Magaguadavic River Monitoring and Recovery Program

Final Report

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Abstract

The Magaguadavic River is located near the heart of the North America's East Coast aquaculture industry, and monitoring work here since 1992 provides the best data set for this region on the potential frequency of interaction between cultured and wild Atlantic salmon, and on the population status of this discrete population. Cultured fish may enter this river by escaping from hatcheries located within the watershed, or after their escape from sea cage sites.

The NB Wildlife Trust Fund provided support in 2002 to the Atlantic Salmon Federation to work within the Magaguadavic river system. The project objectives (" the deliverables") identified in the proposal and our accomplishments to meet them were:

1. Maintain the existing adult and juvenile salmon monitoring program on the Magaguadavic River.

Accomplishments 2002:

- Seven one sea winter wild salmon returned to Magaguadavic fish ladder trap in 2002 (down from 17 in 2001). Those fish were released into the river, where they have the opportunity to spawn with the gene bank adults (see below).
- Thirty -five escaped cultured salmon captured in Magaguadavic fishway trap in 2002 (down from 130 in 2001). Those fish were removed and sent away for disease screening.
- Thirty-four escaped cultured salmon were screened for viral and bacterial pathogens in 2002. No positive test results were obtained.
- The 2002 Magaguadavic smolt run was estimated at 460 individuals (95% confidence limits 280 – 2970). About 88% of the run was composed of escaped hatchery smolt, with the remainder being wild. In 2001, the smolt run was estimated at 290 (95% confidence limits, 265-1680), with 88% being hatchery escapees. In 2001, wild smolt output would thus be estimated to range from 32 to 202 individuals (12% of the above confidence limits). With seven wild adults returning in 2002, wild smolt to wild adult survival rates for the 2001 year class would range from 22% to 3.5%. In our opinion, lower values are more probable.

2. Pit tag all Magaguadavic broodstock currently being reared in captivity so that they may be readily identified for mating purposes.
3. Run DNA pedigree analysis on the broodstock so that mating plans can be established.
4. Acoustically tag and track movements of Magaguadavic broodstock (first generation hatchery reared fish from wild parents) in the river to determine spawning performance and success. This information will be important for determining the spawning suitability of first generation artificially reared fish (from wild parents).

Accomplishments 2002:

- Pit tagging and pedigree analysis completed.
- One hundred and three adults were released to the river to spawn naturally.

- A Captive mating plan has been developed for mating broodstock to maintain genetic diversity. Two hatcheries have agreed to rear eggs to various life stages for release into the river as part of the recovery program.
- The artificial egg incubation experiments had to be cancelled because the broodstock that were to provide the eggs unexpectedly stopped their maturation process and reabsorbed their ovaries or testes.
- Thirty acoustically tagged fish were released into the river.
- There was extensive print and television press coverage on the first release (see web www.asf.ca and go to Magaguadavic Recovery Program).
- Movements of the fish were tracked through a combination of moored receiver units at set waypoints, and through weekly active tracking when weather permitted. Acoustic receivers have been deployed under the ice in the river to continue to follow fish movements post-spawning.
- None of the early-release fish moved upstream to headwater spawning areas from the Magaguadavic headpond. This was very disappointing, however, some of these were found near spawning locations (i.e. Linton Stream and possibly other suitable tributaries) in the lower river. Ten acoustically tagged fish released near headwater spawning areas in late October were found to be moving among spawning grounds in late November. It is planned to monitor their spawning success by sampling juvenile salmon in these areas during 2003.

Methodologies for the work, and additional details on the results are presented elsewhere in this report. The 2002 efforts, and previous years work are documenting the following trends:

Wild salmon returns have steadily declined from 293 fish in 1992 to seven in 2002. Escaped cultured salmon composed from 34% to 90% of the annual salmon run during this time period. Escapees entered the river later than wild salmon in all years and their numbers peaked in September and October.

The 1993-2002 average egg deposition was only 23.5% of the conservation target set for the river by the Department of Fisheries and Oceans. Escapee salmon had the potential to contribute 14% of the average estimated egg deposition from 1992-1996, however, after 1996 no cultured fish have been permitted to enter the river to avoid genetic introgression of cultured genotypes.

No pathogenic bacterial or viral organisms were found in wild and cultured salmon tested during 1992-1996, and since 1999. However, in 1997 five of 34 cultured salmon tested were suspect for hemorrhagic kidney syndrome. In 1998, one of 61 fish screened for viral and bacterial diseases tested positive for BKD. Infectious Salmon Anemia (ISA) was detected in four of 58 cultured escapees in 1999. ISA was also found in wild salmon entering the Magaguadavic River for the first time globally.

Few wild smolt have been detected leaving the river system. Escaped hatchery smolt have comprised from 33% to 88% of the overall smolt run from 1999 to 2002. Landlocked salmon have been recorded leaving the river during smolt migration in the spring.

Salmon parr have been rare in the Magaguadavic River, with the largest numbers being escaped cultured juveniles found in the vicinity of commercial salmon hatcheries. Wild juvenile salmon numbers in the Magaguadavic River received a boost in 2002 when 29,000 unfed fry were stocked in the watershed.

Thirty broodstock (F1 generation from wild parents) were acoustically tagged and tracked in the Magaguadavic River to assess behavior and spawning success. None of the 20 tagged fish released in late summer in the lower river migrated to the spawning grounds in the upper river. Most fish moved into Lake Utopia near a commercial hatchery where they were originally reared to smolt. Most of the ten fish released in the upper river in late October remained near spawning grounds until late November.

Introduction

This document presents the results of the Atlantic Salmon Federation's 2002 field work supported by the Wildlife Trust Fund, and summarizes the trends observed in this monitoring program that has been maintained for adult and juvenile Atlantic salmon on the Magaguadavic River since 1992.

This report also summarizes a tracking experiment that was conducted in 2002 to evaluate the effectiveness of rearing F1 progeny (from wild Magaguadavic Atlantic salmon broodstock spawned in 1998) to the adult stage in captivity, and then releasing them into the Magaguadavic River for natural spawning.

