REPORT ON ATLANTIC SALMON SMOLT SAMPLING EFFORTS AT MOORE DAM, SPRING 2009

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Final Report

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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. 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 in the skimmer gate of the Moore Dam in 2004 as the mechanism to conduct the evaluation.

Since installation, the sampler 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 sampler as a downstream passage route has been studied and a series of modifications made to improve its effectiveness. In this sixth year, a guide net was installed in the forebay perpendicular to the centerline of the sampler entrance. Hatchery-reared Atlantic salmon smolts were tagged, released in the reservoir and recaptured in the sampler.

The sampler was operated from 22 April to 23 June 2009. Collected salmon were enumerated and live smolts were transported to, and released below the McIndoes Development. A summary of the 2009 results follows.

<u>Stream-reared smolts</u>

- Between 22 April and 23 June, 3,183 stream-reared smolts were collected; the greatest number of smolts collected in one day (N=558) occurred on 1 June. Over a five day period from 31 May to 4 June 48% of the catch was collected.
- There was a weak modality to the passage distribution, peaking in early June. Peak passage days appeared to follow flow patterns more closely than water temperature (Figures 4-1, 4-5 and 4-10).
- On most days, the sampler was checked and the fish removed from the collection tank three times; in the morning (721.2 h), afternoon (298.4 h) and evening (438.5 h), for a total of 1,458.1 hours of sampling. Catch-per-unit-effort (CPUE) was highest (4.29 smolts/h, SD=11.42) during the evening collection, and lowest (1.22 smolts/h, SD=0.25) during the morning collection (Table 4-1). Overall CPUE was 2.18 smolts/h (SD=7.65).
- Mortality was 1.4%, the lowest to date. Low mortality was likely due to the effectiveness of the trash boom at limiting debris build-up on the sampler, and reduced handling of smolts during collection and transport to the McIndoes Development.

<u>Hatchery-reared smolts</u>

- Between 6 and 29 May, 889 tagged hatchery-reared smolts were released in the Moore forebay and up to 1 mi upstream of the dam. Of those, 329 (37%) were collected in the fish sampler.
- A guide net installed at and perpendicular to the sampler entrance did not increase hatchery-reared smolt passage to the sampler. The effectiveness of the guide net was measured through comparison of mark-recapture results obtained this year and results collected from past years. The greatest proportion of returns occurred in 2006 (46.8%) when the attraction flow shelf was installed. Using an exact test of goodness of fit, no significant difference (P=0.37) was

found between the number of tagged smolts collected in 2009 and the average number collected in 2006 and 2007 (i.e., after the flow shelf was installed).

Table of Contents

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

°C	degree Celsius
cfs	cubic foot per second
CPUE	catch-per-unit-effort
CRASC	Connecticut River Atlantic Salmon Commission
d	day
FERC	Federal Energy Regulatory Commission
FMF	Fifteen Mile Falls
ft	foot
gal	gallon
h	hour
hp	horsepower
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

LIST OF TABLES

LIST OF FIGURES

Appendix Figure 1. A. Daily average water temperature in the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2004. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2004.

Appendix Figure 4. A. Daily average water temperature in the Connecticut River at Gilman, VT, and the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2007. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2007.

Appendix Figure 5. A. Daily average water temperature in the Israel River and the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2008. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2008.

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 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 2009 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 evaluate the attractiveness of the sampler as a downstream passage route for salmon smolts, including assessing smolt behavior in the vicinity of the skimmer gate entrance. Mark-recapture techniques were used in 2004, 2005, and 2006. 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.

This year a guide net was installed in the forebay perpendicular to the centerline of the sampler entrance. The hypothesis was that the net would guide smolts moving along the face of the dam to the entrance of the sampler, similar to the leader end of a pound net. The effectiveness of the guide net was tested using hatchery-reared Atlantic salmon smolts that were tagged, released in the reservoir and recaptured in the sampler.

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). 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 2-3).

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 2-4). The discharge pipe is adjustable vertically and 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.

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 (Figure 2-4).

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 water surface at the entrance of the skimmer gate to extend the flow-net range into the forebay (Figure 2-5); and,

- A specially designed trash boom was anchored around the skimmer gate entrance to deflect large debris from the sampler (Figure 2-6).

A targeted discharge not-to-exceed 500 cfs for downstream passage onto the fish sampler has been in place since 2004 and continued in 2009. 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 (Figure 3-1). After all fish were removed, the valve was opened 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 (Figure 3-2). 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). However, following last year’s practice to reduce handling stress, live stream-reared smolts were not handled individually. Hatchery smolts were tagged with colored streamer or floy tags and therefore easily distinguished from stream-reared smolts. Stream-reared smolts were examined passively while in transport to the holding tanks, the transport tank and to the river. As a result, 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, and position of the upper and lower sampler sections, 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 operators. 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 as necessary.

3.2 Guide Net

In an effort to improve guidance of Atlantic salmon smolts into the sampler at Moore Dam, TransCanada installed a guide 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 3-3). 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. Thirty-foot support poles made of 2 in PVC piping were attached at either end and in the middle of the net to stabilize the net in the water column during station operation. The net was deployed on 22 April, on 23 April the support pole on the downstream end of the guide net snapped in half dislodging the net from its set position. The sampler was shut down and the net collected for redeployment the following day. The net was redeployed using 3-in HDPE piping for the end support poles, an anchoring system was deployed on the downstream end, and the net was tied off to the boater boom instead of the trash boom (Figures 3-4 and 3-5).

The performance of the net was evaluated by mark-recapture methods. The ratio of the number of tagged smolts collected to the number of tagged smolts released in 2009 after installation of the guide net was used as a measure of bypass effectiveness and those data were assessed in relation to the ratios of tagged smolts collected in the sampler in studies conducted in previous years when there was no guide net installed (2004–2008).

Three separate groups of 200 tagged salmon each were scheduled to be released into the reservoir at approximately five day intervals. Two additional release groups, of 144 and 145 fish, were added because both fish and tags were available. These groups were not available for release until the end of May, about the middle of the smolt migration. They were released only two days apart to give them as much time as possible to acclimate to the new environment and begin their migration. Each fish had a unique tag differentiated by tag number. Fish were released at dusk at three locations: approximately 50 ft upstream of and in line with the net, approximately 200 ft upstream of and in line with the net, and approximately 1 mile upstream of the dam in the middle of the river, near the Waterford, VT boat launch (Figure 3-4). All tagged fish collected from the sampler were enumerated, their tags removed, and released below the McIndoes development.

3.3 Hatchery-Reared Fish Procurement Tagging and Release

Hatchery-reared fish were obtained from the US Fish and Wildlife Service's (USFWS) Pittsford National Fish Hatchery in Pittsford, VT. Smolts were handled as little as possible to minimize stress related to tagging. Smolts were selected for size (>160 mm total length, TL), anesthetized in a 40 mg/L solution of buffered tricane-methanesulfonate (MS-222) measured for total length (mm) and a subset weighed (g). Six hundred fifteen smolts were tagged with Hallprint yellow polyethylene streamer tags, and 300 were tagged with Floy Tag Manufacturing Inc. red anchor floy tags. Each tag was imprinted with a unique number allowing for identification of each tagged fish. Both tag types were inserted through the musculature of the mid-back, at the midline of the dorsal fin (Figure 3-6). The streamer tags were inserted with a disposable applicator needle attached to the tag. Floy tags were inserted with a tag specific tagging gun.

Streamer tagged fish were tagged at the hatchery and transported in 180-gal-aerated tanks, to circular holding tanks on the headworks of the Moore development. Floy tagged fish were tagged on site at least one day after transport to the Moore development. After transport, fish were acclimated to within 2 oC of ambient water temperature at a rate of approximately 2 oC per hour. Water from Moore Reservoir flowed continuously through two 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. Air pumps were available if dissolved oxygen levels fell below 7 ppm. Tagged smolts were held at least 24 h before release.

Streamer tagged fish were released in the reservoir within 400 meters of the dam and approximately 200 meters from the apex of the guide net with the boater boom. These 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 20, but more often 15 fish were placed in the garbage containers for transport to the release site. Three release groups of 200 fish per group were released between 5 and 16 May. Five tagged fish from each group were held for 3-5 days to assess tag loss and survival and then released below the McIndoes development.

Floy tagged fish were released approximately one mile upstream of the Moore Dam near Waterford VT. These fish were transported in a truck mounted 180 gal, aerated transport tank to the Waterford boat ramp where they were transferred to plastic containers filled with approximately 20 gal of water and placed on a boat. The fish were motored to approximately the mid-line of the river and released. Two release groups of 144 and 145 fish were released on 27 and 29 May, respectively. One tag from the first release group was ejected from the fish before release. Five tagged fish from each group were held for 3-5 days to assess tag loss and then released below the McIndoes development.

3.4 Environmental Conditions and Station Operations

Water temperature was monitored in the Moore Reservoir near the entrance to the Moore Dam skimmer gate, in the Connecticut River near Gilman, VT and in the Israel River, a tributary to the

Connecticut River, near Lancaster NH (Figure 1-2). Temperature was recorded from 24 April through 24 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 generally made three times a day. A morning collection was made everyday and afternoon and evening collections were made most days. Catch-per-unit-effort (CPUE) was calculated for each of the three collection categories and for daily collections for both stream-reared and hatchery-reared smolts. 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. 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 14:30 h on 22 April and was closed at 11:50 h on 23 June 2009. The skimmer gate was closed from 15:15 h on 23 April through 18:30 h on 24 April when supports holding the guide net broke, requiring repair. Other short-term skimmer gate closings (ranging from approximately 20 – 45 min) occurred throughout the season when the sampler screen elevation was adjusted. When a collection was made, the lower end of the sampler was raised high enough to curtail flow from to the collection tank. However, this operation did not prevent fish from passing over the skimmer gate to be passed to the collection tank when the lower end of the sampler was again lowered to a fishing position. The sampler operated for 1,458.1 h.

Sampling periods, defined as the period of time the sampler operated between fish removal from the collection tank, ranged from 1.3 h to 14.4 h, and averaged 8.5 h. The sampler collection tank was checked 171 times over the course of the study and fish collected in the tank were processed an average of 3 times per day between 22 April and 23 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 60 of the 62 days of sampler operation and in 136 of the 171 sampling events. The greatest number of stream-reared smolts collected in one collection event was 459 during the 1 June evening collection, a total of 535 stream-reared smolts were collected on this day. The seasonal distribution of the smolt migration was mildly modal in pattern (Figure 4-1). Over a five day period from 31 May to 4 June 48% of the catch was collected; 17.5% of the catch was collected on 1 June. Only on four other days were more than 100 stream-reared smolts collected. Peak collection days generally occurred just after flow peaked; however, flow peaks were not always followed by high smolt collection numbers. 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.

For analysis of CPUE, sample periods were divided into three categories based on when collections were made. The three categories were Morning, Afternoon, and Evening. This is a change from previous years when the categories were based on the time of sunset and sunrise. This change was made because time of day passage, relative to sunset and sunrise, was not found to be significant in previous years study and was not an objective of this year's study.

Of the 1,458.1 h of sampling, 49.5% were represented in the Morning collection, 30% in the Evening collection, and 20.5% in the Afternoon collection. CPUE for stream-reared salmon smolts was highest for the Evening collection at 4.29 smolts/h (SD=11.42) (Table 4-1). CPUE for stream-reared smolts collected in the Afternoon was 4.42 (SD=2.79), in the Morning was 1.22 (SD=1.98), and overall was 2.18 smolts/hour (SD=7.2).

CPUE for hatchery-reared salmon smolts was highest for the Morning collection at 0.26 smolts/h (SD=0.32) (Table 4-1). CPUE for hatchery-reared smolts collected in the Evening was 0.23 (SD=1.45), in the Afternoon was 0.12 (SD=0.39), and overall was 0.23 smolts/hour (SD=0.9).

Salmon smolts were not examined as closely for injuries this year as they were in past years. Tagged fish were easily recognized due to the type of tag used (yellow streamer and red floy), negating the need to handle each fish individually. 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 3,183 smolts collected, 98.0% (3,120) had no observable injuries, 0.3% (1) showed obvious descaling, 0.1% (4) had lacerations, 0.4% (4) were moribund, and 1.4% (44) died (Table 4-2). One fish that was collected alive but died due to wounds, appeared to have been preyed upon. It had a gouge approximately 25 mm long in its back (Figure 4-2). Another smolt was removed, dead from the mouth of a brown trout.

Length and age data were collected beginning in 2005 from smolt moralities. Length data from stream-reared smolts collected between 2005 and 2009 show two distinct frequency distributions within each sample year, suggesting two age classes of smolts passing the sampler (Figure 4-3). 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 the subset of fish aged was dominated by age-2 smolts. Only one of the 38 smolts (1.19% of the stream-reared smolts collected) was age-3. Length-at-age distributions for the years 2005 through 2009 show distinct length-age relationships in some years (e.g., 2005, possibly 2008 and 2009) but not in others (e.g., 2007) (Figure 4-4).

4.3 Guide Net Evaluation

Five groups of between 144 and 200 Atlantic salmon smolts were released between 6 and 29 May (Table 4-4). Of the 889 smolts released, 329 (37%) were recovered from the sampler collection tank. Release group three had the greatest percent of fish recaptured (46.5%) and group five had the smallest percent of recaptured fish (28.3%). Group three fish were released closest to the sampler, and group five were released at the farthest release point (approximately 1 mile upstream of the dam) and latest in the season (29 May).

Mean time-at-large (the amount of time between release and recapture) for all fish was 12.13 d (SD=8.00), and ranged from 7.67 d (SD=6.14) for smolts in group five to 15.09 d (SD=8.79) for smolts in group one. Mean time-at-large decreased by release group, suggesting that the amount of time smolts took to enter the sampler was more closely related to when smolts were released relative to the migration season and smolt physiology, than proximity of the release site relative to the sampler. The frequency distribution of tagged hatchery reared smolts collected in the sampler was similar to the distribution of stream reared smolts collected in the sampler (Figure 4-5).

The effectiveness of the guide net installed at the sampler was measured through comparison of mark-recapture results obtained this year and results collected from past years. Hatchery smolts were released in five of six monitoring years (2004-2009), to assess passage efficiency of the Moore Dam fish sampler. A mark-recapture study was not conducted in 2008. Release locations ranged from within the forebay area to 11 mi upstream below Gilman Dam in Gilman, VT. In total, 4,078 hatchery smolts were released and 902 (22%) were recaptured in the sampler collection tank. The greatest proportion of returns occurred in 2006 (46.8%) the year the attraction flow shelf was installed to increase the net range of flow at the sampler entrance, and a 2 day spill event occurred at the dam (Table 4-5). The flow shelf had a pronounced effect on the proportion of tagged smolts collected in the sampler as evidenced by the proportion of returns in 2004 and 2005 compared with returns in 2006, 2007 and 2009. No such increase was observed this year with the guide net installed. Although a greater proportion of tagged smolts retuned this year compared to 2007, it was not substantial. An exact test of goodness of fit was used to examine whether the proportion of tagged smolts recaptured in 2009 was higher than in 2006 and 2007 (after the flow shelf was installed). Assuming the mean proportion recaptured in 2006 and 2007 (37.6%) is the hypothetically expected value then Ho= N recollected in 2009 = 37.6%. A two tailed Exact Test probability (P= 0.37) shows no significant difference in 2009 (observed = 37.0%) from the hypothetical expected (37.6%).

Six of the 889 (0.7%) returned hatchery smolts died before being released below the McIndoes development; 1 from group one, 2 from group two, 2 from group three, and 1 from group four.

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. A graph of the Gilman monitoring station data showed two events of high and low spikes that ranged from a delta of more than 4 oC to more than 7 oC in less than a 24 h period. These spikes were not registered at the other monitoring stations, suggesting the thermisters were out of the water during those time periods. The suspect data were removed from the data set.

Mean daily water temperature was generally slightly 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. Fluctuation in water temperature occurred more often at the Israel River monitoring station compared to the others but it increased fairly gradually over the study period, with few temperature spikes (Figures 4-6, 4-7 and 4-8). Water temperature ranged from 3.3 to 20.8 oC at the Israel River monitoring station, from 5.2 to 18.4 oC at the Gilman monitoring station and 4.2 to 20.7 oC 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 4-9). The sampler opened for the season as flows were coming down from a high of over 14,000 cfs. During the study period, approximately five peak inflow and discharge events occurred, four were followed by brief increases in the number of stream-reared smolts collected. On 27 May, four days leading up to the four-day period when 17 % of the smolts were collected, inflow dropped to 1,860 cfs (daily average), the lowest flows of the season to that date. Over the next three days inflow rose to a peak of 5,660 cfs (daily average) on 30 May, an increase of 3,800 cfs (Figure 4-10). No spill events occurred during the assessment period.

The proportion of flow through the skimmer gate, relative to total station discharge, ranged from 1.87 to 100 % (mean = 48.33 %) and was most often 1-15 %, and 100 % of total station discharge (Figure 4-11A). 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 4-11B). 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 4-10B and 4-9). Daily CPUE for smolts did not appear to be directly affected by proportion of flow to the skimmer gate over a seasonal scale (Figure 4-11C).

4.5 Resident Species

Over 6,600 resident fish representing 19 species were collected in the sampler (Table 4-6). The most abundant species collected were spottail shiner (Notropis hudsonius, 67 %) rock bass (Ambloplites rupestris, 19 %) and yellow perch (Perca flavescens, 5 %).

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 assess the effectiveness of a guide net 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 22 April, following ice-off (ice-off occurred early in the previous week), when pond elevation could be brought up high enough to provide adequate flow through the sampler (4-5 ft above the skimmer gate crest) and after the trash boom, boat barrier and guide net were installed. On 23 April a support pole on the guide net snapped requiring a shut-down of the sampler and redeployment of the net on 24 April.

