

New Brunswick Wildlife Trust Fund

Project title: Fish Passage Effects Monitoring Program for St. George Hydroelectric Redevelopment

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Summary of Final Report: March 2005

Accountability: Key metrics from our proposal, and results:

- 1) Assess downstream movements of salmon smolt through the Magaguadavic River reservoir to determine whether any delays occurred. Assess the efficacy of the bypass facility at attracting smolt.

Results: A total of 1,706 smolt marked with Visible Implant Elastomer tags (at the Mactaquac Biodiversity Facility) were released into the Magaguadavic River at four different sites from 6 to 25 May 2004 during the natural smolt migration period. The only means of downstream passage by the head of tide dam (in St. George) was either through the new downstream fish passage facility or through the turbines at the upgraded hydroelectric facility. Only 37 (2.2%) smolts (from the release groups) were recaptured in the fish passage facility. Travel times from the initial fish releases to the time of recapture ranged from 1 to 51 days, and averaged 14.9 days. The remaining 1,669 (97.8%) fish would have passed through the turbines to exit the river, or else they would have either died (predation or natural mortality) or remained for an additional year in the river. This is a significant decrease in the fraction of smolts using the bypass, compared to what occurred prior to the dam 'upgrade'. Up to 50% found the bypass in previous years.

- 2) Monitor downstream passage of gaspereau.

Results: Adult gaspereau were first observed (leaving the Magaguadavic River) in the downstream fish passage facility on 2 July 2004. The last fish was recorded on 9 October. Eighty-seven percent of the adult gaspereau downstream migrants were captured over a 3-week period (8 to 26 July). The highest one-day count in the downstream bypass facility was 250 (14 July). The total number of adult gaspereau collected in the fish bypass was 1,054 (1,000 live, 54 dead). This accounts for only about 1% of the estimated number of gaspereau that ascended the river in 2004, and strongly suggest that post spawned fish are not using the bypass channel.

The first juvenile gaspereau (progeny from adult spawners in 2004) was recorded in the downstream fish bypass facility on 1 August. The last fish was recorded on 1 November. Ninety-percent of the downstream run occurred from mid August to mid September. During that period observations were made above and below the dam and the for the most part fish that used the passage facility were permitted to free swim (no trapping was done) since numbers of fish often exceeded 1,000. The fork lengths (from 41 fish) averaged 5.53 ± 0.26 SD cm. Total lengths averaged 6.25 ± 0.26 SD cm. Small numbers of birds were observed above the dam during peak gaspereau migration. However, several birds were often observed below the tailrace during the same period. Birds consisted of seagulls, bald eagles, and kingfishers.

3) Monitor upstream passage of salmon.

Results: Wild salmon returns to the Magaguadavic fish ladder in 2004 were a record low two fish. Those fish had non-invasive tissue samples (partial fin clip) taken for DNA screening before being released into the river. A total of 17 escaped farmed salmon were recorded in the Magaguadavic fish ladder in 2004. This was the lowest number of escapes since the monitoring program began in 1992. Disease screening of all escapee salmon detected one fish positive for Infectious Salmon Anemia (ISA) and one fish positive for bacterial kidney disease. It was the second consecutive year that ISA was detected in escapees ascending the river. Due to the small number of salmon ascending the fish ladder in 2004, no assessments were performed to test whether the new tailrace output attraction flows affected upstream fish movements to the fish ladder.

4) Monitor upstream passage of gaspereau.

Results: In 2004, the first gaspereau was recorded ascending the Magaguadavic River fish ladder on 10 May and the last fish was recorded on 6 August. The upstream run peaked from 7 to 11 June with more than 70,000 fish estimated during that time. Overall, more than 106,000 were estimated to have ascended the river in 2004. Biological data collected from fish included lengths, weights, scales, sex, and otoliths.

We have prepared a comprehensive report titled 'Fish Passage Effects Monitoring Program for St. George Hydroelectric Redevelopment' that presents the results of this year's work in more detail, and combines it with data from previous years to document salmon population trends. A copy of that report is attached.

Fish Passage Effects Monitoring Program for St. George Hydroelectric Redevelopment

INTRODUCTION

The Magaguadavic River has become an important site for monitoring the status of New Brunswick's western Fundy Greenland migratory Atlantic salmon (*Salmo salar*) populations. It is also located in the heart of the New Brunswick salmon farming industry, and research there has provided much needed information on the interactions between wild and escaped farmed salmon, and on the success of actions taken by the industry to attempt to reduce these interactions. The continuous monitoring of wild and escaped farmed salmon at this site since 1992 has provided a data time series that is used by ICES (the International Council for the Exploration of the Seas) and Canadian authorities to identify trends, and to set regulatory measures for both the salmon farming industry, and the conservation of wild Atlantic salmon populations. In addition, in 2003, a time series of counts of gaspereau (*Alosa pseudoharengus*) was begun on the Magaguadavic that can be used as a regional indicator of the status of this species. Gaspereau is an important species from an ecological perspective, and is also harvested commercially.

Over a 12-month period, beginning in 2003, the hydroelectric facility situated at the head of tide in the Magaguadavic River underwent a major upgrade. The facility's power generation capacity increased from 3.7 to 15 MW and four Francis turbines were replaced with two Kaplan variable pitch propeller turbines. In addition, a new downstream fish passage facility replaced the existing one. The refitting of the hydroelectric facility is a major change to environmental conditions in the river, and it potentially could have a great impact upon the river's wild salmon population. For example, it could significantly change the migration path and survival of smolt in fresh water compared to those observed in 1998 – 2003. This would affect calculations of smolt to adult survival rates for the salmon. It could also have changed the ability of wild and escaped farmed fish to find the fish ladder that provides passage around the dam. These changes could also compromise the utility of the present time series data, because if the changes in environmental conditions significantly affected the fish in the river, then comparing future returns or survival to those in the past is a bit like comparing apples to oranges.

In 2003, we assessed fish passage at the upgraded hydroelectric facility, situated in St. George, New Brunswick. The specific objectives were to: (1) monitor downstream movement rates of Atlantic salmon smolt through the reservoir and to assess the efficacy of the new downstream passage facility for attracting smolt, (2) monitor downstream passage of gaspereau at the passage facility, (3) monitor upstream passage of Atlantic salmon at the head of tide fish ladder, and (4) monitor upstream passage of gaspereau at the fish ladder.

METHODS

Study Area

The Magaguadavic River is the sixth largest river in New Brunswick. It originates in Magaguadavic Lake in the southwest part of the province and flows southeasterly 111 km to Passamaquoddy Bay (an offshoot of the Bay of Fundy) near St. George (Figure 1). There are 103 named tributaries and more than 55 lakes within a drainage area of 1,812 km². A 13.4 m high dam (built in 1903) is located at the head of

the tide. A pool and weir fish ladder bypasses the dam for upstream fish passage. From 1968 to 2003, a hydroelectric facility equipped with Francis runner-type turbines, generated about 3.7 megawatts (MW) of power at the head of tide dam. In 2004, the hydroelectric facility had been upgraded to produce up to 15 MW of power, and the Francis turbines were replaced with two Kaplan variable pitch propeller turbines. A sluiceway intended for downstream fish passage was situated adjacent to the penstock of the 3.7 MW hydroelectric facility. The sluiceway was replaced with a new downstream fish passage facility when the hydroelectric facility was upgraded. The entrance to the new fish passage facility is centered 1.65 meters above the penstock of the 15 MW facility. Water storage reservoirs are located in Digdeguash and Magaguadavic Lakes.