STUDY SITE

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 97 km to Passamaquoddy Bay near St. George. There are 103 named tributaries and more than 55 lakes within a drainage area of 1812 km^2. A 13.4 m high dam (built in 1903) located at the head of the tide is equipped with Francis runner-type turbines, which generate about 3.7 megawatts of power. Currently, the owners of the site are upgrading the hydroelectric potential of the river. Dams are being reconstructed, the headpond is being altered, and new turbines with a higher hydroelectric capacity are being installed. A pool and weir fish ladder bypasses the dam for upstream fish passage. This is not affected by the redesign. All salmon arriving at the Magaguadavic River from the ocean must pass through the fish ladder (Figure 1). A sluiceway intended for downstream fish passage is situated adjacent to the penstock. Water storage reservoirs are located in Digdeguash and Magaguadavic Lakes.

The Magaguadavic River is situated near the center of North American East Coast Atlantic salmon aquaculture industry, and large numbers of escaped cultured salmon from sea-cages have entered the river in recent years. Three commercial salmon hatcheries that together produce about two million smolts for the sea-cages are located within the drainage, and cultured juvenile salmon are escaping from those sites.

The Magaguadavic system supports a sport fishery for anadromous and landlocked Atlantic salmon, brook trout (*Salvelinus fontinalis*), and introduced smallmouth bass (*Micropterus dolomieui*). Also, non-indigenous sea-run 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).

METHODS

Adult Sampling Regimes

Since 1992, June to November salmon counts have been made in the St. George fish ladder trap (except in 1996 when monitoring did not begin until July). Wild salmon returning from the sea were distinguished from cultured escapees using external morphology and scale characteristics (Carr, 1995). Biological sampling included a fork length measurement, external morphology, scale and tissue samples, and external observations for parasites.

Disease screening was conducted historically by three agencies: (1) the New Brunswick Department of Agriculture Fisheries and Aquaculture (NBDAFA) 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 1997-2002), and (3) the Research and Productivity Council in Fredericton (RT-PCR screening for an array bacterial and viral pathogens). Currently, the DFO Moncton laboratory processes all our disease samples.

Wild fish screened for disease were found dead in the river or had non-lethal mucus (from gills) samples taken. Wild broodstock had blood, mucus, and reproductive fluids sampled for disease screening by RT-PCR analysis. By contrast all escapees were either found dead in the river, or deliberately sacrificed for disease tests.

<u>Conservation Requirements</u>
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 m^2 of juvenile rearing substrate and a deposition of 2.4 eggs/m^2 (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 m^2 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 - 2001. The 1992-1995 average MSW sex ratios were 18% males and 82% females and the undetermined sexes in 1996 were adjusted similarly.

For the escapees, the 1SW sex ratios from 1995-1998 were adjusted after applying the 1992-1994 average of 64% females and 36% males to the undetermined 1SW sexes. The 1992-1994 average MSW sex ratios of 34% males and 66% females were used to calibrate the undetermined MSW sexes.

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.

Juvenile Salmon Sampling Regimes

Parr and Fry

Accessible juvenile rearing habitat was identified throughout the Magaguadavic watershed. Open monitoring stations were established, including sites in the vicinity of commercial salmon hatcheries (see Figure 1). Where we could gain access, juvenile salmon were captured by electrofishing. Captured salmon were anaesthetized, weighed, and measured, and a sample of scales and tissue was taken before release. Catches per unit effort (relative abundance) were calculated as the number of fry (0+ parr) and parr ($\geq$ 1+ parr) caught per 100 seconds fishing time.

Smolt

Smolt were sampled leaving the Magaguadavic watershed from 1999 to 2002.
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. 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 2002. Captured salmon were anaesthetized, weighed, and measured, and a sample of scales and tissue was taken before release. From 2000 to 2002, 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.

Escaped juvenile salmon in the river, 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, 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. These fish were adipose fin clipped for ready identification. Landlocked salmon annually released into lakes in the system by the Provincial government are also fin clipped.

Broodstock Tracking

Tags and tagging Procedures

V16-4H-R04K coded ultrasonic tags, termed "pingers" (15 mm diameter X 65 mm length; weight 10 g in water, produced by Vemco Limited, Shad Bay, Nova Scotia) were used to tag Atlantic salmon broodstock. Each pinger had an individual identification on frequency 69.0 kHz, with a minimum and maximum delay of 20 to 69 seconds between transmissions. Each tag has an expected life of 570 days. Pingers were surgically implanted in the peritoneal cavity of the fish. Approximate fish size ranged from 550mm to 950mm and weighed from 4 kg to 6 kg.

Fish were tagged at their respective rearing facilities (Mactaquac Biodiversity Centre and the Huntsman Marine Science Center (HMSC)). Anaesthetized fish (using Clove oil: [40 mg/L]) were placed ventral side up in a V-shaped trough with moist paper toweling for support. Germex was used to sterilize all surgical tools, sutures, and pingers. Furacin was used to clean the ventral surface of the fish prior to making a two cm mid-ventral incision beginning two cm anterior to the pelvic fins. The pinger was inserted into the peritoneal cavity under the incision. Three to four sutures (4-0 Ethilon black monofilament nylon with

FSL circular cutting needle) were applied to close the incision and a tissue cement (Vetbond) was used to seal the incision and stitches. Furacin was sprayed on the closed incision. Fish recovered in under 10 minutes from the anesthesia. The tagged broodstock were monitored for a minimum of seven days following surgery to allow for a recovery period before being released into the Magaguadavic River.

Release Protocols

Geneticists from the Magaguadavic breeding committee determined what level of kin versus non-kin individuals should be released into the river to minimize the potential for inbreeding. Once the 30 fish were selected, kin versus non-kin individuals was randomized in the releases. Equal numbers of freshwater (Mactaquac) and saltwater (HMSC) reared fish were tagged and released. Sexes and family (sibling) crosses were evenly distributed in the samples, and members of each family had representatives that had been reared in fresh and salt water. Ten fish, classified as early releases, were liberated over a seven-day period in August (five each from Mactaquac and HMSC) in the lower section of the Magaguadavic River. A second release (10 fish), mimicking the first release, occurred in September. A third release of 10 fish (five each from Mactaquac and HMSC) in October, classified as late releases, occurred in the upper reaches of the Magaguadavic River near spawning grounds.

Tracking

Movements of tagged fish were monitored by positioning submersible receivers (VEMCO VR2 single channel receiver) at strategic locations in the river. Each unit has a built-in omni directional hydrophone with data logging components programmed to decode pinger tag number and date/time of each detection. Weekly active searches for tagged fish were performed using boats equipped with VR60 receivers having either directional or omnidirectional hydrophones.

