An Assessment of the Effectiveness of the Fish Diversion Screen at Trout River Lake, Nova Scotia

1996 Final Report
to
Nova Scotia Power Inc.

prepared by

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December, 1996

ACER Publication No. 42

EXECUTIVE SUMMARY

The purpose of this project was to investigate the effectiveness of the fish diversion screen at Trout River Lake in diverting young-of-the-year alewives moving downstream from Trout River Lake into the upper Gaspereau River via Trout River. Zooplankton nets were used to capture young alewives in the vicinity of the screen on 20 days between July 5 and August 29, 1996. Nets were deployed on 573 occasions resulting in the capture of 2028 juveniles, 59 larvae and 46 eggs.

Eggs were only captured on July 8 but may have been missed early in the study while we experimented with methodologies. While the number of eggs captured was low, because the ratio of the volume sampled by the net to the volume of the discharge through the screen is very small, this catch may be an indication that early in the study, eggs were passing through the screen at a rate of over 400,000 per day. Larval alewives were captured between July 8 and July 25. During this period the rate of larval passage through the screen ranged between 0 and 245,000 larvae per day (mean ≈ 8,000 larvae per day).

Comparisons of catches upstream of the 1/4 inch mesh panels, upstream of the 1/8 inch panels, downstream of the 1/4 inch mesh panels, downstream of the 1/8 inch panels and in the bypass stream indicate that the 1/4 inch mesh probably does not act as a barrier for larval alewives, the 1/8 inch mesh acts as a semipermeable barrier and that larval alewives, which have low mobility relative to the currents, have difficulty locating the bypass in its current location.

Similar comparisons for juvenile alewives indicate that both meshes act as a barrier and the effectiveness of this barrier increases with increased fish size. Juveniles are more mobile than larvae and appear better able to locate the bypass.

Larval and small juvenile alewives were found impinged on the 1/8 inch mesh, although impingement on the 1/4 inch mesh did not appear significant. Larvae apparently pass through the larger mesh and larger juveniles appear to be strong enough swimmers to avoid impingement on the screen.

Results of surveys at the end of August indicate that large numbers of juvenile alewives were present in Lumsdens Pond and Black River Lake at this time. Alewives still present in Gaspereau Lake at the end of August were smaller than those captured in the lower part of the system, indicating the downstream exodus could extend well into the fall. This later portion of the run may be the result of juveniles moving downstream into Gaspereau Lake from spawning areas upriver, or could be the result of a break in the spawning run due to some environmental factor.

ACKNOWLEDGMENTS

Thanks go out to the numerous people who assisted with this project. The field crew consisted of two full time members: Keir Daborn and Mike Chapman, both of whom worked long hours without complaint. Ken Meade measured water velocities and produced the maps for this report. Terry Toner had valuable input into the design of the study.

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1.0 INTRODUCTION

Providing for safe downstream passage for young fish at hydroelectric dams remains a difficult problem. The Black River - Gaspereau River watershed in Nova Scotia (Figure 1), which has been extensively modified for hydroelectric generation, supports a stock of anadromous alewives (*Alosa pseudoharengus*) which spawn in the upper reaches of the watershed during the spring. Adults are fished both recreationally and commercially as they ascend this system during May and June.

Adults ascend the system by way of the old Gaspereau River channel during May and June, entering Gaspereau Lake (the primary spawning area), via the Lane Mills fishway.

Alewife eggs, larvae and juveniles for the most part follow the dominant currents as they descend through the system. When the control gate at Forest Home is open, dominant currents carry these fish downstream through Trout River Lake, Little River Lake and Methals Lake (Figure 2), after which they must move past 5 hydroelectric generating stations in order to complete their descent to the sea.

A fish diversion screen was built at the outlet of Trout River Lake (Figure 3) for the purpose of reducing the number of alewives moving through the lower system. This screen diverts fish into a bypass stream which leads, via Trout River, to the old Gaspereau River channel. Alewives descending the system by this route need only move past one hydroelectric station (White Rock) before reaching the sea.

The fish diversion screen is about 54 m long, and is oriented more or less perpendicular to the main flow of water. Typical water depths at the screen range between about 1.3 m to about 1.9 m. The screen is comprised of 31 panels, each 1.73 m wide. During most of the 1996 season, one half of the panels (at the north end of the screen) had a 1/8 inch mesh size, while the other half (at the south end of the screen) was comprised of 1/4 inch mesh.

A 0.3 m wide bypass weir is located on the north bank, about 1 m upstream of the screen.

This study was undertaken to collect data pertaining to the effectiveness of the screen, and to provide information which might be of use if the screen was to be redesigned.

