Characteristics of the Gaspereau River Alewife Stock and Fishery - 1998.

Final Report (Draft)
to
Nova Scotia Power Inc.

prepared by

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EXECUTIVE SUMMARY

The Gaspereau River - Black River watershed, which was extensively modified for hydro-electric generation between 1910 and 1950, supports a stock of anadromous alewives (*Alosa pseudoharengus*) that is fished both commercially and recreationally as it ascends the river to spawn. Since 1964, the annual spawning run in this river has averaged about 1.1 million fish. The 1998 run consisted of about 550,000 fish, known to be the smallest run since 1992. The catch in 1998 (2,800 pails) was smaller than 80% of the catches since 1964. Reduced abundance of age 4 alewives accounted for 75% of the reduction in stock size since 1997.

A total count of alewives ascending the fish ladder at White Rock in 1998 (upstream of most fishing activities) indicated that over 171,000 alewives ascended the ladder, the highest escapement from the fishery of the 7 years for which counts are available. A partial count of alewives ascending the ladder at Lanes Mill was used to estimate that just under 97,000 alewives entered Gaspereau Lake to spawn this year. Estimates of transit time from the White Rock ladder to Gaspereau Lake ranged between 2 and 7 days.

Alewives sampled during 1998 were the smallest on average compared to those from 5 previous assessments. Based on back-calculated length-at-age, this reduction in size apparently occurred as a result of poor growth at sea during 1997.

The ecology of young-of-the-year (YOY) alewives in Gaspereau Lake was studied during the summer and fall of 1998 in order to collect data useful for the development of management strategies for these fish in this watershed. Larval abundance was higher in 1998 than in 1997, an observation consistent with the increased spawner abundance. Zooplankton abundance was also higher in 1998, suggesting an adequate supply of food.

YOY out-migration was monitored at the outlet to the Gaspereau River between early July and mid-November. Out-migration rates were highest during the third week of September. Just under 0.5 million YOY were estimated to have exited the lake via this outlet during the study period. Alewives were still present in the lake in late September, and an estimated 1.1 million moved downstream when the control gate at Forest Home was opened during the third week of this month. YOY out-migrants were large enough for the Trout River Pond fish diversion screen to be effective by mid-August.

River flow in the old Gaspereau River (10 c.f.s.) was about 1/3 that of 1997. Adult alewives did not appear willing to move downstream at the reduced flow, and many remained in the system until the gate at Forest Home was opened in late September. Adults were not observed taking this route in 1997.

Age 1+ alewives were observed leaving Gaspereau Lake in the fall, suggesting that not all alewives will emigrate if the Forest Home control gate is kept closed into the fall as was the case in 1997.

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1. INTRODUCTION

1.1 Background

The alewife (*Alosa pseudoharengus*) is an anadromous species of fish that is native to eastern North American rivers from the Gulf of St. Lawrence to North Carolina (Scott and Scott 1988). Adults ascend rivers to spawn during spring, returning to the sea shortly thereafter. Spawning occurs in headwater lakes, stillwaters and back eddies, and eggs hatch in 3 to 8 days at Nova Scotia ambient temperatures. Young-of-the-year (YOY) remain in fresh water until mid-summer to fall, at which time they migrate to sea (Loesch 1987). Alewives then remain at sea until reaching sexual maturity after a period of 3 to 6 years. Alewives can live to over 10 years of age, and may spawn 5 or more times during their life.

In a review of the status of Alosa stocks in eastern North America, Rulifson (1994) identified over 100 rivers and streams in Nova Scotia that support alewife stocks. The majority of these stocks were listed as in decline, although little data exist about these populations. Dams were identified as the primary factor responsible for this decline.

The Black River - Gaspereau River watershed in Nova Scotia (Figure 1) supports a stock of anadromous alewives. This stock is fished both recreationally and commercially as it ascends the system to spawn during May and June. The value of the commercial fishery has averaged $288,000 per year (range: $24,000 to $1,000,000) during the last 25 years (DFO, unpublished data). This value fluctuates with the variation in the catch and the price of the fish. The value of the recreational fishery to the local economy is not known.

During the last 80 years, this watershed has been extensively modified for hydroelectric generation, including diversions of the Black River, Gaspereau River, Forks River, and numerous smaller brooks and streams. Most the major modifications were completed by the early 1950’s, although upgrades and minor changes to the system are ongoing. The system currently consists of over a dozen lakes interconnected by manmade canals and natural waterways (Figure 2). Five hydroelectric generating stations and numerous storage and diversion dams are present in the system. These structures affect fish migration and ecology within the watershed.

Adult alewives typically ascend the watershed by way of the old Gaspereau River channel to spawn in lakes at the head of the system. Eggs hatch during late June and early July, and YOY then utilize these lakes as nursery areas prior to emigrating seaward during late summer and fall. Alewives mature at 3 to 6 years of age, at which time they return to freshwater to spawn. While at sea, they undergo extensive migrations along the Atlantic seaboard, where they support bycatch and directed intercept fisheries along the eastern seaboard of the United States.

Figure 1. Loc. Map.

Figure 2. Watershed map.

Nova Scotia Power Inc. (NSPI), in conjunction with government agencies, community groups and educational and research institutions, has been working towards reducing the impact of its activities upon local fish stocks. Fish ladders, diversion screens, spillways and control gates are some of the tools used by NSPI to limit their impact on these stocks. The operation of these facilities is fine-tuned as the ecology of these stocks is better understood. Water management strategies, designed to optimize water availability for other users as well as hydroelectric generation, are currently being tested. At this time, upstream passage for alewives to spawning areas in the headwater lakes is provided by two pool-and-weir fishways: one bypassing the White Rock Generating Station, and the other bypassing the storage dam at the outlet of Gaspereau Lake at Lanes Mill. This latter facility was rebuilt in 1997, allowing better operation over a wider range of heads. A third fishway provides passage between Gaspereau and Aylesford Lakes. Post-spawning adults typically return to sea via the old Gaspereau River, thus bypassing four of the five generating stations. Eggs, larvae and juvenile alewives tend to follow the dominant flow patterns when moving downstream. The control gate at Forest Home is therefore closed when the adults enter Gaspereau Lake to spawn, and re-opened after YOY are large enough that a diversion screen, located near the outlet of Trout River Pond, is effective. This screen redirects YOY back to the old Gaspereau River via Trout River.

In order to assess the effectiveness of these strategies, as well as to better manage the fishery, the status of the stock has been monitored intermittently throughout the last three decades. Information about the performance of the fishery, life history data and stock size has been collected. Assessments of this stock were conducted by the federal Department of Fisheries and Oceans (DFO) between 1982 and 1984 (Jessop and Parker 1988), in 1995 by NSPI (unpublished data) and by the Acadia Centre for Estuarine Research (in collaboration with NSPI) during 1997 (Gibson and Daborn 1997). Biological data relating to this stock were also collected during an evaluation of the fish ladder at White Rock in 1970 (Dominy 1971). Gibson and Daborn (1997) summarize these assessments. During years when assessments were conducted, the spawning run has averaged c.537,000 fish (range: 165,000 to 1,082,000 fish). However, all assessments have been conducted in years when the catch was less than the 30-year median, and therefore lead to an underestimate of the stock size. The stock is comprised mainly of first time spawners, 4 or 5 years of age. Fishing mortality undoubtedly contributes to this truncated age frequency distribution, as estimates of the exploitation rate have ranged from 56.7 % in 1983 to 86.5 % in 1997.

Less information exists about juvenile alewives in this watershed. Jessop and Parker (1988) monitored the distribution of YOY within the watershed during 1983. Information about the timing of out-migration and the size of migrating YOY was collected as part of an assessment of the Trout River Pond diversion screen during 1996 (Gibson 1996).

During the summer and fall of 1997, the ecology of young-of-the-year alewives in Gaspereau Lake was studied to collect data useful for the development of management strategies for these fish in this watershed. YOY alewives were present in all regions of Gaspereau Lake throughout the summer. Larvae were captured until the week of July

27th, after which only juveniles were captured. Alewives were large enough for the Trout River Lake diversion screen to be effective by mid-August. Decreases in zooplankton abundance in Gaspereau Lake in early July, and bimodal YOY length frequency distributions throughout July and August suggest that intraspecific competition may limit alewife reproductive success in this watershed. As part of the study, out-migration was monitored at the outlet to the Gaspereau River (Lanes Mill). Out-migration rates were highest during October, but the timing of out-migration appeared to have been influenced by discharge volumes from the lake and by the configuration of the control gate at this outlet, emphasizing the importance of these parameters for migrating fish. About 1.2 million YOY were estimated to have exited the lake via this outlet during the study period in 1997. Alewives were still present in the lake in late October, a large number of which moved downstream when the control gate at Forest Home was opened on October 23rd.

During the late 1990's, system maintenance and upgrades have necessitated flow restrictions in parts of the watershed during summer and fall. These closures have provided test cases for various water management strategies relating to alewives. This assessment in 1998 is of particular interest because in 1994, much of the system was not operated during the late summer and fall while the diversion dam at the White Rock headpond was under re-construction. This was the first year in recent history that the outlet from Gaspereau Lake at Lanes Mill was the only route of passage for out-migrating YOY alewives until late in the fall. Since most alewives return to spawn at 4 years of age, 1998 is the first year during which this strategy can be evaluated.

1.2 Objectives

This project was undertaken to provide further information about this stock, focusing on an assessment of the stock and fishery in 1998 and out-migration of young-of-the-year. As part of a peripheral study on YOY electivity (food selection), larval and zooplankton abundance was estimated in Gaspereau Lake and is included in this report. Specific objectives of this project include:

1. Assessment of the alewife stock and fishery

    Information about the status of the stock in 1998, including stock size, fishery exploitation rates, morphological data (length and weight), and life history characteristics (age, growth rates, age at maturity, previous spawning history and mortality rates) were determined and are compared to data collected in previous years.

2. Timing and rate of adult migration

    As part of the current management strategy, the control gate at Forest Home is closed when alewives first enter the lake. Information about the timing of the spawning run and the length of time required for alewives to reach Gaspereau

Lake was therefore collected as part of this study.

3. YOY out-migration at Lanes Mill

As was the case during 1997, a plan to keep the control gate at Forest Home closed until fall presented the opportunity to further evaluate the potential of the outlet at Lanes Mill as a passage for out-migrating juveniles. Factors such as the timing of out-migration events, the size of fish at out-migration, and relationships with environmental factors such as temperature and water flow were to be studied at this location, at lower river flows than in 1997.

4. YOY abundance and size in Gaspereau Lake

The abundance and size of YOY were monitored in Gaspereau Lake. These data are used to compare reproductive success (using larval density as an index of abundance) with 1997, and to provide information about the size of YOY throughout the season. This later information is necessary to determine the earliest time of the year at which the diversion screen at Trout River Pond becomes effective.

5. Evaluation of a plan to open the Forest Home control gate briefly in mid-July

In order to provide food for smallmouth bass downstream of Gaspereau Lake, the control gate was opened at Forest Home on two days in July. Passage of larval alewives downstream was monitored during this period.

6. YOY out-migration at the Trout River Pond fish diversion screen

The final portion of this study involved monitoring alewife out-migration at the Trout River Pond fish diversion screen after the control gate at Forest Home was opened during the fall. Objectives of this portion included determining if significant numbers of alewives remained in Gaspereau Lake in late fall and evaluating the effectiveness of the screen at this time.

2. METHODS

2.1 Alewife Count at White Rock (Total Count)

As was the case in previous studies, data to assess the status of the alewife stock were collected as fish ascended the fish ladder bypassing the White Rock generating station. Alewives were counted as they passed through a v-notch, counting weir located near the top of the ladder. When attendants were not present and at night, the weir was closed to prevent fish passage, thus ensuring a total count.

Number of alewives per 15-minute interval was recorded for all intervals between 0800h and 2000h (0730h to 2030h during peak migration) during the majority of the run. During periods at the beginning and end of the run, when few fish were ascending the ladder, the length of the count interval was increased and the weir operated as a trap. The trap was checked several times daily to enumerate these fish. This allowed researchers to focus on other aspects of this project while still meeting the objective of a total count.

Fork length, weight and sex were recorded for 10 fish more or less randomly selected from every 1000 alewives that ascended the ladder. Scale samples were also collected from these fish and used to determine age and previous spawning history. The criteria of Cating (1953) and Judy (1961) for determining spawning marks and annuli on American shad scales was used while processing these scales. These criteria are commonly used for alewives (Marcy 1969). Scales were cleaned with water, mounted on glass slides and projected on Bristol board with a projecting microscope prior to reading.

All fish sampled were externally examined to confirm that they were in fact alewives and not blueback herring (*Alosa aestivalis*). We also monitored the catch at Millett’s net site, using peritoneum color as the primary distinguishing characteristic between the species.

Water temperature, water levels above and below the White Rock dam, and weather observations were recorded four times daily throughout the spawning run. Water temperature was also monitored using a temperature data logger (Vemco Minilog-T) located in the fishway just downstream of the counting weir.

