Report on Atlantic Salmon Smolt Sampling Efforts at Moore Dam, Spring, 2011

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REPORT ON ATLANTIC SALMON SMOLT SAMPLING EFFORTS AT MOORE DAM, SPRING 2011

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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 283.5 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 fish sampler and collection tank (collectively referred to as the fish trap) in the skimmer gate of the Moore Dam in 2004 as the mechanism to conduct the evaluation.

Since installation, the fish trap has 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 trap as the collection point for a trap and transport operation has been studied and a series of modifications made to improve its effectiveness. In this eighth year, a current inducer fish guidance system was evaluated as a means of directing smolts to the entrance of the fish trap. Seven current inducers were installed in the forebay and hatchery-reared smolts were tagged and released in proximity to the flow net created by the guidance system. Tagged smolts recaptured in the fish trap were enumerated and comparisons were made with previous mark-recapture study returns.

The trap was operated from 9 May to 20 June 2011. It was opened later in the season compared to previous years because of a late ice-off, unusually high flows, and a hoist transformer failure. Collected salmon were enumerated and live smolts were transported to, and released below the McIndoes Development. Hatchery smolts were marked with streamer tags and 826 were released in Moore Reservoir. A summary of the 2011 results follows.

<u>Stream-reared smolts</u>

- Between 9 May and 20 June, 1,471 stream-reared smolts were collected; the greatest number of smolts collected in one day (N=178) occurred on 18 May. Over 80% of the catch was collected between 16 and 31 May, and 90% was collected by 1 June.
- There was a strong modality to the passage distribution, peaking in mid-late May. Peak passage days appeared to follow gradually increasing water temperature and tracked somewhat with flow peaks (Figures 4-1 and 4-6).
- In general, the fish trap was checked and fish removed from the collection tank three times a day: in the morning (between 06:32 and 08:20), afternoon (between 11:05 and 14:40) and evening (between 16:15 and 19:30). Catch-per-unit-effort (CPUE) was highest (1.91 smolts/h, SD=2.53) during the morning collection, and lowest (0.78 smolts/h, SD=1.16) during the afternoon collection (Table 4-1). Overall CPUE was 2.07 smolts/h (SD=2.22).
- Mortality was 5.5%. This is an increase from previous years and was likely due to two factors: 1) an unusually high number of resident fish, smolt mortalities peaked when resident fish abundance in the collection tank peaked (Figure 5-1C); 2) unusually high inflows occurred before the fish trap was opened, increasing debris load in the reservoir (Figure 4-6).

Hatchery-reared smolts

- A current inducer fish guidance system was installed and operational when the fish trap was opened on 9 May.
- Hatchery fish were tagged with numbered, and color-coded streamer tags (N=826). Four groups of 197 to 211 fish per group were released between 12 and 22 May.
- The proportion of fish collected in the trap ranged from 53.3 to 65.4% for the four groups, and averaged 58.8%.
- Tag-recapture results suggest the current inducer fish guidance system improved passage to the fish trap. Tag-recapture results from previous years ranged from 4.5 to 48.1%.
- An estimate of smolt production above Moore Dam (an estimate of the number of smolts expected to move downstream in the spring) was compared to the number of smolts collected in the fish trap for each year of study. This year the ratio of the difference between the two numbers was the smallest. This supports the suggestion that passage improved this year. However, it is not clear if passage improvement is a result of the current inducer guidance system, the unusually high water year, or an arbitrary occurrence.
- Monitoring of smolt passage numbers with the current inducer fish guidance system installed in the forebay should be continued.

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

˚C	Degree Celsius
CFD	Computational flow dynamics
cfs	Cubic foot per second
CPUE	Catch-per-unit-effort
CI	Confidence Interval
CRASC	Connecticut River Atlantic Salmon Commission
FERC	Federal Energy Regulatory Commission
FMF	Fifteen Mile Falls
ft	Foot
gal	Gallon
h	Hour
HP	Horsepower
mm	Millimeter
MS 222	Tricane methanesulfonate
Msl	Mean sea level
N	Number
NH	New Hampshire
NHFG	New Hampshire Fish and Game Department
Smolts/h	Smolts per hour
TL	Total length
TransCanada	TransCanada Hydro Northeast
USFWS	United States Fish and Wildlife Service
VT	Vermont
VTFWD	Vermont Fish and Wildlife Department
USFWS	United States Fish and Wildlife Service
USGS	Unites States Geological Survey

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 (VTFWD), 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 (referred to collectively as a fish trap) 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 2011 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 fish trap 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 fish trap 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, 2010, and 2011. 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 fish trap were used in lieu of hatchery fish because the hatchery fish were suspected of having reverted to parr.

This year current inducers were installed in the forebay to create flow patterns intended to direct smolts to the skimmer 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 fish trap. This suggested that surface flow strength or direction was not sufficient to cue smolts 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 before the fish trap was opened for the season. The effectiveness of the current inducer guidance system was tested using hatchery-reared Atlantic salmon smolts that were tagged, released in the reservoir, and recaptured in the fish trap.

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 skimmer 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 remained relatively stable throughout the study period due to the high inflows in early spring. The elevation of the reservoir was 807.2 in early May and 807.5 at the end of June. The license provides for 320-cfs-year-round minimum flows (NEP 1997).

2.2 Moore Dam Skimmer Gate and Fish Trap

An inclined-plane sampler discharging to a collection tank (the fish trap), was installed at the skimmer gate during early 2004 and has since been monitored for Atlantic salmon smolt passage (Normandeau Associates, Inc. 2005, 2006, 2007, 2008, 2009, 2010). The inclined plane portion of the fish trap was 14.5 ft wide and consisted of two screened sections connected on a pivot (Figure 2-1). The upstream section was approximately 9 ft long by 14.5 ft wide; the elevation of this section was adjustable. The downstream section was approximately 21 ft long by 14.5 ft wide and pivoted at its junction with the upstream section. The angle of the downstream section to the upstream section was adjusted to optimize the amount of water passing over the screens. The screen sections were made of 1.25-in by 0.375-in aluminum bars placed parallel to one another, creating gaps that dewatered the discharge passing through the skimmer gate (Figure 2-2). The gap width was originally set at 3/16 inch in 2004 and was not changed. A flow guidance structure was built on top of the upstream screen to facilitate even water flow and proper velocity across the downstream end of the screen (Figure 2-2).

At the end of the downstream screen was an angled, fabricated metal trough with solid sides that connected to a 12-inch-diameter discharge pipe (Figure 2-2). The discharge pipe conveyed water from the trough to the collection tank. The collection tank was 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. 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 fish trap prior to the 2005, 2006 and 2010 passage seasons to improve the effectiveness and efficiency of the trap to attract salmon smolts. Modifications made prior to the 2005 monitoring season included:

- The 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; additional netting was 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 debris boom was anchored around the skimmer gate entrance to deflect large debris from the fish trap (Figure 2-3).

In 2010, two overhead lights were installed near the fish trap. 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 skimmer gate, the other, a 400W metal halide flood light was located on the ceiling of the skimmer gate entry way to illuminate the tunnel-like passage area. The lights were set on timers to operate between twilight and dawn (Figure 2-4).

In 2009 and 2010 a guide net was installed in the forebay in an effort to improve guidance of Atlantic salmon smolts into the skimmer gate entrance. The net was not deployed this year, in favor of assessing the individual effect of the current inducer guidance system.

A targeted discharge not-to-exceed 500 cfs for downstream passage through the fish trap has been in place since 2004 and continued in 2011. 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 Fish Trap

The trap was monitored during each day of operation. A sampling event entailed raising the downstream screen section, allowing the collection tank to drain, and dip-netting all fish out of the collection tank. After all fish were removed, the downstream screen section was lowered to resume water flow over the screen and fish passage 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; individual handling was generally not necessary to determine if a fish was tagged. Tagged fish were handled minimally to remove the tag. Because fish were not individually handled and visually inspected, only gross observations of physical condition were noted. All live salmon were transported below the FMF Project and released in the tailwater of the McIndoes Development. Scale samples for aging were taken from most of the 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, operating conditions such as pond elevation, skimmer gate position, position of the upstream screen section, and the Station operator’s expectation of pond fluctuation before the next collection, were recorded. Sampling period (period of time the fish trap was operating between sampling events) also was recorded. Adjustments to the downstream screen section were made by Normandeau personnel when necessary. Adjustments to the skimmer gate, upstream screen section, and collection tank platform, were made by TransCanada personnel. Fluctuation in the reservoir elevation of approximately 1 ft necessitated a gate adjustment, after which, the upstream screen, downstream screen, and collection tank platform were adjusted accordingly.

3.2 Current Inducer Fish Guidance System

TransCanada contracted Lakeside Engineering to install a current inducer fish guidance system in the forebay of the Moore Development. Configuration of a guidance system necessary to create guiding currents to the bypass skimmer gate was based on a CFD model of the site with turbine flows, created by Alden Labs, and flow measurements taken in 2010 after a preliminary system was installed. 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, and field measurements, TransCanada decided to install a total of seven (7) current inducer units. Four units were installed along the dam (units 1 through 4, starting on the NH side), and three units were installed along the boat barrier, equidistant from one another beginning about 50 ft upstream of the skimmer gate entrance (unit 5) and ending near the NH shoreline (units 6 and 7; Figure 3-1). Units 2 and 3 were 4 HP units, and units 1, 4, 5, 6 and 7 were 15 HP units. Design and installation specifications for the current inducer fish guidance system are provided in Lakeside Engineering (2010)'s report to TransCanada.

3.2.1 Current Inducer Effectiveness Evaluation

The effectiveness of the current inducer system was evaluated by mark-recapture methods. Hatchery reared tagged fish were released as early in the migration season as possible, after the current inducers were installed and the fish trap opened. The ratio of the number of tagged smolts collected to the number of tagged smolts released was 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). All tagged fish collected from the fish trap were enumerated and released below the McIndoes Development.

3.3 Hatchery 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 anesthetized in a 40 mg/L solution of buffered tricane-methanesulfonate (MS-222) and measured for total length (mm); a sub group (N=50) was measured for weight (g). Streamer tags, colored and numbered polyethylene strips glued to a needle and purchased from Floy Tag & Mfg, Inc., were used to mark the fish. Four colors were used; one for each of four release groups, and each tag was individually numbered. Fish were marked by pushing the needle through the back musculature, below the dorsal fin, and then cutting off the needle (Figure 3-2).

Hatchery fish were transported in a 180-gal-aerated tank, to circular holding tanks on the headworks of the Moore Development. Water from Moore Reservoir flowed continuously through the 200-gal holding tanks via a submersible pump and garden hoses. If water temperature in the holding tanks was more than 2°C greater than water temperature in the transport tank at the time of arrival, fish were acclimated to the higher temperature at a rate of approximately 2°C per hour. Aeration in the holding tanks, in addition to continuous flow, was achieved with an electric air pump and stone aerating system, and by placing the garden hose discharge above the surface of the water to create a waterfall effect. Smolts were held at least overnight to acclimate before tagging and were tagged on site. Tagged fish were held overnight before release.

Tagged fish were released in the forebay approximately 300 ft upstream and in line with the fishway entrance and just outside of the boat barrier (Figure 3-1). Fish were lowered from the headworks of the dam in 5-gal buckets 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.

Four groups of tagged smolts totaling 826 fish were released between 12 and 22 May. Six fish were tagged and held to assess tag retention. All six tags were intact after 10 days, when the tags were removed and the smolts released below the McIndoes Development. There were some mortalities and tag losses prior to release. Three tags from the first group of fish fell out before release. Six fish died before release: one each from the first and second groups, and four from the fourth group.

3.4 Environmental Conditions and Station Operation

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 7 May through 20 June, with Onset TidbiT™ temperature loggers. Each station had a redundant logger and 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 generally made three times a day: morning, afternoon and evening. An occasional exception occurred when staff traveled to the hatchery to pick-up fish and were not able to make an afternoon collection. 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 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. Percent of flow to the skimmer gate (and therefore onto the fish trap) relative to total station discharge was calculated.

4.0 RESULTS

4.1 Fish Trap Operation

The Moore fish trap began operating at 14:28 on 9 May and was closed at 12:25 on 20 June 2011. The opening was delayed from the targeted one-week before 1 May, due to late ice-off, unusually high flows, and a hoist transformer failure. TransCanada installed the boater and debris booms on 25 April, after ice-off. Current inducer installation began that week but was curtailed by high flows that necessitated spill through the Moore Dam Tainter gates from 27 April through 1 May. On 29 April, the fish trap was opened at about 14:00 to allow smolt passage, but was closed within three hours to prevent smolt mortalities that might have occurred from the significant amount of debris that quickly accumulated on the screen and in the outlet pipe. No smolts were collected during this time. It was decided not to open the fish trap until the current inducers were installed and operating, which was 6 May. However, a heavy debris load had collected in the forebay and the opening was delayed until the next morning (Saturday) when the fish trap could be monitored through the day to reduce the potential for smolt mortalities. When the skimmer gate was opened on 7 May, the downstream screen hoist did not function, though it had operated the day before. The transformer failed and could not be replaced until Monday. On Monday 9 May, the transformer was replaced and the fish trap was opened. Through the rest of the season the fish trap was closed only when the height of the skimmer gate was adjusted to adjust for reservoir height. The trap operated for over 960 h.

Sampling periods, defined as the period of time the fish trap operated between fish removal from the collection tank, ranged from 0.2 h to 18.75 h, and averaged 7.9 h. The fish trap collection tank was checked 122 times and fish collected in the tank were processed an average of 2.9 times per day (ranging from 2 to 3 times per day) (Appendix Table 1). Debris load was sporadically heavy, causing some smolt and resident fish mortalities. The discharge pipe clogged with debris (tree logs and branches, buckets, and other flotsam) on a number of occasions. Debris was removed and the pipe unclogged as soon as practicable.

