MIRAMICHI SALMON ASSOCIATION

CONSERVATION FIELD PROGRAM REPORT 2018

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

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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 2018. 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, 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, remove spawning obstructions, and collect broodstock. The MSA is grateful to all those who assisted in the safe and successful delivery of the 2018 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.

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Overview

This report is a review of the 2018 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 7 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. 2018 marked the 11th 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 between May 4th and 5th, 2018. Following capture, kelt were held temporarily in a submerged live box at the Johnston bridge. 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 38 Vemco VR2w acoustic receivers were placed throughout the freshwater and tidally influenced portions of the Northwest (12), Southwest (16), and main stem Miramichi Rivers (10) 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).

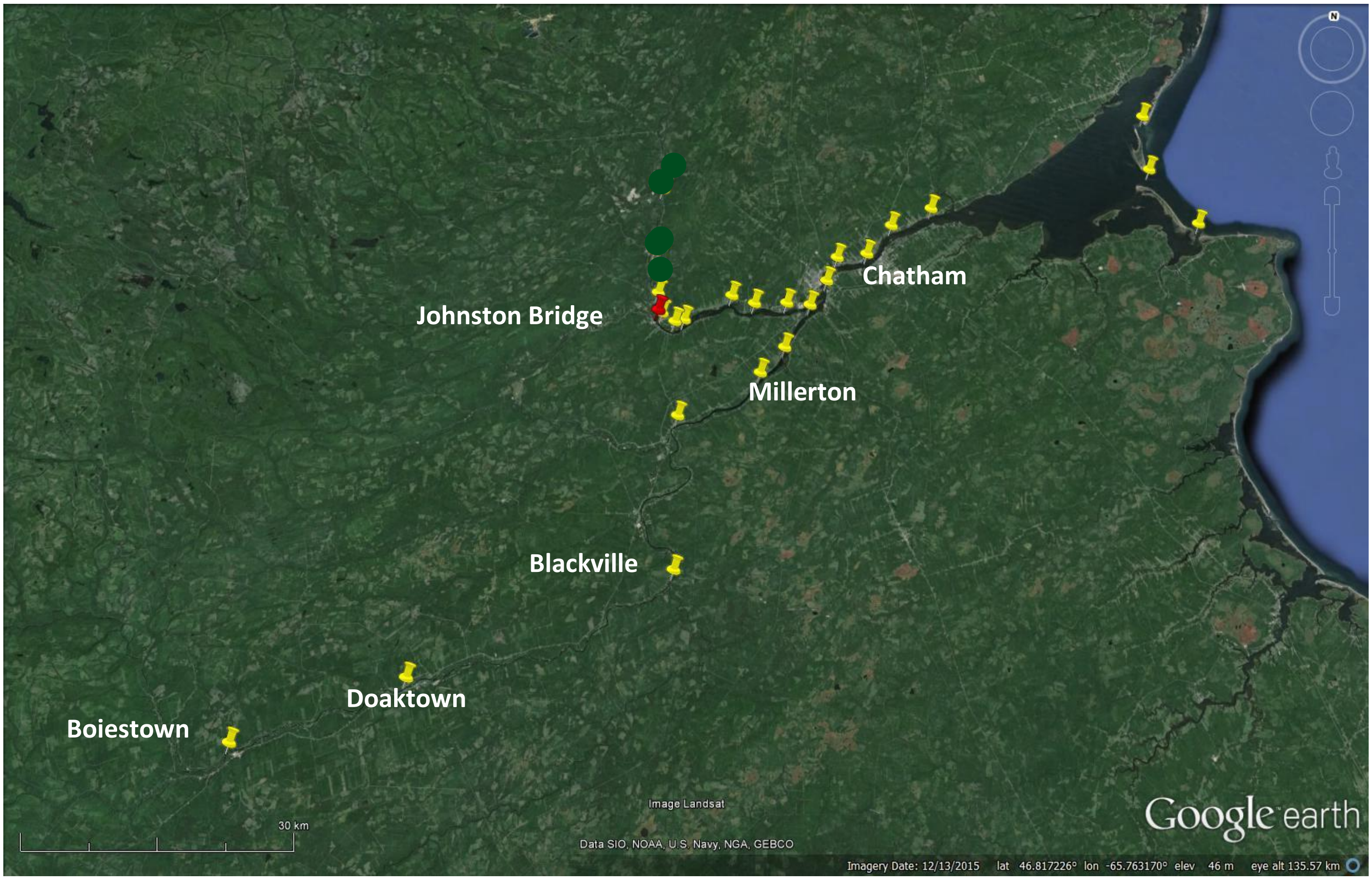


Figure 1a. Locations of acoustic receivers throughout the Miramichi River and Bay in 2018. The red pin indicates tagging location and yellow pins indicate acoustic receivers used for tracking kelt movements to determine survival out of the Miramichi River and Bay.

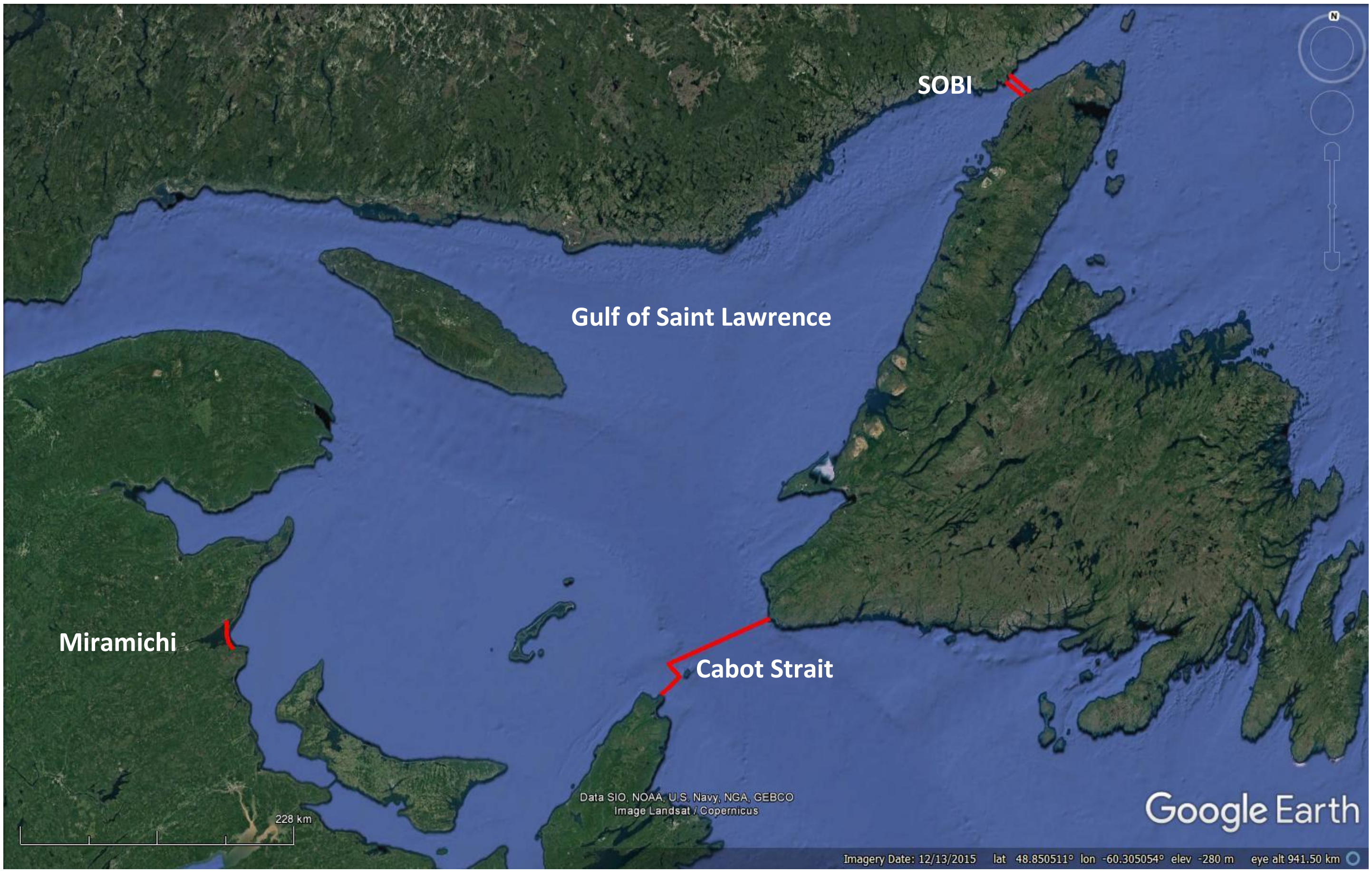


Figure 1b. Location of acoustic receivers (red lines) along Miramichi Bay, the Cabot Strait, and the Strait of Belle Isle (SOBI). The lines at the SOBI are 3.5km apart.

Results

A total of 24 kelt were tagged in with internal, long term V16 acoustic tags in 2018. Of the 24 tagged fish, 8 were female, 15 were male, and 1 was unknown. They ranged in size from 1kg to 6.6kg (2.2lbs to 14.5lbs) and 53.5cm to 96.0cm (21.1in to 37.8in).

Movement and Survival through the Northwest River and Miramichi Bay

Acoustic receiver detections showed that all of the 24 fish (100%) survived out of the Miramichi River and into Miramichi Bay. Their in-river timeframe was spread out over 32 days, and their detection dates at the outer Bay receivers occurred over a 31-day period, with the last one crossing into the Bay on June 17th. Tag 50783 was the only consecutive spawner to return in 2018 (Table 1).

Movement and Survival in the Marine Environment

All of the acoustic tags (100%) were detected at the outer Miramichi Bay receivers between May 18th and June 17th. It is assumed these fish were traveling east and entered the Gulf of Saint Lawrence. Tags 50768, 50770, 50771, 50774, 50775, 50777, 50779, 50781, 50784, 50786, 50787, and 50789 were detected at the SOBI array between July 4th and July 24th.

Table 1. Total number of kelt with acoustic tags and % survival through various locations from 2008 and 2018. * 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	2018
Kelts Tagged (#)	50	50	50	50	35	16	21	24	26	8	24
Head of Tide (%)	100	100	100	100	100	100	95	100	96	100	100
River Mouth (%)	96	92	90	94	94	75	85	100	96	88	100
Miramichi Bay (%)	94	92	90	94	94	69	85	100	96	88	100
Strait of Belle Isle (%)	44	18	14	30	30	38	33	38	37	38	50
Consecutive returns (%)	6	8	18	10	10	0	10	31	4	0	1
Alternate returns (%)	8	0	10	4	0	6	0	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 2018 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 tagged and then released.

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 38 Vemco VR2w acoustic receivers were placed throughout the freshwater and tidally influenced portions of the Northwest (12), Southwest (16), and main stem Miramichi Rivers (10) 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. 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).