RESULTS

Adult Salmon Returns

Wild Adult salmon

Wild salmon numbers in the Magaguadavic River have decreased from 293 fish in 1992 to a low of seven fish in 2002 (Figure 2). Total wild returns in 2002 were only 8% of the average return of 87 fish in the 1992 to 2002 period. Wild salmon entered the river from 26 July to 12 September in 2002 (Figure 3).

Cultured Escapees

In 2002, there were 35 escapees recorded at the fishway. The number of escapees entering the river has ranged from 30 fish in 2000 to 1200 fish in 1994 (Figure 2). A Passamaquoddy Bay sea-cage failure in 1994 resulted in the escape of an estimated 20,000 fish. This probably accounts for the increased numbers of cultured salmon entering the Magaguadavic River in 1994 and 1995. Cultured escapees entered the river later than wild fish in all years and their numbers generally peaked in either September or October (Figure 3).

Spawning Escapement

Conservation egg requirements for the river were never met in the 1992 - 2002 period, and the 10-year average egg depositions were only 23.5% of target level (Table 1).

In 2002, seven wild 1SW (four females) salmon were released to the river and potentially deposited an estimated 13,688 eggs (Table 1). In addition, 103 captive-reared adult salmon (F1 generation progeny of 1998 wild adult returns) were released into the river. Based on secondary sexual characteristics, 56 (20 females) of those fish were sexually mature. Total potential egg deposition was 122,500 eggs representing only 9.1% of the river's conservation requirement (Table 1).

No cultured escaped salmon have been intentionally released into the river since 1996. In the 1992-1996 periods, cultured escapees contributed an average of 14.8% of the total eggs (Table 1). One escapee 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 (Table 1).

Disease Screening

In 2002, 34 escaped cultured salmon were screened for viral and bacterial pathogens. None tested positive. Due to the small number of wild fish returning to this river, no wild fish were stressed by disease sampling.

Summarizing disease testing results over the last 11 years, a total of 34 wild and 483 escaped cultured salmon were screened for pathogens from 1992 to 2002 (Table 2). Some non-pathogenic bacteria cases were detected in wild and escapee salmon between 1992 and 1999. The infectious Salmon Anemia (ISA) virus was detected in both wild and escapee fish in 1999. Since 1999, all fish screened for disease have tested negative.

Four wild fish tested positive for bacterial pathogens from 1992 to 1994 (Table 2). *Aeromonas* was detected in four wild fish. Two *Pseudomonas* cases and one *Vibrio* case were also reported for wild salmon. *Aeromonas*, *Pseudomonas*, and *Vibrio* are considered non-pathogenic. They are not the primary cause of mortalities but are signs of stress. In 1999, three of fifteen wild fish collected for broodstock purposes died from Infectious Salmon Anemia (ISA) virus. Globally, these were the first documented cases of ISA in wild Atlantic salmon. Further tests (PCR analysis of blood and mucus samples, necropsies) confirmed that eleven of the twelve remaining wild broodstock tested positive for ISA (Table 2). The wild broodstock were held in three tanks (independent water supply in each) at the Atlantic Salmon Federation's Broodstock Building, which uses cool (8°C), brackish, well water. The use of well water makes it highly unlikely that this water supply was the source of infection. Thus, at least one fish in each tank was infected prior to transfer from the Magaguadavic River.

Pathology examinations for cultured salmon tested from 1992-1999 detected 46 bacterial non-pathogenic cases (Table 2). The bacteria included *Aeromonas*, *Pseudomonas*, *Vibrio, Edwardsella tarda, bacterial kidney disease* (BKD), and *infectious pancreatic necrosis* (IPN) (Table 2). In addition, five of 34 cultured salmon examined in 1997 were suspect for

HKS (Hemorrhagic Kidney Syndrome, now termed Infectious Salmon Anemia or ISA) based on visual inspection of pathologies in post mortem exams. Four of the suspect HKS cases showed symptoms of Aeromonas. Unfortunately, no viral cultures were done on these fish. In 1999, four of 58 aquaculture escapees tested positive for the Infectious Salmon Anemia (ISA) virus (Table 2).

Juvenile Salmon Estimates

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 88% over the 1999 to 2002 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 (0+ parr) from hatcheries.

Most smolts were captured below the dam in St. George (Figure 5). In addition to smolt, landlocked salmon were captured below the dam in each of the four years (ranging from 30 to 67 fish, see Figure 5).

Beginning in 2000, a population estimate was derived by incorporating mark-recapture data into a Bayesian estimation procedure (Gazey and Staley 1986) to describe the most probable estimate (mode) of smolt migrating from the river. The Bayesian estimator suggested the most probable number of wild smolt migrating from the Magaguadavic River was 1300 (CI: 730 – 3,060, marks=26, recaptures=5, catch=253) in 2000, 290 (CI: 265 – 1,680, marks=10, recaptures=1, catch=29) in 2001, and 460 (CI: 280 – 2,970, marks=13, recaptures=2, catch=71) in 2002. These estimates should be treated with caution due to the low recapture rate and high confidence intervals. Capture efficiency of the trap below the dam from 2000 to 2002 ranged from 10% to 19%.

Parr Relative Abundance

Juvenile densities have been monitored since 1994 at as many as eight mainstem and 15 tributary sites in the Magaguadavic watershed. Parr have been rare, with the largest catches being found in the vicinity of the hatcheries (Figure 6). With the exception of 0+ parr in 2002, the average numbers of 0+ and $\geq$1+ parr at sites away from hatcheries have trended downwards since 1997 (Figure 6)**.** In June 2002, 29,000 unfed fry (from the Mactaquac Biodiversity Center, see restoration program below) were released into a tributary of the Magaguadavic watershed, and this accounted for the increased numbers of 0+ wild parr.

Wild Magaguadavic Salmon Restoration Program

In 1998, seven wild broodstock were spawned and eggs were incubated at Connors Brothers (now Heritage Salmon) Lake Utopia hatchery. In June 2000, smolt were moved from the hatchery to a Cooke's Aquaculture sea cage grow out site near Great Duck Island, Grand Manan, and to a freshwater grow out site at the Department of Fisheries and Oceans (DFO)

Mactaquac Biodiversity Center, French Village, New Brunswick. The Magaguadavic salmon at the sea cage site were moved in January 2002 to Huntsman Marine Science Center (HMSC), St. Andrews, NB. The move was necessary because the cage site had to be fallowed before spring in accordance with Bay Management Strategies for farmed salmon and because of the presence of the ISA virus in the region.

