The 1997 Alewife Spawning Migration in the Gaspereau River, Nova Scotia

Final Report
to
Nova Scotia Power Inc.

prepared by

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EXECUTIVE SUMMARY

The Gaspereau River - Black River watershed, which has been extensively modified for hydro-electric generation, supports a stock of anadromous alewives which are fished both commercially and recreationally as it ascends the river to spawn. Since 1964, the catch in this river has averaged 166.9 t (range: 24.9 t - 471.4 t). During 1997 fisherman caught 115.8 t or about 611,000 alewives.

A total count of alewives ascending the fish ladder at White Rock (upstream of most fishing activities) indicated that 95,433 alewives ascended the ladder between May 13 and June 22, 1997. Using this value as an estimate of escapement, the 1997 exploitation rate was estimated as 86.5 %. This estimate is probably biased high.

A partial count of alewives ascending the ladder at Lanes Mills (22,409 individuals counted) was used to estimate that c. 44,000 alewives entered Gaspereau Lake this year. Estimates of transit time from the White Rock ladder to Gaspereau Lake ranged from 13 days at the start of the run to about 3 days near the end. Abnormally high river flows during the early part of the run may have slowed transit relative to normal conditions.

A linear regression model relating the daily alewife count at White Rock to water temperature, water level and alewife abundance downstream was able to explain 64 % of the variability in the counts at White Rock..

Alewives sampled during 1997 were on average younger (mean age males = 4.29 yr.; females = 4.5 yr.) than those from 4 previous assessments. Mean fork lengths (males = 255.5 mm; females = 265.0 mm) were smaller than all years except 1995. Instantaneous mortality rates were estimated as 1.39 for males and 1.21 for females, values within the range of previous assessments, although instantaneous mortality was probably underestimated in this assessment.

ACKNOWLEDGMENTS

We wish to take this opportunity to thank the many people who assisted both directly and indirectly with this assessment. Keir Daborn, Mark Johnston, Trevor Lawley and Scott Moffitt formed the basis of the field crew for the White Rock and Lanes Mills alewife counts. Jessica Vast aged the scales and assisted with data analysis. Terry Toner and Ken Meade served as scientific contacts with Nova Scotia Power Inc., and Jack Andrews and Garfield Langille assisted with the logistics when working around the system. Terry Millett provided counts of the numbers of alewives per pail from his net site, and Hank Sweeney (Fisheries and Oceans Canada) provided catch statistics both for 1997 and for previous years. All the individuals mentioned above, as well as numerous other residents and users around the Gaspereau - Black River watershed, contributed substantially to this report by providing insights and observations of this system over the decades, while showing a genuine concern for the preservation of the resources this system provides.

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1. INTRODUCTION

The alewife (*Alosa pseudoharengus*) is an anadromous species indigenous to rivers on the eastern seaboard of North America from North Carolina to Labrador (Scott and Scott 1988). Adults ascend the rivers during the spring to spawn and then return to the sea, where they undergo extensive migrations along the Atlantic seaboard. Young-of-the-year alewives move downstream into the estuaries during the summer and fall, and remain at sea for 3 to 6 years before first returning to freshwater to spawn. Local commercial and recreational alewife fisheries exist on many Bay of Fundy rivers and this species is therefore of local economic importance. The species also supports bycatch and directed intercept fisheries along the eastern seaboard of the United States.

During a study to ascertain the status of *Alosa* along the eastern seaboard of the United States and Canada, 30 rivers along the Nova Scotian Bay of Fundy coast were identified as supporting alewife stocks (Rulifson 1994). All these stocks were listed as 'in decline', although biological data are limited or unavailable for many of these stocks. Dams were identified as the most important physical or chemical factor potentially involved in the decline.

The Black River - Gaspereau River watershed in Nova Scotia (Figure 1) supports a stock of anadromous alewives that is fished both recreationally and commercially as it ascends the system to spawn during May and June. Adults typically ascend the system 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 young-of-the-year (YOY) then utilize these lakes as nursery areas prior to emigrating seaward during late summer and fall.

The Black River - Gaspereau River watershed has been extensively modified for hydroelectric generation during the last 80 years. The present system was constructed in stages between 1919 and 1952, including diversions of the Black River, Gaspereau River, Forks River, and numerous smaller brooks and streams. Upgrades and modifications to the system are ongoing. The system currently consists of over a dozen lakes interconnected by manmade canals and natural waterways.

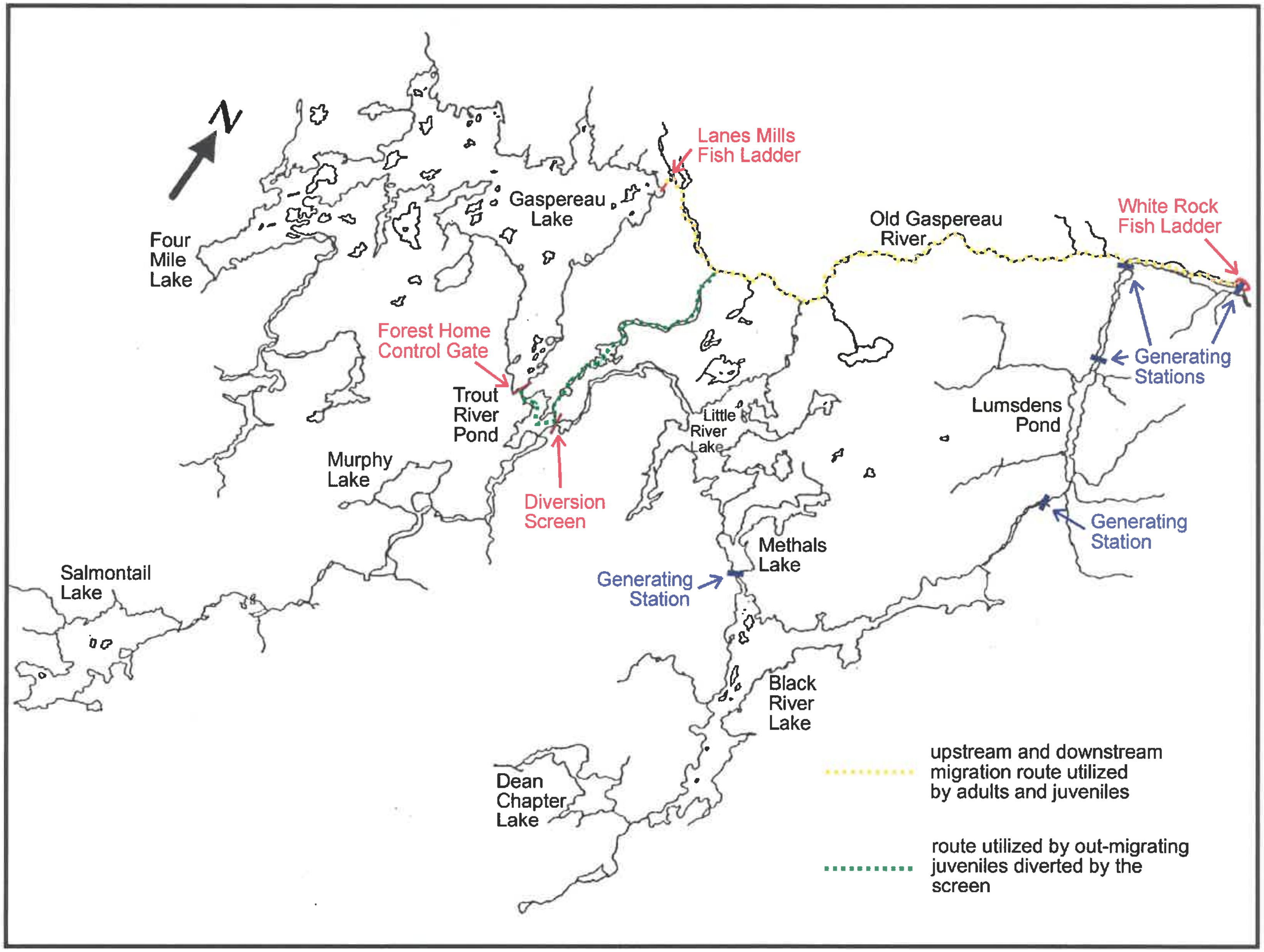

Figure 1. Map of the Gaspereau River System.

Five generating stations and numerous storage dams are currently present on the system, which present obstacles for migrating fish. Nova Scotia Power Inc. (NSPI), in conjunction with government agencies and community groups, has been working towards reducing the impact of these structures upon fish stocks, utilizing equipment and methodologies (fish ladders, diversion screens, spillways, water management, etc.) that are updated as the ecology of these stocks is better understood. Currently, 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 Mills. 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. When the control gate at Forest Home is open, these fish may be carried downstream through Trout River Pond, Little River Lake and Methals Lake, after which they must move past the five generating stations in order to reach the sea. However, a fish diversion screen was constructed near the outlet of Trout River Pond which redirects fish into the old Gaspereau River channel via Trout River. This screen appears effective in diverting larger juveniles, but eggs and larvae are able to pass through the screen (Gibson 1996). This problem has been circumvented in part by keeping the control gate at Forest Home closed until mid summer, by which time most YOY alewives are large enough to be diverted by the screen.

While fish and water management strategies are improved as knowledge of the stocks increases, indicators are required to assess the effectiveness of these changes. In the case of alewives, the status of the stock, based on parameters such as the performance of the fishery, life history data, and estimates of the stock size, provides such an indicator. Assessments of this stock were conducted by the federal Department of Fisheries and Oceans (DFO) between 1982 and 1984 (Jessop and Parker 1988) and in 1995 by NSPI (unpublished data). Biological data relating to this stock were also collected during an evaluation of the fish ladder at White Rock in 1970 (Dominy 1971).

The present study was undertaken to provide further information about the current status of the stock and to collect information about the timing and duration of both upstream and downstream adult migration events, parameters that are relevant for the development of water strategies to manage adult alewives.

2. METHODS

2.1 Alewife Count At White Rock (Total Count)

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. A screen just downstream of the weir allowed the weir to be closed, blocking off the passage of fish. A screen located just upstream of the weir could be opened to allow upstream passage of fish, or closed so that the weir functioned as a trap. Throughout most of the study, the downstream gate was left closed at night, and when the attendants were not present, to ensure a total count. Towards the end of the run (after June 4th), the gates were left open to allow the downstream passage of post-spawning alewives which would accumulate upstream of the weir during the day.

Number of alewives per 15 minute interval was recorded for all intervals between 0800h and 2000h (2100h during peak migration) during the majority of the run. During the later portion of the run, the length of the count interval was increased and the weir operated as a trap in order to enumerate stragglers. This allowed researchers to focus on other aspects of this project while still meeting the objective of a total count.

Morphometric information (fork length, weight, sex) were recorded for 5 fish more or less randomly selected from every 500 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 alewife (Marcy 1969). Scales were cleaned with water, mounted on glass slides and projected on Bristol board with a projecting microscope prior to reading.

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 Mills (Partial Count)

A partial count of the alewives ascending the ladder into Gaspereau Lake at Lanes Mills was conducted to give an indication of the timing of movement into the lake relative to the ascension of the ladder at White Rock. Alewives were counted as they passed over a white counting board while exiting the ladder into the lake. Alewives were counted between 1630h and 1930h daily throughout most of the run. Observations at White Rock and initial observations at Lanes Mills indicated that this was the period during which activity was greatest. Incidental monitoring at other times was also carried out in order to increase the number of tagged fish observed entering the lake (see below). 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.

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 in two ways: by observation of tagged fish and by the time lag between the passage of fish representing percentiles (multiples of 10) at the two ladders.

Alewives were tagged at the White Rock ladder on three occasions during the spawning run. The tag consisted of a small piece of flagging tape (about 3 mm x 25 mm) fastened to the posterior end of the dorsal fin with a tiny staple (this method was chosen after testing visible implant tags which were not easily detected without removing the fish from the water). Different colors were used to delimit different days. This method provided recognition of groups (based on marking day), but not of individual fish. High tag loss was anticipated, but not expected to bias the estimates of migration times.

Migration times were also estimated by comparing the time at which the first fish, the last fish, and the 10*i* percentiles (where *i* is an integer between 1 and 9) passed through each ladder.

2.4 Outmigration from Gaspereau Lake

Initial intentions were to monitor the rate at which alewives moved out of the lake after spawning (expected to be observed simultaneously while monitoring upstream migration). However, when leaving the lake, alewives have a tendency to play in the current between buckets in the ladder, often moving up and down between buckets (or in and out of the lake) several times before moving downstream. This behavior renders counting impractical and therefore qualitative observations only are presented in this report.