The run pattern was somewhat modal this year, somewhat similar to patterns observed in 2005 and 2007 (Normandeau Associates 2006, 2008) though with a peak later in the season. This year peak passage numbers seemed to follow flow more closely than water temperature, as compared to last year when water temperature appeared to influence passage. An increase of approximately 4,000 cfs over a four day period was followed by 48 % of the smolt passage numbers over the next 5 day period. Four other peak flow events were followed by brief increases in the number of stream-reared smolts collected. Empirically, because live smolts were not measured, fish passing early in the season were larger than those passing three to four weeks later. Last year, 11 fish collected one day after the sampler was opened died due to debris load; scale analysis identified them at age-3. Larger smolts passing through the sampler early in the season are likely age-3 and possibly 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).

Though water temperature fluctuated more in the Israel River than in the Connecticut River near Gilman, or in the Moore Reservoir, it increased fairly steadily through the monitoring season at all monitoring stations. Water temperature reached 10 oC at all monitoring stations within a week of the sampler being opened. No obvious correlation between water temperature and smolt passage was observed.

The number of smolts passing the sampler this year was greater than any previous year. Smolts entering the Moore sampler are the product of salmon fry stocked in tributaries above the Moore Dam by NHFG and VTFG. 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 NHFG and VTFG 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 2005-2009 (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 2003-2007 were compared with the number of smolts collected in the sampler from 2005-2009 (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=0.11, P= 0.86) or the relationship between the estimated production number and the number of smolts collected at the sampler (R=0.73, 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. Significant correlations were not found for either variable last year. Over the five years, production estimates increased gradually each year from 2005 to 2007, fell slightly in 2008 and increased significantly in 2009. 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 slightly in 2007.

The majority (97%) of fish that were aged, 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 in the fist 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 (1.4%) was the lowest to date. Last year, debris load on the sampler at the beginning of the season caused early mortalities when sticks and leaves clogged the sampler discharge pipe. Debris load this year was much lighter and did not cause sampler operational problems. This, and reduced handling of smolts during collection and transport likely contributed to the low mortality observed. Though hatchery fish were tagged and released this year, visually noticeable streamer and floy tags were used so that only hatchery fish needed to be handled. Two smolts died of predation that likely occurred in the collection tank. One smolt was found in the mouth of a brown trout and the other had a gouge in its back, probably from a predatory fish in the collection tank.

The guide net installed perpendicular to the entrance of the sampler remained in place from 24 April through 23 June. Though initial deployment of the net failed after one day, modifications resulted in a stable support and anchoring system that withstood generation flows pulling the net toward the turbines and debris buildup on the net. However, smolt passage did not appear to increase due to the net. The proportion of recaptured hatchery-reared smolts (37%) was not significantly greater than in 2006 and 2007, when the attraction flow platform was in place. The proportion of smolts returning by release group increased over the first three releases to a peak of 46.5% for the third release group and then declined to 28.3% for the last release group. Since the distribution of catch over time was similar to the catch distribution for stream-reared smolts, inflow and discharge likely had some affect on passage. Mean days-at-large was smallest for smolts released farthest from the sampler (i.e., groups four and five); however, they were also the last smolts released and the sampler was closed within 26 and 24 days of their release. The number of days-at-large ranged as high as 31.5 d for smolts released earlier. Though earlier releases are more open to predation effects that would, in a simple mark–recapture experiment, result in lower observed recaptures, the recapture rate by group did not indicate any such trend since the proportion of recaptured smolts was higher in the earlier groups.

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 one week earlier than in past years and was used by smolts that may have been holdovers from last year.
- Survival has improved with 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.
- Installation of a guide net at the entrance to the sampler did not appear to improve smolt passage.

6.0 LITERATURE CITED

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Normandeau Associates Inc. 2007. Atlantic salmon smolt report on fish sampling effort at Moore Dam, spring 2006. Report prepared for TransCanada Hydro Northeast, Inc., Concord, NH.

Normandeau Associates Inc. 2008. Atlantic salmon smolt report on fish sampling effort at Moore Dam, spring 2007. Report prepared for TransCanada Hydro Northeast, Inc., Concord, NH.

Normandeau Associates Inc. 2009. Atlantic salmon smolt report on fish sampling effort at Moore Dam, spring 2007. Report prepared for TransCanada Hydro Northeast, Inc., Concord, NH.

Table 3-1. Codes used to document condition of salmon smolts collected in the Moore sampler, spring 2009.

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 and hatchery-reared Atlantic salmon smolts collected at the Moore sampler, spring 2009. 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 Range**
Morning	60	721.22	9.92 -14.42	11.82	1.36	5:30 - 8:15
Afternoon	49	298.38	3.92 - 8.33	6.09	1.04	10:00 - 14:50
Evening	62	438.48	1.25 - 13.83	7.19	2.54	15:75 - 20:23

SR Smolts				CPUE			
Time Category	**Number**	**Mean**	**SD**	**Overall CPUE**	**Mean**	**SD**	**SE**
Morning	877	14.38	27.33	1.22	1.15	1.98	0.25
Afternoon	424	8.65	15.83	1.42	1.47	2.79	0.40
Evening	1882	30.85	74.57	4.29	4.37	11.42	1.46

HR Smolts				CPUE			
Time Category	**Number**	**Mean**	**SD**	**Overall CPUE**	**Mean**	**SD**	**SE**
Morning	186	3.48	4.10	0.26	0.29	0.32	0.04
Afternoon	37	4.94	1.85	0.12	0.54	0.39	0.06
Evening	101	7.84	4.78	0.23	0.93	1.45	0.19

Table 4-2. Physical condition and potential cause of mortality for stream-reared salmon smolts collected in the Moore sampler, spring 2009. 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.

	Atlantic Salmon	
Condition	**Number**	**Percent**
No injuries	3,120	98.02
Descaling	1	0.03
Eye injury	0	0.00
Contusions, and …	0	0.00
Lacerations, and …	4	0.13
Moribund, and …	14	0.44
Dead, and …	44	1.38
Potential Cause of Mortality		
Debris load (stuck in pipe or clogged tank)		0.0
Collection / Handling Stress (died in holding tank or tansport tank)	41	93.2
Sampler Adjustment / Water Level (jumped/spilled out of tank, dry on sampler)	1	2.3
Predation	2	
Not specified - dead when collected		0.0

Table 4-3. Number of stream-reared Atlantic salmon smolts collected at the Moore sampler from 2005 through 2009, 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 Collection**	**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*	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	-	-	-

* 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.

Table 4-4. Release and return data for five groups of hatchery-reared Atlantic salmon smolts released upstream of a guide net installed at the Moore Dam sampler, spring 2009.

Release Group	Number Released	Release Date	Number Returned	% Return	Date Range of Return	Days at Large Range	Days at Large Mean	Days at Large SD	Release Location
1	200	5/6/09	73	36.50	5/7/09 - 6/5/09	0.4 - 30.0	15.1	8.8	~200 ft from net/buoy apex
2	200	5/12/09	77	38.50	5/13/09 - 6/21/09	0.5 - 29.5	14.6	8.2	~200 ft from net/buoy apex
3	200	5/16/09	93	46.50	5/16/09 - 6/18/09	0.0 - 31.5	11.2	7.6	~50 ft from net/buoy apex
4	144	5/27/09	45	31.25	5/31/09 - 6/20/09	3.5 - 23.6	9.1	4.9	~1 mile upstream
5	145	5/29/09	41	28.28	5/30/09 - 6/22/09	0.5 - 23.5	7.7	6.1	~1 mile upstream

Table 4-5. Annual release and return data for Atlantic salmon smolts released above the Moore Dam in the years 2004, 2005, 2006, 2007 and 2009.

Year	Number Released	Number Returned	% Return	Release Location, as Distance from Dam (mi)
2004[a]	1386	127	9.16	forebay - 11 (mostly 4.5)
2005[b]	896	40	4.46	11
2006[b,c,d]	805	377	46.83	11
2007	102	29	28.43	forebay -1
2009[e]	889	329	37.01	forebay -1

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 - Smolt from collection tank

Table 4-6. Resident fish species and number collected in the Moore sampler between 22 April and 23 June 2009.

Common Name	Scientific Name	Number Collected	Percent of Total
Spottail shiner	*Notropis hudsonius*	4422	66.909
Rockbass	*Ambloplites rupestris*	1251	18.929
Yellow perch	*Perca flavescens*	311	4.706
Common shiner	*Notropis cornutus*	270	4.085
Brown trout	*Salmon trutta*	95	1.437
Smallmouth bass	*Micropterus dolomieui*	61	0.923
Golden shiner	*Notemigonus crysoleucas*	55	0.832
Blacknose dace	*Rhinichthys atratulus*	38	0.575
Black crappie	*Pomoxis nigromaculatus*	26	0.393
Northern redbelly dace	*Phoxinus eos*	26	0.393
Pumpkinseed	*Lepomis gibbosus*	20	0.303
Rainbow trout	*Oncorhynchus mykiss*	12	0.182
Rainbow smelt	*Osmerus mordax*	7	0.106
Northern pike	*Esox lucius*	4	0.061
White sucker	*Catostomus commersoni*	3	0.045
Brown bullhead	*Ictalurus nebulosus*	3	0.045
Largemouth bass	*Micropterus salmoides*	3	0.045
Brook trout	*Salvelinus fontinalis*	1	0.015
Tessellated darter	*Etheostoma olmstedi*	1	0.015

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 for production of this report.

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	N/A	10,608	3,183

[1] Fry stocking numbers provided by NHFG and VTDFW.
[2] Salmon smolt production numbers provided by VTDFW.
[3] Installation of the sampler was compleded in 2004, shortly after the smolt migration had begun.

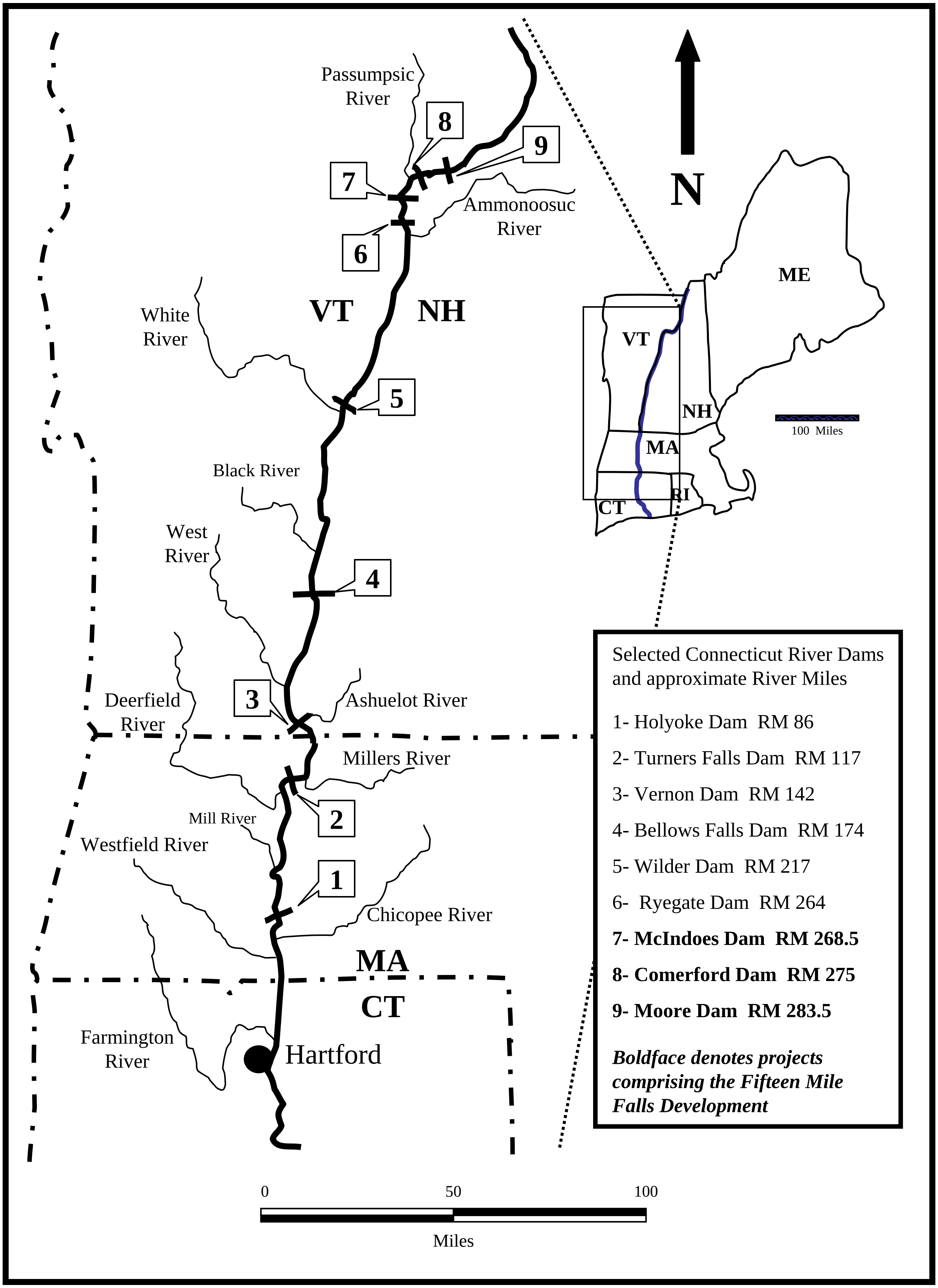


Figure 1-1. Location of the Fifteen Mile Falls Project on the Connecticut River.

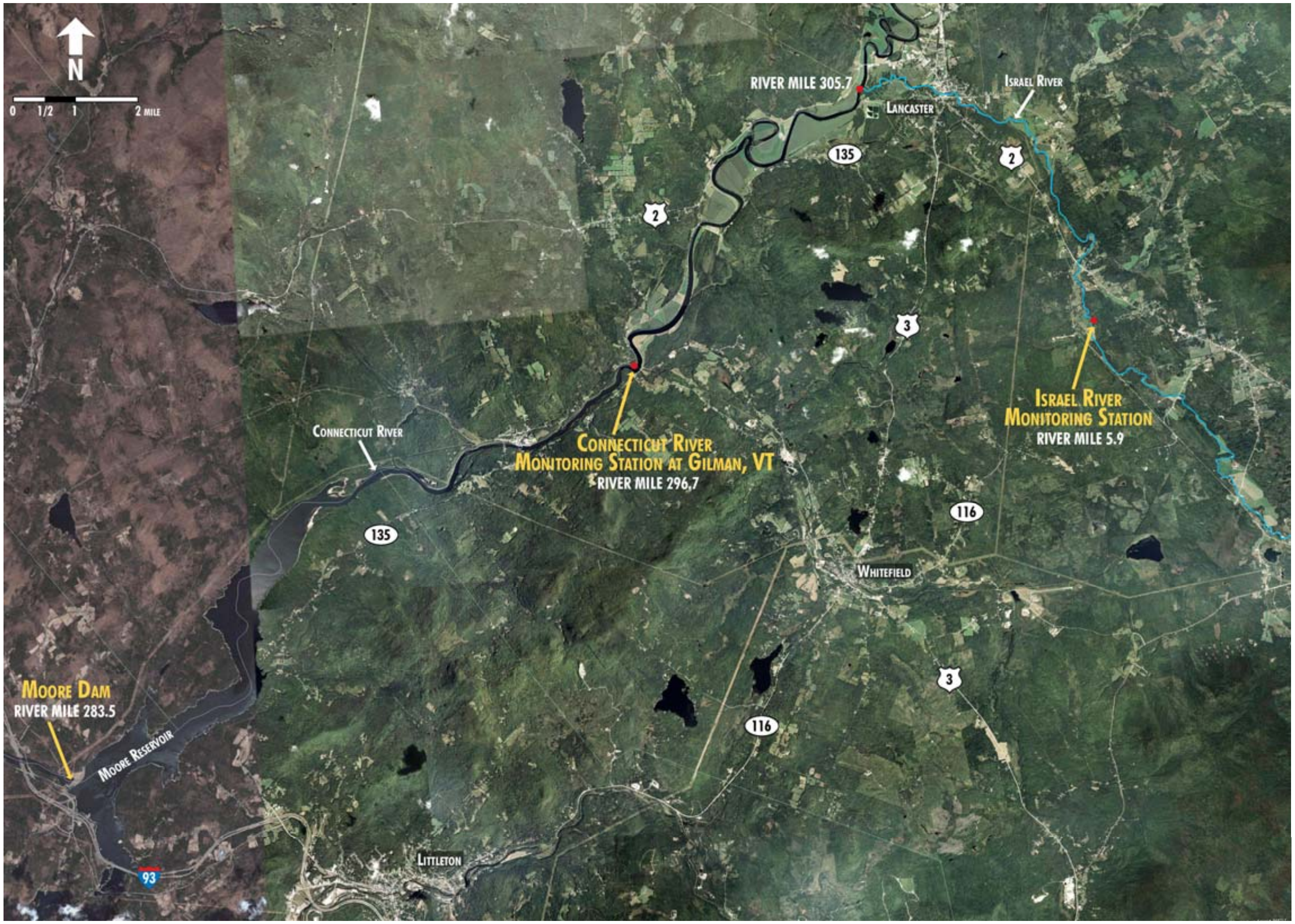


Figure 1-2. Location map showing the Moore Dam and three monitoring stations: Moore Reservoir, Connecticut River at Gilman, VT and Israel River.

