REPORT ON ATLANTIC SALMON SMOLT SAMPLING EFFORTS AT MOORE DAM, SPRING 2008

MARCH 2009

Final Report

REPORT ON ATLANTIC SALMON SMOLT SAMPLING EFFORTS AT MOORE DAM, SPRING 2008

Prepared for
TRANSCANADA HYDRO NORTHEAST, INC.
4 Park Street
Suite 402
Concord, NH 03301

Prepared by
NORMANDEAU ASSOCIATES, INC.
917 Route 12, #1
Westmoreland, NH 03467

R-21282.000

March 2009

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 Federal Energy Resources Commission (FERC) approved a fifth 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 Atlantic 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. In the fourth year, problems with allocated hatchery-reared smolts resulted in the use of stream-reared fish collected in the sampler. During 2008, the fifth year of study focused on monitoring the seasonal timing, duration, and abundance of the stream-reared Atlantic salmon migratory run at Moore Dam.

The sampler was operated from 25 April to 27 June 2008. Collected salmon were enumerated and live smolts were transported to, and released below the McIndoes Development. A summary of the 2008 results follows.

- Between 26 April and 27 June, 691 stream-reared smolts were collected; the greatest number of smolts collected in one day (N=70) occurred on 11 June.
- There was not a strong modality to the passage distribution, as had been observed in 2005, 2006, and 2007. Distribution more closely followed water temperature in the Israel River compared to water temperature in the Moore Reservoir.
- Catch-per-unit-effort (CPUE) was highest (0.72 smolts/h, SD=1.41) during sample periods that included daytime and nighttime hours, and lowest (0.31 smolts/h, SD=0.60) during sample periods that included only daytime hours. Overall CPUE was 0.58 smolts/h (SD=1.04); 691 smolts were collected in 1,376.3 hours of sampling.
- Mortality was 3.7%, up slightly from last year when the lowest to date was recorded, but lower than other passage years. Low mortality was likely due to the effectiveness of the trash boom at limiting debris build-up on the sampler, and reduced handling of smolts during collection and transport to the McIndoes Development.
- Apparent holdovers, as suggested by size distribution were captured by the sampler shortly after the sampler was opened.

Based on the results of the last five 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 the last week of April this year provided early passage for smolts that were likely holdovers from last year.
- ➢ Installation of a debris boom at the entrance of the skimmer gate reduces debris load on the sampler, thereby reducing smolt mortality caused by debris.

Table of Contents

Acronyms, Abbreviations, and Definitions

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

List of Tables

List of Figures

1.0 INTRODUCTION

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

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

Consultation with agencies resulted in a plan of study for a minimum two-year evaluation, with the second year contingent upon approval from the agencies. The first year of study was conducted in 2004 and evaluations have continued through 2008 with agency approval granted prior to each year of study. The primary goals each year have been to qualify the seasonal timing of the downstream migration of stream-reared Atlantic salmon smolts and to quantify the number passing the development. These goals were met during each year of study except the first. In 2004 the sampler was not opened until mid-May when construction was completed. Daily passage numbers through June suggested that the migratory run started before the mid-May opening.

A secondary goal has been to evaluate the attractiveness of the sampler as a downstream passage route for salmon smolts, including assessing smolt behavior in the vicinity of the skimmer gate entrance. Mark-recapture techniques were used in 2004, 2005, and 2006. Radio telemetry tracking also was conducted in 2005 and acoustic telemetry was used in 2007 to assess behavior near the skimmer gate. Hatchery-reared Atlantic salmon smolts were used as proxy to stream-reared fish in each year except 2007.

2.0 PROJECT DESCRIPTION

2.1 Moore Development

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

The Moore Development operates as a daily peaking station and passes discharge directly into the Comerford Development reservoir. Elevation changes in Moore Reservoir average approximately 1 ft per day and generally have approached the normal operating level (~el. 804 – 806 ft msl) by mid-May (NEP 1996). The license provides for 320-cfs-year-round minimum flows (NEP 1997).

2.2 Moore Dam Skimmer Gate and Sampler

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

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

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

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

- A fixed netting structure was added to two sides of the collection tank and additional netting added mid-season to keep fish from jumping out of the collection tank or splashing out when conveyed through the pipe (Figure 2-4).

Changes made prior to the 2006 monitoring season included:

- A 14.5 ft by 25 ft wooden attraction flow shelf was submerged approximately five feet below water surface at the entrance of the skimmer gate to extend the flow-net range into the forebay (Figure 2-5); and,
- A specially designed trash boom was anchored around the skimmer gate entrance to deflect large debris from the sampler (Figure 2-6).

A discharge, not-to-exceed 500 cfs, for downstream passage onto the fish sampler was targeted through the 2008 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). As in past years, the physical condition of each salmon smolt was noted in accordance with a coding system developed for the evaluation (Table 3-1). However, in an effort to reduce handling stress, live smolts were not handled individually, as they had been in previous years when tagged hatchery smolts were also collected and required identification. This year, smolts were examined passively while in transport to the holding tanks, the transport tank and to the river. As a result, gross physical condition observations were made. All live salmon were transported below the FMF Project and released in the tailwaters of the McIndoes development. Scale samples were taken from salmon smolts that died during the evaluation. Resident fish removed from the collection tank were identified to species, enumerated, surveyed for gross injuries, and returned to Moore Reservoir.

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

3.2 Environmental Conditions and Station Operations

Water temperature was monitored in the Moore Reservoir near the entrance to the Moore Dam skimmer gate and in the Israel River, a tributary to the Connecticut River, near Lancaster N.H., and approximately 22.2 river miles upstream of the Moore Dam (Figure 1-2). Temperature was recorded from 27 April through 1 July, with Onset TidbiT™ temperature loggers. Each station had a redundant logger; loggers were placed approximately 3 and 6-ft-below the water surface in the Moore Reservoir and approximately 1 ft off the bottom in the Israel River. Temperature was were recorded every 15 minutes.

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

3.4 Data Collection and Analysis

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). 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 and for daily collections.

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

4.0 RESULTS

4.1 Sampler Operation

The Moore sampler began operating at 13:30 h on 25 April and was closed at 13:30 h on 27 June 2008. The skimmer gate was closed from 10:30 h on 27 April through 12:00 h on 30 April while emergency repairs were made to a spill gate at TransCanada’s Bellows Falls Dam that was not closing properly and affecting pond elevations in the Connecticut River system. Other short-term skimmer gate closings (ranging from approximately 10 – 40 min) occurred throughout the season when the sampler screen elevation was adjusted. Water flow from the sampler to the collection tank was curtailed when a sample was taken and fish were removed from the collection tank. The sampler operated for 1,362.3 h.

Sampling periods, defined as the period of time the sampler operated between fish removal from the collection tank, ranged from 1.0 h to 23.7 h, and averaged 10.8 h. The sampler collection tank was checked 128 times over the course of the study and fish collected in the tank were processed an average of 2 times per day between 25 April and 27 June (ranging from 1 to 3 times per day) (Appendix Table 1).

As a result of the pattern of spring runoff experienced, water levels in the Moore Reservoir were high through the spring, causing 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. On 26 April, the morning after the sampler was opened for the season, the discharge pipe was found clogged with debris, causing the mortality of numerous resident fish and 13 salmon smolts. No other smolt mortalities were directly attributable to debris load.

4.2 Salmon Smolt Collection

Stream-reared Atlantic salmon smolts were collected on 59 of the 61 days of sampler operation and in 92 of the 128 sampling events. The greatest number of stream-reared smolts collected in one day was 70 on 11 June. The seasonal distribution of the smolt migration showed no distinct pattern (Figure 4-1). Over the season there were two peak collection days when more than 24 smolts were collected: 37 smolts collected on 17 May and 70 smolts collected on 11 June. Those peak collection days occurred around water temperature spikes; no characteristic flows were associated with the spikes.

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 overlapped both daytime and nighttime hours). Effort was calculated as the number of hours the sampler was operated within each category.

Of the 1,376.3 hours sampled, 49% fell in the Day category, 40% in the Day and Night category, and 11% in the Night category. CPUE for salmon smolts was highest in the Day and Night category at 0.72 smolts/h (SD=1.41) (Table 4-1). Night CPUE was 0.54 (SD=043), Day CPUE was 0.31 (SD=0.60) and overall CPUE was 0.58 smolts/hour (SD=1.04). Despite a relatively small sample number, mean catch-per-hour for nighttime samples was higher than for daytime samples. Although the Day and Night category is the highest, this could be because sample collections in this category tended to capture the nighttime periods, which tended to be higher.

Salmon smolts were not examined as closely for injuries this year as they were in past years. Tag-recapture studies were not conducted this year, negating the need to handle each fish individually. Smolts were examined for gross injuries as they were netted from the collection tank, and when they were transported from the buckets to the holding tank, the holding tank to the transport tank, and the transport tank to the river. Of the 691 smolts collected, 96.2% (665) had no observable injuries, 3.6% (25) died, and one was moribund (Table 4-2).

Length data collected from stream-reared smolts in 2005 (n=94), 2006 (n=95), 2007 (n=110) and 2008 (N=20) show two distinct frequency distributions within each sample year, suggesting two age classes of smolts passing the sampler (Figure 4-2). Analysis of scale samples collected in 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 4-3). In 2008 the subset of fish aged (N=20; 2.9% of the smolts collected) were dominated by the age-3 cohort (60%), with age-2 cohorts (40%) completing the sample. However, all but one of the age-3 fish were collected on 26 April, the morning after the sampler was opened. This biased the age sample to early migrants that may have been holdovers from last year. Therefore, the age distribution of the 2008 smolt migration run was not clearly identified. Length at age distributions for the years 2005 through 2008 show distinct length-age relationships in some years (e.g., 2005, possibly 2008) but not in others (e.g., 2007) (Figure 4-3).

