

# MIRAMICHI SALMON ASSOCIATION

## CONSERVATION FIELD PROGRAM REPORT 2015



*In Cooperation with:*

Atlantic Salmon Federation

Barbour's

Department of Fisheries and Oceans

J.D. Irving Ltd.

Miramichi Headwaters Salmon Federation

Miramichi Watershed Management Committee

Northumberland Salmon Protection Association

Rocky Brook Camp – International Paper

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Last but not least, the MSA would like to thank the work and dedication of our directors, members, and volunteers for their support in ensuring the MSA continues to provide world class stewardship and conservation for Atlantic salmon on the Miramichi.

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## *Overview*

This report is a review of the 2015 Miramichi Salmon Association (MSA) field and research programs implemented in the Miramichi River watershed. The MSA was started in 1953 as a non-profit conservation group dedicated to protecting the Miramichi River. The MSA has acted as a conservation advocate on behalf of anglers, outfitters, guides, and all others with economic, environmental, and recreational interests in the river. Managed by volunteers from Canada, the USA, and abroad, as officers and directors, the MSA remains cooperative with, but independent of, government or special interests influence. It responds in the end only to its growing conservation membership. The MSA employs 6 full-time staff, two seasonal field technicians, and several summer students.

The MSA has evolved since 1953 from primarily a conservation advocate group to a non-profit conservation group whose work focuses on research and field programs. Through partnerships with government organizations and other non-profit groups, the MSA has been crucial in increasing the amount that is known about Atlantic salmon on this river and assessing the current status of many life stages on this fish on the Miramichi, and providing funding to other important programs that would otherwise not be able to take place.

In addition, the MSA also oversees the Miramichi Salmon Conservation Centre (MSCC) located in South Esk, NB, which is used to produce Atlantic salmon and brook trout fry for enhancement activities.

## *Kelt Tracking*

### **INTRODUCTION**

Adult Atlantic salmon (*Salmo salar*) that migrate to river systems to spawn and remain in freshwater over winter are called kelt. As river discharge rates and water temperatures begin to increase in early spring, kelt that have survived the winter migrate downstream to feed and recondition in the Miramichi Estuary and Bay before moving into the Gulf of St. Lawrence (GOSL). Studies of repeat spawner egg deposition have estimated that these fish account for 25-40% of the total eggs deposited annually in the Miramichi River. Repeat spawners to the

The marine ecology of adult Atlantic salmon has been identified as a knowledge gap in scientific literature. Based on past acoustic studies of Miramichi kelt, survival through the river and bay has averaged 90%, suggesting the vast majority of kelt mortality is occurring in the marine environment. Information on marine mortality, feeding behaviour, and migratory routes of Miramichi salmon is limited and could be of considerable value in the creation of conservation strategies to ensure the continued health of our native salmon population. Understanding areas of high mortality may shed light on predation sources, the impact of marine commercial fishing on salmon bycatch, and the effects of trophic shifts and climate change on salmon populations.

The use of satellite tags is a novel approach to track the movement, water temperature, and depth of Atlantic salmon in North America. Numerous studies have tracked adult and smolt movements through the use of internally implanted acoustic tags. These studies have proven effective in monitoring the movements and survival of individuals transitioning from the river to inner bay habitat, but are restricted in their ability to detect movements in large marine bodies. The placement of acoustic receiver arrays in rivers and narrow portions of estuaries and bays allows for a high probability of detecting tagged individuals as they move past these points. The cost and logistics of deploying receivers in vast areas of open water to have high confidence in tag detection is unrealistic in most studies. Satellite tags allow for detection of daily movements without being in close proximity to a receiver unit, while also recording detailed information regarding water temperature and depth. Data collected from these devices is transmitted once the tag is deployed, which occurs after a pre-set date or following four days of no detected

pressure change (assumed mortality). Geo-positioning is determined by recording daily light intensity and duration, which is correlated to sunrise/sunset timing to produce one daily location. Delayed tag transmission, combined with a single averaged daily location, prevents the fine scale study of fresh and brackish water movements. As such, the use of both satellite and acoustic technologies allows for both fine and coarse scale study of individual fish.

The purpose of this multi-year study is to advance the current understanding of the behaviour and survival of repeat spawning salmon from the Miramichi River as they emigrate from freshwater to recondition for future spawning events. In order to study both short term and long term trends, kelt were implanted with large acoustic tags with battery lives over two years, or small acoustic tags coupled with external satellite tags for study of less than six months. The information gained from temperature, depth, and movements in the marine environment will be examined to provide insight into the behaviour of salmon foraging and migrating through marine waters.

## **METHODS**

### **Study Area**

The Northwest Miramichi watershed drainage area of 3,950 km<sup>2</sup> makes up approximately one third of the total watershed of the Miramichi River. The Northwest Miramichi basin includes two major river systems: the Little Southwest Miramichi River (1,324 km<sup>2</sup>) and the Northwest Miramichi River (2,078 km<sup>2</sup>) which merge in a delta at the head of tide near Red Bank. From head of tide, the Northwest Miramichi connects approximately 23km downstream to the Southwest Miramichi before flowing into Miramichi Bay.

### **Tagging**

Kelt were captured by angling near Red Bank, NB from May 3<sup>rd</sup> – 14<sup>th</sup>, 2015. Following capture, kelt were held temporarily in a submerged live box. Fish were then placed in a clove oil bath (anaesthetic) for several minutes until equilibrium was lost and movement was minimal. For fish receiving acoustic tags only, Vemco V16 transmitters were inserted into the body cavity by making a small incision on the ventral surface of the fish, off center, between the pectoral and pelvic fins. Once the tag was inserted, the incision was stitched using 2 or 3 sutures and the



kelt placed back in the live box to recover. Time out of the water for this procedure was 2 to 3 minutes, with water passed regularly through the gills and over the body during the surgery.

Microwave Telemetry Inc. X-Tag pop-off satellite transmitters were selectively outfitted onto the kelt with a fork length over 71cm while the fish was still anaesthetized from the insertion of a Vemco V9 transmitter. Pop-off tags were anchored to the fish by two hard plastic plates on each side of the body located just below the dorsal fin. The plates were held in place by a plastic coated wire that passed through the dorsal musculature. During all surgeries, the fish were kept moist and water was continually passed over their gills. The combined time out of the water for acoustic and satellite tagging was 3 to 4 minutes.

#### Receiver Placement

A total of 21 Vemco VR2w acoustic receivers were placed throughout the freshwater and tidally influenced portions of the Northwest (9), Southwest (7), and main stem Miramichi Rivers (5) to detect in-river movements and survival rates. Additional receivers were placed to form detection gates between openings at barrier islands near the mouth of Miramichi Bay at Neguac Beach, Portage Island, and Huckleberry Gully. In past years only one line of receivers was placed at the Strait of Belle Isle but in 2015 a second line was added, 3.5km north of the first line, to increase the chances of tag detection (Figure 1a&b).

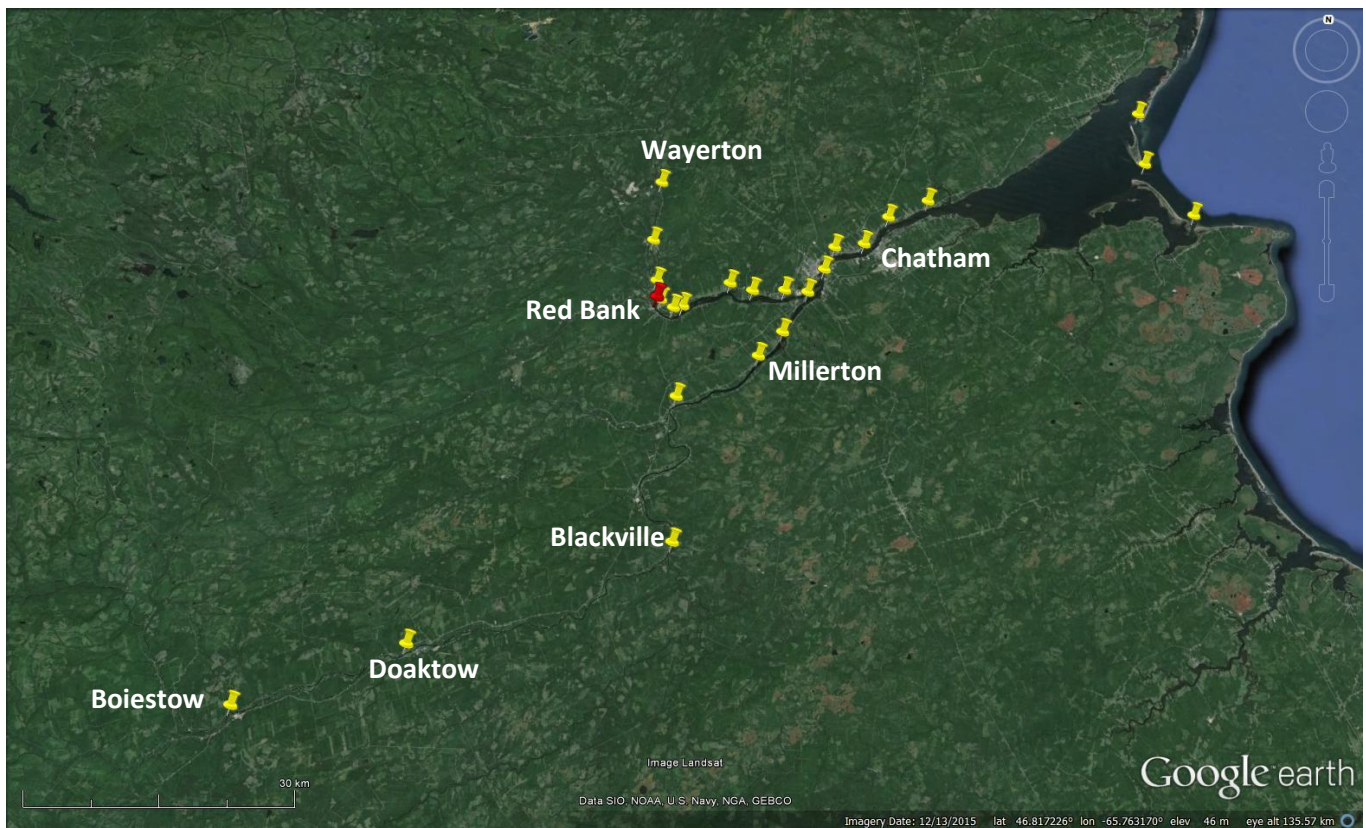


Figure 1a. Locations of acoustic receivers throughout the Miramichi River and Bay in 2015. The red pin indicates tagging location and yellow pins are receivers used for tracking movements to determine survival out of Miramichi River and Bay.

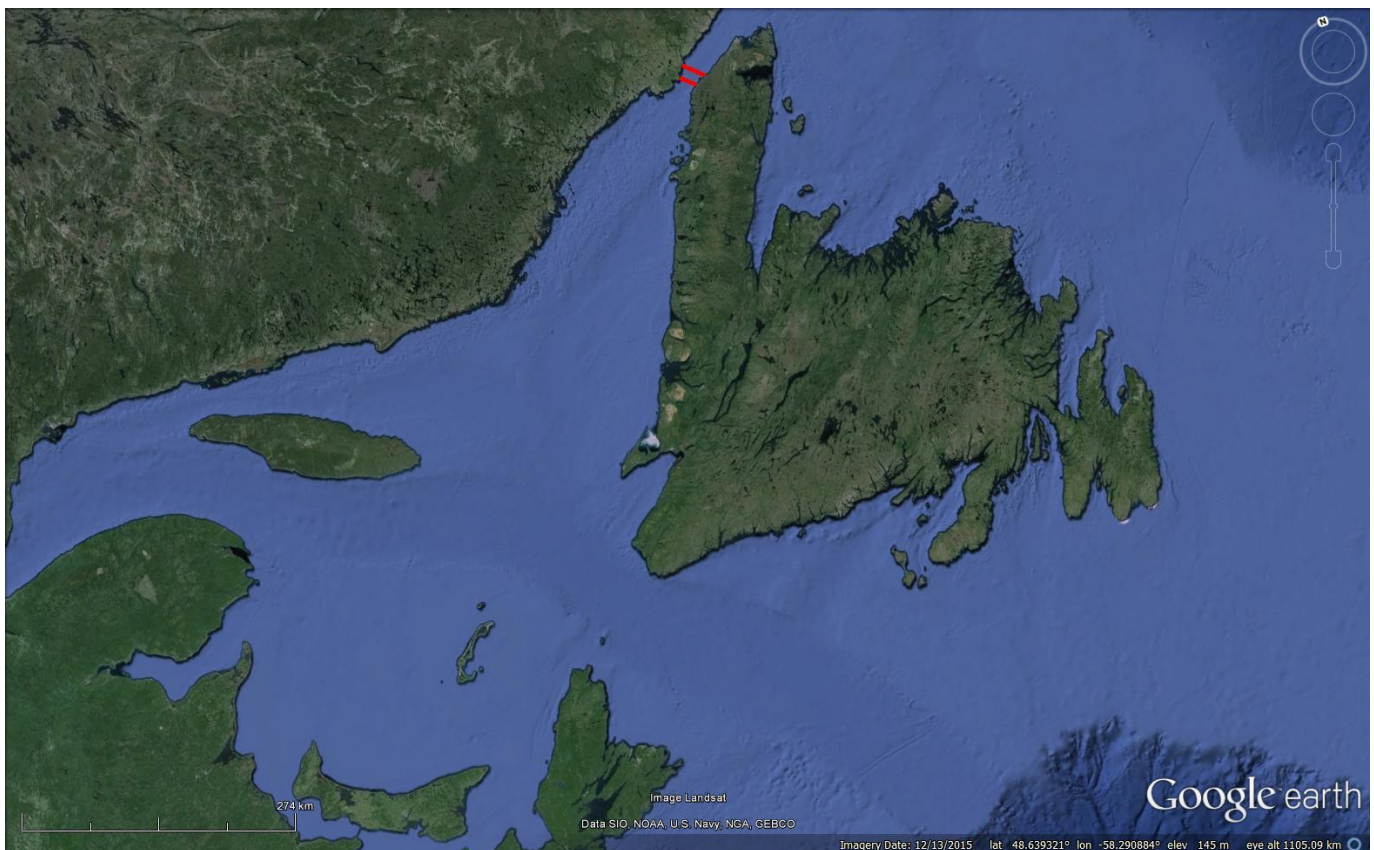


Figure 1b. Location of acoustic receivers (red lines) in the Strait of Belle Isle. The lines are 3.5km apart.

## RESULTS

A total of 24 kelt were tagged in 2015 - 11 with external satellite tags and internal V9 acoustic tags, and 13 with internal, long term V16 acoustic tags. All of the kelts tagged this year were female, ranging in size from 70cm (26.7in) to 97.8cm (38.5in).

### *Movement and Survival through the Northwest River and Miramichi Bay*

Acoustic receiver detections showed that all 24 of the fish (100%) survived out of the Miramichi River and into Miramichi Bay. The 11 satellite tagged fish, spent anywhere from 3 to 26 days in the river before moving into the Bay. Once in the bay, these fish remained there for 1 to 16 days before moving on to the Gulf of St. Lawrence at the end of May/early June. No satellite tagged fish returned as consecutive spawners in 2015.

For the 13 fish tagged with acoustic tags only, their in-river timeframe was spread out over 22 days, and their detection dates at the outer Bay receivers occurred over a 21 day period, with the last one crossing into the Bay on June 9<sup>th</sup>. Four of these fish returned as consecutive spawners in 2015 (tags 24811, 24812, 24814, and 58537) and re-entered the Bay between July 7<sup>th</sup> and 15<sup>th</sup>. Of these four, three of them traveled up the SW branch to the Blackville area at the end of July, after which two of them were picked up at the Cassilis receiver in early October on their way upstream. The third fish was not detected again. The last fish (that did not enter the SW branch) was last detected in Red Bank on July 29<sup>th</sup>.

### *Movement and Survival in the Marine Environment*

In 2015, all 24 tagged kelt successfully made it out of Miramichi Bay. Thirteen of these kelt were tagged with long term V16 acoustic tags, while the remaining eleven were equipped with pop-off satellite transmitters along with short term V9 acoustic tags. Five of the eleven satellite tags failed to transmit, leaving six tags that transmitted temperature, depth, and movement data through the Gulf of St. Lawrence (GOSL), Strait of Belle Isle (SOBI), and Atlantic Ocean.

#### *Satellite Tags:*

Tag 148254 was not detected entering the Gulf. This does happen occasionally, as fish can slip by the receiver lines. The satellite data shows that she headed north to Anticosti Island, staying in water approximately 10m deep and a temperature of 5-10°C. She may have gone around the island before moving south again into the western Gulf. She dove a couple of times in mid-June up to 40m before the tag popped prematurely on June 17<sup>th</sup> and began transmitting. Predation may have been the cause, but further investigation and analysis is required before this can be confirmed.

Tag 148255 entered the Gulf on May 8<sup>th</sup>. There were detections on two of the three channels leading out of the Bay for this fish over the next three weeks. After this, satellite tag data shows that she traveled to the western Gulf, south of Anticosti Island, and occupied depths of 10-20m and temperatures of 5-10°C. Near the end of June she starting moving toward the SOBI, and crossed on July 8<sup>th</sup>. Near this date she dove once to 50m. She stayed close to the continental shelf moving north to the tip of Quebec before retracing her path south for a short while, and making a few dives to 30m. The average water temperature she was in was 5°C after crossing the SOBI. The tag popped on its programmed pop-off date of August 31<sup>st</sup> near Nachvak Fjord. All signs indicate this fish was still alive at that time.

Tag 148256 entered the Gulf on May 14<sup>th</sup>. She headed north towards Anticosti Island and then southeast to the middle of the Gulf. This pattern is slightly different than what we have seen with past fish, as they usually spend more time in the western Gulf. She remained in depths of up to 30m and 5-10°C during this time. She was not detected at the SOBI, which unfortunately happens on occasion. She crossed this area sometime between July 6<sup>th</sup> and 16<sup>th</sup>, which is typical timing for this portion of the migration. She moved north along the coast of Labrador over the next 3 weeks, remaining in depths of up to 30m. At the beginning of August she made a dive to 300m and a spike in temperature to 24°C was observed. The data suggests this fish was predated near Kidlialuit Island.

Tag 148257 entered the Gulf on May 14<sup>th</sup>. She remained in the western Gulf at depths up to 27m and temperatures between 5-10°C. The tagged popped prematurely on June 2<sup>nd</sup> north of Prince Edward Island (PEI). More investigation is necessary to determine if this was a predation event, as the tag was not ingested.

Tag 148258 entered the Gulf on June 3<sup>rd</sup> and headed north into Chaleur Bay and then northeast to the tip of the Gaspé Peninsula. She occupied shallower water at this time, between 2-20m and water temperature of 10-18°C. Around June 10<sup>th</sup> she dove to 48m and remained at that depth for roughly 10 days; the temperature in this area dropped to 1°C. The tagged popped off prematurely on June 21<sup>st</sup> in the Shediac Valley. It appears this fish died, although the reason for mortality is not immediately obvious, as typical signs of predation were not present. More investigation and analysis is required.

Tag 148259 entered the Gulf on June 4<sup>th</sup>. Just over a month later on July 10<sup>th</sup>, she was detected at the SOBI. Unfortunately this satellite tag did not transmit and it is impossible to determine why at this point. If the fish was predated upon, the tag, antennae, or pop-off mechanism could have been damaged. These tags cannot transmit from below the surface. However, all is not lost as these tags are buoyant and may be found eventually. In 2015, two tags washed up on beaches – one in Greenland and one in Ireland, and these tags were returned.

Tag 148260 entered the Gulf on May 19<sup>th</sup>, and was detected at all three Bay exits over 6 days. On July 8<sup>th</sup> it was recorded at the SOBI. Unfortunately this satellite tag did not transmit. The tag may eventually be recovered if it washes ashore.

Tag 148261 was not recorded entering the Gulf because the internal acoustic tag was rejected and detected continuously in the Reb Bank area. She occupied depths of 2-10m and water temperatures of 10-15°C in mid-late May. In early June she dove to 50m and 1°C, where

she remained until the satellite tag popped prematurely on June 22<sup>nd</sup> off the northern tip of PEI. Further investigation is required to determine this fish's story.

Tag 148262 entered the Gulf on May 16<sup>th</sup>. Unfortunately this satellite tag did not transmit, however it was found on a beach on the Magdalene Islands. The tag was returned and shows signs that the release mechanism activated but failed to release properly. The tag has been sent back to the manufacturer for data extraction and the results are still pending.

Tag 148263 entered the Gulf on May 22<sup>nd</sup> and was detected at two of the Bay exits over two weeks. This fish was not recorded at the SOBI and unfortunately the satellite tag did not transmit. The tag may eventually be recovered if it washes ashore.

Tag 148264 entered the Gulf on May 27<sup>th</sup>. She was detected at the SOBI five weeks later on July 6<sup>th</sup>. Unfortunately this satellite tag did not transmit. The tag may eventually be recovered if it washes ashore.

#### *Acoustic Tags:*

All of the acoustic tags were detected at the outer Bay receivers between May 18<sup>th</sup> and June 9<sup>th</sup>. It is assumed these fish were traveling east and entered the GOSL. Tags 24810, 24815, 24816, 24818, and 58537 were detected at the SOBI array between July 3<sup>rd</sup> and 10<sup>th</sup>. Historic acoustic tag information is available in Table 1.

**Table 1.** Total number of kelt with acoustic tags and % survival through various locations from 2008 and 2015. \* indicates this information is not available until next year and only applies to kelts which received long term acoustic transmitters.