2.2 Alewife Count at Lanes Mill (Partial Count)

A partial count of the alewives ascending the ladder into Gaspereau Lake at Lanes Mill was conducted to determine the timing of movement into the lake relative to ascension of the ladder at White Rock, and to estimate the number of alewives entering Gaspereau Lake. Alewives were counted as they passed over a white counting board while exiting the ladder, typically during the latter part of the day. Water temperature, water level in the lake and weather observations were also recorded on each day. A second temperature data logger was deployed in this fishway to provide more detailed temperature information.

The number of alewives entering Gaspereau Lake was estimated based on the assumption that diel variability in activity level was similar at the White Rock and Lanes Mill fishways. We calculated the proportion of alewives that ascended the White Rock ladder each day during the Lanes Mill count period, and used this value to estimate the total number of alewives ascending the Lanes Mill ladder on that day. The assumption of similar activity rates was not tested.

2.3 Migration Times between White Rock and Gaspereau Lake

The rate of adult upstream migration between the White Rock Ladder and Gaspereau Lake was determined by estimating the time lag between the passage of fish representing percentages of the total run (multiples of 10) at the two ladders throughout the migration period. This approach was used in 1997 and gave results similar to observation of marked fish. Estimated daily totals were used to determine the percentiles at Lanes Mill, since count periods at Lanes Mill were not the same on all days. Thus, the time lag between the first alewife ascending the White Rock ladder and the first alewife to ascend the Lanes Mill ladder was used as an estimate of migration rate. Similarly, the lag between 10 % of the alewives ascending the White Rock ladder and 10 % of the alewives ascending the Lanes Mill ladder was also used as an estimate of migration rate, as was the lag between 20 % of the alewives ascending each ladder. In this way, estimates were calculated for each percentile.

2.4 Statistical Analysis of Fishery and Life History Characteristics

Mean length, maximum observed length, mean age, maximum observed age, mean age at maturity, sex ratios, percent repeat spawners, Von Bertalanffy's growth coefficient and theoretical maximum length (asymptotic length), and instantaneous mortality were calculated for males and females in order to describe the stock.

Population growth rates, expressed as Von Bertalanffy's growth coefficient and theoretical maximum length, were estimated by iteratively seeking a least squares solution to the Von Bertalanffy growth equation (Ricker 1975):

$$l_t = \mathrm{L}_\infty (1 - e^{-\mathrm{K}(t - t_o)})$$

where:

l_t = length at age t — L_∞ = theoretical maximum length

K = growth coefficient — t_o = theoretical age when length = 0.

Data used for fitting this model were a composite of two sets. Length-at-age for ages 1 to 3 years was estimated by back-calculating from the distances between annuli measured on a set of scales from 50 males and 50 females (randomly chosen from those aged). Because scale erosion or re-absorption occurs when alewives spawn, use of this method for older age classes would lead to erroneous estimates. Therefore length-at-age for the older age classes was estimated from the length of the fish in each age class in the 1997 sample. This information was not available for the younger age classes since alewives do not typically return to spawn until they are about 4 years old, necessitating the above back-calculations.

Instantaneous mortality (Z) was estimated in two ways. As was the case in 1997, Z was estimated as the slope of the line:

$$\ln N_t = \ln N_0 - Z(t)$$

where:

N_t = size of the age class at age t
N_0 = theoretical size of the age 0 class
t = age in years
and
Z = instantaneous rate of mortality

Prior to fitting this line, the sizes of the age 4, 5 and 6 classes were adjusted by the percent mature in each age class to account for immature fish not represented in the spawning run. This approach to estimating mortality requires the assumption that recruitment is constant each year, or that enough year classes are present in the data set that variability in recruitment averages out. Both assumptions are violated in this instance, although the approach is often used when the assessment is conducted in only one season.

Because of the above violations, we calculated total annual mortality (A) by estimating the size of the 4 year and 5 year age classes in 1997 (by correcting for the proportion immature), and comparing these to the size of the 5 year and 6 year age classes in 1998:

$$A = 1 - \frac{N_{1998}}{N_{1997}}$$

where: N_{1998} = the size of a given year class in 1998
and N_{1997} = the size of the same year class in 1997

By following these cohorts through time, a better estimate of mortality is obtained. The instantaneous mortality rate (Z) was then calculated from the total annual mortality as:

$$Z = -\ln(1-A)$$

Fishery exploitation rates were calculated using catch statistics (number of pails caught) provided by DFO and counts of the number of alewives per pail, provided by a local fisherman.

2.5 Monitoring YOY Out-migration at Lanes Mill

Out-migration of young-of-the-year alewives at Lanes Mill (the outlet of Gaspereau Lake to the Gaspereau River) was monitored by sampling with a 0.5 m diameter zooplankton net deployed in the fishway. The volume of water filtered by the net was calculated from water velocities measured by a General Oceanics Inc. torpedo flow meter (model 2031; high velocity rotor) mounted inside the net. Deployments were typically of 0.5 hr duration, although they were shortened when large numbers of alewives were captured. Catches were enumerated in the field and the majority of fish released alive in the lower part of the fishway. A sample of alewives was collected from representative catches and preserved in isopropanol until further analysis in the laboratory.

Sampling was conducted at an intensity that covered between 5% to 10% of the total time available during each month. Sampling times were therefore chosen to emphasize time periods during the day when alewives were expected to move, primarily during the late evening and at dawn.

To obtain an estimate of the number of YOY alewives leaving Gaspereau Lake via Lanes Mill, the number of alewives captured during a deployment was standardized first to the density of alewives (number/m^3), based on flow meter readings, and then to the rate of out-migration (number/hr.), based on discharge volumes supplied by NSPI. Because sampling was stratified to increase the probability of catching fish by fishing at times when alewives were expected to be moving, the mean rate of out-migration calculated from the samples for a given time period would be a biased estimator of the true mean rate of out-migration for that time. To correct for this bias, the day was divided into 24 strata (each 1 hour long). The mean rate of migration was then calculated for each strata and summed to obtain final estimates using methods summarized by Krebs (1989):

1. Stratified mean migration rate (number/hr.):

$$x_{st} = \frac{\sum_{h=1}^{24} N_h x_h}{N}$$

2. Stratified migration total:

$$X_{st} = N x_{st}$$

3. Variance of the stratified mean migration rate:

$$\mathrm{var}(x_{st}) = \sum_{h=1}^{24}\left[\frac{w_h^2 s_h^2}{n_h}\left(1 - f_h\right)\right]$$

4. Variance of the migration total:

$$\mathrm{var}(X_{st}) = N^2 \mathrm{var}(x_{st})$$

5. Confidence intervals were obtained from t-distributions after estimating the effective number of degrees of freedom:

where:

1. N_h = Size of stratum h (number of days in the time period in question)
2. N = Size of the statistical population (N_h x 24 hr/day)
3. W_h = stratum weight (N_h/N)
4. h = stratum number (hour: 1 to 24)
5. x_h = observed mean for stratum h
5. s_h^2 = observed variance of stratum h
6. n_h = sample size in stratum h
7. f_h = sample fraction in stratum h (n_h/N_h)
8. $g_h = N_h(N_h-n_h)/n_h$

$$\text{d.f.} = \frac{\left(\sum_{h=1}^{24} g_h\, s_h^2\right)^2}{\sum_{h=1}^{24}\left[g_h^2 s_h^4 / \left(n_h - 1\right)\right]}$$

Water temperature at Lanes Mill was monitored using a temperature data logger (Vemco Minilog-T), deployed in the fishway throughout the summer, set to record hourly. Temperature loggers were also deployed just upstream of the confluence of Trout River and Gaspereau River, about 0.5 km upstream of White Rock, and just downstream of the bridge in Gaspereau to provide a more complete record of water temperature in the river.

2.6 Monitoring YOY Distribution and Size in Gaspereau Lake

Larval and pre-juvenile alewife distribution and abundance in Gaspereau Lake was monitored using a 0.6 m (1 mm mesh size) diameter bow-mounted pushnet. Samples were collected by pushing the net in a straight line for 5 minutes at a pre-determined throttle setting. Samples were collected from 5 regions of the lake (Figure 3). Average boat velocity was 1.4 m/s while sampling. Sampling was limited to relatively open areas when using the pushnet because of the shallow depths and rocky substrate in Gaspereau Lake. The volume of water filtered by the net was calculated from flow measurements taken with a model 2030 General Oceanics torpedo flow meter mounted inside the net. The net was closed off against the shore at the end of the tow, at which time the catch was identified and enumerated. All sampling was conducted during the late evening (1 hour before sunset to 1 am) in an attempt to minimize time of day effects in the resulting data set.

Water temperature was monitored at a water quality station near the centre of the lake at a depth of 1 m and at the bottom (12 m) using temperature data loggers set to record hourly. Surface and bottom dissolved oxygen samples were collected bi-weekly. Samples were collected using a Van Dorn sampler and fixed in the field. Dissolved oxygen concentrations were determined by sodium azide modified Winkler titrations (A.P.H.A. 1995) in the laboratory.

Zooplankton was sampled using a 5 l Juday grab sampler. Samples (composites of two grabs) were collected every two weeks from July 2nd to Aug 25th at 15 stations throughout Gaspereau Lake on each sample day. Samples were stored in 1 litre Mason jars, fixed with formalin (c. 5% final concentration) and enumerated in the laboratory.

Zooplankton was identified and enumerated by subsampling (5 replicates) the collected samples and counting the organisms present in the subsample under a dissecting microscope (10 to 50 times magnification). Subsample volumes varied depending on the density of organisms in the sample and ranged from 1 to 5 ml. Counts were standardized by the sample volume to obtain the number of organisms per litre.

Figure 3. Map of Gaspereau Lake.

2.7 YOY Out-migration at the Trout River Pond Fish Diversion Screen

Out-migration of young-of-the-year alewives at the Trout River Pond fish diversion screen was monitored by sampling with a 0.5 m diameter zooplankton net deployed in the bypass stream. The net was deployed at the downstream end of a culvert and captured all fish moving through the culvert when in place. Nets were deployed once every 5 minutes (10 to 60 seconds per deployment) when sampling. Water temperature at this location was monitored with a temperature logger set to record hourly.

2.8 Laboratory Methods (YOY)

Larval fish were identified in the laboratory using Jones *et al*. (1978) as a guideline for identification. Samples of alewives from representative deployments were preserved in isopropanol and measured (fork length to the nearest 0.1 millimeter) in the laboratory. A sample of 20 alewives was measured both fresh in the field and after preservation for 10 days to determine the amount of shrinkage associated with this procedure. Fresh lengths averaged 6.2 % longer than preserved lengths (s.d. = 2.4 %). All lengths reported herein are corrected for this shrinkage.

2.9 Experimental Alewife Release at Forest Home

During 1998, the gate at Forest Home was opened for two 24 hour periods during late June and early July to allow YOY alewives to move downstream in order to supply food for smallmouth bass in the reservoirs in the lower part of the watershed. One meter diameter, 1 mm mesh zooplankton nets were used to monitor passage in the canal about 30 m below the control gate. Nets were deployed in two positions across the canal, one about 1/3 the canal width from the north bank, and the other about 1/3 the canal width from the south bank. The volume of water filtered by each net was measured with a General Oceanics flow meter mounted within the net. The net on the south bank filtered 8 - 9 % of the total flow, while the net on the north bank filtered 5 - 7 % of the flow. Deployment duration varied depending on the zooplankton by-catch volume (several liters/deployment), ranging typically between 10 and 20 minutes.

Downstream passage of alewives was monitored for 15 hours of the first day of release (1015h to 2230h on June 24, and 0545h to 0830h on June 25) and for 12 hours on the second day (1400h July 9 to 0200h July 10). These times were chosen to allow monitoring during the morning on one day and monitoring at night on the other, thus allowing the estimate to be weighted by the time of day if diel periodicity was significant.

3. RESULTS

3.1 Alewife Count at White Rock (Total Count)

During 1998, alewives were first observed at Millett's net site on the Gaspereau River on April 17th. The fish ladder was watered up on April 24th, and checked for fish 3 times daily (0.5 hr. each time) through April 26th. The counting weir in the ladder was closed April 27th, and the first alewives captured in the ladder (6 in total) were captured on that day. The weir was checked several times each day through May 2nd, and daily totals remained under 500 during this time. Continuous monitoring of the weir began on May 3rd (3,934 fish). The count peaked on May 6th, when 21,871 alewives ascended the ladder (Figure 4), and remained greater than 500/day through June 7th. Monitoring continued until June 12th, at which time a few stragglers were still ascending the ladder. In total, 171,639 alewives were counted while ascending the White Rock fish ladder. Ninety-nine percent of these fish were counted between May 3rd and June 7th. Ninety-five percent of the run ascended the ladder between May 4th and June 5th. The time and number of alewives counted at White Rock during each count interval throughout this study are recorded in Appendix 1.