4.3 Water Temperature, River Flow, and Station Discharge

Water temperature recorded on the redundant thermistors deployed in the Israel River were similar, therefore, the data from each thermistor for corresponding 15 minute increments were averaged. Water temperature recorded on the two thermistors deployed in the Moore Reservoir were slightly different and therefore are reported separately. Mean water temperature in the Moore Reservoir generally followed mean water temperature in the Israel River but with less fluctuation, and it remained high toward the end of the monitoring period when temperature in the Israel River began to drop (Figures 4-4 and 4-5). The lowest water temperature recorded in the Israel River was 3.1^o C on 1 May; the highest temperature was 25.6^o C recorded on 10 June, one day before the peak in smolt collections occurred (Figure 4-1). A spike in water temperature in the Israel River between 7-10 June was compared with air temperature recorded in Whitefield, NH to consider whether minimal river flow had exposed the thermistors to air temperature. Maximum daily air temperature was 5-10^{o}C higher than water temperature during this period, indicating the thermistors had recorded water temperature, not air temperature. In the Moore Reservoir the lowest temperature was 6.6^o C recorded on 4 May; the highest temperature was 22.5^o C on 15 June (Figure 4-6). The two days of peak smolt passage occurred around temperature spikes, suggesting some relationship.

Average daily discharge from the Moore Development closely followed average daily inflow recorded at the Dalton, NH USGS gauging station (Figure 4-7). The sampler opened for the season as flows were coming down from a high of over 16,000 cfs. During the study period, inflow peaked at 15,400 cfs on 30 April, the day the sampler reopened after being closed for two days due to mechanical problems at the downstream Bellows Falls dam. There was no apparent increase in salmon smolt passage at the sampler during this flow event or during the less significant peak of 7,110 cfs on 19 June. There was no apparent connection between in-flow to the Moore Reservoir and smolt passage distribution through the season (Figure 4-8). No spill events occurred during the assessment period.

The proportion of flow through the skimmer gate, relative to total station discharge, ranged from 1.87 to 100% (mean = 47.56 %) and was most often 1-15%, and 100% of total station discharge (Figure 4-9A). High proportional flows through the skimmer gate occurred when there was little or no turbine discharge, and low proportional flows to the skimmer gate occurred when turbine discharge was high. Averaged hourly proportional flow to the skimmer gate demonstrated the stations daily peaking operation. Proportional flow to the skimmer gate was higher during night hours when flow to the turbines was low (Figure 4-9B). Averaged daily proportion of flow to the skimmer gate showed little variation during the smolt migration season, except at the beginning and towards the end of the sampling period. During these events, the proportion of station flow exiting the skimmer gate was continuously small over a number of days (Figure 4-9B). The first event occurred for about the first week of operation when problems with a spill gate at Bellows Falls Project necessitated water from Moore Dam storage to be released in order to maintain elevation at the Bellows Falls Project. This resulted in continuous daily turbine discharge to downstream reaches. The second event occurred over a few days in mid-June when high flows into the system required continuous station operation to maintain pond levels. The daily average proportional flow through the skimmer gate during these periods was less than 15% of the flow through the station. Daily CPUE for smolts did not appear to be directly affected by proportion of flow to the skimmer gate over a seasonal scale (Figure 4-9C).

4.4 Resident Species

Over 6,000 resident fish representing 19 species were collected in the sampler (Table 4-4). The most abundant species collected were spottail shiner (*Notropis hudsonius*, 61%) rock bass (*Ambloplites rupestris*, 20%) and yellow perch (*Perca flavescens*, 11%). Predation of shiners by northern pike and rockbass was observed in the collection tank.

5.0 DISCUSSION

The purpose of this evaluation was to obtain information on the timing and abundance of the stream-reared Atlantic salmon smolt migration past the Moore Dam. This objective was achieved. TransCanada was requested by the agencies to open the sampler one week earlier this year, i.e., on 24 April, to see if the run would begin earlier if passage was available. The sampler was opened on the afternoon of 25 April, following ice-off and when pond elevation could be brought up high enough to provide adequate flow through the sampler. On the morning of 26 April, the discharge pipe was found almost completely clogged with debris and fish. Thirteen smolts were found dead in the pipe, representing 52% of the smolt mortalities for the year. Subsequently, the morning collection occurred earlier, close to sunrise. No further smolt mortalities were determined to have occurred from debris load.

The run pattern was somewhat different this year compared to past years when modal (Normandeau Associates 2006, 2008) and tri-modal (Normandeau Associates 2007) distributions were observed. No distinct modality was observed this year. Daily collection numbers varied through the season and somewhat followed periods of increasing temperature in the Israel River. The number of smolts collected exceeded 25 on only two days: 17 May when 37 smolts were collected and 11 June when 70 were collected. The 11 June collection suggests a likely relationship between water temperature and the number of smolts collected. Water temperature in the Israel River jumped from 13 to 21^{o}C over a five-day period before 11 June. If this rapid warming occurred in most tributaries it may have cued smolts to move downstream. This was the first year water temperature was recorded in a tributary river, where temperature fluctuations were greater than in the Moore Reservoir and main-stem Connecticut River - the location of temperature monitoring stations in previous years.

This year, the sampler was opened a week earlier than in previous years. When it was opened, water temperature in the Israel River was just over 11^{o}C. It dropped over the following days and gradually reached 10^{o}C about a week-and-a-half later. This initial warming may have been a migratory cue for smolts collected in the first days of sampler operation. Temperature in the Moore Reservoir increased gradually through the season, as was observed last year. However, the modal distribution of the smolt run last year was not observed this year. Though the distribution of the smolt run this year was unlike any other sample year, it resembled the 2006 sample season more than any other. Water temperature in the Moore Reservoir and discharge from the Moore station showed greater fluctuation in 2006 than this year.

The number of smolts passing the sampler this year was lower than the past three years when the sampler was operational for the full migration season, but lower than the first year (N=254) of study when the sampler was opened late in the season (Table 4-3). Smolts entering the Moore sampler are the product of salmon fry stocked in tributaries above the Moore Dam by NHFG and VTFG. The majority of fry mature to the smolt stage and begin migrating two years after stocking. Index streams above the Moore Dam are sampled by the NHFG and VTFG and data are used to develop smolt production estimates for the upcoming migration season. These two variables were compared with the number of smolts collected at the Moore sampler during the years 2005-2008 (2004 was not included because the sampler was opened late in the season) using Pearson's correlation coefficient. Because fry smoltify in approximately two years, fry stocking numbers from 2003-2006 were compared with the number of smolts collected in the sampler from 2005-2008. No statistical correlation was found for either variable; the relationship between the number of smolts collected at the sampler and number of fry stocked (R=0.82, P=0.18) was closer than the relationship between the number of smolts collected at the sampler and the estimated production number (R=0.05, P=0.94). The lack of correlation is not surprising considering there were only four data points (four years). Over the four years production estimates increased each year to a peak in 2007 and then dropped slightly in 2008 to around the 2006 range. The number of fry stocked from 2003 to 2006 increased slightly to a peak in the second year (2004), dropped in the third year (2005) and dropped again in the last year (2006). This pattern also describes smolt collection numbers from the sampler between 2005 and 2008. These comparisons suggest that factors other than numbers of fry stocked and numbers of smolts estimated to be produced in the habitat are driving the number of smolts captured in the sampler.

Sixty percent of the aged fish were age-3; however, the subsample of aged fish was small, only 2.9% of the run, and biased from high mortality on the first full day of sampling. Eleven of the twelve age-3 smolts were collected the morning after the sampler was opened. These may represent a group of last year's age-2 fish that over-wintered in the reservoir. Only one of the nine smolts that was aged and collected after 26 April was age-3. If the first pulse of smolts collected were holdovers from last year, the remaining age data, though limited, suggests the majority of the 2008 run was age-2 smolts. This coincides with data from previous years that indicates the proportion of age-2 fish is increasing over time. This may be due to the availability of passage. There may be proportionally fewer holdovers each year.

Percent mortality (3.6%) was higher than last year (2.5%), when the lowest to date was recorded, but lower then 2004 through 2006 (3.7% - 13.0%). The loss of thirteen smolts on 26 April was just over half of the total loss for the season. Debris load on the sampler and in the discharge pipe lead to the early mortalities but did not appear to be a factor later in the season. More frequent checks of the sampler for debris load early in the season when debris load is high may reduce this source of mortality. Smolts were handled less this year because fish were not tagged and therefore did not need to be examined for tags, which may have helped to keep the mortality rate low. A few smolts were found dead on the ground. Netting around the top of the collection tank reduces the probably that these fish jumped from the collection tank. More likely, flow over the skimmer gate increased for brief periods of time due to acute pond water surface elevation fluctuations beyond what the collection tank and lower sampler were set to accommodate. When this happens, a portion of the water exiting the discharge pipe can spill to the ground rather than the collection tank. This does not appear to happen often but can be addressed through close communication between field staff and station operators.

5.4 Conclusions

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

- The inclined plane sampler is effective at collecting fish that pass over the skimmer gate, providing a non-turbine emigration route past the station for salmon that are stocked above the Moore Reservoir.
- This year the sampler was opened close to a week earlier than in past years and was used early by a small group of smolts that may have been holdovers from last year.
- Some smolts appear to be able to holdover in the reservoir, or nearby tributaries and pass downstream the following year if they do not pass the sampler in the year they migrated to the reservoir. However, it would be preferable that smolts enter the sampler rather than reside in the reservoir for an additional year with associated mortality.
- While debris load on the sampler and in the collection tank increases mortality, survival has improved with installation of a debris boom in 2006, and by conducting sampling events at night and early morning, close to sunrise. Early in the season, an additional check of the sampler in the afternoon for debris load may further reduce mortality associated with debris load.

6.0 LITERATURE CITED

Federal Energy Regulatory Commission (FERC). 2002. Final environmental assessment for hydropower license. Fifteen Mile Falls Hydroelectric Project, FERC Project No. 2077-016, New Hampshire and Vermont.

NEP. 1997. Fifteen Mile Falls (Project L.P. #2077) Settlement Agreement (dated 6 August 1997).