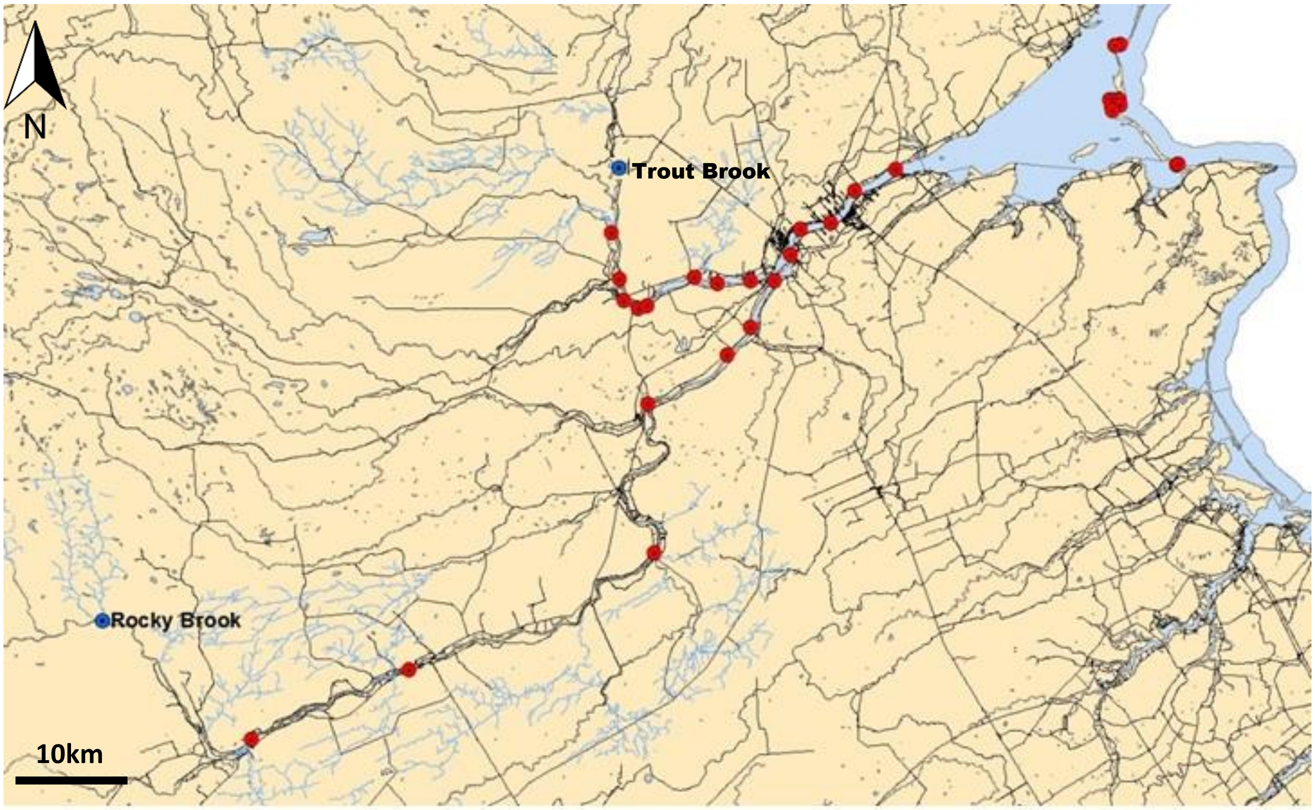


Figure 2a. Acoustic receiver locations (red dots) in the Miramichi River and Bay in 2018. Smolt tagging and release locations are represented by a blue dot – Trout Brook on the Northwest branch and Rocky Brook on the Southwest branch.

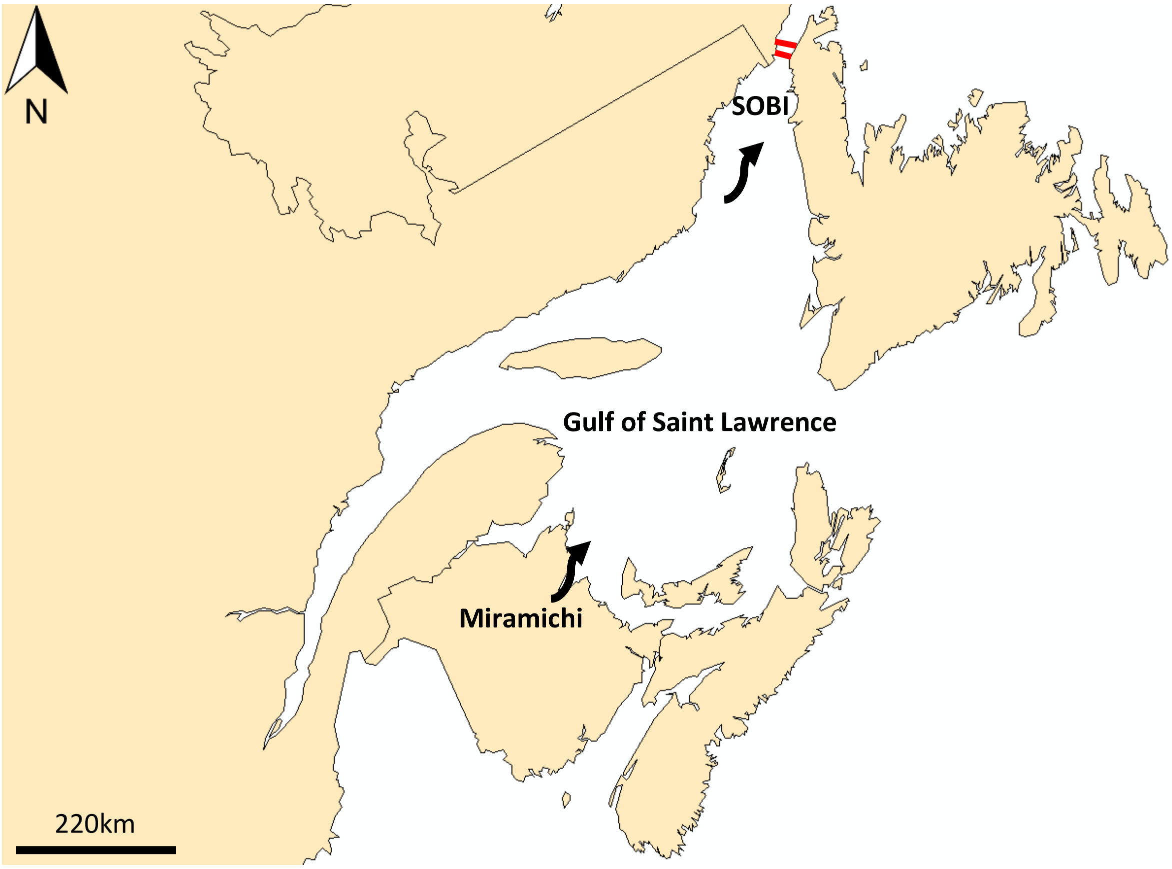


Figure 2b. Acoustic receiver locations (red lines) across the Strait of Belle Isle in 2016. A second line was added north of the original line in 2015. The lines are 3.5km apart. Suspected fish movement paths are indicated with a black arrow.

Results

Northwest River

From May 17th – 20th, a total of 80 smolts were captured at the Northwest smolt wheel near Trout Brook. Of the initial 80 fish tagged, 75 of them (94%) were detected on the receiver at Red Bank, as well as at the head of tide (HOT) in Cassilis, indicating a 6% mortality rate from the tagging location to HOT. There were 57 fish detected at the Nelson receiver, which indicates 77% survival between the point of release and the main channel of the river. Survival in the main channel of the river from Nelson to Loggieville was 63.5% of the remaining fish, and 7.5% from the tagging location. Only 6 fish (8%) of the smolts tagged at Trout Brook survived out of the estuary (past the barrier receiver lines), and 6% (5 fish) 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, 74 (93%) of them were detected at the receiver in Boiestown, however at the head of tide (HOT) in Millerton, only 51 of the 80 fish were detected, indicating a 64% survival rate from the tagging location to HOT. Another 18% of the fish were lost between Millerton and Nelson. Survival in the main channel of the river from Nelson to Loggieville was 51% of the remaining fish, and 24% from the tagging location. Only 19 (24%) of the smolts tagged at Rocky Brook survived out of the estuary (past the barrier receiver lines), and 8% to the SOBI (Figure 3b).

In total, 16% of the smolts leaving the entire Miramichi River survived to exit the estuary, and 7% survived to the SOBI.

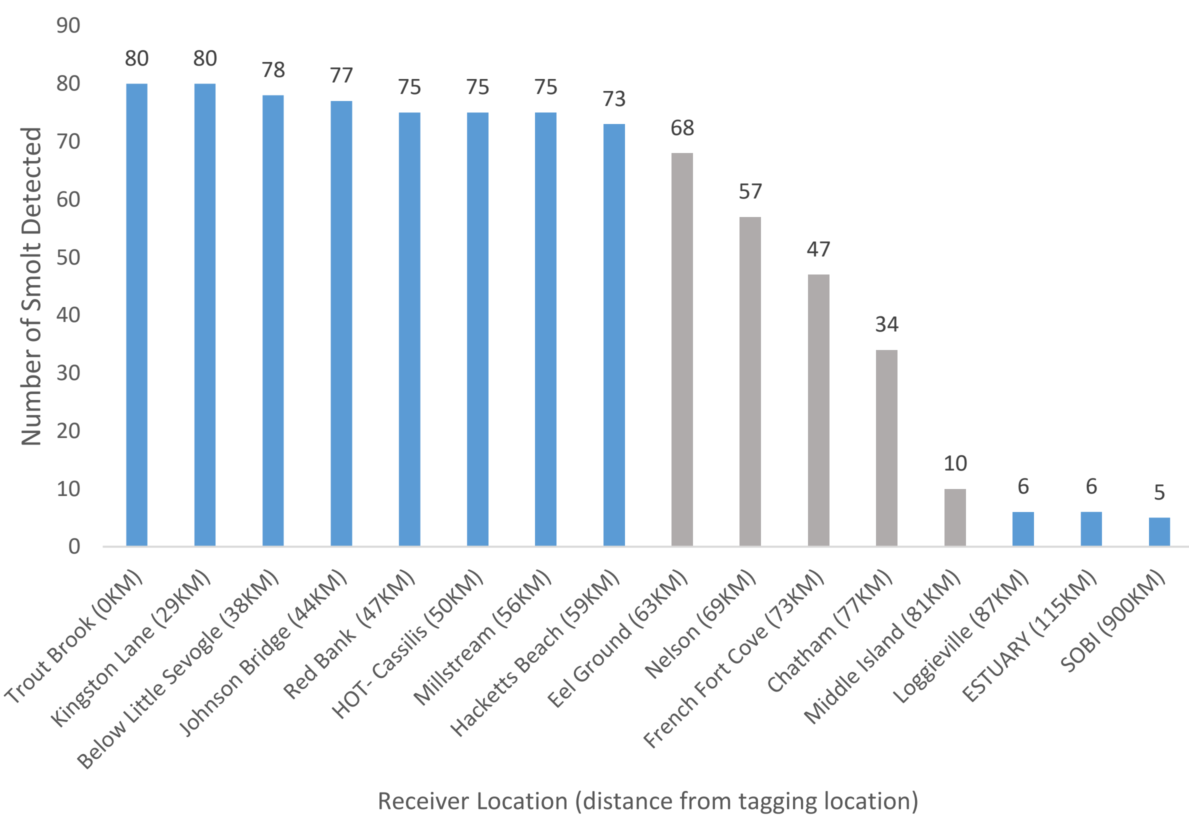


Figure 3a. Survival numbers of acoustic tagged smolts from the Northwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2018. The highest percentage of mortality occurred between Eel Gound and Middle Island (58 fish/73%), marked in grey.