2.5 Statistical Analysis

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):

$$l_t = L_\infty(1 - e^{-K(t-t_0)})$$

where:

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

K = growth coefficient — t_0 = 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 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. Very few 3 year olds were captured, and these were not included in this analysis.

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.

3. RESULTS

3.1 Alewife Count At White Rock (Total Count)

The first observation of alewives in the Gaspereau River of which we are aware was the capture of three fish near the Millett's net site on Friday, May 2nd. The ladder was watered up on May 5th, and, while monitoring at the counting weir began on this date, the first alewife did not ascend the ladder until May 13th. The daily count increased to nearly 2,000 by May 15th and remained high for the next two weeks (Figure 2). The count peaked on May 22nd, when just over 18,500 alewives ascended the ladder. Daily counts dropped to under 500/day on June 5th. Monitoring continued until June 22nd, at which time a few stragglers were still ascending the ladder. In total, 95,433 alewives were counted ascending the White Rock Fishway. Ninety-nine percent of these fish were counted between May 14th and June 14th. Ninety-five percent of the run ascended the ladder between May 16th and June 5th. Appendix I contains the time and number of alewives counted at White Rock during each count interval throughout the study.

3.2 Alewife Count At Lanes Mills (Partial Count)

Visual checks for fish below the Lanes Mills fish ladder began May 17th. A fisherman reported capturing an alewife about 1 km downstream of the ladder on May 16th, although very few alewives appeared to be present at that time. Monitoring at Lanes Mills began on May 22nd, and the first alewives (102 counted) were observed taking the ladder on May 26th (alewives were probably delayed by abnormally high river flows - see discussion). As shown in Figure 3, counts peaked on May 28th (5375 alewives during the daily count period) and dropped to under 100 alewives during the count period on June 2nd. Counts remained low through June 9th (33 alewives in total between June 4th and June 9th) after which counting was confounded by the downstream migrants (upstream migrants were not abundant at this time). In total, 22,409 alewives were counted entering the lake between May 26th and June 9th (of which 14,793 were counted during the daily count period of 1630h to 1930h). Appendix II contains the time and number of alewives counted during each count interval at Lanes Mills throughout the study.

By assuming patterns of daily movement at Lanes Mills are similar to those at White Rock, where 33.6% of the fish counted ascended the ladder between 1630h and 1930h, we estimate that about 44,026 alewives (95 % C. I. = 43,388 to 44,691 alewives) entered Gaspereau Lake during the 1997 spawning run.

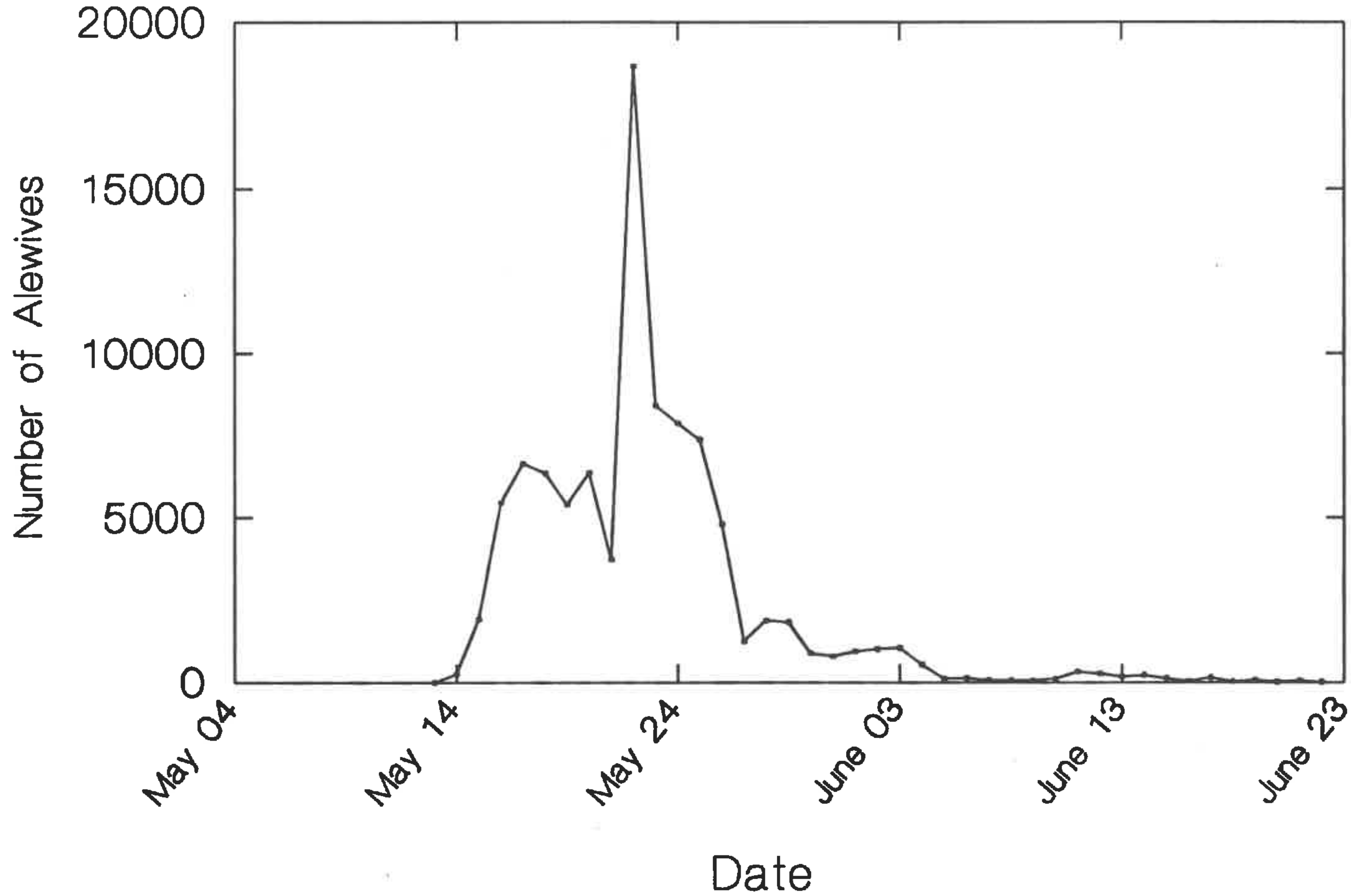

Figure 2. The number of alewives ascending the White Rock fish ladder each day throughout the 1997 spawning run.

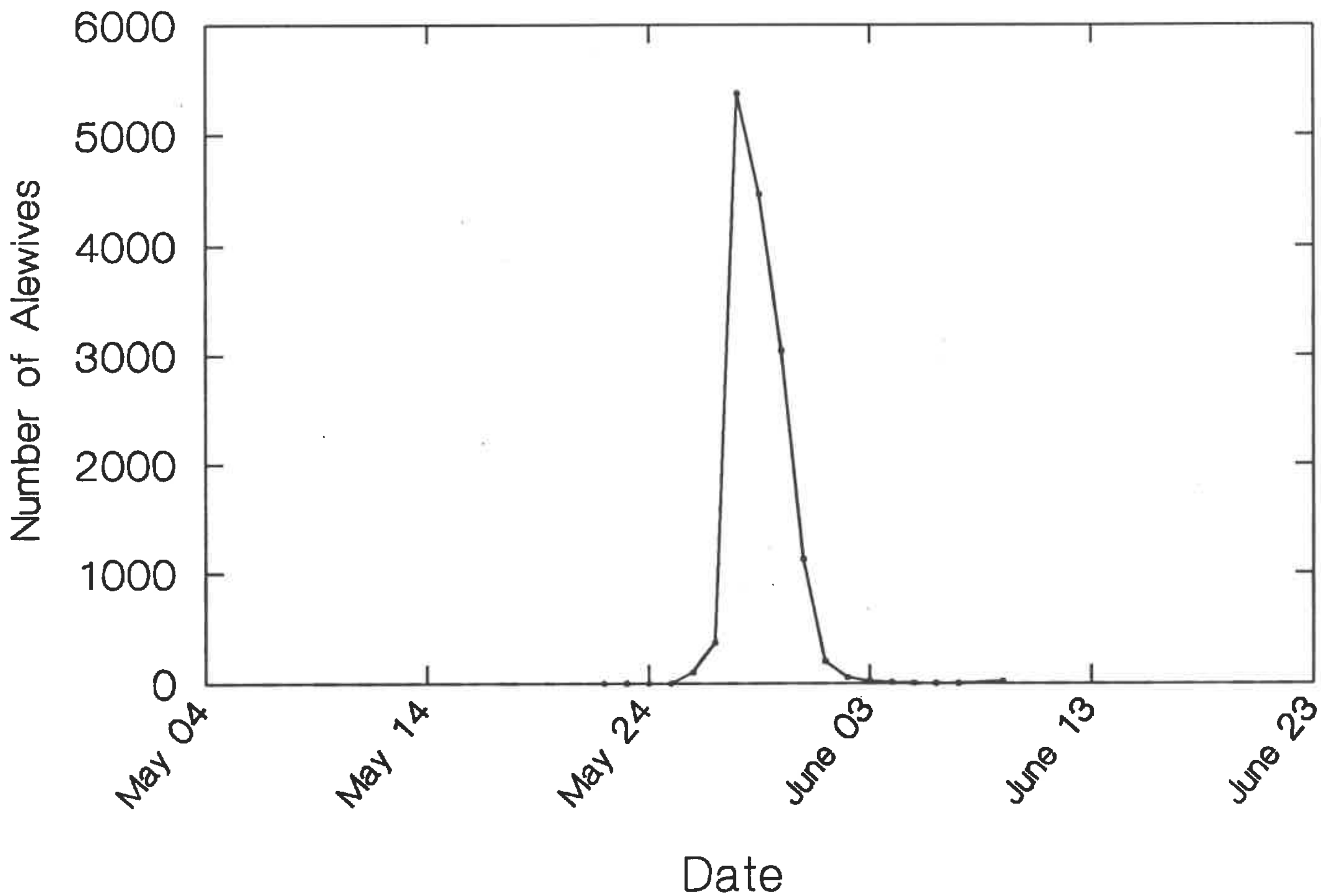

Figure 3. The number of alewives ascending the the Lanes Mills fish ladder between 1630 h and 1930 h daily during the 1997 spawning run.

3.3 Migration Times Between White Rock and Gaspereau Lake

Upstream migration times were estimated in two ways: by determining the elapsed time between fish representing 10*i* percentiles ascending the ladders at White Rock and Lanes Mills, and by marking a number of fish at White Rock and timing how long it takes them to reach Lanes Mills.

3.3.1 Estimated migration times based on comparisons of percentiles

Based on a comparison of elapsed time between observation of alewives representing percentiles ascending the ladders, alewives took between 13 days and 2 days to travel from the White Rock ladder to Gaspereau Lake (Table 1). Migration times appear strongly correlated with the time during the run: the later portion of the run ascending the river much faster than the earlier portion. This may be further evidence that high river flows may have slowed the earlier fish. For example, 10 days elapsed between the passage of the first alewife and that representing the 60th percentile at White Rock, whereas these events were only separated by 3 days at Lanes Mills.

Table 1. Dates upon which alewives representing 10ith percentiles ascended the fish ladders at White Rock and Lanes Mills in 1997.

Percentile	White Rock Count (n)	White Rock Date	Lanes Mills Count (n)	Lanes Mills Date	Elapsed Time (days)
first alewife	1	May 13	1	May 26	13
10th	9,544	May 17	1,479	May 28	11
20th	19,089	May 18	2,959	May 28	10
30th	28,633	May 20	4,438	May 28	8
40th	38,177	May 22	5,917	May 29	7
50th	47,722	May 22	7,396	May 29	7
60th	57,266	May 23	8,876	May 29	6
70th	66,810	May 24	10,355	May 30	6
80th	76,354	May 25	11,834	May 30	5
90th	85,899	May 28	13,314	May 30	2
last alewife	N/A		N/A		

3.3.2 Estimated migration times from observations of tagged fish

Alewives were tagged at the White Rock fish ladder on three occasions (May 20th, 23rd and 27th) during the spawning run. Migration times estimated from observations of tagged fish entering the lake (Table 2) support those based on percentiles. The first group of tagged alewives (tagged on May 20th) averaged 8.8 days to travel between the White Rock ladder and Gaspereau Lake, whereas the last group (May 27th) averaged 4.5 days to make this journey.