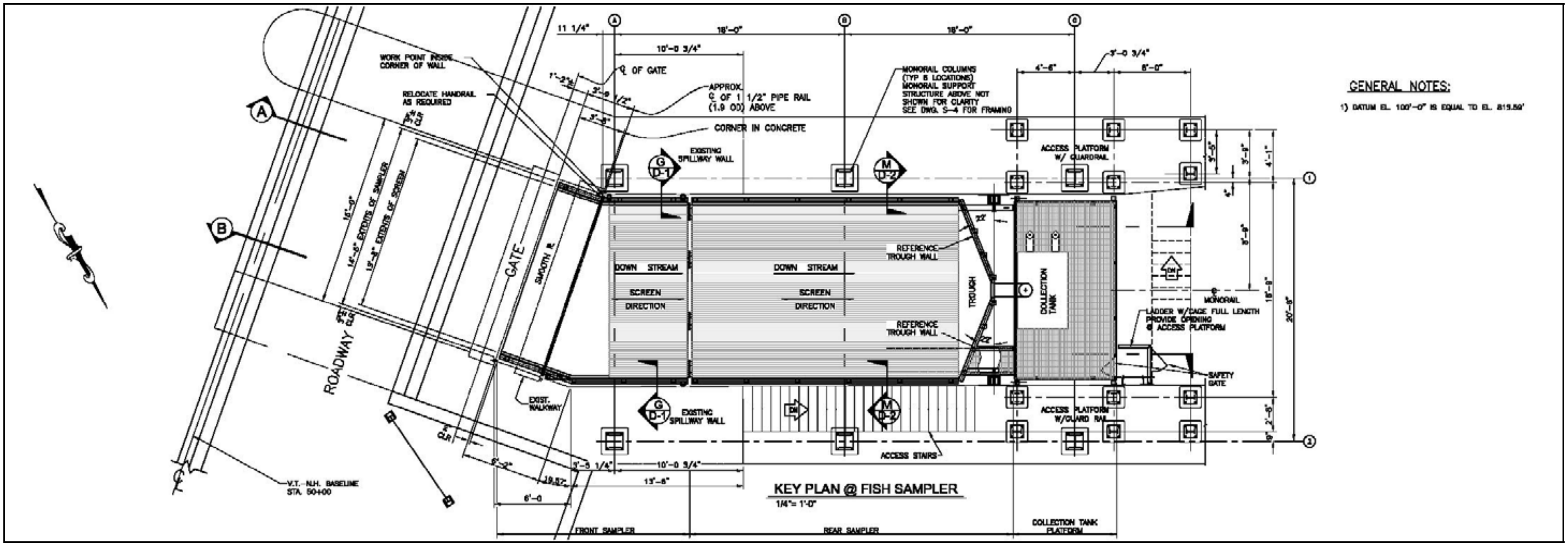


Figure 2-1. Key plan of TransCanada's Moore Development inclined plane sampler. The plan does not show flow reflectors installed after the sampler was erected. Plan drawing prepared by Kleinschmidt.

Figure 2-2. Dewatering surface of the Moore Development fish sampler.

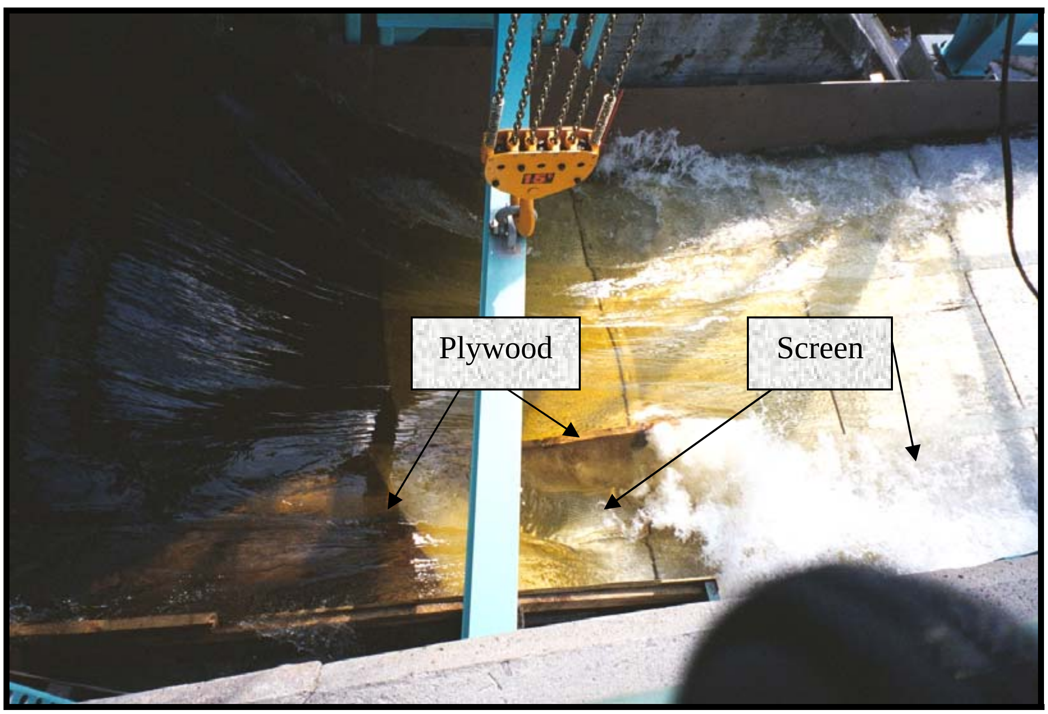


Figure 2-3. Moore Development, inclined plane sampler showing plywood flow adjusters.

Figure 2-4. Downstream end of the Moore fish sampler in fishing mode, showing the discharge pipe and collection tank.

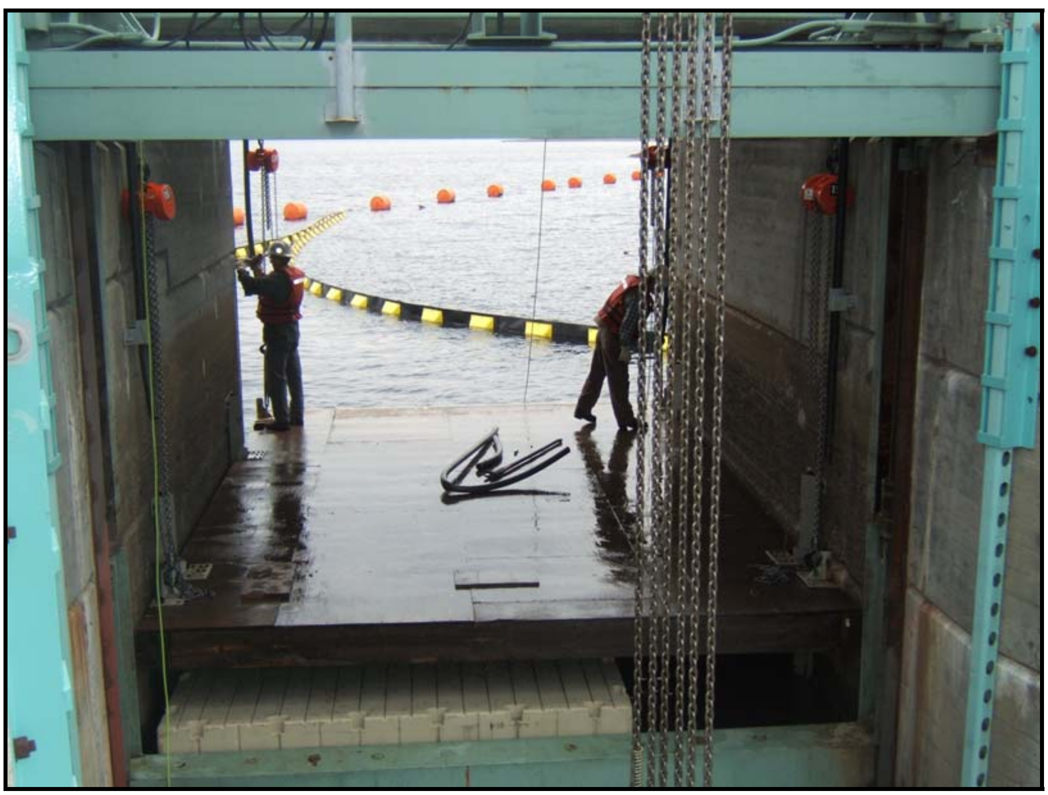


Figure 2-5. Moore Development, attraction flow shelf raised for repairs. View is looking upstream through the skimmer gate entrance to Moore Reservoir.

Figure 2-6. Moore Dam trash boom installed at the entrance to the skimmer gate.

Figure 3-1. Fish collection tank and discharge pipe. The lower end of the sampler screen is raised to curtail flow to the collection tank while the sample is collected.

Figure 3-2. Moore Development, monorail system used to transport fish from the sampler collection tank to the transport tank.

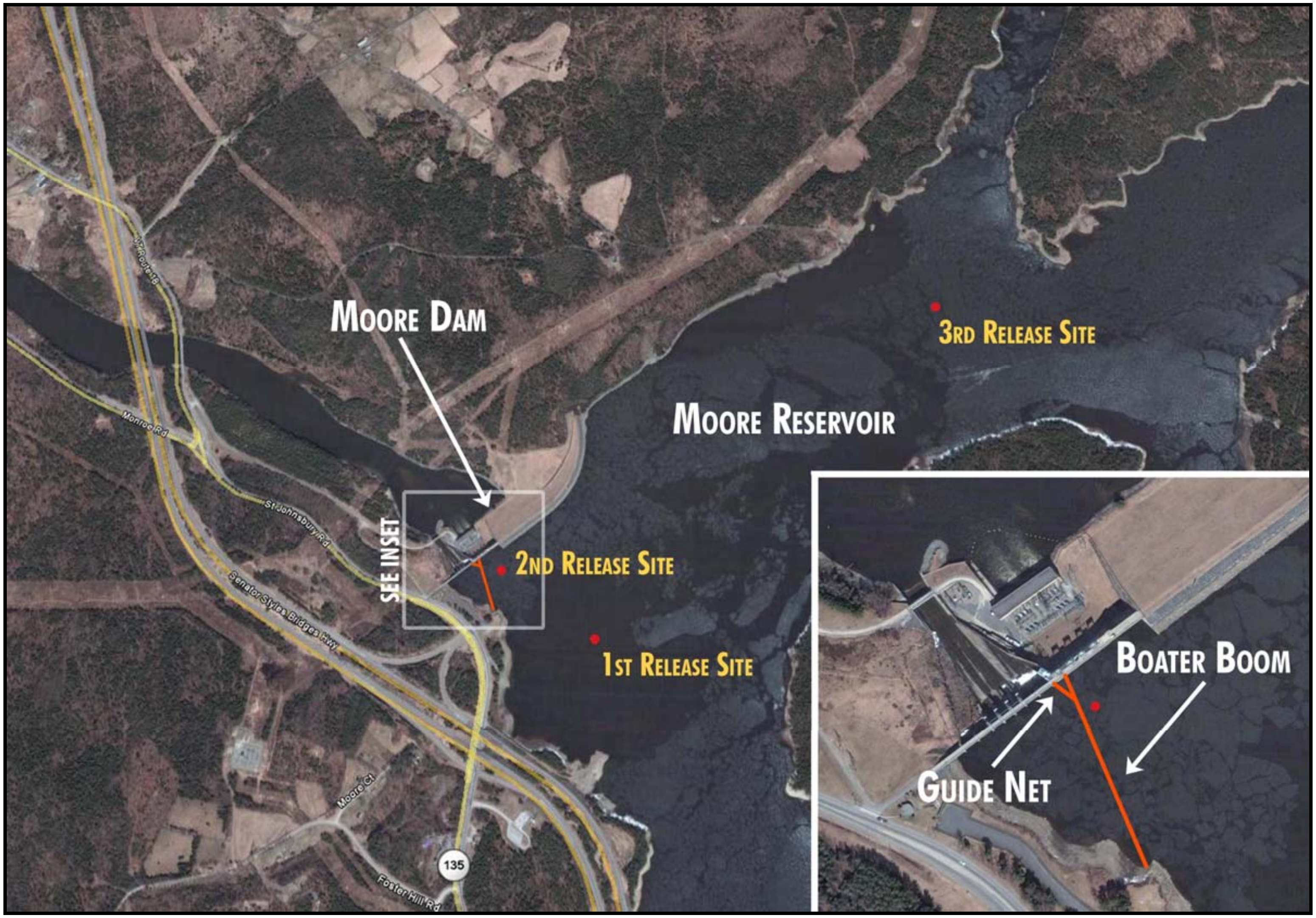


Figure 3-3. Location map showing the orientation of the guide net and the three locations where tagged hatchery-reared smolts were released, spring 2009.

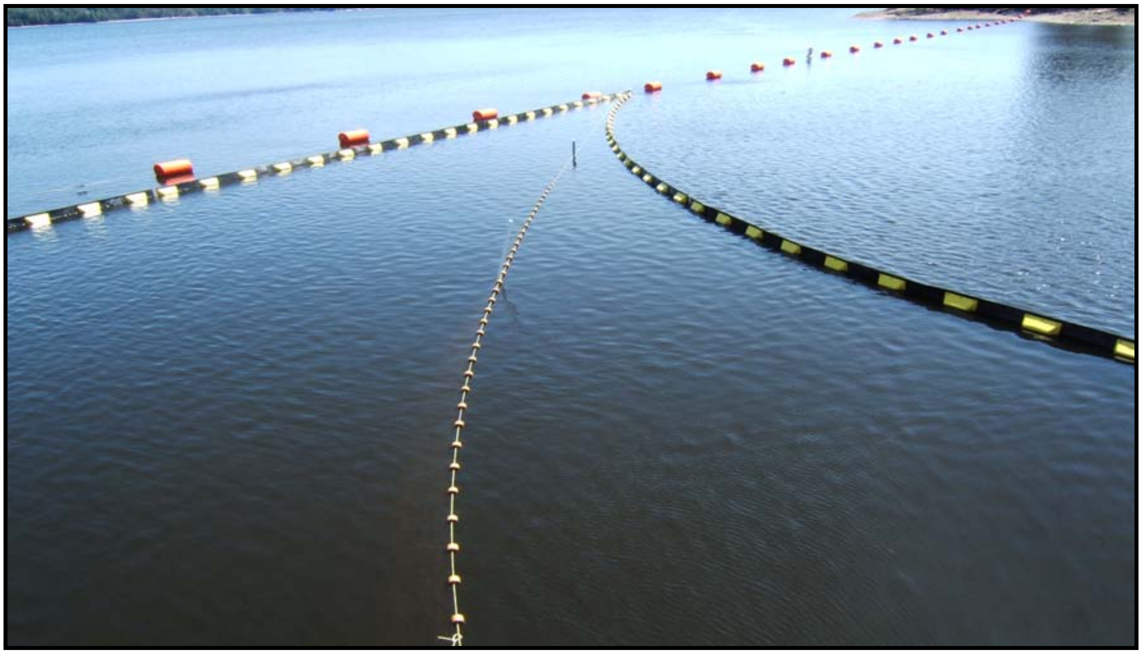


Figure 3-4. Guide net installed perpendicular to the fish sampler entrance (i.e., skimmer gate entrance) at Moore Dam, spring 2009.

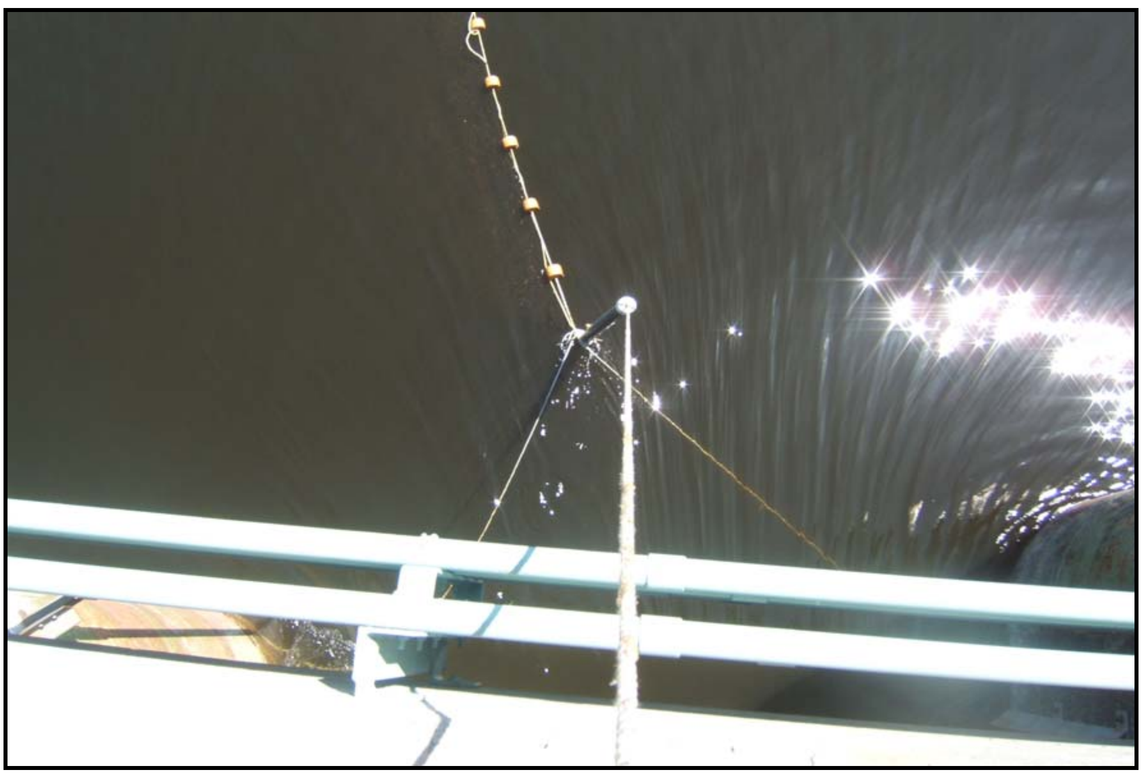


Figure 3-5. Downstream end of guide net installation at the fish sampler entrance (i.e., skimmer gate entrance) on Moore Dam, spring 2009.

Figure 3-6. Hatchery-reared Atlantic salmon smolt tagged with a Hallprint yellow polyethylene streamer tag, spring 2009.