The Magaguadavic system supports a sport fishery for anadromous and landlocked Atlantic salmon, brook trout (*Salvelinus fontinalis*), and introduced smallmouth bass (*Micropterus dolomieu*). Also, non-indigenous rainbow trout (*Oncorhynchus mykiss*) have been recorded in the river but their origin is unknown. A limited sport dip net fishery occurs during the spring in Lake Utopia tributary streams for two populations of landlocked smelt: rainbow smelt (*Osmerus mordax*) and dwarf smelt. A commercial fishery exists in the lower sections of the river for American eels (*Anguilla rostrata*) during their seaward migration in the fall. The spring run of alewives (*Alosa pseudoharengus*) is sometimes fished for lobster bait in the tidal waters.

Wild salmon ascend the river from June until early November. Spawning occurs from late October until mid November. Wild salmon spend two to four years in the river before they migrate to sea as smolt (Carr 1995).

Upstream Fish Passage

Magaguadavic River Fish ladder

The head of tide fish ladder (constructed in 1928) has a series of 43 pools, each 30.5 cm higher than the other, allowing fish access over the 13.4 m dam. Two resting pools are located at spaced intervals along the fishway. Water flow is controlled through a 1-m² opening at the upstream end of the fish ladder by adjusting a steel-plated gate. An electrically powered trap having a false, hoistable floor with a cradle was constructed in the fourth pool from the top of the fish ladder in 1992 to allow for the capture of all fish species ascending the fish ladder.

Atlantic salmon

Wild salmon returning from the sea were distinguished from farmed escapees using external morphology and scale characteristics (Carr, 1995). Captured fish were placed in an aquarium and anesthetized with clove oil (see Anderson et al. 1997). Biological sampling included a fork length measurement, external morphology, scale (aging and origin discrimination) and tissue (DNA screening) samples, and external observations for parasites (i.e. sealice).

Disease screening overtime has been conducted by three agencies: (1) the New Brunswick Department of Agriculture Fisheries and Aquaculture (NBDFAFA) in St. George (post-mortem exams for bacterial pathogens), (2) the Department of Fisheries and Oceans in Moncton (bacterial and virology screening in 1995, and from 1997-2004), and (3) the Research and Productivity Council in Fredericton (RT-PCR screening for an array bacterial and viral pathogens). Most wild fish screened for disease were found

dead in the river. Wild broodstock had blood, mucus, and reproductive fluids sampled for disease screening by RT-PCR analysis. In 2000 and 2001, wild fish were non-lethally screened for the Infectious Salmon Anemia virus by conducting RT-PCR analysis of gill mucus swabs. All escapees (1992-2004) were either found dead in the river, or deliberately sacrificed for disease tests. Since 1996, escaped farmed salmon have been removed from the river. Wild salmon, with the exception of a few broodstock collected from 1996 to 1999, have been released into the river.

Egg depositions required for conservation purposes in the Magaguadavic River watershed were calculated as follows:

Interim required depositions of 1.35 million eggs is based on an estimated 563,000 m² of juvenile rearing substrate and a deposition of 2.4 eggs/m² (Anon MS 1978). Spawners required to obtain those eggs were estimated at 140 1SW and 230 MSW salmon. Measurements from orthophotographic maps and air photos (Amiro 1993) estimated 9.33 million m² of available habitat (>0.125 gradient). For wild fish, we used the 1992-1995 average sex ratios of 60% males and 40% females for 1SW fish and applied it to fish of unknown sexes in 1996 - 2004. The 1992-1995 average MSW sex ratios were 18% males and 82% females and the undetermined sexes in 1996 and 2000 were adjusted similarly.

Once the total female escapement was determined for each of the years, the mean length-fecundity relationship for Saint John River salmon ($Y=430.19e^{0.03605x}$, Marshall and Penney MS 1983) was used to estimate potential egg deposition from the fish passed through the fish ladder.

Gaspereau

In 2003 and 2004, gaspereau counts were estimated at the fish ladder. Total counts of fish were recorded in the fish ladder trap (fourth pool from top of ladder) during the early and later stages of the run when daily numbers were less than 1,000. During that period the trap was monitored a minimum of 5 to 10 times per day. During the peak stages of the run (>1,000 fish per day), gaspereau were diverted around the trap. A white board was installed in the downstream opening of the third pool from the top of the fish ladder to facilitate in the estimation of gaspereau counts. Gaspereau were counted (using a clicker) at hourly intervals ranging from 08:00 to 20:00 hours for a 15-minute period per hour. The hourly interval counts were variable within and between years. Three times a week, up to 200 gaspereau were measured (fork and total lengths) and as many as 50 fish were kept for further sampling (scales, otoliths, lengths, weights, sex, maturity status).

Other observations

Additional daily observations recorded at the fish ladder included water temperature, weather conditions, and occurrence of other fish species.

Downstream Fish Passage

Atlantic salmon

Salmon smolts (wild and escapees from commercial hatcheries) were sampled leaving the Magaguadavic watershed from 1999 to 2004. Escaped juvenile salmon captured in the river, and/or moving out to sea as smolts, were identified based on age, and physical characteristics. Wild Magaguadavic salmon become smolt at age $\geq 2+$ (Carr 1995). By contrast, escaped cultured fish become smolt at age 1+. Fins of cultured fish are also often eroded. A satellite-rearing program released wild

origin fish to the river in 1997. Hatchery fish (unfed fry and fingerlings for enhancement purposes) have also been released annually in the river since 2003. These fish (except unfed fry) were adipose fin clipped for identification. Landlocked salmon annually released into lakes in the system by the Provincial government are also fin clipped.

1999-2003 Monitoring Period (3.7 MW Hydroelectric Facility)

A fykenet was placed in a bypass channel below the St. George dam during the spring sampling period from 1999 to 2001. A counting fence replaced the fykenet in 2002 and 2003. In addition, a fykenet was placed in the outlet of Linton Stream in 1999, and a smolt wheel was placed in the river’s mainstem at Lee Settlement from 1999 to 2003. Captured salmon were anaesthetized, weighed, and measured, and a sample of scales and tissue was taken before release. From 2000 to 2003, smolts captured in the smolt wheel were marked to facilitate identification upon recapture at the lower site so that the smolt output of the river could be determined.