Table 2. Migration times estimated from observations of tagged fish.

Date	Time	Number tagged	Number observed entering the lake	Mean transit time (days)	Minimum transit time (days)	Maximum transit time (days)
May 20	1730h - 1930h	300	5	8.8	8	10
May 23	1615h - 1945h	400	38	7.9	6	10
May 27	1545h - 1915h	500	8	4.5	4	5

3.3.3 Outmigration

Post-spawning downstream migrating adults were first observed (surprisingly) at the White Rock dam on June 3rd, 6 days prior to the first observations of post-spawning adults leaving Gaspereau Lake. Downstream migrants were present in the vicinity of the White Rock dam from June 3rd through June 22nd at which time monitoring was discontinued. Adults were observed leaving Gaspereau Lake from June 9th onwards. As mentioned, counts at this location were confounded by the tendency of fish to 'play' in the current, moving in and out of the ladder several times before actually moving downstream. This problem aside, outmigration peaked around June 15th, and dwindled to only a few fish observed by July 7th. When the flow was switched from the ladder to the control gate

(July 14th), observation of adults became more difficult as they didn't need to pass over the counting board. Adults were observed sporadically until Oct. 1st while monitoring juvenile outmigration.

3.4 Stock Characteristics

Stock characteristics are estimated from data collected at the White Rock fish ladder.

3.4.1 Fork length

Fork lengths were measured on a sample of 446 females and 506 males. Length frequency distributions derived from these data are shown in Figure 4. Females were, on average, slightly larger than males (Table 3). The largest alewife captured during this project was a female with a fork length of 315 mm. The largest male captured was 287 mm in length.

Table 3. Fork length summary statistics for the 1997 Gaspereau River alewife spawning run.

Statistic:	Males	Females
n	506	446
Mean (mm)	255.5	265.0
Standard Deviation	10.5	14.1
Minimum (mm)	218.0	235.0
Maximum (mm)	287.0	315.0

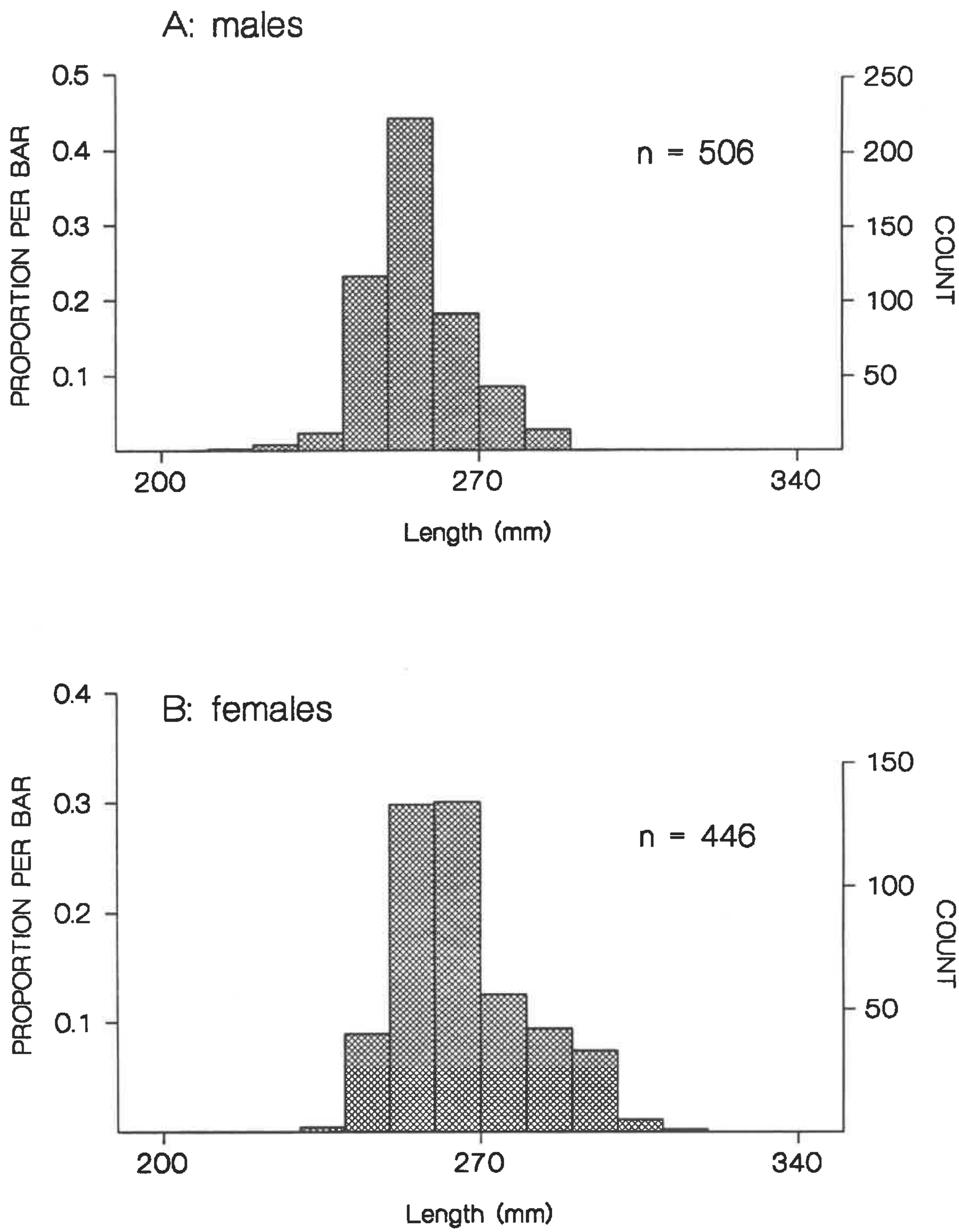

Figure 4. Fork length frequency distributions estimated for male (a) and female (b) alewives in the 1997 Gaspereau River spawning run.

3.4.2 Sex Ratio

Males outnumbered females overall by a ratio of 1.13 : 1. The sex ratio varied during the sampling period, as shown in Figure 5. Males appeared more abundant towards the beginning and the end of the run, whereas females were relatively more abundant during the middle.

3.4.3 Age and Maturity

Ages ranged from 3 to 6 years for males, and from 4 to 7 years for females, as shown by the age frequency distributions in Figure 6. These distributions are based on ages determined from scales collected from 218 females and 245 males. Summaries of these distributions are presented in Table 4.

Table 4. Age summary statistics for the 1997 Gaspereau River alewife spawning run.

Statistic:	Males	Females
n	245	218
Mean (yr)	4.29	4.50
Standard Deviation	0.59	0.76
Minimum (yr)	3	4
Maximum (yr)	6	7

Age at first maturity ranged from 3 to 5 years for males and 3 to 6 years for females (Figure 7). Mean age at first maturity was 4.11 years (s.d. = 0.39) for males and 4.18 years (s.d. = 0.42) for females. Less than 20% of the fish were repeat spawners (15.1 % for males, 24.8 % for females).

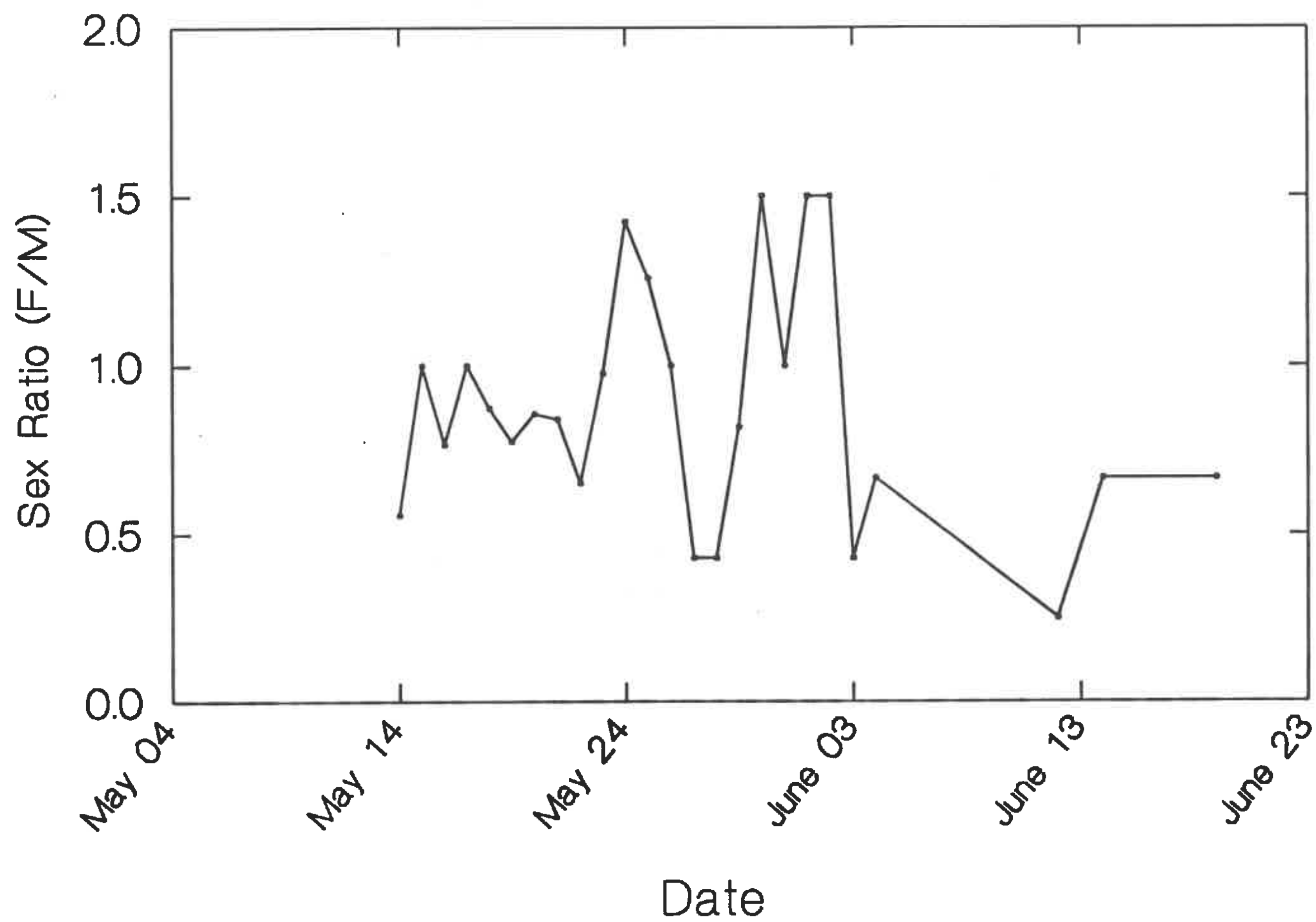

Figure 5. Variation in sex ratio of the fish sampled at White Rock during the 1997 alewife count.

