Miramichi Salmon Association
Conservation Field Program Report
2013

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Introduction

Beaver dams are known to act as barriers to adult Atlantic salmon during upstream spawning migrations, impeding access to habitat in the higher reaches of brooks and streams. Female salmon have been documented to congregate below beaver dams in large numbers, building multiple redds in small confined portions of the stream, at times in habitat of lower quality than that which would otherwise be available. These redds can become overlapped and highly crowded, reducing overall egg survival and negatively impacting the production of juvenile salmon within the stream. The areas of stream rendered inaccessible through damming are typically excellent spawning and juvenile habitat, often of higher quality than would be available in downstream stretches. These areas are generally characterized by a high percentage of gravel and cobble substrate, cold ground feed water, and low densities of large fish and avian predators. After multiple years of habitat blockage, these upstream stretches risk becoming devoid of salmon fry and parr, which over time has the potential to lower the number of stream imprinted adult salmon returning to these locations. Improving access to upstream habitat could have a beneficial effect on egg survival and juvenile production on individual streams, and if completed on multiple streams within a watershed has the potential to increase the total number of returning adult salmon in subsequent years.

In order to achieve maximum benefit from dam breaching efforts, it is important to consider the behavioural changes and movement timing of salmon. Atlantic salmon on the Miramichi River typically begin moving out of holding pools on large rivers from late September to late October to seek out spawning habitat. During this time salmon begin moving into low order streams to establish territory for the creation of redds. As these fish begin migrating into the upstream portions of small lotic systems they are likely to encounter dams on streams with high populations of beavers. Although smaller dams may be overcome during high water flows, large dams act as a barrier to further upstream movement. Active beaver dams are often repaired within a relatively short (<24 hours) time frame, meaning that removal or notching of dams must be aligned with upstream salmon migration, otherwise the effort and resources required to remove the barrier could be wasted.

Past initiatives of the Miramichi Salmon Association have shown the potential for beaver dam management as a tool for salmon conservation. Beaver dam notching during the critical salmon run period has had recent success within the watershed, with several examples showcasing improved juvenile recruitment. Prior to 2006 few salmon fry were found on Betts Mills Brook near Doaktown NB despite the construction of a fish ladder at a major highway crossing, a short distance upstream from the brook mouth. In 2006, a major beaver dam that had been blocking the fish ladder was removed, with an additional

21 beaver dams notched or removed, resulting in adult salmon access to more than 50,000m^2 of spawning habitat. Electrofishing results by the DFO and MSA revealed the presence of fry in Betts Mills Brook the following year. Additionally, Porter Brook and Big Hole Brook each have high quality salmon habitat and when salmon were able to access spawning habitat upstream of their respective beaver dams, high densities of salmon fry were present during electrofishing surveys the following year.

Providing access to spawning habitat for adult Atlantic salmon will ensure that the Miramichi River maintains strong juvenile production. High numbers of juveniles emigrating to sea has the potential to increased adult salmon returns, improving the prospects of continued conservation of this iconic species and providing the Miramichi outfitters, guides, and local fishermen high quality Atlantic salmon fishing.

Methods

In late September and early October of 2013, Miramichi Salmon Association staff flew fixed wing and helicopter reconnaissance flights throughout the Southwest and Northwest Miramichi watersheds to locate and mark tributaries of high beaver activity. The initial flight survey used a Cessna 310, with a Cessna 337 used for the remainder of fixed wing flights, and the final survey conducted by helicopter. Beaver dam locations were marked with Garmin GPS units and mapped using Google Earth in order to plan and coordinate dam management activities. Beginning in mid-October, MSA staff as well as contracted crews started the notching and removal of beaver dams from selected tributaries. Dams were accessed by foot in locations where logistics allowed, otherwise stream portions were canoed in order to access beaver impoundments. All dams management actions were completed by the end of October. A small number of active beaver dams were re-notched on a second occasion following dam repair by beavers.

Results

The first reconnaissance flight for beaver dams was taken September 18th, 2013. During the flight it was determined that water levels within in the river system were too high to allow for high accuracy location of beaver ponds. After water levels subsided to more manageable levels, fixed wing flights were undertaken September 30th and October 1st, and a helicopter flight October 5th, 2013. Beaver dam management initiated October 12th and continued until October 29th, 2013. In the Northwest Miramichi basin 7 tributaries (Fig. 1) were worked on, removing a total of 34 beaver dams. Five of these tributaries including the Northwest Millstream, Catamaran Brook, Little River, Little Sevogle, and Sheephouse Brook contained all 34 active dams which were breached, while portions of the North and South branches of the Sevogle were cleared of dead falls which may have impeded salmon movement. On the Southwest system beaver dam work was completed on 15 tributaries

(Fig. 2), including the breaching of 63 individual dams, with an additional 13 active dams being breached on a second occasion. The total number of dams removed was 112 dams on 22 tributaries throughout the Miramichi watershed.

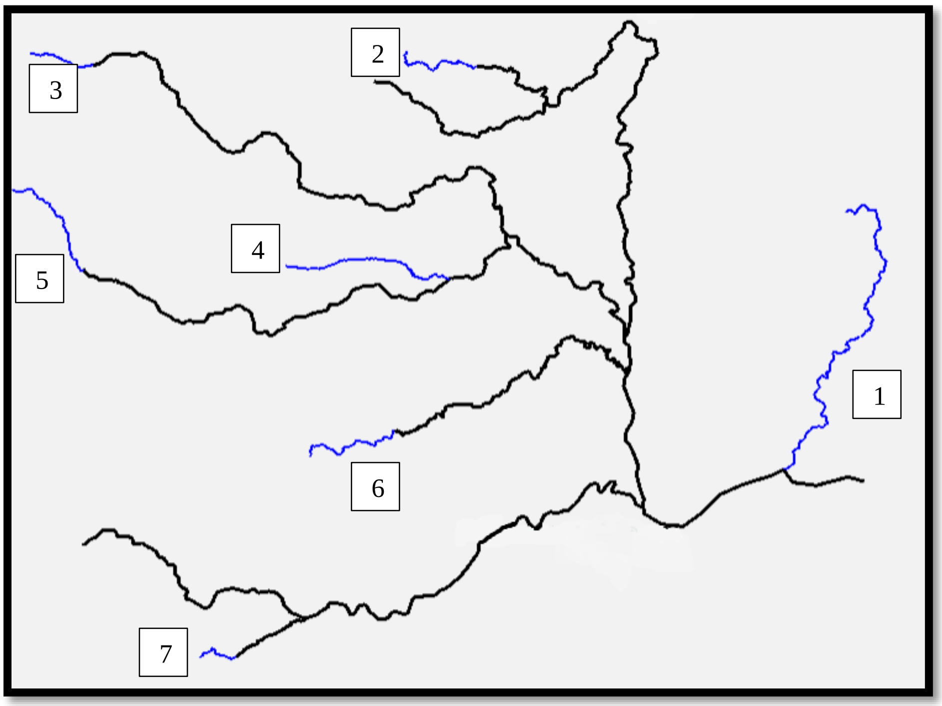


Figure 1.1 Tributary streams, highlighted in blue, in the Northwest Miramichi watershed in which active beaver dam breaching was undertaken. (In order from 1 to 7: Northwest Millstream, Little River, North Sevogle, Sheephouse, South Sevogle, Little Sevogle, Catamaran Brook)

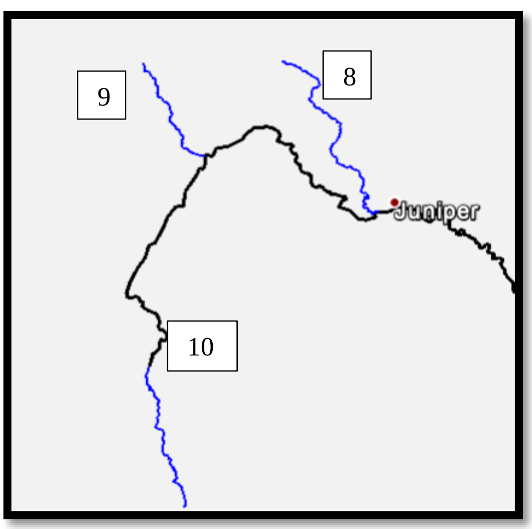


Figure 1.2 Tributary streams, highlighted in blue, in the headwaters of the Southwest Miramichi watershed in which active beaver dam breaching was undertaken. (In order from 8 to 10: Big Teague, Elliot Brook, South Branch of Southwest Miramichi)

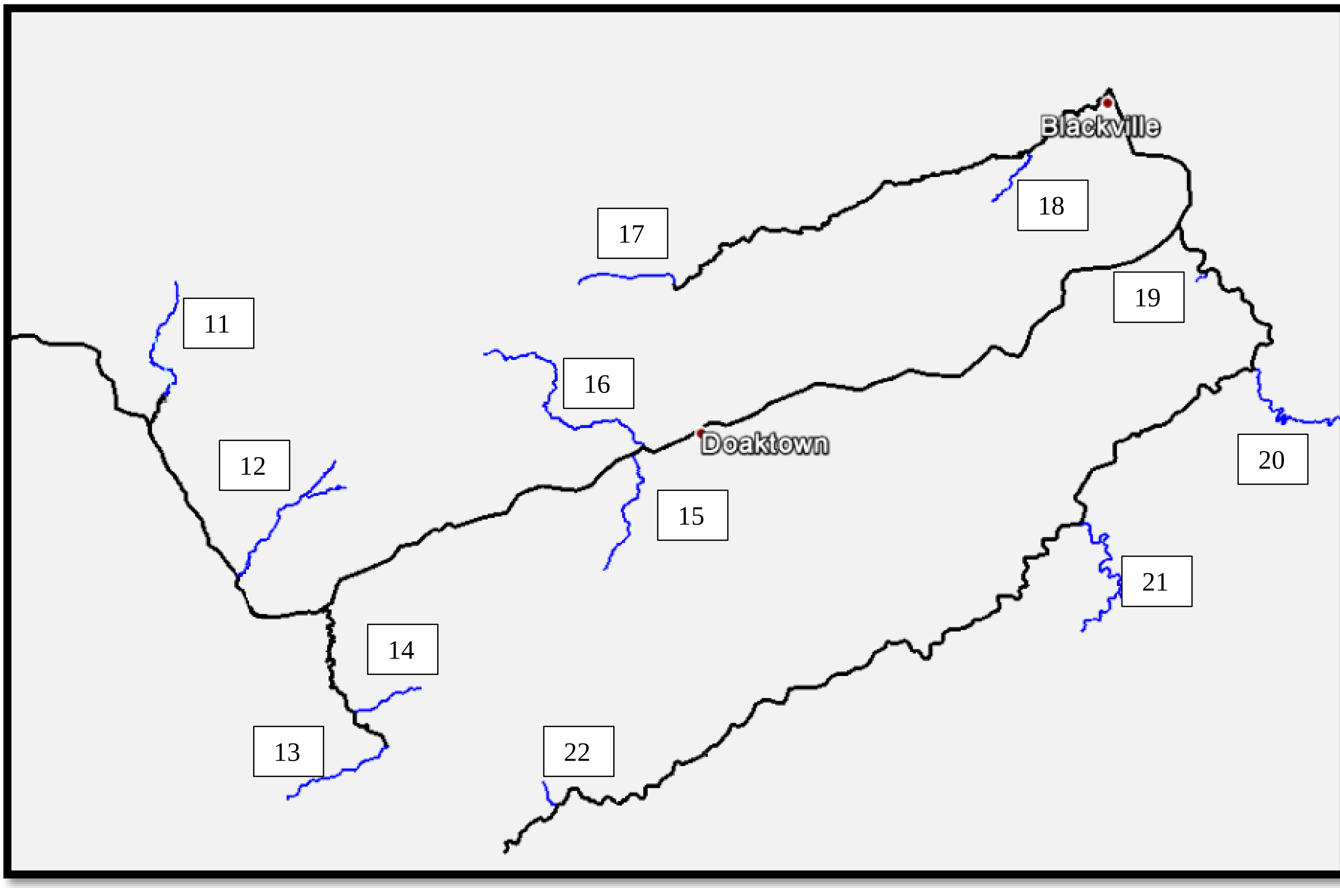


Figure 1.3 Stretches of tributary streams, highlighted in blue, in the Southwest Miramichi watershed in which active beaver dam breaching was undertaken.

11. Salmon Brook
12. Porter Brook
13. Burntland Brook
14. East Burntland Brook
15. Betts Mill Brook
16. Big Hole Brook,
17. Bartholomew River
18. Otter Brook (Bartholomew)
19. Otter Brook (Cains)
20. Sabbies Brook
21. 6 Mile Brook
22. Lower Otter Brook

Discussion

Aerial surveys throughout the entire watershed revealed a large number of tributaries with high levels of beaver dam impoundment, more than would be possible to remove during the scope of this project. Streams selected for dam breaching were chosen based on suspected quality of stream habitat for Atlantic salmon spawning and rearing purposes, as well as ease of accessibility for field crews. Due to the large scope of this project, both in the number of dams targeted for breaching (>100) and the significant size of the watershed (13,552 km^2), aerial surveys proved extremely valuable for efficient coordination and deployment of field crews. The quality of data gained from aerial surveys was highly dependent on air craft type and water levels. During our initial flight, high water levels made spotting head ponds above beaver dams difficult, which are typically the best indicator for the presence of dams. Furthermore, the location of the wings on the aircraft during this survey only accommodated the spotting of dams while in a banked position. All other flights used a push-pull designed plane or a helicopter, both of which allowed for easy viewing, with the helicopter having the added benefit of holding position over dams for the most accurate GPS coordinates. In past years the MSA has been involved in tributary specific dam breaching activities, which allowed for canoeing entire stretches of a limited number of small streams. This approach would have been in-effective for the 2013 program, as limited man hours would have been allocated to streams which did not require dam breaching activities. As such it is recommended that push-pull or helicopter based aerial surveys continue for the second year of this program.

