ATLANTIC SALMON SMOLT REPORT ON FISH SAMPLING EFFORTS AT MOORE DAM, SPRING 2005

MARCH 2006

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R-20304.000

March 2006

Executive Summary

The Fifteen Mile Falls Project is a three development hydroelectric project on the upper Connecticut River owned by TransCanada Hydro Northeast, Inc. 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 on the Vermont side, in Caledonia County. The FERC approved a two-year study plan to evaluate the timing and season of smolt passage at Moore Dam, prior to filing a fish passage plan, required by the FERC license. TransCanada constructed an inclined-plane sampler in the skimmer gate at the Moore Dam as the mechanism to conduct the evaluation.

The first year of study was conducted in 2004. This report provides results from the second year of study. The study included monitoring the timing (diurnal and seasonal), duration, and abundance of the stream-reared Atlantic salmon migratory run at Moore Dam. In addition, radio telemetry was used to obtain preliminary information on the attractiveness, to smolts, of the skimmer gate entrance as a downstream passage route; and radio frequency identification (RFID) was used to assess diurnal passage for hatchery-reared smolts.

The sampler was monitored from 25 April to 24 June 2005. Collected salmon were identified as hatchery radio-tagged, hatchery PIT-tagged, or stream-reared, and all live salmon were transported to and released into the tail waters of McIndoes station. Hatchery fish were obtained from the US Fish and Wildlife Service's Pittsford National Fish Hatchery in Pittsford, VT. Fish were tagged at the hatchery, transported to the Moore Dam where they were held overnight, and released the next day, just downstream of the Dalton Hydro tailrace in Gilman, VT. One-hundred-fifty-one smolts were radio tagged and 894 smolts were PIT tagged. All were released in six groups between 5 May and 2 June. A summary of the results are as follows:

Stream-Reared Smolts

- 1,404 stream-reared smolts were collected between 5 May and 24 June; on 3 June 158 smolts were collected, the greatest number in a one-day period;
- Catch-per-unit-effort (CPUE) was highest (5.26 smolts/h) during the Evening category (between sunset and sunrise), and lowest (0.88 smolts/h) during the Day and Evening category, Overall CPUE for stream-reared smolts was 1.17 smolts/h;
- Mortality was 13%, due in part to heavy debris loads on the sampler;
- The full migratory run of stream-reared smolts was observed; the run began in early May, peaked in early June and was substantially decreased by 24 June, when the sampler was closed for the season.

Hatchery Smolts

- CPUE for hatchery smolts was 0.26 smolts/h, and was highest (1.27 smolts/h) during the Evening category;
- Mortality was 9%, due in part to heavy debris loads on the sampler.

Radio Telemetry

- Of the 151 smolts released, 150 (99%) passed a mid-river monitoring station between the release site and the Moore Dam;
- At the Moore Dam, 133 (89%) were detected;
- Thirty passed the Dam via the skimmer gate and five passed through the turbines;
- Mean travel time from the release site to the mid-river station was 10 hr 14 min; mean travel time from the mid-river station to the Dam was 3 days 14 min;
- Residency time ranged from 1 min to over 2 days; mean residency time was4 hrs 53 min;

RFID

- 284 (32%) of 894 PIT tagged smolts were collected in the sampler;
- Due to equipment malfunction, only 40 (14%) were correctly read at the sampler;
- Days-at-large ranged from 4 to 32.

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

- The inclined plane sampler was effective at collecting fish that passed over the skimmer gate;
- Debris load in the sampler affects mortality rate but survival may be improved through more frequent sampling events and a debris exclusion system;
- Radio telemetry suggests that hatchery smolts released upstream of the Moore Reservoir have difficulty finding the skimmer gate opening for downstream passage;
- RFID PIT technology was not an effective tool at the Moore sampler for collecting data on date and time of day passage by smolts;
- Total length and weight measurements for stream-reared smolts should be collected to better characterize the condition of smolts and to put age and growth into context with lower basin subpopulations.

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Acronyms, Abbreviations, and Definitions

°C	degree Celsius
cfs	cubic foot per second
CPUE	catch per unit of effort
CRASC	Connecticut River Atlantic Salmon Commission
d	day
el	elevation
FERC	Federal Energy Regulatory Commission
FMF	Fifteen Mile Falls
ft	foot
g	gram
gal	gallon
h	hour
hp	horsepower
mg/L	milligram per liter
mi	mile
min	minute
mm	millimeter
MS 222	tricane-methanesulfonate
msl	mean sea level
NH	New Hampshire
NHFGD	New Hampshire Fish and Game Department
RM	river mile
rpm	revolutions per minute
Sample event	Brief period of time when water conveyed from the Moore Dam inclined plane 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 Moore Dam inclined plane sampler was operational.
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

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1.0 INTRODUCTION

The Fifteen Mile Falls Project (FMF) is a three development hydroelectric project on the upper Connecticut River (Figure 1-1) formerly owned by USGen New England, Inc. (USGen NE) and currently owned by TransCanada Hydro Northeast, Inc. (TransCanada). The Federal Energy Regulatory Commission (FERC) license for the project was transferred to TransCanada on 24 January 2005 (FERC Project No. 2077). The three developments 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 to USGenNE for continued operation of the project on 8 April 2002. Article 410 of the license required that within 180 days of being notified by the NH Fish and Game Department (NHFGD), the VT 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. USGenNE 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, USGenNE 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. USGenNE 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. USGenNE proposed to evaluate and characterize smolt downstream passage by constructing an inclined-plane sampler in the skimmer gate at 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 USGenNE.

