MIRAMICHI SALMON ASSOCIATION

CONSERVATION FIELD PROGRAM REPORT 2017

In Cooperation with:
Atlantic Salmon Federation
Department of Fisheries and Oceans
J.D. Irving Ltd.
Miramichi Headwaters Salmon Federation
Miramichi Watershed Management Committee
Northumberland Salmon Protection Association
Rocky Brook Camp – International Paper

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Acknowledgements

The research and conservation programs the Miramichi Salmon Association strives to deliver would not be possible without the support and contributions of numerous individuals and organizations. The MSA would like to thank the New Brunswick Wildlife Trust Fund for its continued support of several field programs – stocking, and electrofishing. The MSA would also like to thank the Atlantic Salmon Conservation Foundation for its contribution to cold water pool projects. The generous financial support of these conservation organizations affords the MSA opportunity to continually work towards salmon conservation on the Miramichi.

The MSA would also like to recognize the efforts and expertise of the organizations which partnered in and supported field programs during 2017. 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 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. 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 2017 field program.

Finally, 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.

Table of Contents

List of Tables

Table of Figures

Overview

This report is a review of the 2017 Miramichi Salmon Association (MSA) field and research programs implemented in the Miramichi River watershed. The MSA was started in 1953 as a non-profit conservation group dedicated to protecting the Miramichi River. The MSA has acted as a conservation advocate on behalf of anglers, outfitters, guides, and all others with economic, environmental, and recreational interests in the river. Managed by volunteers from Canada, the USA, and abroad, as officers and directors, the MSA remains cooperative with, but independent of, government or special interests influence. It responds in the end only to its growing conservation membership. The MSA employs 6 full-time staff, seasonal field technicians, and several summer students.

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

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

Kelt Tracking

Introduction

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

Satellite tags were used on fish from the Northwest Miramichi River from 2012 – 2015 (4 years), after which the project was moved to the Restigouche River. Only acoustic tags were used on the Northwest Miramichi River from 2016, and 2017 marked the 10th year of the acoustic tag study. 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.

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 on May 5th, 2017. 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. 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. After a minimum of one-hour recovery time, the fish was released.

Receiver Placement

A total of 17 Vemco VR2w acoustic receivers were placed throughout the freshwater and tidally influenced portions of the Northwest (6), Southwest (6), and main stem Miramichi Rivers (5) to detect in-river movements and survival rates. New in 2016 were additional receivers placed at Cassilis ((+1, 2 total) and Loggieville (+2, 3 total) in an effort to strengthen detections in these areas (more directly related to the smolt tracking project, as the receivers are used in that study as well). Receivers were also placed to form detection gates between openings at barrier islands near the mouth of Miramichi Bay at Neguac Beach, Portage Island, and Huckleberry Gully. In past years only one line of receivers was placed at the Strait of Belle Isle but in 2015 a second line was added, 3.5km north of the first line, to increase the chances of tag detection (Figure 1a&b).

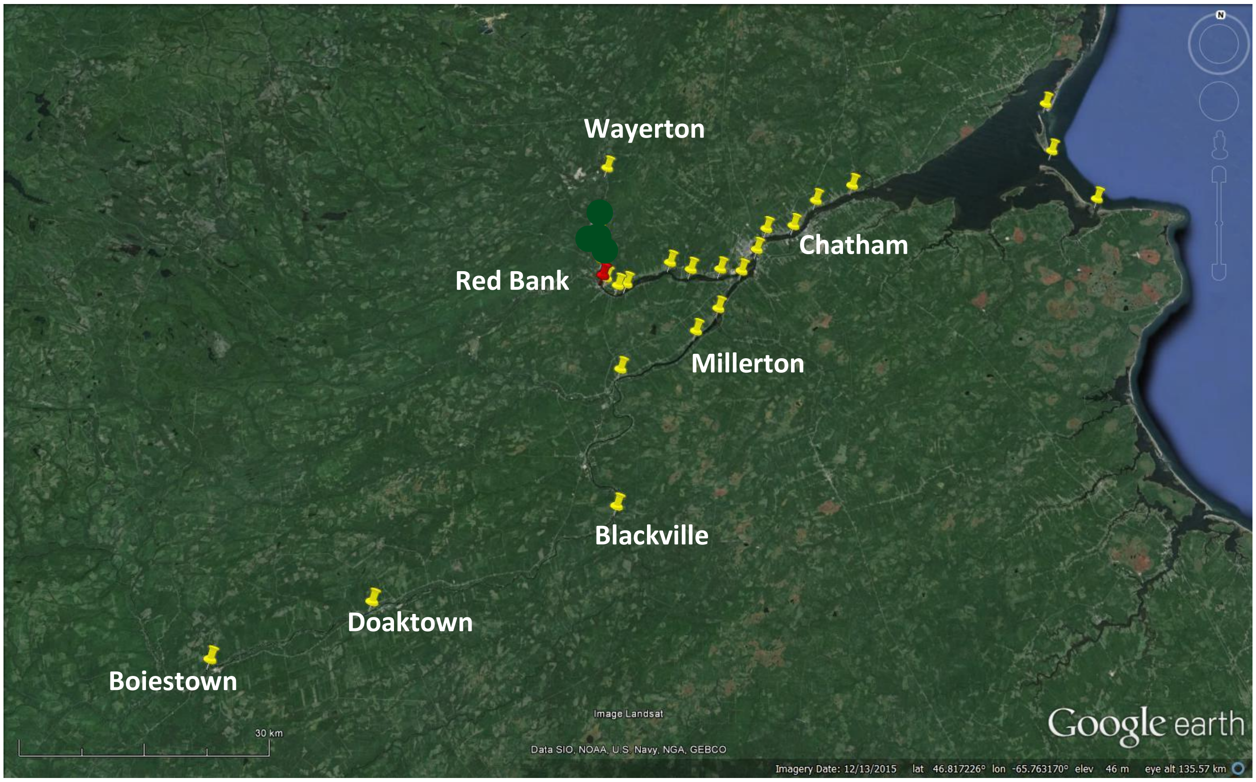


Figure 1a. Locations of acoustic receivers throughout the Miramichi River and Bay in 2017. The red pin indicates tagging location and yellow pins indicate acoustic receivers used for tracking kelt movements to determine survival out of the Miramichi River and Bay.

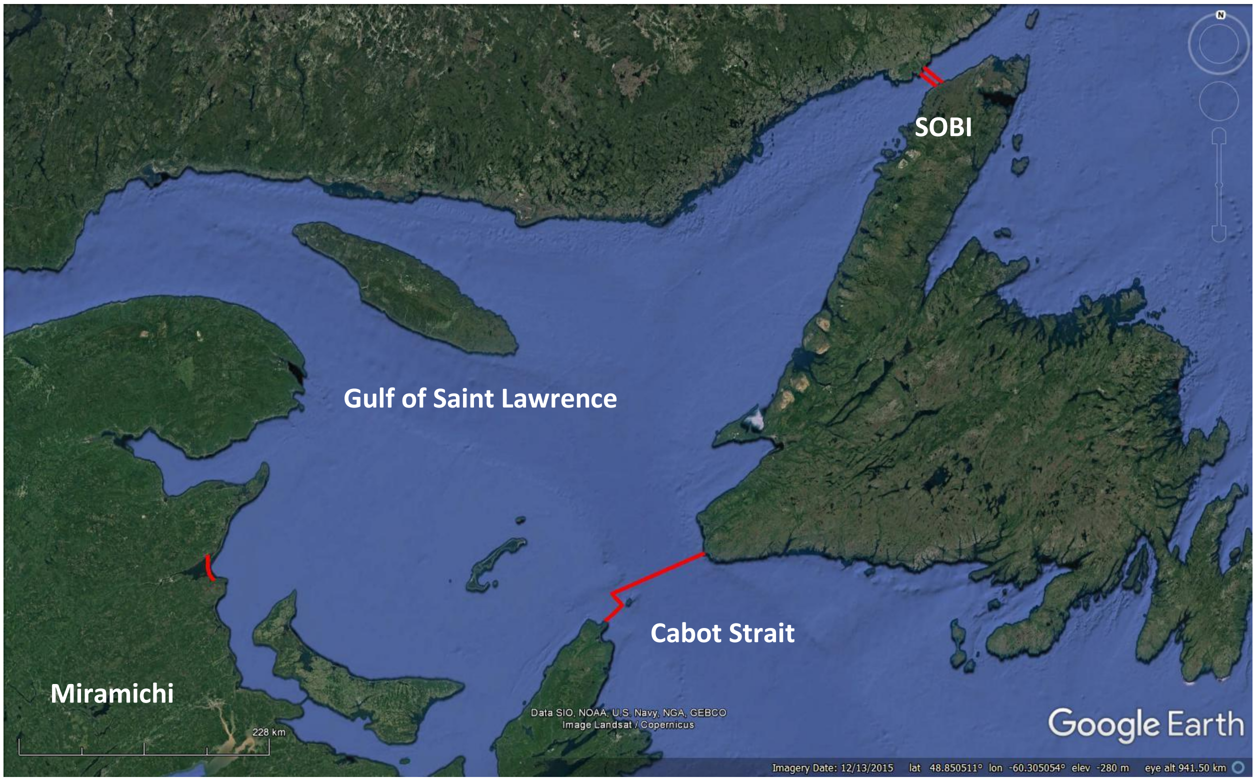


Figure 1b. Location of acoustic receivers (red lines) along Miramichi Bay, the Cabot Strait, and the Strait of Belle Isle (SOBI). The lines at the SOBI are 3.5km apart.

Results

A total of 8 kelt were tagged in with internal, long term V16 acoustic tags in 2017. Of the 8 tagged fish, 7 were female and 1 was male. They ranged in size from 2.9kg to 5.9kg (6.4lbs to 13.0lbs) and 71.0cm to 93.0cm (27.9in to 36.6in).

Movement and Survival through the Northwest River and Miramichi Bay

Acoustic receiver detections showed that 7 of the 8 fish (87.5%) survived out of the Miramichi River and into Miramichi Bay. Their in-river timeframe was spread out over 16 days, and their detection dates at the outer Bay receivers occurred over a 15 day period, with the last one crossing into the Bay on May 21st. None of these fish returned as consecutive spawners.

Movement and Survival in the Marine Environment

Almost all of the acoustic tags (87.5%) were detected at the outer Miramichi Bay receivers between May 19th and May 23rd. It is assumed these fish were traveling east and entered the Gulf of Saint Lawrence. Tags 50722, 50723, and 50724 were detected at the SOBI array between June 26th and July 6th.

Table 1. Total number of kelt with acoustic tags and % survival through various locations from 2008 and 2017. * indicates this information is not available until next year and only applies to kelts which received long term acoustic transmitters.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Kelts Tagged (#)	50	50	50	50	35	16	21	24	26	8
Head of Tide (%)	100	100	100	100	100	100	95	100	96	100
River Mouth (%)	96	92	90	94	94	75	85	100	96	88
Miramichi Bay (%)	94	92	90	94	94	69	85	100	96	88
Strait of Belle Isle (%)	44	18	14	30	30	38	33	38	37	38
Consecutive returns (%)	6	8	18	10	10	0	10	31	4	0
Alternate returns (%)	8	0	10	4	0	6	0	0	0	*

Smolt Tracking

Introduction

Juvenile Atlantic salmon (*Salmo salar*) that 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 (GOSL). Over the past five 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 (which began in 2001), the MSA has been involved in an acoustic tracking study on the Northwest branch since 2013. This study continued in 2017 during the smolt migration in the spring to determine survival rates throughout the Miramichi 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 and the Northwest Miramichi River, which merge in a delta at the head of tide. The Northwest Miramichi River includes a large tributary, the Sevogle River.