Although beaver activity was present throughout the entire watershed, the level of activity varied significantly between river systems. The Little Southwest River, Renous River, Clearwater Stream and Burnthill Brook had very low levels of beaver activity within most of their major tributaries. Streams with low beaver activity were often characterized by riparian zones dominated by coniferous tree species (predominately spruce), or by fast flowing runs on steep gradient tributaries such as the North Pole Stream. However, other systems including the Bartibog and Taxis Rivers appeared to have favorable conditions for beaver but lacked evidence of high beaver activity. Activity was most abundant in the upper stretches of tributaries where channel widths were reduced. Stream habitat in these upper stretches was often characterized with slow flowing, low gradient runs surrounded by peat bog, where water acidity would be sub-optimal for salmon egg and juvenile survival. Stream stretches selected for breaching activity typically had gravel and cobble substrate and significant riffle habitat.

High water levels from late July to early October in the Miramichi watershed likely aided upstream migrating adult salmon in overcoming small beaver dams. This was evident on the Bartholomew River, where field crews noted the presence of redds up stream of multiple beaver dams. However, field crews operating on both the Little Sevogle and Elliot Brook observed that salmon holding downstream of beaver dams moved up immediately following dam breaching. In 2014 efforts will be made to record the number of dams with salmon observed downstream in order to assess the habitat made available for additional spawning, as well as the number of dams with redds or salmon immediately upstream to estimate the number of dams which did not impede upstream migration. In the summer of 2014 electrofishing surveys will be conducted on select streams to assess the impact of the 2013 program on fry production.

Table 1.1 GPS Coordinates of Breached Beaver Dams

Branch	**River/Tributary**		**Lat.**	**Long.**	**Comments**
Northwest	Northwest Millstream	NMS1	47.11785	-65.64007	
		NMS2	47.11726	-65.64016	
		NMS3	47.11761	-65.64007	
		NMS4	47.11809	-65.63809	
		NMS5	47.12198	-65.63007	
		NMS6	47.12005	-65.62149	
		NMS7	47.10796	-65.61944	
		NMS8	47.09816	-65.62139	
		NMS9	47.07069	-65.62527	
		NMS10	47.08313	-65.61523	
		NMS11	47.05764	-65.62925	
		NMS12	47.10648	-65.62103	
Northwest	Little River	NLR1	47.20698	-65.99281	
		NLR2	47.20396	-65.96815	
		NLR3	47.2076	-65.99612	
		NLR4	47.20624	-66.01759	
		NLR5	47.20602	-66.01553	
		NLR6	47.21243	-66.02724	
		NLR7	47.20422	-66.0263	
		NLR8	47.20734	-66.02777	
		NLR9	47.20173	-66.00571	
Northwest	Little Sevogle	NLS1	46.98526	-66.03356	
		NLS2	46.98754	-66.03274	
		NLS3	46.97728	-66.08926	
		NLS4	46.97679	-66.08749	
		NLS5	46.96933	-66.10909	
		NLS6	46.96691	-66.11916	
		NLS7	46.96787	-66.11655	
Northwest	Catamaran Brook	NCB1	46.85701	-66.16598	
		NCB2	46.86132	-66.1792	
		NCB3	46.85919	-66.18714	
		NCB4	46.8592	-66.18609	
		NCB5	46.85597	-66.19082	
		NCB6	46.86016	-66.18225	
Northwest	Sheephouse Brook	NSB1	47.08324	-66.09134	
		NSB2	47.08361	-66.08967	

		NSB3	47.0848	-66.0851	
		NSB4	47.08501	-66.08466	
Southwest	South Branch Miramichi	SBM1	46.555	-67.28786	
		SBM2	46.565	-67.26086	
		SBM3	NA	NA	Approx. 8km downstream of Foreston Bridge
		SBM4	46.54553	-67.25653	
		SBM5	46.52789	-67.30558	
Southwest	Little Teague	SLT1	46.63444	-67.26264	
		SLT2	46.62789	-67.2585	
Southwest	Big Teague	SBT1	46.549	-67.22925	2 Dams at Brook Mouth
		SBT2	46.5647	-67.24219	
		SBT3	46.56542	-67.24117	
		SBT5	46.60483	-67.28942	
		SBT6	46.60555	-67.29058	
		SBT7	46.61553	-67.30194	
		SBT8	46.61903	-67.30444	
		SBT9	46.61298	-67.29844	
Southwest	Elliot Brook	SEB1	46.61559	-67.34337	
		SEB2	46.56178	-67.28925	
		SEB3	46.61728	-67.34658	
		SEB4	46.61436	-67.33708	
Southwest	Salmon Brook	SSB1	46.5915451	-66.546841	Breached on multiple occasions
		SSB2	46.5947247	-66.545345	Breached on multiple occasions
		SSB3	46.6007921	-66.542943	Breached on multiple occasions
		SSB4	46.6152683	-66.53086	Breached on multiple occasions
		SSB5	46.6228359	-66.528261	Breached on multiple occasions
		SSB6	46.6080134	-66.537857	Breached on multiple occasions
		SSB7	46.627414	-66.529929	Breached on multiple occasions
Southwest	Big Hole Brook	SBH1	46.56138	-66.198817	
		SBH2	46.5716865	-66.247676	
		SBH3	46.5769941	-66.243944	
		SBH4	46.5901743	-66.246528	Breached on multiple occasions
		SBH5	46.5934066	-66.257827	Breached on multiple occasions
		SBH6	46.5958481	-66.262052	Breached on multiple occasions

		SBH7	46.5970361	-66.289132	
Southwest	East Burntland Brook	SEBB1	46.4118647	-66.378262	
		SEBB2	46.4194606	-66.350519	
		SEBB3	46.4206815	-66.350389	
Southwest	Burntland Brook	SBB1	46.3932203	-66.361277	Breached on multiple occasions
		SBB2	46.3640774	-66.431442	Breached on multiple occasions
Southwest	Lower Otter Brook	SLO1	46.3618252	-66.241911	
		SLO2	46.3645396	-66.238274	
		SLO3	46.3630526	-66.240047	
Southwest	Porter Brook	SPB1	46.4940696	-66.464845	
		SPB2	46.515828	-66.440195	
		SPB3	46.5132983	-66.434745	
		SPB4	46.5209464	-66.426129	
		SPB5	46.5217297	-66.414206	
		SPB6	46.5315227	-66.415195	
		SPB7	46.5390071	-66.409195	
Southwest	Otter Brook (Cains)	SOBC1	46.6409886	-65.757098	
		SOBC2	46.6413071	-65.757007	
		SOBC3	46.641398	-65.756939	
		SOBC4	46.6416091	-65.756893	
		SOBC5	46.6408168	-65.757066	
Southwest	Betts Mill Brook	SBM1	46.4904481	-66.201343	
		SBM2	46.4978543	-66.19231	
		SBM3	46.5002452	-66.189658	
		SBM4	46.503066	-66.189063	
		SBM5	46.5086045	-66.191482	
		SBM6	46.5136083	-66.193871	
		SBM7	46.5200573	-66.183933	
Southwest	6 Mile Brook	S6M1	46.4536633	-65.856879	
		S6M2	46.4548833	-65.85465	
		S6M3	46.4547242	-65.855285	
		S6M4	46.459023	-65.854104	
		S6M5	46.4593279	-65.853964	
		S6M6	46.4618374	-65.842656	
		S6M7	46.4739453	-65.828549	
		S6M8	46.4831875	-65.828062	
Southwest	Sabbies	SSB1	46.58086	-65.71706	
Southwest	Otter Brook (Bartholomew)	SOBB1	46.69760	-65.89807	
Southwest	Bartholomew	SB1	46.636065	-66.189811	
		SB2	46.637869	-66.166877	
		SB3	46.635932	-66.157994	

<u>Miramichi Kelt Tracking</u>

Introduction

Adult Atlantic salmon (*Salmo salar*) which migrate to river systems to spawn and remain in freshwater over winter are referred to as kelt. As discharge and temperature rates begin to increase in early spring, kelts which have survived the winter migrate downstream to feed and reconditioning in the Miramichi estuary and bay before moving into the Gulf of St. Lawrence. Studies of repeat spawner egg deposition have estimate that these fish account for 25 to 40% of the total eggs annual deposited in the Miramichi River. Repeat spawners to the Miramichi are broken into two life history strategies; alternate spawners, which move through the Gulf of St Lawrence 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. The biological and socio-economic importance of repeat spawners is significant as these fish are generally larger in size than maiden salmon, making them more desirable for catch and release angling, contribute a significant amount of eggs to the river system, and are likely to produce larger eggs with increased chance of survival than those of smaller fish.

The marine ecology of adult Atlantic salmon has been identified as a knowledge gap in the scientific literature. Based on past acoustic studies of Miramichi kelt, survival through the river and bay has averaged over 90%, suggesting that the vast majority of kelt mortality is occurring in the marine environment. Information on marine mortality, feeding behavior, 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, impacts of marine commercial fishing on salmon bycatch, and the effects of trophic shifts and climate change on salmon populations.

The use of satellite tagging is a novel approach to track the movement, 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 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. However, the costs 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 profile. Data collected from these devices is transmitted once the tag is deployed, which occurs after a preset date or following five days of no detected pressure change, which is an assumed mortality. Geo-positioning is determined by recording daily light intensity and duration, which is correlated to sunrise/sunset timing to produce one daily location. Delayed tag transmission combined with a single averaged daily location prevents the fine scale study of fresh and brackish water movements. As such, the use of both satellite and acoustic technologies allows for both fine and coarse scale study of individual fish.

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

Methods

Study Area

The Northwest Miramichi watershed drainage area of 3,950 km^2 makes up approximately one third of the total watershed of the Miramichi River. The Northwest Miramichi basin includes two major river systems, the Little Southwest Miramichi River (1,342 km^2) and the Northwest Miramichi (2,078 km^2) River which flow merge in a delta at the head of tide near Red Bank, New Brunswick. From head of tide, the Northwest Miramichi connects approximately 23 km downstream to the Southwest Miramichi, before flowing into the Miramichi Bay.

Tagging

Kelt were captured by angling May 5 and 6, 2013 throughout the Northwest Miramichi head of tide area, and transported to a tagging location at Cassilis, 3.3km downstream of Red Bank. Additional kelt were captured and May 15 and 16, 2013 at Department of Fisheries and Oceans (DFO) trapnets, and tagged May 16 at Cassilis.

Following capture kelt were temporarily held in a submerged live box. Fish were then placed into a clove oil bath for several minutes to anesthetize until equilibrium was loss and movement was minimal. For animals receiving acoustic only tags, Vemco V 16-4x transmitters were inserted by making a small, off center incision into the body cavity between the pectoral and pelvic fins. Once the transmitter had been inserted the incision was stitched up with 2 or 3 sutures and kelt placed back into the live box to recover. Time out of the water for this procedure was 2 to 3 minutes, with water passed regularly through the gills and over the body during the surgery.

Microwave Telemetry Inc. X-Tag pop-off satellite transmitters were outfitted selectively onto kelt with a fork length over 73cm while the fish was still anesthetize from the insertion of a Vemco V9 transmitter. Pop off tags were anchored to the fish by two hard plastic plates on each side of the body. Plates were located just below the dorsal fin and held in place by a plastic coated wire which was passed through the fishes muscle tissue. During all surgeries fish were kept moist and water was continually passed over their gills. The combined time out of the water for acoustic and satellite tagging procedures was 3 to 4 minutes.

Receiver Placement

A total of 12 Vemco VR2W acoustic receivers were placed throughout the tidally influenced portions of the Northwest Miramichi, Southwest Miramichi, and the main stem of the Miramichi River to detect in river movements and survival rates (Fig 1.). Additional receivers were placed to form detection gates between openings at barrier islands near the mouth of the Miramichi Bay, at Neguac Beach, Portage Island, and Huckleberry Gully (Fig 1.).

Results

During May 5th and 6th 2013, the Miramichi Salmon Association organized in house staff, association members, and local volunteers to angle for kelt near the Red Bank bridge. Over these 2 days a total of 12 kelt were tagged, 9 of which were implanted with V9 acoustic tags and external pop up satellite tags, while the remaining 3 were implanted with large, long term V16 acoustic tags. Catches during the two day angling event were lower than in past years, and as such the number of fish tagged was below our target. To increase the number of tagged individuals available for the 2013 study, an additional 4 kelts captured at DFO trapnets were tagged on May 16th, which included 2 fish outfitted with small internal acoustic tags and pop up satellite tags, and 2 acoustic only fish. The final tally for the 2013 tag deployment came to 11 satellite and 5 acoustic tags, for a total of 16 tagged kelts. Although we missed our target of 25 acoustic tagged adult salmon, we were able to deploy all 10 tags purchased in 2013, along with an additional satellite tag which was recovered and refurbished in 2012.

Survival and Movement through Northwest River and Miramichi Bay

Acoustic receivers detected that 12 of 16 tagged fish (75%) survived out of the Miramichi River system, with 11 of 16 (69%) kelts surviving to make it through Miramichi Bay to the Northumberland Strait (Table 1.). When broken down by tag type, 8 of the 11 satellite tagged fish and 3 of the 5 acoustic tagged fish survived out of Miramichi Bay. Mortality rates were very strongly correlated to capture method, with 100% in river mortality of fish captured by trap net, contrasted to 92% survival to the marine environment of fish captured by angling. On average, satellite and acoustic tagged kelt remained near the Cassilis release site for 3 and 2 days, respectively, but sample sizes were too small to determine a significant difference. Tagged fish entered the Northumberland Strait between May 8th and May 28th, with time to sea following tagging ranging from 3 to 22 days, with a mean of 10 days. In 2013 no tagged fish were recorded to have returned to the Miramichi River as consecutive spawners.

Figure 2.1 Location of acoustic receivers through Miramichi River and Miramichi Bay. Red circles indicate receivers used for tagging location (Cassilis), and survival out of river (Loggieville), yellow circles indicate individual receivers used to track in river movement. Red lines indicate multiple receivers used to determine survival out of Miramichi Bay (Neguac, Portage Island, Huckleberry Gully).

