Tracking Salmon Kelt on the Miramichi River 2014

In collaboration with
The Atlantic Salmon Federation

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Introduction

Adult Atlantic salmon (*Salmo salar*) that migrate to river systems to spawn and remain in freshwater over winter are called kelt. As river discharge rates and water temperatures begin to increase in early spring, kelt that have survived the winter migrate downstream to feed and recondition in the Miramichi estuary and bay before moving into the Gulf of St. Lawrence (GOSL). Studies of repeat spawner egg deposition have estimated that these fish account for 25-40% of the total eggs deposited annually in the Miramichi River. Repeat spawners to the Miramichi are broken into two life history stages: alternate spawners, which move through the GOSL before migrating to the North Atlantic to spawn the following year, and consecutive spawners which remain in the Gulf for several months before returning to spawn the same year. There is a large biological and socio-economic importance related to repeat spawners as these fish are generally larger in size than maiden salmon making them more desirable for catch and release, and they also contribute a significant amount of eggs to the river system, and are likely to produce larger eggs with an increased chance of survival than those of smaller fish.

The marine ecology of adult Atlantic salmon has been identified as a knowledge gap in scientific literature. Based on past acoustic studies of Miramichi kelt, survival through the river and bay has averaged of 90%, suggesting the vast majority of kelt mortality is occurring in the marine environment. Information on marine mortality, feeding behaviour, and migratory routes of Miramichi salmon is limited and could be of considerable value in the creation of conservation strategies to ensure the continued health of our native salmon population. Understanding areas of high mortality may shed light on predation sources, the impact of marine commercial fishing on salmon bycatch, and the effects of trophic shifts and climate change on salmon populations.

The use of satellite tags is a novel approach to track the movement, water temperature, and depth of Atlantic salmon in North America. Numerous studies have tracked adult and smolt movements through the use of internally implanted acoustic tags. These studies have proven effective in monitoring the movements and survival of individuals transitioning from the river to inner bay habitat, but are restricted in their ability to detect movements in large marine bodies. The placement of acoustic receiver arrays in rivers and narrow portions of estuaries and bays

allows for a high probability of detecting tagged individuals as they move past these points. The cost and logistics of deploying receivers in vast areas of open water to have high confidence in tag detection is unrealistic in most studies. Satellite tags allow for detection of daily movements without being in close proximity to a receiver unit, while also recording detailed information regarding water temperature and depth. Data collected from these devices is transmitted once the tag is deployed, which occurs after a pre-set date or following five days of no detected pressure change (assumed morality). Geo-positioning is determined by recording daily light intensity and duration, which is correlated to sunrise/sunset timing to produce one daily location. Delayed tag transmission, combined with a single averaged daily location, prevents the fine scale study of fresh and brackish water movements. As such, the use of both satellite and acoustic technologies allows for both fine and coarse scale study of individual fish.

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

Methods

Study Area

The Northwest Miramichi watershed drainage area of 3,950 km^2 makes up approximately one third of the total watershed of the Miramichi River. The Northwest Miramichi basin includes two major river systems: the Little Southwest Miramichi River (1,324 km^2) and the Northwest Miramichi River (2,078 km^2) which merge in a delta at the head of tide near Red Bank. From head of tide, the Northwest Miramichi connects approximately 23km downstream to the Southwest Miramichi before flowing into Miramichi Bay.

Tagging

Kelt were captured by angling near Red Bank, NB from May 4th – 11th, 2014. Following capture, kelt were held temporarily in a submerged live box. Fish were then placed in a clove oil bath (anaesthetic) for several minutes until equilibrium was lost and movement was minimal. For fish receiving acoustic tags only, Vemco V16 transmitters were inserted into the body cavity by making a small incision on the ventral surface of the fish, off center, between the pectoral and pelvic fins. Once the tag was inserted, the incision was stitched using 2 or 3 sutures and the kelt placed back in the live box to recover. Time out of the water for this procedure was 2 to 3 minutes, with water passed regularly through the gills and over the body during the surgery.

Mircrowave Telemetry Inc. X-Tag pop-off satellite transmitters were selectively outfitted onto the kelt with a fork length over 71cm while the fish was still anaesthetized from the insertion of a Vemco V9 transmitter. Pop-off tags were anchored to the fish by two hard plastic plates on each side of the body located just below the dorsal fin. The plates were held in place by a plastic coated wire that passed through the dorsal musculature. During all surgeries, the fish were kept moist and water was continually passed over their gills. The combined time out of the water for acoustic and satellite tagging was 3 to 4 minutes.

