Kelt Tracking on the Miramichi River 2015

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In cooperation with:
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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 90%, suggesting the vast majority of kelt mortality is occurring in the marine environment. Information on marine mortality, feeding behaviour, and migratory routes of Miramichi salmon is limited and could be of considerable value in the creation of conservation strategies to ensure the continued health of our native salmon population. Understanding areas of high mortality may shed light on predation sources, the impact of marine commercial fishing on salmon bycatch, and the effects of trophic shifts and climate change on salmon populations.

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

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

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 3rd – 14th, 2015. 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.

Microwave 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 21 Vemco VR2w acoustic receivers were placed throughout the freshwater and tidally influenced portions of the Northwest (9), Southwest (7), and main stem Miramichi Rivers (5) 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. In past years only one line of receivers was placed at the Strait of Belle Isle but in 2015 a second line was added, 3.5km north of the first line, to increase the chances of tag detection (Figure 1a&b).

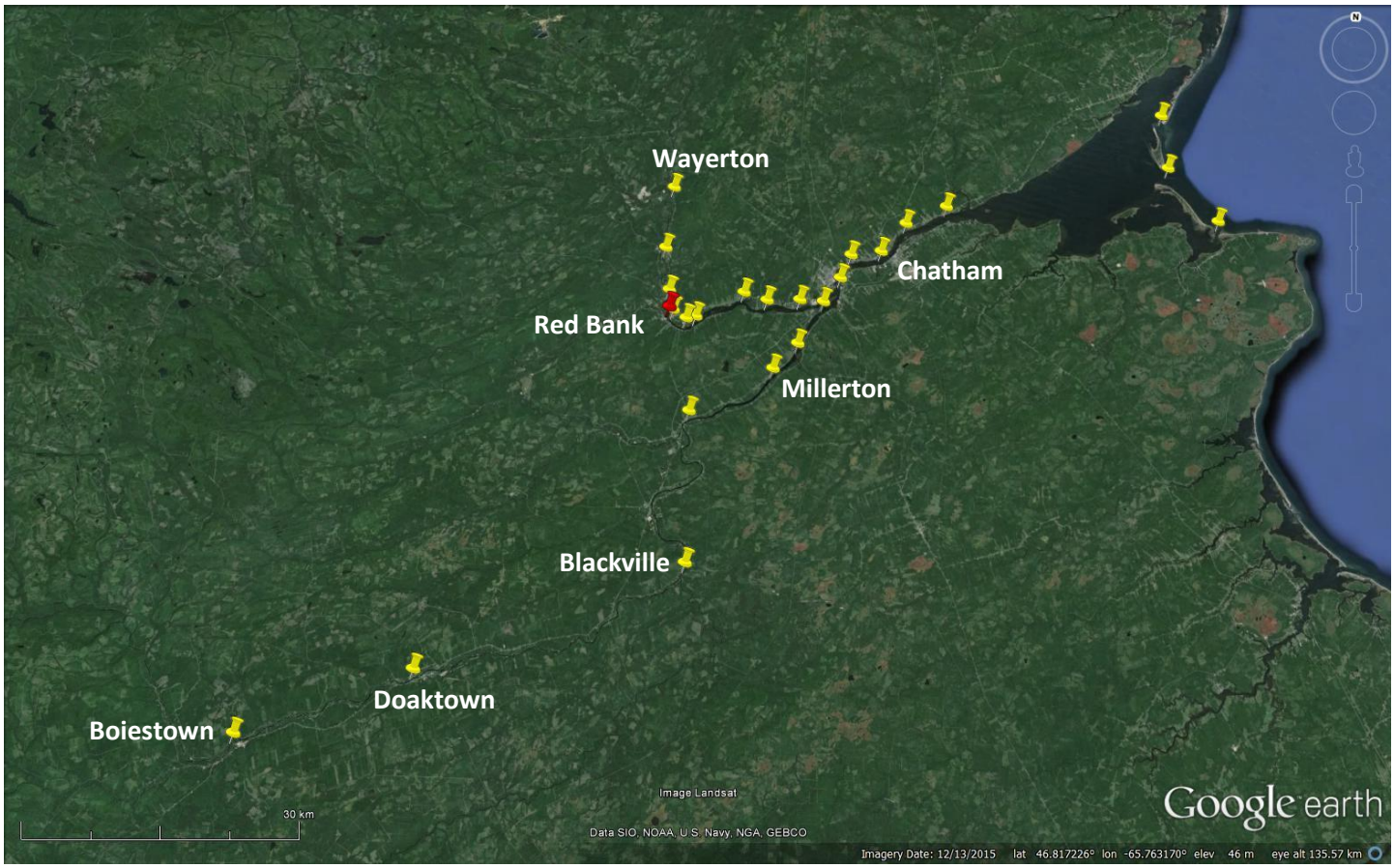


Figure 1a. Locations of acoustic receivers throughout the Miramichi River and Bay in 2015. The red pin indicates tagging location and yellow pins are receivers used for tracking movements to determine survival out of Miramichi River and Bay.