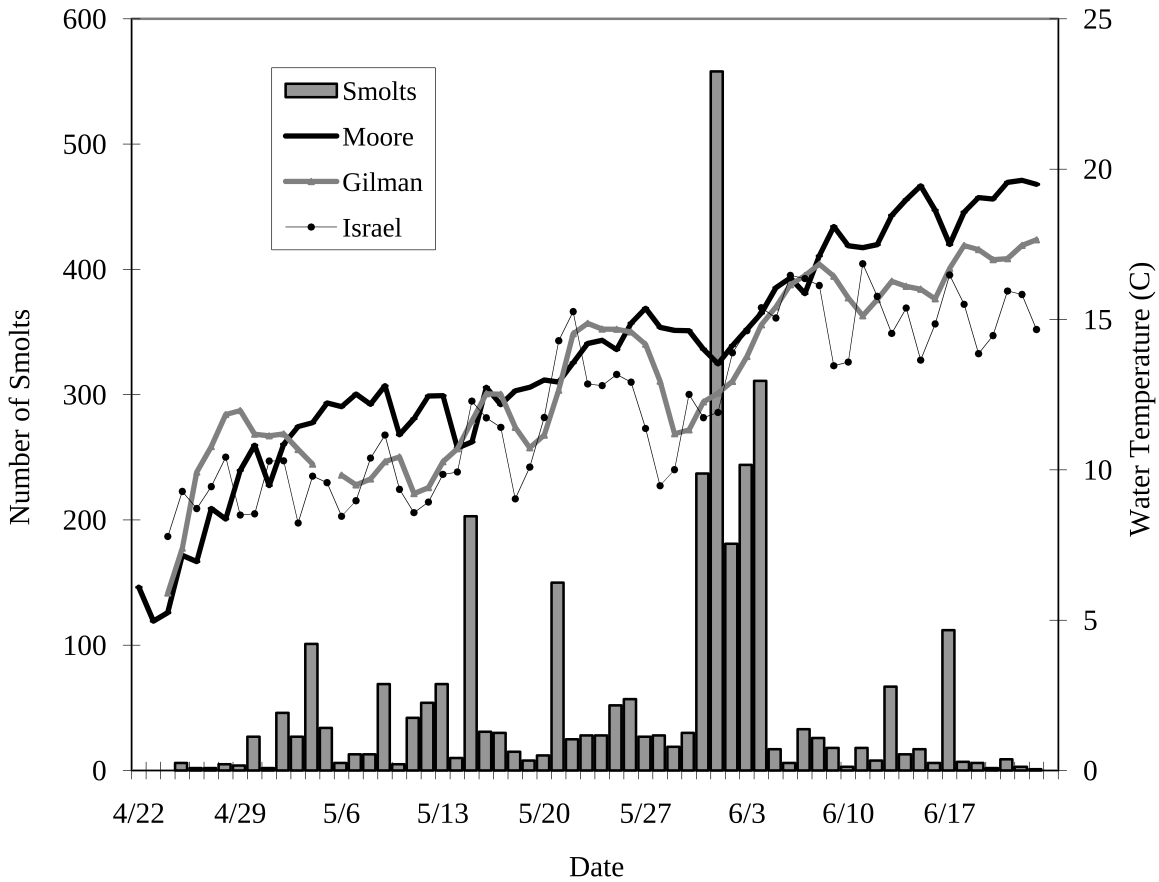


Figure 4-1. Daily average water temperature at the Israel River, Gilman and Moore Reservoir monitoring stations, and daily sum of stream-reared smolts collected in the Moore sampler, spring 2009.

Figure 4-2. Stream-reared Atlantic salmon smolt with gouge on back probably from predation, collected in the Moore sampler, spring 2009.

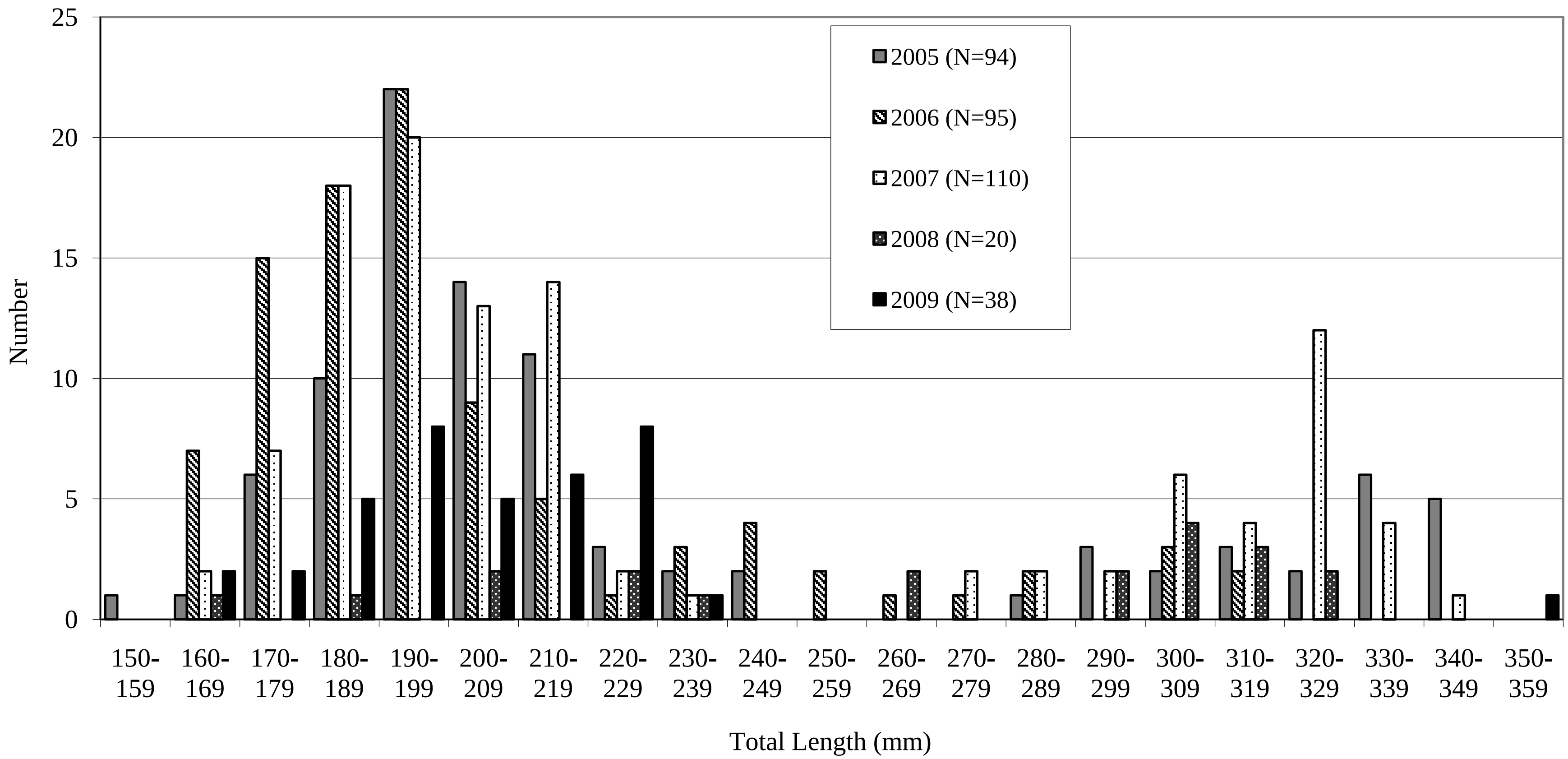


Figure 4-3. Length frequency distribution of a sub-set of stream-reared Atlantic salmon smolts collected at the Moore sampler from 2005 through 2009.

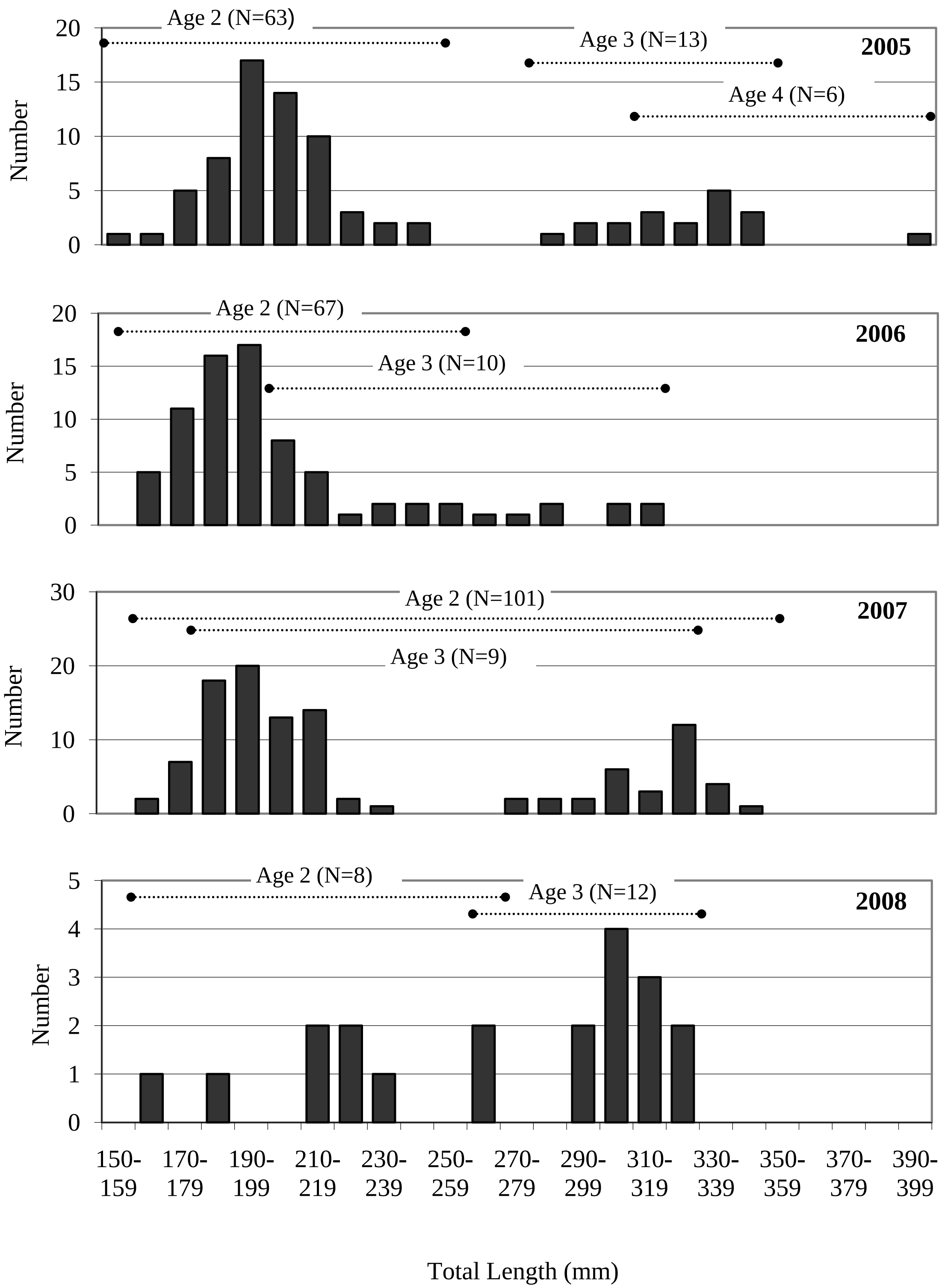


Figure 4-4. Length at age distributions for a sub-set of Atlantic salmon smolts collected at the Moore sampler during the years 2005 through 2008.

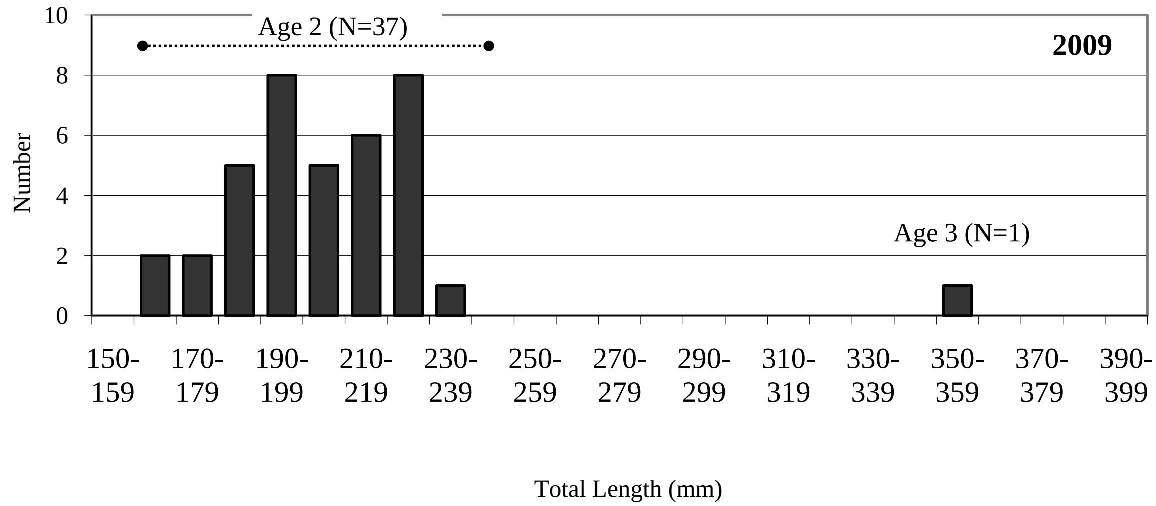


Figure 4-4, cont. Length at age distributions for a sub-set of Atlantic salmon smolts collected at the Moore sampler during the years 2005 through 2008.

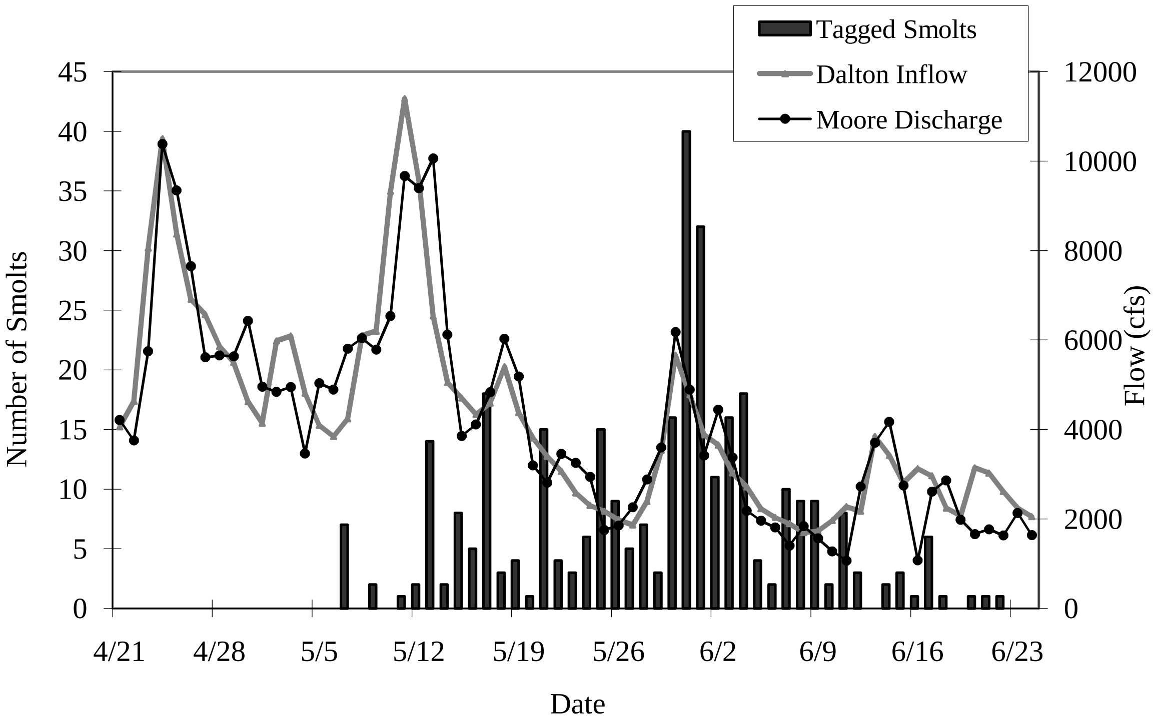
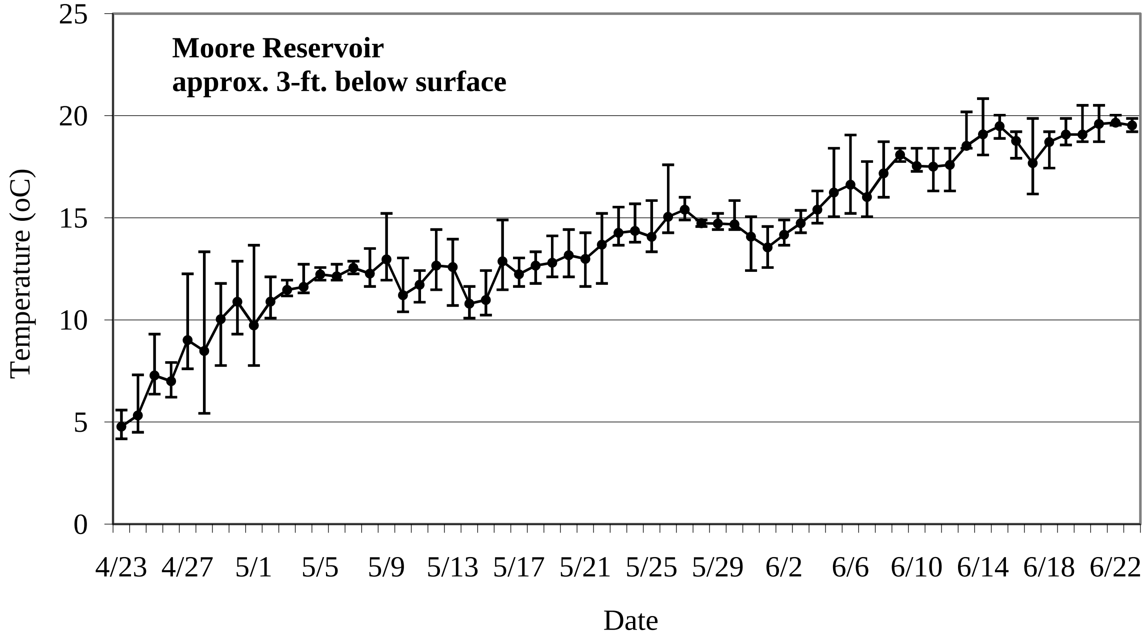


Figure 4-5. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily number of tagged hatchery-reared Atlantic salmon smolts collected at the Moore sampler, spring 2009.