Receiver Placement

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

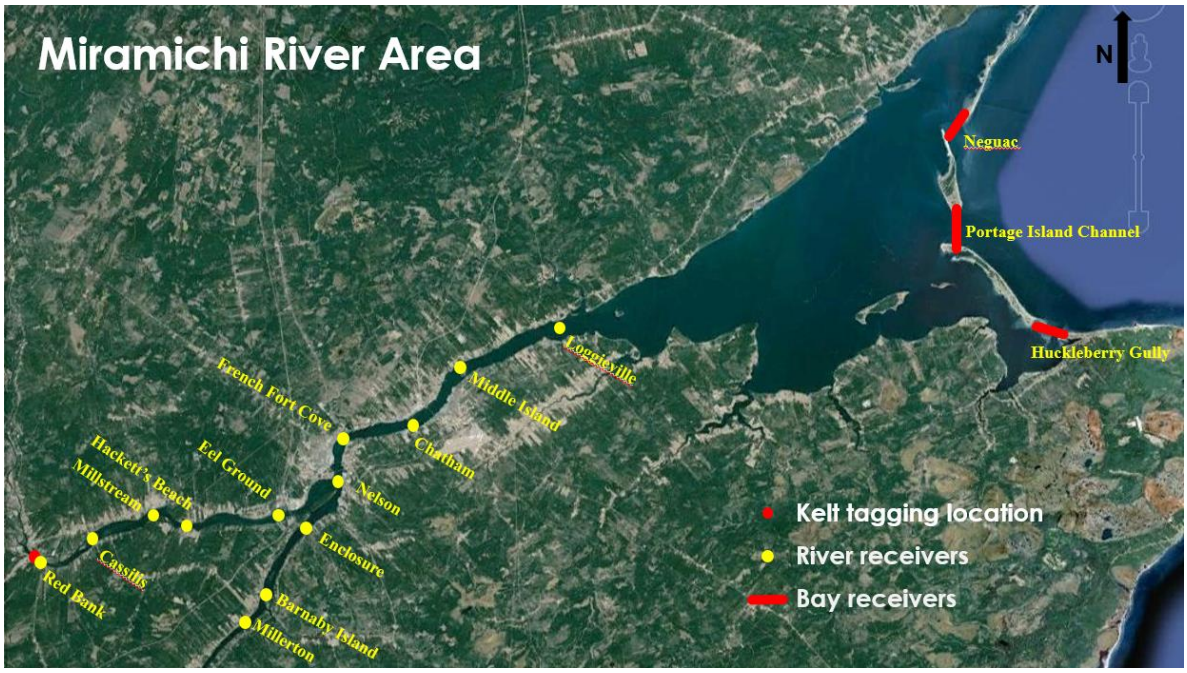


Figure 1. Locations of acoustic receivers throughout the Miramichi River and Bay in 2014. The red circle indicates tagging location, yellow circles are receivers used for tracking movements, and red lines indicate multiple receivers used to determine survival out of Miramichi Bay.

Results

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

Movement and Survival through the Northwest River and Miramichi Bay

Acoustic receiver detections showed that 18 of the 21 fish tagged (86%) survived out of the Miramichi River and Bay. Broken down by tag type, 10 of the 11 satellite tagged fish survived and 8 of the 10 acoustic tagged fish. The 10 satellite tagged fish that survived out of the river system spent anywhere from 3 to 13 days in the river before moving into the bay. Once in the bay, these fish remained there for 1 to 10 days before moving on to the Gulf of St.

Lawrence at the end of May. Two fish tagged with satellite tags returned to the Miramichi River as consecutive spawners; they were detected at the Loggieville receiver on July 7th and July 14th, respectively. One of these fish was captured in a Red Bank gill net and the tag returned to the MSA, and the other was lost near French Fort Cove (the satellite tag never transmitted).

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

Movement and Survival in the Marine Environment

In 2014, a total of 18 tagged kelt successfully made it out of Miramichi Bay. Eight of these kelt were tagged with long term V16 acoustic tags, while the remaining ten were equipped with pop-off satellite transmitters along with short term V9 acoustic tags. Three of the ten satellite tags failed to transmit, one was returned after the fish was caught in a gill net, one washed ashore on PEI, leaving five tags that transmitted temperature, depth, and movement data through the Gulf of St. Lawrence (GOSL), Strait of Belle Isle (SOBI), and Atlantic Ocean.

