Assessment of the 2009 West River, Sheet Harbour Atlantic salmon smolt migration

Photo: E.A. Halfyard

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EXECUTIVE SUMMARY

In response to the issue of acid precipitation, the Nova Scotia Salmon Association initiated an acid rain mitigation program on the West River, Sheet Harbour. This program uses an automated lime doser to buffer the acid waters of this once prolific salmon river. In addition to the mitigation activities on this system, the NSSA also began a monitoring program to assess the rivers salmon smolt production and indirectly the effects of the liming program. This report summarizes the activities from the 2009 salmon smolt monitoring programs.

Salmon were sampled from April 28th to May 26th at two sites, the main branch West River Sheet Harbour and the Little River, a tributary of the West. A rotary screw trap (smolt wheel) was used to sample the main branch and a fyke net were used to sample the Little River. A total of 217 salmon smolts were captured in the smolt wheel and an additional 93 smolts were captured in the fyke net. The mean length of smolts from the smolt wheel and fyke net was 17.3 cm and 16.8 cm, respectively.

Using a stratified mark recapture, the total emigration of salmon smolts from the area above the smolt wheel was estimated at 1889 smolts with 95% confidence intervals of (1673, 2105). The number of smolts that emigrated from the Little River was estimated at 558 smolts with 95% confidence intervals of (467, 649). The estimate for the smolt wheel is lower than the estimates from both 2007 (2441, 95% CI 1452, 3431) and 2008 (2796, 95% CI 1389, 4204). The estimate for the Little River fyke net was lower than the 2007 estimate of 1035 (95% CI 948, 1122). No estimate was made for the Little River in 2008.

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INTRODUCTION

The West River, Sheet Harbour (WRSH), a once prolific salmon river, has been acidified by acid precipitation. In 2005, a lime doser was installed by the Nova Scotia Salmon Association to increase the river waters pH. Since start-up, the lime doser has buffered the acidity of the water to the target pH of 5.5, deemed sufficiently high to prevent acid-related hindrance of salmon production. While electrofishing survey activity has remained relatively constant on this river in recent history, adult abundance estimates via catch data has been lost since the closure of the sport fishery in 1999.

As changes in the river's production capacity are expected to coincide with the acid mitigation project, some estimate of smolt abundance is crucial to assessing the impact of the lime doser.

The WRSH can be divided into three main areas:

Main West River, Sheet Harbour

The Main WRSH red solid oval – Figure 1) is a tannic-stained water, highly deforested, flash-flood prone river. A natural barrier is located some 30000m above the head of tide. The lime doser was installed some 600m above this barrier. There are two, large lake-like pools on the system, the uppermost being River Lake at roughly 0.5 km^3 and the lower, Sheet Harbour lake, at roughly 1.2 km^3. Figure 1 shows the Main West River, Sheet Harbour sampling sites. The solid red oval in figure 1 shows the approximate area of the main river from which smolts were collected by rotary screw trap (smolt wheel), as denoted by SW.

The Killag River

The Killag River (blue solid oval – Figure 1) is the major tributary to WRSH. According to local knowledge, the majority of salmon spawned in this part of the system. The Killag has a rather long and narrow drainage basin, with a main channel length of approximately 27000m. This system is also organic-acid stained. The area in figure 1 surrounded by the solid blue line approximately denotes the section of the Killag river from which the smolt wheel collects smolts.

Little River

The Little River is the second largest tributary of WRSH, also traditionally supporting a large portion of the salmon spawning and rearing habitat. The Little River has a main channel of approximately 16500m. This system is anchored at the headwaters by Lake Alma, a large, shallow impounded lake. This system is relatively clear and historically has been only episodically acidic. Figure 1 shows Little River sampling sites. The dashed blue line in figure 1 shows the approximate area of the Little River from which smolts were collected by fyke nets (location denoted by FN).

