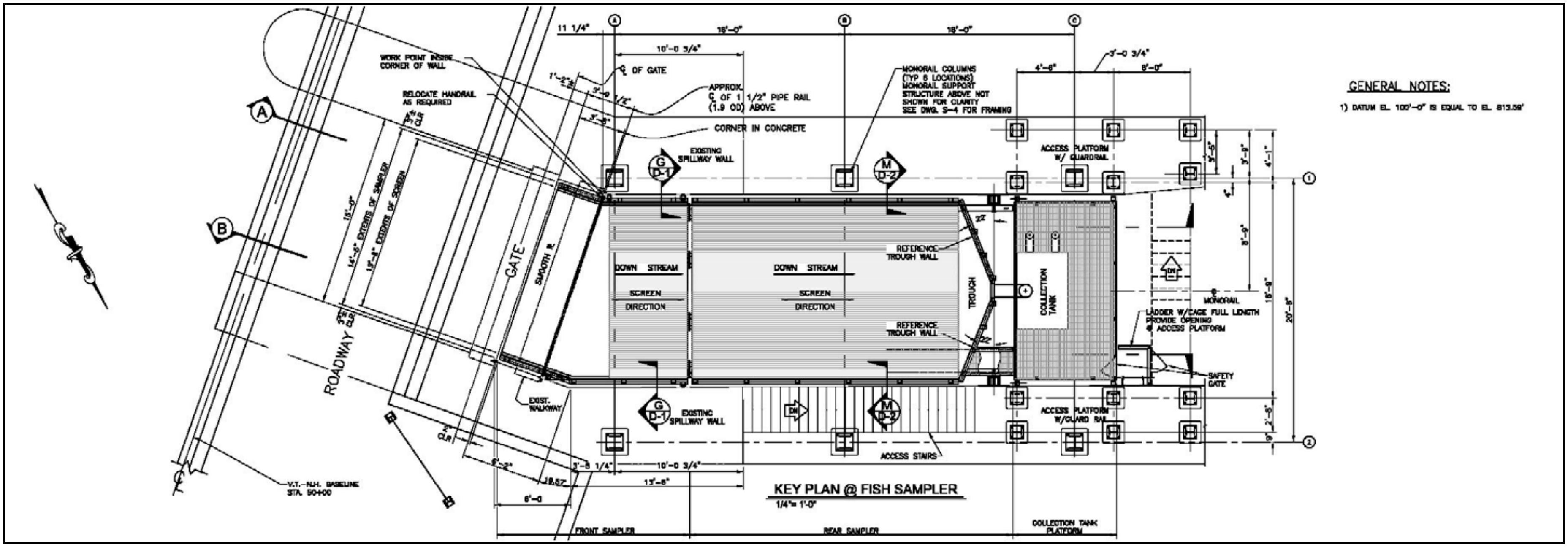


Figure 2-1. Key plan of TransCanada's Moore Development inclined plane sampler. The plan does not show flow reflectors installed after the sampler was erected. Plan drawing prepared by Kleinschmidt.

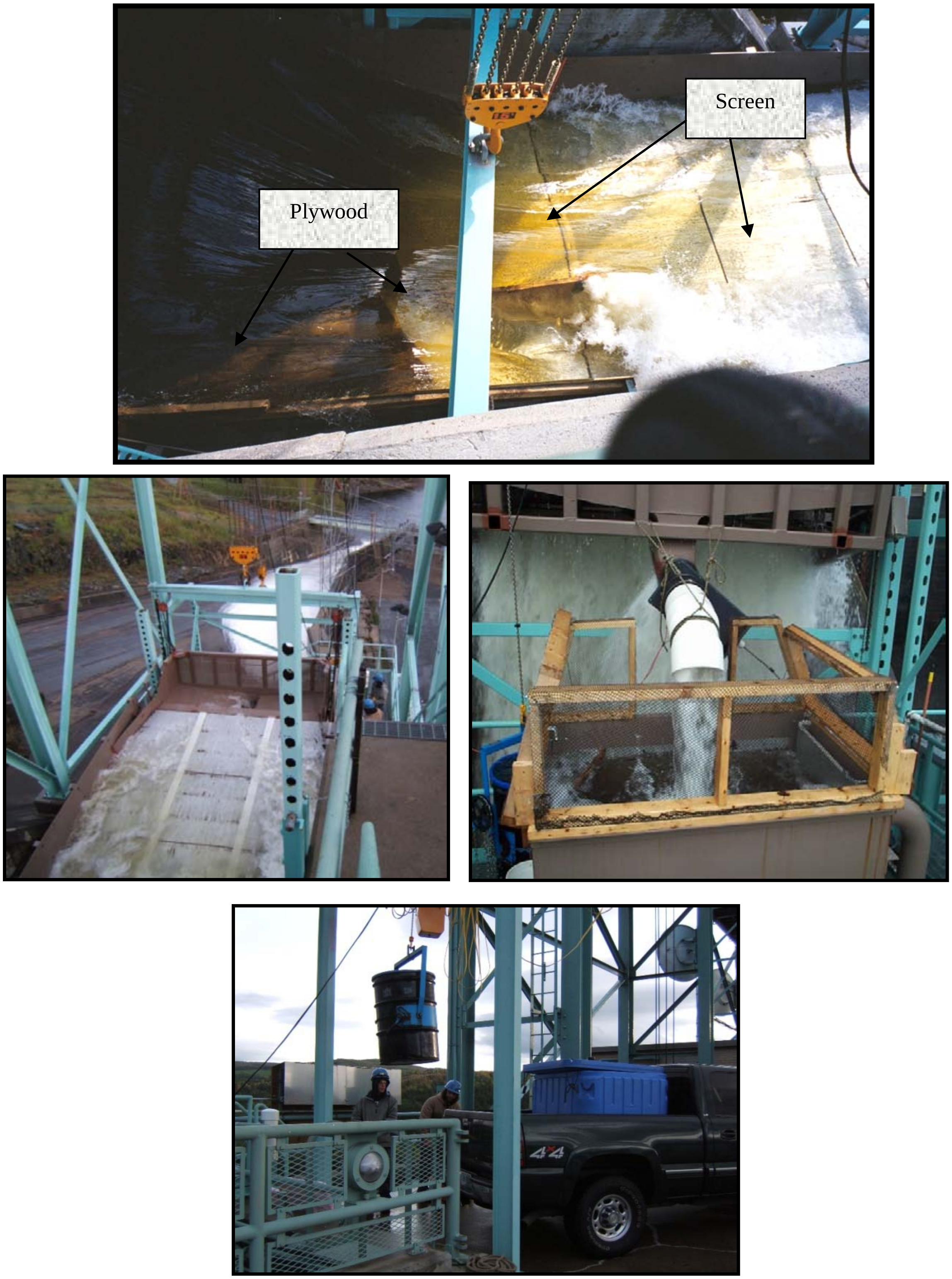


Figure 2-2. Moore Development, inclined plane fish sampler, showing plywood flow adjusters (top), dewatering surface (left), discharge pipe and collection tank (right), and . monorail system used to transport fish from the collection tank to the transport tank (bottom).

Figure 2-3. Moore Development, attraction flow shelf raised for repairs (left); view is looking upstream through the skimmer gate entrance to Moore Reservoir and the debris boom (right).

