REPORT ON ATLANTIC SALMON SMOLT SAMPLING EFFORTS AT MOORE DAM, SPRING 2007

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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. 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 on the west side of the river and Caledonia County, VT on the east side. The FERC approved a fourth year of study 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 of the Moore Dam as the mechanism to conduct the evaluation. The sampler has been monitored seasonally for the passage of stream-reared salmon smolts since 2004. Additionally, the effectiveness of the sampler as a downstream passage route has been assessed with the use of tagged fish. During the first three years of passage, hatchery-reared smolts were used for this assessment. This year, problems with the allocated hatchery-reared smolts resulted in the use of stream-reared fish that were collected in the sampler. This fourth year of study included monitoring the timing (diurnal and seasonal), duration, and abundance of the stream-reared Atlantic salmon migratory run at Moore Dam, and assessing swimming behavior of stream-reared smolts when in the vicinity of the skimmer gate entrance. Study results have been separated into two reports; a description of the migratory run of smolts is provided herein.

The sampler was monitored from 1 May to 22 June 2007. Collected salmon were identified as stream-reared, stream-reared tagged, or hatchery-reared and all live salmon were transported to, and released below the McIndoes Development. The term stream-reared smolts refers to fish that were hatchery spawned and stocked as fry; stream-reared tagged smolts are stream-reared fish collected in the sampler and then tagged and released for a behavioral study conducted this year; hatchery-reared smolts are those that were collected from a hatchery as smolts in 2004, 2005 and 2006, and released in the Moore Reservoir in support of behavioral studies. For this report, stream-reared tagged fish were only counted toward total passage the first time they passed the sampler. Passage data for these fish after they were tagged, are provided under separate cover. A summary of the 2007 results are as follows:

- 1,029 stream-reared smolts were collected between 2 May and 22 June; 90% were collected by 10 June, and the most collected in one day (158) occurred on 25 May when water temperature reached 15.3^{o}C;
- Four hatchery-reared smolts that were tagged and released in Gilman, VT during spring 2006 were collected in the sampler on 12, 14, 21, and 29 May. Two died after retrieval from the sampler.
- Catch-per-unit-effort (CPUE) was highest (1.55 smolts/h) during the Night category (between sunset and sunrise), and lowest (0.08 smolts/h) during the Day and Night category. Overall CPUE was 0.91 smolts/h (1,033 smolts in 1,129.7 hours of sampling);
- Mortality was 3.5%, the lowest to date, likely due to the effectiveness of the trash boom at limiting debris build-up on the sampler, and gained experience in handling smolts during collection and transport to the McIndoes Development;
- The full migratory run of stream-reared smolts appears to have been observed; distribution of the run can be described by a bell-shaped curve with 50% of the run passing within a one-week period of 23 to 28 May.

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

- ➢ The inclined plane sampler was effective at collecting fish that passed over the skimmer gate.

- Opening the sampler by 1 May captures the onset of the smolt emigration past Moore Dam.
- Installation of a debris boom at the entrance of the skimmer gate reduced debris load on the sampler, thereby reducing smolt mortality caused by debris.

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Acronyms, Abbreviations, and Definitions

°C	degree Celsius
cfs	cubic foot per second
CPUE	catch-per-unit-effort
CRASC	Connecticut River Atlantic Salmon Commission
FERC	Federal Energy Regulatory Commission
FMF	Fifteen Mile Falls
ft	foot
gal	gallon
h	hour
hp	horsepower
mi	mile
msl	mean sea level
NH	New Hampshire
NHFGD	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
VIE	visual implant elastomer
VT	Vermont
VTDFW	Vermont Department of Fish and Wildlife
USFWS	United States Fish and Wildlife Service
USGenNE	USGen New England, Inc.

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Figure 4-7. Inflow (cfs) to the Moore Reservoir recorded at USGS Gauge 01131500 located at the Dalton Hydro, and outflow from the Moore Hydro project, recorded by TransCanada, spring 2007.

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. (USGenNE) and currently owned by TransCanada Hydro Northeast, Inc. (TransCanada). The Federal Energy Regulatory Commission (FERC) license for the project was transferred to TransCanada on 7 July 2005 (FERC Project No. 2077). 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 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 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 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 evaluations continued through 2006 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 Project. These goals were met during each year of study except the first. In 2004 the sampler did not open 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. This was studied using mark-recapture techniques in each year of study and radio telemetry tracking in 2005. Hatchery-reared Atlantic salmon smolts were used as proxy to stream-reared fish for these evaluations. During winter 2005 and spring 2006 modifications were made to increase flow at the skimmer gate entrance and reduce debris loading on the sampler. Study goals for 2006 included obtaining information on the effectiveness of these modifications.

At a meeting with stakeholder agencies in January 2007, TransCanada proposed, in addition to continuing their qualitative assessment of passage season and quantification of passage numbers, assessing smolt behavior in the vicinity of the skimmer gate entrance using acoustic telemetry techniques. This technology provides a three-dimensional (x, y and z coordinates) track of a tagged fishes' movement within an identified study area. Agency representatives were amenable to the proposal and approved a fourth year of study.

Results for the 2007 study year have been documented in two separate reports, provide herein are the results of the downstream passage monitoring of stream-reared smolts.

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 been monitored for salmon smolt passage since (Normandeau Associates, Inc. 2005, 2006, 2007). Modifications were made after each passage season to improve the effectiveness and efficiency of the sampler to attract and pass salmon smolts. No structural changes were made between the 2006 and 2007 monitoring seasons.

A trash boom and a flow shelf were installed prior to sampler operation this year; both were used for the first time in 2006. The trash boom was anchored around the skimmer gate entrance to deflect large debris from the sampler (Figure 2-1). The 14ft-8in x 25ft wooden flow shelf (Figure 2-2) was submerged approximately six feet below water surface at the entrance of the skimmer gate to extend the flow-net range into the forebay.

The inclined plane sampler is 14.5 ft wide and consists of two sections connected on a pivot (Figure 2-3). 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 (Figure 2-4). 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 screen is an angled, fabricated metal trough with solid sides that connects to a 12-in-diameter discharge pipe (Figure 2-6). 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 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.

A targeted discharge, not-to-exceed 500 cfs, for downstream passage onto the fish sampler was employed through the 2007 evaluation 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). Salmon were identified as stream-reared, stream-reared tagged, or hatchery-reared. Stream-reared tagged fish were marked with a different colored visual implant elastomer (VIE) behind each eye; these fish were also tagged with an internal acoustic tag for a study conducted in 2007 and reported under separate cover. Hatchery-reared fish were tagged with VIE of the same color behind each eye; these fish were tagged and released for a study conducted during the 2006 migration. Physical condition of each fish was noted in accordance with a coding system developed for the evaluation (Table 3-1). All live salmon were transported below the FMF Project and released in the tailwaters of the McIndoes development. Scale samples were taken from salmon smolts that died during the course of this study and the concurrent behavioral study. Scale aging results for all fish are reported in this study; therefore, the number of mortalities reported for this study is lower than the number of fish from which scales were collected. Resident fish removed from the collection tank were identified to species, enumerated, surveyed for obvious 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) was also 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 accordingly adjusted.

3.2 Environmental Conditions

Water temperature was monitored near the entrance to the Moore Dam skimmer gate and in the tailrace of Dalton Hydro, approximately 11 miles upstream of the Project, between 1 May and 22 June, with Onset HOBO Water Temp Pro™ temperature loggers. Loggers were equipped with a protective boot supplied by Onset and suspended from weighted lines. Each station had a redundant logger; loggers were placed approximately 2-ft-below the water surface and recorded temperature every 15 minutes. Sufficient data were not collected in the Dalton Hydro tailrace and are not presented in this report.

Provisional stream flow data was downloaded from the USGS' national water information web site for gauge number 01131500, Connecticut River near Dalton, NH. This data was used to describe stream flow into the reservoir during the study period.

3.4 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 to the skimmer gate (and onto the sampler) relative to total flow to the units and the skimmer gate was calculated.

The number of smolts removed from the collection tank was tallied for each day. To obtain information on the time-of-day of passage, sample periods were divided into three groups: Day, Night, and Day and Night. Day versus Night was 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 05:39 h on 1 May and 05:03 h on 22 June; sunset occurred at 19:49 h on 1 May and 20:34 h on 22 June. When sample periods fell within both night and day hours, they were grouped in the Day and Night category. Catch-per-unit-effort (CPUE) was calculated for each of the three time categories.

4.0 RESULTS

4.1 Sampler Operation

The Moore Dam sampler began operating at 13:30 h on 1 May and was closed at 13:00 h on 22 June 2007. The skimmer gate was closed for 56.5 h during the monitoring period for repairs and set-up of the behavioral study. The longest period of closure was 19 h between 7 and 8 May when the submerged shelf broke and was repaired. The submerged shelf broke a second time on 15 May, requiring special-order replacement parts. The submerged shelf was taken out of service and moved away from the skimmer gate until it was repaired and replaced on 21 May. The sampler was operated for a total of 1,129.7 h.

Sampling periods, defined as the period of time the sampler operated between fish removal from the collection tank, ranged from 2.9 h to 16.7 h, and averaged 10.4 h. The sampler collection tank was checked 109 times over the course of the study and fish collected in the tank were processed an average of 2 times per day between 1 May and 22 June (ranging from 1 to 4 times per day) (Appendix Table 1). Over 47,000 fish of 23 species, including Atlantic salmon, were processed (Table 4-1). Spottail shiner (*Notropis hudsonius*) made up over 90% of the catch and were twice collected in numbers estimated to be around 20,000 (Figure 4-1).