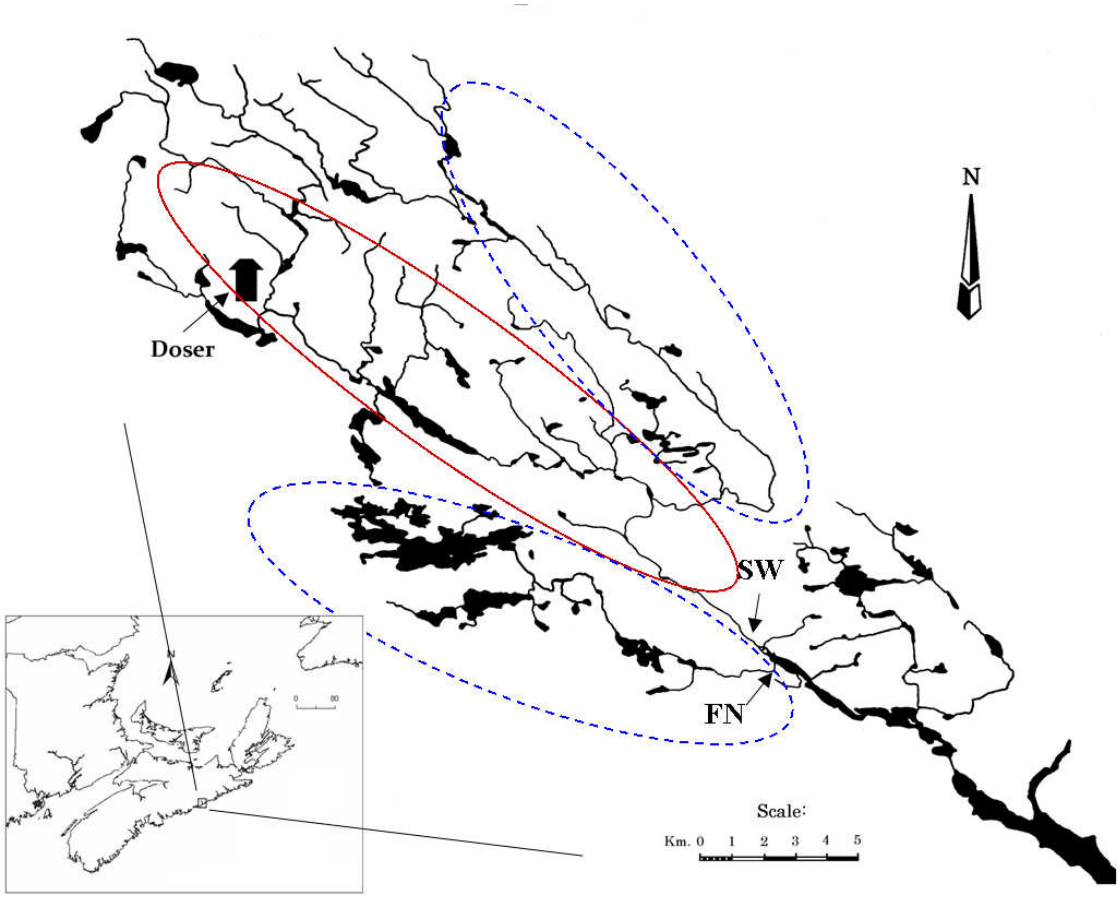

Figure 1 – Map of West River, Sheet Harbour and Nova Scotia indicating the positions of the smolt wheel (SW), fyke nets (FN) and lime doser (Doser). The river section in the solid (red) oval is a treated section of the main branch, WRSH and the two dotted (blue) ovals represent the Killag River (Northern-most oval) and the Little River (Southern-most oval). The smolt wheel samples the main branch WRSH and the Killag River while the fyke nets sample only the Little River.

METHODS

Rotary Screw Trap Installation and Operation

The rotary screw trap (smolt wheel) was installed and operational April 28th, 2009 in Iron Bridge pool, main branch West River, Sheet Harbour. Deflectors of 1.22m by 2.43m by 1.3 cm plywood were installed and anchored with 2.5cm steel rebar to form a north and south wall. A single sheet of plywood was deployed on each side of the smolt wheel or the duration of the project.