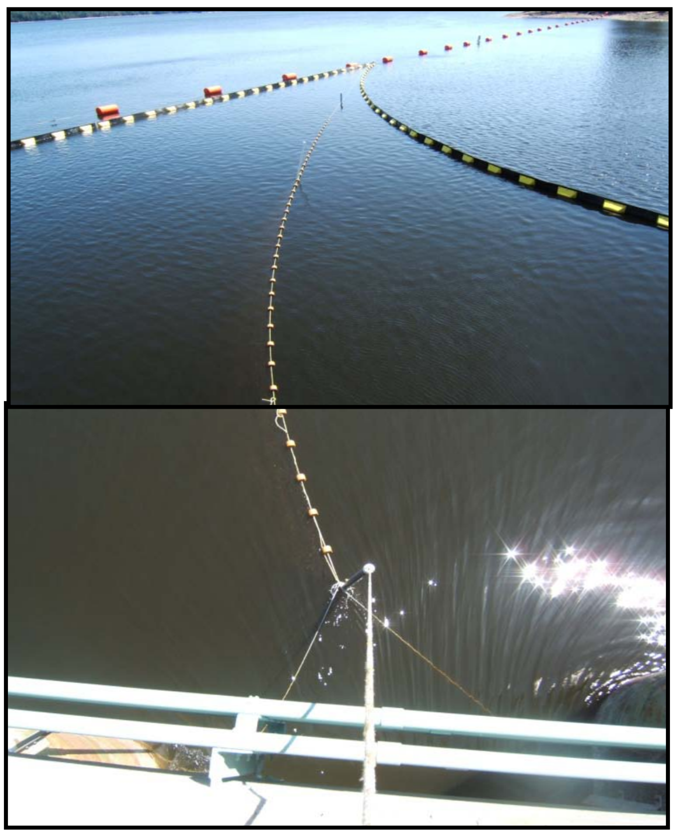


Figure 2-4. Moore Development, guide net installed at the skimmer gate entrance.

Figure 3-1. Map showing the release site for tagged hatchery fish and the location of five units (CI-1 through CI-5) of a current inducer fish guidance system installed in the Moore Reservoir, spring 2010.

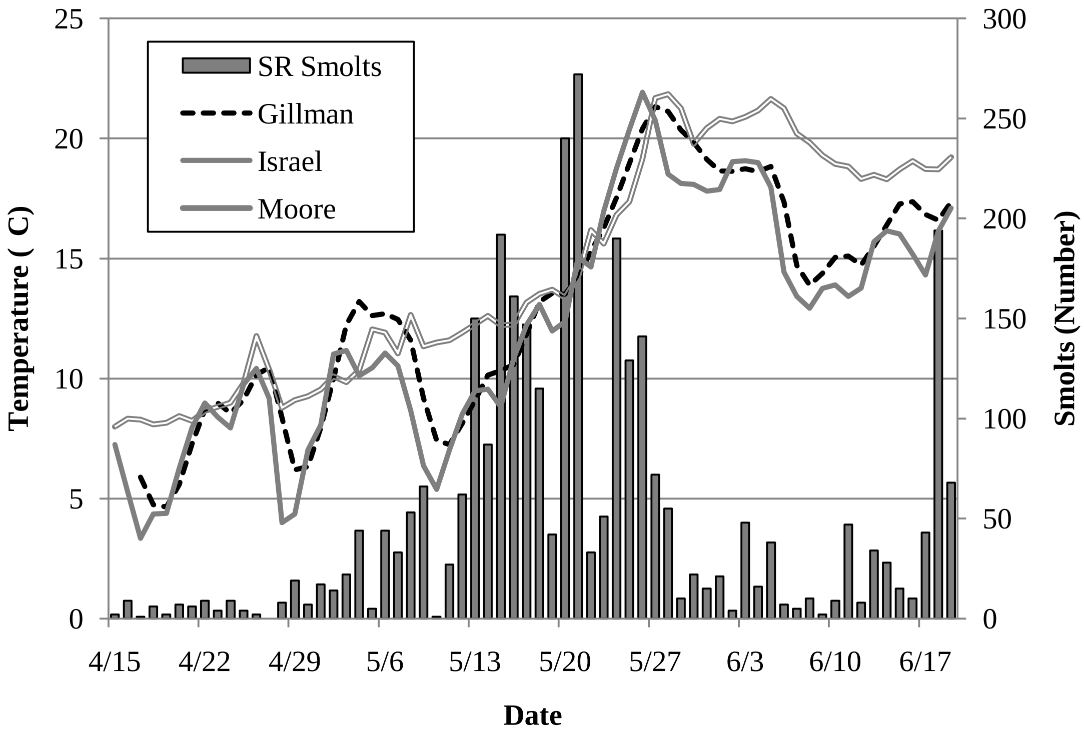


Figure 4-1. Daily average water temperature at the Israel River, Gilman and Moore monitoring stations, and daily sum of stream-reared smolts collected in the Moore sampler, spring 2010.

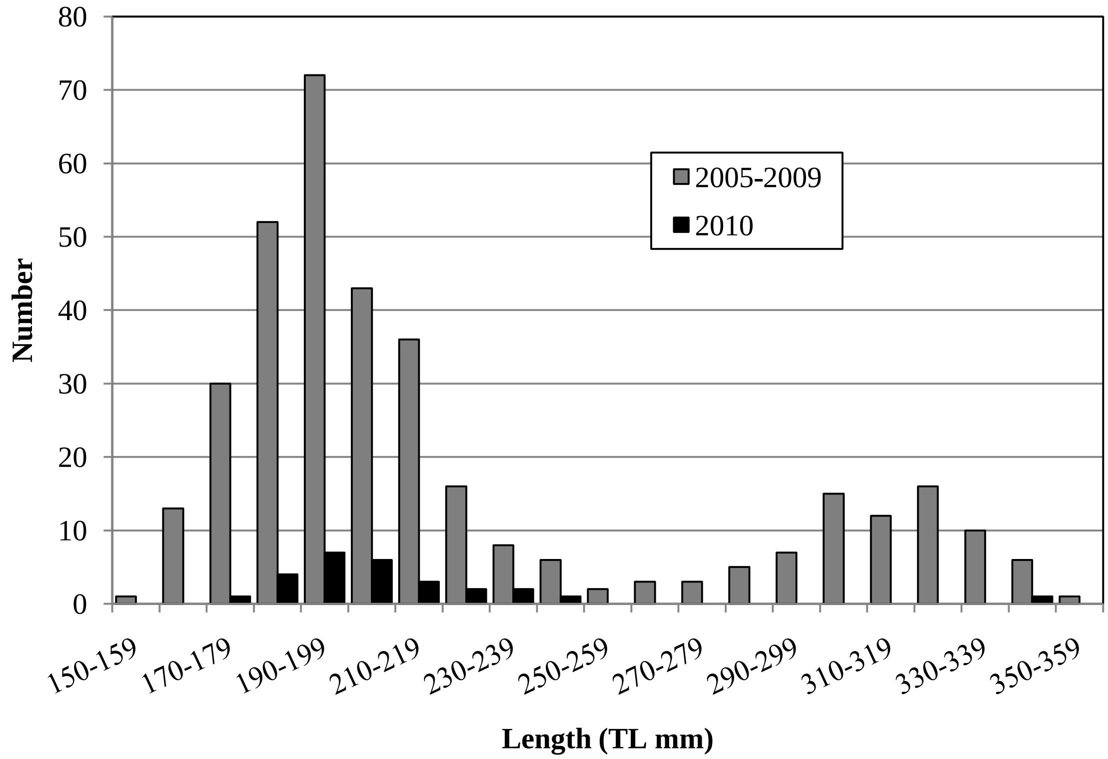


Figure 4-2. Length frequency distribution of a sub-set of stream-reared Atlantic salmon smolts collected at the Moore sampler in 2010 compared with sub sets compiled from the 2005 through 2009 collections.