4.2 Salmon Smolt Collections

Stream-reared Atlantic salmon smolts were collected on each of the 45 days that the fish trap operated and in 100 (82%) of the 122 sampling events. The greatest number of stream-reared smolts taken in one collection event was 118 in the 18 May morning collection. The seasonal distribution of the smolt migration was modal in pattern (Figure 4-1). Over 80% of the catch was collected between 16 and 31 May, and by 1 June 90% of the catch was collected. A total of 1,471 stream reared smolts were collected. This compares to: 240 in 2004 (the fish trap was opened late in the migration season this first year); 1,404 in 2005; 2,473 in 2006; 1,029 in 2007; 691 in 2008; 3,183 in 2009; and 3,214 in 2010. It is likely that some smolts passed the Moore Dam during spill, before the fish trap was opened this year.

For analysis of CPUE, sample periods were divided into three categories relative to when collections were made. The three categories were Morning, Afternoon, and Evening (Table 4-1). The Morning sample period consisted of fish that entered the fish trap after the evening collection was made and before the morning collection was made. Similarly, fish collected in the Afternoon sample period were those that entered the fish trap after the morning collection was made and before the afternoon collection was made; and so on for the Evening collection.

Of 962.6 h of sampling, 55.1% represented the Morning collection, 27.8% the Evening collection, and 17.1% the Afternoon collection. CPUE for stream-reared salmon smolts was highest for the Morning collection at 1.91 smolts/h (SD=2.53), and lowest for the Afternoon collection (0.78 smolts/h, SD=1.16) (Table 4-1). CPUE for stream-reared salmon smolts for the season was 1.31 smolts/h (SD=2.22).

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 1,471 smolts collected, 93.8% (1,380) had no observable injuries, 0.2% (3) showed obvious descaling, 0.7% (1) had contusions, 0.14% (2) had lacerations, 0.34% (4) were moribund, and 5.50% (81) died (Table 4-2).

Length and age data were collected from dead smolts beginning in 2005. Length data from stream-reared smolts collected between 2005 and 2011 show two distinct frequency distributions, suggesting two age classes of smolts passing the fish trap (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 trap was opened, biasing the age sample to early migrants that may have been holdovers from the previous year. The majority of fish aged this year were age-2 (95.9%), three (4.1%) were age-3 smolts. Length-at-age distributions for the years 2005 through 2011 show distinct length-age relationships in some years (e.g., 2005, possibly 2008 and 2009) but not in others (e.g., 2007 and 2011) (Figure 4-3).

4.3 Current Inducer Evaluation

The current inducer fish guidance system was installed and operating when the fish trap was opened. The fish guidance system ran for the season except for approximately four hours on 1 June when TransCanada replaced the transformer supplying the current inducers with a higher capacity unit.

Four groups of tagged fish were released to test the effectiveness of the current inducers fish guidance system. Group 1, consisting of 197 red streamer tagged smolts was released on 12 May; group 2, consisting of 211 blue streamer tagged smolts was released on 15 May; group 3, consisting of 211 brown streamer tagged smolts was released on 18 May; and, group 4, consisting of 207 green streamer tagged smolts was released on 22 May (Table 4-4). All groups were released in the afternoon with release times beginning between 13:00 and 15:40 and lasting an average of about 45 minutes. Evening fish trap collections were made from 2.5 h (group 4) to 5.5 h (group 2) after all fish in the group were released.

Of the 826 fish released, 486 (58.8%) were recaptured in the fish trap (Table 4-4). The proportion returned by group ranged from 53.3% for group 1 to 65.4% for group 2. The number of days between release and recapture (i.e., days at large) ranged from zero for all groups to 32 days for group 2. The mean number of days at large was 5.18 for all groups and ranged from 4.25 days for fish in group 2 to 6.13 days for fish in group 1. For all groups, more than 20% of the fish recaptured were collected in the evening collection following release. Up to 55% of group 2 fish were collected shortly after release, and more than 90% were collected within two weeks of release for all groups (Figure 4-4).

The proportion of fish returned this year was higher than in any other year (Table 4-5), suggesting that that current inducer fish guidance system improved passage to the fish trap. After the attraction flow shelf was installed for the 2006 migration, the percent of tagged fish that were recaptured in the collection tank ranged from 28.4% in 2007 to 48.1% for the first release group in 2010. This does not include the second of the two release groups in 2010 (though it is shown in the table) because those fish were released only eight days before the fish trap was closed.

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 the 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 similar at all three monitoring stations early in the season when flows were high, and varied somewhat when flows decreased in early June (Figure 4-1 and Figure 4-5). During the low flow period, water temperature at the Israel station tended to track water temperature at the Gilman station with a slight time lag. Temperature at the Moore station remained fairly steady during this period and generally warmer (Figures 4-6 and 4-7). Water temperature (15-min readings) ranged from 7.8 to 23.4°C at the Israel River monitoring station, from 9.3 to 20.9°C at the Gilman monitoring station and 9.0 to 21.2°C at the Moore Reservoir monitoring stations during the 9 May through 20 June passage period.

Record high flows occurred this spring. Average daily inflow for the month of April peaked at 34,300 cfs on 29 April, the highest flow on record for that day (years of record were 1927-2010) (Figure 4-8). Spill at all three Fifteen Mile Falls Developments was required to safely pass inflows. Late May inflows of near 16,000 cfs mirrored record flows for a few days. Average daily discharge from the Moore Development closely followed average daily inflow recorded at the Dalton, NH USGS gauge station (see Figure 4-6). During the study period, two peak flow events occurred, which were accompanied by peaks in the number of stream-reared smolts passed to the fish trap. Plotting daily passage numbers of hatchery, streamer-tagged fish against average daily water temperature and average daily flow suggests a pattern of passage similar to stream-reared smolts (Figure 4-9, and see Figures 4-1 and 4-5). Tagged smolt passage numbers, like stream-reared smolt passage numbers, appeared to be more influenced by flow than temperature. Tagged smolt passage numbers were primarily influenced by release day; however, the secondary influence appears to be flow.

The proportion of flow through the skimmer gate, relative to total station discharge, ranged from 3.18 to 49.85% (mean = 12.95%) (Figure 4-10A). High proportional flow through the skimmer gate occurs when there is little or no turbine discharge, and low proportional flow to the skimmer gate occurs when turbine discharge is high. As in previous years, flow to the skimmer gate was maintained at around 500 cfs through the season. Additional inflow is passed through the turbines. In previous years, the proportion of flow through the skimmer gate relative to total station discharge most often fell in the 5-10% and 95-100% frequency categories. This year, flow to the skimmer gate was generally less than 20% of station flow, reflecting the unusually high inflows.

Averaged hourly proportional flow to the skimmer gate demonstrated the stations daily peaking operation, though this year the pattern was not as obvious as in previous years. Proportional flow to the skimmer gate was slightly higher during night hours when flow to the turbines was relatively low (Figure 4-10B). Averaged daily proportion of flow to the skimmer gate was low early in the season when inflow and discharge was high, and increased by the end of the season when inflow and discharge decreased (Figures 4-10B and 4-5). Daily CPUE for smolts appeared to be affected by proportion of flow to the skimmer gate over the seasonal scale, with CPUE greater with a smaller proportion of discharge to the skimmer gate;

however, other factors, such as water temperature and lower instream flow likely have a stronger effect on CPUE (Figure 4-10C).

4.5 Resident Species

Over 9,000 resident fish representing 23 species were collected in the fish trap (Table 4-6). The most abundant species collected was yellow perch (*Perca flavescens)* representing 66% of the resident fish collection. Brown trout (*Salmo trutta*, 6.3%), common shiner (*Notropis cornutus*, 5.7%) and smallmouth bass (*Micropterus dolomieui*, 4.6%) were the next most common resident species collected. The high percentage of yellow perch collected in the trap was twice that of the next highest year, 2010 when 30% of resident fish collection was yellow perch. While the collection of yellow perch this year included many small young-of-year, the abundance of large adults was notable.

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 an assessment of the effectiveness of a current inducer fish guidance system installed in the forebay to guide smolts to the entrance of the fish trap. These objectives were achieved.

TransCanada was requested by the agencies to open the fish trap as early as possible to provide passage for smolts that may be in the reservoir early. The fish trap was opened on the afternoon of 9 May; this opening occurred later in the season than any other year, except 2004 when the fish trap was built. The late opening was the result of late ice-off, unusually high flows, and a hoist transformer failure.

For safety reasons, the boat barrier must be installed before the fish trap can be opened. Installation of the boat barrier requires a minimal amount of ice in the forebay so that a boat can be safely maneuvered to assist with the installation. The boat barrier and the debris boom were both installed on 25 April, after ice-off. It was TransCanada’s intention to install the current inducer fish guidance system after the boat barrier was installed and before the fish trap was opened so that the trap would not have to be shut down after the passage season had started. Current inducer installation began immediately after the boat barrier was installed, but was curtailed by high flows that necessitated spill through the Moore Dam Tainter gates from 27 April through 1 May. For safety reasons boat access to the forebay is not permitted during spill.

TransCanada considered that smolts were probably passing the Moore Development with spill. Preferring to pass smolts via the fish trap than spill, the trap was opened on 29 April, before installation the current inducer fish guidance system was completed. However, within three hours the amount of debris that had accumulated on the screen and in the outlet pipe of the fish trap presented a significant hazard to smolts and the fish trap was closed.

Late in the afternoon of 6 May, current inducer installation and testing was complete; however, the debris load on the debris boom was considerable and the opening was delayed to the next morning, Saturday 7 May, when the fish trap could be monitored regularly through the day to assess and address debris load problems. On May 7, when the hoist for the downstream screen of the fish trap was engaged, it did not respond. TransCanada had conducted a full inspection of the fish trap just a few weeks earlier, and the hoist had been used the day before. The transformer had failed and could not be replaced until Monday. On Monday 9 May, the transformer was replaced and the fish trap was opened. The fish trap and the current inducer guidance system operated through the season with minimal interruption.

The salmon smolt migration exhibited a modal pattern, as was observed in 2005, 2007 and 2010 (Normandeau 2006, 2008, 2010). As in 2007, 2009 and 2010, peak passage this year appeared to follow flow more closely than water temperature, as compared to 2008 when water temperature appeared to influence passage (Normandeau 2008, 2009 and 2010). Inflow peaked twice to over 10,000 cfs and 15,000 cfs between 16 and 31 May when over 80% of the catch was collected. Most of the stream-reared smolts were collected in the morning, indicating an over night or early morning downstream migration.

Researchers have documented the proclivity of smolts to migrate at night (Thorpe and Morgan 1978, Hvidsten *et al.* 1995).

Stream-reared smolt mortalities were high this year; at 5.5% it was the second highest after 2005 when 13% of the stream-reared smolts died. In that year, high debris load was a primary cause of mortality and the impetus to install a debris boom the following year. The debris load in the forebay was high this year due to the high inflows that set adrift vegetative and man-made debris lying on the river bank above the normal high water line. The elevation of the pond was higher than normal for the time of year: 808.3 ft msl on 1 May this year, compared to 800.0 to 802.0 msl from 2006 to 2010. The debris boom prevented much of the debris from entraining on the fish trap and in the collection tank, but not all of it. Tree trunks and branches, buckets and trash cans were all removed from the fish trap. Large debris on the screen can change the surface flow pattern and obstruct passage to the collection tank. Small debris in the collection tank can clog the tank and cause it to overflow. Though few dead smolts were found in the discharge pipe when it was clogged with debris, many smolts likely passed through the pipe when it was partially clogged, causing scale loss and increasing stress. The debris load on the trash barrier, carried by high flows, was significant early in the season and lessened slightly with reduced inflow later in the season. As in past years, a considered effort was made to reduce handling of smolts during collection and transport to reduce stress on the smolts.

Notable this year, was the large number of resident fish collected in the trap. To compare with previous years, the number of resident fish collected was graphed with the total number of smolts collected, and the number of smolt mortalities for each year (Figure 5-1A). A further comparison excluded minnows from the resident fish number. In some years (e.g., 2006 through 2009) minnows comprised more than 60% of the total resident fish collection, and in some years made up less than 15% (2004, 2010 and 2011). Excluding minnows allowed for a more direct comparison between years (Figure 5-1B). Pearson's correlation coefficient was used to test for a relationship between the number of resident fish and the number of smolt mortalities in each year. No statistical correlation was found for the relationship between the number of all resident fish and the number of smolt mortalities ($R=-0.05$, $P= 0.91$), or of the number of resident fish excluding minnows and the number of smolt mortalities ($R=0.625$, $P=0.098$). However, considering the low power (number of years) and relatively high R-value for the relationship between the number of non-minnow resident fish and smolt mortalities, a biological correlation may exist.

The number of non-minnow resident fish collected in 2011 was greater than any other year. Plotting daily collections of resident fish and smolt mortalities shows that smolt mortalities generally occurred on days when the total number of resident fish was high (Figure 5-1C). Carey and McCormick (1998) found that acute handling (netting) and confinement had a significant effect on the stress indicator plasma cortisol in Atlantic salmon smolts, and that plasma cortisol levels retuned to near normal 24 hours after the stressor was eliminated. Carey and McCormick (1998) tested confinement levels that mimicked hatchery transport conditions during stocking: 100g of biomass per 1 liter of water, maintained for three hours. Resident fish are not weighed when collected so a direct comparison of biomass confinement is not possible. Converting biomass to numbers is a less accurate comparison, but possible with the available data. Most of the resident fish collected this year were yellow perch (66%) and an average yellow perch weighs about 150g. The collection tank holds about 3,000 liters of water, equating a confinement level of 100g per liter, to around 2,000 yellow perch equivalents. The greatest number of fish (residents and smolts) collected in the fish trap in one collection event this year was 1,200. This confinement level is much less than the confinement level tested, however, the holding time in the collection tank is usually longer than three hours, and the holding tank usually includes a variety of species. A particular level of crowding is likely more stressful when smolts are crowded with other species that include prey species. These data suggest another factor to be considered when contemplating measures to reduce smolt mortalities. Increasing the number of collections per day when resident fish numbers are high, may help to reduce smolt mortalities. The peak in the number of resident fish collected in the trap at the end of May coincided with a peak inflow event. A significant increase in inflow could be a trigger suggesting that additional collections should be made.

Predation also contributed to smolt mortalities, as was evidenced when the stomach contents of two Northern pike collected in the trap were examined. One of the pike had two smolts in its stomach, a stream-reared and a hatchery-reared, the other had no fish in its stomach.