The proportion of flow through the skimmer gate, relative to total project discharge, ranged from 2.46 to 100% (mean = 48.21 %). 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. Proportional discharge to the skimmer gate was most frequently 0 – 10% of flows (49% combined) and 100% (36.9% of observations, Figure 4-2A). The distribution of hourly averaged proportional flow to the skimmer gate represents one distinct period when the proportion of flow to the skimmer gate was quite low (Figure 4-2B). The daily average proportional flow through the skimmer gate during this period was less than 10% of the flow through the skimmer gate, and was concurrent with high inflow and subsequently high discharge (Figure 4-2C). Hourly average proportional flow to the skimmer gate ranged from 5.1 – 15.4%. Proportion of flow to the skimmer gate was generally higher during night hours when flow to the turbines was low (Figure 4-3).

Water level in the Moore Reservoir is raised through the spring and caused trees and leaves from the shoreline, and detritus stirred up from the sediment to be transported by water and wind currents to the skimmer gate entrance. On a few occasions, sticks and leaves clogged the discharge pipe causing some resident fish mortalities. A trash boom, designed and first used in 2006, significantly reduced the amount of debris entering the sampler.

4.2 Salmon Smolt Collection

Stream-reared Atlantic salmon smolts were collected on 46 of 52 days and in 71 of the 109 sampling events. The greatest number of stream-reared smolts collected in one day was 158 on 25 May. The distribution of the smolt migration over time was described by a bell-shaped curve with 50% of the run passing within a one-week period between 23 and 28 May (Figure 4-4).

For analysis of CPUE, 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), Night (sunset to sunrise) and Day and Night (when sample periods fell within both Day and Night categories). Effort was calculated as the number of hours the sampler was operated within each category. Of the 1,129.7 hours sampled, 59% fell in the Day category and 34% in the Night category; only 7% of the sampling effort occurred during the Day and Night category. CPUE for salmon smolts was highest in the Night category at 1.55 smolts/h. Day CPUE was 0.65 and Day and Night CPUE was 0.08 (Table 4-2). The number of smolts collected during each category was: 436 during Day, 591 during Night, 6 during Day and Night. Collections made during the Day and Night category were few and occurred early in the sampling season when smolt passage numbers were low.

Of the 1,033 smolts collected, 85% (866) had no observable injuries, 10.4% (109) showed some descaling, 1.2% (12) some form of injury (ranging from eye wound to moribund), and 3.5% (26) died (Table 4-3). Examination of fish for injuries and tags, and other handling, such as netting out of the collection box, contributed to descaling of specimens but was not quantified. Therefore, injuries due to the sampler may be overestimated.

Length data collected from stream-reared smolts in 2005 (n=94), 2006 (n=95) and 2007 (n=110) show two distinct frequency distributions within each sample year, suggesting two age classes of smolts passing the sampler (Figure 4-5). Analysis of scale samples collected in 2005 (n= 76) 2006 (n=77) and 2007 (n=109) identified a prominent age-2 cohort, a smaller cohort of age-3 smolts and six fish collected in 2005 that were age-4 (Table 4-4). In 2007 the mean length of age-2 smolts was greater than in the previous two years, and the mean length of age-3 smolts was smaller than in the previous two years. Additionally, the percentage of fish that were identified as age-2 increased in each year (Table 4-4).

Four hatchery smolts that had been tagged and released for studies conducted last year, were collected in the sampler this year on 12, 14, 21 and 29 May. Each was from a different release group and all were released between 9 and 29 May 2006. All were recovered alive from the collection tank but two died before being transported below the McIndoes Development.

4.3 Environmental Parameters

At the skimmer gate, water temperature rose fairly consistently from 6.1^{o} C on 1 May to 22.7^{o} C on 16 June (Figure 4-7). Water temperature was not collected from the loggers set in the Connecticut River at Dalton Hydro, approximately 11 miles upstream of the study site. When the loggers were retrieved at the end of the study one was out of the water and the other apparently lost to the river. The logger retrieved was dislodged on 21 May, when recorded temperature began to reflect air temperature. River flow was high at this time and was likely the cause of the loss.

Average daily discharge from the Moore Development closely followed average daily inflow recorded at Dalton, NH (Figure 4-8). The sampler opened for the season as flows were coming down from a high on 25 April of 19,700 cfs. During the study period, inflow peaked at 16,300 cfs on 18 May and was followed by a less significant peak of 6,010 cfs on 6 June. No spill events occurred during the study period.

4.4 Resident Species

Over 46,000 resident fish representing 22 species were collected in the sampler (Table 4-1). The error around this number is probably high because the majority (>40,000) of fish collected were spottail shiners *(Notropis hudsonius)*, and the majority of these were collected during two sampling periods. Approximate counts were made in an effort to limit the number of mortalities. The next three most abundant species were rock bass (*Ambloplities rupestris*), smallmouth bass (*Micropterus dolomieu*), and yellow perch (*Perca flavescens*). Predation was observed in the collection tank. Four salmon (including one recaptured acoustically tagged smolt) were found dead in the mouths of other fish.

5.0 DISCUSSION

The purpose of this study was to obtain information on the timing and abundance of the stream-reared smolt migration past the Moore Dam. The full migratory run was observed this year, beginning in early May and ending in late June. TransCanada was requested by the agencies to open the sampler one week earlier this year, i.e. on 23 April, to see if the run would begin earlier if passage was available. Though ice on the pond and low pond elevation prohibited an early opening, it does not appear that the run would have begun earlier. The run appeared to follow river flow, peaking about one week after peak flow. When the sampler was opened on 1 May in-flow to the Project was trending down from a peak of almost 20,000 cfs; however, it was almost two weeks later when the run became established with 16 smolts collected on 12 May. The highest rate of temperature increase was observed at this time, rising from 8°C on 7 May to 14°C on 12 May. This suggests that a combination of the significant higher flow event in the preceding days and the increasing river temperatures may have cued smolts to migrate past the Moore Development. The submerged shelf was out of service for repairs from 15 to 21 May, perhaps contributing to the relatively low passage numbers observed this year. CPUE was highest at night when the proportion of flow through the sampler, compared with total flow, was also high. Researchers have documented the proclivity of smolts to migrate at night (Thorpe and Morgan 1978, Hvidsten et al.1995). Combined with higher proportional flow to the sampler at night it is not surprising that the Night category CPUE has been greater than the other two categories during the last three years.

Percent mortality for stream-reared smolts was slightly lower this year than in 2006, when the trash boom was first installed. The boom prevented entrainment of large debris and much of the smaller debris on the sampler and in the collection tank. Large debris on the sampler can change the surface flow pattern and obstruct passage to the collection tank. Small debris in the collection tank can clog the collection tank causing overflow. Though twigs and debris obstructed passage from the PVC pipe to the collection tank on occasion, mortality was minimized by frequent (2-4 times per day) examination of the sampler. Through experience, handling has become more efficient and the may have contributed to the reduction in mortality.

Aging of scales collected from 2005 through 2007 indicates three age classes (age-2, 3 and 4) of smolts passing the sampler, dominated by the age-2 cohort. Age-4 smolts were collected only in 2005 (Table 4-4). The proportion of age-2 fish appears to be increasing over time. This, and the appearance of age-4 fish in the 2005 sample but not the 2006 and 2007 sample, may be due to the availability of passage; holdovers and new recruits are finding their way to the sampler and passing. Smoltification, or the transformation from parr to smolt, occurs prior to migration and involves morphological, physiological and behavioral changes that prepare young salmon for life in the sea. If the migration is not completed smolt may revert back to parr and migrate the following spring. Some proportion of the number of smolts unable to pass the dam in a given year likely found suitable over-wintering habitat in the Moore reservoir and tributaries, allowing for passage the following year. The yearly increase in the proportion of age-2 smolts sampled may also be the result of environmental and, or biological factors. 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).

5.4 Conclusions

Based on the results of the last four 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 project for salmon that are stocked above the Moore Reservoir.

- Opening the sampler by 1 May captures the onset of the smolt emigration past Moore Dam, and to date has occurred before water temperature reaches 10°C.
- Debris load on the sampler and in the collection tank increases mortality rate but survival appears to be improved by installation of a debris boom, and conducting sampling events at night and early morning.

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TABLES

Table 3-1. Codes used to document condition of salmon smolts collected in the Moore sampler, spring 2007.

Code Number	Condition
1	No observed injuries or descalation
2	Minor descalation (<10%)
3	Moderate descalation (10-25%)
4	Major descalation (>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. Fish species and number collected in the Moore Dam fish sampler between 1 May and 22 June 2007.