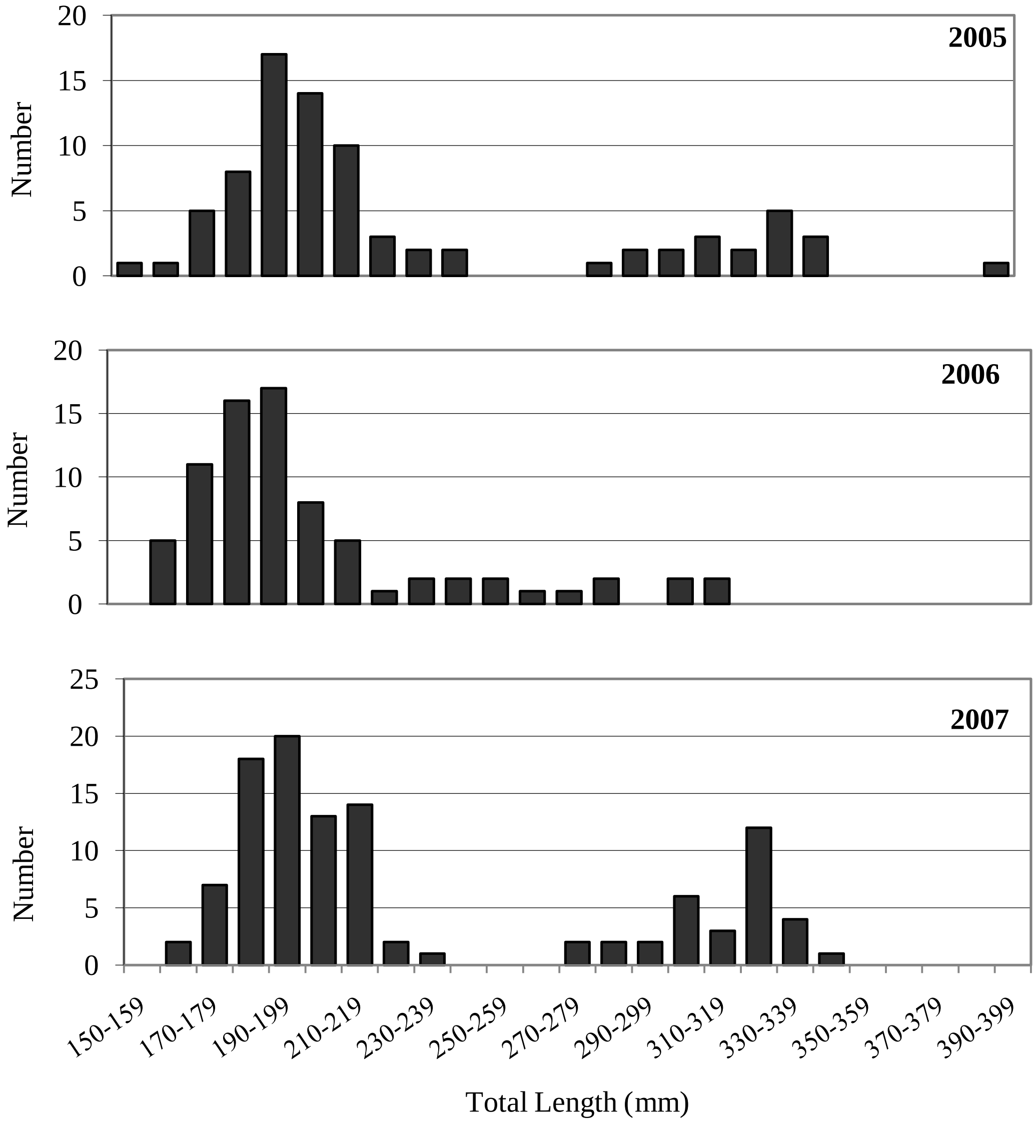


Figure 4-3. Length at age distributions for a sub-set of Atlantic salmon smolts collected at the Moore sampler during the years 2005 through 2010.

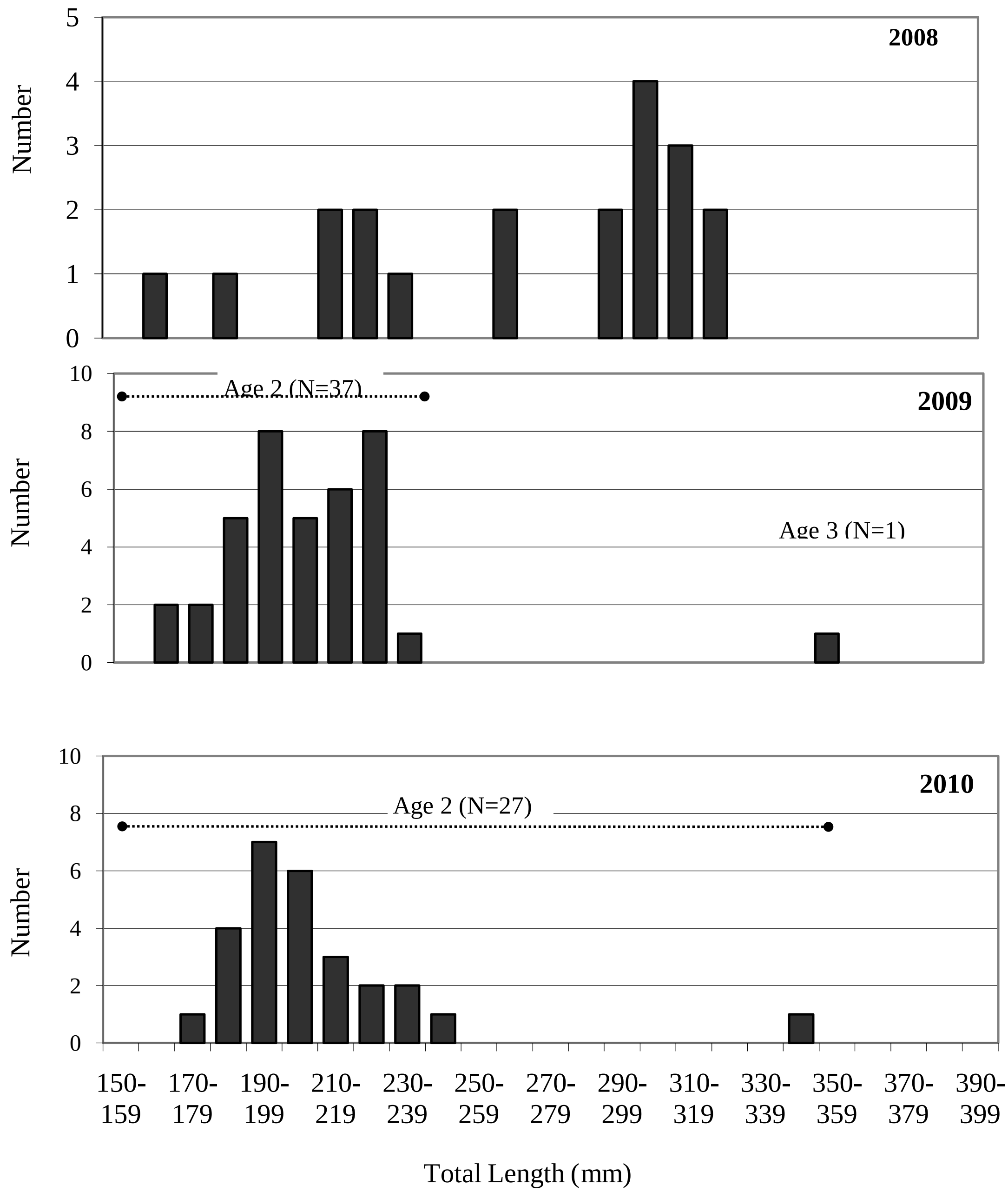


Figure 4-3 cont. Length at age distributions for a sub-set of Atlantic salmon smolts collected at the Moore sampler during the years 2005 through 2010.