The number of smolts passing the fish trap this year ranked fourth from the highest of the eight years of passage. Smolts entering the Moore fish trap are the product of salmon fry stocked in tributaries above the Moore Dam by NHFGD and VTDFW. The majority of stocked 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 fish trap during the years 2005-2011 (2004 was not included because the fish trap was opened late in the season) using Pearson's correlation coefficient. Because fry smoltify in approximately two years, fry stocking numbers from 2003-2009 were compared with the number of smolts collected in the trap from 2005-2011 (Table 5-1, Figure 5-2). No statistical correlation was found for the relationship between the number of fry stocked and the number of smolts collected in the fish trap (R=0.03, P= 0.95) or for the relationship between the estimated production number and the number of smolts collected at the fish trap (R=0.65, P=0.11). 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 fish trap, a biological correlation may exist. Interestingly, this year the number of smolts collected was only 35% less than the estimated production number, this is the lowest deference to date. Over the seven years evaluated, production estimates increased gradually from 2005 to 2007, fell slightly in 2008, increased significantly in 2009 and fell in 2010 and 2011 to its current lowest estimated value of 2,266 parr. The number of fry stocked from 2003 to 2009 increased slightly to a peak in 2004, dropped to the lowest value in 2006 and has increased each year to 189,166 fry stocked above the Moore reservoir in 2009.

Of the 74 fish aged through scale analysis, 95.9% were determined to be age-2, the remaining three were age-3. These fish were collected over the full migration season; two of the age-3 smolts were collected early in the season (11 and 16 May) and one was collected in the middle of the season (30 May). There were no large smolts collected at the beginning of the season, as has been observed in previous years. These early, larger fish are thought to be holdovers: smolts that move downstream at age-2, do not pass into the fish trap, and remain in the reservoir or nearby tributaries until the following spring. This year, holdovers may have passed with spill before the fish trap was opened.

Age data for this year coincides with data from previous years, except 2008, indicating 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 holdovers. 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.

The current inducer fish guidance system was installed and functional before the fish trap was opened. Four groups of tagged hatchery-reared smolts totaling 826 fish were released into the forebay by 22 May, about midway into the peak of the stream-reared smolt run. For all groups, greater than 90% of the smolts recaptured were collected within two weeks of release (Figure 4-4) and less than 10% were collected in the remaining two to three weeks (depending on release date) that the fish trap was opened. This suggests that the smolts were released early enough in the migration season to obtain a representative estimate of passage effectiveness. The return of 60% of the tagged fish suggests that the current inducer fish guidance system improved fish passage to the fish trap. The close relationship between smolt production estimates and the number collected in the fish trap also supports the observation of higher effective passage this year. However, the extremely high flows observed this year may have contributed to the high relative passage.

5.1 Conclusions

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

- The inclined plane fish tarp 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.
- Spill conditions early in the season this year likely provided a conveyance past the Moore Development for some smolts before the fish trap was opened.
- 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.
- Crowding in the collection tank of the fish trap may lead to higher mortalities due to increased stress.
- The percent of hatchery-reared smolt returns was the highest to date, suggesting that the current inducer fish guidance system may have increased smolt passage to the fish trap. Unusually high spring flows may also have contributed to high hatchery-reared returns this year.
- Monitoring smolt passage numbers with the current inducer fish guidance system installed in the forebay should be continued.

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TABLES

Table 3-1. Codes used to document condition of salmon smolts collected in the moore fish trap, spring 2011.

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 fish trap
8	Moribund
9	Dead

Table 4-1. Number of collections made at the fish trap, effort, and catch-per-unit-effort (smolts/h) for stream-reared Atlantic salmon smolts collected at the Moore fish trap, spring 2011. Collections were 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)	42	530.15	11.17 - 18.75	12.62	1.41	6:32 - 8:20
Afternoon (morning set, afternoon collection)	39	164.88	0.2 - 5.05	4.23	0.81	11:05 - 14:40
Evening (afternoon set, evening collection)	41	267.55	2.5 - 9.67	6.53	1.4	16:15 - 19:30

	SR Smolts			CPUE			
Time Category	**Number**	**Mean**	**SD**	**Overall CPUE**	**Mean**	**SD**	**SE**
Morning	1015	24.17	32.02	1.91	1.93	2.53	0.39
Afternoon	128	3.28	4.78	0.78	0.79	1.16	0.19
Evening	328	8.00	17.96	1.23	1.17	2.53	0.40

Table 4-2. Physical condition and potential cause of mortality for stream-reared salmon smolts collected in the Moore fish trap, spring 2011. 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	1,380	93.75	468	95.51
Descaling	3	0.20	0	0.00
Eye injury	0	0.00	0	0.00
Contusions, and …	1	0.07	0	0.00
Lacerations, and …	2	0.14	0	0.00
Moribund, and …	4	0.34	1	0.20
Dead, and …	81	5.51	21	4.26

Table 4-3. Number of stream-reared Atlantic salmon smolts collected at the Moore fish trap from 2005 through 2011, 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]	-	-	-	-	-	-	-	-
2011	1,471	74	5.03%	71	95.9	165-310	200.5	3	4.1	210-330	252.0				

[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. Release and return data for four groups of hatchery-reared Atlantic salmon smolts released in the Moore Reservoir forebay, spring 2011. All fish were released approximately 300 feet upstream from the skimmer gate.

						Days at Large		
Release Group	**Tag Color**	**Number Released**	**Release Date**	**Number Returned**	**% Return**	**Range**	**Mean**	**SD**
1	Red	197	5/12/11	105	53.30	0-24	6.13	5.48
2	Blue	211	5/15/11	138	65.40	0-32	4.25	6.61
3	Brown	211	5/18/11	119	56.40	0-26	4.69	5.20
4	Green	207	5/22/11	124	59.90	0-28	5.89	5.65
Total		*826*		*486*	*58.84*	*0-32*	*5.18*	*5.84*

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, 2010 and 2011.

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 to 1 mi.
2009[e]		889	329	37.01	forebay to 1 mi.
2010[b]	(released 5/10)	333	160	48.05	~ 450 ft
	(released 6/11)[f]	416	66	15.87	~ 450 ft
2011[bg]		826	486	58.84	~ 300 ft

a - Smolts from White River Hatchery

b - Smolts from Pittsford Hatchery

c - Attraction flow shelf and debris boom installed

d - Spill occurred for ~25 h on 11-12 June

e - Smolts from collection tank

f - Fish trap closed 8 days after smolts released

g - Spill occurred for ~4 h on 28 May

Table 4-6. Resident fish species and estimated number collected in the Moore fish trap between 9 May and 19 June 2011.

Common Name	Scientific Name	Number Collected		Percent of Total
Yellow perch	*Perca flavescens*	6004		65.76
Brown trout	*Salmon trutta*	579		6.34
Common shiner	*Notropis cornutus*	520	(approx)	5.70
Smallmouth bass	*Micropterus dolomieui*	422		4.62
Golden shiner	*Notemigonus crysoleucas*	386		4.23
Spottail shiner	*Notropis hudsonius*	375	(approx)	4.11
Unidentified minnow		300	(approx)	3.29
Northern redbelly dace	*Phoxinus eos*	192		2.10
Rockbass	*Ambloplites rupestris*	132		1.45
Rainbow smelt	*Osmerus mordax*	72		0.79
Rainbow trout	*Oncorhynchus mykiss*	50		0.55
Black crappie	*Pomoxis nigromaculatus*	41		0.45
Largemouth bass	*Micropterus salmoides*	15		0.16
Pumpkinseed	*Lepomis gibbosus*	11		0.12
Northern pike	*Esox lucius*	10		0.11
Redbreast sunfish	*Lepomis auritus*	8		0.09
White sucker	*Catostomus commersoni*	3		0.03
Bluegill	*Lepomis macrochirus*	3		0.03
Brook trout	*Salvelinus fontinalis*	2		0.02
Blacknose dace	*Rhinichthys atratulus*	2		0.02
Brown bullhead	*Ameiurus nebulosus*	2		0.02
Fallfish	*Semotilus corporalis*	1		0.01

Table 5-1. Number of salmon fry stocked above the Moore Dam, estimate of smolt production numbers from index sites above the Moore Dam.

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 Fish Trap[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	208,695	6,119	3,214
2011	N/A	2,266	1,471

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

[2] Salmon smolt production numbers provided by VTDFW.

[3] Installation of the fish trap was completed in 2004, shortly after the smolt migration began.

FIGURES

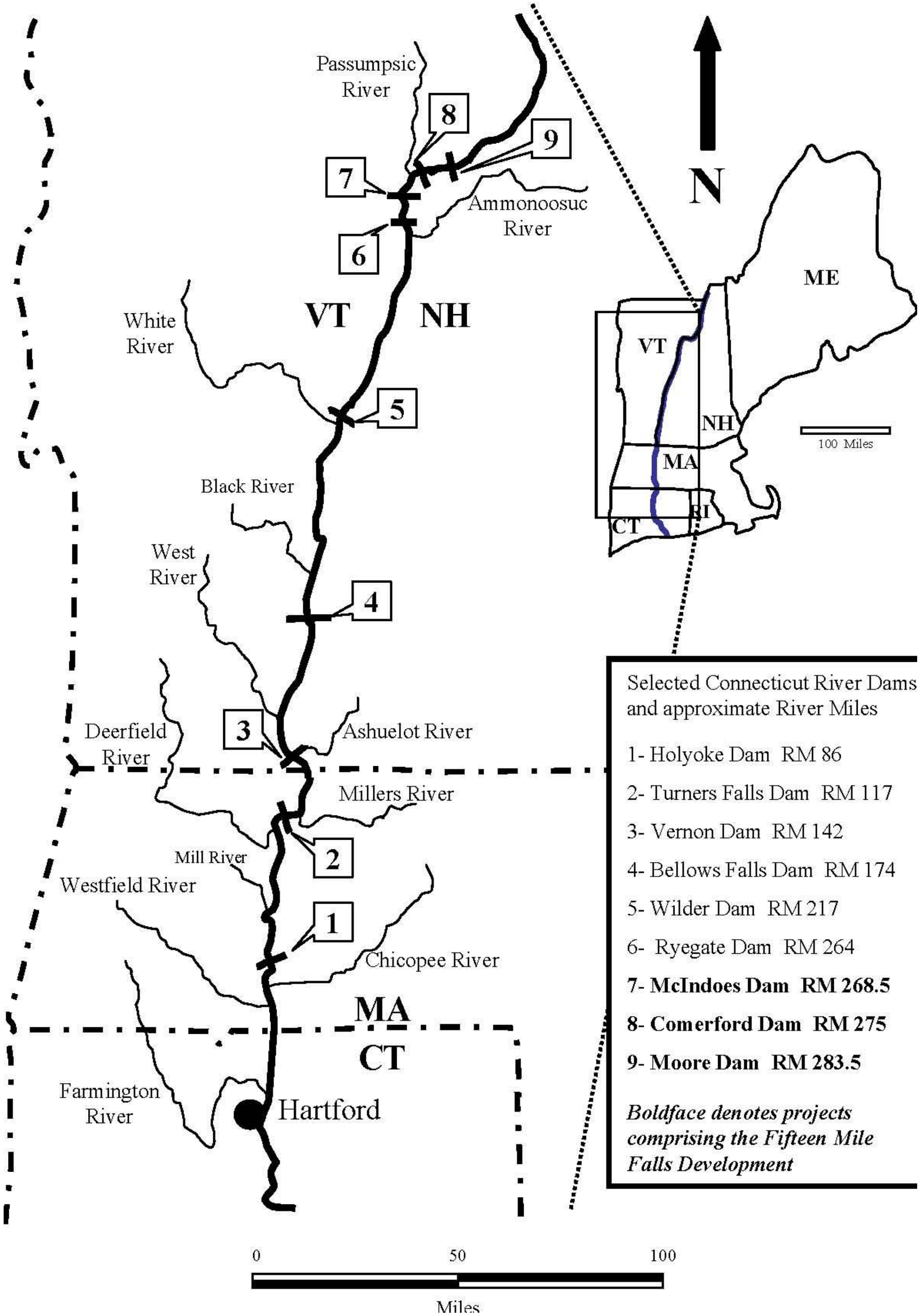


Figure 1-1. Location of the Fifteen Mile Falls Project on the Connecticut River.

