# Miramichi Salmon Association

# Conservation Field Program Report

# 2014

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## Acknowledgements

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The MSA would also like to recognize the efforts and expertise of the organizations which partnered in and supported field programs during 2014. The ongoing work between MSA and the Atlantic Salmon Federation allowed for further research into the movements of both kelt and smolt through the Miramichi River into the marine environment. The Northumberland Salmon Protection Association continued with their technical support of the smolt estimate, operating the Sevogle smolt wheel to provide additional tags for this study. Staff with the Department of Fisheries and Oceans provided technical assistance to operate and deploy equipment for the smolt estimate. The MSA would also like to thank J.D. Irving Ltd for donating a helicopter to perform aerial surveys for the beaver dam program, and both the Rocky Brook Camp and the Miramichi Headwaters Salmon Federation for assisting in stocking and broodstock collection. Electrofishing data donated by the White Rapids and other Small Streams Enhancement Association will be used in future years to determine stocking locations. A special thanks to all the volunteers who helped fish for kelt and collect broodstock. The MSA is grateful to all those who assisted in the safe and successful delivery of the 2014 field program.

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 2014 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 5 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.

# **Miramichi 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 Miramichi are broken into two life history stages: alternate spawners, which move through the GOSL before migrating to the North Atlantic to spawn the following year, and consecutive spawners which remain in the Gulf for several months before returning to spawn the same year. There is a large biological and socio-economic importance related to repeat spawners as these fish are generally larger in size than maiden salmon making them more desirable for catch and release, and they also contribute a significant amount of eggs to the river system, and are likely to produce larger eggs with an increased chance of survival than those of smaller fish.

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 five days of no detected pressure change (assumed morality). 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$^2$ 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$^2$) and the Northwest Miramichi River (2,078 km$^2$) 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 4$^{th}$ – 11$^{th}$, 2014. 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.

Mircrowave 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 12 Vemco VR2w acoustic receivers were placed throughout the tidally influenced portions of the Northwest, Southwest, and main stem Miramichi Rivers 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 (Figure 1).

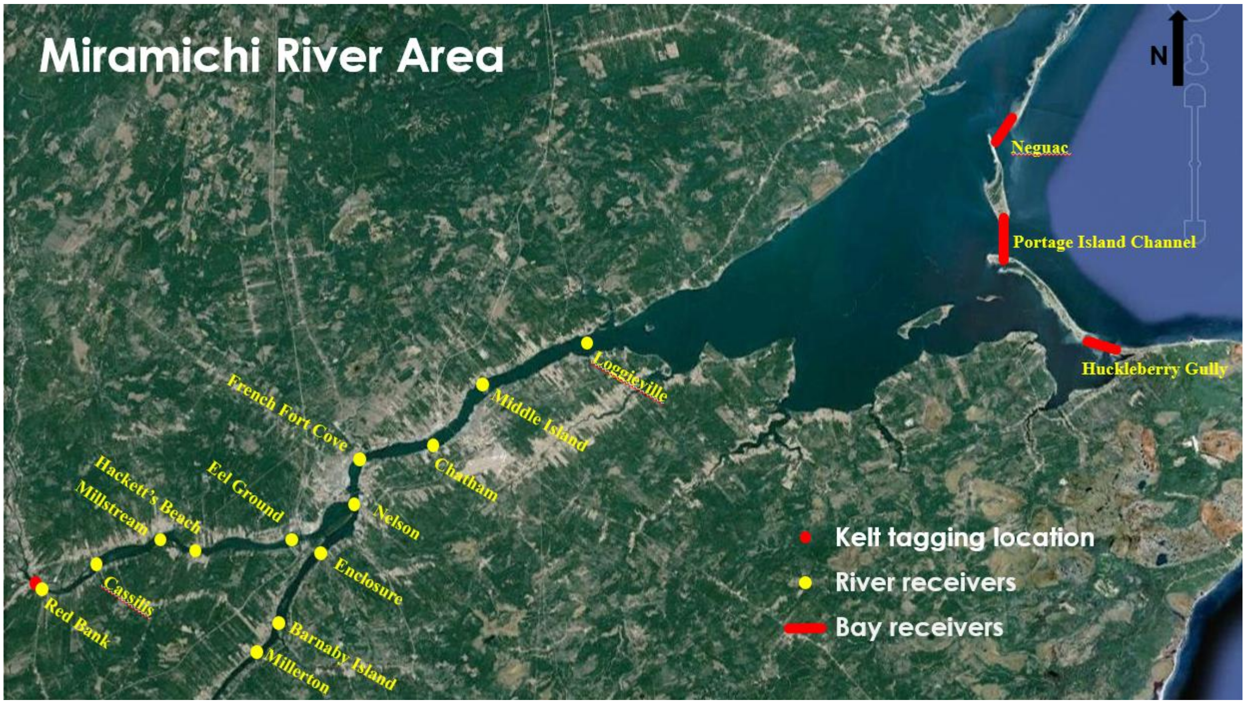



Figure 1. Locations of acoustic receivers throughout the Miramichi River and Bay in 2014. The red circle indicates tagging location, yellow circles are receivers used for tracking movements, and red lines indicate multiple receivers used to determine survival out of Miramichi Bay.

## Results

A total of 21 kelt were tagged in 2014 - 11 with external satellite tags and internal V9 acoustic tags, and 10 with internal, long term V16 acoustic tags. Our target of tagging 25 fish with V16 tags was not reached in 2014 because of low angling activity, resulting in less fish being caught, however we were able to deploy all 11 satellite tags. A total of 17 females were tagged (ten with satellite tags and 7 with acoustic tags only) and four males (one with a satellite tag and three with acoustic tags).

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

Acoustic receiver detections showed that 18 of the 21 fish tagged (86%) survived out of the Miramichi River and Bay. Broken down by tag type, 10 of the 11 satellite tagged fish survived and 8 of the 10 acoustic tagged fish. The 10 satellite tagged fish that survived out of the river system spent anywhere from 3 to 13 days in the river before moving into the bay.

Once in the bay, these fish remained there for 1 to 10 days before moving on to the Gulf of St. Lawrence at the end of May. Two fish tagged with satellite tags returned to the Miramichi River as consecutive spawners; they were detected at the Loggieville receiver on July 7$^{th}$ and July 14$^{th}$, respectively. One of these fish was captured in a Red Bank gill net and the tag returned to the MSA, and the other was lost near French Fort Cove (the satellite tag never transmitted).

For the 8 fish tagged with acoustic tags only that survived out of the river system, their in-river timeframe was spread out over 28 days, and their detection dates at the outer bay receivers occurred over a 15 day period, with the last one crossing on June 1$^{st}$.

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

In 2014, a total of 18 tagged kelt successfully made it out of Miramichi Bay. Eight of these kelt were tagged with long term V16 acoustic tags, while the remaining ten were equipped with pop-off satellite transmitters along with short term V9 acoustic tags. Three of the ten satellite tags failed to transmit, one was returned after the fish was caught in a gill net, one washed ashore on PEI, leaving five 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 136019 was a female that entered the Gulf in late May, and traveled to an area south of Anticosti Island. She remained there for the rest of May and into mid-June. Her depth during this time ranged from 15 to 20m, and water temperatures ranged from 4 – 14°C. Towards the end of June she began moving northeast towards the SOBI, but was never recorded on the receivers there. Around the beginning of July, this fish dove from 20m to 175m, at which point a sharp increase in temperature (to 25°C) was registered on the tag. This is most like a predation event and the tag would have been in the stomach of whatever consumed this fish. The tag continued recording deeper depths (125 – 175m) and the elevated temperature over a few days until the tag was expelled and floated to the surface. The tag began transmitting on July 11$^{th}$.

Tag 136020 was a female that entered the Gulf on May 19$^{th}$. The tag began transmitting on June 7$^{th}$ after being at a constant depth for 4 days, indicating the kelt had died. The satellite tag washed ashore on PEI and transmitted 99% of the data before the battery died. Preliminary depth and temperature data do not point directly to a predation event, but further analysis will be completed during the summer of 2015 to identify the cause of death. This fish remained in relatively shallow depths ranging from 2 – 5m, with one dive to 16m in early June. She remained in water temperatures between 6 and 14°C.

Tag 136021 was a female consecutive spawner. She entered the Gulf on June 1$^{st}$ and remained there for 5 weeks before returning on July 14$^{th}$. She was captured in a gill net on approximately July 18$^{th}$ and the tag was returned to the MSA. While in the Gulf, the average depth she occupied was 30m, with one dive to 140m in early July. She remained in a temperature range of 3 – 15°C.

Tag 136022 was a female that entered the Gulf at the end of May. She continued to travel east further into the Gulf, north of the Magdalen Islands, until mid-June, at which point she headed northeast towards the SOBI. Her depth in during this time averaged 30m and temperatures ranged from 4 – 14°C. At the end of June she headed northeast towards the SOBI and crossed the receiver line there on July 6$^{th}$. The depths and temperatures this fish was in during July was similar to those during the month of June (30m and 4 - 14°C). At the beginning of August, this fish dove down over 1000m and dropped to water temperatures at a constant 4°C. She swam at this depth for approximately 10 days before an ascent was noted. The tag began transmitting on Aug 23$^{rd}$ after four days of constant depth. No temperature spike was noted (obvious predation event), however the fish could have been consumed and the tag cut loose. Further analysis this summer may provide more insight into the cause of death.

Tag 136023 was a female that entered the GOSL on May 20$^{th}$. She moved around the western part of the Gulf between Anticosti Island and the Magdalen Islands for the remainder of May and the first half of June, before traveling northeast towards the SOBI. Her average depth was 20m during this time and water temperatures ranged from 5 – 15°C. She crossed the SOBI receiver line at the beginning of July. She moved around the northern tip of the peninsula on the west coast of Newfoundland and then traveled south again to the northern shore of the province. She stayed in relative constant depths of 20m and temperatures from 5 - 15°C. At the end of July she started moving north again, towards the southern coast of Labrador. By early August she had moved out into the Labrador Sea and began exhibiting diving behaviours up to 800m deep. At these depths, the water temperature was 4°C. She continued to dive and return to the surface for the remainder of August and September. The tag popped halfway between Baffin Island and Greenland on the pre-programmed date of September 30th. All signs indicate this fish was still alive at that time.

Tag 136025 was a female that entered the GOSL around mid-May. She moved around the western part of the Gulf for the rest of May into late June. She headed northeast towards the SOBI at the end of June. She was in depths from 1 – 20m during this time and water temperatures from 4 – 14°C. She crossed the SOBI on July 7th. She then headed northwest to the coast of Labrador and continued to travel northwest in shallower water along the coast (depths ranged from 1 – 20m during this time). The water temperature ranged from 4 – 11°C. In mid-August she was almost to the northern tip of Labrador, near the Torngat Mountains. She did a few dives to 55m, 75m, and 88m towards the end of August, before returning to shallower water in September (1 – 40m). Water temperatures ranged from 3 – 4°C during the September migration. Her tag popped off near the northern tip of Labrador on the pre-programmed date of September 30th. All signs indicate this fish was still alive at that time.

Tag 136027 was a male that entered the Gulf on May 18th. He traveled east to the area south of Anticosti Island during the end of May and stayed there into mid-June. Towards the end of June he moved northeast towards the SOBI. His average depth in the gulf was 20m, with one dive to 150m in mid-June. The water temperature ranged from 3 – 13°C. He crossed the SOBI receiver line on June 29th, the earliest of any fish tagged in 2014. He then headed northwest up the coast of Labrador for the months of July and August. The depths he occupied were between 1 – 30m, except for two dives: one to 200m and one to 250m in mid-August. Water temperature ranged from 2 - 13°C during this time. At the beginning of September, this fish had headed out into the Labrador Sea to the northeast towards Greenland. He dove a couple of times to 575m between Labrador and Greenland, and then moved to shallower waters (1 – 50m) off the coast of Greenland. Water temperatures in September were between 3 – 8°C. His tagged popped near the coast of Greenland, 30km offshore and 200km north of Nuuk on the pre-programmed date of September 30th. All signs indicate this fish was still alive at that time.

*Acoustic Tags:*

Acoustic tags 9715, 9716, 9717, 9718, 9719, 24832, 24833, and 24834 were all detected at the outer Bay receivers between May 18th and June 1st. It is assumed these fish were traveling east and entered the GOSL. Tags 24833, 24835, and 9716 were detected at the SOBI array on July 5th, 11th, and 15th, respectively.

Survival percentages of acoustic and satellite tagged fish from 2008 – 2014 can be seen in Table 1.

Table 1. Total number of kelt that received acoustic tags and % survival through various locations between 2008 and 2014. * indicates that this information is not available until next year and only applies to kelt which received large, long term acoustic transmitters.

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| **Kelts Tagged** | 50 | 50 | 50 | 50 | 35 | 16 | 21 |
| **Head of Tide (%)** | 100 | 100 | 100 | 100 | 100 | 100 | 95 |
| **River Mouth (%)** | 96 | 92 | 90 | 94 | 94 | 75 | 85 |
| **Miramichi Bay (%)** | 94 | 92 | 90 | 94 | 94 | 69 | 85 |
| **Strait of Belle Isle (%)** | 44 | 18 | 14 | 30 | 30 | 38 | 33 |
| **Returned as consecutive (%)** | 6 | 8 | 18 | 10 | 10 | 0 | 10 |
| **Returned as alternate (%)** | 8 | 0 | 10 | 4 | 0 | 6 | * |

*Staging Areas*

Two potential staging areas were noted for fish tagged in 2014: one in the western GOSL, south of Anticosti Island (Figure 2a.), and one off the coast of Labrador in the North Atlantic (Figure 2b). Five fish tagged with satellite tags (136019, 136022, 136023, 136025, 136027) spent time in this area of the Gulf during May and June before migrating further to the Atlantic Ocean. All five of these fish were alternate spawners. Four of these five survived out of the SOBI and traveled into the Labrador Sea. Once there, every one of them showed diving behaviours, ranging from 88 – 1025m. None of the fish exhibited this drastic diving behaviour while in the GOSL. These movements could be associated with predator avoidance or the fish searching for food sources (reconditioning).