Satellite Tags:

Tag 136019 was a female that entered the Gulf in late May, and traveled to an area south of Anticosti Island. She remained there for the rest of May and into mid-June. Her depth during this time ranged from 15 to 20m, and water temperatures ranged from 4 – 14°C. Towards the end of June she began moving northeast towards the SOBI, but was never recorded on the receivers there. Around the beginning of July, this fish dove from 20m to 175m, at which point a sharp increase in temperature (to 25°C) was registered on the tag. This is most like a predation event and the tag would have been in the stomach of whatever consumed this fish. The tag continued recording deeper depths (125 – 175m) and the elevated temperature over a few days until the tag was expelled and floated to the surface. The tag began transmitting on July 11th.

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

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

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

Tag 136023 was a female that entered the GOSL on May 20th. She moved around the western part of the Gulf between Anticosti Island and the Magdalen Islands for the remainder of May and the first half of June, before traveling northeast towards the SOBI. Her average

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

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

Tag 136027 was a male that entered the Gulf on May 18th. He traveled east to the area south of Anticosti Island during the end of May and stayed there into mid-June. Towards the end of June he moved northeast towards the SOBI. His average depth in the gulf was 20m, with one dive to 150m in mid-June. The water temperature ranged from 3 – 13°C. He crossed the SOBI receiver line on June 29th, the earliest of any fish tagged in 2014. He then headed northwest up the coast of Labrador for the months of July and August. The depths he occupied

were between 1 – 30m, except for two dives: one to 200m and one to 250m in mid-August. Water temperature ranged from 2 - 13°C during this time. At the beginning of September, this fish had headed out into the Labrador Sea to the northeast towards Greenland. He dove a couple of times to 575m between Labrador and Greenland, and then moved to shallower waters (1 – 50m) off the coast of Greenland. Water temperatures in September were between 3 – 8°C. His tagged popped near the coast of Greenland, 30km offshore and 200km north of Nuuk on the pre-programmed date of September 30th. All signs indicate this fish was still alive at that time.

Acoustic Tags:

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

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

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

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

Staging Areas

Two potential staging areas were noted for fish tagged in 2014: one in the western GOSL, south of Anticosti Island (Fig 2.), and one off the coast of Labrador in the North Atlantic (Fig 3). Five fish tagged with satellite tags (136019, 136022, 136023, 136025, 136027) spent time in this area of the Gulf during May and June before migrating further to the Atlantic Ocean. All five of these fish were alternate spawners. Four of these five survived out of the SOBI and traveled into the Labrador Sea. Once there, every one of them showed diving behaviours, ranging from 88 – 1025m. None of the fish exhibited this drastic diving behaviour while in the GOSL. These movements could be associated with predator avoidance or the fish searching for food sources (reconditioning).