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 approval for a second year was granted. This report provides results from the second year of study. The study included monitoring the timing (diurnal and seasonal), duration, and abundance of the stream-reared Atlantic salmon migratory run at Moore Dam. In addition, radio telemetry was used to obtain preliminary information on the attractiveness, to smolts, of the skimmer gate entrance as a downstream passage route; and radio frequency identification (RFID) was used to assess diurnal passage for hatchery-reared smolts.

2.0 PROJECT DESCRIPTION

2.1 Moore Development

The Moore Development is located at river mile (RM) 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 rpm (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-plan sampler was installed at the skimmer gate during early 2004 and monitored for salmon smolt passage during spring 2004 (Normandeau 2005). Modifications were made to the sampler after the 2004 evaluation but prior to the 2005 emigration season, and included:

- The sampler discharge pipe was moved from the wall to the floor of the trough (Figure 2-1), reducing the amount of time fish spent in the trough;
- A fixed netting structure was added to two sides of the collection tank (Figure 2-2). Additional netting was added mid-season 2005 (Figure 2-3) to keep fish from jumping out of the collection tank or splashing out when conveyed through the pipe.

A targeted discharge of 450 cfs for downstream passage onto the fish sampler was used throughout the 2005 evaluation. To accomplish this, the skimmer gate was manually adjusted to within approximately one-foot of pond elevation changes.

The inclined plane sampler is 14.5 ft wide and consists of two sections, connected on a pivot (Figure 2-4). The front section, connected to the dam at a horizontal angle, is approximately 9 ft long by 14.5 ft wide; the elevation can be adjusted but the plane surface of this section remains horizontal at all times. The rear section is approximately 21 ft long by 14.5 ft wide and pivots at its junction with the front section. The angle of the rear section to the front section can be adjusted to optimize the amount of dewatering as flow passes 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. The gap width was set at 3/16 in for this study, but could be adjusted if necessary. On top of the screen surface was a set of flow guidance structures designed to facilitate even flow and proper velocity across the downstream end of the screen (Figure 2-5).

At the end of the inclined plane is an angled, fabricated metal trough with solid sides that connects to a 12-in-diameter discharge pipe (Figure 2-1). The elbowed discharge pipe is adjustable vertically and conveys water from the trough to the collection tank. The collection tank is an 8-ft by 4-ft-rectangular open-topped metal box, 4 ft deep. Perforations around top portions 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.

3.0 MATERIALS AND METHODS

3.1 Moore Dam Sampler

The sampler was monitored during each day of operation. A sampling event entailed engaging the shut-off valve on the discharge pipe, allowing the collection tank to drain, and dip-netting all fish out of the tank. After all fish were removed, the valve was opened and the collection tank was re-filled with water. Fish were put either into 5-gal water filled buckets and carried to the processing area located on the headworks of the dam, or transported via the monorail system in a water filled 55-gal drum. Salmon were identified as hatchery radio-tagged, hatchery PIT-tagged, or stream-reared and their physical condition noted in accordance with a coding system developed for the evaluation (Table 3-1). All live salmon were transported to and released into the tailwaters of McIndoes station (Figure 1-1). Resident fish removed from the collection tank were identified to species, enumerated, surveyed for injuries, and returned to Moore Reservoir.

At each sampling event, operation conditions such as pond elevation, gate position, and position of the front and rear sampler sections, were recorded. Sampling period (period of time that the sampler was operating between sampling events) was also recorded. Adjustments to the rear sampler section were made by Normandeau personnel when necessary. Adjustments to the gate, front 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 front sampler, rear sampler, and collection tank platform were accordingly adjusted.

3.2 Hatchery Fish Procurement and Release

Hatchery fish were obtained from the US Fish and Wildlife Service's (USFWS) Pittsford National Fish Hatchery (USFWS) in Pittsford, VT. Smolts were handled as little as possible to minimize stress related to tagging. Fish were tagged at the hatchery and transported in 180-gal-aerated tanks, to circular holding tanks on the headworks of Moore Dam. After transport to the dam, fish were acclimated to within 2^{o}C of ambient water temperature at a rate of approximately 2^{o}C per hour. Water from Moore Reservoir flowed continuously through four holding tanks via a submersible pump and garden hoses. Two tanks held approximately 200 gal, and the other two held 300 gal. 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 placed in holding tanks if dissolved oxygen levels fell below 7 ppm. The greatest number of hatchery fish held in a tank at one time was about 100. This equates to 2 gal of water per smolt for the smaller holding tanks. Tagged smolts were held at the dam overnight, and released the following day.

