Endangered Atlantic Salmon Curtail Their Oceanic Migration

Gilles Lacroix is a research scientist who, over his 40 year career, has witnessed and studied many of the impacts leading to the continued decline of Atlantic salmon. His interest in the mysteries of the silver leapers' migrations steered him to novel telemetry tools to track salmon in the past two decades.

The Atlantic salmon (*Salmo salar*) undertakes extensive migrations, first from natal rivers to oceanic feeding grounds in the North Atlantic, then back to home rivers to spawn. Unlike other salmon species, they can survive spawning to repeat this migration several times. Atlantic salmon abundance has steadily declined throughout its range during the last century because of freshwater habitat loss and pollution, and overexploitation. More recently, the decline accelerated in some regions even with habitat restoration and reduced exploitation, resulting in some populations being listed as endangered. Mortality at sea, possibly related to climate change, is thought to be responsible, though there are few data on the marine phase of salmon. The return of adult salmon to the ocean to recondition, combined with the X-Tag's small size and ability to detach and report at death, provided an ideal opportunity to determine where, when and why salmon are dying in large numbers at sea.

Photo by Ross Jones

Attaching X-Tag to Atlantic salmon in the river. A tagged salmon is recovering in the foreground.

Between 2008 and 2011, 55 salmon were captured and tagged as they returned to sea after spawning in rivers of the Bay of Fundy, Canada. Salmon ranged from 50 to 90 cm, which makes them some of the smallest fish tagged with PSATs. They originated from populations that either persist or are endangered. A secure method of tag attachment had been developed and tested with dummy tags on salmon held in captivity; the tags did not impede swimming or feeding activity, and there was no tag-related mortality or attachment failure. X-Tags were specially programmed to take into account salmon habitat and behaviour to avoid failure in freshwater or premature at-sea triggering of the constant depth release. Thirty-nine of the salmon migrated to sea in the season of tagging, and their tags all provided some archived data. They transmitted at death or after the programmed 4 to 6 months, or they were recovered by beachcombers. A quarter of these tags were returned for full data extraction which gave uninterrupted light intensity, depth and temperature series.

Migrating salmon spent most of their time near the surface which increased the accuracy of light-based daily raw geolocation estimates. Population-specific migration routes were detected for salmon that survived to the end date. Filtered tracks of 2600 to 5000 km were obtained for salmon from the population that persists. They migrated northward along the Continental Shelf, swimming near the surface against the prevailing Labrador Current at a rate of 27 to 50 km per day, which suggests that the tags did not seriously impede performance. Salmon from endangered populations did not complete this rapid migration to distant feeding areas, but proceeded slowly in the coastal zone, making repeated daytime shallow dives indicative of feeding as soon as they left the rivers.

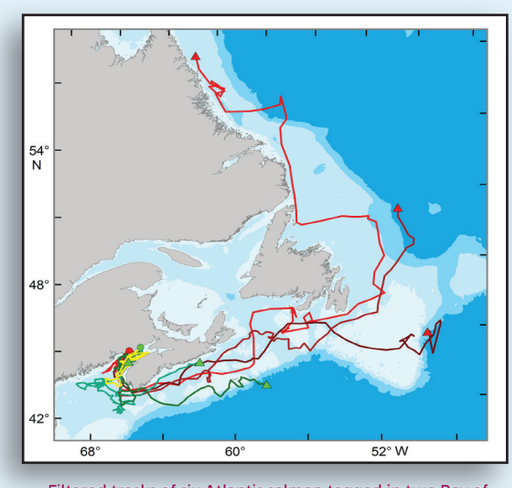
Photo by Tom Benjamin

Details of X-Tag attachment to Atlantic salmon. Monofilament leads from tag to each side of the salmon stabilize the tag.

The distinctive behaviour of the endangered salmon resulted in a curtailed home range. The range boundaries for both coastal and distant migrants were further defined by their thermal preference at sea (0 to 15°C), and their avoidance of adjacent warm waters. For instance, distant migrants avoided entrainment into the warm Gulf Stream and North Atlantic Current, and coastal salmon sought cold thermal refuges in the Bay of Fundy and northern Gulf of Maine during summer. In winter, coastal salmon stayed in freezing habitat by changing their vertical habits and avoiding the supercooled surface layer that can kill salmon. Salmon were previously thought to be absent from these cold, freezing coastal areas during winter.

Changes in bathymetry along migration tracks resulted in marked changes in the vertical movements of salmon that possibly aided in orientation and in locating abundant resources. Salmon made repeated deep dives, some up to 1000 m, lasting up to 2 days when crossing deep ocean channels or when reaching the edge of the Continental Shelf. They then adjusted their migration course or spent time in the area making shallower diurnal dives associated with feeding. Their ability to make repeated dives or rapid deep dives through the thermocline, remain in cold deep water for several hours, and make a gradual ascent back to the surface and regulate buoyancy all attest to the minimal impact of the tags and the benefits of the method of attachment used.

The X-Tags provided evidence of extensive natural mortality of salmon in coastal areas within 2 months of leaving the rivers and no evidence of fishing mortality. Mortality of the endangered coastal salmon was clustered in a few areas inside the Bay of Fundy, whereas the mortality of distant migrants occurred mostly along the Scotian Shelf. Sudden changes in light intensity, depth, and temperature indicate that salmon and tag were frequently eaten by apex predators (11 cases). The identification of key predators from the depth and temperature profiles is the subject of a soon to be published article.



Filtered tracks of six Atlantic salmon tagged in two Bay of Fundy rivers (circles) that survived to end date. Triangles show pop-off locations along Canadian coast for distant (red) and coastal (green) migrants.