	2008	2009	2010	2011	2012	2013	2014	2015
<b>Kelts Tagged</b>	50	50	50	50	35	16	21	24
<b>Head of Tide (%)</b>	100	100	100	100	100	100	95	100
<b>River Mouth (%)</b>	96	92	90	94	94	75	85	100
<b>Miramichi Bay (%)</b>	94	92	90	94	94	69	85	100
<b>Strait of Belle Isle (%)</b>	44	18	14	30	30	38	33	38
<b>Consecutive returns (%)</b>	6	8	18	10	10	0	10	31
<b>Alternate returns (%)</b>	8	0	10	4	0	6	0	*



### *Staging Areas:*

Two potential staging areas have been noted in the past for kelt; one in the western GOSL, south of Anticosti Island (Figure 2a) and one off the coast of Labrador in the North Atlantic (Figure 2b).

Three fish tagged with satellite tags (148254, 148255, 148257) spent time in this area of the Gulf during May and June before migrating further to the Atlantic Ocean. These fish were alternate spawners. One of these three survived out of the SOBI and traveled into the Labrador Sea. Once there, she showed some diving behaviour up to 50m.

A fourth fish (148256) spent time in the more central Gulf before traveling to the SOBI (also an alternate spawner). She exhibited diving behaviour up to 330m in the Labrador Sea. Dives to this depth were not observed in the GOSL area. These movements could be associated with predator avoidance or the fish searching for food sources (reconditioning).

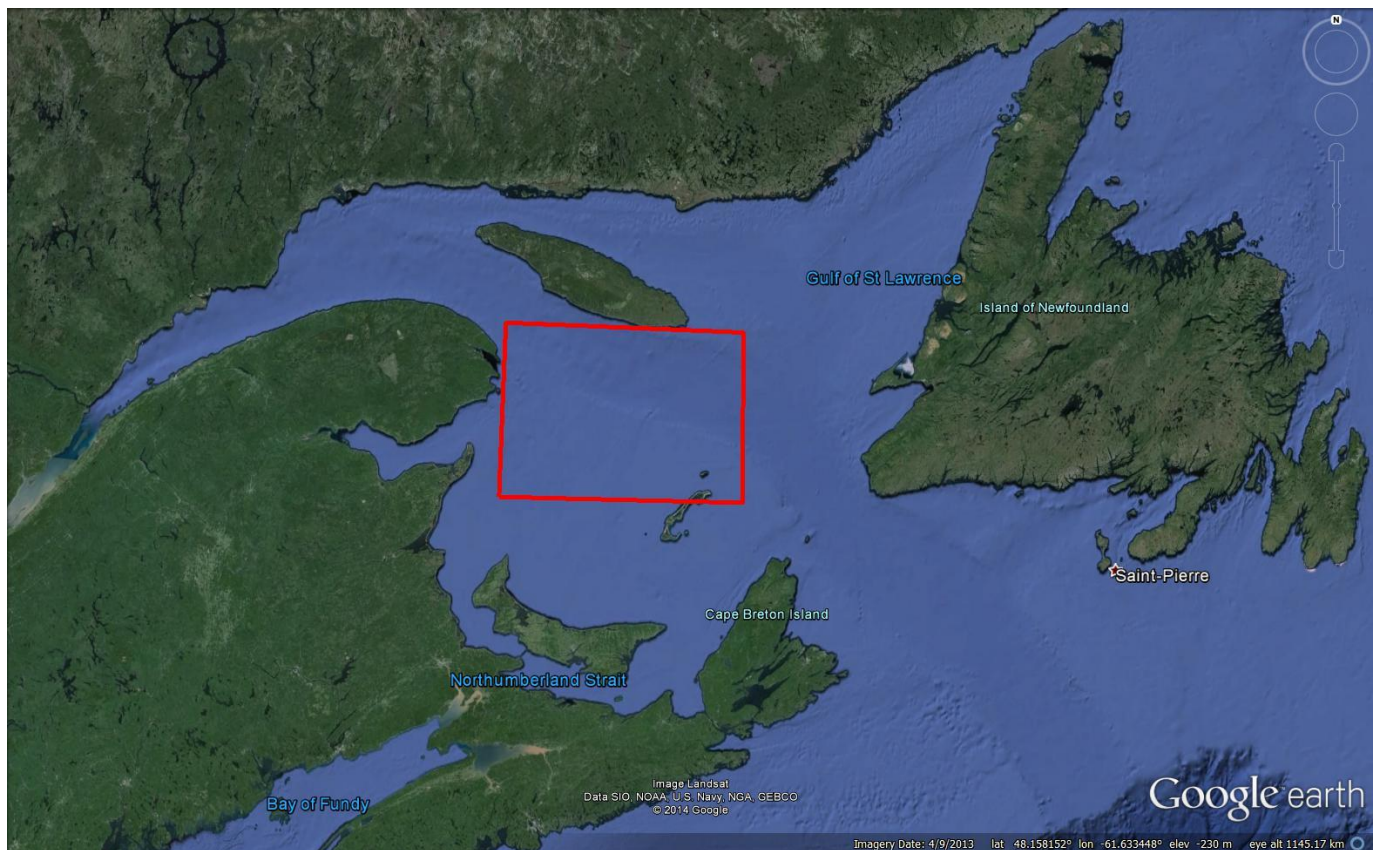


Figure 2a. Potential staging area in the Gulf of St. Lawrence. Four fish occupied this space during the months of May and June in 2015.

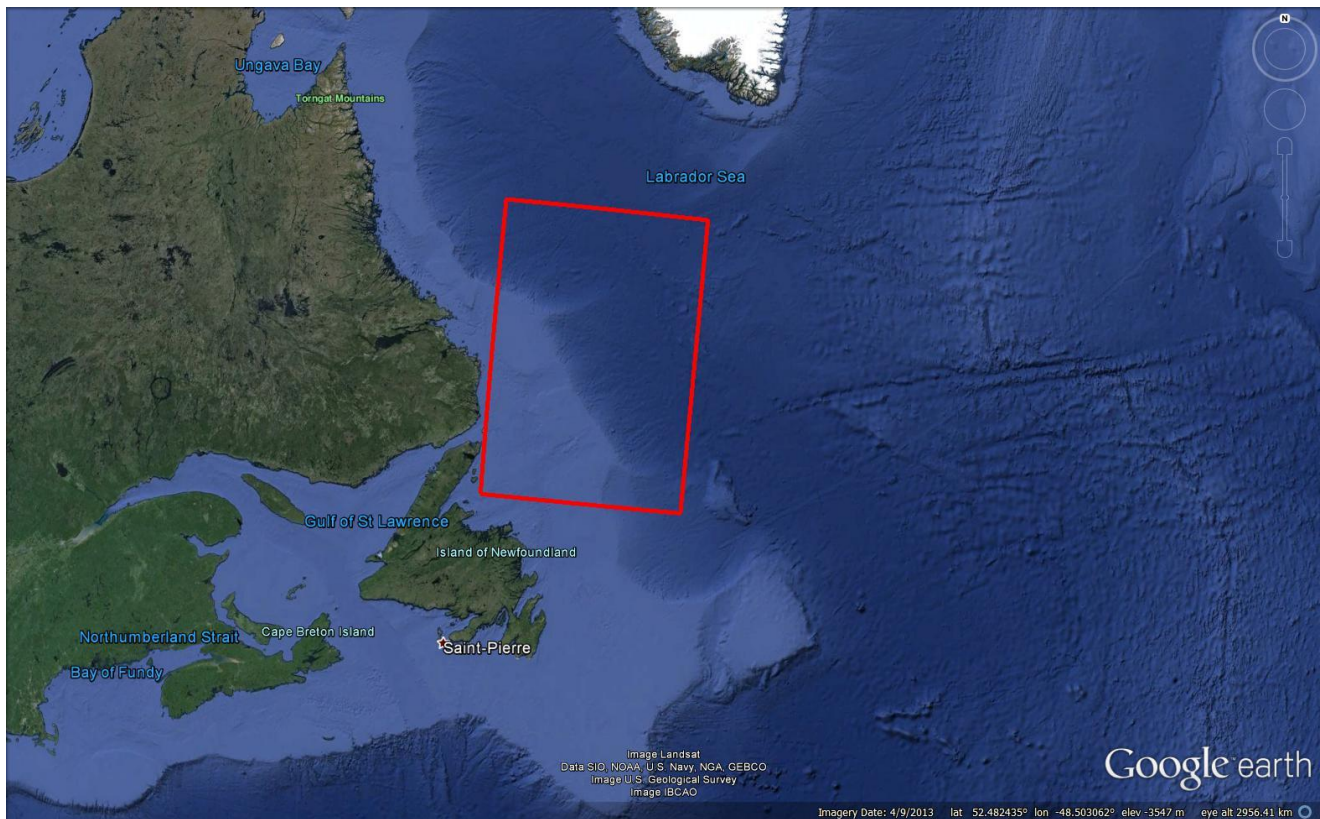


Figure 2b. A second potential staging area in the North Atlantic for alternate spawners. One fish was in this location from mid-July to mid-August 2015.

### Tag Recovery

In 2015, only one satellite tag (148262) was recovered after deployment – it had washed ashore on the Magdalene Islands. This tag will be refurbished and used in 2016. Of the ten remaining satellite tags, four failed to transmit entirely and were not recovered, and six successfully transmitted data from fish that survived out of Miramichi Bay and into the Gulf of St. Lawrence and Atlantic Ocean.

### **DISCUSSION**

In 2015, 55% (6/11) of all satellite tagged kelt successfully transmitted data on fish movements, water temperature, and depth. The five tags that failed to transmit were never detected, however acoustic data showed that all five fish survived out of Miramichi Bay, and three of them to the SOBI (148259, 148260, and 148264).

The failure of satellite tags to transmit could be the result of several factors which include: technical failure, tag damage, or tag obstruction from satellites (i.e.: stuck under



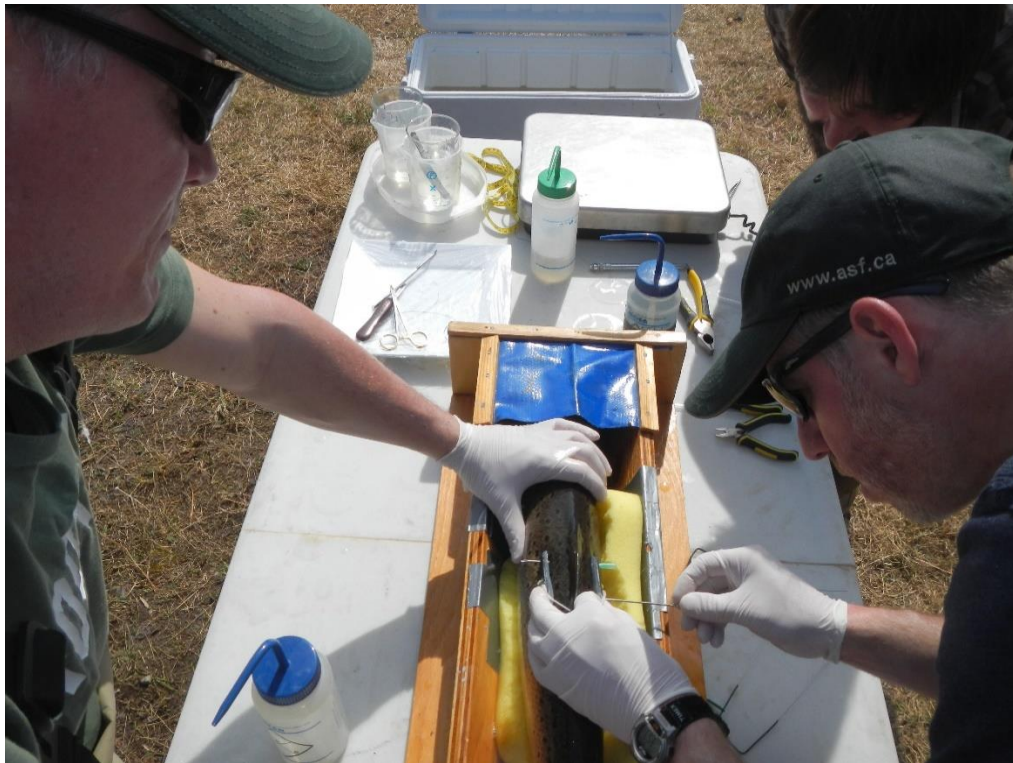
debris, or caught in the stomach of a predator). Despite these failures, discussions with Microwave Telemetry Inc. (MTI), the manufacturer of these tags, suggest that our return rate of data has been strong compared to other studies.

One of the pop-off tags deployed on schedule at the pre-programmed date of August 31<sup>st</sup> near Nachvak Fjord in northern Labrador. Initial satellite data suggests this fish moved through the Strait of Belle Isle on July 8<sup>th</sup>. Although this date may change with more fine scale analysis, it falls within late June – early July, and matches up with the five long-term acoustic tagged fish that passed through in early July as well (24810, 24815, 24816, 14818, and 58538). Given the northern location and late season timing of the transmission from this tag, it is safe to assume this kelt was an alternate spawner on her way to recondition in the cold northern waters of the Atlantic Ocean before returning to spawn in 2016. Advanced analysis of the data from this tag is ongoing, and will be used with past and future data to investigate trends in kelt migrations to determine statistically relevant behavioural patterns which may provide significant insight into the ecology of alternate spawning Atlantic salmon.

Of the five tags that deployed prematurely (four in the GOSL (148254, 148257, 148258, and 148261, and one off the coast of Labrador (148256)), only one has strong supporting evidence of being predated – tag 148256. A dive to 330m was observed in early August, with water temperatures around 10°C. At this depth, a sudden increase in temperature was noted, up to 24°C and most likely points to the tag being consumed and resting in the stomach of a predator. The temperature recorded then decreases to 5°C and the tag depth changes to ocean surface levels; four days later the tag began transmitting. Tags 148254 and 148257 popped after 4 days of constant depth, however a deep dive prior to tag release and the sharp increase in temperature was not seen. This does not mean the fish was not predated, as the tag may just not have been ingested. Tags 148258 and 148261 both show dives to approximately 50m and drops in temperature to 1-2°C for 10-14 days prior to tag release. No temperature spike was observed however. Further analysis of temperature and depth data may provide insight as to what species of animal could have consumed these fish. The sample size from 2015 is too small to draw any significant conclusions from, but pooling the data from these fish, along with kelts from the past and future studies that also prematurely deploy in the Gulf may provide

correlations between survival and water temperature and depth, seasonal commercial fisheries, or predator movements.

Determining movements of individual fish requires considerable work and statistical analysis. Tag position is determined by converting daily recorded light intensity and duration to sunrise and sunset timing each day. Positioning is then determined by calculating the marine area that would have those same times for a specific date. Even though this method is effective, it is susceptible to false locations produced by environment conditions. Dense cloud cover during dawn or dusk where light levels are low can give the impression of delayed sunset or early sunrise, therefore changing the position calculated for the location. An initial correction factor can be applied by averaging positions at a specific date with values collected during the previous days. This method provides a simplified improvement to smooth out data, but is still impacted by outlying erroneous locations. In order to correct for this, all positions need to be compared against local weather conditions during the specific date the animal was thought to be in a given area. At this time, simplified tracks of six kelt have been completed and are included in Appendix 1 of this report. These tracks are not considered final and still need further analysis and refinement.



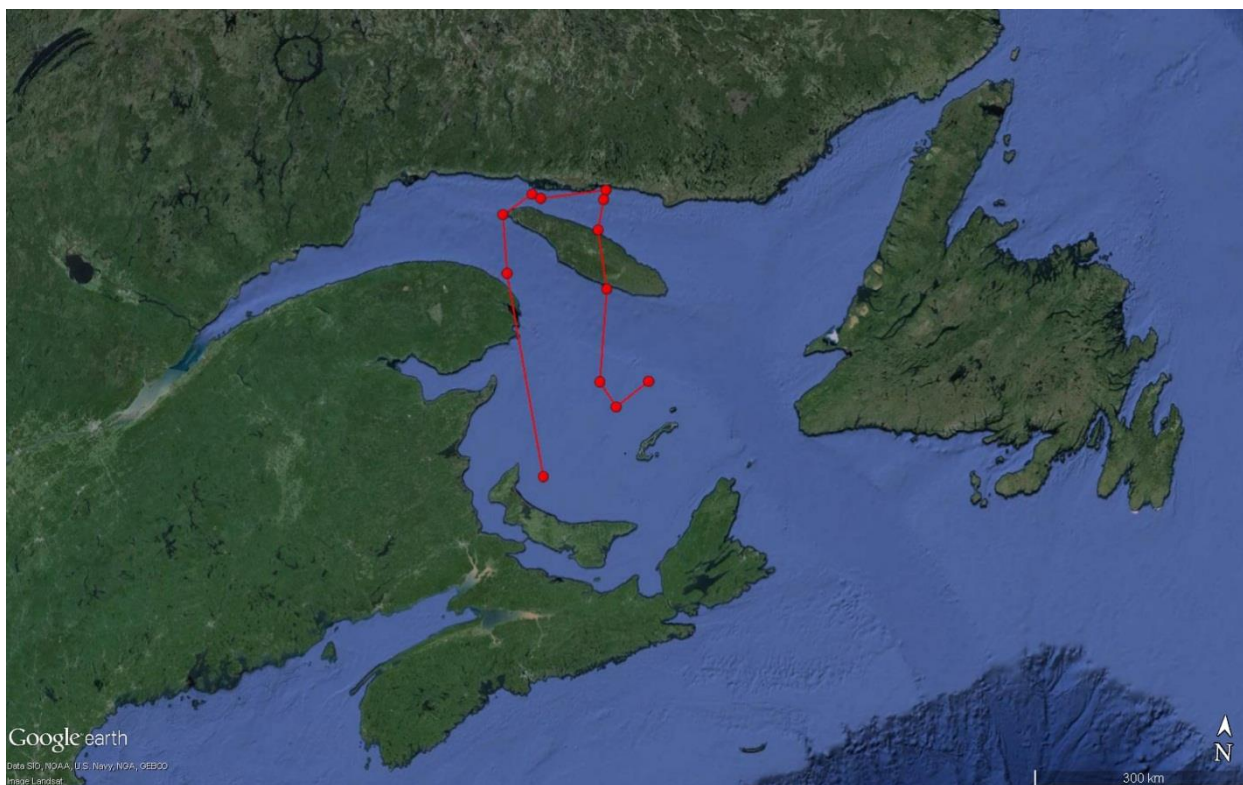
ASF Biologists Jon Carr (left) and Graham Chafe (right) attaching a satellite tag.



Satellite tag attached under the dorsal fin.



APPENDIX 1: Satellite tagged kelt tracks 2015.



Tag 148254



Tag 148255





Tag 148256



Tag 148257



Tag 148258



Tag 148261



## *Smolt Production Estimate*

### **INTRODUCTION**

Declining Atlantic salmon runs in the Miramichi River during the 1970's and early 1980's marked the beginning of increased conservation efforts for this species. Actions plans were put in place, including the closure of the commercial fishery and the mandatory release of all large salmon by anglers. From 1984 – 1992 the stocks rebounded and numbers were on the rise. After 1992 however, stocks began declining again and have continued to do so over the last two decades. Over recent years, the Southwest branch has outperformed the Northwest branch for adult returns. During the 17 years from 1998 – 2014, the Northwest system only reached conservation requirements (for sustainability) during two separate years, whereas the Southwest system met requirements for seven of those years. The average conservation requirement from 1998 – 2014 was 103% on the Southwest and 51% on the Northwest.

Electrofishing results from both the Northwest and Southwest branches of the river have typically shown healthy numbers of salmon fry and parr. It has been assumed that smolt production in these rivers would reflect these high juvenile numbers and therefore high smolt numbers should be produced, however adult returns do not reflect this trend. In 2011 angling regulations on the Northwest Miramichi were modified to a catch and release fishery to reduce human harvesting mortality on grilse, and in 2015 all New Brunswick Rivers became mandatory catch and release fisheries of all Atlantic salmon due to the continual decline in stocks. The initial policy change on the Northwest River in 2011 has likely reduced the angling mortality rate on the this system since then, compared to the Southwest, but the large adults returning on the Northwest are still subjected to non-angling mortality from First Nations Fisheries Allocations. The Northwest River is also the site of a striped bass spawning ground where bass spawn at the same time as smolt are migrating to the ocean. This has the potential to increase smolt mortality rates through predation. Striped bass are also present in the Southwest branch but not concentrated in high numbers as at a spawning area like the Northwest branch.

Smolt population estimates have been carried out in recent years on each branch of the Miramichi River system separately. The MSA has conducted ten years of estimates on the Southwest branch (2001-2010) and three years on the Northwest branch (2011-2013). This year

marks the second year of a new program that focuses on the river as a whole. The decision to change the program stemmed from concerns that over the three years fishing occurred on the Northwest River too many smolt were being missed in the Cassilis trap net because of washouts (the smolt estimates would be artificially low in such cases). The net needed to be in a location where it could be fished continuously without being damaged or washed out. Tidal waters offer more security from spring freshets so a location in the estuary in Chatham was chosen as a new trap net location. Since this location would count smolts from both the Northwest and Southwest Branches, the tagging was expanded to include the Southwest system and four smolt wheels were installed: two on the Northwest system and two on the Southwest.

The purpose of this study is to assess smolt production on the Miramichi River to determine if adequate juvenile production is occurring. An accurate estimation of the total smolt population migrating out of the Miramichi River system to the ocean is a key component to understanding and managing Atlantic salmon in this area. Ocean survival rates of smolt can then be observed in subsequent years as adults return as grilse and salmon and will help guide management decisions to conserve this important stock of salmon.