In May 2002, all fish at HMSC and at Mactaquac were tissue sampled (for DNA pedigree analysis) and pit-tagged (for identification). The DNA pedigree analysis was conducted at the DFO Bedford Institute of Oceanography, Dartmouth, NS. The pedigree analysis was completed to ensure that the genetic integrity of the existing Magaguadavic salmon stock would be maintained through a proper mating plan and in river release strategy. The pedigree analysis confirmed that family (sibling) representation was similar between Mactaquac and HMSC. Thus, the Magaguadavic River Salmon Breeding Committee recommended to use Magaguadavic origin broodstock at Mactaquac for the continuation of the captive breeding program and to release the fish at HMSC into the Magaguadavic River to spawn naturally.

Spawning and Release Summary

In November 2001, 74 of 167 Magaguadavic fish at Mactaquac were spawned and eggs reared to the unfed fry stage. The unfed fry (29,000) were stocked into a tributary (Piskahegan River) of the Magaguadavic River in spring 2002.

A mating plan was prepared for the Magaguadavic Live Gene Bank broodstock remaining at Mactaquac, however, only 50 of 114 were spawned in November 2002. It is probable that Magaguadavic strain salmon are alternate year spawners. The non-mature fish (64) are expected to mature for a second time in 2003 (those fish were first spawned in 2001).

A total of 67 fish from HMSC were grouped and released into established sites (selected by a breeding committee to avoid potential inbreeding) throughout the Magaguadavic River watershed in October 2002 (Table 3). An additional six salmon (from HMSC), which had been taken to the St. George fishway as part of an inbreeding experiment, were released into the lower Magaguadavic headpond in November (Table 3). Thirty acoustically tagged adults (15 each from HMSC and from the Mactaquac Biodiversity Center) were also released (see tracking summary below).

Magaguadavic Broodstock Tracking Summary 2002

A total of 30 captive-reared Magaguadavic broodstock (15 each from Mactaquac and HMSC) were released into the Magaguadavic River from August to October 2002. The objective of the tracking experiment was to evaluate the effectiveness of rearing F1 progeny (from wild Magaguadavic Atlantic salmon broodstock) to the adult stage in captivity, and then releasing them into the Magaguadavic River for natural spawning.

VR2 receivers were strategically positioned throughout the Magaguadavic River drainage and downloaded on a weekly basis (see Figure 7). Receivers were last downloaded (some removed for the winter and some left in river) from 29 November to 6 December. Some

receivers were also left in saltwater for the winter months (tag battery life is viable for a minimum of one year). Tagged fish locations at the end of fall tracking were as follows:

Location	No. Fish
Saltwater	3
Main River (headpond)	5
Main River (above headpond)	5
Lake Utopia	13
Linton Stream	2
Dead	1
Missing	1

Unusually high precipitation resulted in extreme water levels from late October until ice-up. This prevented onsite spawning surveys and redd counts. VR2 receivers will be over wintered at strategic locations to detect any fish movements during the winter months.

No early released fish (in lower river during August and September)) moved upstream of the Magaguadavic headpond. Most fish moved into Lake Utopia near the commercial salmon hatchery where they were reared from eggs to smolt. Preliminary movement analysis suggests that only a few fish moved to spawning locations (i.e. Linton Stream and possibly in small tributaries draining into the lake). At the completion of fall tracking, two fish had left the river and moved into saltwater. Most fish remained in the lake.

The ten-tagged fish released near spawning grounds (late October) showed peak movements among spawning grounds within the first two weeks of November. Four (40%) of the fish remained near the initial site of release. Most fish (late releases) were moving downstream at the completion of the 2002 tracking period and one had moved to sea.

Sexual maturity status for all of the 30 acoustically tagged fish was uncertain. Seven of the final 10 released fish were confirmed to be sexually mature. It was initially assumed that all Live Gene Bank fish would mature in 2002. However, near the onset of spawning it was discovered that less than 50% of the fish were sexually mature (it was thought that most matured a year earlier). It is most probable that the Magaguadavic salmon stock is alternate year spawners. Therefore, many fish may not sexually mature again until 2003. Tag battery life is viable for at least one year.

Tracking will be monitored during the winter months (using VR2 receivers positioned under ice) and throughout 2003 (using VR2s and VR60s). Extensive electrofishing surveys will be conducted to determine spawning success from 2002.

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Table 1. Escapement of wild and escaped cultured Atlantic salmon in the Magaguadavic River during 1992 - 2002. 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.

	Wild			Cultured or stocked						Combined					
Yr	Total spawners	Percent females	Total eggs	Total	Total mature	Percent mature	Percent females	Postsmolt mature	Total eggs	Total escapement	Total spawners	Percent females	Percent cultured spawners	Total eggs	Percent of conserv. Level
92	286	61.5	1014007	148	19	12.8	63.2	1	70712	434	305	61.6	6.2	1084719	80.3
93	254	66.0	912214	152	21	13.8	66.7	3	68021	386	255	66.3	8.2	980234	72.6
94	130	56.2	425979	695	31	4.5	35.5	0	54125	825	161	52.2	19.3	480104	35.6
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	55	36	NA	108867	110	63	38	89	122556	9.1
10 year mean	83.3	51.30	266573											318389	23.6
5 year mean	11.4	47	27716											50238	3.7

** 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 2. Summary of bacteriology and virology disease screening of wild and escaped cultured salmon collected in the Magaguadavic River fish ladder, 1992 - 2002.

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	0	0										
	Cultured	132	132								132	132	
2002	Wild	0	0										
	Cultured	34	34								34	34	
1992-	Wild	34	13	4	2	1					27	13	14
2002	Cultured	483	433	28	11	3	2	1	1	5	390	386	4

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

Table 3. The locations, release dates, sexes, and maturity status of the 73 fish (from HMSC) released into the Magaguadavic River watershed in 2002.