Table 2.1 Total number of kelt which received acoustic tags and percent survival through various locations and times between 2008 and 2013. * indicates that this information is not available until next year, and only applies to kelt which received large, long term acoustic transmitters

Location	2008	2009	2010	2011	2012	Total 2013	Angling only 2013
Kelts Tagged	50	50	50	50	35	16	12
Head of tide (%)	100	100	100	100	100	100	100
River mouth (%)	96	92	90	94	94	75	100
Miramichi Bay (%)	96	92	90	94	89	69	92
Strait of Belle Isle (%)	44	18	14	30	14	38	50
Returned as consecutive (%)	6	8	18	10	6	0	0
Returned as alternate (%)	8	0	10	4	0	*	*

Sea Survival and Movement

In 2013 a total of 11 tagged kelt successfully made it out of the Miramichi Bay. Three of these kelt were outfitted with long term V16 acoustic tags, while the remaining eight were equipped with pop-off satellite transmitters along with short term V9 acoustic tags. Three of the eight satellite tags failed to broadcast leaving five tags which transmitted temperature, depth and movement data.

Gulf of St. Lawrence: Three pop-off tags deployed prematurely within the Gulf of St Lawrence, but preliminary results from these fish have varied. Tag 128023 begin transmitting July 7, 2013 off the eastern tip of the Gaspe Peninsula (Fig 2.2). Data from this tag show a marked increase in depth and temperature starting June 30, and continuing for 2 days. During this time no sunrise or sunset data was available, and the maximum recorded temperature reached 26.37 degrees Celsius. These results strongly indicate that this kelt was predated upon, and that the tag remained in the predators digestive system for 2 days before excretion. After the tag was expelled it floated to the surface on July 2nd, where it remained with unchanging pressure readings which triggered tag transmission.

Tag 128020 first transmitted northwest of the Magdalen Islands July 9, 2013 (Fig 2.2). Temperature and depth data show a slow decline in temperature against a steady increase in depth, indicating that this fish died and began to slowly sink to the bottom, where it remained until its tag deployed. The cause of death cannot be determined, but could be attributed to numerous factors including an injury from a predator attack, inability to find sufficient food, or reduced fitness due to tagging equipment. Results from kelt 128019 (Fig 2.2), which deployed north of PEI on June 17, are still being analyzed by Microwave Telemetry Incorporate and are not yet available for biological interpretation.

Figure 2.2 Initial transmission locations for three satellite tagged kelt in the Gulf of St Lawrence

Strait of Belle Isle and Northern Waters: All three kelt outfitted with large acoustic tags travelled through the Strait of Belle Isle (SOBI), in migration to the waters of North Atlantic and Arctic Oceans. Two animals equipped with pop-off tags travelled through the Strait without being detected by acoustic receivers, but successfully deployed on schedule along the coasts of Labrador and Baffin Island. Temperature and data trends from these fish are still being analyzed, but movement tracks of each can be found in appendix 1 of this report. A third satellite tagged individual was acoustically detected at SOBI but failed to transmit. All fish picked up by sonic receivers were detected between July 6 and 7, 2013. Kelt tagged with Vemco V 16 tags arrived at SOBI receivers 57 to 60 days after last detection at Miramichi Bay, compared to 38 days for the lone detected satellite tag fish.

Figure 2.3 Locations of acoustic receiver lines deployed by ASF to track kelt movements

Figure 2.4 Initial transmission locations of satellite tagged kelt in North Atlantic and Arctic Oceans

Tag Recovery

In 2013 a total of 4 satellite tags were able to be recovered after deployment. Two of these were attached to kelt which did not survive out of the river, a third was found on the south side of Miramichi Bay, and the final recovered tag was picked up off the north coast of PEI. All four tags will be refurbished for use during the 2014 study.

Discussion

In 2013 62.5% (5/8) of all satellite tagged kelt which survived through the Miramichi Bay successfully transmitted data on fish movements, temperature, and depths. Of the tags which failed to transmit, one was detected by acoustic receivers as it moved through the Strait of Belle Isle. The remaining two tags were not detected at the Strait or any other location, indicating that these fish failed to leave the Gulf of St Lawrence or were failed to be detected by acoustic receivers as they left. Failure of satellite tags to transmit could be the result of several factors which include technical failure, tag damage at sea, or lodging in the digestive track of a predator. Despite these failures, discussions with Microwave Telemetry Inc. (MTI) which produce these tags suggest that our return rate of data has been strong compared to other studies.

Two of the satellite pop-off tags deployed on schedule at preprogramed dates of August 31 (Baffin Island), and September 30 (Labrador), 2013. Initial satellite results suggest that these fish moved through the Strait of Belle Isle July 16 and July 3, respectively. Although these dates may be subject to change following further analysis, both fall in early July, during the same time that all acoustically tagged fish (July 6 and 7) were detected. Given the northern location and late season timing of transmission of both tags, it is safe to speculate that these kelts were alternate spawners on their way to recondition in cold northern waters before returning to spawn in 2014. Advanced analysis of the data from these two tags is ongoing, and will be used with past and future data to investigate trends in kelt movements to determine statistically relevant behavioral patterns which may provide significant insight into the ecology of alternate spawning salmon.

Of the two prematurely deployed tags in the Gulf of St Lawrence which data is currently available for, only one at this time can be considered for probable predation. Data on tag 128020, which appears to have sunk to the sea floor, will be compared to other kelt throughout the ongoing study to determine if depth and temperature data before the cessation of movement may have indicated a weaker condition of the fish compared to other tagged animals. Temperature and light analysis from tag 128023 suggest a high probability of predation. Further analysis of temperature and depth occupied this time may provide insight as to what species of animal consumed this kelt. Pop-off dates of both these fish occurred within 2 days of each other, July 7 and 9, 2013 which, after excluding the 5 days of inactivity before transmission, means that these tags were floating at the surface July 2 and 4. Although too small to draw any conclusions from, pooling the data from these fish with kelts from past and future studies which also prematurely deploy in the Gulf may provide correlations between survival and water temperature, seasonal commercial fisheries, or predator movements. Initial biological analysis of kelt 128019 is currently awaiting data summation by MTI.

Determining movement tracks of individual fish requires considerable work and statistical analysis. As previously mentioned, tag position is determined by converting daily recorded light intensity and duration to sunrise and sunset timing. Positioning is then determined by calculating the marine area would have those same times for a specific date. Although this method is effective, it is also prone to false locations produced by environmental conditions. Significant cloud cover during dawn or dusk where light levels are low can give the impression of delayed sunset or early sunrise, thus changing the position calculated for the location. An initial correction factor can be applied by averaging positions at a specific date with values collected during the previous days. This method provides a simplified improvement to smooth out data, but is still impacted by outlying erroneous locations. In order to correct for this, all positions need to be compared against local weather conditions during the specific date the animal was thought to be in a given area. At this time simplified tracks of three kelt have been completed, which are included in Appendix 1 of this report. The locations and times of these tracks are not yet considered final, and are likely to change during further refinement.

In 2013, survival of acoustic only and satellite tagged fish through the river and bay was significantly lower than past years of this study. This is considered an artifact of the study, due the 100% post-tagging mortality of kelt captured from trapnets. The cause of this mortality is likely the combination of several factors including warmer water conditions, stress from the trap net, or possibly poorer fitness of later run kelt. When these fish are included, the survival rates for the Miramichi River (75%) and Miramichi Bay (69%) are the poorest of the study. The exclusion of these fish changes survival rates to 100% and 92%, respectively, which are more in line with averages of 93% and 92% for river and bay survival for studies from previous years. Based on these findings all future sampling events will be planned for earlier in the spring to avoid detrimental impacts to scientific studies and unnecessary harm to the animals. Furthermore, trap netting will be avoided as a fishing option in future studies.

First Feeding Salmon Fry and Trout Stocking

Introduction

Stocking Atlantic salmon early-feeding fry can improve the juvenile production capacity of the Miramichi River by targeting areas with juvenile densities lower than their production potential. Low fry or parr numbers in a stream system could be the result of multiple factors, including poor adult returns, barriers to adult movement into upper stream reaches, or stochastic environmental events such as ice scouring of redds or sub-optimal water temperature conditions. Fry abundance at a given location can act as an indicator of spawning success and year class recruitment of the previous year, whereas parr abundance can reflect spawning success from 2 or more years past. For example, a stream with high parr densities but very low fry densities could be the result of salmon being unable to access those waters during the most recent spawning season, but having access two or more years ago. Large annual variability in fry densities on small tributaries impacted by beaver is to be expected; high water levels in one year could wash out dams allowing for upstream access of spawning adults, while low water levels in other years would leave dams intact resulting in low or no egg deposition. Although fry numbers represent a strong reflection of adult spawning success and egg recruitment due to the small area in which they move, parr numbers are less directly tied to these factors as parr exhibit high mobility within streams.

In order to best target potential stocking locations the Miramichi Salmon Association (MSA) uses data collected during the previous year from two separate annual electrofishing programs. Electrofishing data used for the planning and implementation of the 2013 stocking program can be found in the Miramichi Salmon Association Conservation Report 2012. Using this information is important for several reasons. The Miramichi Salmon Conservation Center (MSCC) has a large but limited capacity to produce salmon fry, which is highly dependent on the success of our broodstock collection program which can vary between years depending on the level of success in obtaining sufficient spawning adults. Since it is impossible to stock every small stream in the Miramichi with a limited number of fish it is important to place hatchery reared salmon fry into streams which will benefit most from their introduction. Conversely, stocking salmon fry into a tributary with high salmon fry abundance could actually result in a net negative effect by increasing the level of competition between fry for limited food resources in streams that are often moderately to highly oligotrophic. To avoid overstocking a location, any site containing more than 100 fry per $100m^2$ is not considered for stocking as it appears to reflect a healthy natural population. Sites with less than 50 fry per $100m^2$ are considered candidates for further stocking. Absence of fry at an already stocked site may indicate that the site does not contain the appropriate habitat or food resources, or that the site may have been subjected to a high level of predation.

Prior to 2010, adipose clipped fall fingerlings were stocked from the Miramichi Salmon Conservation Center (MSCC). In 2010 the MSCC shifted its focus from fall stocking Atlantic salmon fingerlings to stocking early-feeding salmon fry in the early summer. These fry are incubated as eggs on unheated brook water to ensure that the rate of 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 of a hatchery environment, and the improved capacity to develop 'wild' behavior tendencies at a younger age. Early-feeding fry are stocked in June or early July at an between 0.3 and 0.5 grams, which makes fin clipping of these fish impossible to achieve.

In addition to Atlantic salmon fry, the MSCC stocked two strains of brook trout into various locations throughout the Southwest Miramichi. First generation Beadle Brook sea run trout were raised at the MSCC until reaching the size of fry, and were then transported to a satellite tank operated by JD Irving Ltd for continued growth before stocking. Additionally, young of the year brook trout from a domestic hatchery strain originating from Moose Lake, NB, were released into several locations within the Southwest watershed.

Methods

Adult salmon were collected by means of seining and fyke netting from 7 separate watercourses within the Miramichi River system from September to mid-October in 2012. Captured salmon were brought to the MSCC where they were kept and checked regularly for readiness to spawn. Salmon were segregated into separate tanks based upon their river of origin to prevent accidental mixing of strains. Once ripe, female salmon were stripped of their eggs, which were fertilized by a male salmon from the same river system. Immediately following successful spawning, adult salmon were released into the wild via Stewart Brook, approximately 200m upstream of the Northwest Miramichi. Eggs were incubated on brook water without handling until the eyed stage, when dead eggs were removed weekly. Eyed eggs were transferred to incubation boxes in preparation for hatching. After hatching fry were fed a formulated salmonid diet (EWOS #1) for approximately 4 weeks until stocking. All salmon fry were stocked in their river of origin ("river specific stocking").

Sites selected for stocking were chosen based on the low juvenile densities found at the exact or nearby locations from 2012 electrofishing results; and in tributaries that typically have low juvenile production (i.e. Cains and Little Southwest). Additional salmon fry were taken to satellite rearing sites for continued growth before stocking.

Results

From May 17th to June 28th 2013, approximately 87,394 young of the year brook trout were stocked into 9 locations (Table 1). A total of 268,652 early-feeding Atlantic salmon fry were released into 43 locations in tributaries and main river locations of the Miramichi River (Table 2). 26 sites on the Northwest Miramichi River were stocked with a total of 129,369 salmon fry, and 17 sites on the Southwest Miramichi River were stocked with a total of 139,283 salmon fry. In 2013 the Miramichi Headwater Salmon Federation (MHSF) were able to accommodate a high number of salmon in their rearing tank facility, stocking a total of 29,000 salmon fry into 7 locations in the head waters area (Table 4.). 55,942 salmon fry (including the MHSF) and 17,852 brook trout fry were taken to satellite holding tank for future release by local conservation groups (Table 3). Total salmon stocked on the Miramichi in 2013 was 307,727, with a total of 105,246 trout stocked.