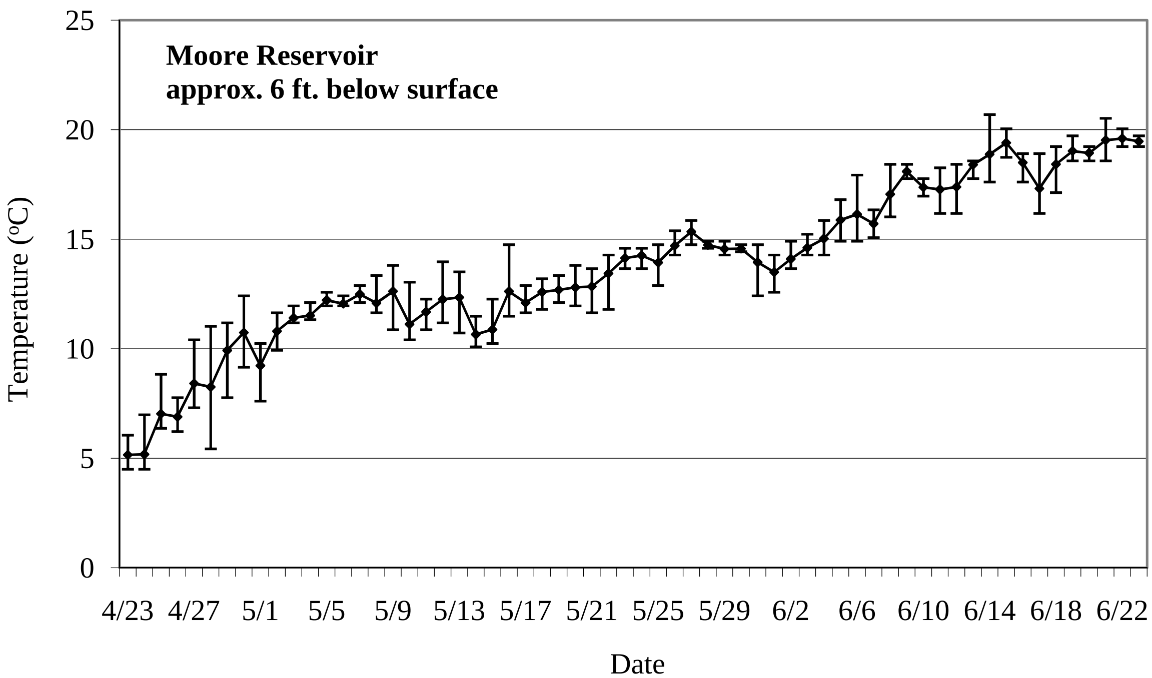
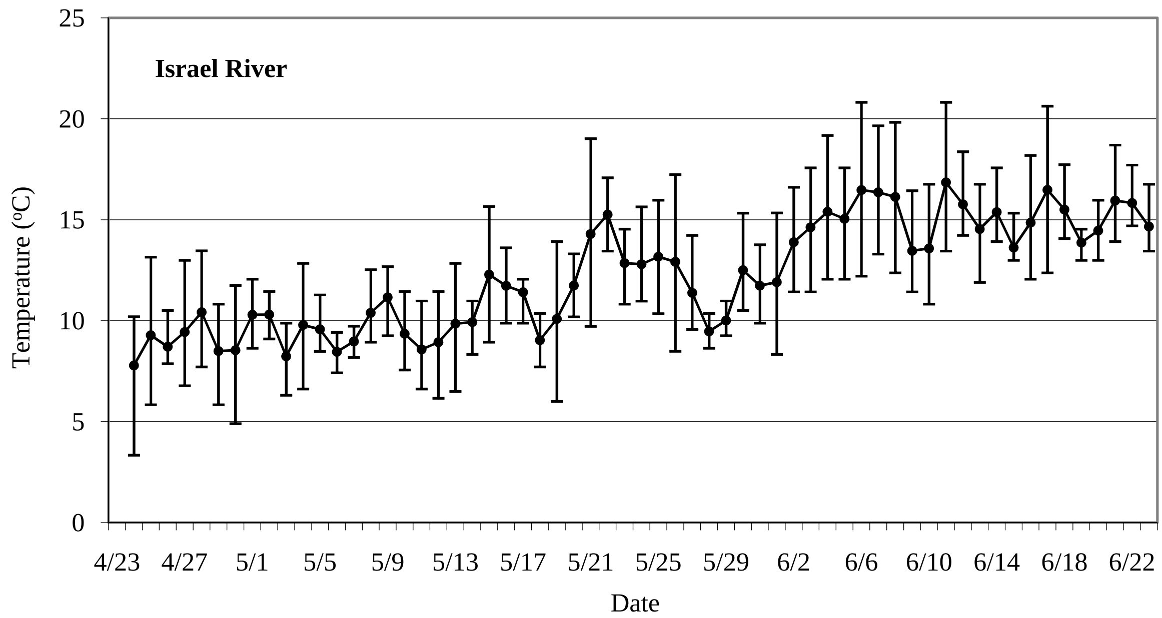


Figure 4-6. Minimum, mean, and maximum daily water temperature in the Moore Reservoir approximately 3-ft and 6-ft below the surface (at the time of deployment) from 23 April through 23 June 2009.



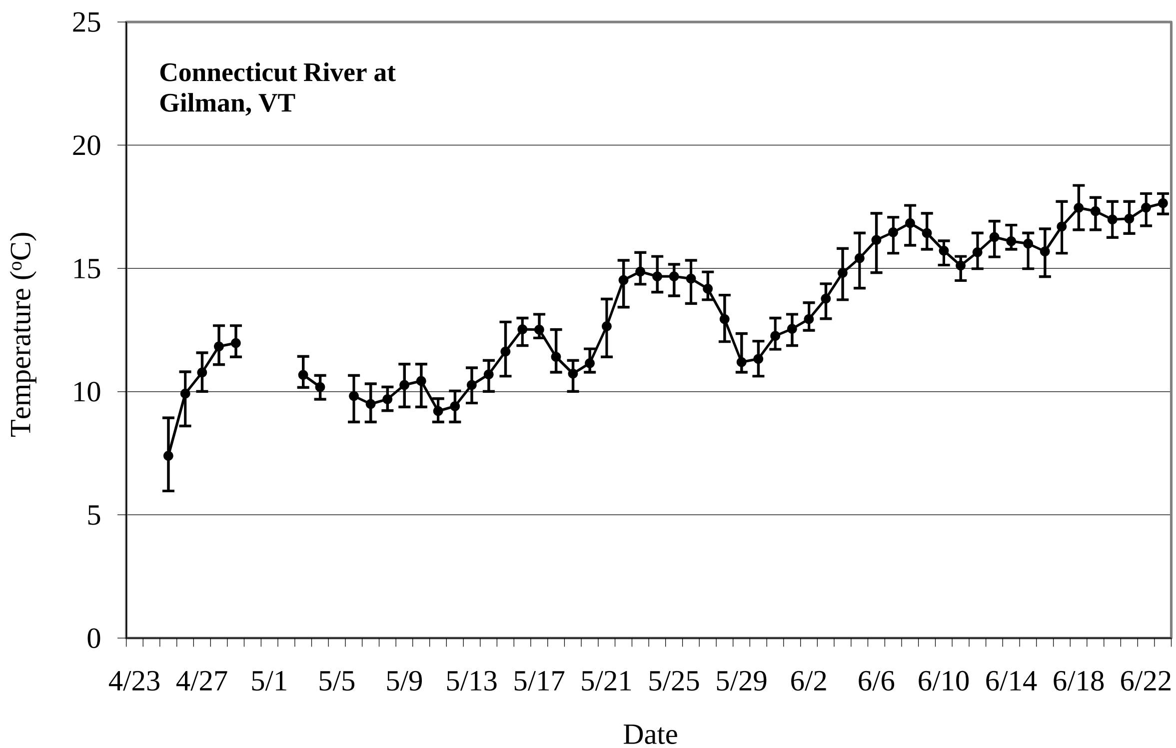


Figure 4-7. Minimum, mean, and maximum daily water temperature in the Israel and Connecticut River (Gilman) monitoring stations from 24 April through 23 June 2009.

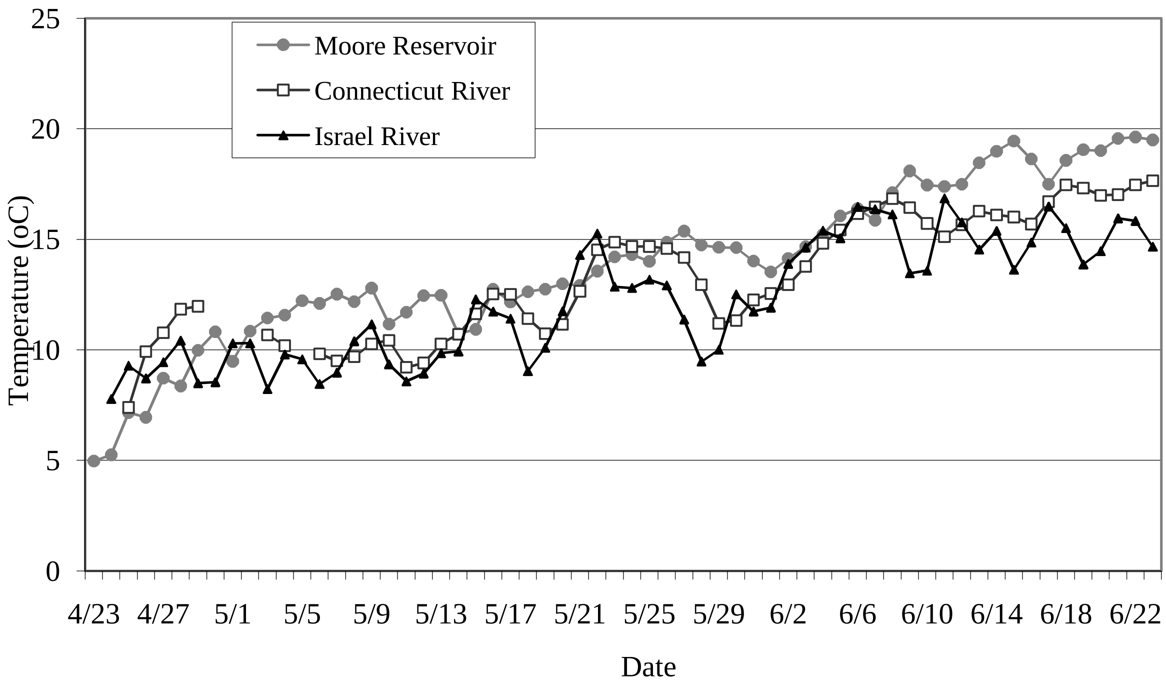


Figure 4-8. Comparison of mean daily water temperature at three monitoring stations, Israel River, Connecticut River at Gilman and Moore Reservoir (3-ft and 6-ft temperature readings averaged) from 23 April through 23 June 2009.

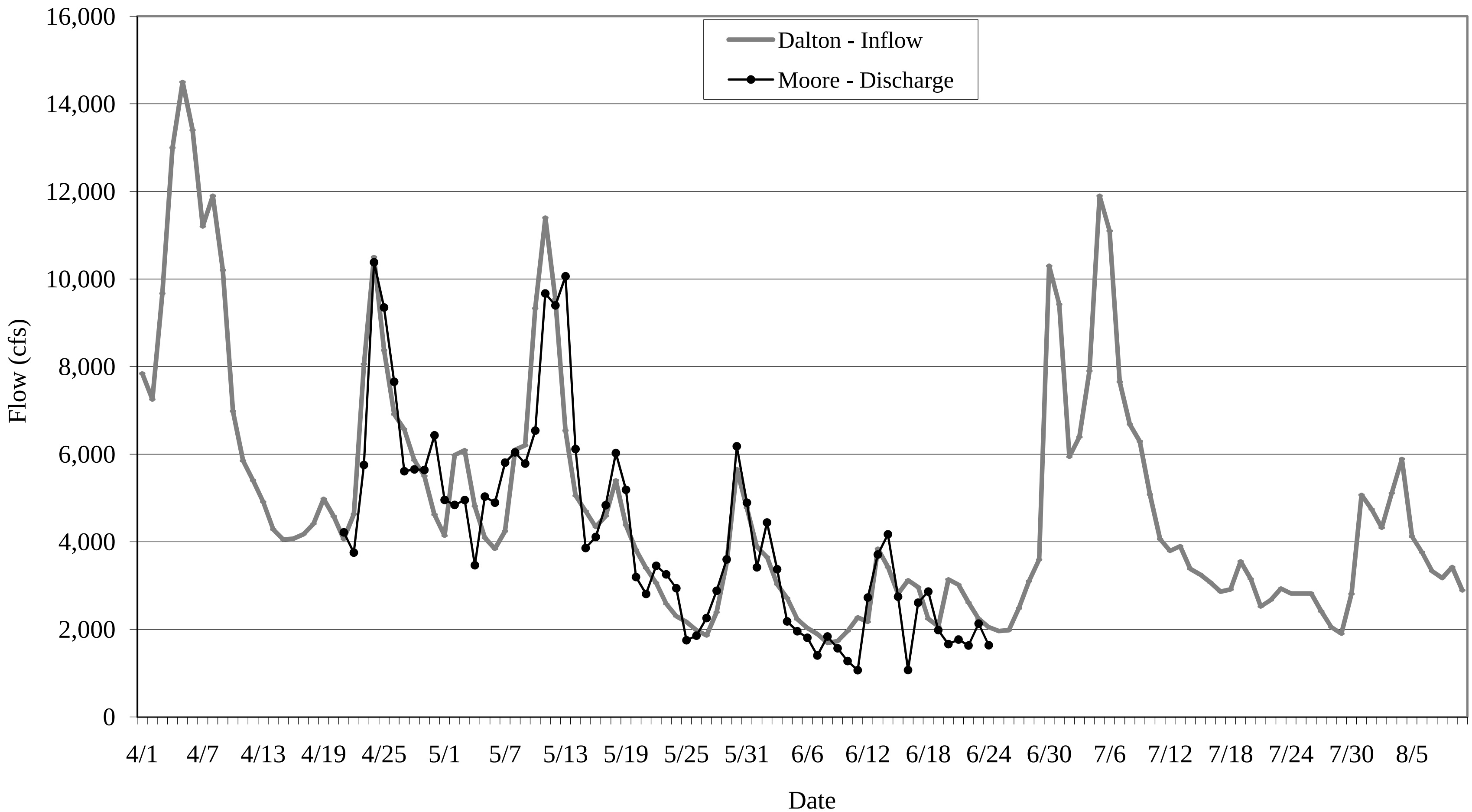


Figure 4-9. Daily average inflow (cfs) to the Moore Reservoir recorded at USGS Gauge 01131500 located at the Dalton Hydro, and outflow from the Moore Development, recorded by TransCanada, spring 2009.

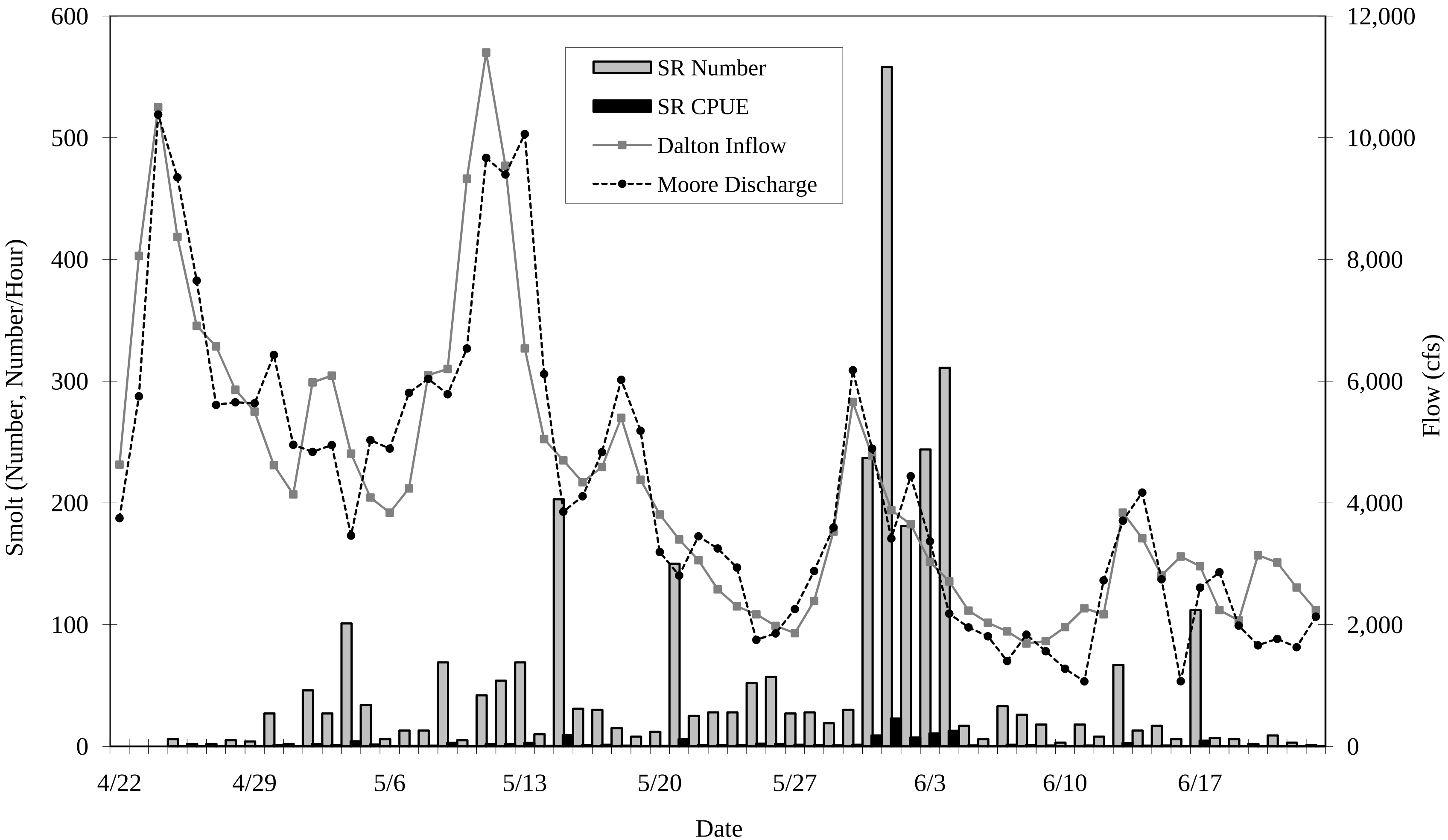


Figure 4-10. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection (number and number per hour) of Atlantic salmon smolts at the Moore sampler, spring 2009.