2004 Monitoring Period (15 MW Hydroelectric Facility)

The upgraded hydroelectric dam in St. George became operational in spring 2004. A total of 1,706 smolts (F2 generation progeny from wild Magaguadavic River parents) were tagged with Visible Implant Elastomer (VIE) tags at the Mactaquac Biodiversity Facility in April 2004. The fish were released into the Magaguadavic River to test the capture efficiency of the new fish bypass collection chamber at the upgraded dam, St. George (Figure 1). The smolts were released during the ‘normal’ smolt migration period (based on previous smolt data and water temperature regimes). The release strategies were as follows:

Date	Time (hours)	No. Smolt	No. Parr	Location	Upstream Distance from dam	ID code (VIE color)
6 May	13:00	431	27	Pomeroy Bridge	51.00 km	Green: left eye
12 May	15:00	446	14	Day Adventure	1.20km	Red: right eye
19 May	11:00	329	31	Lee Settlement	26.00 km	Red: left eye
19 May	21:00	76	11	Near dam entrance	0.03 km	Red: left eye, rv clip
25 May	15:00	335	25	Lee Settlement	26.0 km	Green: right eye
25 May	21:00	89	10	Near dam entrance	0.03 km	Green: right eye, rv clip

The new fish passage facility was monitored a minimum of twice daily during the smolt migration period. Biological sampling protocols for captured fish was similar to those in previous years (1999-2003, see above).

Gaspereau

The timing of the downstream migration was monitored in 2004. Observations of fish (adults and juveniles) at the new fish passage facility were recorded. Biological sampling included lengths (fork and total) and external body condition. Observations were also recorded at and below the tailrace of the dam to monitor for potential fish predators during the downstream migration period.

RESULTS

Upstream Passage of Atlantic salmon

Wild salmon

Wild salmon numbers in the Magaguadavic River have decreased from 293 fish in 1992 to a low of 2 fish in 2004 (Figure 2). Both 1SW female wild salmon returnees entered the river during September in 2004 (Figure 3).

Ratios of 1SW salmon outnumber MSW salmon for the 5 and 10 year averages (Tables 1 and 2). No MSW salmon returned to the river in 2004 (Table 2). The 5-year average sizes of both 1SW and MSW salmon are slightly larger than the 10-year averages (Tables 1 and 2). No repeat wild salmon spawners have been recorded in the Magaguadavic River since 1997.

Farmed Escapees Ascending River

Only 17 escapees were recorded at the fish ladder in 2004. This was the lowest number since the monitoring program began in 1992 (Figure 2). The most escapees on record were 1200 fish in 1994 (Figure 2). Farmed escapees entered the river later than wild fish in all years and their numbers generally peaked from late August to October (Figure 3).

In 2004, it was the first time on record that no MSW escapee salmon ascended the river (Table 5). Increased numbers of escaped postsmolt were observed in the river from 1994 to 1997 when a brackish water cage site reared fall smolt at the mouth of the Magaguadavic River (Table 3). The size of escaped salmon varied, presumably in part depending on the time of escape from cages (Tables 3 - 5).

Spawning Escapement

Conservation egg requirements for the river were never met in the 1995 - 2004 period, nor were the desired escapements of large and all salmon (Table 6). Both have deteriorated significantly over the study period. The 5-year (2000 to 2004) average egg depositions are only 3.6% of target level (Table 6). In 2004, an estimated 0.5% of the conservation level was met, the lowest on record (Table 6).

The highest contribution of estimated escapee spawners was in 1996 when 32.9% were considered to be sexually mature (Table 6). Only one escapee was released into the river since 1997. This fish was mistakenly released into the river in 2000, and it had the potential to contribute 15.9% of the overall egg contribution in that year.

In 2002, 103 captive reared broodstock of Magaguadavic River genetic strain were released into the river. As many as 63% (35 females) were sexually mature. The release of those fish may have increased the overall egg contribution to an estimated 10.8% of the conservation level for that year.

Disease Screening

In 2004, disease screening of all escapee salmon resulted in the detection of one case each of Infectious Salmon Anemia (ISA) and bacterial kidney disease (Table 7). It was the second consecutive year that ISA was detected in escapees ascending the river. No wild salmon were screened for diseases in 2004.

Upstream Passage of Gaspereau

In 2004, the first gaspereau was recorded ascending the Magaguadavic River fishway on 10 May and the last fish was recorded on 6 August. The upstream run peaked from 7 to 11 June with more than 70,000 fish estimated during that time. Overall, more than 106,000 were estimated to have ascended the river in 2004. Biological data collected from fish included lengths, weights, scales, sex, and otoliths. This data was sent to Department of Fisheries and Oceans for a more comprehensive analysis.

Downstream Passage of salmon smolt

Smolt estimates

Smolt monitoring in the Magaguadavic River has detected high numbers of escaped hatchery juveniles leaving the river system. The percentage of hatchery escapee smolts (one year-old smolts) ranged from 33% to 98% over the 1998 to 2004 period (Figure 4). Wild smolts outnumbered hatchery smolts only in 1999 (Figure 4). Some of the smolts classified as wild (two- and three year-old smolts) may have been fish that escaped as fry from hatcheries. Most smolts were captured at the dam in all years (Figure 5).

In 2004, a total of 247 smolts were captured leaving the Magaguadavic River (Figure 5). Of these, 51.0% were hatchery escapees, 22.7% were wild, and 26.3% were from hatchery stockings as part of an enhancement program (Figure 4). Some of the smolt identified as 'wild' may have included escapees or intentional releases (for enhancement purposes) that entered the Magaguadavic system as unfed fry. The numbers, dates, and locations of intentional hatchery releases for enhancement purposes are listed in Table 8. These fish originated from wild origin Magaguadavic River salmon collected from the river in 1998.

Landlocked salmon captures during the smolt monitoring period ranged from 64 (2002) to 31 (2004, see Figure 5). All landlocked salmon were recorded at the collection station at the head of tide dam with the exception of one fish captured in the smolt wheel at Lee Settlement in 2003.

Preliminary Assessment of New Downstream Fish Passage Facility

Fish monitoring commenced at the new fish passage on 12 April and ended on 9 December 2004.

Salmon

The first smolt was observed in the collection facility on 10 May and the last smolt was observed on 14 July. A total of 247 smolts were observed in 2004, of which 56 (22.7%) were wild, 126 (51.0%) were escaped hatchery, 37 (15.0%) were VIE tag recaptures, and 28 (11.3%) were adipose fin clipped (enhancement program). Most smolts (146 or 59%) were collected over a 33-day period when water temperature averaged 13.4 ± 1.73 (standard deviation) °C.

A total of 26 salmon parr and presmolt were observed at the downstream fish passage facility from 18 October to 1 November. Of those, 9 were wild, 7 were escapees, 4 were enhancement releases, and 6 were of unknown origin (Figure 5).

Thirty-one landlocked salmon were observed from 12 May to 4 July (Figure 5). Eight additional landlocked salmon were observed from 18 September to 17 November (Figure 5).

Smolt recaptures in the collection chamber at the new dam was only 2.2% . No spill occurred at the main dam during the 2004 smolt migration period. Thus, the only exit from the main river past the dam for any fish was through the fish bypass facility or the turbines.