Magaguadavic River Release sites	Female Mature	Male Mature	Total Immature	Total Mature	Total Released	Release Date
Millpond	1	4	5	5	10	23-Oct
Thomaston Corner	2	1	8	3	11	22-Oct
Turnover Island	2	7	1	9	10	23-Oct
Graveyard Pool	1	3	4	4	8	23-Oct
Longlookem	3	1	2	4	6	23-Oct
Flume Falls	1	4	0	5	5	23-Oct
MacDougall Inlet	3	5	2	8	10	24-Oct
Upper Trout	4	3	0	7	7	24-Oct
Mag Hpond	0	1	1	1	2	7-Nov
Egg basket study (Mag fishway)	3	6	0	9*	4	8-Dec
				Total released:	**73**	

** 5 fish died*

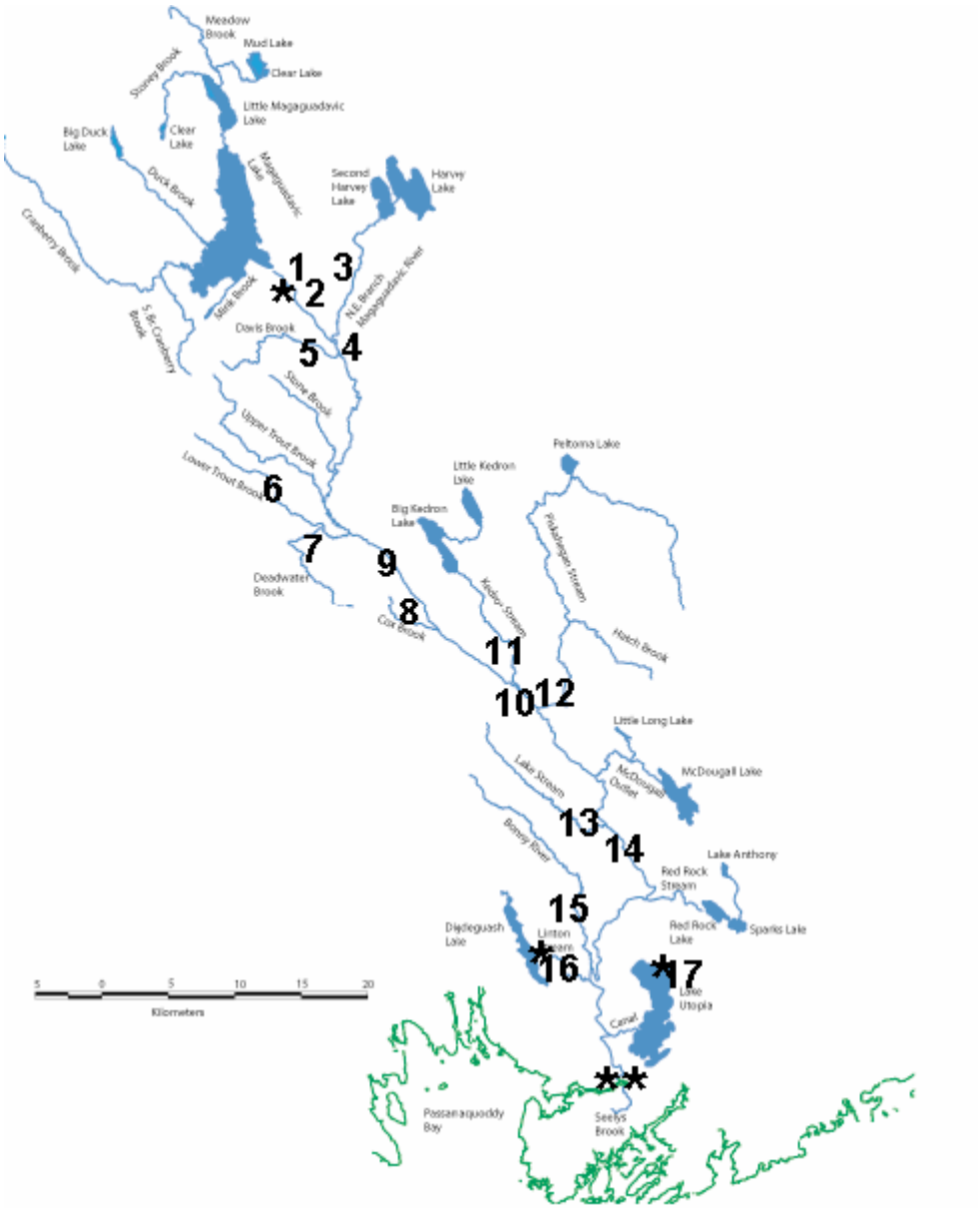
Figure 1. Map of Magaguadavic River showing the locations of various sites and facilities.

1. Magaguadavic River (Cook Hatchery, 2 sites)
2. Magaguadavic River (HWY 3 bridge, 2 sites)
3. North East Branch Magaguadavic River
4. Mouth of Davis Brook
5. Davis Brook (2 sites)
6. Lower Trout Brook
7. Deadwater Stream
8. Cox Stream
9. Magaguadavic River (Flume Bridge)
10. Magaguadavic River (Pomeroy Bridge)
11. Kedron Stream (2 sites)
12. Piskahegan Stream
13. Lake Stream
14. Magaguadavic River (Turnover Island)
15. Bonny River
16. Linton Stream (4 sites)
17. Mill Stream

* Commercial salmon hatcheries

** Magaguadavic fish ladder

Figure 1.