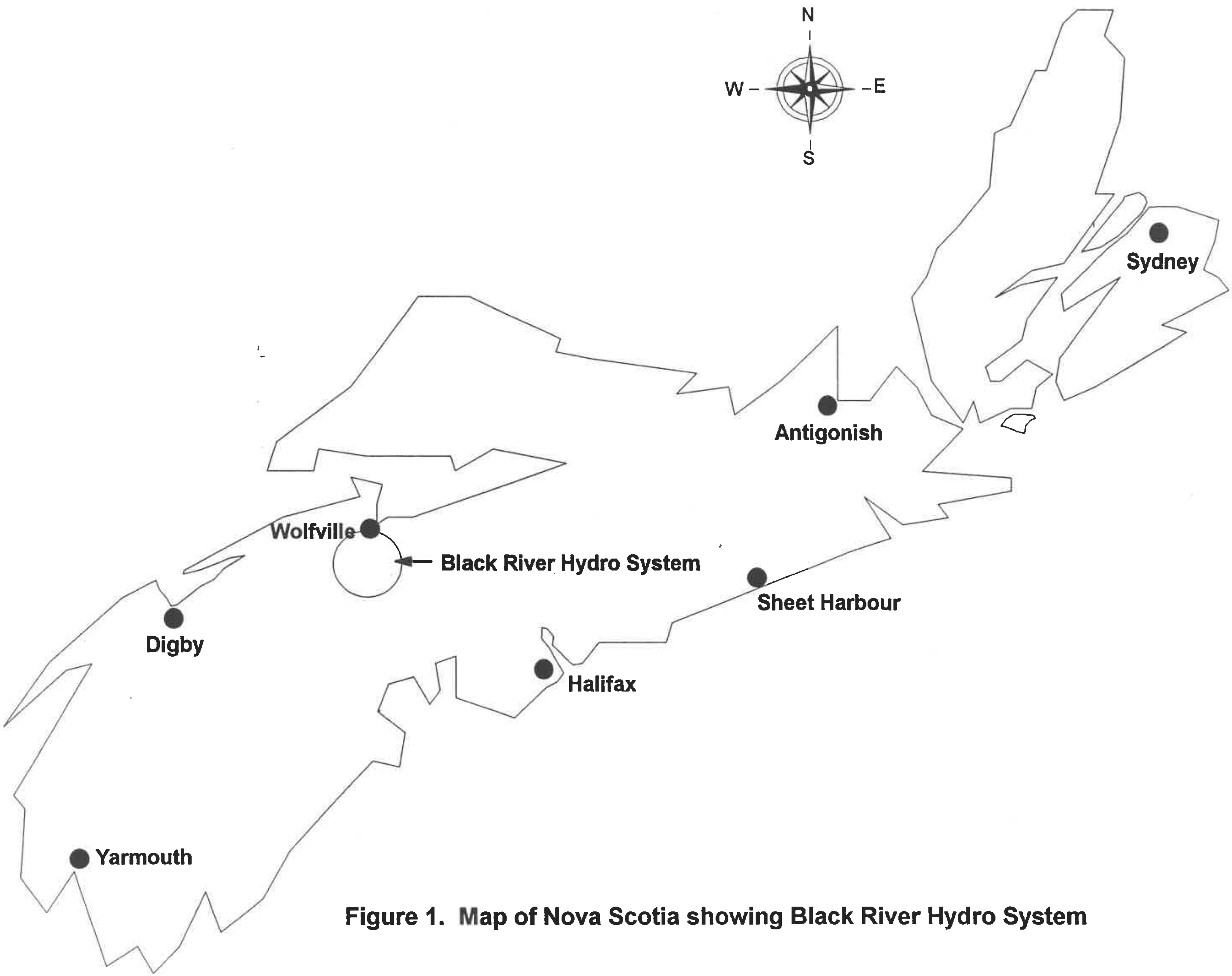

Figure 1. Map of Nova Scotia showing Black River Hydro System

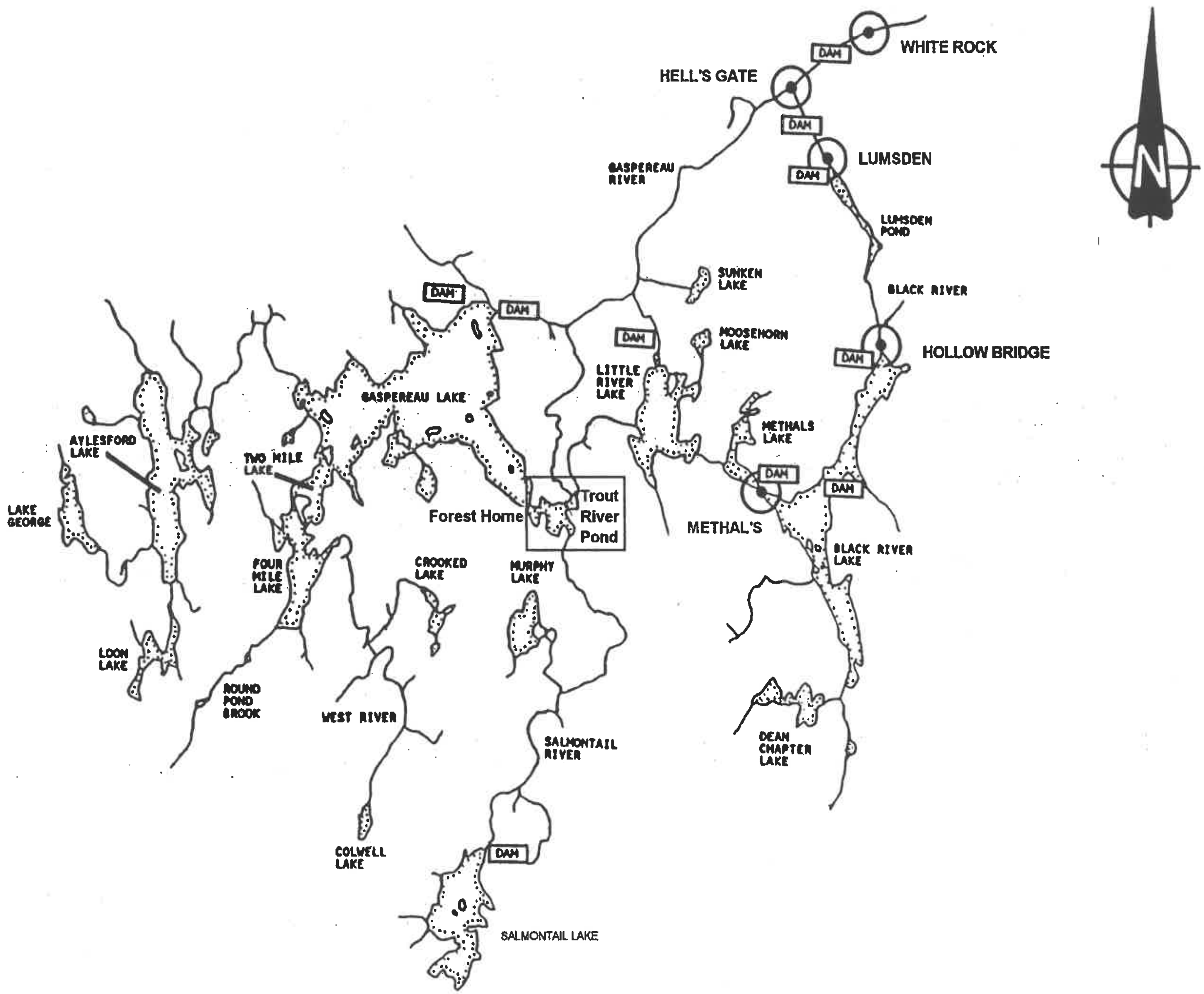

Figure 2: Overview of Black River Hydro System

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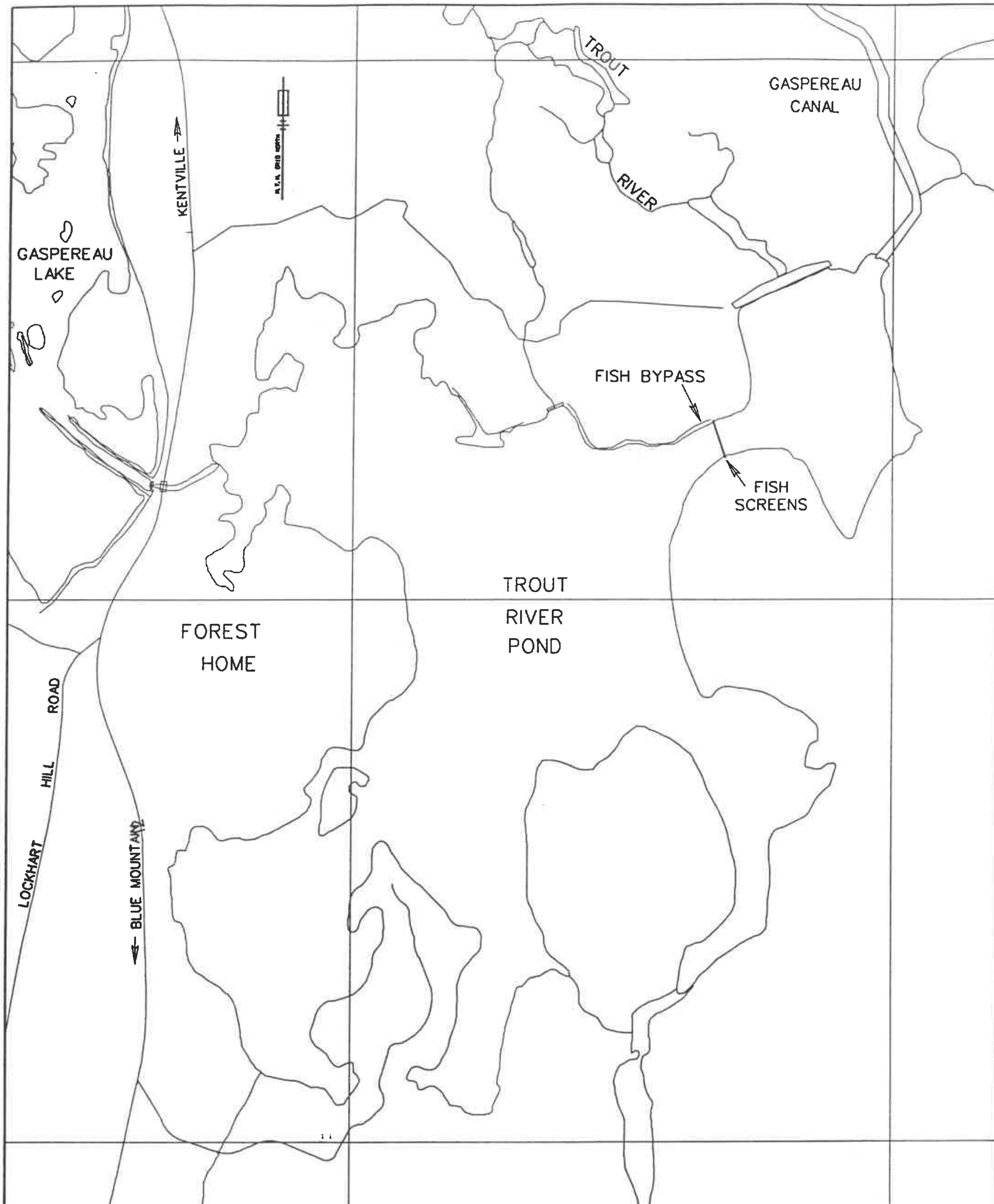

REFERENCE			**Nova Scotia Power Inc.** Halifax, Nova Scotia, Canada
SCALE 1:10,000	UNITS METRIC	DRAWN J.S.	
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			FIGURE 3 — REV

2.0 METHODOLOGY

This project consisted of two components: monitoring alewife movements in the vicinity of the screen, and a survey to determine if large numbers of alewives were still present in parts of the Black River - Gaspereau River system at the end of study.

2.1 Alewife Movements in the Vicinity of the Screen

Methods used during monitoring varied throughout the study, as methods considered suitable for the collection of eggs and larval fish were not considered suitable for the collection of the more mobile juvenile fish. For the most part, samples were collected using zooplankton nets, ranging in size from 0.3 m to 1 m in diameter, and with mesh sizes ranging from 0.5 mm to 3 mm. The volume of water filtered by a net on each deployment was measured using a General Oceanics Inc. torpedo flow meter fitted with a low flow propeller. The number of fish captured on each deployment was standardized by the volume of water passing through the net to allow more valid comparisons between deployments.

Sampling began on July 5, 1996. On this day, a 0.5 m diameter zooplankton net was suspended in the current below the screen and in the fishway, for varying periods of time, as we experimented with different methodologies. After several deployments it became evident that the large zooplankton by-catch (organisms larger than alewife eggs) made sorting and enumerating samples in the field difficult. Six samples were preserved and taken back to the laboratory and sorted under a dissecting microscope.

Samples on July 8 were collected by drifting the 0.3 m plankton net in the current downstream of the screen and in the bypass for intervals of about 10 minutes each time. These samples were also processed in the laboratory using a dissecting microscope.

On July 12, we established a routine that was followed throughout the remainder of the study. During each sampling period, a set of 5 samples was collected hourly. Four samples were collected by towing a 1.0 m diameter net in front of and behind the 1/4 and 1/8 inch meshes. These tows were started at the middle of the screen and pulled towards shore. Each sample was enumerated individually. The fifth sample was collected by deploying the net in the fishway. While this routine was followed throughout the remainder of the study, larger mesh sizes were used in the later part of the study as alewife size and mobility increased. The majority of these samples were processed in the field using a hand lens. At the beginning and end of most sampling trips, a net was deployed downstream of the water control structure at the Lane Mills fishway to determine if significant numbers of fish were moving seaward via this route.

The hypothesis underlying this above sampling regime is that if the screen was not acting as a barrier for downstream movement of fish, larval and juvenile alewives should be equally available for capture above and below the screen, and that as the fish increase in size, the degree of the difference in the densities above and below the screens should increase as it becomes more difficult for fish to penetrate the screens.

2.2 Alewife Surveys

Initial intentions were to survey about 4 locations in the Black River - Gaspereau River system using a bow-mounted, 1 m diameter, push net. This apparatus fished at depth of about 0.25 m to 1.25 m and would be fished at night when alewives were expected to be available for capture in surface waters. We attempted fishing with this setup on four nights, and despite using different mesh sizes and boat speeds, we were unable to capture juvenile alewives with this net (although juvenile smallmouth bass and yellow perch were captured regularly*).

After testing various net configurations in Lumsden's Pond on 2 evenings without capturing an alewife (although very large numbers of alewives were jumping around the boat), we abandoned the method and conducted the survey using a seine net. The seine used was 10 m long by 2 m wide, constructed of 0.3 cm knotless mesh, and fished about the top 1 m of the water column. It was fished at dusk, and relatively deep locations were chosen for seining so the net would not snag on deadfalls and rocks. The net was towed parallel to shore about 20 m by 1 person wading near shore and 2 people in a boat. The net was then closed off against the shore and the catch enumerated.

* This should not be interpreted as a cursory indication of the relative abundance of the three species because the alewives present at the time were quite a bit larger than the bass and perch captured and were thus able to avoid the net.

3.0 RESULTS

3.1 Temporal and Spatial Distribution of Catches at the Diversion Screen

Alewife movements in the vicinity of the Trout River Lake fish diversion screen were monitored on 20 days between July 5 and August 29, 1996. Nets were deployed on 573 occasions resulting in the capture of 2028 juveniles, 59 larvae and 46 eggs.

Sampling on July 5, 1996 was somewhat haphazard as we experimented with different methodologies. No eggs or larval alewives were identified, but due to the sampling approach on this day we do not consider this as evidence that they were not present at this time.