Fish were transported to Gilman, VT and released just downstream of the Dalton Hydro tailrace (Figure 1-2). The transport truck was backed to a point near the discharge and 8-10 smolts were dipped from the tank, placed in a 5-gal bucket, lowered to the water surface (~10 ft) and released by tipping the bucket.

3.2.1 Hatchery Fish Tagging

Smolts were selected for size (>170 mm TL, except for one measuring 119 mm TL), anesthetized in a 40-mg/L-solution of buffered tricane-methanesulfonate (MS-222), measured for total length (mm), and a subset measured for weight (g). Smolts received either a radio transmitter or a passive integrated transponder (PIT tag).

Radio transmitters were implanted in the stomach, through the esophagus so that the antenna protruded from the mouth. If test specimens were quite large (greater than ~220 mm), orthodontic bands were placed on the transmitters to enlarge the transmitter diameter and limit possible regurgitation.

PIT tags were inserted through a small incision made on the approximate mid-line of the ventrum, so that the tag rested horizontally in the fish. A small amount of antibiotic cream was applied to the incision area to limit infection of the wound.

3.3 Monitoring Stations and Equipment

3.3.1 Radio Telemetry

Radio telemetry was used to monitor movement and behavior in Moore Reservoir and near Moore Development. Lotek Wireless, Inc. (Newmarket, Ontario, Canada) radio telemetry equipment was used. Radio transmitters measured approximately 18 mm long, 10 mm in diameter, and weighed less than 2.0 g in water. Five frequencies within the 149 MHz bandwidth were used. Transmitters of each frequency were uniquely identifiable by coded pulse.

Lotek SRX_400 data logging receivers were used to record data as either a single detection event or a period of multiple events, depending on the length of time a tagged smolt resided in a particular reception zone. Date, time of day, tag frequency (i.e., channel), tag pulse code (unique

to each tag), average signal strength, and detection location (i.e., antenna number) were stored for each signal reception. Data were downloaded from receivers several times a week and consolidated into a database for review, verification, and summarization.

Presence and behavior of radio-tagged smolts in the study area were monitored using four monitoring stations. Each station was equipped with one or more aerial antennas and one radio receiver. One station (MS40), consisting of two 9-element antennas, was placed on a pontoon raft at mid-river near the transition of the river from riverine to lacustrine (Figure 1-2). This station was located approximately 3.8 miles downstream from the release site and was deployed to monitor movement of tagged fish into the Moore impoundment. Two monitoring stations were installed on the headworks of Moore Dam to detect presence of smolts at the dam and to monitor their near-field movements relative to the dam, especially in the area of the skimmer gate entrance. These stations were equipped with two 4-element antennas each. A final monitor station, with one 4-element antenna, was installed below the dam, near the powerhouse, to detect turbine passage.

All monitoring stations were configured prior to release of tagged fish to set specific detection zones within the river, the forebay, and the tailrace. Detection zones from the pontoon raft in the impoundment reached both shorelines of the river. The forebay antennas/receivers were set to act as two main antennas and were configured to detect tagged smolts entering the study area. Once a signal was detected via the main antenna, the signal was searched for on each auxiliary antenna. The main antenna configurations had detection zones extending the width of the concrete dam to approximately 500 ft upstream of the powerhouse. Each auxiliary antenna was configured to detect signals approximately 100 ft from the dam. The tailrace monitor was set to detect signals the entire width of the tailrace from approximately the powerhouse to 150 ft downstream of the powerhouse.

3.3.2 Radio Frequency Identification (RFID)

RFID technology offers a method of monitoring individual fish movement and migration. An RFID PIT tag system for fishway monitoring, consists of passive integrated transponders (PIT) and data-logging transponder readers. A Texas Instruments TI-RFID/RDR Series 2000 PIT tag reader and uniquely coded (8-digit) tags weighing 0.6 g in air, and measuring 23 mm long by 3.4 mm diameter, were used for this study. The reader is comprised of an antenna, tuning module, and control module. A computer is used in conjunction with the reader to store retrieved data.

The reader tuning module emits an electromagnetic energizing signal through the antenna that charges a capacitor in the PIT tag. When this occurs the control module directs the tuning module to cease transmitting and to act as a receiving antenna. Upon receiving the transmitted code from the tag, the reader decodes the signal and transmits the code (PIT tag number) to the computer and the record is time-stamped and stored. Energized tags produced 12-13 reads per second.

For this study, the antenna was coiled around the PVC pipe that conveyed water from the sampler to the collection tank, and tuned to resonate at 132.4 kHz. The antenna was attached to the tuning module, which was attached to a control module. Both the tuning and control modules were weatherproofed in plastic and secured to a metal railing between the collection tank platform and the sampler stairwell platform. A laptop-computer housed in a watertight box on the operational platform of the dam was connected to the control module and powered by station AC via a power modulator. A hand-held reader was also available at the site.

3.4 Environmental Conditions

Water temperature was monitored near the entrance to the Moore Dam skimmer gate and in the tailrace of Dalton Hydro between 28 April and 25 June, via Onset HOBO Water Temp Pro™ temperature loggers. Loggers were equipped with a protective boot supplied by Onset and

suspended from weighted lines. Each logger was placed approximately 2-ft-below the water and recorded temperature every 20 min.