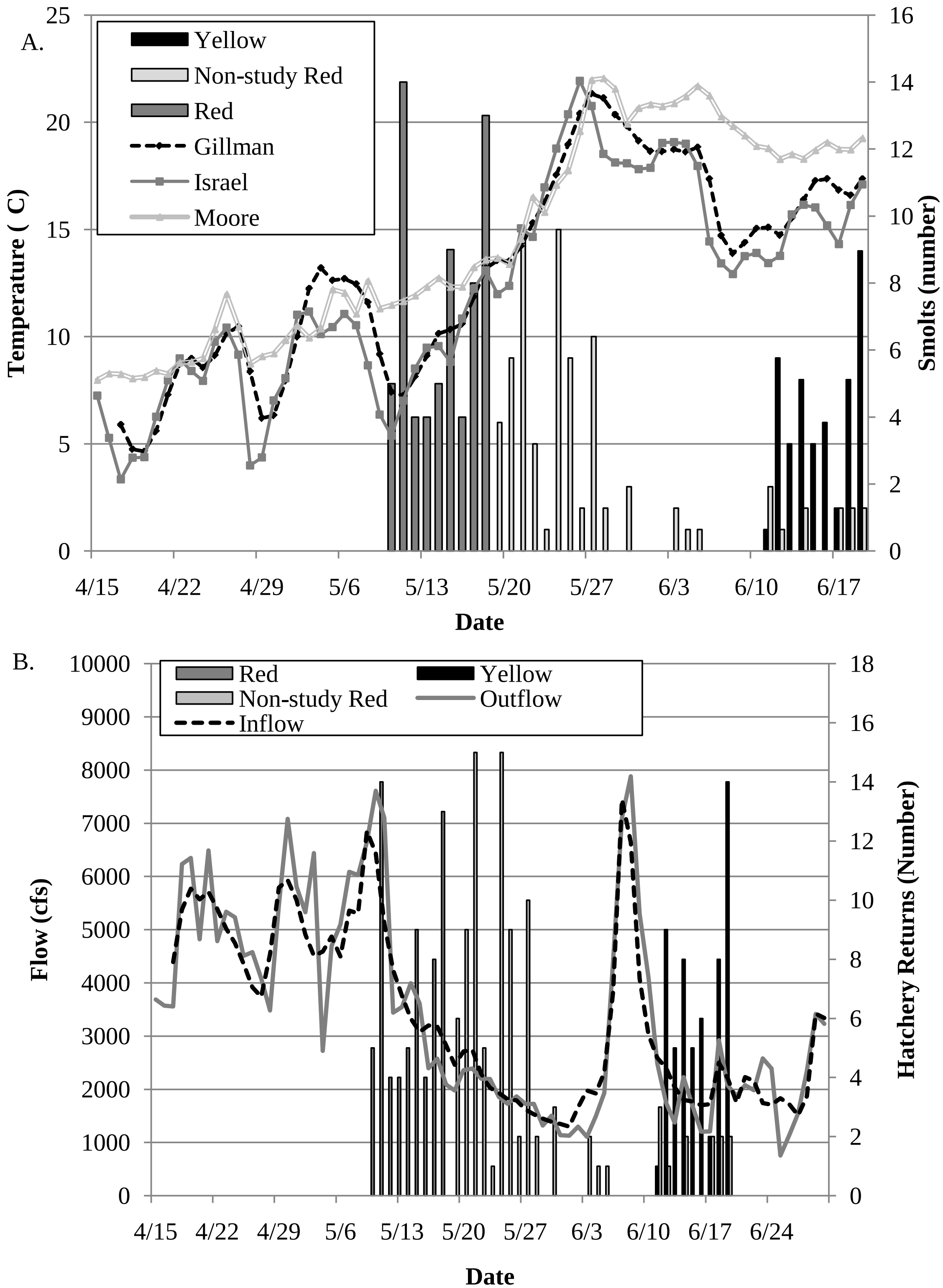
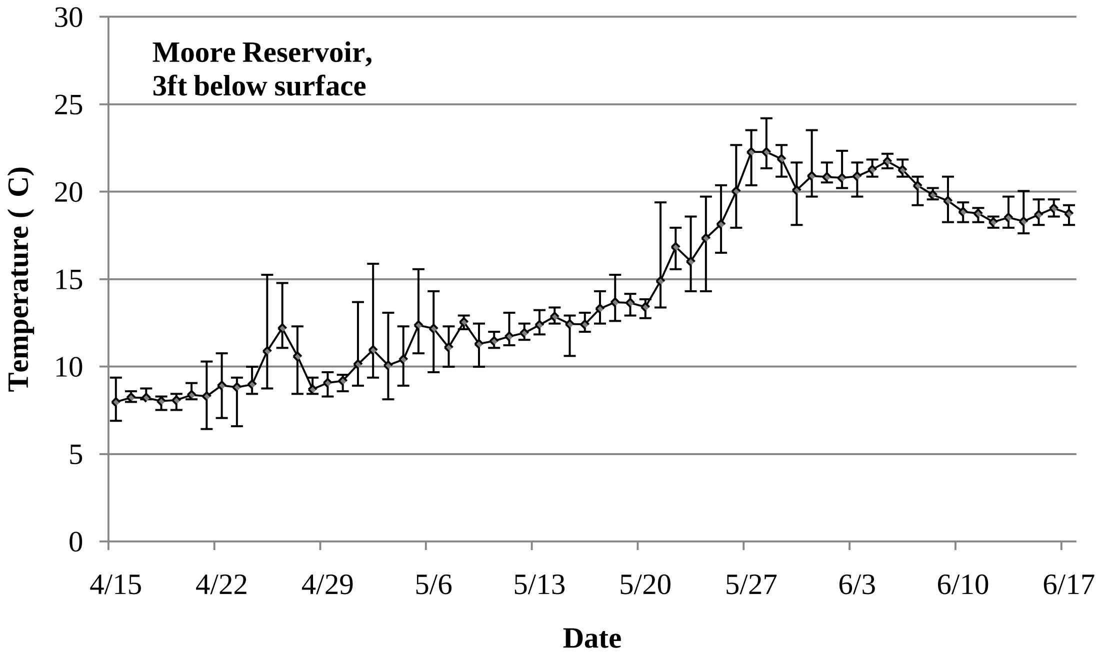


Figure 4-5. Daily sum of tagged hatchery-reared smolts collected in the Moore fish sampler compared with A. daily average water temperature at he Israel River, Gilman and Moore monitoring stations, and B. inflow and outflow, spring 2010.