3.2 Alewife Count at Lanes Mill (Partial Count)

We first observed alewives ascending the Lanes Mill fish ladder in 1998 on May 4th (17 fish in 0.5 hours of observation). Monitoring at Lanes Mill began on May 5th, and 159 were counted during 1.75 hours on this day. The count peaked on May 8th (3659 alewives during the daily count period), and dropped to under 500 alewives during the count period on May 11th (Figure 5). The count then fluctuated between 5 and 825 alewives until June 12th, when the count was discontinued. In total, 24,973 alewives were counted entering the lake between May 4th and June 12th. Appendix II contains the time and number of alewives counted during each count interval at Lanes Mill in 1998. By assuming patterns of daily movement at Lanes Mill are similar to those at White Rock, we estimated that about 96,891 alewives entered Gaspereau Lake during the 1998 spawning run.

3.3 Blueback Herring

Species identity was checked on all fish sampled at the White Rock ladder (external examination only). All 1,713 fish were identified as alewives. About 100 fish were examined for peritoneum color intermittently at Millett's net site throughout the run (100's more were examined externally). On May 28th, 2 blueback herring were identified at this location. Since the fishery closed at the end of May, this method of monitoring was not possible during the later stages of the run. We therefore dipped a further 1,558 fish from the ladder between May 29th and June 12th. External examination of these fish revealed one blueback herring.

Figure 4 White Rock Count

Figure 5 (Lanes Mill Count)

3.4 Migration Times Between White Rock and Gaspereau Lake

Eight days elapsed between the first observation of an alewife in the White Rock ladder and the first observation of an alewife in the Lanes Mill ladder (Table 1). Migration time averaged 3.5 days throughout the study.

Table 1. Dates upon which alewives representing 10ith percentiles ascended the fish ladders at White Rock and Lanes Mill in 1998.

	White Rock		Lanes Mill		Elapsed
Percentile	Count (n)	Date	Count (n)	Date	Time (days)
first alewife	1	April 27	1	May 5	8
10th	17,165	May 4	9,799	May 7	3
20th	34,329	May 5	19,597	May 8	3
30th	51,493	May 6	29,395	May 8	2
40th	68,657	May 7	39,193	May 9	2
50th	85,821	May 9	48,991	May 10	1
60th	102,985	May 11	58,785	May 14	3
70th	120,149	May 15	68,587	May 19	4
80th	137,313	May 21	78,385	May 28	7
90th	154,477	June 1	88,183	June 3	2
last alewife	N/A		N/A		

3.5 Adult Out-migration

Post-spawning adults were first observed leaving Gaspereau Lake on May 28th. As was the case in 1997, movement in and out of the ladder precluded accurate counts of downstream migrants. Adult alewives were observed in Gaspereau Lake near Lanes Mill throughout the summer while monitoring juvenile out-migration, although few moved downstream via the Lanes Mill fish ladder. Adult alewives were still present in the lake in November and were observed leaving the lake via the diversion stream at Trout River Pond early during that month. While not quantified, substantially more adults were observed leaving the lake during the fall in 1998 than in 1997 (none were observed at Trout River Pond during the fall of 1997). River flow at the Lanes Mill outlet during July and August was lower in 1998 (c. 10 c.f.s.) than in 1997 (c. 50 to 80 c.f.s.), suggesting that adults may have had more difficulty locating the outlet during 1998.

3.6 Stock Characteristics

3.6.1 Fork length

Fork lengths were measured on samples of 964 male and 749 female alewives collected throughout the run. Males averaged 246.7 mm in length, and females 257.0 mm (Table 2). Length frequency distributions are shown in Figure 6.

Table 2. Fork length summary statistics for the 1998 Gaspereau River alewife spawning run.

Statistic:	Males	Females
n	964	749
Mean (mm)	247.6	257.0
Standard Deviation	14.7	16.1
Minimum (mm)	214.0	202.0
Maximum (mm)	299.0	302.0

3.6.2 Sex ratio

As estimated by the sex ratio of the fish sampled, males outnumbered females by a ratio of 1.29:1 during 1998.

3.6.3 Age and maturity

Ages ranged from 3 to 7 years for males, and from 4 to 6 years for females, as shown by the age frequency distributions in Figure 7. These distributions are based on ages determined for 199 female and 247 male fish. Summaries of these distributions are presented in Table 3.

Age at first maturity ranged from 3 to 5 years for males and 3 to 6 years for females (Figure 8). Mean age at first maturity was 4.10 years (s.d. = 0.39) for males and 4.19 years (s.d. = 0.42) for females. Repeat spawners comprised 32.7% of female, and 23.5% of male alewives sampled.

Figure 6. Fork length frequency distributions estimated for male (top) and female (bottom) alewives in the 1998 Gaspereau River spawning run.

Figure 7. Age frequency distributions estimated for male (A) and female (B) alewives in the 1998 Gaspereau River spawning run.

Figure 7. Frequency distributions showing age at first spawning for male (A) and female (B) alewives in the 1998 Gaspereau River spawning run.

Table 3. Age summary statistics for the 1998 Gaspereau River alewife spawning run.

Statistic:	Males	Females
n	247	199
Mean (yr)	4.36	4.41
Standard Deviation	0.60	0.58
Minimum (yr)	3	4
Maximum (yr)	7	6

3.6.4 Weight

The weights of 1661 alewives were measured to the nearest two grams during the spawning run. Males averaged 212.3 g and females 244.6 g (Table 4). Weight-length relationships were developed from these data and are shown in Figure 9.

Table 4. Weight summary statistics for the 1998 Gaspereau River alewife spawning run.

Statistic:	Males	Females
n	929	732
Mean (g)	212.3	244.6
Standard Deviation	42.5	50.8
Minimum (g)	124	142
Maximum (g)	366	406

3.6.5 Growth

Von Bertalanffy growth curves (Figure 10) were derived from male and female length-at-age data collected during this assessment for ages 4 to 7 years, combined with back-calculated length-at-age for ages 1 to 3 years (see methods). The theoretical maximum length for the males was estimated as 280.9 mm and for the females as 297.7 mm. Growth coefficients were estimated as 0.52 and 0.48 for the males and females respectively.

Figure 9. Weight-length relationships developed for male (A) and female (B) alewives in the 1998 Gaspereau River spawning run.

Figure 10. Von Bertalanffy growth curves overlaid against fork length-at-age data for male (A) and female (B) alewives collected from the 1998 Gaspereau River alewife spawning run.

3.6.6 Mortality

Instantaneous mortality rates, based on the age structure of the 1998 spawning run, were estimated as 1.76 for male and 1.43 for female alewives (Figure 11). These estimates correspond to annual mortality rates of 82.8% for males and 76.0% for females.

Better estimates of mortality can be obtained by following a cohort or year class through time. Mortality between ages 4 and 5 is lower than that between ages 5 and 6 (Table 5), due to incomplete recruitment into the fishery at age 4.

Table 5. Total annual mortality (A) and instantaneous mortality rates (Z) estimated by comparison of the size of the 1992 and 1993 year classes in 1997 and 1998 (N_t). Year class size is adjusted by the sex ratio and proportion mature for each year.

Year Class	Sex	Age_{1997}	Age_{1998}	N_{1997}	N_{1998}	A	Z
1993	male	4	5	314,821	79,163	0.749	1.380
1993	female	4	5	259,661	72,893	0.719	1.270
1992	male	5	6	86,134	13,397	0.825	1.741
1992	female	5	6	100,500	10,579	0.873	2.065

3.7 The Fishery: Catch Statistics - 1998

Fishermen on the Gaspereau River caught 2,800 pails of alewives (Hank Sweeney DFO, pers. comm.) in 1998. Square net operators caught 2,530 pails, the remainder taken by drift net, gillnet, dip net and jigging. Pails hold c.22.7 kg of fish, which, in 1998 was the equivalent of c.133 alewives (mean number of fish per pail; sd = 8.09, n = 6), implying that the fishery harvested about 372,400 alewives this year. Stock size in 1998, estimated as the sum of the total catch and the White Rock count, is 544,039 fish. The exploitation rate in 1998 is therefore estimated at 68.5%.

Figure 11. Instantaneous mortality rates estimated for male (A) and female (B) alewives in the 1998 Gaspereau River spawning run.

3.8 Comparisons with Other Years

3.8.1 Life history characteristics

Life history characteristics of the Gaspereau River alewife stock for 6 years during the 1980's and 1990's are summarized in Table 6. While not the youngest on average, alewives in 1998 were on average the smallest encountered in any of these assessments. The proportion of age-4 fish decreased from 68.4% to 62.9% between 1997 and 1998, indicating that the decrease in mean fork length between 1997 and 1998 was not due to increased relative abundance of young fish. Rather, it is due to a decrease in length of age-4 fish (Figure 12). Differences in mean length of age-4 alewives between 1997 and 1998 are statistically significant at a 99% confidence level (t-test; males: $p<0.001$, df=343; females: $p<0.001$, df=263). No statistically significant difference was found for age-5 alewives between 1997 and 1998 (t-test; males: $p=0.348$, df=114; females: $p=0.065$, df=114). To determine when this size difference developed, we back-calculated length-at-age for a randomly selected sample of age-4 fish from the 1997 and 1998 samples. Based on this analysis it appears the size difference developed between ages three and four (Table 7).

Table 6. A comparison of 1998 Gaspereau River alewife stock characteristics with those determined in other years.

Statistic	Year	Males	Females
Mean Age (yr) ± standard deviation	1998	4.36 ± 0.60	4.41 ± 0.58
	1997	4.29 ± 0.59	4.50 ± 0.76
	1995	4.79 ± 0.56 (sexes combined)	
	1984	4.8 ± 0.52*	5.0 ± 0.46*
	1983	4.5 ± 0.69*	4.9 ± 0.83*
	1982	5.0 ± 0.49*	5.1 ± 0.49*
Mean Fork Length (mm) ± standard deviation	1998	247.6 ± 14.7	257.0 ± 16.1
	1997	255.5 ± 10.5	265.0 ± 14.1
	1995	257 ± 12.8 (sexes combined)	
	1984	263.0 ± 12.0*	272.8 ± 11.7*
	1983	252.9 ± 15.0*	268.5 ± 17.8*
	1982	268.7 ± 10.6*	279.4 ± 11.6*
Mean Weight (g) ± standard deviation	1998	212.3 ± 42.5	244.6 ± 50.8
	1997	221.4 ± 29.8	253.7 ± 40.3
	1995	367 ± 309 (sexes combined)	
	1984	254.2 ± 38.9*	288.0 ± 44.8*
	1983	232.4 ± 48.6*	290.4 ± 67.4*
	1982	272.1 ± 34.5*	315.7 ± 48.5*
Mean Age at First Spawning (yr) ± standard deviation	1998	4.10 ± 0.39	4.19 ± 0.42
	1997	4.11 ± 0.39	4.18 ± 0.42
	1995	4.6 ± 0.55 (sexes combined)	
	1984	4.63[a]	4.82[a]
	1983	4.36[a]	4.61[a]
	1982	4.89[a]	4.89[a]

* standard deviations calculated from Jessop and Parker (1988)
[a] calculated from Jessop and Parker (1988)

Table 6 (con't). A comparison of 1998 Gaspereau River alewife stock characteristics with those determined in other years.

Statistic	Year	Males	Females
Repeat Spawners (%)	1998	32.7	23.5
	1997	15.1	24.8
	1995	16.9 (sexes combined)	
	1984	15.4	11.5
	1983	12.1	22.0
	1982	8.2	12.2
Instantaneous Mortality Rate (Z)	1998	1.76	1.43
	1997	1.39	1.21
	1995	1.75	
	1984	2.66	
	1983	0.91	
	1982	0.63	
Exploitation Rate (%)	1998	68.5	
	1997	86.5	
	1995	< 88.3 (see text)	
	1984	69.9*	
	1983	56.7*	
	1982	80.9*	

* values calculated from catch statistics adjusted by weight (see text)

Figure 12. A comparison of back-calculated length-at-age of 4 year old male (A) and female (B) alewives sampled from the Gaspereau River in 1997 and 1998.

Table 7. A comparison of back-calculated length-at-age of age 4 alewives sampled in 1997 and 1998.

		1997			1998		
Sex	Age	Fork Length (mm)	S.E.M.	N	Fork Length (mm)	S.E.M.	N
Female	1	93.7	2.3	31	96.7	4.2	38
	2	171.6	3.3		178.9	2.9	
	3	217.7	2.3		218.4	2.6	
	4	256.8	2.0		250.1	2.3	
Male	1	90.3	1.7	34	100.4	3.7	51
	2	168.8	2.1		178.3	2.6	
	3	214.5	1.5		216.8	2.5	
	4	251.8	1.1		245.7	1.8	

3.8.2 The Fishery

The 1998 alewife catch on the Gaspereau River (2,800 pails) was slightly more than one third of the 1964 – 1998 mean catch and exactly one half the median catch for the same time period (Table 8).

Table 8. Summary of Gaspereau River alewife catches between 1964 and 1998:

Statistic	Catch (pails)
Mean	7,215
Minimum	1,099
Maximum	20,744
Median	5,600
1998 catch	**2,800**

Spawning escapement in 1998, measured as the number of fish ascending the White Rock ladder, was the highest for the 7 years for which data are available (Table 9). With the exception of 1998, catches have been greater than 5000 pails since 1993. Extrapolation on the basis of 120 fish/pail implies that the run is the smallest during this time period. Catches in 1991 and 1992 were less than 4000 pails. Without counts of escapement for these years, we are unable to determine whether these runs were larger or smaller than that of 1998.

