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The Design and Operation of a Picket Weir to Sample Brook Trout and Landlocked Salmon in Tributaries to Moosehead Lake

Progress Report No. 1

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Summary

A picket weir was designed and fabricated for sampling wild Brook Trout and Landlocked Salmon on their spawning migrations in tributaries to Moosehead Lake. The weir was installed on Socatean Stream in 2009 then on the Roach River in 2010 and 2011. Staff utilized radio telemetry and Passive Integrated Transponder (PIT) tags to monitor movements and estimate mortality. A total of 132 fish were equipped with radio telemetry transmitters and 872 fish were implanted with PIT tags during the three years of sampling.

Post-spawning mortality rates for wild male Brook Trout ranged from 44-63% during the study. Sixteen to twenty-five percent of surviving Brook Trout returned to spawn in a second consecutive year, while less than 3% of the Landlocked Salmon returned to the Roach River.

The winter sanctuary areas established in the 1930s, 1950s, and 1960s to protect wild Brook Trout are still effective. Many of the tagged Brook Trout utilized these areas during the winter months and were therefore unavailable for angler harvest.

The weir will be a valuable tool for fisheries managers in the Moosehead Lake Region and other areas of the state in future fisheries studies.

KEYWORDS: BKT, LLS, AGE & GROWTH, AGE FREQUENCY, SIZE FREQUENCY, EXPLOITATION RATE, MIGRATION, MOVEMENTS, HOMING, REGULATIONS, SURVIVAL, TAGGING, MORTALITY, WEIR.

Abstract

Brook Trout (*Salvelinus fontinalis*) are an important game species in Maine, and have been the subject of research for decades. In 1956, a weir was constructed on Socatean Stream to evaluate the spawning run in this tributary to Maine's largest wild Brook Trout lake. A new portable picket weir was fabricated in 2008 to replicate the earlier sampling of mature Brook Trout in Socatean Stream. The weir was then moved to the larger Roach River to sample Brook Trout and Landlocked Salmon (*Salmo salar*) in 2010. A total of 132 fish were equipped with radio telemetry transmitters and 872 fish were implanted with Passive Integrated Transponder tags during the three years of sampling to monitor movement, to evaluate the effectiveness of established refuge areas, and to assess post-spawning mortality.

Post-spawning mortality for male Brook Trout ranged from 44-63% in the three years of sampling in Moosehead Lake tributaries. The percent of tagged Brook Trout returning to the Roach River for a second consecutive year ranged from 16-24% and 7-8% for the third year. The percent of Landlocked Salmon returning for a second consecutive year of spawning ranged from 0-3% and less than 1% during the third year.

The winter refuge areas on Moosehead Lake that were established in the 1930s, 1950s and 1960s to protect Brook Trout are still effective. Forty-six percent of the surviving Brook Trout in Socatean Stream that traveled to Moosehead Lake overwintered in an area closed to ice fishing. Similarly, 63% of the surviving Brook Trout from the Roach River utilized these sanctuary areas.

The newly designed picket weir will be a valuable tool to evaluate spawning runs of wild Brook Trout and Landlocked Salmon in the future.

Introduction

Brook Trout (*Salvelinus fontinalis*) are important to Maine's natural and cultural history. Native Americans utilized these fish as food and there are many landmarks named after this key fish species. There is a long, rich history of sporting camps, hotels, and guiding revolving around Brook Trout (trout) angling, primarily in the North Woods of Maine in the late 1800s and early 1900s. While many of the camps are gone, the tradition of trout fishing endures. A statewide survey of resident and nonresident anglers by Responsive Management in 2015 indicated that 58% and 64% of open water and ice anglers, respectively, targeted trout, respectively, making trout Maine's most sought after gamefish. In 2005, the Maine Legislature recognized their importance to Maine's history and future by designating trout a State Heritage fish.

The Fisheries Division has been collecting data on trout since the Division's inception in 1950. Protective regulations were implemented on many of Maine's best trout fisheries in the early years of the Division. There has been much work on wild and native trout in Maine over the past 60 years to advance management of this important species. Maine was recently recognized as the only state across the original distribution of trout to have significant numbers of intact populations in lakes exceeding 5,000 acres. Wild trout populations in these large lakes can be much more complex than those in smaller ponds. Larger lakes have more extensive watersheds and connectivity than smaller systems, which can be utilized by the various life stages of trout. These waters tend to have two season fisheries and multiple game species which makes management multifaceted. We are still learning about trout populations in these large oligotrophic systems.

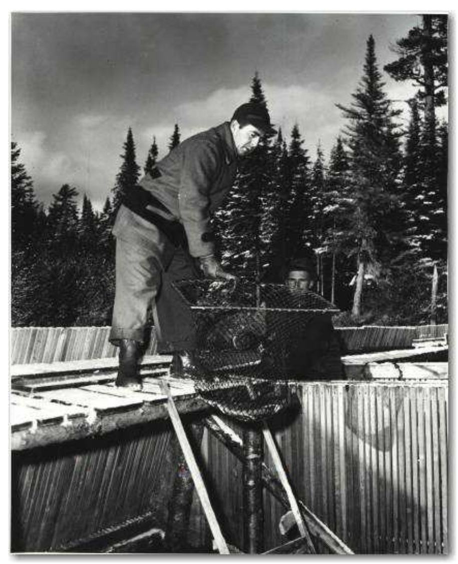

Figure 1. Fisheries Biologists Roger AuClair and Dave Locke tend the weir on Socatean Stream in 1956.

In 1956, Roger AuClair, the first Regional Fisheries Biologist assigned to the Moosehead Lake Region, and his assistant Dave Locke, constructed a wooden fish weir on Socatean Stream, a well-known spawning tributary to Moosehead Lake (Figure 1). The first weir attempt was blown out during a high-water event that year. The weir was redesigned and the staff returned in 1957 in another attempt to sample the spawning run of trout. This time the weir was constructed and anchored on a ledge protruding into the stream. The anchors are still present today and parts of the wooden picket weir can be found in the woods adjacent to the site. The project was very successful and the biologists handled over 1,200 wild trout (AuClair 1982) allowing for an intensive tagging assessment as well as collecting basic life history information on a brook trout population from a large oligotrophic lake with a substantial drainage area.

In 2005, the Fisheries Division staff in the Moosehead Lake Region reassessed the data collection techniques that were currently utilized to assess the fisheries on Maine's largest lake. Collection of trout data was heavily reliant on winter clerk surveys. Recent restrictive bag and size limits resulted in diminishing sample sizes. It was determined that a larger sampling event was needed, and one that could be periodically repeated. It had been nearly 50 years since the last sampling at Socatean Stream but the spawning run was still present. However, the abundance of trout in that run was unknown. It was determined that a new, modern weir could be used to once again assess the spawning run of wild trout on Socatean Stream. In fact, a brief review of existing weir designs led us to believe that a reusable, portable weir could be used at multiple sites around Moosehead Lake and the entire Region. This type of weir could become an important tool in evaluating wild trout spawning runs in small and large streams in Maine. The new weir was designed in 2008 and fabricated in 2009 (Figure 2). The first installation occurred on Socatean Stream in August 2009. The weir was moved to the Roach River, another major trout spawning tributary to Moosehead Lake, in 2010 and 2011.

Figure 2. The finished Socatean Stream weir in 2009.

The objective of the study at Socatean Stream included a comparison of the current spawning population to that observed by AuClair in 1956 and 1957. This was prior to the establishment of several severe competitors including Yellow Perch (*Perca flavescens*), Smallmouth Bass (*Micropterus dolomieu*), and White Perch (*Morone americana*). Fishing techniques and technology had also changed as well as angler use and land use patterns. New techniques were also available to fisheries managers in 2009 compared to the 1950s. We planned to utilize Passive Integrated Transponder (PIT) tags and radio telemetry to assess post-spawning mortality, trout movements throughout the year, homing, and the effectiveness of several large sanctuary areas that were closed to ice fishing for the sole purpose of protecting trout.

The objectives were the same at the Roach River in 2010 and 2011, although we would be able to extend the study to evaluate wild Landlocked Salmon (*Salmo salar*) since the river had a prolific run. We also hoped to evaluate and refine the development of a weir that would allow us to sample large numbers of wild trout and Landlocked Salmon (salmon) and lead to a standard site and methods that could be used in the future to develop trends in abundance for Moosehead Lake and other waters around the Region.