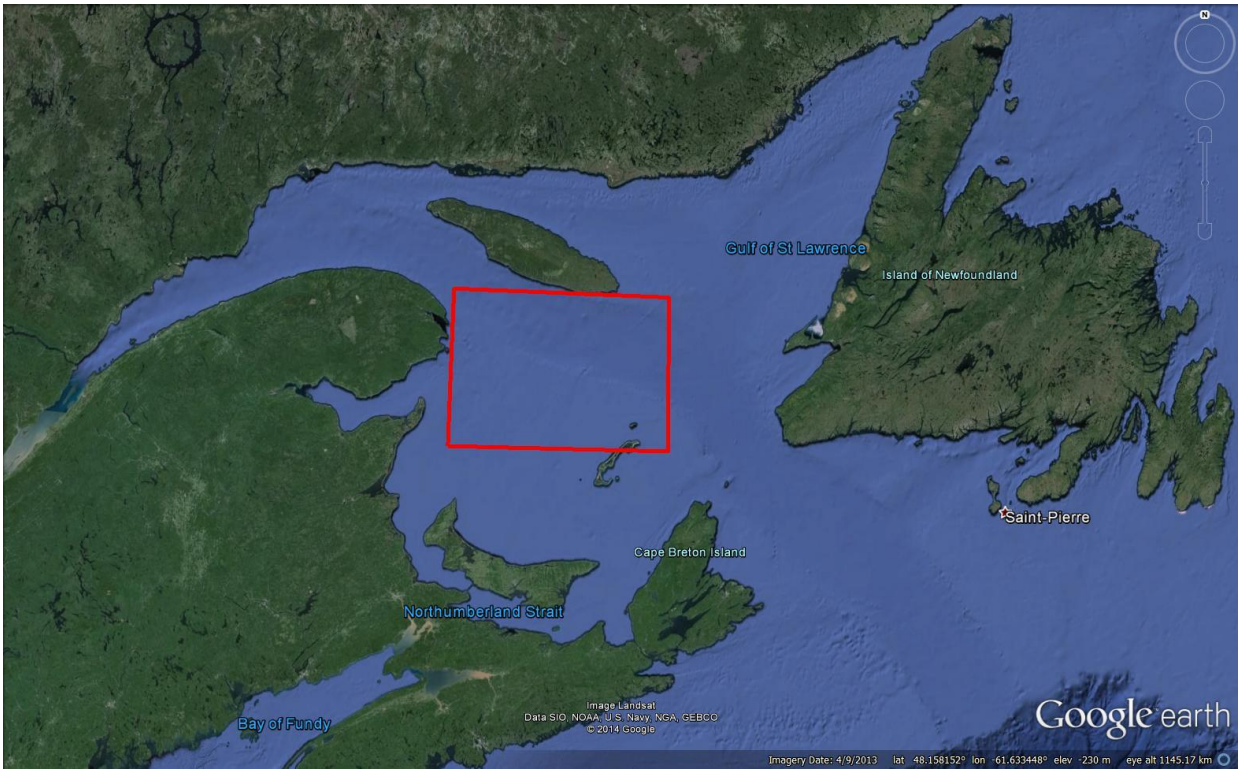


Figure 2. Potential staging area in the Gulf of St. Lawrence. Five fish occupied this space during the months of May and June in 2014.

