Smolt Tracking on the Miramichi River 2016

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Introduction

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

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

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

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

Typically with any internal tagging surgery, there is a mortality percentage associated with the surgical procedure (most studies put this percentage around 10%). To try and determine the effect of tagging for the smolt tracking study in 2016, pre-smolts were collected in the fall of 2015 from the Northwest and Southwest Rivers and held over winter at the Miramichi Salmon Conservation Centre (MSCC). These fish were tagged in early March of 2016 and their survival, behaviour, and tag retention was documented to ratify the 10% mortality assumption.

The timing of the smolt release after surgery may also play a part in their survival, so in 2016 a day vs. night release of tagged fish component was added to the project to determine any temporal differences in survival.

As a compliment to the Atlantic Salmon Federation's smolt tracking program to estimate the survival of smolts from the Southwest branch of the Miramichi River (which began in 2001), the MSA has been involved in an acoustic tracking study on the Northwest branch since 2013. This study continued in 2016, in tandem with the tag retention study, during the smolt migration in the spring to determine survival rates throughout the Miramichi River and estuary.

Methods

Study Area

The Northwest Miramichi watershed drainage area of 3,950km^2 makes up approximately one third of the total watershed of the Miramichi River. The Northwest

Miramichi basin includes two major river systems: the Little Southwest River and the Northwest Miramichi River, which merge in a delta at the head of tide. The Northwest Miramichi River includes a large tributary, the Sevogle River.

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

Collection & Tagging

The fish collected from the Northwest and Southwest branches in 2016 were divided into 2 major groups per branch - "captive" and "wild". The captive fish were wild pre-smolts collected in the fall of 2015 and held over the winter months at the MSCC until their release in the spring of 2016. The wild fish were smolts collected and released in the spring of 2016 (and spent no time in captivity at the MSCC). The captive group was further divided into 2 sub-groups (per branch) – "winter tagging" and "spring tagging". The tagging procedures for each group are outlined below.

Captive Groups

Atlantic salmon pre-smolts (10cm+) were collected from the Northwest and Southwest branches of the Miramichi River in October 2015. Fish from the Northwest were collected at two sites using a backpack electrofisher – Miners Bridge and Trout Brook. Pre-smolts from the Southwest branch were collected from a rotary screw trap (RST) installed at the mouth of Rocky Brook. The fish were transported back to the MSCC in an x-actic tank with oxygenated water. Both stocks of fish were kept in 6' circular fibreglass tanks (kept separate by stock) on well water and fed daily over the winter months.

Winter Tagging

During the first week of March in 2016, 29 fish from the Northwest and 27 fish from the SW (56 total) were surgically tagged with internal Vemco V8 acoustic transmitters. The

transmitters were all tested before insertion to ensure they functioned properly. The fish were placed in a clove oil anaesthetic bath for 3-5 minutes to sedate them prior to surgery. The incision was made off-centre near the pelvic fins, on the ventral surface of the fish, to insert the tag into the body cavity. The incision was closed with 1 – 2 sutures and the fish was placed in a recovery bath until it was swimming upright. Time out of the water for this procedure was 2 – 3 minutes per fish, with water passed through the gills during surgery. After recovering fully the fish was returned to the larger fiberglass tank. Weights and lengths of each fish were also recorded. The fish were observed daily after the surgery and any irregular behaviours, mortalities, or tag expulsions were noted. Food was introduced again three days after surgery and continued daily until mid-May.

Spring Tagging

A further 29 fish from the Northwest and 30 fish from the Southwest (59 total) were tagged during the third week of May 2016. The fish from each stock were transported from the MSCC to Rocky Brook on the Southwest and to Miners Bridge on the NW to undergo the same surgical procedure (with the same tags) as mentioned above in the winter tagging group. These fish were left to recover in live boxes near the shore, for a minimum of one hour, to ensure equilibrium recovery before being released.

Wild Group

Atlantic salmon smolts were captured via RST on the Northwest Miramichi River (N = 61) and at the mouth of Rocky Brook (N = 59) during the third week of May 2016. Only fish greater than 13cm were held for tagging (to allow for room in the body cavity for the transmitter). The fish were held in live boxes just off shore until the following morning (to allow for digestion and therefore easier tag insertion) when they were transported to their respective tagging locations. The Northwest fish were taken to Miners Bridge (approximately 27km upstream of the RST) in an x-actic tank on a truck. The Rocky Brook fish were tagged at Rocky Brook Fishing Camp, which is situated at the mouth of Rocky Brook, near the RST.