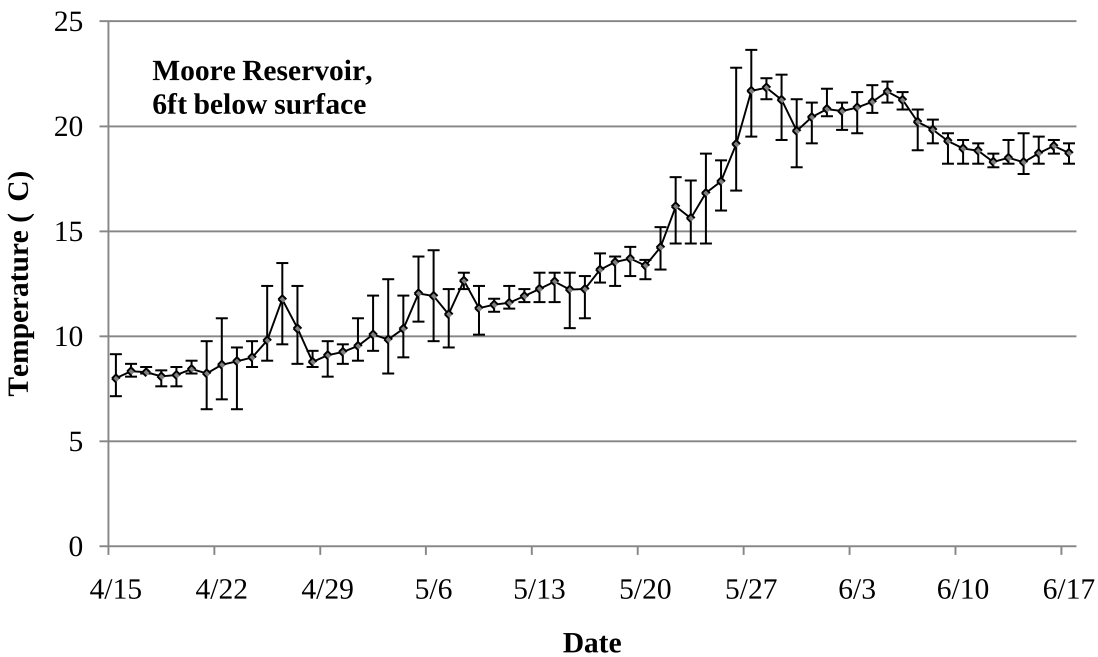
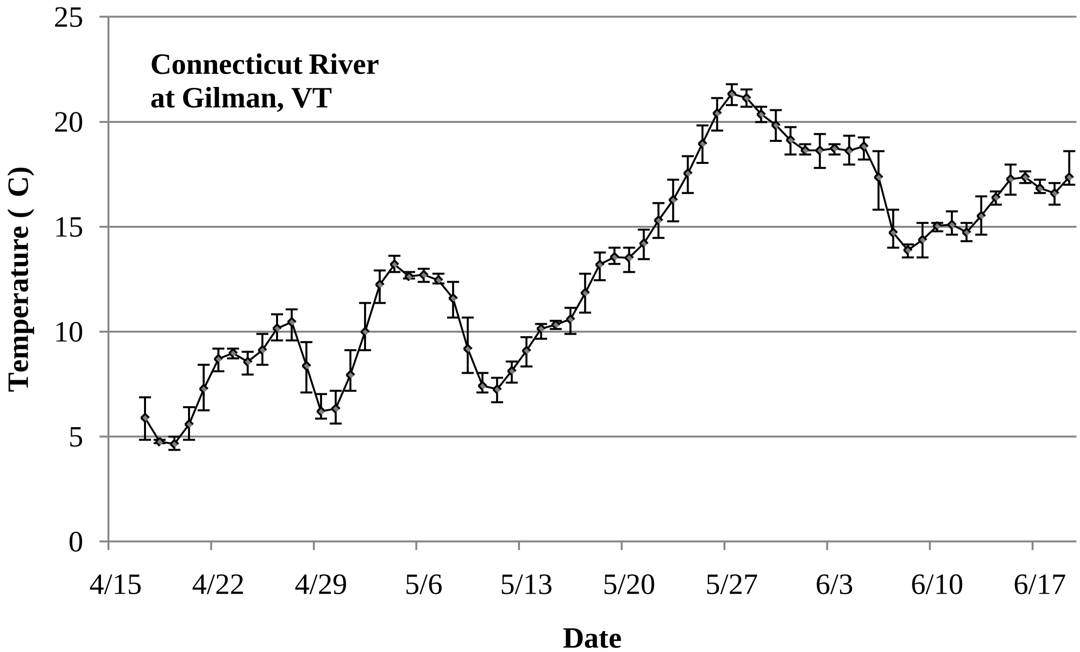


Figure 4-6. Minimum, mean, and maximum daily water temperature in the Moore Reservoir approximately 3-ft and 6-ft below the surface (at the time of deployment) from 16 April through 19 June 2010.



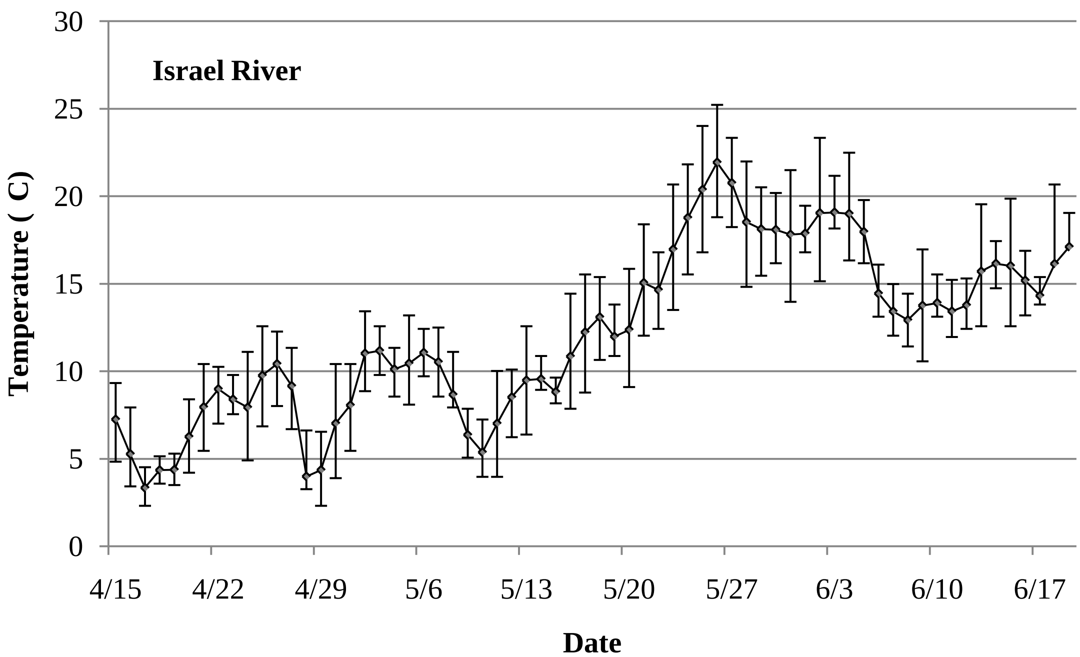


Figure 4-7. Minimum, mean, and maximum daily water temperature in the Israel and Connecticut River (Gilman) monitoring stations from 16 April through 19 June 2010.