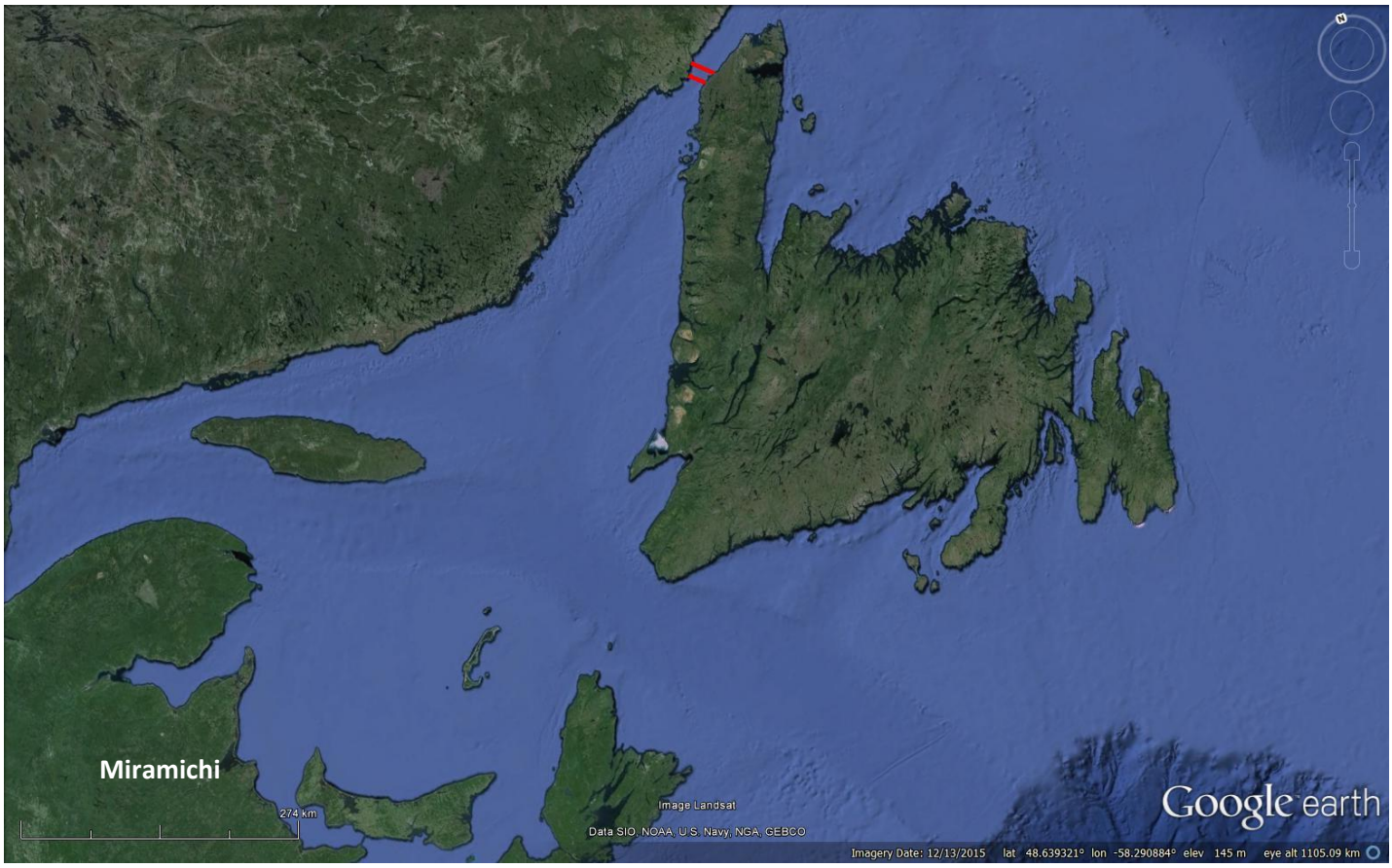


Figure 1b. Location of acoustic receivers (red lines) in the Strait of Belle Isle. The lines are 3.5km apart.

Results

A total of 24 kelt were tagged in 2015 - 11 with external satellite tags and internal V9 acoustic tags, and 13 with internal, long term V16 acoustic tags. All of the kelts tagged this year were female, ranging in size from 70cm (26.7in) to 97.8cm (38.5in).

Movement and Survival through the Northwest River and Miramichi Bay

Acoustic receiver detections showed that all 24 of the fish (100%) survived out of the Miramichi River and into Miramichi Bay. The 11 satellite tagged fish, spent anywhere from 3 to 26 days in the river before moving into the Bay. Once in the bay, these fish remained there for 1 to 16 days before moving on to the Gulf of St. Lawrence at the end of May/early June. No satellite tagged fish returned as consecutive spawners in 2015.

For the 13 fish tagged with acoustic tags only, their in-river timeframe was spread out over 22 days, and their detection dates at the outer Bay receivers occurred over a 21 day period, with the last one crossing into the Bay on June 9th. Four of these fish returned as consecutive spawners in 2015 (tags 24811, 24812, 24814, and 58537) and re-entered the Bay between July 7th and 15th. Of these four, three of them traveled up the SW branch to the Blackville area at the end of July, after which two of them were picked up at the Cassilis receiver in early October on their way upstream. The third fish was not detected again. The last fish (that did not enter the SW branch) was last detected in Red Bank on July 29th.

Movement and Survival in the Marine Environment

In 2015, all 24 tagged kelt successfully made it out of Miramichi Bay. Thirteen of these kelt were tagged with long term V16 acoustic tags, while the remaining eleven were equipped with pop-off satellite transmitters along with short term V9 acoustic tags. Five of the eleven satellite tags failed to transmit, leaving six 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 148254 was not detected entering the Gulf. This does happen occasionally, as fish can slip by the receiver lines. The satellite data shows that she headed north to Anticosti Island, staying in water approximately 10m deep and a temperature of 5-10°C. She may have gone around the island before moving south again into the western Gulf. She dove a couple of times in mid-June up to 40m before the tag popped prematurely on June 17th and began transmitting. Predation may have been the cause, but further investigation and analysis is required before this can be confirmed.