The recapture of fish released 30m upstream from the bypass entrance was only 3.0% (Table 9). None of the 76 fish released 30 m above the dam on 19 May were recaptured. Of the 89 smolts released at the same site on 25 May, only 5 (3.0%) were recaptured in the bypass collection chambers. VIE tagged smolt travel times (# days from release to recapture) from the release site (30m above the dam) to the collection facility ranged from 1 to 14 days and averaged 7.5 ± 9.2 days (Table 9).

Smolt recaptures (in the collection facility) from releases 1.2 km above the dam was only 2.2% (Table 9). It took the tagged (VIE) fish from 1 to 31 days and averaged of 17.9 ± 11.2 days to travel from the release site to the fish bypass collection facility (Table 9).

Only 0.5% (2 fish, see Table 9) of smolt released the furthest upstream (Pomeroy Bridge: 51 km above dam) were recaptured. It took the two recaptures 47 and 51 days to travel from Pomeroy Bridge to the bypass collection facility (Table 9).

VIE tagged smolt released at Lee Settlement had a recapture rate of 3.0% (Table 9). It took those fish from 2 to 37 days and an average of about two weeks (13.7 ± 12.1 days) to reach the bypass collection facility (Table 9). The 3.0% recapture rate for VIE tagged smolt in 2004 (at the new dam) was much lower than for each of the four years that recapture data was recorded for marked fish released at Lee Settlement and recaptured at the original fish bypass (St. George dam). The recapture rates during those years (2000 – 2003) ranged from 5.9 - 54% at the original facility (Table 9).

Avian predators (cormorants, mergansers, gulls, osprey) were observed staging on boom logs (30 m above the fish bypass entrance) during the smolt run in 2004. The highest incidence of birds was noticed early in the morning and in the evening. Previously (before the dam upgrade), few birds were observed near the fish bypass entrance.

Only 10 smolts (1 VIE and 9 unmarked) were found dead in the collection facility. Minimal scale loss was observed on the dead fish. All live fish collected were in good external condition, indicating that the passage into the collection chambers poses a minimal risk. Water flows/turbulence within the collection chambers seem adequate (no observations of fish struggling in the current near the screens).

Gaspereau

Adult gaspereau were first observed in the downstream fish passage facility on 2 July 2004. The last fish was recorded on 9 October. The total number of gaspereau collected in the fish bypass was 1,054 (1,000 live, 54 dead). Eighty-seven percent of the adult gaspereau downstream migrants were captured over a

3-week period (8 to 26 July). The highest one-day count in the facility was 250 (14 July). A white fungus was observed on some of the adults. Less than 1% (1,054) of the adult gaspereau (out of the more than 100,000 that ascended the river through the fish ladder from 10 May to 6 August) were observed in the fish bypass collection chambers. This indicates that most fish are not leaving the river, and that several may possibly be going through the turbines.

The first juvenile gaspereau (progeny from adult spawners in 2004) was recorded in the downstream fish bypass facility on 1 August. The last fish was recorded on 1 November. Ninety-percent of the downstream run occurred from mid August to mid September. During that period observations were made above and below the dam, and for the most part, fish that used the bypass facility were permitted to free swim (no trapping was done) since numbers of fish were often in the thousands. The fork lengths (from 41 fish) averaged 5.53 ± 0.26 SD cm. Total lengths averaged 6.25 ± 0.26 SD cm. Scant numbers of birds were observed above the dam during peak gaspereau migration. However, several birds were often observed below the tailrace during the same period. Birds consisted of seagulls, bald eagles, and kingfishers.

American Eels

American eels were observed in the downstream fish passage facility from 6 October to 3 November 2004. Daily numbers observed ranged from 1 to 21, totaling more than 80 during that period.

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Table 1. Numbers, percentages, and mean lengths (X in cm, with standard deviations = SD) of 1SW wild Atlantic salmon in Magaguadavic River from 1995 to 2004. Sexes were determined from secondary sexual characteristics.

Year	Male			Female			Undetermined		Combined	
	Tot	%	X ± SD	Tot	%	X ± SD	Tot	X ± SD	Tot	X ± SD
1995	34	69	55.4 ± 2.64	15	31	55.6 ± 2.83			49	55.5 ± 2.70
1996	24	75	56.2 ± 3.15	8	25	56.1 ± 2.21	16	55.7 ± 3.16	48	56.1 ± 2.89
1997	20	63	56.1 ± 3.50	12	37	56.1 ± 1.93	3	57.6 ± 0.46	35	56.2 ± 2.85
1998	15	71	57.1 ± 3.17	5	29	60.3 ± 3.53	8	54.4 ± 2.95	28	56.9 ± 3.73
1999	7	47	57.4 ± 4.42	8	53	61.2 ± 4.30	4	57.9 ± 4.09	19	59.1 ± 4.47
2000	2	67	59.1 ± 1.77	1	33	52.6	10	57.3 ± 2.41	13	57.2 ± 2.64
2001	3	38	58.6 ± 0.67	4	50	59.1 ± 2.1	1	60.5	8	59.1 ± 1.53
2002	2	40	58.3 ± 4.60	3	60	57.6 ± 1.25	2	57.3 ± 1.20	7	57.7 ± 2.11
2003	2	67	47.9 ± 11.46	1	33	56.0	0	0	3	50.6 ± 9.35
2004	0	0	0	2	100	58.0 ± 1.41	0	0	2	58.0 ± 1.41
10 yr mean		56	56.1 ± 3.55		28	57.3 ± 3.45		56.3 ± 3.10		56.5 ± 3.45
5 yr mean		32	56.3 ± 6.49		34	57.3 ± 2.34		57.6 ± 2.30		57.2 ± 3.82

Table 2. Numbers, percentages, and mean lengths (X in cm, with standard deviations = SD) of MSW wild Atlantic salmon in Magaguadavic River from 1995 to 2004. No MSW wild salmon returned to the river in 2002 and 2004. Sexes were determined from secondary sexual characteristics.

Year	Male			Female			Undetermined		Combined	
	Tot	%	X ± SD	Tot	%	X ± SD	Tot	X ± SD	Tot	X ± SD
1995	15	50	75.8 ± 2.83	15	50	74.8 ± 3.27			30	75.3 ± 3.46
1996	2	18	77.8 ± 0.75	9	82	74.9 ± 2.83	10	77.6 ± 4.00	21	76.5 ± 3.60
1997	0	0		24	100	76.6 ± 2.97	0		24	76.6 ± 2.97
1998	0	0		3	100	75.7 ± 0.85	0		3	75.7 ± 0.85
1999	0	0		5	100	80.9 ± 3.35	0		5	80.9 ± 3.35
2000	0	0		0	0		1	77.0	1	77.0
2001	1	11	81.5	8	89	77.8 ± 6.64	0		9	78.2 ± 6.33
2003	0	0	0	3	100	81.9 ± 2.12	0		3	81.9 ± 2.12
2004	0	0	0	0	0	0	0	0	0	0
10 yr mean		17	76.3 ± 3.65		76	76.6 ± 4.04		77.6 ± 4.00	15.6	76.7 ± 3.94
5 yr mean		6	81.5		89	78.9 ± 5.95		77.0	3.6	79.0 ± 5.51

Table 3. Numbers, percentages, mean lengths (X in cm, with standard deviations = SD) of postsmolt escaped cultured Atlantic salmon in Magaguadavic River from 1995 to 2004. Sexes were determined from secondary sexual characteristics.