Common Name	Scientific Name	Number Collected	Percent of Total
Black crappie	*Pomoxis nigromaculatus*	16	0.034
Northern redbelly dace	*Phoxinus eos*	7	0.015
Blacknose dace	*Rhinichthys atratulus*	3	0.006
Bluegill	*Lepomis macrochirus*	2	0.004
Brook trout	*Salvelinus fontinalis*	1	0.002
Brown bullhead	*Ictalurus nebulosus*	4	0.009
Brown trout	*Salmon trutta*	180	0.386
Common shiner	*Notropis cornutus*	7	0.015
Fallfish	*Semotilus corporalis*	2	0.004
Golden shiner	*Notemigonus crysoleucas*	102	0.219
Largemouth bass	*Micropterus salmoides*	4	0.009
Northern pike	*Esox lucius*	7	0.015
Pumpkinseed	*Lepomis gibbosus*	14	0.030
Rainbow smelt	*Osmerus mordax*	7	0.015
Rainbow trout	*Oncorhynchus mykiss*	22	0.047
Redbreast sunfish	*Lepomis auritus*	2	0.004
Rockbass	*Ambloplites rupestris*	2482	5.326
Smallmouth bass	*Micropterus dolomieui*	1118	2.399
Spottail shiner	*Notropis hudsonius*	42116	90.382
Tessellated darter	*Etheostoma olmstedi*	10	0.021
White sucker	*Catostomus commersoni*	2	0.004
Yellow perch	*Perca flavescens*	490	1.052

Table 4-2. Catch-per-unit-effort (smolts/h) for the three time-categories sampled at the Moore sampler. CPUE is the number of smolts collected divided by the number of hours sampled for each time-category.

Time Category	**Effort (h)**	**Smolts**	**CPUE (smolts/h)**
Day	669.8	436	0.65
Night	381.2	591	1.55
Day and Night	78.67	6	0.08
Total	*1129.67*	*1033*	*0.91*

Table 4-3. Physical condition of salmon smolts collected in the Moore sampler, spring 2007. 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 conditions.

	Atlantic Salmon	
Condition	**Number**	**Percent**
No injuries	886	85.03
Descaling	109	10.36
Eye injury	1	0.09
Contusions, and …	1	0.09
Lacerations, and …	2	0.19
Moribund, and …	8	0.75
Dead, and …	26	3.48

Table 4-4. Number of stream-reared Atlantic salmon smolts collected at the Moore sampler in 2005, 2006 and 2007, and the number, percent, and range in length of a sub-set of smolts that were aged using scale analysis.

			Age-2				Age-3				Age-4			
Year	**N Smolts Collected**	**N Aged**	**N**	**% of Aged**	**Length Range (mmTL)**	**Mean Length (mmTL)**	**N**	**% of Aged**	**Length Range (mmTL)**	**Mean Length (mmTL)**	**N**	**% of Aged**	**Length Range (mmTL)**	**Mean Length (mmTL)**
2005	1,404	82	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	67	87.0	162-257	193.3	10	13.0	201-310	274.7	0	0.0	-	
2007	1,029	110	101	91.8	160-340	228.1	9	8.2	187-332	256.1	0	0.0	-	

FIGURES

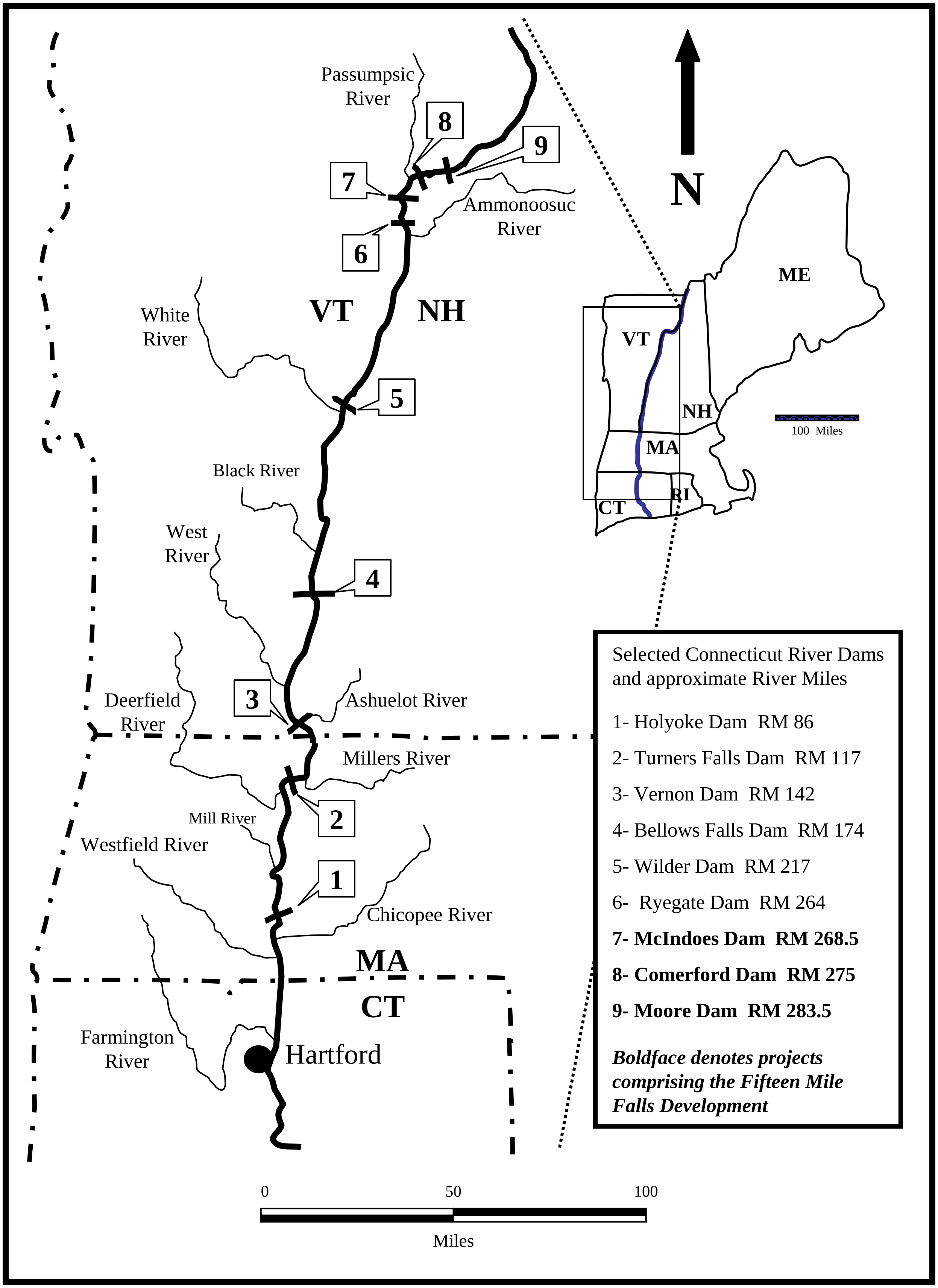

Figure 1-1. Location of the Fifteen Mile Falls Project on the Connecticut River.

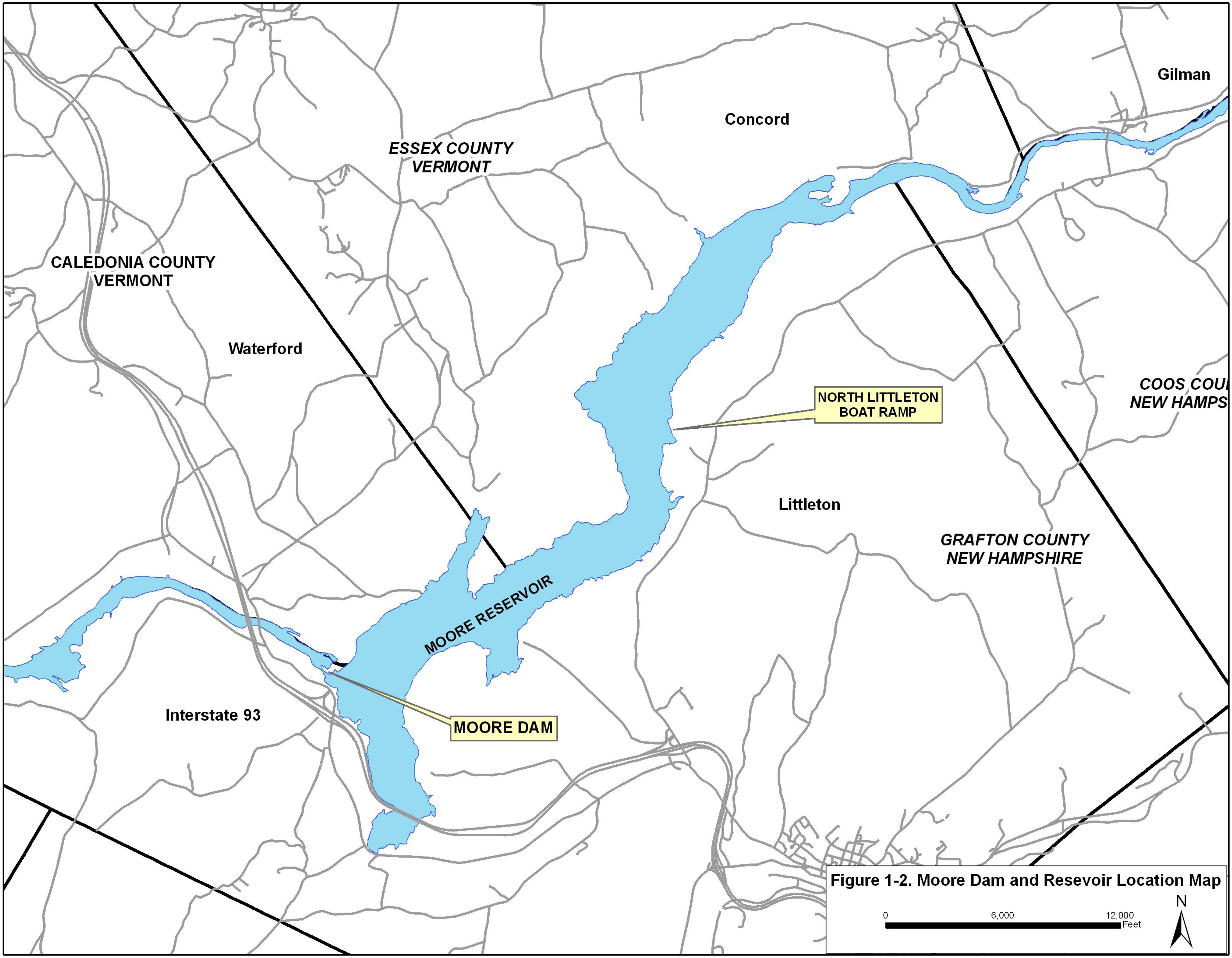

Figure 1-2. Moore Dam and Resevoir Location Map

Figure 2-1. Moore Dam trash boom installed at the entrance to the skimmer gate.