The smolts were tagged with the same type of tags and procedure stated in the winter captive group description. The fish were left to recover in live boxes near the shore for a minimum of one hour, to ensure equilibrium recovery, before being released.

Release

The fish from the captive groups were all released during the late evening. The fish from the wild groups were split into two release groups – late morning (day) and late evening (night).

Captive Groups

Winter Tagging

The 29 fish tagged from the Northwest River and the 27 fish tagged from the Southwest River were released during the third week of May 2017. The Northwest fish were released at Miners Bridge and the Southwest fish were released at the mouth of Rocky Brook.

Spring Tagging

The 29 fish tagged from the Northwest River and the 30 fish tagged from the Southwest River were released during the third week of May 2017. The Northwest fish were released at Miners Bridge and the Southwest fish were released at the mouth of Rocky Brook.

Wild Group

Of the 61 wild fish collected from the Northwest River, 32 of them were released during the day and 29 of them were released during the night. Of the 59 wild fish collected from the Southwest River, 30 of them were released during the day and 29 of them were released during the night. The Northwest fish were released at Miners Bridge and the Southwest fish were released at the mouth of Rocky Brook.

Receiver Placement

A total of 17 Vemco VR2w acoustic receivers were placed throughout the freshwater and tidally influenced portions of both the Northwest and Southwest Miramichi Rivers. In 2016 a second receiver was added in Cassilis (considered head-of-tide) in an effort to increase detections. Five receivers were placed along the main stem of the Miramichi River between Beaubears Island and Loggieville, with an additional 2 receivers added to the Loggieville location in 2016 to increase detections. A further 11 receivers were also placed to form detection gates between openings at barrier islands near the mouth of Miramichi Bay at Neguac Beach, Portage Island, and Huckleberry Gully . An additional receiver line at the Strait of Belle Isle (SOBI) was deployed in 2015, 3.5km north of the original line so that two lines of detection were present to increase the chances of tag detections in this area (Figure 1a&b).