3.5 Data Collection and Analysis

Temperature data were downloaded at the end of the study and raw data from each logger compiled, checked for gross inaccuracies, and graphed. Operations data, including flow through the skimmer gate, and unit generation and flow, were provided by TransCanada. Percent of flow through the skimmer gate (and onto the sampler) in relation to generation flow, was calculated.

The number of stream-reared and hatchery fish removed from the collection tank was tallied for each day. To obtain information on time-of-day passage, sample periods were divided into three groups: Day, Evening, and Day and Evening. Day versus Evening distinctions were made based on the timing of sunrise and sunset as documented for Littleton, NH (www.sunrisesunset.com). During the course of the study, sunrise occurred at 0532 h on 5 May and at 0503 h on 24 June; sunset occurred at 1954 h on 5 May and at 2035 h on 24 June. When sample periods fell within both evening and daytime hours, they were grouped in the Day and Evening category. Catch per unit of effort (CPUE) was calculated for each of the three time categories and separately for stream-reared and hatchery smolts.

The recapture rate of PIT tagged fish was determined, and the functionality of the technology at the site assessed. Radio telemetry data was processed for each tagged smolt and transit and residency times identified.

4.0 RESULTS

4.1 Sampler Operation

The Moore Dam sampler began operation on 25 April 2005 and operated approximately every other day until 5 May. During this time, the sampler was operated at different times of the day: daylight hours on 27, 29 April, and 2 May; and overnight 25 April and 4 May. After the first salmon smolts were collected during the 4 May overnight operation, the sampler was operated almost continuously from 1700 h on 5 May through 1400 h on 24 June. Occasionally the sluice gate was closed for short periods (ranging from approximately 0.5 to 3.0 h) to reset the skimmer gate, clear debris from the sampler, and once when operators working from a boat in the forebay were cleaning the dam headworks.

Sampling periods, defined as the period of time the sampler operated between fish removal from the collection tank, ranged from 45 min to 18 h 15 min, and averaged 5 h 40 min. The sampler collection tank was checked 212 times over the course of the study and fish collected in the tank were processed an average of four times per day between 5 May and 23 June (range of 2 to 7 times per day) (Appendix Table 1). Overall, approximately 11,247 fish of 23 species were processed, including salmon.

Flow over the skimmer gate and onto the sampler averaged approximately 490 cfs over the period of operation (i.e., 1,191 hours). Flows were categorized into 25-cfs increments and the proportion of time each category occurred was calculated (Figure 4-1). The flow category with the greatest (36%) percentage of occurrence was 450-499 cfs; the lowest percent occurrence was the 205-299 cfs category. Percent of flow through the skimmer gate relative to flow through the turbines ranged from 3% to >100% (when flow over the skimmer gate was greater than flow through the turbines). A frequency distribution of this relationship, with percent flow in bins of 10-percentage points, indicates that for 33% of the hours the sampler was operated, flow through the skimmer gate was greater than 100 percent of turbine flow (Figure 4-2). Flow through the skimmer gate was between 3% and 20% of turbine flow 62% of the time.

Debris load on the sampler during 2005 contributed to a 12% smolt mortality statistic (stream-reared and hatchery combined). Sixty-seven percent of the smolt mortalities occurred between 29 May and 1 June, when debris load was especially high. The number of smolts passing during that period represented 16% of the 2005 run past the Moore Development.

4.1.1 Stream-Reared Salmon Smolts

Stream-reared Atlantic salmon smolts were collected on 46 of 56 days and in 146 of the 212 sampling events. Of the 1,404 stream-reared smolts collected, 94% (n=1,326) were collected by 15 June. The greatest number of stream-reared smolts collected in one day was 158, on 3 June. Based on the frequency distribution of numbers collected over time, the salmon run began in early May, peaked in early June and subsided by 24 June, when the sampler was closed for the season (Figure 4-3).

For analysis of catch-per-unit-effort, sample periods were divided into three categories based on the time of sunset and sunrise in Littleton, NH (www.sunrisesunset.com). The three categories were Day (sunrise to sunset), Evening (sunset to sunrise) and Day and Evening (when sample periods fell within both Day and Evening categories). Effort was calculated as the number of hours the sampler was operated within each category. Of the 1,199.15 hours sampled, 53% of the time (or effort) fell in the Day and Evening category, 41% in the Day category and 6% in the Evening category. CPUE for stream-reared smolts was highest in the Evening category with 5.26 smolts/h. Day, and Day and Evening CPUE for stream-reared smolts were similar at 0.95 and 0.88 smolts/h, respectively (Table 4-1). Stream-reared and hatchery smolts were collected more often during the Evening category relative to the total effort expended (Figure 4-4).