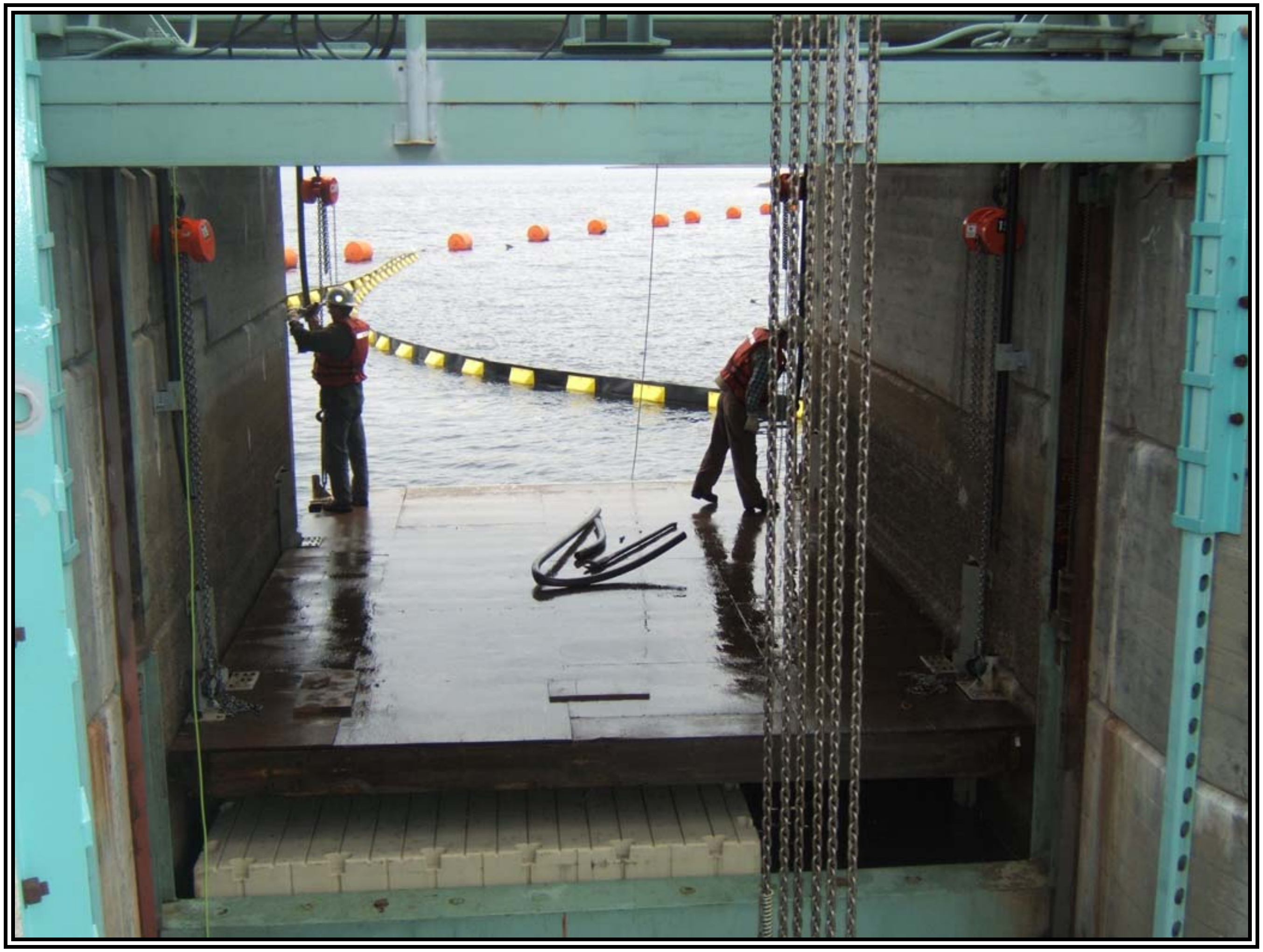

Figure 2-2. Attraction flow platform raised above waterline for repairs. View is looking through the skimmer gate entrance to Moore Reservoir.

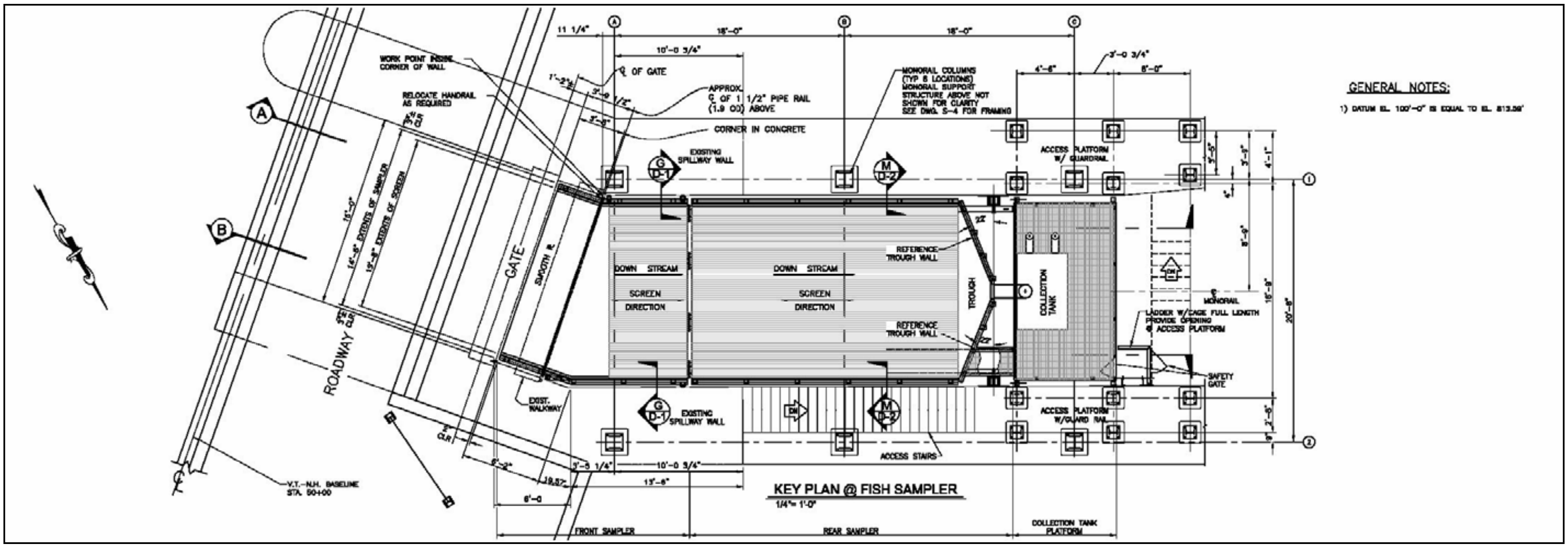

Figure 2-3. Key plan of TransCanada's Moore Development inclined plane sampler. The plan does not show flow reflectors installed after the sampler was erected. Plan drawing prepared by Kleinschmidt.

Figure 2-4. Dewatering surface of the fish sampler at Moore Dam.