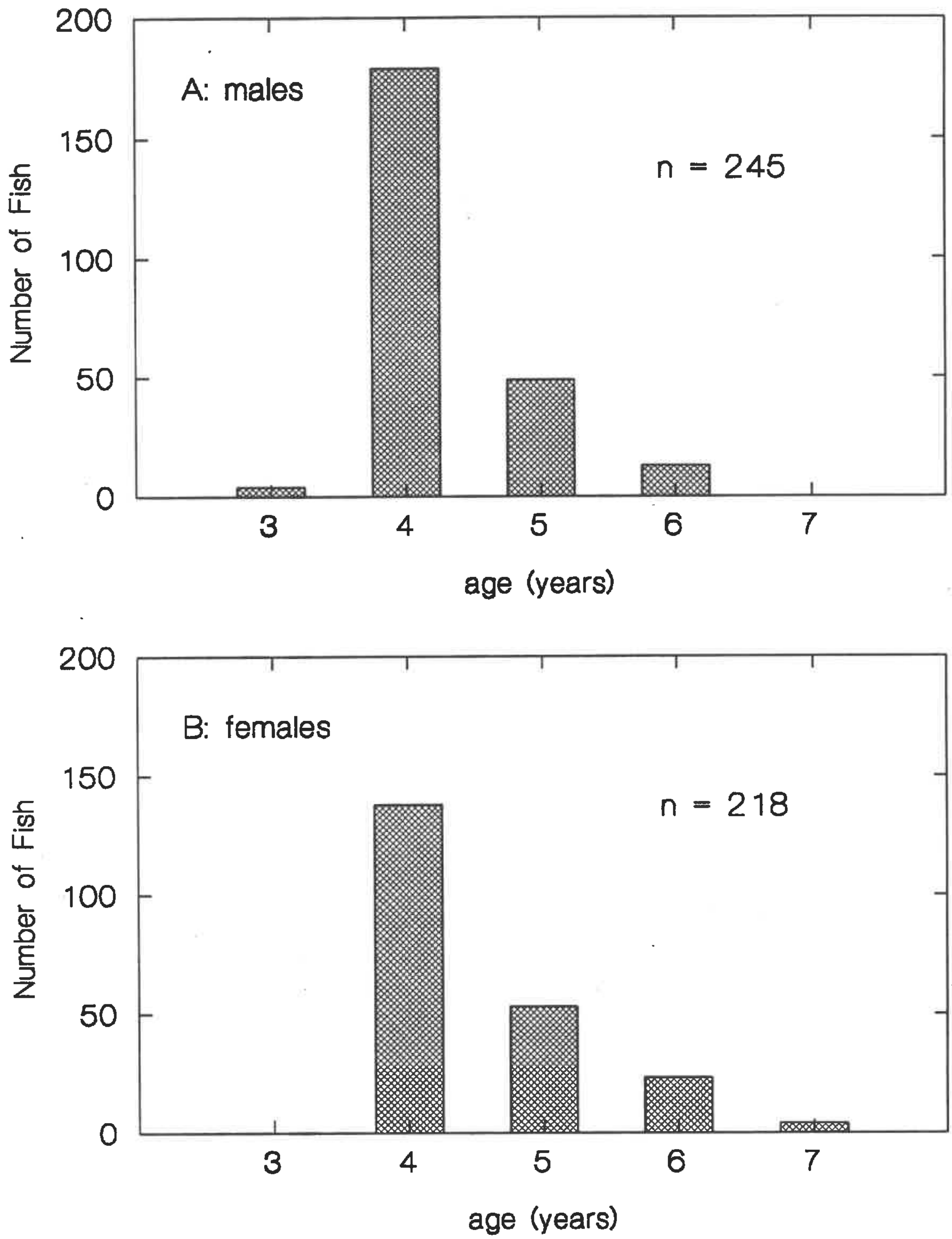

Figure 6. Age frequency distributions estimated for male (a) and female (b) alewives in the 1997 Gaspereau River spawning run.

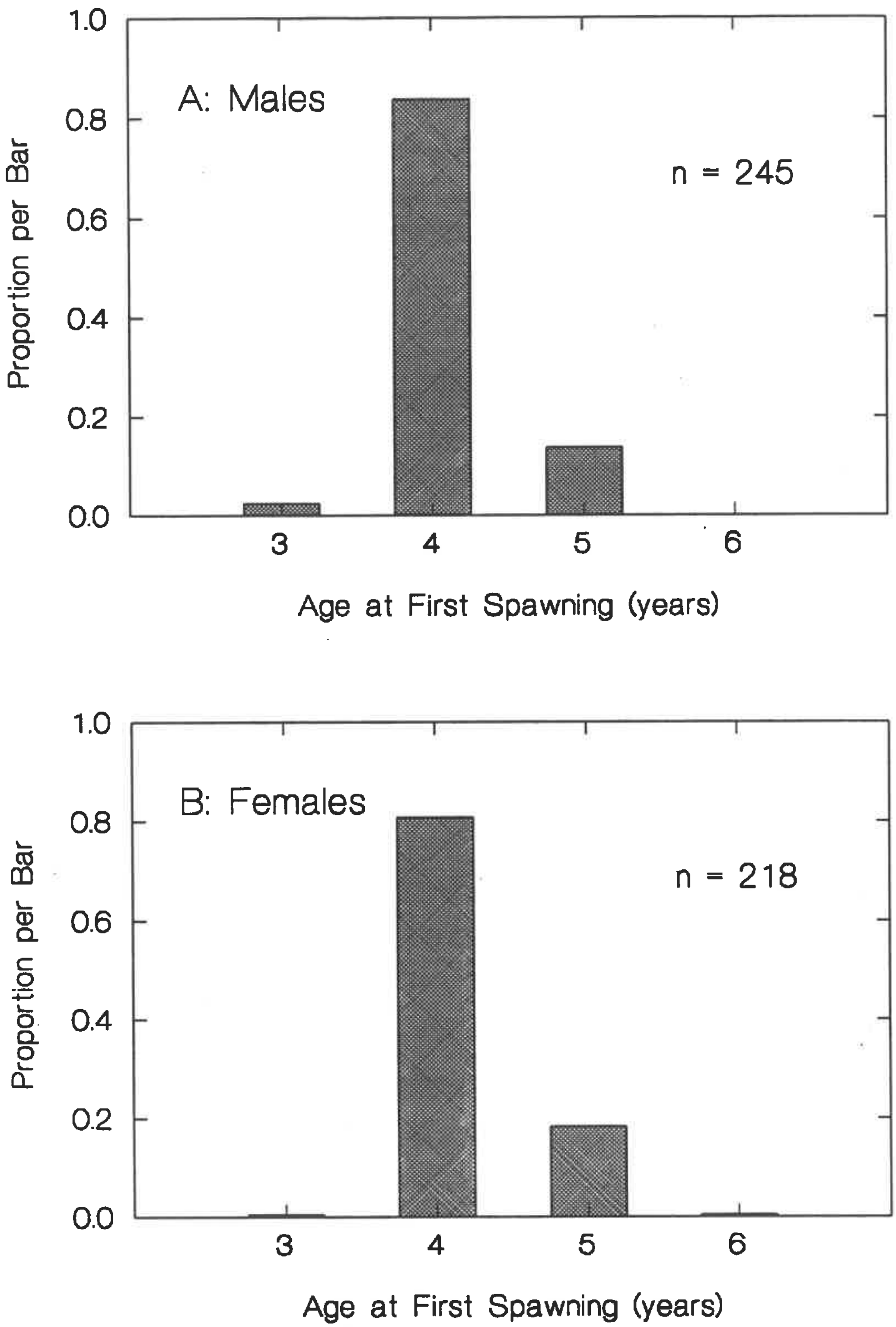

Figure 7. Frequency distributions showing age at first spawning for male (a) and female (b) alewives in the 1997 Gaspereau River spawning run.

3.4.4 Weight

Weight measurements, to the nearest 2 grams, were taken in the field from 371 female and 419 males during the 1997 spawning run (Table 5). These data were used to develop weight-length relationships for each sex, as shown in Figure 8.

Table 5. Weight summary statistics for the 1997 Gaspereau River alewife spawning run.

Statistic:	Males	Females
n	419	371
Mean (g)	221.4	253.7
Standard Deviation	29.8	40.3
Minimum (g)	122	162
Maximum (g)	310	420

3.4.5 Growth

Von Bertalanffy growth curves (Figure 9) were derived from male and female length-at-age data collected during this assessment for ages 4 - 8 yr, combined with back-calculated length-at-age for ages 1 to 3 yr (see methods). The theoretical maximum length for the males was estimated as 302.8 mm and for the females as 318.4 mm. Growth coefficients were estimated as 0.42 and 0.39 for the males and females respectively.

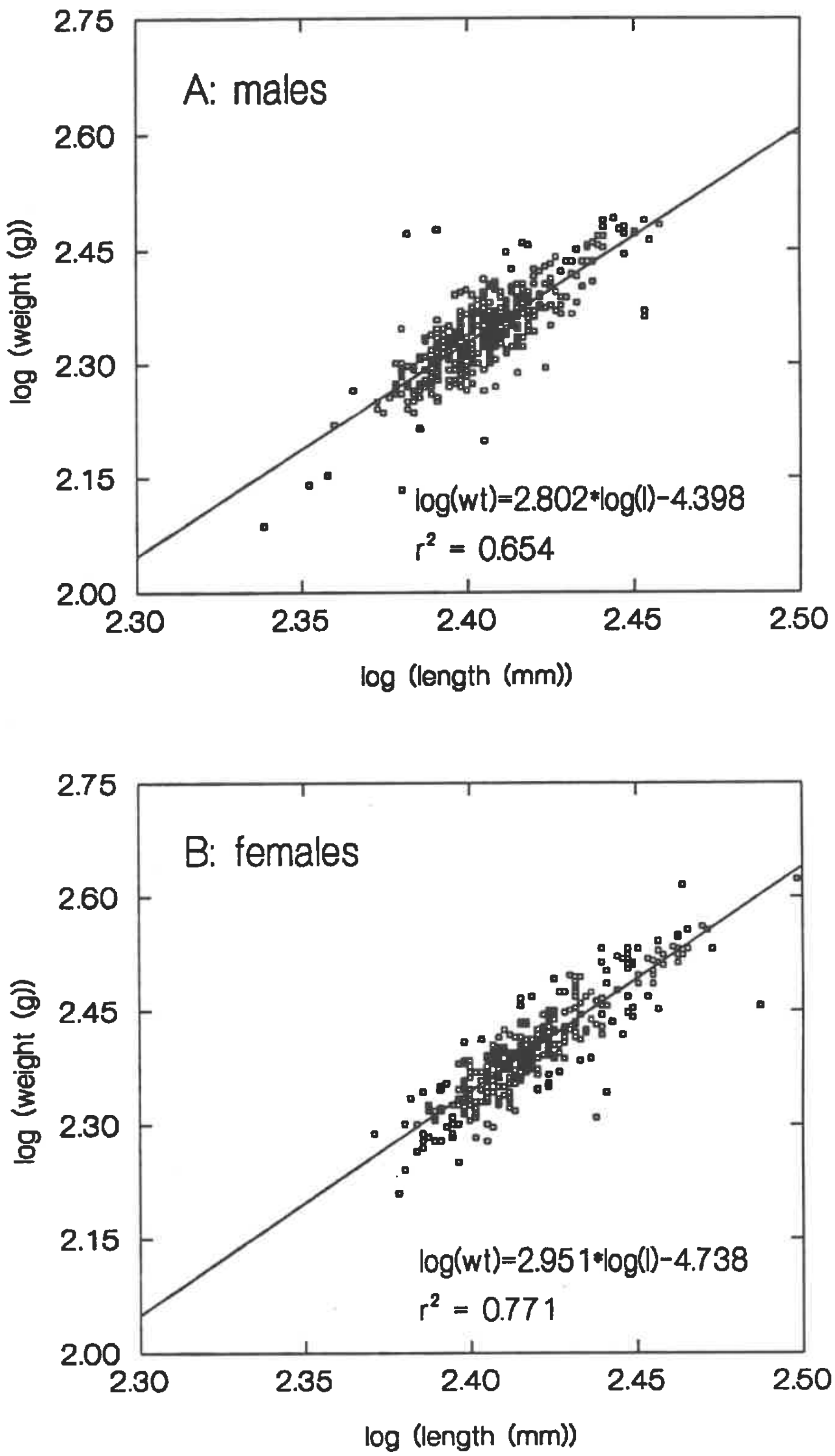

Figure 8. Weight-length relationships developed for male (a) and female (b) alewives in the 1997 Gaspereau River spawning run.