## **METHODS**

### **Study Area**

The Miramichi River watershed drainage area is approximately 12,000 km<sup>2</sup>. The system is divided into two large branches – the Northwest and the Southwest. The Southwest system encompasses 2/3's of the total drainage area, while the Northwest system is smaller – occupying 1/3 of the total area.

### **Design**

The smolt production estimate for the Miramichi River used a two-sample mark-recapture study design. Four rotary screw traps (RST's) or smolt wheels were installed in early May. Two traps were located on the Northwest system – one on the Northwest River (operated by MSA) and one on the Sevogle (operated by NSPA), and two traps were located on the Southwest system – one on the Cains River (operated by MSA) and one on Rocky Brook



(operated by IP) (Figure 3). The original plan for 2015 was to have a smolt wheel at the mouth of the Dungarvon River on the Southwest system (not the Cains), but due to road damage from ice flows field crews were unable to access this area and the Cains was chosen as a secondary location. The wheels are held in place by a large overhead cable that spans the width of the river. A second cable connects from this main line to the wheel, where two pontoons keep the wheel partially afloat and allow the trap to rotate fully (the current forces the wheel to turn) without hitting the bottom of the river.

Any fish entering the trap were funneled through the rotating wheel into a holding box at the back of the trap. The rotating wheel prevented any fish from escaping the box. All fish caught in the live box were collected and sorted. Each species was identified, counted, and released except for smolts. Fork lengths were taken from 25 fish which were then tagged with small, individually numbered streamer tags. Any remaining unmeasured smolts were also tagged. All fish were released after tagging. For the purpose of this study all juvenile Atlantic salmon greater than 100mm (FL) were considered smolt.

A single large trap net was installed just upstream of the Centennial Bridge on the Chatham side of the Miramichi River to capture smolt leaving the estuary (Figure 1). Tagged smolt captured at the trap net allows us to get an estimate of the number of smolt moving out of the Miramichi River system. The total smolt run is determined by a ratio of the number of smolt tagged upstream at the smolt wheels, the number of tagged smolt that are recaptured in the trap net, and the number of untagged smolt captured in the trap net. The trap net was fished daily, generally at low tide, and the smolt were sorted from the rest of the species caught. Sub-samples of up to 100 smolt were measured, 20 of which were lethally sampled for length, weight, age, and sex information. All smolts captured were counted and checked for streamer tags.

### Permits

The Navigable Waters Permit from the Department of Transportation, Instream Data Collection Devices Permit from the local Department of Environment, and the Scientific Collection Permit from the Department of Fisheries and Oceans were all obtained prior to starting this project.

## RESULTS

### Population Estimate

The Northwest smolt wheel operated from May 10<sup>th</sup> – June 1<sup>st</sup>. The smolt wheel on the Sevogle operated from May 13<sup>th</sup> – 31<sup>st</sup>. The Cains smolt wheel operated from May 10<sup>th</sup> – May 21<sup>st</sup>, on May 22<sup>nd</sup> the water levels had dropped and the wheel was no longer fishing. It was repositioned and began fishing again from May 23<sup>rd</sup> – 29<sup>th</sup>. The Rocky Brook wheel operated from May 8<sup>th</sup> – June 1<sup>st</sup>.

A total of 1,965 smolt were tagged in 2015 - Northwest (801), Sevogle (269), Cains (414), and Rocky Brook (481). The peak of the smolt run for each wheel was as follows: Northwest – May 18<sup>th</sup> (110 fish), Sevogle – May 23<sup>rd</sup> & 25<sup>th</sup> (53 fish), Cains – May 17<sup>th</sup> (103) (Figure 4).

The trap net operated from May 18<sup>th</sup> – June 5<sup>th</sup>. High east winds, large swells, and poor weather conditions kept crews from fishing the trap on May 20<sup>th</sup>, 21<sup>st</sup>, 23<sup>rd</sup>, 24<sup>th</sup>, and June 3<sup>rd</sup>. The trap net held up against late spring ice and never had to be lifted, nor did it wash out.

A total of 6554 smolt were captured at the trap net, three of which had been tagged upstream. All three tagged fish were from the Southwest River system (one from Rocky Brook and two from the Cains). The fish from Rocky Brook was tagged on May 11<sup>th</sup> and recaptured in Chatham on May 18<sup>th</sup>. The Cains smolts were both tagged on May 17<sup>th</sup> and both recaptured on May 22<sup>nd</sup>.

Using the survival information from acoustic receivers deployed for our smolt tracking program, the survival rate of smolts to Chatham was 40%. Applying a 60% mortality rate to our population estimate (using the Peterson Model) gives a smolt estimate of 1,717,148 (95% CI 582, 743 – 5,151,444). This equates to 3.18 smolts/100m<sup>2</sup>.

### Sampling Data

The male to female sex ratio was 1:1.6, respectively. Average fork length for females was 12.9cm ( $\pm$  0.98cm) and for males was 12.5cm ( $\pm$  0.99cm) (Figure 5a). Average weight for females was 20.3g ( $\pm$  4.34g) and for males was 19.1g ( $\pm$  4.58g) (Figure 5b).

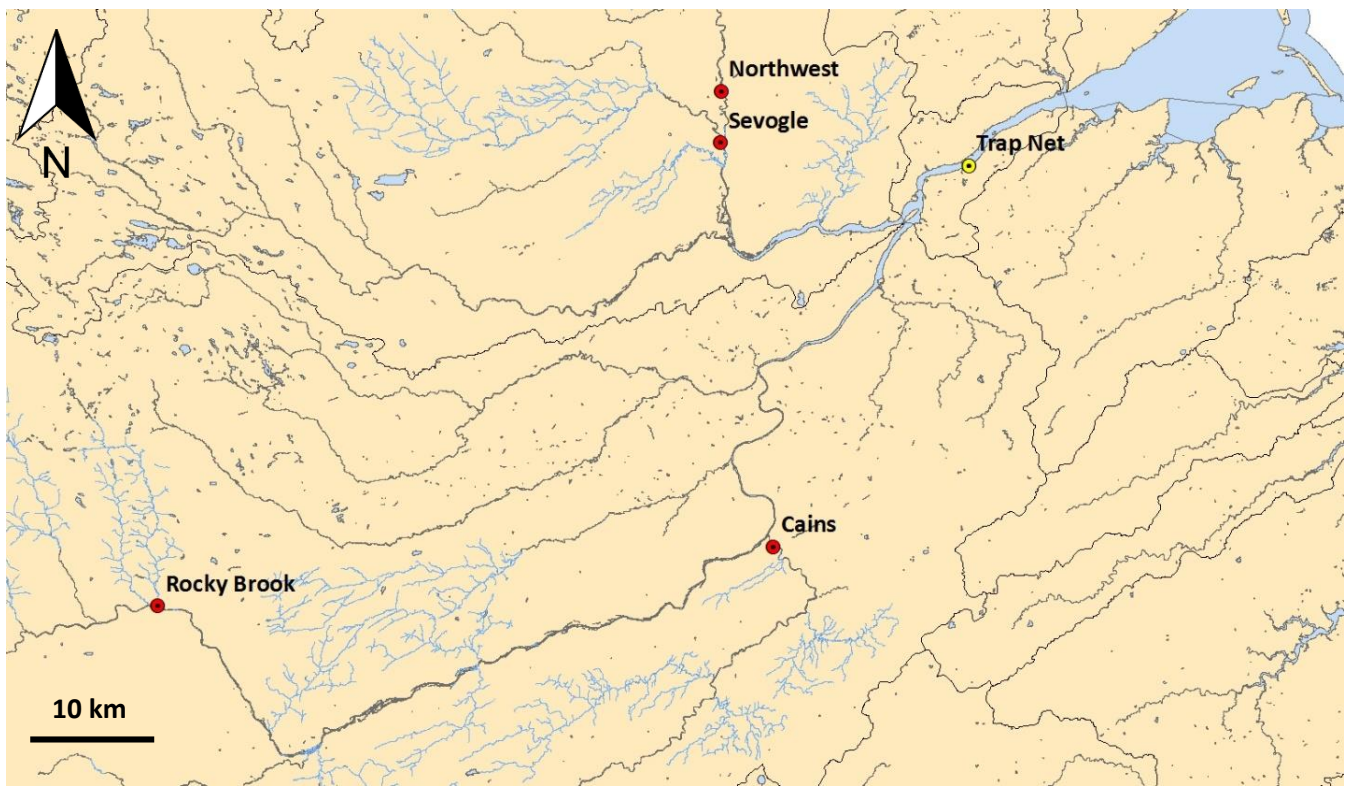


Figure 3. Locations of the four smolt wheels (red dots) operating in 2015 and the trap net in Chatham (yellow dot).

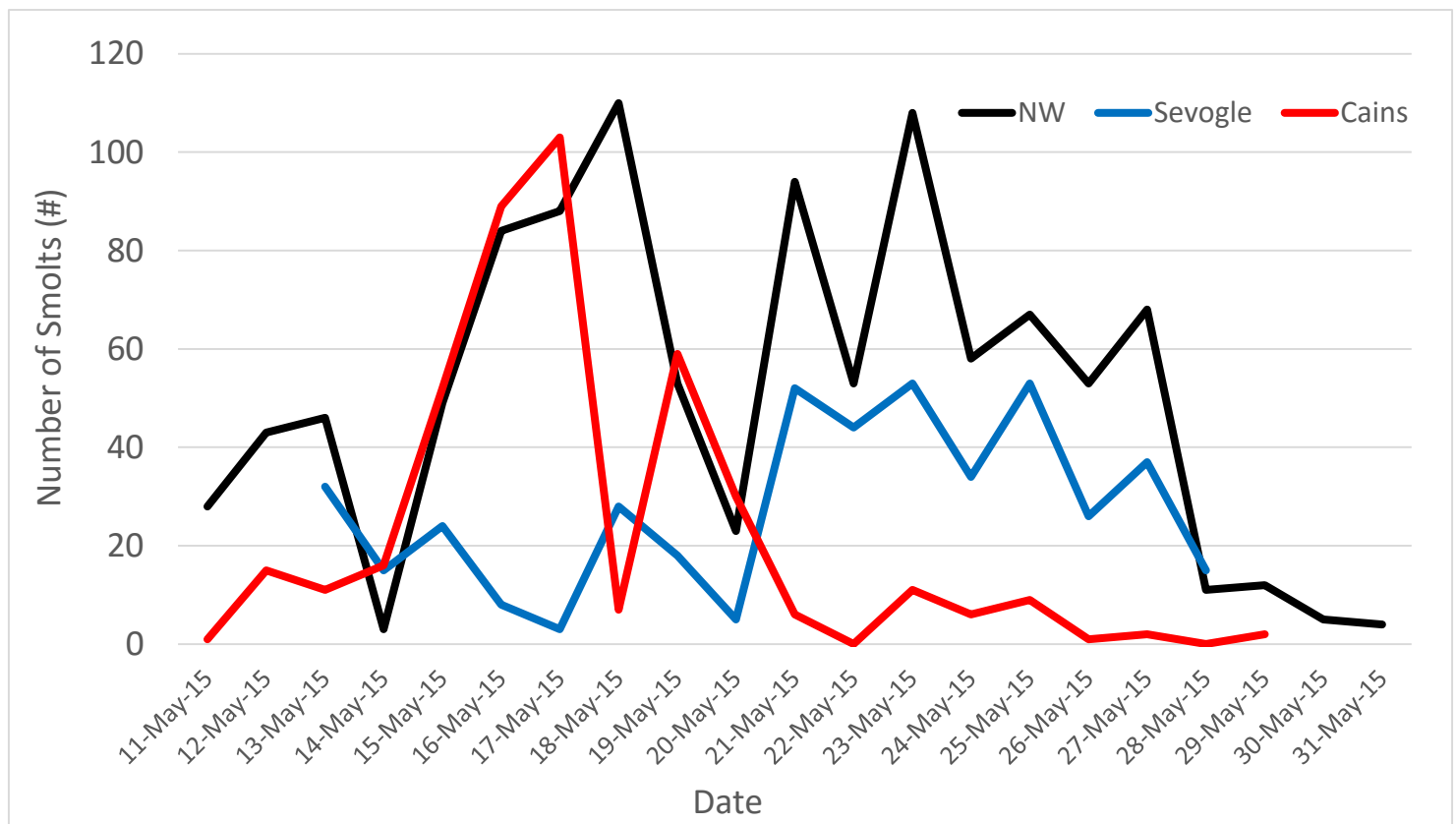


Figure 4. Daily smolt counts at the three wheels operated by MSA and the NSPA during May of 2015. Peak numbers occurred on the Northwest on May 18<sup>th</sup>, on the Sevogle on May 23<sup>rd</sup> and 25<sup>th</sup>, and on the Cains on May 17<sup>th</sup>.

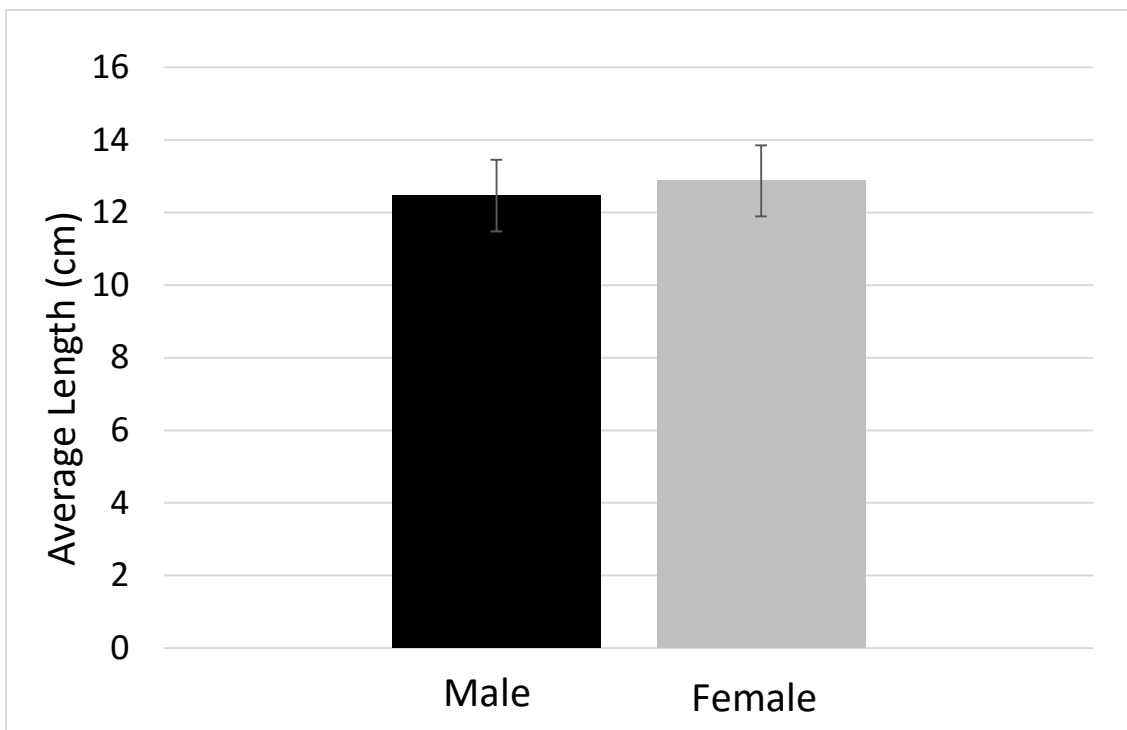


Figure 5a. Average fork length (cm) for male and female smolts sampled at the Chatham trap net in the spring of 2015.

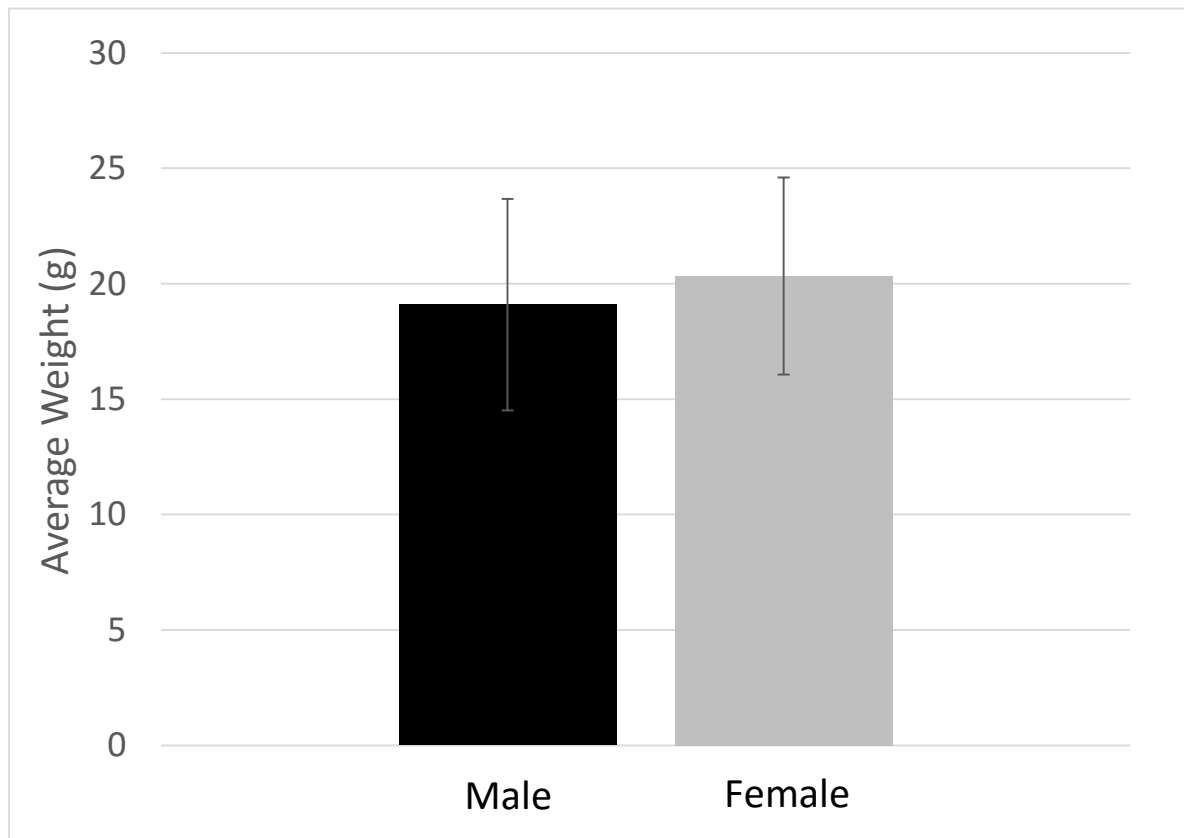


Figure 5b. Average weight (g) for males and female smolts sampled at the Chatham trap net in the spring of 2015.

## DISCUSSION

The Miramichi River needs 1.8 million smolt migrating to the ocean every year in order to sustain a healthy adult population – roughly 1.2 million from the Southwest branch and 600,000 from the Northwest. The standard estimate is 3.0 smolt/100m<sup>2</sup>. In 2014 the trap net was relocated to Chatham, however no estimate could be produced because of the high volume of fish caught – too many for our crews to sample, and the net had to be dumped out. The three years of data from the Northwest system before that have shown variable and sometimes conflicting results; in 2011 and 2013 smolt production exceeded 3.0 smolt/100m<sup>2</sup> and in 2012 was estimated at only 2.0 smolt/100m<sup>2</sup>. Difficulties with equipment damage from weather and high water levels occurred during these years and may have impacted estimates. Earlier data from 2006 – 2010 on the Southwest system indicated that smolt production estimates exceeded requirements for all years except 2008. Even with these high smolt estimates the adult returns have continued to decline.

For the 2015 smolt estimate program, alterations were made to our trap net to reduce the volume of fish the net could carry (in the hopes of minimizing the number of fish caught so crews could actually count them all in a day). The leader from shore was also shortened, with only half of the panels dropped in the river. These adjustments were successful, and a much more manageable number of fish were caught this year. Our recapture numbers were very low however (3 tags or 0.15% of total marks), and this caused our estimate to be highly inflated (overestimated). Typically, a 10% mortality is assumed with tagging studies, but with the data available to us from our smolt tracking program, a 60% mortality rate was actually observed to the Chatham area, and that percentage was applied to our estimate, which decreased the number substantially.

We also were not able to fish the trap on five separate days because of high east winds which caused large (>2-3ft) swells, making conditions unsafe for the field crews. The trap net remained fishing during this time, and although the number of fish inside never reached levels similar to 2014, this extra time in the net adds stress to the fish trapped in it for the extended period.

A new strategy is in place for the smolt estimate program in 2016. The MSA plans to relocate the trap net back to the Northwest River because of the problems that have occurred at the Chatham location the last two years. The trap net will be installed at the mouth of Stewart Brook near the Miramichi Salmon Conservation Centre (MSCC), which is downstream of Cassilis, and in an area where trap nets are not impacted by freshets or high winds. This should allow the trap to be fished safely every day and not have to be lifted because of weather conditions. This adjustment in the smolt estimate program is part of a larger project which is seeking funding from the Collaboration for Atlantic Salmon Tomorrow (CAST) initiative to help conserve and improve Atlantic salmon returns on the Miramichi River. The new trap net location will serve as a recapture platform for our smolt estimate program on the Northwest River and also as a collection point for wild smolts to be transferred to the MSCC as part of the adult rearing program also associated with CAST.