NEP. 1996. Fifteen Mile Falls (Project L.P. #2077) Initial Consultation Document, Vol. 1. Prepared by Louis Berger Associates for New England Power Co.

Normandeau Associates Inc. 2005. Atlantic salmon smolt report on fish sampling effort at Moore Dam, spring 2004. Report prepared for USGen New England, Inc., Concord, NH.

Normandeau Associates Inc. 2006. Atlantic salmon smolt report on fish sampling effort at Moore Dam, spring 2005. Report prepared for TransCanada Hydro Northeast, Inc., Concord, NH.

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

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

Table 3-1. Codes used to document condition of salmon smolts collected in the Moore sampler, spring 2008.

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

Table 4-1. Catch-per-unit-effort (smolts/h) for Atlantic salmon smolts collected during three time categories at the Moore sampler, spring 2008.

		Smolts			Effort			CPUE			
Time Category	**Observations**	**Number**	**Mean**	**SD**	**Hours (sum)**	**Mean**	**SD**	**Overall CPUE**	**Mean**	**SD**	**SE**
Day	61	212	3.475	7.777	676.05	11.083	3.700	0.31	0.29	0.60	0.08
Night	16	79	4.938	3.881	146.24	9.140	0.303	0.54	0.54	0.43	0.11
Day and Night	51	400	7.843	5.915	554.01	10.863	3.173	0.72	0.93	1.41	0.20

Table 4-2. Physical condition and potential cause of mortality for salmon smolts collected in the Moore sampler, spring 2008. For the last four conditions listed, fish were noted to have either that condition only, or that condition and one or more of the previous listed conditions.

	Atlantic Salmon	
Condition	**Number**	**Percent**
No injuries	665	96.24
Descaling	0	0.00
Eye injury	0	0.00
Contusions, and …	0	0.00
Lacerations, and …	0	0.00
Moribund, and …	1	0.14
Dead, and …	25	3.62
Potential Cause of Mortality		
Debris load (stuck in pipe or clogged tank)	13	52.0
Collection / Handling Stress (died in holding tank)	7	28.0
Sampler Adjustment / Water Level (jumped/spilled out of tank, dry on sampler)	3	12.0
Not specified - dead when collected	2	8.0

Table 4-3. Number of stream-reared Atlantic salmon smolts collected at the Moore sampler from 2005 through 2008, and the number, percent, and range in total length (mm) of a sub-set of smolts that were aged using scale analysis.

				Age-2				Age-3				Age-4			
Year	**N Smolts Collected**	**N Aged**	**% of Collection**	**N**	**% of Aged**	**Length Range**	**Mean Length**	**N**	**% of Aged**	**Length Range**	**Mean Length**	**N**	**% of Aged**	**Length Range**	**Mean Length**
2005	1,404	82	5.84%	63	76.8	152-248	199.6	13	15.9	284-340	315.8	6	7.3	325-395	344.7
2006	2,473	77	3.11%	67	87.0	162-257	193.3	10	13.0	201-310	274.7	0	-	-	-
2007	1,029	110	10.69%	101	91.8	160-340	228.1	9	8.2	187-332	256.1	0	-	-	-
2008*	691	20	2.89%	8	40.0	165-261	213.0	12	60.0	265-325	303.3	0	-	-	-

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

Table 4-4. Resident fish species and number collected in the Moore sampler between 25 April and 27 June 2008.

Common Name	Scientific Name	Number Collected	Percent of Total
Spottail shiner	*Notropis hudsonius*	3661	60.986
Rockbass	*Ambloplites rupestris*	1225	20.406
Yellow perch	*Perca flavescens*	649	10.811
Smallmouth bass	*Micropterus dolomieui*	159	2.649
Rainbow smelt	*Osmerus mordax*	101	1.682
Golden shiner	*Notemigonus crysoleucas*	82	1.366
Brown trout	*Salmon trutta*	33	0.550
Pumpkinseed	*Lepomis gibbosus*	27	0.450
Black crappie	*Pomoxis nigromaculatus*	21	0.350
Rainbow trout	*Oncorhynchus mykiss*	11	0.183
Blacknose dace	*Rhinichthys atratulus*	10	0.167
Common shiner	*Notropis cornutus*	7	0.117
Brook trout	*Salvelinus fontinalis*	4	0.067
White sucker	*Catostomus commersoni*	4	0.067
Northern pike	*Esox lucius*	3	0.050
Northern redbelly dace	*Phoxinus eos*	3	0.050
Fallfish	*Semotilus corporalis*	1	0.017
Brown bullhead	*Ictalurus nebulosus*	1	0.017
Largemouth bass	*Micropterus salmoides*	1	0.017

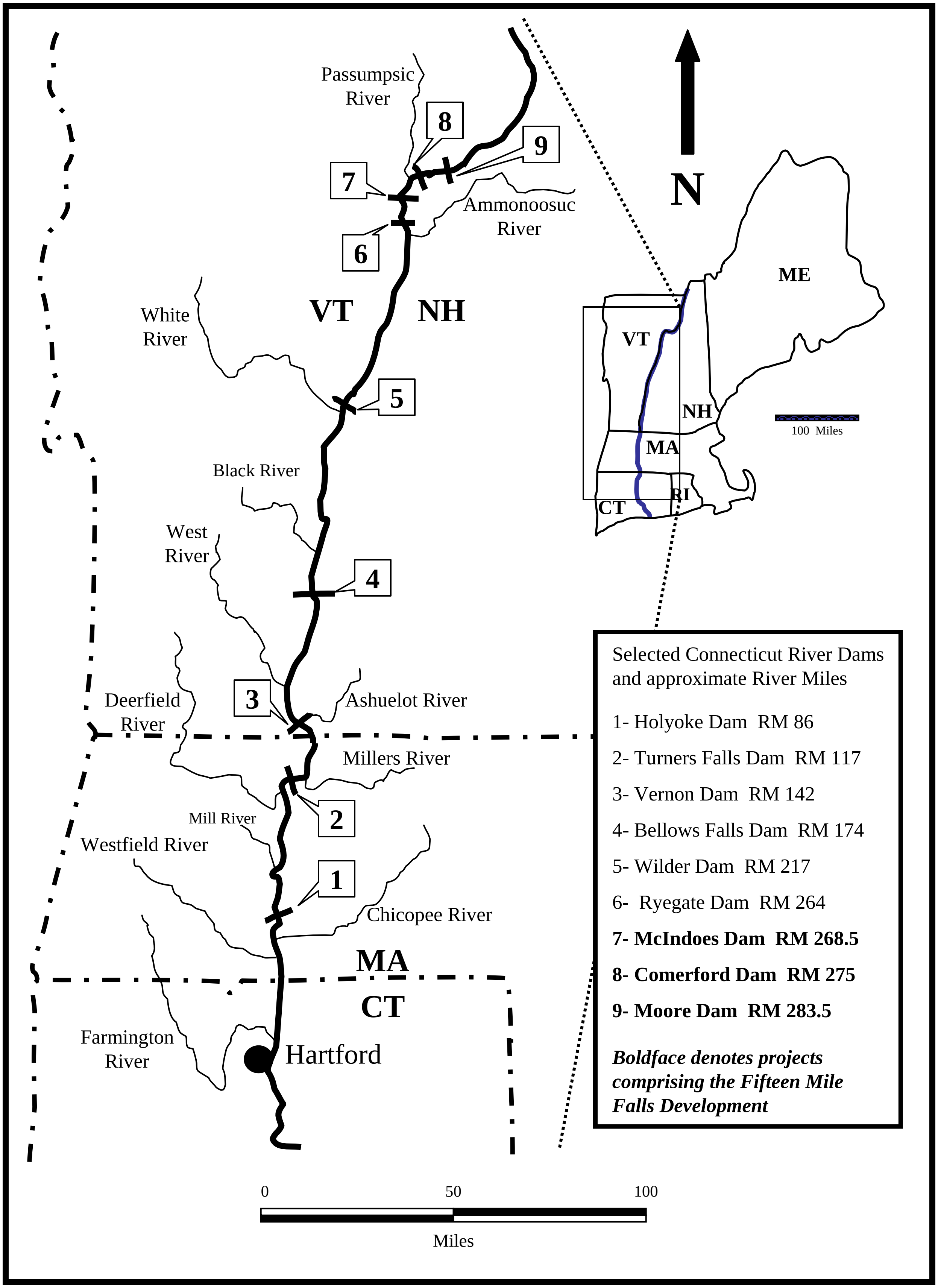


Figure 1-1. Location of the Fifteen Mile Falls Project on the Connecticut River.

Figure 1-2. Location map showing the Moore Dam and the Israel River temperature monitoring station.