Fyke Net Installation/ Operation

A single Fyke net was installed in Little River April 28th, 2009. The fyke net was similar to those described in 2008 (Halfyard and Hastey 2008) to include a catch box which was attached to the bag of the fyke net to collect and hold fish. It's primary purpose was to provide a reduced flow environment for the captured fish, thus reducing stress and the likelihood of injury. The catch box had a flat plywood front with a 15.24cm pipe where the fyke net attached and the fish entered through. Three rectangular water escape holes (approx. 30cm by 25cm) were cut in the remaining sides and covered with galvanized wire mesh (1.25 cm) allowing for the flow through of water at a controlled rate. The boxes were weighed down with four (30.5cmx30.5cm) cement patio blocks placed on the inside and excess space was packed tight with gravel. The box was anchored in place with steel rebar and large rocks around the outside edges.

The fyke net bag was attached to the catch box with a stainless steel hose clamp and two plastic zip-ties. One of the zip-tie was used to pull back and secure any excess net around the entrance of the pipe that would cause the net to budge out and collect debris potentially blocking the pipe entrance. The second pull-tie was used to close off fyke net bag at the pipe entrance preventing fish from swimming out of the catch box back into fyke net bag.

The most efficient method for cleaning the wings of the fyke net while keeping it attached to the catch box was to remove one arm at a time from the rebar, clean it off and then replace. Only in high flows when a large amount of debris was captured in the fyke net did the bag have to be removed from the catch box.

Catch Monitoring, Sampling and Marking

Each morning, fish were emptied from the holding bin/nets, identified to species and counted. For salmon smolts, as random subset of fish were measured for fork length. Also, salmon smolts were examined for marks used in the efficiency tests, generally either an anal fin clip or a pelvic fin clip. Scale samples were taken on a random sample of fish, and ages were back-calculated via the Fraser-Lee equation (Murphy and Willis 1996).

Hydrological / Physical Monitoring

Two Hobo – Onset pendant temperature loggers were deployed at the start of the project at each of the two capture sites. Temperature was recorded every hour. A staff gauge located at the lime doser was read at the start of the day (0700h) and the water level recorded. This staff gauge is used as a proxy for hydrologic conditions across the system.

Salmon Smolt Yield Estimates

The statistical design adopted for this study was that of simple stratified design, implementing a Chapman-modified Petersen (Ricker 1975, Carlson et al. 1998, Volkhardt et al. 2007).

Using the smolt mark recapture data, information can be arranged so that;

h = Stratum index
L = Number of strata
U_h = Smolt population estimate for strata h
Mh = Number of smolts marked and released in strata h
mh = Number of marked smolts recaptured in strata h
uh = Number of unmarked smolts captured in strata h
N = Smolt estimate for entire study period

These variables are then plugged into the following equations;

Equation 1 - Single strata estimator

$$\tilde{U}_h = \tilde{N}_h — M_h = \frac{u_h (M_h+1)}{m_h+1}$$

Equation 2 – Single strata variance

$$\tilde{V}(\tilde{U}_h) = \frac{(M_h+1)(u_h+m_h+1)(M_h-m_h)u_h}{(m_h+1)^2 (m_h+2)}$$

Equation 3 – Overall estimator

$$N = \sum_{h=1}^{L} \tilde{U}_h$$

Equation 4 – Overall variance

$$v(N) = \sum_{h=1}^{L} v(\tilde{U}_h)$$

Equation 5 – 95% Confidence intervals for overall estimator

$$95\%\ CI = \tilde{U} \pm 1.96\sqrt{v(N)}$$

RESULTS

Hydrological / Physical Monitoring and Trap / Net Operation

Water height, as measured by the staff gauge at the lime doser (main branch, WRSH) was at its lowest on May 17th, and again on the 27th and reached its maximum height on May 7th. Two obvious rain event occurred, the first and largest of which occurred on May 6th/7th and the second on May 18th/19th (Figure 2), neither of which were as destructive as the floods of 2008 (see Halfyard and Hastey 2008). Median water height was 1.35m (S.E. = 0.01), which was again lower than that of 2007 (median = 1.38m, S.E. = 0.03) and 2008 (median = 1.45m, S.E. = 0.02).

The smolt wheel drum operated at acceptable but low RPM across most of the sampling period (Median= 4.4, S.E.= 0.3), however there were two periods where low flow contributed to low wheel RPM (May 15 to 18, post May 24)(Figure 2).