Chatham trap net

## Smolt Tracking

### INTRODUCTION

Juvenile Atlantic salmon which have undergone physiological changes to transition from freshwater to saltwater are referred to as smolt. These salmon have begun a process known as smoltification where they exhibit negative rheotaxis (consistent downstream movement), silvering of the body, and a decrease in body condition due to increased growth in length. Smolts migrate from natal tributaries and rivers or from pre-smolt overwintering staging areas to estuaries as freshwater temperatures start to rise in the spring. On the Miramichi River smolt movements typically start between late April and early May and conclude in late May or early June. During this time the majority of the total smolts from a river or tributary will migrate within a short window of five to six days. This peak movement is often observed during times of high water discharge following a rain event and when water temperatures are near 10°C. Upon entering brackish water, these fish may be required to stall downstream movements to allow for physiological acclimation to the salt water.

Striped bass (*Morone saxatilis*) are a large generalist fish species native to the Northumberland Strait and Gulf of St. Lawrence (GOSL). Over the past 5 years their population numbers have increased in the Miramichi Estuary. The only known location of successful spawning for the entire GOSL population occurs between May and June in the upper portion of the tidally influenced water of the Northwest Miramichi River. During this time a large number of mature, breeding striped bass from various locations throughout the Northumberland Strait and Gulf region will move into this area for several weeks.

The timing of the striped bass migration closely coincides with the salmon smolt migration. This spatial and temporal overlap raise concerns regarding the survival of Northwest Miramichi salmon smolts. Striped bass are opportunistic feeders and cases of smolt predation on both Atlantic and Pacific salmon species (*Oncorhynchus spp.*) have been documented to varying degrees throughout North America in both native and non-native ranges of the species. With the recent decline in adult salmon returns to the Northwest Miramichi River, there is potential that increased levels of predation may greatly impact the survival rates of the smolts,

therefore reducing the number of smolts leaving the Miramichi system to a level that also reduces the number of adults returning in subsequent years.

The use of acoustic technology is an effective way to estimate the survival of a fish population in a river or estuary. Fish implanted with acoustic transmitters are identified as they move through the detection field of an acoustic receiver. For Atlantic salmon smolt, the placement of multiple receivers throughout a river system allows for the detection of tagged fish as they move downstream to the marine environment. Changes in the percentage of tagged fish detected moving downstream through a river can indicate the level of survival through the system. The placement of receivers between barrier islands in an estuary allow for estimates on the percentage of tagged fish which survived to the ocean.

As a compliment to the Atlantic Salmon Federation's smolt tracking program to estimate the survival of smolts from the Southwest branch of the Miramichi River, an acoustic tagging study was carried out on the Northwest branch during the 2015 smolt migration to determine survival rates throughout the river and estuary.

## **METHODS**

### **Study Area**

The Northwest Miramichi watershed drainage area of 3,950km<sup>2</sup> makes up approximately one third of the total watershed of the Miramichi River. The Northwest Miramichi basin includes two major river systems: the Little Southwest River (1,342km<sup>2</sup>) and the Northwest Miramichi River (2,078km<sup>2</sup>) which merge in a delta at the head of tide. The Northwest Miramichi River includes a large tributary, the Sevogle River, which has a drainage area of 799km<sup>2</sup>.

### **Tagging**

Atlantic salmon smolt were captured by a rotary screw trap (RST) on the Northwest Miramichi River immediately upstream of the mouth of Trout Brook. Only fish greater than 13cm were held for tagging (to allow for room in the body cavity for the transmitter). The fish were held in live boxes off the shore until the following morning (to allow for digestion and



therefore easier tag insertion) when they were transported to the tagging location in an x-actic tank on a truck. The smolts were tagged at Miner's Bridge, approximately 27km upstream of the RST.

Prior to surgery the fish were placed in a clove oil bath for several minutes until equilibrium was lost and movement was minimal. Vemco V8 acoustic tags were used during surgery. The tag was inserted by making a small incision on the ventral surface on the fish, off-center, between the pectoral and pelvic fins. The incision was closed with two sutures and the fish placed into a recovery box (live well) for observation. Time out of the water for this procedure was 2 – 3 minutes per fish, with water passed through the gills during surgery. The smolts regained equilibrium within one hour after the surgery and were then released.

#### Receiver Placement

A total of 14 Vemco VR2w acoustic receivers were placed throughout the tidally influenced portions of the Northwest and Southwest Miramichi River. An additional three receivers were placed on the main stem of both the Northwest and Southwest (new in 2015) rivers to detect in-river movements and survival rates. Receivers were also placed to form detection gates between openings at barrier islands near the mouth of Miramichi Bay at Neguac Beach, Portage Island, and Huckleberry Gully. An additional receiver line in the Strait of Belle Isle (SOBI) was deployed in 2015, 3.5km north of the original line so that two lines of detection were present to increase the chances of tag detections in this area (Figure 6a&b).

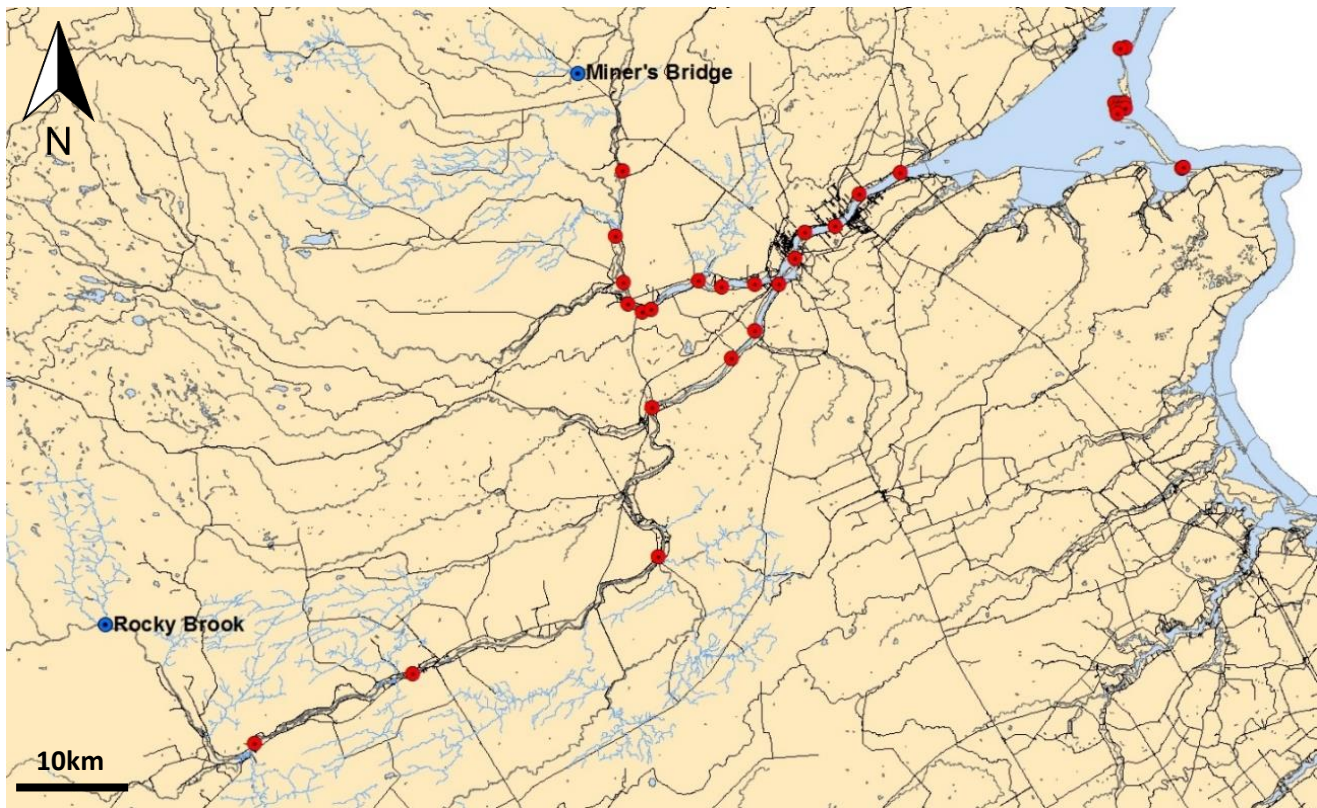


Figure 6a. Acoustic receiver locations (red dots) in the Miramichi River and Bay in 2015. Smolt tagging and release locations are represented by a blue dot – Miner's Bridge on the Northwest branch and Rocky Brook on the Southwest branch.

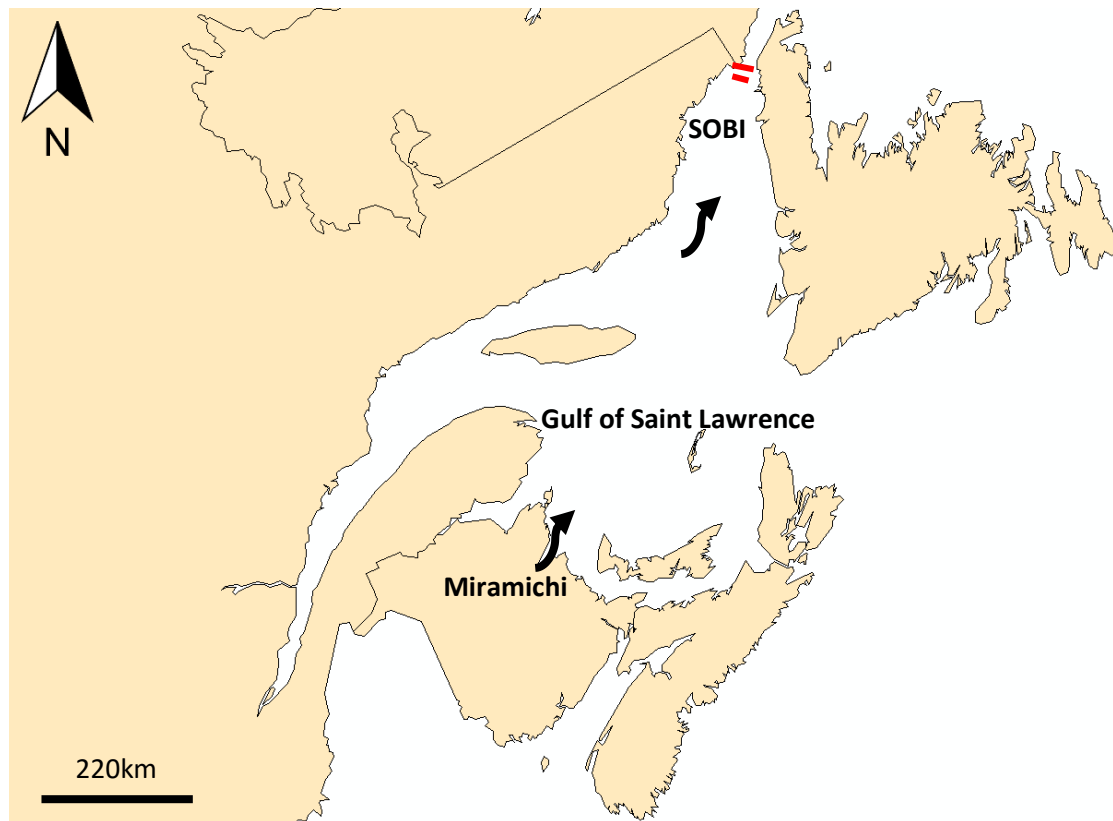


Figure 6b. Acoustic receiver locations (red lines) across the Strait of Belle Isle in 2015. A second line was added north of the original line in 2015. The lines are 3.5km apart. Suspected fish movement paths are indicated with a black arrow.

## RESULTS

### Northwest River

From May 20<sup>th</sup> – 26<sup>th</sup>, a total of 80 smolts were captured at the Northwest smolt wheel and transported upstream to the tagging site located at Miner's Bridge. Of the initial 80 fish tagged, 71 of them (89%) were detected on the first receiver at Kingston Lane, however at the head of tide (HOT) in Cassilis, only 63 of the 80 fish (79%) were detected, indicating a 21% mortality rate from the tagging location to HOT. Another 23% of the fish were lost between Cassilis and Nelson. Survival in the main channel of the river from Nelson to Loggieville was 69% of the remaining fish, and 39% from the tagging location. Only 29 fish (36%) of the smolts tagged at Miner's Bridge survived out of the estuary (past the barrier receiver lines), and 21% to the SOBI (Figure 7a).

### Southwest River

On May 20<sup>th</sup> & 21<sup>st</sup>, 80 smolts captured at the Rocky Brook smolt wheel were tagged and released. Of the initial 80 fish tagged, 59 (74%) of them were detected at the first receiver in Boiestown and the same number at the HOT in Millerton. At the second receiver in Doaktown however, 64 tags (80%) were detected indicating poor receiver reception in Boiestown. The mortality rate from the tagging location to the HOT was 26%. Another 29% of the fish were lost between Millerton and Nelson. Survival in the main channel of the river from Nelson to Loggieville was 94% of the remaining fish, and 43% from the tagging location. Only 32 fish (40%) of the smolts tagged at Rocky Brook survived out of the estuary (past the barrier receiver lines), and 14% to the SOBI (Figure 7b).

In total, 38% of the smolts leaving the entire Miramichi River survived to exit the estuary, and 18% survived to the SOBI.

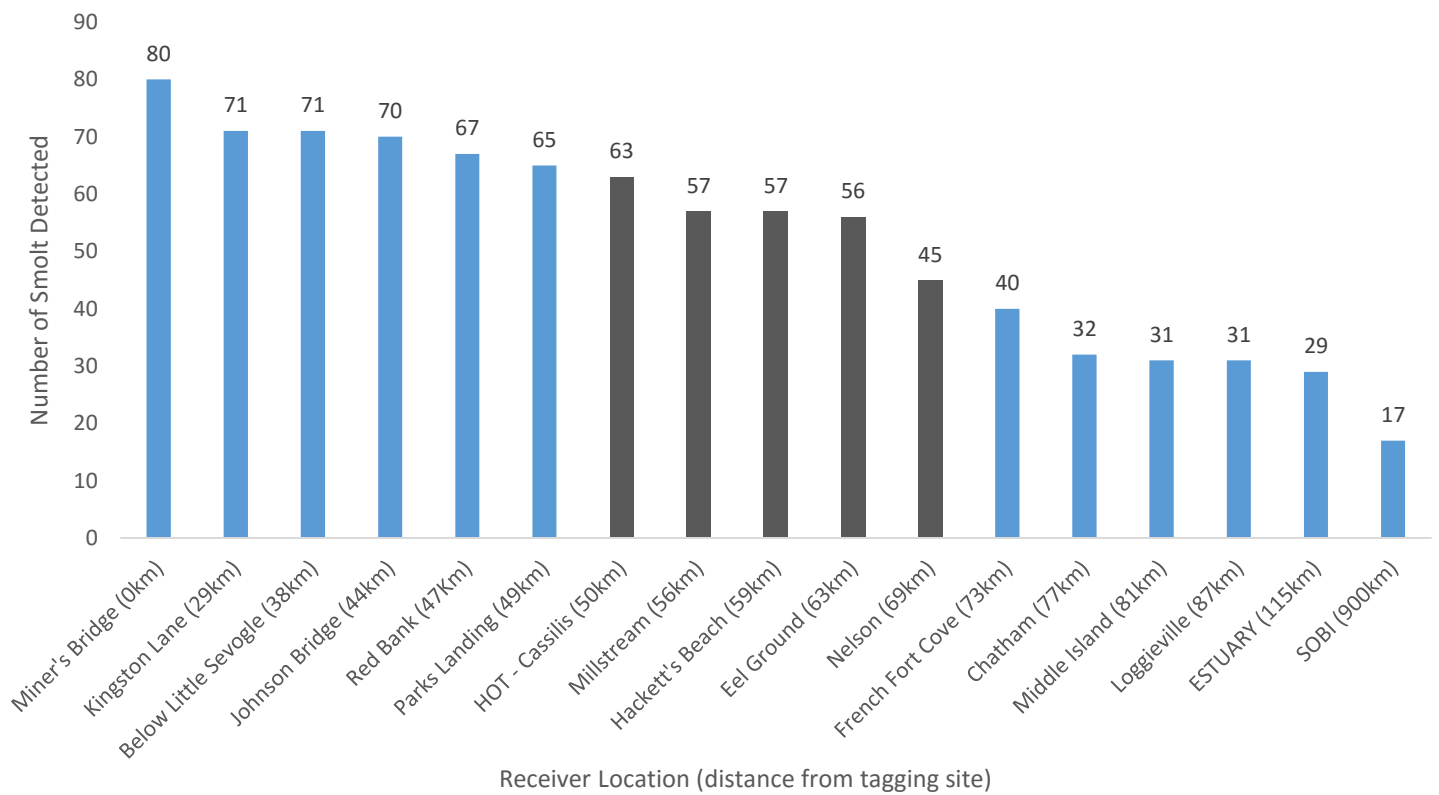


Figure 7a. Survival numbers of acoustic tagged smolts from the Northwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2015. The highest percentage of mortality occurred between Cassilis and Nelson (18 fish/23%), marked in grey.

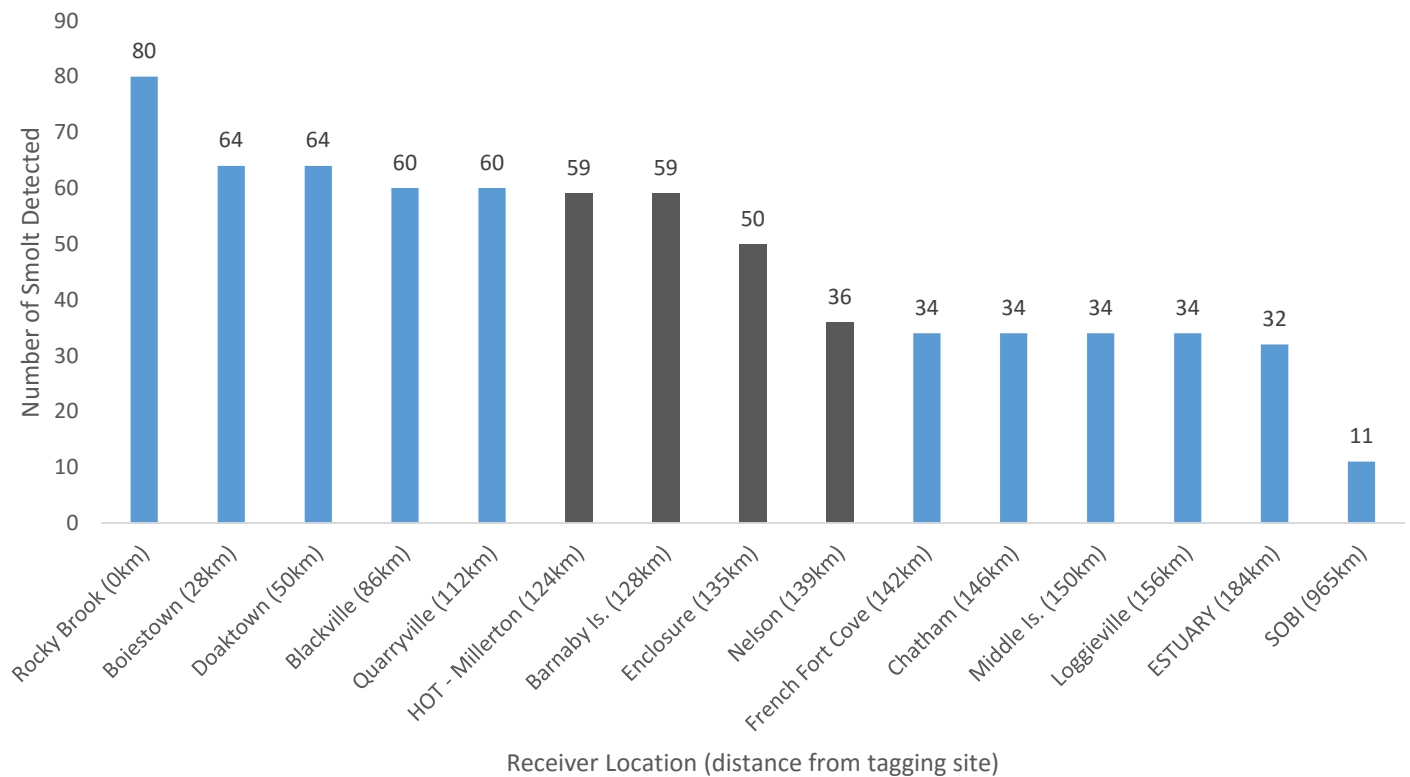


Figure 7b. Survival numbers of acoustic tagged smolts from the Southwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2015. The highest percentage of mortality occurred between Millerton and Nelson (21 fish/29%), marked in grey.

## DISCUSSION

Survival numbers from the 2015 tagging study are less than desirable for the Miramichi River, however they were better than numbers recorded in 2014. The fish that successfully survived tagging (a 10% mortality rate is assumed for tagging studies) and were detected exiting Miramichi Bay was only 36%.

The highest areas of loss on the Northwest were between the head of tide at Cassilis and Nelson (18 fish/23%) where striped bass are most prevalent, and from the tagging location at Miner's bridge to Cassilis (17 fish/21%) (Figure 2a). The highest survival rate was observed between Loggieville and the estuary receivers, as only 2 fish (3%) were lost. For the Northwest River in total, 0.44 smolt/km were lost.