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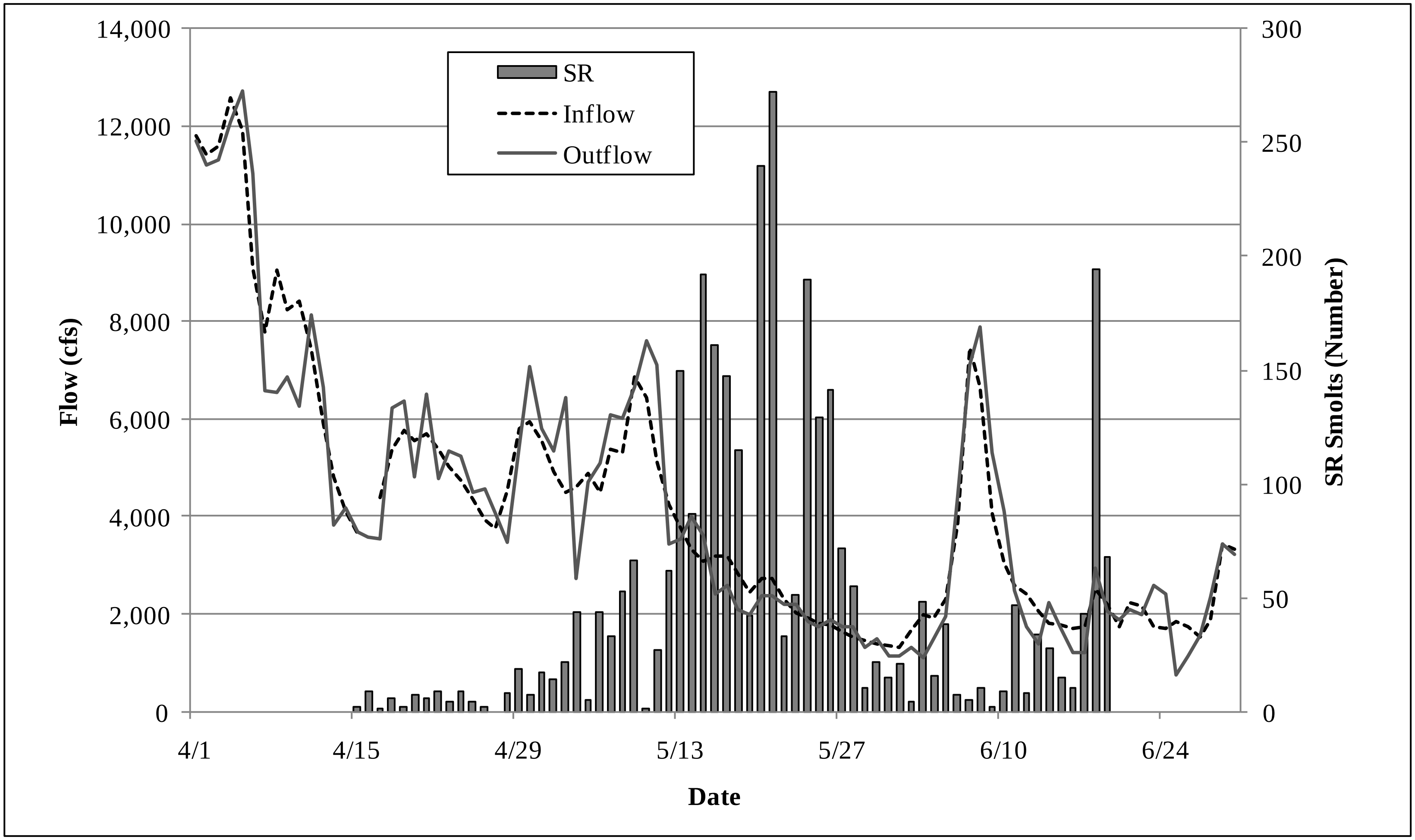

Figure 4-8. Daily average inflow (cfs) to the Moore Reservoir recorded at USGS Gauge 01131500 located at the Dalton Hydro, and outflow from the Moore Development, recorded by TransCanada, compared with daily collection (number) of Atlantic salmon smolts at the Moore sampler, spring 2010.

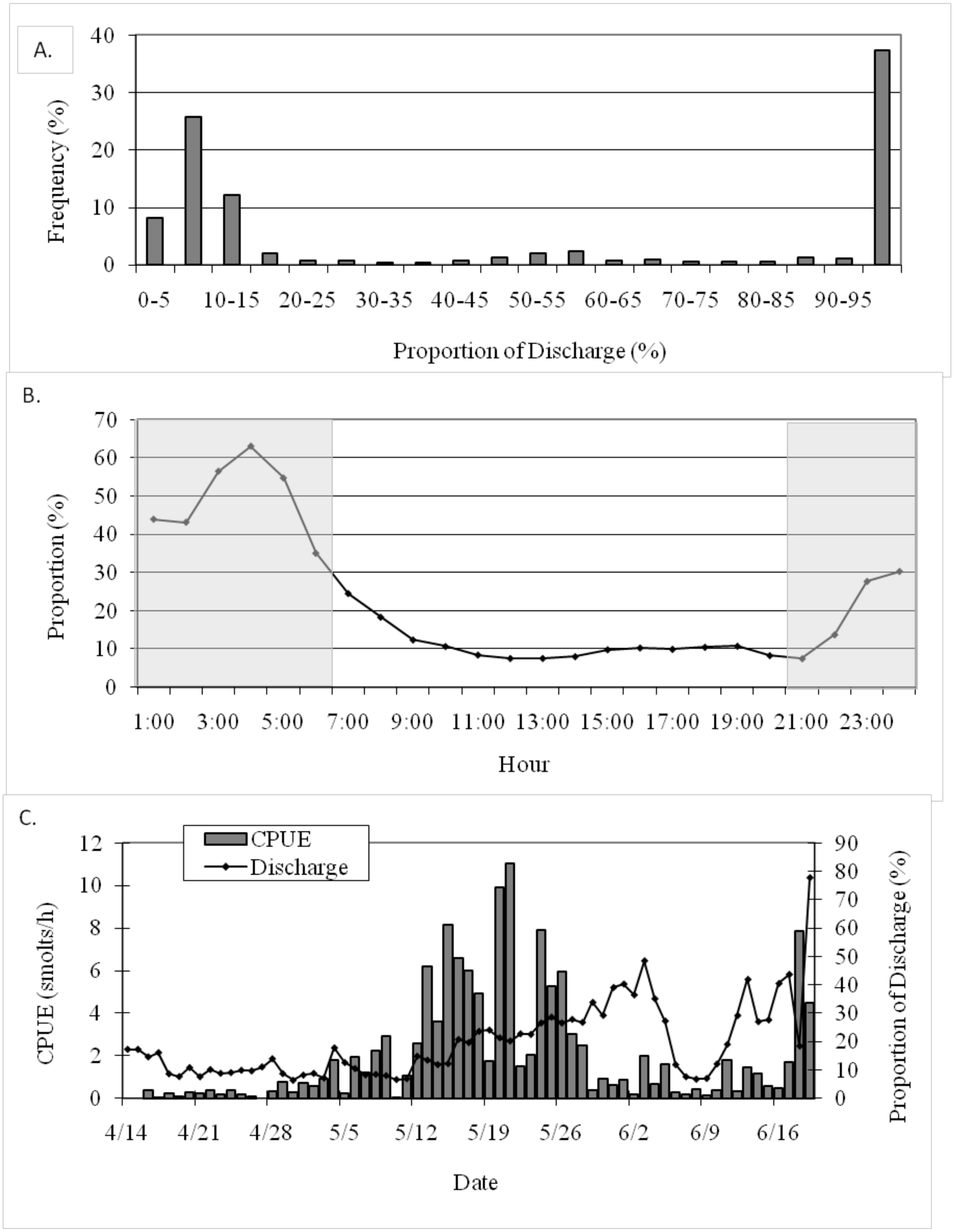

Figure 4-9. A. Frequency distribution of proportion of discharge (turbine flow + skimmer gate flow) to the skimmer gate; B. Hourly average proportion of discharge to the skimmer gate (shaded areas are approximate nighttime hours); C. Daily average proportion of discharge to the skimmer gate and daily average collection of smolts per hour (CPUE) by date.