In 1998, 68% of the stock was 4 years of age. Recruitment of the 1994 year class into the fishery in 1998 was therefore c.359,000 fish. Recruitment of the 1993 year class into the 1997 fishery was c.484,000 fish.

Table 9. Summary of yearly alewife counts at the White Rock fish ladder, estimated stock size, and the annual catch and exploitation rates of the Gaspereau River alewife fishery.

Year	Alewife Count	Catch (number of fish)	Stock Size	Exploitation Rate (%)
1998	**171,639**	**372,400*** **	**544,039**	**68.5**
1997	95,433	611,520*	706,953	86.5
1995	126,933 (part.)	954,960*	>1,081,893	<88.3
1984	111,100	212,966**	324,066	69.9
1983	114,800	150,408**	265,208	56.7
1982	50,400	254,068**	304,468	80.9
1970	60,527	480,000*	540,527	88.9

* assumes 120 alewives/pail
** number of alewives/pail adjusted by mean weight/alewife
*** assumes 133 alewives/pail

3.8.3 Timing of the spawning run

The 1998 alewife spawning run began earlier than any of the runs for which counts are available (Table 10). Based on this limited data set, there does not appear to be a trend towards earlier runs (the 1997 and 1995 runs were the latest of this set).

Table 10. Timing of the alewife run ascending the White Rock ladder during years in which alewives were counted.

Year	1st day with a count > 1% of the total count	Last day with a count > 1% of the total count
1998	**May 3**	**June 4**
1997	May 14	June 14
1995	May 14	June 10

1984	May 8	June 3
1983	May 4	June 9
1982	May 12	June 12

3.9 Abundance of Larvae in Gaspereau Lake

The number of alewives captured with a pushnet, standardized by the volume of water filtered by the net, provides an index of larval abundance that can be used to compare abundance between lake sections and between years. Abundance was measured on two days: July 2nd and July 16th. The net was deployed 19 times resulting in the capture of 381 larvae. Larvae were most abundant in the Two Mile Lake and Four Mile Lake section on July 2nd (Figure 13), and was similar in all lake sections on July 16th.

Direct comparison of larval abundance for the same time period between 1997 and 1998 does not provide a valid comparison because adult alewives entered Gaspereau Lake about two weeks later in 1997 than in 1998. However, peak abundance in 1998 (July 16th) was 1.2 times higher than in 1997 (July 10th), and both abundance estimates in 1998 were higher than all abundance estimates in 1997 except July 10th (Table 11). Together these facts suggest that larval abundance was higher in 1998 than in 1997. This conclusion is also supported by estimates of the number of spawners each year (about twice as many in 1998).

Table 11. A comparison of alewife larval abundance indices (number captured per cubic meter of water filtered by the net) estimated for Gaspereau Lake in 1997 and 1998.

1997					1998			
Date	Mean	N	S.E.M.		Date	Mean	N	S.E.M.
June 24	0.137	23	0.04					
July 2	0.049	19	0.013		July 2	0.179	10	0.058
July 10	0.190	17	0.093					
July 16	0.029	22	0.016		July 16	0.227	6	0.081
July 22	0.053	16	0.023					
July 30	0.012	6	0.012					

Figure 13. Indices of YOY Alewife abundance in Gaspereau Lake on two days during 1998: the mean number captured per tow (top) and the mean density (bottom). Error bars are one standard error of the mean.

3.10 Environmental Data

3.10.1 Temperature

Temperature data loggers were deployed in the fishway bypassing the White Rock dam, the outlet of Gaspereau Lake at Lanes Mill, the center of Gaspereau Lake (surface and bottom), in the Gaspereau River just upstream of the Deep Hollow Bridge in White Rock, in the upper Gaspereau River downstream of the stillwater and at Terry Millett's square net site (downstream of the bridge in Gaspereau). The time and duration of these deployments varied depending upon data requirements. Temperature loggers were set to record the temperature hourly.

In total, 20,280 temperature observations were recorded by these loggers. Time series (hourly temperature) for each location are presented in Appendix III. Table 12 contains a summary of the values recorded by month.

Gaspereau Lake was moderately stratified when the temperature loggers were first deployed at the water quality station (Appendix IIIa). This stratification broke down during late June, presumably due to high winds at that time. While temperature differences developed between surface and bottom water intermittently throughout the rest of the summer, no stable stratification developed during this time.

As was the case in 1997, water temperatures at Lanes Mill (Appendix IIIb) showed considerably more variation than at the water quality station. Water temperatures at Lanes Mill warmed rapidly during the early summer, reaching a maximum of 28.8 °C on July 16th. Temperatures regularly fluctuated 4 to 5 °C daily at this time, presumably in response to changes in air temperature and solar radiation.

Daily temperature fluctuations in the Gaspereau River between Lanes Mill and White Rock were monitored just downstream of a stillwater (Appendix IIIc) in the upper third of the river, and just upstream of the Deep Hollow bridge. Daily temperature fluctuations increased with distance downstream, as evidenced by the wide fluctuations at Deep Hollow Bridge of up to 10 °C daily during June and July (Appendix IIId). Similar to 1997, peaks in daily temperature coincide roughly with peaks at Lanes Mill which, given a distance of about 11 km between the loggers, is indication that temperature in the river near White Rock varies more as a function of air temperature and solar radiation than of lake water temperature at Lanes Mill.

Water temperature in the Gaspereau River downstream of the bridge in Gaspereau also fluctuated by up to 10 °C during July and August. The maximum temperature recorded at this location was 29.6 °C on August 10th (Appendix IIIe).

Table 12. Monthly temperature summary statistics for 6 locations in the Gaspereau River watershed during 1998: the surface (1m depth) and bottom (10.5 m depth) of Gaspereau Lake near the centre (G.L.S. and G.L.B., respectively), the outlet of Gaspereau Lake at Lanes Mill (O.L.M.), the Gaspereau River 0.5 km upstream of Deep Hollow Bridge in White Rock (D.H.B.), near Terry Millett's square net site (T.M.S.), within the White Rock fish ladder (W.R.F.), and below the stillwater in the upper Gaspereau River (G.R.S.).

		Location						
Month	Statistic	W.R.F.	O.L.M	G.L.S.	G.L.B.	D.H.B.	T.M.S.	G.R.S.
May	mean	14.59	16.82			15.02		
	s.d.	1.97	2.08			2.76		
	min.	9.3	12.70			9.60		
	max.	18.5	22.30			24.00		
June	mean	17.86	18.59	19.56	17.40	17.01		
	s.d.	1.28	2.82	0.87	0.64	3.21		
	min.	15.8	12.00	17.80	16.30	10.50		
	max.	20.8	25.00	21.60	19.30	26.60		
July	mean	20.43	22.89	21.55	19.25	20.50	22.67	23.91
	s.d.	0.77	2.12	1.49	0.95	2.90	2.02	1.55
	min.	19.00	17.70	18.00	18.00	15.10	18.70	20.20
	max.	21.00	28.80	24.80	22.10	27.80	27.40	27.90
August	mean		22.27	21.63	20.59	20.22	21.80	21.90
	s.d.		1.83	1.06	0.53	2.63	2.53	1.77
	min.		18.70	20.00	19.80	14.50	17.30	18.40
	max.		27.30	25.40	23.20	27.60	29.50	26.40
September	mean		17.05	17.48	17.24	15.59	17.52	16.83
	s.d.		2.21	2.02	1.96	2.54	2.37	2.36
	min.		12.70	14.60	14.40	10.20	12.70	12.60
	max.		23.10	21.30	20.50	22.90	25.40	22.80
October	mean		9.73	12.26	12.25	9.17	10.95	12.11
	s.d.		1.74	1.56	1.57	2.25	1.79	1.91
	min.		5.90	10.40	10.50	2.90	5.50	9.00
	max.		16.50	15.10	15.10	16.50	17.30	15.50
November	mean		4.81					
	s.d.		1.56					

	min. max.		0.70 8.10					

3.10.2 Zooplankton

Zooplankton samples were collected on 6 dates between June 18th and August 25th, from the five sections of the lake. Estimates of mean zooplankton abundance for each lake section and date (Figure 14) ranged between 5 and 48 organism/l at 1 meter depth. The cladocerans *Daphnia spp*., *Holopedium sp*., *Bosmina sp*. and unidentified copepod nauplii were the most common organisms in the samples. Zooplankton abundance was higher in 1998 than in 1997 (range 1 to 20 organisms/l), primarily due to the presence of copepod nauplii that were less abundant during the earlier year.

3.10.3 Dissolved Oxygen

Dissolved oxygen concentration was determined from surface and bottom water samples collected twice monthly at the water quality station in Gaspereau Lake throughout the summer. Surface samples were more saturated than bottom samples (Table 13) and all samples were adequately oxygenated.

Table 13. Dissolved oxygen concentrations measured at the water quality station (see Figure 3) in Gaspereau Lake during the summer of 1997.

Date	Depth (m)	Dissolved Oxygen(mg/l)	Temperature (°C)	Oxygen Saturation(%)
July 2	1.0	8.64	18.8	92.0
July 2	12.5	8.58	18.2	90.3
July 16	1.0	8.60	23.5	100.4
July 16	12.0	8.52	19.8	92.5
July 30	1.0	8.10	22.5	92.8
July 30	13.0	7.84	21.9	88.8
Aug. 13	1.0	8.40	21.5	94.4
Aug. 13	13.0	8.40	21.0	93.5
Aug. 25	1.0	8.88	20.9	98.6
Aug. 25	13.5	8.20	20.1	89.6

Figure 14. Zooplankton abundance in Gaspereau Lake during July and August of 1998.

3.11 Experimental Alewife Release at Forest Home

In order to supply food (in the form of YOY alewives) for smallmouth bass downstream of Gaspereau Lake, the control gate at Forest Home was opened for two 24 hour periods, in late June and early July (June 24 - 25 and July 9 - 10, 1998). Downstream passage of fish was monitored for 15 hours during the first release period, and for 12 hours during the second release period.

Because alewife larvae have limited mobility, and because of the high turbulence within the canal, we intended to assume that larval density would be the same throughout the canal. This assumption would allow a simple calculation of the total number of alewives moving downstream, but did not prove valid. During the first release period alewife density on the north side of the canal was 0.035 alewives/m^3, and 0.142 alewives/m^3 on the south side. Density was more homogeneous during the second release period: 0.011 and 0.013 alewives/m^3 on the north and south sides respectively. Inspection of flow data indicated that the majority of water moved along the south side of the river. Diel variability was not apparent on either day. Because the south side catches were more representative of the total flow, using these catches, and standardizing by the total flow (9.2 m^3/s), provides an estimate indication of the number of alewives moving downstream. From this method, we estimate that c. 113,500 alewives moved downstream during the first release period, while c. 10,300 alewives moved downstream during the second period (Table 14). The majority of alewives captured were larvae, and were smaller than the larvae and pre-juveniles captured in Gaspereau Lake during the same time period. An undetermined number of adult alewives also moved downstream during this release. Several schools of 10 to 40 adults were observed moving up and down the canal during both periods of release.

Table 14. Summary of alewife catches while monitoring the alewife release at Forest Home.

Date	Net Location	Statistic (number of alewives per deployment)	Result	Estimate of the number of YOY moving downstream per day (! (5% C.I.)
June 24-25	south side	mean	38.9	**113,452 (50,510 – 176,394)**
		standard deviation	22.1	
		minimum	1	
		maximum	70	
		n	10	
June 24-25	north side	mean	7.9	27,777 (6,055 – 49,500)
		standard deviation	7.8	
		minimum	1	
		maximum	25	
		n	10	
July 9-10	south side	mean	5	**10,735 (6,541 – 14,928)**
		standard deviation	5.6	
		minimum	0	
		maximum	18	
		n	12	
July 9-10	north side	mean	4	8,448 (2,275 – 14,621)
		standard deviation	31	
		minimum	12.1	
		maximum	7.9	
		n	12	

3.12 YOY Out-migration at Lanes Mill

YOY out-migration at Lanes Mill was monitored from July 6th to November 12th. Nets were deployed 519 times on 40 days in the field, resulting in the capture of 14,350 YOY alewives (the majority of which were immediately released). The distribution of these catches throughout this period is shown in Figure 15 as the mean number of alewives captured per net deployment during each week of the season. Figure 16 shows a similar distribution standardized by the volume of water filtered by the net. As shown, alewife catches were highly variable during the summer and fall. No alewives were captured during the weeks of Aug. 3rd, Sept. 21st, or Nov. 9th. Peak densities occurred during the weeks of Aug. 24th, Oct. 5th and Nov 2nd.

Figure 15. LM juv catches

Figure 16. LM juv densities
Estimates of the number of alewives emigrating from Gaspereau Lake each month are shown in Table 15. For all months, the stratified mean number of alewives per hour was lower than the normal mean, showing the effect of the sampling bias (sampling primarily when fish would be expected to migrate). Stratified means were used to calculate monthly total estimates. Alewives were only captured on one day in November (Nov. 3rd). The estimate for this month is high due to one large catch on that day, and therefore may be an overestimate due to this outlier. In total, about 0.5 million YOY alewives were estimated to have moved downstream via Lanes Mill (Table 15).