Table 3.1 Numbers and distribution of brook trout fry from the Miramichi Salmon Conservation Center

Date	Stock	River	Origin	Stocking Location	# Fish	Lat.	Long.
17-May-13	Domestic	SW Miramichi	Moose Lake	Quarryville Bridge	5000	46.828	65.787
17-May-13	Domestic	SW Miramichi	Moose Lake	Blackville Park	5000	46.735	65.827
17-May-13	Domestic	SW Miramichi	Moose Lake	Doaktown Bridge	5000	46.559	66.122
17-May-13	Domestic	SW Miramichi	Moose Lake	Burntland Bridge	8323	46.46	66.412
27-May-13	Domestic	SW Miramichi	Moose Lake	Betts Mill Bk - Rt 8	6250	46.538	66.183
27-May-13	Domestic	SW Miramichi	Moose Lake	Upper Blackville Bridge	20625	46.619	65.878
29-May-13	Domestic	SW Miramichi	Moose Lake	Bloomfield Bridge	17961	46.483	66.483
04-Jun-13	Domestic	SW Miramichi	Moose Lake	Juniper @ Juniper Station	10000	46.55	67.19
04-Jun-13	Domestic	SW Miramichi	Moose Lake	Divide Rd @ Argyler cross	9235	46.52	67.34

Table 3.2 Numbers and distribution of first feeding Atlantic salmon fry from the Miramichi Salmon Conservation Center

Date	Sub-basin	Stock Origin	Site	# Fish	Lat.	Long.
02-Jul-13	SW Miramichi	Rocky Brook	Rocky Brook	26877	46.7795	66.7257
03-Jul-13	SW Miramichi	Cains	Salmon Brook	755	46.6448	65.6132
03-Jul-13	SW Miramichi	Cains	East Branch- 6 Mile	2500	46.6448	65.6132
03-Jul-13	SW Miramichi	Cains	Cains River @ Mahoney Camp	5000	46.5052	65.8733
04-Jul-13	SW Miramichi	Juniper	Juniper Bridge	10412	46.5489	67.2246
04-Jul-13	SW Miramichi	Juniper	Foreston Bridge	10412	46.5285	67.3083
04-Jul-13	SW Miramichi	Juniper	Juniper	10413	46.5205	67.3328
05-Jul-13	SW Miramichi	Clearwater	Clearwater River	36000	46.758	66.8407
11-Jul-13	SW Miramichi	Clearwater	White Rapids Bk @ Old Dam	4000	46.7912	65.8033
11-Jul-13	SW Miramichi	Clearwater	Morse Bk	3000	46.6681	65.8503
11-Jul-13	SW Miramichi	Clearwater	Moorse-Donnolly Bk	2000	46.5579	65.9501
11-Jul-13	SW Miramichi	Clearwater	Donnolly	2000	46.5737	65.8903
11-Jul-13	SW Miramichi	Clearwater	Big Hole Brook	4000	46.5938	66.2986
11-Jul-13	SW Miramichi	Clearwater	Below Doaktown Bridge	4000	46.5706	66.0824
11-Jul-13	SW Miramichi	Clearwater	Mill Brook	1000	46.5719	66.0178
11-Jul-13	SW Miramichi	Clearwater	Infront of Museum	4000	46.5516	66.1446
11-Jul-13	SW Miramichi	Clearwater	Mill Brook	3000	46.4828	66.2065
10-Jul-13	NW Miramichi	LSW	Trib of Libby Brook	4000	46.8747	66.3315

10-Jul-13	NW Miramichi	LSW	Devils Brook Trib	4000	46.8743	66.2277
10-Jul-13	NW Miramichi	LSW	Devils Brook	5500	46.8736	66.2283
10-Jul-13	NW Miramichi	LSW	Upper Libbys	4000	46.8944	66.3917
10-Jul-13	NW Miramichi	LSW	Libbys Brook- Jim Boldons Rd	4000	46.9043	66.4029
10-Jul-13	NW Miramichi	LSW	Little North Pole	4000	46.9844	66.5187
10-Jul-13	NW Miramichi	LSW	Main Stem of LSW	5303	46.9705	66.5309
10-Jul-13	NW Miramichi	LSW	Squaw Barrow	4000	46.9731	66.7004
10-Jul-13	NW Miramichi	LSW	County Line Brook	4000	46.9273	66.742
10-Jul-13	NW Miramichi	LSW	Crooked Brook Tuadook	4000	46.9149	66.776
10-Jul-13	NW Miramichi	LSW	East Branch of West Branch	4000	47.0431	66.7653
08-Jul-13	NW Miramichi	NW	Fjord to Big Hole Camp	12000	47.0472	65.8334
08-Jul-13	NW Miramichi	NW	End of Kingston Lane	8000	47.0821	65.8303
08-Jul-13	NW Miramichi	NW	Trout Brook	4000	47.0943	65.8353
08-Jul-13	NW Miramichi	NW	Mouth of Pats Brook	8000	47.1575	65.8315
08-Jul-13	NW Miramichi	NW	Up on NW	8000	47.2149	65.8092
08-Jul-13	NW Miramichi	NW	Cross Wayerton	8000	47.151	65.8378
08-Jul-13	NW Miramichi	NW	Mountain Brook	8000	47.2032	66.0732
09-Jul-13	NW Miramichi	NW	NW Headwaters- Mtn Bill Gray	5000	47.5758	66.4434
09-Jul-13	NW Miramichi	NW	NW Headwaters	4308	47.2499	66.4021
09-Jul-13	NW Miramichi	NW	NW Headwaters- Near Spruce Lk	5000	47.2494	66.3926
09-Jul-13	NW Miramichi	NW	Tomogonops	4000	47.3262	66.054
09-Jul-13	NW Miramichi	NW	Tomogonops	4000	47.3052	66.0133
09-Jul-13	NW Miramichi	Sevogle	Barracks Bk	5000	47.0717	66.2938
09-Jul-13	NW Miramichi	Sevogle	Big South	5000	47.0932	66.3121
09-Jul-13	NW Miramichi	Sevogle	North Branch- Slack Lk Rd	4172	47.2039	66.3202

Table 3.3 Distributions to other organizations for continued growth and stocking

Delivery Date	Organization	Species	Stock Origin	# Fish
04-Jul-13	Miramichi Headwaters Salmon Federation	Atlantic Salmon	Juniper	32000
28-Jun-13	Miramichi Headwaters Salmon Federation	Brook Trout	Moose Lake	2500
28-Jun-13	Rocky Brook Camp	Atlantic Salmon	Juniper	10075
28-Jun-13	Rocky Brook Camp	Brook Trout	Moose Lake	3075
05-Jun-13	Irving	Brook Trout	Beedle Brook	12277
15-Jul-13	Friends of the Kouchibouguacis	Atlantic Salmon	Kouchibouguacis	6904
10-Jul-13	Elsipogtog 1st Nations	Atlantic Salmon	Richibucto	6963

Table 3.4 Numbers and distribution of first feeding salmon fry by the Miramichi Headwaters Salmon Federation

Stock Origin	Location	# Fish	Lat	Long
Juniper	Juniper Bridge	5000	46.54888	67.22462
Juniper	Picnic area upstream of bridge	4500	46.54696	67.23041
Juniper	Big Teague Bridge	3900	46.5578	67.23321
Juniper	Little Teague Bridge	3900	46.59343	67.25243
Juniper	Beaufort Bridge	3900	46.55498	67.28764
Juniper	Elliot Brook	3900	46.56181	67.28935
Juniper	Lake Brook	3900	46.53031	67.30959

Juvenile Electrofishing Assessment

Introduction

The Miramichi Salmon Association (MSA) continued its electrofishing program in 2013 to assess the suitability of tributaries as stocking locations for 2014. The MSA also worked co-operatively with the Department of Fisheries and Oceans (DFO) Science Branch to survey historic baseline sites that are monitored on a yearly basis to assess Atlantic salmon juvenile abundances on the Miramichi River system. Both electro-fishing 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 and wild parr (1+, 2+) vary in size by site; however, parr 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.

Electro-fishing sites in both surveys are generally 2nd to 4th order streams and are tributaries to major rivers where salmon historically spawn; however, sites may also include some main river locations. The headwater tributary streams are the major focus of the MSA electrofishing program as they are considered feeder streams to the major rivers and maybe under-seeded with juvenile salmon in the event that adult salmon were unable to access these waters to spawn. Generally, swift moving water less than 60cm in depth with gravel, rocky substrate characterize 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, predation avoidance, and seeking 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 of the annual electrofishing program were to:

1. Determine future stocking distribution of early-feeding fry:
   The Miramichi Salmon Conservation Center (MSCC) annually collects and spawns adult salmon from major streams in the Miramichi watershed for the purpose of stocking early feeding fry back to their natal systems. In order to achieve effective stocking results in 2014, electrofishing surveys were carried out during the summer of 2013 to identify high quality juvenile habitat with low fry and parr densities. Determining wild densities allows for avoidance of overstocking areas with healthy juvenile densities and for the targeting of naturally tributaries which are naturally under-seeded or devoid of juvenile salmon. Any site containing more than 50 fry per 100m^2 is not considered for stocking as it appears to

reflect a healthy natural population, where sites below this value are considered for stock compensation.

2. Evaluating stocking success
   To evaluate the effectiveness of the MSCC stocking program, electrofishing surveys were conducted on stretches of streams which were seeded in late June and early July 2013 with early feeding fry. These densities were contrasted against fry densities at unstocked locations to compare densities. Stocked location densities significantly above unstocked locations were considered to reflect successful survival of hatchery fry following stocking.

3. Estimating juvenile abundance using baseline locations
   Juvenile Atlantic salmon abundance surveys were conducted in partnership between DFO and MSA. These surveys monitored baseline sites which in some cases have been electrofished for over 40 years, and allow for the estimation of absolute juvenile abundances.

Methods

On small, low order streams or shallow portions of large rivers, back-pack electrofishing is a highly effective capture method for multiple fish species, including Atlantic salmon, *Salmo salar*. Electricity is generated by a battery located on the back-pack of the electrofisher. An anode wand (positive) and the cathode tail (negative) are placed in the water. The electric current moving between the wand and tail produces 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. As the individual operating the back pack initiates an electrical current, other crew members collect stunned fish with dip-nets and a small seine net. Captured fish are placed in a bucket of water and held until the site is completed, after which they are counted, measured and released.

The catch-per-unit-effort (CPUE) method, which samples a known length of stream for a predetermined time of approximately 500 seconds, was used during MSA/DFO electrofishing surveys to determine fish densities as part on the ongoing baseline survey of the Miramichi watershed. The density of salmon fry and parr from each site was then used to estimate the absolute number of juveniles per site by comparing the values against a trend line generated from multi-pass removal surveys from 2006 to 2012. Removal surveys were not conducted in 2013 due to high water levels, but a description of the method can be found in 2012 MSA Annual Field Report. All fish species were counted and measured, with scale samples removed from salmon parr for age analysis by DFO scientist.

The MSA electrofishing surveys used a shorter duration of typically 200 seconds per site and targeted optimal habitat types to assess the suitability of tributaries for future stocking, and to compare sites stocked in 2013 to unstocked sites to determine if fry densities were noticeably different. All fish were identified to species, with lengths and weights are recorded. Substrate type (rocky, gravel, etc.), stream type (riffle, run, etc.), water and air temperature, and site dimensions were also recorded.

Results

Electrofishing assessment of stocking early-feeding salmon fry in late spring

A total of 36 electrofishing sites were assessed between July 31 and August 19, 2013 in the Miramichi watershed for consideration of future stocking. Seven of the sites had been stocked with first-feeding fry from the Miramichi Salmon Conservation Centre between June 28 and July 11, 2013. Average fry densities were 51 fry per $100m^2$ at the un-stocked sites (n=29) and 132 fry per $100m^2$ (n=7) at sites previously stocked with first-feeding fry. Stocked sites had a significantly higher average density, with a mean considered above the minimum fry density required to sustain a healthy population (50 fry per $100m^2$). Of the 29 sites that were not stocked, fourteen sites had no fry and three site had less than 10 fry per $100m^2$. All stocked location had fry present, ranging from 44 to 261 fry per $100m^2$. The MSA identified 23 of the electrofished sites as having fry densities lower than the target number and of these, all but two had not been stocked during the summer of 2013. The high survival of first-feeding fry at stocked sites following initial stocking was similar to results from previous years.

Juvenile population assessment survey (MSA/DFO)

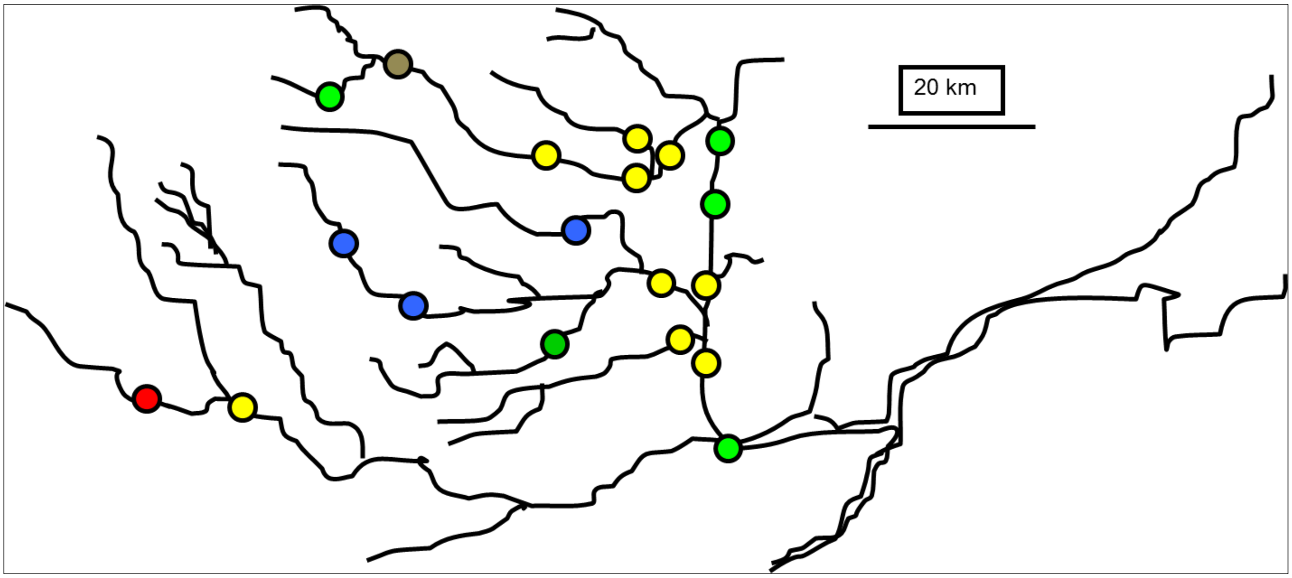
From August 26 to October 3, 2013 a total of 30 baseline sites were electrofished in several tributaries as part of the MSA/DFO cooperative program. Limited opportunities to electrofish due to high water events throughout the watershed resulted in most effort being focused on the Renous and Northwest Rivers. High water levels throughout the summer interfered with sampling attempts, resulting in a lower number of baseline sites surveyed compared to past years, and no closed site, removal surveys being run. On days where electrofishing could be safely carried out, water levels were typically above average for most locations, which may have had confounding effects on the results. The ability to capture fish is reduced in higher water levels as fish can become more dispersed within a site, and become harder to see as water turbidity increases. Parr are also known to be highly mobile and avoid high discharges by moving to areas with reduced water velocity. These factors reduce our ability to make accurate inferences about juvenile production on the Miramichi in 2013.

Final results from the 2013 juvenile population assessments are currently in the final draft stage and will be published on the Department of Fisheries and Oceans website as a document titled "Assessment of Atlantic Salmon (*Salmo salar*) in Salmon Fishing Area 16 in the Southern Gulf of St. Lawrence".