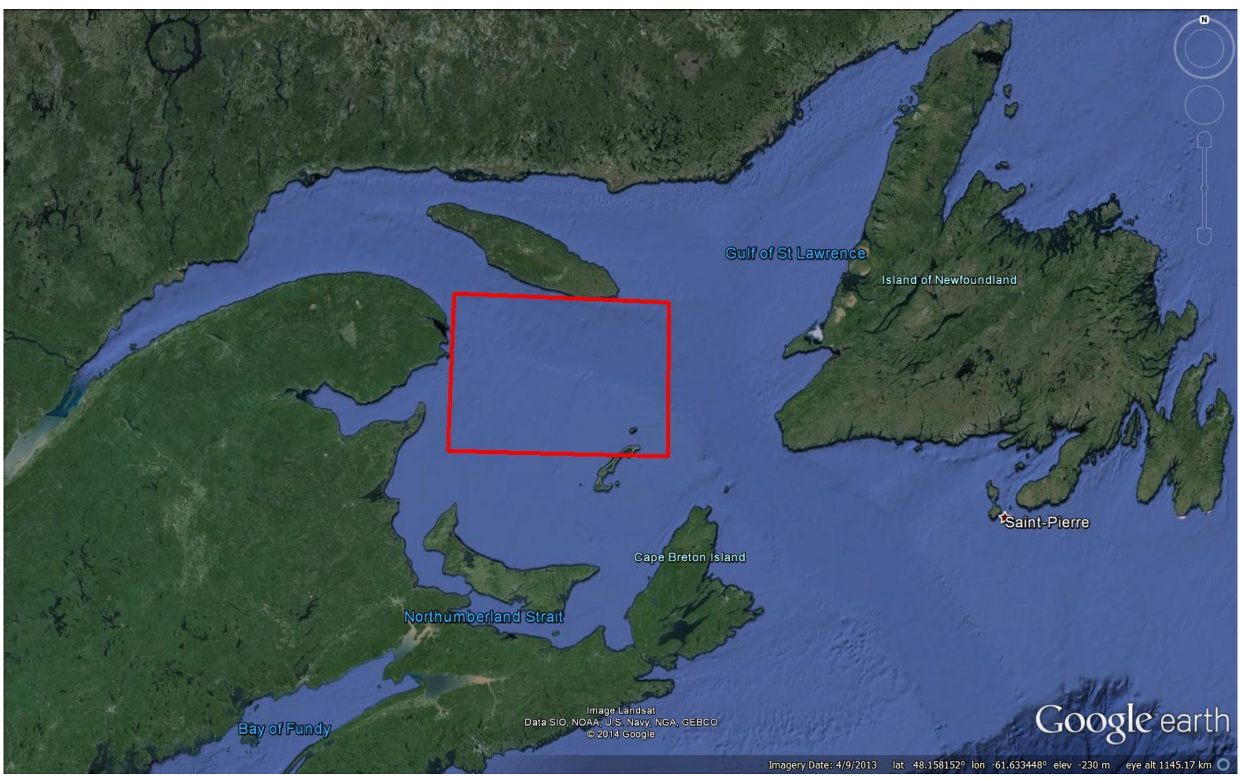



Figure 2a. Potential staging area in the Gulf of St. Lawrence. Five fish occupied this space during the months of May and June in 2014.

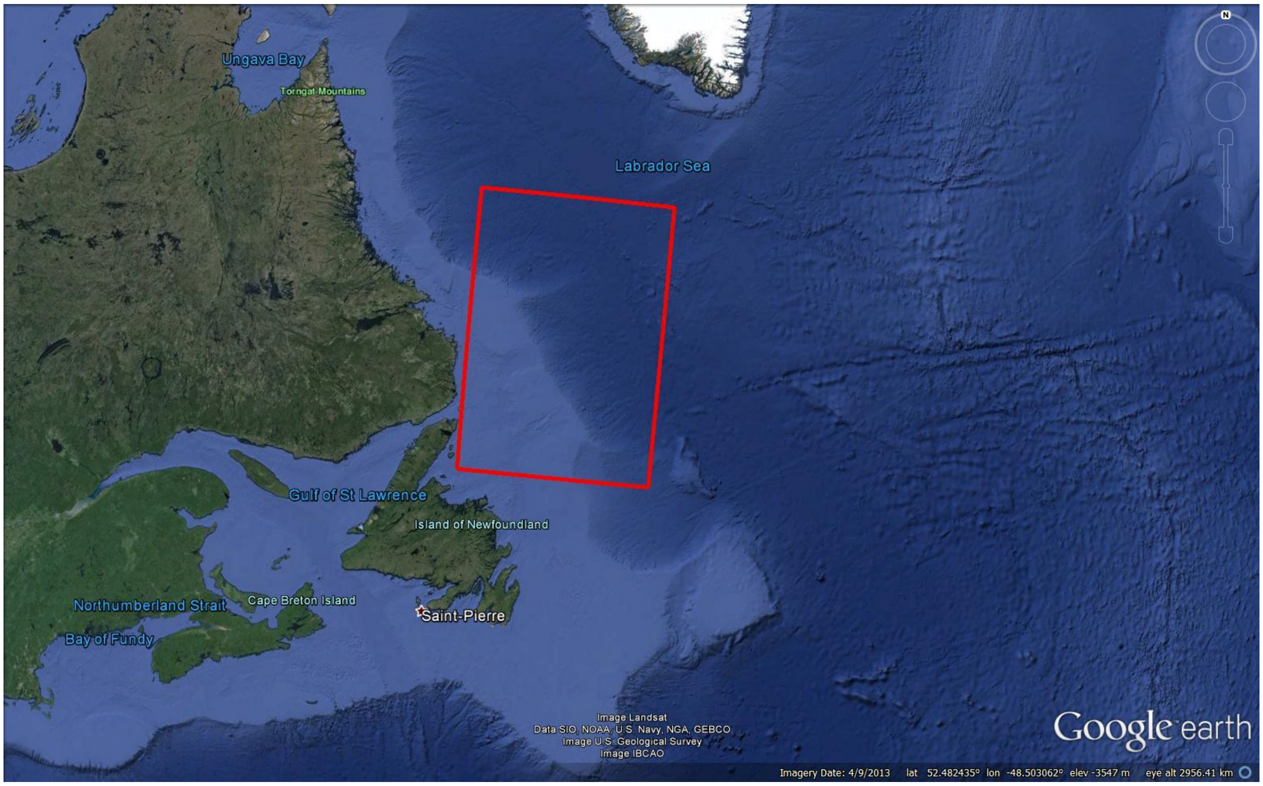



Figure 2b. A second potential staging area in the North Atlantic for alternate spawners. Four fish were in this location from mid-July to mid-September 2014.

***Tag Recovery***

In 2014, only one satellite tag (out of eleven) was recovered after deployment - the tag was from a female consecutive spawner that was captured in a Red bank gill net. This tag will be refurbished and used in 2015. Another tag that ended up on the shore of PEI transmitted 99% of its data before the battery died; we were unable to recover it in time. Of the nine remaining satellite tags, four failed to transmit entirely and were not recovered and five successfully transmitted data from fish that survived out of Miramichi Bay and into the Gulf of St. Lawrence and Atlantic Ocean.

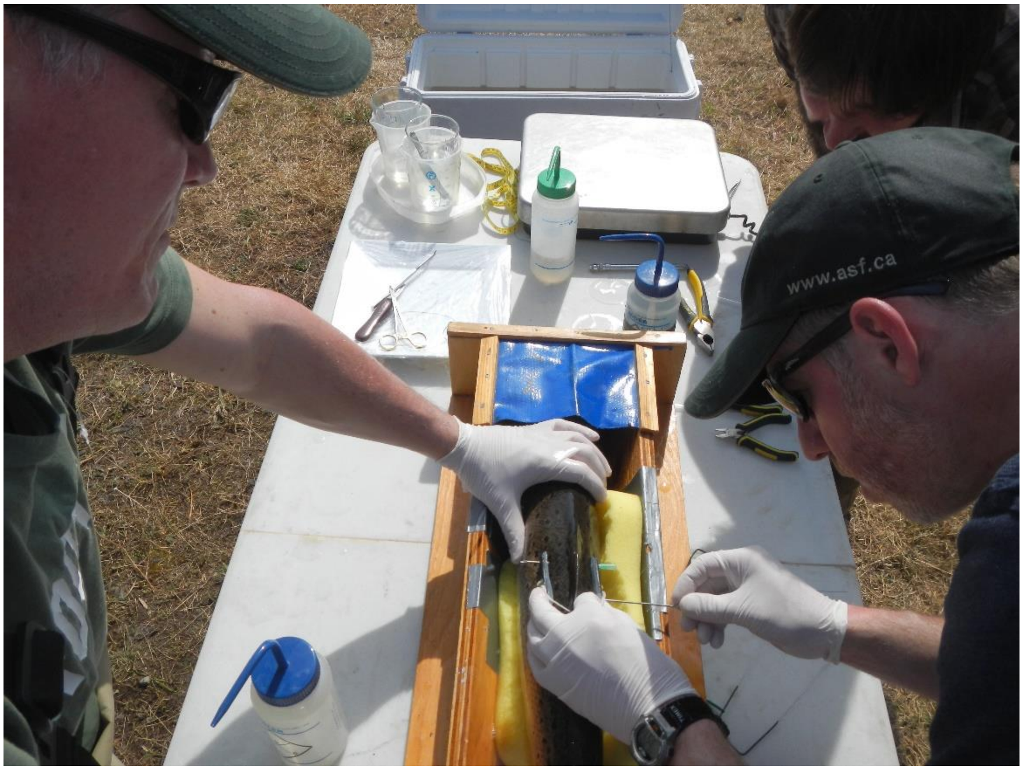
## Discussion

In 2014, 55% (6/11) of all satellite tagged kelt successfully transmitted data on fish movements, water temperature, and depth. Four of the tags which failed to transmit were never detected, however acoustic data showed that three of these four fish survived out of Miramichi Bay, the fourth was lost near Cassilis and never moved downstream. One of the surviving three fish was a consecutive spawner, but the fish was lost near French Fort Cove in July. The fifth tag that did not transmit data (out of the eleven satellite tags) was another consecutive spawner that was caught in a gill net. That tag was returned to us, however data extraction from the tag has not been completed yet, and no tracks are available at this time. The data will be available in the future after extraction and analysis is completed. 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.

Three of the pop-off tags deployed on schedule at the pre-programmed date of September 30$^{th}$ (one halfway between Baffin Island and Greenland (136023), one off the northern tip of Labrador (136025), and one off the coast of Greenland (136027)). Initial satellite data suggests these fish moved through the Strait of Belle Isle on July 1$^{st}$, July 7$^{th}$, and June 29$^{th}$, respectively. Although these dates may change with more fine scale analysis, they all fall within late June – early July, and match up with the three long-term acoustic tagged fish that passed through in early July as well (tags 24833, 24835, 9716). Given the northern location and late season timing of the transmission from these three tags, it is safe to assume that these kelts were alternate spawners on their way to recondition in the cold northern waters of the Atlantic Ocean before returning to spawn in 2015. Advanced analysis of the data from these tags 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 two tags that deployed prematurely (one south of the SOBI (136019) and one off the southern coast of Labrador (136022)), only one has supporting evidence of being predated – tag 136019. A dive to 175m was observed in early July, and water temperatures around 10°C. At this depth, a sudden increase in temperature was noted, up to 25°C and most likely points to the tag being consumed and resting in the stomach of a predator. The temperature recorded then decreases to 12°C and the tag depth changes to ocean surface levels; four days later the tag began transmitting. Tag 136022 popped after four days of constant depth, however 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. This fish also made a deep dive (over 1000m) and remained there for a couple weeks, at a temperature of 4°C, before a surface ascent was observed. The tag began transmitting after four days at the surface. 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 2014 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.

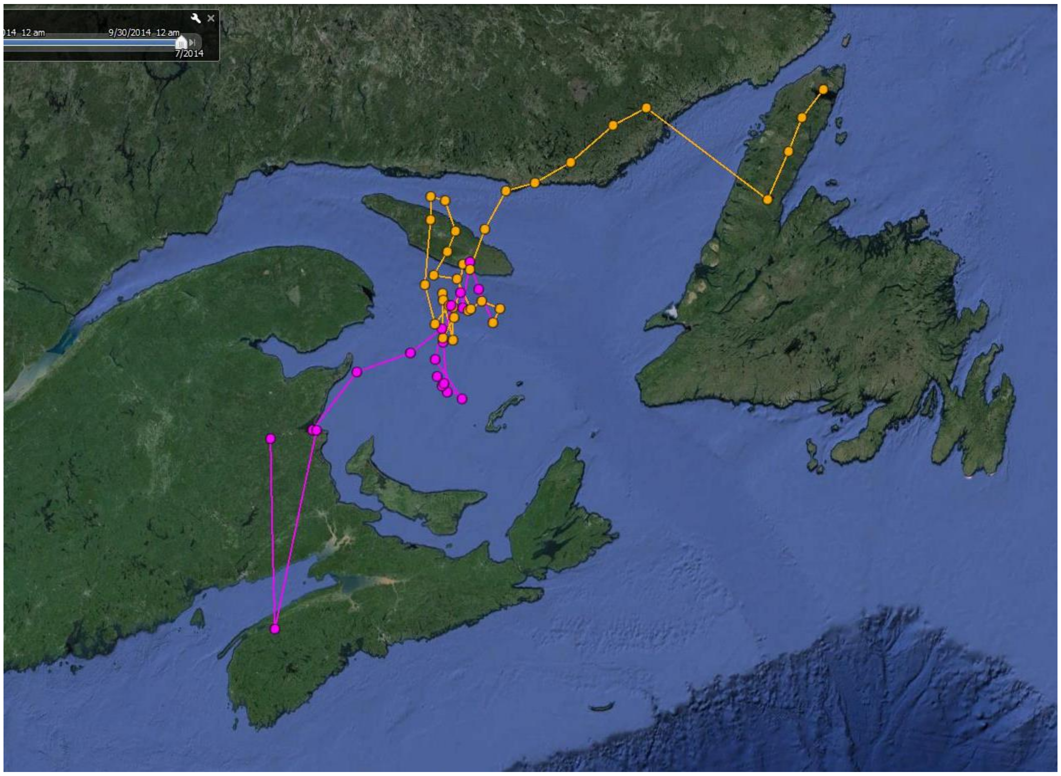
Determining movements of individual fish requires considerable work and statistical analysis. Tag position is determined by converting daily recorded light intensity and duration to sunrise and sunset timing each day. Positioning is then determined by calculating the marine area that would have those 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.



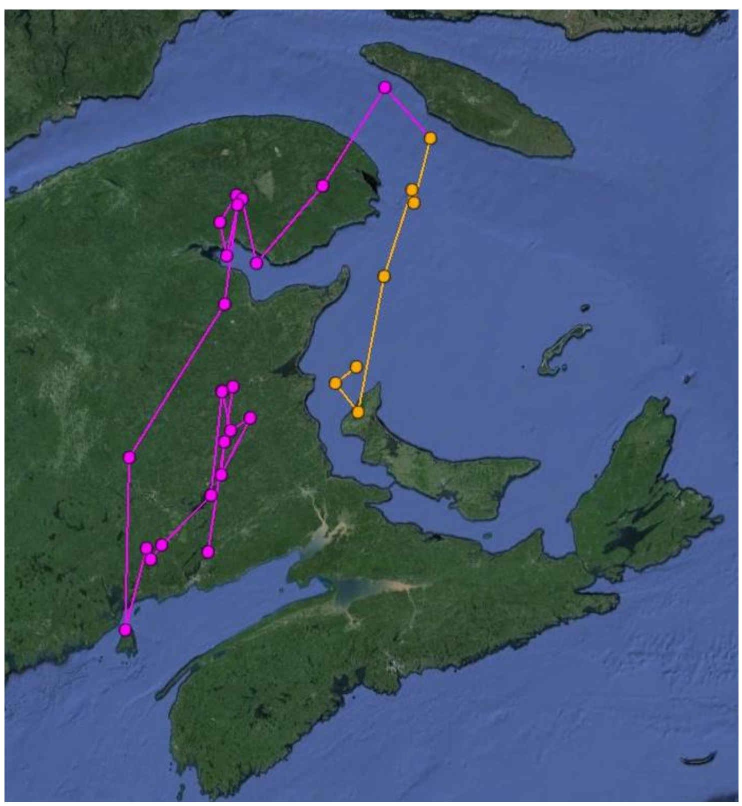
ASF Biologists Jon Carr (left) and Graham Chafe (right) attaching a satellite tag.