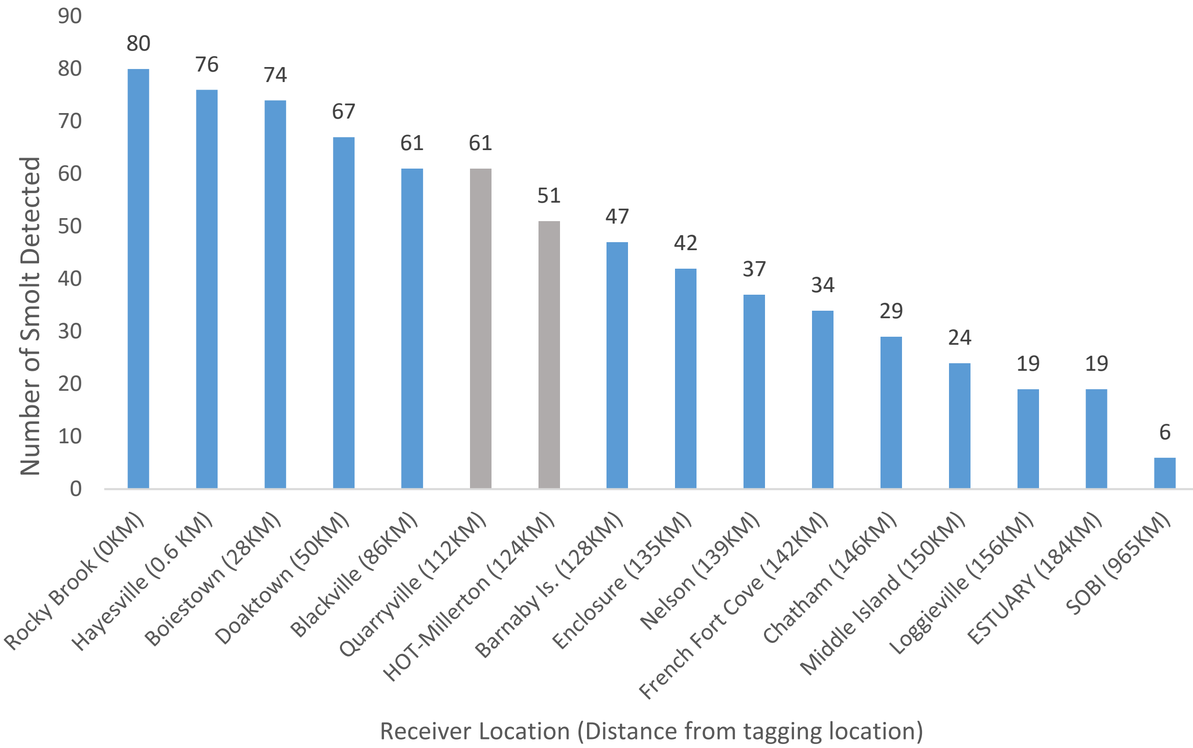


Figure 3b. Survival numbers of acoustic tagged smolts from the Southwest River at each receiver deployed in the Miramichi River, Bay, and the SOBI in 2018. The highest percentage of mortality occurred between Quarryville and Millerton (10 fish/), marked in grey.

Discussion

Survival numbers from the 2018 tagging study are less than desirable for the Miramichi River, similar to the numbers recorded in 2017. The fish that successfully survived tagging (a 10% mortality rate is assumed for tagging studies) and were detected exiting Miramichi Bay was only 16%.

The highest areas of loss on the Northwest were between Eel Ground and Middle Island (58 fish/73%) where striped bass are most prevalent (Figure 2a). The highest survival rate was observed between Millstream and Hacketts Beach, as only 2 fish (3%) were lost. For the Northwest River in total, 0.64 smolt/km were lost.

On the Southwest branch the highest areas of loss were between Quarryville and Millerton (10 fish/13%) (Figure 2b). The highest survival rate was observed between Haysville and Boiestown, with the section only losing 2 fish (3%). For the Southwest River in total, 0.33 smolt/km were lost.

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. It is also important to note that the amount of loss throughout the Southwest Miramichi River was much more consistent than on the Northwest Miramichi. 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 2018 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 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 2018, 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 2019 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 2017 for broodstock from 5 tributaries on the Miramichi River – Sevogle River, Clearwater Brook, Burnthill 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 0.5/0.7) for approximately 3 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 102,500 first-feeding Atlantic salmon fry were stocked into 40 sites in 3 tributaries of the Miramichi River (Figure 4 and Figure 5). The Northwest system received 12,000 fry and the Southwest system 90,500 (Table 2a&b). An additional 55,000 fry were taken to satellite holding tanks for future release by local conservation groups (Table 3). Furthermore, 7,057 brook trout fry were distributed to a satellite tank rearing location (Table 4).

Acknowledgements

The MSA would like to thank the following groups for their support with this project:

- J.D. Irving Ltd. (rearing salmon and trout fry for fall distribution)
- Miramichi Headwaters Salmon Federation (rearing salmon fry for fall distribution)

Table 2a. Distribution of first-feeding Atlantic salmon fry from the Miramichi Salmon Conservation Centre in 2018 on the Northwest branch of the Miramichi River.

Branch	Stock Origin	Site	# of fish	Latitude	Longitude
Northwest	SEV	Sheephouse Brook	2000	47.08032	-66.02063
Northwest	SEV	Little Sheephouse Brook	2000	47.09533	-66.06610
Northwest	SEV	Travis Brook	2000	47.04454	-66.22082
Northwest	SEV	Johnston Brook	2000	47.04835	-66.22823
Northwest	SEV	Barracks Brook	4000	47.07144	-66.29350

Table 2b. Distribution of first-feeding Atlantic salmon fry from the Miramichi Salmon Conservation Centre in 2018 on the Southwest branch of the Miramichi River.

Branch	Stock Origin	Site	# of Fish	Latitude	Longitude
Southwest	JUN	MSW South Branch	2500	46.51832	-67.17802
Southwest	JUN	Lake Brook 1	2500	46.52872	-67.30836
Southwest	JUN	Beaver Brook	2500	46.54557	-67.25680
Southwest	JUN	Big Teague Brook 1	2500	46.55782	-67.23327
Southwest	JUN	MSW South Branch 1	2500	46.55424	-67.24503
Southwest	JUN	Big Teague Brook 2	2500	46.57346	-67.24913
Southwest	JUN	Little Teague Brook 1	2500	46.59091	-67.26986
Southwest	JUN	Elliott Brook 3	2500	46.58252	-67.30682
Southwest	JUN	Little Teague Brook 2	2500	46.61014	-67.29575
Southwest	JUN	Elliott Brook 2	2500	46.61554	-67.34232
Southwest	JUN	Elliott Brook 1	2500	46.62121	-67.36756
Southwest	JUN	Little Teague Brook 3	2500	46.63517	-67.31507
Southwest	JUN	Juniper Brook	2500	46.53901	-67.18600
Southwest	JUN	Wiley Brook	2500	46.54035	-67.30801
Southwest	JUN	Lake Brook 3	2500	46.51888	-67.33205
Southwest	JUN	Lake Brook 4	2500	46.52052	-67.33271
Southwest	CAINS	Sabbies 1	2500	46.61304	-65.59956
Southwest	CAINS	Sabbies Bridge	2500	46.5812	-65.59464
Southwest	CAINS	Sabbies 3	2500	46.51913	-65.74319
Southwest	CAINS	Millets road	2500	46.25182	-65.757819
Southwest	CAINS	Six Mile 1	2500	46.49404	-65.800424
Southwest	CAINS	Ten Mile Trib.	2500	46.421914	-65.987598
Southwest	CAINS	Ten Mile Brook	2500	46.411336	-65.998845
Southwest	CAINS	Blue Rock Brook	2500	46.383036	-65.07138
Southwest	CAINS	Branch Off Muzzeroll	2500	46.497929	-66.073564
Southwest	CAINS	North Cains Branch	2500	46.337663°	-66.322352°
Southwest	CAINS	Main Cains River	2500	46.318824°	-66.288830°
Southwest	CAINS	McKenzie Brook	2500	46.457166	-66.012158
Southwest	CAINS	Cains 2	2500	46.499989	-65.873058
Southwest	CAINS	Mahoney Brook	2500	46.509094	-65.871673
Southwest	CAINS	Brads Camp	2500	46.50598	-65.873058
Southwest	CAINS	Found Brook	2500	46.553311°	-65.821549°
Southwest	CAINS	Lythco Brook	2500	46.558013°	-65.810058°
Southwest	CAINS	Main Cains 2	5500	46.434783°	-66.018785°
Southwest	CAINS	Tyler’s Camp	2500	46.559639	-65.804227

Table 3. Distribution of first-feeding Atlantic salmon fry to satellite holding tanks for continued growth and stocking in 2018.

Stock Origin	Organization	# of fish	Latitude	Longitude
Juniper	Miramichi Headwaters Salmon Association	15000	46.51831	-67.17829
Clearwater	J.D. Irving Ltd.	17500	46.55475	-67.16395
Burnthill	J.D. Irving Ltd.	22500	46.55475	-67.16395

Table 4. Distribution of brook trout fry to satellite tanks for continued growth and stocking in 2018.

Stock Origin	Organization	# of fish	Latitude	Longitude
Juniper	Miramichi Headwaters Salmon Association	1725	46.51831	-67.17829
Beadle Brook	J.D. Irving Ltd.	5332	46.55475	-67.16395

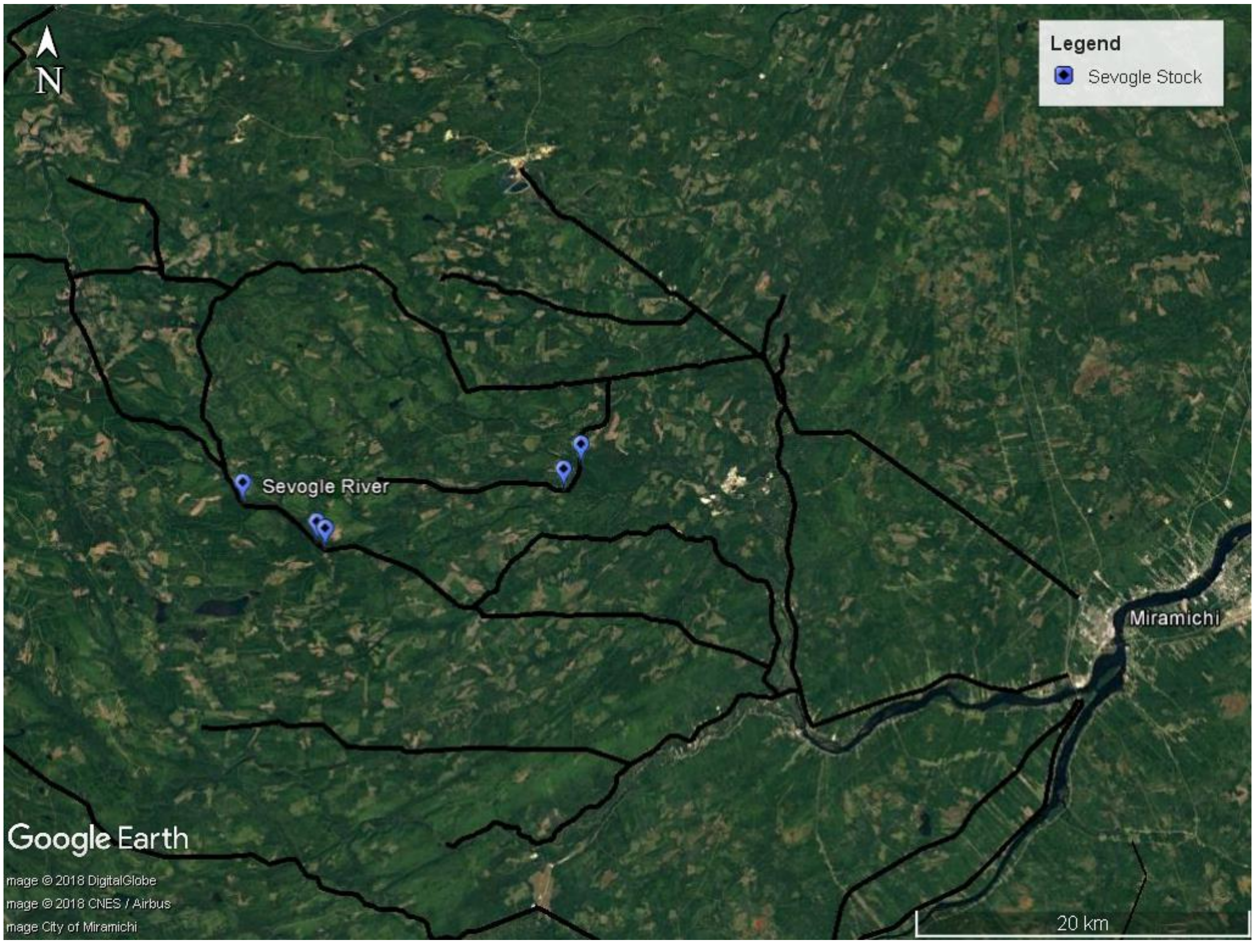


Figure 4. Stocking sites of salmon fry distributed on the Northwest Miramichi River in 2018.