This report presents the results from the studies completed on Socatean Stream and the Roach River from 2009-2013. It also details the construction of the weir so that other fisheries biologists can use this as a guide for future projects.

Study Area

Socatean Stream

Socatean Stream flows from the Socatean Ponds, in Plymouth Twp, about eight miles to the northwest shore of Moosehead Lake. These two small headwater ponds are perched on the height of land just south of Seboomook Lake between the Penobscot and Kennebec drainages. The stream was used for driving logs well into the 1900s. The remnants of log driving dams can still be found throughout the stream. Socatean Stream is free from any residential development. The riparian area is heavily forested with softwood, primarily spruce, fir, and cedar. There are several large gravel pits in close proximity to the stream that are still actively utilized for road maintenance by the commercial landowner. There are numerous smaller feeder brooks and groundwater springs along the entire length of Socatean Stream which makes the stream a source of cool spring water to the lake. There is a substantial set of falls located between the road crossings on the Williams Brook Road and the Tomhegan Stream Road. These falls could be impassable to fish at certain flows. Most of the stream sections are low velocity with scattered beaver dams that also present obstacles for fish moving upstream, especially during periods of low water. There are no active man-made dams or water control structures on this stream system.

Roach River

The Roach River flows approximately six miles from First Roach Pond to the confluence with Moosehead Lake in the southeast corner of Spencer Bay. A concrete dam on the outlet of First Roach Pond regulates the flow into the Roach River. There is a long history of dams at this site. The dam was originally constructed to facilitate log drives. It was used for water storage for downstream hydroelectric projects after the cessation of log drives in the 1970s. The dam is currently owned and operated by the Department of Inland Fisheries and Wildlife (DIFW) for the primary purpose of salmon and trout production. Typical operation includes capturing spring melt to fill First Roach Pond to an elevation between seven and eight feet. The DIFW attempts to maintain this elevation for the period of Memorial Day to Labor Day. The normal summer flow is approximately 100 ft^3/s. The pond is slowly drained after the first week of September. The flows are ramped up two or three times during the month of September to provide optimum fall fishing flows in the river between First Roach Pond and Moosehead Lake. The pond is typically at or near its minimum elevation by mid-October when the gates are opened fully to pass all water until the following spring.

There is some development near the dam including a store, private camps, and two sporting camps/campgrounds at Kokadjo. The river below Kokadjo is totally undeveloped. In fact, there are only a few fishing access trails into the river.

The river flows through mixed forest over the six miles to Moosehead Lake. The river is predominately run/riffle habitat with very few true pools to hold adults in the summer months. There are no obstacles to fish passage. The entire length of the river is ideal salmon nursery habitat.

In the late 1930s, several large areas of Moosehead Lake were closed to ice fishing to protect post-spawning trout. The closures were the direct result of large catches of trout during the winter months (Figure 3).

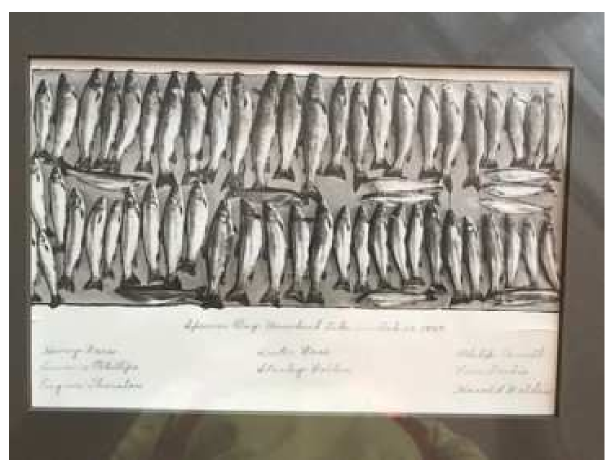

Figure 3. Photo of a large catch of Brook Trout from Spencer Bay in the winter of 1937. Photo courtesy of Leighton Wass.

These trout were overwintering at the mouths of known spawning tributaries Public concern over the excessive harvest resulted in the closure of Spencer Bay, Socatean Bay, and the mouth of Moose Brook. These closures remain today and could be fully evaluated with radio telemetry studies.

Methods and Materials

Evaluation of different weir designs

The initial plan for the Moosehead weir was to use it to evaluate the run of wild trout on Socatean Stream, which Roger Auclair had surveyed 50 years earlier.

Research into the type of weir that would best suit our applications resulted in several different designs. A search on the Internet identified a company in Montana that commercially builds fish traps. We contacted Ironwood Specialties LLC and inquired about their product, and explained what we were planning to build and how it was going to be used. We provided the specifications for our weir and they in turn developed a price quote to build, deliver, and install their fish trap.

Their fish trap design had a few drawbacks. First it was very heavy and bulky, which would require large equipment, such as a crane or an excavator, to transport and place the weir into the stream. Second, specialized equipment would be needed to anchor part of the weir to the streambed. This was not conducive for sampling remote streams in our Region. Third, the smallest bar spacing they could provide was 1 in and we required ½ in spacing. Finally, the overall cost of their weir exceeded our budget.

We also evaluated a resistance board weir design that the Maine Atlantic Salmon Commission had used on some of Maine's Downeast Rivers for sampling anadromous runs of Atlantic Salmon. This style of weir was similar to the one Ironwood Specialties LLC had designed and had similar drawbacks. The resistance board weir and trap would also need larger equipment to transport material to the sampling location and additional specialized equipment for installation.

Ironwood Specialties LLC personnel provided us with references of state and federal agencies, as well as a few non-governmental organizations. One reference was the Idaho Fish and Game Department. We contacted the Idaho Fisheries Research Division and explained our project and goals. They provided us with photos of two “picket style” weirs they had used on two rivers to sample runs of Kokanee Salmon and steelhead. Although their weir wasn’t exactly what we were looking for, we used their photos along with additional correspondence to modify and design a “picket weir” that met our objectives.

Constraints for the Moosehead Weir

We identified three main issues that needed to be addressed if we were going to use a picket weir for similar applications in the future, including: accessing the stream, transporting the material, and dealing with varying flows.

Accessibility

Selecting a site for the weir was very important. All efforts were made to locate the weir downstream of all potential spawning habitat to capture most of the spawning run. We determined the best route to the site once a location was identified. The adjacent property owners were contacted early in the site selection process to work out logistics for accessing the site. We tried to get to within a reasonable distance of the stream (less than 1/8 mile) by truck, but getting to the precise site location was still difficult. This required building an access trail. Commercial paper companies assisted us by using mechanized equipment such as a harvester or excavator, but most were constructed using hand tools such as chainsaws or brush saws to gain access by ATV’s and small trailers.

Portability

Many of the rivers and streams we sampled were situated in remote settings. Access to these locations required traveling over unimproved dirt roads and unmaintained old logging roads. We determined that the weir should be built so that it could be transported using 4x4 pickup trucks and trailers to access and sample these locations. In most cases the gear was transported via an access trail to the edge of the stream by ATV and small trailers or by hand. The weir, when disassembled, is designed so the pieces are light enough to be moved by one or two individuals.

Flows

The weir has been used on streams with both natural and regulated flows. When sampling a regulated stream, we can increase or decrease flows. We decide when flow changes occur and can artificially increase the flow to help draw fish into a river or stream. The dam gates are adjusted to provide a more constant flow throughout the spawning season. The duration of these flows is dependent on the volume of water in the reservoir and the size of the release. A regulated flow tends to be more stable with less fluctuation over a period. However, in some instances natural inputs from unregulated tributaries can flow into the regulated portion of the river. This can be difficult to account for during periods of heavy precipitation. Gate adjustments were made at the dam to decrease flow in the regulated portion of the river to offset natural run-off entering the system during these events.

Sampling streams with unregulated flows has proven to be a challenge. Increased fall flows in a natural setting typically vary from year to year, making it difficult to coordinate sampling efforts. Flows in unregulated streams tend to increase and drop more quickly. High flows have proven to be difficult to sample due to increased debris loads on the weir. Sampling during the fall coincides with leaf drop. Leaves and woody debris become impinged on the blocking panels and creates a dam effect which increases the water level behind the weir. This increased elevation and water pressure can create scour holes under and around the ends of the weir that fish can pass through. There is an increased risk of missing some of the spawning run during these high-water events.