Meadow Brook
Mud Lake
Clear Lake
Stoney Brook
Little Magaguadavic Lake
Big Duck Lake
Clear Lake
Ducks Brook
Magaguadavic Lake
Second Harvey Lake
Harvey Lake
Cranberry Brook
S. Br. Cranberry Brook
Mink Brook
Davis Brook
N.E. Branch Magaguadavic River
Stone Brook
Upper Trout Brook
Lower Trout Brook
Peltoma Lake
Little Kedron Lake
Big Kedron Lake
Kedron Stream
Pinkerington Stream
Deadwater Brook
Cold Brook
Hatch Brook
Little Long Lake
McDougall Outlet
McDougall Lake
Lake Stream
Bonny River
Lake Anthony
Red Rock Stream
Digdeguash Lake
Linton Stream
Red Rock Lake
Sparks Lake
Lake Utopia
Canal
Passamaquoddy Bay
Seelys Brook
1
2
3
4
5
6
7
8
9
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11
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16
17
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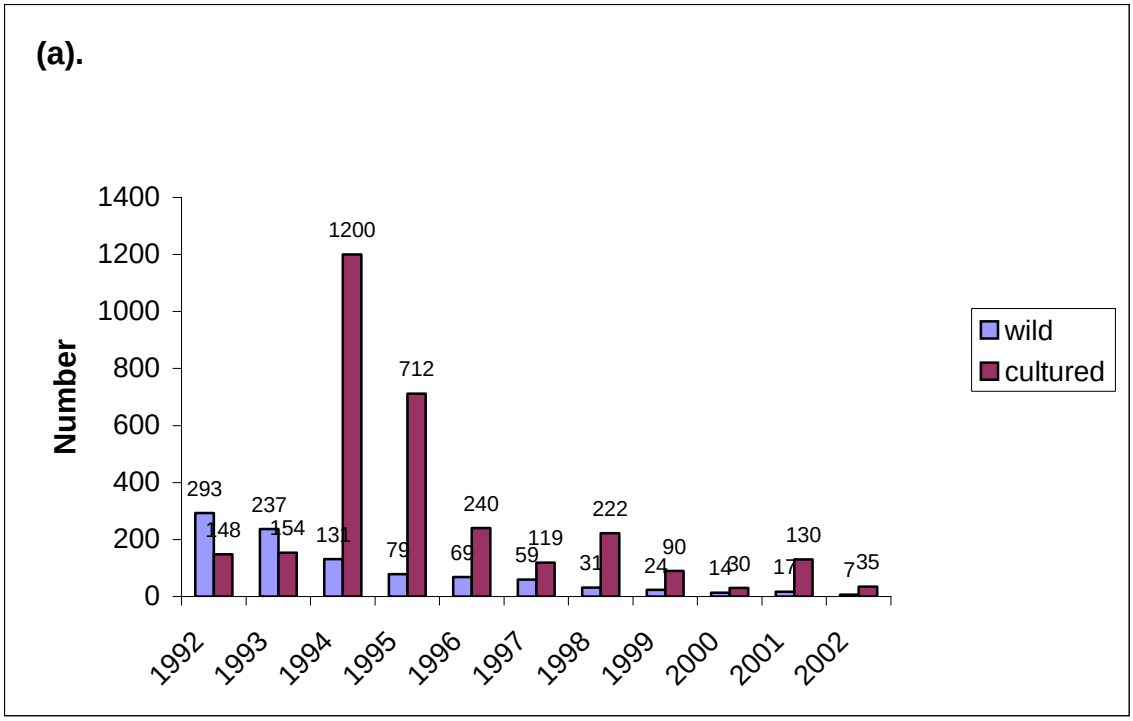
5 0 5 10 15 20
Kilometers

Figure 2. Wild and cultured Atlantic salmon recorded in the fish ladder near the mouth of the Magaguadavic River from 1992 to 2002: (a) total numbers and (b) percentages.



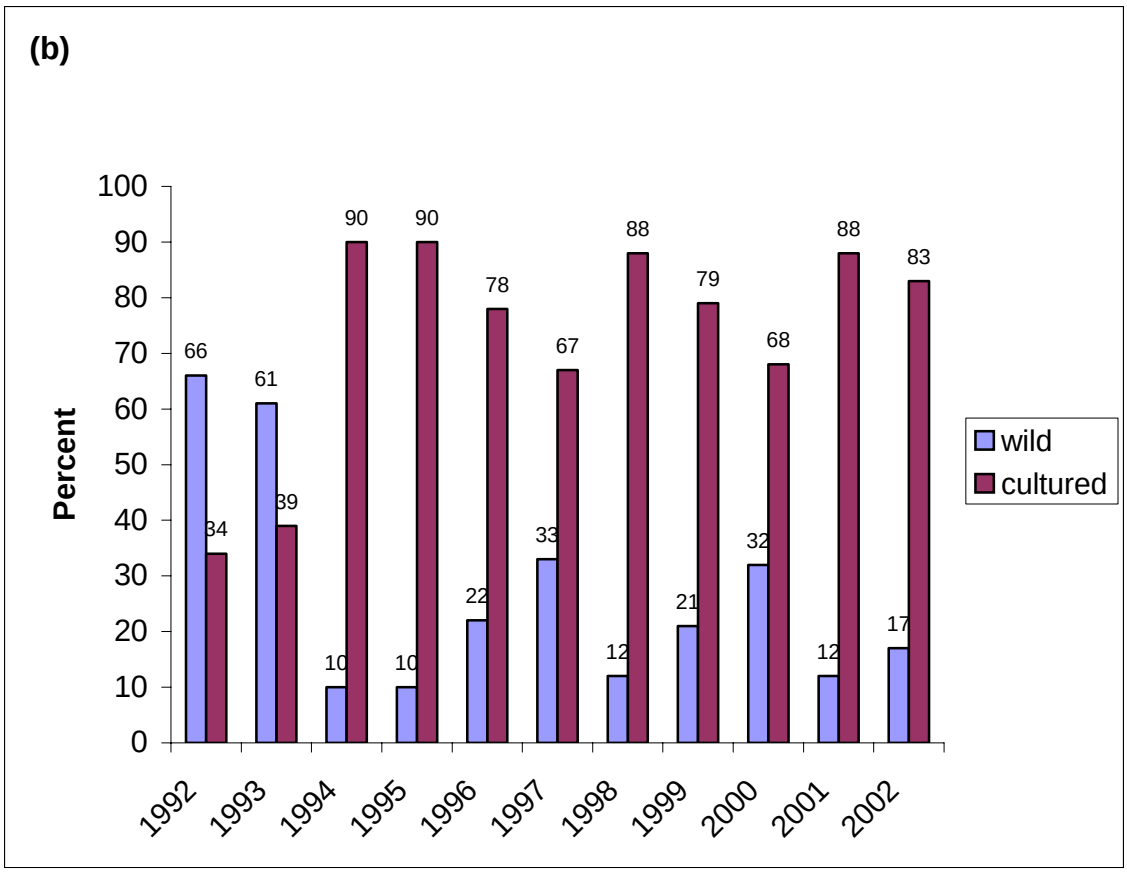


Figure 3. Monthly total numbers of wild and cultured Atlantic salmon recorded at the fish ladder trap at the head of tide in the Magaguadavic River, 1997 – 2002.