Satellite tag attached under the dorsal fin.

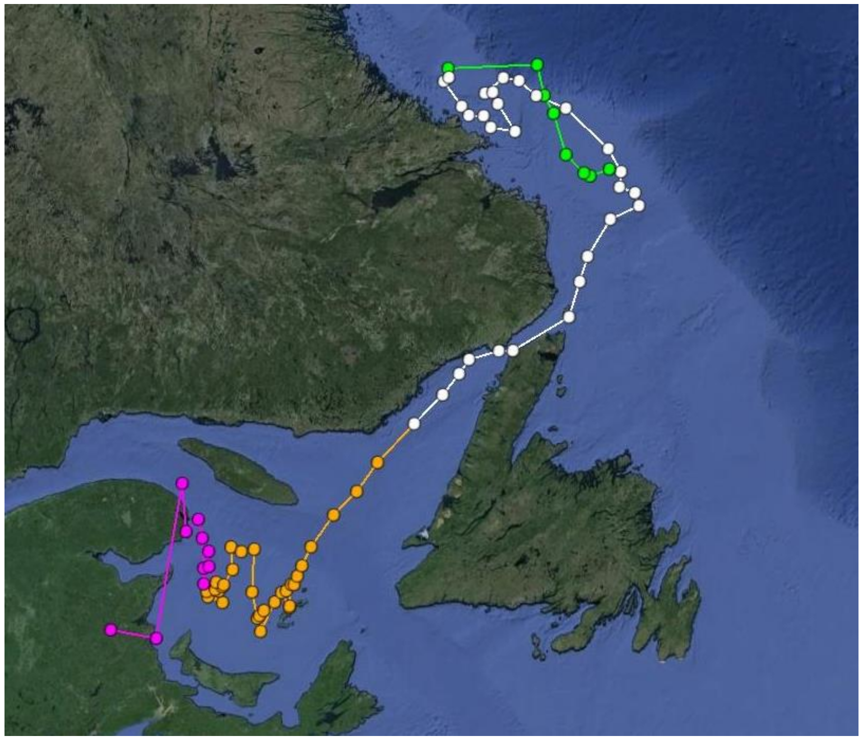
Appendix 1: Satellite tagged kelt tracks 2014.



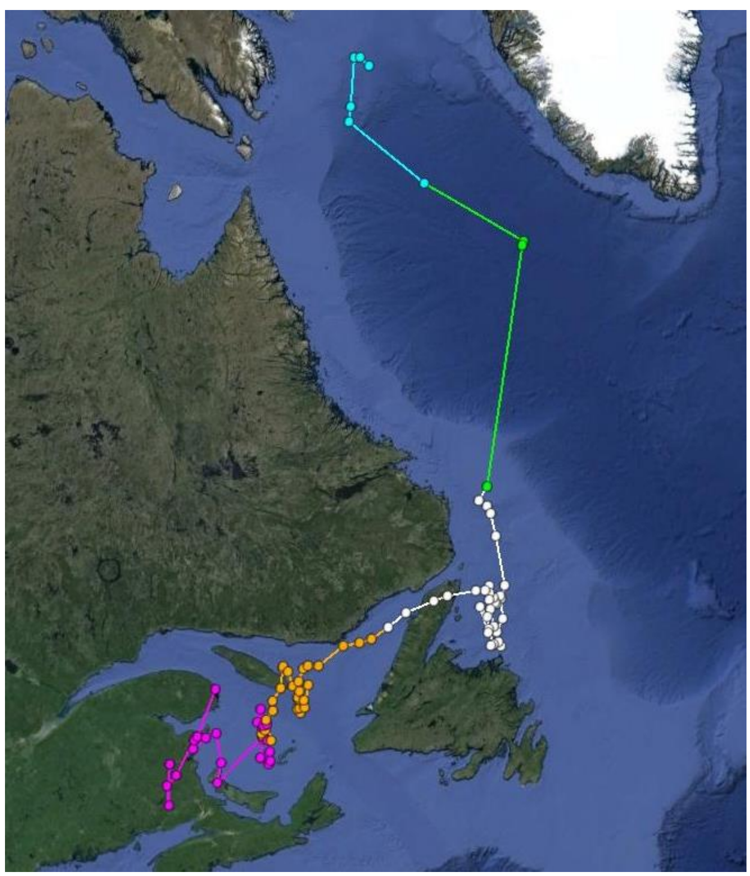
Tag 136019



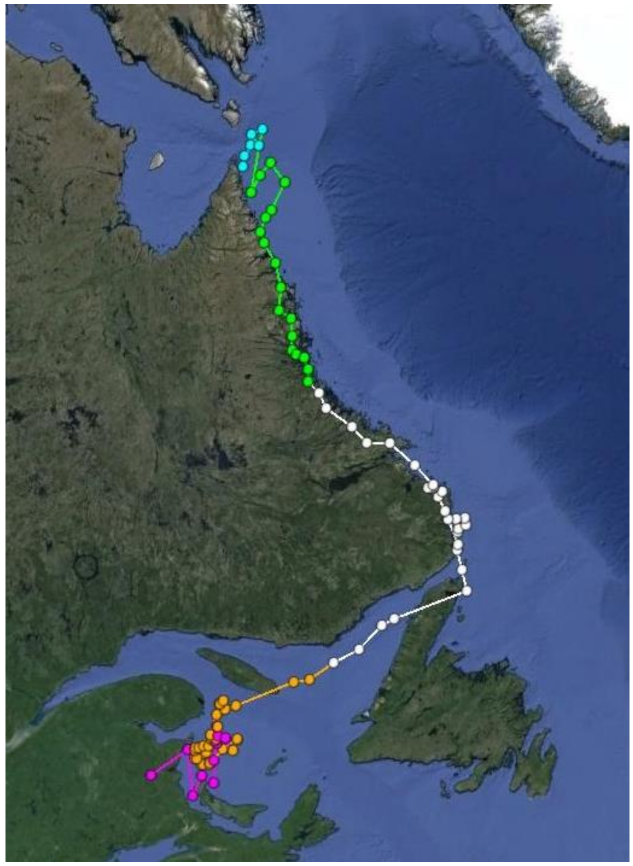
Tag 136020



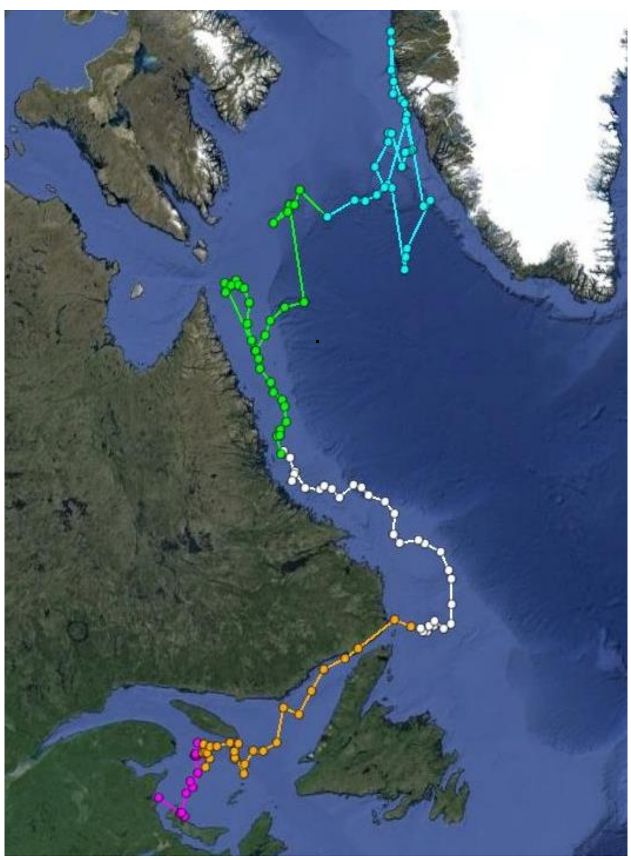
Tag 136022



Tag 136023



Tag 136025



Tag 136027

## 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 15 years from 1998 – 2013, 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 – 2013 was 105% on the Southwest and 53% 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. This policy has likely reduced the angling mortality rate on the Northwest system 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 and the last three years have focused on the Northwest branch. This year marks the first year of a new five year program that focuses on the river as a whole. The decision to change the program stemmed from concerns that over the last three years 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 and four smolt wheels in total were in place this year: 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 $km^2$. 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). The original plan for 2014 was to have a smolt wheel at the mouth of the Dungarvon River on the Southwest system (not the Cains), but due to damage from late 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 smolt. Fork lengths were taken on 25 smolt and scale samples were taken from 5 of these. The 20 smolt not scale sampled were 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. 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 smolt 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

The Northwest smolt wheel operated from May 13th – 19th, was raised on May 19th because of high water and reset on May 22nd. The wheel was operational again from May 23rd to May 26th. The smolt wheel on the Sevogle operated from May 12th to May 15th, was raised on May 15th because of high water, and reset on May 17th. The wheel was operational on May 18th and then lifted again on May 19th because of a heavy rain event and dangerous water levels. The wheel was reset on May 25th and operational from May 26th – 27th. The Cains smolt wheel was operational from May 17th – 26th. A total of 1444 smolt were tagged from the Northwest (273), Sevogle (293), and Cains (878) wheels. The peak of the smolt run for the Northwest was May 17th with 82 fish, the peak for the Sevogle was May 27th with 85 fish, and the peak for the Cains was May 20th with 211 fish.

The trap net operated from May 21st – 26th. High swells and poor weather conditions on May 27th kept crews from fishing the trap. The trap net held up against late spring ice and never had to be lifted, nor did it wash out.

From May 21st – 23rd the number of smolt caught in the trap net ranged from 89 to 1465. The number of smelt caught during the same timeframe ranged from 158 to 3070. On May 24th the net was so full of fish that estimates had to be made by dumping net scoops out. One scoop was sorted and counted for species and that number was applied to all other scoops removed. A 12 hour day resulted in a smolt estimate of 11,285 and a smelt estimate of 95,955. On May 25th it became apparent that the net had even more fish in it, and again estimates had to be made by dumping out net scoops and by lowering the net to allow the fish to escape without being scooped. Rough estimates for this day were 20,000 smolt and >400,000 smelt. At this point we knew a mark-recapture estimate for smolt this year had been compromised so we made an effort to try a new method to improve the project for next year. At the end of the day on May 25th, 4.5 meters of the leader (the section closest to the trap and farthest from shore) was lifted to try and reduce the catch numbers for the next day. On May 26th 598 smolt and 7,500 smelt were counted, a much more reasonable number of fish to handle in a day.

Mark-recapture analysis for this year was rendered impossible because we were unable to use a consistent recapture method. The smolt population estimate for 2014 is unknown. By adjusting the leader in 2014 to decrease fish counts, we are confident the trap can be operated better for the 2015 field season.

## Discussion

The Miramichi River needs upwards of two 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$^2$. The three years of data from the Northwest system have shown variable and sometimes conflicting results. In 2011 and 2013 smolt production exceeded 3.0 smolt/100m$^2$ and in 2012 was estimated at only 2.0 smolt/100m$^2$. 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.

The 2014 field season suffered from a late spring and ice melt, as well high water levels that made for challenging field work operations. The wheels on the Northwest and Sevogle Rivers were lifted multiple times during high water, and most likely missed a large portion of the smolt run from these rivers, as smolt migrations have been shown to increase during high water events.

This was the first year for this new study of estimating smolt leaving the entire Miramichi River system. In most recent years the Northwest system had been the focus because of declining adult returns. The Chatham trap net was newly constructed this year. There was a delay in fabrication, along with extra time needed to alter the net, after delivery, to have it fit the pickets (wooden framework) at the site. The original plan was to the have the net installed at most two days after the first smolt were tagged, but the first wheels were already installed when the delay was presented. The delay in trap net installation may have reduced our smolt catch numbers at the trap net, as there was an eight day period after the first smolt were tagged until the trap net was operational. The new trap net was larger than the trap net used in previous years to recapture smolt. The length of the leader and the length and width of the net itself were more than double the previous year's trap. The efficiency of this trap net was unknown before using it and after fishing for roughly one week it became apparent that the net caught far too many fish for our field crews to handle on a daily basis.

Two-way mark-recapture calculations require consistent marking and recapturing techniques to produce an accurate estimate. With the large catch numbers at the trap net (which we were unable to count), the mark-recapture calculations for this year are impossible to determine.

The inability to determine an estimate this year does not allow for comparisons to be made to previous years. In the spring of 2015, a section of the leader on the trap net will be lifted for the entire duration of the smolt study in an effort the reduce catch numbers, and to provide a consistent recapture method to allow for more accurate smolt estimates.


Smolt wheel operation on the Cains River in 2014.

Fishing the Northwest wheel in 2014.

Sorting fish at the Chatham trap net.

## Smolt Survival Study

### 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 saxatalis*) are a large generalist fish species native to the Northumberland Strait and Gulf of St. Lawrence. 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 2014 smolt migration to determine survival rates throughout the river and estuary.

## Methods

### *Study Area*

The Northwest Miramichi watershed drainage area of 3,950km$^2$ 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$^2$) and the Northwest Miramichi River (2,078km$^2$) 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$^2$.

### *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 was placed in a clove oil bath for several minutes until equilibrium was lost and movement was minimal. Both Vemco V8 and V9 acoustic tags were used during surgery, at a 2:1 ratio, respectively. 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 and five receivers were placed on the main stem of the Miramichi River 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 (Figure 3).