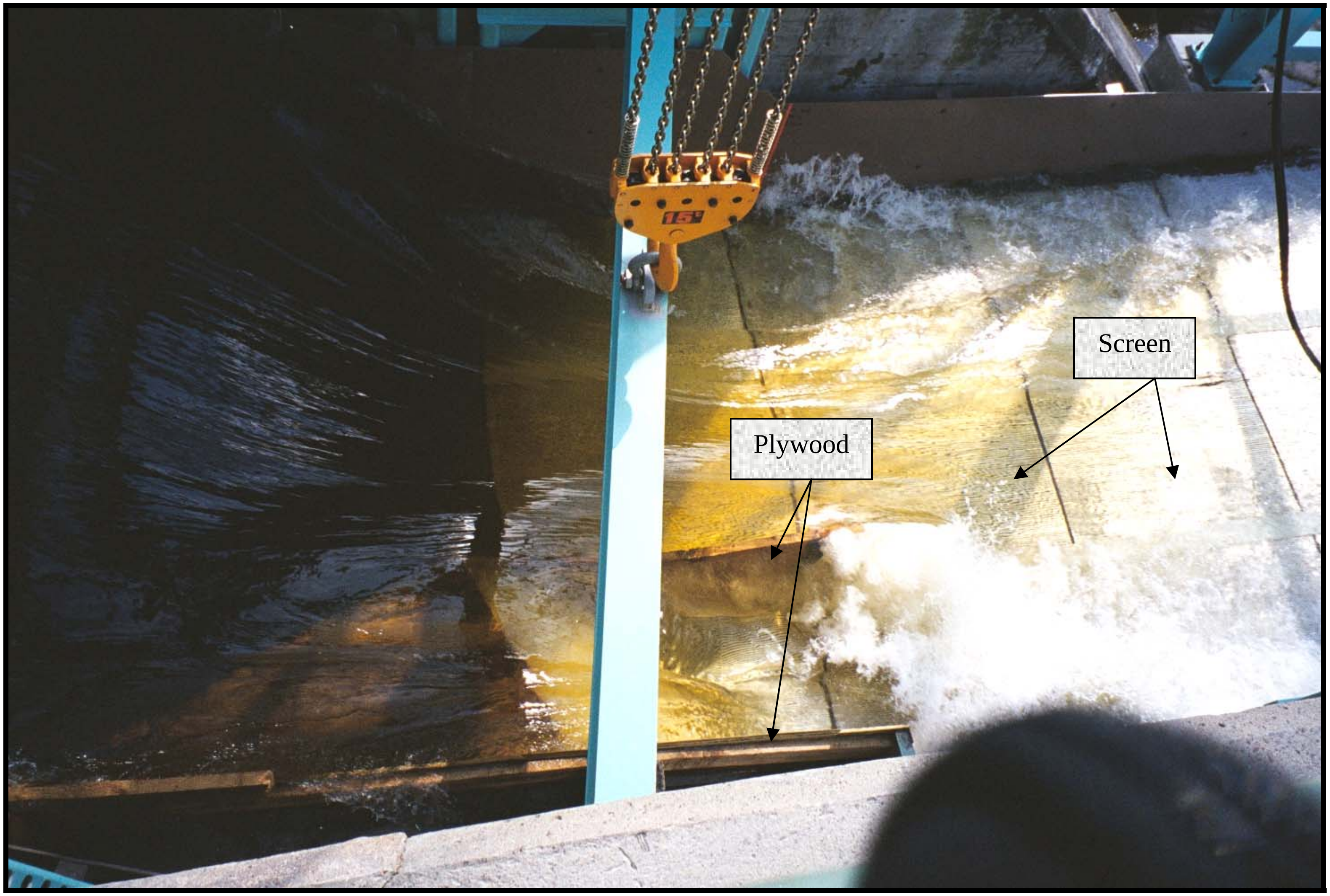

Figure 2-5. Moore Development, inclined plane sampler showing plywood flow adjusters.

Figure 2-6. Downstream end of the Moore Dam fish sampler in fishing mode, showing the elbowed discharge pipe and collection tank.

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. Transporting fish from the sampler collection tank to the transport tank via the monorail system, spring 2007.

Figure 4-1. A portion of the evening collection on 10 May 2007 showing abundance of spottail shiners. The count was estimated for spottail shiners on this occasion.

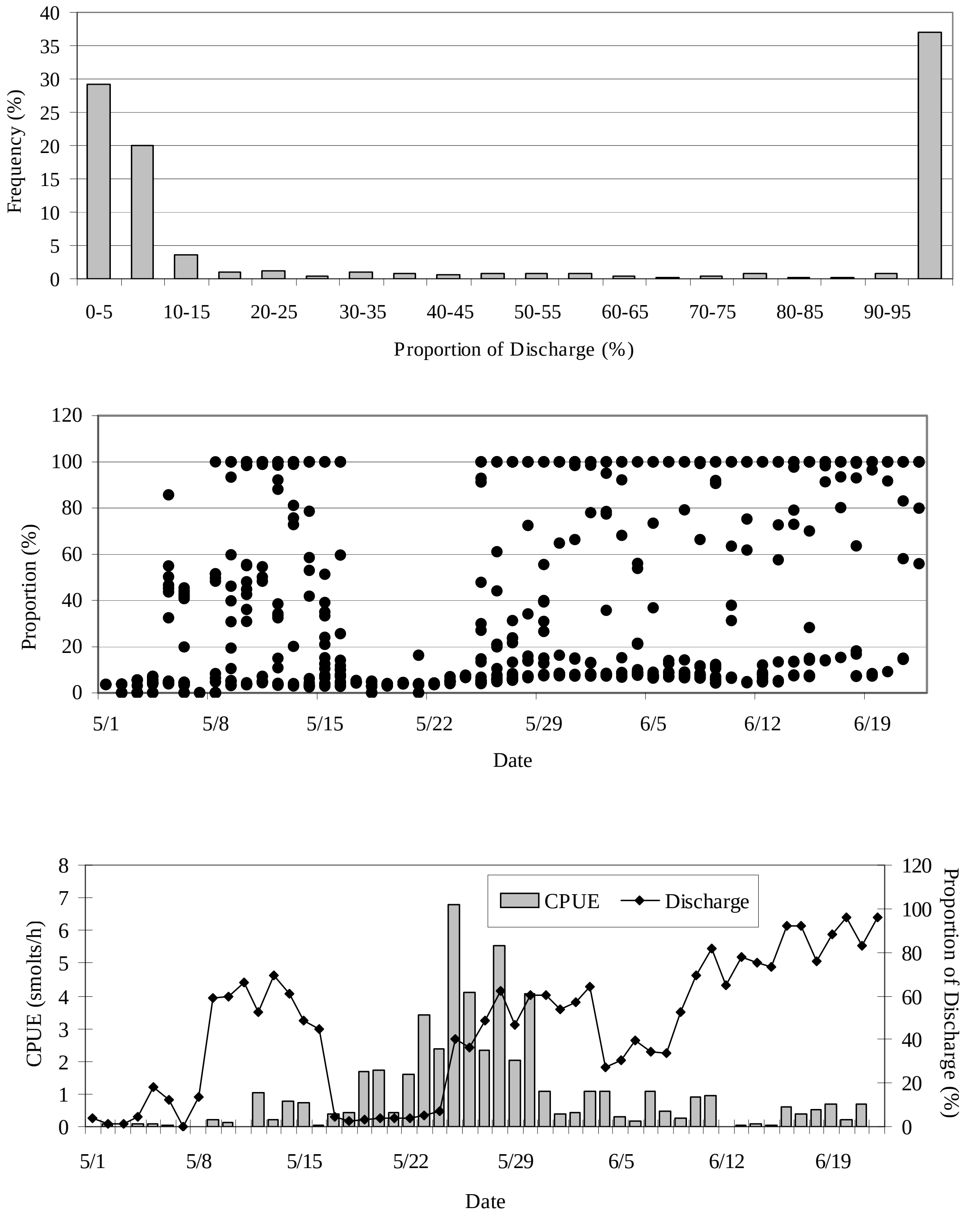

Figure 4-2. A. Frequency distribution of proportion of discharge (turbine flow + skimmer gate flow) to the skimmer gate; B. Hourly average proportion of discharge to the skimmer gate; C. Daily average proportion of discharge to the skimmer gate and daily average catch-per-unit-effort (CPUE = smolts captured per hour fished) by date.