Year	Male		Female		Undetermined		Combined	
	Tot	X ± SD	Tot	X ± SD	Tot	X ± SD	Tot	X ± SD
1995	30	24.8 ± 4.60	0		23	30.2 ± 7.08	53	27.2 ± 6.39
1996	13	29.4 ± 7.72	11	36.2 ± 4.13	22	33.9 ± 4.62	46	33.2 ± 5.93
1997	23	25.5 ± 3.23	0		14	33.0 ± 5.62	37	28.3 ± 5.63
1998	0		0		8	35.2 ± 3.81	8	35.2 ± 3.81
1999	7	33.2 ± 8.12	4	29.8 ± 5.68	0		11	32.0 ± 7.23
2000	2	21.8 ± 0.35	0		1	37.0	3	26.8 ± 8.81
2001	3	30.8 ± 13.81	4	33.6 ± 2.72	1	35.7	8	32.8 ± 7.80
2002	5	33.1 ± 3.86	0		1	27.5	6	32.2 ± 4.15
2003	2	42.1 ± 0.21	0		5	42.7 ± 4.42	7	42.5 ± 3.62
2004	1	40.0	0		1	30.2	2	35.1 ± 6.93
10 yr mean		25.6 ± 6.79		34.3 ± 4.90	13.3	33.3 ± 6.24		30.7 ± 7.03
5 yr mean		32.8 ± 8.78		33.6 ± 2.72		39.6 ± 5.81		35.1 ± 7.70

Table 4. Numbers, percentages and mean lengths (X in cm, with standard deviations = SD) of 1SW escaped cultured salmon in Magaguadavic River from 1995 to 2004. Sexes were determined from secondary sexual characteristics.

Year	Male			Female			Undetermined		Combined	
	Tot	%	Ave \pm SD	Tot	%	X \pm SD	Tot	X \pm SD	Tot	X \pm SD
1995	184	44	61.5 \pm 7.58	242	56	60.4 \pm 7.68	65	56.8 \pm 3.99	491	60.4 \pm 7.40
1996	57	34	59.1 \pm 4.31	112	66	59.1 \pm 4.43	5	57.8 \pm 5.13	174	59.0 \pm 4.42
1997	18	34	61.4 \pm 5.57	35	66	57.7 \pm 5.11	6	56.8 \pm 7.14	59	58.7 \pm 5.78
1998	38	36	67.4 \pm 9.35	72	64	65.5 \pm 8.79	101	64.8 \pm 7.71	211	65.5 \pm 8.49
1999	17	47	59.2 \pm 10.03	19	53	62.0 \pm 11.87	20	65.9 \pm 9.96	56	62.5 \pm 10.83
2000	2	29	64.3 \pm 1.77	5	71	62.8 \pm 3.40	18	60.3 \pm 5.69	25	61.1 \pm 5.18
2001	70	62	68.2 \pm 8.35	43	38	66.7 \pm 6.12	7	62.9 \pm 7.32	120	64.5 \pm 7.70
2002	15	58	61.4 \pm 7.44	11	42	65.2 \pm 9.71	3	64.5 \pm 5.55	29	63.1 \pm 8.19
2003	4	29	70.6 \pm 17.02	4	29	64.3 \pm 2.50	6	74.8 \pm 10.01	14	72.0 \pm 10.04
2004	8		77.2 \pm 13.48	6		78.3 \pm 6.22	1	60.5	15	76.5 \pm 11.16
10 yr mean			62.2 \pm 8.32			61.5 \pm 7.85		62.2 \pm 8.36		61.9 \pm 8.12
5 yr mean			64.2 \pm 9.61			67.1 \pm 7.37		62.7 \pm 10.24		64.9 \pm 9.14

Table 5. Numbers, percentages and mean lengths (X in cm, with standard deviations = SD) of MSW escaped cultured Atlantic salmon in Magaguadavic River from 1995 to 2004. No MSW escaped cultured salmon were captured at the fish ladder in 2002 and 2004. Sexes were determined from secondary sexual characteristics.

Year	Male			Female			Undetermined		Combined	
	Tot	%	X ± SD	Tot	%	X ± SD	Tot	X ± SD	Tot	X ± SD
1995	113	72	71.3 ± 5.49	43	28	70.3 ± 4.38	12	66.5 ± 2.65	168	70.7 ± 5.22
1996	3	17	74.4 ± 2.55	15	83	71.3 ± 5.18	2	80.2 ± 1.30	20	72.6 ± 5.37
1997	6	33	75.4 ± 4.28	12	67	72.4 ± 3.75	5	68.7 ± 3.51	23	72.4 ± 4.47
1998	1	33	84.5	2	67	71.9 ± 2.90	0		3	76.1 ± 6.39
1999	4	40	82.6 ± 8.67	6	60	72.0 ± 3.34	14	71.6 ± 4.43	24	73.5 ± 6.37
2000	0			0			2	78.7 ± 1.63	2	78.7 ± 1.63
2001	2	50	86.2 ± 5.94	2	50	78.2 ± 0.92	0		4	82.2 ± 5.80
2003	1	50	80.0	0	0		1	77.8	2	78.9 ± 1.56
2004	0	0	0	0	0		0	0	0	0
10 yr mean			72.3 ± 5.67			71.2 ± 4.53		70.4 ± 5.33		72.0 ± 6.09
5 yr mean			86.1 ± 4.20			78.2 ± 0.92		78.4 ± 1.25		81.2 ± 4.71

Table 6. Escapement of wild and escaped cultured Atlantic salmon in the Magaguadavic River during 1995 - 2004. Numbers of spawners are based on fish classed as sexually mature, and total egg deposition is based on sex ratio, mature female fork length, and fecundity for age classes 1SW and MSW for wild and cultured spawners. Mature postsmolts are all precocious males that escaped from brackish water sites. The mean length-fecundity relationship for St. John River salmon ($Y=430.19e^{0.03605x}$, Marshall and Penney MS 1983) was used to estimate potential egg deposition. The conservation requirement is 1.35 million eggs.