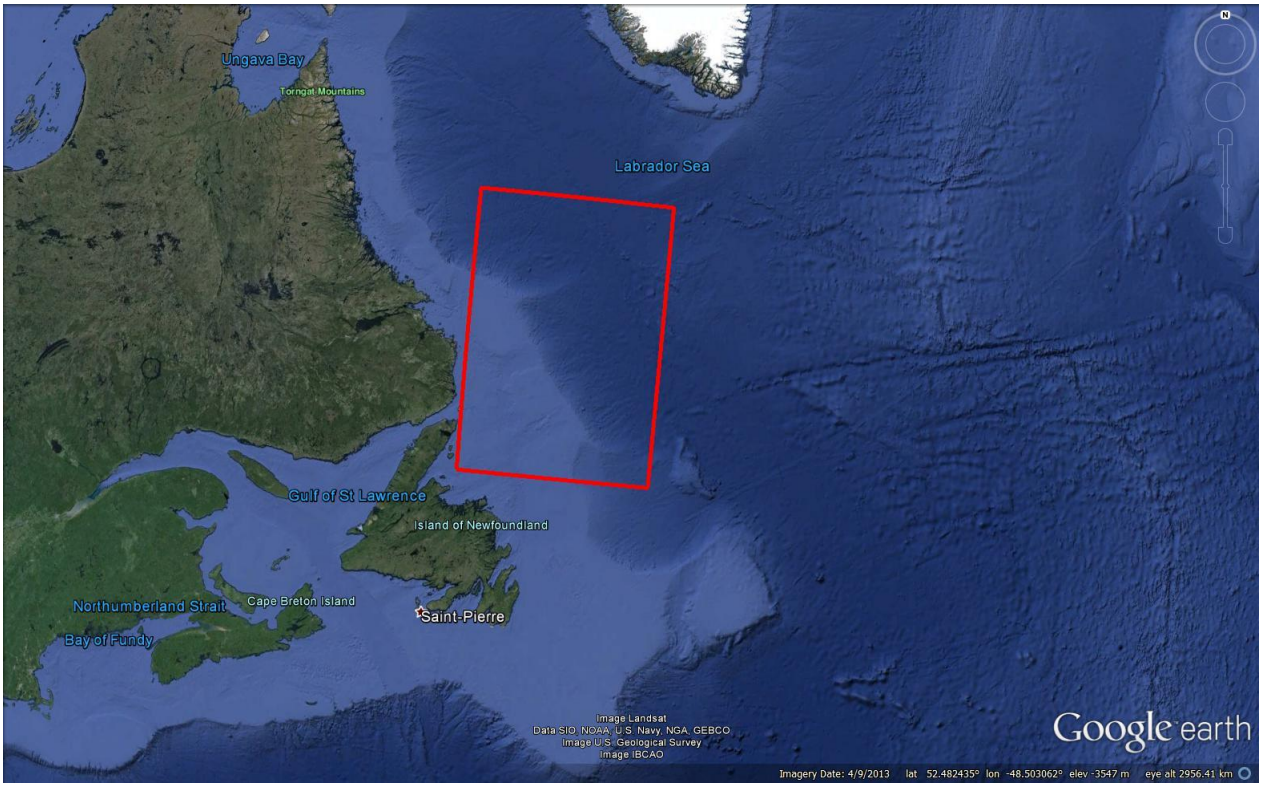


Figure 3. A second potential staging area in the North Atlantic for alternate spawners. Four fish were in this location from mid-July to mid-September 2014.

Tag Recovery

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

Discussion

In 2014, 55% (6/11) of all satellite tagged kelt successfully transmitted data on fish movements, water temperature, and depth. Four of the tags which failed to transmit were never detected, however acoustic data showed that three of these four fish survived out of Miramichi Bay, the fourth was lost near Cassilis and never moved downstream. One of the surviving three fish was a consecutive spawner, but the fish was lost near French Fort Cove in July. The fifth tag that did not transmit data (out of the eleven satellite tags) was another consecutive spawner that was caught in a gill net. That tag was returned to us, however data extraction from the tag has not been completed yet, and no tracks are available at this time. The data will be available in the future after extraction and analysis is completed. The failure of satellite tags to transmit could be the result of several factors which include: technical failure, tag damage, or tag obstruction from satellites (i.e.: stuck under debris, or caught in the stomach of a predator). Despite these failures, discussions with Microwave Telemetry Inc. (MTI), the manufacturer of these tags, suggest that our return rate of data has been strong compared to other studies.

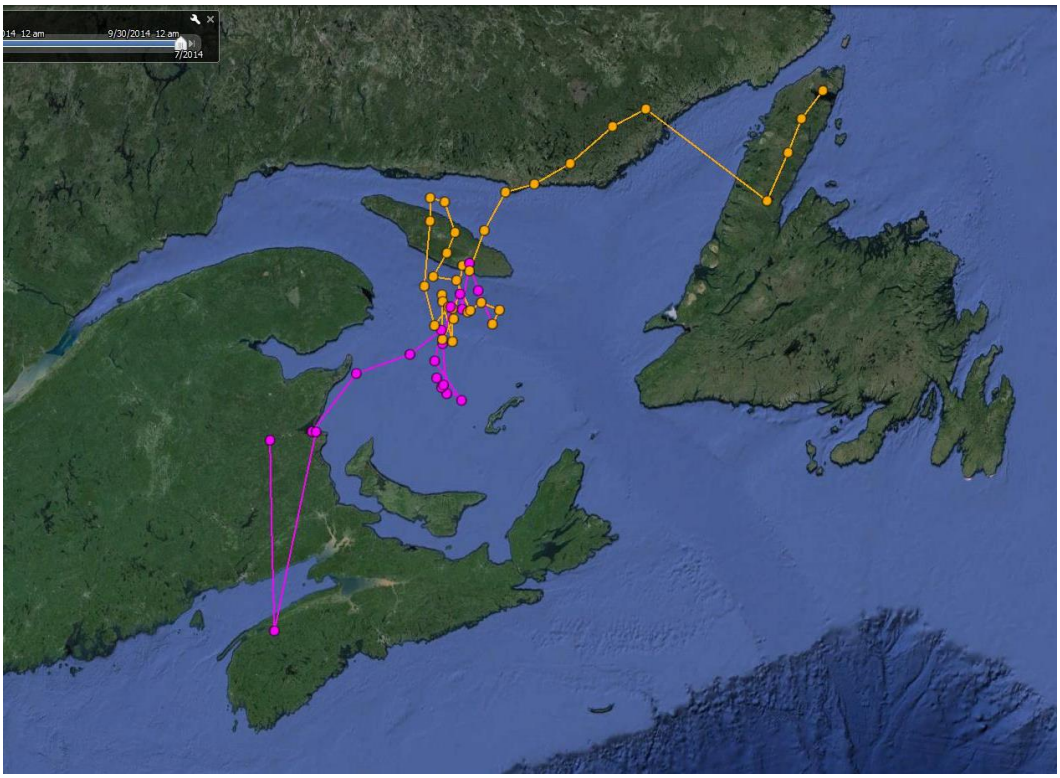
Three of the pop-off tags deployed on schedule at the pre-programmed date of September 30th (one halfway between Baffin Island and Greenland (136023), one off the northern tip of Labrador (136025), and one off the coast of Greenland (136027)). Initial satellite data suggests these fish moved through the Strait of Belle Isle on July 1st, July 7th, and June 29th, respectively. Although these dates may change with more fine scale analysis, they all fall within late June – early July, and match up with the three long-term acoustic tagged fish that passed through in early July as well (tags 24833, 24835, 9716). Given the northern location and late season timing of the transmission from these three tags, it is safe to assume that these kelts were alternate spawners on their way to recondition in the cold northern waters of the Atlantic Ocean before returning to spawn in 2015. Advanced analysis of the data from these tags is ongoing, and will be used with past and future data to investigate trends in kelt migrations to determine statistically relevant behavioural patterns which may provide significant insight into the ecology of alternate spawning Atlantic salmon.