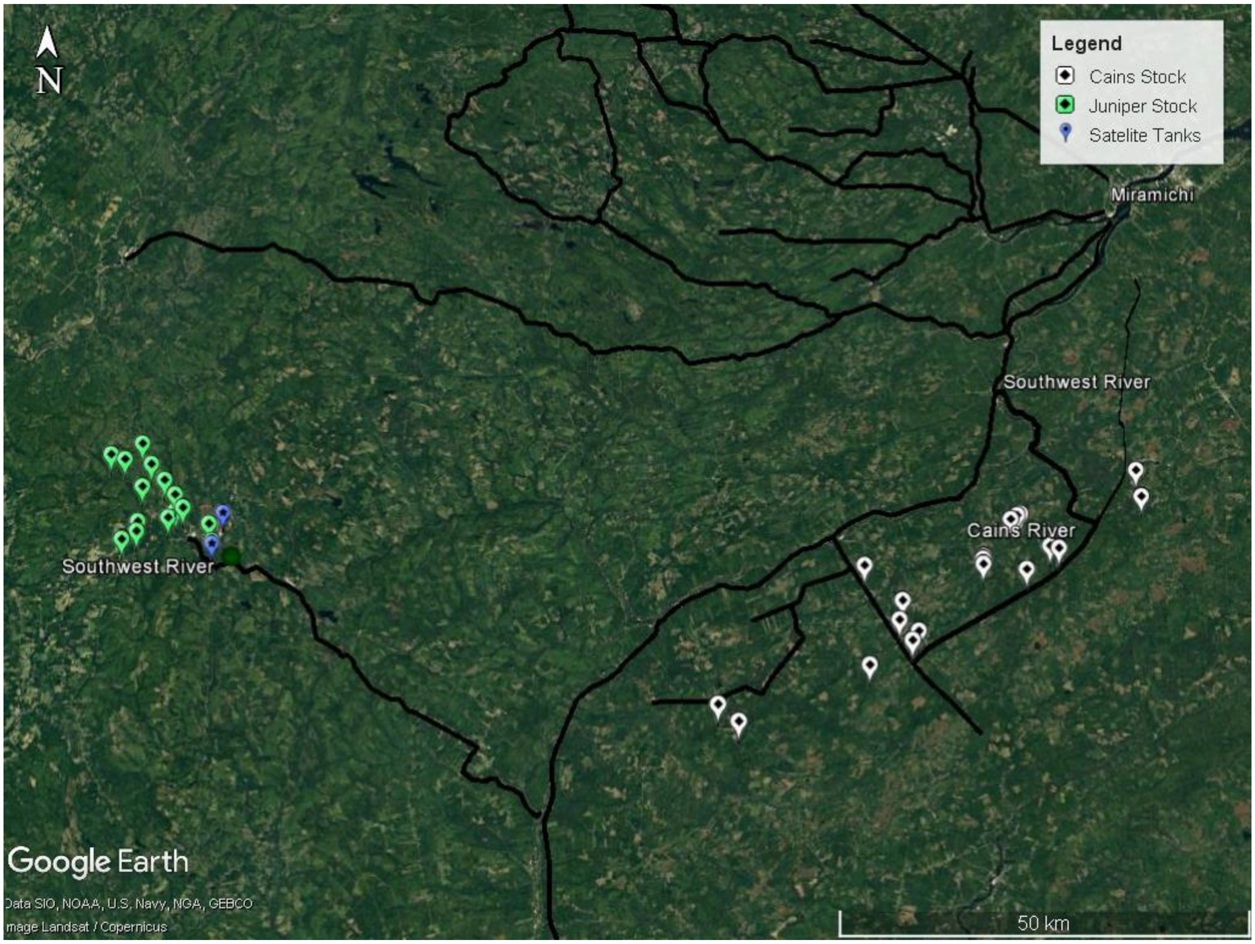


Figure 5. Stocking sites of salmon fry distributed on the Southwest Miramichi River in 2018.

Juvenile Electrofishing Assessment

Introduction

The Miramichi Salmon Association (MSA) continued its electrofishing program in 2018 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 2018 annual electrofishing program were to:

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

   The Miramichi beaver dam management program resulted in 42 dams breached in 2017 over the entire Miramichi watershed. Upstream locations from where some of these dams were removed were part of the focus for electrofishing crews in 2018 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 2017 and 2018 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 2019, electrofishing surveys were carried out during the summer of 2018 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 7th and September 29th, 2018 on the Miramichi River system. MSA alone surveyed 19 sites, while MSA and DFO worked together on 53 sites.

Beaver dam removal success from previous year

In total, 68% (13/19) of the sites electrofished in 2018 focused on areas upstream of beaver dams removed in 2018 (11 on the Southwest and 2 on the Northwest). Ten of these sites had fry present, with fry densities ranging from 0 to 57.1 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

6 of 19 sites (44%) were surveyed to assess the previous two year's stocking success. Of these 6 sites, 4 were stocked in 2017 (3 on the Northwest and 1 on the Southwest) and 6 in 2018 (3 on the Northwest and 3 on the Southwest). Fry were found in all sites stocked in 2018 and parr were found in all sites stocked in 2017. Fry densities ranged from 6.8 to 70.5/100m^2 and parr densities ranged from 3.8 to 27.3/100m^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 2017 were poor quality habitat for juvenile Atlantic salmon. 10 of the 13 sites surveyed contained fry in 2018, which leaves 3 sites available for potential stocking locations in 2019 (Tables 5 – 7).

Table 5. Salmon fry abundance assessments calculated using the CPUE method for 13 sites electrofished in 2018 by the MSA upstream of beaver dams removed in 2017.

River Branch	**Site**	**Fry/100m^2**
Northwest	Sevogle	9.1
Northwest	North Branch of the NW Miramichi River	0.0
Southwest	Sabbies 1	1.9
Southwest	Salmon Brook 1	0.0
Southwest	Otter Brook	0.0
Southwest	Muzzeroll Brook	0.9
Southwest	Betts Mills Brook	57.1
Southwest	Muzzeroll Brook 2	16.1
Southwest	Six Mile 2	1.5
Southwest	Salmon Brook 2	12.5
Southwest	Betts Mills 2	1.6
Southwest	Big Hole Brook	31.5
Southwest	Porter Brook	16.1

Table 6. Juvenile abundance assessments calculated using the CPUE method for 6 sites electrofished by the MSA to identify stocking success from 2018.

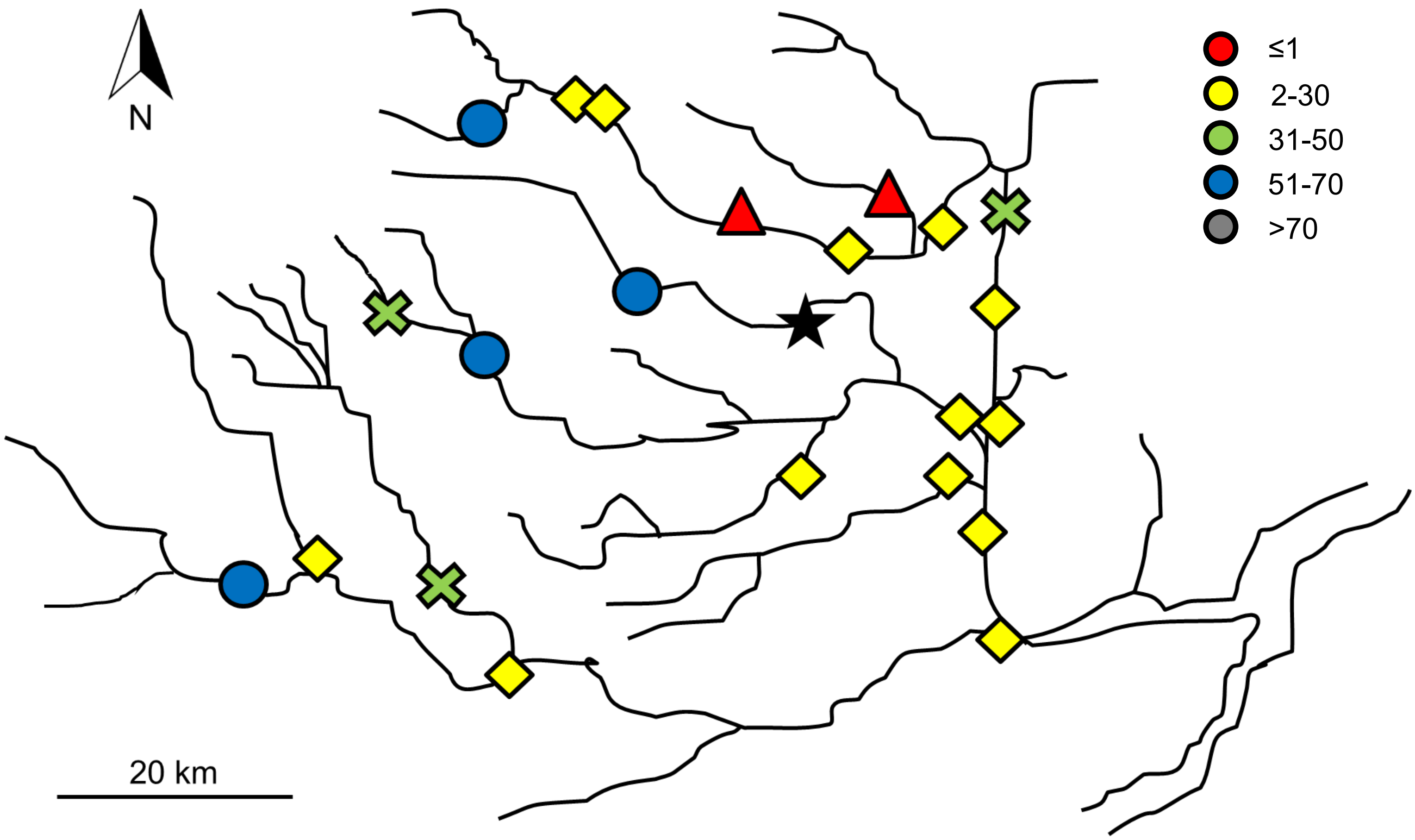
River Branch	**Site**	**Fry/100m^2**
Northwest	Barracks Brook	6.8
Northwest	Johnstons Brook	35.1
Northwest	Travis Brook	5.9
Southwest	Elliott Brook	33.0
Southwest	Little Teague	70.5
Southwest	Six Mile 1	50.0

Table 7. Juvenile abundance assessments calculated using the CPUE method for 4 sites electrofished by the MSA to identify stocking success from 2017.