Mean daily temperature exhibited a relatively steady increase over the sampling period with anticipated diel fluctuations. At the time the loggers were set in place (April 28th), daily high temperature was already exceeding 10ºC at both the Little River and Smolt Wheel sites (Figures 3 and 4).

Smolt Catch

In total, 217 unique smolts were captured in the smolt wheel and an additional 93 smolts were captured in the Little River fyke nets. Of the 217 total smolt captures in the rotary screw trap, 169 or 77 % were captured between May 9th and May 20th (Figure 3). Only a few smolts were captured in the smolt wheel prior to May 5th (N=12 or 6% of total catch).

In the Little River fyke net, 77 of the 93 captured smolts (77%) were captured prior to May 5th. Furthermore, a total of 8 smolts were captured on the first day that the nets were fished (April 28th) and therefore a portion of the smolt run may have been missed (Figure 4).

Salmon Smolt Yield Estimates

Smolt Wheel

The 2008 estimate of smolts from the Main Branch WRSH + Killag River (i.e.. everything above the smolt wheel) was 1889 smolts with 95% confidence intervals of

(1673, 2105). This estimate is considered moderately good as only one days-worth of smolt collection data were partially missing due to a log jam in the trap (May 15th) although this did affect our efficiency trials. This total estimate used two estimates of efficiency which had a mean efficiency of 9.1%. A third estimate was attempted in the middle of the study, however the log jam allowed marked fish to potentially escape unnoticed.

Little River

Unlike the 2008 season, we were able to catch enough smolts from the Little River to facilitate and estimate. We estimated that a total of 558 smolts left the system in 2009 with 95% confidence intervals of (467, 649). Catches were however low enough (N=93) that were able to determine efficiency on only one occasion (strata) and as such the period in which the fyke nets were fished in the Little River was considered a single strata and thus a single efficiency test was extrapolated across all captures.

. Our single strata estimate was approximately 14%. This number may be unreliable due to the low number of smolts used for the efficiency (N=35) and the low number of returns (N=5). This efficiency is dramatically lower than the efficiency obtained in 2007 (approx. 93%), however two nets were used that year.

Smolt Length and Weight

Of the smolts captured in the smolt wheel, 122 were measured for fork length. The mean length was 17.3 cm (S.E.=0.17) (Figure 5). This is smaller to last years mean of 18.4 cm (N=189).

Similarly, of the smolts captured in the Little River, 68 were measured with a mean length of 16.8 cm (S.E.=0.11) (Figure 5). This again is smaller than last years mean length of 18.4 cm (N=25).

The smallest smolt captured was 13.8 cm (Little River) and the largest was 26.9 cm (Smolt Wheel).

Other Fish Species

In the smolt wheel, a total of 140 brook trout, 191 white suckers, 73 yellow perch, 40 American eel and 48 lake chub were captured. In the Little River fyke nets, a total of 84 brook trout, 248 white suckers, 558 yellow perch, 34 American eels, 6 Lake chub and 10 brown bullhead were captured (Table 1). In the Little River, the number of yellow perch was only a small fraction of that captured in 2008 (N=2226). Again, as in 2009, the average size of the yellow perch captured was estimated to be in the 10-12 cm range. Many of the brook trout appeared to be anadromous fish on their downstream migration to the estuary as confirmed by our pilot acoustic telemetry study.

DISCUSSION/RECOMMENDATIONS

Salmon smolt yield estimate

Because of the relationship between trap efficiency and relative error (as summarized in figure 1 of Carlson et al 1998), the sample size required to give a reasonable alpha of 0.05 is rather large. Given that the entire smolt emigration is small, the error around our estimate is rather large and thus our confidence is accordingly low. This is an unfortunate effect of small population size and will be a reality of the project in the future.