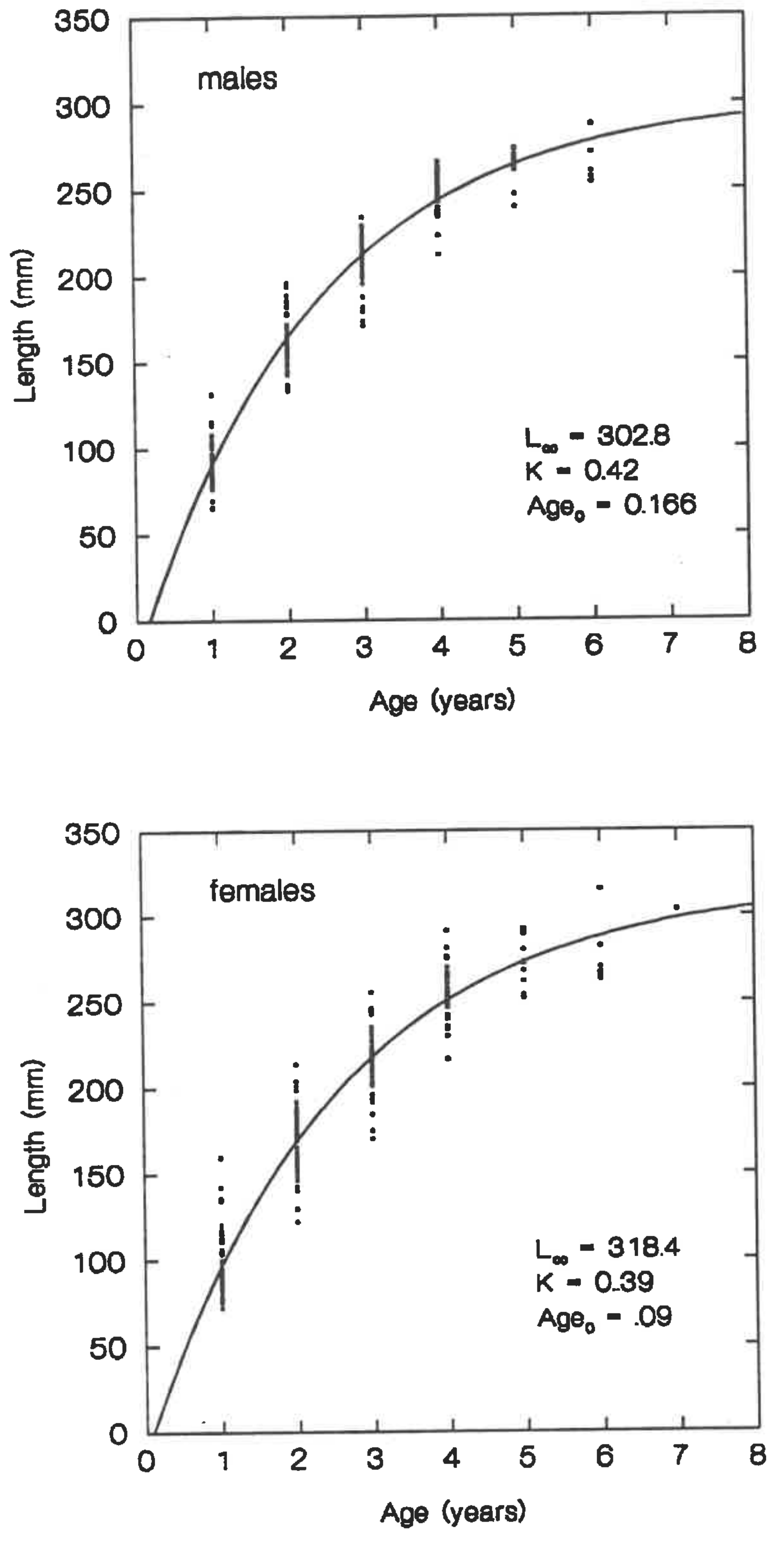

Figure 9. Von Bertalanffy growth curves overlaid against fork length at age data for male (a) and female (b) alewives collected from the 1997 Gasperea River alewife spawning run.

3.4.6 Mortality

Instantaneous mortality rates were estimated as 1.39 for male and 1.21 for female alewives based on survival estimated from year class sizes for the 4 through 7 year age classes (Figure 10). These estimates correspond to annual mortality rates of 75.1% for males and 70.2% for females.

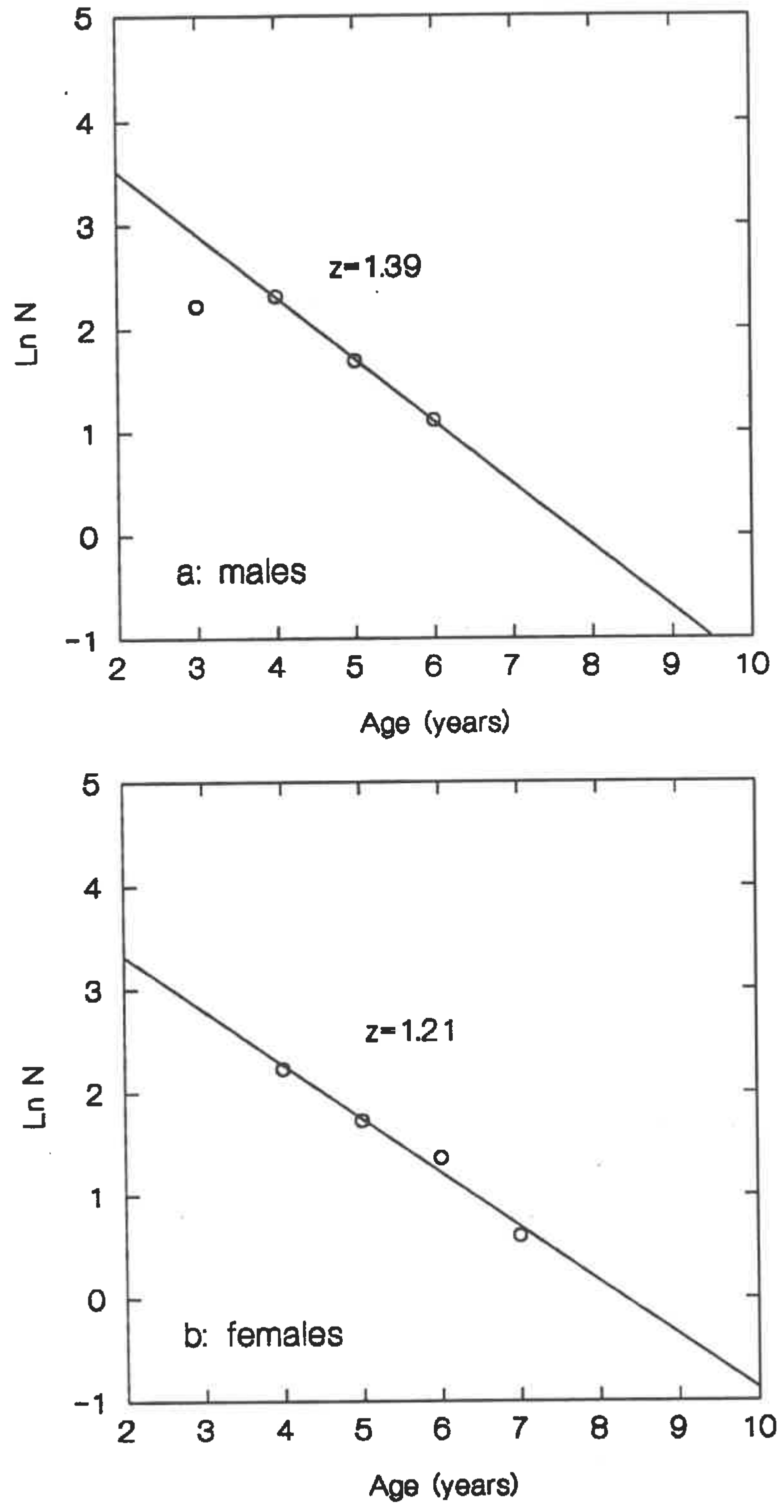

Figure 10. Instantaneous mortality rates estimated for male (a) and female (b) alewives from the 1997 Gaspereau River spawning run.

3.5 The Fishery

3.5.1 Catch statistics - 1997

In 1997, fishermen on the Gaspereau River captured an estimated 5,096 pails of alewives (Hank Sweeney, pers. comm.). Fifteen square net sites were operated on the river, catching 4,596 pails (the remaining 500 pails taken by drift net, gillnet, dip net and jigging). Pails hold about 22.7 kg of fish, which is the equivalent of about 120 alewives (mean number of fish per pail; s.d. = 7.53, n = 6), implying that the fishery harvested about 611,520 alewives this year. Using the sum of the total catch and the White Rock count as an estimate of the size of the stock, the fishery exploitation rate in 1997 is estimated at 86.5%.

3.6 Comparisons With Other Years

3.6.1 Life history characteristics

Life history data for the Gaspereau River alewife stock are available for the years 1982 - 1984 (Jessop and Parker 1988), and 1995 (NSPI, unpublished data). Alewives sampled during the 1997 spawning run were on average younger than those sampled during other assessments (Table 6). They were also both smaller (except for 1983 males) and lighter than those measured during the early 1980's. Alewives measured in 1995 (mean fork length = 257 mm) were smaller than those in 1997 (mean fork length of males and females = 260.3 mm). The mean weight recorded in 1995 was substantially higher than in other years and is probably unreliable. Mean age at first spawning was the lowest recorded in any of the assessments. Relatively more female repeat spawners were present in 1997 than in other years for which data are available, and the percentage of male repeat spawners was at the upper end of the range for these years. The instantaneous mortality rate this year (1.30 - sexes combined) was slightly less than the average of 1.45 for the 5 years for which data are available.

Table 6. A comparison of 1997 Gaspereau River alewife stock characteristics with those determined in 1982, 1883, 1984 and 1995.

Statistic	Year	Males	Females
Mean Age (yr) ± standard deviation	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	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	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	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)
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Table 6 (con't). A comparison of 1997 Gaspereau River alewife stock characteristics with those determined in 1982, 1883, 1984 and 1995.

Statistic	Year	Males	Females
Repeat Spawners (%)	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)	1997	1.39	1.21
	1995	1.75	
	1984	2.66	
	1983	0.91	
	1982	0.63	
Exploitation Rate (%)	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)

3.6.2 The Fishery

Alewife catch data for the Gaspereau River are available for the period between 1964 and 1997 and show considerable fluctuation (Figure 11). Catches ranged between a low of 1,099 pails in 1988 and a high of 20,744 pails in 1978 (Table 7). The 1997 alewife catch of 5,096 pails is about 12% lower than the 1964 - 1997 median catch of 5,743 pails.

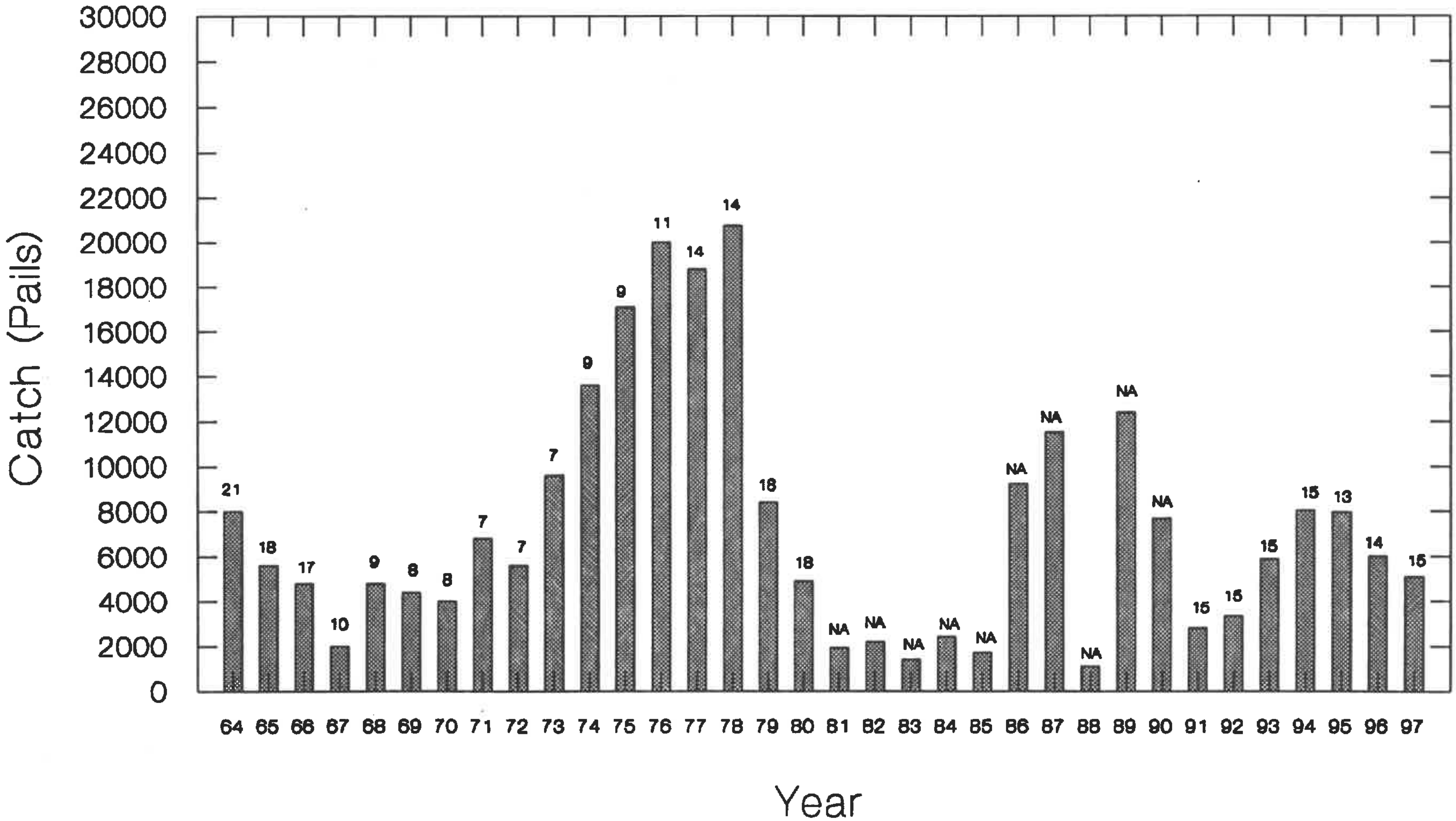

Figure 11. Annual catch (number of pails) for the Gaspereau River alewife fishery. The numbers over the bars are the number of sites fished each year.