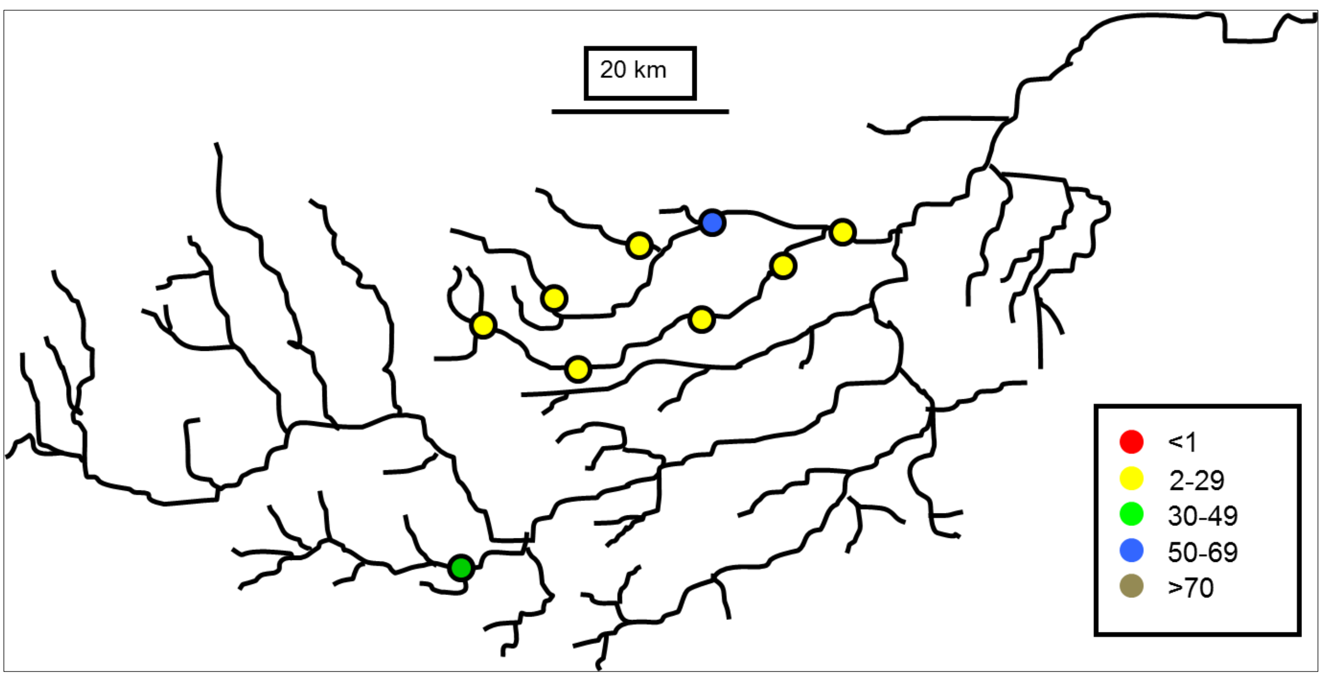
Table 4.1 Juvenile abundance calculated using 200 sec shocking in optimal habitat to identify future stocking locations. Sites with less than 50 fry per $100m^2$ are candidate sites for future stocking efforts while sites that had been stocked in 2012 were also identified.

River	Site	Catch per $100m^2$ Fry	Catch per $100m^2$ Parr	Stocked in 2013
Main Southwest	Porter Brook South Branch	2.9	0.0	N
Main Southwest	Porter Brook North Branch	0.0	0.0	N
Main Southwest	Porter Brook Main Stem	189.1	30.3	N
Main Southwest	Porter Brook, below long brook	78.0	50.3	N
Main Southwest	Elliott Brook	81.4	52.4	N
Main Southwest	Main Elliott Brook	175.9	28.5	N
Main Southwest	Elliott Brook	0.0	8.2	N
Main Southwest	Little Teogue	0.0	20.2	N
Sevogle	Johnstone Brook	0.0	15.8	N
Little Southwest	Aesculapius	36.9	32.7	N
Cains	Sutherland	0.0	0.0	N
Cains	North Cains Bridge	0.0	8.8	N
Cains	Sling Dung Brook	0.0	4.4	N
Cains	Mckinley Brook	3.8	10.6	N
Cains	Bantalor Brook	0.0	0.0	N
Northwest	North Branch Tomogonops (2)	191.7	50.2	Y
Northwest	North Branch Tomogonops	79.5	58.5	Y
Northwest	Little River	0.0	4.1	N
Northwest	Mountain Brook	44.0	53.9	Y
Northwest	West Branch 6 Mile Brook	7.3	15.2	N
Cains	Sabies	16.5	19.0	N
Cains	Otter Brook at Bridge	0.0	0.0	N
Cains	Main Cains	0.0	0.0	N
Cains	Betts Mill Brook	195.4	7.1	Y
Cains	Upper Mozzeral Off Bettsburg	0.0	0.0	N
Main Southwest	West Branch Burtland	0.0	14.6	N
Little Southwest	Devils Brook	261.4	21.9	Y
Little Southwest	Crooked Brook	105.5	48.5	Y
Little Southwest	Squaw Barren	47.5	24.6	Y
Little Southwest	Below Barrier	278.6	60.3	N
Little Southwest	Above Goodwin Lake	321.3	81.7	N
Northwest	South Branch	11.5	7.9	N
Main Southwest	Big Hole	0.0	0.0	N
Main Southwest	Crooked Brook	13.5	0.0	N
Main Southwest	Donnely Brook on Joe Branch	206.3	0.0	N
Bartholomew	South Branch Bartholomew	59.9	0.0	N

A.



B.



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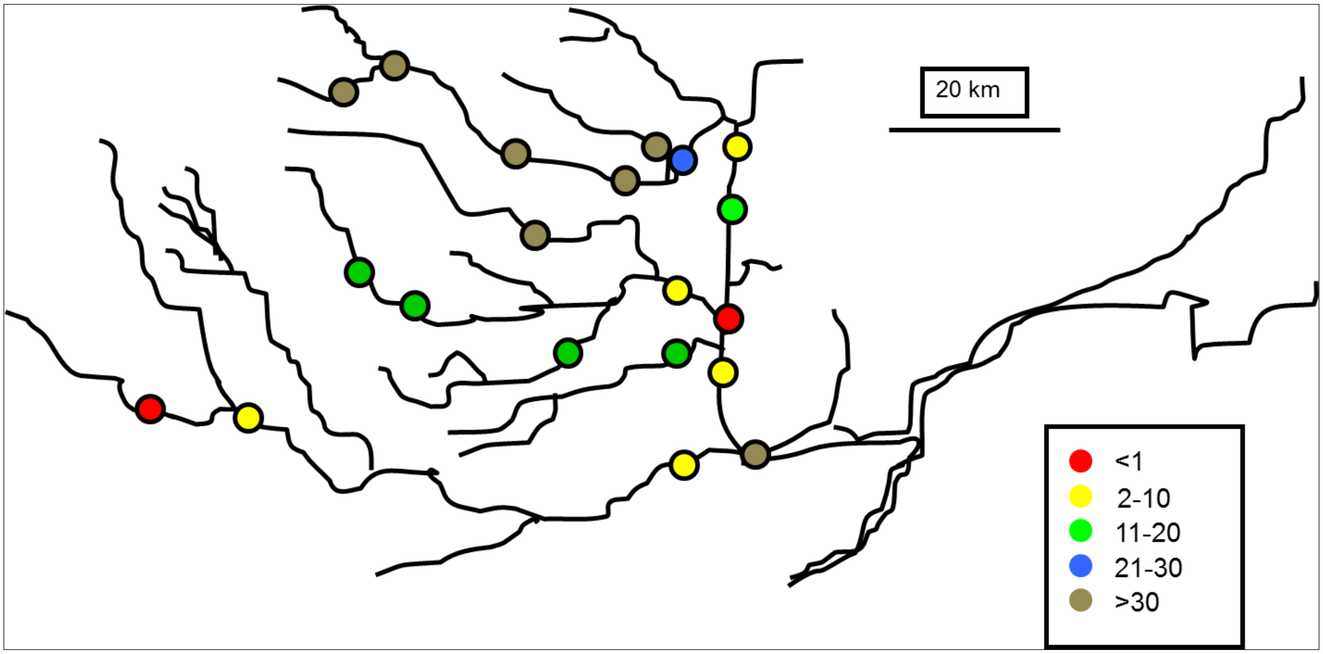

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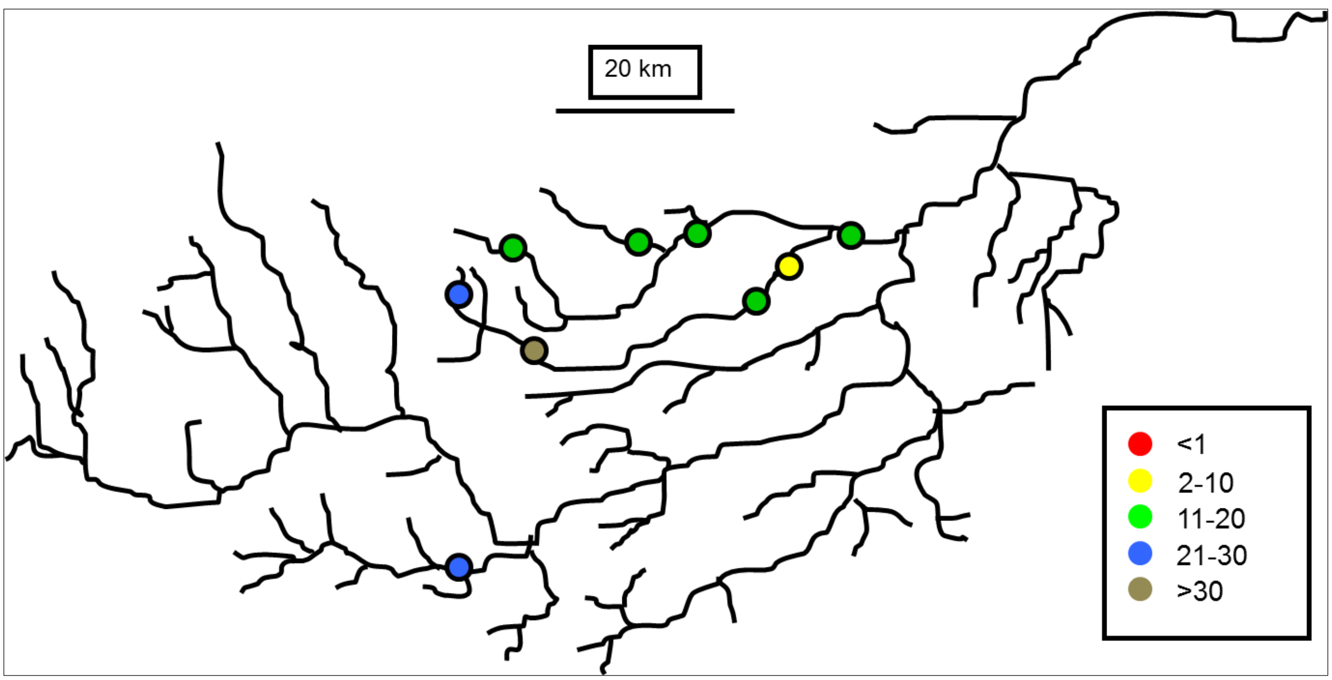

Fig 4.1 Preliminary juvenile density results from the 2013 MSA/DFO annual electrofishing program with: (A) fry densities in Northwest Miramichi River and tributaries, (B) fry densities in Southwest Miramichi River and tributaries, (C) parr densities in Northwest Miramichi River tributaries, and (D) parr densities in Southwest Miramichi River tributaries. Fry density classifications range from <1, 2-29, 30-49, 50-69, and >70 fry per 100m^2. Parr density classifications range from <1, 2-10, 11-20, 21-30, and >30 parr per 100m^2.

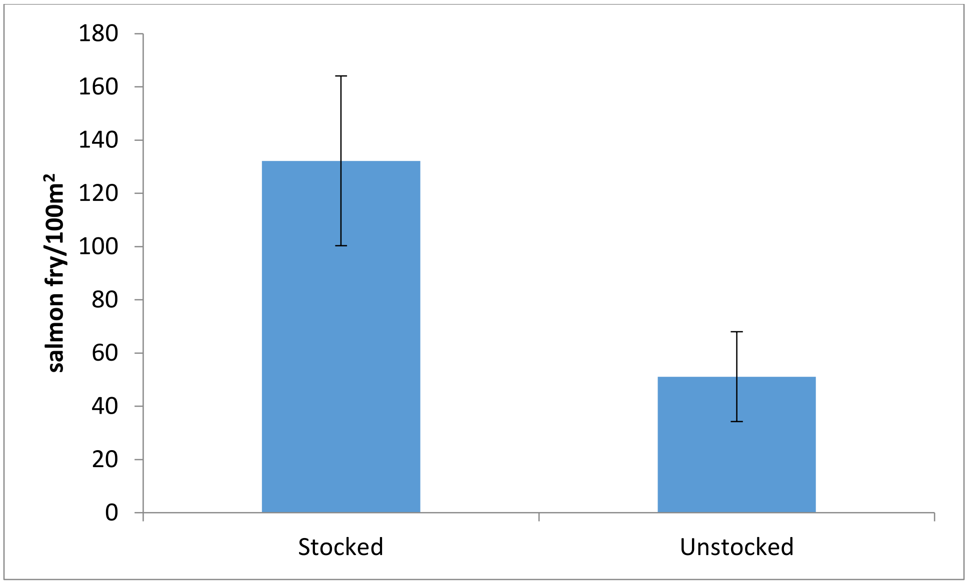

Fig 4.2 Comparison of the calculated densities of fry at sites stocked with first feeding fry in 2013 to unstocked sites. Average fry density at stocked (132.15 fry/100m2, SE+/- 31.88) was unstocked (51.03 fry/100m2, SE+/-16.92) sites was significantly different (p=0.0486)

<u>Northwest Miramichi Smolt Production Estimate</u>

Introduction

The decline in the number of adult Atlantic salmon returning to the Northwest Miramichi has been cause for serious concern. Despite multiple management actions, including the closure of commercial fisheries and implementation of catch and release on portions of the Northwest Miramichi, annual returns of adult salmon remain poor. The level of adult returns directly impacts egg deposition within a river system, and therefore is a major factor in a watersheds ability to produce age-0 juvenile salmon. On the Miramichi River an egg deposition of 2.4 eggs/m^2 is considered the density required to maintain a healthy adult population, and is referred to as a conservation requirement. Over recent years the Northwest River has been out performed by the Southwest with regards to conservation requirements. From 1998 to 2012 the Northwest system reached or exceeded conservation requirements two separate years, compared to seven years over the same period on the Southwest system. Even during exceptionally high adult returns in 2011, the Northwest Miramichi only reached a conservation requirement of 132%, compared to 220% for the Southwest Miramichi. Furthermore, whereas the Southwest Miramichi averaged a conservation requirement of 103% (range 77% to 119%) in the years 1998 – 2009, the Northwest Miramichi averaged less than 50% (range 26% to 111%) of spawning escapement over the same period.