The first eggs and larval alewives were encountered on July 8 (the second day of monitoring). Eggs were captured drifting through the screen at a rate of 0.44/min. in a 0.3 m diameter net (Table 1). This was the only day that eggs were captured. Ten eggs were captured in the bypass stream and 36 were captured downstream of the diversion screen. One larval alewife was captured in the bypass on this day.

Table 1. A summary of the rate of capture of alewife eggs while fishing with a 0.3 m diameter zooplankton net suspended below the fish diversion screen and in the bypass stream on July 8, 1996.

Statistic	Below the Diversion Screen	In the Bypass Stream
number of sets	8	3
mean no. eggs/min.	0.44	1.73
s. d. no. eggs/min.	0.64	2.01
min. no. eggs/min.	0.00	0.19
max. no. eggs/min.	1.70	4.00

While the number of eggs captured was low, the ratio of the area sampled by the net to the cross-sectional area of the screen is relatively small and therefore these eggs may indicate that large numbers were moving through the screen on this day. For example, on July 10, water velocity averaged about 0.21 m/s through the screens. A 0.3 m diameter net would therefore filter about 0.9 m^3/min., yielding a mean density of about 0.5 eggs per cubic meter of water. Discharge through the screen on July 10, 1996 was about 10.2 m^3/s. Eggs would therefore move pass the screen at a rate of about 300/min. or about 430,000 per day.

Larval alewives were present in low numbers on July 10. Sampling on this date consisted of towing the 0.3 m net downstream of the screen from one shore to the other, followed by deploying the net in the fishway for 5 minutes. One pair of samples was collected each hour for 24 hours. Seventeen larval alewives were captured downstream of the screen, while two were captured in the bypass stream. The net filtered on average 2.5 m^3 of water per tow downstream of the screen, implying that averaged over the day, larval alewives were present in the water below the screen at a density of about 0.28 individuals/m^3. Using the July 10 discharge measurements, these data imply that larval alewives were moving through the screen at a rate of about 245,000 per day.

As mentioned, a monitoring routine was established on July 12 which was followed throughout the remainder of the study. Table 2 contains a summary of the mean number of alewives (larval and juvenile combined) per tow each day, prior to standardizing by the volume of water filtered by the nets on each deployment, while following this routine. Direct comparison of these numbers tends to overestimate fishway usage as the volumes of water filtered by the nets in the fishway were substantially higher than those of the deployments in front of and behind the diversion screen.

Alewife larvae were captured intermittently until the July 24 - 25 sampling trip, after which time none were captured (Figure 4 - mean number per sample; Figure 5 - mean density). Between July 12 and July 25 larval density downstream of the screen averaged 0.009 larvae/m^3 (min. = 0.00/m^3, max. = 0.27/m^3). Given a discharge of 10.2 m^3/s, these data imply that larvae were moving through the screens at an average rate of about 7,900 per day during this period.

Larvae were present at the highest density in front of the 1/8 inch mesh, and at the lowest density in the fishway (Figure 6). The difference in mean density above and below the 1/4 inch mesh was not statistically significant (t-test; $p = 0.89$, $df = 64$), while the p-value comparing densities above and below the 1/8 inch mesh (t-test; $p=0.12$, $df=57$) indicates that a difference of this magnitude would occur by chance only about 1 time in 10 if alewife densities above and below the screen were equal.

Table 2. Summary of the mean number of alewives captured per tow each day during routine monitoring at the Trout River Lake fish diversion screen. These data are not standardized by water volume passing through the net. Values in brackets are standard deviations and number of deployments).

Date	Bypass Mean (s.d., n)	Downstream 1/8 Mean (s.d., n)	Upstream 1/8 Mean (s.d., n)	Downstream 1/4 Mean (s.d., n)	Upstream 1/4 Mean (s.d., n)
July 12	0.00 (0.00, 5)	0.00 (0.00, 5)	0.00 (0.00, 5)	0.00 (0.00, 5)	0.00 (0.00, 5)
July 15	0.00 (,1)	0.00 (,1)	0.00 (,1)	0.00 (,1)	0.00 (,1)
July 16	0.00 (0.00, 7)	0.17 (0.41, 6)	0.33 (0.52, 6)	0.00 (0.00, 6)	0.17 (0.41, 6)
July 18	0.00 (0.00, 12)	0.17 (0.39, 12)	0.58 (0.79, 12)	0.08 (0.29, 12)	0.00 (0.00, 12)
July 22	0.00 (0.00, 6)	0.00 (0.00, 6)	0.00 (0.00, 6)	0.00 (0.00, 6)	0.00 (0.00, 6)
July 24	67.8 (72.6, 5)	0.60 (1.34, 5)	4.60 (9.21, 5)	0.40 (0.89, 5)	2.60 (4.34, 5)
July 26	47.5 (117.6, 20)	0.21 (0.71, 19)	9.95 (25.2, 20)	0.35 (0.67, 20)	3.85 (6.72, 20)
July 31	0.00 (0.00, 6)	0.29 (0.49, 7)	0.00 (0.00, 7)	0.00 (0.00, 5)	0.40 (0.89, 5)
Aug. 02	0.00 (0.00, 7)	0.00 (0.00, 7)	13.86 (36.6, 7)	0.00 (0.00, 7)	0.29 (0.76, 7)
Aug. 07	0.00 (0.00, 6)	0.17 (0.41, 6)	0.00 (0.00, 6)	0.00 (0.00, 6)	0.00 (0.00, 6)
Aug. 09	0.43 (0.79, 7)	0.00 (0.00, 6)	33 (80.3, 6)	0.00 (0.00, 6)	15.00 (36.7, 6)
Aug. 13	0.00 (0.00, 6)	0.00 (0.00, 6)	0.17 (0.41, 6)	0.00 (0.00, 6)	0.17 (0.41, 6)
Aug. 15	0.00 (0.00, 7)	0.00 (0.00, 7)	0.00 (0.00, 7)	0.00 (0.00, 7)	0.00 (0.00, 7)
Aug. 20	0.00 (,1)				
Aug. 26	0.00 (0.00, 3)	0.00 (0.00, 3)	0.00 (0.00, 3)	0.00 (0.00, 3)	0.00 (0.00, 3)
Aug. 29	0.00 (0.00, 4)	0.00 (0.00, 4)	0.00 (0.00, 4)	0.00 (0.00, 4)	0.00 (0.00, 4)

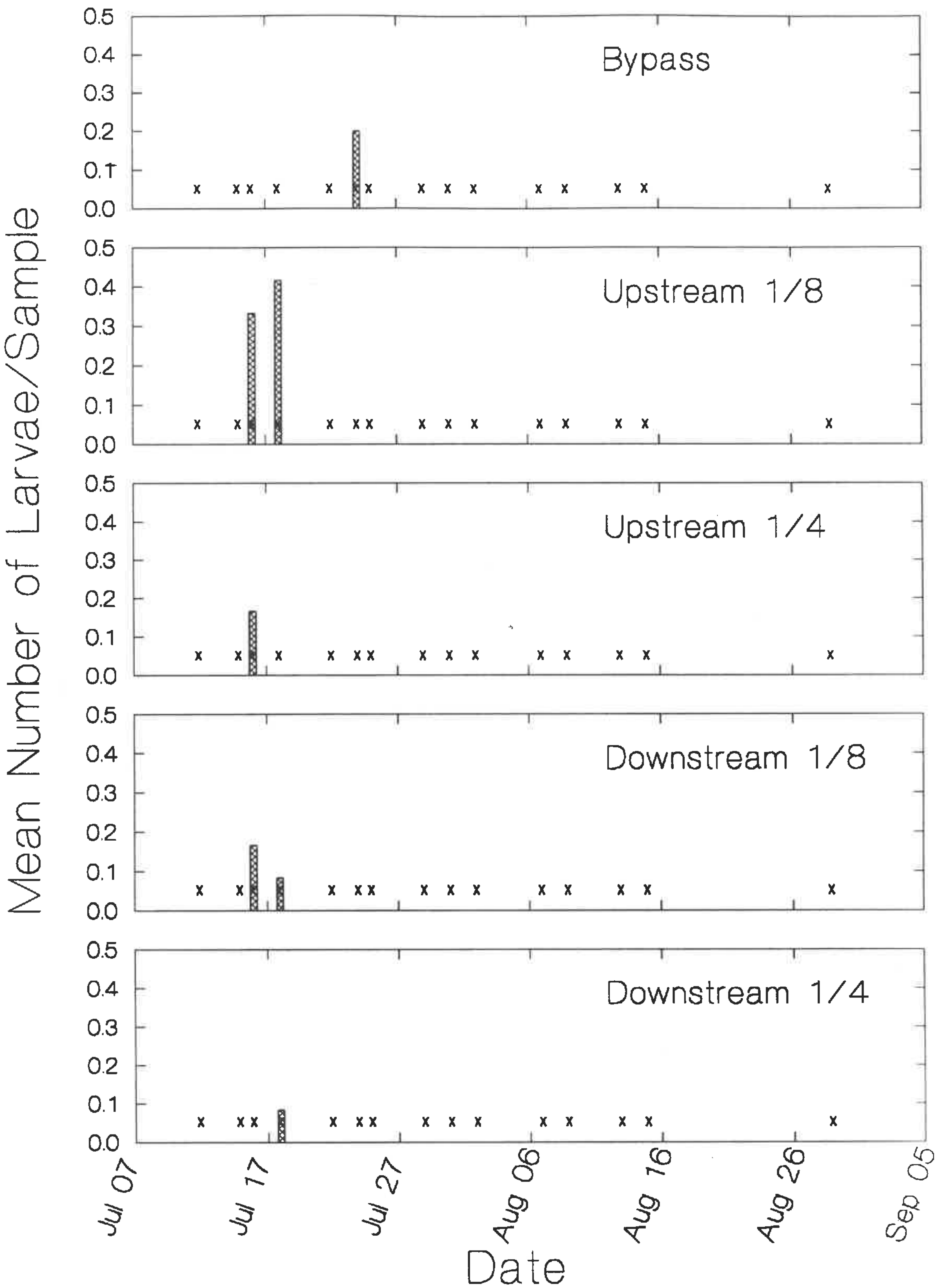

Figure 4. Time series showing the mean number of larval alewives per sample on each sampling day for each location sampled during routine monitoring. X's mark sample days.