The Southwest Miramichi watershed drainage area of 7700km^2 makes up the remaining two-thirds of the total watershed of the Miramichi River. The Southwest basin includes many smaller river systems, such as the Renous River, the Dungarvon River, the Cains River, and Rocky Brook.

Collection & Tagging

Atlantic salmon smolt were captured by a rotary screw trap (RST) on the Northwest Miramichi River immediately upstream of the mouth of Trout Brook. Only fish greater than 13cm were held for tagging (to allow for room in the body cavity for the transmitter). The fish were held in live boxes off the shore until the following morning (to allow for digestion and therefore easier tag insertion) when they were transported to the tagging location in an x-actic tank on a truck. The smolts were tagged at Miner's Bridge, approximately 27km upstream of the RST.

Prior to surgery the fish were placed in a clove oil bath for several minutes until equilibrium was lost and movement was minimal. Vemco V8 acoustic tags were used during surgery. The tag was inserted by making a small incision on the ventral surface on the fish, off-centre, 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 17 Vemco VR2w acoustic receivers were placed throughout the freshwater and tidally influenced portions of both the Northwest and Southwest Miramichi Rivers. In 2016 a second receiver was added in Cassilis (considered head-of-tide) in an effort to increase detections. Five receivers were placed along the main stem of the Miramichi River between Beaubears Island and Loggieville, with an additional 2 receivers added to the Loggieville location in 2016 to increase detections. A further 11 receivers were also placed to form detection gates between openings at barrier islands near the mouth of Miramichi Bay at Neguac Beach, Portage Island, and Huckleberry Gully. An additional receiver line at the Strait of Belle Isle (SOBI) was deployed in 2015, 3.5km north of the original line so that two lines of detection were present to increase the chances of tag detections in this area (Figure 2a&b).

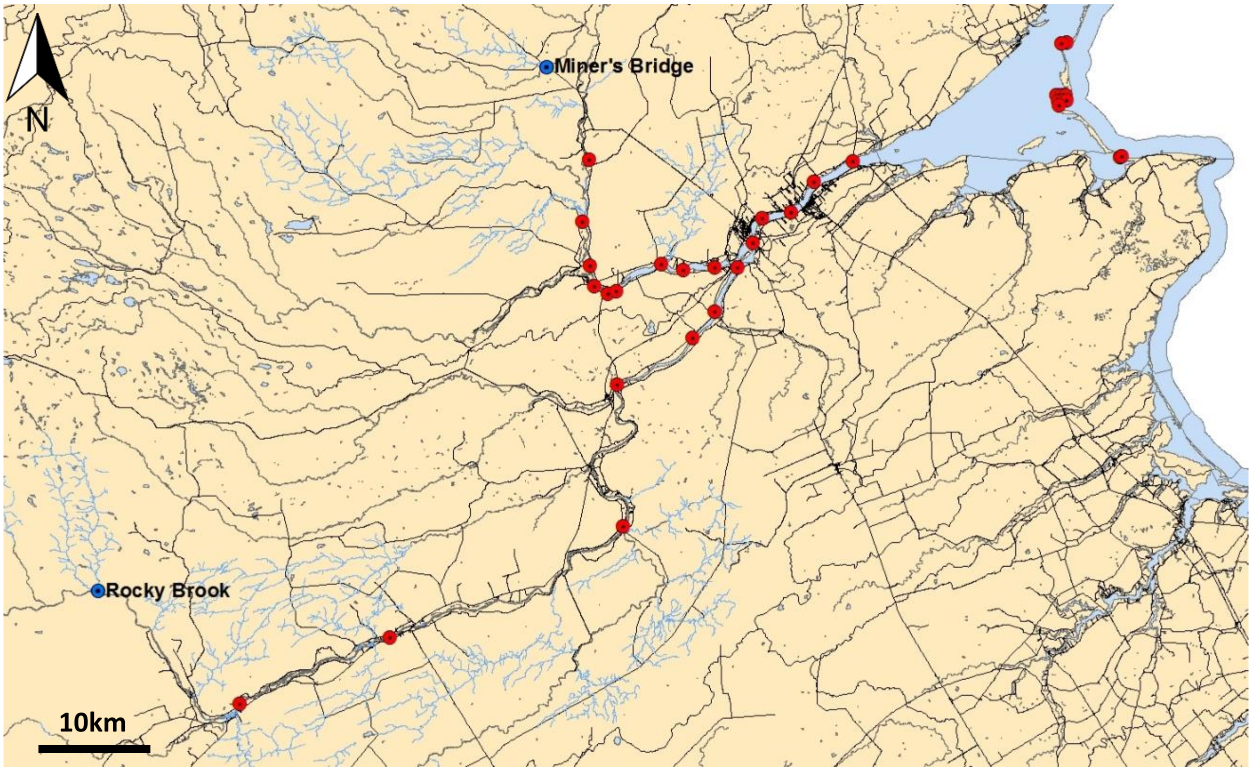


Figure 2a. Acoustic receiver locations (red dots) in the Miramichi River and Bay in 2017. Smolt tagging and release locations are represented by a blue dot – Miners Bridge on the Northwest branch and Rocky Brook on the Southwest branch.

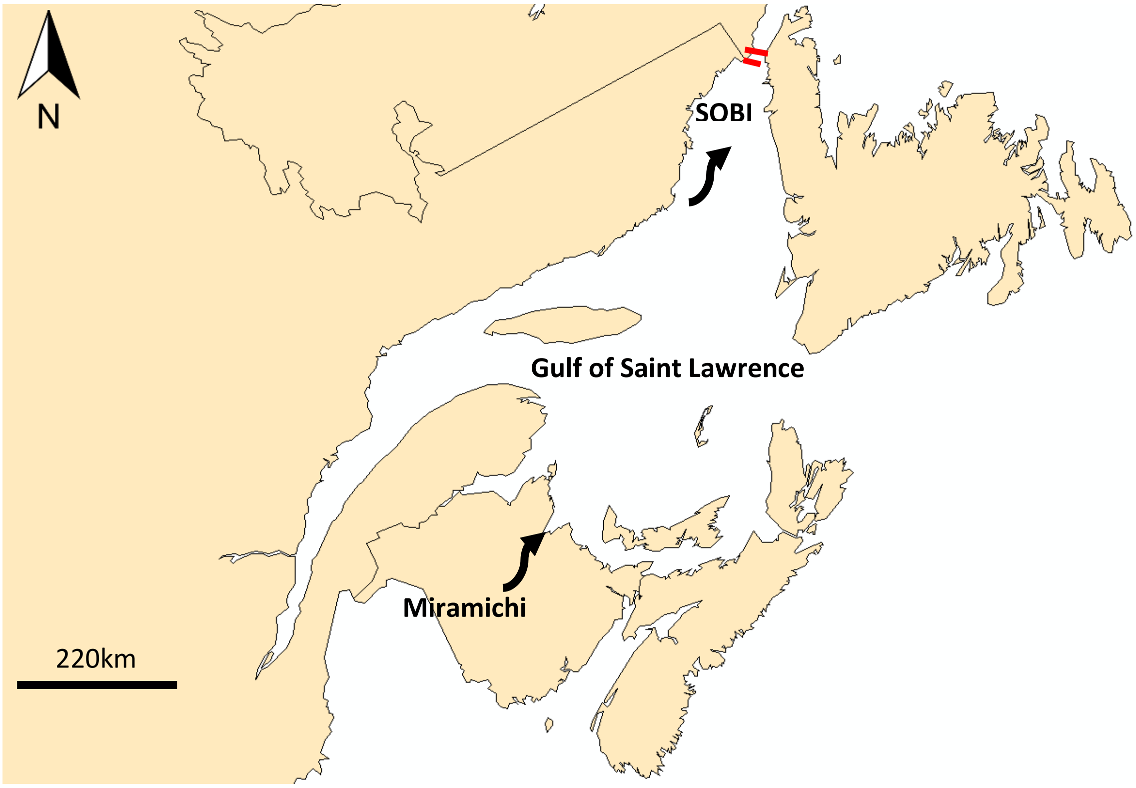


Figure 2b. Acoustic receiver locations (red lines) across the Strait of Belle Isle in 2017. A second line was added north of the original line in 2015. The lines are 3.5km apart. Suspected fish movement paths are indicated with a black arrow.

Results

Northwest River

From May 17th – 25th, a total of 80 smolts were captured at the Northwest smolt wheel and transported upstream to the tagging site located at Miner's Bridge. Of the initial 80 fish tagged, 64 of them (80%) were detected on the first receiver at Red Bank, however at the head of tide (HOT) in Cassilis, only 53 of the 80 fish (66%) were detected, indicating a 34% mortality rate from the tagging location to HOT. Another 30% of the fish were lost between Cassilis and Nelson. Survival in the main channel of the river from Nelson to Loggieville was 62% of the remaining fish, and 13% from the tagging location. Only 6 fish (8%) of the smolts tagged at Miner's Bridge survived out of the estuary (past the barrier receiver lines), and 5% to the SOBI (Figure 3a).

Southwest River

On May 19th & 20th, 80 smolts captured at the Rocky Brook smolt wheel were tagged and released. Of the initial 80 fish tagged, 66 (83%) of them were detected at the first receiver in Boiestown, however at the head of tide (HOT) in Millerton, only 55 of the 80 fish (69%) were detected, indicating a 31% mortality rate from the tagging location to HOT. Another 13% of the fish were lost between Millerton and Nelson. Survival in the main channel of the river from Nelson to Loggieville was 64% of the remaining fish, and 33% from the tagging location. Only 11 fish (14%) of the smolts tagged at Rocky Brook survived out of the estuary (past the barrier receiver lines), and 5% to the SOBI (Figure 3b).

In total, 11% of the smolts leaving the entire Miramichi River survived to exit the estuary, and 5% survived to the SOBI.