Table 7. Summary of Gaspereau River alewife catches between 1964 and 1997:

Statistic	Catch (pails)
Mean	7,345
Minimum	1,099
Maximum	20,744
Median	5,743
1997 catch	5,096

Exploitation rates from other years are not as readily available. Extrapolating from catch statistics in tonnes, Jessop and Parker (1988) estimated that the fishery harvested 190,800, 132,000 and 220,700 alewives in 1982, 1983 and 1984 respectively. Exploitation rates based on these data averaged 66% (range: 53% - 79%) for these years. These rates are not directly comparable to the 1997 estimate due to the methodological differences in estimating the number of fish harvested. Assuming 120 alewives per pail, and counts of 2,190, 1,380 and 2,420 pails harvested in 1982, 1983, and 1984 respectively (Hank Sweeney, pers. comm.), exploitation rates would be estimated to average 71.8% for these years (range: 59.1% - 83.9%). If the number of alewives per pail is adjusted by the weight differences between years, more appropriate estimates of exploitation rates would then average 69.1 % (range: 56.7% - 80.9%).

In 1995, 7,958 pails of alewives were harvested in the Gaspereau River (Hank Sweeney, pers. comm), implying (assuming 120 alewives/pail) a catch of 954,960 alewives. A partial count of escapement from the fishery (number of alewives ascending the White Rock ladder) yielded a count of 126,933 alewives (NSPI, unpublished data). Based on these numbers, the 1995 exploitation rate could not have exceeded 88.3% and was probably substantially lower (due to the fact that the count of escapement was incomplete). Based on these calculations, the 1997 exploitation rate appears higher than those estimated from previous assessments.

During 1970, Dominy counted 60,527 alewives ascending the White Rock fish ladder. Four thousand pails of alewives were harvested from the river that year (Hank Sweeney, pers. comm.), implying an exploitation rate (assuming 120 alewives/pail) of 88.9%.

These data are summarized in Table 8. The alewife count at White Rock in 1997 was more or less in the middle of the range of previous counts, while the exploitation rate was at the upper end of the scale.

Table 8. Summary of yearly alewife counts at the White Rock fish ladder, and the commercial catch and exploitation rates of the Gaspereau River alewife fishery.

Year	Catch (pails)	Catch (number of alewives)	Alewife Count	Exploitation Rate (%)
1997	5,096	611,520*	95,433	86.5
1995	7,958	954,960*	126,933 (partial)	<88.3
1984	2,420	212,966**	111,100	69.9
1983	1,380	150,408**	114,800	56.7
1982	2,190	254,068**	50,400	80.9
1970	4,000	480,000*	60,527	88.9

* assuming 120 alewives/pail

** number of alewives/pail adjusted by mean weight/alewife

Based on the six years for which data are available, the count at the White Rock ladder is a poor predictor of the total size of the run ($r^2 = 0.18$). On this river, the annual harvest is a better predictor ($r^2 = 0.992$), probably because of the relatively high exploitation rate.

3.7 Environmental parameters

Regression analyses were used to determine if the daily alewife count at White Rock could be predicted from environmental parameters (mean daily water temperature, mean daily tailrace water level and mean daily headpond water level), and if so which parameters had the greatest influence on the count. Alewife abundance in the river was identified as another factor which would influence the count, and was quantified using the catch-per-unit-effort (C.P.U.E. - kg/hr) at Terry Millett's net site. Preliminary analysis indicated little or no relationship between the headpond waterlevel level and the count, so this parameter was dropped from the model.

The variations in temperature, tailrace water level, and C.P.U.E. throughout the study period are shown in Figure 12 together with the daily count. Some patterns are apparent. The rapid increase in alewife abundance (C.P.U.E.) on May 13th was coincidental with an increase in mean daily temperature from 8.2 °C to 10.4 °C, while a decline in daily counts (May 26th to 28th) occurred at the same time as a decrease in water level in the tailrace.

Time series analyses were used to investigate these patterns. Besides the above observation, no significant relationships were found using linear regression (after differencing to remove autocorrelation) between daily C.P.U.E. and daily mean tailrace water level ($r^2 = 0.103$, $p = 0.244$) or daily mean water temperature ($r^2 = 0.049$, $p = 0.328$). Log transformations and lagging variables did not substantially improve the relationships.

The relationship between the daily count and these variables was better, after transforming the data as follows. The daily count and alewife abundance data were log (X+1) transformed to reduce residual heteroscedasticity. Cross correlations between alewife abundance and the daily count indicated a lag of 7 days between fluctuations in these parameters, so alewife abundance was lagged by this amount. All data series showed

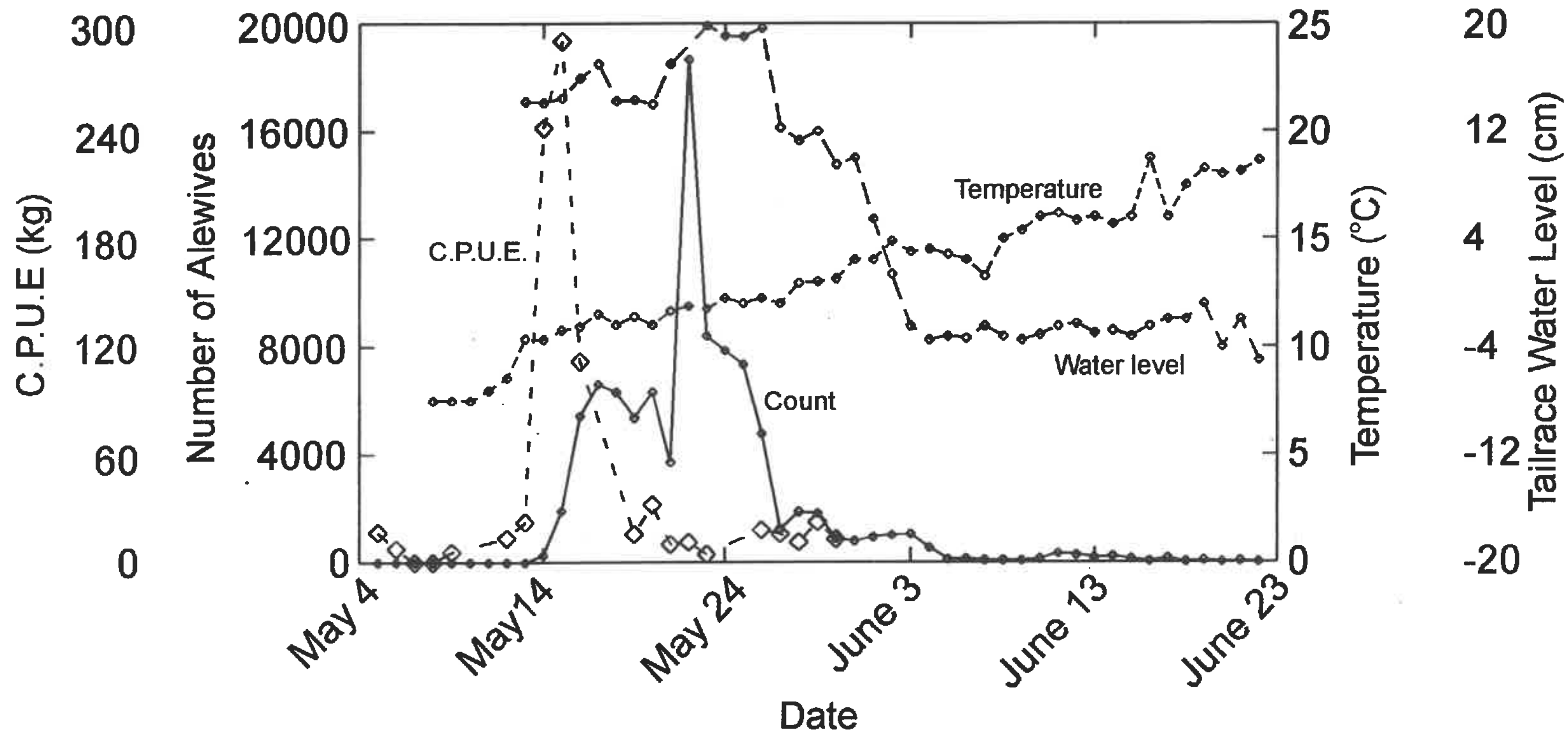

Figure 12. Daily alewife count at the White Rock Fish Ladder in 1997 overlaid against water temperature, water level and the downstream alewife catch.

high autocorrelation, which was removed by differencing the data. These variables were incorporated into a linear model using stepwise regression, and were able to explain 63.7% of the variation in the daily counts. The results of this analysis are summarized in Table 9.

Table 9. Results of the stepwise regression analysis relating the daily alewife count at White Rock to alewife abundance in the river, water temperature and tailrace water level.

Variable	Proportion of the variance attributable to the variable (R^2)	Coefficient	Standard error of the coefficient	P-value (2-tail)
H_2O temperature	0.249	2.416	0.910	0.024
alewife abundance	0.159	-0.549	0.294	0.091
H_2O level	0.137	0.400	0.159	0.031
abundance - H_2O level interaction	0.092	-0.318	0.199	0.141
constant	N/A	0.377	0.356	0.314
model R^2	0.637			

4. DISCUSSION

4.1 The Alewife Counts

The count of alewives ascending the ladder at White Rock in 1997 (95,433 alewives) was within the range of previous counts (50,400 to 126,933). The duration of the run (20 days for 95% of the fish to ascend the ladder) was also similar to other years: 14 days in 1982, 33 days in 1983 and 24 days in 1984 (Jessop and Parker 1988).

The partial count of 22,409 alewives entering Gaspereau Lake implied a total of c. 44,000 alewives entered the lake. What happened to over half of the fish which ascended the ladder at White Rock remains a question.

Undoubtedly, a portion of these fish (perhaps a substantial portion) fell prey to fishermen in South Alton. Fishing efforts in this area need to be closely monitored to determine the numbers captured in this area, if relationships between escapement from the fishery downstream from the White Rock dam and recruitment are to be properly understood.

The presence of outmigrating post-spawning adults at White Rock prior to post-spawners leaving Gaspereau Lake implies that a portion of the alewives spawned in the system downstream of the lake. In hindsight, this is not surprising, since a number of still waters exist between the White Rock dam and Gaspereau Lake which could provide suitable spawning areas for alewives (e.g. the White Rock headpond). Alewives are also known to spawn in small back eddies in lotic environments (Loesch 1987), and it is not unreasonable to assume that some do so in the Gaspereau River. A small number of alewife eggs and larvae were captured downstream of the White Rock dam during the spring of 1997 (Gibson and Daborn in preparation) implying that a portion of alewives also spawn downstream of this dam. Spawning locations upstream of White Rock may not have been typical in 1997 due to the high river flows during the first part of the migration. However, given the effort being placed on managing alewives in Gaspereau Lake and on excluding them from much of the system, whether or not a large portion of them spawn in areas other than the lake is an important question which needs to be further addressed.

4.2 Environmental Parameters

Two components need to be considered when attempting to relate the alewife count at the White Rock ladder to environmental parameters: conditions that are conducive to alewife migrations in the river, and conditions that favor alewives taking the ladder.

The onset of the spawning run followed a sharp increase in temperature from 8.2 °C to 10.4 °C between the 10th and 13th of May. This observation is consistent with those of Jessop and Parker (1988) that during 1982 to 1984, the first major peak in counts occurred when mean daily water temperature reached between 10.1 °C and 13 °C. The poor correlation between mean daily water temperature and daily C.P.U.E. ($r^2 = 0.049$) may be an indication that temperatures may serve as a cue for the onset of the run, after which temperature becomes a less important determinant of migration rates. This hypothesis is not consistent with the observation that fluctuations in mean daily water temperature explained nearly 25% of the variability in daily alewife counts at the White Rock Ladder (Table 8). This inconsistency could possibly be explained by a closer examination of what is being measured. The C.P.U.E data give an indication of abundance in the river. If alewives remain in the river for 6 to 7 days and move up and down the river during that time prior to taking the ladder (as suggested by Dominy 1971), abundance may not be an adequate measure of migration activity. Counts at the ladder, however, are a function of directed movement upstream, which are probably a better indicator of migration activity. Therefore, it seems reasonable to conclude that temperature fluctuation does influence the rate of upstream migration.