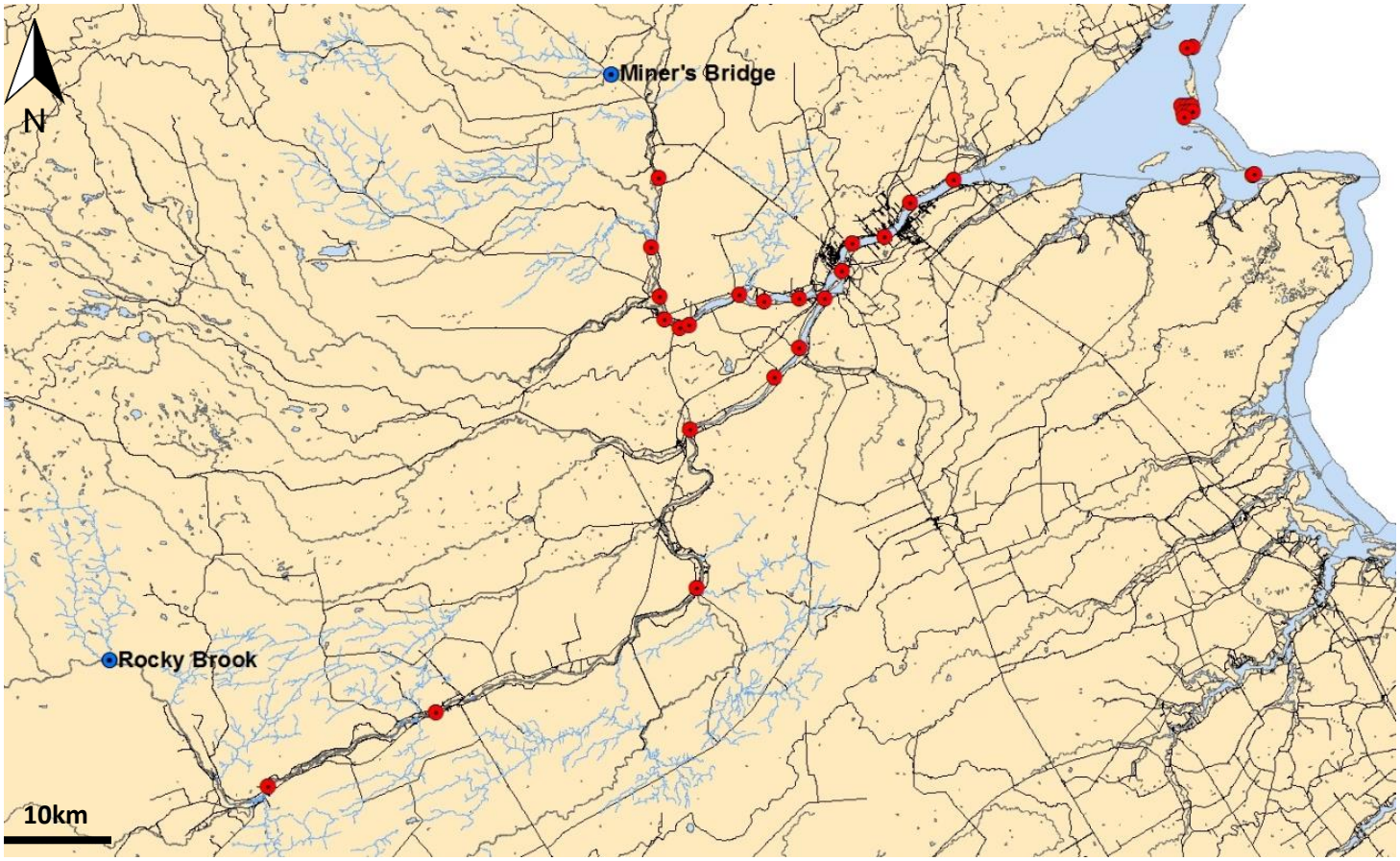

Figure 1a. Acoustic receiver locations (red dots) in the Miramichi River and Bay in 2016. Smolt tagging and release locations are represented by a blue dot – Miners Bridge on the Northwest branch and Rocky Brook on the Southwest branch.