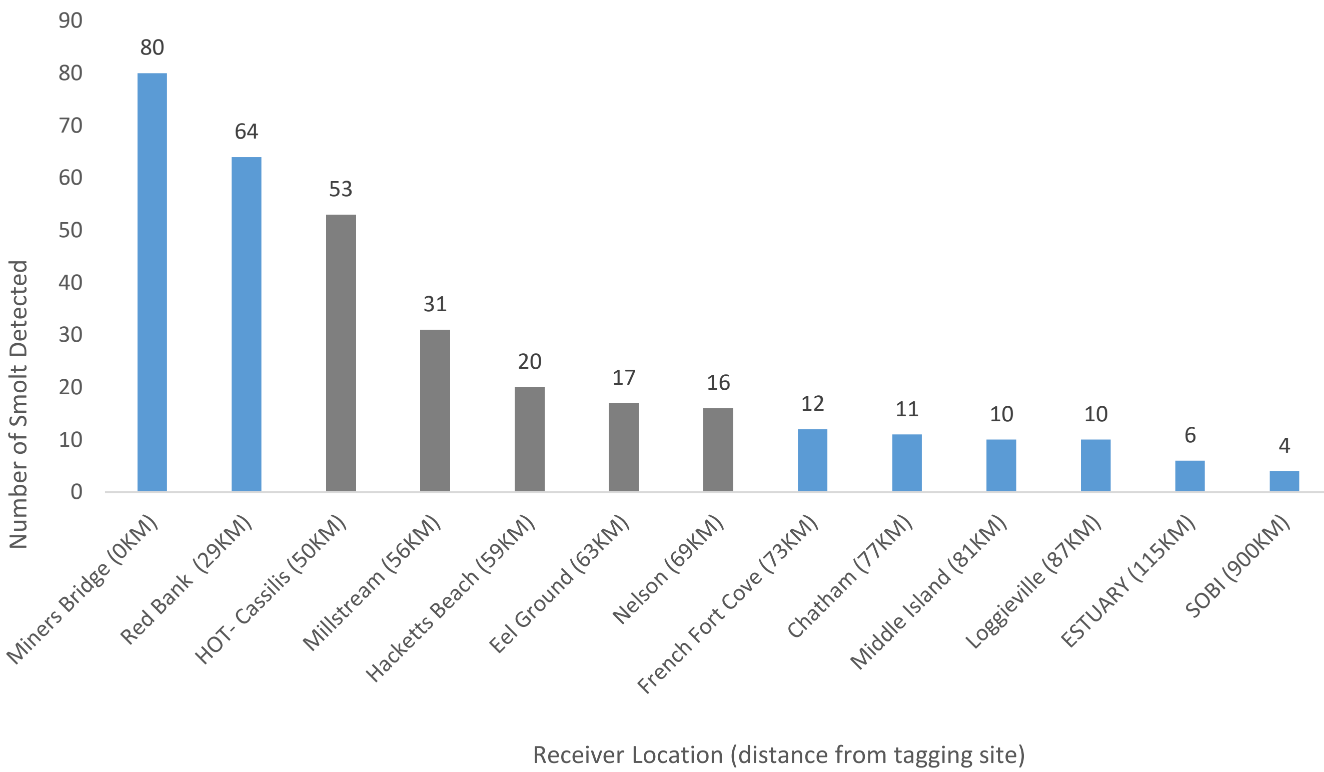


Figure 3a. Survival numbers of acoustic tagged smolts from the Northwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2017. The highest percentage of mortality occurred between Cassilis and Nelson (37 fish/30%), marked in grey.

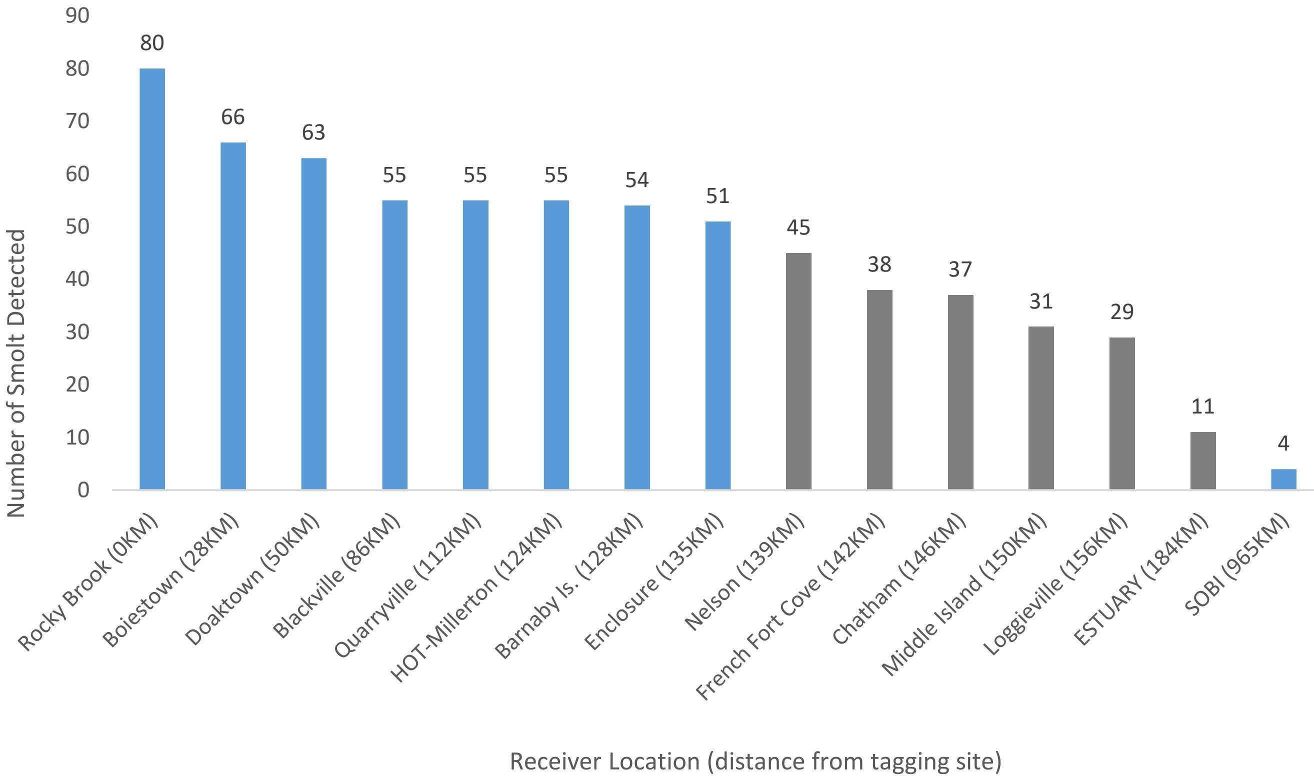


Figure 3b. Survival numbers of acoustic tagged smolts from the Southwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2017. The highest percentage of mortality occurred between Nelson and Loggieville (34 fish/43%), marked in grey.

Discussion

Survival numbers from the 2017 tagging study are less than desirable for the Miramichi River, similar to the numbers recorded in 2016. The fish that successfully survived tagging (a 10% mortality rate is assumed for tagging studies) and were detected exiting Miramichi Bay was only 11%.

The highest areas of loss on the Northwest were between the head of tide at Cassilis and Nelson (37 fish/30%) where striped bass are most prevalent, and from the tagging location at Miner's bridge to Cassilis (27 fish/34%) (Figure 3a). The highest survival rate was observed between French Fort Cove and Loggieville, as only 2 fish (3%) were lost. For the Northwest River in total, 0.88 smolt/km were lost.

On the Southwest branch the highest areas of loss were between Nelson and the Estuary (34 fish/43%) (Figure 3b). The highest survival rate was observed between Blackville and the Enclosure, with the section only losing 4 fish (5%). For the Southwest River in total, 0.88 smolt/km were lost.

The second receiver line placed in the SOBI in 2015 has shown that the first line did not always pick up all the fish moving through the Strait. Of the 4 smolts that survived to the SOBI from the Northwest River, 4 fish were picked up by the first line, 1 on the second line, and 4 on both lines. Of the 4 fish that survived to the SOBI from the Southwest River, 3 were picked up on the first line, 3 on the second line, and 4 on both lines. This error percentage can be modeled and applied to smolt tracking data from previous years to produce a more accurate estimate than originally thought.

It is important to note that there are multiple sources of smolt predation within the tidally influenced waters of the Northwest Miramichi River, and that at this time it is not possible to quantify the level of tagged smolt mortality that can be attributed to striped bass. Avian predation from mergansers, gulls, and cormorants, as well as fish predation by trout, tomcod, or reconditioning kelt could all contribute to natural smolt mortality in the river. In order to narrow the sources of predation, detailed study of individual tag data is required. For 2017 data, further analysis will be carried out by the Atlantic Salmon Federation (ASF) 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 2017, a new Vemco acoustic predator tag was used by the Atlantic Salmon Federation. The predator tags change their signal code ID if a fish is consumed, and they are picked up by the more sensitive VR2W-180 kHz receivers. This data is being analyzed by the Atlantic Salmon Federation who will be publishing a peer reviewed report in the coming year.

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 2017, tagging efforts were staggered on the Northwest River over multiple days to allow for detection of movement and survival changes over time. This information would then be available for comparison to striped bass tracking research, conducted by DFO, to determine the times of greatest overlap between the species. This combined research should allow for a more precise understanding of the interaction between the species. Efforts will be made again in 2018 to spread the tagging out over multiple days to try and determine temporal overlap between smolts and striped bass and to add more data to the smolt tracking and survival databases.

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 could destroy a redd, 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 number 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. However, there are still locations that raise fall fingerlings for stocking purposes. Atlantic salmon and brook trout fry were raised this year in satellite rearing stations run in collaboration with J.D. Irving Ltd. and the Miramichi Headwaters Salmon Federation. The objective of the stocking program is to improve Atlantic salmon production in the headwaters of the Miramichi watershed.

The number of broodstock collected from the Northwest system was decreased in 2015 because of a new initiative, which would see a decreased need for stocking on this branch. The Collaboration for Atlantic Salmon Tomorrow (CAST) initiative began in 2014 with plans to collect smolts from the Northwest Miramichi River and grow them at the Miramichi Salmon Conservation Centre (MSCC) until maturity, after which they would be released to spawn naturally in the wild. Smolt to adult survival has decreased in the last decade, resulting in a decreased number of adults returning to the river. This part of the CAST initiative would increase the number of spawning adults in the Northwest Miramichi.

Methods

Adult salmon were collected from September to mid-October 2016 for broodstock from six tributaries on the Miramichi River – Northwest River, Sevogle River, Little Southwest River (LSW), Clearwater Brook, the Main Southwest River in Juniper, and the Cains River. These fish were held at the MSCC and 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 in trays until the eyed stage, when dead eggs were removed daily. Eyed eggs were transferred to upwelling incubation boxes in preparation for hatching. After hatching, fry were fed a formulated salmonid diet (Skretting Nutra XP 1.0/EWOS #1CR) for approximately 5 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. Additional salmon fry were taken to satellite rearing sites for continued growth before stocking.

Results

Approximately 235,031 first-feeding Atlantic salmon fry were stocked into 67 sites in five tributaries of the Miramichi River (Figure 4 and Figure 5). The Northwest system received 93,431 fry and the Southwest system 84,113 (Table 2a&b). An additional 57,487 fry were taken to satellite holding tanks for future release by local conservation groups (Table 3). Furthermore, 2,619 brook trout fry were distributed to a satellite tank rearing location (Table 4).

Table 2a. Distribution of first-feeding Atlantic salmon fry from the Miramichi Salmon Conservation Centre in 2017 on the Northwest branch of the Miramichi River.