Despite recording poor conservation requirement levels, electrofishing results from the Northwest Miramichi have typically shown healthy densities of Atlantic salmon fry and parr. It seems reasonable to assume that smolt production should be positively correlated with juvenile densities, and should therefore follow that a river system with high juvenile densities should have high smolt productivity. However, this progression implies that high smolt production should result in sustaining spawning returns to the Northwest Miramichi, and this has not been observed. Therefore, an accurate estimation of the total smolt population emigrating from the Northwest Miramichi River to the marine environment is an essential component to understanding and managing Atlantic salmon in this watershed and a way to determine the ocean survival rate of smolts returning as grilse and salmon.

One of the most well used methods of establishing an accurate estimate of riverine smolt production is through a mark-recapture study. Two-sample mark-recapture studies for estimatin smolt abundance include tagging a marking location or trap, and the recapturing of marked fish at a second recapture trap. The percentage of marked fish recaptured at the second trap is used to establish recapture trap efficiency over different time strati, which is then applied to the total number of smolt captured at the trap to give an estimate of the population.

In response to low adult returns to the Northwest Miramichi angling regulations were modified in 2011 to a catch and release fishery in parts of the watershed to reduce human caused harvesting mortality. Although this management policy has likely reduced the rate of angling based mortality, Northwest salmon are still subjected to significantly higher sources of non-angling mortality from

First Nations Fisheries Allocations. Furthermore, the Northwest system is the site of large congregations of pre-spawning and spawning striped bass during the same time as Atlantic salmon smolts are migrating into the estuary. Although the scientific correlation between striped bass predation and smolt survival is not well understood at this time, it is possible that adult bass are having an additive mortality impact on seaward moving juvenile salmon. The study of smolt production in the Northwest system, in combination with movement tracking of tagged smolt and the timing, number, and feeding habits of striped bass spawners has the potential to shed further light onto the relationship between these two species, to allow for the development of an adaptive ecosystem based management approach to the Miramichi Watershed.

The 2013 smolt population estimates from this study represents the third year of the multi-year Northwest Miramichi River smolt production project. The purpose of this project is to assess smolt production on the Northwest Miramichi system, to determine if adequate juvenile production is occurring in the Northwest Miramichi River System. This project is run in joint partnership between the Miramichi Salmon Assocation (MSA) and the Northumberland Salmon Protection Assocation (NSPA). Data resulting from this project will be used to allow science based management decisions to be made for the Northwest Miramichi system and to facilitate further research into the ecological influences of striped bass on salmon smolts.

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 (1,342 km^2) and the Northwest Miramichi (2,078 km^2) River which flow merge in a delta at the head of tide. The Northwest Miramichi River includes a large tributary, the Big Sevogle River, with a drainage area of 799 sq. km^2.

Design

The smolt production estimate for the Northwest Miramichi system used a two-sample mark-recapture study design, using three rotary screw traps (RST's) installed on the system's largest tributaries as marking locations. RST's, commonly referred to as smolt wheels, were installed in early May on the Little Southwest, Northwest, and Sevogle rivers. Smolt wheels were held in place by large overhead cables spanning the width of the river acting as a support line for the entire structure. From this support line a second cable hung down and attached to the RST, centering the trap over a desired location with a depth that would facilitate full rotation of the wheel without contacting bottom. The buoyancy of smolt wheel pontoons floated the trap, while the flow of water spun the submerged wheel and prevented the trap from swaying within the river. Smolts migrating downstream had the potential to enter into the RST, where the rotating action of the wheel funneled fish into to the trap box located at the rear of the smolt wheel and prevented fish from escaping.

During each day of operation field crews used boats to access the RST's and collect captured fish. Once retrieved, 25 smolts were measured to fork length, 20 of which received clear, individually numbered streamer tags while the remaining 5 were used for scale samples. Remaining unmeasured smolts were tagged with clear, individually numbered streamer tags and released along shore adjacent to the wheel, with the exception of days with high catches in which it became unfeasible to tag all individuals. Other fish species and smaller juvenile salmon were counted and released. For the purpose of the study all Atlantic juvenile salmon > 100mm FL were considered smolts to be used in the mark recapture experiment.

A single large trapnet was installed in the estuary of the Northwest Miramichi at Cassilis to function as the recapture trap. Tagged smolt recaptured at the Cassilis trap net allowed for the calculation of trap efficiency by comparing numbers of recaptured fish to the total number of fish tagged. The total smolt run from the Northwest Miramichi was determined using smolts tagged upstream at the Sevogle, Northwest and Little Southwest smolt wheels, the number of tagged smolt that are recaptured at the Cassilis trap, and the number of untagged smolt captured at the Cassilis trap. The Cassilis trapnet was fished daily at low tide, with smolt sorted from the rest of the species captured. Each day, sub-samples of up to 100 smolts were measured, 20 of which were lethal sampled for detailed information on length, weight, sex and age. All smolt captured were counted and checked for streamer tags.

Stream course distance from rotary screw traps to the Cassilis trapnet were 7.9 km on the Little Southwest, 15.7 km on the Sevogle, and 22.4 km on the Northwest River.

Results

The Sevogle and Northwest smolt wheels operated from May 4 to May 31 excluding the May 25 to 29 due to high water levels. The Little Southwest smolt wheel operated from May 9 to May 24 excluding May 13 to May 16 due to damage from woody debris. The estuary trap net at Cassilis operated from May 10 to May 31 but the trapnet leader was raised from May 25 to 29 to avoiding washing out from the debris moving from high water levels.

The peak of the smolt run for the Sevogle River occurred May 12 with 638 smolt and May 11 on the Northwest River with 460 smolt. The peak of the smolt run on the Little Southwest River was on May 11, 2012 with 126 smolt. In 2013 a total of 3464 smolts received tags, 1482 on the Sevogle, 1560 on the Northwest Miramichi, and 422 on the Little Southwest Miramichi. Total smolt captures at RST's was 1733 on the Sevogle, 1727 smolt on the Northwest River, and 652 on the Little Southwest.

At the Cassilis estuary trapnet 12776 smolts were captured, 39 of which had been tagged at the upstream smolt wheels. After accounting for a combined 10% mortality and tag loss of marked fish, the recapture efficiency at Cassilis was 1.25%. Smolt production on the entire Northwest Miramichi River system, after assuming mortality and tag loss was estimated at 982,669 smolt (95% CI 684,294 to 1,281,044) using the Pooled Peterson estimate from SPAS software, and

1,050,000 using the median value from a Bayesian population estimate (95% CI 775,000 to 1,475,000). These two estimates produced smolt production values of 5.85 and 6.25 smolt/m^2, respectively.

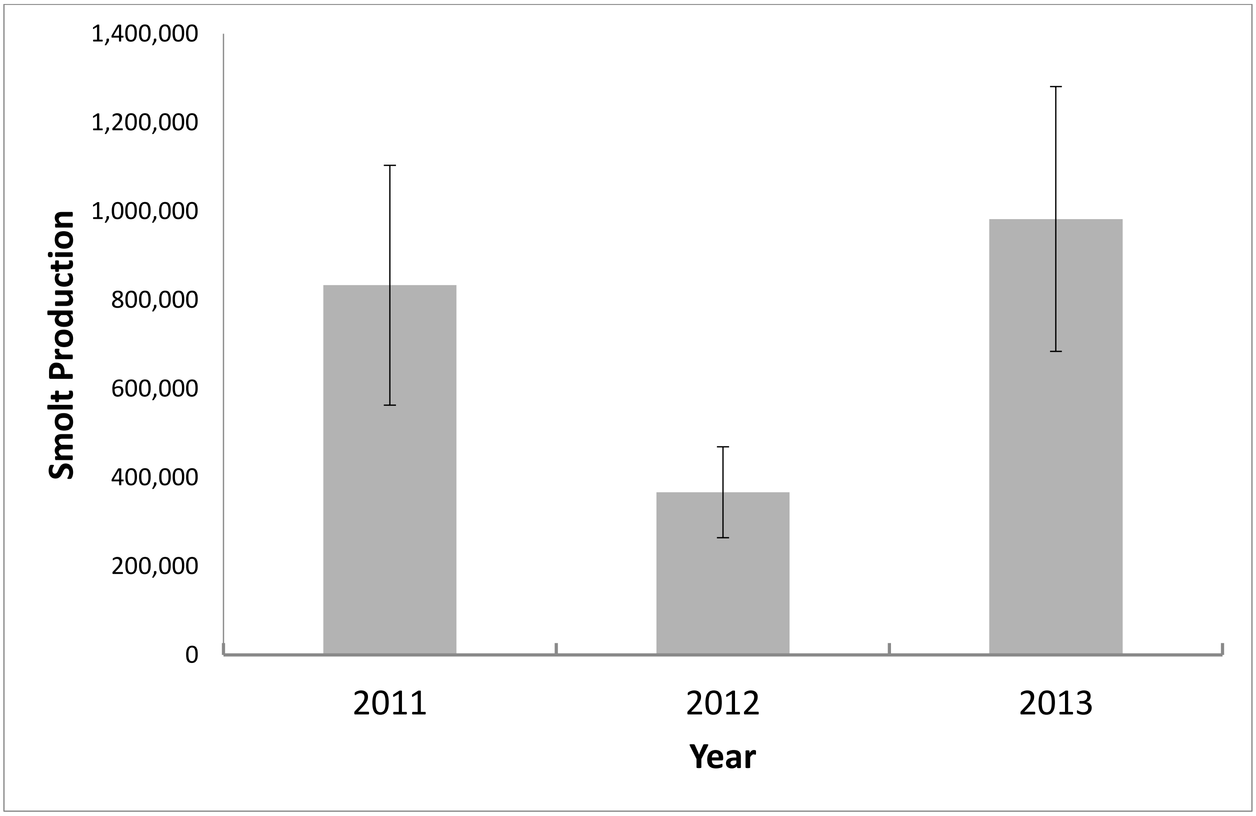

Figure 5.1 Smolt production estimates for entire Northwest Miramichi. Estimates from recapture of tagged fish at Cassilis trap net. 2011 – 765,000 smolt (4.6 per 100m^2), 2012 – 328,000 (2.0 per 100m^2), 2013 – 982,669 smolt (5.85 per 100m^2)

Movement of fish following tagging varied across tributaries. The minimum and maximum time of recapture after of tagging was 2 and 7 days on the Northwest, 1 and 5 days on the Sevogle, and 1 and 3 days on the Little Southwest. Excluding movements of smolt tagged before being available for recapture within 1 day (May 4 to 8), the mean and mode of time of recapture was 4 and 2 days for Northwest (n=7), and 3 and 2 days for Sevogle (n=19). From May 4 to 8 for the Northwest River, the mode for time of recapture after tagging was 5 days (n=5), with a mean of 4 days. Two of these fish were tagged May 8 with movements of 2 days and 3 days before recapture. No smolt tagged on the Sevogle from May 4 to 8 was recaptured.

Discussion

During the three year study of smolt on the Northwest Miramichi, estimates of juvenile production have varied considerably, with unexpected and sometimes confounding results. In 2011 and 2013 smolt production significantly exceeded 3.0 smolt/100m^2, considered the production target to meet conservation requirements, by 50 and 100%, respectively. These values are surprising, as the years in which these fish were first produced had fewer adults than required to meet spawning requirement, which one might expect to to correlate to production below 3.0 smolt/100m^2. Furthermore, smolt production estimates from one-way mark recapture studies conducted in 2011 and 2012 on the tributaries used for tagging in the current study did not match well. The combined estimates of the Little Southwest, Sevogle and Northwest Rivers in 2011 was 164,800 smolt, compared to an estimate of 765,000 smolt for the entire system at the Cassilis trapnet from the two-way mark recapture study, a nearly 5 fold difference in estimates.

Smolt production on the Northwest Miramichi has used a two-sample mark recapture design to determine a total estimate of migrating smolts. This study design requires one or more marking stations in upstream locations, and one downstream recapture station. In 2013 due to logistical issues, the Cassilis trapnet used for recapture was not installed until May 10th, six days after the start of tagging on the Sevogle and Northwest. Fish tagged during this time may have moved through the river system before the trapnet was operational, leaving them unavailable for capture. Based on mean and mode values of smolt movement time, it is probable that a reasonable percentage of fish tagged during this time were not available for recapture. Similar issues with delayed trapnet installation occurred in 2011 where, after the exclusion of days in which RST's did not operate due to high water events, a total of 10 tagging days occurred in which the downstream trapnet was not operational. Tagged fish unavailable for recapture cause the recapture efficiency to become negatively skewed, artificially inflating the population estimate. To correct for this error, movement trends of smolt could be analyzed to determine the distribution of recapture time after tagging for each smolt wheel. This could then be applied to days in which fish were tagged while the recapture trap was not operational, to conservatively remove tags from the population estimate which had a high probability of being unavailable for recapture. For this past year's study it is difficult to make corrections for tag availability due to small sample sizes from each tributary in 2013. Analysis is currently underway to compare movement of smolt from each tributary from all years of the study, to determine movement patterns and their correlation to water temperature and stream discharge.