Yr	Wild			Cultured or Stocked				Combined							
	Total spawn	% fem	Tot eggs	Total	Tot mat	% mat	% fem	Post Smolt mat	Tot eggs	Tot escapemnt	Tot spawn	% fem	% cult spawn	Tot eggs	% Cons Level
95	79	38.0	143575	208	45	21.6	46.7	0	86143	287	124	41.1	36.3	229718	17.0
96	62	45.2	140623	240	79	32.9	55.7	8	178370	302	141	51.1	56.0	318993	23.6
97	48	62.5	157322	0	0	0	0	0	0	48	48	62.5	0	157322	11.7
98	16	43.8	30447	0	0	0	0	0	0	17	16	43.8	0	30447	2.3
99	4	25	3250	0	0	0	0	0	0	4	4	25	0	3250	0.2
00	13	38.5	19845	1	1	100	100	0	3741	14	14	42.9	7.1	23586	1.7
01	17	70.6	71349	0	0	0	0	0	0	0	17	70.5		71349	5.3
02	7	57.1	13688	103	56	63	35	NA	92537	80	53	39.6	86.8	106225	7.9
03	5	60.0	19250	0	0						5	60.0	0	19250	1.4
04	2	100	6962	0	0	0	0	0	0	6962	2	100	0	6962	0.5
10 yr mean			60631											98343	7.3
5 yr mean			26219											48741	3.6

** In 2002, the “cultured or stocked” section represents F1 generation captive reared progeny of 1998 wild adult returns that were released into the Magaguadavic River.

Table 7. Summary of bacteriology and virology disease screening of wild and escaped cultured salmon collected in the Magaguadavic River fish ladder, 1992 - 2004.

Year	Origin	Bacteriology						Virology					
		# sample	No Pathogens	Aeromonas	Pseudeomonas	Vibrio	BKD	IPN	Edwardsella tarda	HKS*	# sample	No Pathogens	ISA
1992	Wild	7	3	2	1	1							
	Cultured	0											
1993	Wild	2	0	1	1								
	Cultured	2	1	1									
1994	Wild	1	0	1									
	Cultured	23	17	4		2							
1995	Wild	0											
	Cultured	99	74	13	11				1		61	61	
1996	Wild	0											
	Cultured	0											
1997	Wild	3	3										
	Cultured	15	4	10		1							
	Cultured	34	29							5			
	Cultured										19	19	
1998	Wild	0											
	Cultured	60	59				1				60	60	
1999	Wild	20	6								20	6	14
	Cultured	58	56				1	1			58	54	4
2000	Wild	1	1								7	7	
	Cultured	28	28								28	28	
2001	Wild												
	Cultured	132	132								132	132	
2002	Wild												
	Cultured	34	34								34	34	
2003	Wild	1	1								1	0	
	Cultured	12	11					1			12	11	1
2004	Cultured	17	15				1				17	16	1
1992-2004	Wild	35	14	4	2	1					28	14	14
	Cultured	514	459	28	11	3	3	2	1	5	419	418	6

*HKS= Hemorrhagic Kidney Syndrome, later termed Infectious salmon anemia virus (ISA).

Table 8. Stocking summary of Atlantic salmon for the Magaguadavic River watershed, 2002 to 2004. Fish progeny originated from wild salmon collected from the river in 1998.

Release site	Year	Date	Mark	Age	No. Fish
Piskahegan River	2002	06/05/02	1	0	30000
Magaguadavic River	2002	August	7	3	10
Magaguadavic River	2002	September	7	3	10
Magaguadavic River	2002	October	7	3	10
Magaguadavic River and tributaries	2002	October	8	3	69
Davis Brook	2003	06/11/03	1	0	5125
Magaguadavic River (near Pratts Brook)	2003	06/11/03	1	0	5125
Kedron Stream	2003	06/11/03	1	0	10306
Magaguadavic River (above Flume Bridge)	2003	07/29/03	1	0	1500
Cox Brook	2003	07/29/03	1	0	250
Millikens Brook	2003	07/29/03	1	0	1500
Lake Stream	2003	07/29/03	1	0	800
Bonny River	2003	07/29/03	1	0	250
Magaguadavic River (above Second Falls)	2003	07/29/03	1	0	1000
Magaguadavic River and tributaries	2003	September	3	0	5000
Upper Trout Brook	2004	05/26/04	3	0	5000
Cox Brook	2004	05/26/04	3	0	4831
Piskahegan River	2004	05/26/04	3	0	10000
Davis Brook	2004	05/26/04	3	0	5000
Magaguadavic River (Pomeroy Bridge)	2004	05/06/04	9	1	431
Magaguadavic River (Day Advent. Center, St. George)	2004	05/12/04	9	1	446
Magaguadavic River (Lee Settlement)	2004	05/19/04	9	1	329
Magaguadavic River (30m above dam intakes)	2004	05/19/04	9	1	76
Magaguadavic River (Lee Settlement)	2004	05/25/04	9	1	335
Magaguadavic River (30m above dam intakes)	2004	05/25/04	9	1	89
N.E. Branch@ hwy 3	2004	9/24/2004	3	0	1000
Davis@ Hwy. 3	2004	9/24/2004	3	0	1000
Magaguadavic @ Pratts brook	2004	9/24/2004	3	0	1000
Magaguadavic@ D.F.O. camp	2004	9/24/2004	3	0	1000
Magaguadavic @ Flume bridge	2004	9/24/2004	3	0	1500
Magaguadavic@ Graveyard pool	2004	9/24/2004	3	0	1500
Piskahegan@ ford	2004	9/24/2004	3	0	1000
Lake stream	2004	9/24/2004	3	0	434

MARKS:

1=no mark

3=adipose fin clip

7=acoustic tag (adipose clip and pit tag or carlin tag)

8= floy tag and adipose clip

9=adipose clip and VIE tag

Table 9. Summary of Magaguadavic River Atlantic salmon smolt recaptures at the smolt bypass facility, St. George dam. Data includes number of smolt marked, recaptured, travel times to the dam, and the general spillage (water discharge) at the main dam in St. George. From 2000 to 2003 the original fish bypass was operational. In 2004, the upgraded dam with the new fish collection facility was operational.

Hydro Dam	Year	Mark/release Location (upstream distance from the head of tide dam)		No. smolt marked & released	No. recaptured (%) at St. George dam bypass site	Travel time (days) from release to recap site		Dam spillage during smolt run
Original (3.7 MW)	2000	Lee Settlement (26 km)	Total	72	39 (54%)	Mean \pm SD 6.3 \pm 5.1	Range 1 - 27	Minimal High Minimal Moderate
	2001	Lee Settlement (26 km)	Total	13	1 (7.7%)	22.0		
	2002	Lee Settlement (26 km)	Total	29	3 (10.3%)	17.3 \pm 18.0	5 - 38	
	2003	Lee Settlement (26 km)	Total	17	1 (5.9%)	3.0		
	2000 to 2003	Lee Settlement (26 km)	Combined totals	131	44 (33.6%)	11.3 \pm 8.3	1 - 38	
New (15MW)	2004	Lee Settlement (26 km)	Total	664	20 (3.0%)	13.7 \pm 12.1	2 - 37	None
	2004	Pomeroy Bridge (51 km)	Total	431	2 (0.5%)	49 \pm 1.4	47 - 51	None
	2004	Day Adventure (1.2 km)	Total	446	10 (2.2%)	17.9 \pm 11.2	1 - 31	None
	2004	Dam (.03 km)	Total	165	5 (3.0%)	7.5 \pm 9.2	1 - 14	None

*** When spillage occurred at the dam (St. George), there's a high chance of smolt exiting the main river over the dam, rather than through the downstream passage facility.

Figure 1. Map of Magaguadavic River watershed . The * indicates locations of commercial salmon hatcheries.