Branch	Stock Origin	Site	# of fish	Latitude	Longitude
Northwest	SEV	Travis Brook	2478	47.045	-66.221
Northwest	SEV	Johnston Brook	2478	47.048	-66.229
Northwest	SEV	Clearwater Brook	2478	47.101	-66.233
Northwest	SEV	Barracks Brook	4957	47.071	-66.293
Northwest	SEV	South Branch Bridge	4957	47.094	-66.312
Northwest	SEV	South Branch 1	4957	47.110	-66.321
Northwest	SEV	Little Sheephouse Brook	2664	47.095	-66.006
Northwest	SEV	Sheephouse Brook	5328	47.080	-66.021
Northwest	SEV	Peabody Lake Brook	2664	47.118	-66.135
Northwest	SEV	North Branch Bridge	2664	47.203	-66.321
Northwest	SEV	North Branch	7992	47.208	-66.354
Northwest	SEV	South Branch	2664	47.104	-66.318
Northwest	SEV	Travis Brook	1085	47.045	-66.221
Northwest	SEV	Johnston Brook	2516	47.048	-66.228
Northwest	SEV	South Branch Bridge	2516	47.094	-66.312
Northwest	SEV	South Branch	2516	47.110	-66.321
Northwest	SEV	South Branch	2516	47.103	-66.317
Northwest	SEV	South Branch	5032	47.089	-66.311
Northwest	LSW	North Branch North LSW	2529	46.984	-66.519
Northwest	LSW	Bridge	2529	46.970	-66.531
Northwest	LSW	Below Smith Forks	4354	46.962	-66.581
Northwest	LSW	Squaw Barron Brook	5058	46.973	-66.700
Northwest	LSW	County Line Brook	2529	46.927	-66.742
Northwest	NW	Mountain Brook	3615	47.203	-66.073
Northwest	NW	Northwest South Branch	2071	47.249	-66.393
Northwest	NW	Gill Brook	2071	47.245	-66.213
Northwest	NW	Stoney Brook	2071	47.153	-66.057
Northwest	NW	Trout Brook	4142	47.115	-65.798

Table 2b. Distribution of first-feeding Atlantic salmon fry from the Miramichi Salmon Conservation Centre in 2017 on the Southwest branch of the Miramichi River.

Branch	Stock Origin	Site	# of Fish	Latitude	Longitude
Southwest	JUN	Juniper Brook	2524	46.539	-67.185
Southwest	JUN	Big Teague 1	2524	46.558	-67.233
Southwest	JUN	Big Teague 2	5048	46.563	-67.243
Southwest	JUN	Big Teague 3	2524	46.573	-67.249
Southwest	JUN	Elliot Brook	2524	46.583	-67.307
Southwest	JUN	Little Teague	2524	46.635	-67.315
Southwest	JUN	South Branch SW	2524	46.554	-67.254
Southwest	JUN	South Branch SW 2	2524	46.529	-67.309
Southwest	JUN	White Rapids Brook	1000	46.769	-65.858
Southwest	JUN	North Branch Hudson Brook	500	46.755	-65.846
Southwest	JUN	Main Branch Hudson Brook	500	46.758	-65.845
Southwest	JUN	South Branch Hudson Brook	200	46.757	-65.844
Southwest	JUN	White Rapids Brook	2000	46.789	-65.801
Southwest	JUN	Four Mile Brook	500	46.609	-66.079
Southwest	JUN	Fowler Meadow Brook	1000	46.619	-66.108
Southwest	JUN	Ledbetter's Brook	1000	46.619	-66.112
Southwest	JUN	Davis Landing Brook	800	46.600	-66.209
Southwest	JUN	Lake Brook	500	46.860	-65.795
Southwest	JUN	Watch Brook	200	46.705	-65.904
Southwest	JUN	Washed out bridge	200	46.720	-65.870
Southwest	JUN	Brandy/Mersereau Brook	100	46.690	-65.840
Southwest	JUN	Zacks Brook	300	46.674	-65.847
Southwest	JUN	Morse Brook	1000	46.668	-65.849
Southwest	JUN	Morse Brook	1000	46.698	-65.786
Southwest	JUN	Hallihan Brook	200	46.712	-65.819
Southwest	JUN	Watson Brook	500	46.730	-65.880
Southwest	CAINS	Tyler's Camp	2517	46.560	-65.804
Southwest	CAINS	Cains 1	2517	46.558	-65.810
Southwest	CAINS	Mahoney Brook	2517	46.509	-65.872
Southwest	CAINS	Brads Camp	2517	46.506	-65.873
Southwest	CAINS	Cains 2	2517	46.500	-65.884
Southwest	CAINS	McKenzie Brook	2517	46.457	-66.012
Southwest	CAINS	Ten Mile Brook	2517	46.412	-65.998
Southwest	CAINS	Muzzroll Brook	2517	46.498	-66.073
Southwest	CAINS	West Branch Lower Otter Brook	2517	46.386	-66.269
Southwest	CAINS	Salmon Brook	2507	46.645	-65.613
Southwest	CAINS	East Branch Sabbies River	7521	46.564	-65.684
Southwest	CAINS	Six Mile Brook	5014	46.483	-65.828
Southwest	CAINS	Ten Mile Brook Tributary	2507	46.422	-65.988
Southwest	CAINS	Blue Rock Brook	5014	46.383	-66.071
Southwest	CAINS	North Branch Cains River	4681	46.331	-66.341

Table 3. Distribution of first-feeding Atlantic salmon fry to satellite holding tanks for continued growth and stocking in 2017.

Stock Origin	Organization	# of fish	Latitude	Longitude
Juniper	Miramichi Headwaters Salmon Association	22457	46.51831	-67.17829
Clearwater	J.D. Irving Ltd.	35030	46.55475	-67.16395

Table 4. Distribution of brook trout fry to satellite tanks for continued growth and stocking in 2017.

Stock Origin	Organization	# of fish	Latitude	Longitude
Beadle Brook	J.D. Irving Ltd.	2619	46.55475	-67.16395

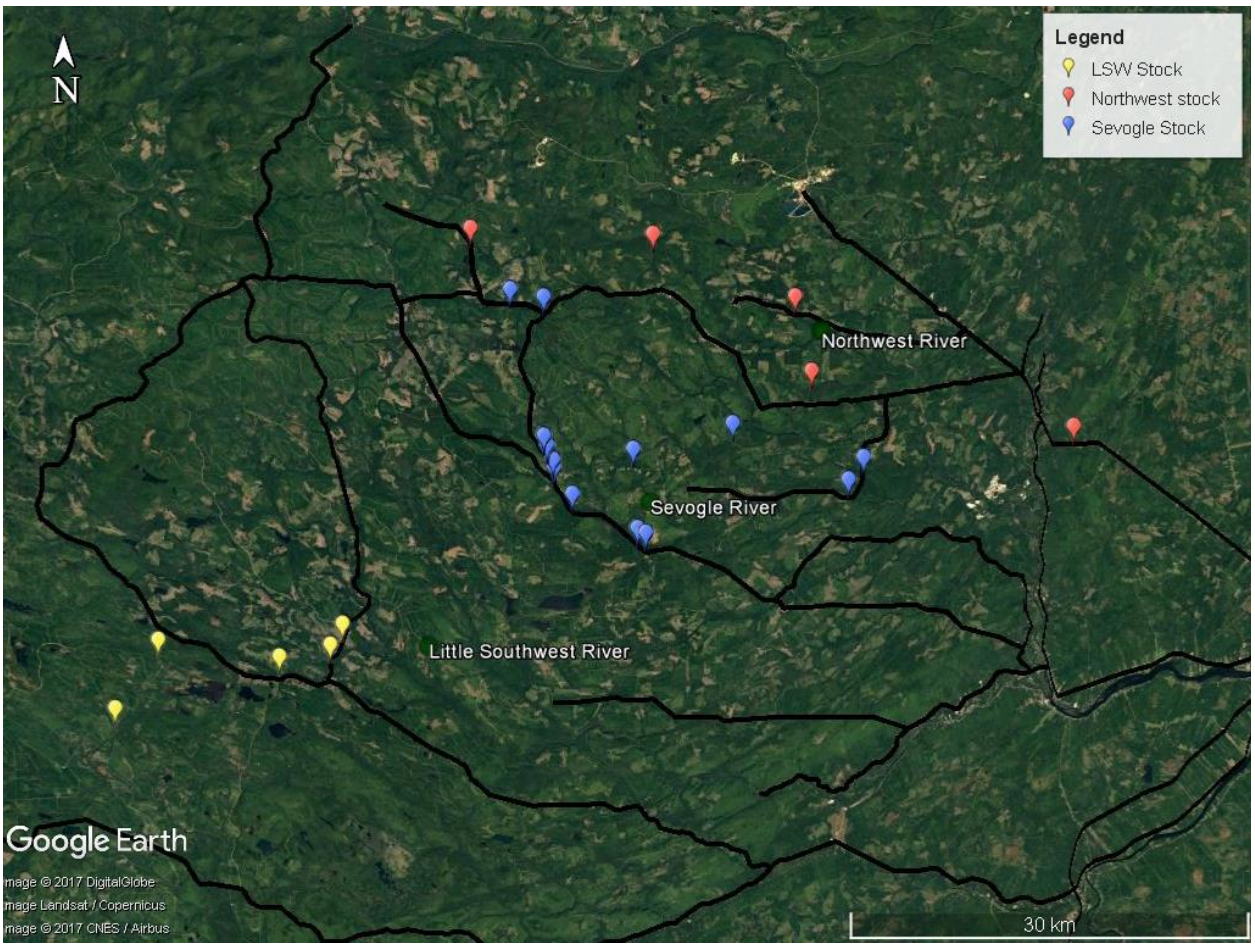


Figure 4. Stocking sites of salmon fry distributed on the Northwest Miramichi River in 2017.

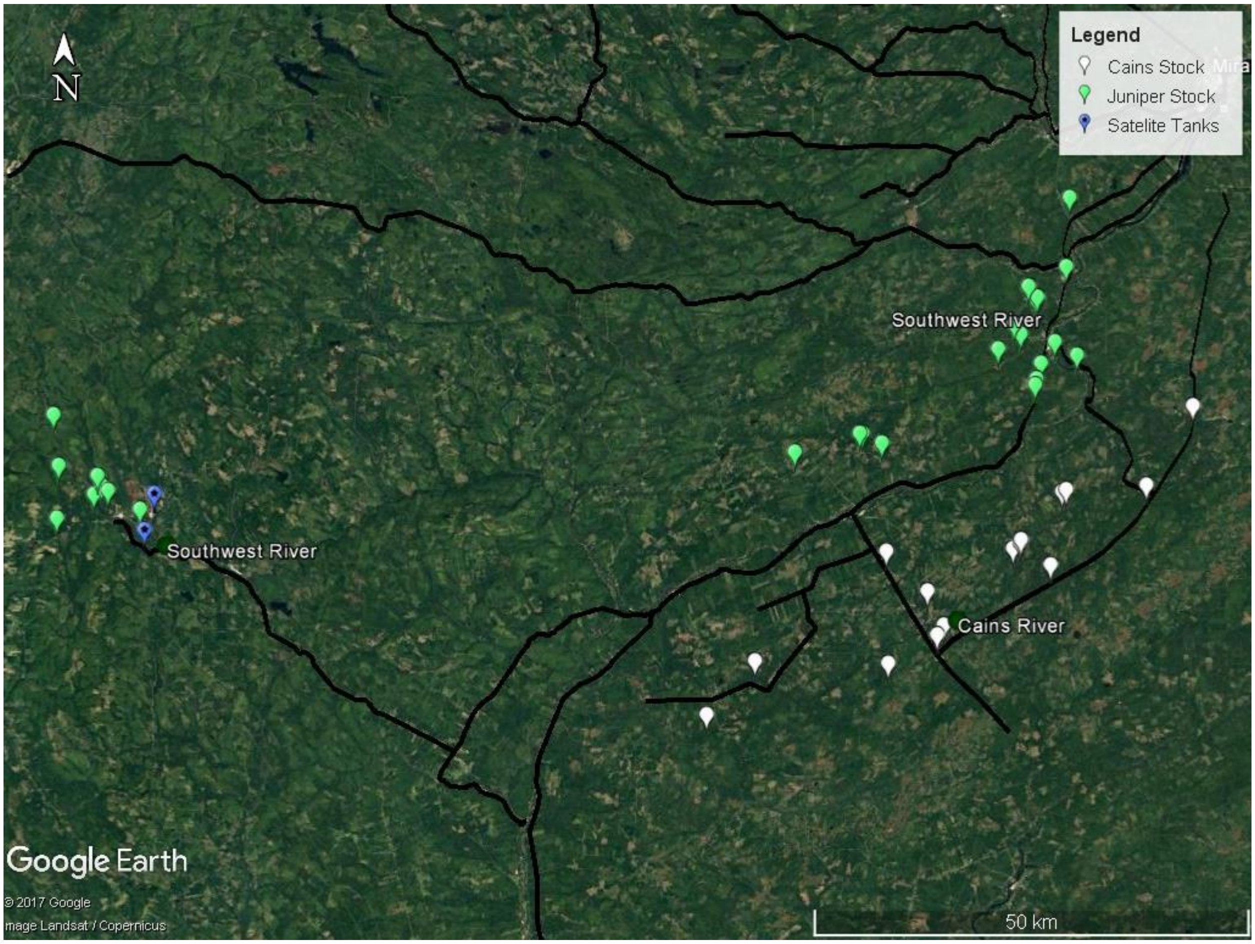


Figure 5. Stocking sites of salmon fry distributed on the Southwest Miramichi River in 2017.