Fabrication

The weir was initially designed by DIFW Fisheries Biologists. We contacted Cianbro Corporation (Cianbro) in Pittsfield, ME and provided them with draft sketches and a material list. Cianbro structural engineers reviewed the design and specifications we had developed and made a few structural modifications to the weir’s material. They recommended using thinner steel material for a few of the components which would make them lighter for handling purposes, but still provide adequate strength. Cianbro’s fabrication shop handled the work of ordering, cutting, and drilling the steel. A DIFW Fisheries Biologist worked closely with an independent contractor who completed the welding and fabrication of the weir components.

There are essentially five different components of the weir that required fabrication: tripods, blocking panels, entrance panels, collection box, and fyke.

<u>Tripods</u>

Fourteen tripods were constructed of 6 ft x 2½ in square steel tubing. They were designed so the two back legs are situated downstream to anchor and support the weir as flow pushes against it. The single front leg faces upstream and the blocking panels tie into and rest against it. The two back legs of the tripod have a 2 in x 5 in x ¼ in tab welded on the top of each. The tabs are bent at approximately 30 degree angles and have a ¾ in hole through the center. The ends of a three-foot piece of ¼ in chain are welded 18 in from the bottom of each back leg. The chain prevents the back legs from spreading when subjected to pressure resulting from water pushing against the blocking panels. The front leg of the tripod has a ¾ in hole drilled through it, 1 in from the top. A 4 in x 5/8 in grade 8 bolt is used to connect the three legs at the top by running it through the two tabs of the back legs and the hole in the top of the center leg. The front leg contains two tabs made of 3 in x 2 in x 3/16 in angled steel. Tabs are cut 2 in long, and have two ears measuring 3 in x 2 in and 2 in x 2 in. The 3 in x 2 in ear has a 1 in hole drilled in the center of it. Two tabs are placed on the leading edge of the front leg 18 in from the top and bottom of the front leg such that the 2 in x 2 in ear is welded to the leg with the 3 in x 2 in tab facing up (Figure 4).

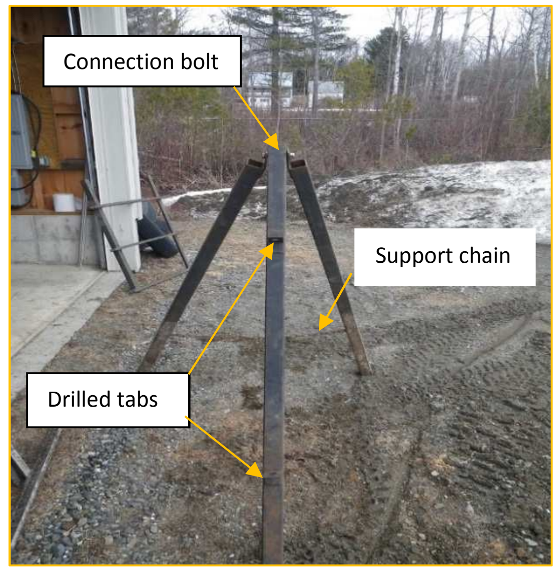

Figure 4. Tripod for supporting the blocking panels.

Blocking Panels

The blocking panels are the large panels which span the stream and extend from each side of the entrance of the collection box to the shore on either side. Blocking panels are supported at each end by a tripod or anchored into the streambank. These panels prohibit fish movement upstream or downstream of the weir site. The blocking panels consist of 6 ft x 3 in x ¼ in channeled steel, with 1 in holes that start ¼ in from the end and spaced ½ in apart and run lengthwise down the center of the piece of steel. There are 8 holes per linear foot of channeled steel. Each section of the blocking panel contains two pieces of the drilled channeled steel. Sections of ½ in pipe with an outside diameter of 0.84 in are slid through the holes in the channeled steel to form the "picket" appearance. Three different lengths of pipe (5, 6, and 7 ft) are used to accommodate varying water depths across the stream (Figure 5).

Figure 5. View of blocking panels spanning the stream.

Entrance Panels

The entrance panels are the heaviest pieces of the weir, weighing approximately 80 lbs. There are two sets of entrance panels used on the weir. One set is used when collecting fish moving upstream and the other for collecting fish moving downstream. The only difference between the two sets is the leading angle of the panel where it attaches to the blocking panels. The set used on the upstream collection box is angled at 55 degrees forward at the top and the set used on the downstream collection box is angled 55 degrees backward at the bottom. The exterior frame is constructed of 2 in x 2 in angled steel. The front portion of the panel is triangular shaped and is comprised of a ½ in square, 3 mm wire mesh-screen measuring 4 ft high by 3 ft long and 5 ft on the angled side. The screen is held in place with a 2 in x 2 in exterior frame and a 1 in x 1 in interior frame both 3/16 in thick, and drilled with ¼ in

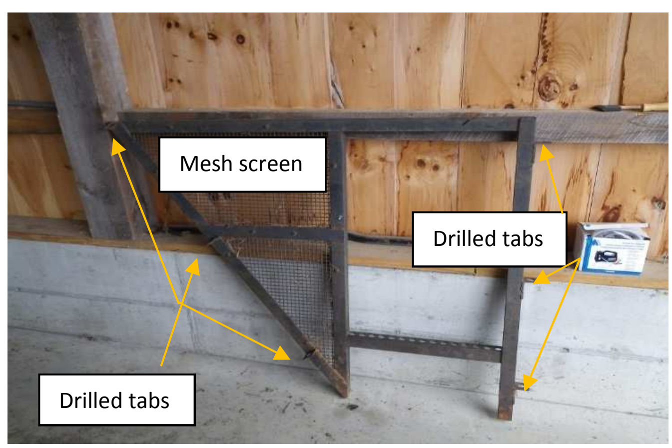

Figure 6. Left frame of the upstream entrance panel.

holes and bolted together. Two - 20 in x 2 in x 3/16 in pieces of flat steel are welded to the outer edge of the angled portion of the frame on either side of the mesh screen for added support. The back 2 ft portion of the angled steel frame is drilled with 1 in holes and spaced ½ in apart. These holes accept the 5 ft long, ½ in pipe with an outside diameter of 0.84 in to close in this portion of the frame. The panels have three - 2 in x 2 in tabs drilled with a 1 in hole in the center and are evenly spaced from top to bottom and are welded to the side of the angled portion of the screened frame. The end pipe from the blocking panel is passed through these two tabs tying the two panels together. There are three similar tabs on the back leg of each entrance panel that tie into each side of the front panel and the three side rails on either side of the collection box by a single 6 ft pipe (Figure 6).

Fyke

The fyke is used to funnel fish from the entrance into the collection box (Figure 7). The small end is located inside the collection box and is approximately 12 in off the bottom of the stream bed, making it difficult for fish to find the opening to escape. The initial fyke consisted of a wooden frame covered with a ½ in wire material. However, it was replaced due to beavers chewing on the frame. A second fyke, with a similar design was constructed using 1 in angled steel and covered with ½ in metal diamond screen. The back has a welded flange on either side which allows it to be lowered into a slot on the front panel of the collection box. The new fyke was designed to accommodate both deep and shallow water depths. The fyke is placed in the entrance panel with the steeper sloped side facing the stream bed in deep water installations. However, if water depths are shallow or they drop during a sampling event, the opening into the collection box can become exposed. The fyke can be pulled out of the slot in the entrance panel, flipped 180 degrees, and placed back into the slot so that the shallow sloped side is facing the stream bed. The fyke would then be lower in the water column and this allows fish to successfully enter the collection box.

Figure 7. Top view of the fyke inside the collection box.

Collection Box

The collection box is the part of the weir that holds the fish (Figures 7 and 8). Studies designed to collect fish moving into and dropping out of a stream require two collection setups. Each collection box is comprised of a front panel, a back panel, and two side panels made of six (3 per side) 8 ft x 2 in x 2 in angled steel. The front and back panels are welded rigid frames (Figures 9 and 10).

Figure 8. Outside view of the collection box.