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APPENDIX

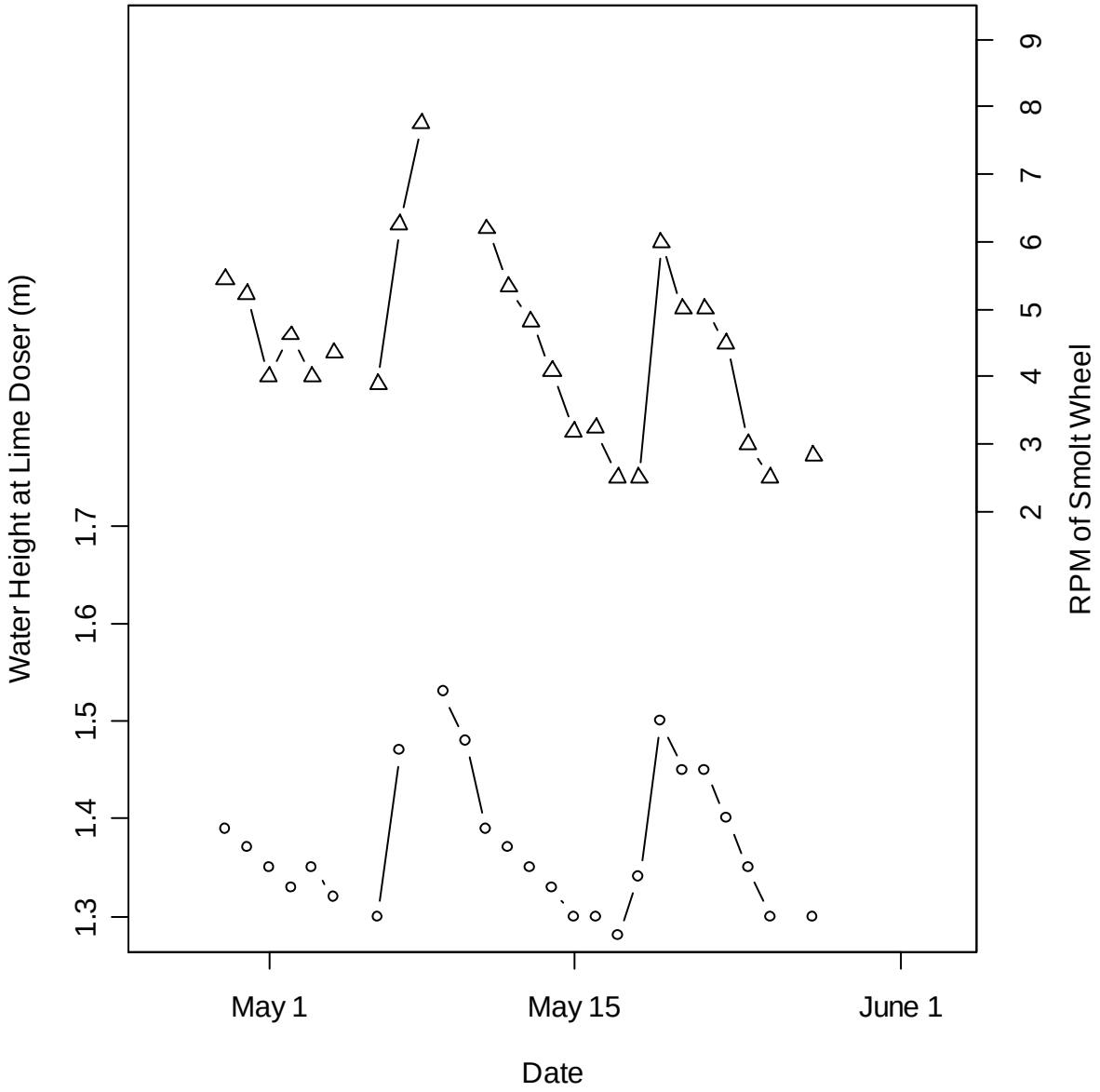

Figure 2 – Water height (m) at lime doser staff gauge (round points) and the associated RPM of the smolt wheel drum (triangle points).