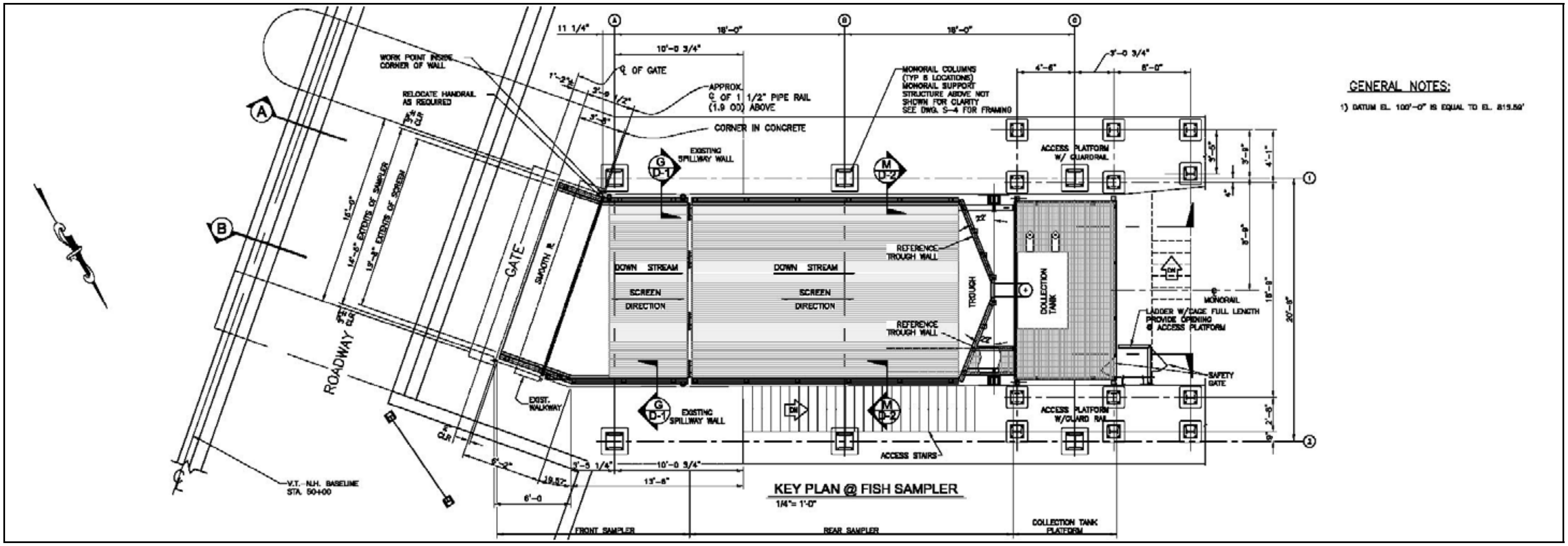


Figure 2-1. Key plan of TransCanada's Moore Development inclined plane sampler. The plan does not show flow reflectors installed after the sampler was erected. Plan drawing prepared by Kleinschmidt.

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

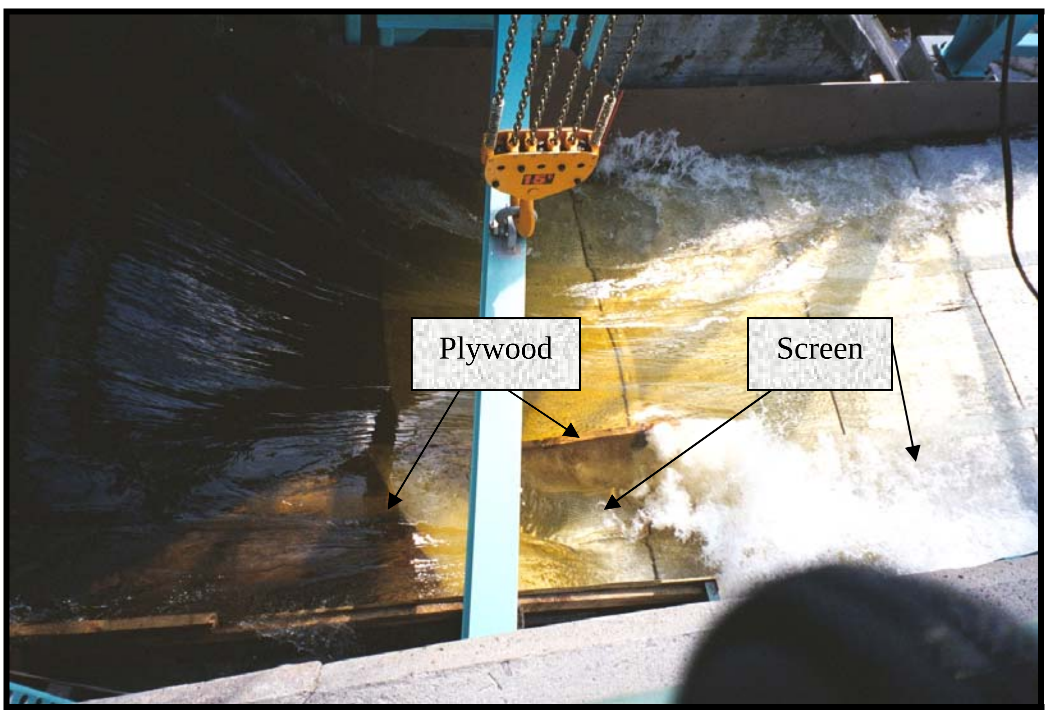


Figure 2-3. Moore Development, inclined plane sampler showing plywood flow adjusters.

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

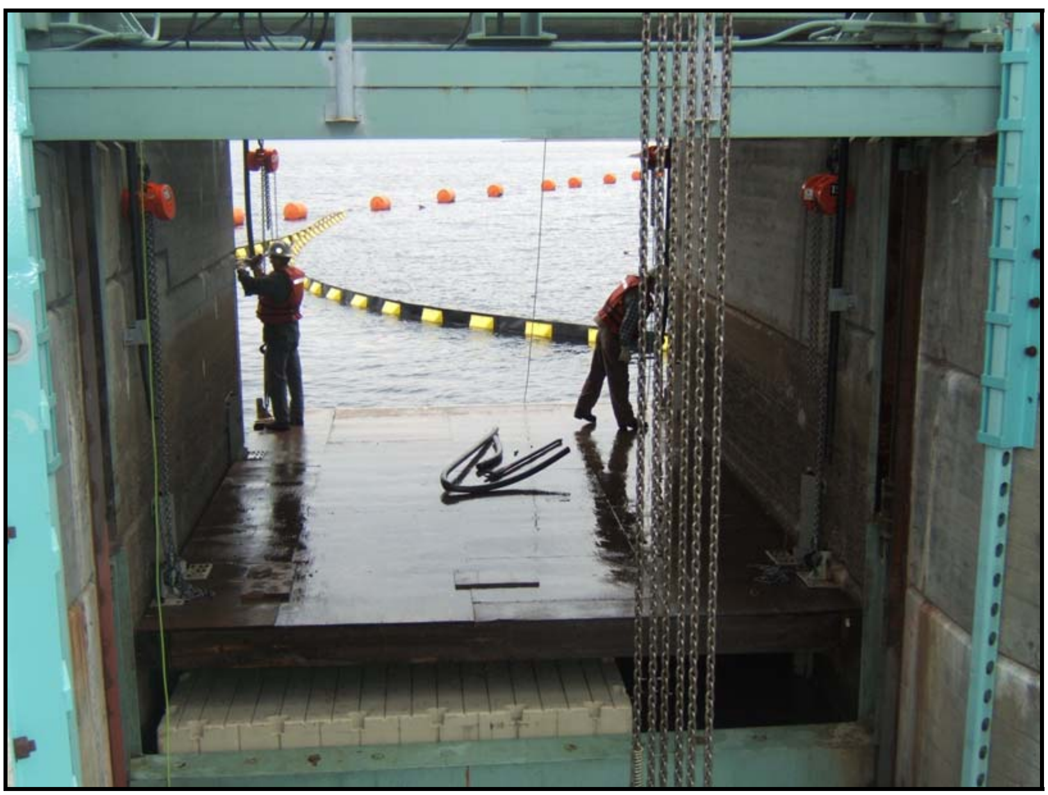


Figure 2-5. Moore Development, attraction flow shelf raised for repairs. View is looking upstream through the skimmer gate entrance to Moore Reservoir.

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

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

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

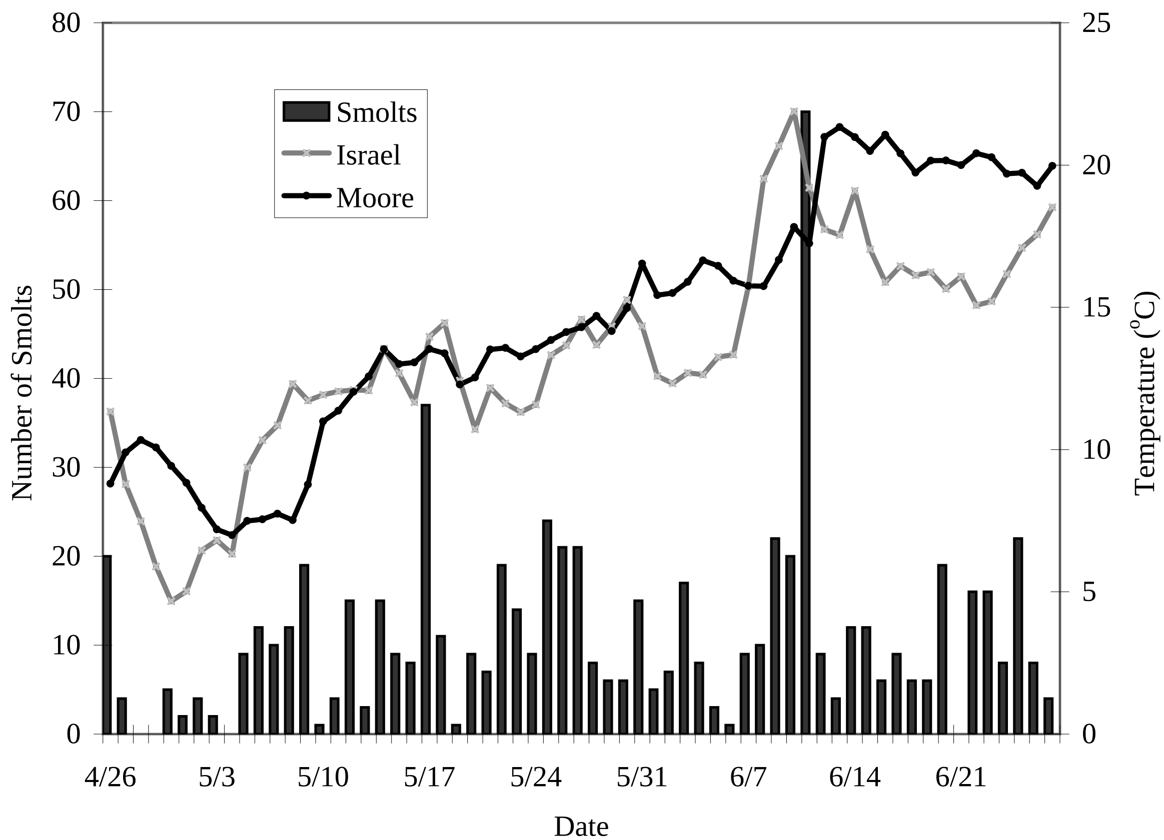


Figure 4-1. Daily average water temperature at the Israel River monitoring station and Moore Reservoir monitoring station, and daily sum of stream-reared smolts collected in the Moore sampler, spring 2008.