Juvenile Electrofishing Assessment

Introduction

The Miramichi Salmon Association (MSA) continued its electrofishing program in 2017 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 3rd or 4th 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 2017 annual electrofishing program were to:

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

   The Miramichi beaver dam management program resulted in 76 dams breached in 2016 over the entire Miramichi watershed. Upstream locations from where some of these dams were removed were part of the focus for electrofishing crews in 2017 to determine if adult salmon were able to access these areas for spawning.

2. *Evaluate spring stocking success:*

   Electrofishing surveys were conducted on stream stretches stocked with first-feeding fry in late June and early July of 2016 and 2017 to assess fry survival rates. Stocked location densities that are higher than unstocked locations are considered to reflect successful survival of hatchery fry following stocking.

3. ***Determine future stocking sites of spring first-feeding fry:***
   Broodstock are collected annually from major rivers/streams in the Miramichi watershed and spawned at the Miramichi Salmon Conservation Centre (MSCC). The fry produced are returned to their native river system. In order to achieve effective stocking results in 2018, electrofishing surveys were carried out during the summer of 2017 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.

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 72 electrofishing sites were assessed by MSA and DFO field crews between August 14nd and October 2rd, 2017 on the Miramichi River system. MSA alone surveyed 16 sites, while MSA and DFO worked together on 56 sites.

Beaver dam removal success from previous year

In total, 56% (9/16) of the sites electrofished in 2017 focused on areas upstream of beaver dams removed in 2016 (7 on the Southwest and 2 on the Northwest). Four of these sites had fry present, with fry densities ranging from 0 to 12.2 fry/100m^2 (Table 5). Sites with fry present were in lower to midstream reaches of the tributaries, suggesting adult salmon did make it past dams that were breached in the lower sections, but were not able to access the more upstream habitat. Beavers can repair active dams within a 24-hour time frame, so the timing of notching/removing dams is crucial in helping the fish access ideal spawning habitat.

Field crews can only access and remove so many dams per day and the efficiency of the beavers in repairing them can still pose problems for adult salmon migrating upstream to spawn.

Evaluating spring stocking success

7 of 16 sites (44%) were surveyed to assess the previous two year's stocking success. Of these 7 sites, 3 were stocked in 2016 (all on the Northwest) and 4 in 2017 (3 on the Northwest and 1 on the Southwest). Fry were found in all sites stocked in 2017 and parr were found in all sites stocked in 2016. Fry densities ranged from 24.5 to 268.1/100m^2 and parr densities ranged from 4.9 to 14.9/100m^2 (Table 6 & 7). The high survival of first-feeding fry at stocked sites can help to increase the overall juvenile salmon production in the river, therefore the MSA will continue to stock first-feeding fry in the future.

Determine future stocking sites of spring first-feeding fry:

Many of the sites surveyed to assess beaver dam removal success from 2016 were poor quality habitat for juvenile Atlantic salmon. Only 4 of the 9 sites surveyed contained fry in 2017, which leaves 5 sites available for potential stocking locations in 2018 (Tables 5 – 7).

Table 5. Salmon fry abundance assessments calculated using the CPUE method for 9 sites electrofished in 2017 by the MSA upstream of beaver dams removed in 2016.

River Branch	Site	Fry/100m^2
Northwest	Little River	0.0
Northwest	North Branch of the NW Miramichi River	9.0
Southwest	Bartholomew 1	0.0
Southwest	Bartholomew 2	1.7
Southwest	Betts Mills Brook 1	12.2
Southwest	Betts Mills Brook 2	0.0
Southwest	Big Hole Brook	0.0
Southwest	Gordons Brook	0.9
Southwest	East Branch Six Mile Brook	0.0

Table 6. Juvenile abundance assessments calculated using the CPUE method for 4 sites electrofished by the MSA to identify stocking success from 2017.

River Branch	Site	Fry/100m^2
Northwest	Barracks Brook	24.5
Northwest	Slack Lake Bridge	32.7
Northwest	Travis Brook	268.1
Southwest	West Six Mile Brook	38.2

Table 7. Juvenile abundance assessments calculated using the CPUE method for 8 sites electrofished by the MSA to identify stocking success from 2017.

River Branch	Site	Parr/100m^2
Northwest	Clearwater Brook	9.3
Northwest	North Sevogle	4.9
Northwest	Johnson Brook	14.9

Juvenile abundance using baseline locations (MSA/DFO)

From August 28th to October 2nd 2017, 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 36% (20/56) of all sites contained greater than 30 fry/100m^2, 32% (18/56) of sites contained between 30 and 50 fry/100m^2, 32% (18/56) of sites contained between 1 and 30 fry/100m^2, and no site contained zero fry (Figure 6a&b). Parr densities were high (>20 parr/100m^2) at 32% (18/56) of sites, 41% (23/56) of sites contained between 10 and 20 parr/100m^2, 21% (12/56) of sites contained between 1 and 10 fry/100m^2, and only 5% (3/56) of sites contained zero parr (Fig 6c&d).

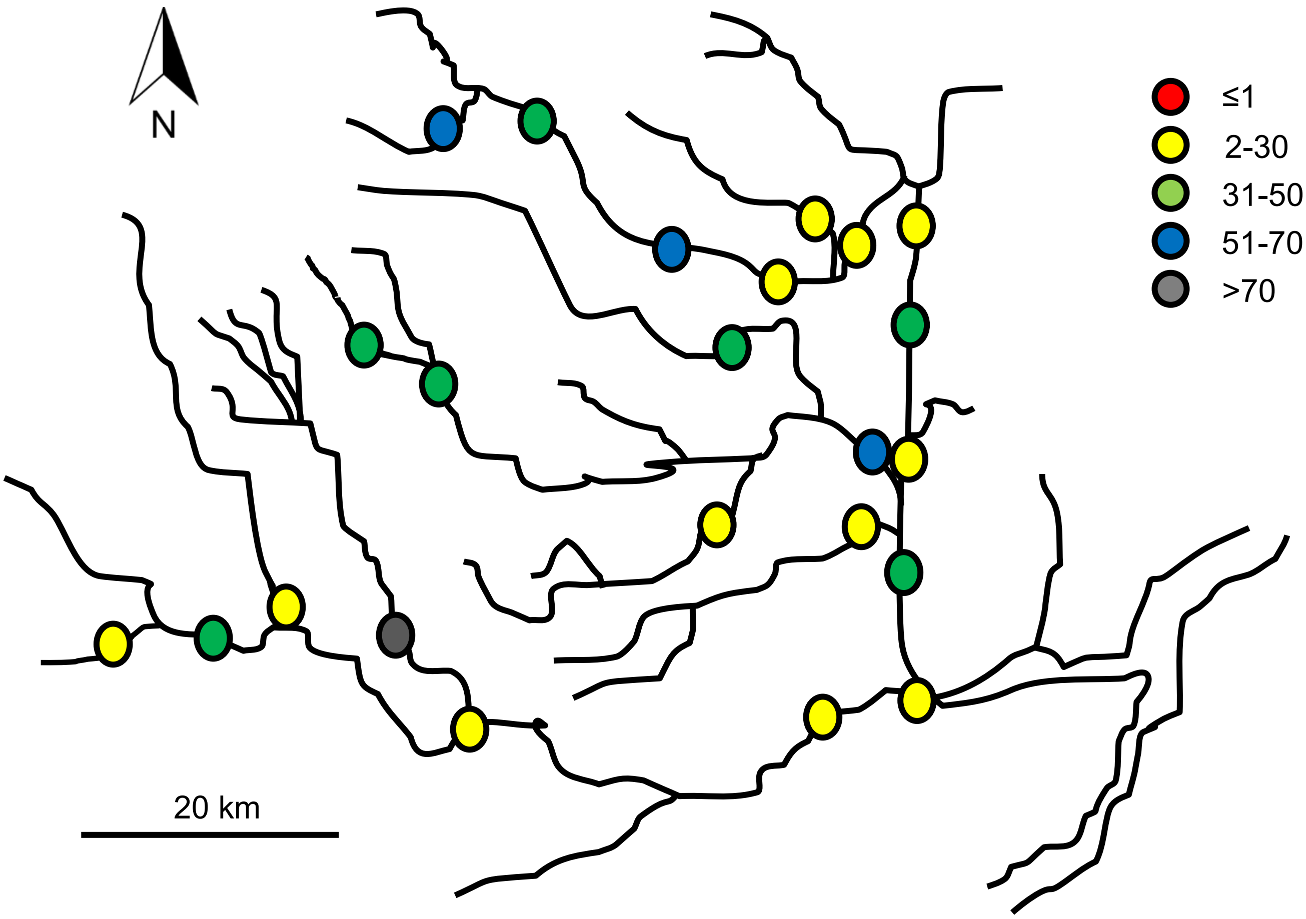


Figure 6a. Northwest Miramichi fry densities 2017.