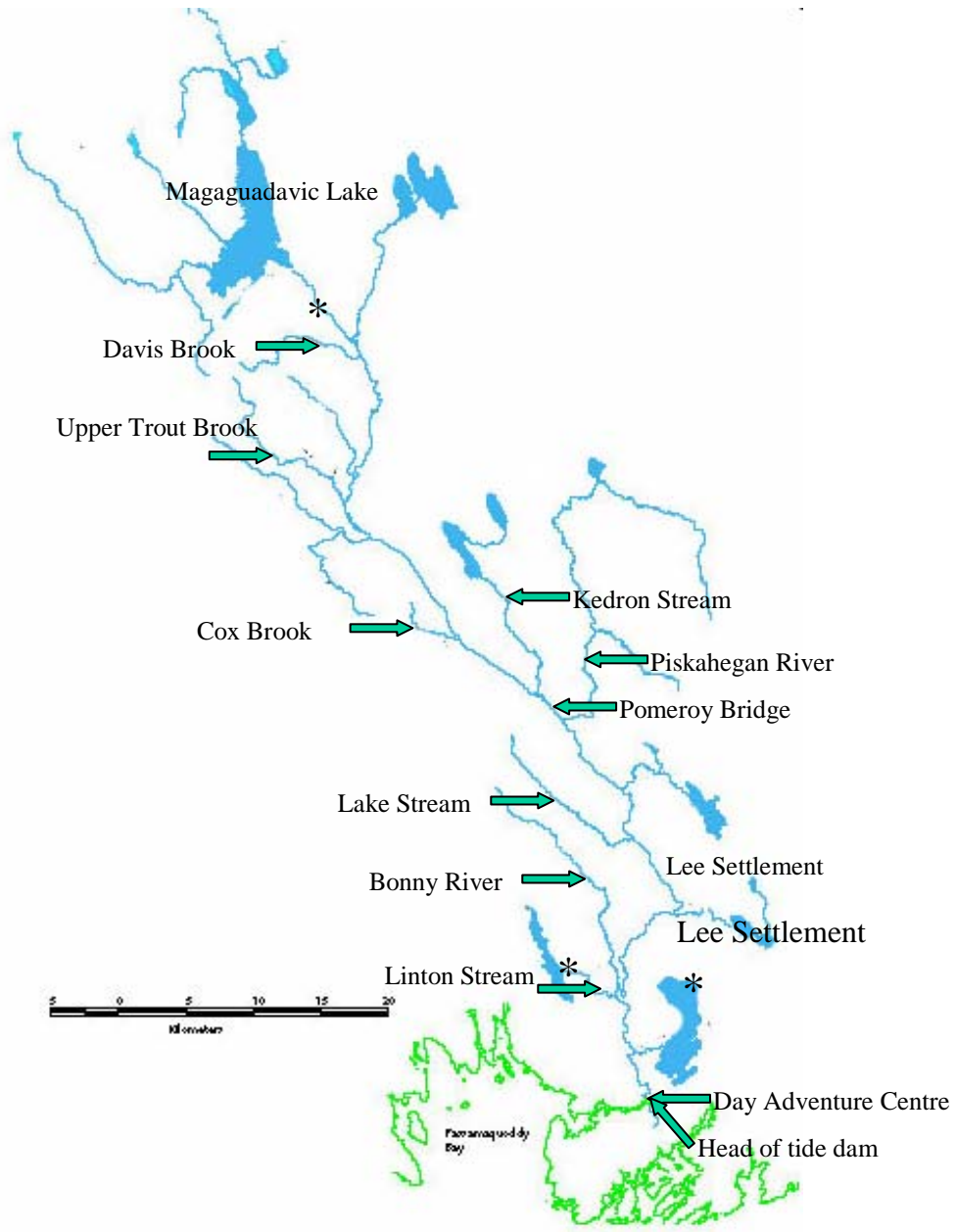
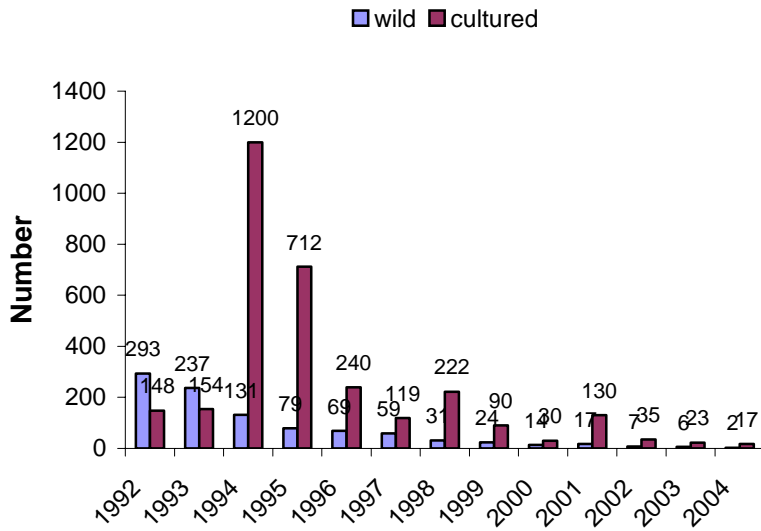


Figure 2. Wild and cultured Atlantic salmon (a) total numbers and (b) percentages recorded at the fish ladder trap at the head of tide in the Magaguadavic River, NB, 1992-2004.

(a)



(b)

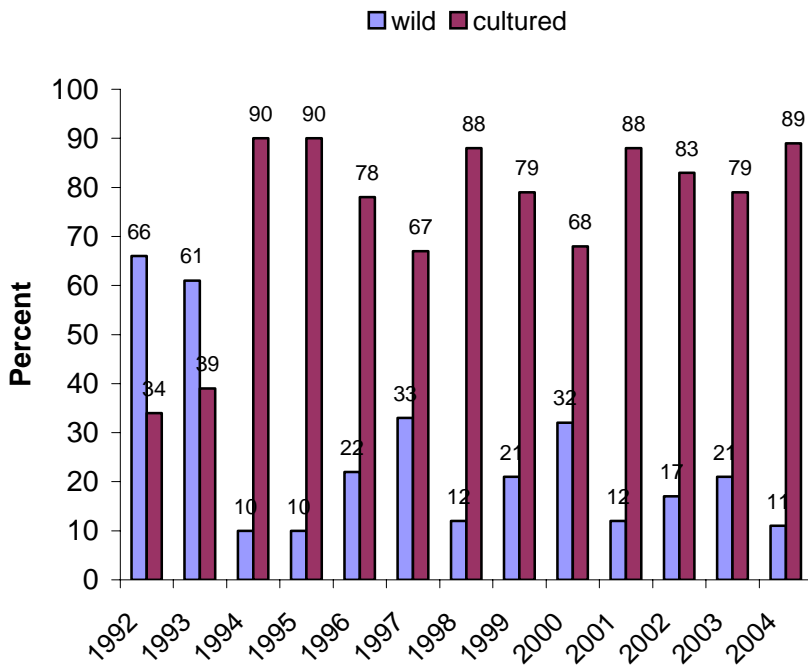


Figure 3. Monthly total numbers of wild and farmed Atlantic salmon recorded at the fish ladder trap at the head of tide in the Magaguadavic River, NB, 1999-2004.