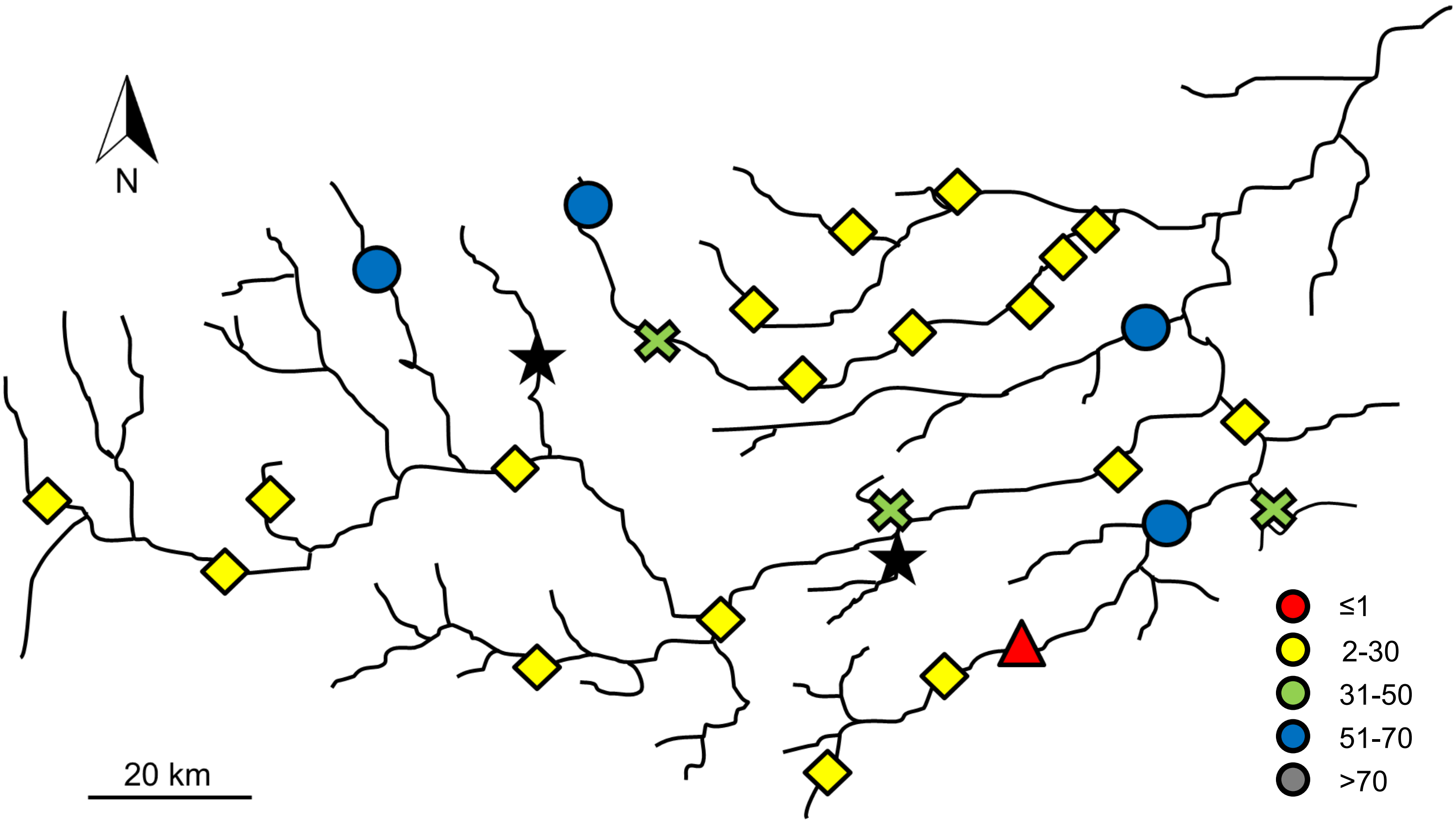
River Branch	Site	Parr/100m^2
Northwest	Barracks Brook	3.8
Northwest	Johnstons Brook	27.3
Northwest	Travis Brook	27.2
Southwest	Six Mile 1	15.8

Juvenile abundance using baseline locations (MSA/DFO)

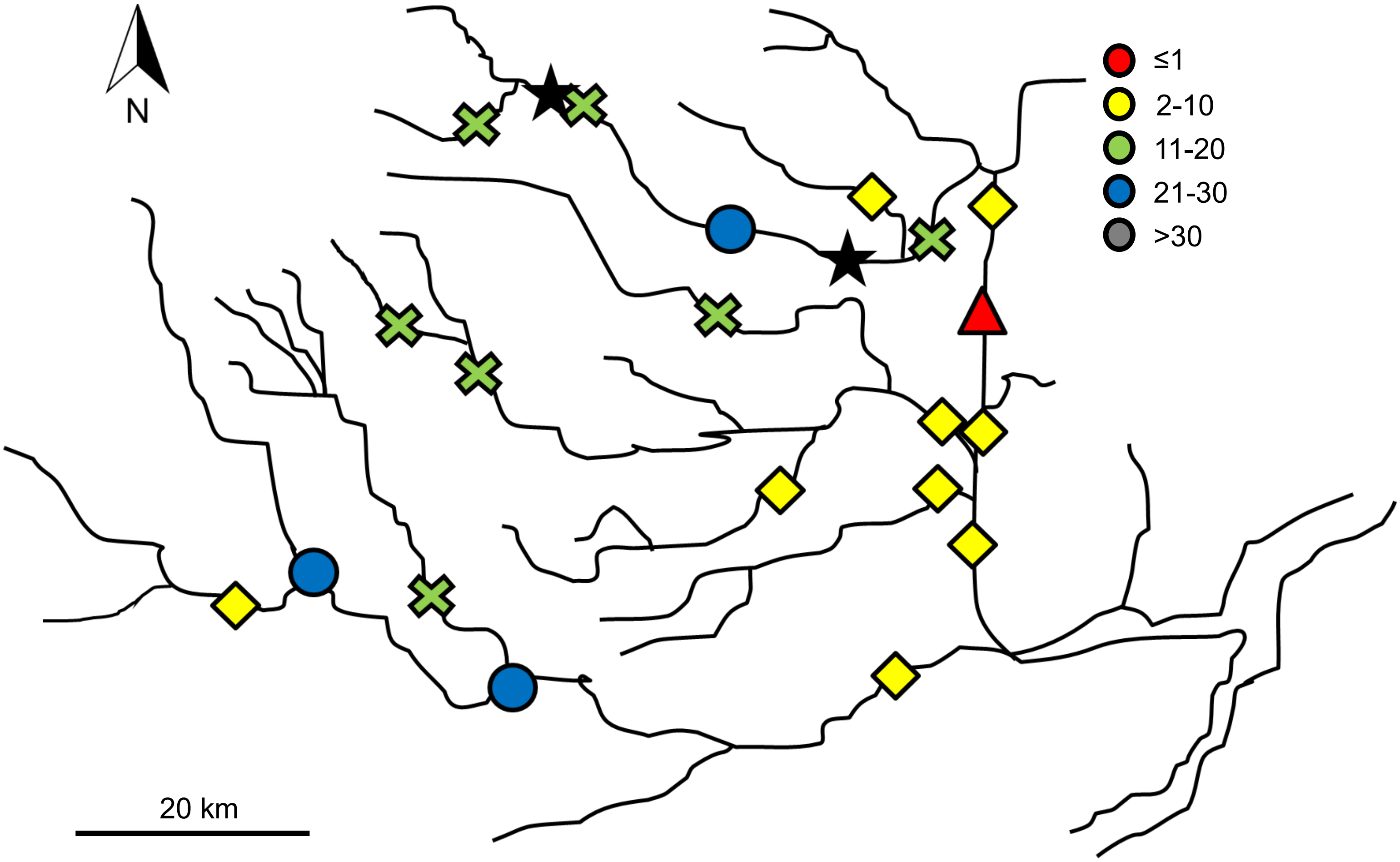
From August 27th to September 29th 2018, a total of 53 baseline sites were electrofished in several tributaries as part of the MSA/DFO cooperative program. Preliminary results from the assessment revealed high fry densities at many sites in both the Northwest and Southwest Miramichi Rivers, as 30% (16/53) of all sites contained greater than 30 fry/100m^2, 11% (6/53) of sites contained between 30 and 50 fry/100m^2, 66% (35/53) of sites contained between 1 and 30 fry/100m^2, and two sites (3%) contained less than 1 fry/100m^2 (Figure 6a&b). Parr densities were high (>20 parr/100m^2) at 15% (8/53) of sites, 30% (16/53) of sites contained between 10 and 20 parr/100m^2, 38% (20/56) of sites contained between 1 and 10 fry/100m^2, and only 4% (2/53) of sites contained zero parr (Figure 6c&d).