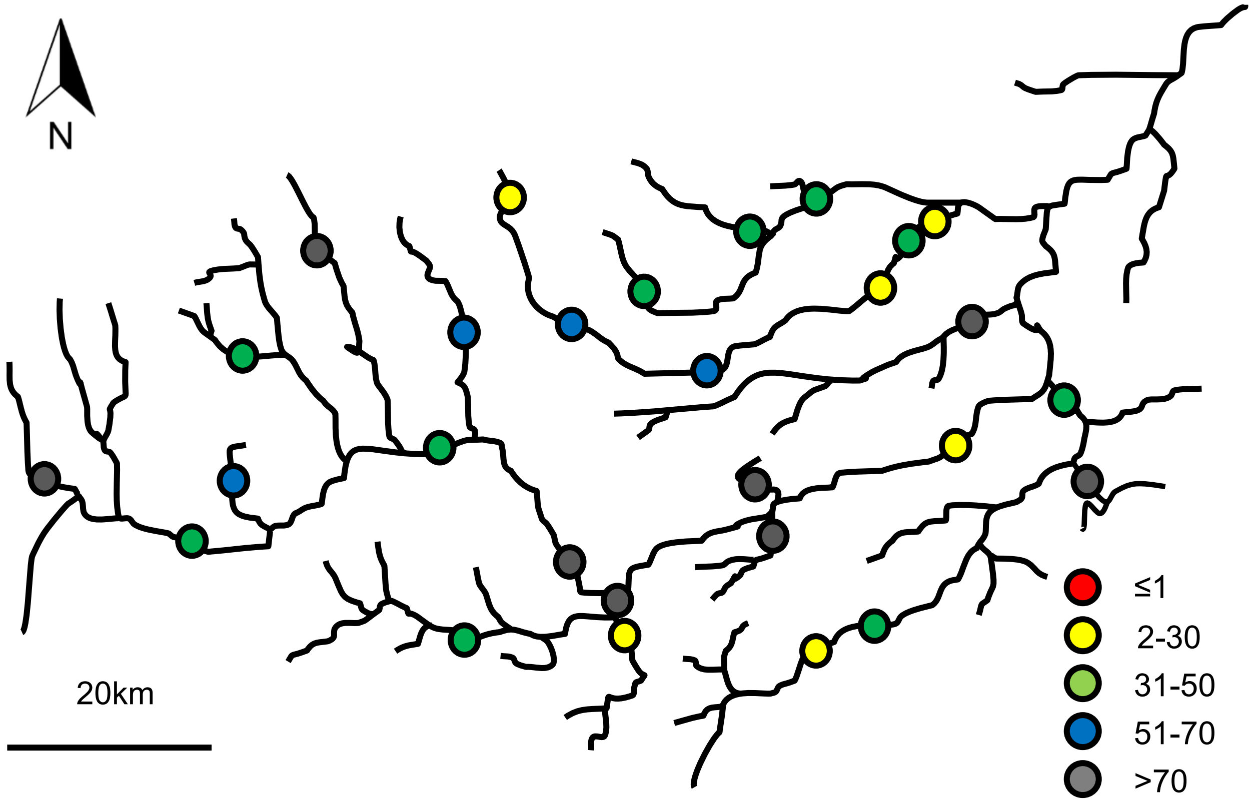


Figure 6b. Southwest Miramichi fry densities 2017.

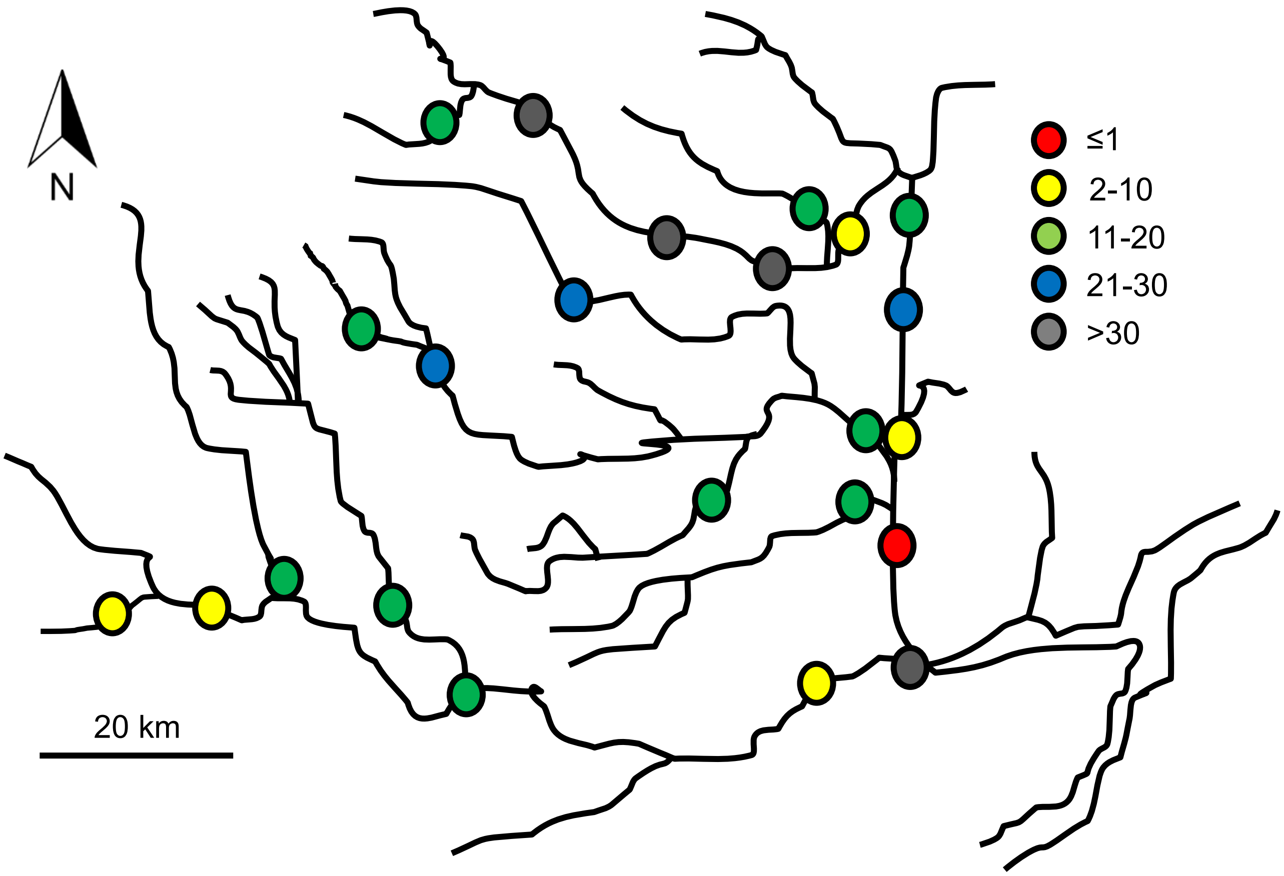


Figure 6c. Northwest Miramichi parr densities 2017.

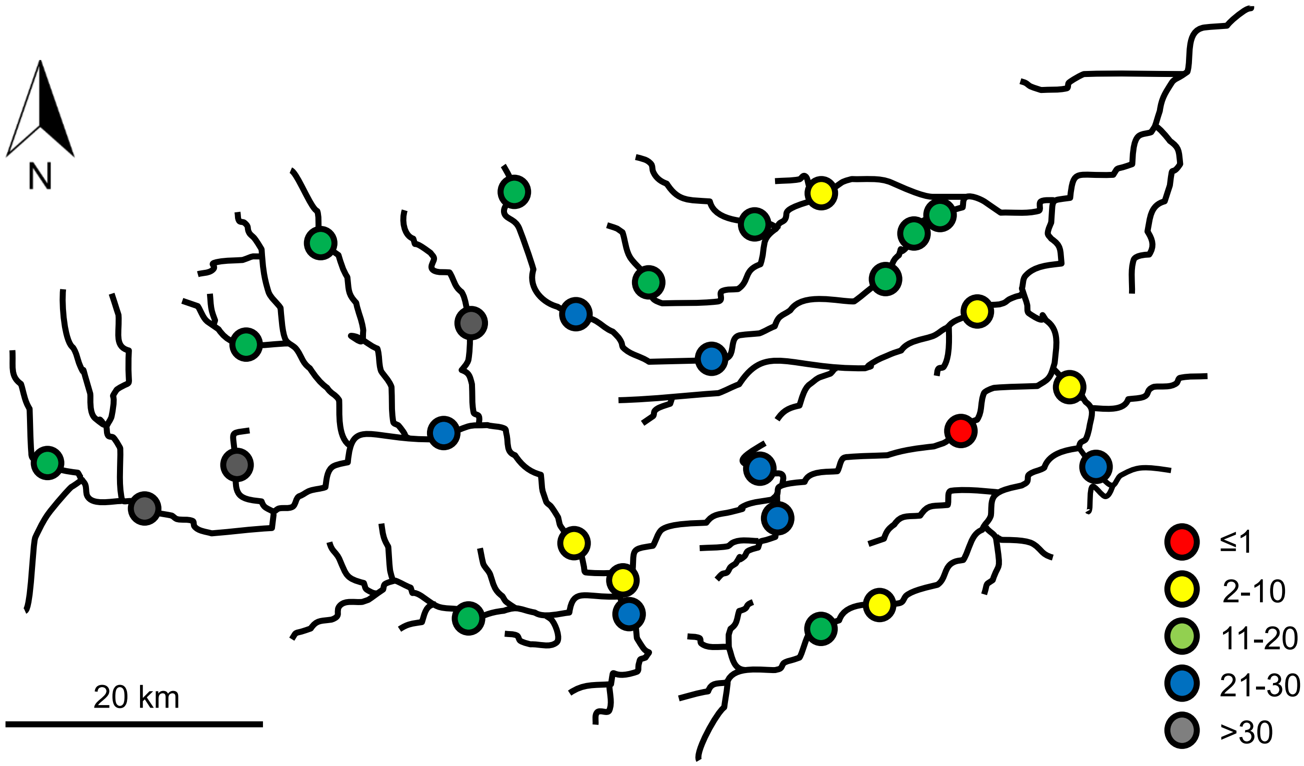


Figure 6d. Southwest Miramichi parr densities 2017.

Figure 6: Preliminary juvenile density results from the 2017 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, 2-30, 31-50, 51-70, and >70 per 100m^2. Parr densities range from ≤1, 2-10, 11-20, 21-30, and >30 per 100m^2.

Cold Water Pool Restoration

Introduction

Pools that are located directly downstream of cold water brooks can be critically important habitat to adult and juvenile salmon during 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 two brooks in 2017: Salmon Brook on the Cains River and Hudson Brook on the Southwest.

Salmon Brook

This brook enters the Cains River on the right (south) bank and flows into relatively deep water. The mouth of the brook had a high amount of sediment deposit which caused flow to trickle out over the sediment, which resulted in reduced energy flow and inhibited the brook’s cold water from reaching far enough into the river where the salmon prefer to hold in deeper water during the low flow and increased temperature months in the summer.

The project design was to remove the sediment deposition and increase flow conveyance at the mouth of the brook, to help ensure that there is a concentration of cold water exiting the brook where it meets the Cains River. The channel was reshaped using a rock toe along the brook and another was installed to tie into the Cains River banks where it meets the brook. Four wing deflectors were also installed to concentrate and center the flows in the brook. Narrowing the brook and installing the wing deflectors will help discourage further sediment depositions, improve cold water flow to into the river and improve aquatic habitat downstream. Boulders were placed in the pool to discourage poaching.

The habitat enhancement work was completed in September.

Before

After

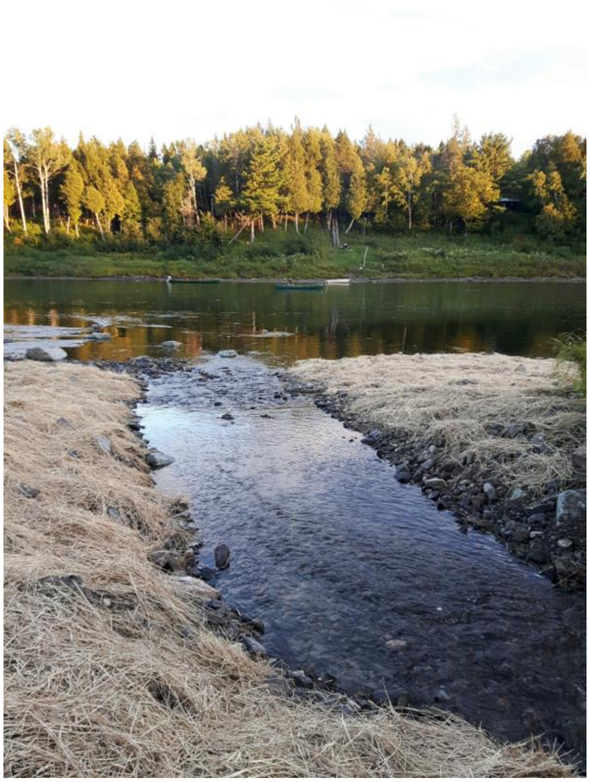
Hudson Brook

This a private brook located in Blackville, an area in the lower stretch of the river system, and owned by the Hudson Brook Salmon Club who funded the project. The brook flows from the left (north) bank and enters the Miramichi River, creating a cold-water refuge for Atlantic salmon during warm water periods. The site is easily accessible, rendering it susceptible to predation and poaching. This project design was to improve flow conveyance at the mouth of the brook, to help ensure that a concentration of cold water exiting the brook meets the Southwest Miramichi river.