On the Southwest branch the highest areas of loss were between the head of tide at Millerton and Nelson (23 fish/29%) and from the tagging location at Rocky Brook to Millerton and the estuary to the SOBI, both at 21 fish lost and 26% mortality (Figure 2b). The highest survival rate was observed between Nelson and Loggieville, and between Loggieville and the estuary, with each section only losing 2 fish each (2.5%). For the Southwest River in total, 0.26 smolt/km were lost.

The second receiver line placed in the SOBI in 2015 has shown that the first line did not always pick up all the fish moving through the Strait. Of the 17 smolts that survived to the SOBI from the Northwest River, three fish were picked up by the first line, six on the second line, and eight on both lines. Of the 11 fish that survived to the SOBI from the Southwest River, four were picked up on the first line, one on the second line, and six on both lines. This error percentage can be modeled and applied to smolt tracking data from previous years to produce a more accurate estimate than originally thought.

It is important to note that there are multiple sources of smolt predation within the tidally influenced waters of the Northwest Miramichi River, and that at this time it is not possible to quantify the level of tagged smolt mortality that can be attributed to striped bass. Avian predation from mergansers, gulls, and cormorants, as well as fish predation by trout, tomcod, or reconditioning kelt could all contribute to natural smolt mortality in the river. In order to narrow the sources of predation, detailed study of individual tag data is required. For

2015 data, further analysis will be carried out by the Atlantic Salmon Federation to look at the behaviour of the fish which did not reach Miramichi Bay, specifically whether fish exhibited atypical movements likely attributed to another animal (i.e.: consumption). In 2016 a new Vemco acoustic predator tag will be used in this study, along with regular acoustic tags. The predator tags change their signal code ID if a fish is consumed, but will still be picked up by the same receivers used in previous years. With this information we will be able to monitor if, when, and where a fish is predated upon.

In past years, the smolts tagged were all released on the same day, which left us unable to determine if changes in survival occur over the duration of the juvenile migration. On the Northwest River, striped bass are known to stage in distinct areas before, during, and after spawning. The changing position of the bass over the course of the smolt run may influence their spatial overlap with juvenile salmon, changing the likelihood of predation. The feeding behaviour of striped bass while they occupy these areas is also not fully understood. In 2015, tagging efforts were staggered on the Northwest River over multiple days to allow for detection of movement and survival changes over time. This information would then be available for comparison to striped bass tracking research, conducted by DFO, to determine the times of greatest overlap between the species. Research of striped bass stomach contents, which is carried out over several weeks by DFO, could be used to determine if changes in the occurrence of smolts on the stomach contents matches with peaks in the smolt migration. This combined research should allow for a more precise understanding of the interaction between the species. Efforts will be made again in 2016 to spread the tagging out over multiple days to try and determine temporal overlap between smolts and striped bass.



Acoustic tagged smolts recovering after surgery

## *Salmon Fry and Trout Stocking*

### **INTRODUCTION**

Stocking Atlantic salmon first-feeding fry can improve the juvenile production capacity of the Miramichi River by targeting areas that are under-seeded or not accessible to wild spawning adults. An electrofishing survey is carried out each year by the Miramichi Salmon Association (MSA) to assess areas of the river that are lacking adequate numbers of fry or parr. Low fry or parr numbers could be the result of multiple factors, including: poor adult returns, barriers to adult movement into upper stream reaches (i.e.: beaver dams), environmental events such as ice scouring that destroys redd's, or less than optimal water conditions. Areas with zero/minimal fry present will be targeted to stock and efforts will also be made to identify and remove any impediments to natural spawning. The majority of these areas are located in small tributaries and the headwaters of the Miramichi River. Small brooks and streams often have good quality habitat and lower numbers of predators than larger downstream locations. These narrow waterways may be inaccessible however, because of barriers or decreased water levels in low flow years.

Juvenile abundance electrofishing surveys and smolt estimates are used to aid in determining specific tributaries that may need additional stocking. Since it is impossible to stock every small stream in the Miramichi with a limited numbers of fish, it is important to place hatchery salmon fry into streams that will benefit most from their introduction. Stocking salmon fry into a tributary with high salmon fry abundance could negatively impact those fish by increasing the level of competition for food resources. To avoid this, any site containing more than 100 fry/100m<sup>2</sup> is not considered for stocking as it appears to reflect a healthy natural population. Sites with less than 50 fry/100m<sup>2</sup> are considered candidates for further stocking. The absence of fry at an already stocked site may indicate that the site does not contain the appropriate habitat or it may have too many predators.

Prior to 2010, fall fingerlings were stocked and identified by an adipose clip (removal of the adipose fin). In 2010 the MSA shifted the focus from Atlantic salmon fall fingerlings to stocking first-feeding salmon fry in the early summer. These fry are incubated as eggs on

unheated brook water to ensure that the rate of egg development is similar in timing to that of wild eggs. The stocking of fry over fingerlings has several benefits, including the reduced risk of fish contracting a pathogen while in artificially high densities at the hatchery, and the improved capacity to develop “wild” behaviour tendencies at a younger age. First-feeding fry are stocked out in June/July at an average size of 0.5g which makes fin clipping impossible. However, there are still locations that raise fall fingerlings for stocking purposes. Atlantic salmon fry, young of the year brook trout, and yearling brook trout were raised this year in satellite rearing stations run in collaboration with J.D. Irving Ltd., the Miramichi Headwaters Salmon Federation, and Rocky Brook Camp & Barbour’s.

The objective of this program is to improve Atlantic salmon production in the headwaters of the Miramichi watershed.

## **METHODS**

Adult salmon were collected from September to mid-October 2014 for broodstock and held at the Miramichi Salmon Conservation Centre (MSCC). The fish were kept separated based on their river of origin. Once ripe, female salmon were stripped of their eggs, which were then fertilized by a male salmon from the same river. Immediately following spawning, the adults were released back into the wild via Stewart Brook, which runs beside the MSCC. Eggs were incubated on brook water until the eyed stage, when dead eggs were removed weekly. Eyed eggs were transferred to incubation boxes in preparation for hatching. After hatching, fry were fed a formulated salmonid diet (Corey 0.7CR/EWOS #1CR) for approximately 4 weeks until stocking. All salmon fry were stocked in their river of origin (“river specific stocking”).

Stocking sites were selected based on low juvenile densities found at the exact or nearby locations from the previous year’s electrofishing results and in tributaries that typically have low juvenile production (i.e.: Cains and Little Southwest). Additional salmon fry were taken to satellite rearing sites for continued growth before stocking.



## RESULTS

Approximately 231,313 first-feeding Atlantic salmon fry were stocked into 80 sites in seven tributaries of the Miramichi River (Figure 8a&b). The Northwest system received 112,819 fry and the Southwest system 118,494 (Table 2). An additional 21,000 fry were taken to satellite holding tanks for future release by local conservation groups (Table 3). Additionally, 40,000 brook trout parr and 1,200 yearlings were distributed to two satellite tank rearing locations (Table 4).



Stocking fish on the LSW

Table 2. Distribution of first-feeding Atlantic salmon fry from the Miramichi Salmon Conservation Center in 2015.

Branch	Stock Origin	Site	# of fish	Latitude	Longitude
Northwest	Sevogle	Johnston Brook	2544	47.04431	-66.22250
Northwest	Sevogle	Travis Brook	2621	47.04831	-66.22865
Northwest	Sevogle	Clearwater Brook	2502	47.10792	-66.23544
Northwest	Sevogle	SEV SB 1	2536	47.11050	-66.32037
Northwest	Sevogle	SEV SB 2	2556	47.08518	-33.60534
Northwest	Sevogle	SEV branch	1500	47.15705	-66.33582
Northwest	Sevogle	SEV NB Slack Lake	7615	47.20343	-66.32047
Northwest	Sevogle	SEV NB 1	2775	47.21760	-66.38605
Northwest	Sevogle	SEV NB 2	9232	47.20736	-66.35497
Northwest	Sevogle	SEV NB 3	2527	47.20560	-66.34550
Northwest	Sevogle	SEV NB Bear Lake	5136	47.21634	-66.25765
Northwest	Sevogle	Sheephouse Road	7047	47.13484	-65.98288
Northwest	LSW	North Pole Road @ bridge	2503	46.97046	-66.53089
Northwest	LSW	Smith Forks	2249	46.96208	-66.58373
Northwest	LSW	Squaw Barron Brook	1710	46.97311	-66.70039
Northwest	LSW	County Line Brook	1165	46.92739	-66.74204
Northwest	LSW	LSW 1	1943	47.04220	-66.76453
Northwest	LSW	LSW 4	938	46.98436	-66.51875
Northwest	NW	Crawford 1	2507	47.22731	-66.23008
Northwest	NW	Crawford 2	2552	47.25215	-66.21417
Northwest	NW	NW SB 1	2483	47.24985	-66.40220
Northwest	NW	NW SB 2	2591	47.25008	-66.39289
Northwest	NW	NW SB 3	2493	47.23538	-66.36326
Northwest	NW	NW NB 1	2709	47.27582	-66.44077
Northwest	NW	NW NB 2 (Bill Gray Mtn)	4995	47.28469	-66.38902
Northwest	NW	Trout Brook 1	2483	47.09631	-65.83664
Northwest	NW	Trout Brook 2	2535	47.09433	-65.83585
Northwest	NW	Pat's Brook 1	2512	47.18386	-65.84186
Northwest	NW	Pat's Brook 2	2446	47.18360	-65.84142
Northwest	NW	Stoney Brook	2493	47.15270	-66.05717
Northwest	NW	NW Main 3	2555	47.11620	-65.77396
Northwest	NW	Mountain Brook	3423	47.20321	-66.07328
Northwest	NW	Little River 1	2498	47.22708	-66.04102
Northwest	NW	Little River 2	2455	47.21888	-66.03860
Northwest	NW	Little River 3	9990	47.23083	-66.05357
Southwest	Rocky Brook	LL Road	17021	46.77917	-66.72535
Southwest	Rocky Brook	Below Fish Brook	12765	46.75488	-66.67578
Southwest	Rocky Brook	Brown Lake Bridge	8511	46.71358	-66.64512

Branch	Stock Origin	Site	# of fish	Latitude	Longitude
Southwest	Juniper	Juniper Brook	3021	46.53908	-67.18337
Southwest	Juniper	Teague 1	4605	46.58400	-67.26054
Southwest	Juniper	Teague 2	2995	46.57277	-67.24854
Southwest	Juniper	Teague 3	2986	46.55768	-67.23286
Southwest	Juniper	Elliott Brook 1	3021	46.62125	-67.36763
Southwest	Juniper	Elliott Brook 2	2992	46.61568	-67.34216
Southwest	Juniper	Elliott Brook 3	3018	46.58263	-67.30670
Southwest	Juniper	Little Teague 1	3040	46.61448	-67.30224
Southwest	Juniper	Little Teague 2	3000	46.59232	-67.27435
Southwest	Juniper	MSW Branch 1	3000	46.55526	-67.2879
Southwest	Juniper	MSW Branch 2	3008	46.54552	-67.25654
Southwest	Juniper	White Rapids Brook	500	46.769	-65.858
Southwest	Juniper	North Branch Hudson Brook	100	46.754	-65.846
Southwest	Juniper	South Branch Hudson Brook	100	46.757	-65.844
Southwest	Juniper	Main Hudson Brook	100	46.758	-65.845
Southwest	Juniper	Smith Lake Outlet	500	46.782	-65.815
Southwest	Juniper	Hallihan Brook	100	46.712	-65.819
Southwest	Juniper	Brandy/Mersereau Brook	50	46.692	-65.842
Southwest	Juniper	Zack's Brook	100	46.674	-65.847
Southwest	Juniper	Morse Brook	300	46.668	-65.849
Southwest	Juniper	Four Mile Brook	150	46.609	-66.079
Southwest	Juniper	Fowler Meadow Brook	150	46.619	-66.108
Southwest	Juniper	Ledbetters Brook	150	46.619	-66.112
Southwest	Juniper	Davis Landing Brook	100	46.590	-66.229
Southwest	Juniper	Big Hole Brook	500	46.593	-66.319
Southwest	Juniper	South Branch Big Hole Brook	100	46.572	-66.358
Southwest	Juniper	North Br. Bartholomew River	1000	46.625	-66.326
Southwest	Juniper	South Br. Bartholomew River	1000	46.616	-66.327
Southwest	Cains	Tyler's Camp	2512	46.55928	-65.80551
Southwest	Cains	Mahoney Brook	598	46.50875	-65.87188
Southwest	Cains	Brad's Camp	2000	46.50561	-65.87334
Southwest	Cains	Salmon Brook 1	2520	46.64459	-65.61313
Southwest	Cains	East Branch Sabbies	2559	46.56364	-65.68284
Southwest	Cains	West Branch Sabbies	2437	46.51891	-65.74332
Southwest	Cains	East Branch Six Mile	2437	46.49400	-65.80071
Southwest	Cains	West Branch Six Mile	2547	46.48274	-65.82861
Southwest	Cains	Cains tributary	1023	46.41129	-65.99825
Southwest	Cains	Otter Brook	2001	46.64071	-65.75723
Southwest	Cains	North Cains 1	1771	46.33765	-66.32243

<b>Branch</b>	<b>Stock Origin</b>	<b>Site</b>	<b># of fish</b>	<b>Latitude</b>	<b>Longitude</b>
Southwest	Cains	North Cains 2	1772	46.33103	-66.34133
Southwest	Clearwater	Clearwater Bridge	8931	46.65402	-66.76901
Southwest	Clearwater	Christiana Pool	7403	46.66230	-66.77250

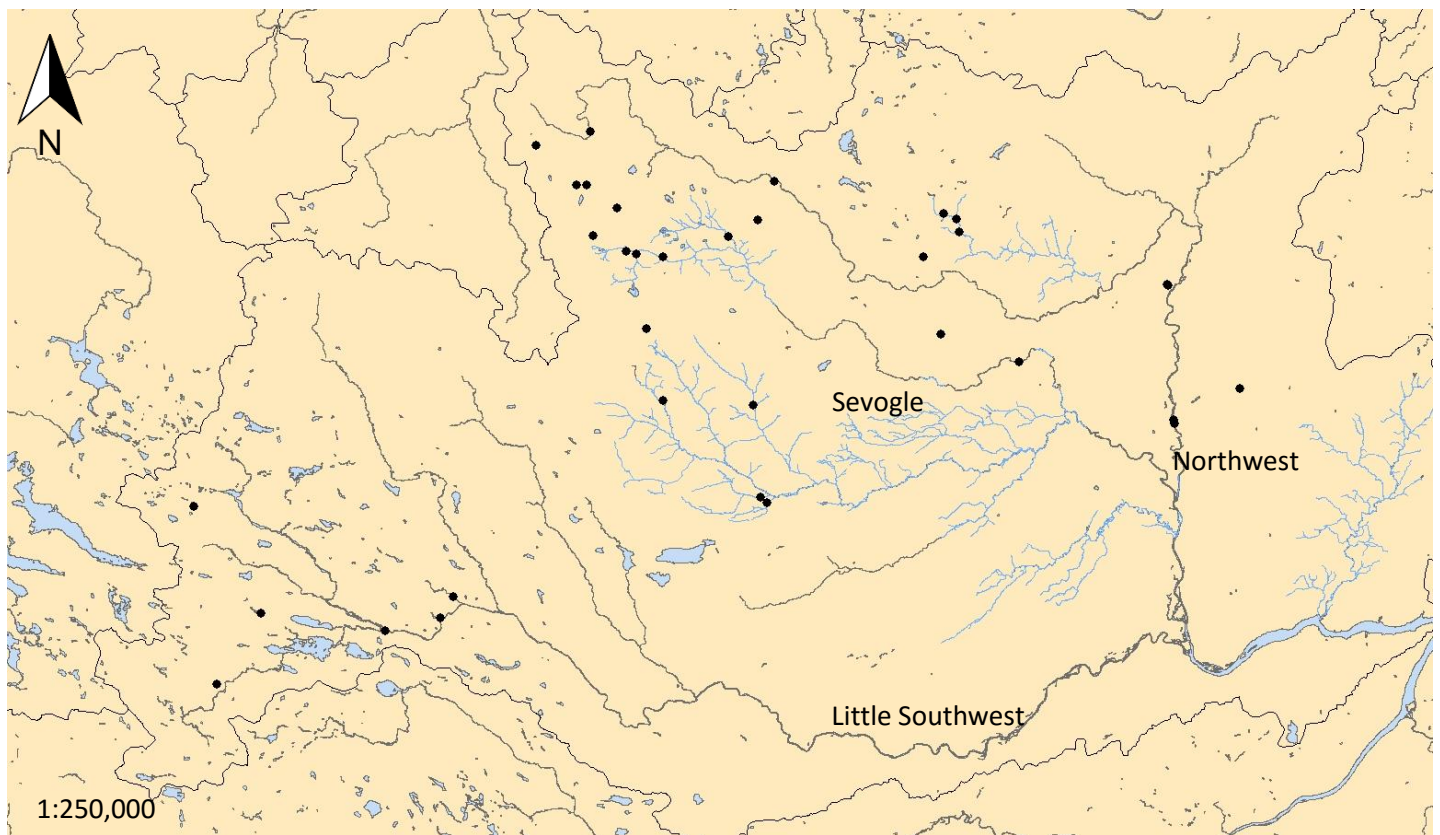
Table 3. Distribution of first-feeding Atlantic salmon fry to satellite holding tanks for continued growth and stocking.

<b>Stock Origin</b>	<b>Organization</b>	<b># of fish</b>	<b>Latitude</b>	<b>Longitude</b>
<b>Juniper</b>	Miramichi Headwaters Salmon Association	6000	46.51831	-67.17829
<b>Clearwater</b>	J.D. Irving Ltd.	10000	46.55475	-67.16395
<b>Clearwater</b>	MSA and Clearwater and Rocky Bend Camps	5000	46.63315	-66.75891

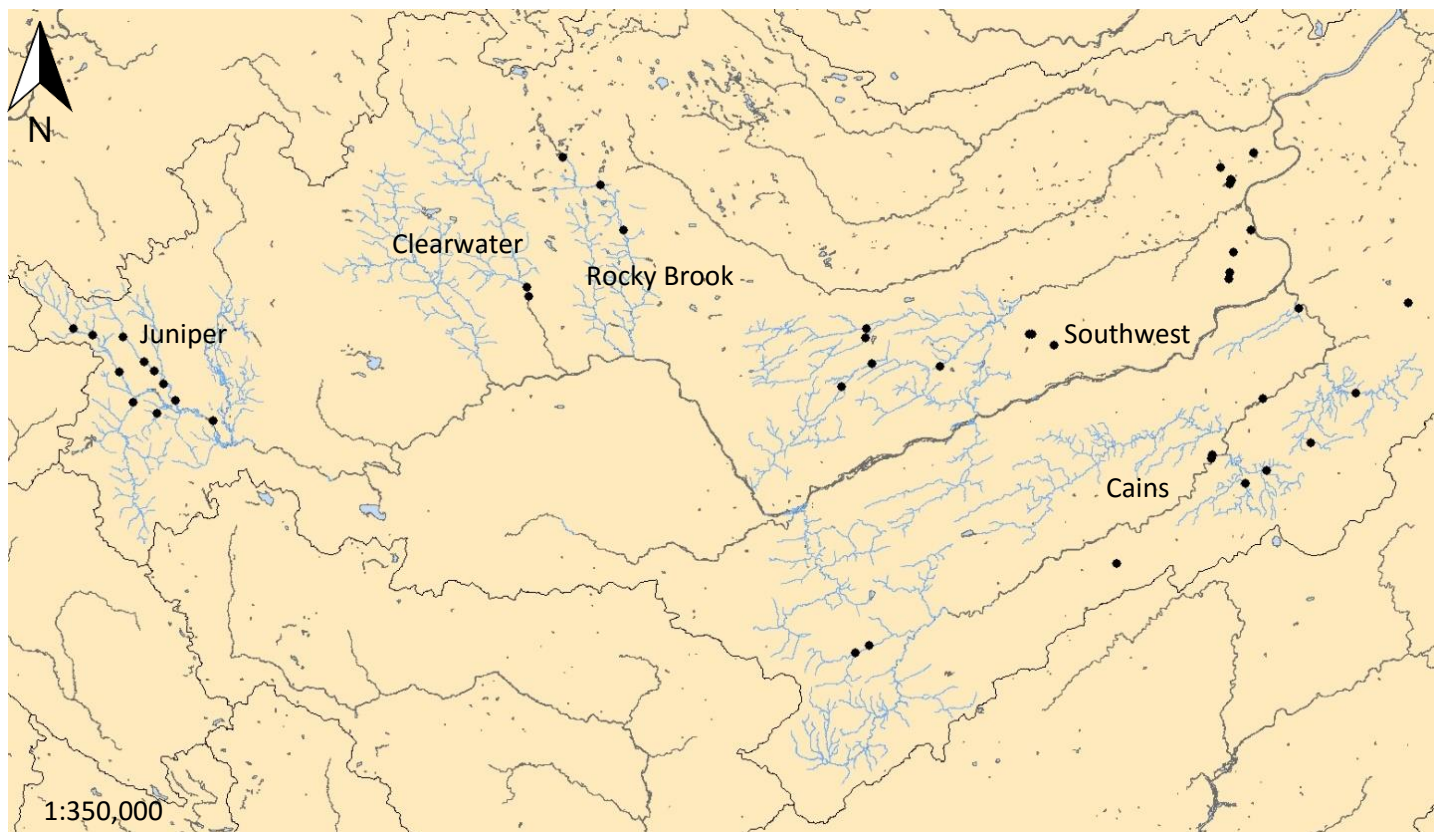
Table 4. Distribution of brook trout parr and yearlings to satellite tanks for continued growth and stocking.