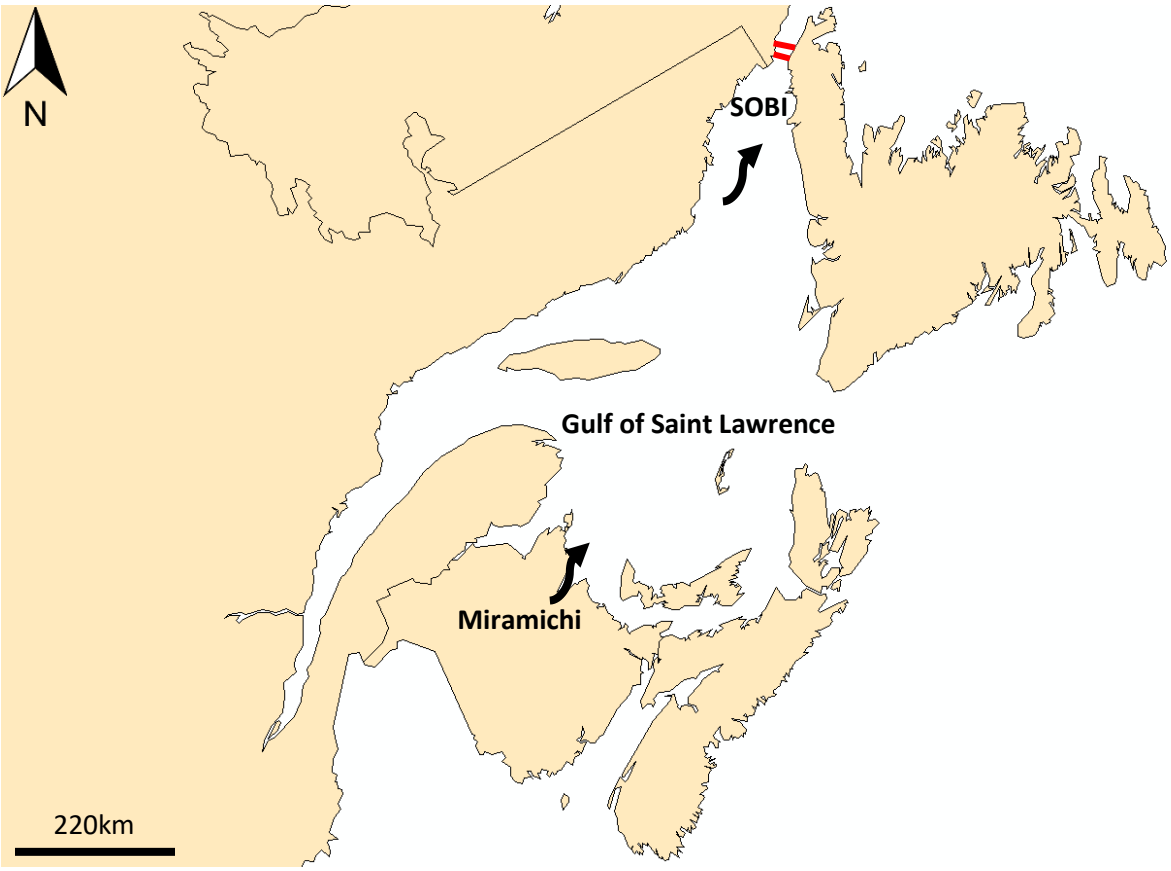

Figure 1b. Acoustic receiver locations (red lines) across the Strait of Belle Isle in 2016. A second line was added north of the original line in 2015. The lines are 3.5km apart. Suspected fish movement paths are indicated with a black arrow.

Results

Northwest River

Captive Group - Winter

Detection percentages at the HOT (Cassilis), Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 79%, 59%, 34%, and 24%.

Captive Group – Spring

Detection percentages at the HOT, Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 45%, 34%, 14%, and 3%.

Wild – Day

Detection percentages at the HOT, Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 81%, 50%, 25%, and 9%.

Wild – Night

Detection percentages at the HOT, Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 76%, 55%, 31%, and 17%.

Summarized detections from all the tagged smolts from the Northwest Miramichi River at the HOT, Loggieville, Outer Bay, and SOBI (respectively) are as follows: 71%, 50%, 26%, and 13% (Figure 2a).