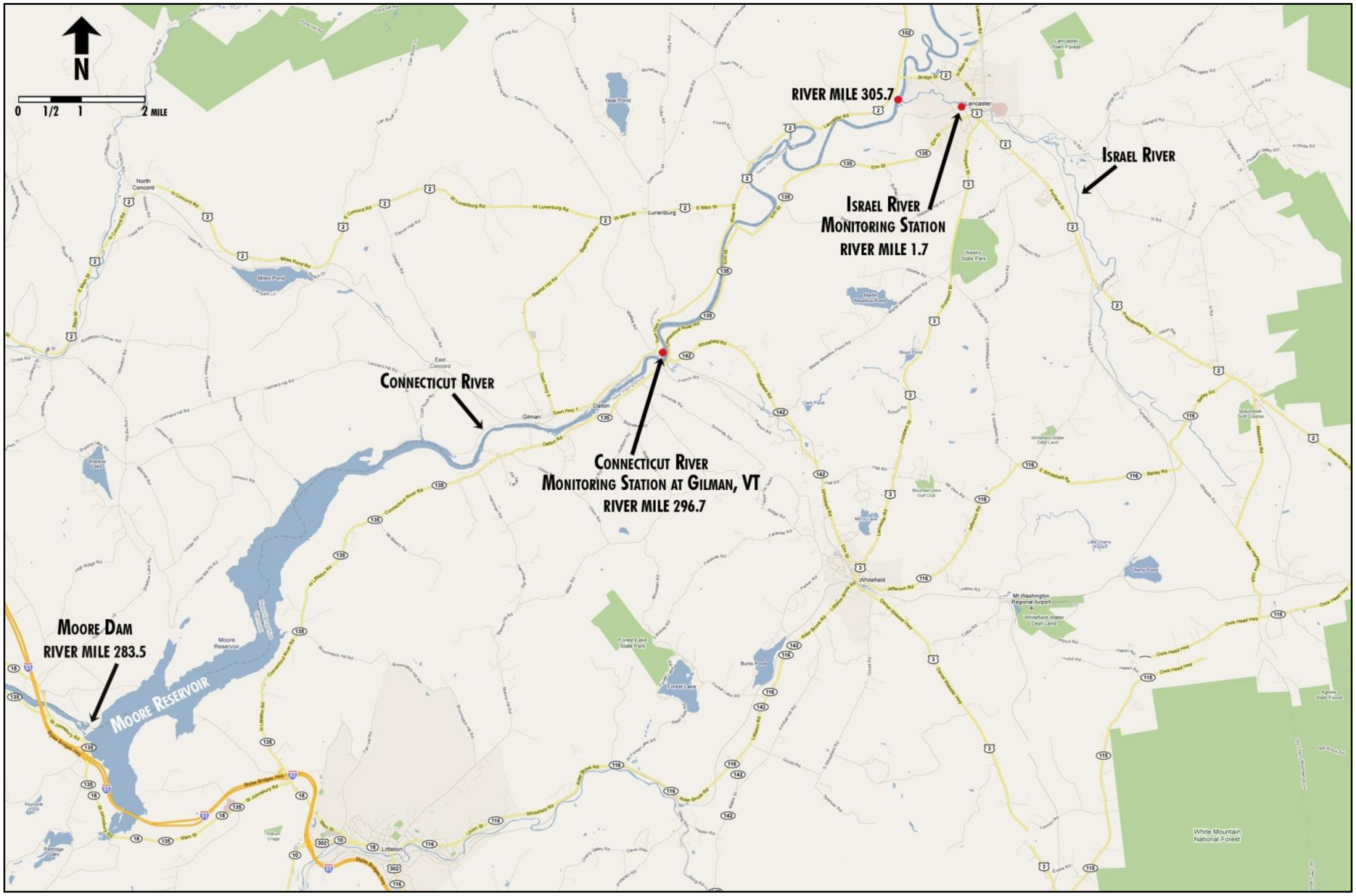


Figure 1-2. Location map showing the Moore Dam and three water temperature monitoring stations: Moore Reservoir, Connecticut River at Gilman, VT and Israel River.

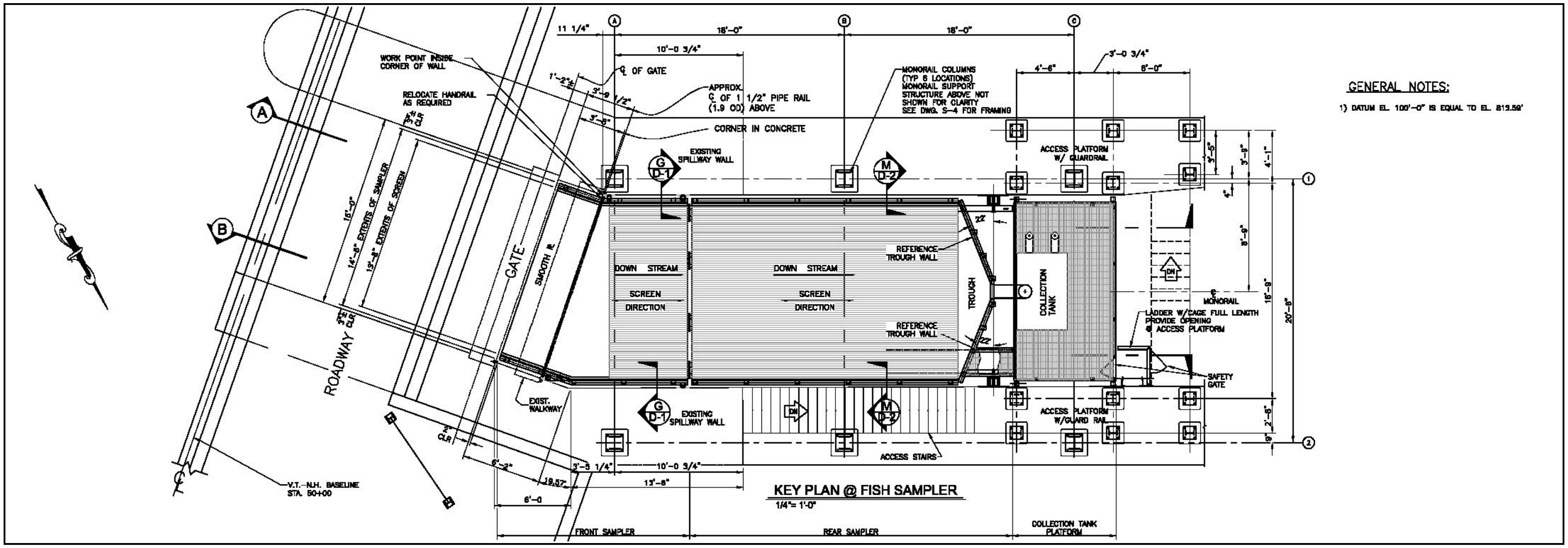


Figure 2-1. Key plan of TransCanada's Moore Development inclined plane sampler. The plan does not show flow reflectors installed after the fish trap was erected. Plan drawing prepared by Kleinschmidt.

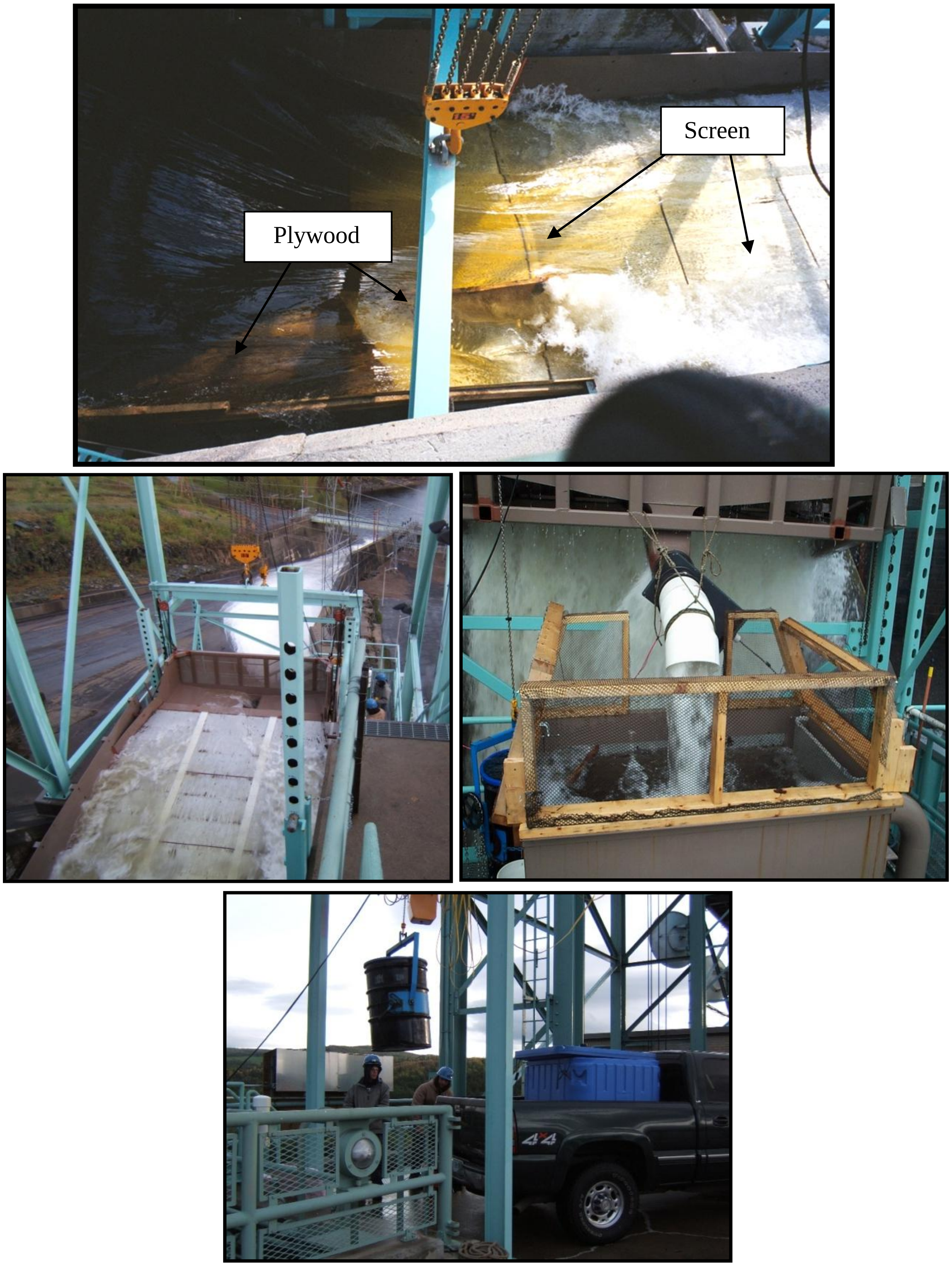


Figure 2-2. Moore fish trap showing plywood flow adjusters (top), dewatering surface (middle left), discharge pipe and collection tank (middle right), and monorail system used to transport fish from the collection tank to the transport tank (bottom).


Figure 2-3. Moore fish trap 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 fish trap forebay attraction light. The skimmer gate attraction light is not visible from this angle.

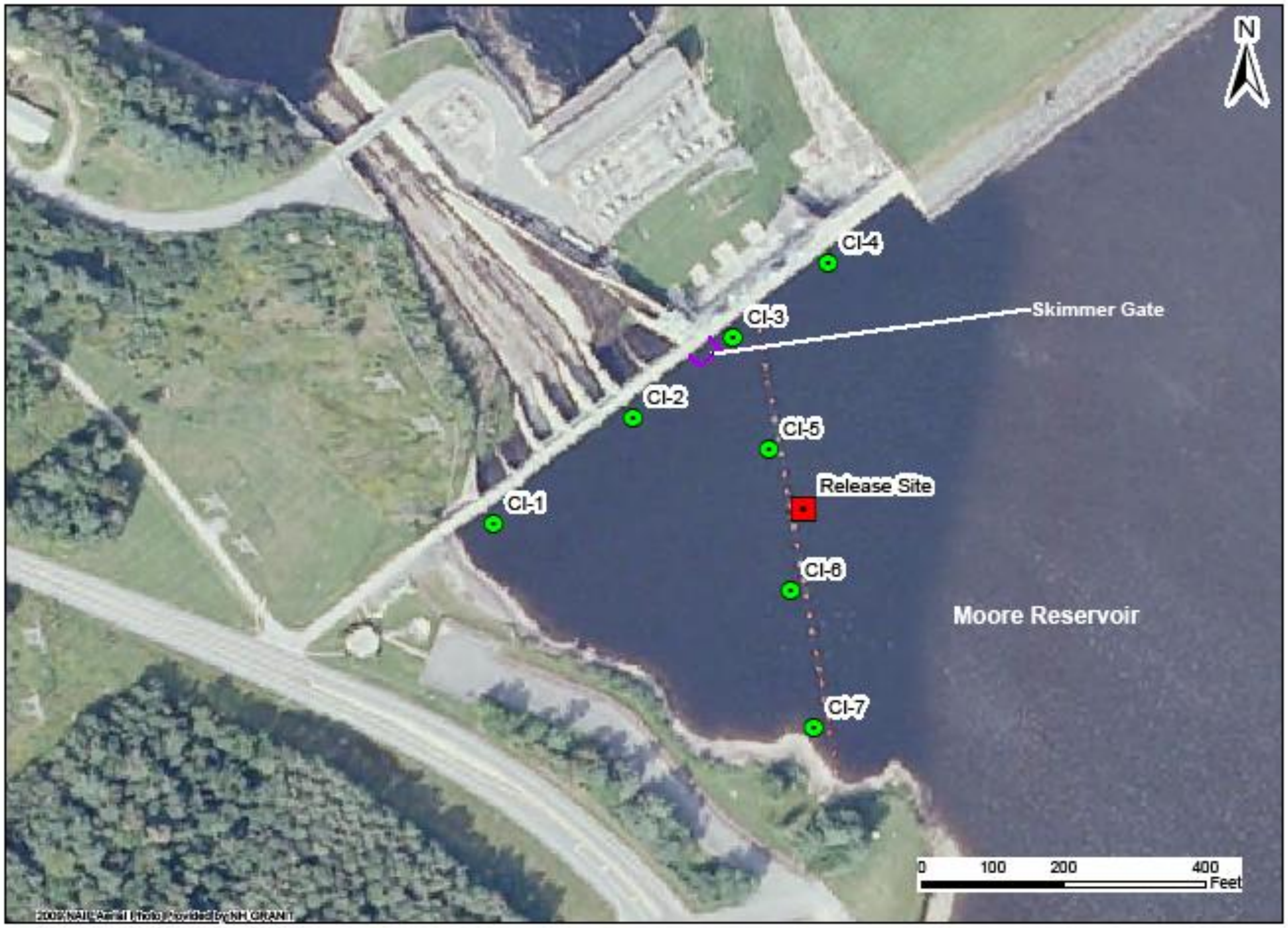


Figure 3-1. Aerial view of the Moore dam and reservoir showing the configuration of the seven current inducers (CI-1 through CI-7) relative to the skimmer gate entrance and the boat barrier; and, the release site for the tagged hatchery fish, spring 2011.

Figure 3-2. A red streamer tag attached to a hatchery Atlantic salmon smolt (top). Two blue streamer tagged hatchery Atlantic salmon smolts in a bucket with five stream-reared Atlantic salmon smolts after retrieval from the fish trap collection tank (below), spring 2011.