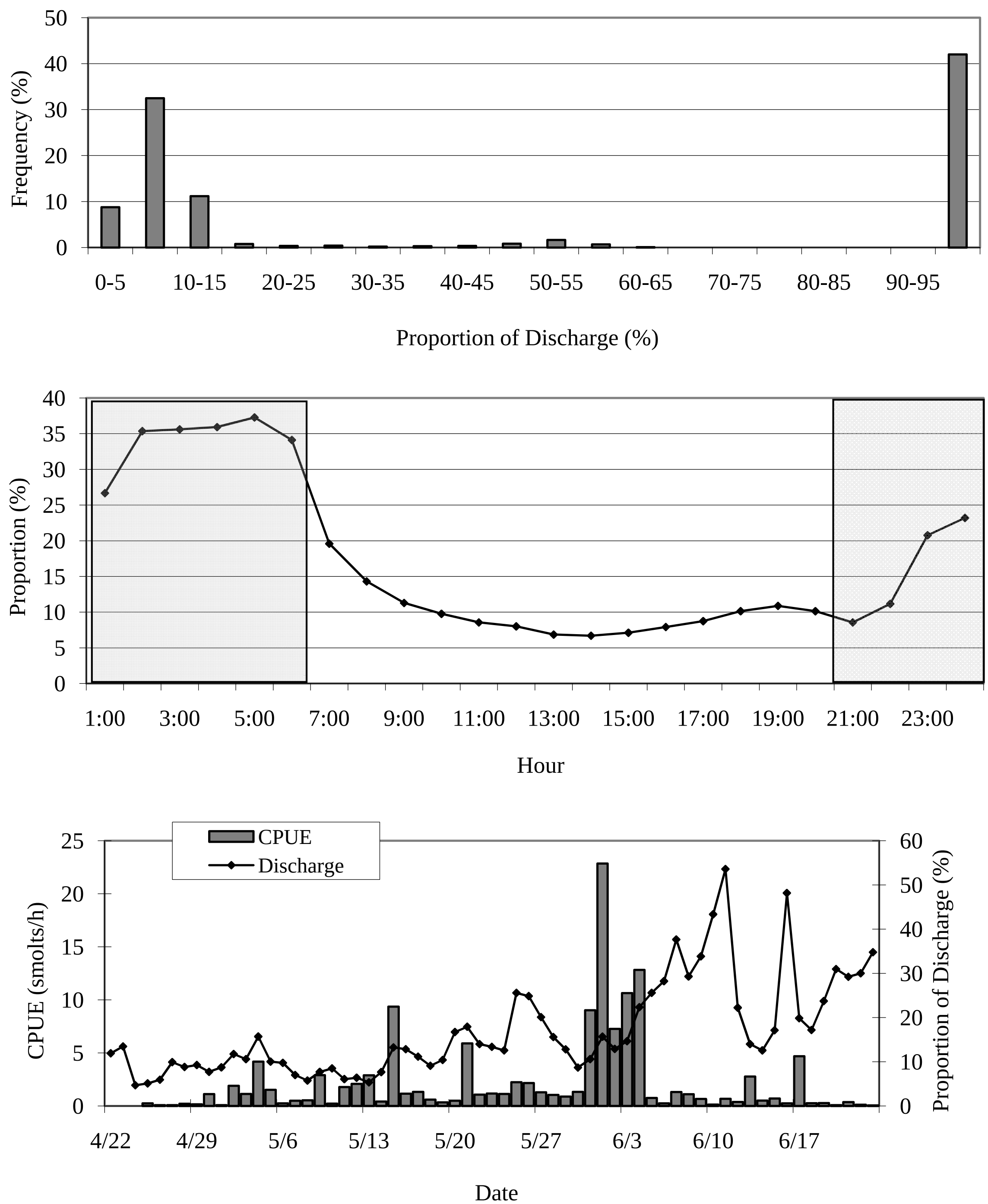


Figure 4-11. A. Frequency distribution of proportion of discharge (turbine flow + skimmer gate flow) to the skimmer gate; B. Hourly average proportion of discharge to the skimmer gate (shaded areas are approximate nighttime hours); C. Daily average proportion of discharge to the skimmer gate and daily average collection of smolts per hour (CPUE) by date.

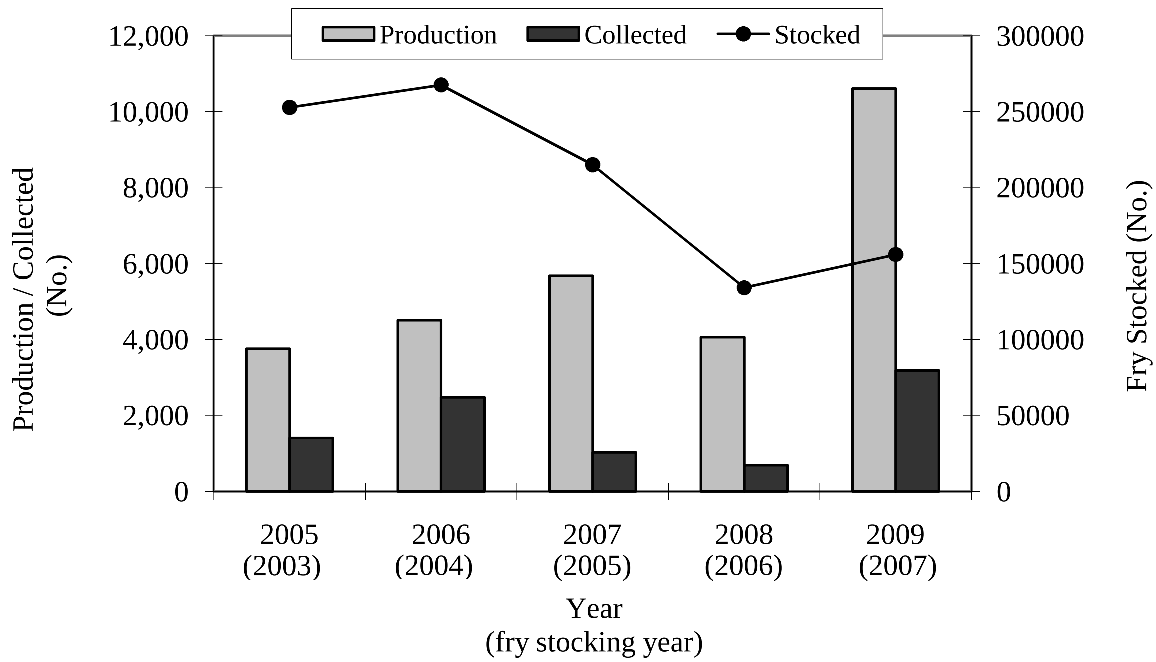


Figure 5-1. Comparison of the number of salmon fry stocked above the Moore Dam, estimated production of salmon smolts from index sites above the Moore Dam and salmon smolts collected in the Moore sampler for the years the sampler was opened by May 1. Because fry smoltify in approximately two years, salmon fry stocking numbers from 2003-2007 are compared with 2005-2009 production estimates and the number of smolts collected in the sampler.

Appendix Table 1. Number of Atlantic salmon smolts (stream-reared and hatchery-reared) collected in the Moore Dam sampler during each of 171 sampling periods, spring 2009. 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	HR Smolts	Total Smolts	SR CPUE	HR CPUE	Total Smolts CPUE
Evening	4/22/09	14:30	4/22/09	19:35	5.08	0	0	0	0.00	0.00	0.00
Morning	4/22/09	19:55	4/23/09	5:30	9.92	0	0	0	0.00	0.00	0.00
Afternoon	4/23/09	5:35	4/23/09	10:00	4.50	0	0	0	0.00	0.00	0.00
Evening	4/23/09	10:30	4/23/09	15:15	5.25	0	0	0	0.00	0.00	0.00
Morning	4/24/09	18:30	4/25/09	5:35	11.08	6	0	6	0.54	0.00	0.54
Afternoon	4/25/09	6:00	4/25/09	12:20	6.75	0	0	0	0.00	0.00	0.00
Evening	4/25/09	12:30	4/25/09	18:50	6.50	0	0	0	0.00	0.00	0.00
Morning	4/25/09	19:00	4/26/09	5:30	10.67	1	0	1	0.09	0.00	0.09
Afternoon	4/26/09	5:37	4/26/09	12:23	6.88	1	0	1	0.15	0.00	0.15
Evening	4/26/09	12:32	4/26/09	19:32	7.15	0	0	0	0.00	0.00	0.00
Morning	4/26/09	19:38	4/27/09	5:30	9.97	0	0	0	0.00	0.00	0.00
Afternoon	4/27/09	5:35	4/27/09	13:35	8.08	2	0	2	0.25	0.00	0.25
Evening	4/27/09	13:40	4/27/09	19:30	5.92	0	0	0	0.00	0.00	0.00
Morning	4/27/09	19:35	4/28/09	5:25	9.92	5	0	5	0.50	0.00	0.50
Afternoon	4/28/09	6:55	4/28/09	12:10	6.75	0	0	0	0.00	0.00	0.00
Evening	4/28/09	12:40	4/28/09	19:25	7.25	0	0	0	0.00	0.00	0.00
Morning	4/28/09	19:30	4/29/09	5:25	10.00	4	0	4	0.40	0.00	0.40
Afternoon	4/29/09	6:45	4/29/09	12:40	7.25	0	0	0	0.00	0.00	0.00
Evening	4/29/09	12:50	4/29/09	19:25	6.75	0	0	0	0.00	0.00	0.00
Morning	4/29/09	20:30	4/30/09	5:25	10.00	3	0	3	0.30	0.00	0.30
Afternoon	4/30/09	6:00	4/30/09	13:10	7.75	4	0	4	0.52	0.00	0.52
Evening	4/30/09	13:40	4/30/09	19:20	6.17	20	0	20	3.24	0.00	3.24
Morning	4/30/09	19:50	5/1/09	5:40	10.33	2	0	2	0.19	0.00	0.19
Afternoon	5/1/09	5:48	5/1/09	13:05	7.42	0	0	0	0.00	0.00	0.00
Evening	5/1/09	13:10	5/1/09	19:25	6.33	0	0	0	0.00	0.00	0.00
Morning	5/1/09	19:30	5/2/09	5:35	10.17	3	0	3	0.30	0.00	0.30
Afternoon	5/2/09	5:55	5/2/09	12:15	6.67	5	0	5	0.75	0.00	0.75
Evening	5/2/09	12:40	5/2/09	19:30	7.25	38	0	38	5.24	0.00	5.24
Morning	5/2/09	20:00	5/3/09	5:25	9.92	3	0	3	0.30	0.00	0.30
Afternoon	5/3/09	5:35	5/3/09	12:20	6.92	19	0	19	2.75	0.00	2.75
Evening	5/3/09	12:50	5/3/09	19:20	7.00	5	0	5	0.71	0.00	0.71
Morning	5/3/09	19:25	5/4/09	5:30	10.17	2	0	2	0.20	0.00	0.20
Afternoon	5/4/09	5:45	5/4/09	13:30	8.00	59	0	59	7.38	0.00	7.38
Evening	5/4/09	14:15	5/4/09	19:30	6.00	40	0	40	6.67	0.00	6.67
Morning	5/4/09	19:55	5/5/09	5:25	9.92	7	0	7	0.71	0.00	0.71
Evening	5/5/09	5:40	5/5/09	17:50	12.42	27	0	27	2.17	0.00	2.17
Morning	5/5/09	18:45	5/6/09	6:10	12.33	5	0	5	0.41	0.00	0.41
Evening	5/6/09	6:25	5/6/09	17:10	11.00	1	0	1	0.09	0.00	0.09
Morning	5/6/09	17:20	5/7/09	6:10	13.00	10	6	16	0.77	0.46	1.23
Afternoon	5/7/09	6:25	5/7/09	12:15	6.08	3	1	4	0.49	0.16	0.66
Evening	5/7/09	13:15	5/7/09	19:00	6.75	0	0	0	0.00	0.00	0.00

Appendix Table 1 (cont.). Number of Atlantic salmon smolts (stream-reared and hatchery-reared) collected in the Moore Dam sampler during each of 171 sampling periods, spring 2009. 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	HR Smolts	Total Smolts	SR CPUE	HR CPUE	Total Smolts CPUE
Morning	5/7/09	19:15	5/8/09	6:05	11.08	2	0	2	0.18	0.00	0.18
Afternoon	5/8/09	6:15	5/8/09	12:10	6.08	2	0	2	0.33	0.00	0.33
Evening	5/8/09	13:20	5/8/09	19:20	7.17	9	0	9	1.26	0.00	1.26
Morning	5/8/09	19:40	5/9/09	6:10	10.83	61	1	62	5.63	0.09	5.72
Afternoon	5/9/09	6:50	5/9/09	12:15	6.08	4	1	5	0.66	0.16	0.82
Evening	5/9/09	12:20	5/9/09	19:05	6.83	4	0	4	0.59	0.00	0.59
Morning	5/9/09	19:18	5/10/09	6:10	11.08	2	0	2	0.18	0.00	0.18
Afternoon	5/10/09	7:05	5/10/09	12:25	6.25	2	0	2	0.32	0.00	0.32
Evening	5/10/09	12:30	5/10/09	17:35	5.17	1	0	1	0.19	0.00	0.19
Morning	5/10/09	18:15	5/11/09	7:05	13.50	22	1	23	1.63	0.07	1.70
Evening	5/11/09	7:15	5/11/09	17:05	10.00	20	0	20	2.00	0.00	2.00
Morning	5/11/09	17:15	5/12/09	7:30	14.42	31	2	33	2.15	0.14	2.29
Afternoon	5/12/09	7:50	5/12/09	13:05	5.58	17	0	17	3.04	0.00	3.04
Evening	5/12/09	13:15	5/12/09	19:00	5.92	6	0	6	1.01	0.00	1.01
Morning	5/12/09	19:15	5/13/09	6:30	11.50	26	12	38	2.26	1.04	3.30
Afternoon	5/13/09	6:40	5/13/09	12:40	6.17	18	1	19	2.92	0.16	3.08
Evening	5/13/09	12:50	5/13/09	18:50	6.17	25	1	26	4.05	0.16	4.22
Morning	5/13/09	19:00	5/14/09	6:25	11.58	7	1	8	0.60	0.09	0.69
Afternoon	5/14/09	6:40	5/14/09	10:30	4.08	0	0	0	0.00	0.00	0.00
Evening	5/14/09	10:40	5/14/09	18:45	8.25	3	1	4	0.36	0.12	0.48
Morning	5/14/09	18:55	5/15/09	6:55	12.17	22	1	23	1.81	0.08	1.89
Evening	5/15/09	7:10	5/15/09	16:25	9.50	181	7	188	19.05	0.74	19.79
Morning	5/15/09	17:00	5/16/09	6:20	13.92	11	1	12	0.79	0.07	0.86
Afternoon	5/16/09	6:30	5/16/09	11:20	5.00	11	1	12	2.20	0.20	2.40
Evening	5/16/09	11:30	5/16/09	18:55	7.58	9	3	12	1.19	0.40	1.58
Morning	5/16/09	19:15	5/17/09	6:40	11.75	11	15	26	0.94	1.28	2.21
Afternoon	5/17/09	6:55	5/17/09	13:25	6.75	4	2	6	0.59	0.30	0.89
Evening	5/17/09	13:35	5/17/09	17:30	4.08	15	1	16	3.67	0.24	3.92
Morning	5/17/09	17:45	5/18/09	6:46	13.27	10	3	13	0.75	0.23	0.98
Afternoon	5/18/09	6:55	5/18/09	12:10	5.40	4	0	4	0.74	0.00	0.74
Evening	5/18/09	12:20	5/18/09	18:30	6.33	1	0	1	0.16	0.00	0.16
Morning	5/18/09	18:40	5/19/09	6:10	11.67	8	3	11	0.69	0.26	0.94
Afternoon	5/19/09	6:30	5/19/09	12:10	6.00	0	0	0	0.00	0.00	0.00
Evening	5/19/09	12:20	5/19/09	18:10	6.00	0	1	1	0.00	0.17	0.17
Morning	5/19/09	18:25	5/20/09	6:35	12.42	11	1	12	0.89	0.08	0.97
Afternoon	5/20/09	6:50	5/20/09	14:50	8.25	0	0	0	0.00	0.00	0.00
Evening	5/20/09	15:00	5/20/09	17:55	3.08	1	0	1	0.32	0.00	0.32
Morning	5/20/09	18:05	5/21/09	6:30	12.58	61	6	67	4.85	0.48	5.32
Evening	5/21/09	6:55	5/21/09	19:20	12.83	89	9	98	6.94	0.70	7.64
Morning	5/21/09	19:50	5/22/09	6:35	11.25	21	4	25	1.87	0.36	2.22
Afternoon	5/22/09	7:00	5/22/09	12:08	5.55	3	0	3	0.54	0.00	0.54

Appendix Table 1 (cont.). Number of Atlantic salmon smolts (stream-reared and hatchery-reared) collected in the Moore Dam sampler during each of 171 sampling periods, spring 2009. Effort is calculated as the number of hours between the current End Time and the previous End Time.