Of the two tags that deployed prematurely (one south of the SOBI (136019) and one off the southern coast of Labrador (136022), only one has supporting evidence of being predated – tag 136019. A dive to 175m was observed in early July, and water temperatures around 10°C. At this depth, a sudden increase in temperature was noted, up to 25°C and most likely points to the tag being consumed and resting in the stomach of a predator. The temperature recorded then decreases to 12°C and the tag depth changes to ocean surface levels; four days later the tag began transmitting. Tag 136022 popped after four days of constant depth, however the sharp increase in temperature was not seen. This does not mean the fish was not predated, as the tag may just not have been ingested. This fish also made a deep dive (over 1000m) and remained there for a couple weeks, at a temperature of 4°C, before a surface ascent was observed. The tag began transmitting after four days at the surface. Further analysis of temperature and depth data may provide insight as to what species of animal could have consumed these fish. The sample size from 2014 is too small to draw any significant conclusions from, but pooling the data from these fish, along with kelts from the past and future studies that also prematurely deploy in the Gulf may provide correlations between survival and water temperature and depth, seasonal commercial fisheries, or predator movements.

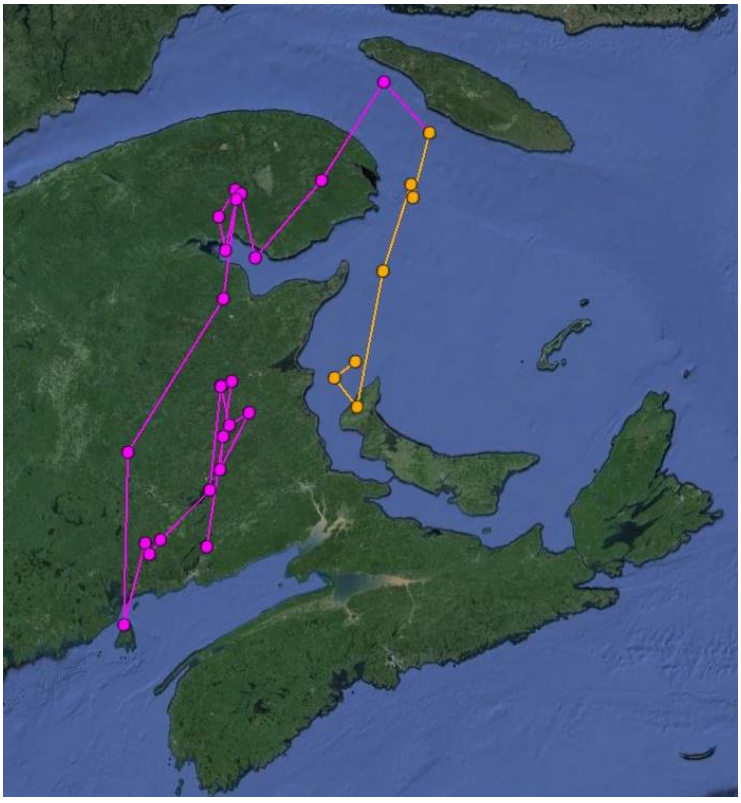
Determining movements of individual fish requires considerable work and statistical analysis. Tag position is determined by converting daily recorded light intensity and duration to sunrise and sunset timing each day. Positioning is then determined by calculating the marine area that would have those same times for a specific date. Even though this method is effective, it is susceptible to false locations produced by environment conditions. Dense cloud cover during dawn or dusk where light levels are low can give the impression of delayed sunset or early sunrise, therefore changing the position calculated for the location. An initial correction factor can be applied by averaging positions at a specific date with values collected during the previous days. This method provides a simplified improvement to smooth out data, but is still impacted by outlying erroneous locations. In order to correct for this, all positions need to be compared against local weather conditions during the specific date the animal was thought to be in a given area. At this time, simplified tracks of six kelt have been completed and are