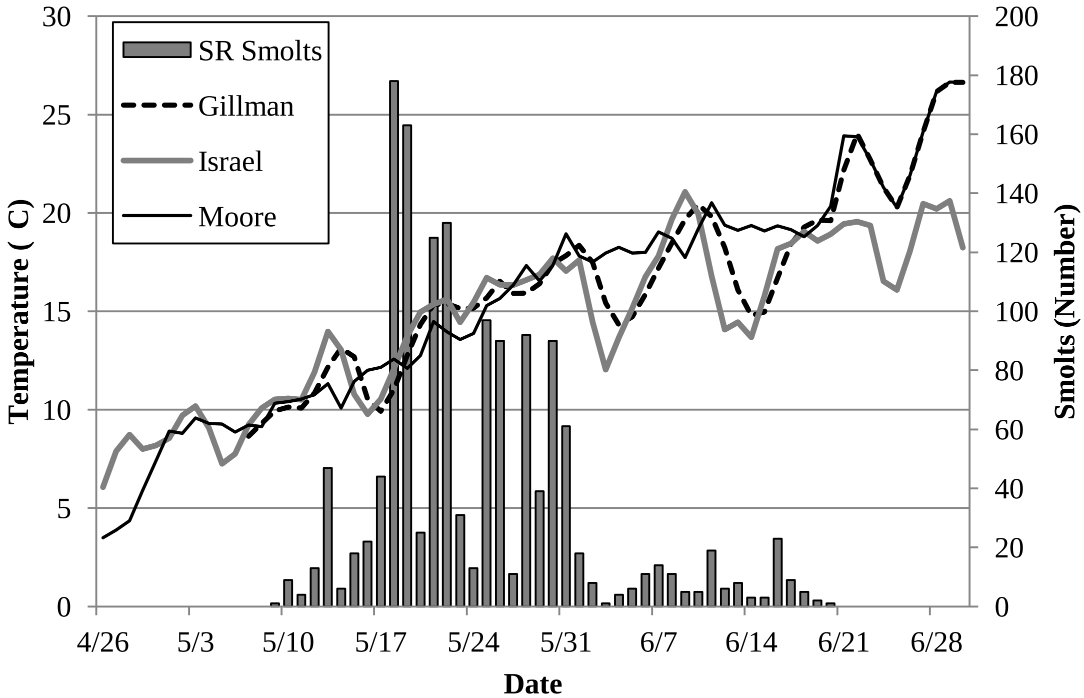


Figure 4-1. Daily average water temperature at the Israel River, Gilman and Moore monitoring stations, and daily sum of stream-reared smolts collected in the Moore fish trap, spring 2011.

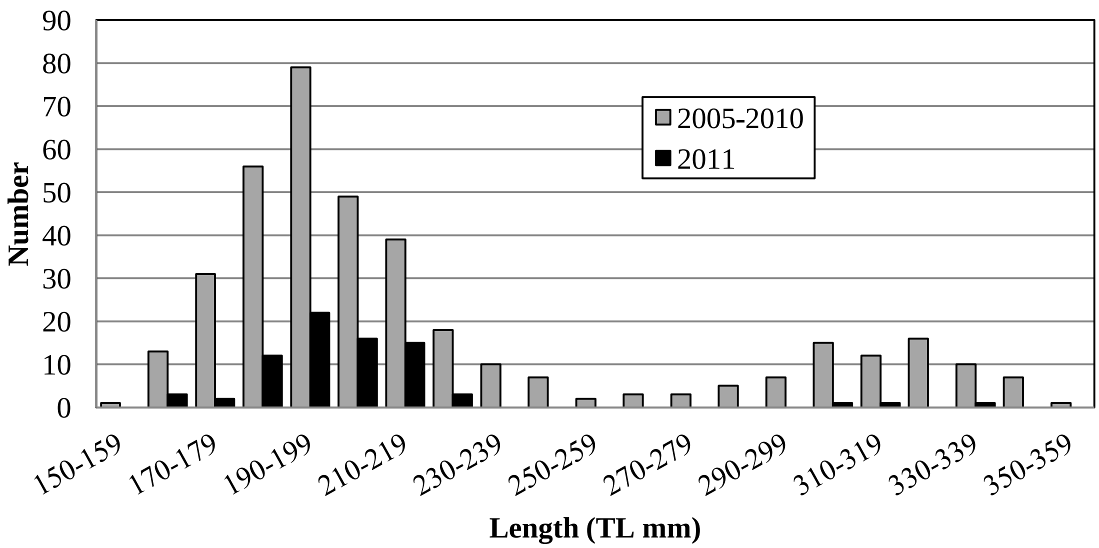


Figure 4-2. Length frequency distribution of a sub-set of stream-reared Atlantic salmon smolts collected in the Moore fish trap in 2011 compared with collections made in 2005 through 2010.

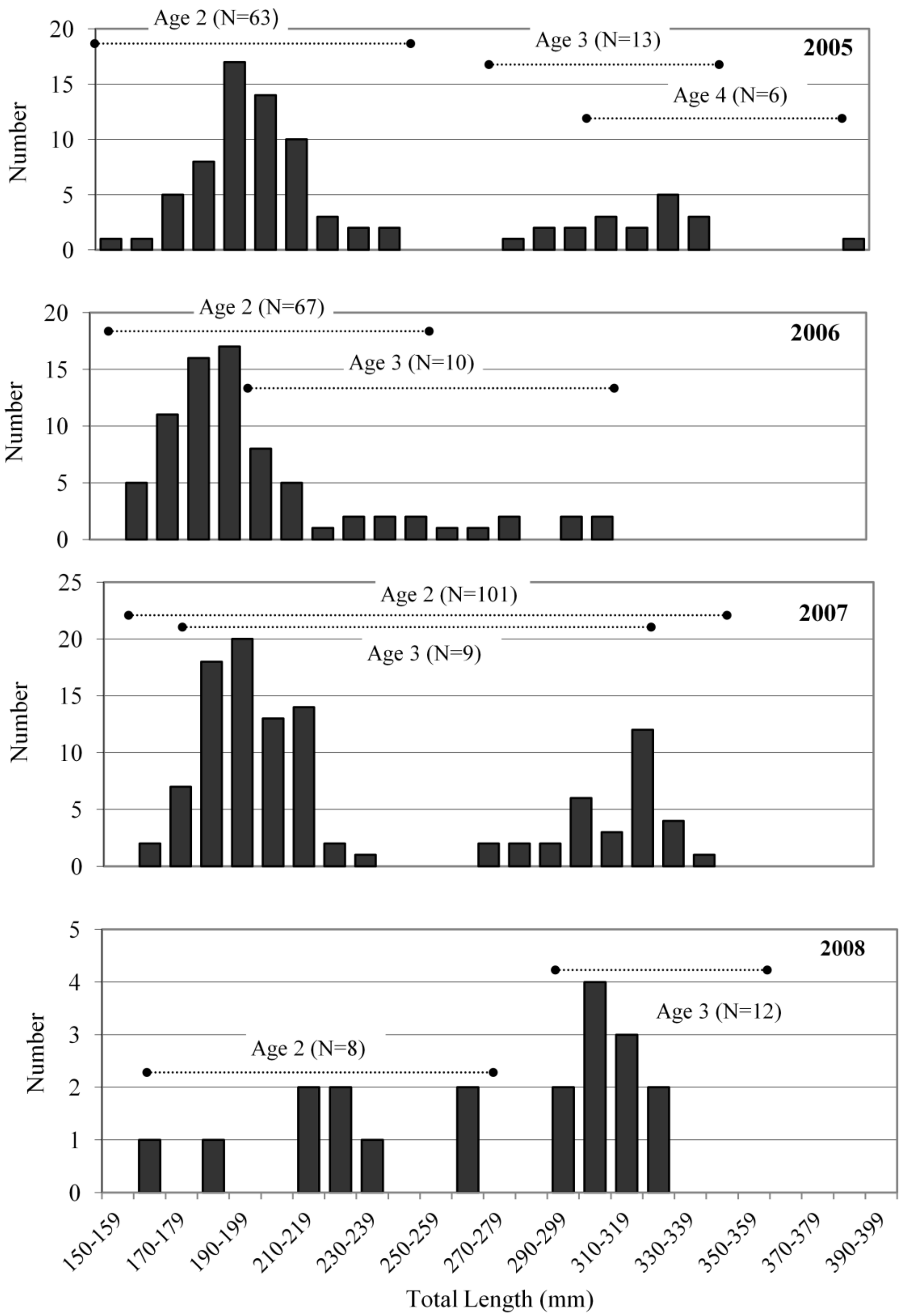


Figure 4-3. Length at age distributions for a sub-set of Atlantic salmon smolts collected at the Moore fish trap during the years 2005 through 2011.

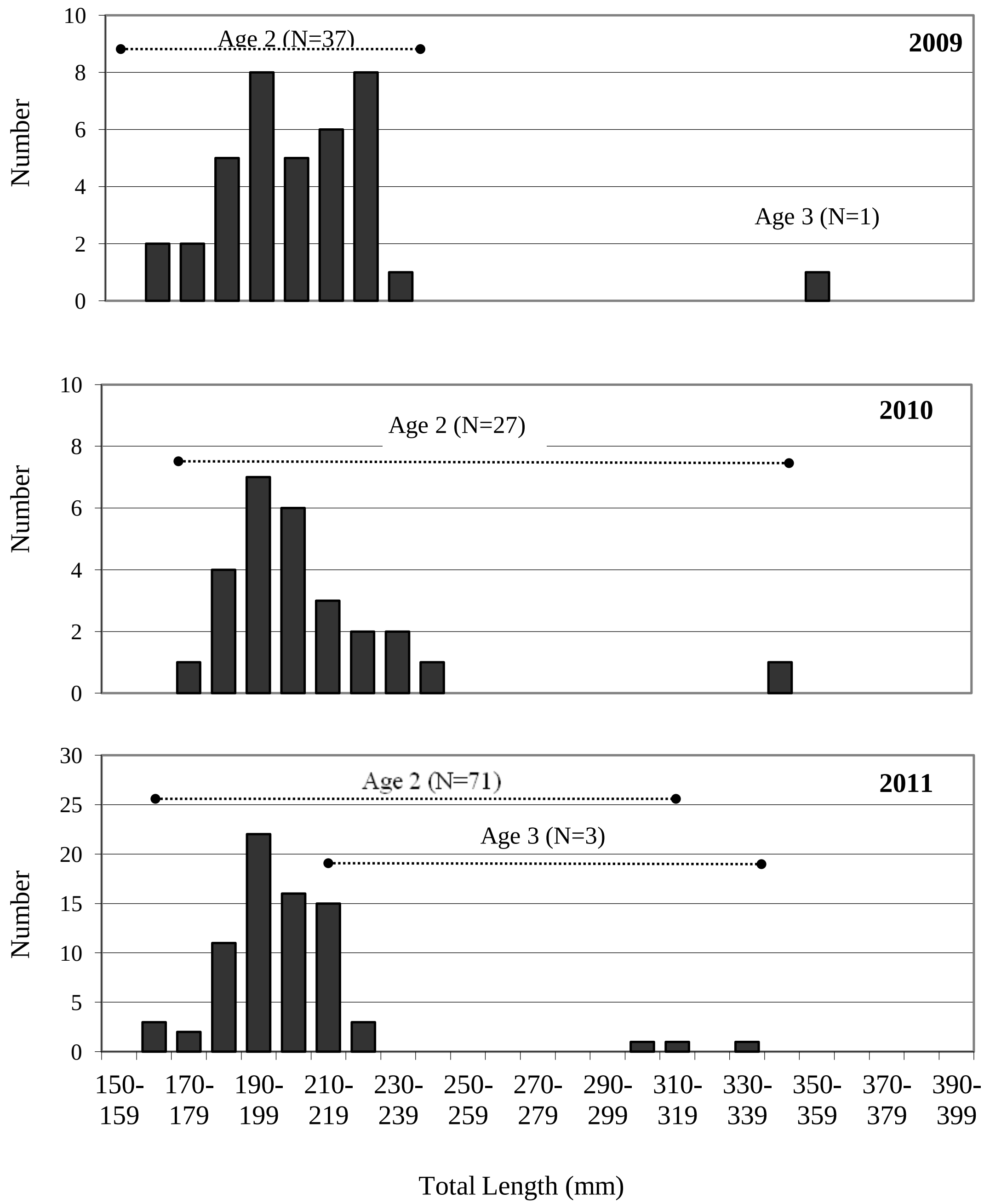

2009
Age 2 (N=37)
Age 3 (N=1)
Number
0
2
4
6
8
10
2010
Age 2 (N=27)
Number
0
2
4
6
8
10
2011
Age 2 (N=71)
Age 3 (N=3)
Number
0
5
10
15
20
25
30
150-159
170-179
190-199
210-219
230-239
250-259
270-279
290-299
310-319
330-339
350-359
370-379
390-399
Total Length (mm)

Figure 4-3. Continued.

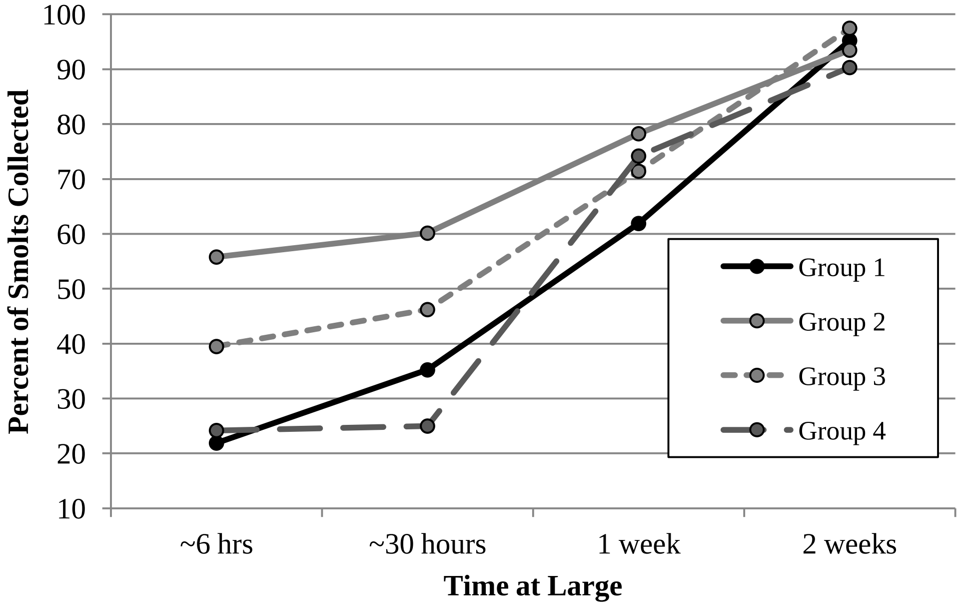


Figure 4-4. Time at large (time from release to collection in the fish trap) for tagged smolts by release group.