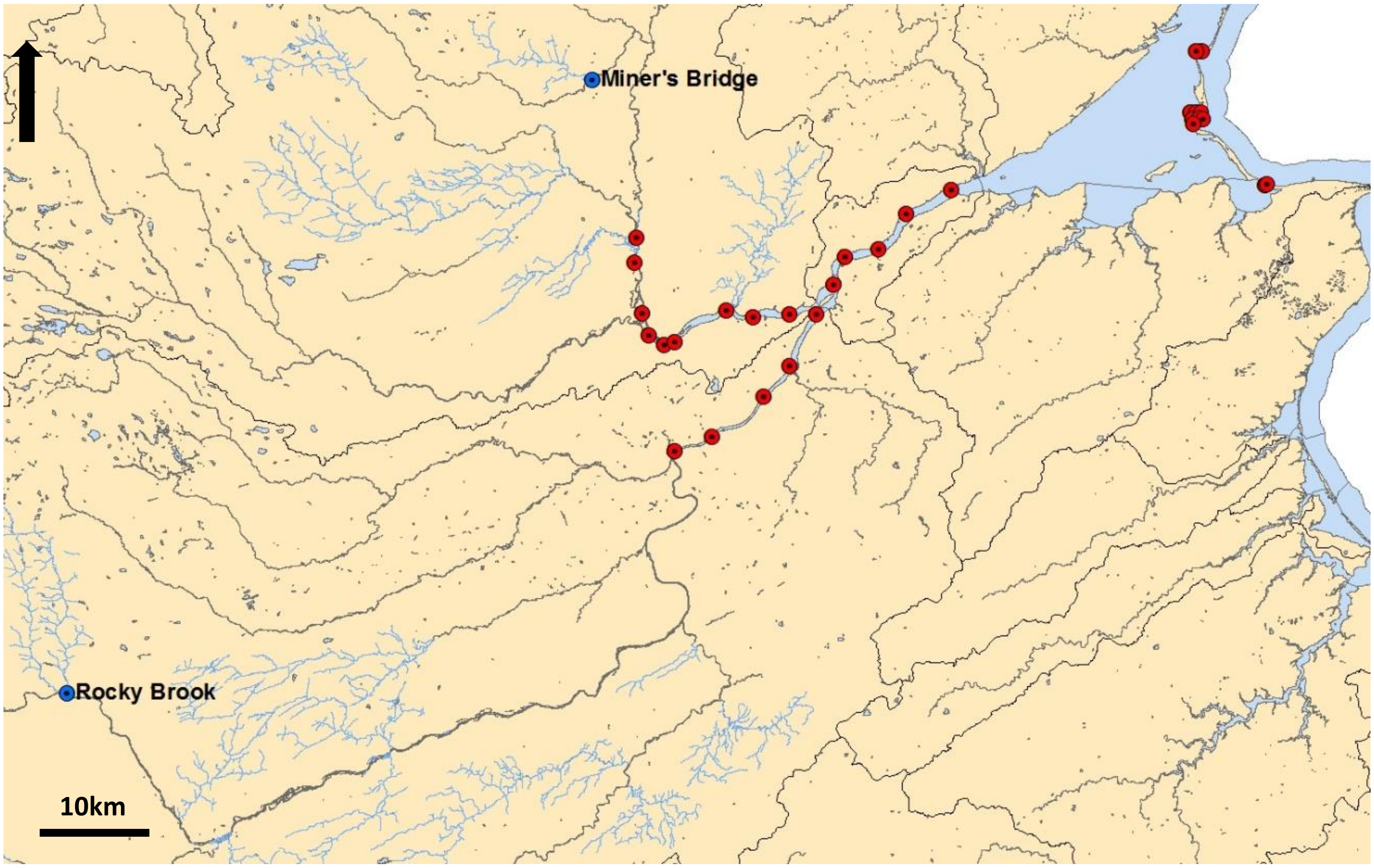



Figure 3. Acoustic receiver locations (red dots) in the Miramichi River and Bay in 2014. Smolt tagging and release locations are represented by a blue dot – Miner's Bridge on the Northwest branch and Rocky Brook on the Southwest branch.

## Results

*Northwest River*

On May 28th and 31st, 50 smolts captured at the Northwest smolt wheel were transported upstream to the tagging site located at Miner's Bridge. Of the initial 50 fish tagged, 28 of them (56%) were detected on the first receiver at Big Hole Pool (BHP), however at the head of tide (HOT) in Cassilis 40 of the 50 fish (80%) were detected, indicating a 20% mortality rate from the tagging location to HOT, and poor tag reception at the BHP receiver (as the missing tags were detected downstream). Another 20% of the fish were lost between Cassilis and Nelson. Survival in the main channel of the river from Nelson to Loggieville was 80% of the remaining fish, and 48% from the tagging location. Only 14% (7/50) of the smolts tagged at Miner's Bridge survived out of the estuary (past the barrier receiver lines), and 10% to the Strait of Belle Isle (SOBI) (Figure 4a).

*Southwest River*

On May 27th, 29th, and 30th, 80 smolts captured at the Rocky Brook smolt wheel were tagged and released. Of the initial 80 fish tagged, 40 (50%) of them were detected at the first receiver in Quarryville, and 50 (63%) at HOT in Millerton (this is because of poor receiver reception in Quarryville, as the 10 missing fish were detected downstream). From Millerton to Nelson, 6 fish were lost (12% mortality of the 50 remaining fish). In the main river, a further 6 fish were lost up to Loggieville – a mortality rate of 12% again. Survival from the tagging location to the estuary was 31%, and 9% to the SOBI (Figure 4b).

In total, 25% of the smolts leaving the entire Miramichi River survived to exit the estuary, and 9% survived to the SOBI.

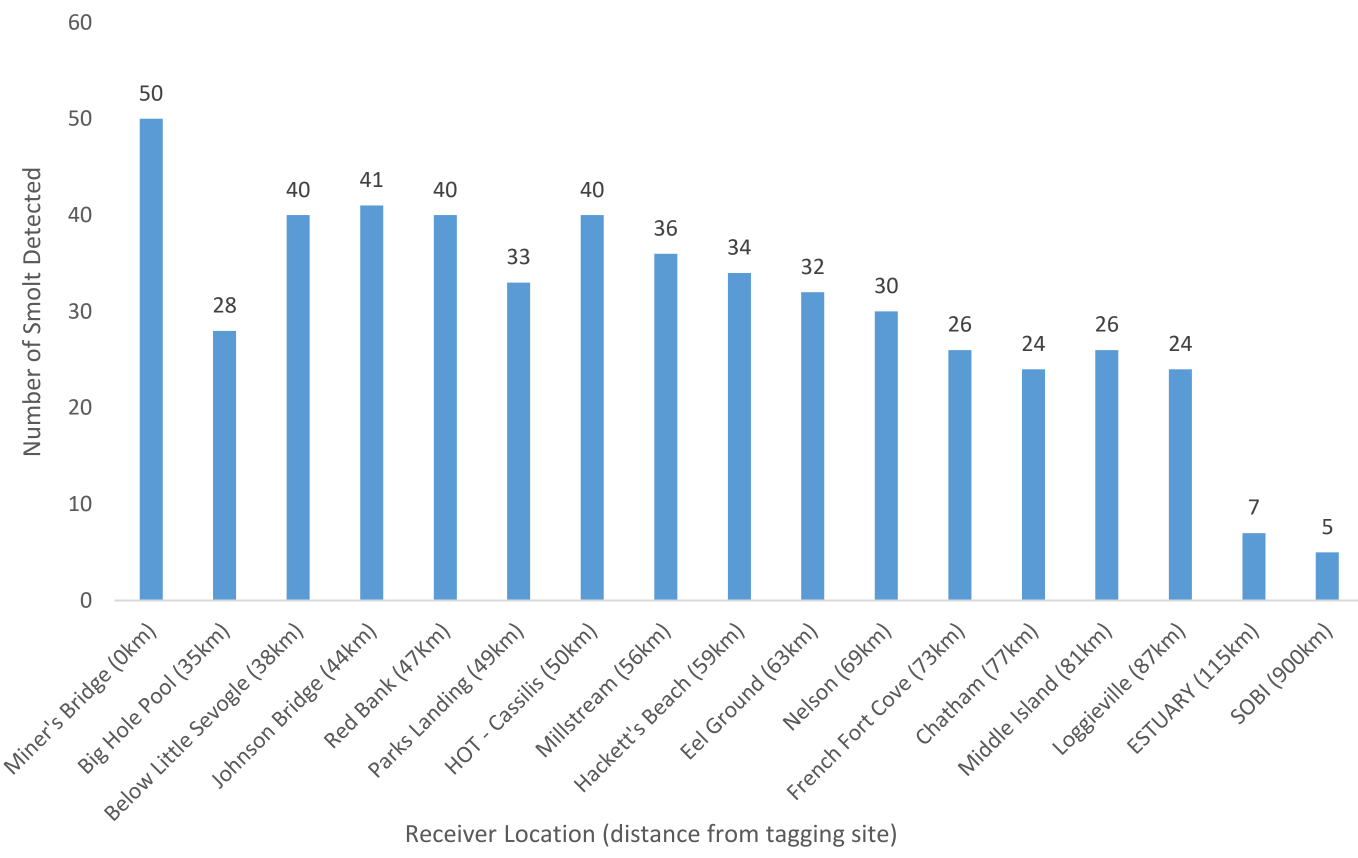



Figure 4a. Survival numbers of acoustic tagged smolts from the Northwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2014. The low detection numbers at Big Hole Pool and Parks Landing are the result of poor receiver detection, as these fish showed up on receivers further downstream.

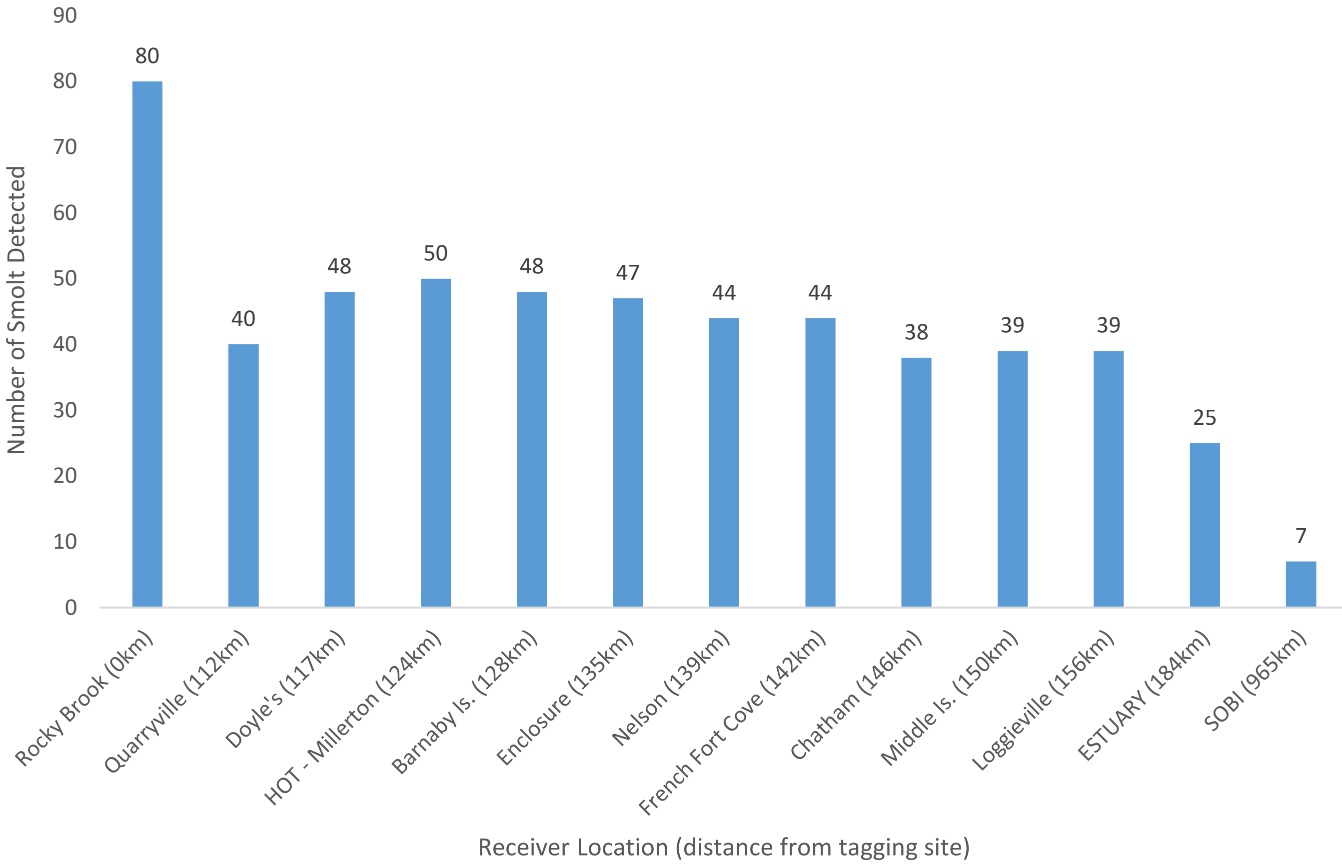



Figure 4b. Survival numbers of acoustic tagged smolts from the Southwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2014. The low detection numbers at Quarryville and Doyle's are the result of poor receiver detection, as these fish showed up on receivers further downstream.

## Discussion

Survival numbers from the 2014 tagging study are less than desirable for the Miramichi River. The fish that successfully survived tagging (a 10% mortality rate is assumed for tagging studies) and were detected exiting Miramichi Bay was less than 15% from the Northwest branch. Only 50 smolts were tagged on the Northwest branch due to the minimum size required for tagging; the other smolts caught were too small. The highest areas of loss on the Northwest were from the tagging site at Miner's Bridge to the first receiver at Big Hole Pole (9 fish went missing (adjusted for the poor receiver reception), or 18%) and from Loggieville to the estuary receivers (17 fish missing, or 34%). From Big Hole Pool to Cassilis (15km stretch) the mortality rate was very low (2%). From Cassilis to Nelson (19km), the area where the striped bass are most prevalent, a further 10 fish (20%) were lost, which is a loss of 1.05 smolts/km. For the Northwest River in total, 0.37 smolt/km were lost.

On the Southwest branch, 38% of the fish (30/80) were not detected at the first receiver in Quarryville (adjusted for poor receiver reception). From Quarryville to Loggieville (44km stretch), 11 smolts (22%) were lost. From Loggieville to the estuary receivers, 14 fish (18%) were unaccounted for. The smolt loss per km on the entire Southwest River was 0.30.

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 2014 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 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 2014, the hope was to stagger the tagging efforts 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. The timing of the smolt run and number of smolts available in 2014, along with the scheduling of the small tagging crew, did not allow for tagging to occur over multiple days on the Northwest River. Tagging at Rocky Brook began on May 27th, after which the crew moved to the Northwest to tag 48 fish on May 28th. A large run of fish then traveled through the wheel at Rocky Brook and the crew traveled back there to ensure all 80 fish would be tagged for the season (tagging continued on May 29th and 30th). On May 31st, the crew returned to the Northwest to hopefully tag the remainder of the 80 fish, but only two fish were available for tagging, as the others were too small. The catches at the Northwest wheel were decreasing, as this was nearing the end of the smolt run, and the tagging efforts ceased after the 50 fish were tagged. Efforts will be made again in 2015 to spread the tagging out over multiple days to try and determine temporal overlap between smolts and striped bass.

## 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$^2$ is not considered for stocking as it appears to reflect a healthy natural population. Sites with less than 50 fry/100m$^2$ 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.

Young of the year brook trout were also raised this year in satellite rearing stations run in collaboration with J.D. Irving and the Miramichi Salmon Headwaters Federation.

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 2013 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 (EWOS #1) 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

From June 25$^{th}$ to July 22$^{nd}$ 2014, approximately 306,118 first-feeding Atlantic salmon fry were stocked into 64 sites in seven tributaries of the Miramichi River. The Northwest system received 123,200 fry and the Southwest system 182,918 (Table 2). An additional 45,873 fry were taken to satellite holding tanks for future release by local conservation groups (Table 3). Additionally, 21,810 brook trout parr were distributed to two satellite tank rearing locations (Table 4).