Of the 1,404 stream-reared smolts collected, 83.9% (n=1,178) had no observable injuries, 1.8% (n=25) had some form of injury (ranging from descaling to laceration), 1.3% were moribund (n=19), and 13.0% (n=182) died (Table 4-2). Examination of fish for injuries and other handling, such as netting out of the collection box, contributed to descaling of specimens but was not quantified. Therefore, the injury rate due to the sampler may be overestimated. As mentioned earlier, significant debris load in the sampler contributed to the mortality rate. Debris load, recorded on data sheets during each sampling event, was rated at the highest level during the three days (30 May – 1 June) of highest smolt mortality (Table 4-3).

4.1.2 Hatchery Salmon Smolts

The CPUE for hatchery salmon (PIT and radio tagged) was 0.26 smolts/h, compared to 1.17 smolts/h for stream-reared smolts (Table 4-1). The highest CPUE (1.27 smolts/h) occurred during the Evening time-category. CPUE for hatchery salmon during the Day, and Day and Evening time-categories was 0.22, and 0.18 smolts/h, respectively.

The condition of hatchery fish recaptured in the sampler was generally similar to that for stream-reared salmon (Table 4-2). Eighty-nine percent (n=280) exhibited no injuries, 0.9% (n=3) had other injuries, 1.3% (n=4) were moribund, and 8.6% (n=27) died prior to release. The handling of fish pre-release and during recapture procedures may have affected injury rates, especially descaling.

4.2 Radio Telemetry

A total 151 Atlantic salmon smolts were radio tagged and released into the Connecticut River at Gilman VT for the Moore evaluation (Table 4-4 and Appendix A, Tables 2-6). Six groups were released between 5 May and 2 June at water temperatures ranging from 9.0 to 13.7^{o} C. Tagged salmon ranged in size from 174 to 264 mm total length (TL); mean and median lengths were 217 and 215 mm TL, respectively.

Overall, 150 (99.3%) of the 151 salmon released were monitored passing MS40 (pontoon raft monitoring station); 133 (88.7%) emigrated to and were detected at Moore Dam. Travel times

from the release site to MS40 varied widely from 2 hr 13 min to just under 6 days 8 hr (Table 4-5). The mean travel time was 10 hr 14 min: median was 1 day 46 min. Travel times from MS40 to Moore Dam varied from 7 hr 35 min to well over 13 days. Median and mean travel times from MS40 to Moore Dam were 3 days 14 hr 20 min and 3 days 14 min, respectively. Tagged smolts were detected at Moore Dam on many discrete occasions (defined as non-detection for at least one hour) for a wide range of total residency times. Times ranged from just 1 min to just over 2 days (median = 7 hr 59 min; mean = 4 hr 53 min). Overall, 30 radio tagged smolts passed via skimmer gate and were collected in the sampler; five passed the Development through intakes and were detected in the tailrace.

4.2.1 Release Group 1

Release group 1 was released into the Connecticut River at Gilman VT on 5 May at 12:15 PM (Appendix Table 2). Thirty smolts were put into the tailrace of Dalton Hydro at a water temperature of 9^{o}C (Figure 4-5). All 30 were detected and logged at MS40 in times ranging from 3.5 hr to well over 6 days from release. Mean and median times to MS40 from release were 2 days 18 hr 54 min and 2 days 4 hr 5 min, respectively. Twenty-four (80.0%) of these tagged smolts were detected at Moore Dam. Times from MS40 to Moore Dam ranged from just under 1 day to well over 10 days. Mean and median times were just over 4 days.

Group 1 smolts were detected at the dam on numerous discrete occasions between 5 May and 9 June. The number of individual fish discrete detections ranged from two to 25. Associated time spans in which these detections occurred ranged from 0.7 to 20 days. Total residency time (sum of durations that individual smolts were detected) ranged from 37 min to 2 days 1hr 34 min. Just four tagged smolts passed the dam; they were collected in the sampler after 6, 6, 9 and 24 days from their first detection at the dam (Appendix Table 2). Water temperatures during the period Group 1 smolts were present near the dam ranged from 6.3 to 23.4^{o}C (Figure 4-6).

4.2.2 Release Group 2

The second release group comprised 28 salmon smolts and was released on 13 May at 12:30 PM (Appendix Table 3). Water temperature was 11.0^{o}C (Figure 4-3). All released smolts were detected at MS40 in from just less than three hours to just over three days from release. Average transit time to the monitor station was 12 hr 52 min; median time was 7 hr 3 min. Of the 28 smolts passing MS40, 26 (92.9%) continued downstream and were recorded at Moore Dam. Mean transit time from MS40 to the dam was 4 days 17 hr 13 min; median time was 4 days 3 hr 6 min. Transit times to Moore Dam ranged from just more than a day to just more than 11 days.

Smolts from this release group were detected at Moore over multiple occasions between 13 May and 4 June. One salmon was detected only once for less than one minute, another was detected 28 discrete times over the course of 17 days: this smolt logged over 35 hr in the vicinity of the dam. Two smolts traveled to the dam, moved back upstream and were logged at MS40, then back downstream and detected at the dam again. Mean and median individual detections were approximately 12 each. Corresponding time spans were near 9 days. Mean and median combined residency times were 11 hr 51 min and 8 hr 5 min, respectively. Seven smolts from this group passed Moore Dam; five were taken from the sampler and two passed via turbines. Time to passage from first detection at the dam was 4.5 and 7.5 days for turbine passed fish and from just under 2 hr to over 17 days for skimmer gate passed smolts (Appendix Table 3). Water temperature in the forebay ranged from 8.8 to 19.8^{o}C during presence of Group 2 smolts (Figure 4-6).