Table 15. Estimates of the number of alewives per month and the total number of alewives to have exited Gaspereau Lake via Lanes Mill during 1998.

Month	Number of deployments	Mean number/hr	Stratified mean number/hr	Stratified estimate of monthly total	Total 95% C.I. lower limit	Total 95% C.I. upper limit
July	90	51.2	23.7	17,641	0	57,868
August	152	333.5	107.8	80,246	0	162,537
September	119	359.8	229.8	165,435	0	338,273
October	122	174.4	96.8	72,002	21,727	122,277
Nov. 1-20	36	828.6	311.1	149,335	n/a	n/a
Total				**484,659**	**21,727**	**680,955**

3.13 Alewife Out-migration at Trout River Pond

Alewives moved into Trout River Pond immediately after the gate was opened Sept. 20th. Very large numbers of alewives had accumulated in front of the diversion screens by Sept. 24th when the bypass was opened. Most of these fish moved downstream within two days of the bypass being opened. While we did not sample at night, juvenile alewives were not present in the bypass stream until mid-morning, and catches tapered off each day about an hour before dusk. Estimates of the number of migrants each day is therefore the mean number of alewives per hour (estimated by standardizing each count to the rate per hour), multiplied by 8.5 hours. The highest number of downstream migrants occurred when the bypass stream was first opened (Table 16). Repairs to the Methals Lake generating station necessitated re-closing the Forest Home control gate on Oct. 7th. Very few alewives migrated downstream via the diversion after the gate was reopened on Nov. 9th. By estimating the number of YOY migrants on days not sampled as the mean number of YOY migrants of the previous and next sampling days, we estimate that c. 1.1 million alewives left Gaspereau Lake via Trout River Pond during 1998. While not quantified, a large number of adults (1,000+) left Gaspereau Lake via this route during late September and early October.

Table 16. Summary of daily number of juveniles to move downstream via the bypass stream at the Trout River Pond diversion screen in1998.

Date	N	Number of YOY captured	Estimated daily total	Daily Total 95% C.I.
Sept. 24	34	6,261	500,896	351,347 to 650,454
Sept. 25	56	4,863	221,459	134,036 to 308,643
Sept. 26	52	801	790	0 to 2,363
Sept. 27	12	214	54,570	0 to 136,374
Sept. 30	60	1,202	27,463	0 to 63,860
Oct. 3	60	1,669	57,477	3,901 to 111,052
Oct. 6	54	507	4,785	0 to 12,784
Nov. 9	41	2	1	0 to 1
Nov. 10	74	0	0	0 to 0
Nov. 11	65	0	0	0 to 0
Nov. 13	6	408	1,063	248 to 1,878

3.14 Age 1+ Alewives in Gaspereau Lake

Age 1+ alewives were captured while emigrating from Gaspereau Lake at both Lanes Mill and at the Trout River Pond fish diversion screen. These fish were first recognized by size (Figure 17), and their ages confirmed by the presence of a single annulus on some, but not all scales. This pattern is consistent with another anadromous alewife stock that over winter during their first year (Walton 1983). At the diversion screen, age 1+ alewives were caught on two days: Oct. 6th (16 captured) and Nov. 11th (78 captured). These data imply that 152 and 121 age 1+ alewives moved downstream on these days, respectively. With the exception of one fish captured in November, age 1+ alewives were captured at Lanes Mill only during October. In total, 198 of these fish were captured at this location, implying that 3,874 age 1+ alewives (95% C.I.: 1,861 – 5,887) moved seaward via Lanes Mill during this month.

Figure 17. Length frequency histogram showing the difference in size between age 0+ and age 1+ alewives captured at Lanes Mill on Oct. 18, 1998.

3.15 Size of Migrating Juveniles

Fork lengths were measured on 1297 YOY alewives captured at Lanes Mill throughout this study. All YOY captured during July were juveniles or pre-juveniles, and the larger juveniles were not captured until the week of Aug. 10^{th} (Figures 18.1 and 18.2). Size frequency distributions were intermittently bimodal until the end of September.

Comparison of the lengths of YOY out-migrants at Lanes Mill in 1998 with those in 1997 (Figure 19) shows some interesting patterns. Out-migrants in 1998 were smaller than those captured in 1997 until the week of Aug. 10^{th}. Out-migrants in 1998 were then larger until the third week of September after which size differences did not appear significant.

Figure 18.1. Length frequency distributions for YOY alewives captured at Lanes Mill from the week of July 6^{th} to the week of Sept. 7^{th}, 1998.

Figure 18.2. Length frequency distributions for YOY alewives captured at Lanes Mill from the week of Sept. 14th to the week of Nov. 2nd, 1998.

Figure 19. Length comp

4. DISCUSSION

4.1 The Alewife Counts

The 1998 Gaspereau River alewife spawning migration was different from that of other years in a number of ways. For example, although the catch this year was only half the 1964 – 1998 median, the number of alewives escaping the fishery to ascend the ladder at White Rock in 1998 was the highest recorded (171,639 alewives), and over twice the average of the seven years for which counts are available. The duration of the run was long: 33 days for 95% of the fish to ascend the ladder, as compared to the 22.7 day mean duration for other years that counts were conducted (1982 – 1984, 1995 and 1997).

In 1997, we estimated that c.50% of the alewives that ascended the White Rock ladder entered Gaspereau Lake (Gibson and Daborn 1997). High river flows early in the season were though to have impeded the run. During this assessment, we estimated that 96,891 alewives entered Gaspereau Lake, or 56% of the fish that ascended the ladder at White Rock, even though river flows between Gaspereau Lake and White Rock in 1998 did not appear excessive. The fate of the remaining fish is not known. Undoubtedly, a portion of these fish fall prey to fishermen in South Alton. Fishing efforts in this area are not closely monitored, although fishing activity in this area may substantially reduce the number of spawners reaching Gaspereau Lake. It is likely that a portion of the stock spawn in the still waters and back eddies between the White Rock dam and Gaspereau Lake. The relative importance of spawning/nursery areas downstream of Gaspereau Lake needs to be evaluated as part of a management plan for this species.

4.2 Stock Size

The 1998 alewife catch (2,800 pails) was smaller than 80% of the catches since 1964. Even when combined with the highest recorded escapement at the White Rock ladder, the run must still have been smaller than any other during the last 7 years. This assessment can therefore be added to the collection of assessments conducted in years when the return was below the average for the last 34 years. Collectively, these assessments appear to indicate a spawning run consisting of 265,000 to 1.1 million alewives. These values do not indicate the true size range of the spawning run, because with the exception of the 1995 assessment, all were conducted during years when the catch was below the 1964 – 1998 median catch of 5,746 pails. Assuming all alewives not captured ascend the ladder, escapement from the fishery averages c.25% (extrapolated from Table 9). Also assuming an average of 120 alewives per pail, these values suggest a mean run size of 1,101,000 alewives (median: 861,500 alewives; range: 165,000 to 3,111,000).

A number of biases exist within these estimates. For example, the assumption that all alewives not captured by the fishery take the ladder is not valid. There are indications that some fish spawn downstream of the White Rock dam (Gibson and Daborn 1998). Additionally, some immature alewives probably follow adult fish into the lower part of the river, but do not complete the spawning run. These fish may be available to the fishery, but because they do not complete the run are not enumerated at the ladder. These biases may be relatively large, as evidenced by a comparison of fishing, natural and total mortality. For example, comparison of the number of 5 year old fish in the stock in 1997 with the number of 6 year old fish in 1998 provides estimates of total annual mortality of 85% for both sexes combined (Table 5). This estimate is slightly less than the 1997 estimated exploitation rate of 86.5%. Alewives typically undergo high natural post-spawning mortality, and annual natural mortality is 60 – 65% (e.g. Crecco and Gibson 1990). Given that total annual mortality cannot be less than the combined effects of fishing exploitation and natural mortality, our estimates of exploitation and total mortality are not consistent. If a number of alewives enter the river but do not take the ladder, our exploitation rates would be biased high.

An accurate determination of exploitation is essential to understanding the dynamics of this stock. Crecco and Gibson (1990) report annual fishing mortality rates at the maximum sustainable yield (u_{msy}) and at stock collapse (u_{coll}) for four North American alewife stocks. The means of these parameter estimates are 64.5% and 77.0% respectively (some of these stocks have been subjected to sustained higher fishing mortality without actually collapsing). Given that our estimates of exploitation exceed these mean estimates of u_{msy} in 6 of the 7 years for which data is available, and u_{coll} in 3 of the seven years, accurate assessments of the fishing exploitation rate should receive high priority.

The 1998 spawning run (c.544,000 fish) was 77% the size of the 1997 run (c.707,000 fish). This reduction in size is due in part to high exploitation in 1997, however given the high reliance of the fishery on first time spawners, recruitment variability plays a more important role in determining the size of the spawning run. Recruitment of age-4 alewives was c.359,000 and c.484,000 individuals in 1998 and 1997 respectively, a reduction of c.125,000 fish. Given that the 1998 spawning run was smaller than the 1997 run by c.163,000 fish, recruitment variability accounts for about 75% of the reduction in the size of the run.

Why recruitment was lower in 1998 cannot be ascertained with the available data. Age-4 fish in 1998 belong to the 1994 year class. The catch in 1994 (8,022 pails; 5,886 pails in 1993) was the highest of the 1990’s, suggesting that fish were abundant that year. However, given that the positive relationship that exists between catch and spawner escapement is weak (Gibson and Daborn 1997), we cannot conclude that spawner abundance was also highest in 1994. Young-of-the-year alewives typically undergo high mortality due to intra-specific competition and environmental conditions, so these factors may also have contributed to reducing the year class size. Additionally, during 1994, the White Rock headpond was drained for maintenance on the canal between the headpond and the White Rock dam. YOY alewives descending the old Gaspereau River were piped through the construction area, and water did not flow through the remainder of the system during the construction period. We do not know the effects of these activities upon the stock that year, although data collected during this study and during 1997 suggest that many YOY alewives will not leave Gaspereau Lake via Lanes Mill at current flow levels.

4.3 Adult Migration Rates

Migration time between the White Rock and Lanes Mill fish ladders averaged 3.5 days in 1998. Migration was substantially more rapid than in 1997, when almost two weeks elapsed between the first alewives ascending the two ladders. Migration in 1997 was probably atypical because of high river flows early in the season. River flow therefore needs to be considered if migration rates are used to predict when the gate at Forest Home is to be closed based on when the first alewives ascend the White Rock ladder.

4.4 Stock Characteristics

The Gaspereau River alewife stock exhibits life history characteristics similar to those of other rivers with high exploitation rates (e.g. D.F.O. 1997), such as a truncated age-frequency distribution. Of the 446 alewives that were aged, only one was older than 6 years. Alewives from unexploited stocks can reach 10+ years of age (Scott and Scott 1988).

While not the youngest on average, alewives of the 1998 spawning run were on average smaller than those measured during any other assessment on this river. The reduction in mean weight of 17% since the early 1980’s has direct fishery implications, since alewives are sold by weight. The decreases in fork lengths and weights between 1997 and 1998 are not due to increased relative abundance of age-4, virgin fish in 1998, as might be expected given the high exploitation rate last year. The decrease is size is due primarily to the fact that age-4 alewives were smaller in 1998 than in 1997 (these fish correspond to the 1994 and 1993 year classes respectively). Apparently, this decrease was due to reduced growth of the 1994 year class between ages 3 and 4 years. Given that the age-4 alewives are only slightly smaller than the age 4-alewives in 1983 (Jessop and Parker 1988), this reduction in size may be within the natural variation exhibited by the stock. Comparison with other stocks (e.g. St. John River) would help determine whether oceanic conditions for growth were poor during 1997

4.5 YOY in Gaspereau Lake

As was the case in 1997, larval alewives were present throughout Gaspereau Lake during July. YOY abundance indices (number per cubic meter of water filtered by the net) were higher in 1998 than in 1997, an observation consistent with the higher spawner abundance in 1998.

The temperature and oxygen data collected from Gaspereau Lake in 1998 shows a different pattern than in 1997, but leads to similar conclusions. As suggested in 1997, stratification occurs intermittently in Gaspereau Lake. In 1997, a pronounced thermocline was present at a depth of about 3 m in early July, which was broken down by strong winds later in the month, about the time the hypolimnion was going anaerobic. This stratification did not develop in 1998, and the hypolimnion remained well oxygenated throughout the season. Comparatively weak stratification did develop intermittently throughout the summer, but was broken down by the winds.

Zooplankton densities were higher in 1998 than in 1997, primarily due to the presence of copepod nauplii that were comparatively scarce in 1997. Cladoceran densities were more or less similar in both years. Both groups of organisms are important food sources for YOY alewives: larvae feed mainly on copepod nauplii, while juveniles prefer the larger cladocerans (Jemie Lent, unpublished data).