To enhance the habitat features, the brook was reshaped by installing a rock toe along the left and right banks of the brook as it merges with the riverbank. This directs the cold water into the deep refuge area where the salmon typically hold. The mouth of the brook was also altered to approximately 5m in width. boulder clusters were installed in the existing pool to discourage poaching efforts, as fish will not be as easily spotted and nets will no longer sweep cleanly through the pool.

The habitat enhancement work was completed in September.

Before



After

Beaver Dam Management

Introduction

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

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

Beaver dam removal initiatives by the Miramichi Salmon Association in the past have shown potential as a tool for salmon conservation. Several locations within the watershed have shown improved juvenile counts after the dams were notched during critical salmon migrations. Before 2006, very few salmon fry were found on Betts Mills Brook near Doaktown, NB despite the construction of a fish ladder, just upstream from the mouth of the brook, at a highway crossing. In 2006 a large beaver dam blocking the fish ladder was removed and an additional 21 dams were notched or removed on the brook. This opened more than 50,000m^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 a helicopter reconnaissance flight on the Southwest Miramichi watershed to locate and GPS beaver dams. Flight paths for 2017 were determined ahead of time based on previous year's results and known beaver activities in given areas. The flight was done on October 5th and surveyed eleven tributaries on the Southwest system: Burntland Brook, Porter Brook, Salmon Brook, Muzzeroll Brook, Six Mile Brook, the Main Cains River, Otter Brook, Leighton Brook, Big Hole Brook, Burnthill Brook, and Clearwater Brook. Tributaries on the Northwest system were not flown, but areas were checked based on previous year's information and known beaver activity.

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 September 28th and finished on November 3rd. Active dams were notched on multiple occasions following repairs by beavers.

Results

In the Northwest Miramichi basin, 4 dams were initially breached by field crews on three tributaries – the Sevogle, the north branch of the Sevogle, and the Northwest Millstream (Figure 7). In the Southwest Miramichi basin, 39 dams were initially breached by field crews on 10 tributaries (Big Hole Brook, Betts Mills Brook, Rocky Brook, Porter Brook, Sabbies River, Six Mile Brook, Salmon Brook, Muzzeroll Brook, Otter Brook, and the Main Cains) (Figure 8 a&b).

Dams on Big Hole Brook, Betts Mills Brook, Rocky Brook, Sabbies River, Six Mile Brook, Salmon Brook, and the north branch of the Northwest River had to be breached on multiple occasions after beavers repaired them. A total of 43 dams were initially breached in 2017 (Appendix 1).

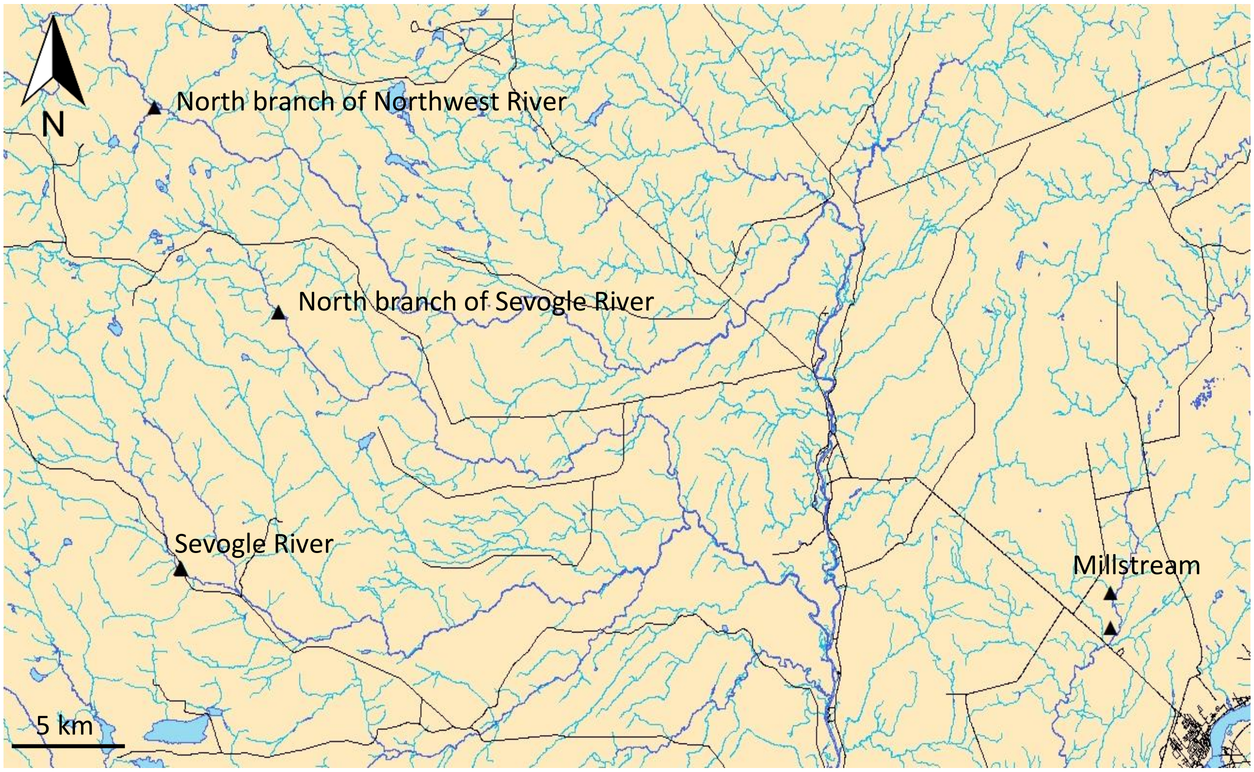


Figure 7: Tributaries of the Northwest Miramichi watershed. Beaver dams breached in 2017 are marked with a '▲'.

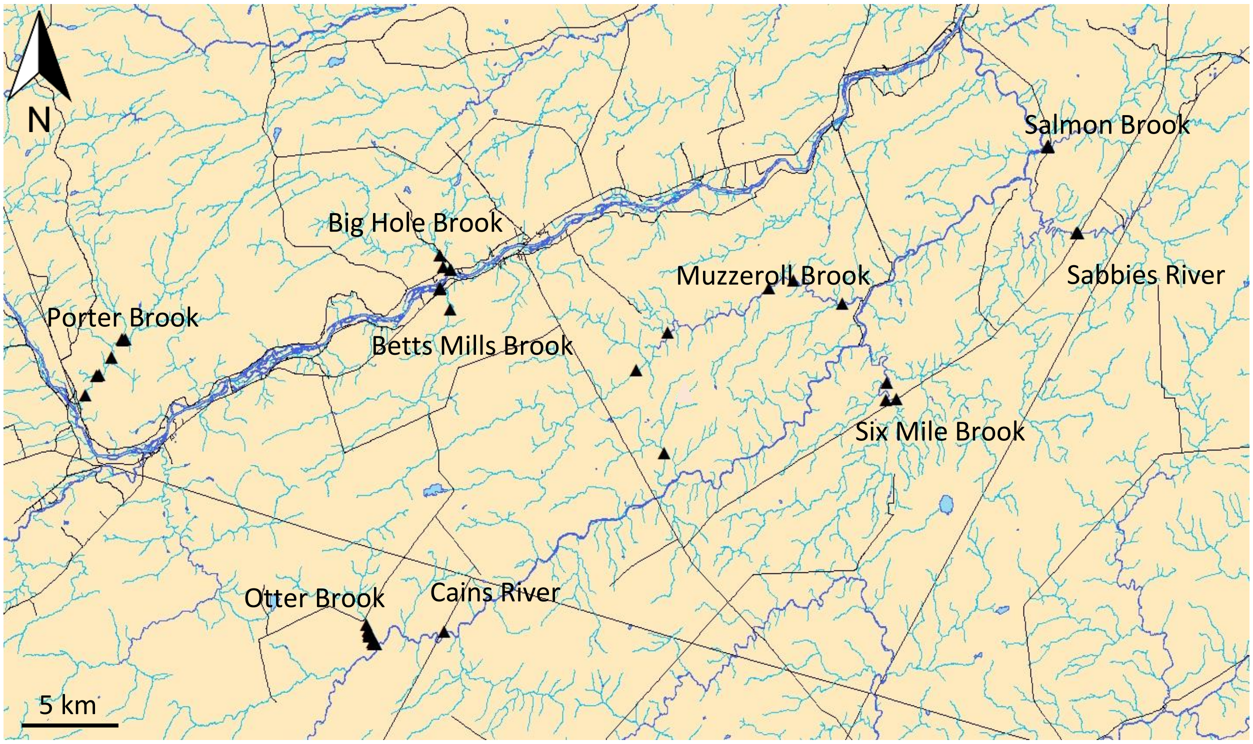


Figure 8a: Tributaries of the Southwest Miramichi watershed. Beaver dams breached in 2017 are marked with a '▲ '.

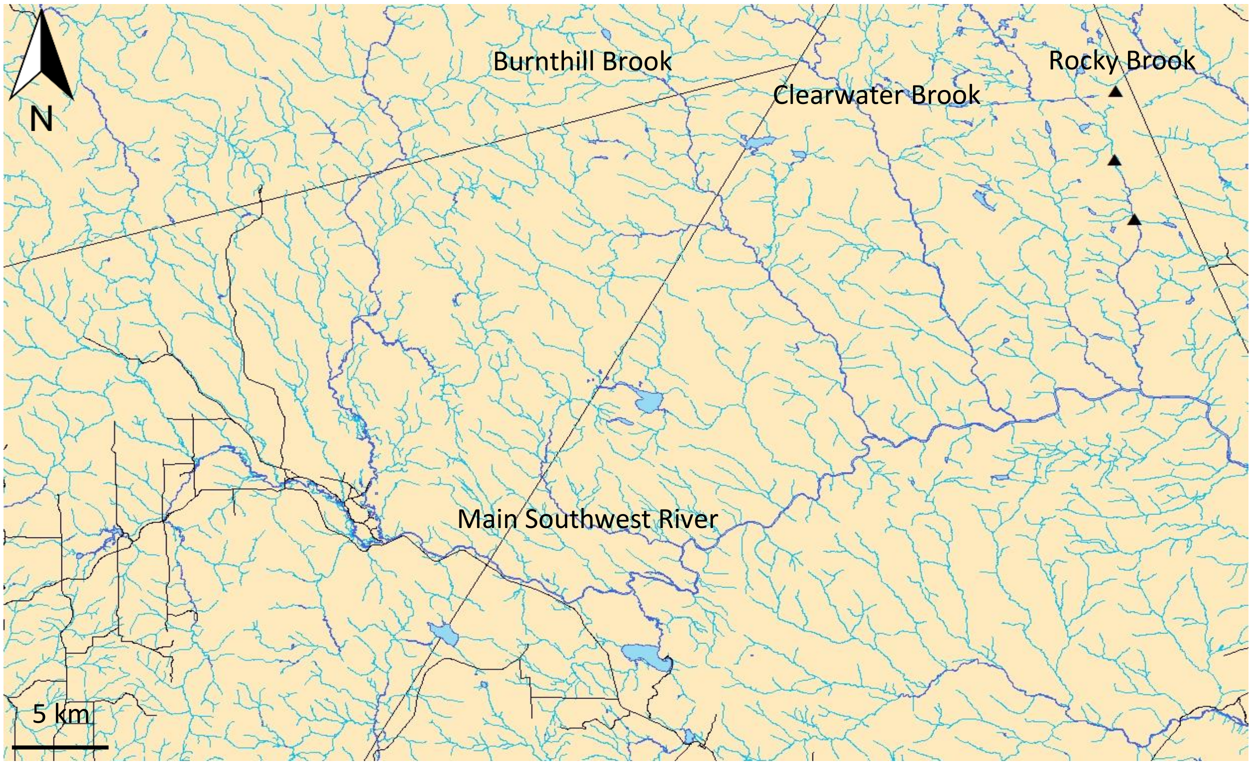


Figure 8b: Tributaries of the Southwest Miramichi watershed. Beaver dams breached in 2017 are marked with a '▲ '.