Tag 148255 entered the Gulf on May 8th. There were detections on two of the three channels leading out of the Bay for this fish over the next three weeks. After this, satellite tag data shows that she traveled to the western Gulf, south of Anticosti Island, and occupied depths of 10-20m and temperatures of 5-10°C. Near the end of June she starting moving toward the SOBI, and crossed on July 8th. Near this date she dove once to 50m. She stayed close to the continental shelf moving north to the tip of Quebec before retracing her path south for a short while, and making a few dives to 30m. The average water temperature she was in was 5°C after crossing the SOBI. The tag popped on its programmed pop-off date of August 31st near Nachvak Fjord. All signs indicate this fish was still alive at that time.

Tag 148256 entered the Gulf on May 14th. She headed north towards Anticosti Island and then southeast to the middle of the Gulf. This pattern is slightly different than what we have seen with past fish, as they usually spend more time in the western Gulf. She remained in depths of up to 30m and 5-10°C during this time. She was not detected at the SOBI, which unfortunately happens on occasion. She crossed this area sometime between July 6th and 16th, which is typical timing for this portion of the migration. She moved north along the coast of Labrador over the next 3 weeks, remaining in depths of up to 30m. At the beginning of August she made a dive to 300m and a spike in temperature to 24°C was observed. The data suggests this fish was predated near Kidlialuit Island.

Tag 148257 entered the Gulf on May 14th. She remained in the western Gulf at depths up to 27m and temperatures between 5-10°C. The tagged popped prematurely on June 2nd north of Prince Edward Island (PEI). More investigation is necessary to determine if this was a predation event, as the tag was not ingested.

Tag 148258 entered the Gulf on June 3rd and headed north into Chaleur Bay and then northeast to the tip of the Gaspé Peninsula. She occupied shallower water at this time, between 2-20m and water temperature of 10-18°C. Around June 10th she dove to 48m and remained at that depth for roughly 10 days; the temperature in this area dropped to 1°C. The tagged popped off prematurely on June 21st in the Shediac Valley. It appears this fish died, although the reason for morality is not immediately obvious, as typical signs of predation were not present. More investigation and analysis is required.

Tag 148259 entered the Gulf on June 4th. Just over a month later on July 10th, she was detected at the SOBI. Unfortunately this satellite tag did not transmit and it is impossible to determine why at this point. If the fish was predated upon, the tag, antennae, or pop-off mechanism could have been damaged. These tags cannot transmit from below the surface. However, all is not lost as these tags are buoyant and may be found eventually. In 2015, two tags washed up on beaches – one in Greenland and one in Ireland, and these tags were returned.

Tag 148260 entered the Gulf on May 19th, and was detected at all three Bay exits over 6 days. On July 8th it was recorded at the SOBI. Unfortunately this satellite tag did not transmit. The tag may eventually be recovered if it washes ashore.

Tag 148261 was not recorded entering the Gulf because the internal acoustic tag was rejected and detected continuously in the Reb Bank area. She occupied depths of 2-10m and water temperatures of 10-15°C in mid-late May. In early June she dove to 50m and 1°C, where

she remained until the satellite tag popped prematurely on June 22nd off the northern tip of PEI. Further investigation is required to determine this fish's story.

Tag 148262 entered the Gulf on May 16th. Unfortunately this satellite tag did not transmit, however it was found on a beach on the Magdalene Islands. The tag was returned and shows signs that the release mechanism activated but failed to release properly. The tag has been sent back to the manufacturer for data extraction and the results are still pending.

Tag 148263 entered the Gulf on May 22nd and was detected at two of the Bay exits over two weeks. This fish was not recorded at the SOBI and unfortunately the satellite tag did not transmit. The tag may eventually be recovered if it washes ashore.

Tag 148264 entered the Gulf on May 27th. She was detected at the SOBI five weeks later on July 6th. Unfortunately this satellite tag did not transmit. The tag may eventually be recovered if it washes ashore.

Acoustic Tags:

All of the acoustic tags were detected at the outer Bay receivers between May 18th and June 9th. It is assumed these fish were traveling east and entered the GOSL. Tags 24810, 24815, 24816, 24818, and 58537 were detected at the SOBI array between July 3rd and 10th.

Table 1. Total number of kelt with acoustic tags and % survival through various locations from 2008 and 2015. * indicates this information is not available until next year and only applies to kelts which received long term acoustic transmitters.

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

Staging Areas

Two potential staging areas have been noted in the past for kelt; one in the western GOSL, south of Anticosti Island (Figure 2a) and one off the coast of Labrador in the North Atlantic (Figure 2b).

Three fish tagged with satellite tags (148254, 148255, 148257) spent time in this area of the Gulf during May and June before migrating further to the Atlantic Ocean. These fish were alternate spawners. One of these three survived out of the SOBI and traveled into the Labrador Sea. Once there, she showed some diving behaviour up to 50m.

A fourth fish (148256) spent time in the more central Gulf before traveling to the SOBI (also an alternate spawner). She exhibited diving behaviour up to 330m in the Labrador Sea. Dives to this depth were not observed in the GOSL area. These movements could be associated with predator avoidance or the fish searching for food sources (reconditioning).