The back panel has two - 4 ft x 2 in x 2 in upright pieces of angled steel (undrilled) that have three - 4 ft x 2 in x 2 in angled steel (drilled). Similar to the 6 ft channel pieces of the blocking panels, all pieces receiving pipes are drilled with 1 in holes spaced ½ in apart and run lengthwise down the center of the angled steel.

Figure 10. View of the back panel of the collection box.

The front panel is constructed of two - 4 ft x 2 in x 1 in upright pieces of angled steel spaced 24 in apart and each has a 2 ft x 2 in x 2 in piece of angled steel welded onto the side of them at the bottom to form a slot or track which the fyke slides securely into. There are three - 4 ft x 2 in x 2 in cross pieces of angled steel with 1 in holes spaced ½ in apart and run lengthwise down the center that are located at the very top and bottom of the front panel. The middle cross piece is located 22 in down from the top. A solid 2 ft x 1 ½ in x 1 ½ in piece of angled steel is welded to the middle cross piece between the two upright pieces to form a shelf. This shelf supports the short pipes which lie along the top

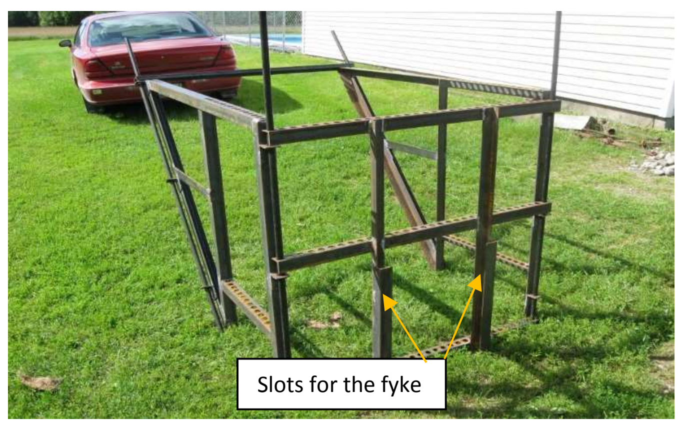

Figure 9. View of the front panel frame of the collection box connected to the two side entrance panel frames.

of the fyke to form a suspended panel above the fyke (Figure 11). A piece of plywood is typically placed over the top of the collection box to keep birds and other predators from entering the box.

Site selection

The physical characteristics of the site are very important. The site needed to have a well-defined channel with moderately sloped banks. We determined that stream banks comprised of coarse material, such as boulders or ledge, remained stable when anchoring the ends of the weir into the bank. Low flood plain areas should be avoided due to increased widths of the stream and the additional weir material needed to traverse the flood plain.

Figure 11. View of shelf for the short pipes and slots for the fyke to slide into on the front panel of the collection box.

Low stream banks made it easier for water to flow around the ends of the weir during high flow events. The streambed should contain rough or coarse material such as cobble and small boulders. The coarse material tended to remain in place during high flow events and was not as prone to scouring under or around the ends of the weir.

A straight section of stream with relatively uniform depth and flow across the channel is preferred. The site needs a 4 ft wide by 8 ft long area that is void of large boulders and that will maintain approximately 1 ft of water during low flow periods. This area is where the collection box was positioned. The cross section of streambed where the weir was placed needed to be void of any large boulders or logs. Large boulders can be difficult to work around and in some cases, prohibit the pipes in the blocking panels from setting securely along the bottom, leaving holes that fish can pass through. The sites needed to contain large stationary objects such as boulders or trees in and along the edge of the stream that were used as anchor points to help support the weir. These should be located no more than 100 ft upstream of the weir.

Transporting

We had to consider how we would transport the materials to and from the site with minimal machinery when designing the weir. The weir material and associated gear were loaded onto pickup trucks and utility trailers for transport to the weir site (Figure 12).

Figure 12. Weir parts and gear loaded for transport to the stream.

Figure 13. Transporting material to the weir site using ATV's and trailers.

The road conditions used to reach the access trails often determined how heavy we loaded the trucks. If roads were rough or muddy the loads were lighter, however if road conditions were favorable, more material was hauled on a single truck. We transported all the material for a weir spanning a 55 ft wide stream on three pickup trucks and one utility trailer in one situation where access was good. It was loaded into the back of an ATV equipped with a rear dump box or onto small utility trailers and towed by ATV’s (Figure 13). Several trips were needed to move the material from the trucks to the weir site where it was placed near the stream bank and organized. It should be noted that when off-loading the material at the stream bank, it should be stock piled in an organized fashion (Figure 14).

Installing

The weir is typically installed in three stages and should be completed by at least three people. The first stage includes positioning and setting up the framework. Then the pipes are installed and then the structure is secured. The most critical step installing the weir is the placement of the entrance panels and framework for the collection boxes in the stream. This spot should maintain

Figure 14. Material organized and ready to be assembled.

approximately 1 ft of depth for fish to successfully pass through the fyke and to hold fish in the collection box during low flow situations.

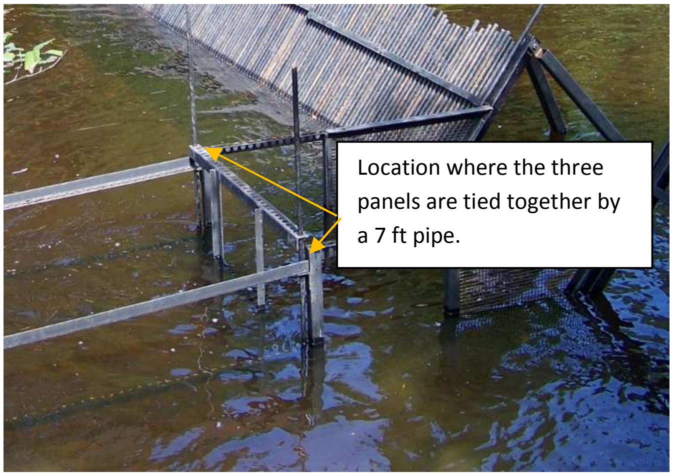

Figure 16. View of the entrance panels, front panel of the collection box and drilled angled steel, tied together by 7 ft pipes.

The three tabs on the backs of the left and right entrance panels, the ends of the front panel to the collection box, and the six drilled pieces of angled steel that form the sides of the collection box were tied together by inserting a 7 ft pipe through the intersection of all three components (Figure 15). The back panel of the collection box was then tied to the other ends of the six pieces of drilled angled steel by inserting a 7 ft pipe on either side of the back panel. One tripod was placed on the outside edge of each entrance panel for stability and to establish the proper angle of the front leg of the tripod and the blocking panel as it extends across the stream. Two sections of 6 ft drilled channel iron were tied into the three tabs located on the side of the front portion of the entrance panel and the tabs on the leading edge of the tripod by running a 7 ft piece of pipe through these at the same time. Tripods were placed approximately 5 ft apart and run perpendicular across the stream. It was important to keep the angles of the front and back legs for each tripod the same. The channeled steel pieces were laid on the tabs of the front legs on the tripods and tied together using 7 ft pieces of pipe. Some overlap of the 6 ft channeled steel occurred. Close attention was needed to assure that we maintained the same number of open holes on the top and bottom pieces of channeled steel between the pipes tying the front legs of the tripods. We noted that if the number of open holes on top and bottom differed, then the pipes will not line up correctly and openings larger than ½ in will result potentially allowing fish to pass through the weir. When uneven pipes were encountered, the pipes were pulled out and the channeled steel was realigned so there were the same number of open holes on the top and bottom

Figure 15. Use of PVC sections, resting on tab of front tripod leg to maintain level channels in the blocking panel when moving up the streambank.

channels. The elevation of the tripods varied when the stream bed was uneven or when tying the blocking panels into and up the stream bank. One and one half inch PVC pipe was used by cutting it into appropriate lengths that allowed the 6 ft channels to rest on rather than the tabs on the front leg of the tripod and run the pipe through to keep the 6 ft drilled channels level (Figure 16).

Support cables

Once the weir was completed we used ¼ in to ⅜ in cables to help support the structure during high flow events. The number of cables we used varied from site to site, and was based on the width of the stream and the potential flows that could occur during high water events. Typically, one was placed on each end of the weir, one on each corner of the upstream portion of the collection box, and others were evenly spaced across the weir to help support the weight of debris and the force of the water against the weir (Figure 17). The cable was attached to the upstream leg of a tripod by wrapping it around and securing it with a cable clamp. The other end of the cable was then fastened to something stationary, such as a tree or boulder, upstream of the weir. Small loops were placed in the cable using cable clamps, and then a come-a-long was used to tighten and secure the cable back onto itself with additional cable clamps.