The recapture site during this study, located shortly downstream of the convergence of the Little Southwest and Northwest rivers, has been highly susceptible to spring freshets. During each of the past three years the trap has been washed out or forced to be lifted during high water events following precipitation. Multiple studies have shown that smolt migration rates increase during moderate high water events, which may mean that our smolt estimates have been skewed as the study has been unable to account for smolt numbers during peak runs. Further analysis of movement patterns may allow for increased refinement of smolt estimates by attempting to conservatively quantify the number of tags which moved past Cassilis while the trap net was inactive.

The disparity between tributary specific and system wide estimates in past years may be the result of pre-smolt movements the previous fall. In other tributary systems on Miramichi River high numbers of large juvenile salmon have been observed to move downstream during the fall, possibly to stage in lower positions of the river system before migrating to sea the following spring. Smolt which moved downstream of the rotary screw trap locations would not be available for capture as untagged fish. Although the recapture efficiency of tagged smolts would not be affected by the absence of these fish, the number of untagged fish available for capture would be reduced. This reduction would cause the smolt estimate for these systems to be artificially low. The three year smolt production study on the Northwest Miramichi was not designed to address the impact of pre-smolt behavior on the system, but these movements may warrant future research.

In order to address these confounding issues the MSA has chosen to re-focus the intent of the study from a smolt estimate on the Northwest system to an estimate of the entire Miramichi watershed. During the 2014 field season three marking sites will be operated throughout the entire watershed; the Sevogle and Northwest Rivers on the Northwest system, and the Dungarvon River on the Southwest system. Furthermore, smolts tagged by Rocky Brook Camp during their annual fall pre-smolt population estimate on Rocky Brook will be available for recapture. In order to determine a river wide estimate of smolt migration the recapture trap net will be relocated downstream of the convergence of the Northwest and Southwest Miramichi, in a location between Bushville and Chatham. Moving the trap net to a more downstream location will reduce the intensity of freshets, increasing our ability to continue sampling during high water events. Adjusting our study specifically to a watershed level estimate of smolts will no longer require the recycling of smolts on individual tributaries, and as such we will not be developing tributary specific estimates which have possibly been biased by the effect of pre-smolt movement in the fall. Smolt wheel locations for this study have been chosen for tributaries, which in past studies, have been shown to have high catch rate in order to optimize our ability to add tagged individuals to the study. The Little Southwest Miramichi will not be used as a tagging location as it has generally been out performed by the Sevogle and Northwest wheels.

Repositioning the trap net below the confluence of the branches of the Miramichi will also allow for further research opportunities. In 2014 the MSA will participate with DFO in a tagging study of bright salmon returning to the Miramichi. Salmon captured at the downstream site will be tagged and released for re-capture at DFO trap nets on the SW and NW branches as part of a mark-recapture survey to improve the accuracy of adult return estimates. This improved adult estimate will provide valuable information for future salmon management policies.

<u>Northwest Smolt Survival Study</u>

Introduction

Juvenile Atlantic salmon (*Salmo salar*) which have undergone physiological changes to transition from fresh to saline water are typically referred to as smolt. Juvenile salmon which have initiated smoltification begin exhibiting negative rheotaxis (consistent downstream movement), silvering of the body, and reductions in body condition from increased growth in length. Smolts migrate from natal tributary and river systems or from pre-smolt overwintering staging areas to estuaries as freshwater temperatures rise. On the Miramichi River, smolt movements typically start between late April to early May, and conclude in late May or early July. During this time, the majority of the total smolts from a river or tributary will emigrate within a short window of 5 to 6 days. This peak movement is often observed during times of high discharge following a precipitation event, and in water temperatures close to 10°C. Upon entering brackish water, these fish may be required to reduce or stall downstream movements to allow for physiological acclimation to salt water.

Striped bass (*Morone saxatalis*), a large generalist fish species native to the Northumberland Strait and Gulf of St Lawrence, has markedly increased in numbers in the Miramichi Estuary over the past five years. The only known location of successful spawning for the entire Gulf of St Lawrence population occurs between May and June in the upper portion of the tidally influenced water of Northwest Miramichi. During this time a significant 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 striped bass migration closely coincides with salmon smolt migration. Due to this temporal and spatial overlap there are concerns for the survival of Northwest Miramichi salmon smolts. Striped bass are considered opportunistic feeders, and cases of smolt predation on both Atlantic salmon 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 returns to the Northwest Miramichi, there is a potential that increased levels of predation may significantly impact in river survival rates of emigrating juvenile salmon, reducing the number of smolts leaving Miramichi Bay to a level that the return of adults could be lowered.

The use of acoustic technology is an effective way to estimate the survival of a fish population within a river and estuary system. Individuals 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 detection of tagged fish as they travel downstream in their migration to marine waters. Changes in the percentage of tagged fish detected moving downstream through a river can indicate the level of survival through the system. Furthermore, the placement of receivers between barrier islands in an estuary allow for estimates on the percentage of tagged fish which survived to the marine environment.

In order to estimate the survival of smolts from the Northwest Miramichi, an acoustic tagging study was carried out during the 2013 smolt migration to determine survival rates throughout the river and estuary system.

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 (1,342 km^2) and the Northwest Miramichi (2,078 km^2) River which flow merge in a delta at the head of tide. The Northwest Miramichi River includes a large tributary, the Big Sevogle River, with a drainage area of 799 sq. km^2.

Tagging

Atlantic salmon smolt were captured by a rotary screw trap (RST) on the Northwest Miramichi immediately upstream of the mouth of Trout Brook, and transported the following day to a tagging location in the community of Sevogle, approximately 1.7 km downstream of the capture site and 17.9 km upstream of Red Bank Bridge. Smolts were kept overnight to allow for digestion of stomach contents, which allows for increased ease of tag insertion.

Following capture smolt were temporarily held in a submerged live box, before being moved to an oxygenated tank for transportation of the tagging site where fish were once again held in a submerged live box. Prior to surgery fish were placed into a clove oil bath for several minutes until equilibrium was loss and movement was minimal. Vemco V 9 transmitters were inserted by making a small, off center incision into the body cavity between the pectoral and pelvic fins. Once the transmitter had been inserted the incision was closed with 2 or 3 sutures and the smolt placed into a recovery live box for observation. Time out of the water for this procedure was 2 to 3 minutes per fish, with water passed through the gills periodically during surgery. Smolts typically regained equilibrium with 1 hour following surgery, and were released in small batches shortly following recovery.

Receiver Placement

A total of 12 Vemco VR2W acoustic receivers were placed throughout the tidally influenced portions of the Northwest Miramichi, Southwest Miramichi, and the main stem of the Miramichi River to detect in river movements and survival rates (Fig 1.). Additional receivers were placed to form detection gates between openings at barrier islands near the mouth of the Miramichi Bay, at Neguac Beach, Portage Island, and Huckleberry Gully (Fig 1.).

Results

On May 10, 2013 smolts captured at the Northwest rotary screw trap from the previous day were transported downstream to the tagging site. A total of 40 smolts implanted with V9 acoustic transmitters were released over the course of several hours following observation to ensure recovery from anesthetic and surgery. Of the initially tagged fish, 35 were detected by the first receiver at the head of tide in Red Bank, and were considered post-release survival. Based on post-release numbers, the largest drop in detection success between successive receivers occurred within a 3.08 km long area between Millstream (85.7%) and Hackett's Beach (62.9%), where a total of 22.8% (8 smolt) of post-released fish were not detected again. Between multiple receivers, a detection loss of 27.7% (11 smolt) occurred within the 7.40 km stretch between Nelson (47.7%) and Chatham (20%). Comparatively, losses in detection were few from Red Bank to Millstream (14.3% of total post-release loss over 9.69 km), Hackett's Beach to Nelson (11.4% loss over 9.82 km) and Chatham to the barrier Islands of the Miramichi Bay (8.6% loss over 38.52 km).

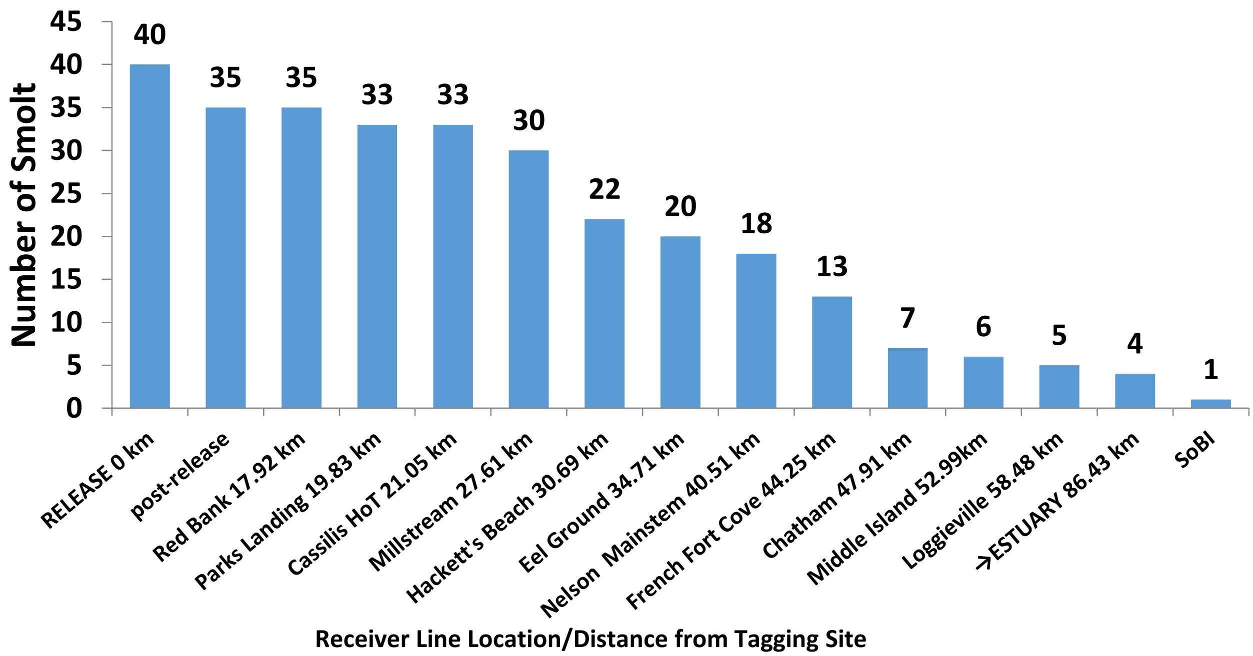

Figure 6.1: Bar graph of acoustic tagged smolt from the Northwest Miramichi detected at receivers placed throughout the river, bay and the Strait of Belle Isle (SOBI). Location names indicate the site of the receiver, and listed denote the river distance from receiver location to tagging site. Red Bank and post-release bar are equal values taken from the same receiver. Graph courtesy of ASF biologist Steve Tinker.

Discussion

At face value, the numbers from 2013 tagging study do not paint a particularly optimistic picture of smolt survival through the Northwest Miramichi. Based on post-released smolts, which are fish that successfully survived tagging to make to it downstream to the first receiver, 11.4% of tagged smolts were detected exiting through Miramichi Bay. These fish are assumed to have successfully survived to the Gulf of St Lawrence. Overall 23 of 35 (65.7%) post-release smolt were lost between Millstream and Chatham, a 20.3 kilometer long portion of river, for an average loss of 1.13 smolt/km. The area of highest loss occurred between Millstream and Hackett's Beach, with a loss of 2.56 smolt/km.

Figure 6.2 Map of area between Cassilis and Chatham receivers. Areas in blue indicate high loss of smolts. 23 or 35 (65.7%) of post-release smolts were lost between Millstream and Chatham.

It is important to note that there are multiple sources of smolt predation within the tidally influenced waters of the Northwest Miramichi, and that at this time it is not possible to quantify the level of tagged smolt mortality which can be assigned 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 data from individual tags is required. For 2013 data, further analysis will be carried out by the Atlantic Salmon Federation to look at the behaviour of fish which did not reach Miramichi Bay, specifically whether fish exhibited atypical movements likely attributed to another animal. To better understand the level of mortality which can be attributed to striped bass, the design of 2014 study will be modified to allow for better comparisons to striped bass behaviour.

Limits in the design of this study reduce our ability to make projections on smolt survival over the entirety of the smolt run. Since all tagged fish were released within the same day, we are unable to determine if changes in survival occur over the duration of juvenile migration for the Northwest Miramichi. Striped bass are known to stage in distinct areas before, during, and after spawning. The changing position of bass over the course of the smolt run may influence their spatial overlap with juvenile salmon, changing the likelihood of predation. Furthermore, the feeding behaviour of striped bass while they occupy these areas is not fully understood. To address these issue, tagging during the 2014 study will be staggered over multiple days to allow for detection of movement and survival changes over time. This information will then be available for comparison to striped bass tracking research being conducted by DFO to determine times of greatest overlap. Research of bass stomach contents, which will be carried out over several weeks by DFO, could be used to determine if changes in the occurrence of smolts in the stomach contents matches with peaks and ebbs of smolt migration. This combined research should allow for a more precise understanding of the interaction between these two species.

The impact of animal recovery after tagging is of interest in determining likelihood of artificially influenced predation. In 2013 smolt were tagged 17.92 km above head of tide. It would be possible for tagged smolts to move through this area within 1 to 2 days, at which time the animals could still exhibit impaired movement due to the insertion of the transmitter. A smolt moving in an atypical or injured manner may be more likely to be predated upon due to reduced capacity to escape, and through triggering predation attempts which would otherwise not occur. It is also probable that striped bass may have been above the receiver location, so that some smolt were already exposed to predation before first detection. In 2014, smolt will be tagged and released at Miners Bridge, which will provide an additional 29.3 km of river to allow for recovery. Additional receivers will be placed throughout the freshwater portion of the Northwest to detect for changes in survival before reaching tidally influenced waters.