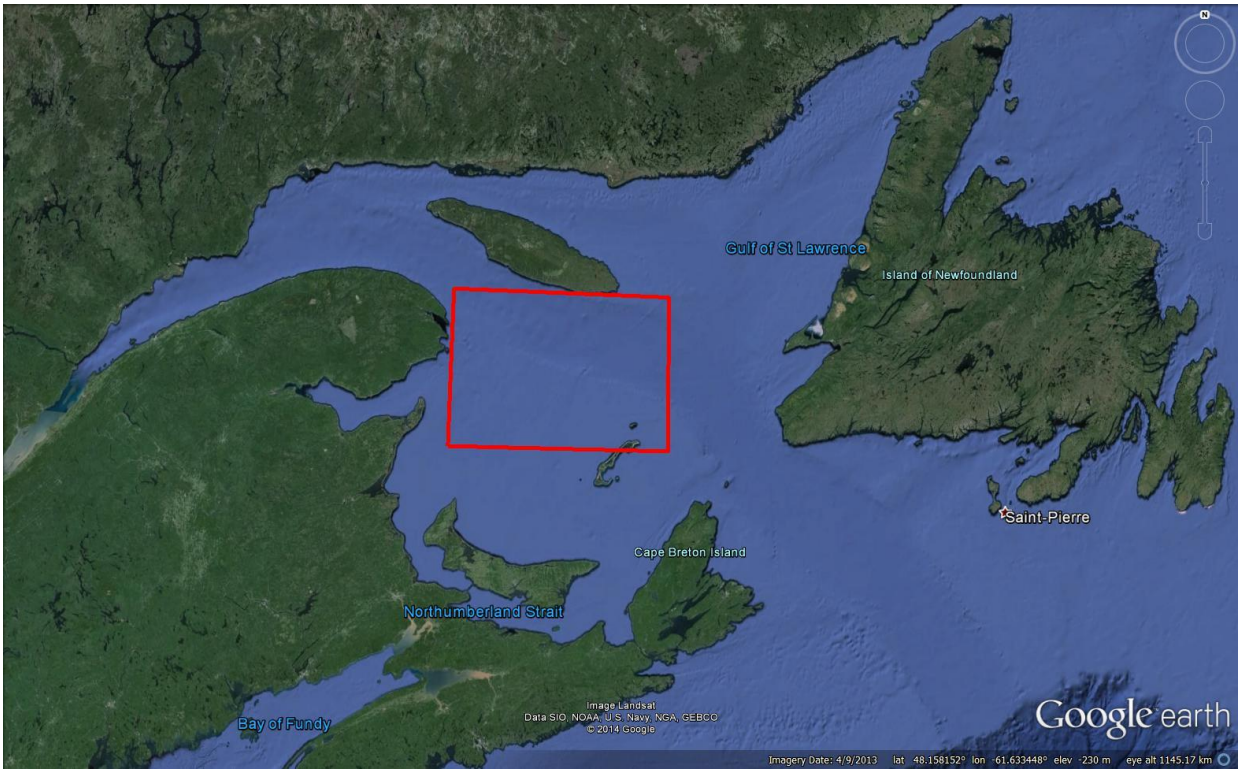


Figure 2a. Potential staging area in the Gulf of St. Lawrence. Four fish occupied this space during the months of May and June in 2015.

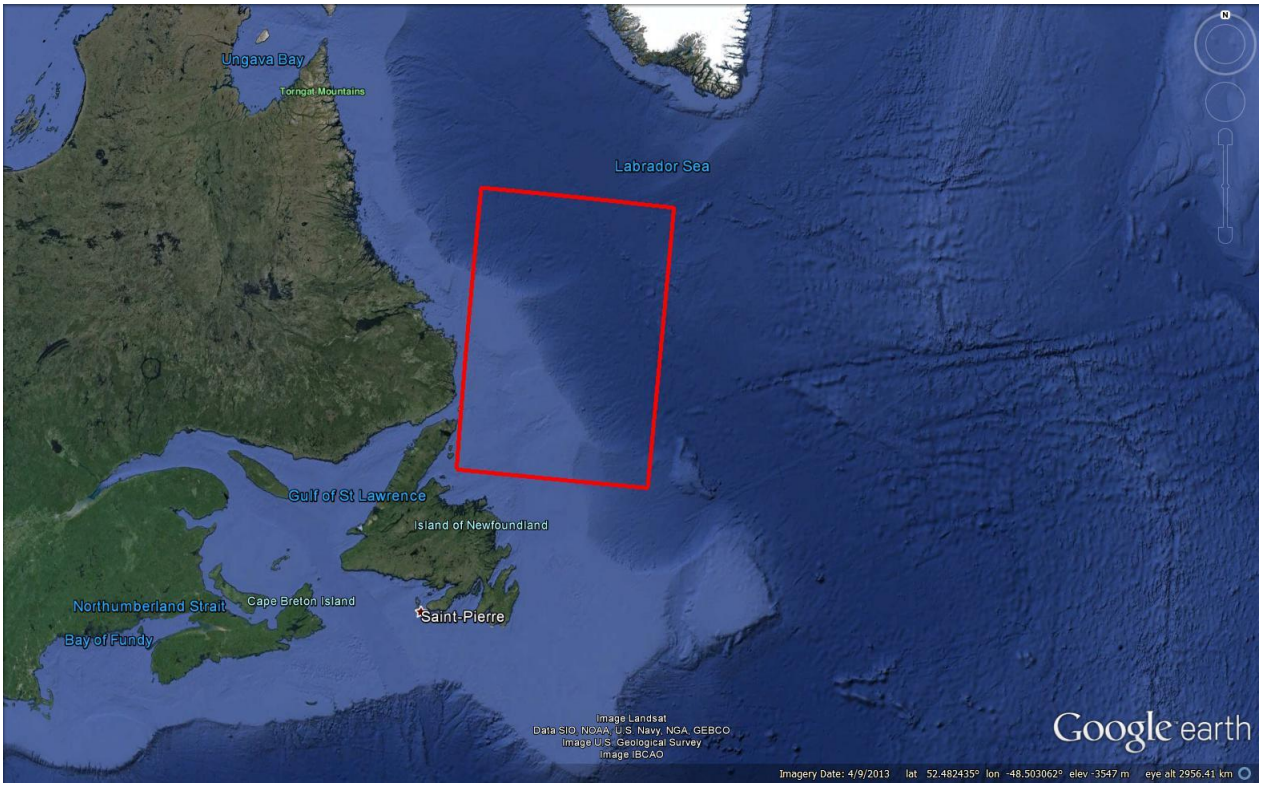


Figure 2b. A second potential staging area in the North Atlantic for alternate spawners. One fish was in this location from mid-July to mid-August 2015.