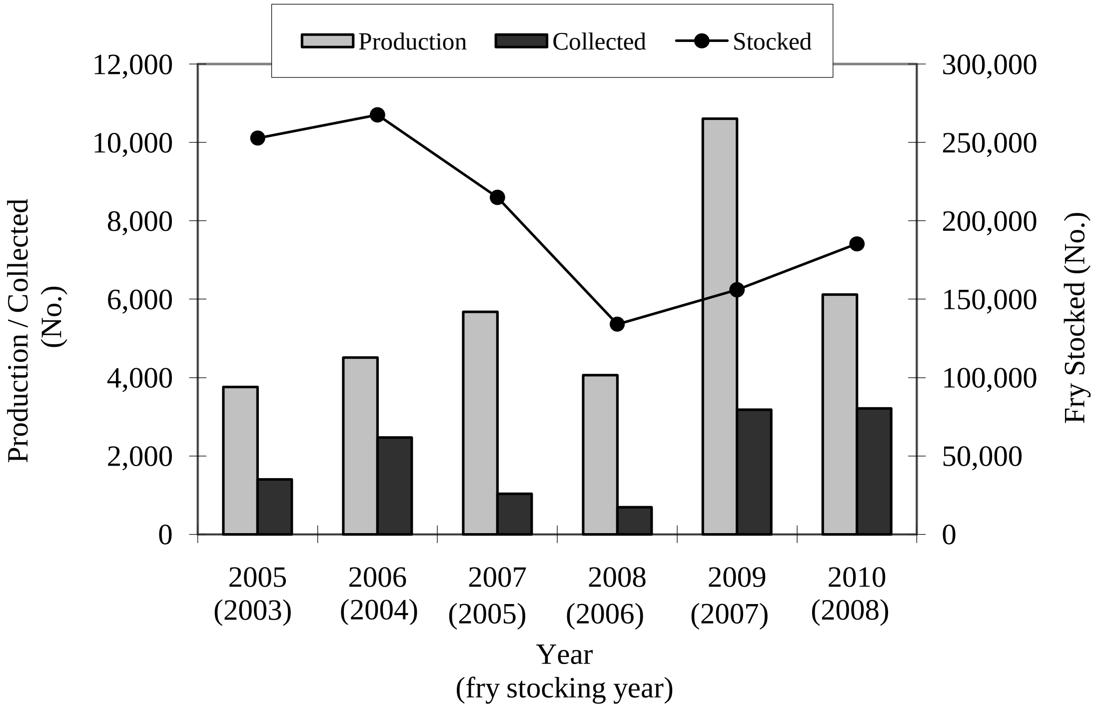

Figure 5-1. Comparison of the number of salmon fry stocked above the Moore Dam, estimated production of salmon smolts from index sites above the Moore Dam and salmon smolts collected in the Moore sampler for the years the sampler was opened by May 1. Because fry smoltify in approximately two years, salmon fry stocking numbers from 2003-2008 are compared with 2005-2010 production estimates and the number of smolts collected in the sampler.

Appendix Table 1

Appendix Table 1. Number of stream-reared Atlantic salmon smolts collected in the Moore Dam sampler during each of 175 sampling periods, spring 2010. Effort is calculated as the number of hours between the current End Time and the previous End Time.

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
24 hour	4/14	14:00	4/15	14:00	24	2	0
Evening	4/15	14:30	4/15	18:10	4	0	0
Morning	4/15	18:15	4/16	7:00	13	9	1
Afternoon	4/16	7:20	4/16	13:30	7	0	0
Evening	4/16	14:00	4/16	18:35	5	0	0
Morning	4/16	18:45	4/17	7:00	13	1	0
Afternoon	4/17	7:15	4/17	13:16	6	0	0
Evening	4/17	13:40	4/17	18:16	5	0	0
Morning	4/17	18:25	4/18	6:52	13	5	0
Afternoon	4/18	7:05	4/18	13:05	6	0	0
Evening	4/18	13:10	4/18	18:25	5	1	0
Morning	4/18	18:35	4/19	6:50	12	2	0
Afternoon	4/19	7:00	4/19	12:28	6	0	0
Evening	4/19	12:31	4/19	18:15	6	0	0
Morning	4/19	18:20	4/20	6:55	13	3	0
Afternoon	4/20	7:05	4/20	12:30	6	4	1
Evening	4/20	12:39	4/20	18:00	6	0	0
Morning	4/20	18:12	4/21	6:55	13	5	0
Afternoon	4/21	7:05	4/21	12:23	5	1	0
Evening	4/21	12:34	4/21	18:10	6	0	0
Evening	4/21	18:20	4/21	19:15	1	0	0
Morning	4/21	19:30	4/22	6:50	12	6	1
Afternoon	4/22	7:01	4/22	12:05	5	3	1
Evening	4/22	12:10	4/22	18:48	7	0	0
Morning	4/22	18:58	4/23	6:48	12	2	0
Afternoon	4/23	7:00	4/23	12:25	6	2	0
Evening	4/23	12:30	4/23	18:40	6	0	0
Morning	4/23	18:48	4/24	6:55	12	1	0
Afternoon	4/24	7:05	4/24	12:05	5	2	0
Evening	4/24	12:10	4/24	18:30	7	6	1
Morning	4/24	18:40	4/25	6:48	12	2	0
Afternoon	4/25	6:55	4/25	12:45	6	0	0
Evening	4/25	12:50	4/25	18:12	5	2	0
Morning	4/25	18:18	4/26	6:45	13	2	0
Afternoon	4/26	6:55	4/26	12:34	6	0	0
Evening	4/26	12:40	4/26	18:05	5	0	0

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
Morning	4/26	18:10	4/27	6:52	13	0	0
Afternoon	4/27	7:00	4/27	12:28	6	0	0
Evening	4/27	12:35	4/27	18:25	6	0	0
Morning	4/27	18:28	4/28	7:00	13	5	0
Afternoon	4/28	7:13	4/28	12:29	5	3	1
Evening	4/28	12:33	4/28	18:03	6	0	0
Morning	4/28	18:11	4/29	6:47	13	12	1
Afternoon	4/29	6:59	4/29	12:40	6	1	0
Evening	4/29	12:45	4/29	18:30	6	6	1
Morning	4/29	18:46	4/30	6:45	12	7	1
Afternoon	4/30	7:15	4/30	12:14	5	0	0
Evening	4/30	12:23	4/30	18:05	6	0	0
Morning	4/30	18:15	5/1	6:40	13	11	1
Afternoon	5/1	6:45	5/1	14:26	8	6	1
Evening	5/1	14:33	5/1	18:17	4	0	0
Morning	5/1	18:23	5/2	6:57	13	13	1
Afternoon	5/2	7:05	5/2	12:14	5	1	0
Evening	5/2	12:22	5/2	18:10	6	0	0
Morning	5/2	18:15	5/3	6:45	13	22	2
Afternoon	5/3	7:00	5/3	12:33	6	0	0
Evening	5/3	12:40	5/3	18:03	6	0	0
Morning	5/3	18:12	5/4	6:43	13	44	3
Afternoon	5/4	7:12	5/4	12:15	5	0	0
Evening	5/4	12:19	5/4	18:31	6	0	0
Morning	5/4	18:35	5/5	8:45	14	3	0
Afternoon	5/5	9:00	5/5	13:22	4	2	0
Evening	5/5	13:25	5/5	16:20	3	0	0
Morning	5/5	16:25	5/6	7:05	15	44	3
Evening	5/6	7:54	5/6	14:50	7	0	0
Morning	5/6	14:55	5/7	6:50	17	30	2
Evening	5/7	7:36	5/7	15:02	8	3	0
Evening	5/7	15:12	5/7	17:50	4	0	0
Morning	5/7	18:47	5/8	6:48	13	52	4
Afternoon	5/8	7:33	5/8	13:15	6	0	0
Evening	5/8	13:19	5/8	18:34	5	1	0
Morning	5/8	18:44	5/9	7:00	13	14	1
Evening	5/9	7:30	5/9	15:18	8	0	0
Evening	5/9	15:25	5/9	17:15	2	52	27
Morning	5/9	17:20	5/10	6:49	14	0	0