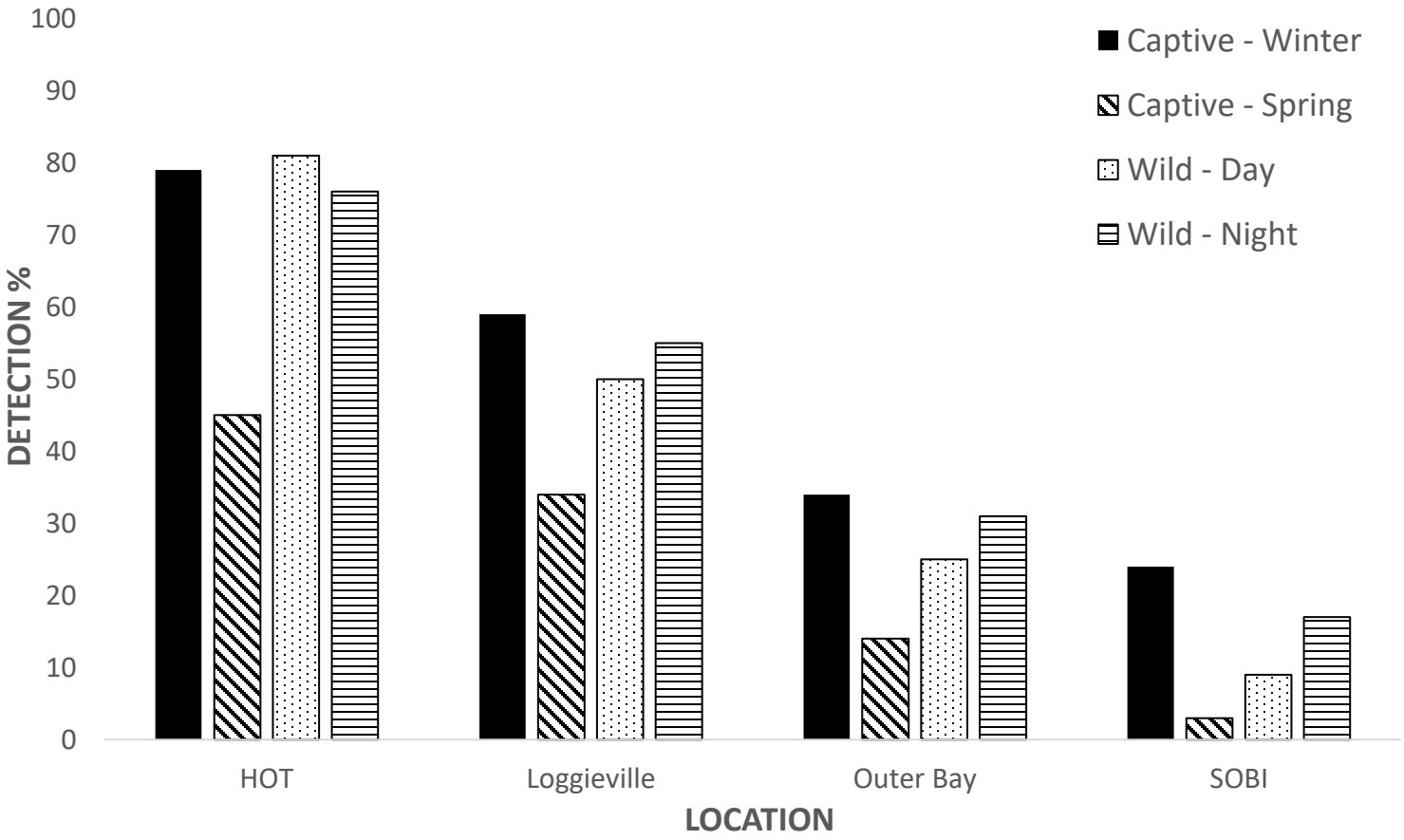

Figure 2a. Detection percentages of acoustic tagged smolts from the Northwest Miramichi at key receiver locations in the Miramichi River, Bay, and the SOBI in 2016. The groups are separated into each of the four tagging groups: Captive – Winter, Captive – Spring, Wild – Day, and Wild – Night.

Southwest River

Captive Group - Winter

Detection percentages at the HOT (Quarryville), Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 15%, 7%, 7%, and 0%.

Captive Group – Spring

Detection percentages at the HOT, Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 10%, 7%, 3%, and 3%.

Wild – Day

Detection percentages at the HOT, Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 50%, 43%, 17%, and 13%.

Wild – Night

Detection percentages at the HOT, Loggieville, Outer Bay, and SOBI (respectively) for this group is as follows: 48%, 45%, 14%, and 14%.

Summarized detections from all the tagged smolts from the Southwest Miramichi River at the HOT, Loggieville, Outer Bay, and SOBI (respectively) are as follows: 31%, 26%, 10%, and 8% (Figure 2b).