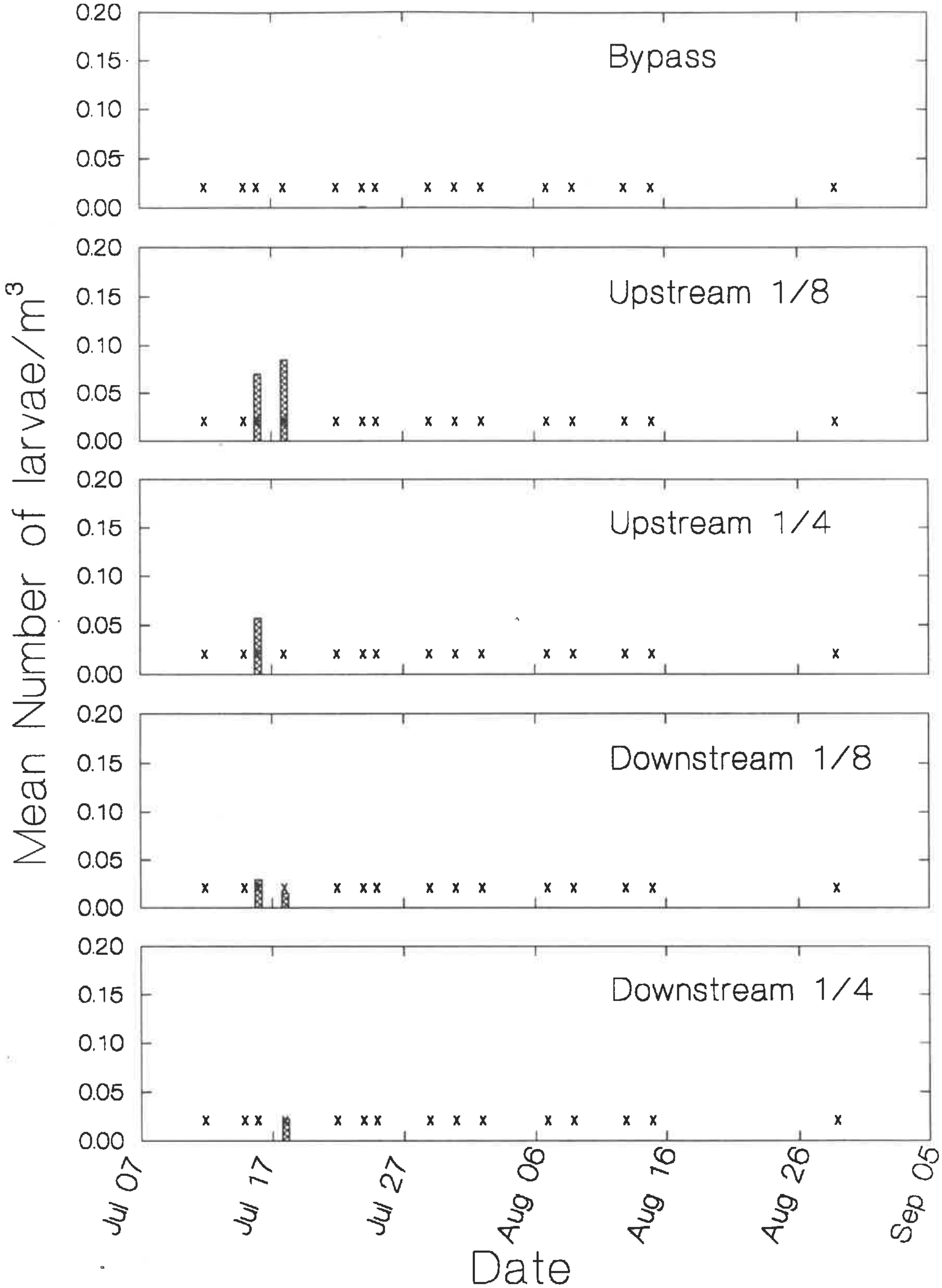

Figure 5. Time series showing the mean density of larval alewives per sample on each sampling day for each location sampled during routine monitoring. X's mark sample days.

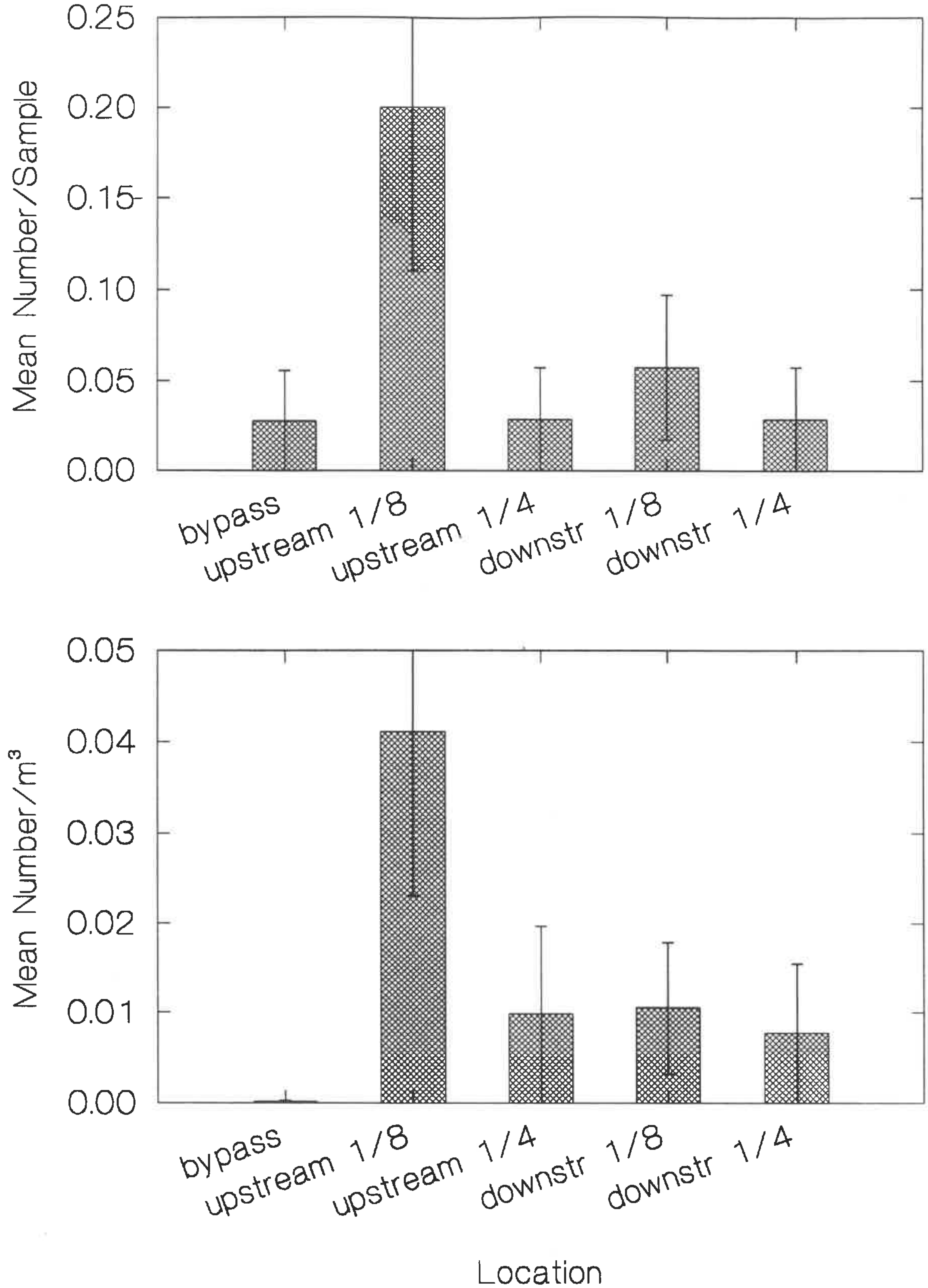

Figure 6. The mean number of larval alewives per sample (top) and the mean density of larval alewives (bottom) at each sampling location between July 12 and July 25. Error bars are standard error of the mean.

Figure 7 (mean number per sample) and Figure 8 (mean density) show the distribution of juvenile alewife catches. Juveniles were first encountered on July 18, but only 9 alewives were captured during 17.5 hours of monitoring on this day. On July 24, 376 juvenile alewives were captured during 8 hours of monitoring, of which 338 were captured in the fishway. Catches remained high through July 29 (896 alewives captured), but dropped to 1 alewife on July 31. Alewife movements were monitored on 8 days during August, but significant numbers were only captured on August 9 (289 alewives). No alewives were captured in the vicinity of the screen after August 13, although they were still present in the system (see seine surveys below).

Very few juveniles were captured below the diversion screen (Figure 9). Statistically significant differences exist between densities of juveniles immediately upstream and downstream of both the 1/8 inch mesh (t-test; $p = 0.03$, $df = 97$) and 1/4 inch mesh (t-test; $p = 0.04$, $df = 91$). Differences in juvenile densities in the fishway, above the 1/8 inch mesh and above the 1/4 inch mesh are not statistically significant (ANOVA; $p = 0.78$, $df = 2, 302$).

Alewife passage at the Lane Mills Fishway was monitored at the start and end of most sample days by deploying a zooplankton net in the Gaspereau River below the control gate. Only 3 larval alewives were captured at this location throughout the study period.