Moores-Donnelly Brook Coldwater Pool Survey

Introduction

Pools which lay directly downstream of cold water brooks can be critically important habitat to adult and juvenile salmon during warm water events in the main stem of a river. The presence of these pools creates areas of thermal refugia during times of high water temperatures, where large numbers of salmon and trout of various life stages can hold position until surrounding water temperatures decrease. Without isolated pockets of cold water, these fish would be forced to remain exposed to warm water conditions, leading 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 lower reaches of the river which are less influenced by groundwater sources. As such, 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. However, in the case of salmon pools where cold water is present, fish will still attempt to hold in these areas during warm water events despite reduced habitat quality (reduced depth, changes in water flow, changes in substrate composition) in order to avoid thermal stress. Salmon which use this habitat may become more exposed to predation, poaching, or reduced benefit of cold water due to changes in stream flow.

The area located downstream of the mouth of Moores-Donnelly Brook was previously identified as a cold water pool which had shown signs of degradation with regards to pool depth and dilution of incoming cold water. In 2013 the Miramichi Salmon Association contracted Parish Geomorphic to conduct an engineering survey of the area to develop a restoration plan for conservation purposes. The following page is directly from an overview summary of the scope of work produced by Parish Geomorphic. For those who are interested in the full engineering report, please feel free to contact me through alex@miramichisalmon.ca for more details.

1.0 Scope of Work

During high temperature events in the Main Southwest Miramichi River (MSW), juvenile and adult Atlantic salmon seek cold water refuge at locations where tributaries and springs enter the river. Donnelly Brook is one such tributary that provides cold water. At the confluence with the MSW, the mouth of Donnelly Brook has accumulated gravel, thus reducing the energy of the brook as it enters the river. Consequently, there is reduced flow of cold water into the downriver thermal refuge holding pool for Atlantic salmon.

Restoration work will focus on maintaining the energy of flow from the brook and transferring it downriver to the holding pool. This will be accomplished by narrowing the bankfull width at the mouth of the brook to approximately 10 m (an appropriate width for that size of brook) and redirecting the flow into the thalweg of the MSW side channel. Large rock (1.0 m diameter) will be used to narrow the channel. Another objective is to ensure that material transported by the brook in the future is not deposited at its mouth. Re-establishing the MSW side channel thalweg on the outside bend, where it meets Donnelly Brook, will provide the energy required to transport material away from the confluence. Re-alignment of the thalweg will be achieved by removing the gravel bar currently at the mouth of the brook and installing 3 rock spurs along the outer bend on the right bank. These structures will create scour to the depth of the current thalweg and also turn the water away from the right bank, maintaining energy in the thalweg.

Work will involve 2-3 days of trucking large rock to the site, and 1 day of in-stream construction. Parish Geomorphic will lay out the site to ensure efficiency and accuracy during construction. Parish Geomorphic will also provide construction oversight and conduct a post construction survey (WAWA Permit requirement).

*From"Cold Water Habitat Restoration: Confluence of Donnelly Brook and Main Southwest Miramichi River- Scope of Work & Cost Estimate" December 2, 2013. Parish Geomorphic

Appendix 1. Mapping of Kelt Movements

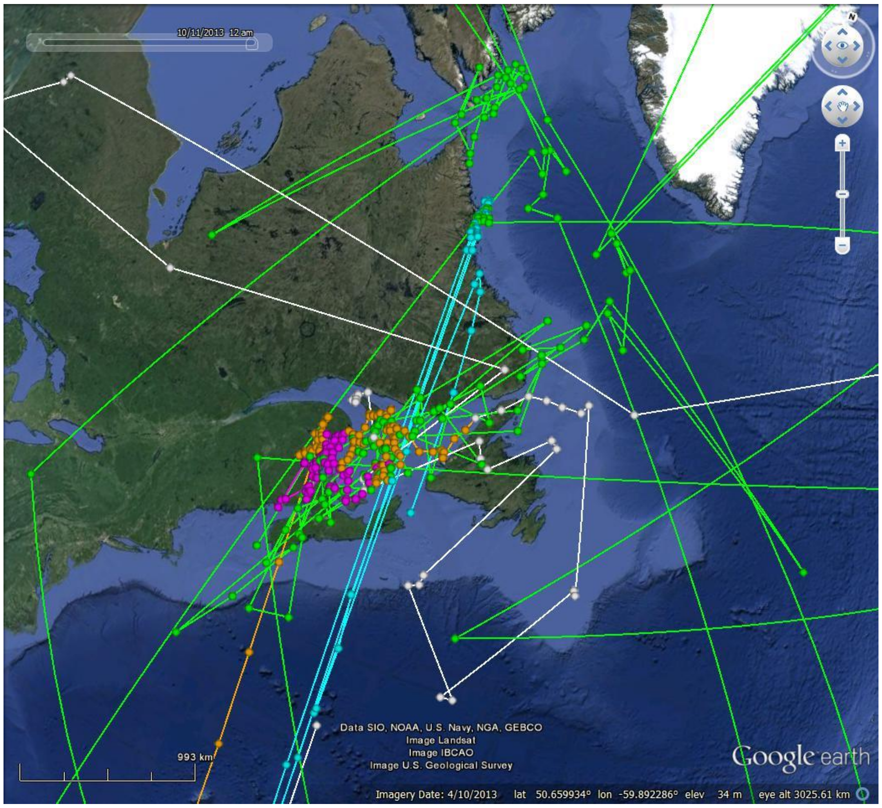

Figure A.1 Unrefined tracks of five satellite tagged kelt from the Northwest Miramichi. Colors indicated individual fish movements.

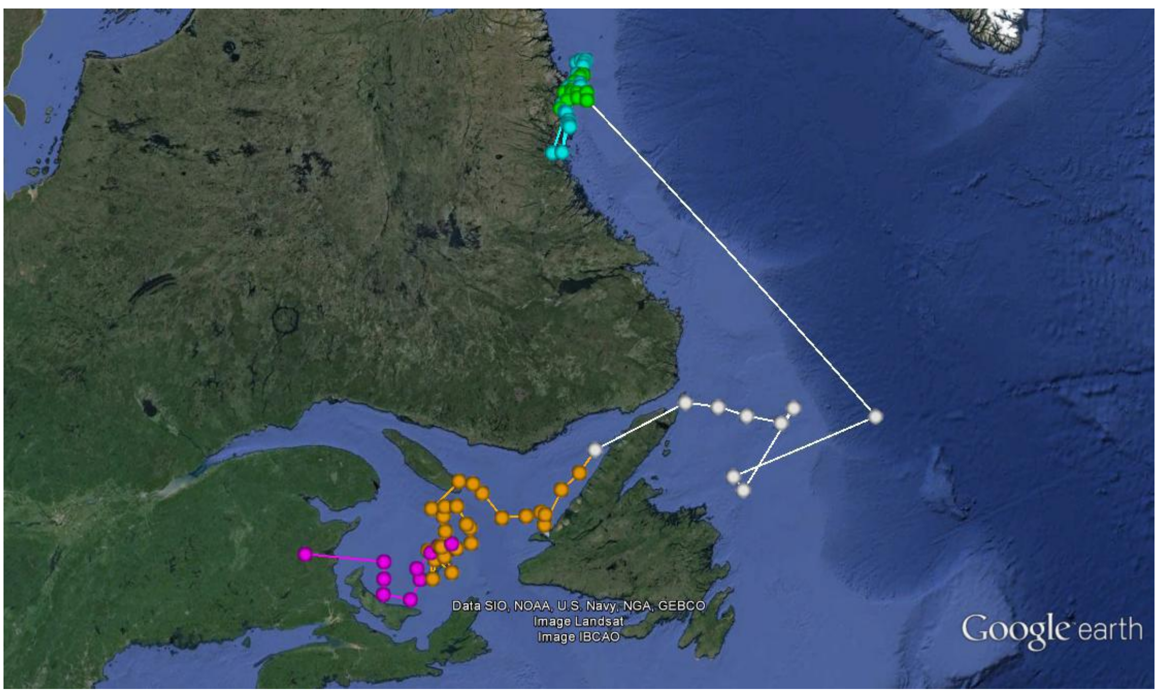

Figure A.2 Smoothed track of kelt 128022 which deployed off the coast of Labrador September 30, 2013. Colors indicate month (Pink: May, Orange: June, White: July, Green: August, Blue: September)

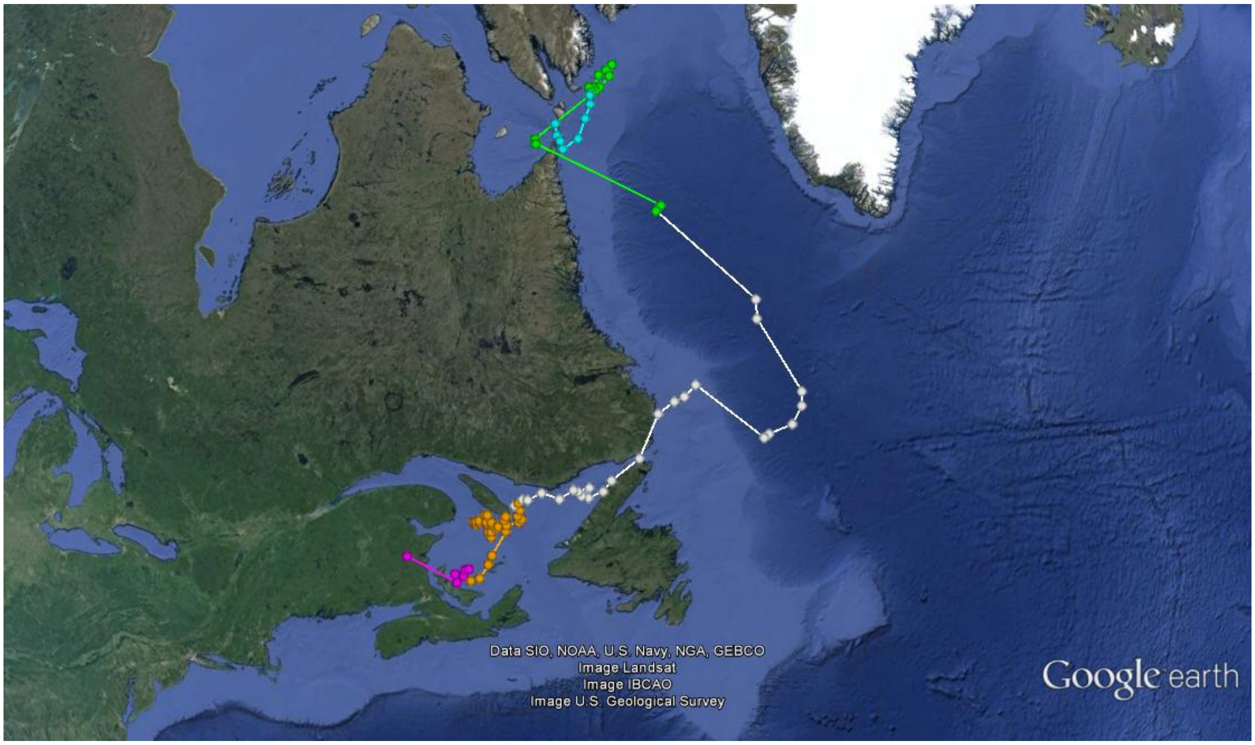

Figure A.3 Smoothed track of kelt 128017 which deployed off the southern tip of Baffin Island August 31, 2013. Colors indicate month (Pink: May, Orange: June, White: July, Green: August, Blue: September). All blue Septembers tracks are an artifact of the tag transmission while floating at sea

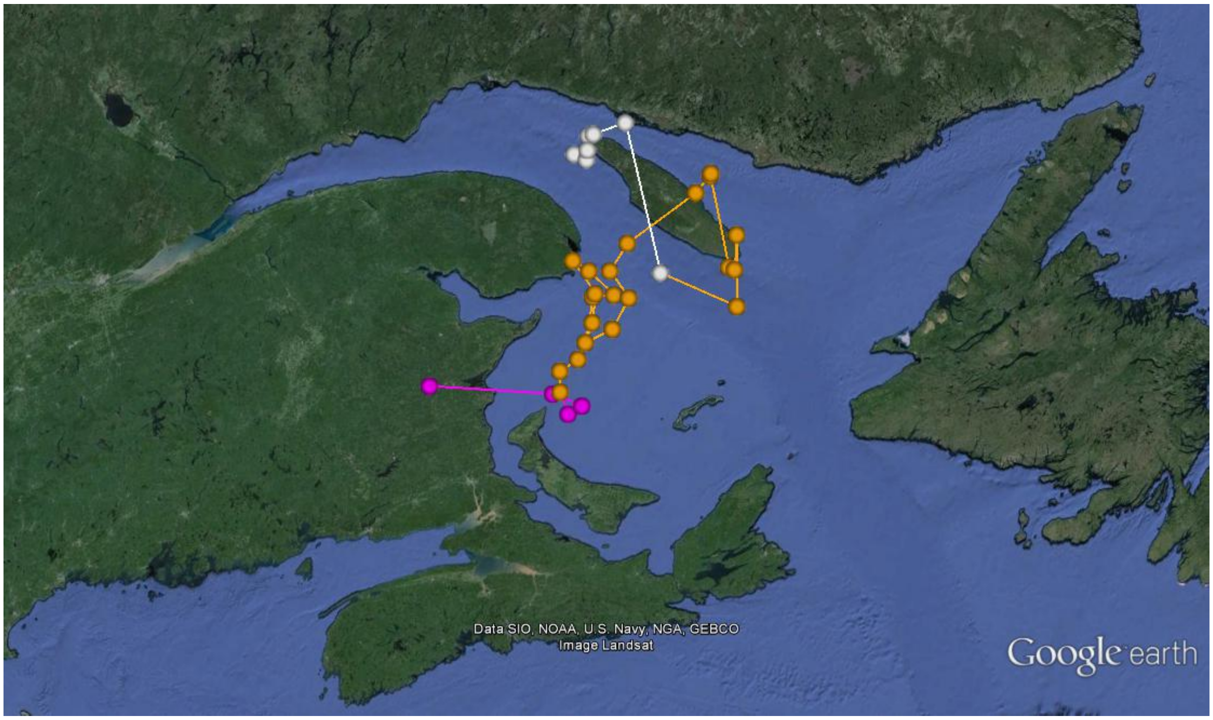

Figure A.4 Smoothed track of kelt 128023 which deployed off the coast of Gaspe September 30, 2013. Colors indicate month (Pink: May, Orange: June, White: July)