Tag Recovery

In 2015, only one satellite tag (148262) was recovered after deployment – it had washed ashore on the Magdalene Islands. This tag will be refurbished and used in 2016. Of the ten remaining satellite tags, four failed to transmit entirely and were not recovered, and six successfully transmitted data from fish that survived out of Miramichi Bay and into the Gulf of St. Lawrence and Atlantic Ocean.

Discussion

In 2015, 55% (6/11) of all satellite tagged kelt successfully transmitted data on fish movements, water temperature, and depth. The five tags that failed to transmit were never detected, however acoustic data showed that all five fish survived out of Miramichi Bay, and three of them to the SOBI (148259, 148260, and 148264).

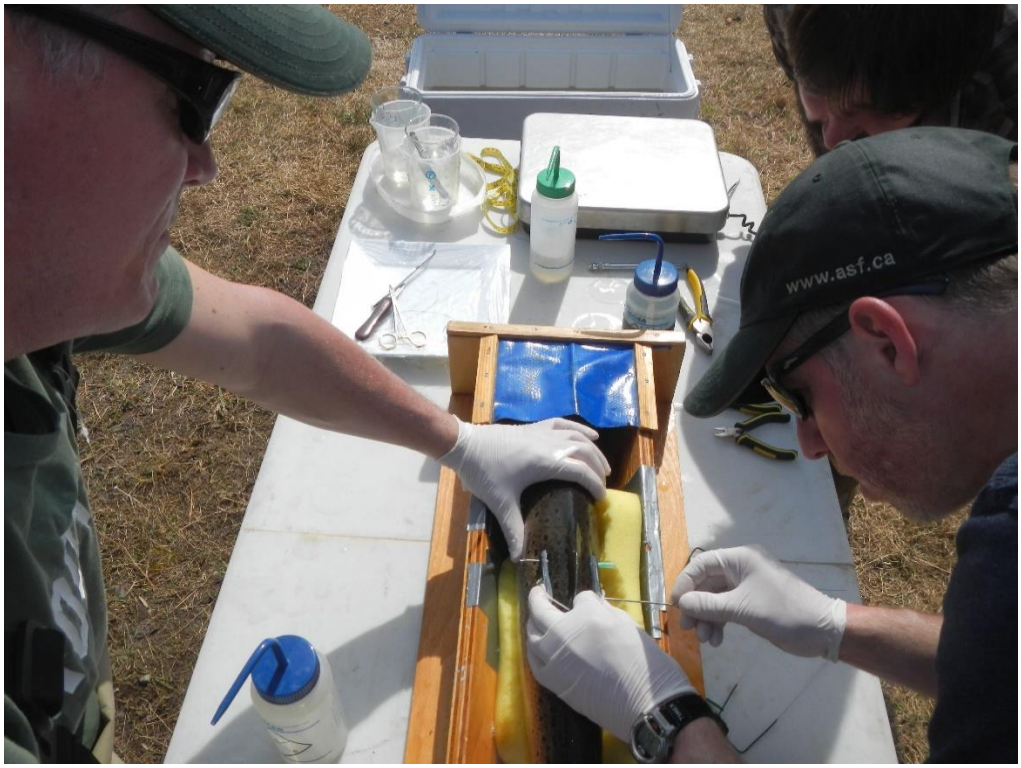
The failure of satellite tags to transmit could be the result of several factors which include: technical failure, tag damage, or tag obstruction from satellites (i.e.: stuck under debris, or caught in the stomach of a predator). Despite these failures, discussions with Microwave Telemetry Inc. (MTI), the manufacturer of these tags, suggest that our return rate of data has been strong compared to other studies.

One of the pop-off tags deployed on schedule at the pre-programmed date of August 31st near Nachvak Fjord in northern Labrador. Initial satellite data suggests this fish moved through the Strait of Belle Isle on July 8th. Although this date may change with more fine scale analysis, it falls within late June – early July, and matches up with the five long-term acoustic tagged fish that passed through in early July as well (24810, 24815, 24816, 14818, and 58538). Given the northern location and late season timing of the transmission from this tag, it is safe to assume this kelt was an alternate spawner on her way to recondition in the cold northern waters of the Atlantic Ocean before returning to spawn in 2016. Advanced analysis of the data from this tag 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 five tags that deployed prematurely (four in the GOSL (148254, 148257, 148258, and 148261, and one off the coast of Labrador (148256)), only one has strong supporting evidence of being predated – tag 148256. A dive to 330m was observed in early August, with water temperatures around 10°C. At this depth, a sudden increase in temperature was noted, up to 24°C and most likely points to the tag being consumed and resting in the stomach of a predator. The temperature recorded then decreases to 5°C and the tag depth changes to ocean surface levels; four days later the tag began transmitting. Tags 148254 and 148257 popped after 4 days of constant depth, however a deep dive prior to tag release and 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. Tags 148258 and 148261 both show dives to approximately 50m and drops in temperature to 1-2°C for 10-14 days prior to tag release. No temperature spike was observed however. 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 2015 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.