<b>Stock Origin</b>	<b>Organization</b>	<b># of fish</b>	<b>Latitude</b>	<b>Longitude</b>
<b>Beadle Brook</b>	J.D. Irving Ltd.	40000	46.55475	-67.16395
<b>Moose Lake</b>	Miramichi Headwaters Salmon Association	1200	46.51831	-67.17829





(a)



(b)

Figure 8. Stocking sites of salmon fry distributed on the Northwest (a) and Southwest (b) Miramichi Rivers in 2015.

## *Juvenile Electrofishing Assessment*

### **INTRODUCTION**

The Miramichi Salmon Association (MSA) continued its electrofishing program in 2015 to assess juvenile Atlantic salmon populations in the smaller tributaries of the Miramichi River watershed. The MSA also worked co-operatively with the Department of Fisheries and Oceans (DFO) Science Branch on another survey using historic baseline sites that are monitored on an annual basis to assess Atlantic salmon juvenile abundance on the Miramichi River system. Both electrofishing surveys target Atlantic salmon and brook trout juveniles, but other fish species are often collected as by-catch. In this report, Atlantic salmon juveniles are listed as fry and parr, with the parr consisting of 1+ and 2+ age classes. Wild salmon fry (0+) are typically less than 60mm in length in late summer. Wild parr vary in size by site, but are grouped together in length by year class and generally do not exceed 120mm. There is typically a higher abundance of fry than parr, as fewer salmon are present in successive age classes due to mortality and predation. If this trend is not observed, it could be viewed as an indication that fry survival is low and should be investigated.

Electrofishing sites in both surveys are generally 3<sup>rd</sup> or 4<sup>th</sup> order streams and are tributaries to major rivers where salmon historically spawn; however sites may also include some main river locations. The tributary streams are the major focus of the MSA electrofishing program as they are considered feeder streams to the major rivers and can be under-seeded with juvenile salmon in the event adults were unable to access these areas to spawn (i.e.: barriers, low water levels). Generally, swift moving water less than 60cm deep with gravel or rocky substrate is characterized as juvenile salmon habitat. Adult salmon migrate as far upstream as possible to spawn, but juveniles in their first, second, or third year can move around quite extensively in search of food, to avoid predation, or to seek out over-wintering habitat. During the warm water periods in the summer months, juveniles (parr more often than fry) also move throughout the river seeking cold water refuge.

The main objectives for the 2015 annual electrofishing program were to:



1. Evaluate previous year's beaver dam removal success:

The Miramichi beaver dam management program resulted in 167 dams breached in 2014 over the entire Miramichi watershed. Upstream locations from where some of these dams were removed were a large focus for electrofishing crews in 2015 to determine if adult salmon were able to access these areas for spawning.

2. Evaluate spring stocking success:

Electrofishing surveys were conducted on stream stretches stocked with first-feeding fry in late June and early July of 2014 to assess fry survival rates. Stocked location densities that are higher than unstocked locations are considered to reflect successful survival of hatchery fry following stocking.

3. Determine future stocking sites of spring first-feeding fry:

Broodstock are collected annually from major rivers/streams in the Miramichi watershed and spawned at the Miramichi Salmon Conservation Centre (MSCC). The fry produced are returned to their native river system. In order to achieve effective stocking results in 2016, electrofishing surveys were carried out during the summer of 2015 to identify high quality juvenile habitat (gravel, or rocky substrate) with low fry and parr densities. Determining wild densities allows for avoidance of overstocking areas with healthy juvenile densities and for the targeting of tributaries that are naturally under-seeded or devoid of juvenile salmon. Any site containing more than 50 fry/100m<sup>2</sup> is not considered for stocking as it appears to reflect a healthy natural population, where sites with densities below this value are considered for stocking.

4. Estimate juvenile abundance using baseline locations:

Juvenile Atlantic salmon abundance surveys were conducted in partnership with DFO. These surveys monitor baseline sites, some of which have been electrofished for over 40 years, and allow for the estimation of absolute juvenile abundance in these areas.

## METHODS

Electrofishing is the use of electricity for the active capture of fish; electricity is generated by a battery located on the backpack of the electrofisher. An anode wand (positive) and cathode tail (negative) are placed in the water. The electric current moving between the wand and tail produce an electric field which can render fish immobile (galvanonarcosis) or cause them to move towards the electrofisher (galvanotaxis). A crew of three people wearing water tight chest waders and rubber gloves enter the site facing upstream. While the electrofisher stuns the fish, the other crew members collect the fish with dip nets and a small seine net as the fish are drawn up to the water surface by the electrical current. The fish are placed in a bucket of water and held until the site is completed.

There are two methods for measuring density in a given area: catch-per-unit-effort (CPUE) and closed-site depletion (or removal). The MSA survey for assessing headwater areas for stocking uses the CPUE method exclusively. CPUE sweeps are continued back and forth along the stream from bank to bank until a predetermined amount of time has elapsed on the electrofisher, approximately 200-500 seconds depending on the site. CPUE calculations are standardized so all densities reflect a 500 second sampling time and 100m<sup>2</sup> area to allow for comparisons. The crew then samples the captured fish on shore for length and abundance counts for each species. The fish are then released back into the stream. The depletion method, only performed during the MSA/DFO juvenile assessment, is done by capturing all fish from a measured section of stream rather than the timed CPUE method. A 200m<sup>2</sup> section of stream is measured and barricaded with fine nets at the upper and lower ends of the site. This “closed site” is then swept three to four times, removing all fish or until an acceptable reduction in fish occurs (usually four sweeps). This method produces an actual density for a known area and is used to calibrate the formula for the timed CPUE method.

All fish are identified to species and lengths and weights are recorded. Substrate type (rocky, gravel, etc.), stream type (riffle, run, etc.), water and air temperature, site dimensions, and GPS locations are recorded.

## RESULTS

A total of 87 electrofishing sites were assessed by MSA and DFO field crews between August 7<sup>th</sup> and October 21<sup>st</sup>, 2015 on the Miramichi River system. MSA alone surveyed 29 sites, while MSA and DFO worked together on 58 sites.

### Beaver dam removal success from previous year

In total, 76% (22/29) of the sites electrofished in 2015 focused on areas upstream of beaver dams removed in 2014 (18 on the Southwest and 4 on the Northwest). Nine of these sites had fry present, with fry densities ranging from 0 to 74.2 fry/100m<sup>2</sup> (Table 5). Sites with fry present were in lower to midstream reaches of the tributaries, suggesting adult salmon did make it past dams that were breached in the lower sections, but were not able to access the more upstream habitat. Beavers can repair active dams within a 24 hour time frame, so the timing of notching/removing dams is crucial in helping the fish access ideal spawning habitat. Field crews can only access and remove so many dams per day and the efficiency of the beavers in repairing them can still pose problems for adult salmon migrating upstream to spawn.

### Evaluating spring stocking success

Only seven sites (of 29) were surveyed to assess the previous year's stocking success because of the large focus put on surveying areas upstream of beaver dams removed in 2014. Of these seven sites, five of them contained parr and four of those had greater than 5 parr/100m<sup>2</sup> (Table 6). The high survival of first-feeding fry at stocked sites can help to increase the overall juvenile salmon production in the river, therefore the MSA will continue to stock first-feeding fry in the future.

### Determine future stocking sites of spring first-feeding fry:

Many of the sites surveyed to assess beaver dam removal success from 2014 were good quality habitat for juvenile Atlantic salmon. Only nine of the 22 sites surveyed contained fry in 2015, which leaves 13 sites available for potential stocking locations in 2016 (Table 5).

Table 5. Salmon fry abundance assessments calculated using the CPUE method for 22 sites electrofished in 2015 by the MSA upstream of beaver dams removed in 2014.

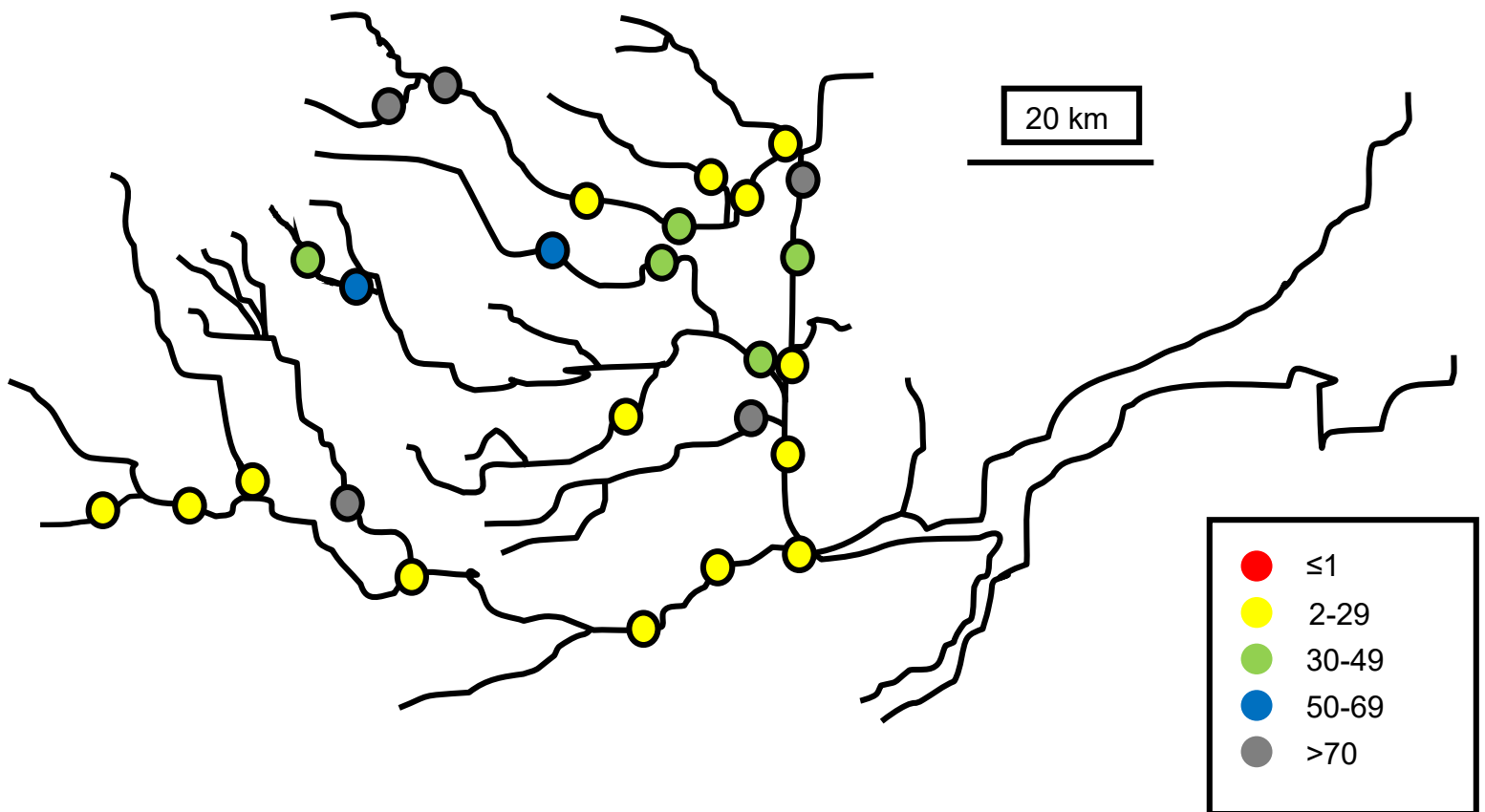
<b>River</b>	<b>Site</b>	<b>Fry/100m<sup>2</sup></b>
MSW	Betts Mills Brook (upper)	0.0
MSW	Betts Mills Brook (middle)	0.0
MSW	Betts Mills Brook (lower)	3.6
MSW	Big Hole Brook (upper)	28.1
MSW	Big Hole Brook (middle)	0.0
MSW	Big Hole Brook (lower)	0.0
MSW	Crooked Bridge Brook	0.0
MSW	Porter Brook (upper)	0.0
MSW	Porter Brook (lower)	28.8
MSW	Burntland Brook	0.0
MSW	Mckinley Brook	0.0
NW	Below bridge on CI road	5.5
NW	Bellefond	0.0
NW	Little River (upper)	7.0
NW	Little River (lower)	13.9
Cains	Muzzeroll Bk (bridge on GL road)	6.6
Cains	Otter Brook (below bridge)	0.0
MSW	South branch in Juniper above Foreston bridge 1	19.6
MSW	South branch in Juniper above Foreston bridge 2	74.2
MSW	Elliott Brook (upper)	0.0
MSW	Elliott Brook (lower)	0.0
MSW	Big Teague	0.0

Table 6. Juvenile abundance assessments calculated using the CPUE method for 7 sites electrofished by the MSA to identify stocking success from 2014.

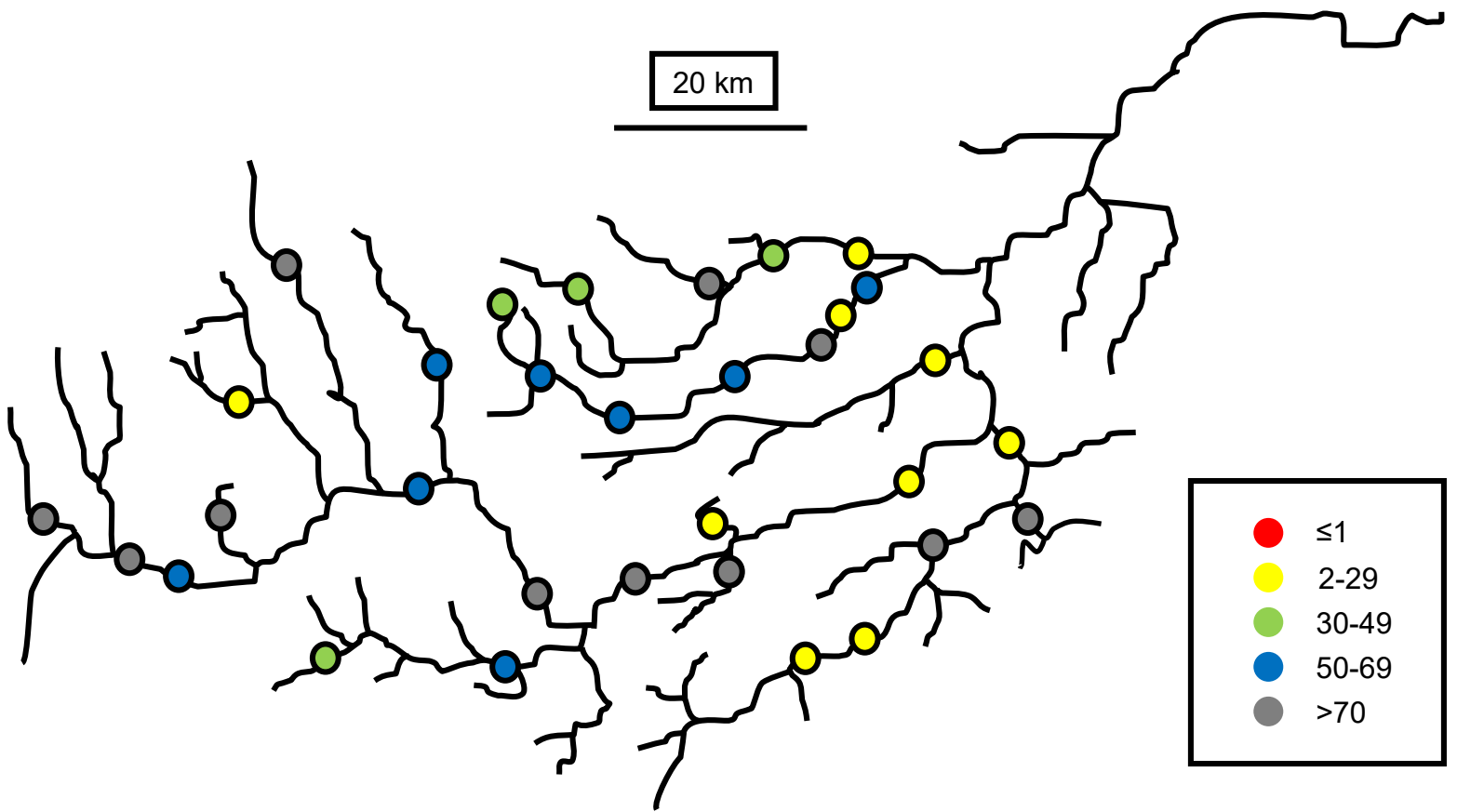
<b>River</b>	<b>Site</b>	<b>Parr/100m<sup>2</sup></b>
Cains	Sling Dung Brook	17.0
Cains	McKinley Brook	9.7
NW	Pats Brook	1.1
MSW	Moore's Donnelly Brook	6.8
MSW	Burntland Brook 1 (main)	8.7
MSW	Burntland Brook 2 (west branch)	0.0
MSW	Burntland Brook 3 (east branch)	0.0

Juvenile population assessment survey (MSA/DFO)

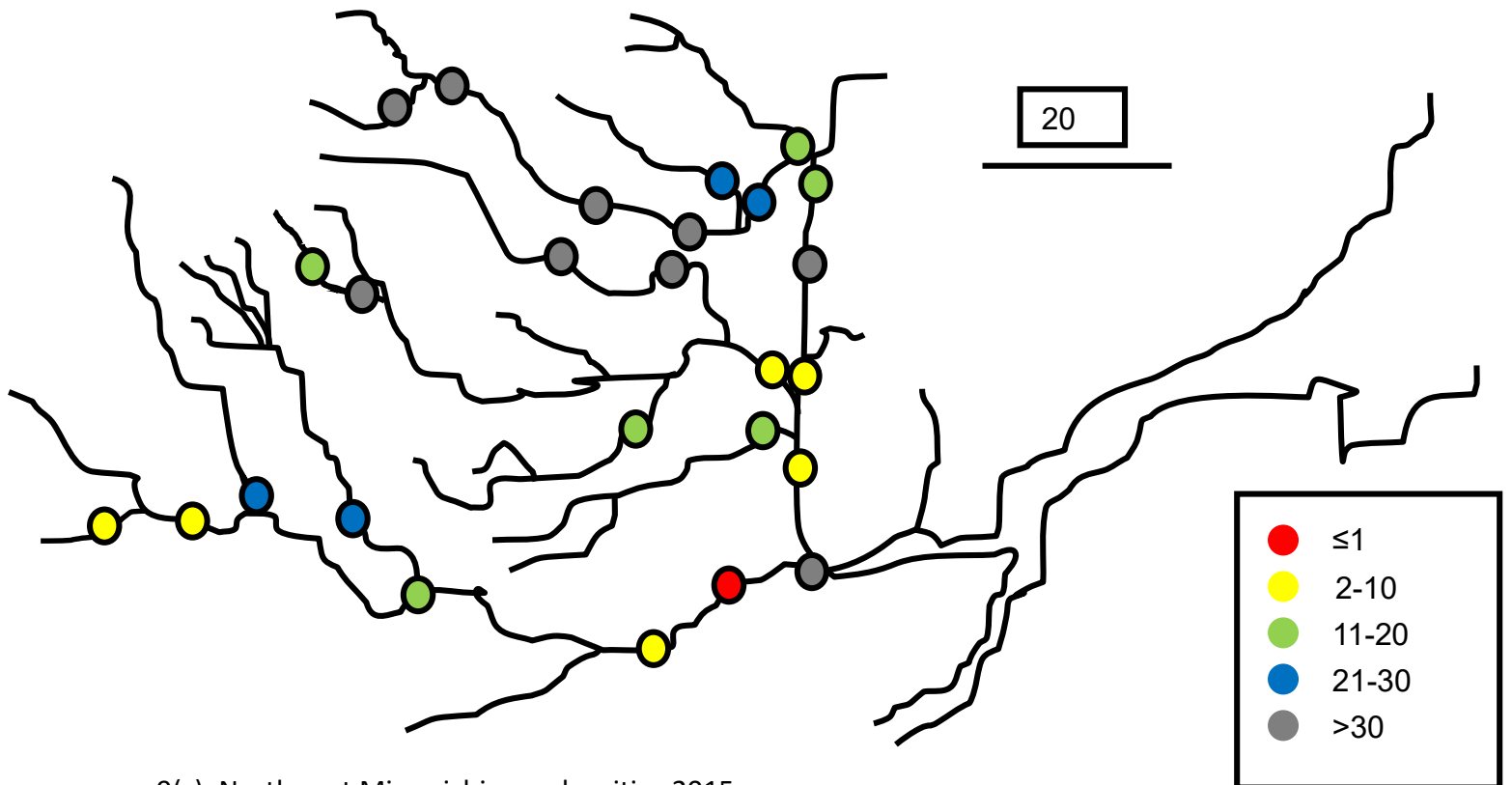
From August 24<sup>th</sup> to September 24<sup>th</sup> 2015, a total of 58 baseline sites were electrofished in several tributaries as part of the MSA/DFO cooperative program. Preliminary results from the assessment revealed high fry densities at many sites in both the Northwest and Southwest Miramichi Rivers, as 60% (35/58) of all sites contained greater than 30 fry/100m<sup>2</sup> (Fig 9a&b). No site contained zero fry and 40% (23/56) of sites had between 30 and 50 fry/100m<sup>2</sup>. Parr densities were high (>20 parr/100m<sup>2</sup>) at 48% (28/58) of sites, and only 5% (3/58) of sites contained zero parr (Fig 9c&d).



9(a). Northwest Miramichi fry densities 2015.