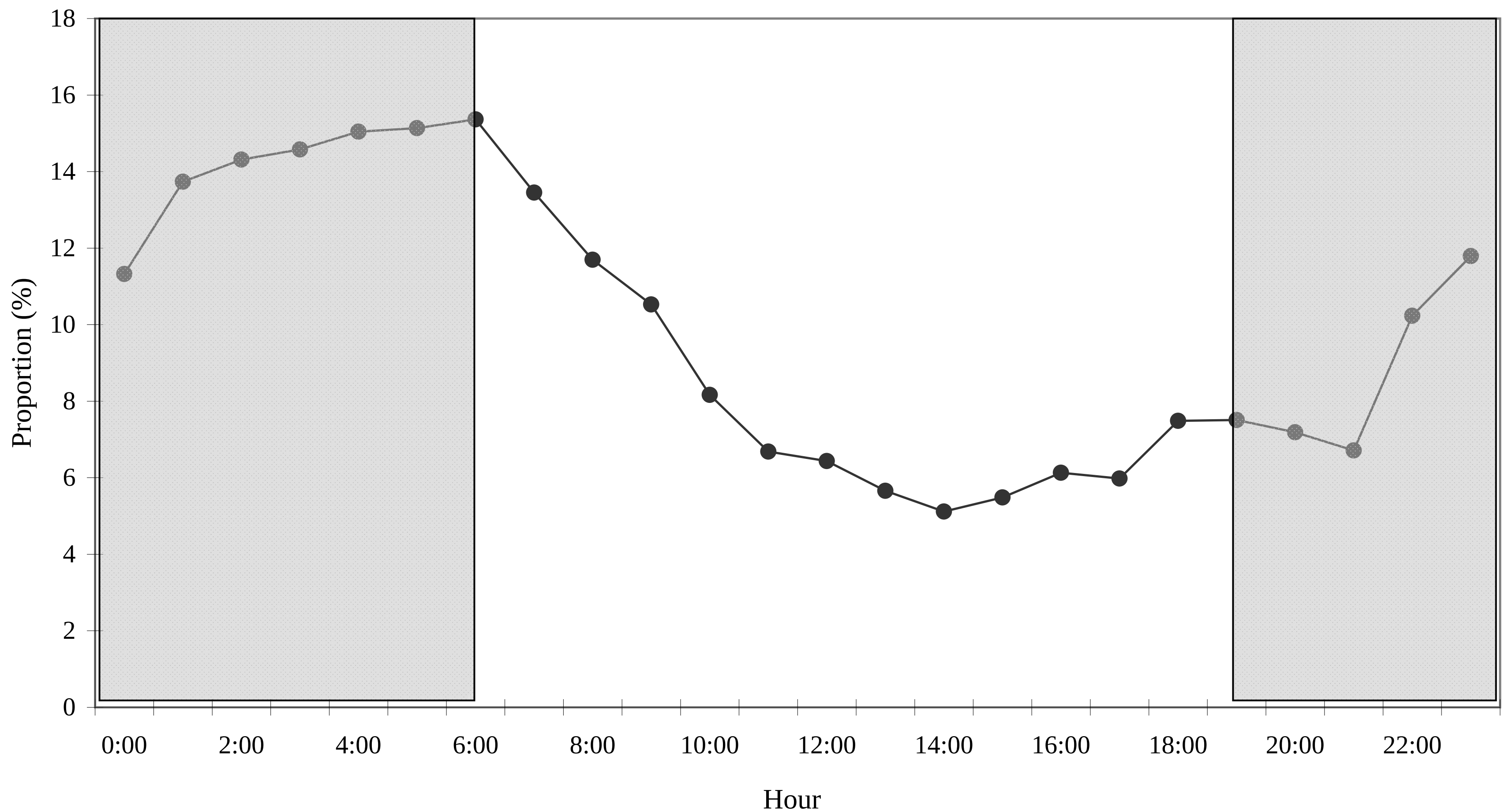

Figure 4-3. Proportion of flow to the skimmer gate sampler relative to total Project flow (i.e., flow through the skimmer gate plus turbine discharge), averaged hourly over the period of sampler operation, 2007. Shaded areas are approximately the hours between sunset and sunrise.

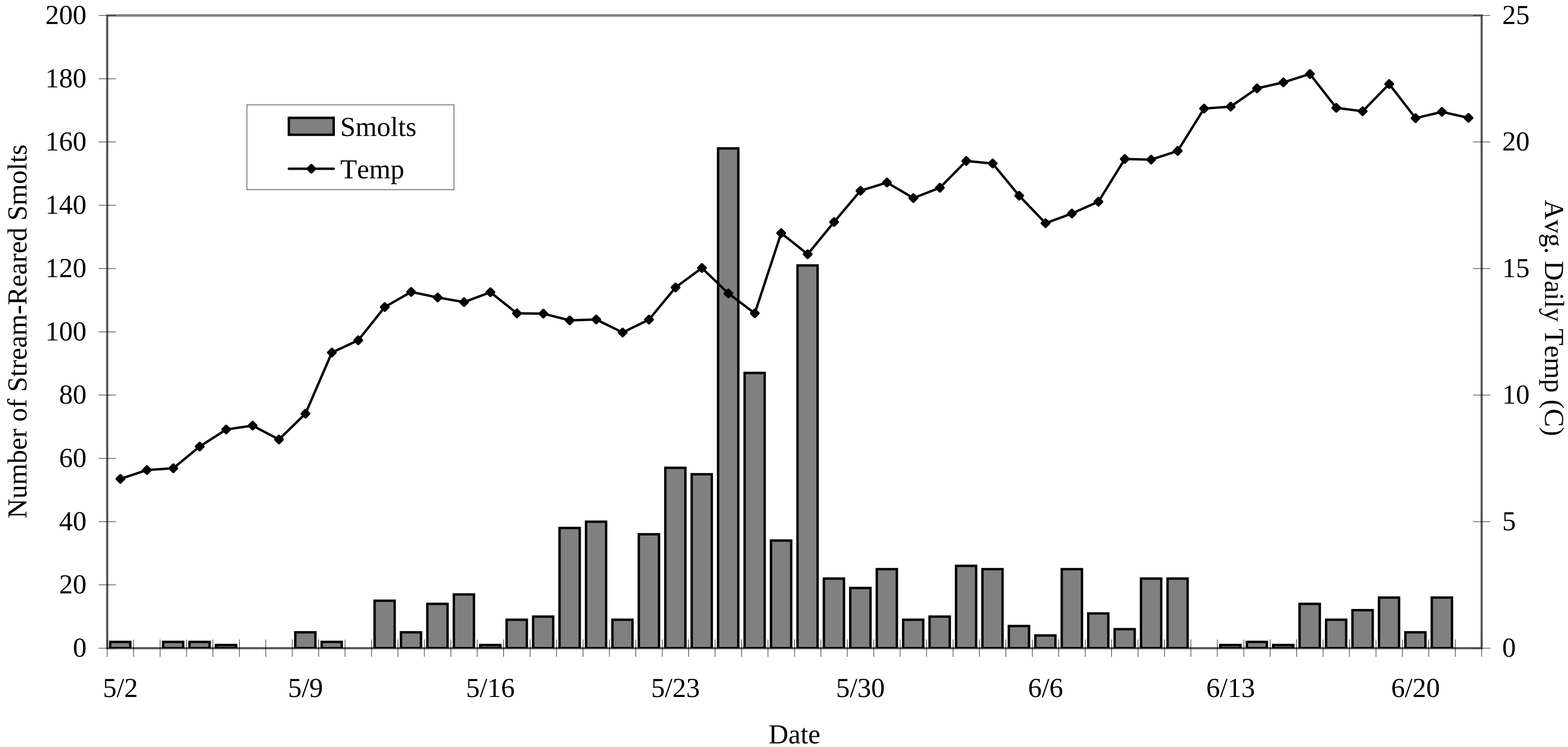

Figure 4-4. Average daily water temperature and daily smolt collections at Moore Dam, 2007.

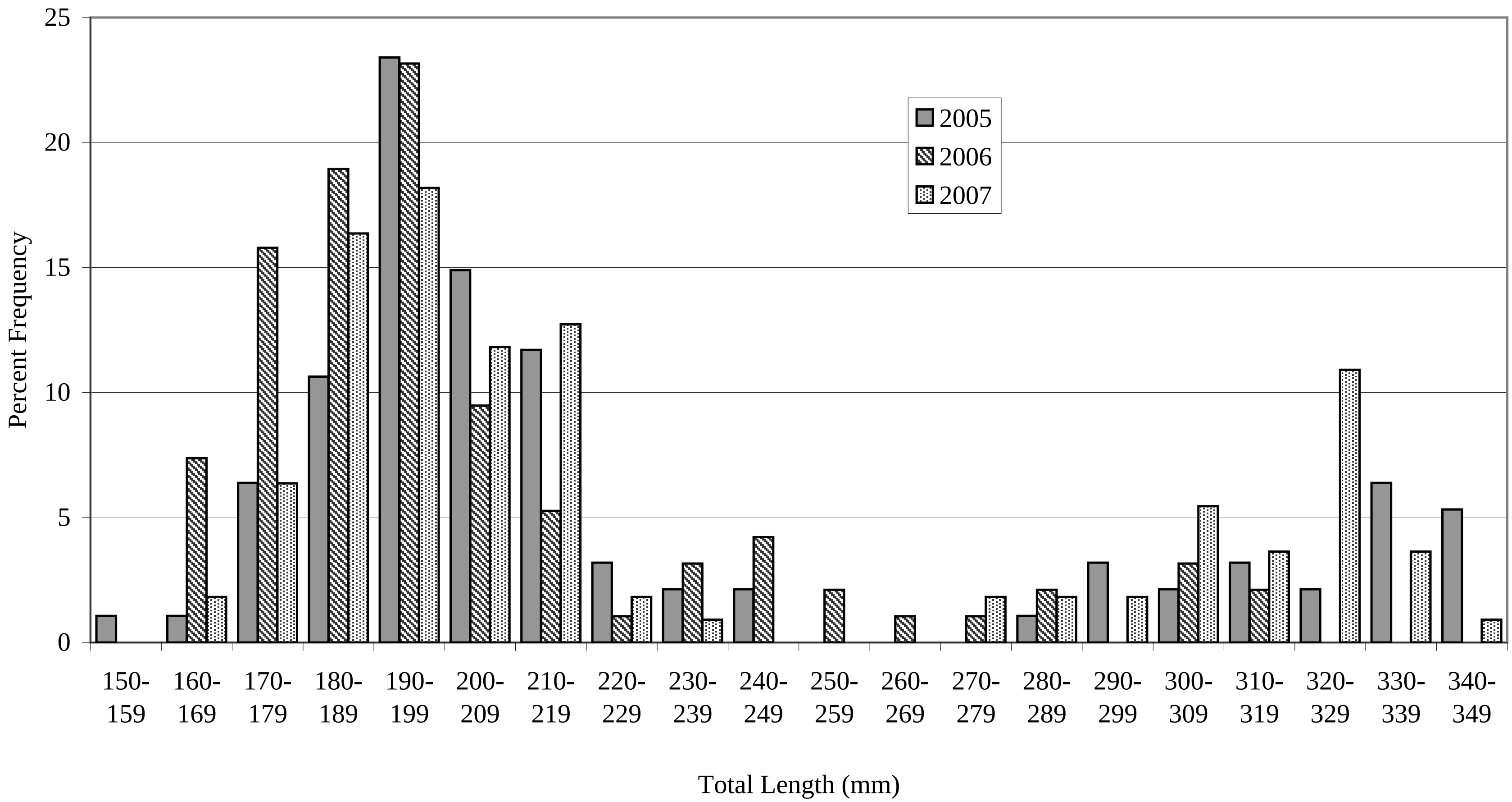

Figure 4-5. Length frequency distribution (%) of a sub-set of stream-reared Atlantic salmon smolts collected from the Moore Dam sampler in 2005 (n=94), 2006 (n=95), and 2007 (n=110).