4.2.3 Release Group 3

At 12:10 PM on 17 May, group 3 (n=30) was released into the River at Gilman (Appendix Table 4). Water temperature at time of release was 10.2^{o}C (Figure 4-5). Twenty-nine (96.7%) of the smolts released arrived at MS40 in from just over 2 hr to just less than 3 days. The average time

to reach MS40 was 11.5 hr; median time was 5 hr. Some 26 (89.7%) of the 29 smolts logged at MS40 were detected at Moore Dam. Average and median times from MS40 to the dam were just less than 3 days and just greater than 3 days, respectively. Times ranged from 10 hr 41 min to 7 days 8 hr 15 min.

Most smolts from this group spent at least seven hr combined residence near the dam. Mean residence time was 8.5 hr; median time was 7 hr. Time spent near the dam ranged from 36 min to 1 day 3.5 hr. Discrete individual smolt detection events ranged from one to 26; mean and median were both 12. Four fish from this group passed Moore via skimmer gate after from 0.5 hr to over 17 days from initial detection at Moore; no smolts passed through turbines. Water temperatures at Moore ranged from 8.8 to 25.5^{o}C (Figure 4-6).

4.2.4 Release Group 4

A total of 28 tagged smolts was released in this group. Fish were released at 11:30AM on 20 May (Appendix Table 5) at a water temperature of 12.6^{o}C. All smolts released were monitored and recorded at MS40 in from 3.5 hr to 1 day 8 hr. Median time to this monitor station was just 4 hr 43 min. All fish continued downstream and were eventually detected at Moore Dam. Transit times to the dam from MS40 varied from just less than 14 hr to greater than 13 days; mean and median times were 3 days 3 hr 8 min and 2 days 3 hr 52 min, respectively.

These 28 tagged smolts were detected on the monitoring stations at Moore Dam multiple times between 20 May and 10 June. The average number of detections for individual fish was eight and the median number was seven. One smolt was detected on 18 discrete occasions over a 12.6 day time period. Individual fish residence times near the dam ranged from just under 1 hr to just more than 1 day. Median and mean times were 4 hr 47 min and 6 hr 17 min, respectively. Water temperatures near the skimmer gate ranged from 9.1 to 25.5^{o}C (Figure 4-6) during the period these smolts were present. Overall, nine smolts passed Moore Dam; three passed through turbines and six passed the skimmer gate and were collected in the sampler. Times from first detection at Moore to passage for turbine passed fish were 0.8, 3.5, and 4.2 days; times for skimmer gate passed fish ranged from 7.4 to 14.0 days.

4.2.5 Release Group 5

Group 5 was released at 11:30 AM on 27 May. Nineteen tagged smolts were released at Gilman at a water temperature of 10.1^{o}C. All smolts were detected passing MS40 in times from release ranging from 3.5 hr to almost 3.5 days; median and mean transit times were 14 hr 26 min and 18 hr 5 min, respectively (Appendix Table 6). Sixteen (84.2%) from this group were detected at Moore Development. Transit times from MS40 varied from 16.5 hr to just over 5.5 days. Mean and median times were approximately 3 days each.

Tagged smolts were logged on monitoring stations at the dam from one to 16 discrete occasions; average occasions numbered 7.5. Total residency times varied from 19 min to 17.5 hr. Median and mean residency were 4.5 and 6.1 hr, respectively. Smolts from this group were monitored at Moore between 30 May and 14 June; water temperatures ranged from 12.1 to 25.5^{o}C (Figure 4-6). Seven tagged smolts from this group passed into the sampler. Times from first detection at the dam until passage ranged from less than 1 hr to just over 12 days.

4.2.6 Release Group 6

Sixteen radio tagged smolts were released into the Connecticut River at Gilman on 2 June (Appendix Table 7). Water temperature at the release site was 13.7^{o}C. All 16 were detected passing MS40 in times ranging from 7.5 hr to just over 1 day; median time was just more than 4 hr and mean time was 6.5 hr. Some 13 (81.3%) of these arrived at Moore Dam at an average time of 2 days 17 hr 28 min; median time was 2 days 18 hr 28 min. Minimum time from MS40 was 7.5 hr and maximum time was just over 5 days. Once at the dam, these 13 smolts spent an

average 2.5 hr near field of the dam over an average 5 separate occasions. Residency time varied from 37 min (1 occasion) to just over 8 hr (23 discrete occasions over 10 days). Smolts from this group were present near the dam from 4 through 21 June. Water temperature ranged from 13.3 to 25.5°C during this time period. No fish were detected passing Moore through turbines. Four passed via skimmer gate and were collected in the sampler. Those passing by skimmer gate were present near the dam for from 1.3 to 5.4 days.