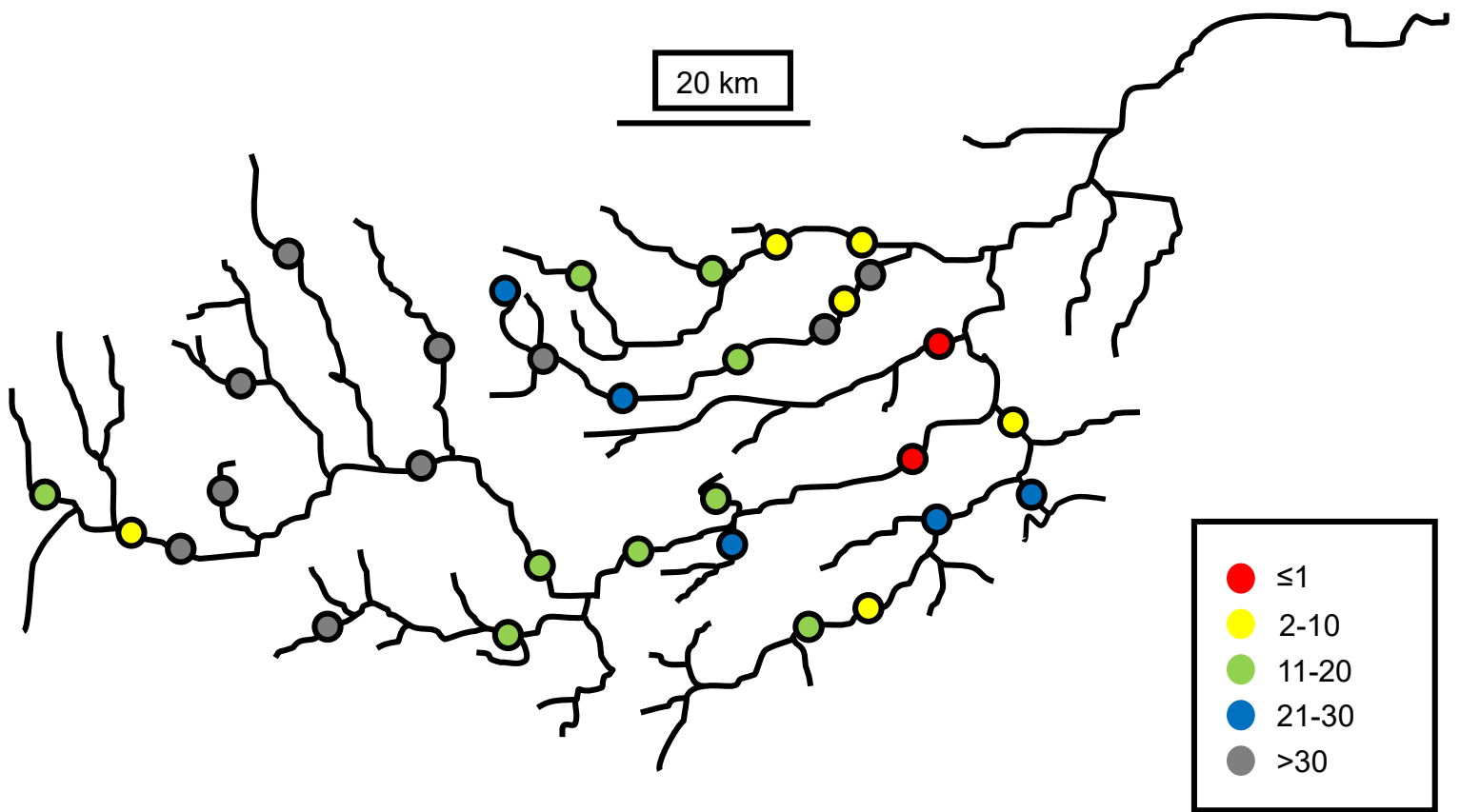


9(b). Southwest Miramichi fry densities 2015.



9(c). Northwest Miramichi parr densities 2015.





9(d). Southwest Miramichi parr densities 2015.

Figure 9: Preliminary juvenile density results from the 2015 DFO/MSA annual electrofishing program – (a) fry densities at sites on the Northwest Miramichi River system, (b) fry densities at sites on the Southwest Miramichi River system, (c) parr densities on the Northwest Miramichi River system, (d) parr densities on the Southwest Miramichi River system. Fry densities range from  $\leq 1$ , 2-29, 30-49, 50-69, and  $>70$  per 100m<sup>2</sup>. Parr densities range from  $\leq 1$ , 2-10, 11-20, 21-30, and  $>30$  per 100m<sup>2</sup>.

## *Cold Water Pool Restoration*

### **INTRODUCTION**

Pools that are located directly downstream of cold water brooks can be critically important habitat to adult and juvenile salmon during warm water events in the main stem of a river. The presence of these pools creates areas of thermal refugia during times of high water temperatures, where large numbers of salmon and trout, of various life stages, can hold position until surrounding water temperatures decrease. Without isolated pockets of cold water, these fish would be forced to remain exposed to warm water conditions that lead to physiological stress and potential mortality. With the current understanding of climate change science, the Miramichi watershed is likely to see an increase in the frequency, intensity, and duration of warm water events during the summer, particularly in the lower reaches of the river which are less influenced by colder groundwater sources. The Miramichi Salmon Association has identified these pools as habitat of significant value in protecting adult and juvenile salmon.

Pools within a river can become degraded in quality from a variety of natural and anthropogenic sources. Regardless of the cause, the degradation of a salmon pool typically reduces the number of fish which would have previously been found in this water. In the case of cold water pools however, fish will still attempt to hold in these areas during warm water events despite reduced habitat quality (shallow water, changes in water flow or substrate composition) to avoid thermal stress. Salmon that use this habitat may become more exposed to predation, poaching, or reduced benefit of cold water due to changes in stream flow.

### **RESULTS**

The MSA completed restoration work on four brooks in 2015: Doak Brook and Indiantown Brook on the Southwest and Otter Brook and Pat's Brook on the Northwest.

#### *Doak Brook*

This brook enters the SW Miramichi River on the right (south) bank and flows into relatively deep water. The mouth of the brook has been widening over time, which has resulted

in reduced energy flow and inhibited the brook's cold water from reaching far enough into the river where the salmon prefer to hold in deeper water during the low flow and increased temperature months in the summer.

A rock toe was installed at the mouth of the brook, to increase the energy, along the right bank. A nature-like point bar was also installed on the downriver side of the confluence which will direct cold water into the deeper area of the river where the salmon hold. An embedded rock toe was also installed to help the brook transition into the river.

The habitat enhancement work was completed on September 14<sup>th</sup>, with further enhancement following on September 26<sup>th</sup> with the installation of a large cement pad boat ramp. This ramp will prevent tire spinning and erosion when boats are launched in this area, which is located within the cold water plume of the brook.



New boat ramp



Point bar at Doak Brook



### Indiantown Brook

This brook is located in Quarryville, an area in the lower stretch of the river system, and flows from the left (north) bank and enters the Miramichi River in a deep area, creating a cold water refuge for Atlantic salmon during warm water periods. The site is easily accessible, rendering it susceptible to predation and poaching.

To enhance the habitat features, boulder clusters were installed in the existing pool. These clusters will cause flow separation around the rocks, which forms eddies. These eddies diffuse sunlight, providing overhead cover for fish. This altered flow also generates scour that form pockets of deeper water and promote settling of coarse substrate which improves substrate diversity. Such features provide ideal conditions for juvenile and adult salmonids. These boulder clusters will also discourage poaching efforts, as fish will not be as easily spotted and nets will no longer sweep cleanly through the pool.

The habitat enhancement work was completed on September 17<sup>th</sup>.



Rock clusters installed at Indiantown Brook



### Otter Brook

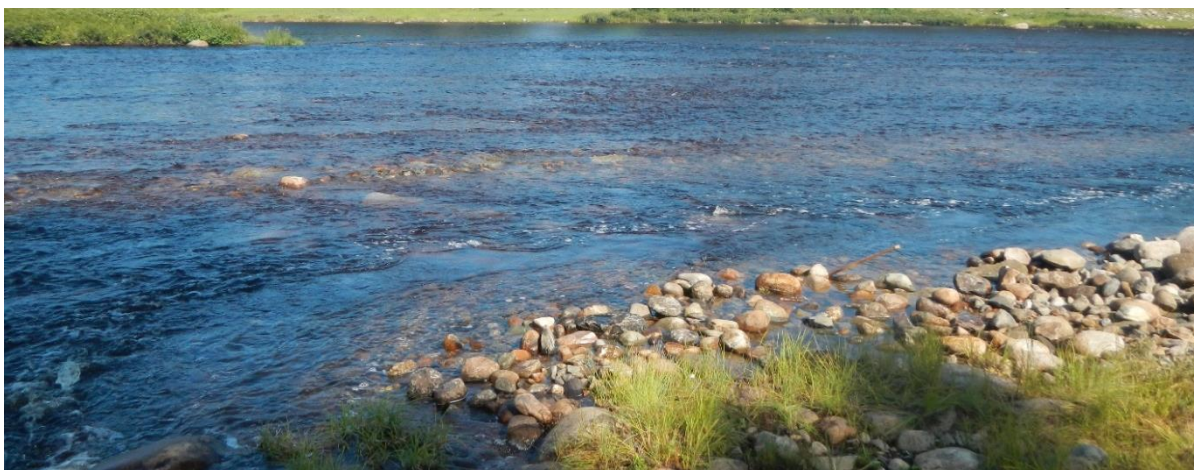
This brook is located 6.5km downstream of Catamaran Brook and enters the Little Southwest (LSW) Miramichi River on the right (south) bank. The LSW is very shallow in this area during typical low summer flows, and the cold water plume created by the brook is known to provide thermal refuge for juvenile salmon. Enhancing the plume will transform the area into a refuge for adult Atlantic salmon as well.

The water depth was increased at the mouth of the brook by installing a rock v-weir upstream in the LSW to concentrate flow and encourage scouring at the mouth of Otter Brook. The v-weir was set at an elevation so as to create scour and direct flow from the shallow river into a concentrated area where the cold water meets the river. Rock spurs were also installed downstream of the confluence to keep the cold water plume turned away from the shallow riverbank and to help scour and maintain deeper water in the refuge zone. A row of embedded boulders were placed near the outer edge of the cold water plume so in summer low flows, cold water from the brook is able to concentrate in the scoured area without mixing with warm river water.

The habitat enhancement work was completed on September 16<sup>th</sup>.



Enhancement work on Otter Brook



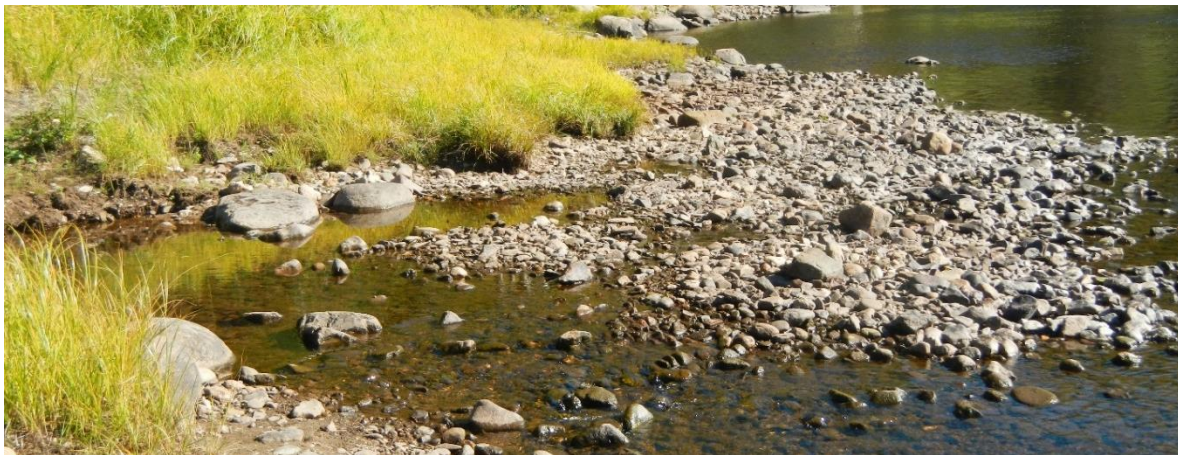
Rock weir completed

### Pat's Brook

This brook is located 6.8km upstream of Trout Brook and enters the Northwest Miramichi River on the left (north) bank. The river is shallow in this area during typical low summer flows and the cold water plume created by the brook is known to provide thermal refuge for juvenile salmon.

A rock v-weir was installed upriver set at an elevation that will create scour at the mouth of the brook. This will direct flow from the shallow river into a concentrated area where cold water meets the river. Channel material was removed downstream of the v-weir to encourage flow direction and create greater depth in the refuge. Rock spurs installed with the v-weir will help keep the cold water plume turned away from the shallow riverbank and directed into the deeper pool.

The habitat enhancement work was completed on September 28<sup>th</sup>.



Pat's Brook before



Pat's Brook after



Two more brooks have been identified by the MSA for habitat enhancement work (Figure 10). Parks Brook on the LSW was surveyed in 2015 and restoration work is expected to occur in 2016. Salmon Brook on the Cains River will be surveyed in 2016 and work completed in 2017, subject to funding.

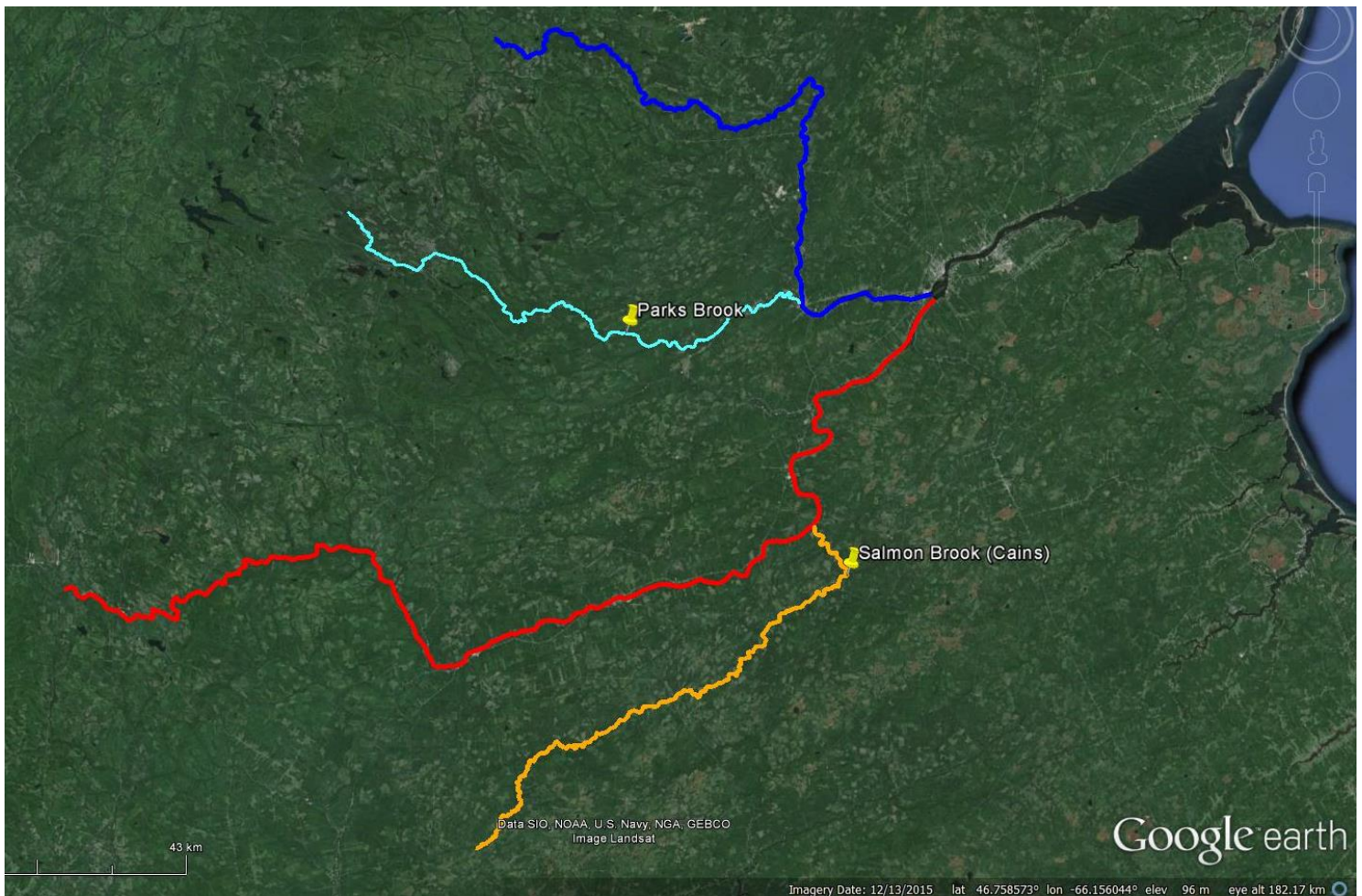


Figure 10. Locations of brooks for habitat enhancement work in 2016 and potentially 2017. Parks Brook is located on the LSW (light blue) and Salmon Brook is located on the Cains (orange).

## *Beaver Dam Management*

### **INTRODUCTION**

Beaver dams are known barriers to adult Atlantic salmon migrating upstream to spawn, blocking access to habitat in the upper reaches of brooks and streams. Female salmon have been observed below beaver dams in large numbers and are forced to build multiple redds in confined areas of the stream, often with habitat of lower quality than would otherwise be available. The survival of eggs in these crowded, overlapping redds is severely reduced and can negatively impact juvenile salmon production within the stream. Upstream areas of brooks and streams are often excellent spawning and juvenile habitat with a high percentage of gravel and cobble substrates, cold ground fed water, and low numbers of predators. After several years of blocked access, these upstream reaches run the risk of becoming devoid of salmon fry and parr which can potentially lower the number of stream imprinted adult salmon returning to these areas. Improving access to upstream habitat on individual streams could be beneficial to egg survival and juvenile production. If upstream habitat on multiple streams within a watershed is improved the total number of returning adult salmon in the following years could be increased.

To achieve the maximum benefit of dam breaching efforts, the timing of behaviour changes and movements of salmon must be considered. On the Miramichi River these fish typically begin moving out of large holding pools, and travel upstream to find spawning habitat, from late September to late October. Salmon are likely to encounter beaver dams in these upstream areas with high populations of beavers. Small dams may not pose much of an issue during high water flows, as the fish are able swim over them, but large dams will stop any further upstream movements. Beavers can repair active dams within a 24 hour time frame, which means the notching or removal of the dams must be correctly timed with the upstream migrations of the salmon so as to not waste time and resources.

Beaver dam removal initiatives by the Miramichi Salmon Association in the past have shown potential as a tool for salmon conservation. Several locations within the watershed have shown improved juvenile counts after the dams were notched during critical salmon migrations. Before 2006, very few salmon fry were found on Betts Mills Brook near Doaktown,

NB despite the construction of a fish ladder, just upstream from the mouth of the brook, at a highway crossing. In 2006 a large beaver dam blocking the fish ladder was removed, and an additional 21 dams were notched or removed on the brook. This opened more than 50,000m<sup>2</sup> of spawning habitat for the salmon. Electrofishing results by DFO and MSA showed salmon fry present in Betts Mills Brook the following year. Big Hole Brook (also near Doaktown) and Porter Brook (near Boiestown) both have high quality salmon habitat and with the removal of dams on these watercourses adults were able to access to upstream sections. High densities of salmon fry were noted in both of these brooks the following year.

By providing access to crucial spawning habitat for adult Atlantic salmon in the Miramichi River, we will ensure that a strong juvenile production rate is maintained. High numbers of juvenile salmon migrating to the ocean could potentially increase the number of adult salmon returning, improving the conservation outlook for this iconic Miramichi River species.

## **METHODS**

Miramichi Salmon Association staff flew helicopter and fixed wing aircraft reconnaissance flights on the Northwest and Southwest Miramichi watersheds to locate and GPS beaver dams. Flight paths for 2015 were determined ahead of time based on last year's results and known beaver activities in given areas. The first flight was done September 17<sup>th</sup> using a fixed wing aircraft that surveyed four tributaries on the Northwest system (Little River, the north branch of the North Sevogle River, the Little Sevogle River, and the Northwest Millstream) and four tributaries on the Southwest system (Bartholomew River, Sabbies River, Six Mille Brook, and Muzzeroll Brook). The second day of flying was done on October 14<sup>th</sup>, using a helicopter, and surveyed ten tributaries on the Southwest system: Burntland Brook, Porter Brook, Salmon Brook, Rocky Brook, Sisters Brook, Clearwater Brook, Burnthill Brook, the south branch of the Main Southwest River, Big Teague Brook, and Elliott Brook.

Any dams discovered were marked with hand-held Garmin GPS units and mapped using Google Earth and ArcGIS software to coordinate ground crew activities. Dams were accessed on foot and removed when possible, otherwise stream sections were canoed to remove the

impoundments. Field crews began accessing and removing dams on October 7<sup>th</sup> and finished on October 28<sup>th</sup>. A small number of active dams were notched on multiple occasions following repairs by beavers.