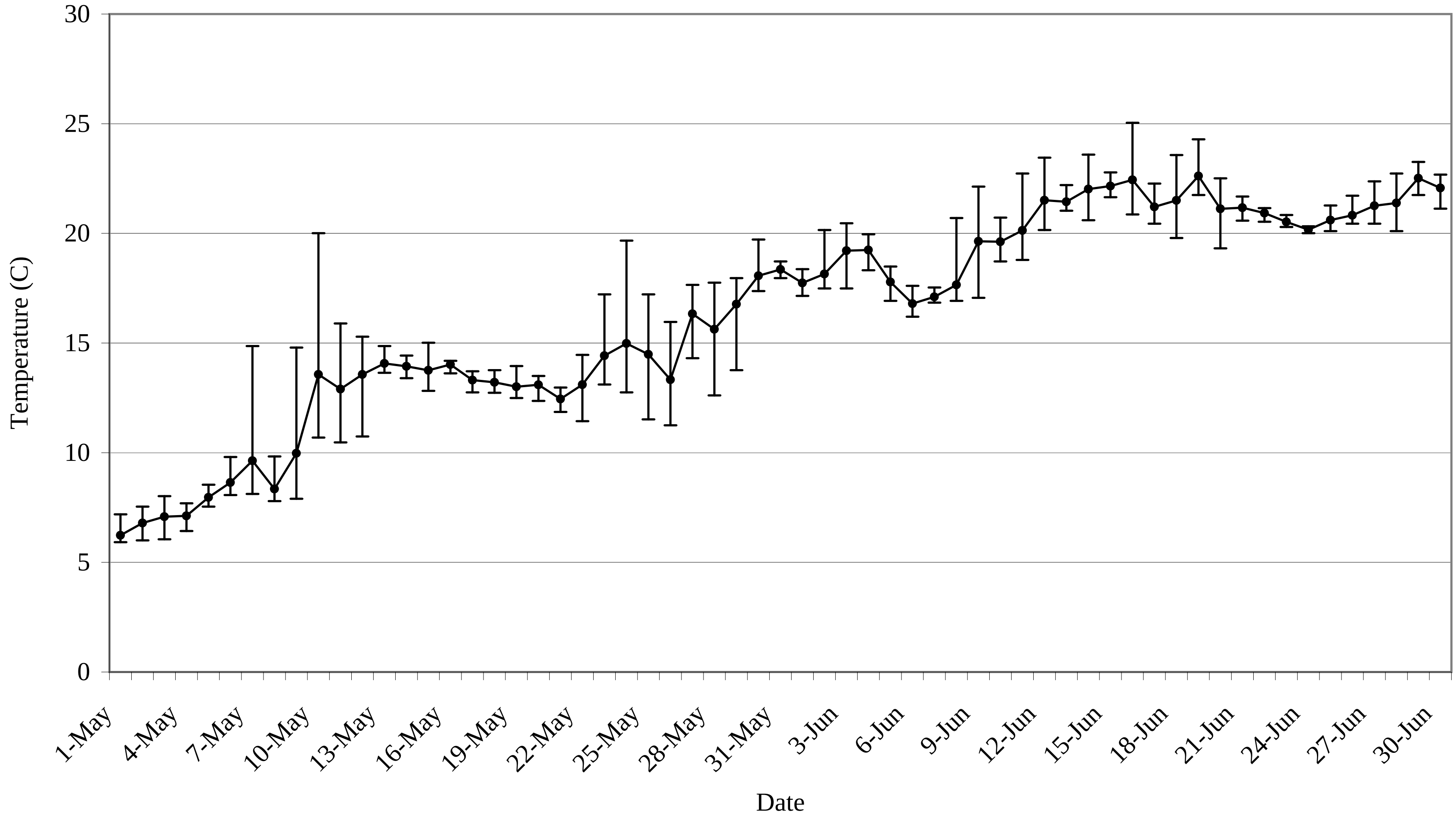

Figure 4-6. Minimum, mean, and maximum daily water temperature in the Moore Reservoir at the Moore Dam skimmer gate entrance.

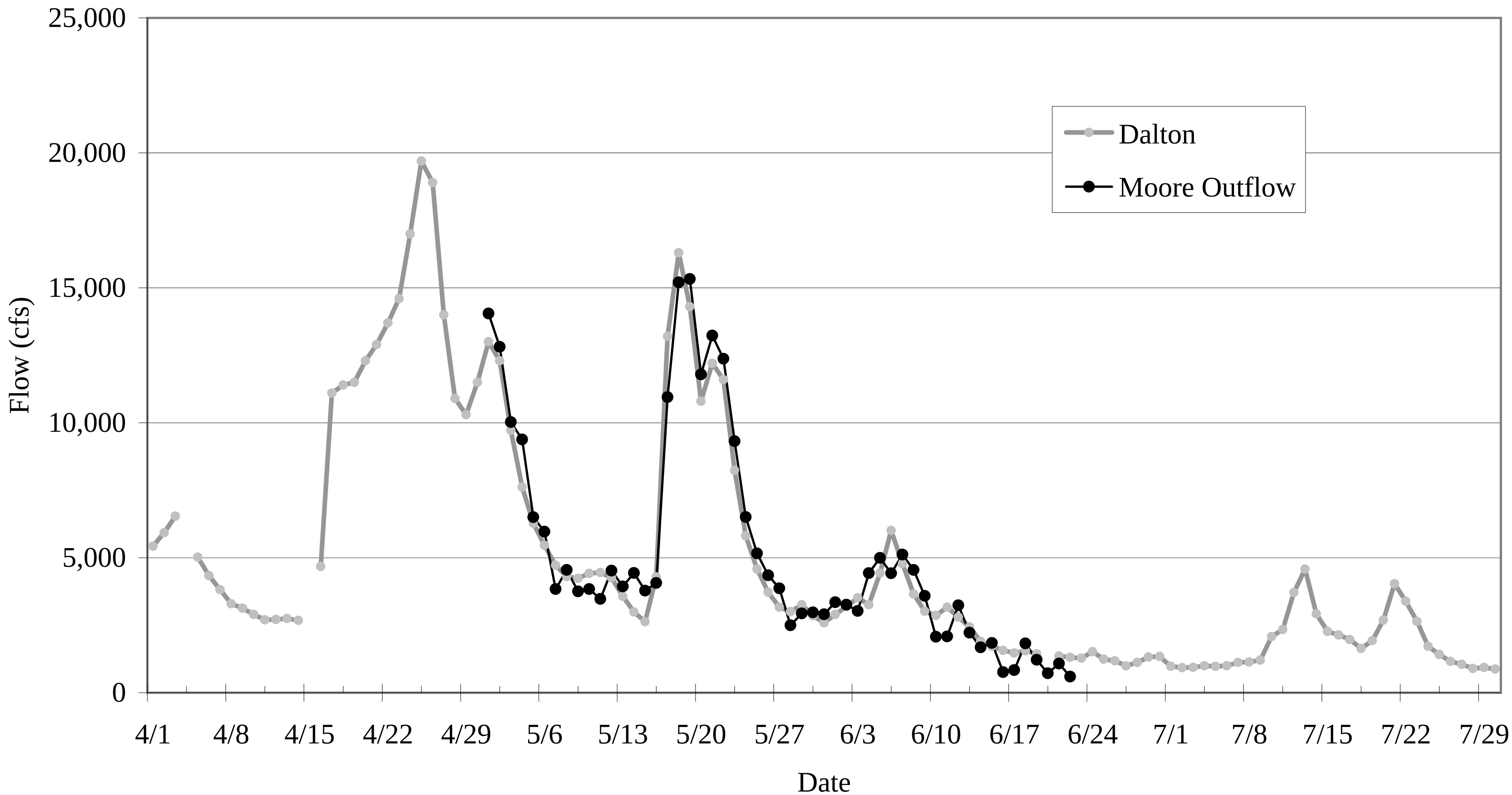

Figure 4-7. Inflow (cfs) to the Moore Reservoir recorded at USGS Gauge 01131500 located at the Dalton Hydro, and outflow from the Moore Hydro project, recorded by TransCanada, spring 2007.

APPENDIX

Appendix Table 1. Number of Atlantic salmon smolts collected in the Moore Dam sampler during each of 109 sampling periods, spring 2007. Data are sorted by set-date and set-time.