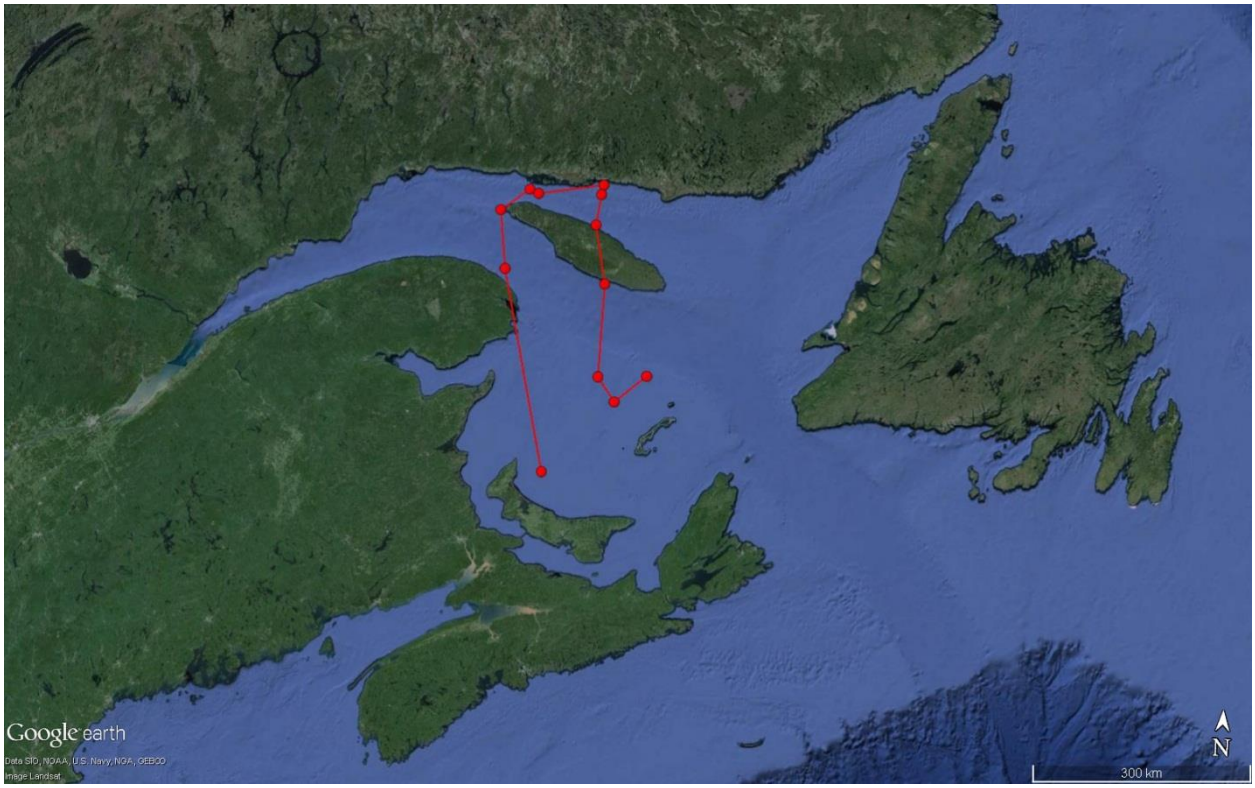
Determining movements of individual fish requires considerable work and statistical analysis. Tag position is determined by converting daily recorded light intensity and duration to sunrise and sunset timing each day. Positioning is then determined by calculating the marine area that would have those 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.



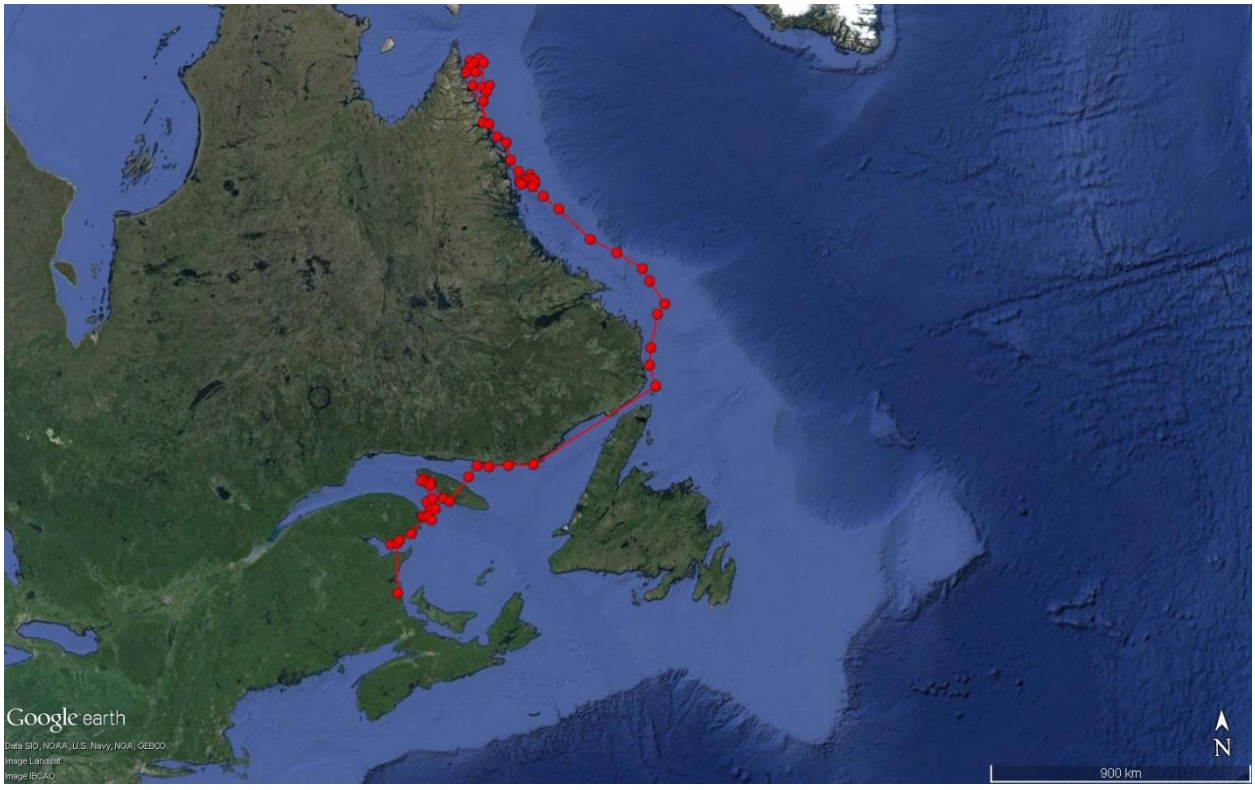
ASF Biologists Jon Carr (left) and Graham Chafe (right) attaching a satellite tag.