The poor correlation between daily C.P.U.E. and tailrace water level may be due to the practice of keeping tailrace water levels more or less constant throughout the fishing season. Had water levels shown more variation, this relationship may have improved substantially.

Environmental parameters had more influence on the number of alewives taking the ladder than on the catch-per-unit-effort. The linear regression model relating fluctuations in the daily count to downstream abundance, water temperature and tailrace water level was able to explain 63.7 % of the variability in daily counts. Tailrace water level, and tailrace water level coupled with downstream abundance, explained 22.9 % of this variability. Dominy (1971) reported that on a seasonal basis, tailrace water level had more influence on fish movement (implying the number of alewives ascending the ladder) than did water temperature.

The tailrace water level could influence the alewife counts in two ways: by affecting density and rates of movement in the river, or by affecting the ease with which they take the ladder. The entrance to a ladder is perhaps its most important element (Clay 1961) and water level is an important aspect of entrance configuration. Dominy (1971) suggested that 5 or 6 days were required for alewives to take the ladder at White Rock, after reaching the base of the dam, and that this delay may increase the exploitation rate on the river. The lag of 7 days between down river catches and the count at the ladder suggest this is still the case. Additionally, while tailrace water levels are held relatively constant throughout the fishing season, levels were dropped at the end of the fishing season, which may not coincide with the end of the spawning run. If reducing the water level had the effect of reducing the efficiency of the entrance to the ladder, this activity may have reduced the number of adults spawning upriver. While maintaining optimal water levels later into the season is one option, re-designing the ladder entrance to operate over a wider range may be a more feasible solution.

4.4 Stock Size

For the six years for which counts are available, estimates of the annual Gaspereau River alewife spawning run have ranged between 265,000 and 1.1 million fish. These values are less than the average size of the run during the last few decades, because all counts except 1995 (7,958 pails) were conducted during years when the catch was below the 1964 - 1997 median catch of 5,743 pails.

A number of biases exist within these calculations. For example, escapement from the fishery is estimated by counting alewives ascending the White Rock fish ladder, which requires the assumption that all alewives not captured take the ladder. Since there are indications that some fish may spawn below the dam, this assumption is not valid. Also, some immature alewives probably follow adult fish into the lower part of the river, but do not complete the spawning run (none were sampled at the White Rock ladder in 1997). The presence of what appear to be partial spawning marks on some scales at ages 2 and 3 years may be evidence that immature alewives in this system do enter the lower river. These fish may be available to the fishery, but because they do not complete the run are not enumerated at the ladder. For these reasons the exploitation rates are probably biased high.

Other evidence exists that supports this conclusion. The 1997 actual total mortality rates are 75.1% for males and 70.2% for females. These values are probably underestimates, because, while they are corrected by the proportion of alewives recruiting into the spawning population in each age class, they are not corrected for mortality of immature fish while at sea. Actual total mortality is interpreted as the sum of mortality from all sources (fishing and natural), and therefore cannot continually be less than the exploitation rate. The rates are not directly comparable, because of the methods by which they are calculated. Actual total mortality is effectively an average for the age classes existing in the population (ages 4 through 7), whereas the exploitation rates are specific to the year for which they are calculated. It is possible for the exploitation rate in a given year to exceed the actual mortality rate calculated that year, since the effect of a high exploitation rate on the mortality rate would not be detectable until the next year. If these estimates are reasonably accurate, the implication is that the exploitation rates in 1995 and 1996 were lower than that of 1997. A larger database, including data from sequential years is necessary to better analyze the dynamics of this stock.

It is interesting to note that the size of the alewife population on the Gaspereau River has fluctuated in a pattern that intuitively appears similar to that of the alewife stock in the Saint John River in New Brunswick. Using the annual harvest as a predictor of the size of the Gaspereau River stock (Figure 11) and estimates of stock size based on both harvest and escapement for the Saint John River (Jessop 1990), it appears that since the 1960's both stocks peaked around 1978, declined in the early 1980's and then peaked again around 1987 - 1989. Such a correlation would make sense for a number of reasons.

It could be interpreted as evidence that phenomena occurring at sea have important implications in determining recruitment. It could also be interpreted as evidence that meteorological conditions during critical periods for larvae and juveniles play an important role, as suggested by Crecco and Savoy (1987) for American shad. Meteorological conditions might be similar in the two systems, since the systems are relatively close geographically. Finally, fishing intensity undoubtedly follows the price of the fish, which would be expected to follow similar patterns for the two river systems. These factors probably interact to form a reasonable explanation for such a correlation.

4.5 Migration Rates

Migration times between the fish ladders at White Rock and Lanes Mills were estimated by marking fish and by comparing the time at which fish representing percentiles ascended each ladder. While the results from these methods are in good agreement, caution should be taken in their interpretation. Alewives at the beginning of the run required about 10 to 13 days to reach Gaspereau Lake, while alewives towards the end of the run required about 4 to 5 days. These estimates are higher than that of Jessop and Parker (1988) which averaged 3.8 days (n = 5). While it is normal for the later alewives to ascend the river more rapidly (Dominy 1971), this condition was exacerbated by high river flows during the first part of the run. While flows were not measured during the migration, alewives were observed holding up in pools downstream of the Lanes Mills ladder until the flows decreased to a level which allowed them to move upstream. At the time of writing a new ladder and control gate at Lanes Mills is under construction which should allow operation of the ladder over a wider range of heads in Gaspereau Lake. The resulting increased control over river flows should thus allow alewives to reach the lake without undue delay. Because of the delay this year, estimated migration times were probably longer than those to be expected under more optimal conditions. If the data are to be used to determine appropriate lags between the time alewives ascend the ladder at White Rock and water management activities in the system (e.g. closing the gate at Forest

Home), the work should be repeated under conditions simulating normal operating conditions.

As mentioned, fewer alewives were estimated to have entered Gaspereau Lake than were counted ascending the ladder at White Rock. These fish may introduce a bias when estimating migration times from the comparison of percentiles. If the proportion of alewives not entering the lake was higher during the first part of the run, the effect would be to overestimate migration times. Conversely, if the proportion was higher during the later part of the run migration times would be underestimated. We do not know whether such a bias exists in these data.

4.4 Stock Characteristics

Life history characteristics of the Gaspereau River alewife stock are similar to those of other rivers with high exploitation rates (e.g. D.F.O. 1997). The population is dominated by first time spawners (84.9 % of males and 75.2 % of females), and the majority of fish fall into three age classes (ages 4, 5, and 6 yr).

The current data are too limited to determine trends, however some patterns may be evident. The number of repeat spawners (15.1 % for males and 24.8 % for females) is higher than in other assessments (except males in 1984). Possible explanations for this observation are lower mortality during 1995 and 1996 than previously observed, or else recruitment was proportionally lower for the 1997 spawning stock than during previous assessments. Given that instantaneous mortality rates calculated for 1997 fell in the middle of the range observed, the latter is likely the case. Because the mean age in 1997 (4.29 yr for males and 4.50 yr for females) was slightly lower than that of the other assessments, the weak age class is probably the age 5 (1992 year class) or age 6 (1991 year class). Data from sequential years is required for a more complete analysis of these patterns.

During this assessment males were relatively more abundant than females at the beginning of the run, a pattern observed in many other rivers (Loesch 1987). A similar pattern for this river was reported by Dominy (1971). Overall, the male:female ratio was

1.13:1. Similarly, Jessop and Parker (1988) reported that the sex ratio did not differ significantly from 1:1 in 1982 and 1984, while in 1983 males outnumbered females by a ratio of 1.3:1. This pattern is also similar to many other rivers (Loesch 1987).

5. CONCLUSIONS

As is typical for alewife stocks, the Gaspereau River stock fluctuates in size over a fairly wide range. Factors such as conditions at sea, climatological conditions during early life stages, predation (both in freshwater and at sea), exploitation, water and fish management in the Gaspereau River watershed and intrinsic factors, all contribute to these fluctuations. While some of these factors (such as conditions at sea) are for practical purposes outside the scope of management of this stock, many of the factors are influenced directly by anthropogenic activities and therefore are suitable for consideration as part of a management plan.

With all other factors optimized, the size of the Gaspereau River alewife stock is ultimately limited by the carrying capacity of nursery areas within the watershed. Before an optimal exploitation rate can be established, knowledge of the potential of the nursery areas and the number of adults required to reach that potential is required. Alewives have high fecundity, thus producing a large number of offspring. These undergo high mortality, induced either by climatological conditions, or, if those conditions are favorable, by density dependent mortality. Without an understanding of the above relationships, it is not possible to say that simply increasing the number of spawners (by reducing exploitation) would be sufficient to increase the size of the stock.

This study has raised questions about the assumption that the majority of alewives move up to Gaspereau Lake and beyond to spawn. Unusually high flows in the upper Gaspereau River may have been responsible for the low number of alewives estimated to have entered Gaspereau Lake relative to the number ascending the ladder at White Rock, but in hindsight it is reasonable to assume that not all of them do. Future stock assessments should be designed in a way that addresses this question during years when flows are nearer the norm, since an understanding for implications of instream spawning is necessary before stock recruitment relationships can be understood. The first question is simply to determine whether a portion of the fish do not reach Gaspereau Lake. A more intensive count at Lanes Mills coupled with a count at White Rock would be the best way to obtain this information. Mark-recapture protocols (marking at White Rock, recapture at

Lanes Mills) would not in itself answer this question, since the methodology gives a population estimate at the time of marking. Close monitoring of fishing activities in South Alton should be conducted at the same time to help determine the cause of fish are not reaching the lake.

This study also raised a question about the effectiveness of the ladder at White Rock. If alewives are delayed prior to taking the ladder and move up and down the river during the delay, alewives would be more susceptible to capture by the fishery than if they moved upriver without delay. Water level undoubtedly plays an important role in the efficiency of the entrance to the ladder. This relationship deserves further consideration. If deemed appropriate, re-configuring the entrance to operate over a wider range of water levels is probably the easiest way to improve its efficiency. Determining the effectiveness of the ladder would require an estimate of the total number of alewives entering the river. Mark-recapture protocols would be suitable for answering this question, if alewives were marked at the head of the estuary and recaptured at the upstream exit of the ladder. This approach could also be used to address the question of whether immature adults follow the spawning run into the river.

While the exploitation rate calculated for 1997 was high, there is evidence that it may be overestimated by using the count at the White Rock ladder to estimate escapement, and that the rate fluctuates substantially between years. While a target exploitation rate is an alternative in the absence of biological information, a target escapement would provide a better management tool. A better understanding of stock-recruitment relationships in this system is required before such a target can be established, which would require a better understanding of factors determining year class successs and stock dynamics.

Stock assessments provide an indication of stock size and the number of spawners in a run. To provide better interpretation of the resulting statistics, assessments should be conducted in sequential years, since factors such as exploitation are not detectable until the following year. This information, coupled with estimates of outmigrating juveniles (interpreted as year class strength) are necessary to understand these relationships. Stock assessments such as this one, and research about YOY ecology and outmigration from

Gaspereau Lake (Gibson and Daborn, in preparation) are therefore steps in the right direction, even if at times they appear to raise more questions than they answer.

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APPENDIX I. RESULTS OF ALEWIFE COUNTS AT THE WHITE ROCK FISH LADDER IN 1997.

Appendix I. Results of alewife counts at the White Rock fish ladder in 1997.

1. Fishway at W.R. watered up on May 5, 1997.

2. May 5 (1400h - 1500h): no alewives

3. May 6 (0800h - 0830h): no alewives

4. May 6 (1900h - 2000h): no alewives

5. May 7 (0800h - 0830h): no alewives

6. May 7 (1200h - 1230h): no alewives

7. May 7 (1900h - 1930h): no alewives

8. May 8 (0800h - 0830h): no alewives

9. May 8 (1200h - 1230h): no alewives

10. May 8 (1900h - 1930h): no alewives

11. May 9 to May 13: Trap closed continuously. Checked at 0800h, 1200h, 1600h, 2000h daily. First alewife captured On May 13 at 1515h. Only one captured that day.