Figure 17. View of support cables connected to the weir panels and upstream portion of the collection box.

Walkway and Platform

The collection box was typically positioned in or near the thalweg of the channel. However, if it was possible we tried to locate it within 6 ft to 8 ft of the stream bank. This allowed the construction of a walkway and work platform. The walkway typically extended from the stream bank out to the edge of the collection box. This was extremely helpful when entering and exiting the collection box during tending. It was constructed of dimensional lumber and plywood or a combination of lumber and cedar posts. A simple 4 ft x 8 ft platform was constructed using 2x6s and topped by a sheet of ¾ in plywood.

The platform was then leveled from the bank to the collection box then attached to six posts positioned upright on the bottom of the stream and cross-braced for support. The six posts should be long enough to extend above the platform and wooden 2 x 4 rails attached between them on either side, approximately 36 in above the platform to create a rail for safety (Figure 18). A ladder was lowered from the work platform into the collection box to gain access. On one occasion a ladder was positioned against the outside of the collection box to enter the collection box when a walkway could not be constructed.

Figure 18. Walkway/work platform extending from the streambank to the collection box.

Rip-Rap

Rocks were placed along the upstream ends of the blocking panels where they tied into the stream banks to help the overall performance of the structure and assure that fish didn't circumvent the weir. Small rocks were also placed on the upstream side of the blocking panels where the pipes met the stream bed. Special attention was made in the corners where the blocking panels and entrance panels met. Debris plugged the blocking panels and water tended to funnel into these corners creating scour holes under the panels during high water events. This additional coarse material helped stabilize the banks and streambed from eroding during high flows (Figure 19).

Figure 19. Rip-rap material piled along the streambank to reduce potential erosion during high flow events.

Modifications

The process of taking something from drawings to cutting and fabricating and then placing it in a stream and have it catch fish was not without challenges. Several modifications were made to the weir from its initial design. Some alterations were subtle, such as tab placement to maintain ½ in spacing, the creation of a rigid framework for the back of the collection box to increase stability, and making the fyke out of steel rather than wood due to beavers chewing on them.

However, the biggest challenge to overcome, as it was for Roger Auclair 50 years earlier, was scouring that resulted from fall rain events and leaf drop. The combination of these factors often resulted in heavy debris loads that created a damming effect and the high water resulted in scour holes under and around the weir.

We developed drop-down panels to help reduce the damming effect created by the leaves/debris on the blocking panels. These drop-down panels were designed to act as automatic relief valves during high flows. The openings created by these panels allowed water and debris to pass through the weir, thus reducing the amount of pressure behind it (Figure 20). The panels are 3 ft x 4 ft and the frame is built from 2 in x 3 in lumber. A 3 ft x 1 in x 1 in piece is fastened in the center of the frame for stability. On the 3 ft sides, 1 in holes were recessed 1 in by drilling into the wood and spaced ½ in apart. PVC conduit was cut to the appropriate length to insure a snug fit into the frame to create a panel with similar bar spacing as the blocking panels. For flotation, three bullet-style buoys were attached to the top of the panel and the PVC conduit was filled with expanding spray foam insulation. A one-foot strip of rigid mesh (½ in x 1 in) was attached to each side of the panel to help cover the opening between the drop-down panels and the opening in the blocking panel. To attach the drop-down panel to the weir, a third 6 ft piece of drilled channeled steel was needed to raise it approximately 12 in above the lowest piece of 6 ft channeled steel in the blocking panel. The panels are attached to the third piece of channeled steel by wrapping four – 6 in diameter loops of 3/16 in cable through the bottom of the panel and around the channeled steel. Shorter (2½ ft and 3 ft) pieces of pipe were used to close off the area between the middle and lowest channel pieces. This seals off the area below the drop-down panel, prohibiting fish passage and creates an opening for water to pass through. The top of the drop-down panel will float as the flow in the stream increases. Fish moving upstream tend to swim near the stream bottom and underneath the panels which are closed off by the rigid mesh on either side.

Figure 20. Drop-down panels installed in the weir. Note the shorter pipes at the bottom of the large opening.

The size of the weir determined how many drop-down panels were installed. Generally, we used one drop-down panel for every 25 ft of weir. However, more can be used if stream flows are known to have extreme fluctuations. Placement of the drop-down panel along the weir was also important. We installed one in the blocking panel adjacent to the entrance panel of the collection box. On large streams (> 75 ft wide) we placed drop-down panels on each side of the collection box and along the blocking panels as deemed appropriate. We tried to identify where most of the flow was in the thalweg and placed a drop-down panel in the weir in that location.

Security

Weir sites were typically located in remote areas so security and surveillance is difficult. The district game warden that patrols the area was notified whenever a weir was installed. When time permitted, they checked on it and noted any activity going on in the area.

Figure 21. Visitors and their dog looking at the weir.

Strategically placed cameras were also installed at the weir sites and along access roads and trails leading to it. The cameras were used to collect pictures and documented any activity should the weir be vandalized. The weirs tended to gain attention by the public but no major vandalism occurred (Figure 21).

Three - 5 ft pipes were placed across the top of the collection box, a piece of ½ in plywood was placed on top of the pipes and secured with a cable and a lock. This was not 100% secure, but did make it difficult for anyone access the collection box.

Operation

Material was moved to the weir site during early August and was fully assembled by August 15. The weir was routinely tended every 2-3 days. It was often necessary to tend it more frequently when the catch of fish increased or debris loads on the weir panels increased typically during leaf drop.

Two individuals typically tended the weir. One person entered the collection box and a towel or fine screen was placed over the end of the fyke to keep fish from escaping the collection box. Fish were then netted with a dip net and the second individual transferred them to a smaller holding pen placed in the stream along the shore or in a processing tub filled with fresh water. Approximately 10-15 fish were removed from the collection box at a time and placed in a tub of anesthetic. The fish, once sedated, were more easily handled. One individual handled the fish, collecting biological information including length, weight, scale sample, sex, maturity, and fin clips. A temporary mark (caudal clip) was applied to all fish. Hooking injuries and external parasites were also noted. The second staff member would record this information. The fish was then placed in a tub of fresh water until it fully recovered. The fish were then transferred to a bucket of fresh water and carried a short distance upstream (or downstream, depending on the direction the fish was moving) of the weir, and released along the shore or in a pool of slower moving water.

Studies designed to monitor fish movements by using radio and PIT tags require more staff when tending the weir. This work was best completed using 3-4 individuals, especially when the catch was high. Two individuals performed surgeries and the other two collected and recorded data.

The blocking panels were cleared of leaves and woody debris each time the weir was tended. The weir was inspected for scour holes or evidence of vandalism during each tend. The pipes were lowered to the streambed to close the gap and rock substrate were placed in the scoured spot to secure and stabilize the area when scour holes were detected.

<u>Safety</u>

There were several times during the study that the weir could not be safely tended due to excessive flows. Weather forecasts predicted such events, so staff took precautionary measures and remove sections of the weir to allow water and fish to pass. Staff had to wait until the flows receded before re-installing the removed sections and then conducted any required maintenance.

Dismantle

The timing of a spawning run by trout and salmon can vary greatly on the same stream from year to year. We operated the weir as long as fish continued to move upstream. On two occasions, we needed to remove the weir after it received significant damage caused by high water events.

The weir was dismantled and placed on the streambank on pallets or posts. This kept the material off the ground which allowed the pieces to dry before transporting. Pipes were separated by lengths, and specific pieces of the framework and panels were organized accordingly. A concerted effort was made to inspect the pipes for damage as they were removed, especially when it was dismantled due to a high-water event. All damaged pipes should be removed from the inventory. Cables were taken down and coiled. Other hardware, such as nuts and bolts, were placed in separate containers. This helped when hauling it from the stream to the trucks and trailers, as well as when arriving at the storage facility to pack away for winter. When possible the weir has been stored in a dry, covered location.

For one study, the walkway/work platform was removed from the stream and stored intact at the site above the high-water mark of the stream and was used the following year. Otherwise, it was taken apart and transported back to the storage facility along with all the other weir components.