Table 2. Distribution of first-feeding Atlantic salmon fry from the Miramichi Salmon Consevation Centre.

| Date Stocked | Branch | Stock Origin | Site | # of fish | Latitude | Longitude |
|---|---|---|---|---|---|---|
| 25-Jun-14 | Southwest | Rocky Brook | Rocky Brook | 21789 | 46.75955 | -66.67800 |
| 26-Jun-14 | Northwest | Sevogle | Bridge near Slack Lake Rd | 3550 | 47.20310 | -66.31951 |
| 26-Jun-14 | Northwest | Sevogle | North Branch | 3550 | 47.20856 | -66.35300 |
| 26-Jun-14 | Northwest | Sevogle | North Branch | 3600 | 47.20566 | -66.34549 |
| 26-Jun-14 | Northwest | Sevogle | South Branch | 3500 | 47.10637 | -66.31868 |
| 26-Jun-14 | Northwest | Sevogle | Travis Brook | 3575 | 47.04814 | -66.22858 |
| 26-Jun-14 | Northwest | Sevogle | Johnstone Brook | 3500 | 47.04416 | -66.22157 |
| 26-Jun-14 | Northwest | Sevogle | Clearwater Brook | 2300 | 47.10959 | -66.23521 |
| 26-Jun-14 | Northwest | Sevogle | Bear Lake Brook | 3700 | 47.21623 | -66.25768 |
| 26-Jun-14 | Northwest | Sevogle | North Branch | 3550 | 47.20822 | -66.35380 |
| 26-Jun-14 | Northwest | Sevogle | North Branch | 2175 | 47.20350 | -66.32050 |
| 26-Jun-14 | Northwest | Sevogle | North Branch | 4550 | 47.20563 | -66.34533 |
| 27-Jun-14 | Northwest | Northwest | Big Hole Camp bridge | 3530 | 47.05000 | -65.83294 |
| 27-Jun-14 | Northwest | Northwest | Northwest | 3530 | 47.08201 | -65.83039 |
| 27-Jun-14 | Northwest | Northwest | Trout Brook | 3530 | 47.09459 | -65.83587 |
| 27-Jun-14 | Northwest | Northwest | Northwest | 3570 | 47.09467 | -65.83592 |
| 27-Jun-14 | Northwest | Northwest | Northwest | 3510 | 47.15281 | -65.88553 |
| 27-Jun-14 | Northwest | Northwest | Patty's Brook | 3510 | 47.15843 | -65.83039 |
| 27-Jun-14 | Northwest | Northwest | Northwest | 3673 | 47.15969 | -65.84489 |
| 27-Jun-14 | Northwest | Northwest | Patty's Brook | 3490 | 47.18365 | -65.84136 |
| 27-Jun-14 | Northwest | Northwest | Mouth of Tomogonops | 7226 | 47.23314 | -65.83323 |
| 27-Jun-14 | Northwest | Northwest | Portage River | 7499 | 47.22261 | -65.80909 |
| 27-Jun-14 | Northwest | Northwest | Northwest | 7113 | 47.22819 | -65.82598 |
| 27-Jun-14 | Northwest | Northwest | Northwest | 3522 | 47.18945 | -65.81766 |
| 27-Jun-14 | Northwest | Northwest | Northwest | 3591 | 47.21549 | -65.80902 |
| 30-Jun-14 | Southwest | Juniper | Doak Brook | 3525 | 46.55106 | -66.12446 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 30-Jun-14 | Southwest | Juniper | Betts Mills Brook | 3525 | 46.53182 | -66.18076 |
| 30-Jun-14 | Southwest | Juniper | Betts Mills Brook | 7175 | 46.60010 | -66.26590 |
| 30-Jun-14 | Southwest | Juniper | East Branch Burntland | 3625 | 46.42291 | -66.33920 |
| 30-Jun-14 | Southwest | Juniper | Burntland Brook | 3525 | 46.39168 | -66.36240 |
| 30-Jun-14 | Southwest | Juniper | Burntland Brook | 3800 | 46.36434 | -66.43310 |
| 30-Jun-14 | Southwest | Juniper | Main SW | 3575 | 46.57458 | -66.05964 |
| 30-Jun-14 | Southwest | Clearwater | White Rapids Brook | 3486 | 46.78940 | -65.80170 |
| 30-Jun-14 | Southwest | Clearwater | McKenzie Brook | 3555 | 46.70077 | -65.76564 |
| 30-Jun-14 | Southwest | Clearwater | Black Brook | 3486 | 46.66343 | -65.77341 |
| 30-Jun-14 | Southwest | Clearwater | Moores Donnelly Brook | 3647 | 46.57363 | -65.89027 |
| 30-Jun-14 | Southwest | Clearwater | Moores Donnelly Brook | 3624 | 46.55752 | 65.95001 |
| 30-Jun-14 | Southwest | Clearwater | Mill Brook | 3486 | 46.57216 | -66.01737 |
| 30-Jun-14 | Southwest | Clearwater | Salmon Museum | 7133 | 46.55102 | -66.14474 |
| 02-Jul-14 | Southwest | Juniper | Main SW South Branch | 7275 | 46.54507 | -67.22330 |
| 02-Jul-14 | Southwest | Juniper | Main SW South Branch | 7532 | 46.55455 | -67.25672 |
| 02-Jul-14 | Southwest | Juniper | Main SW South Branch | 7661 | 46.55533 | -67.28783 |
| 02-Jul-14 | Southwest | Juniper | Elliott Brook | 7275 | 46.58256 | -67.30694 |
| 02-Jul-14 | Southwest | Juniper | Little Teague | 7575 | 46.58388 | -67.26064 |
| 02-Jul-14 | Southwest | Juniper | Elliott Brook | 7446 | 46.62143 | -67.36754 |
| 02-Jul-14 | Southwest | Juniper | Elliott Brook | 5665 | 46.61567 | -67.34233 |
| 03-Jul-14 | Northwest | Northwest | Stoney Brook | 3460 | 47.15280 | -66.05680 |
| 03-Jul-14 | Northwest | Northwest | Crawford stretch | 3600 | 47.22728 | -66.22957 |
| 03-Jul-14 | Northwest | Northwest | South Branch | 10660 | 47.25008 | -66.39289 |
| 03-Jul-14 | Northwest | Northwest | South Branch | 6440 | 47.24985 | -66.40220 |
| 03-Jul-14 | Northwest | Northwest | North Branch | 2800 | 47.27582 | -66.44077 |
| 04-Jul-14 | Southwest | Cains | Salmon Brook | 3620 | 46.64462 | -65.61314 |
| 04-Jul-14 | Southwest | Cains | Salmon Brook | 3640 | 46.63881 | -65.63110 |
| 04-Jul-14 | Southwest | Cains | East Branch Sabbies | 3960 | 46.56364 | -65.68284 |
| 04-Jul-14 | Southwest | Cains | West Branch Sabbies | 3620 | 46.51891 | -65.74332 |
| 04-Jul-14 | Southwest | Cains | Sling Dung Brook | 3900 | 46.30610 | -66.28322 |
| 04-Jul-14 | Southwest | Cains | McKinley Brook | 3720 | 46.29325 | -66.28078 |
| 04-Jul-14 | Southwest | Cains | North Cains | 5420 | 46.33105 | -66.34116 |
| 04-Jul-14 | Southwest | Cains | Muzzeroll | 5320 | 46.45929 | -66.18999 |
| 04-Jul-14 | Southwest | Cains | Mahoney Brook | 3090 | 46.50875 | -65.87188 |
| 04-Jul-14 | Southwest | Cains | Otter Brook | 3090 | 46.64071 | -65.75723 |
| 11-Jul-14 | Southwest | Clearwater | Clearwater Bridge | 14153 | 46.66243 | -66.77250 |
| 22-Jul-14 | Northwest | LSW | Squaw Barren Brook | 698 | 46.97314 | -66.70038 |
| 22-Jul-14 | Northwest | LSW | Country Line Brook | 698 | 46.92731 | -66.74187 |

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

| Date | Stock Origin | Organization | # of fish | Latitude | Longitude |
|---|---|---|---|---|---|
| 2-Jul-14 | Juniper | Miramichi Headwaters Salmon Association | 7168 | 46.51831 | -67.17829 |
| 10-Jul-14 | Burnthill | J.D. Irving | 28534 | 46.55475 | -67.16395 |
| 11-Jul-14 | Clearwater | MSA and Clearwater and Rocky Bend Camps | 10171 | 46.63315 | -66.75891 |

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

| Date | Stock Origin | Organization | # of fish | Latitude | Longitude |
|---|---|---|---|---|---|
| 5-Jun-14 | Juniper | Miramichi Headwaters Salmon Association | 4000 | 46.51831 | -67.17829 |
| 9-Jun-14 | Beadle Brook | J.D. Irving | 17810 | 46.55475 | -67.16395 |

## <u>Juvenile Electrofishing Assessment</u>

### Introduction

The Miramichi Salmon Association (MSA) continued its electrofishing program in 2014 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$^{rd}$ or 4$^{th}$ 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 2014 annual electrofishing program were to:

1. *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 2015, electrofishing surveys were carried out during the summer of 2014 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$^2$ 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.

2. *Evaluate spring stocking success:*

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

3. *Evaluate previous year's beaver dam removal success:*

   The Miramichi beaver dam management program resulted in 112 dams breached in 2013 over the entire Miramichi watershed. Upstream locations from where some of these dams were removed were a large focus for electrofishing crews in 2014 to determine if adult salmon were able to access these areas for spawning.

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 in 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$^2$ 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$^2$ 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 93 electrofishing sites were assessed by MSA and DFO field crews between August 5th and October 6th, 2014 on the Miramichi River system. MSA alone surveyed 37 sites, while MSA and DFO worked together on 56 sites.

*Determining future stocking sites of first-feeding fry*

Thirteen sites (of 37), concentrated on the Cains and Main Southwest Rivers, were surveyed to look for suitable habitat for future stocking. Over 75% of these thirteen sites contained no fry, but had good habitat. Five sites with zero fry had beaver dams in the vicinity. Three sites had parr densities higher than 20 parr/100m$^2$, while six sites had zero parr (Table 5). Sites with low juvenile densities could be potential stocking locations in the future.

*Electrofishing assessment of stocking first-feeding salmon fry in late spring*

Only three sites (of 37) were surveyed to assess spring stocking success because of the large focus put on surveying areas upstream of beaver dams removed in 2013. Moores Donnelly Brook, Doak Brook, and a site on the North Cains were all stocked in early summer 2014 and had densities of 147.7, 163.9, and 466.1 fry/100m$^2$, respectively when electrofished in August of 2014. 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.

*Beaver dam removal success from previous year*

In total, 57% (21/37) of the sites electrofished in 2014 focused on areas upstream of beaver dams removed in 2013 (12 on the Southwest and 9 on the Northwest). Ten of these sites had fry present, with fry densities ranging from 0 to 240.4 fry/100m$^2$ (Table 6). 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.

Table 5. Juvenile abundance assessments calculated using the CPUE method for 13 sites electrofished by the MSA to identify potential future stocking sites. Sites with <50 fry/100m$^2$ are candidate sites for future stocking locations. Sites with a * had beaver dams nearby.

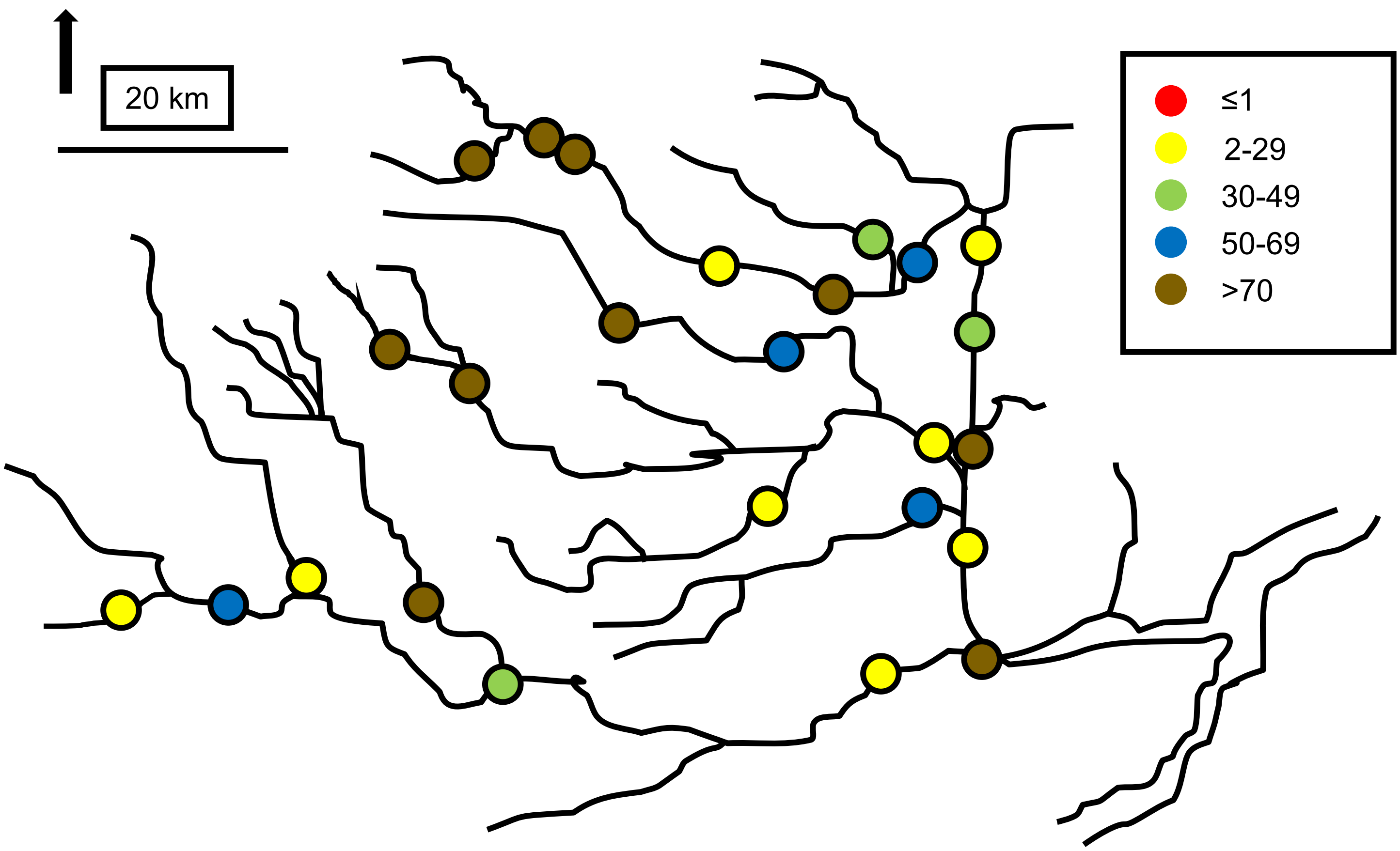
| River | Site | Fry/100m$^2$ | Parr/100m$^2$ |
|---|---|---|---|
| Cains | North Cains* | 0 | 24.4 |
| Cains | 10 Mile Brook | 0 | 0 |
| Main SW | Black Brook | 0 | 132.4 |
| Cains | Blue Rock Brook | 0 | 13.0 |
| Cains | East Muzzeroll* | 0 | 78.7 |
| Cains | Perogue Brook (Muzzeroll trib)* | 0 | 0 |
| Cains | East Sabbies (upper) | 73.4 | 0 |
| Cains | East Sabbies (upper)* | 0 | 5.6 |
| Cains | East Sabbies (upper)* | 0 | 0 |
| Cains | tributary to East Sabbies | 104.3 | 0 |
| Main SW | Grey Rapid Brook | 48.5 | 34.4 |
| Cains | Leighton Brook | 0 | 0 |
| Cains | Salmon Brook (upper) | 0 | 3.3 |

Table 6. Salmon fry abundance assessments calculated using the CPUE method for 21 sites electrofished in 2014 by the MSA upstream of beaver dams removed in 2013.