included in Appendix 1 of this report. These tracks are not considered final and still need further analysis and refinement.

Appendix 1.



Tag 136019



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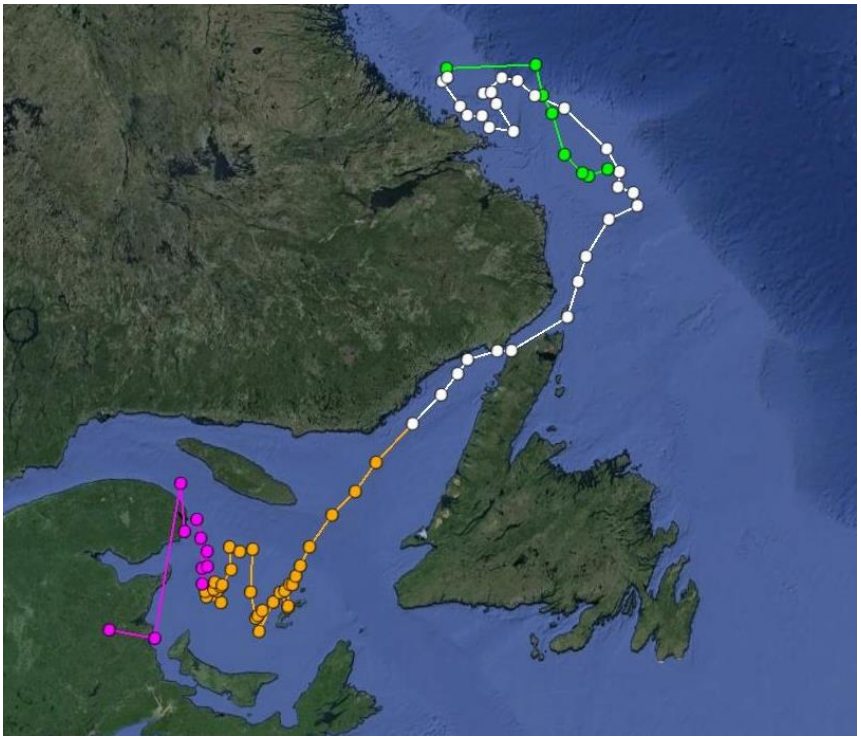

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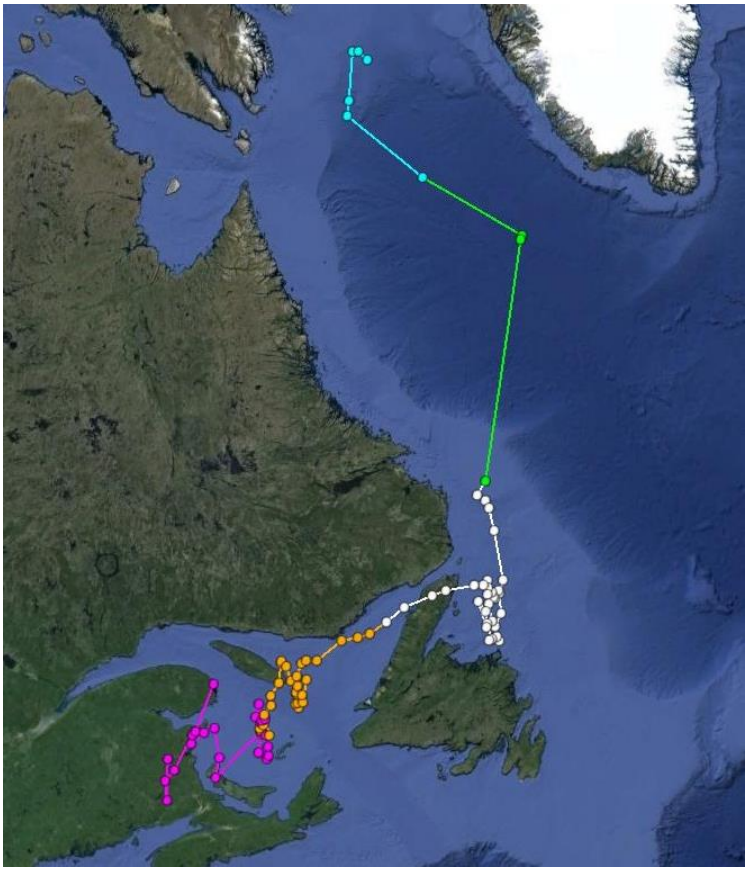