On one occasion the access road to the weir site became impassable because of muddy conditions in the fall. In this case, we secured the weir material above the high-water mark and covered it with tarps and waited to remove it when road conditions improved the next summer.

Radio telemetry tagging

Radio transmitters were surgically implanted into 40 male trout on Socatean Stream in 2009 (Table 1). Forty-nine transmitters were implanted in male trout and 43 male salmon in 2010 on the Roach River. Females were not selected in either study because we did not want to damage their fully developed egg sacs. Tags were purchased from Advanced Telemetry Systems (ATS). The model F1835 transmitters had a pulse rate of 40ppm, a pulse width of 22ms, and a battery capacity life of 654 days. The tag frequencies ranged from 148.000 to 149.999 MHz. These ATS transmitters were equipped with mortality switches that turned on after 24 hours of inactivity. The mortality signal had a pulse rate of 80ppm. We had previously purchased two ATS R4500S dataloggers and two handheld R2000 receivers. One of the dataloggers was placed at the weir site during studies on Socatean Stream and the Roach River. The other was placed at the confluence of the stream/river and Moosehead Lake. These remote dataloggers were placed in waterproof Pelican cases and secured to a tree with a chain and lock. The antenna was mounted above the unit in the tree. The unit was powered by a 12v marine battery and a single 2 ft x 3 ft solar panel. Handheld receivers were used in canoes and on foot to locate fish. Antennas were also mounted on a fixed-wing aircraft to periodically locate fish in the stream and lake from the air.

All transmitters were tested to ensure they were working properly. Anesthetized fish were cradled in a wet towel that was positioned in a fish measurement board. A tube was placed in the fish's mouth to supply a gravity-fed flow of water with a light dose of anesthesia. A small incision (approximately ¾ to 1 in) was made in the abdominal cavity between the pelvic and pectoral fins. The activated, sterilized transmitter was placed in the body cavity. The transmitter antenna was fed through a 16-gauge hypodermic needle that made an opening through the body cavity where it laid externally posterior to the pelvic fins. The incision was closed using 3 to 4 monofilament sutures. Fish were recovered in aerated tubs with fresh water prior to being released a short distance upstream from the weir site.

<u>Passive Integrated Transponders (PIT tags)</u>

All male and female trout that were not selected for radio transmitters in 2009 at Socatean Stream were implanted with 21mm PIT tags from OregonRFID. In 2010 and 2011 on the Roach River, we implanted PIT tags into only male trout and salmon after it was determined that many of the females tagged in 2009 had purged their tags during the spawning process. All fish received an adipose fin clip.

The surgical process was very similar to that used for implanting ATS tags, although sutures were not needed because the incision was much smaller. Super glue was used to close the incision after the PIT tag was implanted in the body cavity.

The dataloggers were powered by several 6v batteries in series attached to a 4 ft x 5 ft solar panel. The antenna consisted of a single loop of 6-gauge welding cable that encompassed a cross-section of the entire stream/river. Standard metal fence posts supported it, however the metal posts caused interference, so the antenna wire was run through short pieces of garden hose at each attachment location. There were a few sources of interference with the PIT tag antenna. Initially, the antenna was placed along the weir and around the downstream fyke opening, but there was too much interference from the steel framework. The best system included storing the batteries and solar panel controller in a separate cooler from the datalogger. Also, shielded wiring was used to connect the batteries to the datalogger and for the connection from the solar panels to the controller. Initially, we had the PIT tag antenna, PIT tag datalogger, and ATS datalogger powered from the same battery bank. However, we found that we could not keep the system powered for more than a few days. We resolved this by separating them and using a larger solar panel for the PIT tag system as described above.

Table 1. Number of fish tagged by location, year, species, and method during the weir operation on Moosehead Lake tributaries.

Location	Year	Number of ATS tags	Number of PIT tags
Socatean Stream	2009	40 (Male trout)	310 (Male and Female trout)
Roach River	2010	49 (Male trout)	321 (Male trout and salmon)
Roach River	2011	43 (Male salmon)	241 (Male trout and salmon)

In 2009, we were able to use data from a local online weather station to track precipitation near Socatean Stream. A rain gage was setup in the clearcut at the entrance to the Roach River weir site in 2010 and 2011. Staff gages were placed in the stream near the weir at both sites to monitor relative changes in flow and recording thermometers were installed in Socatean Stream in 2009 and the Roach River in 2011. It should be noted that flow in the Roach River was controlled by the dam on First Roach Pond which was under DIFW operation. There is one major tributary to the Roach River below the dam which can augment flows especially after heavy precipitation.

Results

<u>Socatean Stream - 2009</u>

The weir was operational on 08/19/09 in Socatean Stream. The first tend occurred on 08/22/09 after a 0.38 in rain event and nine mature trout were captured. The water temperature was 21.5^{o}C. The catch ranged from three to nine trout over the next three tends. There was a rain storm on 08/28/09 and 08/29/09 that dropped approximately 0.45 in of rain in the drainage. On 9/2/09, Fisheries staff paddled the section of Socatean Stream from the falls to the weir and breached multiple beaver dams. These two events resulted in temporary increases in stream flow. Forty-three trout were taken on the next tend. There was an extended period of dry weather for the first 22 days of September and only five trout were captured after the 09/03/09 tend until 09/25/09. The trout catch increased for the next two weeks peaking at 146 fish on 10/08/09. It should be noted that there were several days when fish were able to circumnavigate the weir due to washouts from rain events. The weir was removed on 10/16/09. The only fish caught on this date were in the downstream collection box. Daily catch data are presented in Table 2.

Table 2. Total catch of Brook Trout by tending date on Socatean Stream 2009.

Date	Females	Males	Immature	Total
08/21/09	5	4	0	9
08/24/09	4	4	1	9
08/26/09	1	2	0	3
08/28/09	2	4	0	6
09/03/09	23	15	0	43
09/06/09	5	1	1	7
09/08/09	0	0	0	0
09/09/09	0	0	0	0
09/14/09	0	0	0	0
09/17/09	3	2	0	5
09/21/09	0	0	0	0
09/23/09	0	0	0	0
09/25/09	14	13	0	27
09/28/09	28	15	0	43
10/01/09	22	12	0	34
10/05/09	11	1	0	12
10/06/09	1	0	0	1
10/08/09	91	54	0	145
10/09/09	8	14	0	22
10/10/09	1	1	0	2

10/15/09	4	1	0	5
10/16/09	0	2	0	2
All	223	145	2	370

Three hundred seventy trout were handled in 2009 at the weir on Socatean Stream. They ranged in length from 9.1 to 21.1 in and averaged 13.8 in. Detailed age and growth data are presented in Table 3. The only other fish species taken in the weir in 2009 were a single Creek Chub (*Semotilus atromaculatus*) and a Lake trout (*Salvelinus namaycush*).

Table 3. Length and Fulton's K Factors for Brook Trout in Socatean Stream 2009.

Age	N	Mean Length (in)	Standard Error		N	Mean K Factor	Standard Error
None	154	13.5	0.1		154	0.90	0.01
2	63	12.1	0.1		62	0.90	0.01
3	112	13.7	0.1		111	0.86	0.01
4	40	15.4	0.2		40	0.86	0.01
5	1	17.9	.		1	1.04	.
All	370	13.5	0.1		368	0.88	0.00

Radio Telemetry Tracking

The first radio transmitter was implanted in a male trout on 08/24/09. The remaining 39 tags were implanted over the duration of the tending and the last transmitter was implanted on 10/16/09. Ground tracking was completed randomly as time was available. We made 10 different observations from the ground by accessing the stream at road crossings, trails, and the weir site in 2009. Two complete float trips by canoe from the headwaters to the weir were done on 10/14/09 and 11/03/09. Two aerial tracking events covering the entire stream were scheduled on 10/08/09 and 10/15/09. The ATS datalogger at the weir site was operational through 11/24/09 to detect downstream movement of tagged trout. Four flights were conducted on 01/08/10, 02/09/10, 04/02/10, and 11/03/10 that covered all of Moosehead Lake, including the tributaries, and outlet.