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	Smolts	CPUE
Day	5/1/2007	13:30	5/1/2007	16:30	3.00	0	0.00
Day and Night	5/1/2007	16:55	5/2/2007	8:30	15.58	2	0.13
Day and Night	5/2/2007	15:50	5/3/2007	8:30	16.67	0	0.00
Day and Night	5/3/2007	20:00	5/4/2007	8:05	12.08	1	0.08
Day	5/4/2007	11:00	5/4/2007	20:00	9.00	1	0.11
Day and Night	5/4/2007	22:30	5/5/2007	8:50	10.33	2	0.19
Day	5/5/2007	9:15	5/5/2007	10:40	1.42	0	0.00
Day	5/5/2007	16:50	5/5/2007	19:45	2.92	0	0.00
Day and Night	5/5/2007	20:00	5/6/2007	8:45	12.75	1	0.08
Day	5/6/2007	9:20	5/6/2007	18:30	9.17	0	0.00
Day and Night	5/6/2007	18:45	5/7/2007	6:00	11.25	0	0.00
Day	5/8/2007	15:30	5/8/2007	20:10	4.67	0	0.00
Night	5/8/2007	20:15	5/9/2007	5:45	9.50	5	0.53
Day	5/9/2007	6:00	5/9/2007	14:15	8.25	0	0.00
Day	5/9/2007	14:25	5/9/2007	20:15	5.83	0	0.00
Night	5/9/2007	20:20	5/10/2007	5:35	9.25	1	0.11
Day	5/10/2007	6:25	5/10/2007	20:10	13.75	1	0.07
Night	5/10/2007	20:55	5/11/2007	5:40	8.75	0	0.00
Day	5/11/2007	6:20	5/11/2007	20:20	14.00	0	0.00
Night	5/11/2007	20:45	5/12/2007	5:40	8.92	3	0.34
Day	5/12/2007	6:30	5/12/2007	20:20	13.83	13	0.94
Night	5/12/2007	20:40	5/13/2007	5:40	9.00	5	0.56
Day	5/13/2007	6:25	5/13/2007	20:15	13.83	0	0.00
Night	5/13/2007	20:55	5/14/2007	5:25	8.50	8	0.94
Day	5/14/2007	6:10	5/14/2007	13:20	7.17	7	0.98
Day	5/14/2007	15:00	5/14/2007	20:20	5.33	0	0.00
Night	5/14/2007	20:40	5/15/2007	5:20	8.67	4	0.46
Day	5/15/2007	6:29	5/15/2007	11:30	5.02	0	0.00
Day	5/15/2007	13:30	5/15/2007	20:21	6.85	0	0.00
Night	5/15/2007	20:40	5/16/2007	5:10	8.50	13	1.53
Day	5/16/2007	5:50	5/16/2007	20:25	14.58	1	0.07
Night	5/16/2007	20:50	5/17/2007	5:22	8.53	9	1.05
Day	5/17/2007	6:10	5/17/2007	20:15	14.08	10	0.71
Night	5/17/2007	20:35	5/18/2007	5:45	9.17	0	0.00
Day	5/18/2007	6:50	5/18/2007	7:10	0.33	0	0.00
Day	5/18/2007	7:25	5/18/2007	8:30	1.08	0	0.00
Day	5/18/2007	14:45	5/18/2007	20:28	5.72	0	0.00
Night	5/18/2007	20:45	5/19/2007	5:30	8.75	38	4.34
Day	5/19/2007	5:50	5/19/2007	20:20	14.50	0	0.00
Night	5/19/2007	20:40	5/20/2007	5:30	8.83	38	4.30
Day	5/20/2007	6:10	5/20/2007	20:30	14.33	2	0.14
Night	5/20/2007	20:55	5/21/2007	5:25	8.50	5	0.59
Day	5/21/2007	5:48	5/21/2007	11:00	5.20	1	0.19
Day	5/21/2007	14:20	5/21/2007	20:17	5.95	4	0.67
Night	5/21/2007	20:42	5/22/2007	5:35	8.88	28	3.15
Day	5/22/2007	6:05	5/22/2007	20:15	14.17	8	0.56

Appendix Table 1. Continued.

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	Smolts	CPUE
Night	5/22/2007	20:25	5/23/2007	5:20	8.92	57	6.39
Day	5/23/2007	5:55	5/23/2007	20:21	14.43	0	0.00
Night	5/23/2007	20:53	5/24/2007	5:20	8.45	41	4.85
Day	5/24/2007	6:12	5/24/2007	20:36	14.40	14	0.97
Night	5/24/2007	21:09	5/25/2007	5:30	8.35	16	1.92
Day	5/25/2007	6:00	5/25/2007	20:30	14.50	142	9.79
Night	5/25/2007	21:25	5/26/2007	5:30	8.08	33	4.08
Day	5/26/2007	5:55	5/26/2007	20:20	14.42	54	3.75
Night	5/26/2007	20:55	5/27/2007	5:15	8.33	24	2.88
Day	5/27/2007	5:55	5/27/2007	20:40	14.75	10	0.68
Night	5/27/2007	21:09	5/28/2007	5:01	7.87	15	1.91
Day	5/28/2007	5:58	5/28/2007	20:33	14.58	106	7.27
Night	5/28/2007	21:26	5/29/2007	5:10	7.73	9	1.16
Day	5/29/2007	5:39	5/29/2007	20:35	14.93	14	0.94
Night	5/29/2007	21:05	5/30/2007	5:20	8.25	5	0.61
Day	5/30/2007	5:40	5/30/2007	20:35	14.92	14	0.94
Night	5/30/2007	20:50	5/31/2007	5:20	8.50	24	2.82
Day	5/31/2007	5:45	5/31/2007	20:34	14.82	1	0.07
Night	5/31/2007	20:45	6/1/2007	5:15	8.50	9	1.06
Day	6/1/2007	5:35	6/1/2007	20:35	15.00	0	0.00
Night	6/1/2007	20:50	6/2/2007	5:30	8.67	9	1.04
Day	6/2/2007	5:45	6/2/2007	20:45	15.00	1	0.07
Night	6/2/2007	20:52	6/3/2007	5:20	8.47	26	3.07
Day	6/3/2007	5:55	6/3/2007	20:40	14.75	0	0.00
Night	6/3/2007	20:59	6/4/2007	5:10	8.18	25	3.05
Day	6/4/2007	5:51	6/4/2007	20:40	14.82	0	0.00
Night	6/4/2007	21:05	6/5/2007	5:01	7.93	5	0.63
Day	6/5/2007	5:25	6/5/2007	20:30	15.08	2	0.13
Night	6/5/2007	20:50	6/6/2007	5:05	8.25	1	0.12
Day	6/6/2007	5:15	6/6/2007	15:25	10.17	0	0.00
Day	6/6/2007	15:40	6/6/2007	20:40	5.00	0	0.00
Night	6/6/2007	20:50	6/7/2007	5:05	8.25	3	0.36
Day	6/7/2007	5:15	6/7/2007	20:30	15.25	25	1.64
Night	6/7/2007	20:50	6/8/2007	5:12	8.37	9	1.08
Day	6/8/2007	5:45	6/8/2007	20:30	14.75	2	0.14
Night	6/8/2007	20:55	6/9/2007	5:10	8.25	6	0.73
Day	6/9/2007	5:30	6/9/2007	21:15	15.75	0	0.00
Night	6/9/2007	21:25	6/10/2007	5:12	7.78	21	2.70
Day	6/10/2007	5:35	6/10/2007	20:40	15.08	1	0.07
Night	6/10/2007	20:50	6/11/2007	5:15	8.42	8	0.95
Day	6/11/2007	5:25	6/11/2007	20:38	15.22	0	0.00
Night	6/11/2007	20:55	6/12/2007	5:08	8.22	14	1.70
Day	6/12/2007	5:50	6/12/2007	20:35	14.75	0	0.00
Night	6/12/2007	20:50	6/13/2007	5:00	8.17	1	0.12
Day	6/13/2007	5:25	6/13/2007	20:35	15.17	0	0.00
Night	6/13/2007	20:50	6/14/2007	5:10	8.33	2	0.24
Day	6/14/2007	5:30	6/14/2007	20:35	15.08	0	0.00
Night	6/14/2007	21:00	6/15/2007	5:10	8.17	1	0.12

Appendix Table 1. Continued.

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	Smolts	CPUE
Day	6/15/2007	5:26	6/15/2007	20:40	15.23	0	0.00
Night	6/15/2007	20:50	6/16/2007	5:10	8.33	13	1.56
Day	6/16/2007	5:35	6/16/2007	20:35	15.00	1	0.07
Night	6/16/2007	20:50	6/17/2007	5:20	8.50	9	1.06
Day	6/17/2007	5:35	6/17/2007	20:35	15.00	0	0.00
Night	6/17/2007	20:45	6/18/2007	5:15	8.50	11	1.29
Day	6/18/2007	5:20	6/18/2007	20:38	15.30	1	0.07
Night	6/18/2007	20:52	6/19/2007	5:05	8.22	16	1.95
Day	6/19/2007	5:28	6/19/2007	20:38	15.17	0	0.00
Night	6/19/2007	20:50	6/20/2007	5:10	8.33	5	0.60
Day	6/20/2007	5:29	6/20/2007	20:30	15.02	0	0.00
Night	6/20/2007	20:40	6/21/2007	5:12	8.53	16	1.88
Day	6/21/2007	5:35	6/21/2007	20:30	14.92	0	0.00
Night	6/21/2007	20:40	6/22/2007	5:16	8.60	0	0.00
Day	6/22/2007	5:26	6/22/2007	13:00	7.57	0	0.00