3.2 Alewife Surveys

Surveys were conducted in Lumsden's Pond, the lower basin of Black River Lake, Methals Lake and the lower basin of Gaspereau Lake between August 26 - 29, 1996. Table 3 contains the number of alewives captured in each net deployment, and shows the high degree of heterogeneity in the catches. The mean number of alewives per seine at each location is as follows:

Gaspereau Lake - 3.2 alewives (6 seines)
Methals Lake - 0 alewives (5 seines)
Black River Lake - 29.5 alewives (6 seines)
Lumsden's Pond - 145 alewives (5 seines)

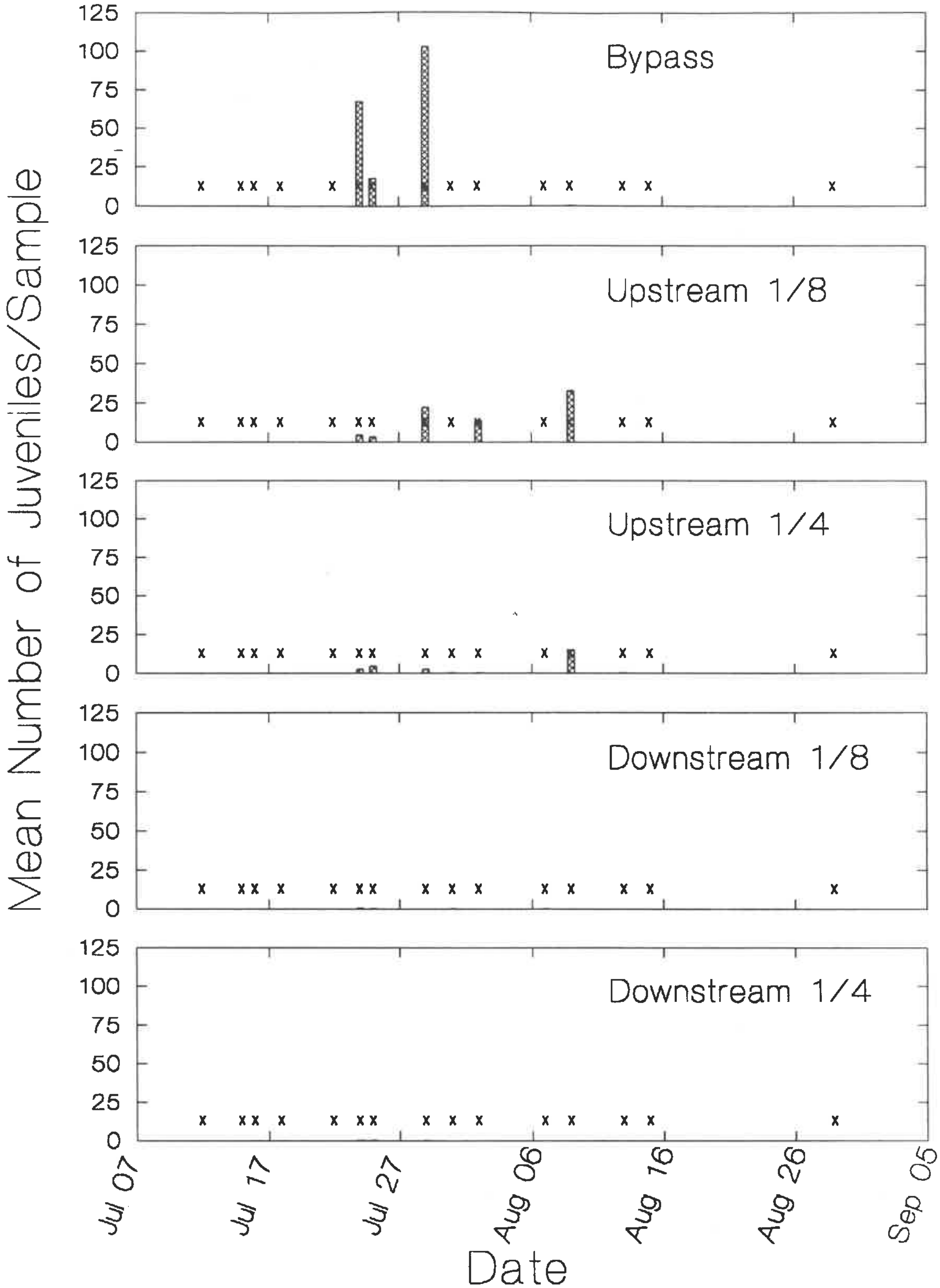

Figure 7. Time series showing the mean number of juvenile alewives per sample on each sampling day for each location sampled during routine monitoring. X's mark sample days.

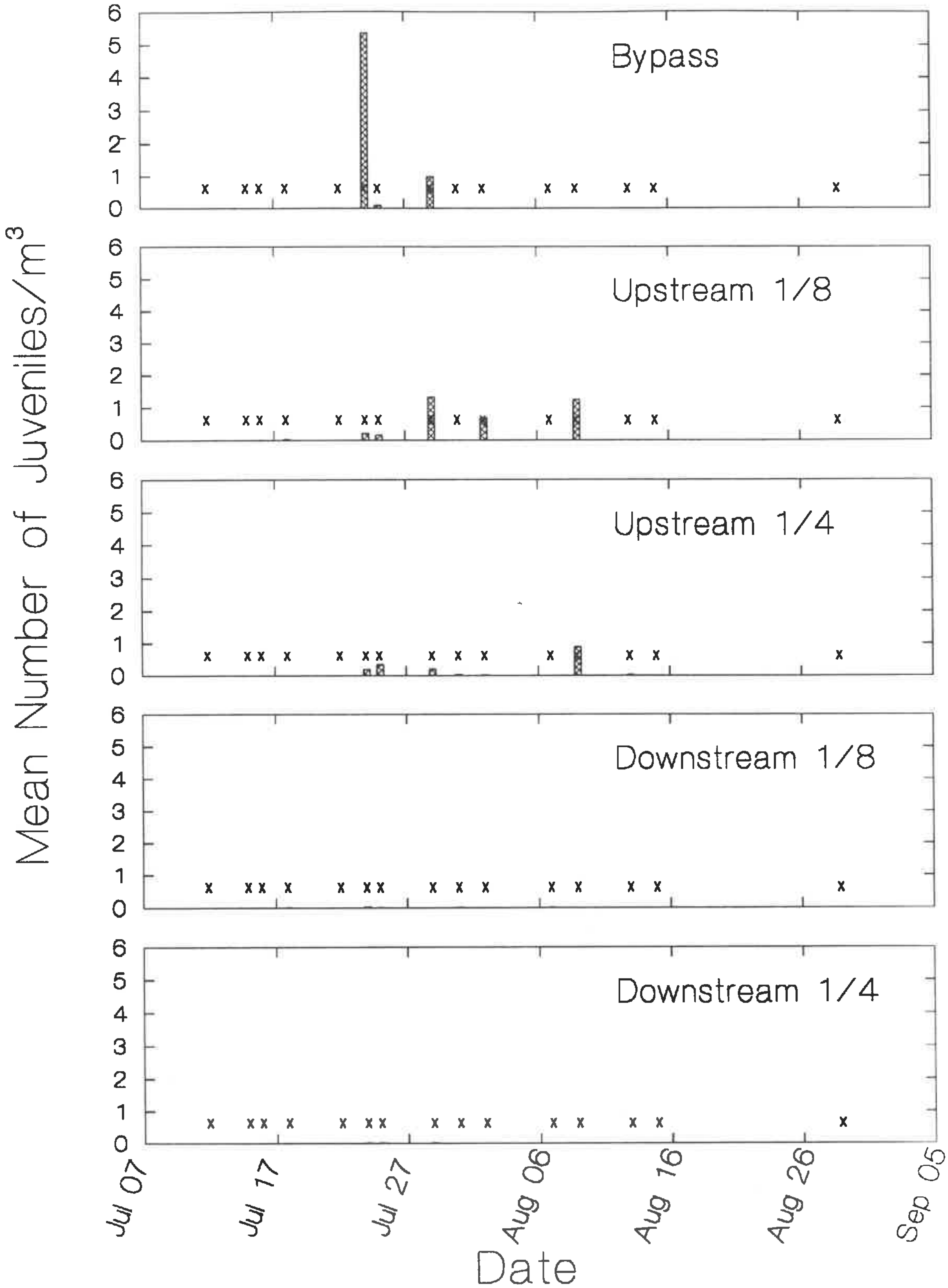

Figure 8. Time series showing the mean density of juvenile alewives per sample on each sampling day for each location sampled during routine monitoring. X's mark sample days.