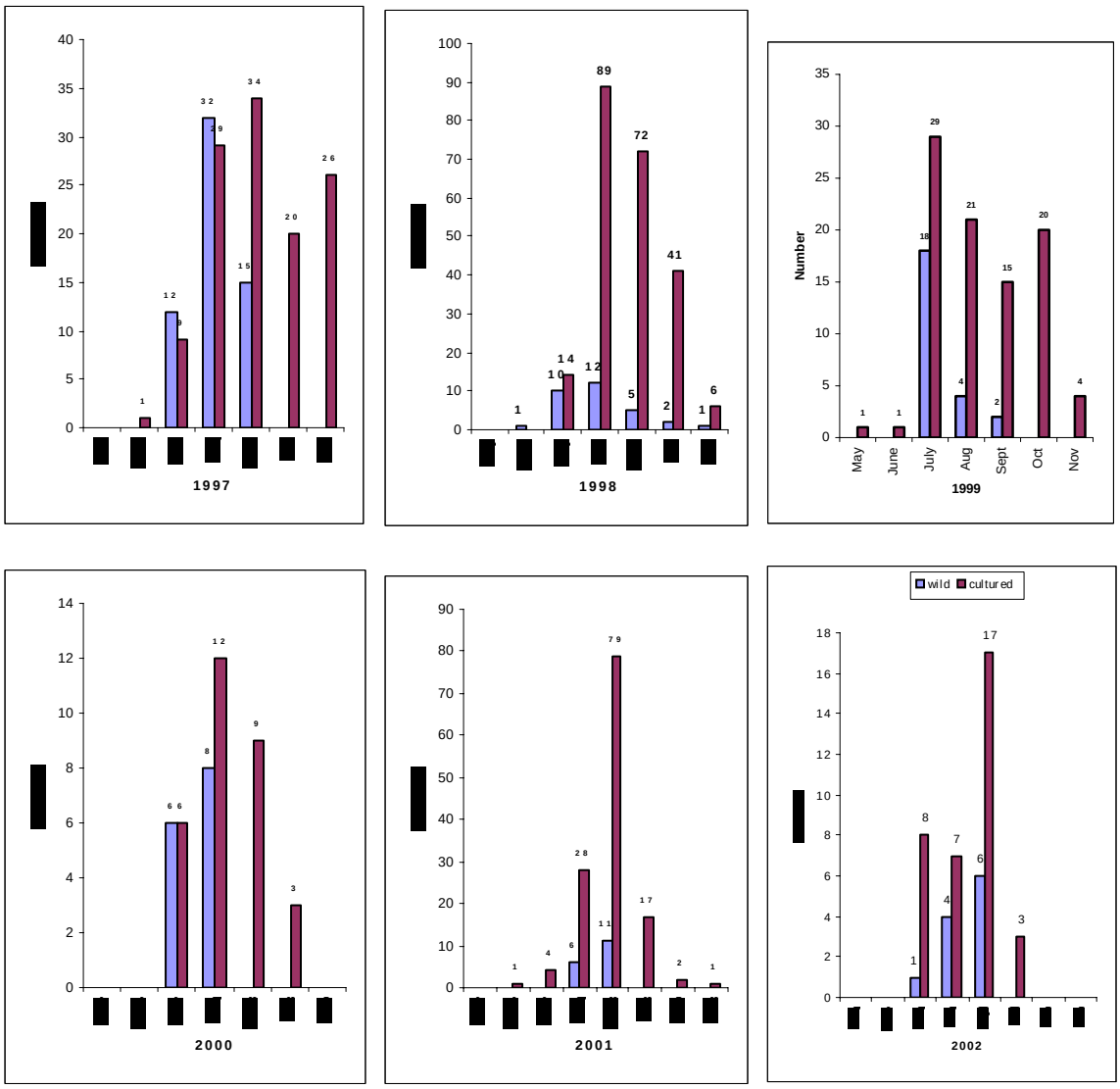


Figure 4. The percent of wild, hatchery, and unknown origin Atlantic salmon smolt captured leaving the Magaguadavic River watershed from 1999 – 2002.

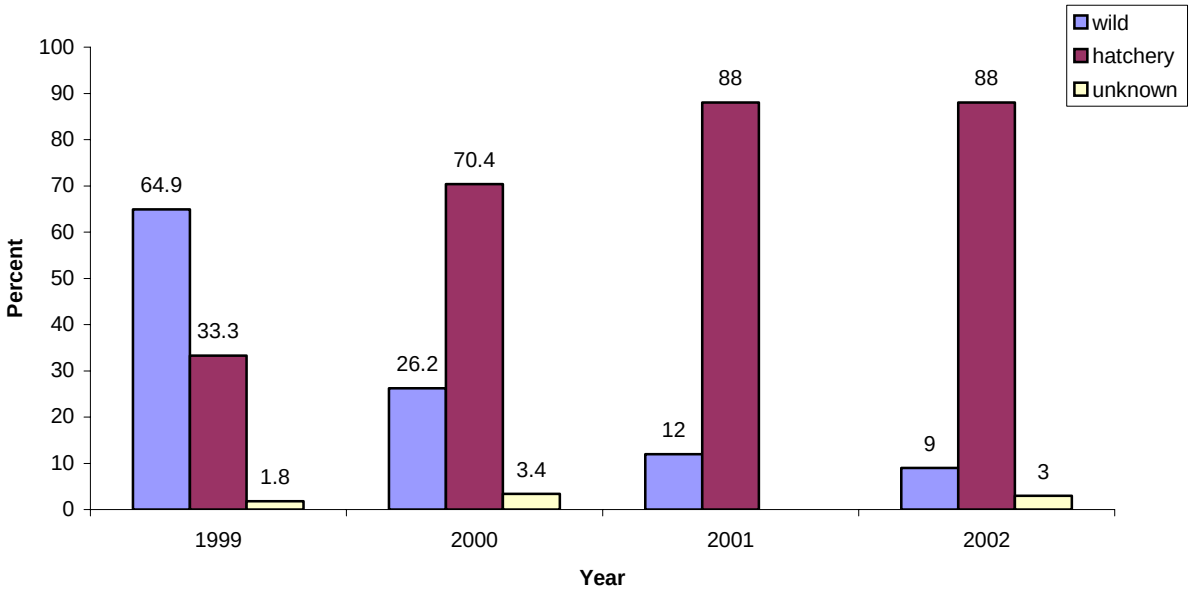


Figure 5. The numbers of wild, hatchery and unknown origin Atlantic salmon smolt captured in the spring at sites in the Magaguadavic River watershed from 1999 – 2002. Numbers of captured landlocked salmon in the smolt output are also included.