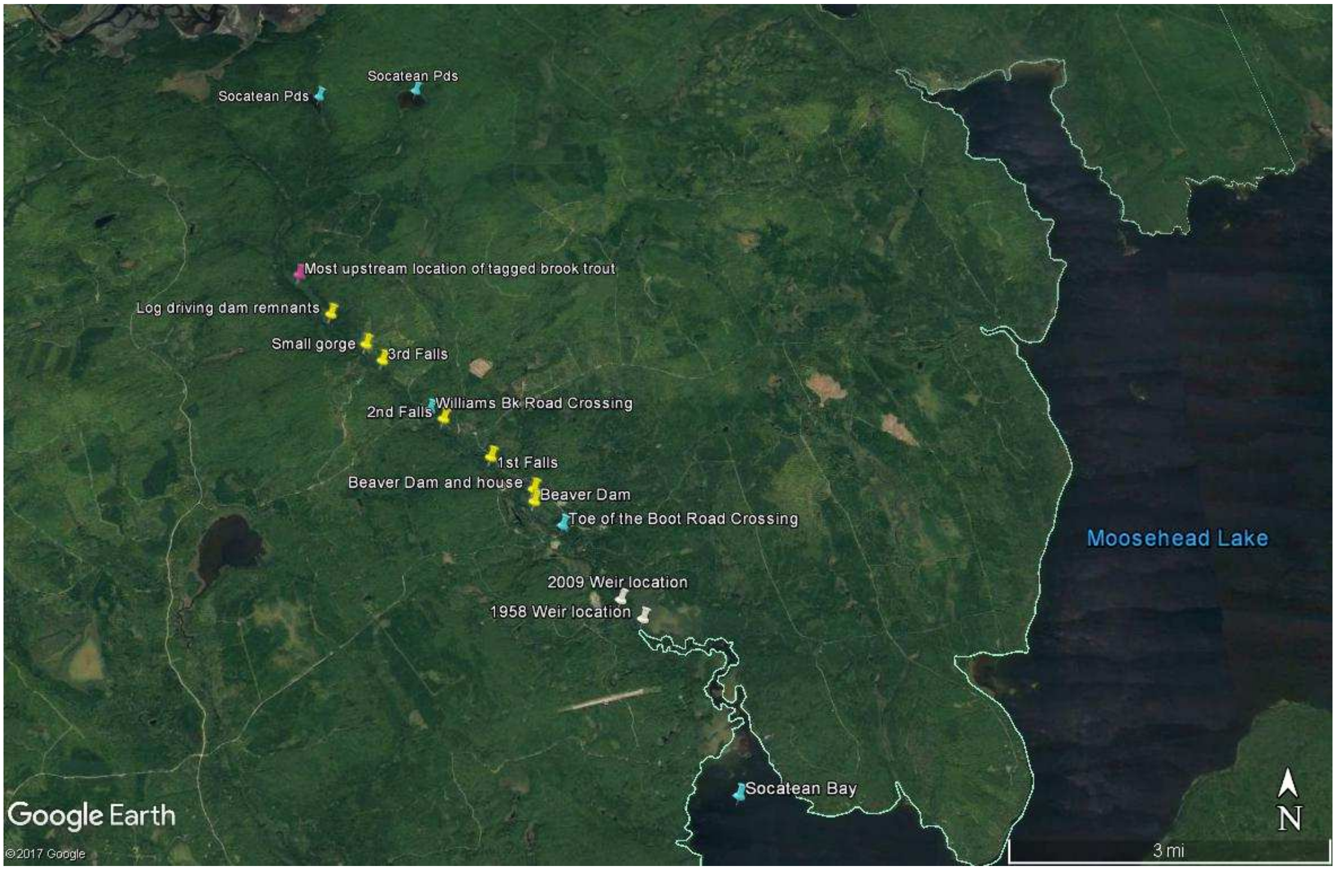

Figure 22. Map showing features and weir locations in Socatean Stream.

The ATS dataloggers were redeployed and operational from 07/15/10 through 11/15/10 to monitor returning fish. We determined the fate of 39 of the 40 tagged trout by combining information from these tracking events. Fish 148.224 was tagged on 10/01/09. It was not located during two partial ground counts or a flight completed before it was detected at the weir datalogger on 10/14/09, presumably dropping downstream. This fish was never detected again during the duration of the study. Either the tag experienced a failure or it is possible that it was the victim of an avian predator that removed the transmitter from the study area.

Fish 149.033 traveled the furthest upstream. It was located approximately five miles above the weir site on 10/14/09. This trout had successfully passed over three sets of falls and the remnants of an old timber crib driving dam (Figure 22). We located six major spawning areas within Socatean Stream during the tracking. Some, if not all, of these sites were associated with a source of ground water. Beaver dams were common obstacles in Socatean Stream in 2009, yet trout negotiated passage at some point in their fall migration. One of the largest spawning concentrations of trout was located just above the bridge on the Williams Brook Road. For fish to reach this site, they had to pass over multiple large beaver dams and two sets of falls. Many redds were observed in this area during the 10/14/09 tracking event while only a few were observed downstream between the bridge and the weir. A second canoe tracking event took place on 11/03/09 and many redds were observed in the section of Socatean Stream between the two bridges and just downstream of the Toe of the Boot Road crossing. A few more redds were observed between this lower bridge and the weir site. Adult fish were observed in these areas as well, indicating that spawning was still occurring in early November.

On 11/16/09, thirteen ATS tagged trout had dropped below the weir datalogger and were between the weir and the lake, fourteen were still above the weir datalogger in the stream, two were in Moosehead Lake, one was not located, and the remaining ten tagged fish were emitting mortality signals. Three weeks later, on 12/08/09, only two trout remained in the stream, thirteen were now residing in the lake, twenty-four were confirmed mortalities, and one remained unknown. We confirmed that five of the fish that were in the lake were located in Socatean Bay within the area closed to ice fishing. Another tagged fish had traveled to Spencer Bay and was within that protected area that is closed to ice fishing. Therefore, 46% of the surviving trout that had dropped into the lake after spawning in Socatean Stream were in areas closed to ice fishing. The remaining seven fish were in areas open to ice fishing. Three of these fish were harvested over the 2010 ice fishing season. Another tagged fish was reportedly caught and released near Farm Island on 01/31/09. Fish 148.264 had been located near this area on the 01/08/10 flight and was never detected again during the study.

There were potentially 11 tagged trout in the lake or stream at the conclusion of the 2009 ice fishing season. Six ATS tagged trout were located on an aerial survey on 04/02/10. Only one fish had changed location since the 01/08/10 flight. That one fish left Socatean Bay and relocated near Williams Brook.

Only one other flight was schedule in 2010 and that occurred on 11/03/10, however, dataloggers were active and tracking on foot did occur during the year. Six of the eleven presumed living tagged trout were never located after the 2010 ice out. One fish, which overwintered near the mouth of the Moose River, was located up in the Moose River during the November flight. The remaining four tagged fish all returned to Socatean Stream/Socatean Bay in the fall of 2010.

PIT Tags

One hundred male trout received PIT tags in 2009 in Socatean Stream. A total of 209 females were tagged and one immature fish. We constructed a PIT tag wand in the summer of 2010 and utilized it on one of the major spawning areas. We located 12 PIT tags in old redds from the fall of 2009. All the tag numbers corresponded to female trout tagged the previous fall. Two PIT tagged females did return in the fall of 2010. Based on these findings, we did not include any of the females in the analysis.

Male PIT tagged trout began their downstream post-spawn migration on 10/8/09; however, only four fish dropped out in October and two of those fish had been recently captured and tagged. These fish likely did not spawn upstream of the weir. Peak downstream movement occurred on 11/07/09 when eight PIT tags were recorded on the antenna. The last fish was recorded on 11/27/09. A total of 47 trout were recorded on the downstream PIT tag datalogger in 2009.

One PIT tagged fish was reported caught by anglers near Sugar Island on 06/28/10. The fish was a 15.3 in female that was tagged in Socatean Stream on 10/01/09 and was detected on the downstream data logger on 10/09/09.

The PIT tag antenna was re-installed on 07/15/10, but we had a few power issues that resulted in gaps in the data. We also received 5.5 in of rain during the first week of October which resulted in another data gap during a peak period of movement. Therefore, the returning fish data are incomplete for 2010. Five PIT tagged male trout were recorded on the datalogger in September. We did not record any trout leaving the stream later in the fall that had not been recorded moving upstream in September, despite the periods of data loss.