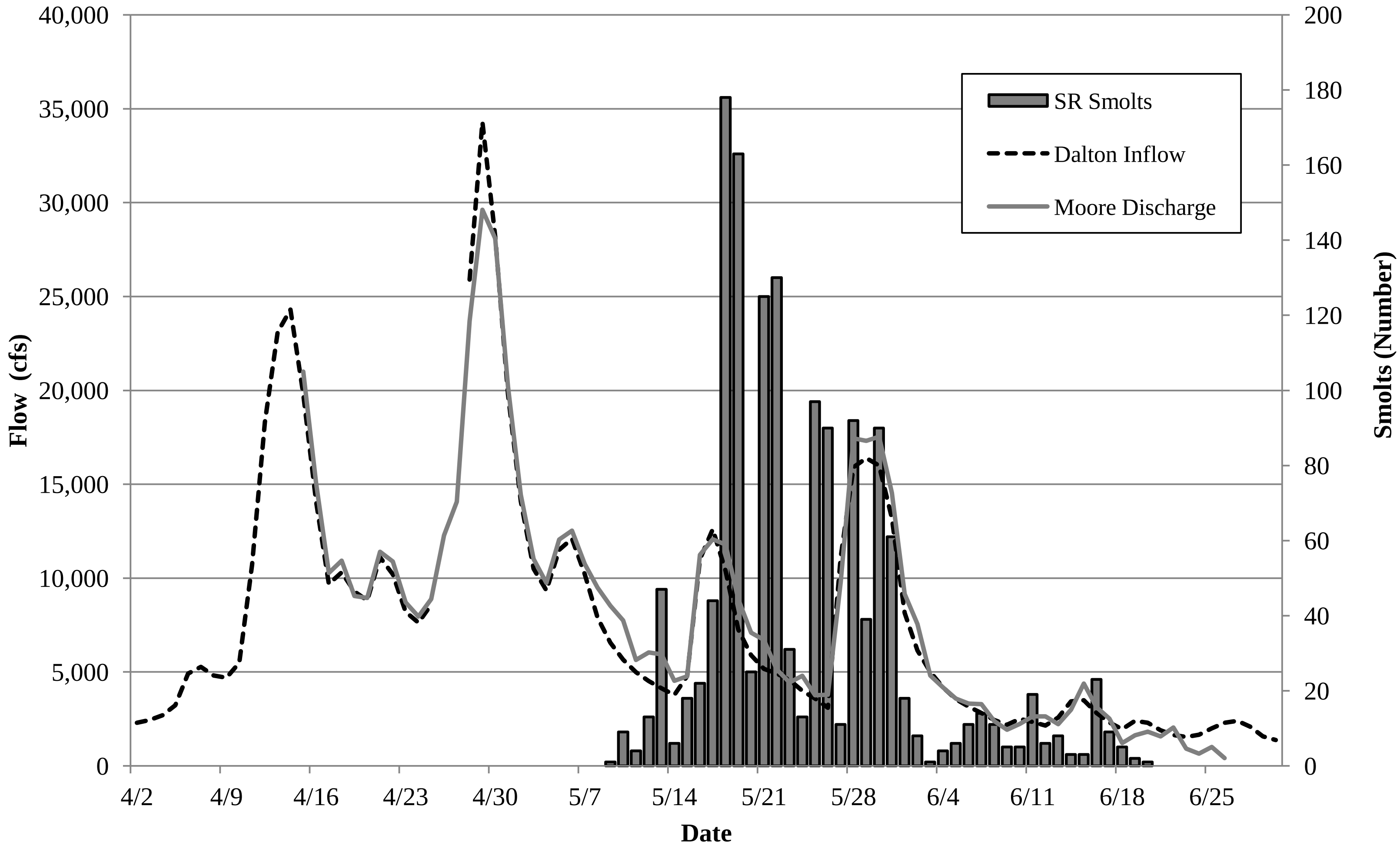


Figure 4-5. Daily average inflow (cfs) to the Moore Reservoir recorded at USGS Gauge 01131500 located at the Dalton Hydro, and outflow from the Moore Development, recorded by TransCanada, compared with daily collection (number of Atlantic salmon smolts at the Moore fish trap, spring 2011

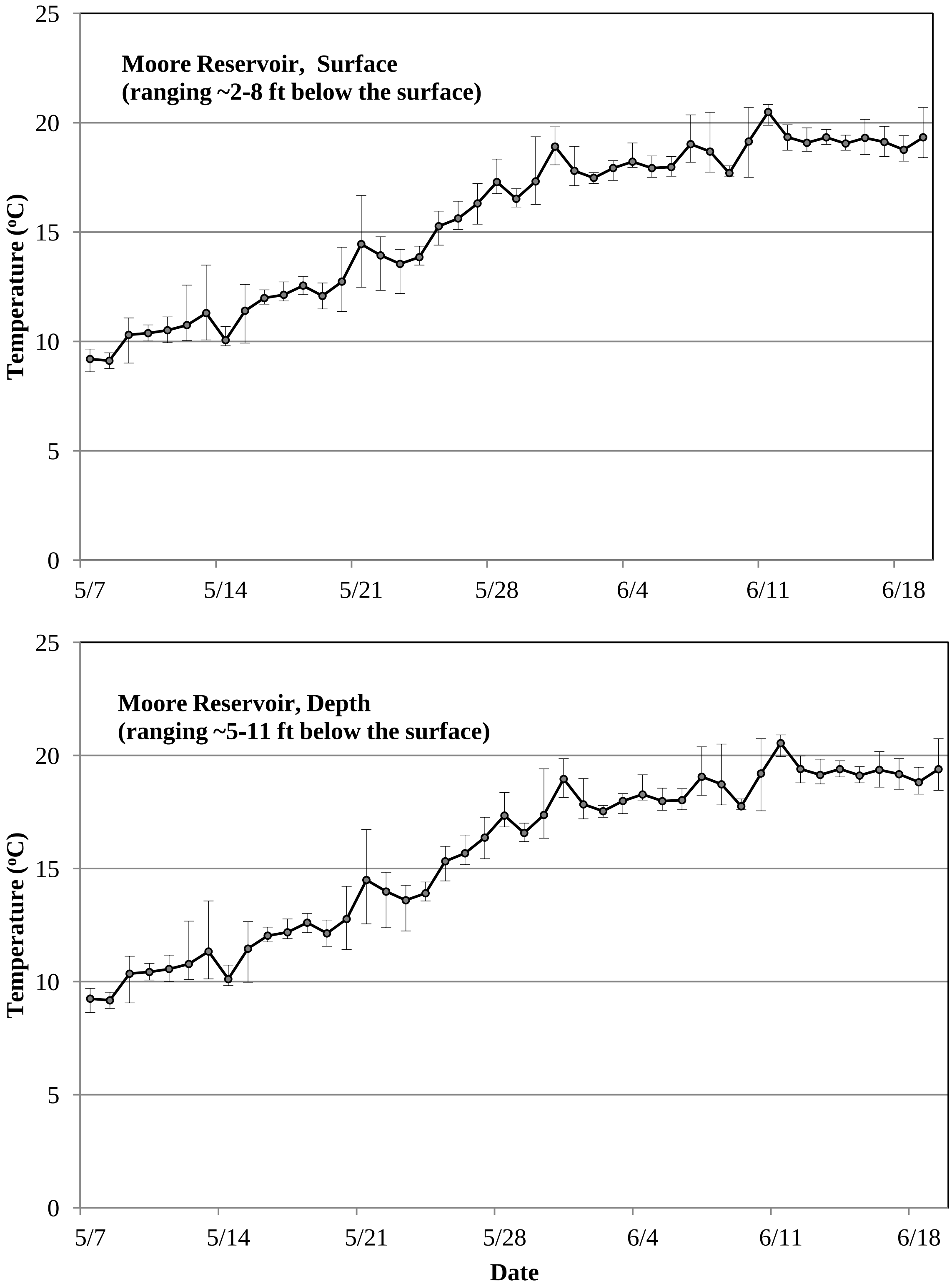
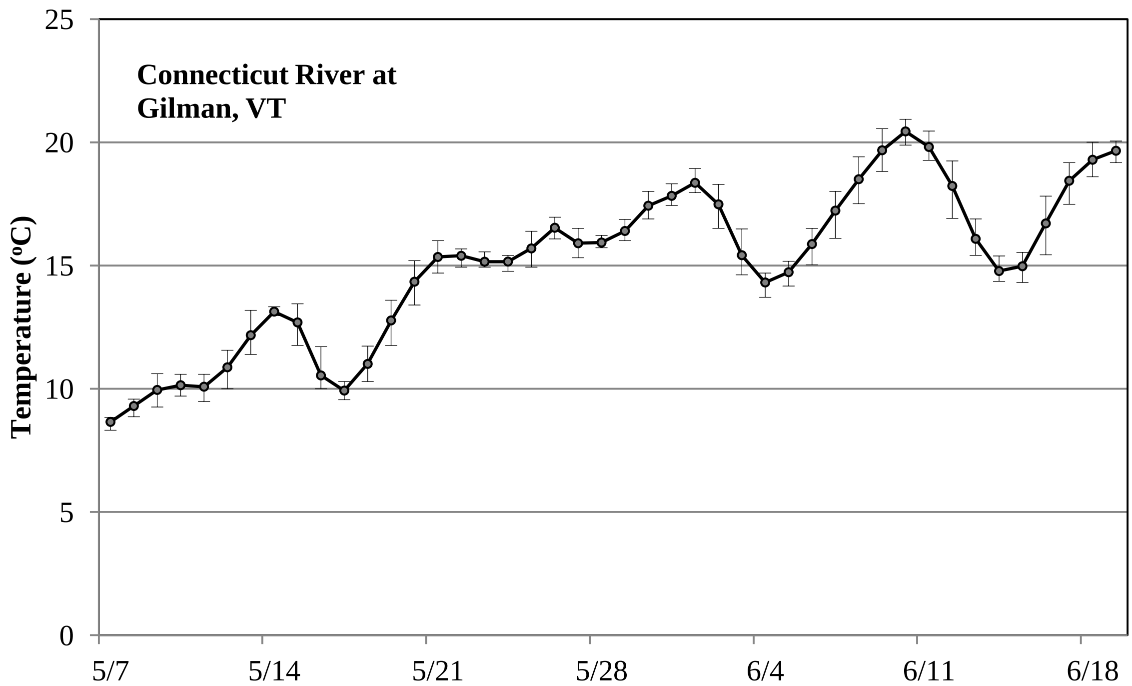


Figure 4-6.Mminimum, mean, and maximum daily water temperature in the Moore reservoir approximately 3-ft and 6-ft below the surface (at the time of deployment) from 7 may through 19 June 2011.



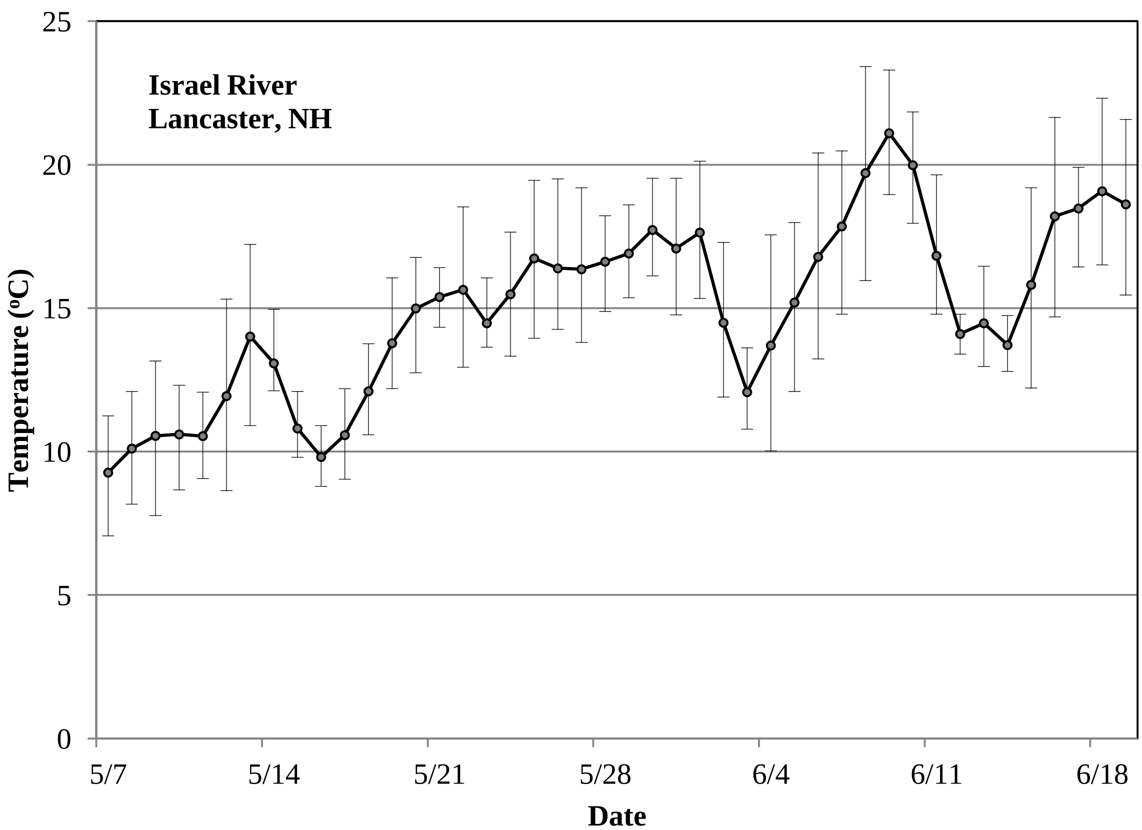


Figure 4-7. Minimum, mean, and maximum daily water temperature in the Israel River and Connecticut River monitoring stations from 7 May through 19 June 2011.