12. The results of all subsequent counts may be found in the following tables.

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1997.

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
800	815	0	74	542	414	612	380	451	308
815	830	0	22	115	128	172	103	367	62
830	845	0	16	79	55	70	35	119	69
845	900	0	6	86	72	107	78	114	67
900	915	0	9	43	155	61	65	85	25
915	930	2	9	92	98	110	78	26	14
930	945	0	14	72	76	120	82	126	21
945	1000	3	11	56	73	63	41	136	58
1000	1015	4	6	26	131	96	38	200	58
1015	1030	1	10	112	154	26	64	100	32
1030	1045	0	14	121	66	107	56	53	76
1045	1100	0	16	18	100	60	39	74	19
1100	1115	0	17	98	53	146	46	83	45
1115	1130	0	9	33	30	128	47	113	59
1130	1145	7	21	68	77	67	54	85	52
1145	1200	1	13	123	182	103	11	89	39
1200	1215	0	6	68	111	153	27	97	38
1215	1230	0	17	111	81	140	98	56	76
1230	1245	0	18	63	41	150	86	153	85
1245	1300	3	22	109	137	152	43	125	64
1300	1315	0	15	89	84	94	82	97	110
1315	1330	5	11	110	55	94	78	150	54
1330	1345	5	20	108	103	30	41	149	86
1345	1400	0	16	117	98	241	85	179	48
1400	1415	4	29	71	160	85	95	110	57
1415	1430	5	20	94	141	163	102	200	60
1430	1445	3	18	124	123	91	99	135	31
1445	1500	1	10	53	71	109	90	179	58
1500	1515	3	42	172	154	171	86	175	45
1515	1530	11	31	128	130	147	150	170	42
1530	1545	10	49	107	127	78	105	209	103
1545	1600	3	32	128	182	154	173	143	66
1600	1615	7	65	88	186	145	140	150	79
1615	1630	4	63	123	162	138	130	136	124
1630	1645	13	51	159	110	106	119	155	99
1645	1700	9	19	143	196	133	106	173	83
1700	1715	6	133	80	120	146	170	187	100
1715	1730	8	112	130	195	131	101	65	152
1730	1745	12	95	196	220	65	203	76	90
1745	1800	12	61	136	205	103	167	137	105
1800	1815	17	84	135	195	196	203	124	88
1815	1830	7	110	137	216	219	190	127	115
1830	1845	18	70	170	215	170	173	-16	210
1845	1900	11	99	157	260	125	164	59	60
1900	1915	12	110	134	194	174	275	90	85
1915	1930	9	82	113	155	111	136	91	62
1930	1945	23	71	92	243	171	226	96	156
1945	2000	17	75	109	89	92	218	137	88
Daily	**Total**	**256**	**1923**	**5438**	**6623**	**6325**	**5378**	**6335**	**3723**

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1997.

Time Period		Date and Count							
start (h)	end (h)	May 22	May 23	May 24	May 25	May 26	May 27	May28	May 29
800	815	845	718	279	732	234	68	48	290
815	830	232	64	35	109	32	9	8	27
830	845	121	42	39	120	18	18	41	61
845	900	131	86	97	109	37	9	6	21
900	915	187	82	13	86	26	12	10	38
915	930	217	85	25	52	9	0	0	11
930	945	146	40	22	86	25	15	2	74
945	1000	227	112	21	46	30	13	1	35
1000	1015	157	96	23	107	31	4	10	1
1015	1030	298	65	27	88	35	13	9	8
1030	1045	190	75	15	168	51	22	10	21
1045	1100	201	68	13	70	54	5	6	24
1100	1115	208	66	18	60	18	3	3	23
1115	1130	275	92	27	64	58	7	13	25
1130	1145	126	93	25	69	46	18	5	38
1145	1200	275	125	52	49	18	2	23	11
1200	1215	264	71	61	41	21	7	22	31
1215	1230	157	148	13	31	49	14	10	39
1230	1245	61	177	36	113	63	48	20	28
1245	1300	328	164	31	139	13	33	20	11
1300	1315	348	177	94	115	100	36	28	76
1315	1330	328	81	98	137	89	51	27	54
1330	1345	332	117	64	150	80	28	36	30
1345	1400	295	75	71	179	68	71	24	25
1400	1415	281	171	42	109	80	15	8	17
1415	1430	338	262	60	230	48	48	16	16
1430	1445	416	152	128	279	69	36	26	24
1445	1500	372	231	50	216	143	14	15	66
1500	1515	412	232	119	255	154	22	28	40
1515	1530	424	247	159	290	103	4	38	40
1530	1545	500	144	168	217	184	37	61	60
1545	1600	424	270	130	261	125	36	64	54
1600	1615	442	251	149	248	241	34	59	46
1615	1630	435	175	198	245	216	62	41	71
1630	1645	465	200	281	274	195	55	130	77
1645	1700	358	250	203	270	106	43	87	23
1700	1715	455	140	319	237	318	11	93	38
1715	1730	474	208	281	138	190	96	116	45
1730	1745	481	320	310	190	158	23	105	8
1745	1800	379	210	303	121	182	32	65	1
1800	1815	458	166	360	162	198	2	133	68
1815	1830	533	195	362	121	114	51	93	38
1830	1845	551	221	434	108	142	30	51	18
1845	1900	320	87	252	112	118	23	77	30
1900	1915	468	232	418	47	52	2	54	6
1915	1930	428	282	291	58	128	14	69	18
1930	1945	571	178	320	110	95	1	33	11
1945	2000	480	112	316	61	90	29	37	11
2000	2100	1513	545	1008	72	141	24		
2100	2400	750							
Daily Total		**18677**	**8400**	**7860**	**7351**	**4795**	**1250**	**1881**	**1828**

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1997.

Time Period		Date and Count								
start (h)	end (h)	May 30	May 31	June 1	June 2	June 3	June 4	June 5	June 6	June 7
800	815	54	30	54	40	68	2	0	-1	0
815	830	4	18	11	1	23	3	0	0	0
830	845	9	1	4	0	8	1	0	2	0
845	900	12	19	6	1	1	4	1	2	0
900	915	4	6	15	3	3	6	0	0	0
915	930	3	6	0	0	6	0	0	0	0
930	945	0	0	4	0	6	3	0	0	0
945	1000	13	1	4	0	12	3	0	1	0
1000	1015	8	5	8	0	5	5	0	0	0
1015	1030	4	0	18	0	39	0	0	0	0
1030	1045	11	5	6	0	1	6	0	1	0
1045	1100	7	11	5	4	15	14	0	0	0
1100	1115	26	10	2	1	9	1	0	0	0
1115	1130	4	1	21	0	12	9	0	2	0
1130	1145	5	8	13	1	14	1	1	0	0
1145	1200	6	24	8	1	9	8	1	0	0
1200	1215	13	11	22	0	5	14	0	0	0
1215	1230	12	24	14	4	14	35	1	0	0
1230	1245	35	5	9	6	34	9	0	0	0
1245	1300	14	13	6	0	20	26	0	0	0
1300	1315	8	25	27	0	18	9	2	0	0
1315	1330	44	14	14	59	4	11	2	3	0
1330	1345	22	32	41	1	7	24	9	3	0
1345	1400	22	40	8	0	74	30	1	3	1
1400	1415	26	12	50	3	23	44	4	2	1
1415	1430	39	14	39	2	42	21	4	3	3
1430	1445	39	6	23	44	4	6	3	3	1
1445	1500	42	41	32	37	69	11	7	8	1
1500	1515	18	52	31	28	33	10	10	2	0
1515	1530	23	27	7	20	43	16	3	4	3
1530	1545	66	28	87	78	59	12	1	3	10
1545	1600	41	25	60	40	69	21	1	13	8
1600	1615	0	33	16	59	38	28	2	23	8
1615	1630	10	12	51	85	10	18	9	6	7
1630	1645	19	14	38	21	20	23	7	6	7
1645	1700	15	31	37	34	38	2	24	7	7
1700	1715	24	25	4	57	3	11	13	1	4
1715	1730	42	29	2	111	17	34	2	8	6
1730	1745	18	36	9	86	16	10	5	6	4
1745	1800	17	21	47	3	33	8	3	7	3
1800	1815	4	9	16	87	7	9	2	7	0
1815	1830	14	6	12	1	0	7	2	1	1
1830	1845	14	14	9	22	18	10	0	2	0
1845	1900	4	10	12	10	16	1	1	2	0
1900	1915	16	6	4	30	20	4	0	1	2
1915	1930	15	13	15	22	14	9	0	2	1
1930	1945	23	10	14	12	31	3	0	3	1
1945	2000	13	13	4	0	26	3	0	0	0
2000	2100									0
Daily Total		**882**	**796**	**939**	**1014**	**1056**	**545**	**121**	**136**	**79**

Appendix I (con't). Results of alewife counts at the White Rock fish ladder in 1997.

Time Period		Date and Count							
start (h)	end (h)	June 8	June 9	June 10	June 11	June 12	June 13	June 14	June 15
800	1200	3	2	20	29	46	22	45	14
1200	1600	44	22	23	58	102	92	92	48
1600	2000	31	46	82	236	127	68	85	67
Daily Total		**78**	**70**	**125**	**323**	**275**	**182**	**222**	**129**

Time Period		Date and Count							
start (h)	end (h)	June 16	June 17	June 18	June 19	June 20	June 21	June 22	
800	1200	2	23	8	15	2	31	0	
1200	1600	7	72	12	54	0	12	7	
1600	2000	42	58	12	13	22	16	9	
Daily Total		**51**	**153**	**32**	**82**	**24**	**59**	**16**	

APPENDIX II. RESULTS OF ALEWIFE COUNTS AT THE LANES MILLS FISH LADDER IN 1997.

Appendix II. Results of alewife counts at the Lanes Mills fish ladder in 1997.

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 takng 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 Mills fish ladder in 1997.

Time Period		Date and Count					
start (h)	end (h)	May 26	May 27	May 28	May 29	May 30	May 31
1400	1415					321	
1415	1430				226	302	
1430	1445			57	149	348	110
1445	1500			101	182	275	72
1500	1515			155	186	280	89
1515	1530			196	300	262	48
1530	1545			196	359	275	69
1545	1600			271	393	286	41
1600	1615			236	377	301	66
1615	1630			267	366	275	92
1630	1645	8	14	314	349	298	103
1645	1700	8	16	307	343	328	107
1700	1715	9	18	330	291	295	73
1715	1730	7	27	362	248	261	114
1730	1745	7	35	422	351	243	91
1745	1800	11	31	492	413	235	72
1800	1815	10	25	478	458	185	80
1815	1830	11	32	582	482	153	117
1830	1845	8	50	563	384	150	120
1845	1900	9	51	535	395	267	91
1900	1915	6	39	507	378	349	78
1915	1930	8	33	483	375	278	83
Daily Total:		**102**	**371**	**6854**	**7005**	**5967**	**1716**

Appendix II (con't). Results of alewife counts at the Lanes Mills fish ladder in 1997.

Time Period		Date and Count					
start (h)	end (h)	June 1	June 2	June 3	June 4	June 5	June 6
1530	1545	18					
1545	1600	27					
1600	1615	22					
1615	1630	20					
1630	1645	16	9	2		0	0
1645	1700	21	8	4	1	0	0
1700	1715	15	8	1	1	0	0
1715	1730	16	4	4	4	0	0
1730	1745	21	0	2	1	0	0
1745	1800	19	3	1	0	0	0
1800	1815	20	3	0	0	1	0
1815	1830	9	6	1	1	1	0
1830	1845	21	4	1	0	0	0
1845	1900	13	5	4	1	0	0
1900	1915	11	4	0	0	0	0
1915	1930	15	2	2	0	0	0
Daily Total:		**284**	**56**	**22**	**9**	**2**	**0**

Time Period		Date and Count					
start (h)	end (h)	June 7	June 8	June 9	June 10		
1630	1645	0		0	2		
1645	1700	0		4	0		
1700	1715	0		5	0		
1715	1730	0		5	0		
1730	1745	0		4	1		
1745	1800	0		0	0		
1800	1815	0		0	3		
1815	1830	0		1	2		
1830	1845	0		0	2		
1845	1900	0		0	0		
1900	1915	0		2	1		
1915	1930	0		0	1		
Daily Total:		**0**		**21**	**12**		

Downstream migrants moving in and out of the ladder confounded counts after June 9th, but upstream migrants were not abundant after this time.