Satellite tag attached under the dorsal fin.

Appendix 1: Satellite tagged kelt tracks 2015.



Tag 148254



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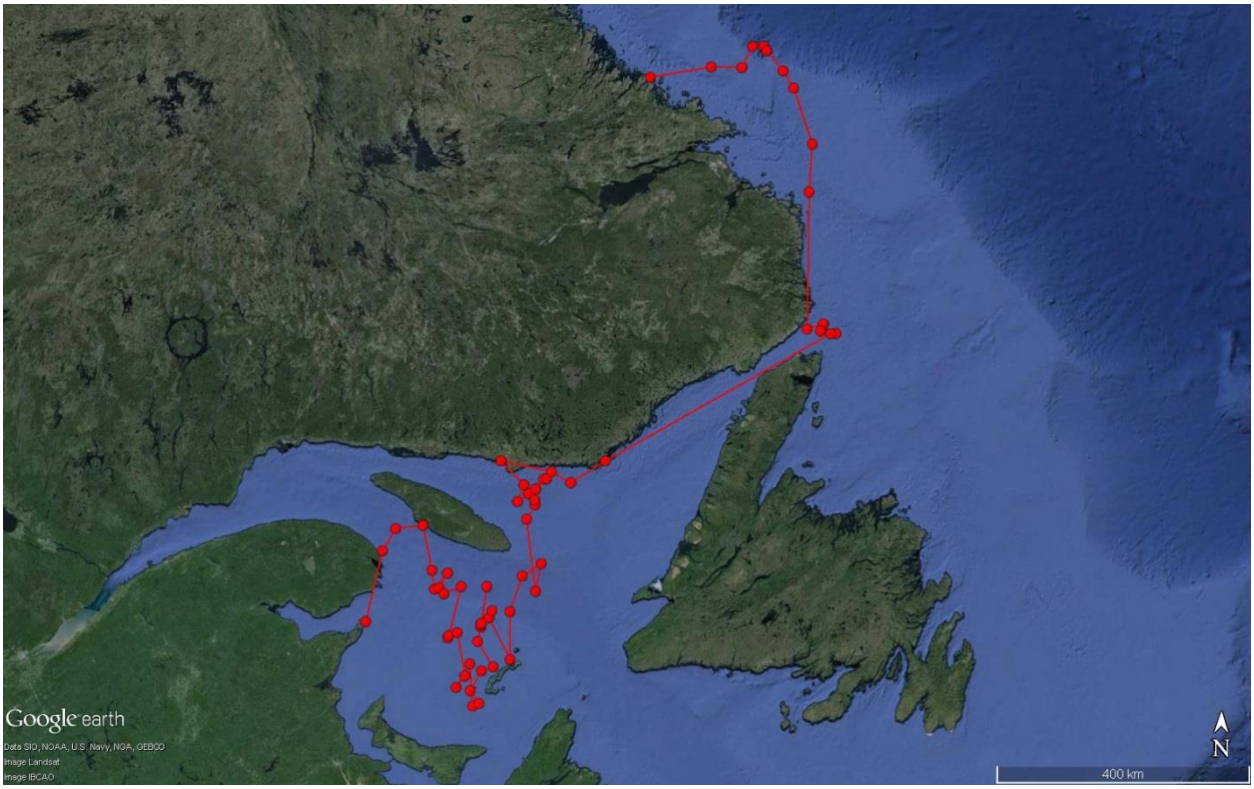
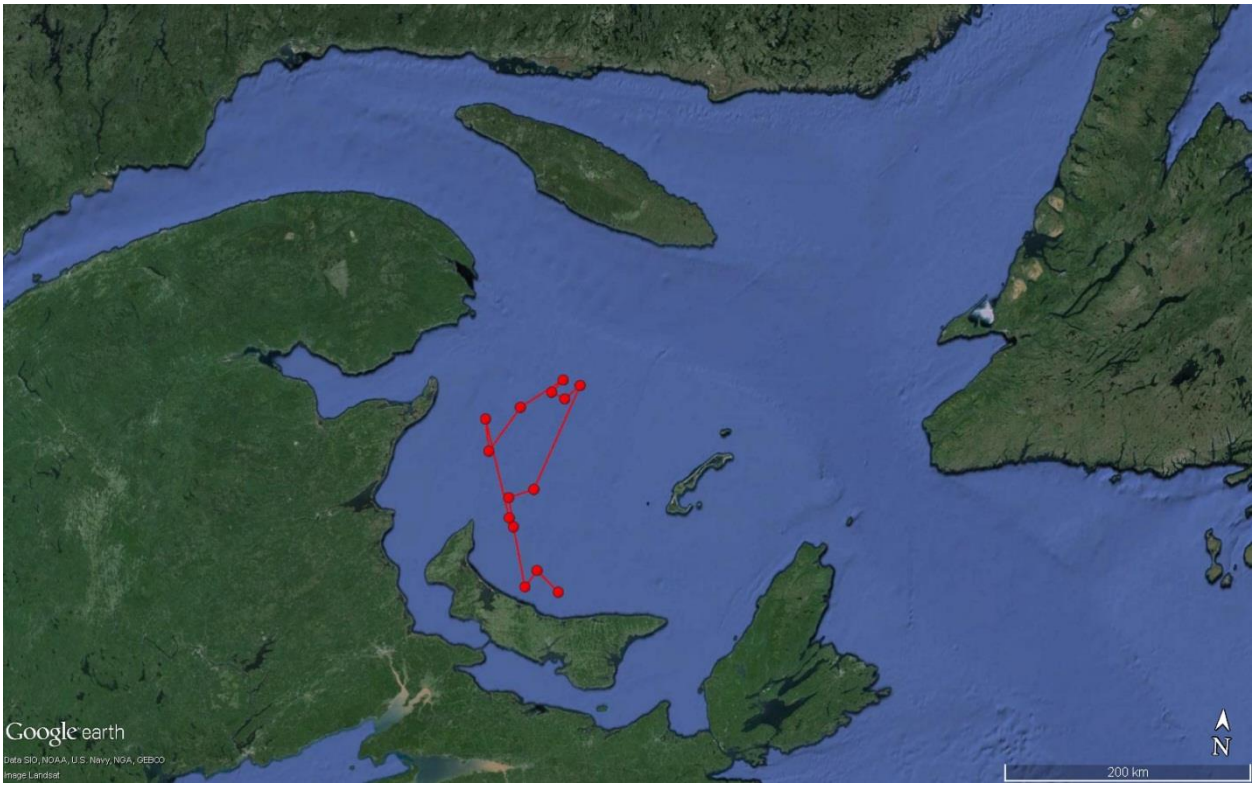
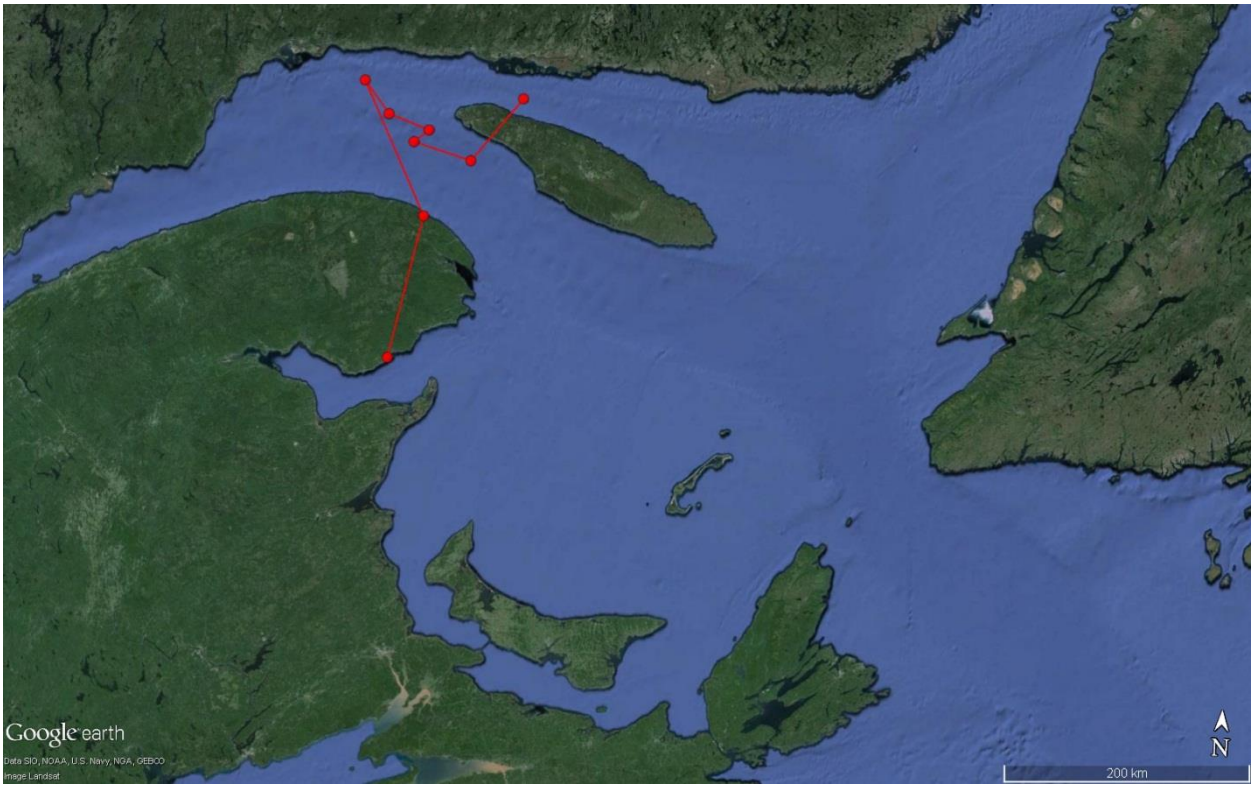


Tag 148256



Tag 148257

Tag 148258



Tag 148261