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
Evening	5/10	7:13	5/10	15:04	8	1	0
Evening	5/10	15:10	5/10	16:59	2	0	0
Morning	5/10	17:03	5/11	7:06	14	27	2
Afternoon	5/11	7:23	5/11	12:05	5	0	0
Evening	5/11	12:10	5/11	18:09	6	0	0
Morning	5/11	18:11	5/12	6:55	13	61	5
Afternoon	5/12	7:17	5/12	12:14	5	1	0
Evening	5/12	12:40	5/12	18:10	6	0	0
Morning	5/12	18:15	5/13	6:51	13	52	4
Afternoon	5/13	7:26	5/13	12:05	5	1	0
Evening	5/13	12:13	5/13	18:07	6	97	15
Morning	5/13	18:30	5/14	6:45	13	85	7
Afternoon	5/14	7:15	5/14	12:10	5	2	0
Evening	5/14	12:20	5/14	18:25	6	0	0
Morning	5/14	18:35	5/15	6:43	13	192	15
Afternoon	5/15	7:30	5/15	12:40	5	0	0
Evening	5/15	12:45	5/15	17:50	5	0	0
Morning	5/15	18:06	5/16	6:51	13	76	6
Afternoon	5/16	7:29	5/16	12:15	5	9	2
Evening	5/16	12:29	5/16	18:00	6	76	13
Morning	5/16	18:30	5/17	6:55	13	86	7
Afternoon	5/17	7:40	5/17	12:15	5	5	1
Evening	5/17	12:30	5/17	18:50	7	56	9
Morning	5/17	19:05	5/18	6:51	13	99	8
Afternoon	5/18	7:36	5/18	12:10	5	16	3
Evening	5/18	12:15	5/18	18:12	6	0	0
Morning	5/18	18:21	5/19	6:21	13	40	3
Afternoon	5/19	7:09	5/19	12:00	5	2	0
Evening	5/19	12:05	5/19	18:13	6	0	0
Morning	5/19	18:23	5/20	6:49	13	13	1
Afternoon	5/20	7:03	5/20	12:15	5	11	2
Evening	5/20	12:21	5/20	18:06	6	216	35
Morning	5/20	18:35	5/21	8:43	14	94	7
Afternoon	5/21	9:01	5/21	12:00	3	19	6
Evening	5/21	12:15	5/21	18:20	7	159	23
Morning	5/21	19:15	5/22	6:50	12	32	3
Afternoon	5/22	7:30	5/22	12:25	5	0	0
Evening	5/22	12:30	5/22	17:15	5	1	0
Morning	5/22	17:20	5/23	6:50	14	42	3

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
Afternoon	5/23	7:15	5/23	12:15	5	8	2
Evening	5/23	12:20	5/23	18:15	6	1	0
Morning	5/23	18:20	5/24	6:45	14	189	14
Afternoon	5/24	7:55	5/24	12:15	4	1	0
Evening	5/24	12:20	5/24	18:15	6	0	0
Morning	5/24	18:20	5/25	6:45	13	79	6
Afternoon	5/25	7:25	5/25	12:15	5	1	0
Evening	5/25	12:20	5/25	18:15	6	49	8
Morning	5/25	18:45	5/26	6:45	13	96	7
Afternoon	5/26	7:45	5/26	12:20	5	15	3
Evening	5/26	12:35	5/26	18:15	6	30	5
Morning	5/26	18:25	5/27	6:47	13	69	5
Afternoon	5/27	7:15	5/27	12:20	5	0	0
Evening	5/27	12:25	5/27	18:10	6	3	1
Morning	5/27	18:20	5/28	6:45	13	51	4
Evening	5/28	7:15	5/28	16:35	9	4	0
Morning	5/28	16:40	5/29	7:20	15	9	1
Evening	5/29	7:30	5/29	18:05	11	1	0
Morning	5/29	18:10	5/30	7:20	13	22	2
Evening	5/30	7:30	5/30	18:10	11	0	0
Morning	5/30	18:15	5/31	7:10	13	13	1
Evening	5/31	7:20	5/31	18:20	11	2	0
Morning	5/31	18:25	6/1	7:20	13	18	1
Evening	6/1	7:30	6/1	18:09	11	3	0
Morning	6/1	18:14	6/2	7:11	13	4	0
Evening	6/2	7:21	6/2	18:12	11	0	0
Morning	6/2	18:17	6/3	7:20	13	48	4
Evening	6/3	7:40	6/3	18:35	11	0	0
Morning	6/3	18:40	6/4	6:45	12	15	1
Evening	6/4	6:55	6/4	18:20	12	1	0
Morning	6/4	18:30	6/5	7:20	13	38	3
Evening	6/5	7:35	6/5	17:45	10	0	0
Morning	6/5	17:55	6/6	7:25	14	7	1
Evening	6/6	7:35	6/6	17:35	10	0	0
Morning	6/6	17:40	6/7	7:15	14	5	0
Evening	6/7	7:25	6/7	18:20	11	0	0
Morning	6/7	18:30	6/8	7:15	13	8	1
Evening	6/8	7:25	6/8	18:20	11	2	0
Morning	6/8	18:30	6/9	7:15	13	2	0

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
Evening	6/9	7:25	6/9	16:55	6	0	0
Morning	6/9	17:05	6/10	8:20	15	9	1
Evening	6/10	8:30	6/10	17:15	9	0	0
Morning	6/10	17:20	6/11	7:20	14	47	3
Afternoon	6/11	7:35	6/11	13:09	6	0	0
Evening	6/11	13:15	6/11	19:15	6	0	0
Morning	6/11	19:20	6/12	7:20	12	7	1
Evening	6/12	7:30	6/12	18:20	11	1	0
Morning	6/12	18:30	6/13	7:12	13	19	1
Evening	6/13	7:20	6/13	17:50	11	15	1
Morning	6/13	18:00	6/14	7:15	14	24	2
Evening	6/14	7:30	6/14	17:40	10	4	0
Morning	6/14	17:50	6/15	7:15	14	9	1
Evening	6/15	7:25	6/15	19:18	12	6	1
Morning	6/15	19:21	6/16	7:20	12	10	1
Evening	6/16	7:30	6/16	17:08	10	0	0
Morning	6/16	17:12	6/17	7:15	14	38	3
Evening	6/17	7:25	6/17	18:15	11	5	0
Morning	6/17	18:25	6/18	7:15	13	31	2
Evening	6/18	7:30	6/18	18:30	12	163	14
Morning	6/18	19:10	6/18	8:00	13	68	5
Afternoon	6/19	8:35	6/19	10:20	2	0	0