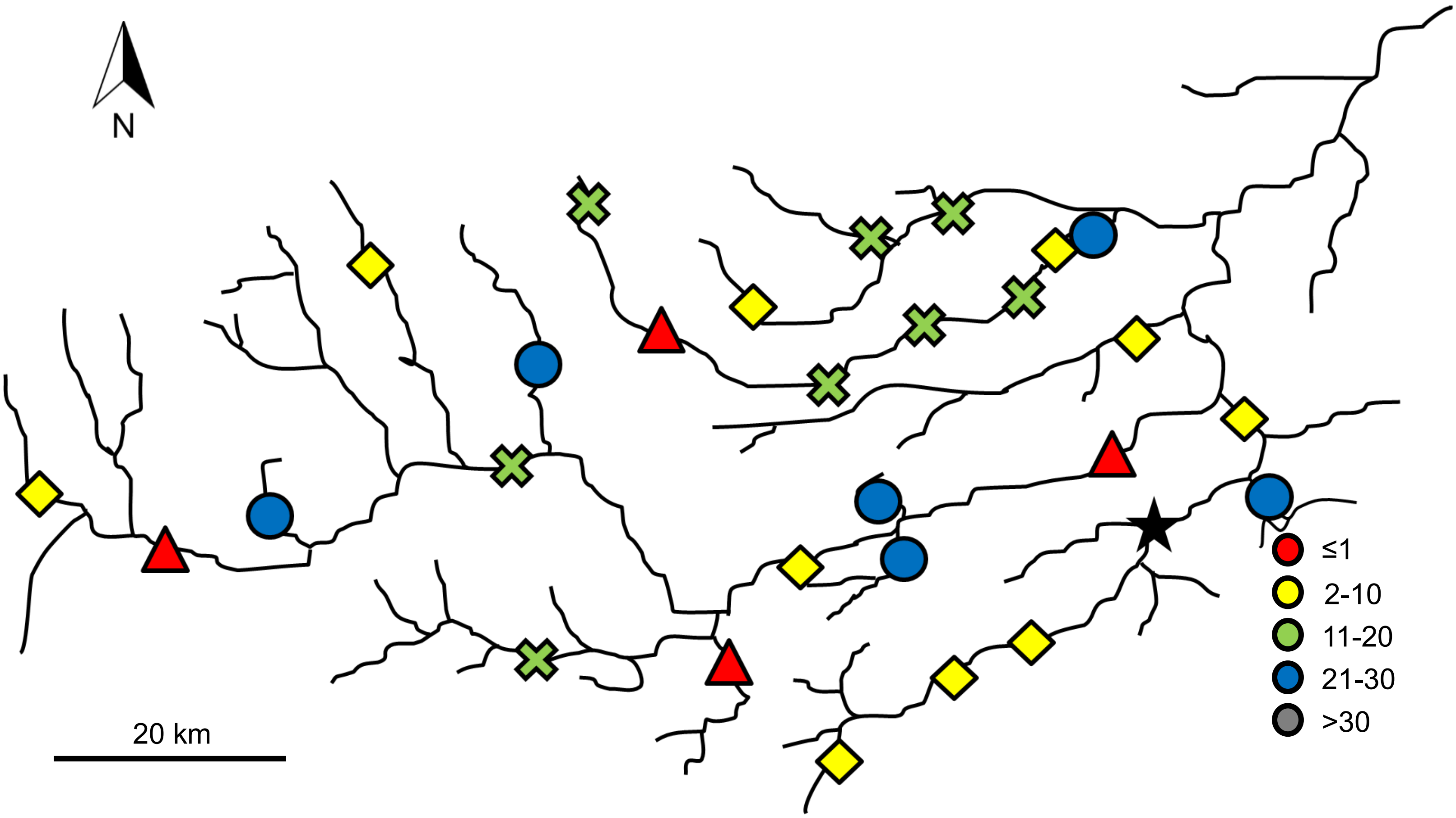
6(a). Northwest Miramichi fry densities 2018.



6(b). Southwest Miramichi fry densities 2018.



6(c). Northwest Miramichi parr densities 2018.



6(d). Southwest Miramichi parr densities 2018.

Figure 6: Preliminary juvenile density results from the 2018 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 100m2. Parr densities range from ≤1, 2-10, 11-20, 21-30, and >30 per 100m2.

Cold Water Habitat Restoration

Introduction

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 areas of thermal refugia are critical 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 cold-water habitats as areas of significant value in protecting adult and juvenile salmon.

Habitat 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 habitat typically reduces the number of fish which would have previously been found in this water. In the case of cold-water inlets and 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 Burntland brook on the Southwest Miramichi river in 2018. Burntland Brook is a tributary of the MSW River. The confluence where work was performed is located downstream of Highway 8 and enters on the west side of the river. The brook generally flows west as it meets the MSW River. 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 Southwest Miramichi River. The channel was reshaped by installing a rock toe, starting roughly 9 meters upstream from the confluence on the right bank. The rock toe was extended downstream into the river a couple extra meters compared the original design to protect the toe from ice and high flows. With the narrowing of the brook heading into the river, the concentrated flow will be effective at keeping material from accumulating and keep flow moving in a downstream direction into the main river. The brook is now approximately 11 m wide as it enters the river.

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

The Miramichi Salmon Association did ground reconnaissance on the Southwest Miramichi watershed and the Northwest Miramichi Watershed, to locate and GPS beaver dams. The assessed locations were determined ahead of time based on the previous year's results and known beaver dam areas.

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 2nd and finished on October 20th. Active dams were notched on multiple occasions following repairs by beavers.

Results

In the Northwest Miramichi basin, 4 dams were initially breached by the field crew on two tributaries – Little River and the Northwest Millstream (Figure 7). In the Southwest Miramichi basin, 11 dams were initially breached by field crews on 6 tributaries (Big Hole Brook, Betts Mills Brook, Porter Brook, Salmon Brook, the Bartholomew, Gordon Brook) (Figure 8). Dams on Big Hole Brook, Betts Mills Brook, Salmon Brook, and Little River had to be breached on multiple occasions after beavers repaired them. A total of 16 dams were initially breached in 2018 (Appendix 1).

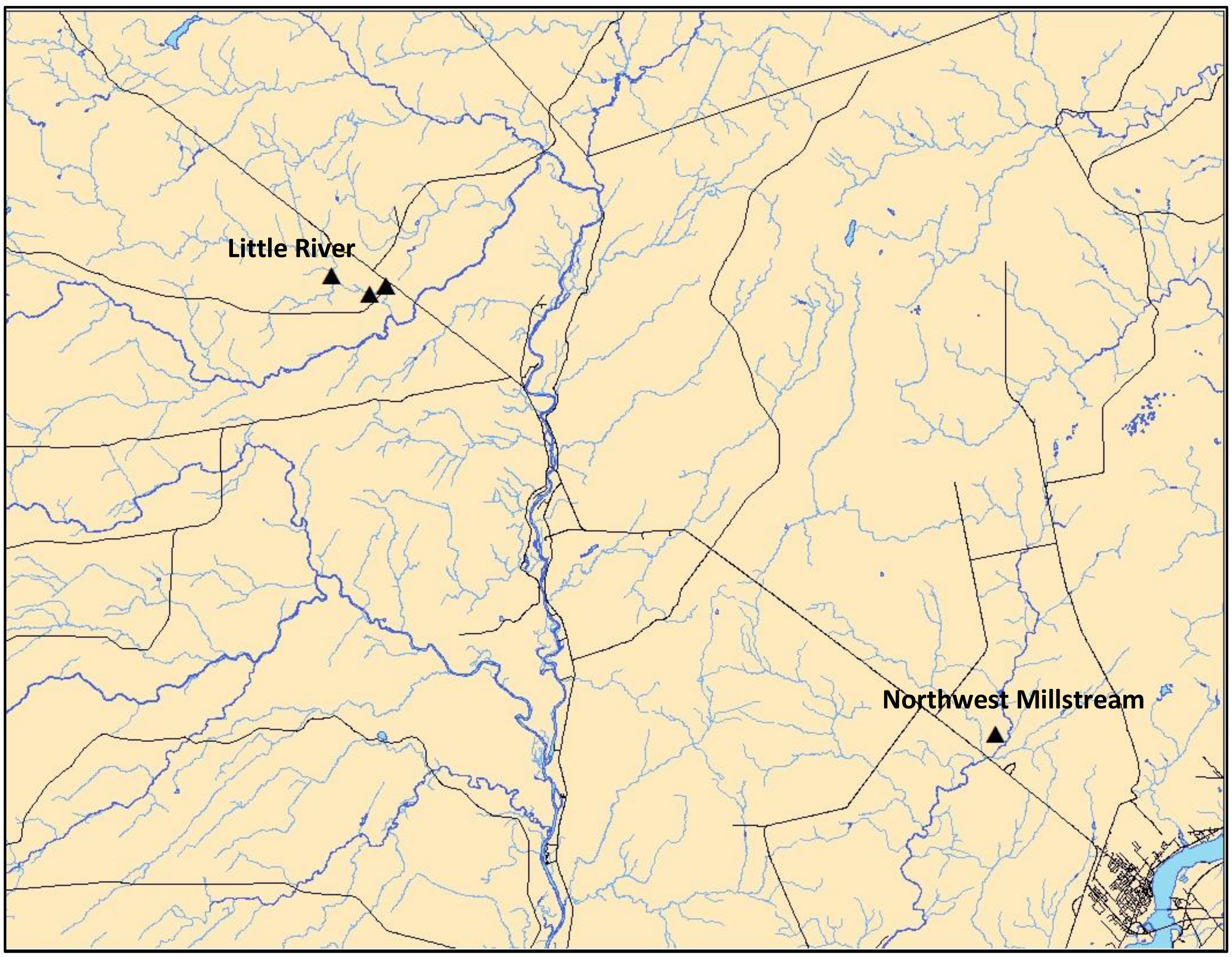


Figure 7: Tributaries of the Northwest Miramichi watershed. Beaver dams breached in 2018 are marked with a '▲'.

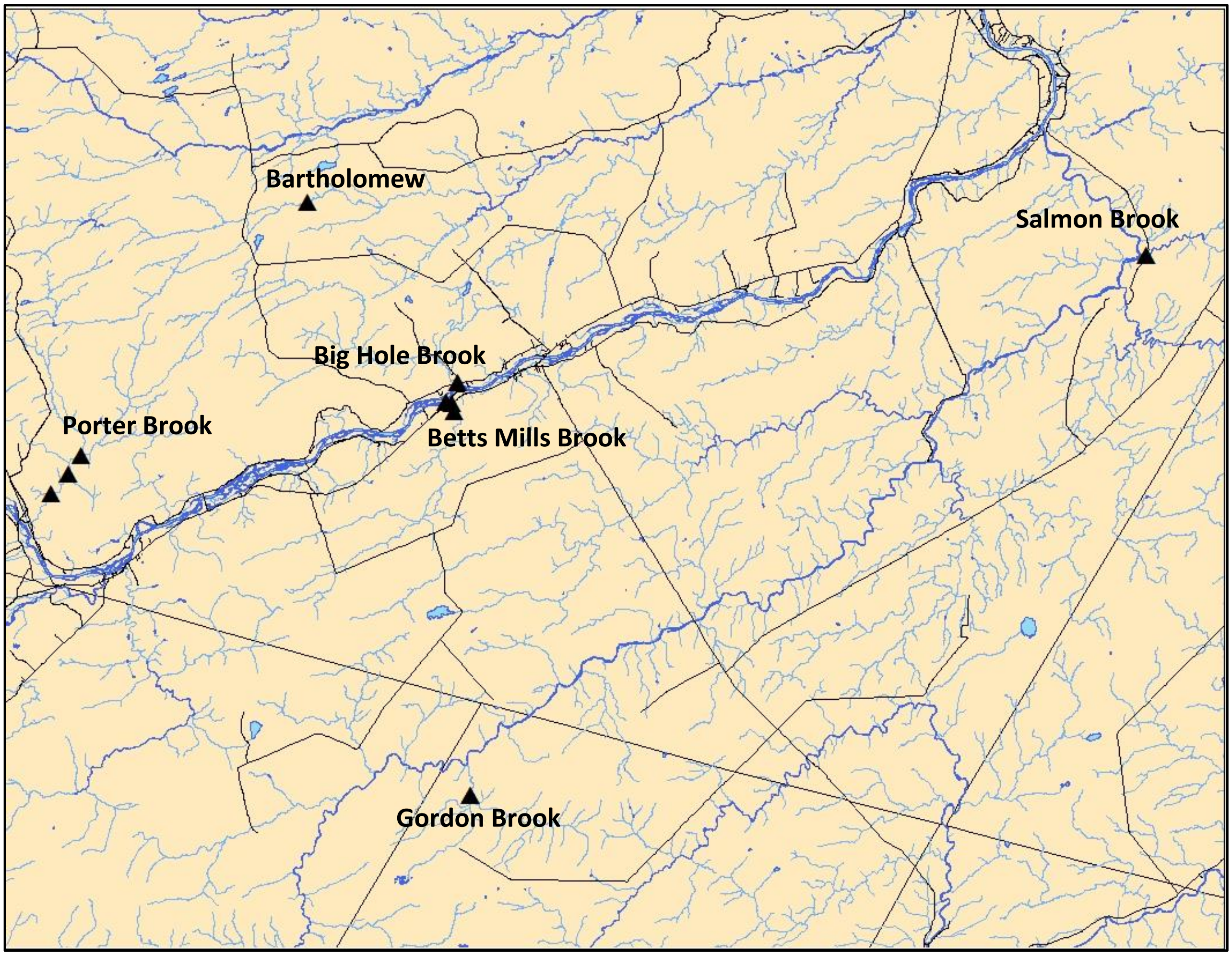


Figure 8: Tributaries of the Southwest Miramichi watershed. Beaver dams breached in 2018 are marked with a '▲'.