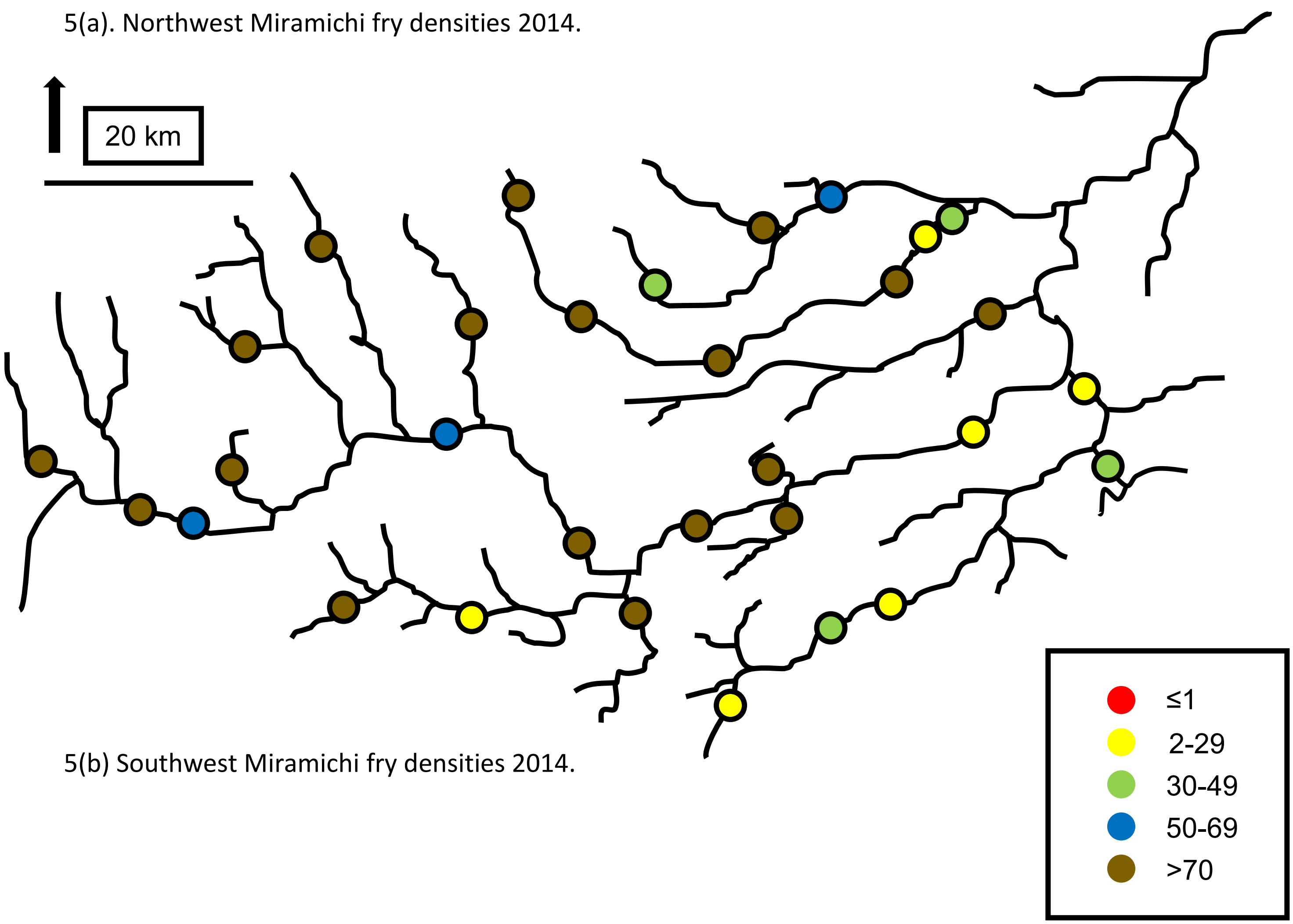
| River | Site | Fry/100m$^2$ |
|---|---|---|
| Main SW | Big Hole Brook (above Crooked Bridge Brook) | 0 |
| Main SW | Big Hole Brook | 27.6 |
| Main SW | Big Hole Brook (lower stretch) | 157 |
| Main SW | Betts Mills Brook | 0 |
| Cains | 6 Mile Brook (upper stretch, west) | 0 |
| Cains | 6 Mile Brook (west Acadia Road) | 31.7 |
| Cains | Salmon Brook (upper bridge) | 0 |
| Cains | Salmon Brook (middle) | 0 |
| Cains | Salmon Brook (lower) | 18.9 |
| Cains | Otter Brook (upper) | 0 |
| Main SW | Porter Brook (upper) | 0 |
| Main SW | Porter Brook (@ junction of Long Brook) | 122.1 |
| NW | Little River (upper) | 0 |
| NW | Littler River (middle) | 2.5 |
| NW | Little River (below middle) | 0 |
| NW | Little River (lower) | 185.5 |
| NW | Little Sevogle (bridge) | 0 |
| NW | Little Sevogle (lower bridge) | 219.1 |
| Sevogle | Sheephouse (upper put in) | 0 |
| Sevogle | Sheephouse (middle) | 86.4 |
| Sevogle | Sheephouse (@ bridge, lower) | 240.4 |

*Juvenile population assessment survey (MSA/DFO)*

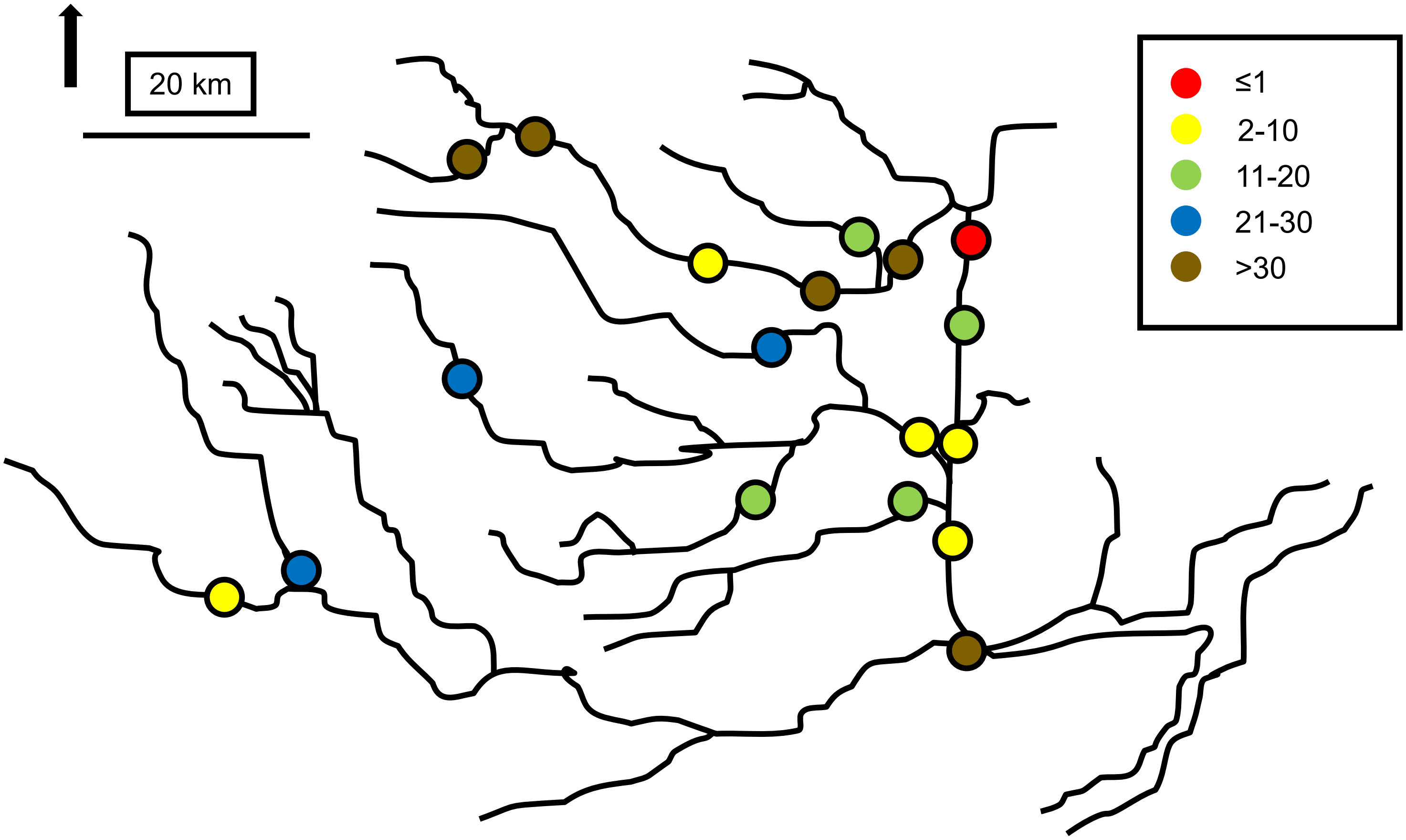
From August 25$^{th}$ to September 16$^{th}$ 2014, a total of 56 baseline sites were electrofished in several tributaries as part of the MSA/DFO cooperative program. Preliminary results from the assessment revealed high fry densities at many sites in both the Northwest and Southwest Miramichi Rivers, as 75% (42/56) of all sites contained greater than 30 fry/100m$^2$ (Fig 5a&b). No site contained zero fry and only 9% (5/56) of sites had fewer than 30 fry/100m$^2$. Parr densities were high (>20 parr/100m$^2$) at 52% (29/56) of sites, and only 3.5% (2/56) of sites contained zero parr (Fig 5c&d).



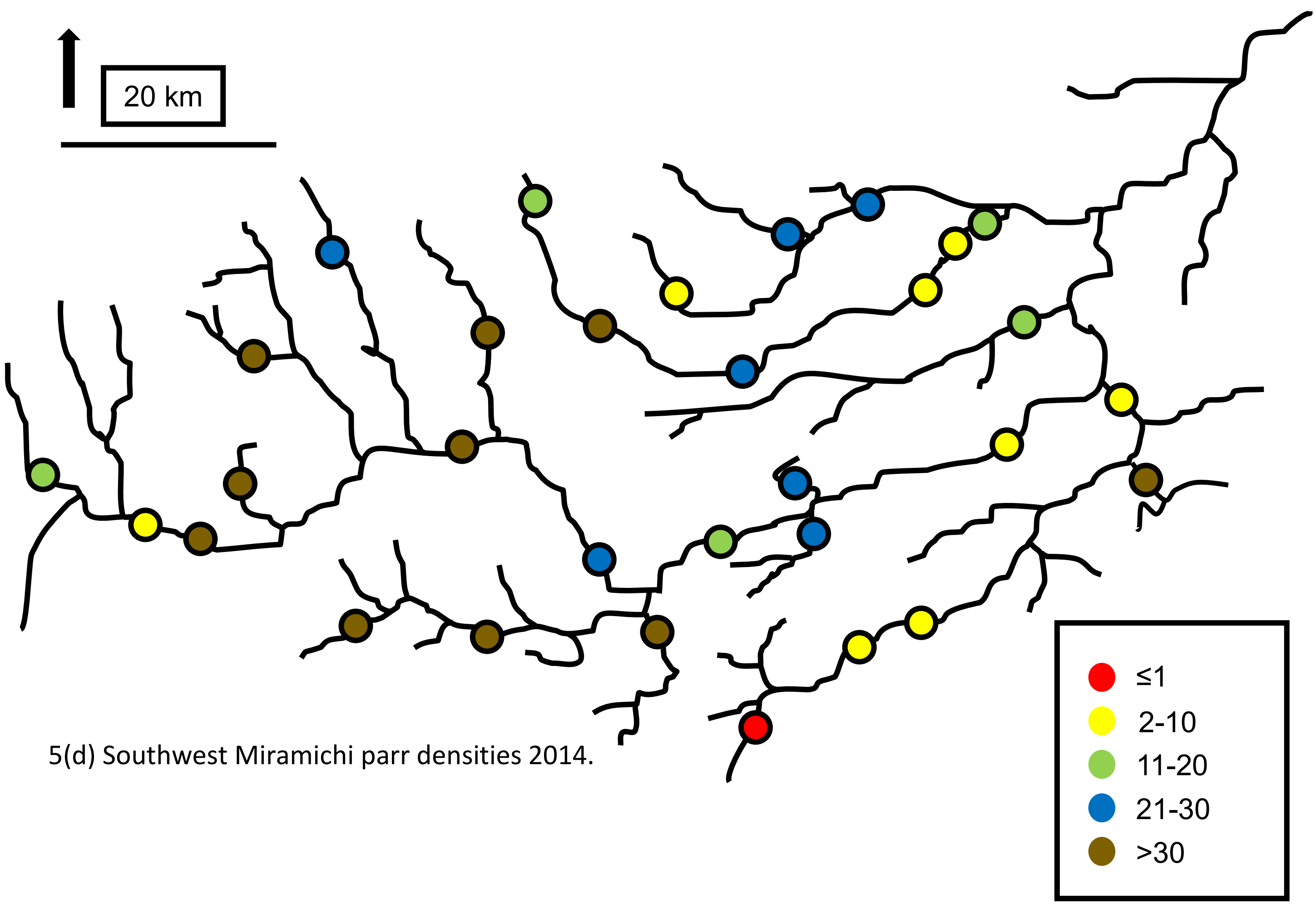

5(a). Northwest Miramichi fry densities 2014.




5(b) Southwest Miramichi fry densities 2014.




5(c) Northwest Miramichi parr densities 2014.




5(d) Southwest Miramichi parr densities 2014.

Figure 5: Preliminary juvenile density results from the 2014 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 ≤1, 2-29, 30-49, 50-69, and >70 per $100m^2$. Parr densities range from ≤1, 2-10, 11-20, 21-30, and >30 per $100m^2$.

# <u>Coldwater Pool Restoration</u>

## Introduction

Pools that are located directly downstream of cold water brooks can be critically important habitat to adult and juvenile salmon during warms water event 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 Moores-Donnelly Brook on the Main Southwest Miramich River in 2014. This brook had an accumulation of gravel at the mouth and consequently reduced cold water flow into the downriver thermal refuge pool located on the main river. Using heavy equipment, the banks near the outlet of Donnelly Brook were narrowed and the thalweg of the main river was redirected (by installing rock weirs) to an outside bend.