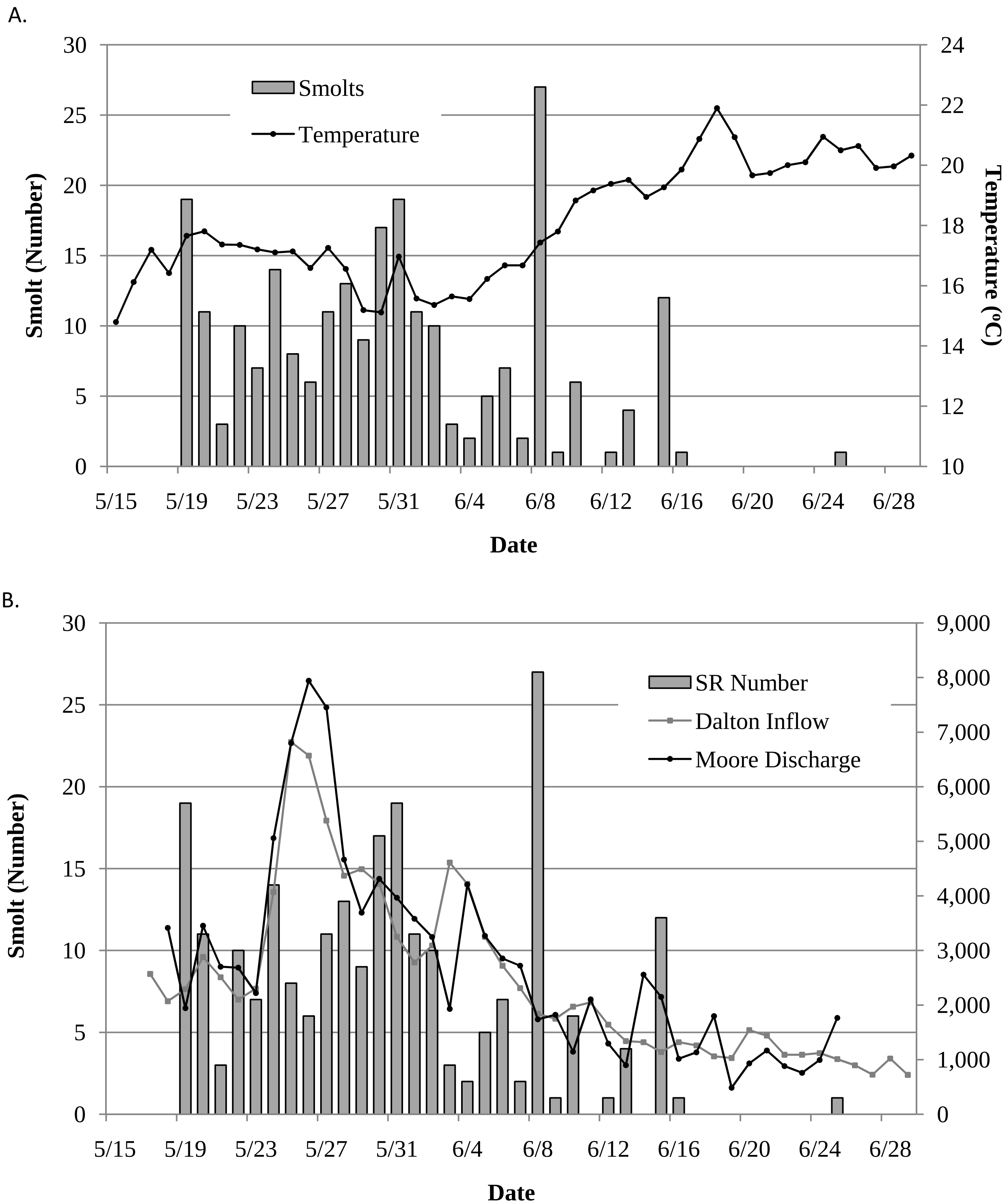
Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	HR Smolts	Total Smolts	SR CPUE	HR CPUE	Total Smolts CPUE
Evening	5/22/09	12:15	5/22/09	18:30	6.37	1	0	1	0.16	0.00	0.16
Morning	5/22/09	18:40	5/23/09	6:15	11.75	26	3	29	2.21	0.26	2.47
Afternoon	5/23/09	6:35	5/23/09	12:25	6.17	1	0	1	0.16	0.00	0.16
Evening	5/23/09	12:30	5/23/09	18:20	5.92	1	0	1	0.17	0.00	0.17
Morning	5/23/09	18:30	5/24/09	6:15	11.92	10	1	11	0.84	0.08	0.92
Afternoon	5/24/09	6:30	5/24/09	12:25	6.17	0	0	0	0.00	0.00	0.00
Evening	5/24/09	12:30	5/24/09	19:00	6.58	18	5	23	2.73	0.76	3.49
Morning	5/24/09	19:10	5/25/09	6:50	11.83	25	11	36	2.11	0.93	3.04
Afternoon	5/25/09	7:05	5/25/09	12:15	5.42	0	3	3	0.00	0.55	0.55
Evening	5/25/09	12:30	5/25/09	18:10	5.92	27	1	28	4.56	0.17	4.73
Morning	5/25/09	18:25	5/26/09	6:40	12.50	17	3	20	1.36	0.24	1.60
Afternoon	5/26/09	6:55	5/26/09	11:15	4.58	6	0	6	1.31	0.00	1.31
Evening	5/26/09	11:25	5/26/09	20:33	9.30	34	6	40	3.66	0.65	4.30
Morning	5/26/09	20:50	5/27/09	6:55	10.37	21	5	26	2.03	0.48	2.51
Afternoon	5/27/09	7:20	5/27/09	12:20	5.42	0	0	0	0.00	0.00	0.00
Evening	5/27/09	12:25	5/27/09	17:20	5.00	6	0	6	1.20	0.00	1.20
Morning	5/27/09	17:40	5/28/09	6:40	13.33	24	7	31	1.80	0.53	2.33
Afternoon	5/28/09	7:20	5/28/09	11:15	4.58	4	0	4	0.87	0.00	0.87
Evening	5/28/09	11:30	5/28/09	20:05	8.83	0	0	0	0.00	0.00	0.00
Morning	5/28/09	20:15	5/29/09	5:30	9.42	10	3	13	1.06	0.32	1.38
Afternoon	5/29/09	5:40	5/29/09	12:25	6.92	5	0	5	0.72	0.00	0.72
Evening	5/29/09	12:35	5/29/09	17:30	5.08	4	0	4	0.79	0.00	0.79
Morning	5/29/09	18:00	5/30/09	6:25	12.92	7	1	8	0.54	0.08	0.62
Afternoon	5/30/09	6:45	5/30/09	14:45	8.33	14	2	16	1.68	0.24	1.92
Evening	5/30/09	14:55	5/30/09	16:00	1.25	9	13	22	7.20	10.40	17.60
Morning	5/30/09	16:15	5/31/09	6:20	14.33	202	23	225	14.09	1.60	15.70
Evening	5/31/09	7:35	5/31/09	18:15	11.92	35	17	52	2.94	1.43	4.36
Morning	5/31/09	19:00	6/1/09	7:25	13.17	27	4	31	2.05	0.30	2.35
Afternoon	6/1/09	7:30	6/1/09	12:25	5.00	72	0	72	14.40	0.00	14.40
Evening	6/1/09	12:45	6/1/09	18:40	6.25	459	28	487	73.44	4.48	77.92
Morning	6/1/09	21:00	6/2/09	8:30	13.83	4	2	6	0.29	0.14	0.43
Afternoon	6/2/09	9:00	6/2/09	12:25	3.92	27	9	36	6.89	2.30	9.19
Evening	6/2/09	12:35	6/2/09	19:35	7.17	150	0	150	20.93	0.00	20.93
Morning	6/2/09	20:05	6/3/09	6:20	10.75	11	3	14	1.02	0.28	1.30
Afternoon	6/3/09	6:30	6/3/09	12:25	6.08	51	4	55	8.38	0.66	9.04
Evening	6/3/09	12:35	6/3/09	18:30	6.08	182	9	191	29.92	1.48	31.40
Morning	6/3/09	18:45	6/4/09	6:20	11.83	17	3	20	1.44	0.25	1.69
Afternoon	6/4/09	6:35	6/4/09	12:20	6.00	44	8	52	7.33	1.33	8.67
Evening	6/4/09	12:30	6/4/09	18:45	6.42	250	7	257	38.96	1.09	40.05
Morning	6/4/09	19:45	6/5/09	6:25	11.67	12	2	14	1.03	0.17	1.20

Appendix Table 1 (cont.). Number of Atlantic salmon smolts (stream-reared and hatchery-reared) collected in the Moore Dam sampler during each of 171 sampling periods, spring 2009. Effort is calculated as the number of hours between the current End Time and the previous End Time.

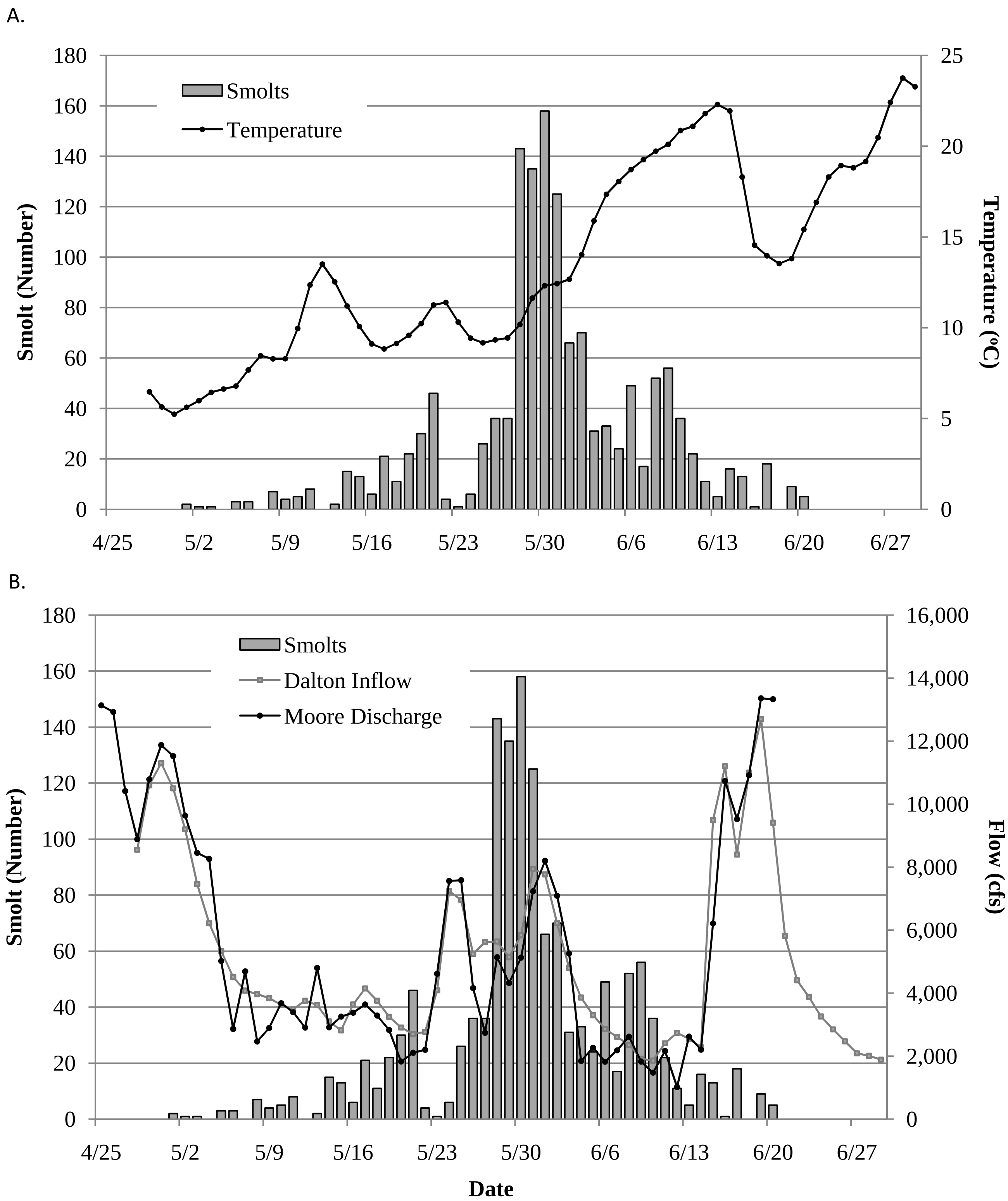
Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	SR Smolts	HR Smolts	Total Smolts	SR CPUE	HR CPUE	Total Smolts CPUE
Afternoon	6/5/09	6:40	6/5/09	12:20	5.92	3	0	3	0.51	0.00	0.51
Evening	6/5/09	12:30	6/5/09	17:15	4.92	2	2	4	0.41	0.41	0.81
Morning	6/5/09	17:25	6/6/09	6:30	13.25	1	1	2	0.08	0.08	0.15
Afternoon	6/6/09	6:45	6/6/09	12:30	6.00	5	1	6	0.83	0.17	1.00
Evening	6/6/09	12:45	6/6/09	17:20	4.83	0	0	0	0.00	0.00	0.00
Morning	6/6/09	17:25	6/7/09	6:35	13.25	4	5	9	0.30	0.38	0.68
Afternoon	6/7/09	6:45	6/7/09	12:20	5.75	3	0	3	0.52	0.00	0.52
Evening	6/7/09	12:25	6/7/09	18:15	5.92	26	5	31	4.39	0.85	5.24
Morning	6/7/09	18:30	6/8/09	6:30	12.25	5	5	10	0.41	0.41	0.82
Evening	6/8/09	6:45	6/8/09	17:35	11.08	21	4	25	1.89	0.36	2.26
Morning	6/8/09	17:55	6/9/09	6:15	12.67	7	6	13	0.55	0.47	1.03
Afternoon	6/9/09	6:30	6/9/09	12:15	6.00	11	3	14	1.83	0.50	2.33
Evening	6/9/09	12:30	6/9/09	20:20	8.08	0	0	0	0.00	0.00	0.00
Morning	6/9/09	20:25	6/10/09	6:15	9.92	0	0	0	0.00	0.00	0.00
Evening	6/10/09	6:25	6/10/09	18:00	11.75	3	2	5	0.26	0.17	0.43
Morning	6/10/09	18:10	6/11/09	6:25	12.42	14	8	22	1.13	0.64	1.77
Evening	6/11/09	6:55	6/11/09	20:15	13.83	4	0	4	0.29	0.00	0.29
Morning	6/11/09	20:25	6/12/09	6:20	10.08	7	1	8	0.69	0.10	0.79
Evening	6/12/09	6:35	6/12/09	17:00	10.67	1	2	3	0.09	0.19	0.28
Morning	6/12/09	17:05	6/13/09	6:20	13.33	14	0	14	1.05	0.00	1.05
Evening	6/13/09	6:35	6/13/09	17:10	10.83	53	0	53	4.89	0.00	4.89
Morning	6/13/09	17:20	6/14/09	6:25	13.25	4	1	5	0.30	0.08	0.38
Afternoon	6/14/09	6:35	6/14/09	13:15	6.83	9	1	10	1.32	0.15	1.46
Evening	6/14/09	13:21	6/14/09	18:15	5.00	0	0	0	0.00	0.00	0.00
Morning	6/14/09	18:20	6/15/09	6:30	12.25	13	3	16	1.06	0.24	1.31
Afternoon	6/15/09	6:40	6/15/09	12:25	5.92	1	0	1	0.17	0.00	0.17
Evening	6/15/09	12:30	6/15/09	18:21	5.93	3	0	3	0.51	0.00	0.51
Morning	6/15/09	18:27	6/16/09	6:28	12.12	2	1	3	0.17	0.08	0.25
Afternoon	6/16/09	6:45	6/16/09	12:18	5.83	2	0	2	0.34	0.00	0.34
Evening	6/16/09	12:25	6/16/09	18:36	6.30	2	0	2	0.32	0.00	0.32
Morning	6/16/09	18:41	6/17/09	6:20	11.73	17	3	20	1.45	0.26	1.70
Evening	6/17/09	6:40	6/17/09	18:30	12.17	95	3	98	7.81	0.25	8.05
Morning	6/17/09	18:50	6/18/09	6:20	11.83	5	1	6	0.42	0.08	0.51
Afternoon	6/18/09	6:35	6/18/09	12:18	5.97	2	0	2	0.34	0.00	0.34
Evening	6/18/09	12:25	6/18/09	20:23	8.08	0	0	0	0.00	0.00	0.00
Morning	6/18/09	20:28	6/19/09	6:20	9.95	1	0	1	0.10	0.00	0.10
Afternoon	6/19/09	6:28	6/19/09	12:25	6.08	5	0	5	0.82	0.00	0.82

Appendix Table 1 (cont.). Number of Atlantic salmon smolts (stream-reared and hatchery-reared) collected in the Moore Dam sampler during each of 171 sampling periods, spring 2009. 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	HR Smolts	Total Smolts	SR CPUE	HR CPUE	Total Smolts CPUE
Evening	6/19/09	12:33	6/19/09	18:20	5.92	0	0	0	0.00	0.00	0.00
Morning	6/19/09	18:26	6/20/09	7:45	13.42	1	1	2	0.07	0.07	0.15
Afternoon	6/20/09	7:55	6/20/09	14:12	6.45	1	0	1	0.16	0.00	0.16
Evening	6/20/09	14:20	6/20/09	18:08	3.93	0	0	0	0.00	0.00	0.00
Morning	6/20/09	18:11	6/21/09	8:15	14.12	8	0	8	0.57	0.00	0.57
Afternoon	6/21/09	8:35	6/21/09	13:15	5.00	0	0	0	0.00	0.00	0.00
Evening	6/21/09	13:23	6/21/09	18:20	5.08	1	1	2	0.20	0.20	0.39
Morning	6/21/09	18:26	6/22/09	7:42	13.37	3	1	4	0.22	0.07	0.30
Afternoon	6/22/09	7:52	6/22/09	12:25	4.72	0	0	0	0.00	0.00	0.00
Evening	6/22/09	12:35	6/22/09	18:45	6.33	0	0	0	0.00	0.00	0.00
Morning	6/22/09	18:55	6/23/09	6:45	12.00	1	0	1	0.08	0.00	0.08
Afternoon	6/23/09	6:52	6/23/09	11:50	5.08	0	0	0	0.00	0.00	0.00