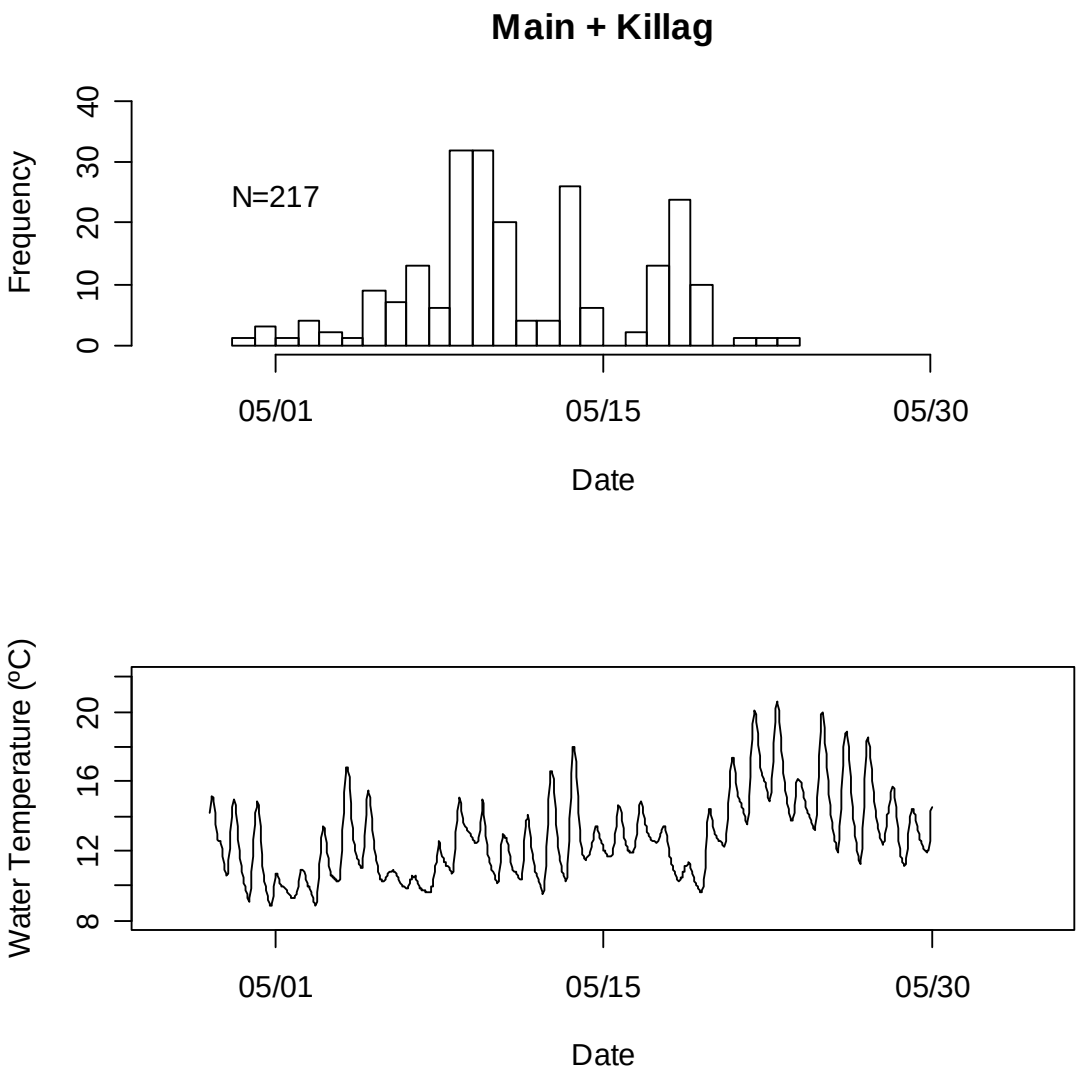

Figure 3 - Smolt catch (# of smolts) and water temperature (ºC) for the rotary screw trap set on the main branch, West River, Sheet Harbour.