By re-establishing the thalweg on this bend, where the river meets Donnelly Brook, enough energy will be present to transport material away from the mouth of Donnelly Brook and maintain the cold water input into the pool in the future.

Three more brooks were identified (by the MSA) and surveyed (by Parish Geomorphic) in 2014 – Indiantown Brook and Doak Brook on the Main Southwest and Otter Brook on the Little Southwest. Restoration work will begin on these three brooks in 2015. A fourth location, Pat's Brook, on the Northwest will be surveyed and restored in 2015.

Moores-Donnelly Brook before restoration work in 2014.


Rock weir installation.

Moores- Donnelly Brook after restoration work in 2014.

# 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 50,000$m^2$ 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 2014 were determined ahead of time based on last year's results and known beaver activities in given areas. The first flight was done September 25th using a helicopter and focused on seven tributaries on the Southwest system: Burnthill Brook, Clearwater Stream, Sisters Brook, Rocky Brook, Salmon Brook, Porter Brook, and Burntland Brook. Flights resumed on October 3rd and 6th using a fixed wing aircraft, and focused on nine tributaries on the Southwest system: the south branch of the Main Southwest River, Elliott Brook, Big Teague Brook, Little Teague Brook, Bartholomew River, Muzzeroll Brook, Six Mile Brook, McKinley Brook, and North Cains River, and five tributaries on the Northwest system: Little River, the north branch of the North Sevogle River, Sheephouse Brook, Little Sevogle River, and the Northwest Millstream. 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 8th and finished on October 28th. A small number of active dams were notched on multiple occasions following repairs by beavers.

## Results

In the Northwest Miramichi basin, a total of 28 beaver dams were breached on four tributaries - Little River, the North Sevogle, Little Sevogle, and the Northwest Millstream (Figure 6a). In the Southwest system, beaver dam work was carried out on 21 tributaries and 139 dams were breached (Figure 6b&c). An additional 14 dams in the Southwest basin were breached on second and third occasions. No dams on the Northwest system were breached a second time.

A total of 167 beaver dams were breached in 2014 on 25 tributaries throughout the Miramichi watershed.

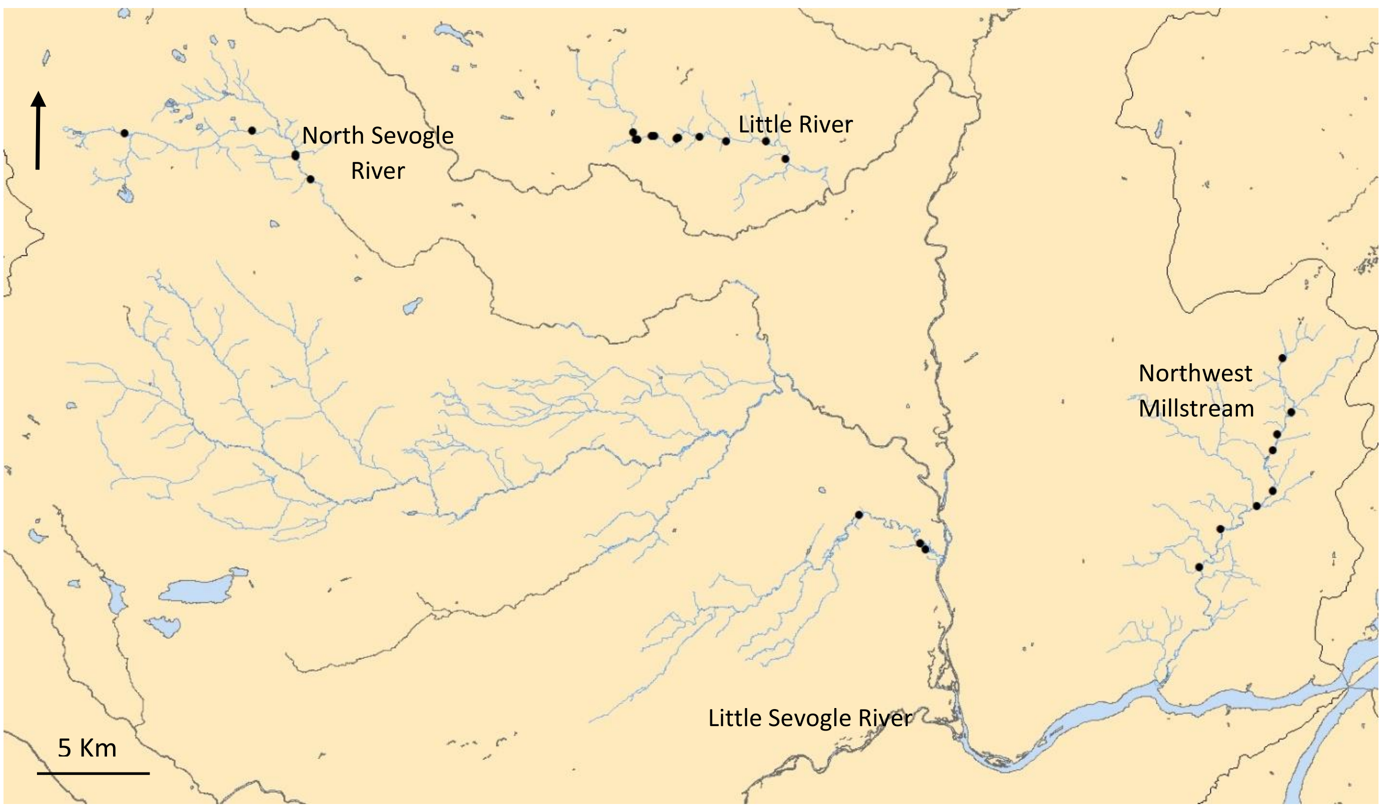



Figure 6a: Tributary rivers and streams in the Northwest Miramichi watershed where beaver dam breaching/removal took place in 2014. Dams removed/breached are marked with a "•".

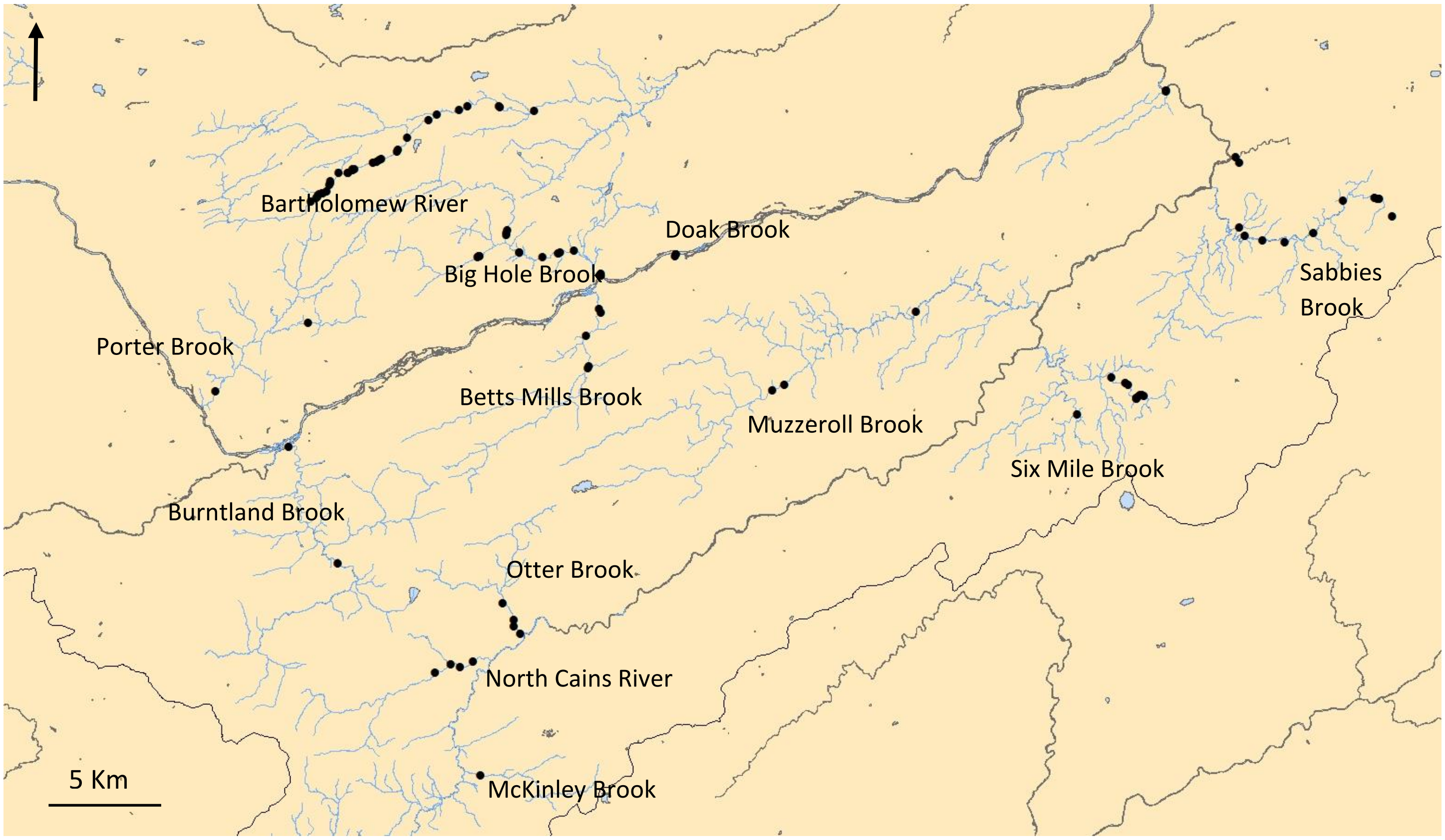



Figure 6b: Tributary rivers and streams in the Southwest Miramichi watershed where beaver dam breaching/removal took place in 2014. Dams removed/breached are marked with a "•".

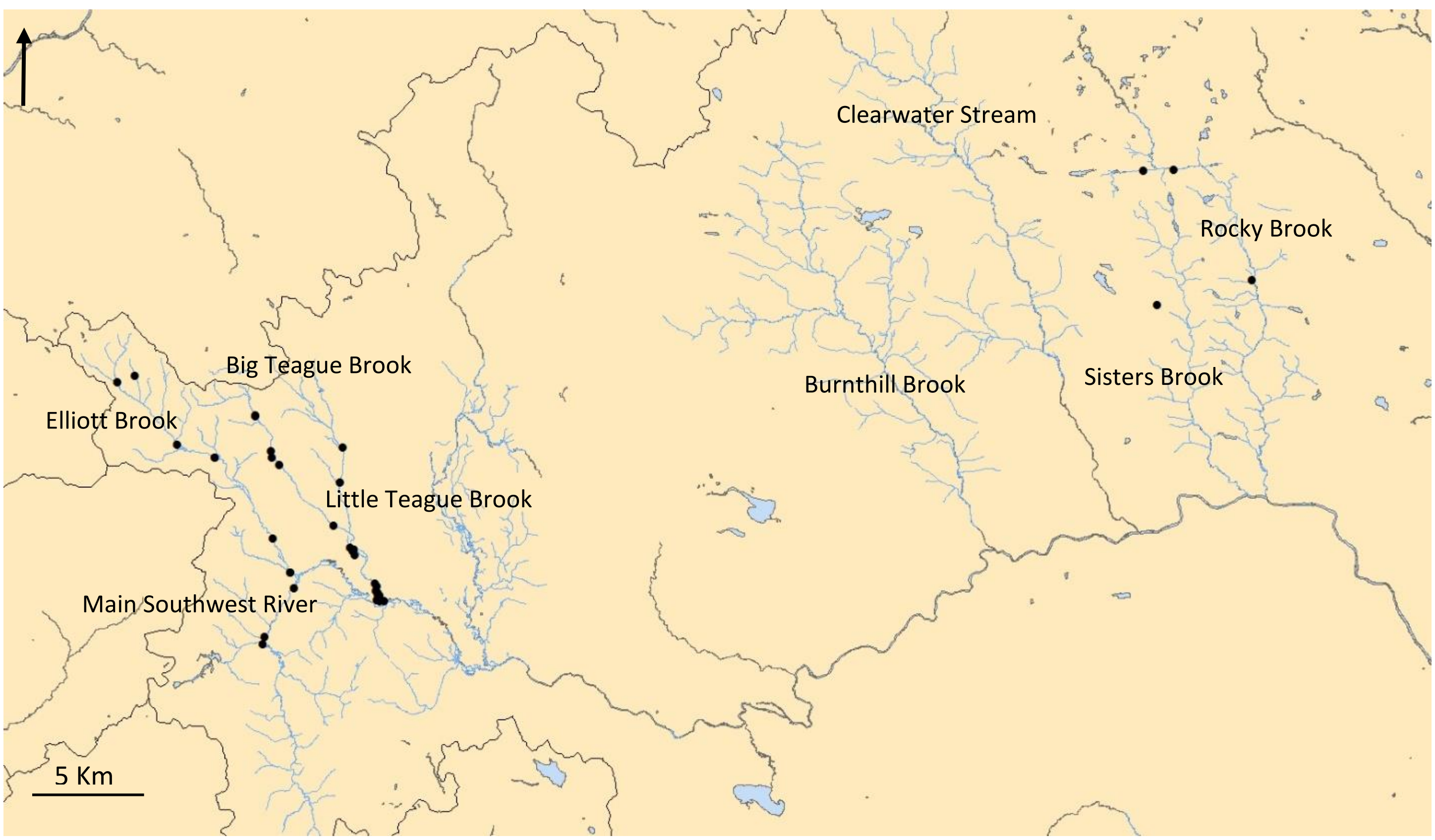



Figure 6c: Tributary rivers and streams in the Southwest Miramichi watershed where beaver dam breaching/removal took place in 2014. Dams removed/breached are marked

## 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. Flights paths for 2014 were chosen based on beaver activity locations noted in 2013, 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). These changes in 2014 presented a decreased number of beaver activities located in aerial surveys (68 dams) compared to 2013 (>100 dams), but field crews were actually more efficient and able to remove more dams in 2014 than in 2013 – 167 compared to 112.

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, Six Mile 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. Dams were most abundant in upstream stretches of tributaries where channel widths are narrow and water is slow flowing.

Water levels in 2014 were low compared to 2013, making access to dams easier, but also increasing the importance of removing as many dams being as possible in high quality spawning areas because salmon returning would have decreased chances of making it up over these obstructions. One dam in particular on Muzzeroll Brook had to be breached on three separate occasions. On the last visit to this site, field crews noted approximately 30 salmon in the area waiting to move upstream. Dams located on Big Hole Brook, Burntland Brook, and Sabbies Brook were also breached a second time.

Over half the electrofishing surveys completed in the summer of 2014 by MSA focused on areas upstream of beaver dams removed in 2013; twelve sites on the Southwest and nine on the Northwest. Ten of these sites had fry present and were located on Big Hole Brook, Porter Brook, Salmon Brook, Six Mile Brook, Little River, Sheephouse Brook, and Little Sevogle 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 2015 electrofishing surveys will be conducted upstream of dams breached/removed in 2014 to assess the impact of the program on fry production.