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. In a typical year, a helicopter survey would be conducted, and flight paths chosen based on beaver activity locations noted in previous years (focusing on larger and wider tributaries of the Miramichi River which offer clear line-of-site observations from the air of the dams, and on areas where river access is easy to moderately acceptable for field crews). In 2018, the helicopter was not available for the MSA to use until very late in the season, so all of the reconnaissance was done on foot by the field crews. Because water levels were very low, the focus of the beaver dam management in 2018 was on salmon habitat that historically had high beaver activity.

The number of dams breached in 2018 (16) was less than that of 2017 (42) due to water levels being extremely low during the fall of 2018, no access to the aerial observation, and there being limited access to for the field crews. 2015 dam breaching was low (35) 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 2018, 2017 and 2016 (92) and is most likely related to the water level being ideal during those field seasons as opposed to the poorer water conditions of 2018, 2017 and 2016.

In the Southwest system, Porter Brook, had zero to relatively low levels of beaver activity whereas Salmon Brook, Big Hole Brook, Gordon Brook, and Betts Mills Brook had higher activity levels. In the Northwest system, Little River had high levels of beaver dam activity, while the Northwest Millstream had low levels.

Over half (68%) of the electrofishing surveys completed in the summer of 2018 by MSA focused on areas upstream of beaver dams removed in 2017; 11 on the Southwest and 2 on the Northwest. Out of the 13 sites surveyed, 8 of these sites had fry present, which were located on Big Hole Brook, Salmon Brook, Porter Brook, Betts Mills Brook, Six Mile Brook, Muzzeroll Brook, the Sabbies, and the 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 2019 electrofishing surveys will be conducted upstream of dams breached/removed in 2018 to assess the impact of the program on Atlantic salmon fry production.

Acknowledgements

The Miramichi Salmon Association would like to thank the following people for their help with this program:

- UNB/ CRI field crews for their help removing dams on the Northwest Millstream
- Ken Cogswell for his help notching a dam on Gordon Brook
- MREAC/NBCC for their help assessing and removing a dam on the Bartholomew.

Table 7. GPS coordinates of breached beaver dams in 2018.

Date	Tributary	Latitude	Longitude	Active (Y/N)	Initial/Return Visit (I/R)	Breached on Return (Y/N)
2-Oct-18	Big Hole Brook	46.54821	-66.17975	Y	Initial	N/A
2-Oct-18	Betts Mills Brook	46.53871	-66.18777	Y	Initial	N/A
6-Oct-18	Gordon Brook	46.35239	-66.17204	Y	Initial	N/A
9-Oct-18	Salmon Brook	46.60628	-65.70615	Y	Initial	N/A
9-Oct-18	Big Hole Brook	46.54820	-66.17976	Y	Return	Y
9-Oct-18	Betts Mills Brook	46.53856	-66.18342	N	Initial	N/A
9-Oct-18	Betts Mills Brook	46.53871	-66.18777	Y	Return	Y
10-Oct-18	Little River	47.19202	-65.90708	Y	Initial	N/A
11-Oct-18	Northwest Millstream	47.051667	-65.633056	Y	Initial	N/A
12-Oct-18	Little River	47.19202	-65.90708	Y	Return	Y
12-Oct-18	Little River	47.18953	-65.91453	Y	Initial	N/A
12-Oct-18	Little River	47.18789	-6590802	N	Initial	N/A
13-Oct-18	Gordon Brook	46.35239	-66.17204	Y	Return	Y
15-Oct-18	Salmon Brook	46.60628	-65.70615	Y	Return	Y
15-Oct-18	Betts Mills Brook	46.53871	-66.18777	Y	Return	Y
16-Oct-18	Little River	47.19202	-65.90708	Y	Return	Y
16-Oct-18	Little River	47.19550	-65.93164	Y	Initial	N/A
17-Oct-18	Bartholemew	46.63357	-66.28238	Y	Initial	N/A
18-Oct-18	Porter Brook	46.51402	-66.43871	N	Initial	N/A
18-Oct-18	Porter Brook	46.50530	-66.44756	Y	Initial	N/A
18-Oct-18	Porter Brook	46.49619	-66.45888	Y	Initial	N/A
18-Oct-18	Porter Brook	46.48782	-6646687	Y	Initial	N/A

19-Oct-18	Betts Mills Brook	46.53457	-66.18251	Y	Initial	N/A
20-Oct-18	Gordon Brook	46.35239	-66.17204	Y	Return	Y

Striped Bass Egg and Larval Survey

Introduction

The striped bass (Morone saxatilis) is a native, large-bodied anadromous fish species which overwinters in estuaries or coastal areas and spawns in many of the freshwater/ brackish water estuaries of the Atlantic coast of North America ranging from the St. Lawrence River to the St. Johns River in northeastern Florida (COSEWIC, 2012). The Southern Gulf of St. Lawrence population of striped bass ranges from eastern Quebec to Nova Scotia and out into the Atlantic Ocean as far as Prince Edward Island. It is known as a single population with a distinct genetic makeup that is isolated from other striped bass populations in Atlantic Canada and the Eastern United States (Chaput, 1995).

Striped bass were once a very sought-after recreational fish species in the Maritimes, but due to overharvesting, the abundance of striped bass returning to the spawning grounds of Northwest Miramichi dropped to very low levels in the mid-1990s (Robichaud-Leblanc et. al, 1996). Because of this, management efforts were enacted first with the closure of the commercial fishery (1996), the recreational fishery (2000), and the suspension of First Nations fishing for food, social, and ceremonial purposes (2000) (DFO, 2013). In 2004, the conservation status for striped bass in the southern Gulf was labeled as “threatened” because of its extremely low numbers and single known spawning location (COSEWIC, 2004).

Some researchers believed that striped bass historically spawned in the Nepisiguit, Tabusintac, Miramichi, Kouchibouguac, Richibucto, and St. Lawrence rivers (Rulifson and Dadswell 1995). They are not documented to be successfully spawning there now. The only known location of successful spawning for the entire Southern Gulf of St. Lawrence population occurs between May and June in the upper portion of the tidally influenced water of the Northwest Miramichi River (Douglas et al., 2009). Because of this fact, the COSEWIC status for the Southern Gulf of Saint Lawrence population is still listed as “Special Concern”, with the last assessment being in 2012 (COSEWIC, 2012).

The abundance of striped bass (Morone saxatilis) in the Southern Gulf of Saint Lawrence has increased significantly since the early 2000s (re-opening the recreational and aboriginal fishery in 2013) with the most recent estimate of spawner abundance being 994,000 fish in 2017, achieving its recovery limit (DFO, 2018). Even with this increase in abundance, The Northwest Miramichi estuary remains the only confirmed spawning location for this population and it remains listed as a population of “special concern”; However, there has been no effort to sample in other estuaries that may be contributing to the increase in population size.

The objective of the Miramichi Salmon Association was to sample three rivers in the Southern Gulf for the presence of striped bass eggs and larvae.

Methods

Study Area

The Northwest Miramichi (NW) watershed drainage area of 3,950km2 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 (SW) watershed drainage area of 7700km2 makes up the remaining two-thirds of the total watershed of the Miramichi River. The Southwest Miramichi basin includes many smaller river systems, such as the Renous River, the Dungarvon River, the Cains River, and Rocky Brook.

The Tabusintac watershed has a drainage area of 717km2 which includes all of the lakes and streams that drain into the Tabusintac bay (Herrell and Methven, 2009). The mouth of the bay is protected from the Gulf of Saint Lawrence by an ever-shifting dune system and is located north of the Miramichi river in the Acadian peninsula in Northeastern New Brunswick.

Sampling

Ichthyoplankton sampling took place from June 13th ,2018 to June 20th, 2018 for Striped bass eggs and larvae on 3 river systems: 2 study sites on the Northwest Miramichi River (Figure 1) which served as the control, 4 sites on the Southwest Miramichi River (Figure 2), and 5 sites on the Tabusintac River (Figure 3). After spawning behaviour had been identified in the various rivers, Miramichi Salmon Association (MSA) staff went out in a small outboard motor boat to sample locations downstream of suspected/ known spawning sites, where eggs and larvae were suspected to have drifted. At each site, locations were marked with a hand-held Garmin etrex 20 GPS unit and the vessel anchored. Water temperature and dissolved oxygen readings were taken with a YSI dissolved oxygen meter. Secchi depths were taken at the substrate and at the point of reappearance on the shadowy side of the boat, in order to estimate the maximum sampling depth. This was to ensure that the plankton net used would remain at a depth where it would not hit bottom and collect sediment.

Figure 9. Ichthyoplankton sampling locations ([46.957454°, -65.686032°] and [46.963738°, -65.705295°]) on the Northwest Miramichi River on June 13th, 2018.

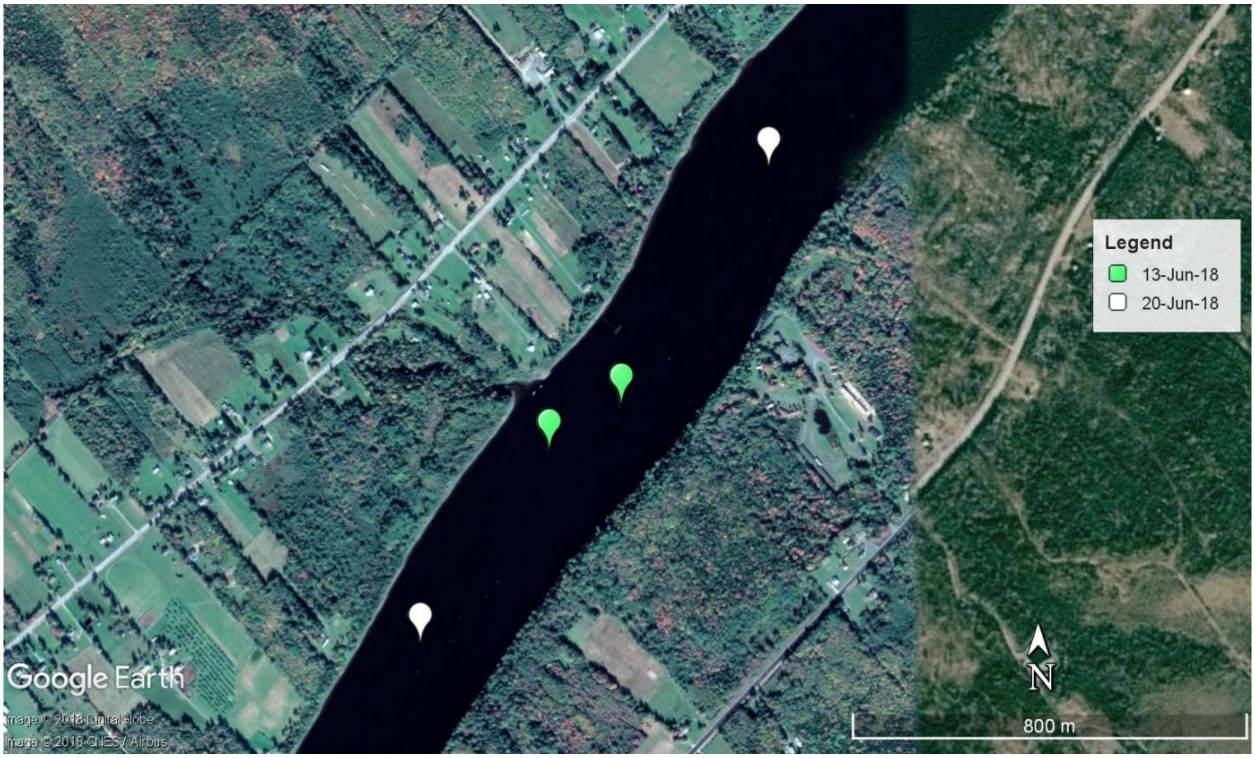


Figure 10. Ichthyoplankton sampling locations on the Southwest Miramichi River on June 13th, 2018 ([46.876166°, -65.663802°], and [46.875337°, -65.665718°]) and June 20th, 2018 ([46.871829°, -65.669179°], and [46.880460°, -65.659881°]).