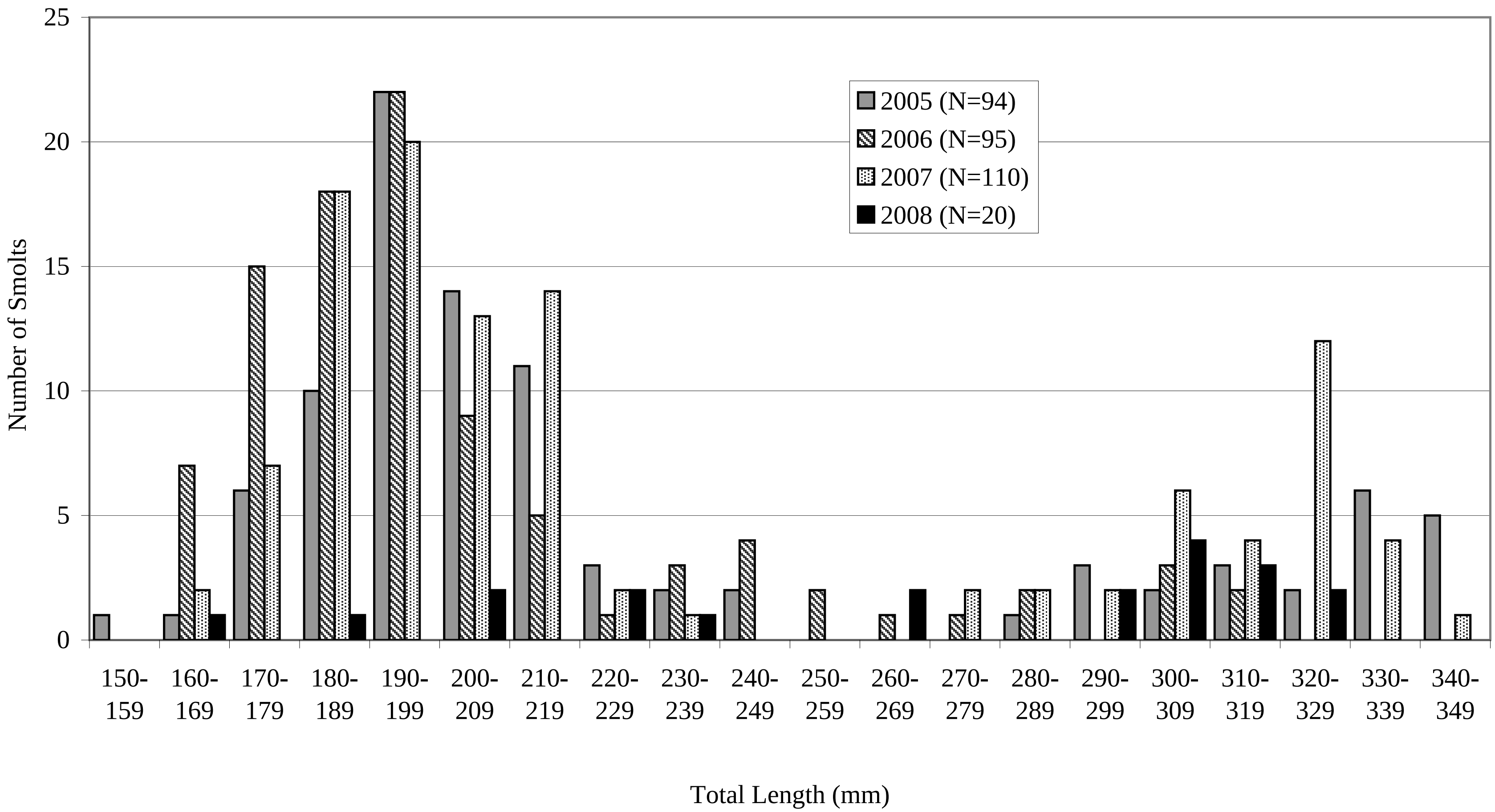


Figure 4-2. Length frequency distribution of a sub-set of stream-reared Atlantic salmon smolts collected at the Moore sampler from 2005 through 2008.

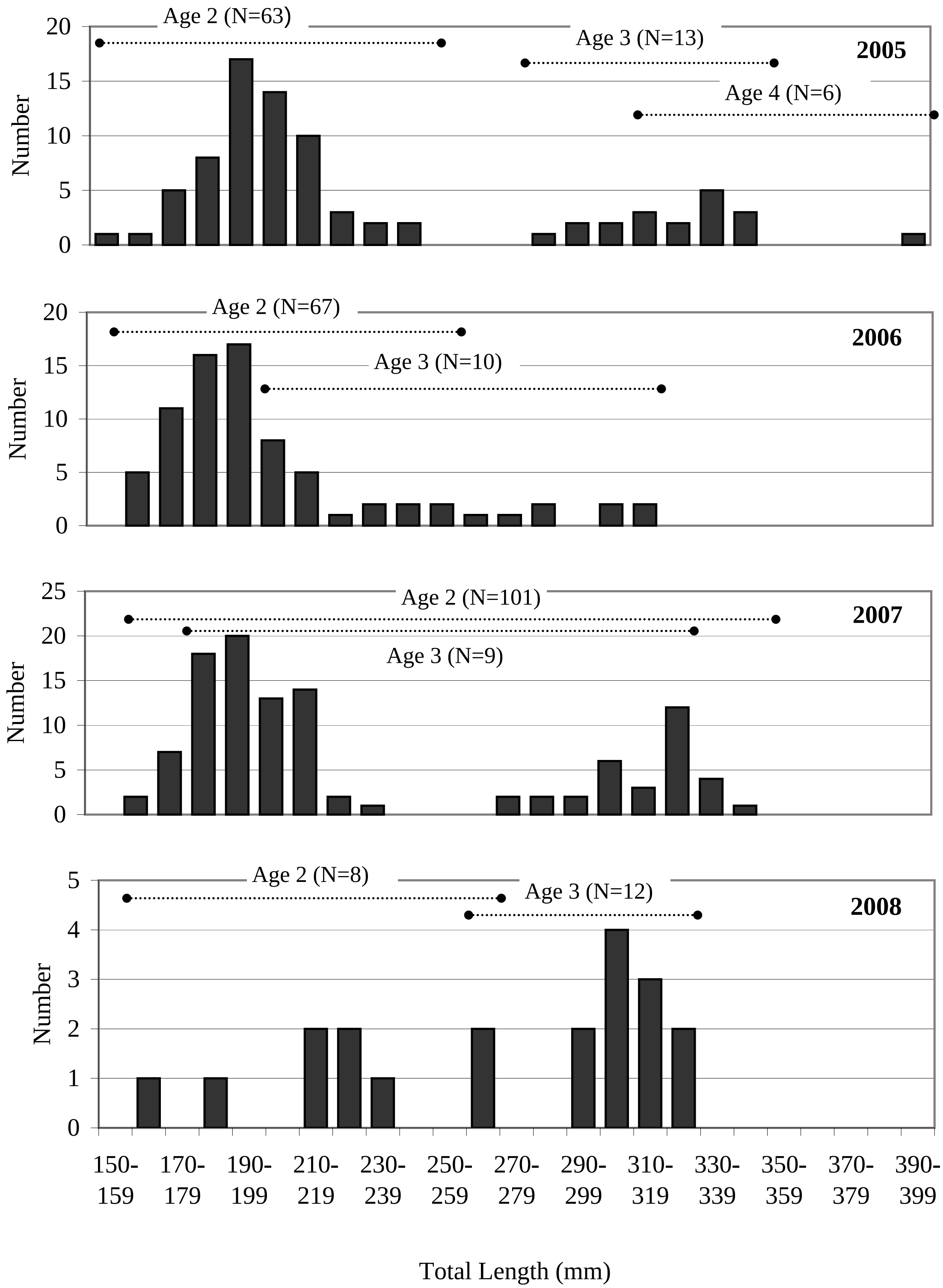
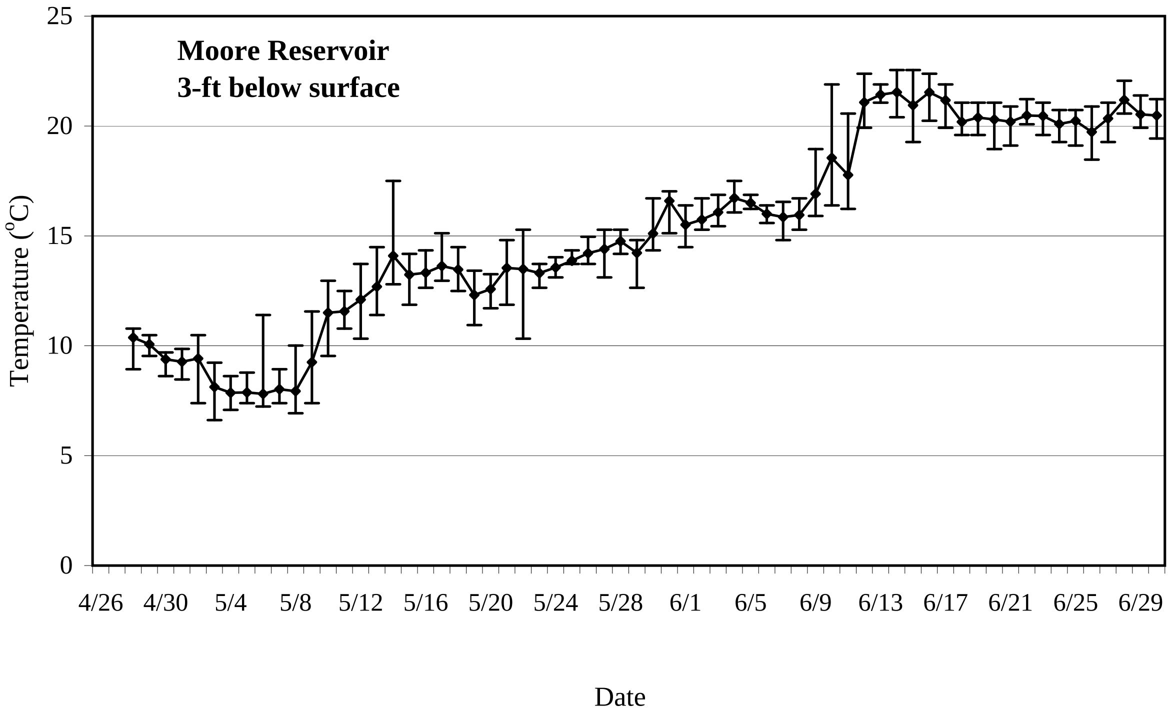


Figure 4-3. Length at age distributions for a sub-set of Atlantic salmon smolts collected at the Moore sampler during the years 2005 through 2008.