Zooplankton abundance did not show the marked decline in early July that was observed in 1997. However, given that anadromous and landlocked clupeid stocks are known to severely impact zooplankton populations (Dettmers and Stein 1992, Gorman *et al.* 1991) and that food availability is known to effect YOYgrowth and survival (Welker *et al*. 1994, Crecco and Savoy 1985, Johnson and Drokkin 1995), intraspecific competition should not be ruled out as a potentially limiting factor for this stock.

Water temperatures in the Gaspereau River are a cause for concern. Maximum temperatures recorded in both the old Gaspereau River between Gaspereau Lake and White Rock (27.8°C), and in the Gaspereau River downstream of the White Rock generating station (29.5°C) are extremely high for almost any indigenous species of fish. At low river flows, the river loses its meander, reducing the number of undercut banks and pools that can provide refuge from these temperatures. Gibson and Daborn (1998) showed that increasing the river flow reduces the range of the daily temperature fluctuations, thus mediating these high temperatures.

4.6 YOY Out-migration at Lanes Mill

Relative to 1997, comparatively few YOY alewives were captured in the outflow at Lanes Mill during July and early August. Additionally, YOY migrating during this time period in 1998 were substantially smaller than those migrating during the same time period in 1997, suggesting that these fish were entrained by the flow. Given that the flow in 1998 was about 1/3 to 1/5 the flow in 1997, it appears intuitive that only smaller fish would be entrained. The first occasion on which YOY of a larger size were captured was during the week of August 10th, suggesting that this was the onset of active migration in 1998. Catches were highly variable throughout the remainder of the season, peaking during the week of September 28th. In total, about 0.5 million alewives were estimated to have left Gaspereau Lake via Lanes Mill during 1998, in comparison with 1.2 million in 1997. Given that both spawner abundance and larval density was higher in 1998 than 1997, these data suggest that alewives either have difficulty finding this outlet at low flows, or are unwilling to move downstream at these flows. The presence of adults in the lake during October also supports this conclusion. No adults were observed moving downstream at the Trout River Pond diversion screen in 1996 or 1997, although a good number (1,000+) did so in 1998. The effect of delayed out-migration on these adults is not known, although this delay very likely disrupts seasonal migratory patterns at sea, such as those documented for American shad (Dadswell *et al*. 1987). Schools of both adult and juvenile alewives were observed in Gaspereau Lake throughout the summer and early fall directly upstream of the entrance to the ladder that did not move downstream. These observations are further evidence of the reluctance of these fish to emigrate under low flow conditions.

4.7 Alewife Out-migration at Trout River Lake

Large numbers of YOY alewives moved into Trout River Lake as soon as the gate was opened at Forest Home on Sept. 20th. The majority of these moved downstream when the bypass was opened on Sept. 24th. Alewives were still migrating when the Forest Home gate was re-closed on Oct. 7th, although comparatively few moved downstream after the gate was re-opened on Nov. 9th. In total, about 1.1 million alewives left Gaspereau Lake via this route during 1998.

Alewives tend to school back and forth across the front of the screen in an attempt to find a passage downstream. Alewives appear to have difficulty locating the entrance to the bypass stream in its current location. If the screen is to continue to play a role in alewife management, reconfiguring the entrance so that the screens guide the fish directly to it should reduce the amount of time alewives spend in front of the screen and thus reduce impingement. As part of such a reconfiguration, the feasibility of deepening the bypass stream and weir should be investigated in order to allow the stream to operate over a wider range of heads. This would allow greater flexibility if the control gate at Forest Home were intermittently opened and closed during the late summer.

4.8 Experimental Alewife Release at Forest Home

We estimated that c.100,000 alewives moved downstream during the first release period (June 24 – 25) and that c.10,000 moved downstream during the second release period (July 9 – 10). This decrease in downstream migrants in July is similar to the pattern observed in 1996 while monitoring at the Trout River Pond diversion screen (245,000/day on July 10, but only 7,900/day between July 12 and July 25, 1996). This decrease can be explained in two ways. If smaller larvae are entrained, and larger larvae and pre-juveniles are able to avoid entrainment, as YOY grow, a greater proportion of the fish would be able to avoid entrainment. The fact that alewives captured at Forest Home were on average smaller than those captured in Gaspereau Lake during the same time period supports this hypothesized behavior. Additionally, larval abundance would be lower in the lake on the second day, as larvae develop, grow, and die. This behavioral pattern has potential water management implications, since it may be possible to open the control gate at Forest Home for a brief period in July, without a large number of alewives moving downstream.

The choice to release larvae by opening the gate, as opposed to releasing adults down river prior to spawning, was not a successful strategy for keeping adult alewives out of the lower portion of the watershed. Schools of 10 to 40 adults were seen in the canal on the second day of release. We do not know if we were repeatedly seeing the same school and therefore do not have any indication of the number of adults that moved downstream. Adults were present in the lake near Lanes Mill during this time period and schools of a few hundred were readily seen feeding in the vicinity of the dam at dusk. These fish did not seem interested in moving downstream, probably due to the low flows at this location this year. Ensuring timely downstream migration of adults prior to opening the gate, by increasing flows at Lanes Mill, would help keep adults out of the lower portion of the watershed.

Larvae of other species were also captured while monitoring at Forest Home, including yellow perch and smallmouth bass as well as adult smallmouth bass, white perch and white suckers.

4.9 Age 1+ Alewives in Gaspereau Lake

Over 4,000 age 1+ alewives were estimated to have left Gaspereau Lake during 1998. These fish almost certainly over-wintered in the watershed, since no fish of this size were observed moving upriver, and scales lacked a check mark often put down when fish move into salt water. No age 1+ alewives were observed leaving Gaspereau Lake during 1997 or 1996, suggesting that not all alewives left Gaspereau Lake in 1997 when the gate at Forest Home was opened much later than in 1996 or 1995.

We are aware of one other anadromous alewife stock in which YOY over-winter in fresh water: the dwarf alewife stock in Walker Pond in Maine. These fish exhibit substantially reduced growth and are 80% to 85% the fork length of other nearby stocks at maturity. It is an interesting coincidence that out-migration at Walkers Pond is impeded by stop logs until early September (Walton 1983).

4.10 Recruitment

In total, about 1.7 million juveniles were estimated to have emigrated from Gaspereau Lake in 1998. The spawning run included c. 359,000 age 4 alewives, which implies, at an age 4 maturity rate of 82%, a stock of 438,000 age 4 alewives in 1998.

Instantaneous natural mortality rates (M) of alewives at sea, particularly juveniles, are not known. Jessop and Parker (1988) estimated the instantaneous natural mortality rate of Gaspereau River age 4 yr. and older alewives to be 0.68. Chaput and Alexander (1989) estimated natural mortality (excluding mortality associated with spawning) of southern Gulf of St. Lawrence alewives to be about 0.44 for alewives 4 years old and older. Values of 0.4 are sometimes used in the absence of better data, for example D.F.O. (1997), again for age 4 yr. and older fish. Rates are probably higher for very young fish. Assuming an instantaneous mortality rate of 0.5, and a 0+ age class size of 1.7 million individuals in 1998, about 230,000 age 4 alewives would be expected to be present in this stock in the year 2002 (about half the size of the 1998 age 4 stock). These estimates do not allow for reproduction occurring downstream of Gaspereau Lake, although some reproduction (probably not a significant amount relative to that in Gaspereau Lake) occurs in this area (Gibson and Daborn 1998). A similar analysis suggested that reproductive success in 1997 was also not adequate to maintain the stock at current levels (Gibson and Daborn 1998). Continuing the comparison with 1997, the 1998 spawners were nearly twice as abundant, larval abundance was higher in Gaspereau Lake, but only c.65% of the number of fish were estimated to have emigrated from Gaspereau Lake.

A number of factors could be limiting reproductive success in Gaspereau Lake. If intraspecific competition within nursery areas is a limiting factor, increasing the size of the spawning run would not increase reproductive success. Reducing competition by increasing the amount of available nursery area within the watershed, or ensuring easy access to nursery areas in the Minas Basin may be the only ways to alleviate this pressure. Pre-juveniles and juvenile alewives apparently survive well in the Annapolis River estuary at salinities of 28 mg/l in July and August (Gibson and Daborn 1995). Whether they would survive equally well in the Minas Basin (which is a very different body of water than the Annapolis River above the headpond: lower water temperatures, much higher tidal range and higher suspended sediment concentrations) is unknown, although juvenile *Alosa* (spp.?) are regularly captured with beach seines in the Minas Basin during mid summer.

The introduction of smallmouth bass to this watershed is unquestionably impacting alewives in this system, both through intense predation and probably through larval and juvenile competition. The increase in abundance of these bass may be having more of an impact on alewives than any other change in the watershed since the period of high catches of the late 1970’s, and is a factor which needs to be considered when developing a management plan.

5. CONCLUSIONS

The 1998 Gaspereau River alewife spawning run was one of the smallest for which data are available. This fact, coupled with evidence that reproductive success has been poor during the last two years, suggests that stock recovery is not imminent.

Because the Gaspereau River stock typically fluctuates in size over a fairly wide range, we are unable to determine why recruitment was low in 1998 with the available data. This decrease was coincidental with a change in water management in 1994 (when system maintenance necessitated that the gate at Forest Home be kept closed through the fall), but without estimates of the numbers of out-migrating young-of-the-year, we do not know whether this change effected YOY survival. We do know that conditions for growth at sea were poor during 1997 (as evidenced by the decreased growth between ages 3 and 4 years relative to growth of the 1993 age class in 1996). These conditions may also have affected survival. Numerous other possible explanations for the low recruitment also exist (e.g. climatological conditions during the larval stage is known to effect *Alosa* survival). However, given the coincidence above, if keeping the gate at Forest Home closed until fall is to be considered as a possible long term strategy, a precautionary approach must be recommended to ensure that recruitment is not affected. Such an approach should include opening the gate earlier in another year to measure whether the number of YOY emigrants increases substantially as a result. It is also important to consider flow at the Lanes Mill outlet when evaluating this strategy. At c.10 c.f.s., flows at Lanes Mill did not appear adequate to attract out-migrating adults and juveniles. Flows should be maintained at a level that ensures timely out-migration of post-spawning adults and if the gate at Forest Home is closed, timely out-migration of juveniles. Increased flows at Lanes Mill would also mediate water temperatures in the Gaspereau River.

Exploitation rate estimates for this stock are high, although there is evidence that it may be overestimated by using the count at the White Rock ladder to estimate escapement. Exploitation also fluctuates substantially between years, and appears to be determined somewhat by chance. In 1998, most the fish entered the river on a weekend when the fishery was closed. Quantification of the biases within these estimates is necessary to better manage this stock. These biases could be measured concurrently with an assessment of the effectiveness of the White Rock fish ladder by incorporating a mark-recapture protocol into a future assessment. By marking fish as they first enter the river and counting them as they ascend the White Rock ladder, an estimate of the total run size would be obtained. From this estimate, ladder effectiveness and exploitation rate biases could be obtained.

The long term sustainability of this stock will ultimately require collaboration between the fishers and water managers. If exploitation rates are as high as estimated, then a reduction in the rate could increase the long-term yield, but only if water is managed in a way that optimizes the potential of increased spawner abundance. Conversely, optimizing water management for alewives is only viable if spawner abundance is adequate to maintain or increase the size of the stock. With all other factors optimized, the size of the

Gaspereau River alewife stock is limited by the carrying capacity of nursery areas within the watershed. While we don't know the upper limit of the carrying capacity, because the stock is presently smaller than in recent years, we do know that the limit is well above the present stock size. Given the present stock size, and the biological and economic importance of this species, timely resolution of these issues is warranted.

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APPENDIX I. RESULTS OF ALEWIFE COUNTS AT THE WHITE ROCK FISH LADDER IN 1998.

Appendix I. Results of alewife counts at the White Rock fish ladder in 1998.

1. April 24: Fishway at White Rock watered up

2. April 25: Ladder checked at 830h, 1200h and 1600h, 0.5 hr. per visit: no alewives

3. April 26: Ladder checked at 900h, 1400h and 1900h, 0.5 hr. per visit: no alewives

4. April 27: Ladder checked at 800h and 1330h, 0.5 hr. per visit: no alewives
Counting weir closed for the first time at 1330h
6 alewives captured this day

5. Counting weir closed continuously and checked at the following times:

April 28:
0800h: 8 alewives
1000h: 1 alewife
1200h: 3 alewives
1600h: 0 alewives
1900h; 3 alewives

April 29:
0800h: 7 alewives
1200h: 1 alewife
1600h: 0 alewives
1900h: 3 alewives

April 30:
0800h: 9 alewives
1200h: 5 alewives
1600h: 4 alewives
2000h: 47 alewives

May 1:
1010h: 35 alewives
1200h: 6 alewives
1600h: 52 alewives
1800h: 20 alewives
2000h: 18 alewives

May 2:
0800h: 9 alewives
1200h: 7 alewives
1600h: 35 alewives
1800h: 77 alewives
1815h: 22 alewives
1830h: 12 alewives
2000h: 108 alewives

6. The results of all subsequent counts may be found in the following tables. Counts earlier than 0800h are added to the 0800h - 0815h count. The ‘↓‘ symbol infers that count periods are combined.