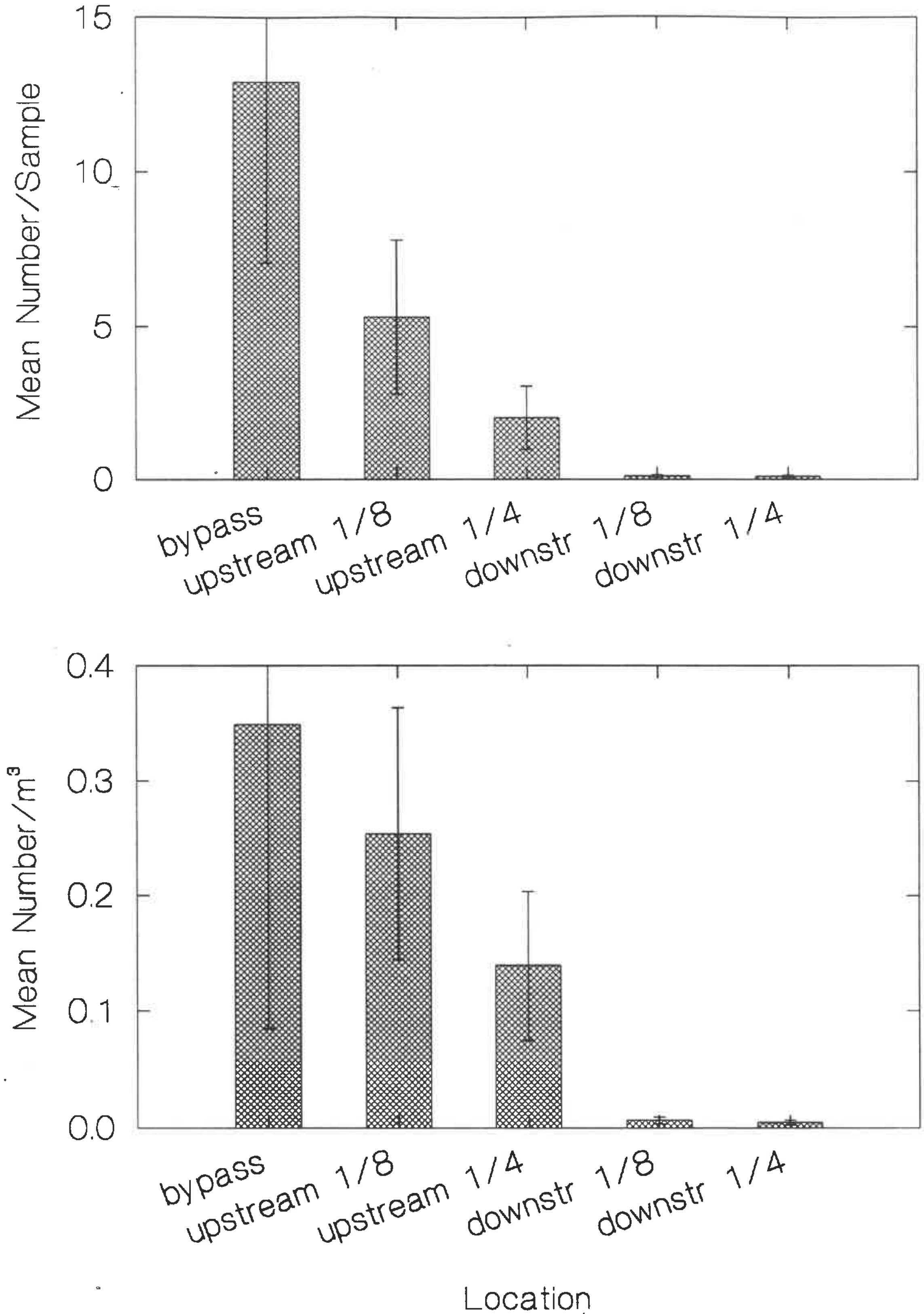

Figure 9. The mean number of juvenile alewives per sample (top) and the mean density of juvenile alewives (bottom) captured at each sampling location between July 12 and August 29. Error bars are standard error of the mean.

Visual observations also confirm that large numbers of alewives were present in the lower part of the system during and after the survey. Comparatively large numbers of alewives were observed jumping around dusk while conducting the surveys in Lumsdens Pond and Black River Lake. Additionally, alewives (easily more than 200,000) were observed schooling on several occasions near the Black River Lake dam in early and mid September.

Table 3. Alewife catches while seining in the Gaspereau - Black River System.

Location	Date	Seine No.	Number of Alewives
Lumsden's Pond	960826	1	0
		2	2
		3	6
		4	24
		5	692
Methals Lake	960828	1	0
		2	0
		3	0
		4	0
		5	0
Black River Lake	960828	1	0
		2	0
		3	1
		4	112
		5	64
		6	0
Gaspereau Lake	960829	1	0
		2	0
		3	0
		4	8
		5	11
		6	0

3.3 Fork Lengths of Captured Alewives

Fork lengths of alewives captured at the diversion screen, which were measured to the nearest 0.1 mm on a subsample of most alewife catches throughout the study, are summarized in Table 4. Mean fork lengths increased throughout the summer (Figure 10).

Table 4. Summary of fork length measurements from larval and juvenile alewives captured in the vicinity of the Trout River Lake Fish Diversion Screen.

Date	Sample Size	Mean (mm)	Standard Deviation	Minimum (mm)	Maximum (mm)
July 08	1	16.30	-	16.3	16.3
July 10	10	13.02	2.99	8.1	16.4
July 11	10	12.9	5.14	5.0	19.8
July 16	4	13.77	4.42	7.4	17.0
July 18	10	32.09	6.71	16.0	41.7
July 19	15	21.31	9.56	0.5	44.1
July 24	247	35.59	7.32	13.2	59.2
July 25	180	37.57	6.45	21.8	53.3
July 26	10	34.79	9.37	12.9	44.9
July 29	111	38.63	8.91	22.5	66.0
Aug. 01	3	41.93	10.62	34.0	54.0
Aug. 02	8	45.38	5.96	36.1	52.3
Aug. 07	1	25.60	-	25.6	25.6
Aug. 09	38	50.82	12.21	25.8	83.0
Aug. 14	2	44.65	2.33	43.0	46.3

Differences in the mean size of alewives captured at each location are statistically significant (ANOVA; $p = 0.00$, $df = 4, 605$) as fish captured upstream of the screen averaged slightly larger than those captured downstream (Figure 11). Additionally, the range of sizes captured was larger upstream of the screen and in the bypass stream than downstream of the screen, as shown in the length frequency distributions for alewives captured at each of the sampling locations (Figure 12).

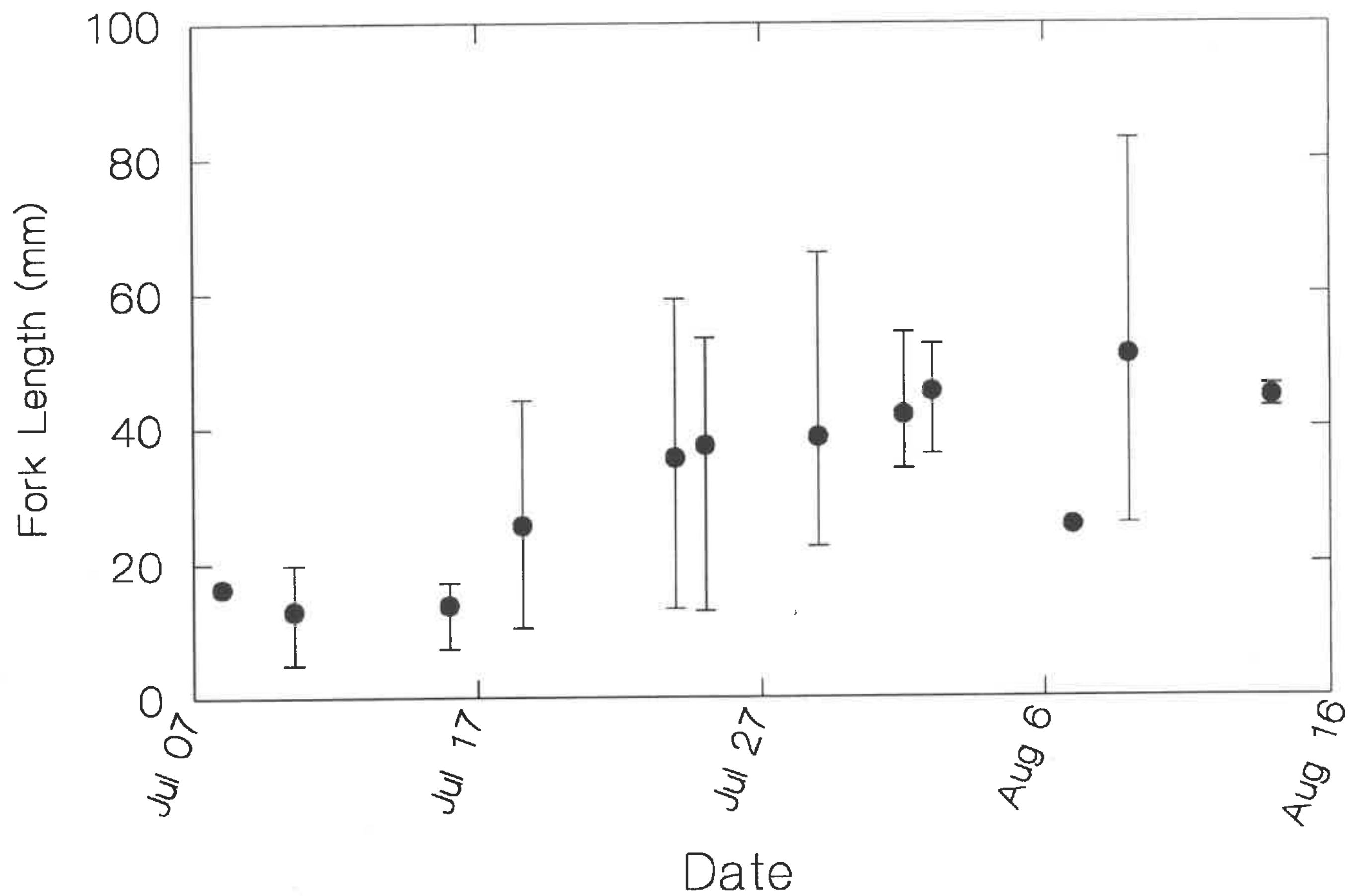

Figure 10. The mean fork length of alewives captured at all sampling locations combined on each sampling day. Error bars are maximum and minimum.