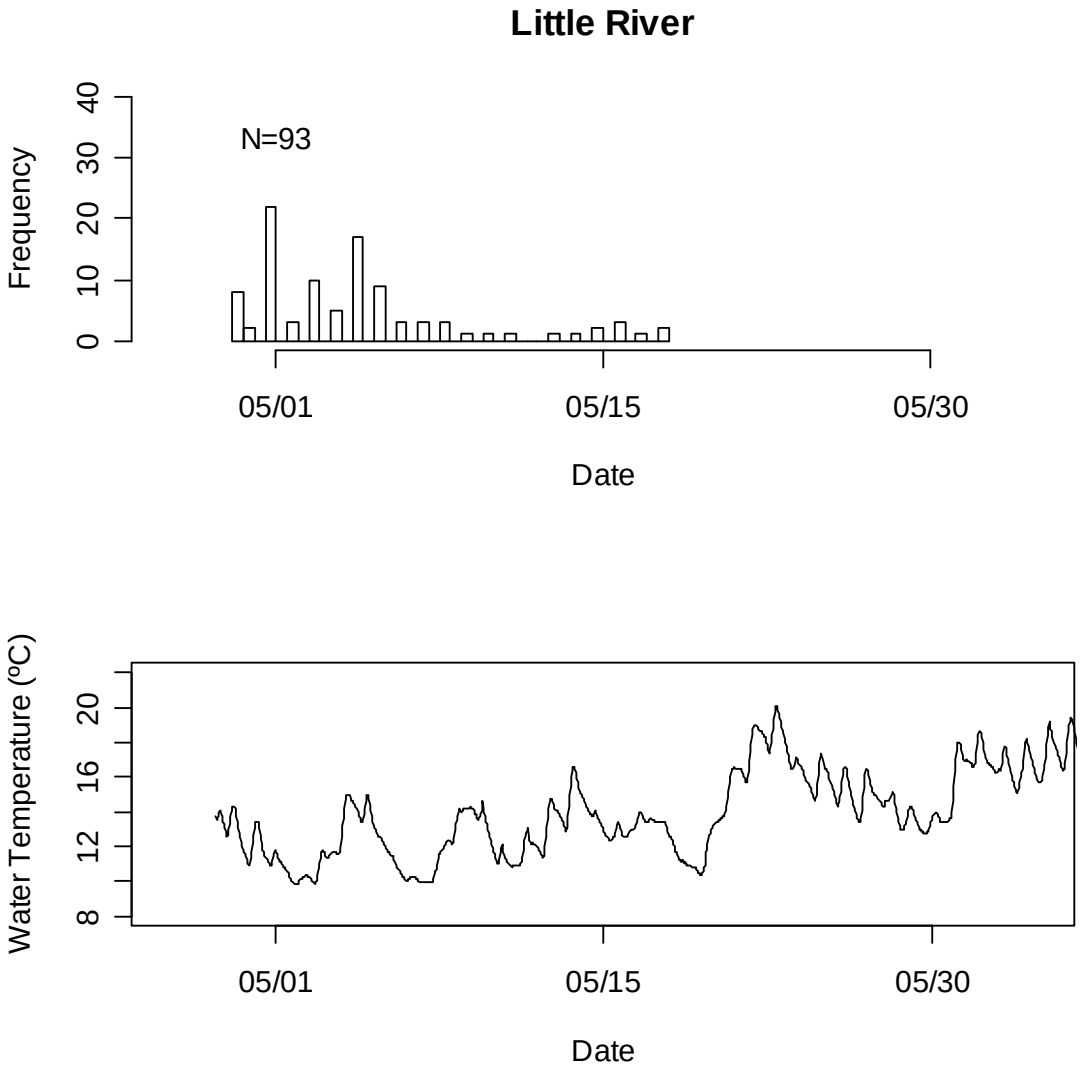

Figure 4 – Smolt catch (# of smolts) and water temperature (ºC) for the fyke nets set on the Little River.