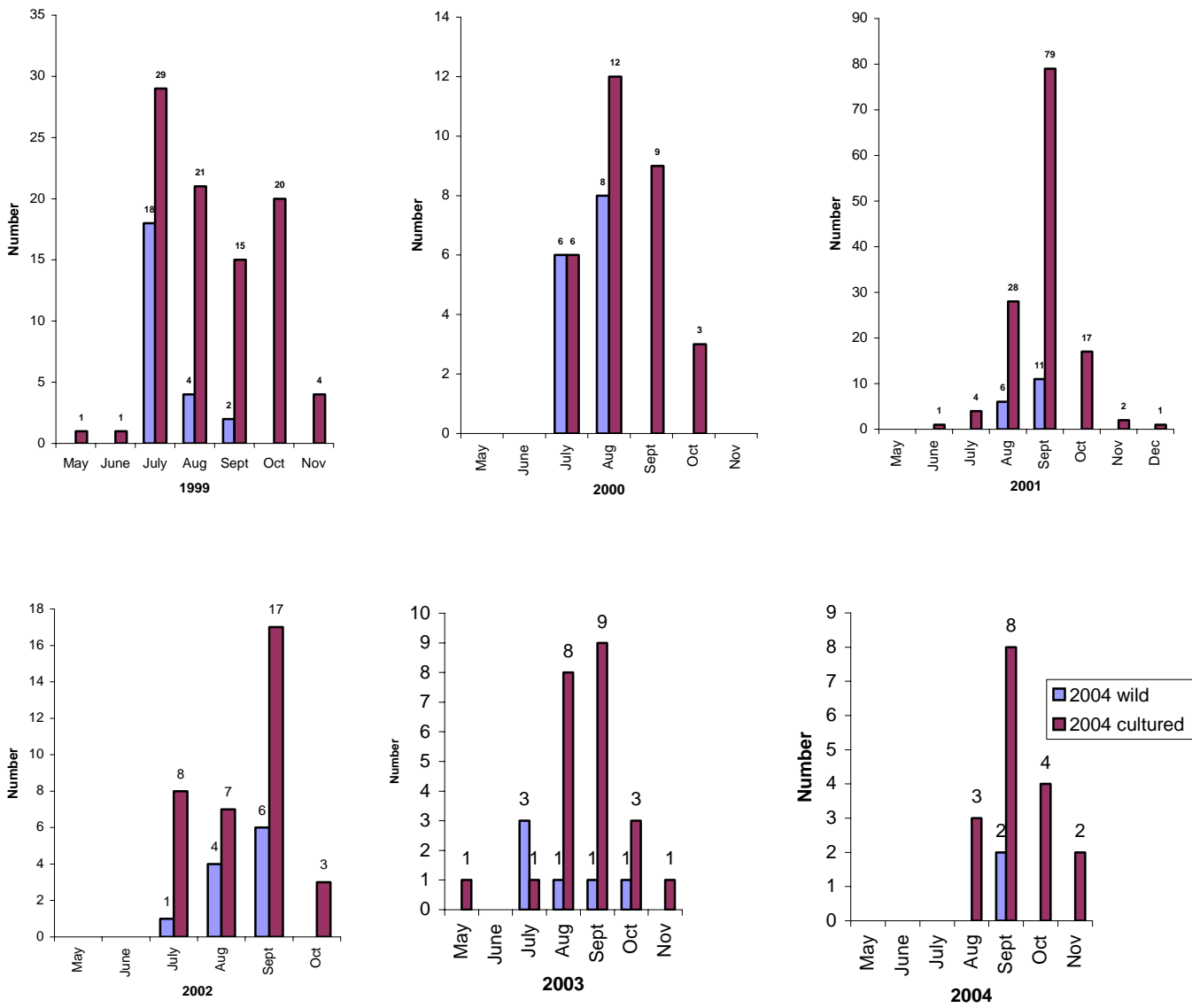


Figure 4. The percent of wild, escaped hatchery, enhancement stocked, and unknown origin Atlantic salmon smolts recorded leaving the Magaguadavic River watershed from 1999 to 2004.

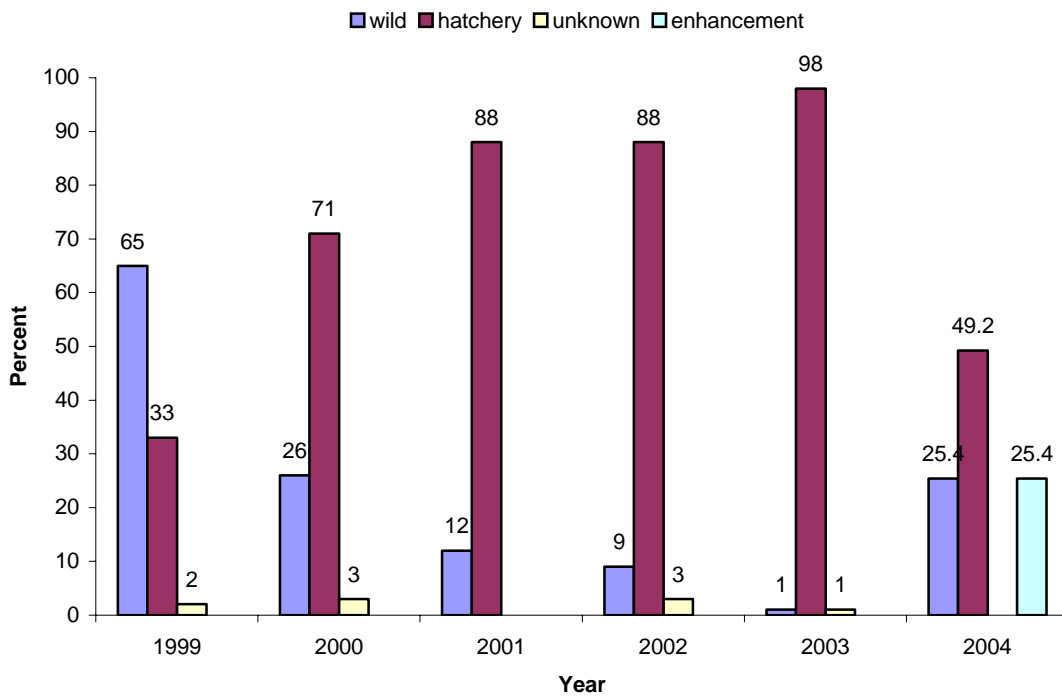


Figure 5. The numbers of wild, hatchery, enhancement stocked, and unknown origin Atlantic salmon smolt captured at sites in the Magaguadavic River watershed from 1999 to 2004. Numbers of landlocked salmon are also included. From 1999 to 2003, fish captures were from the spring. In 2004, both spring and fall captures are included.