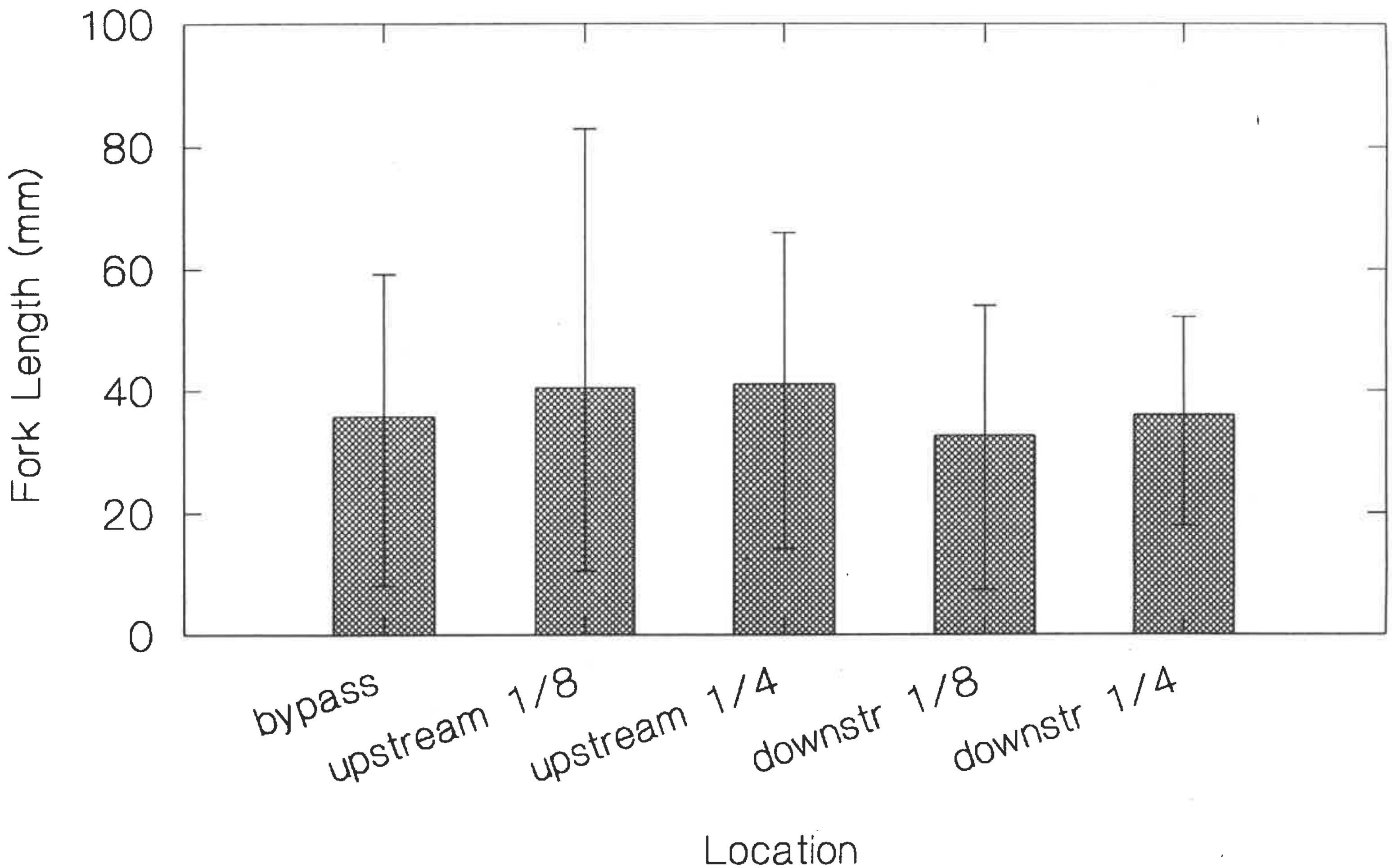

Figure 11. **The mean fork length of alewives captured at each sampling location** throughout the project. Error bars are maximum and minimum.

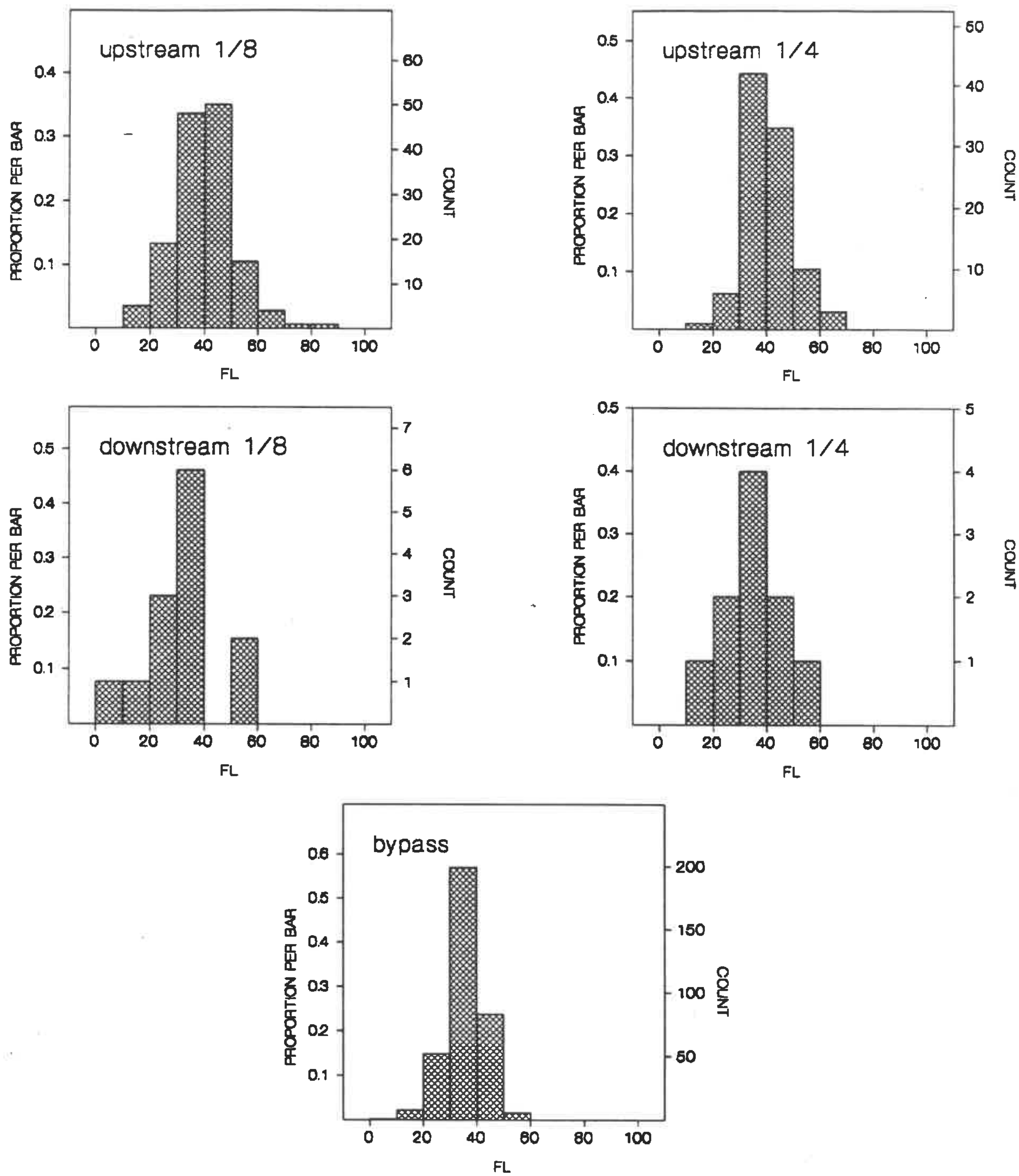

Figure 12. Fork length frequency distributions of alewives captured at each sampling location throughout the study.

Based on samples collected while seining, alewives in the lower Black River - Gaspereau River System were substantially larger than those in Gaspereau Lake (Table 5) and those captured by the screen.

Table 5. Summary of fork length measurements from juvenile alewives captured while seining in Lumsden's Pond, Methals Lake, Black River Lake and Gaspereau Lake.

Location	Date	Sample Size	Mean (mm)	Standard Deviation	Minimum (mm)	Maximum (mm)
Lumsden's Pond	Aug. 26	10	109.4	6.62	102	117
Methals Lake	Aug. 28	no fish				
Black River Lake	Aug. 28	12	109.5	4.74	98	116
Gaspereau Lake	Aug. 29	18	53.9	9.8	43.9	72.1

Maximum body depth and fork length were measured on a sample of 107 alewives collected on July 10, 18 and 24. As shown in Figure 13, all but the largest larvae are physically small enough to pass through a 1/8 inch aperture, and only the smallest juveniles could pass through a 1/4 inch aperture. From Figure 13, it also appears that alewives longer than about 22 mm FL could only pass through a 1/8 inch aperture with difficulty and that alewives longer than about 32 mm FL could not easily pass through a 1/4 inch aperture. The proportions of each sample of fish for which fork length was measured, that were smaller than these limits on each sampling day is shown in Table 6.

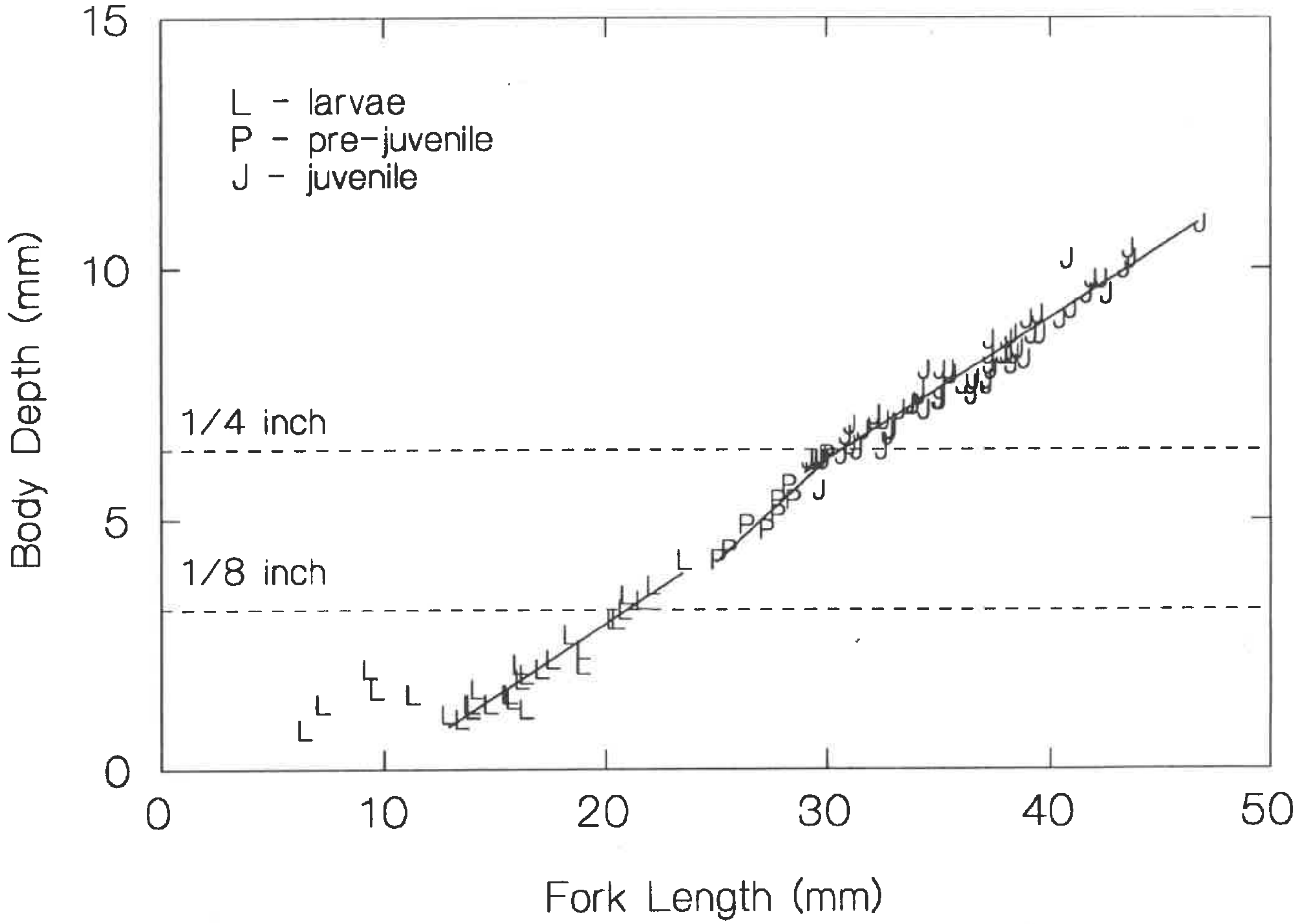

Figure 13. The relationship between fork length and maximum body depth for larval (L), pre-juvenile (P) and juvenile (J) alewives from a sample of 107 alewives captured on July 10, 18 and 24.