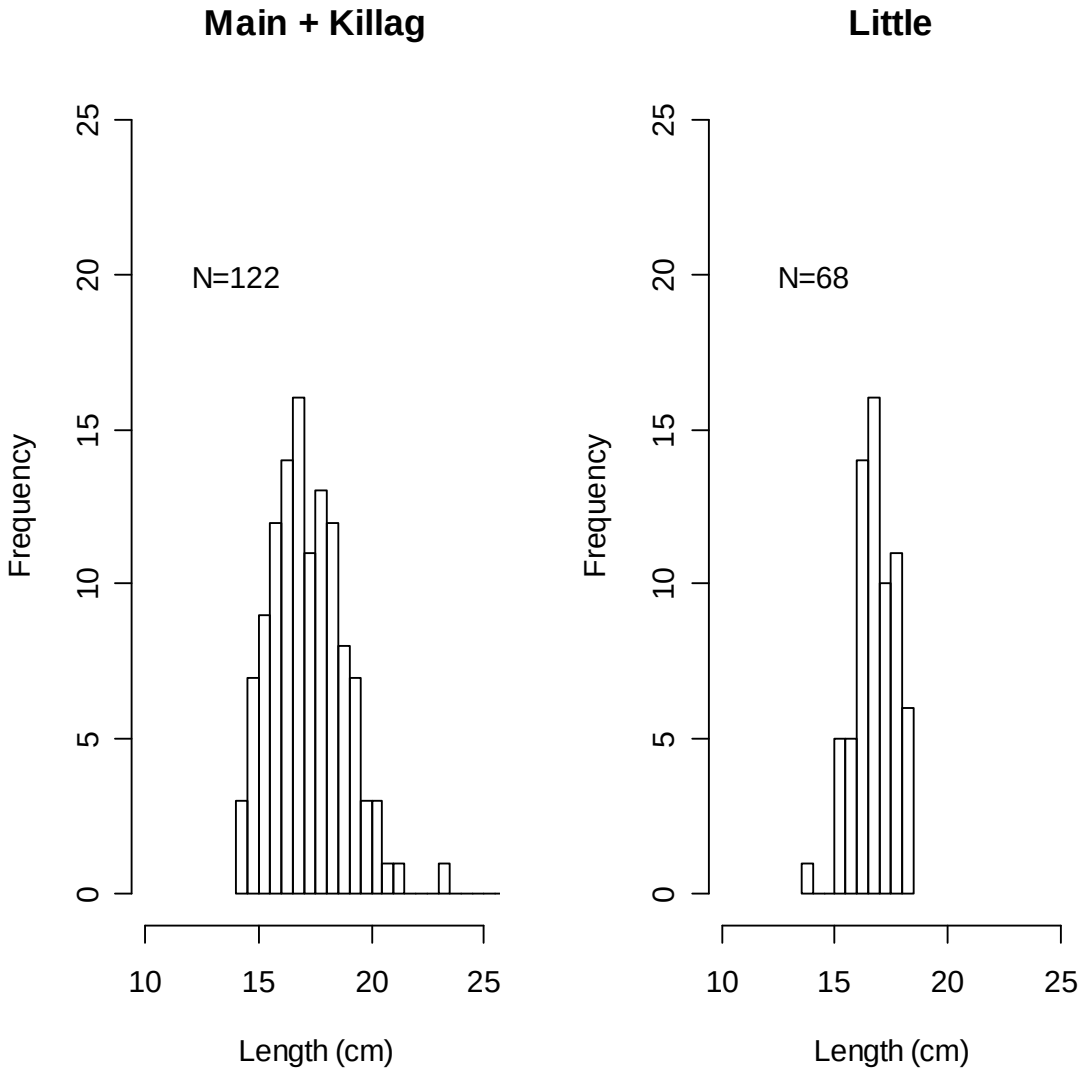

Figure 5 – Fork length histograms for smolts captured in the smolt wheel (Main River + Killag River) and the fyke nets (Little River). Length categories represent 0.5 cm intervals.

Figure 6 - G. Ferguson (background) and E. A. Halfyard (foreground) removing fish from holding bin of smolt wheel 2009. Photo: Al McNeill

Figure 7 - Fyke net deployment on Little River. Note plywood holding bin attached to "cod" end of net. Photo: Al McNeill

Species	Smolt Wheel (Main WRSH + Killag River)	Fyke Net (Little River)
Atlantic Salmon Smolts	217	93
Atlantic Salmon Parr	8	6
Brook Trout	140	84
White Sucker	191	248
Yellow Perch	73	558*
American Eel	40	34
Lake Chub	48	6
Brown Bullhead	2	10

Table 1 – Total captures of all species at both sites from April 27^{8h} to May 26th 2009.
* On two occasions yellow perch were not counted due to high numbers – a value of 50 was arbitrarily assigned on both occasions.
In addition, 2 golden shiners and a banded killifish were positively identified in the Smolt Wheel. Also, 2 golden shiners and 2 creek chub were captured in the Little River fyke net.