4.2.7 Manual Tracking

Toward the end of the study, two manual tracking excursions (18 and 23 June) were conducted. The entire impoundment upstream as far as approximately 1 mile downstream of the release site was surveyed. Only five signals were found (Figure 4-7). Four of the signals were relatively close to Moore Dam; the remaining signal was approximately 2.5 mi upstream of North Littleton Launch Area near the VT shoreline. On the second tracking excursion, water clarity was such that transmitter 24-80 was visually seen lying on the bottom approximately eight feet deep. It was unclear whether the other signals were from live fish.

4.3 Radio Frequency Identification

Eight hundred ninety four Atlantic salmon smolts from the Pittsford National Hatchery were tagged with passive integrated transponder (PIT) tags and released. PIT tagged smolts ranged in size from 119 to 295 mm TL, with a mean length of 215 mm TL. Weight ranged from 42 to 220 g; mean weight was 91 g.

Six releases of from 46 to 223 salmon were conducted between 5 May and 2 June. Two releases contained fewer than 100 fish. All fish were released at Gilman VT at water temperatures ranging from 6.6 to 12.8°C (Table 4-6).

Of the 894 smolts released, 284 (32%) were collected in the sampler by 23 June (Table 4-6). Due to equipment malfunction, only 40 (14%) of the tags were correctly read. One was recorded on the exit-pipe antenna and the others were read with a hand-held reader after being removed from the collection tank. Of the 40 tags read, the percent recapture per release group ranged from 2.3 to 10.9% with the highest occurring in the 26 May release group. Last year, the Gilman release site was the farthest from the dam and had the lowest recapture rate at 3% (6 smolt returns of 180 released). Days-at-large ranged from 4 to 32, with the mean per-release group decreasing through the season.

4.4 Environmental Parameters

Average daily water temperatures at Gilman, VT and Moore Dam during the study period ranged from 6.1 to 23.0°C and 5.6 to 23.3°C, respectively (Figure 4-8). Inflow to Moore Reservoir ranged from 2,158 to 13,198 cfs between 5 May and 19 June (available period of record) (Figure 4-9). Moore Development discharge ranged from 1,021 to 13,358 cfs.

4.5 Resident Species

Nine-thousand-five-hundred-twenty-nine resident fish, representing 22 species and one unidentified fish, were collected in the sampler (Table 4-7). Eighty-eight percent of the fish were alive and 12% dead when processed from the sampler. Four species, rock bass (*Ambloplities rupestris*), silvery minnow (*Hybognathus nuchalis*), yellow perch (*Perca flavescens*), and smallmouth bass (*Micropterus dolomieu*) represented 82% of the resident fish collected. Predation in the collection tank was apparent, and likely resulted in a lower number of minnows retrieved from the tank than were actually collected.

5.0 DISCUSSION

5.1 Stream-Reared Salmon

The purpose of this two-year study was to obtain information on the timing and abundance of the stream-reared smolt migration past the Moore Dam. This year, the full migratory run was observed; the run began in early May, peaked in early June and was substantially decreased by 24 June, when the sampler was closed for the season. By 15 June, 94% of all stream-reared smolts collected, had passed through the sampler.

Timing of the smolt run appeared to be influenced primarily by water temperature; salmon runs start in earnest once the temperature remains above 10^{o}C (Mills 1989). During this study, water temperature steadily increased from 10^{o}C at the end of May. Over a 4-day period, 1-4 June, 40% of the stream-reared salmon run had passed. During that time, mean daily water temperature rose from 12.7 to 17.3^{o}C at the Moore Dam (Figure 4-3).

As observed last year, there appeared to be two distinct size groups and possibly age classes of stream-reared smolts passing the dam. The smaller group had a mean TL of approximately 150 mm and the larger group approximately 250 mm TL. This is not unusual; not all members of a sibling population mature in the same year and it is not surprising to find flexibility in the timing of maturation both within and between populations of Atlantic salmon smolts (Thorpe 1987). This was the second year since 2002 that downstream passage, other than through spill or turbines, was available to the stocked salmon population.

Some sample periods were not easily separated into day and evening time-groups, from which CPUE could be calculated to distinguish time of day migration. Therefore, a third group "Day and Evening" was created to capture sample periods that included both segments of a day. As expected, due to the total number of stream-reared salmon collected in each year (240 smolts in 2004 vs. 1,404 smolt in 2005), CPUE was higher for all categories this year. Though results from last year showed only a slightly higher CPUE during the Evening compared to Day and Day and Evening groups (i.e., CPUE = 0.31 smolt/h for Day, 0.36 smolt/h for Evening, and 0.26 smolt/h for Day and Evening), the difference this year was more pronounced. During the Evening category, CPUE was 5.26 smolts/h compared to 0.95 and 0.88 smolts/h for the Day and for the Day and Evening groups, respectively.

The percentage of smolt mortality was higher this year compared to last year due primarily to the larger quantity of debris flowing onto the sampler. TransCanada is developing modifications to reduce this problem during the 2006 migration. The majority (84%) of salmon passing through the sampler experienced few or no injuries. No eye injuries were observed and contusions or lacerations were found on less than 1% of the stream-reared smolts. This number is down from 5% observed in 2004 and may be the result of modifications that were made to the sampler, including moving the sampler exit pipe to the floor of the sampler trough.