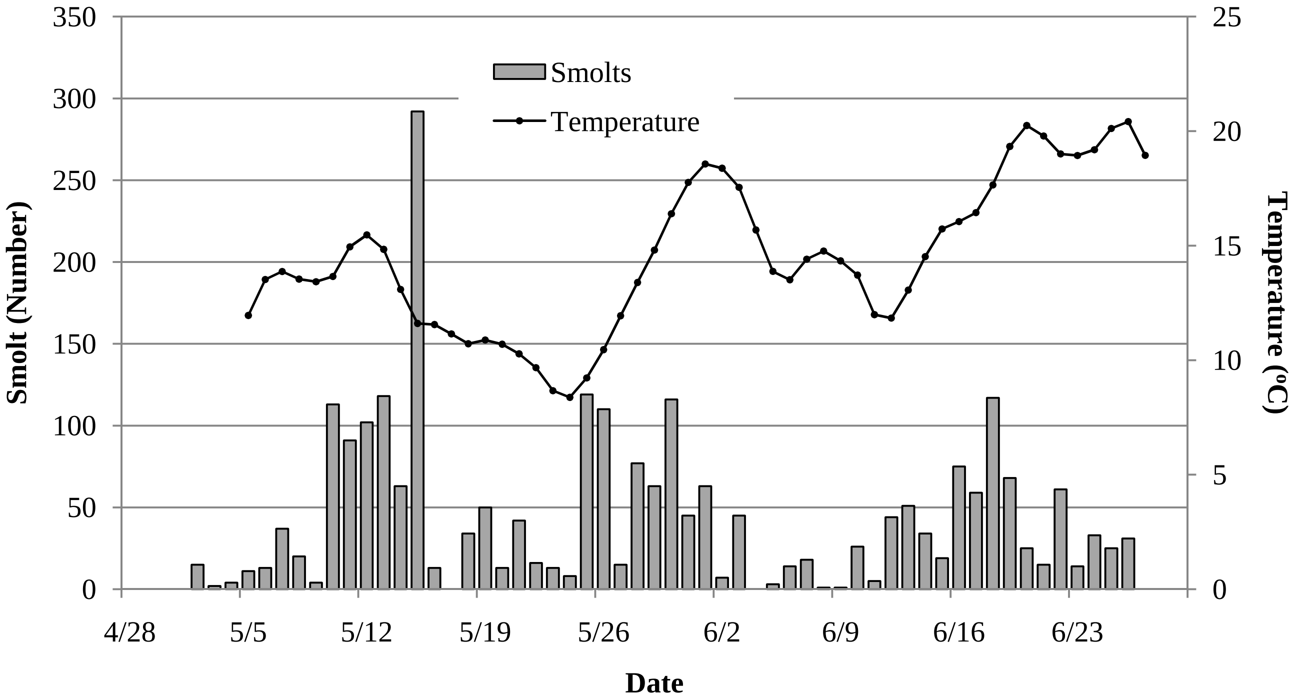


Appendix Figure 1. A. Daily average water temperature in the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2004. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2004.

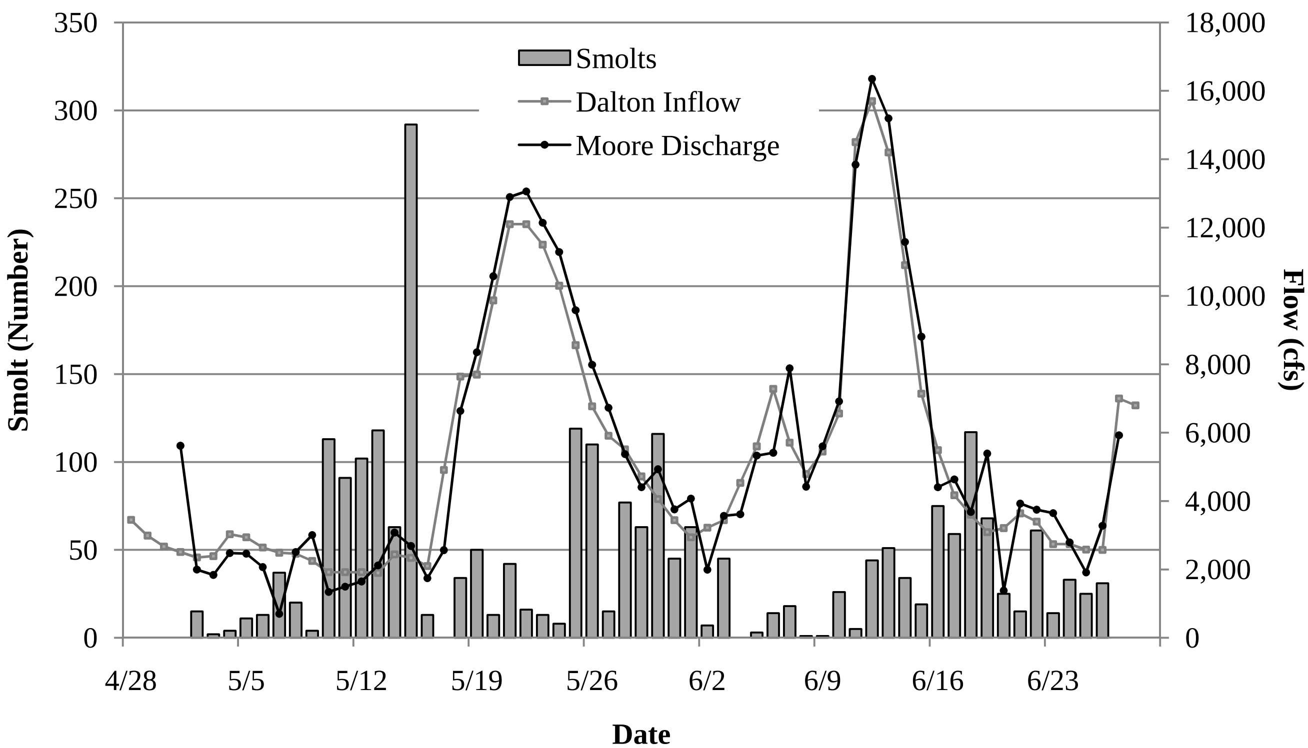


Appendix Figure 2. A. Daily average water temperature in the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2005. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2005.

A.

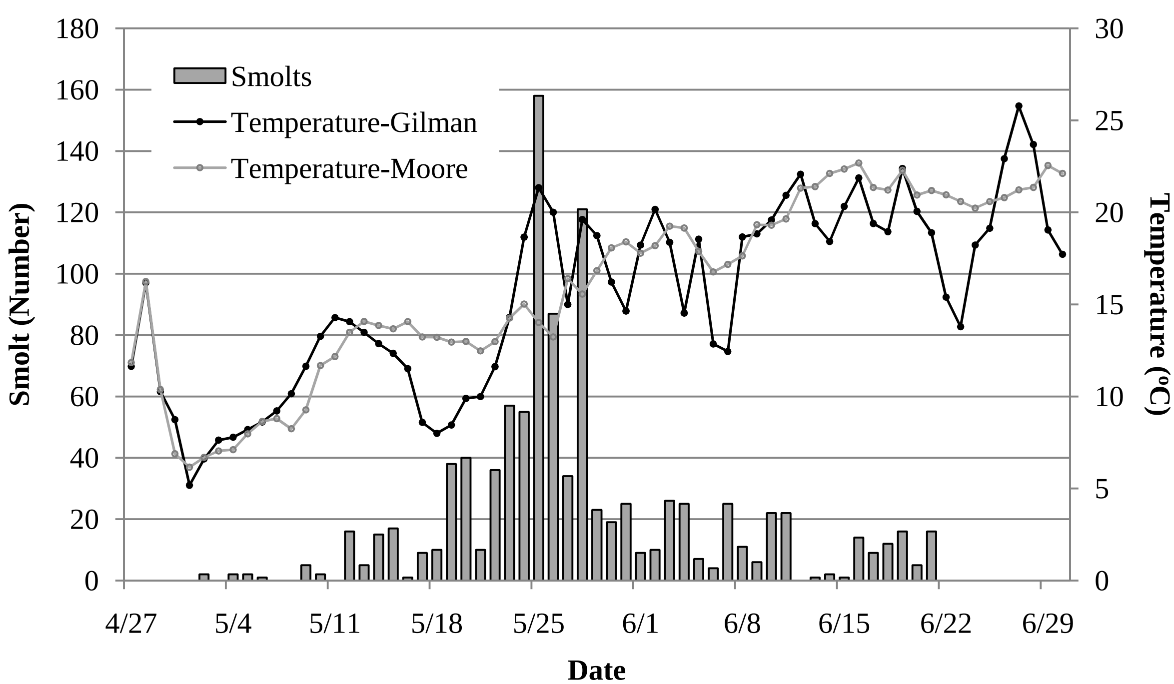


B.

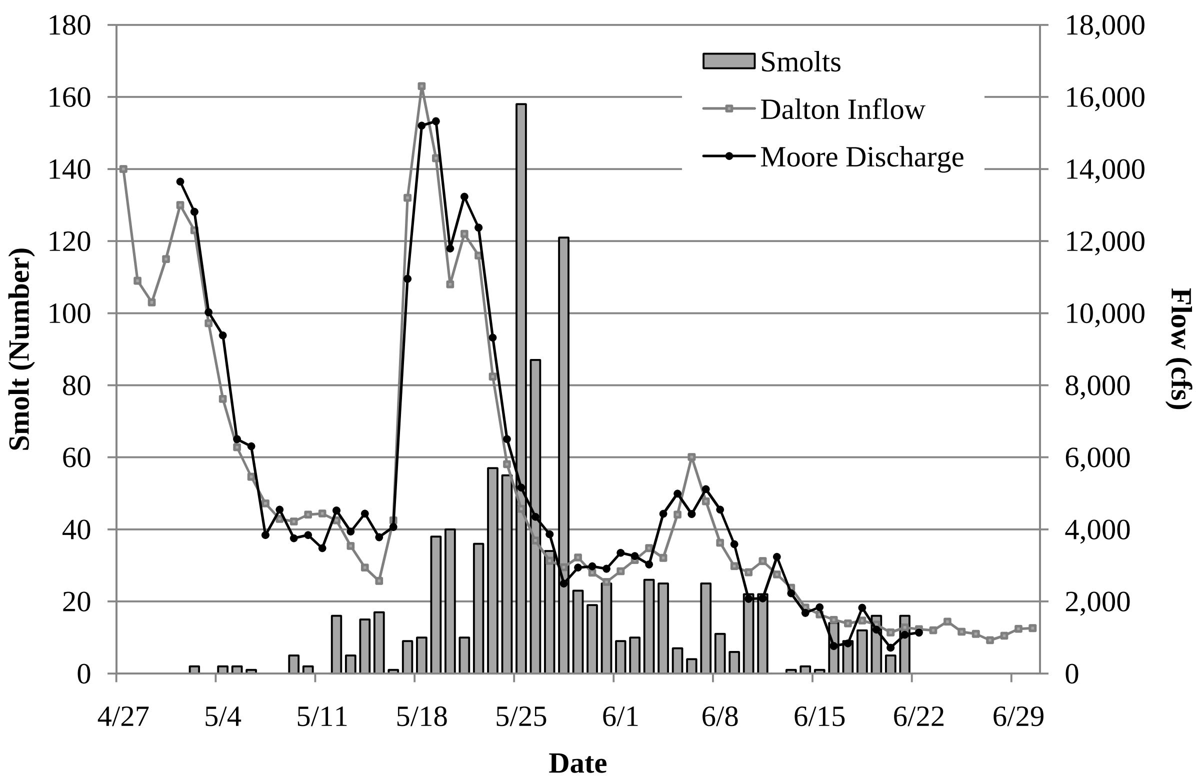


Appendix Figure 3. A. Daily average water temperature in the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2006. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2006.

A.

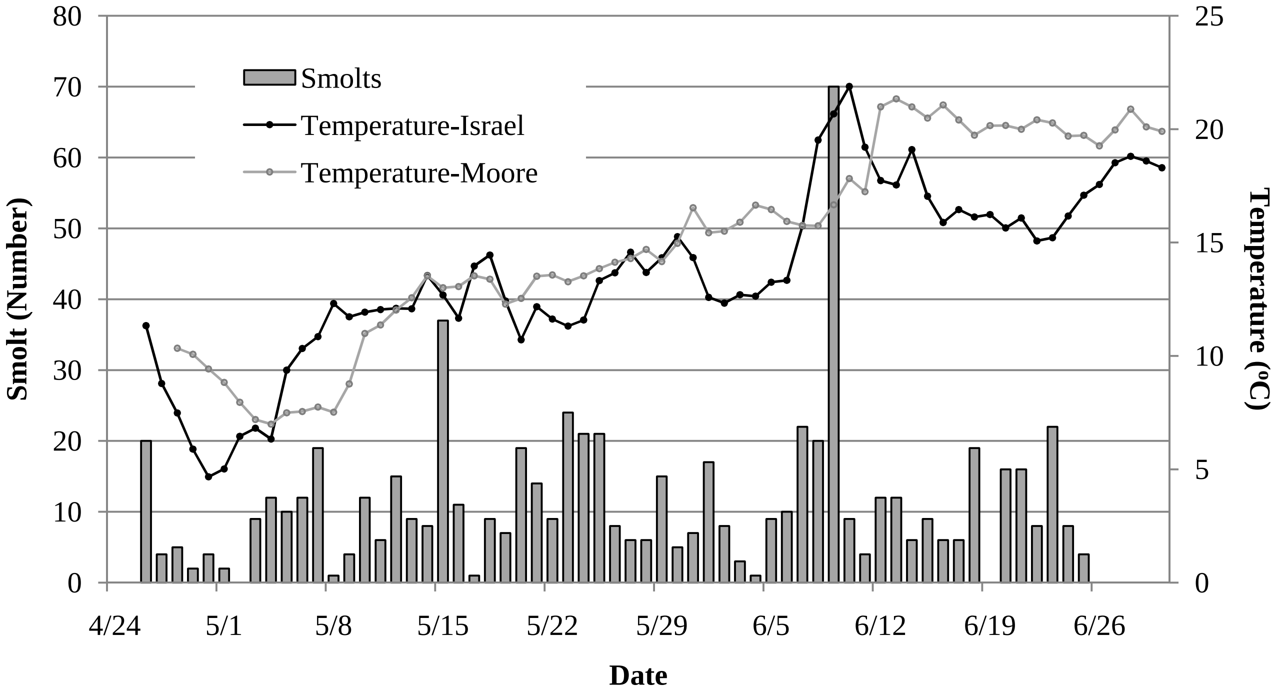


B.

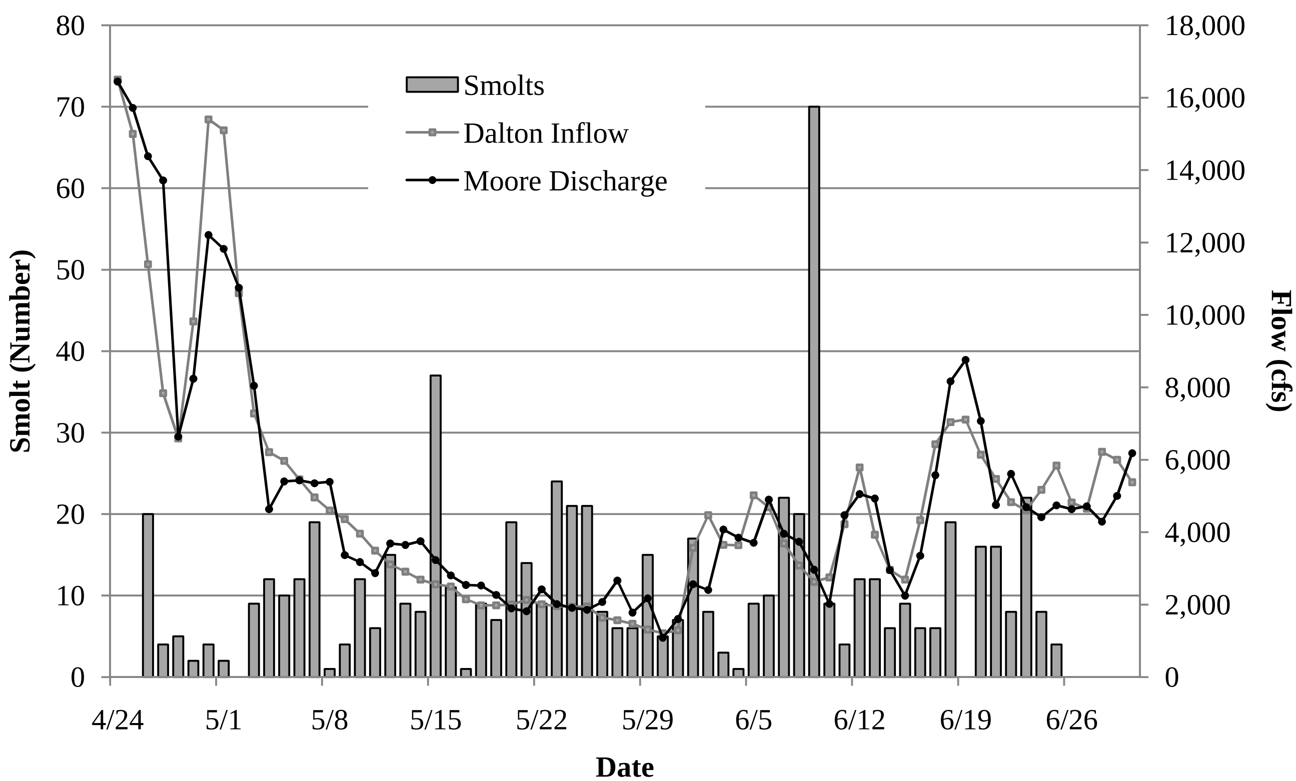


Appendix Figure 4. A. Daily average water temperature in the Connecticut River at Gilman, VT, and the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2007. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2007.

A.



B.



Appendix Figure 5. A. Daily average water temperature in the Israel River and the Moore Reservoir compared with daily collection number of stream-reared Atlantic salmon smolts at the Moore sampler, spring 2008. B. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection number of Atlantic salmon smolts at the Moore sampler, spring 2008.