Discussion

The Miramichi watershed has a large number of tributaries with beaver dam activities, more than would be possible for field crews to remove in the scope of this project. Flights paths for 2017 were chosen based on beaver activity locations noted in previous years, and focused on larger and wider tributaries of the Miramichi River which offered more clear line-of-site observations from the air of the dams, and on areas where river access was easy to moderately acceptable for field crews.

A total of 49 dams/obstructions were observed from the air on the Southwest River; the majority of them on Otter Brook and Porter Brook. Field crews located 32 dams on the Southwest branch in 2017 with a large number of them on the Betts Mills Brook, and Salmon Brook, which were not flown because of the difficulty seeing the tributary from the air. Water levels in 2017 were extremely low compared to previous years and made it difficult to view obstructions from the air, and also limited where crews could canoe sections of rivers. Most dams were accessed on foot, except for those on Big Hole Brook, Otter Brook, and Porter Brook on the Southwest branch.

The number of dams breached in 2017 (42) was less than that of 2016 (76) due to water levels being extremely low during the fall of 2017 and there being limited access to for the field crews. 2015 (35) dam breaching was low because of a large rain storm that occurred during the fall of 2015, that washed out many of the dams. The number of dams removed in 2014 (167) and 2013 (112) exceeded those removed in 2017 and 2016 and is most likely related to the water level being ideal during those field seasons as opposed to the poor water conditions of 2017 and 2016.

Although beaver activity was present throughout the watershed, levels of activity varied between river systems. In the Southwest system, Rocky Brook, Porter Brook, Burntland Brook, and Muzzeroll Brook all had zero to relatively low levels of beaver activity whereas Salmon Brook, Big Hole Brook, Betts Mills Brook, and Sabbies River had higher activity levels. In the Northwest system, the north branch of the Sevogle River and Barracks Brook had high levels of beaver dam activity.

Just over half (56%) of the electrofishing surveys completed in the summer of 2017 by MSA focused on areas upstream of beaver dams removed in 2016; 7 on the Southwest and 2 on the Northwest. Out of the 16 sites surveyed, 4 of these sites had fry present, which were located on the Bartholomew River, Gordon Brook, Big Hole Brook, and the Northwest 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 2018 electrofishing surveys will be conducted upstream of dams breached/removed in 2017 to assess the impact of the program on Atlantic salmon fry production.

Appendix 1: GPS coordinates of breached beaver dams in 2017.

Date	Tributary	Latitude	Longitude	Active (Y/N)	Initial/Return Visit (I/R)	Breached on Return (Y/N)
28-Sep-17	Six Mile	46.48309	-65.82796	N	I	N/A
28-Sep-17	Sabbies	46.56393	-65.68379	Y	I	N/A
28-Sep-17	Salmon Brook	46.60675	-65.70585	Y	I	N/A
2-Oct-17	Sabbies	46.56363	-65.68291	Y	R	Y
2-Oct-17	Sabbies	46.56367	-65.68464	N	I	N/A
2-Oct-17	Salmon Brook	46.60675	-65.70585	Y	R	Y
2-Oct-17	Big Hole Brook	46.95385	-65.65707	Y	I	N/A
2-Oct-17	Barracks Brook	47.079637	-66.300708	Y	I	n/a
4-Oct-17	Muzzeroll Brook	46.45715	-66.01131	Y	I	N/A
4-Oct-17	Big Hole Brook	46.54818	-66.17863	Y	R	Y
4-Oct-17	Barracks Brook	47.07964	-66.30071	y	R	y
4-Oct-17	Depot	47.27451	-66.3195	y	R	n/a
4-Oct-17	Salmon Brook	46.60675	-65.70585	Y	R	Y
4-Oct-17	Sabbies	46.56363	-65.68291	Y	R	Y
5-Oct-17	North Sevogle	47.188	-66.23046	n	I	n/a
6-Oct-17	Big Hole Brook	46.95385	-65.65707	Y	R	Y
6-Oct-17	Salmon Brook	46.60675	-65.70585	Y	R	Y
6-Oct-17	Salmon Brook	46.60643	-65.70606	Y	I	N/A
6-Oct-17	Betts Mills Brook	46.52859	-66.17974	Y	I	N/A
6-Oct-17	Betts Mills Brook	46.5387	-66.188	Y	I	N/A
10-Oct-17	Betts Mills Brook	46.53877	-66.18781	Y	R	Y
10-Oct-17	Salmon Brook	46.60682	-65.70579	Y	R	Y
10-Oct-17	Rocky Brook	46.690556	-66.636111	Y	R	Y
11-Oct-17	Main Cains	46.36966	-66.18562	Y	I	N/A
11-Oct-17	Betts Mills Brook	46.53868	-66.18777	Y	R	Y
11-Oct-17	Muzzeroll Brook	46.49818	-66.03316	Y	I	N/A
11-Oct-17	Muzzeroll Brook	46.51662	-66.00797	Y	I	N/A
12-Oct-17	Muzzeroll Brook	46.53794	-6592776	Y	I	N/A
12-Oct-17	Muzzeroll Brook	46.54195	-65.90849	N	I	N/A
12-Oct-17	Muzzeroll Brook	46.53029	-65.86972	Y	I	N/A
13-Oct-17	Rocky Brook	46.757778	-66.649722	Y	R	Y
16-Oct-17	Barracks Brook	47.08002	-66.3008	y	R	y
16-Oct-17	North Sevogle	47.188	-66.23046	y	R	y
16-Oct-17	Big Hole Brook	46.549567	-66.185278	Y	R	Y
16-Oct-17	Big Hole Brook	46.54822	-66.17975	Y	R	Y

Date	Tributary	Latitude	Longitude	Active (Y/N)	Initial/Return Visit (I/R)	Breached on Return (Y/N)
16-Oct-17	Betts Mills Brook	46.53865	-66.18787	Y	R	Y
16-Oct-17	Sabbies	46.56395	-65.6838	Y	R	Y
17-Oct-17	Big Hole Brook	46.55518	-66.1875	N	R	N
17-Oct-17	Betts Mills Brook	46.53865	-66.18787	Y	R	Y
17-Oct-17	Salmon Brook	46.60678	-65.70591	Y	R	Y
17-Oct-17	Salmon Brook	46.60678	-65.70591	Y	R	Y
18-Oct-17	Rocky Brook	46.757778	-66.649722	Y	R	Y
19-Oct-17	Porter Brook	46.51411	-66.43917	Y	I	N/A
19-Oct-17	Porter Brook	46.50517	-66.44752	Y	I	N/A
19-Oct-17	Porter Brook	46.49652	-66.45682	Y	I	N/A
19-Oct-17	Porter Brook	46.49616	-66.45885	Y	I	N/A
19-Oct-17	Porter Brook	46.48659	-66.46806	Y	I	N/A
19-Oct-17	Porter Brook	46.51437	-66.43632	Y	I	N/A
19-Oct-17	Porter Brook	46.51396	-66.43864	Y	I	N/A
19-Oct-17	Salmon Brook	46.60678	-65.70591	Y	R	Y
19-Oct-17	Betts Mills Brook	46.53865	-66.18787	Y	R	Y
23-Oct-17	Salmon Brook	46.60678	-65.70591	Y	R	Y
23-Oct-17	Betts Mills Brook	46.53906	-66.18707	Y	R	Y
23-Oct-17	Porter Brook	46.49614	-66.45876	Y	I	N/A
23-Oct-17	Porter Brook	46.50534	-66.44754	Y	I	N/A
23-Oct-17	Rocky Brook	46.690556	-66.636111	Y	R	Y
24-Oct-17	Otter Brook	46.37329	-66.24651	N	I	N/A
24-Oct-17	Otter Brook	46.37009	-66.245	N	I	N/A
24-Oct-17	Otter Brook	46.36967	-66.24488	Y	I	N/A
24-Oct-17	Otter Brook	46.36929	-66.24416	Y	I	N/A
24-Oct-17	Otter Brook	46.36889	-66.24419	Y	I	N/A
24-Oct-17	Otter Brook	46.36857	-66.24471	Y	I	N/A
24-Oct-17	Otter Brook	46.36818	-66.24485	Y	I	N/A
24-Oct-17	Otter Brook	46.36743	-66.24486	Y	I	N/A
24-Oct-17	Otter Brook	46.36502	-66.24129	Y	I	N/A
24-Oct-17	Otter Brook	46.36459	-66.24161	Y	I	N/A
24-Oct-17	Otter Brook	46.36382	-66.2412	Y	I	N/A
24-Oct-17	Otter Brook	46.36369	-66.23925	Y	I	N/A
24-Oct-17	North Sevogle	47.188	-66.23046	y	R	y
24-Oct-17	Barracks Brook	47.08001	-66.30077	y	R	y
25-Oct-17	Big Hole Brook	46.95385	-65.65707	Y	R	Y
25-Oct-17	Betts Mills Brook	46.53869	-66.1878	Y	R	Y
26-Oct-17	Salmon Brook	46.60678	-65.70591	Y	R	N
26-Oct-17	Salmon Brook	46.60679	-65.70644	Y	R	N

Date	Tributary	Latitude	Longitude	Active (Y/N)	Initial/Return Visit (I/R)	Breached on Return (Y/N)
26-Oct-17	Salmon Brook	46.60654	-65.70681	Y	R	N
26-Oct-17	North Sevogle	47.188	-66.23046	y	R	n
26-Oct-17	Barracks Brook	47.08001	-66.30077	y	R	n
27-Oct-17	Six Mile	46.48239	-65.83595	N	I	Y
27-Oct-17	Six Mile	46.49113	-65.83536	N	I	Y
27-Oct-17	Northwest Millstream	47.051667	65.633056	y	I	n/a
30-Oct-17	Northwest Millstream	47.066389	65.633056	y	I	n/a
16-Nov-17	Rocky Brook	46.721944	-66.649722	Y	I	Y