## RESULTS

In the Northwest Miramichi basin, eight dams were breached by field crews on two tributaries – Little River and the upper Northwest Millstream. On the Little Sevogle River and lower Northwest Millstream, a total of five dams were observed, but they were washed out and required no further breaching (Figure 11). In the Southwest Miramichi basin, 27 dams were breached by field crews on eight tributaries (Bartholomew River, Big Hole Brook, Betts Mills Brook, Salmon Brook, Porter Brook, Big Teague, Little Teague, and Elliott Brook). A further 15 dams were observed on the Bartholomew River, Big Hole Brook, Muzzeroll Brook, Betts Mills Brook, and the East Sabbies River, but these too were washed out and required no further work (Figure 12a&b). Two dams on Little River and one on Porter Brook were breached a second time after beavers had repaired them. A total of 55 dams were breached in 2015; 35 by MSA field staff and 20 by heavy rains that washed the dams away.

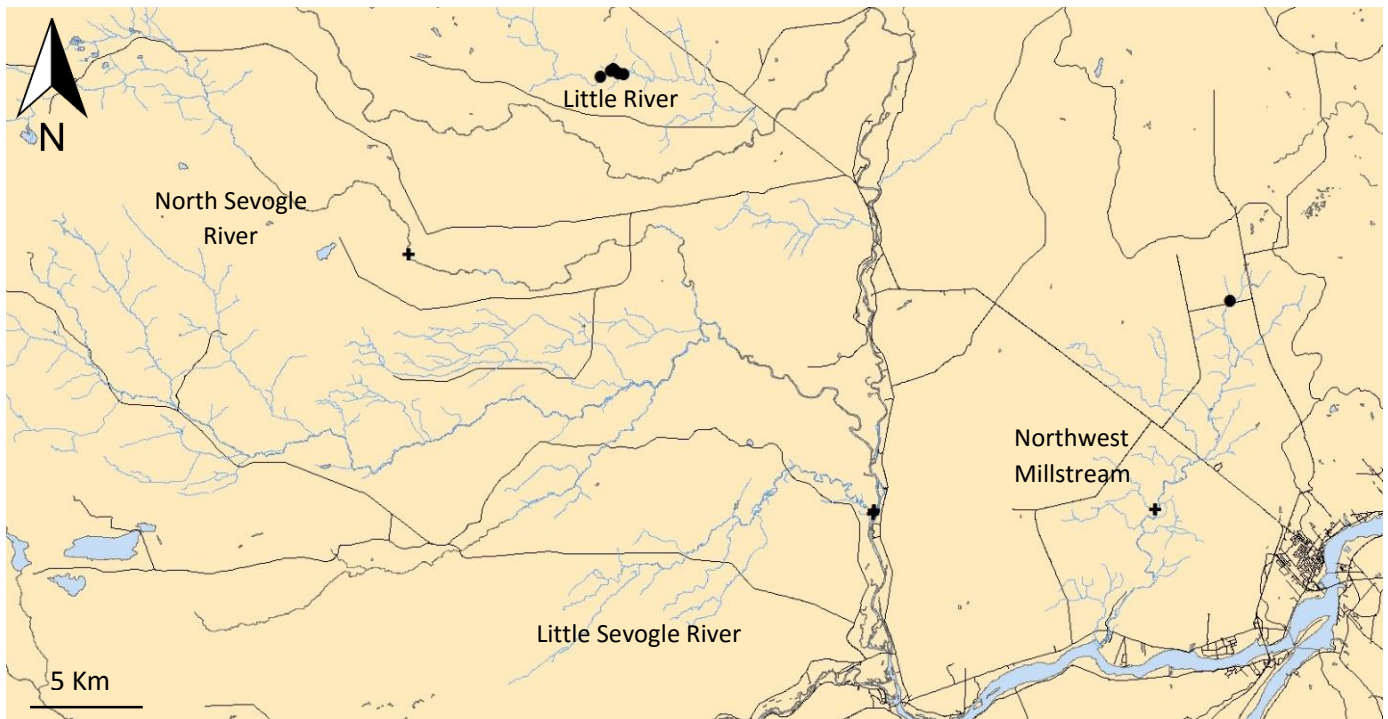


Figure 11: Tributary rivers and streams in the Northwest Miramichi watershed where beaver dam breaching/removal took place in 2015. Dams removed/breached by MSA staff are marked with a “•”. Dams washed out from heavy rains are marked with a “+”.



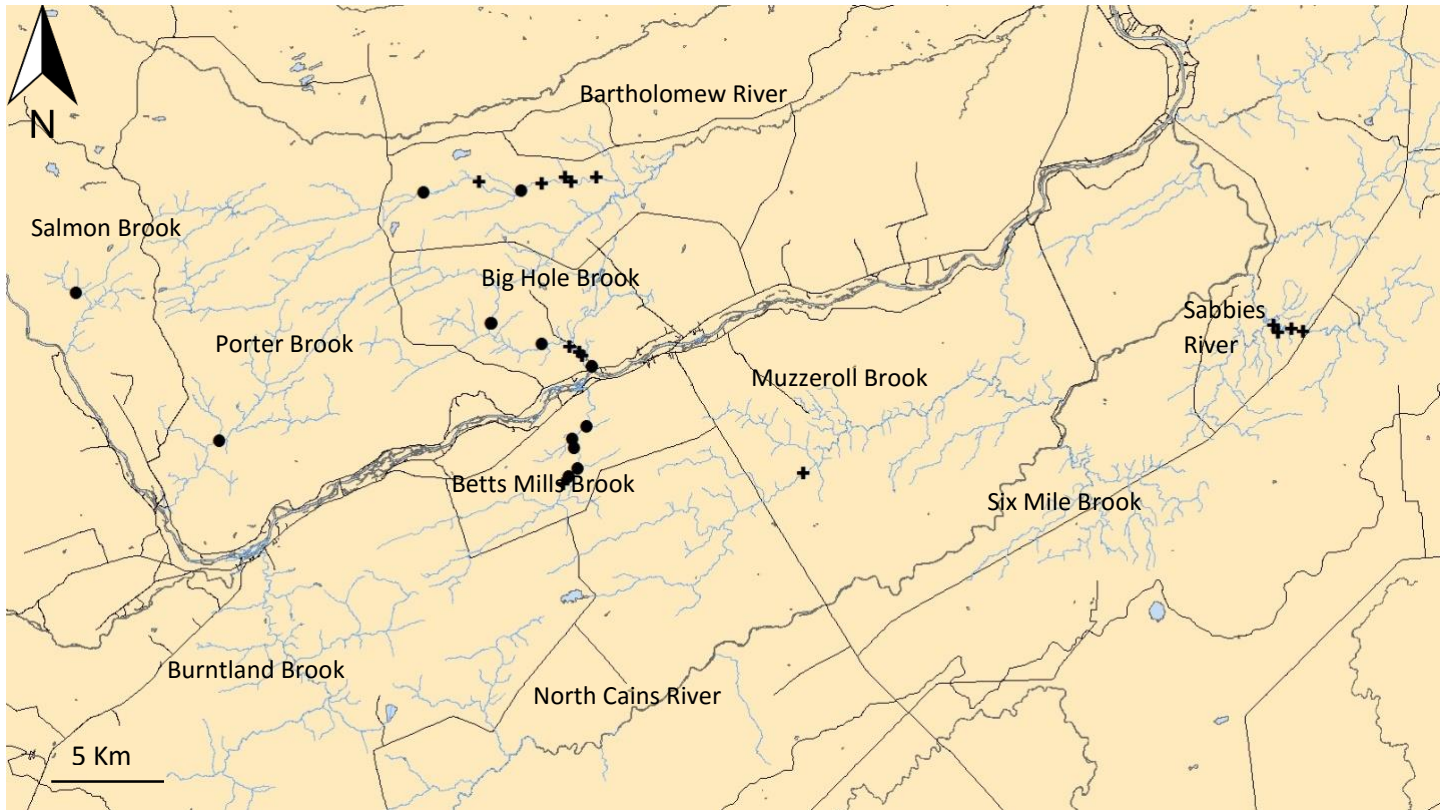


Figure 12a: Tributary rivers and streams in the Southwest Miramichi watershed where beaver dam breaching/removal took place in 2015. Dams removed/breached are marked with a “•”. Dams washed out from heavy rains are marked with a “+”.

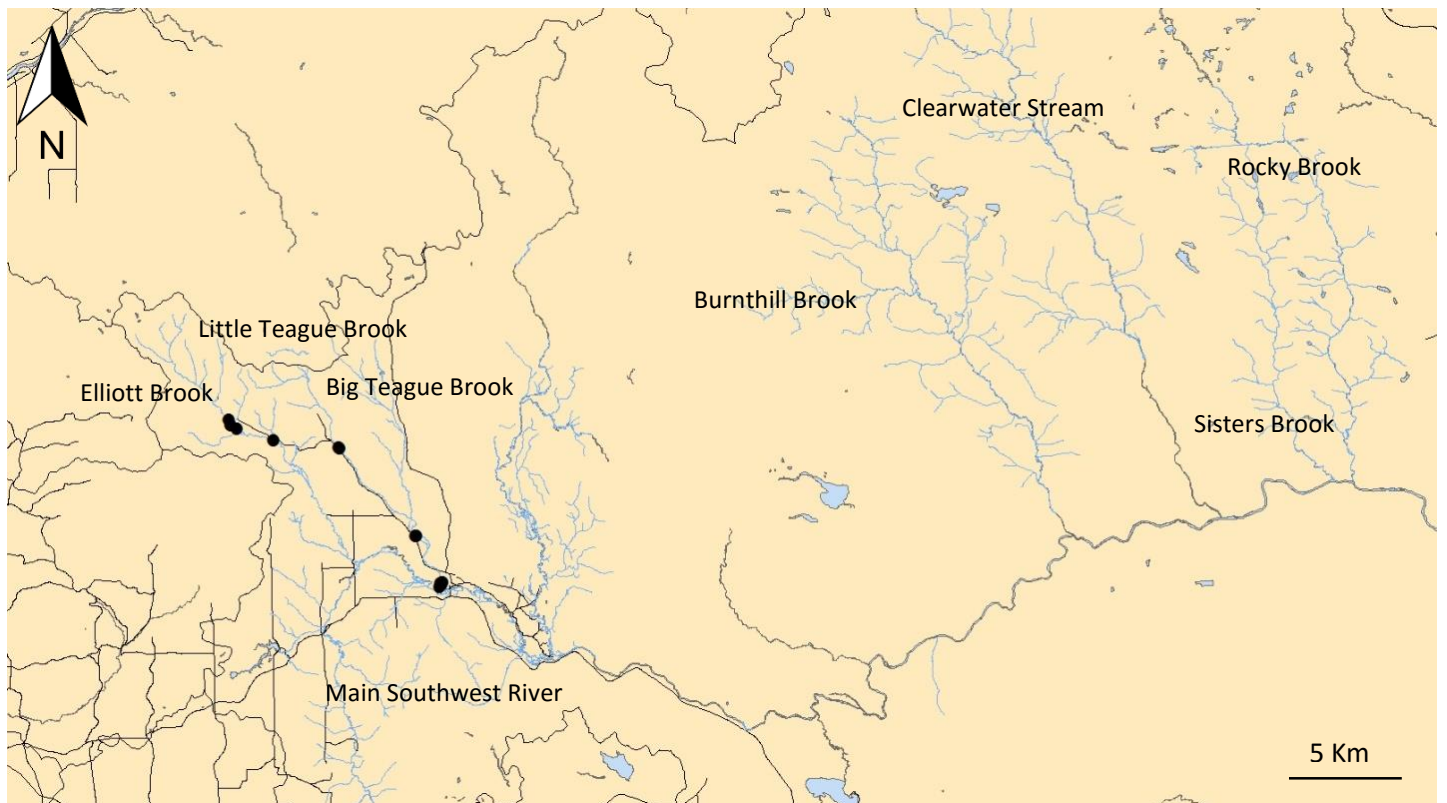


Figure 12b: Tributary rivers and streams in the Southwest Miramichi watershed where beaver dam breaching/removal took place in 2015. Dams removed/breached are marked with a “•”. Dams washed out from heavy rains are marked with a “+”.

## DISCUSSION

The Miramichi watershed has a large number of tributaries with beaver dam activities, more than would be possible for field crews to remove in the scope of this project. Flight paths for 2015 were chosen based on beaver activity locations noted in previous years, and focused on larger and wider tributaries of the Miramichi River which offered more clear line-of-site observations from the air of the dams, and on areas where river access was easy to moderately acceptable for field crews. Streams and brooks that are known spawning locations for salmon and have had high beaver activity in past years were not flown and were added to the dam removal list automatically (i.e.: Big Hole Brook, Betts Mills Brook). This method of conducting aerial surveys follows changes made in the 2014 program to try and maximize efficiency from the air by not flying areas that have commonly exhibited beaver activity.

A total of 43 dams/obstructions were observed from the air, however 55 dams were noted by field crews on the ground in 2015. Of the 55, 35 were removed by hand and 20 were washed out. The number of dams breached in 2015 was less than that of 2013 (112) and 2014 (167) because of a large rain storm that occurred on September 30<sup>th</sup> and October 1<sup>st</sup> in which over 140mm of rain fell in less than two days. Several roads and bridges were washed out with this volume of water, and many beaver dams were destroyed, thus reducing the number of dams MSA field staff could locate and therefore breach. The high water levels in 2015 made canoe runs very easy to facilitate down many tributaries. Larger dams that held up to the high water levels were easily visible and breached, whereas dams that were washed out were completely submerged and/or broken apart, which should allow easy access for fish migrating upstream. Salmon were observed on the Bartholomew River, Six Mile Brook, and the Little Sevogle River at the time of breaching.

Although beaver activity was present throughout the watershed, levels of activity varied between river systems. In the Southwest system, Burnthill Brook, Clearwater Stream, Sisters Brook, Rocky Brook, Salmon Brook, Porter Brook, and Burntland Brook all had relatively low levels of beaver activity whereas Elliott Brook, Big Teague Brook, Little Teague Brook, Bartholomew River, Big Hole Brook, and Sabbies Brook had much higher activity levels. In the



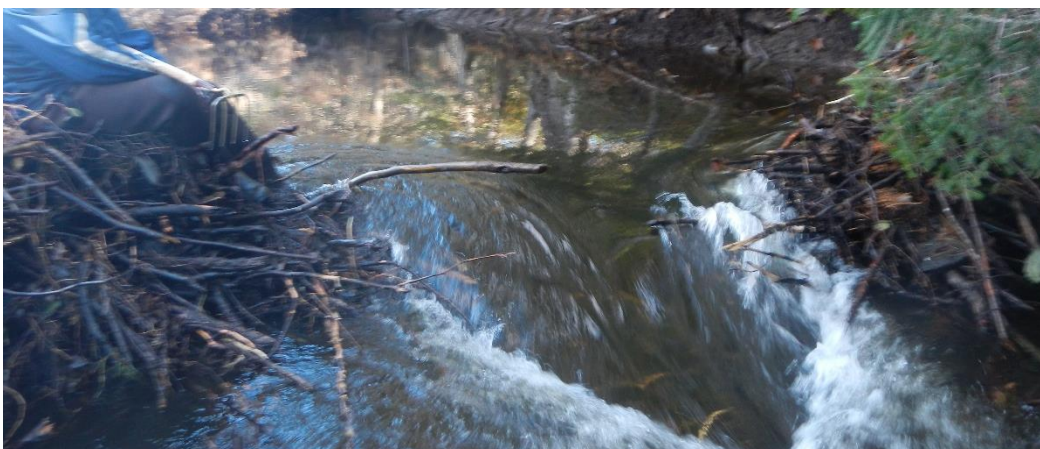
Northwest system, the north branch of the North Sevogle River and the Little Sevogle River had low levels of beaver activity and Little River and the Northwest Millstream had higher dam activity.

Over three quarters of the electrofishing surveys completed in the summer of 2015 by MSA focused on areas upstream of beaver dams removed in 2014; 18 on the Southwest and four on the Northwest. Nine of these sites had fry present and were located on Betts Mills Brook, Big Hole Brook, Porter Brook, Muzzeroll Brook, the Main Southwest River in Juniper, the Northwest Millstream, and Little River. These sites were in lower to midstream reaches of the tributaries, suggesting adult salmon did make it past dams that were breached in the lower sections, but were not able to access the more upstream habitat. Beavers can repair active dams within a 24 hour time frame, so the timing of notching/removing dams is crucial in helping the fish access ideal spawning habitat. Field crews can only access and remove so many dams per day and the efficiency of the beavers in repairing them can still pose problems for adult salmon migrating upstream to spawn.

In the summer of 2016 electrofishing surveys will be conducted upstream of dams breached/removed in 2015 to assess the impact of the program on fry production.



Dam on Porter Brook  
before



Dam on Porter Brook  
after

APPENDIX 2: GPS coordinates of breached/removed and washed out beaver dams in 2015.

Date	Site	Latitude	Longitude	Active/Inactive	Washed Out	Return Visit	Breached on Return
07-Oct-15	Little Sevogle	47.023151	-65.835995	UNK	Y	Y	N
07-Oct-15	Little Sevogle	47.024108	-65.835650	UNK	Y	Y	N
07-Oct-15	Little Sevogle	47.024540	-65.835800	UNK	Y	Y	N
10-Oct-15	NW Millstream	47.023826	-65.665233	UNK	Y	N	N/A
12-Oct-15	Little River	47.204830	-66.000170	Y	N	Y	Y
12-Oct-15	Little River	47.207381	-65.993882	Y	N	Y	N
12-Oct-15	Little River	47.207925	-65.991983	Y	N	Y	N
12-Oct-15	Little River	47.207402	-65.991212	Y	N	Y	Y
12-Oct-15	Little River	47.206447	-65.989251	Y	N	Y	N
12-Oct-15	Little River	47.206336	-65.988991	Y	N	Y	N
12-Oct-15	Little River	47.205939	-65.986025	Y	N	Y	N
14-Oct-15	Bartholomew	46.627798	-66.293046	Y	N	N	N
14-Oct-15	Bartholomew	46.637521	-66.257481	UNK	Y	N	N
14-Oct-15	Bartholomew	46.633310	-66.228450	Y	N	N	N
14-Oct-15	Bartholomew	46.636525	-66.214153	UNK	Y	N	N
14-Oct-15	Bartholomew	46.639415	-66.198137	UNK	Y	N	N
14-Oct-15	Bartholomew	46.637345	-66.193488	UNK	Y	N	N
14-Oct-15	Bartholomew	46.639449	-66.176238	UNK	Y	N	N
15-Oct-15	Big Hole Brook	46.570000	-66.249630	y	N	N	N
15-Oct-15	Big Hole Brook	46.570084	-66.249508	Y	N	N	N
15-Oct-15	Big Hole Brook	46.559842	-66.214634	Y	N	N	N
15-Oct-15	Big Hole Brook	46.549240	-66.179800	Y	Y	N	N
15-Oct-15	Big Hole Brook	46.549240	-66.179800	Y	N	N	N
15-Oct-15	Big Hole Brook	46.558602	-66.195183	UNK	Y	N	N
15-Oct-15	Big Hole Brook	46.556058	-66.188325	UNK	Y	N	N
15-Oct-15	Big Hole Brook	46.554216	-66.186349	UNK	Y	N	N
16-Oct-15	Muzzeroll Brook	46.497760	-66.033910	UNK	Y	N	N
17-Oct-15	Betts Mills Brook	46.493080	-66.200117	UNK	Y	N	N
17-Oct-15	Betts Mills Brook	46.496350	-66.196300	Y	N	N	N
17-Oct-15	Betts Mills Brook	46.500350	-66.189700	Y	N	N	N
17-Oct-15	Betts Mills Brook	46.510230	-66.192350	Y	N	N	N
17-Oct-15	Betts Mills Brook	46.514480	-66.193333	Y	N	N	N
17-Oct-15	Betts Mills Brook	46.520500	-66.183717	Y	N	N	N
19-Oct-15	Salmon Brook	46.584630	-66.537550	Y	N	N	N
20-Oct-15	Porter Brook	46.514040	-66.438330	Y	N	Y	Y
21-Oct-15	North Sevogle	47.131850	-66.117240	UNK	Y	N	N
22-Oct-15	East Sabbies	46.563213	-65.686426	UNK	Y	N	N
22-Oct-15	East Sabbies	46.564717	-65.694371	UNK	Y	N	N
22-Oct-15	East Sabbies	46.562960	-65.704003	UNK	Y	N	N
22-Oct-15	East Sabbies	46.566502	-65.707165	UNK	Y	N	N
22-Oct-15	Big Teague	46.552165	-67.230165	Y	N	N	N
22-Oct-15	Big Teague	46.552081	-67.229878	Y	N	N	N
22-Oct-15	Big Teague	46.551752	-67.230921	Y	N	N	N
23-Oct-15	Elliott Brook	46.615594	-67.341997	Y	N	N	N
23-Oct-15	Elliott Brook	46.622433	-67.370073	Y	N	N	N
23-Oct-15	Elliott Brook	46.620990	-67.366187	Y	N	N	N

Date	Site	Latitude	Longitude	Active/Inactive	Washed Out	Return Visit	Breached on Return
23-Oct-15	Elliott Brook	46.624925	-67.371614	Y	N	N	N
24-Oct-15	Little Teague	46.612972	-67.298694	Y	N	N	N
24-Oct-15	Little Teague	46.612626	-67.298435	Y	N	N	N
24-Oct-15	Little Teague	46.573083	-67.247694	Y	N	N	N
24-Oct-15	Little Teague	46.572947	-67.247475	Y	N	N	N
25-Oct-15	Big Teague	46.552050	-67.230019	Y	N	N	N
25-Oct-15	Big Teague	46.550800	-67.230620	Y	N	N	N
25-Oct-15	Big Teague	46.550167	-67.231583	Y	N	N	N
28-Oct-15	NW Millstream	47.044673	-65.636463	Y	N	N	N