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1998.

Time Period		Date and Count							
start (h)	end (h)	May 3	May 4	May 5	May 6	May 7	May 8	May 9	May 10
800	815	244	574	1758	1711	1245	1182	1015	988
815	830	41	142	470	283	108	46	146	239
830	845	44	100	278	567	231	74	51	256
845	900	32	80	227	452	170	60	230	0
900	915	16	134	43	312	121	79	130	150
915	930	18	68	393	869	142	82	25	84
930	945	23	127	427	579	91	71	71	118
945	1000	38	80	176	108	244	55	6	19
1000	1015	20	58	140	342	268	59	133	281
1015	1030	30	52	372	581	178	177	52	107
1030	1045	24	96	267	365	136	111	93	103
1045	1100	23	24	194	390	116	54	54	233
1100	1115	64	97	250	355	109	184	140	236
1115	1130	34	53	273	200	66	102	92	140
1130	1145	44	134	244	309	306	117	116	166
1145	1200	63	67	203	232	161	79	110	72
1200	1215	9	50	176	309	236	68	115	183
1215	1230	60	86	175	293	155	180	80	58
1230	1245	41	36	143	290	43	162	160	177
1245	1300	47	176	133	254	195	109	156	266
1300	1315	64	89	356	281	482	71	131	171
1315	1330	44	117	350	130	323	201	135	170
1330	1345	93	126	205	562	162	171	168	132
1345	1400	64	133	324	441	374	195	143	96
1400	1415	53	170	236	330	354	191	197	225
1415	1430	64	182	273	409	296	159	170	120
1430	1445	66	198	339	316	374	192	228	159
1445	1500	85	228	264	612	364	104	251	171
1500	1515	44	370	353	468	266	219	299	179
1515	1530	45	274	449	561	414	124	205	153
1530	1545	93	333	443	449	380	133	168	166
1545	1600	104	424	552	469	400	208	155	179
1600	1615	110	319	334	423	401	174	137	118
1615	1630	86	420	368	663	327	170	179	175
1630	1645	79	577	428	384	298	228	131	167
1645	1700	147	563	564	385	250	178	164	137
1700	1715	139	503	606	494	368	160	224	198
1715	1730	101	455	507	482	374	293	132	222
1730	1745	119	491	520	458	331	195	146	184
1745	1800	118	506	704	560	318	212	228	217
1800	1815	71	540	687	508	189	240	240	279
1815	1830	99	494	562	471	349	266	312	387
1830	1845	126	552	653	501	313	337	307	255
1845	1900	89	653	679	485	303	292	382	295
1900	1915	141	616	655	446	260	266	255	313
1915	1930	191	474	667	460	244	189	277	243
1930	1945	150	517	677	398	202	248	426	232
1945	2000	145	396	734	421	235	277	372	200
2000	2030	293	1157		504	209	192		
Daily Total		**3938**	**14111**	**19831**	**21871**	**13481**	**8936**	**9137**	**9419**

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1998.

Time Period		Date and Count							
start (h)	end (h)	May 11	May 12	May 13	May 14	May 15	May 16	May17	May 18
800	815	625	554	304	471	394	705	401	219
815	830	142	173	33	50	67	70	196	246
830	845	73	95	35	21	33	82	36	30
845	900	73	31	43	14	10	119	15	32
900	915	65	51	161	28	9	53	14	36
915	930	58	55	131	5	51	32	28	12
930	945	36	132	5	32	43	59	89	25
945	1000	107	102	22	34	25	25	76	24
1000	1015	55	100	10	36	31	34	32	8
1015	1030	32	63	41	5	3	29	18	24
1030	1045	44	81	26	29	65	29	44	23
1045	1100	76	43	40	16	18	43	21	28
1100	1115	78	55	73	70	23	61	29	36
1115	1130	69	62	11	51	7	41	9	38
1130	1145	101	76	33	73	39	30	16	23
1145	1200	18	90	37	38	29	36	45	22
1200	1215	67	66	27	23	31	45	32	40
1215	1230	88	35	32	36	53	50	32	19
1230	1245	63	53	46	27	19	37	49	24
1245	1300	79	59	32	40	39	86	53	27
1300	1315	82	61	31	34	36	33	43	6
1315	1330	79	71	55	60	36	61	42	36
1330	1345	82	78	49	44	32	38	50	38
1345	1400	92	78	43	24	30	19	37	56
1400	1415	57	57	38	18	26	58	54	45
1415	1430	71	78	31	45	58	66	51	89
1430	1445	88	71	21	46	52	28	35	57
1445	1500	128	62	48	54	53	65	37	27
1500	1515	87	77	45	85	78	44	55	67
1515	1530	84	84	24	37	130	66	53	127
1530	1545	210	65	44	40	98	80	76	137
1545	1600	227	170	73	44	60	67	72	60
1600	1615	192	137	89	56	52	83	55	103
1615	1630	217	166	37	53	35	98	81	64
1630	1645	229	112	49	61	52	100	69	120
1645	1700	339	125	55	0	57	93	73	193
1700	1715	301	147	66	58	13	48	46	52
1715	1730	230	116	55	25	39	68	38	230
1730	1745	228	123	57	10	35	106	28	112
1745	1800	301	138	25	16	28	94	18	83
1800	1815	238	165	56	30	9	76	79	47
1815	1830	207	148	81	54	39	102	60	58
1830	1845	265	107	80	51	88	91	66	77
1845	1900	248	90	60	69	97	120	44	106
1900	1915	289	82	68	57	81	117	49	54
1915	1930	275	65	77	58	107	164	30	99
1930	1945	259	93	104	114	68	97	38	78
1945	2000	269	137	106	128	71	109	41	77
Daily Total		**7323**	**4879**	**2709**	**2470**	**2549**	**3857**	**2655**	**3234**

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1998.

Time Period		Date and Count								
start (h)	end (h)	May 19	May 20	May 21	May 22	May 23	May 24	May 25	May 26	May 27
800	815	774	553	281	278	558	135	255	900	202
815	830	129	98	45	52	112	5	9	364	18
830	845	50	55	21	22	30	0	18	120	13
845	900	49	28	10	12	41	1	52	74	11
900	915	19	26	8	3	20	0	28	72	3
915	930	45	10	14	7	13	0	37	32	5
930	945	44	35	20	9	10	3	9	77	12
945	1000	30	11	30	5	16	5	42	142	11
1000	1015	46	15	31	9	9	4	17	60	2
1015	1030	31	17	25	7	24	8	26	31	0
1030	1045	23	25	15	8	6	9	3	64	1
1045	1100	23	35	11	13	19	0	14	45	4
1100	1115	24	31	34	23	10	13	5	50	5
1115	1130	29	2	13	15	13	8	5	22	4
1130	1145	50	19	22	18	10	8	4	72	5
1145	1200	31	8	14	9	24	7	40	59	4
1200	1215	43	4	17	16	23	9	4	15	11
1215	1230	41	38	9	10	31	2	0	39	4
1230	1245	45	30	6	25	48	16	10	52	7
1245	1300	25	18	8	19	22	12	15	40	25
1300	1315	30	6	15	15	16	12	34	19	↓
1315	1330	31	25	26	14	20	20	9	39	↓
1330	1345	32	28	23	24	25	26	27	42	↓
1345	1400	30	27	29	22	21	4	24	27	59
1400	1415	54	7	1	47	25	2	3	25	↓
1415	1430	33	18	30	43	17	10	2	7	↓
1430	1445	53	51	25	47	32	10	85	18	↓
1445	1500	40	64	32	35	27	3	30	20	↓
1500	1515	30	46	21	44	32	6	20	17	↓
1515	1530	18	35	22	18	19	5	24	23	↓
1530	1545	10	28	2	16	13	5	41	38	↓
1545	1600	26	14	12	21	17	4	42	34	121
1600	1615	23	37	17	26	20	19	25	10	↓
1615	1630	49	55	42	45	11	27	45	16	25
1630	1645	73	20	72	14	14	8	67	26	1
1645	1700	120	40	50	16	11	12	34	21	4
1700	1715	89	24	105	30	17	9	46	8	12
1715	1730	77	15	97	8	11	9	68	21	8
1730	1745	98	16	67	27	7	9	77	8	12
1745	1800	103	34	125	19	6	9	92	7	8
1800	1815	88	31	164	21	11	64	82	17	2
1815	1830	126	36	105	27	7	13	131	15	13
1830	1845	153	45	95	72	8	4	152	17	24
1845	1900	163	46	115	106	11	1	220	16	35
1900	1915	79	84	104	86	10	7	77	20	26
1915	1930	109	88	78	69	7	17	73	16	27
1930	1945	147	95	119	125	7	10	214	24	47
1945	2000	181	90	38	93	8	4			48
Daily Total		**3616**	**2163**	**2265**	**1690**	**1469**	**574**	**2337**	**2881**	**819**

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1998.

Time Period		Date and Count

Time Period		Date and Count								
start (h)	end (h)	May 28	May 29	May 30	May 31	June 1	June 2	June 3	June 4	June 5
800	815	104	116	142	296	699	877	1203	705	296
815	830	17	3	0	166	443	156	253	100	82
830	845	18	6	9	40	57	91	292	48	31
845	900	27	↓	↓	26	131	86	135	54	29
900	915	↓	↓	↓	↓	33	74	91	10	2
915	930	↓	↓	↓	↓	67	20	164	55	4
930	945	↓	↓	↓	41	27	42	141	30	70
945	1000	14	41	↓	↓	35	41	83	19	143
1000	1015	↓	↓	28	38	37	29	74	16	0
1015	1030	↓	↓	↓	↓	34	11	84	21	6
1030	1045	↓	↓	↓	↓	27	15	80	26	19
1045	1100	↓	↓	↓	20	28	26	55	19	12
1100	1115	↓	↓	↓	↓	42	7	62	5	9
1115	1130	↓	↓	↓	16	43	17	79	25	2
1130	1145	↓	↓	↓	↓	38	15	83	19	15
1145	1200	71	65	↓	16	15	19	95	36	9
1200	1215	↓	↓	15	↓	30	↓	96	32	↓
1215	1230	35	↓	↓	25	10	↓	64	17	↓
1230	1245	15	↓	↓	↓	23	↓	75	15	↓
1245	1300	↓	↓	↓	35	25	↓	51	14	↓
1300	1315	↓	↓	↓	↓	21	↓	87	20	↓
1315	1330	81	↓	↓	23	23	↓	107	13	↓
1330	1345	↓	↓	↓	↓	17	368	37	31	↓
1345	1400	39	77	↓	9	4	↓	64	21	178
1400	1415	↓	↓	62	↓	15	↓	66	61	↓
1415	1430	↓	↓	↓	26	7	↓	104	25	↓
1430	1445	↓	↓	↓	↓	17	↓	74	23	↓
1445	1500	↓	↓	↓	27	17	↓	64	20	69
1500	1515	↓	8	28	↓	10	171	108	35	16
1515	1530	↓	8	↓	32	14	23	67	20	9
1530	1545	68	1	↓	↓	16	57	132	34	10
1545	1600	↓	8	↓	26	46	46	53	26	12
1600	1615	31	1	16	↓	44	33	90	56	9
1615	1630	6	5	↓	17	35	46	87	51	12
1630	1645	0	9	19	↓	54	17	136	44	3
1645	1700	0	↓	↓	↓	90	48	84	51	1
1700	1715	13	14	29	↓	124	30	78	58	2
1715	1730	0	↓	↓	35	70	32	73	37	6
1730	1745	4	13	↓	↓	69	34	107	83	6
1745	1800	8	↓	↓	96	78	25	204	66	5
1800	1815	4	19	39	72	77	7	↓	89	4
1815	1830	5	14	25	57	123	20	172	45	12
1830	1845	7	10	18	69	53	2	90	75	8
1845	1900	3	↓	20	63	41	282	41	↓	10
1900	1915	2	30	24	73	121	165	98	192	10
1915	1930	8	8	18	133	117	211	115	120	7
1930	1945	11	3	16	99	95	300	128	83	6
1945	2000	2	2	78	74	103	314	123	61	15
2000	2100						864			
Daily Total		**593**	**461**	**586**	**1650**	**3345**	**4521**	**5849**	**2711**	**1076**

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1998.