Table 6. The proportion of the sample of alewives measured that were less than 32 mm fork length and less than 22 mm fork length.

Date	Sample Size	Proportion < 32 mm FL	Proportion < 22 mm FL
July 08	1	1.000	1.000
July 10	10	1.000	1.000
July 11	10	1.000	1.000
July 16	4	1.000	1.000
July 18	10	0.300	0.100
July 19	15	0.867	0.733
July 24	247	0.215	0.065
July 25	180	0.183	0.006
July 26	10	0.200	0.100
July 29	111	0.306	0.000
Aug. 01	3	0.000	0.000
Aug. 02	8	0.000	0.000
Aug. 07	1	1.000	0.000
Aug. 09	38	0.053	0.000
Aug. 14	2	0.000	0.000

3.4 Impingement in the Screen

When the screens were being cleaned concurrently with sampling at the diversion screen, notes were taken on the numbers of fish impinged in the screen. On July 12, a total of 21 alewives were removed from the 1/8 inch mesh, while none were found impinged in the 1/4 inch mesh. Similar patterns were observed on July 16 (25 from the 1/8 inch mesh, none in the 1/4 inch mesh), July 18 (21 from the 1/8 inch mesh, none in the 1/4 inch mesh) and July 24 ((8 from the 1/8 inch mesh, 1 in the 1/4 inch mesh). Nova Scotia Power personnel reported removing large numbers from the screens on July 22 (about 40 in one panel of 1/8 inch mesh - 17 panels total).

Fork lengths were measured for alewives removed from the 1/8 inch mesh on July 18. These fish averaged 23.8 mm in length (min. = 13.6 mm, max = 29.3 mm, S.D. = 5.5 mm).

4.0 DISCUSSION

Three life stages of alewives, as well as intermediary forms, were encountered while sampling at the screen. Eggs were present on July 8, but may have been missed earlier in the study as we experimented with methodologies (alternatively, it may have taken time for the eggs to drift downstream though Trout River Lake after the water control gate was opened earlier in July). While the number of eggs captured (46) was low, because the cross-sectional area sampled by the nets and sampling time were small relative to the area of canal and the length of the day, these eggs are evidence that eggs could have been moving downstream at a rate of over 400,000/day on July 8. A high zooplankton by-catch, which made sample processing quite time consuming, precluded the use of larger nets or longer sampling times in this study.

Larval alewives were captured from July 10 until July 25. The number of larvae captured was also low, but for the reasons stated above may be evidence that large numbers of larvae were passing through the screen (245,000/day based on the July 10 sample; 7,900/day on average between July 12 and July 25).

The distribution of larval alewife catches between the 5 locations sampled (Figure 6) makes sense intuitively. Comparatively few larvae were captured in the bypass stream, which perhaps is an indication that alewife larvae lack the mobility to find its entrance where it is currently located. Because the volume of water flowing down the bypass (0.12 m^3/sec on July 10) is very small relative to that moving down the canal (10.2 m^3/sec on July 10), entrainment of larvae into the bypass by the current would be expected to be low. Therefore the majority of larval alewives, being carried along primarily by the current, would not end up in the bypass.

Larval catches above and below the 1/4 inch mesh were similar, indicating that this mesh does not act as a barrier for larvae. As shown in Figure 13, larvae are thin enough to pass through this mesh, and none were found impinged on these screens. The 1/8 inch mesh appeared to act as a semipermeable barrier with respect to larvae, as the mean density of larvae upstream of this mesh was about 3 times higher than the density downstream of these screens. This difference may or may not be statistically significant (depending on the choice of the critical p-value), but it makes sense intuitively that this screen would act as a barrier, particularly if somewhat clogged with algae and debris. The fate of larvae whose passage is impeded is unknown. Possible fates include remaining upstream of the screen for a period of time before moving downstream through these screens, moving downstream through the 1/4 inch mesh, and impingement on the screen. While the numbers of larvae removed from the screens while they were being cleaned appeared small, these numbers may be an underestimation of the real impingement on these screens, as only those that are gilled are likely to remain in the screen as it is removed to be cleaned. Fish which have tired and drifted against the screen would be expected to wash off as the screen is pulled. Predation on impinged fish would also lead to an underestimation of this impact.

Juvenile alewives were captured between July 18 and August 13, although the results of the seine surveys indicate that alewives were still present in Gaspereau Lake in early September. As mobility increased with increased size, net avoidance and net escapement made representative sampling more and more difficult as the season progressed. Catches in late July and early August may therefore underestimate densities at these times. However, when juvenile alewives were present in the vicinity of the screen, they were easily visible to the eye. Alewives were not observed near the screen after August 13, so escapement is not adequate to explain why they weren't captured in this area in late August. This factor is somewhat confusing given they were still present upstream at this time.

Juvenile alewives were captured at the highest density in the fishway, although the difference in densities in front of the screen and in the fishway was not statistically significant. Of the 2028 juveniles captured in all locations combined, only 20 were captured downstream of the screen, indicating that the screen is effective in impeding the passage of juveniles. Juveniles appear more able to find the bypass than larvae, as shown by the higher proportion of the juvenile catch from this location.

Only one alewife was found impinged in the 1/4 inch mesh, perhaps indicating that by the time alewives are large enough so that their passage is impeded by these screens, they are strong enough swimmers to avoid impingement.

The mean fork length of alewives was not very different (although statistically significant) between the five locations, as shown in Figure 11. The mean fork lengths of alewives captured in the fishway and upstream of the screen are probably skewed by large numbers of smaller fish captured at these locations earlier in the study. As shown in Figure 12, the largest specimens were captured in front of the screen. If these larger, more mobile alewives are better able to avoid capture, they would be under-represented in these samples, implying that the true size difference between upstream and downstream alewives may have been greater than estimated in this study.

Alewife catches prior to July 24 were scant relative to the larger catches in late July (although as mentioned these small numbers may be representative of a large number of fish). As shown in Table 4, fork lengths appeared to increase substantially at the same time that catches increased. This may indicate the beginning of active downstream movement by larger juveniles which occurred at about this time and that alewives captured before this time were ones entrained by the currents and are not part of an active downstream movement.

The size limits for alewives capable of passing through the meshes and the proportion of the samples smaller than these limits (Table 6) should be treated conservatively, as they are estimates based only on body depth. No allowances are made for behavioral effects (fish may avoid passing through openings close to their size or alternatively may squeeze through smaller openings), effects of aperture shape or variability in condition factors between years or seasonally within years. Therefore, Table 6 provides only a rough guideline about the proportion of the population which may be re-directed by the 2 mesh sizes. Based on this table, it appears that during this study, a transition period existed between July 19 and July 24 prior to which a high proportion of the population may have been able to pass through both the 1/4 and 1/8 inch meshes and after which the screen may have been an effective barrier to fish passage.

Large numbers of alewives were present downstream of the diversion screen in early September. These fish are further evidence that the small numbers of eggs and larvae captured at the screen are representative of large numbers moving past the screen in early and mid July, if one takes into account the small sample volumes and times.

Juvenile alewives were still present in Gaspereau Lake in late August, and were smaller than those captured lower in the system. The fact that alewives were not captured or observed at the screen after August 13 even through alewives were still present in Gaspereau Lake suggests a discontinuity in the downstream migration. Factors such as juveniles moving into Gaspereau Lake from spawning areas further upriver or a disruption of the spawning run due to environmental factors might account for such a break.

In conclusion, it appears that the effectiveness of the fish diversion screen at Trout River Lake is in part a function of the size of the alewives approaching the fence. As configured during this study (a combination of 1/4 and 1/8 inch meshes), the fence does not act as a barrier for eggs, acts as a semipermeable barrier for larval alewives (which may lack the mobility to find the bypass at its current location), and appears to be an effective barrier to the passage of juveniles, which apparently are able to find the bypass where it is currently placed.

5.0 LITERATURE USED DURING STUDY

Clay, C.H. 1961. Design of Fishways and Other Fish Facilities. The Department of Fisheries of Canada, Ottawa, Ontario. 301 p.

Devore, J.L. 1987. Probability and Statistics for Engineering and the Sciences. 2nd Ed. Brooks/Cole Publishing Company. Monterey, California.

Jones, P.W. , F.D. Martin, and J.D. Hardy. 1978. Development of fishes of the mid-Atlantic Bight: an atlas of egg, larval, and juvenile stages. vol. 1. Acipenseridae through Ictaluridae. Centre for Environmental and Estuarine Studies of the University of Maryland Contribution no. 783. 366 p.

Loesch, J.G. 1987. Overview of the life history aspects of anadromous alewife and blueback herring in freshwater habitats. Am. Fish. Soc. Sym. 1:89-103.

O'Neill, J.T. 1980. Aspects of the life histories of anadromous alewife, *Alosa pseudoharengus* (Wilson), and blueback herring, *A. aestivalis* (Mitchell), in the southwest Margaree River and Lake Anslie, Nova Scotia, 1987-1979. M. Sc. thesis, Department of Biology, Acadia University, Wolfville, N.S. 306 p.

Scott, W.B. , and M.G. Scott. 1988. Atlantic Fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219: 731 p.