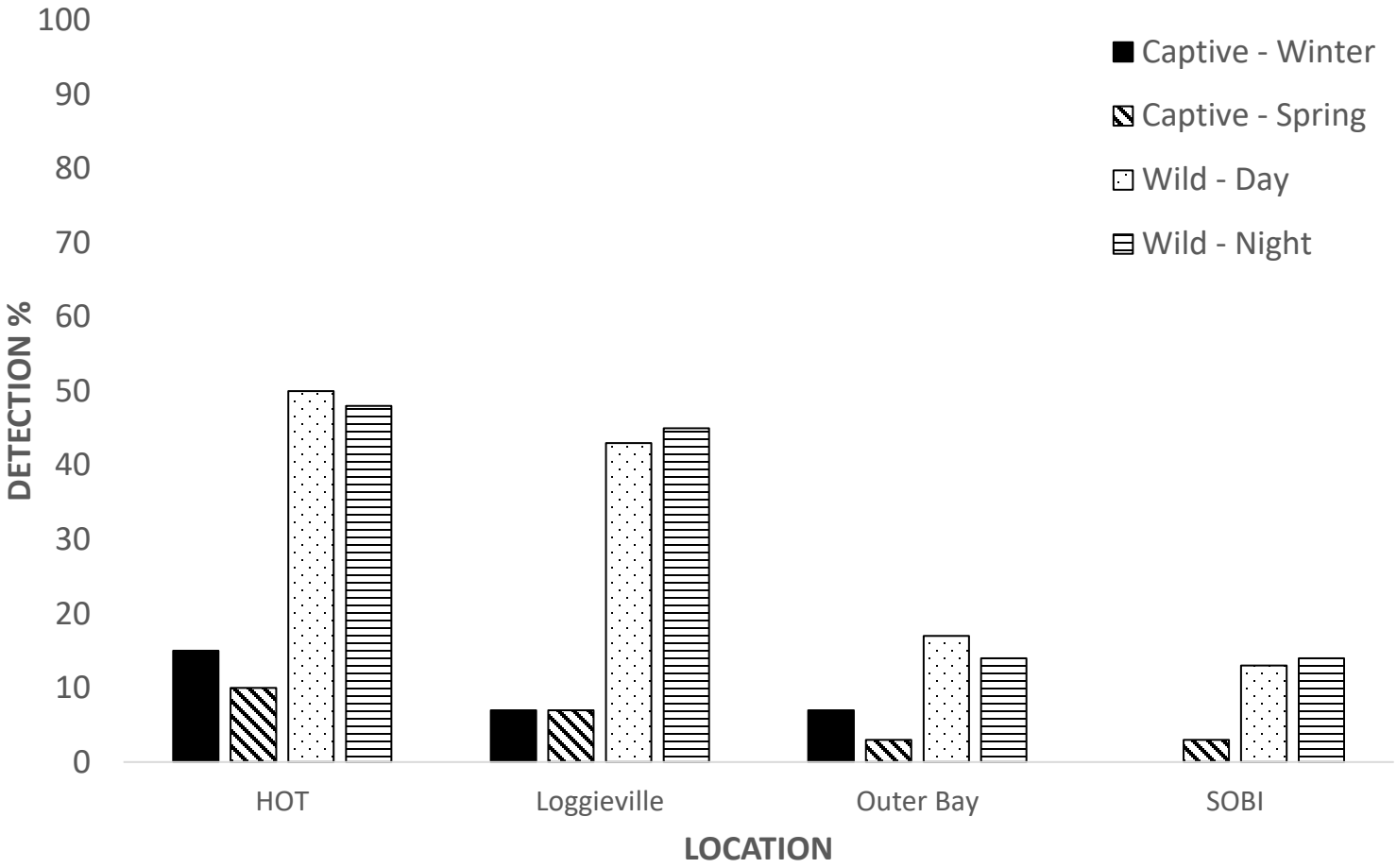

Figure 2b. Detection percentages of acoustic tagged smolts from the Southwest Miramichi at key receiver locations in the Miramichi River, Bay, and the SOBI in 2016. The groups are separated into each of the four tagging groups: Captive – Winter, Captive – Spring, Wild – Day, and Wild – Night.

Discussion

The three main questions that were trying to be answered during the 2016 smolt tracking study were as follows:

1. Is there an effect on survival when fish are tagged in the winter vs. tagged in the spring, when both groups have been kept in captivity? (Captive-Winter vs. Captive-Spring)
2. Is there an effect on survival when fish are kept in captivity, tagged, and remain in captivity until being released vs. fish that are caught from the wild, tagged, and released the same day? (Captive vs. Wild)
3. Is there an effect on survival when wild fish (no time spent in captivity) are tagged and released during the day of tagging vs. the night of tagging? (Wild – Day vs. Wild – Night).

Northwest

1. The Captive-Winter group of fish showed higher detection rates than the Captive-Spring group at each of the four key receiver locations (HOT, Loggieville, Outer Bay, and SOBI), suggesting their survival percentages were higher in general than their captive counterpart.
2. The Captive-Winter group of fish had the highest number of detections in general at each of the four key sites. The wild fish had more detections (and assumed higher survival) than the Captive-Spring group at each location. The Wild-Night group had very similar detection percentages to the Captive-Winter group.
3. In general the Wild – Night group of fish had higher numbers of detections at the four sites compared to the Wild – Day group, however the differences were not as substantial as those seen between the Winter – Captive and Spring – Captive groups.

Southwest

1. The Captive – Winter group of fish had slightly higher numbers of detections at 3 of the 4 key locations than the Captive – Spring group, however both groups had extremely low detection numbers (and assumed survival) in general.
2. Both Captive groups had dramatically lower detection numbers than their wild counterpart's at all four locations.
3. There was no substantial difference between the Wild – Day and Wild – Night groups regarding detection numbers. Wild fish survival in general was low.

The fish from the Northwest Miramichi River had better overall detection numbers (and assumed survival) throughout their journey from freshwater to the ocean than the Southwest Miramichi River fish, however the percentages are still less than desirable from both branches. The number of smolt surviving their migration to the sea has been decreasing over the last decade. This was only the first year of this tag retention study (i.e.: holding fish in captivity and comparing their survival and behaviour to wild fish) and with the dramatic loss in Captive

Southwest Miramichi fish it is difficult to determine what factors may have played a role in this spike in mortality. The Atlantic Salmon Federation is also working with this data to produce models and more accurate survival percentages for smolt migrating out of the Miramichi River. This tagging project (with captive and wild fish) will continue in 2017 to add more data to the smolt tracking and survival databases.