Figure 12. Ichthyoplankton sampling locations on the Tabusintac River on June 15th, 2018 ([47.337600°, -65.118200°], and [47.339300°, -65.100900°]) and June 19th, 2018 ([47.334489°, -65.129869°], [47.343792°, -65.088103°], and [47.349587°, -65.078656°]).

A plankton net with a mesh size of 500 microns was used to sift water for striped bass eggs and larvae. The net was disinfected and washed down before every use and a flow meter reading taken. The net was then towed in the water column by the boat very slowly in a zig-zag formation for approximately 2 minutes. The contents of the net were washed down into the "cod end" and then transferred to a sample bottle. The flow meter reading was taken again and the sample bottle labeled with the location, sample number, date, and trawl time of collection. The bottles were then sealed and placed in a cooler to protect them from light and to be kept as cool as possible, until they could be examined in the lab at a later time on the day they were sampled.

Identification

The sorting of plankton samples and checking for striped bass eggs and larvae was done with the use of a dissecting microscope. Larvae from the NW samples were identified using the Electric Power Research Institute (EPRI) larval fish and egg key (EPRI, 2017), and then verified by

DFO personnel in order to be sure of the species. The collections from the SW and Tabusintac rivers were also observed under the dissection microscope and compared to the NW for confirmation of species. Small samples of the Striped bass eggs and larvae were preserved in vials of 60% ethanol solution to be used for reference in future identifications.

Results

Sampling

The collections took place below the head of tide (in the tidal fresh water) in each the NW and SW Miramichi rivers, as well as the Tabusintac river. Both Trawls from the Northwest river took place on June 13th, 2018 and covered approximately 1 km of river per collection over a two-minute time period. Water temperatures were 15.5°C at the upriver (UR) site, and 15.8 °C at the downriver (DR) site with average water depths at 8.2m and 5m respectively.

The Southwest river trawls took place on June 13th, 2018 and again on June 20th, 2018. On June 13th each trawl covered approximately 1 km over a two-minute time period (water temperature averaging 16.4 °C, water depth 3.6m UR and 3m DR), however on June 20th each two-minute trawl covered only approximately 600m at the upriver site and 400m at the downriver site due to high winds. The water temperature was averaging at 18.1°C (which was the warmest sampling day) and the average water depth was 3m and 5m respectively.

The Tabusintac river proved to be to be a more difficult spot to sample due to the fact that the winds were high on our sample days and the river wide and relatively shallow. Two trawls were conducted on June 15th, 2018 that each covered approximately 1 km over a two-minute time period (water temperature averaging 15.5 °C, water depth 4m UR and 5.2m DR). On June 19th, 2018 three trawls were conducted in order to sample a wider range on the Tabusintac. The upriver and downriver trawls covered approximately 1 km over a two-minute time period, however the midriver (MD) trawl only covered 550m over two minutes due to high winds. Water temperatures averaged 16.5 °C and water depths were 4.3m at the UR site, 3.4m at the MR site, and 5m at the DR site.

Identification

Because the objective of this project was to identify the presence or absence of striped bass eggs and larvae, samples were observed and species identified but not counted. The NW samples were the first to be looked at since this was the control river and it is already known that Striped bass historically spawn successfully there. When the samples were collected on the river, larvae were so plentiful that you could see them with the naked eye (Figure 4). Under the dissection microscope, both eggs and larvae were identified using illustrations and descriptions from the EPRI larval fish and egg key, and confirmed by DFO scientist Scott Douglas (Figure 5). There were many examples of both eggs and larvae on the NW Miramichi river which were used to compare the samples from the other rivers to.

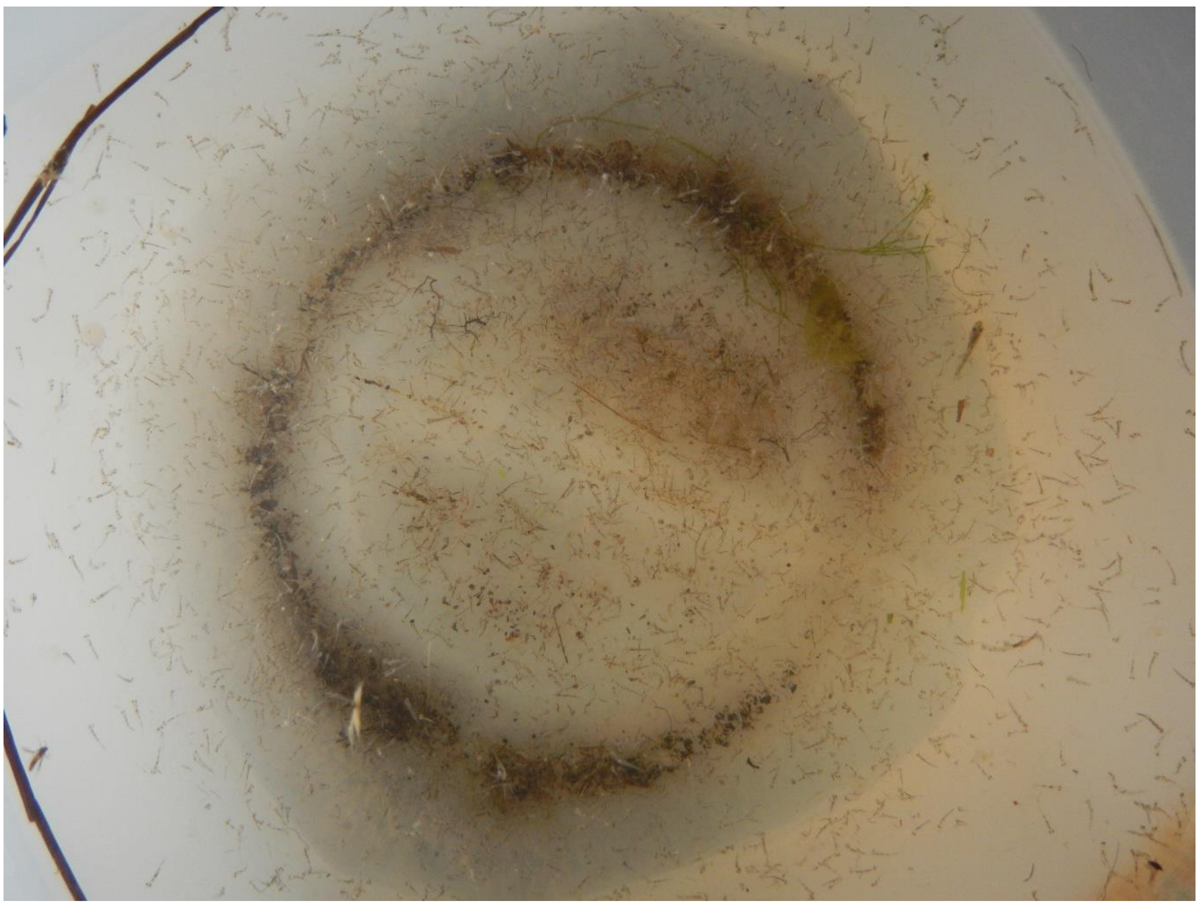


Figure 13. Striped bass larvae immediately after being collected on the Northwest Miramichi River on June 13^{th}, 2018.

Figure 14. Striped bass larvae from the Northwest Miramichi River viewed under a dissection microscope.

The samples collected on June 13th on the SW Miramichi river were also examined by Scott Douglas, and Striped bass eggs and larvae were confirmed in both the upriver and downriver samples (Figure 6). The samples collected on June 20th also had both eggs and larvae present; however, they were less abundant.

No examples of striped bass eggs and larvae were detected in any of the samples taken from the Tabusintac river on both dates of collection.

Figure 15. An example of a striped bass egg and larva side by side viewed under a dissection microscope.

Discussion

The Striped bass egg and larval collections took place approximately 1 week after it was observed that spawning activity had started to subside in the Northwest and Southwest Miramichi rivers. Spawning was observed on the Tabusintac river much earlier than on the NW and SW; however, sampling could not take place due to the lack of L52 scientific license at the time. There was an abundance of Striped bass eggs and larvae examined in the NW river samples. Seeing as it is listed as the singular spawning location for the Southern gulf of St. Lawrence striped bass population (COSEWIC, 2012), this was expected.

Of the four samples that were analyzed from the Southwest Miramichi River, those that were collected on June 13th, 2018 had shown a greater density of eggs and larvae than those that were collected on the 20th. This could be due to a couple of different factors. As it only takes 30-50 days for a striped bass to grow out of its larval stage (COSEWIC, 2012), in this time they could follow the current down river until they are strong enough to maneuver in the water column (Cooper and Polgar, 1981). Because the collections were not conducted until after the spawning season had virtually ended, the larvae could have potentially drifted further downriver than in the location the samples were taken. Another possible factor could have been the high winds that made it much more difficult to maneuver the boat and net during the trawls. Past studies have suggested that striped bass theoretically would not survive to hatch the Southwest Miramichi river due to unattractive environmental conditions that could not support them (Robichaud-Leblanc et. al, 1996), so it was very exciting to observe the presence of the larvae in the samples regardless of the decline in abundance during the second collection day.

The Tabusintac River was sampled due to the fact that it was a historically known spawning location for the Southern Gulf of St. Lawrence population of Striped bass (Melvin, 1991). Because MSA staff was only informed of the spawning taking place on the river but not the specific location that spawning was observed, estimations had to be made as to where the collections should take place. This, along with the late timing of the collections could be a potential factor as to why eggs or larvae were absent in the 5 samples that were taken from the Tabusintac. The larvae could have drifted down further from the sample site before the opportunity arose to start the collections, or spawning could have taken place much further upriver than was estimated.

Even though the survey was successful in finding the presence of striped bass eggs and larvae in the Northwest and Southwest Miramichi Rivers and the absence of striped bass eggs and larvae the Tabusintac river, this project should be continued under a more robust sampling protocol that would characterize the spawning event or quantify the abundance of eggs/larvae. It is suggested that both rivers be sampled more thoroughly, continuing with the ichthyoplankton surveys and also conducting young of the year (YOY) surveys later in the season to observe if the striped bass are developing past the larval stage. It is also suggested that more historic striped bass spawning rivers be sampled in the future for the presence and absence of eggs/larvae.

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