start (h)	end (h)	June 6	June 7	June 8	June 9	June 10	June 11	June 12
800	815	22	347	127	45	6	55	12
815	830	0	9	21	0	↓	↓	count
830	845	0	27	0	2	↓	↓	ended
845	900	0	8	4	0	↓	↓	
900	915	↓	5	0	↓	↓	↓	
915	930	↓	7	0	↓	↓	↓	
930	945	↓	2	↓	↓	↓	↓	
945	1000	2	↓	↓	↓	↓	↓	
1000	1015	↓	↓	↓	↓	↓	↓	
1015	1030	↓	↓	↓	↓	↓	↓	
1030	1045	↓	↓	↓	↓	↓	↓	
1045	1100	↓	↓	↓	↓	↓	↓	
1100	1115	↓	↓	↓	↓	↓	↓	
1115	1130	↓	↓	↓	↓	↓	↓	
1130	1145	↓	↓	↓	↓	↓	↓	
1145	1200	5	107	54	10	2	59	
1200	1215	↓	↓	↓	↓	↓	↓	
1215	1230	↓	↓	↓	↓	↓	↓	
1230	1245	↓	↓	↓	↓	↓	↓	
1245	1300	↓	↓	↓	↓	↓	↓	
1300	1315	↓	↓	↓	↓	↓	↓	
1315	1330	↓	↓	↓	↓	↓	↓	
1330	1345	↓	↓	↓	↓	↓	↓	
1345	1400	↓	↓	↓	↓	↓	↓	
1400	1415	↓	↓	↓	↓	↓	↓	
1415	1430	↓	↓	↓	↓	↓	↓	
1430	1445	↓	↓	↓	↓	↓	↓	
1445	1500	↓	223	126	5	23	107	
1500	1515	↓	↓	↓	↓	↓	↓	
1515	1530	31	↓	↓	8	↓	↓	
1530	1545	9	56	12	3	↓	↓	
1545	1600	6	↓	↓	↓	↓	↓	
1600	1615	0	↓	↓	↓	↓	↓	
1615	1630	0	39	20	↓	↓	↓	
1630	1645	11	↓	↓	↓	↓	↓	
1645	1700	3	11	↓	12	↓	↓	
1700	1715	7	↓	19	↓	↓	↓	
1715	1730	6	13	↓	↓	↓	↓	
1730	1745	13	↓	↓	↓	↓	↓	
1745	1800	6	↓	21	6	↓	23	
1800	1815	1	25	↓	↓	18	↓	
1815	1830	8	↓	20	↓	↓	↓	
1830	1845	8	↓	↓	10	↓	↓	
1845	1900	12	↓	↓	↓	↓	↓	
1900	1915	16	51	17	↓	↓	↓	
1915	1930	12	26	5	6	↓	↓	
1930	1945	22	23	7	↓	↓	↓	
1945	2000	22	18	7	2	13	21	
Daily Total		**222**	**997**	**460**	**109**	**62**	**265**	**12**

APPENDIX II. RESULTS OF ALEWIFE COUNTS AT THE LANES MILL FISH LADDER IN 1998.

Appendix II. Results of alewife counts at the Lanes Mill fish ladder in 1998.

1. May 18 to May 21: Visual checks for alewives in the vicinity of the ladder and downstream of Highway 12 (c. 2hr./day). A few alewives observed May 21st jumping at the base of the Muskrat Cove dam.

2. May 22 (1600h - 1830h): Fishway watered up. No alewives taking the ladder. Alewives (less than 25) observed at base of dam at Muskrat Cove.

3. May 23 (1600h - 1900h): No alewives taking the ladder, but visible just downstream.

4. May 24 (1600h - 1800h): as above.

5. May 25 (1600h - 1800h): as above.

6. May 26 (1600h - 1930h): 1600h - no alewives observed in ladder.
1620h - alewives observed entering bottom of ladder.
1630h - alewives present in upper portion of ladder.
1635h - first observation of an alewife entering the lake.

7. The results of all subsequent counts are contained in the following tables.

Appendix II (con't). Results of alewife counts at the Lanes Mill fish ladder in 1998.

Time Period		Date and Count								
start (h)	end (h)	May 5	May 6	May 7	May 8	May 9	May 10	May 11	May 12	May 13
800	815									
815	830		253							
830	845		215	733						
845	900		81	662						
900	915									
915	930									
930	945									2
945	1000									14
1000	1015									17
1015	1030									35
1030	1045									44
1045	1100									26
1100	1115									28
1115	1130									40
1130	1145									50
1145	1200									50
1200	1215									40
1215	1230									15
1230	1245									
1245	1300									
1300	1315									
1315	1330									
1330	1345					377	35			
1345	1400			230		297	53			
1400	1415			270		396	55			
1415	1430			165		351	70			
1430	1445		162	162	223	237	91			
1445	1500		130	110	311	263	118	29		
1500	1515		212	103	372	318	224	18	99	
1515	1530		339	209	387	300	286	19	99	
1530	1545		278	261	430	158	459	54	71	
1545	1600		345	182	397	133	238	41	68	
1600	1615		297	24	298	92	233	30	37	
1615	1630		188	106	222	66	218	40	14	
1630	1645	57	189	204	295	11	209	27	42	
1645	1700	39		103	174	18	242	48	53	
1700	1715	17	92		232	32	234	65	45	
1715	1730	33	98		318	26	231	56	39	
1730	1745	13							26	
1745	1800								17	
1800	1815								15	
1815	1830									
1830	1845									
1845	1900									
1900	1915									
1915	1930									
1930	1945									
1945	2000									
Daily Total		**159**	**2879**	**3524**	**3659**	**3075**	**2996**	**427**	**625**	**361**

Appendix II (con't). Results of alewife counts at the Lanes Mill fish ladder in 1998.

Time Period		Date and Count								
start (h)	end (h)	May 14	May 15	May 16	May 17	May 18	May 19	May 20	May 21	May 22
800	815									
815	830									
830	845									
845	900									
900	915									
915	930									23
930	945							3		0
945	1000							1		18
1000	1015			31				70		22
1015	1030		27	0				23		22
1030	1045		38	0				19		17
1045	1100		60	0				10		15
1100	1115		26	30				4		2
1115	1130		46	2				38		8
1130	1145		25	6				10		0
1145	1200		59	10				0		19
1200	1215		48	2				0		38
1215	1230		53	0				21		
1230	1245		54	0				4		
1245	1300		62	8				18		
1300	1315						11			
1315	1330						8			
1330	1345						23			
1345	1400						25			
1400	1415						6			
1415	1430						23			
1430	1445						56			
1445	1500						5			
1500	1515	37			34	34	63			
1515	1530	72			30	30	11			
1530	1545	66			50	50	1			
1545	1600	92			24	24	8		36	
1600	1615	67			25	25			20	
1615	1630	74			46	46			13	
1630	1645	48			0	0			0	
1645	1700	34			10	10			53	
1700	1715	26			13	13			5	
1715	1730	24			9	9			0	
1730	1745	27			20	20			15	
1745	1800	29			1	1			14	
1800	1815	23								
1815	1830	26								
1830	1845	53								
1845	1900	62								
1900	1915									
1915	1930									
1930	1945									
1945	2000									
Daily Total		**760**	**498**	**89**	**262**	**240**	**221**	**156**	**184**	**238**

Appendix II (con't). Results of alewife counts at the Lanes Mill fish ladder in 1998.

Time Period		Date and Count								
start (h)	end (h)	May 23	May 24	May 25	May 26	May 27	May 28	May 29	May 30	May 31
800	815									
815	830									
830	845									
845	900									
900	915					8				17
915	930					0				5
930	945			0	24	0				6
945	1000			0	9	15				0
1000	1015			0	18	0				1
1015	1030			0	0	11				3
1030	1045			0	0	1				6
1045	1100			1	18	8				4
1100	1115			0	21	8				
1115	1130			6	14	17				
1130	1145			7	2	0				
1145	1200			4	8	0				
1200	1215	7		10						
1215	1230	15		4						
1230	1245	28								
1245	1300	0								
1300	1315	10								
1315	1330	25								
1330	1345	12	15							
1345	1400	34	0							
1400	1415	30	6							
1415	1430	50	4							
1430	1445	22	18							
1445	1500	51	0							
1500	1515	11	8							
1515	1530	9	5							
1530	1545	22	21							
1545	1600	44	19							
1600	1615	30	4					12	126	21
1615	1630	12	1				28	11	67	8
1630	1645	18	0				7	13	34	30
1645	1700	4	11				10	31	92	25
1700	1715						40	4	111	22
1715	1730						36	0	116	48
1730	1745						35	9	22	15
1745	1800						18	0	32	12
1800	1815						20	25	29	8
1815	1830						45	9	87	36
1830	1845						23	9	63	17
1845	1900						47	2	46	3
1900	1915									
1915	1930									
1930	1945									
1945	2000									
Daily Total		**434**	**112**	**32**	**114**	**68**	**309**	**125**	**825**	**287**

Appendix II (con't). Results of alewife counts at the Lanes Mill fish ladder in 1998.

Time Period	Date and Count

start (h)	end (h)	June 1	June 2	June 3	June 4	June 5	June 6	June 7	June 8	June 9
800	815									
815	830									
830	845									
845	900									
900	915									
915	930									
930	945									
945	1000									
1000	1015									
1015	1030									
1030	1045									
1045	1100									
1100	1115									
1115	1130									
1130	1145									
1145	1200									
1200	1215									
1215	1230									
1230	1245									
1245	1300									
1300	1315									
1315	1330									
1330	1345									
1345	1400									
1400	1415									
1415	1430									
1430	1445									
1445	1500									
1500	1515									
1515	1530									
1530	1545									
1545	1600									
1600	1615	30	0	118	40	0	0	9	0	38
1615	1630	52	1	138	38	0	0	5	18	6
1630	1645	27	1	43	10	0	0	20	57	27
1645	1700	13	0	62	72	0	5	10	8	28
1700	1715	75	0	8	54	6	0	20	39	6
1715	1730	32	5	37	20	6	0	0	0	7
1730	1745	45	0	10	8	0	0	16	17	28
1745	1800	18	1	22	0	0	0	4	4	15
1800	1815	14	7	37	76	0	0	5	10	0
1815	1830	26	0	49	12	0	0	8	20	0
1830	1845	25	2	23	4	0	0	4	12	3
1845	1900	32	2	13	0	0	0	6	0	0
1900	1915									
1915	1930									
1930	1945									
1945	2000									
Daily Total		**389**	**19**	**560**	**334**	**12**	**5**	**107**	**185**	**158**

Appendix II (con't). Results of alewife counts at the Lanes Mill fish ladder in 1998.

Time Period		Date and Count								
start (h)	end (h)	June 10	June 11							

800	815									
815	830	0								
830	845	0								
845	900	0								
900	915									
915	930									
930	945									
945	1000									
1000	1015									
1015	1030									
1030	1045									
1045	1100									
1100	1115									
1115	1130									
1130	1145									
1145	1200									
1200	1215									
1215	1230									
1230	1245									
1245	1300									
1300	1315									
1315	1330									
1330	1345									
1345	1400									
1400	1415									
1415	1430									
1430	1445									
1445	1500									
1500	1515									
1515	1530									
1530	1545									
1545	1600									
1600	1615	25								
1615	1630	29								
1630	1645	18	0							
1645	1700	0	14							
1700	1715	0	36							
1715	1730	46	64							
1730	1745	24	44							
1745	1800	0	36							
1800	1815	64	24							
1815	1830	23	12							
1830	1845	30	28							
1845	1900	10	18							
1900	1915									
1915	1930									
1930	1945									
1945	2000									
Daily Total		**269**	**276**							

APPENDIX III. WATER TEMPERATURES RECORDED AT GASPEREAU LAKE, THE LANES MILL FISH LADDER, THE WHITE ROCK FISH LADDER, THE GASPEREAU RIVER AND TROUT RIVER POND DURING THE SUMMER AND FALL OF 1998.

Appendix IIIa. Water temperatures recorded at the water quality station in Gaspereau Lake during June and July, 1998.

Appendix IIIa (con't). Water temperatures recorded at the water quality station in Gaspereau Lake during August and September, 1998.

Appendix IIIa (con't). Water temperatures recorded at the water quality station in Gaspereau Lake during October, 1998.

Appendix IIIb. Water temperatures recorded at the outlet at Lanes Mill during April and May, 1998.

Appendix IIIb (con’t). Water temperatures recorded at the outlet at Lanes Mill during June and July, 1998.

Appendix IIIb (con't). Water temperatures recorded at the outlet at Lanes Mill during August and September, 1998.

Appendix IIIb (con't). Water temperatures recorded at the outlet at Lanes Mill during October and November, 1998.

Appendix IIIc. Water temperatures recorded in the Gaspereau River, just upstream of the confluence of the Gaspereau River and Trout River, during July and August, 1998.

Appendix IIIc (con't). Water temperatures recorded in the Gaspereau River, just upstream of the confluence of the Gaspereau River and Trout River, during September and October, 1998.

Appendix IIId. Water temperatures recorded in the Gaspereau River 0.5 km upstream of Deep Hollow Bridge during May and June, 1998.

Appendix IIId (con't). Water temperatures recorded in the Gaspereau River 0.5 km upstream of Deep Hollow Bridge during July and August, 1998.

Appendix IIId (con't). Water temperatures recorded in the Gaspereau River 0.5 km upstream of Deep Hollow Bridge during September and October, 1998.

Appendix IIIe. Water temperatures recorded in the Gaspereau River, 0.5 km downstream of the bridge in Gaspereau, during July and August, 1998.

Appendix IIIe (con't). Water temperatures recorded in the Gaspereau River, 0.5 km downstream of the bridge in Gaspereau, during September and October, 1998.

Appendix IIIf. Water temperatures recorded in the White Rock fishway during April and May, 1998.

Appendix IIIf (con’t). Water temperatures recorded in the White Rock fishway during June and July, 1998.