MSA employee Taylor Mullin stands next to a dam on the Little Sevogle in 2014.

Notch made in a dam on the Little Sevogle.

Aerial survey for dams in the Juniper area in 2014.

Appendix 2: GPS coordinates of breached/removed beaver dams in 2014.

| Date | Site | Longitude | Latitude | Active/Inactive | # of Return Visits | Breached on Return |
|---|---|---|---|---|---|---|
| 08-Oct-14 | Doak Brook | -66.12387 | 46.55867 | active | | |
| 08-Oct-14 | Muzzeroll | -66.04356 | 46.49157 | inactive | | |
| 08-Oct-14 | Muzzeroll | -66.05246 | 46.48862 | active | 4 | Yes (3) |
| 08-Oct-14 | Porter Brook | -66.39727 | 46.52424 | inactive | | |
| 09-Oct-14 | Burntland Brook | -66.37610 | 46.40025 | active | 1 | Yes |
| 09-Oct-14 | McKinley Brook | -66.27002 | 46.29116 | active | | |
| 12-Oct-14 | Big Teague | -67.23078 | 46.55339 | x | | |
| 12-Oct-14 | Big Teague | -67.22983 | 46.55189 | x | | |
| 12-Oct-14 | Big Teague | -67.24781 | 46.57319 | x | | |
| 14-Oct-14 | Bartholomew | -66.39519 | 46.58640 | active | | |
| 14-Oct-14 | Bartholomew | -66.39137 | 46.58838 | active | | |
| 14-Oct-14 | Bartholomew | -66.39075 | 46.58878 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.38975 | 46.58956 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.38886 | 46.59018 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.38740 | 46.59066 | active | | |
| 14-Oct-14 | Bartholomew | -66.38658 | 46.59074 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.38396 | 46.59188 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.38132 | 46.59507 | active | | |
| 14-Oct-14 | Bartholomew | -66.38081 | 46.59606 | active | | |
| 14-Oct-14 | Bartholomew | -66.38059 | 46.59671 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.37431 | 46.60111 | active | | |
| 14-Oct-14 | Bartholomew | -66.36803 | 46.60106 | active | | |
| 14-Oct-14 | Bartholomew | -66.36797 | 46.60109 | inactive | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14-Oct-14 | Bartholomew | -66.36787 | 46.60110 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.36459 | 46.60258 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.36441 | 46.60265 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.36396 | 46.60289 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.36349 | 46.60292 | active | | |
| 14-Oct-14 | Bartholomew | -66.36285 | 46.60305 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.34875 | 46.60659 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.34647 | 46.60665 | active | | |
| 14-Oct-14 | Bartholomew | -66.34394 | 46.60762 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.34255 | 46.60818 | active | | |
| 14-Oct-14 | Bartholomew | -66.33143 | 46.61206 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.33038 | 46.61322 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.32331 | 46.61928 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.30752 | 46.62838 | active | | |
| 14-Oct-14 | Bartholomew | -66.30138 | 46.63131 | inactive | | |
| 14-Oct-14 | Bartholomew | -66.28474 | 46.63337 | active | | |
| 14-Oct-14 | Bartholomew | -66.27824 | 46.63531 | active | | |
| 14-Oct-14 | Bartholomew | -66.25504 | 46.63540 | active | | |
| 14-Oct-14 | Bartholomew | -66.25418 | 46.63462 | active | | |
| 14-Oct-14 | Bartholomew | -66.22906 | 46.63284 | active | 1 | Yes |
| 14-Oct-14 | Crooked Bridge Brook | -66.27143 | 46.55792 | active | 1 | Yes |
| 14-Oct-14 | Crooked Bridge Brook | -66.27086 | 46.55821 | active | 1 | Yes |
| 14-Oct-14 | Crooked Bridge Brook | -66.27016 | 46.55825 | active | 1 | Yes |
| 14-Oct-14 | Crooked Bridge Brook | -66.26988 | 46.55839 | active | 1 | Yes |
| 15-Oct-14 | Big Hole Brook | -66.19934 | 46.56083 | inactive | | |
| 15-Oct-14 | Big Hole Brook | -66.17965 | 46.54906 | active | | |

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|---|---|---|---|---|---|---|
| 15-Oct-14 | Big Hole Brook | -66.17921 | 46.54801 | active | | |
| 15-Oct-14 | Big Hole Brook | -66.17970 | 46.54800 | active | 2 | Yes (2) |
| 15-Oct-14 | Big Hole Brook | -66.24876 | 46.57130 | inactive | | |
| 15-Oct-14 | Big Hole Brook | -66.24957 | 46.57000 | active | | |
| 15-Oct-14 | Big Hole Brook | -66.25007 | 46.56926 | active | | |
| 15-Oct-14 | Big Hole Brook | -66.24036 | 46.56011 | active | 1 | Yes |
| 15-Oct-14 | Big Hole Brook | -66.24014 | 46.56018 | active | 1 | Yes |
| 15-Oct-14 | Big Hole Brook | -66.22286 | 46.55739 | active | 1 | Yes |
| 15-Oct-14 | Big Hole Brook | -66.21117 | 46.55929 | inactive | | |
| 15-Oct-14 | Big Hole Brook | -66.21140 | 46.55932 | inactive | | |
| 15-Oct-14 | Big Hole Brook | -66.20982 | 46.56010 | active | 1 | Yes |
| 15-Oct-14 | Doak Brook | -66.12334 | 46.55888 | active | | |
| 15-Oct-14 | Doak Brook | -66.12426 | 46.55763 | active | | |
| 15-Oct-14 | Little Sevogle | -65.84527 | 47.02746 | inactive | | |
| 15-Oct-14 | Little Sevogle | -65.84882 | 47.02989 | active | 1 | No |
| 15-Oct-14 | Little Sevogle | -65.88731 | 47.04232 | active | 1 | No |
| 15-Oct-14 | Rocky Brook | -66.64135 | 46.70102 | inactive | 2 | No |
| 15-Oct-14 | Rocky Brook | -66.71530 | 46.75190 | inactive | 2 | No |
| 15-Oct-14 | Rocky Brook | -66.69435 | 46.75257 | inactive | 1 | No |
| 15-Oct-14 | Sisters Brook | -66.70550 | 46.68960 | inactive | | |
| 16-Oct-14 | Burntland Brook | -66.41197 | 46.46047 | active | | |
| 16-Oct-14 | Porter Brook | -66.46650 | 46.48883 | active | | |
| 16-Oct-14 | Salmon Brook (Cains) | -65.70596 | 46.60674 | active | 1 | Yes |
| 18-Oct-14 | East Sabbies | -65.68644 | 46.56342 | active | | |
| 18-Oct-14 | East Sabbies | -65.69988 | 46.56606 | active | | |
| 18-Oct-14 | East Sabbies | -65.70395 | 46.57065 | active | 1 | Yes |

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|---|---|---|---|---|---|---|
| 18-Oct-14 | North Cains | -66.30389 | 46.34386 | active | | |
| 18-Oct-14 | North Cains | -66.29206 | 46.34849 | active | | |
| 18-Oct-14 | North Cains | -66.28506 | 46.34661 | active | | |
| 18-Oct-14 | North Cains | -66.27521 | 46.34967 | active | | |
| 18-Oct-14 | Northwest Millstream | -65.63708 | 47.04456 | active | | |
| 18-Oct-14 | Northwest Millstream | -65.67356 | 47.01865 | active | | |
| 18-Oct-14 | Northwest Millstream | -65.65977 | 47.03488 | active | | |
| 18-Oct-14 | Otter Brook (Cains) | -66.25311 | 46.37943 | active | | |
| 18-Oct-14 | Otter Brook (Cains) | -66.24537 | 46.37101 | active | 1 | No |
| 18-Oct-14 | Otter Brook (Cains) | -66.24503 | 46.36760 | active | 1 | No |
| 18-Oct-14 | Otter Brook (Cains) | -66.24025 | 46.36385 | active | 1 | No |
| 18-Oct-14 | Otter Brook (Brophy's) | -65.75720 | 46.64077 | inactive | | |
| 18-Oct-14 | Otter Brook (Brophy's) | -65.75755 | 46.64144 | inactive | | |
| 18-Oct-14 | Otter Brook (Brophy's) | -65.75737 | 46.64147 | inactive | | |
| 18-Oct-14 | Salmon Brook (Cains) | -65.70346 | 46.60373 | inactive | | |
| 19-Oct-14 | East Sabbies (upper) | -65.59008 | 46.57538 | active | | |
| 19-Oct-14 | East Sabbies (upper) | -65.59930 | 46.58420 | active | | |
| 19-Oct-14 | East Sabbies (upper) | -65.60060 | 46.58429 | active | | |
| 19-Oct-14 | East Sabbies (upper) | -65.60286 | 46.58482 | active | | |
| 19-Oct-14 | East Sabbies (upper) | -65.62624 | 46.58343 | active | | |
| 19-Oct-14 | East Sabbies (upper) | -65.64884 | 46.56706 | active | | |
| 19-Oct-14 | East Sabbies (upper) | -65.67013 | 46.56260 | active | | |
| 19-Oct-14 | Little River | -66.02790 | 47.20735 | x | | |
| 19-Oct-14 | Little River | -66.02630 | 47.20430 | x | | |
| 19-Oct-14 | Little River | -66.02480 | 47.20452 | x | | |
| 19-Oct-14 | Little River | -66.01580 | 47.20595 | x | | |

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|---|---|---|---|---|---|---|
| 19-Oct-14 | Little River | -66.01410 | 47.20603 | x | | |
| 19-Oct-14 | Little River | -66.00020 | 47.20492 | x | | |
| 19-Oct-14 | Little River | -66.00000 | 47.20510 | x | | |
| 19-Oct-14 | Little River | -65.99930 | 47.20527 | x | | |
| 19-Oct-14 | Little River | -65.98580 | 47.20560 | x | | |
| 19-Oct-14 | Little River | -65.96910 | 47.20345 | x | | |
| 19-Oct-14 | Little River | -65.94380 | 47.20345 | x | | |
| 19-Oct-14 | Little River | -65.93190 | 47.19577 | x | | |
| 20-Oct-14 | Six Mile | -65.82545 | 46.47501 | active | | |
| 20-Oct-14 | West Six Mile (upper) | -65.77603 | 46.48435 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.77763 | 46.48467 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.77840 | 46.48474 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.77924 | 46.48412 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.78159 | 46.48323 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.78177 | 46.48303 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.78774 | 46.48996 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.78996 | 46.49115 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.78180 | 46.48301 | x | | |
| 20-Oct-14 | West Six Mile (upper) | -65.79990 | 46.49406 | x | | |
| 21-Oct-14 | Betts Mills Brook (Upper) | -66.18947 | 46.50053 | inactive | | |
| 21-Oct-14 | Betts Mills Brook (Upper) | -66.18872 | 46.50127 | active | | |
| 21-Oct-14 | Betts Mills Brook (Upper) | -66.19070 | 46.51703 | active | | |
| 21-Oct-14 | Betts Mills Brook (Upper) | -66.17985 | 46.52884 | inactive | | |
| 21-Oct-14 | Betts Mills Brook (Upper) | -66.18063 | 46.53097 | active | | |
| 21-Oct-14 | North Branch North Sevogle | -66.34859 | 47.20787 | x | | |

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|---|---|---|---|---|---|---|
| 21-Oct-14 | North Branch North Sevogle | -66.26803 | 47.20922 | x | | |
| 21-Oct-14 | North Branch North Sevogle | -66.24043 | 47.19862 | x | | |
| 21-Oct-14 | North Branch North Sevogle | -66.24049 | 47.19798 | x | | |
| 21-Oct-14 | North Branch North Sevogle | -66.23105 | 47.18811 | x | | |
| 22-Oct-14 | Northwest Millstream | -65.61950 | 47.10788 | x | | |
| 22-Oct-14 | Northwest Millstream | -65.61480 | 47.08495 | x | | |
| 22-Oct-14 | Northwest Millstream | -65.62370 | 47.07550 | x | | |
| 22-Oct-14 | Northwest Millstream | -65.62650 | 47.06837 | x | | |
| 22-Oct-14 | Northwest Millstream | -65.62700 | 47.05103 | x | | |
| 28-Oct-14 | Muzzeroll Brook (lower) | -65.94534 | 46.52844 | active | | |
| Oct 2014 | Big Teague | -67.26142 | 46.58428 | x | | |
| Oct 2014 | Big Teague | -67.29819 | 46.61250 | x | | |
| Oct 2014 | Big Teague | -67.31500 | 46.63517 | x | | |
| Oct 2014 | Big Teague | -67.25000 | 46.57406 | x | | |
| Oct 2014 | Big Teague | -67.24833 | 46.57253 | x | | |
| Oct 2014 | Big Teague | -67.24714 | 46.57075 | x | | |
| Oct 2014 | Big Teague | -67.23310 | 46.55769 | x | | |
| Oct 2014 | Big Teague | -67.22647 | 46.54928 | x | | |
| Oct 2014 | Big Teague | -67.23171 | 46.55618 | x | | |
| Oct 2014 | Big Teague | -67.23228 | 46.55425 | x | | |
| Oct 2014 | Big Teague | -67.23081 | 46.55236 | x | | |
| Oct 2014 | Big Teague | -67.23144 | 46.54996 | x | | |
| Oct 2014 | Big Teague | -67.23039 | 46.54981 | x | | |
| Oct 2014 | Big Teague | -67.22983 | 46.54920 | x | | |

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|---|---|---|---|---|---|---|
| Oct 2014 | Big Teague | -67.31508 | 46.63511 | x | | |
| Oct 2014 | Big Teague | -67.30328 | 46.61594 | x | | |
| Oct 2014 | Big Teague | -67.30392 | 46.61889 | x | | |
| Oct 2014 | Big Teague | -67.24778 | 46.57311 | x | | |
| Oct 2014 | Elliott Brook | -67.29033 | 46.56231 | x | | |
| Oct 2014 | Elliott Brook | -67.40850 | 46.65028 | x | | |
| Oct 2014 | Elliott Brook | -67.39667 | 46.65339 | x | | |
| Oct 2014 | Elliott Brook | -67.36758 | 46.62128 | x | | |
| Oct 2014 | Elliott Brook | -67.34222 | 46.61558 | x | | |
| Oct 2014 | Elliott Brook | -67.34203 | 46.61553 | x | | |
| Oct 2014 | Elliott Brook | -67.29039 | 46.56225 | x | | |
| Oct 2014 | Elliott Brook | -67.30225 | 46.57811 | x | | |
| Oct 2014 | Little Teague | -67.25707 | 46.60458 | x | | |
| Oct 2014 | Little Teague | -67.25558 | 46.62078 | x | | |
| Oct 2014 | MSW | -67.30858 | 46.52878 | x | | |
| Oct 2014 | MSW | -67.30692 | 46.53228 | x | | |
| Oct 2014 | MSW | -67.28781 | 46.55492 | x | | |