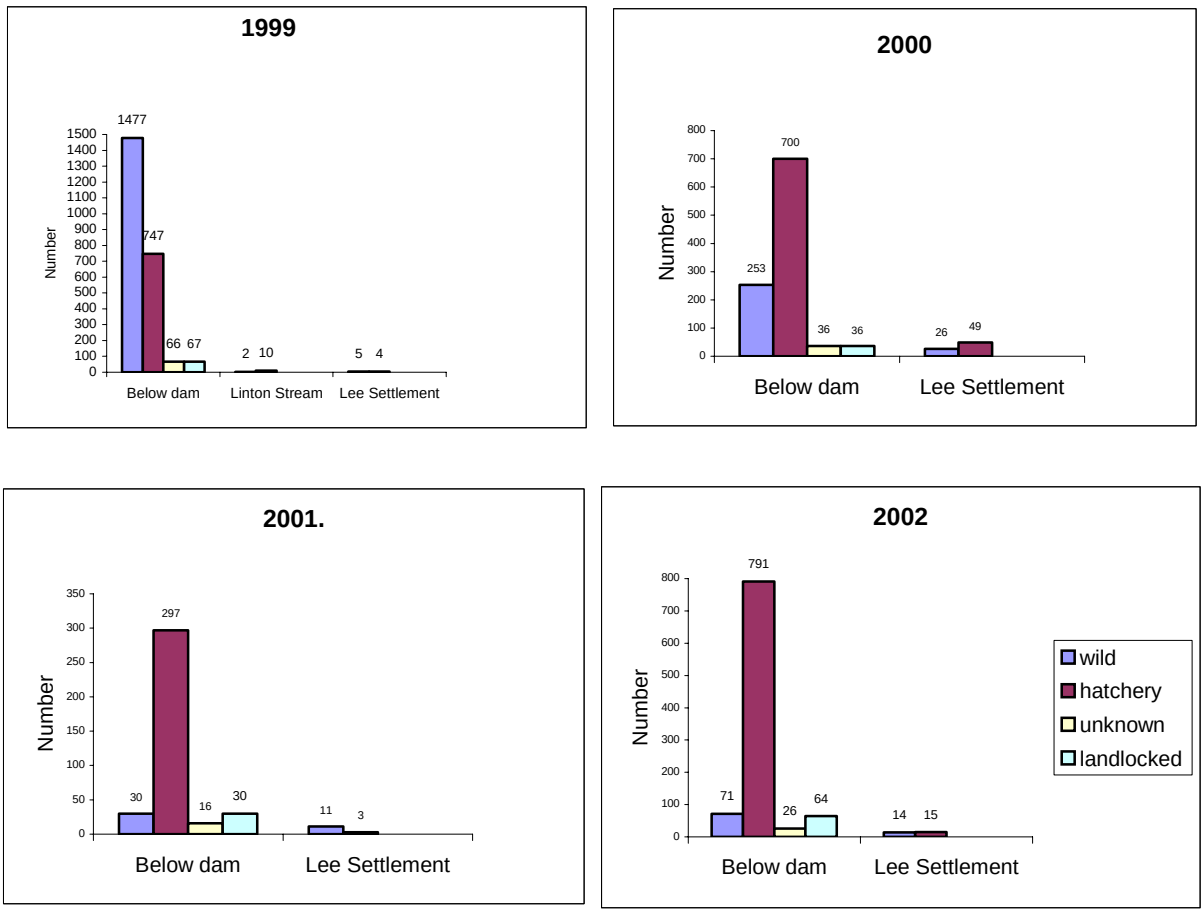


Figure 6. The average number of 0+ parr and ≥ 1+ parr captured per 100 seconds of electroshocking time near and away from hatcheries in the Magaguadavic watershed from 1994 to 2002. The number of electrofishing sites per year is as follows: 1994: 17 away; 1995:10 away; 1996: 23 away and 7 near; 1997: 8 away and 4 near; 1998: 7 away and 4 near; 1999: 4 away and 4 near; 2000: 4 away and 4 near; 2001: 5 away and 4 near; 2002: 11 away and 3 near.

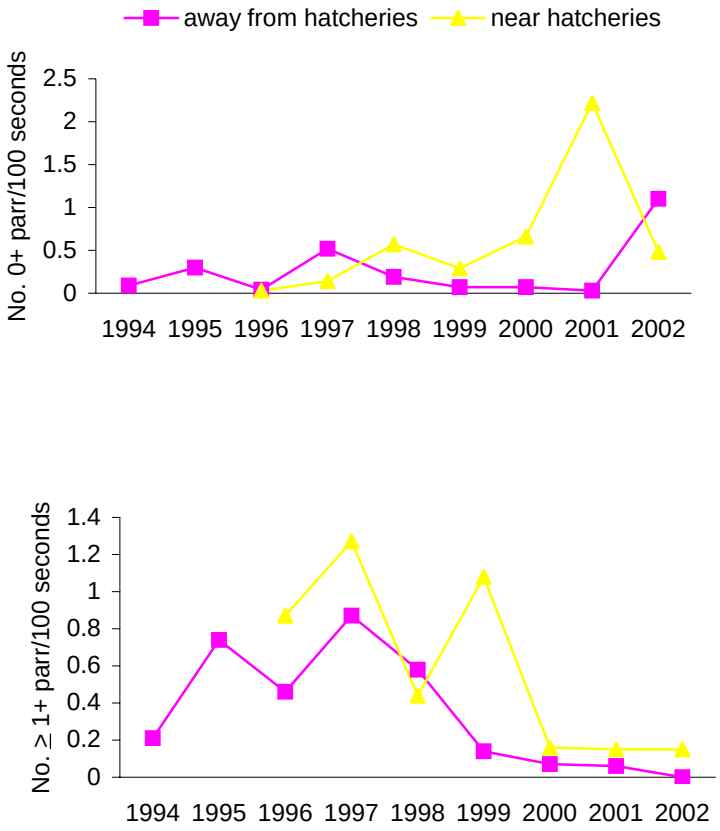


Figure 7. Map of the Magaguadavic River watershed showing the locations of the VR2 tracking receivers