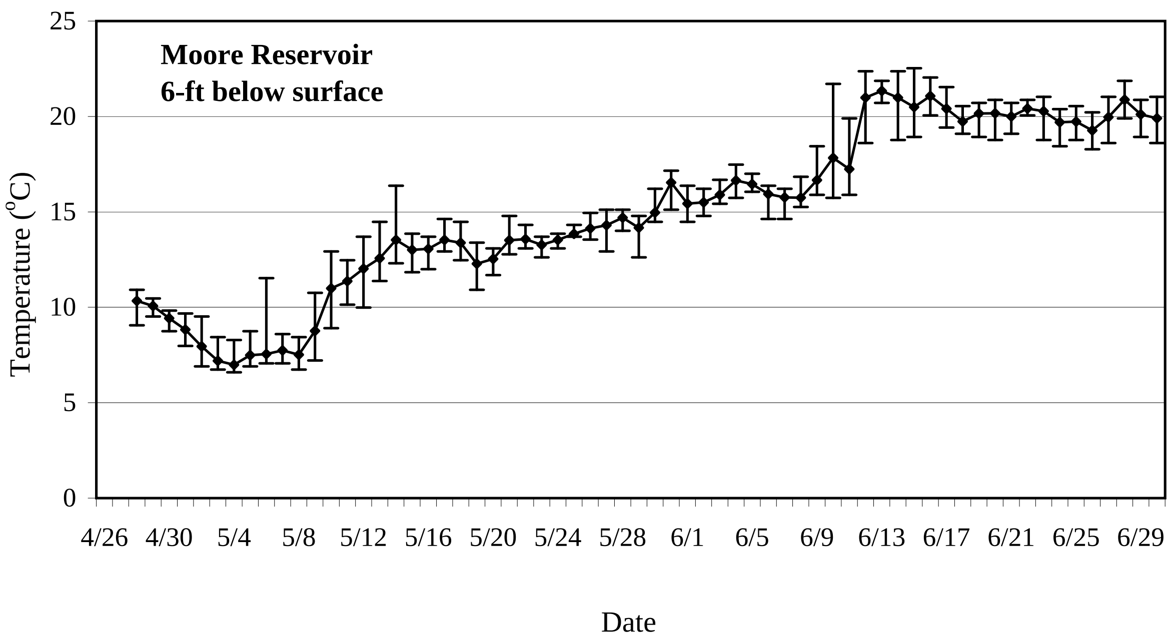


Figure 4-4. Minimum, mean, and maximum daily water temperature in the Moore Reservoir 3-ft and 6-ft below the surface (at the time of deployment) from 26 April through 30 June 2008.

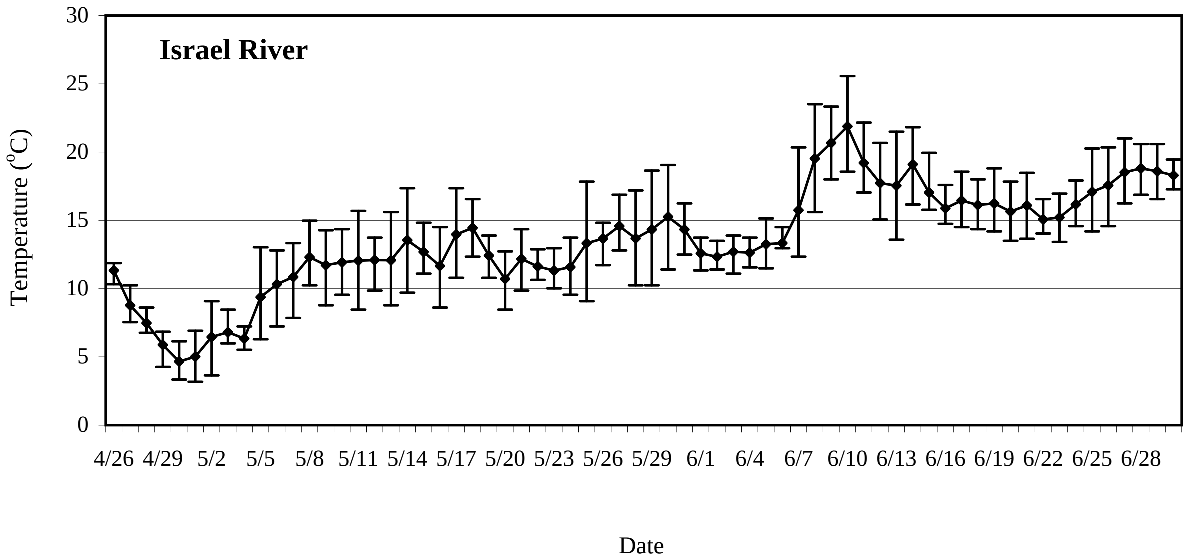


Figure 4-5. Minimum, mean, and maximum daily water temperature in the Israel River monitoring station from 26 April through 30 June 2008.

Figure 4-6. Comparison of mean daily water temperature in the Israel River monitoring station and the Moore Reservoir monitoring stations from 26 April through 30 June 2008.

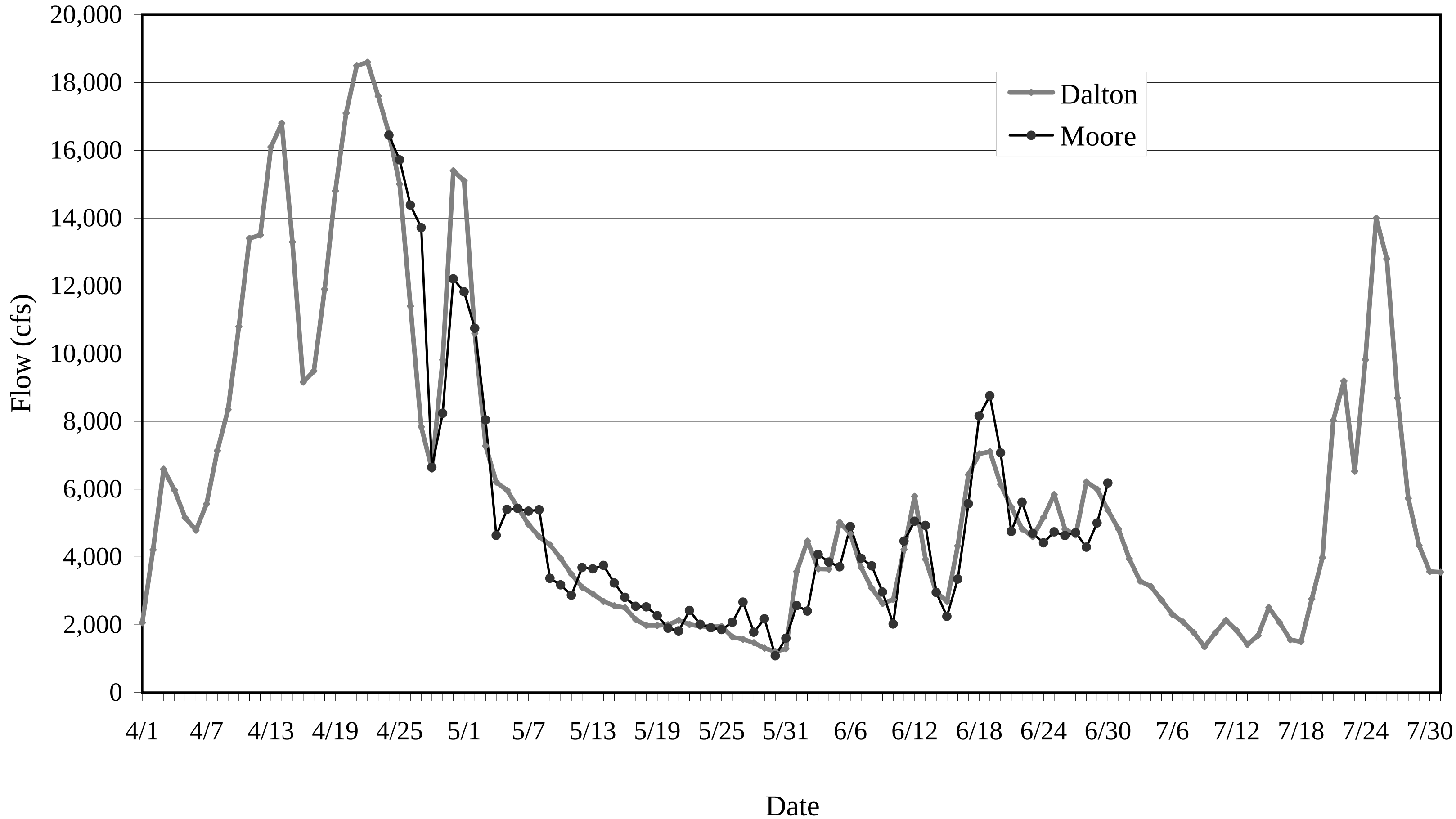


Figure 4-7. Daily average inflow (cfs) to the Moore Reservoir recorded at USGS Gauge 01131500 located at the Dalton Hydro, and outflow from the Moore Development, recorded by TransCanada, spring 2008.