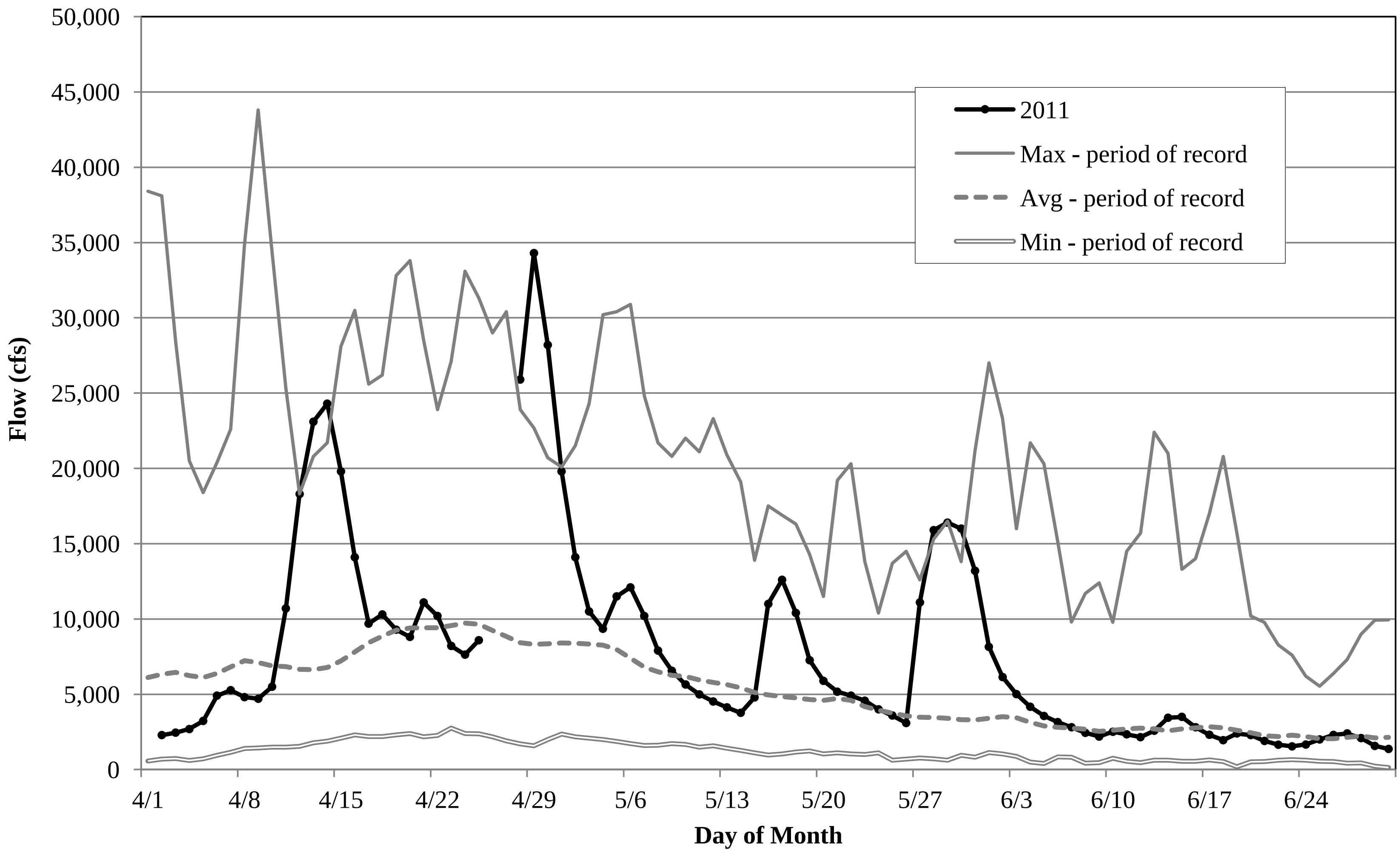


Figure 4-8. Maximum, mean, and minimum period of record (1927-2010) flows recorded at USGS gauge 01131500 located at the Dalton hydro for the months of April through June, compared with flow data from the same gauge for April through June 2011.

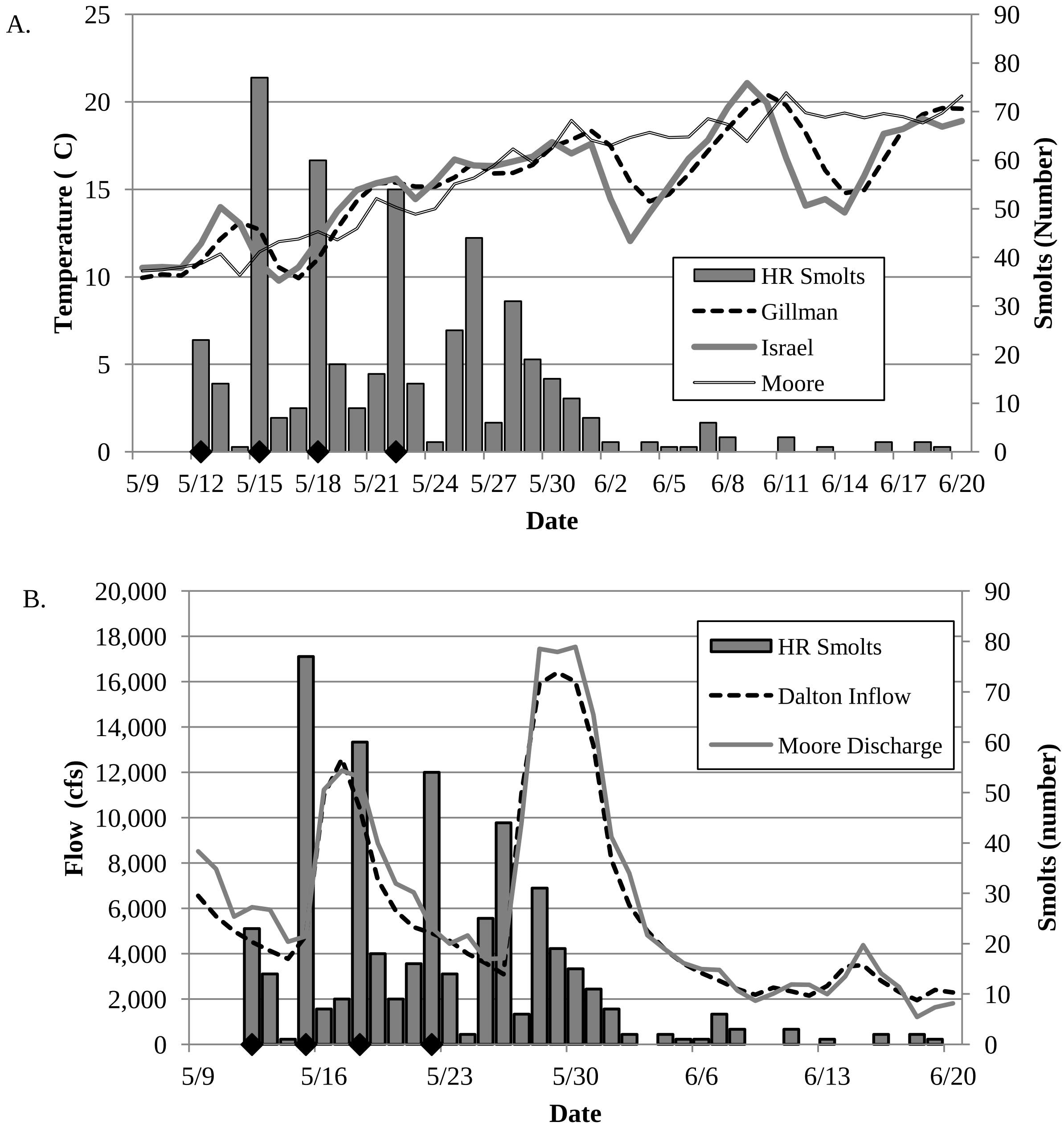


Figure 4-9. Daily sum of tagged hatchery-reared smolts collected in the Moore fish trap compared with A. daily average water temperature at the Israel, Gilman, and Moore monitoring stations, and B. inflow and outflow, spring 2011. Diamond markers indicate days fish were released: Group 1 (N=197) released 12 May; Group 2 (N=211) released 15 May; Group 3 (N=211) released 18 May; Group 4 (N=207) released 22 May.

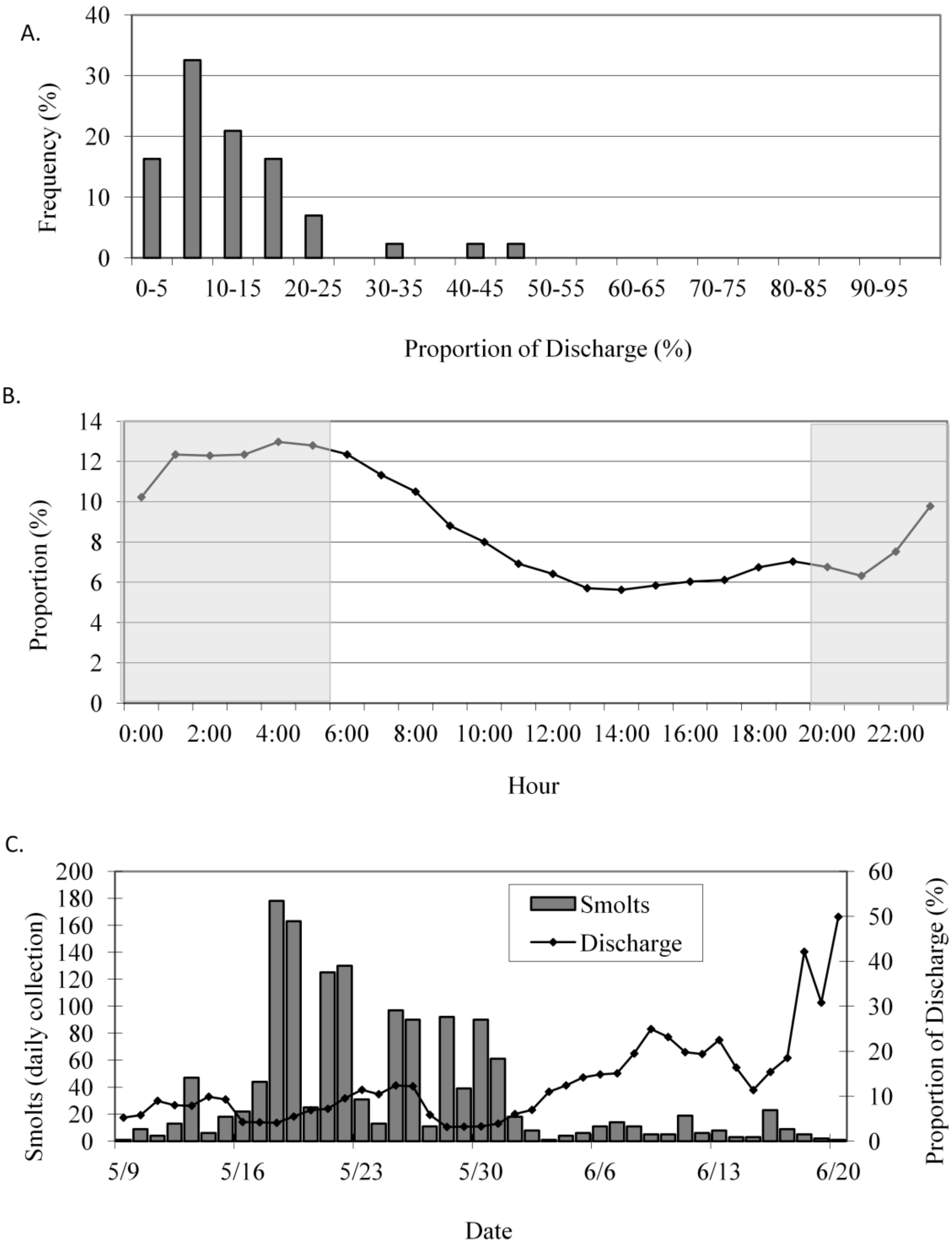


Figure 4-10. A. Frequency distribution of proportion of discharge (turbine flow + skimmer gate flow) to the skimmer gate; B. Hourly average proportion of discharge to the skimmer gate (shaded areas are approximate nighttime hours); C. Daily average proportion of discharge to the skimmer gate and daily total collection of stream-reared smolts.

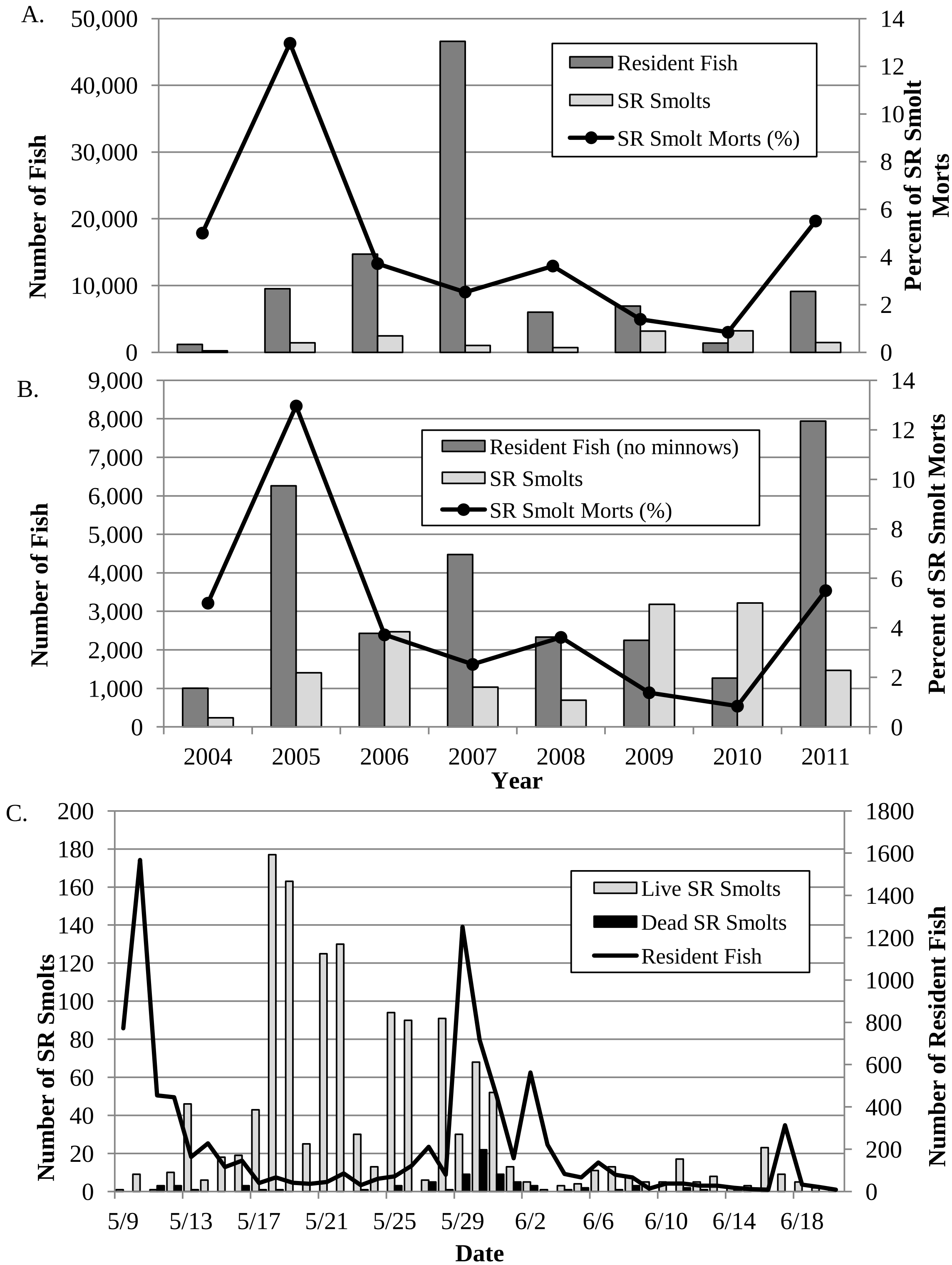


Figure 5-1. A. Annual (2004-2011) number of resident fish and stream-reared smolts collected in the fish trap, and the number of stream-reared smolt mortalities. B. Same as A, but excluding minnows from the number of resident fish collected. C. 2011 daily collection of live and dead stream-reared smolts compared with daily collection of yellow perch and all other resident fish.