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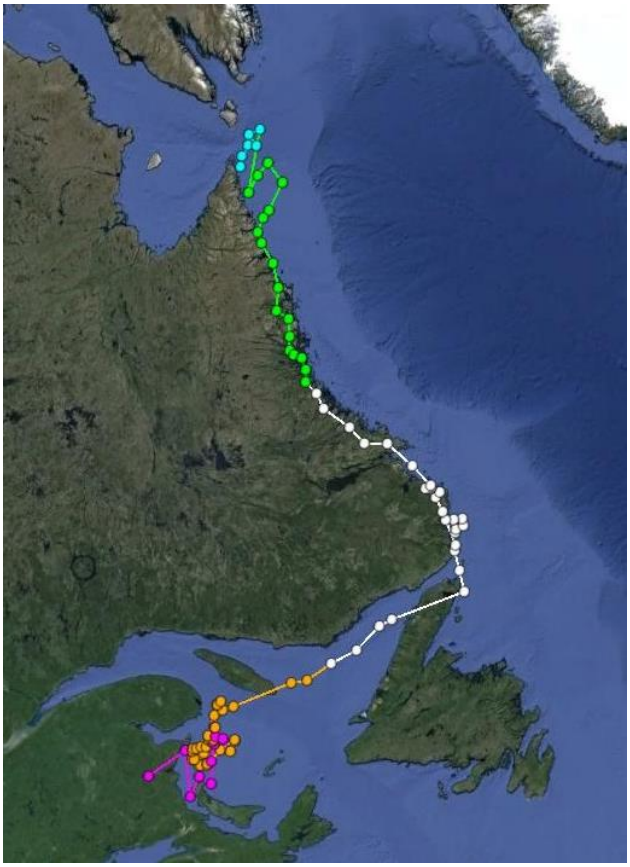
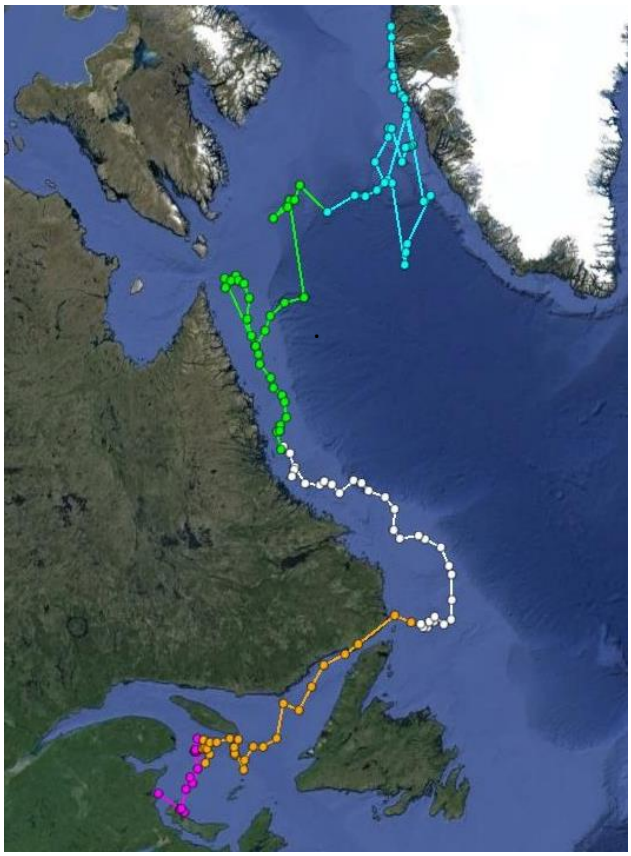


Tag 136025



Tag 136027