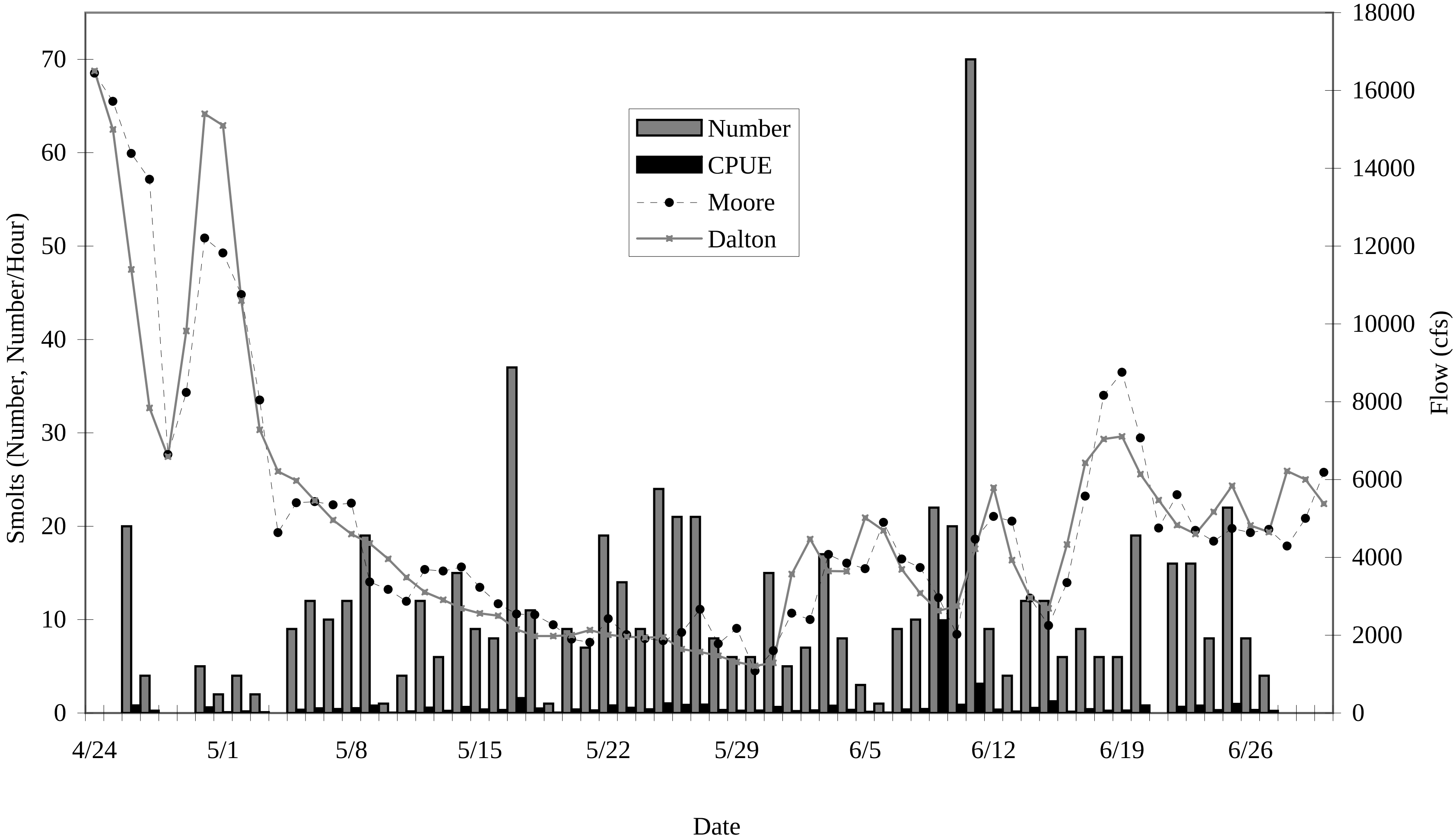


Figure 4-8. Connecticut River inflow to the Moore Development and discharge from the Moore Development compared with daily collection (number and number per hour) of Atlantic salmon smolts at the Moore sampler, spring 2008.

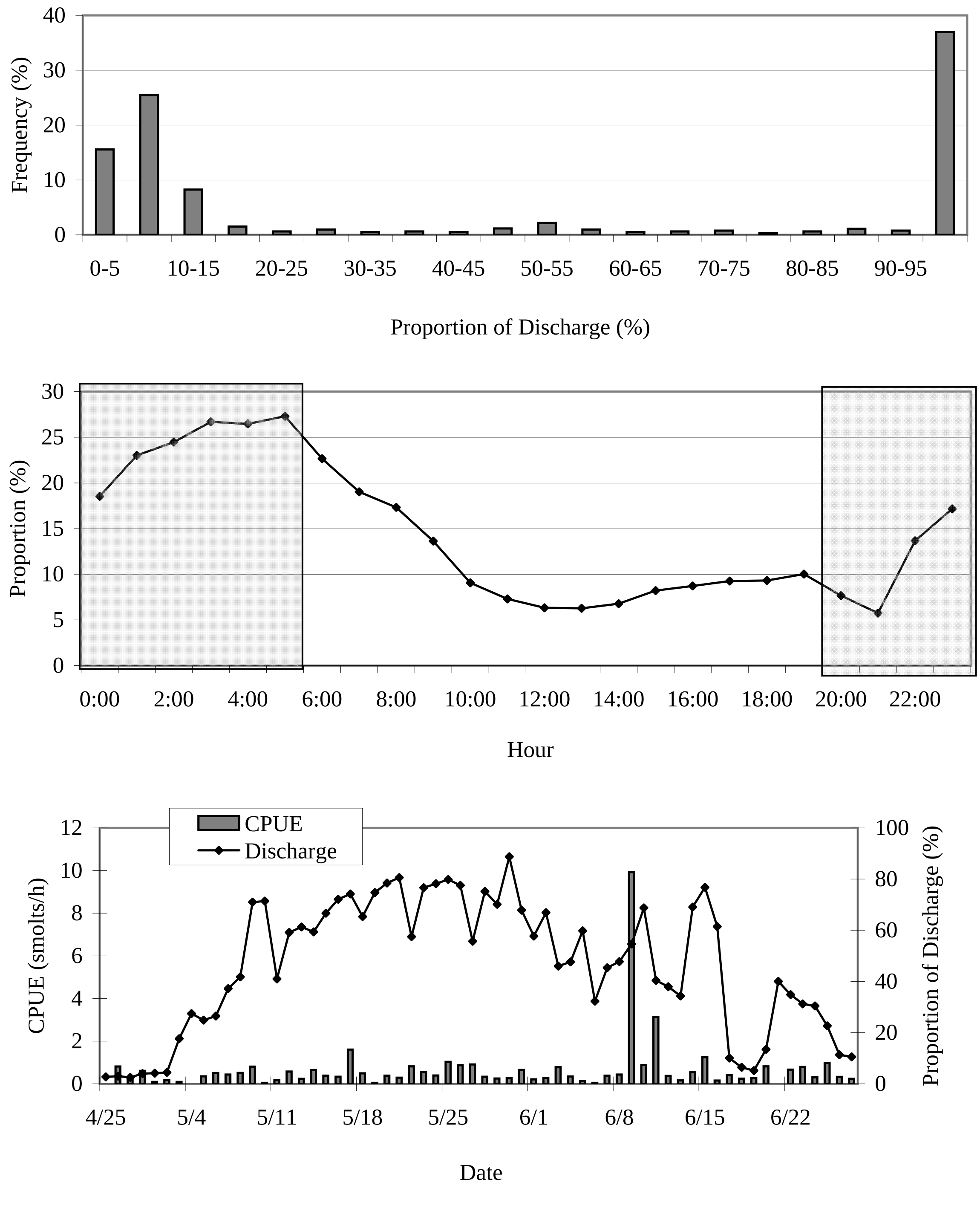


Figure 4-9. A. Frequency distribution of proportion of discharge (turbine flow + skimmer gate flow) to the skimmer gate; B. Hourly average proportion of discharge to the skimmer gate (shaded areas are approximate nighttime hours); C. Daily average proportion of discharge to the skimmer gate and daily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

Appendix Table 1. Number of Atlantic salmon smolts collected in the Moore Dam sampler during each of 128 sampling periods, spring 2008.