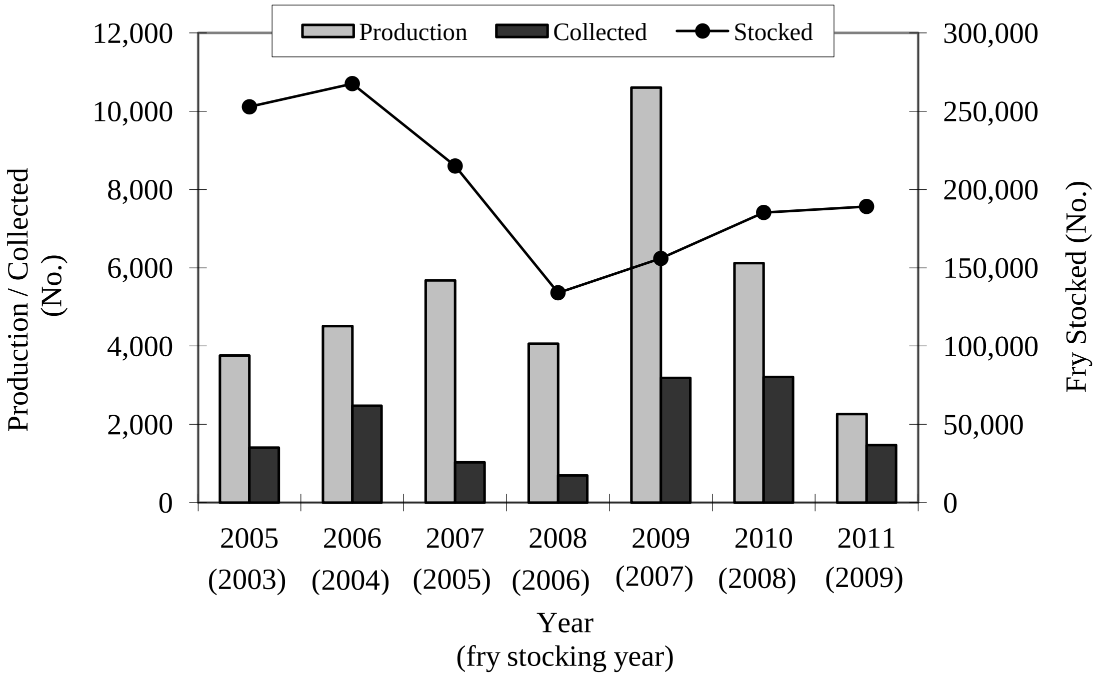


Figure 5-2. Comparison of the number of salmon fry stocked above the Moore Dam, estimated production of salmon smolts from index sites above the Moore Dam and salmon smolts collected in the Moore fish trap for the years 2005-2011. Because fry smoltify in approximately two years, salmon fry stocking numbers from 2003-2009 are compared with 2005-2011 production estimates and the number of smolts collected in the fish trap.

APPENDIX A

Appendix Table 1. Number of stream-reared Atlantic salmon smolts collected in the Moore dam fish trap during each of 122 sampling periods, spring 2011. 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
Afternoon	5/9	14:28	5/9	14:40	0.20	0	0.00
Evening	5/9	15:00	5/9	17:30	2.50	1	0.40
Morning	5/9	17:45	5/10	6:32	12.78	3	0.23
Evening	5/10	6:50	5/10	16:20	9.50	6	0.63
Morning	5/10	17:55	5/11	7:45	13.83	3	0.22
Afternoon	5/11	8:18	5/11	12:10	3.87	0	0.00
Evening	5/11	12:20	5/11	16:45	4.42	1	0.23
Morning	5/11	16:50	5/12	7:15	14.42	8	0.55
Afternoon	5/12	8:35	5/12	12:15	3.67	1	0.27
Evening	5/12	12:30	5/12	19:20	6.83	4	0.59
Morning	5/12	19:35	5/13	7:30	11.92	33	2.77
Evening	5/13	8:05	5/13	17:30	9.42	14	1.49
Morning	5/13	17:45	5/14	7:45	14.00	5	0.36
Afternoon	5/14	8:00	5/14	12:20	4.33	1	0.23
Evening	5/14	12:30	5/14	19:28	6.97	0	0.00
Morning	5/14	19:36	5/15	7:39	12.05	11	0.91
Afternoon	5/15	7:50	5/15	12:22	4.53	5	1.10
Evening	5/15	12:29	5/15	19:15	6.77	2	0.30
Morning	5/15	19:35	5/16	8:15	12.67	21	1.66
Evening	5/16	8:30	5/16	18:10	9.67	1	0.10
Morning	5/16	18:23	5/17	7:20	12.95	41	3.17
Afternoon	5/17	7:40	5/17	12:35	4.92	0	0.00
Evening	5/17	12:50	5/17	18:05	5.25	3	0.57
Morning	5/17	18:22	5/18	7:28	13.10	71	5.42
Afternoon	5/18	8:05	5/18	12:02	3.95	5	1.27
Evening	5/18	12:10	5/18	19:15	7.08	102	14.40
Morning	5/18	19:30	5/19	7:45	12.25	118	9.63
Evening	5/19	9:00	5/19	17:45	8.75	45	5.14
Morning	5/19	18:05	5/20	7:38	13.55	23	1.70
Afternoon	5/20	8:05	5/20	12:55	4.83	2	0.41
Evening	5/20	13:15	5/20	18:20	5.08	0	0.00
Morning	5/20	18:34	5/21	7:25	12.85	102	7.94
Afternoon	5/21	8:10	5/21	12:39	4.48	23	5.13
Evening	5/21	12:45	5/21	16:15	3.50	0	0.00
Morning	5/21	16:23	5/22	7:47	15.40	102	6.62
Afternoon	5/22	8:22	5/22	12:22	4.00	12	3.00
Evening	5/22	12:32	5/22	16:25	3.88	16	4.12
Morning	5/22	16:35	5/23	7:38	15.05	27	1.79

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
Afternoon	5/23	8:08	5/23	12:16	4.13	2	0.48
Evening	5/23	12:30	5/23	19:10	6.67	2	0.30
Morning	5/23	19:10	5/24	7:30	12.33	8	0.65
Afternoon	5/24	7:40	5/24	12:15	4.58	5	1.09
Evening	5/24	12:30	5/24	19:16	6.77	0	0.00
Morning	5/24	19:30	5/25	7:17	11.78	81	6.87
Afternoon	5/25	8:05	5/25	12:17	4.20	5	1.19
Evening	5/25	12:27	5/25	19:20	6.88	11	1.60
Morning	5/25	19:45	5/26	7:17	11.53	68	5.90
Afternoon	5/26	8:30	5/26	12:20	3.83	12	3.13
Evening	5/26	12:30	5/26	19:10	6.67	10	1.50
Morning	5/26	19:21	5/27	7:35	12.23	11	0.90
Afternoon	5/27	8:05	5/27	12:19	4.23	0	0.00
Evening	5/27	12:35	5/27	19:10	6.58	0	0.00
Morning	5/27	19:30	5/28	7:20	11.83	80	6.76
Afternoon	5/28	8:20	5/28	12:15	3.92	6	1.53
Evening	5/28	12:30	5/28	19:20	6.83	6	0.88
Morning	5/28	19:45	5/29	7:15	11.50	26	2.26
Afternoon	5/29	8:40	5/29	13:00	4.33	3	0.69
Evening	5/29	13:50	5/29	19:15	5.42	10	1.85
Morning	5/29	20:00	5/30	7:35	11.58	33	2.85
Afternoon	5/30	8:45	5/30	12:27	3.70	15	4.05
Evening	5/30	12:40	5/30	19:25	6.75	42	6.22
Morning	5/30	20:05	5/31	7:30	11.42	38	3.33
Afternoon	5/31	8:10	5/31	12:25	4.25	5	1.18
Evening	5/31	12:45	5/31	19:25	6.67	18	2.70
Morning	5/31	20:15	6/1	8:05	11.83	15	1.27
Afternoon	6/1	9:00	6/1	12:20	3.33	0	0.00
Evening	6/1	12:55	6/1	19:25	6.50	3	0.46
Morning	6/1	19:55	6/2	7:15	11.33	5	0.44
Afternoon	6/2	7:30	6/2	12:26	4.93	0	0.00
Evening	6/2	12:28	6/2	19:30	7.03	3	0.43
Morning	6/2	20:10	6/3	7:20	11.17	1	0.09
Afternoon	6/3	7:40	6/3	12:25	4.75	0	0.00
Evening	6/3	12:30	6/3	19:25	6.92	0	0.00
Morning	6/3	19:40	6/4	7:15	11.58	4	0.35
Afternoon	6/4	7:30	6/4	12:10	4.67	0	0.00
Evening	6/4	12:20	6/4	17:45	5.42	0	0.00
Morning	6/4	17:45	6/5	8:20	14.58	3	0.21
Afternoon	6/5	8:45	6/5	12:15	3.50	2	0.57

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
Evening	6/5	12:20	6/5	18:25	6.08	1	0.16
Morning	6/5	18:35	6/6	7:20	12.75	3	0.24
Afternoon	6/6	7:36	6/6	12:17	4.68	1	0.21
Evening	6/6	12:25	6/6	19:15	6.83	7	1.02
Morning	6/6	19:30	6/7	7:35	12.08	9	0.74
Afternoon	6/7	7:55	6/7	12:15	4.33	2	0.46
Evening	6/7	12:25	6/7	19:22	6.95	3	0.43
Morning	6/7	19:40	6/8	8:07	12.45	5	0.40
Afternoon	6/8	8:30	6/8	12:50	4.33	4	0.92
Evening	6/8	12:55	6/8	19:20	6.42	2	0.31
Morning	6/8	19:30	6/9	7:25	11.92	0	0.00
Afternoon	6/9	7:50	6/9	12:15	4.42	5	1.13
Morning	6/9	12:30	6/10	7:15	18.75	3	0.16
Afternoon	6/10	7:35	6/10	12:15	4.67	1	0.21
Evening	6/10	12:30	6/10	19:10	6.67	1	0.15
Morning	6/10	19:17	6/11	7:20	12.05	12	1.00
Afternoon	6/11	7:55	6/11	11:05	3.17	2	0.63
Evening	6/11	11:15	6/11	18:00	6.75	5	0.74
Morning	6/11	18:20	6/12	7:10	12.83	5	0.39
Afternoon	6/12	7:20	6/12	12:15	4.92	1	0.20
Evening	6/12	12:20	6/12	19:20	7.00	0	0.00
Morning	6/12	19:40	6/13	7:35	11.92	3	0.25
Afternoon	6/13	7:55	6/13	12:10	4.25	2	0.47
Evening	6/13	12:15	6/13	19:16	7.02	3	0.43
Morning	6/13	19:25	6/14	7:20	11.92	1	0.08
Afternoon	6/14	7:40	6/14	12:20	4.67	1	0.21
Evening	6/14	12:30	6/14	18:42	6.20	1	0.16
Morning	6/14	18:55	6/15	7:30	12.58	0	0.00
Afternoon	6/15	7:40	6/15	12:25	4.75	2	0.42
Evening	6/15	12:35	6/15	19:15	6.67	1	0.15
Morning	6/15	19:24	6/16	7:18	11.90	22	1.85
Afternoon	6/16	7:32	6/16	12:35	5.05	1	0.20
Evening	6/16	12:40	6/16	19:21	6.68	0	0.00
Morning	6/16	19:30	6/17	7:33	12.05	7	0.58
Afternoon	6/17	7:45	6/17	12:20	4.58	1	0.22
Evening	6/17	12:40	6/17	19:19	6.65	1	0.15
Morning	6/17	19:55	6/18	7:20	11.42	1	0.09
Afternoon	6/18	7:35	6/18	12:05	4.50	1	0.22
Evening	6/18	12:15	6/18	19:10	6.92	3	0.43
Morning	6/18	19:25	6/19	7:20	11.92	2	0.17

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	SR CPUE
Afternoon	6/19	7:35	6/19	12:10	4.58	0	0.00
Evening	6/19	13:10	6/19	19:10	6.00	0	0.00
Morning	6/19	19:20	6/20	7:25	12.08	1	0.08
Afternoon	6/20	7:35	6/20	12:25	4.83	0	0.00