5.2 Radio Telemetry

Results of the radio telemetry portion of the sampler evaluation and surface passage of radio tagged smolts tend to support the assertion that emigrating Atlantic salmon smolts in Moore Reservoir encounter conditions that impede timely movement through the impoundment. The primary factor is probably size of the reservoir and subsequent lack of perceptible flow or water current. All radio tagged smolts were released into the Dalton Hydro tailrace, an environment with substantial flow. Smolts would be expected to exhibit positive downstream migration from release to the MS40 monitoring station at a respectable rate since that portion of the River is largely riverine. Figure 5-1 illustrates movement rates for smolts by release group for the riverine portion of the impoundment and for the lacustrine portion. Except for the first release group, all tagged smolts showed a substantially higher movement rate from the release site to MS40. Movement rates for these groups also appeared to be correlated to inflow into the impoundment. Movement rates for all release groups from MS40 to Moore Dam were much lower and generally

the same, regardless of inflow or Development generation (Figure 5-1). The reason for such a low movement rate for release group 1 from the release site to MS40 is unclear. Water temperature at time of release was relatively low (9.0°C), however, it was not considered low enough to impede or prevent emigration. Over the course of the next four releases, water temperature did not rise by more than a few degrees (Figure 5-2), yet movement rates were much higher than that of the first release group.

Although the size and lack of perceptible water current appeared to impede movement to Moore Dam, 133 (88.1%) radio tagged smolts were detected at the Development. Smolts were present multiple times for relatively substantial time periods. Results suggest that the skimmer gate operating at 500 cfs may not afford sufficient attraction for emigrating salmon smolts to enter. Of the 133 tagged smolts that were present at Moore Development, only 30 (22.6%) passed the skimmer gate and were collected in the sampler. The remainder of tagged salmon had many opportunities to enter the sluiceway but did not. Most tagged salmon were monitored near the dam on multiple occasions, traversing close enough to pass into the skimmer gate. Many spent extended periods of time near the dam, while others were detected periodically at the dam.

Although the study was not designed to extensively monitor near the skimmer gate opening, it was possible to glean some information from the data. Of the 103 salmon detected at Moore Development and not passing via the skimmer gate, 73 (70.9%) were detected close, within 15 ft, to the skimmer gate bay. Fifty-one (49.5%) were detected within 5 ft of the gate bay. Of those 103 salmon, 51 (49.5%) passed within 15 ft of the gate bay on multiple occasions (2 to 8 times), and 22 (21.4%) passed within 5 ft of the gate bay from 2 to 5 times. These data strongly suggest that flow to the skimmer gate was not sufficient to attract the tagged smolts.

At least 15 tagged smolts moved extensively throughout Moore Reservoir. They were logged passing MS40, then at Moore Dam, and then back at MS40. One of these was monitored at each location more than once; it had migrated to the dam and back to MS40 a few times before its final detection at the dam. Five tagged salmon were detected in the tailrace, having passed Moore Dam via the turbines. All were monitored in the reservoir near the dam for more than one hour and up to more than eight hours total residency over nine separate occasions, prior to passing.

Due to logistical constraints, manual monitoring of the reservoir was not conducted until near the end of the study. At that time the few fish detected were mostly located in the cove south of the dam. Two others were found upstream of the dam; one was upstream of North Littleton Launch area. Had manual monitoring been done earlier in the study, locations of fish would have been most likely similar to that found in the 2000 study (Normandeau Associates, 2000).

5.3 Radio Frequency Identification

RFID PIT was relatively ineffective at the Moore study site. Though the antenna was tuned and tested prior to start-up, it was discovered early in the study that tagged fish were not being recorded. Through the course of the study numerous attempts were made to rectify the problem, including relocating the tuner and control module closer to the antenna, re-tuning the antenna, re-wiring the system, and changing computers. However, none of these attempts resolved the problem. Factors that could have affected detection efficiency in this study include the rate at which smolts passed through the antenna detection field, orientation of the tag (and smolt) as it passed, metal components of the sampler, and distance between the different components of the system (Armstrong et al. 1996, Castro-Santos et al. 1996).

Bearing in mind that only 14% of the PIT tagged fish were identified from the sampler, it is interesting to note that the mean number of days-at-large steadily decreased from 30.5 days after the first release to 4.0 days after the last release. Increasing water temperature likely influenced the rate at which smolts moved downstream.

5.3 Conclusions

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

- The inclined plane sampler was effective at collecting fish that passed over the skimmer gate;
- Debris load in the sampler affects mortality rate but survival may be improved through more frequent sampling events and a debris exclusion system;
- Radio telemetry suggests that hatchery smolts released upstream of the Moore Reservoir have difficulty finding the skimmer gate opening for downstream passage;
- RFID PIT technology was not an effective tool at the Moore sampler for collecting data on date and time of day passage by smolts;
- Total length and weight measurements for stream-reared smolts should be collected to better characterize the condition of smolts and to put age and growth into context with lower basin subpopulations.

6.0 LITERATURE CITED

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