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	Smolts	CPUE
Day	4/25/2008	13:30	4/25/2008	14:30	1.00	0	0.00
Day and Night	4/25/2008	14:40	4/26/2008	8:30	17.83	20	1.12
Day	4/26/2008	10:10	4/26/2008	16:55	6.75	0	0.00
Day and Night	4/26/2008	17:30	4/27/2008	8:40	15.17	4	0.26
Day	4/27/2008	9:30	4/27/2008	10:30	1.00	0	0.00
Day	4/30/2008	11:30	4/30/2008	19:45	8.25	5	0.61
Night	4/30/2008	21:05	5/1/2008	5:40	8.58	0	0.00
Day	5/1/2008	6:04	5/1/2008	19:55	13.85	2	0.14
Night	5/1/2008	20:35	5/2/2008	5:41	9.10	3	0.33
Day	5/2/2008	5:50	5/2/2008	19:52	14.03	1	0.07
Night	5/2/2008	20:00	5/3/2008	5:43	9.72	2	0.21
Day	5/3/2008	7:05	5/3/2008	19:58	12.88	0	0.00
Night	5/3/2008	20:40	5/4/2008	5:35	8.92	0	0.00
Day	5/4/2008	5:50	5/4/2008	18:05	12.25	0	0.00
Day and Night	5/4/2008	18:15	5/5/2008	6:45	12.50	4	0.32
Day	5/5/2008	6:55	5/5/2008	20:00	13.08	5	0.38
Night	5/5/2008	20:10	5/6/2008	5:45	9.58	11	1.15
Day	5/6/2008	6:00	5/6/2008	20:18	14.30	1	0.07
Night	5/6/2008	20:32	5/7/2008	5:45	9.22	4	0.43
Day	5/7/2008	6:25	5/7/2008	20:12	13.78	6	0.44
Night	5/7/2008	20:25	5/8/2008	5:45	9.33	7	0.75
Day	5/8/2008	6:05	5/8/2008	20:05	14.00	5	0.36
Night	5/8/2008	20:27	5/9/2008	5:40	9.22	8	0.87
Day	5/9/2008	5:50	5/9/2008	20:15	14.42	11	0.76
Night	5/9/2008	20:32	5/10/2008	5:42	9.17	0	0.00
Day	5/10/2008	6:10	5/10/2008	13:10	7.00	1	0.14
Day	5/10/2008	13:35	5/10/2008	20:00	6.42	0	0.00
Night	5/10/2008	20:35	5/11/2008	5:38	9.05	3	0.33
Day	5/11/2008	6:05	5/11/2008	12:52	6.78	1	0.15
Day	5/11/2008	13:19	5/11/2008	20:20	7.02	0	0.00
Night	5/11/2008	20:35	5/12/2008	5:50	9.25	8	0.86
Day	5/12/2008	6:26	5/12/2008	12:30	6.07	4	0.66
Day	5/12/2008	12:50	5/12/2008	18:25	5.58	0	0.00
Day and Night	5/12/2008	18:35	5/13/2008	5:45	11.17	3	0.27
Day	5/13/2008	5:57	5/13/2008	12:39	6.70	3	0.45
Day	5/13/2008	12:50	5/13/2008	20:18	7.47	0	0.00
Night	5/13/2008	20:33	5/14/2008	5:47	9.23	4	0.43
Day	5/14/2008	5:57	5/14/2008	12:59	7.03	2	0.28
Day	5/14/2008	13:10	5/14/2008	20:10	7.00	9	1.29
Day and Night	5/14/2008	20:25	5/15/2008	5:54	9.48	8	0.84
Day	5/15/2008	6:01	5/15/2008	12:50	6.82	1	0.15
Day	5/15/2008	13:00	5/15/2008	20:05	7.08	0	0.00
Night	5/15/2008	20:15	5/16/2008	5:40	9.42	3	0.32

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	Smolts	CPUE
Day	5/16/2008	5:53	5/16/2008	20:34	14.68	5	0.34
Night	5/16/2008	20:44	5/17/2008	5:48	9.07	5	0.55
Day	5/17/2008	6:01	5/17/2008	20:00	13.98	32	2.29
Day and Night	5/17/2008	20:20	5/18/2008	5:50	9.50	1	0.11
Day	5/18/2008	6:00	5/18/2008	18:55	12.92	10	0.77
Day and Night	5/18/2008	19:28	5/19/2008	5:40	10.20	1	0.10
Day	5/19/2008	6:50	5/19/2008	19:50	13.00	0	0.00
Day and Night	5/19/2008	20:06	5/20/2008	6:09	10.05	9	0.90
Day	5/20/2008	6:20	5/20/2008	19:35	13.25	0	0.00
Day and Night	5/20/2008	19:45	5/21/2008	6:18	10.55	6	0.57
Day	5/21/2008	6:28	5/21/2008	20:23	13.92	1	0.07
Day and Night	5/21/2008	20:30	5/22/2008	6:07	9.62	16	1.66
Day	5/22/2008	6:20	5/22/2008	20:00	13.67	3	0.22
Day and Night	5/22/2008	20:05	5/23/2008	5:55	9.83	9	0.92
Day and Night	5/23/2008	6:00	5/23/2008	21:11	15.18	5	0.33
Day and Night	5/23/2008	21:25	5/24/2008	5:55	8.50	4	0.47
Day and Night	5/24/2008	6:15	5/24/2008	20:40	14.42	5	0.35
Night	5/24/2008	20:55	5/25/2008	5:40	8.75	14	1.60
Day	5/25/2008	5:55	5/25/2008	20:25	14.50	10	0.69
Day and Night	5/25/2008	20:35	5/26/2008	5:55	9.33	14	1.50
Day and Night	5/26/2008	6:08	5/26/2008	20:50	14.70	7	0.48
Day and Night	5/26/2008	21:00	5/27/2008	6:20	9.33	11	1.18
Day	5/27/2008	6:35	5/27/2008	20:20	13.75	10	0.73
Night	5/27/2008	20:30	5/28/2008	5:08	8.63	7	0.81
Day	5/28/2008	5:20	5/28/2008	20:50	15.50	1	0.06
Day and Night	5/28/2008	21:00	5/29/2008	5:48	8.80	3	0.34
Day and Night	5/29/2008	6:00	5/29/2008	20:58	14.97	3	0.20
Day and Night	5/29/2008	21:05	5/30/2008	5:58	8.88	6	0.68
Day	5/30/2008	6:30	5/30/2008	12:55	6.42	0	0.00
Day	5/30/2008	13:15	5/30/2008	21:00	7.75	0	0.00
Day and Night	5/30/2008	21:10	5/31/2008	5:50	8.67	14	1.62
Day	5/31/2008	6:05	5/31/2008	20:26	14.35	1	0.07
Day and Night	5/31/2008	20:36	6/1/2008	5:40	9.07	3	0.33
Day	6/1/2008	5:50	6/1/2008	20:30	14.67	2	0.14
Day and Night	6/1/2008	20:40	6/2/2008	6:00	9.33	7	0.75
Day and Night	6/2/2008	6:10	6/2/2008	21:50	15.67	0	0.00
Day and Night	6/2/2008	22:05	6/3/2008	6:10	8.08	13	1.61
Day	6/3/2008	6:20	6/3/2008	20:00	13.67	4	0.29
Day and Night	6/3/2008	20:10	6/4/2008	5:50	9.67	8	0.83
Day	6/4/2008	6:05	6/4/2008	19:37	13.53	0	0.00
Day and Night	6/4/2008	19:45	6/5/2008	5:50	10.08	3	0.30
Day	6/5/2008	6:05	6/5/2008	19:40	13.58	0	0.00
Day and Night	6/5/2008	20:00	6/6/2008	5:55	9.92	1	0.10
Day	6/6/2008	6:10	6/6/2008	19:25	13.25	0	0.00
Day and Night	6/6/2008	19:35	6/7/2008	5:48	10.22	9	0.88

Sampling Period	Set Date	Set Time	End Date	End Time	Effort (h)	Smolts	CPUE
Day	6/7/2008	6:05	6/7/2008	14:20	8.25	0	0.00
Day	6/7/2008	14:30	6/7/2008	19:35	5.08	0	0.00
Day and Night	6/7/2008	19:40	6/8/2008	5:48	10.13	6	0.59
Day	6/8/2008	6:00	6/8/2008	18:50	12.83	4	0.31
Day and Night	6/8/2008	19:02	6/9/2008	21:15	2.22	22	9.92
Day and Night	6/9/2008	21:25	6/10/2008	6:00	8.58	20	2.33
Day	6/10/2008	6:20	6/10/2008	20:25	14.08	0	0.00
Day and Night	6/10/2008	20:35	6/11/2008	5:49	9.23	21	2.27
Day	6/11/2008	6:10	6/11/2008	19:15	13.08	49	3.75
Day and Night	6/11/2008	19:30	6/12/2008	6:05	10.58	9	0.85
Day	6/12/2008	6:25	6/12/2008	20:15	13.83	0	0.00
Day and Night	6/12/2008	20:30	6/13/2008	6:30	10.00	4	0.40
Day and Night	6/13/2008	6:45	6/13/2008	21:30	14.75	0	0.00
Day and Night	6/13/2008	21:40	6/14/2008	5:50	8.17	12	1.47
Day	6/14/2008	6:00	6/14/2008	20:00	14.00	0	0.00
Day and Night	6/14/2008	20:15	6/15/2008	5:50	9.58	12	1.25
Day and Night	6/15/2008	6:10	6/16/2008	5:50	23.67	6	0.25
Day and Night	6/16/2008	6:10	6/16/2008	21:25	15.25	0	0.00
Day and Night	6/16/2008	21:40	6/17/2008	5:55	8.25	5	0.61
Day	6/17/2008	6:15	6/17/2008	19:50	13.58	4	0.29
Day and Night	6/17/2008	20:00	6/18/2008	7:15	11.25	4	0.36
Day	6/18/2008	7:20	6/18/2008	20:35	13.25	2	0.15
Day and Night	6/18/2008	20:55	6/19/2008	6:20	9.42	6	0.64
Day	6/19/2008	6:35	6/19/2008	20:00	13.42	0	0.00
Day and Night	6/19/2008	20:15	6/20/2008	6:15	10.00	19	1.90
Day	6/20/2008	6:30	6/20/2008	19:40	13.17	0	0.00
Day and Night	6/20/2008	20:00	6/21/2008	6:00	10.00	0	0.00
Day	6/21/2008	7:30	6/21/2008	20:05	12.58	0	0.00
Day and Night	6/21/2008	20:15	6/22/2008	5:45	9.50	16	1.68
Day	6/22/2008	6:00	6/22/2008	20:37	14.62	0	0.00
Day and Night	6/22/2008	20:50	6/23/2008	5:50	9.00	16	1.78
Day	6/23/2008	6:05	6/23/2008	17:15	11.17	0	0.00
Day and Night	6/23/2008	17:30	6/24/2008	5:55	12.42	7	0.56
Day	6/24/2008	6:10	6/24/2008	20:00	13.83	1	0.07
Day and Night	6/24/2008	20:20	6/25/2008	7:00	10.67	6	0.56
Day	6/25/2008	7:15	6/25/2008	19:00	11.75	16	1.36
Day and Night	6/25/2008	19:25	6/26/2008	5:47	10.37	8	0.77
Day	6/26/2008	6:15	6/26/2008	20:15	14.00	0	0.00
Day and Night	6/26/2008	20:20	6/27/2008	6:35	10.25	4	0.39
Day	6/27/2008	6:55	6/27/2008	13:30	6.58	0	0.00