<u>Roach River – 2010</u>

The weir was installed on 08/10/10 in the Roach River. The first trout were captured on 08/16/10, but two of these fish were mortalities. The water temperature was 25^{o}C. We removed three dead trout from the upstream side of the weir on 08/23/10 and another stressed trout on 08/30/10. The weir was closed until 09/06/10 in attempt to reduce mortalities that may have been related to warm temperatures. Daily catch data are presented in Tables 4 and 5.

Table 4. Total catch of Brook Trout by tending date on Roach River in 2010.

Date	Females	Males	Immature	Total
08/19/10	1	2	1	4
08/20/10	0	1	0	1
08/23/10	1	2	1	4
08/26/10	2	1	1	4
08/27/10	2	4	0	6
09/07/10	5	4	0	9
09/09/10	18	19	3	40
09/10/10	19	13	1	33
09/13/10	60	40	0	100
09/15/10	51	26	1	78
09/17/10	44	29	1	74
09/19/10	27	15	1	43
09/20/10	11	7	2	20
09/22/10	9	8	1	18
09/24/10	17	4	0	21
09/26/10	17	14	1	32
09/27/10	10	8	0	18
09/29/10	31	16	0	47
10/01/10	16	11	0	27
10/03/10	0	0	0	0
10/06/10	10	4	0	14
10/08/10	1	0	0	1
10/10/10	1	0	0	1
10/12/10	0	1	0	1
All	353	229	14	596

Table 5. Total catch of Landlocked Salmon by tending date on Roach River in 2010.

Date	Females	Males	Immature	Total
08/26/10	1	0	0	1
08/27/10	1	0	0	1
09/07/10	9	9	0	18
09/09/10	9	7	0	16
09/10/10	6	0	0	6
09/13/10	12	13	0	25
09/15/10	20	33	0	53
09/17/10	45	40	0	85
09/19/10	61	57	0	118
09/20/10	21	26	0	47
09/22/10	15	23	0	38
09/24/10	10	21	1	32
09/26/10	26	37	0	63
09/27/10	22	17	0	39
09/29/10	25	17	0	42
10/01/10	24	28	1	53
10/03/10	3	4	0	7
10/06/10	6	7	0	13
10/08/10	3	3	0	6
10/10/10	0	3	0	3
10/12/10	12	6	0	18
All	331	351	2	684

We captured a total of 596 trout ranging in length from 10.1 to 20.1 in and 684 salmon ranging in length from 10.6 to 20.1 in. Four Lake Trout were caught in the weir and they ranged in length from 16.5 to 19.1 in. The only other fish caught were White Suckers. Detailed age and growth data for the trout and salmon are presented in Tables 6 and 7.

Table 6. Length and Fulton's K Factors for Brook Trout in the Roach River in 2010.

Age	N	Mean Length (in)	Standard Error		N	Mean K Factor	Standard Error
None	410	14.0	0.1		407	0.90	0.00
1	1	10.9	.		1	1.01	.
2	55	12.4	0.1		55	0.92	0.01
3	95	14.4	0.1		95	0.90	0.01
4	33	16.2	0.1		33	0.90	0.01
5	2	18.5	0.1		2	1.13	0.01
All	596	14.1	0.1		593	0.90	0.00

Table 7. Length and Fulton's K Factors for Landlocked Salmon in the Roach River in 2010.

Age	N	Mean Length (in)	Standard Error		N	Mean K Factor	Standard Error
None	582	17.0	0.1		582	0.83	0.00
3	15	15.2	0.2		15	0.83	0.02
4	64	17.0	0.1		64	0.85	0.01
5	23	18.1	0.2		23	0.82	0.01
All	684	17.0	0.1		684	0.83	0.00

Radio Telemetry Tracking

ATS transmitters were implanted in 49 mature male trout in 2010. Multiple ground/canoe checks were made to locate the tagged fish in October and November while the fish were still in the Roach River. The ATS datalogger was installed at the weir site to document dates of departure from the river. In addition, four aerial tracking events over Moosehead Lake and the Roach River were scheduled in November and December to assess location and post-spawning mortality before the 2011 ice fishing season.

Forty-one of the tagged trout were located on 10/19/10. Most of the locations were near the major pools in the river and were likely areas of spawning areas. Tagged trout started dropping out of the river as early as 10/13/10 when four trout were recorded on the datalogger. Downstream movement peaked on 10/25/10 when six fish were recorded. The last trout was recorded on 11/04/10.

We determined that 27 (55%) of the ATS tags were emitting a mortality signal prior to the beginning of the ice fishing season. Seventeen tagged fish had successfully exited the river and were in the lake. Twelve (71%) of these fish in the lake were in Spencer Bay which is closed to ice fishing. Two tagged trout were still in the river and another three were not located in the fall and never located throughout the study.

Three flights were scheduled during the winter of 2011. Three of the seventeen trout located in the lake perished over the winter months. These fish were not harvested and two of them were in the areas closed to ice fishing. Three other fish were emitting both alive and mortality signals during the winter flights. All three were determined to be mortalities later in the open water season.

Fish 149.283 was located southeast of Rockwood during the winter flights. This fish was reportedly caught and released by an ice fisherman on 01/18/11. This fish survived and returned to the Roach River to spawn in the fall of 2011.

Fish 149.313 was a 20.1 in male trout captured at the Roach River weir on 09/17/10. This fish had an ATS tag previously implanted in it during a study by Florida Light and Power on the Moose River in 2009. The old tag was removed and a new tag was implanted. The fish was recorded moving downstream in the Roach River on 10/28/10 and located in the Moose River on the 11/03/10 flight. It stayed in this general area until it was harvested by an angler on 05/16/11.

We determined that eleven ATS transmitters were still active just prior to the 2011 spawning season. Ten of these were last located in the lake and one was believed to be in the Roach River. Three other tags had not been located since they were initially implanted, and the remaining 35 tags were emitting mortality signals. We were able to confirm six of the active tags returning to the Roach River in 2011. Fish 149.014 was detected on the datalogger at the weir site on 08/14/11 and detected in the river on the 10/19/11 flight. This fish later returned to Spencer Bay, where the transmitter was emitting a mortality signal on the 12/30/11 flight. Fish 149.084 was detected entering the river on 09/11/11, left the river on 10/21/11, and over-wintered in Spencer Bay in 2012. Fish 149.224 was detected by the datalogger on 09/13/11 and was determined to be a mortality on the 11/09/11 ground check of the river. Fish 149.234 was missed by the datalogger at the entrance to the river but detected in the river on the 10/19/11 flight; however, it was picked up moving downstream on 10/27/11. Fish 149.283 was in the Roach River from 09/17/11 to 11/14/11 and it overwintered in Spencer Bay in 2012. Fish 149.443 was tagged in 2010 and the tag was never detected outside the river. We initially suspected it may have been a mortality even though the mortality switch never activated. The tag was not detected on the 10/19/11 flight however; it was picked up on the datalogger three times in late October of 2011, possibly exiting the river. Three (50%) of the ATS tagged fish that returned in the fall of 2011 became mortalities by the end of the spawning season.

PIT Tags

PIT tags were implanted in 182 mature male trout and 139 mature male salmon in the fall of 2010. Fifty (27%) of the tagged trout dropped downstream through the antenna after 10/15/10. Thirty-four (24%) of the tagged salmon did the same. There were two brief periods when the PIT tag antenna was not functioning due to battery issues that would have resulted in the datalogger missing fish moving downstream. The first occurred on 10/22/10 through 10/23/10 for roughly 10 hours. The other occurred on 10/23/10 through 10/25/10 for approximately 45 hours. Many fish were likely missed by the PIT tag datalogger at this time. The ATS receiver was active during this period and 44% of all fish moving downstream passed the site on these dates. On 10/26/10, the first full day of operation after the power loss, fourteen PIT tags were recorded moving downstream. The number of tags recorded on the datalogger declined to nine the following day and by 11/04/10 only four were detected. The antenna was pulled on 11/09/10 after five days of inactivity.

Two PIT tagged trout were harvested, one in February 2011 in Beaver Cove and the other in August 2011 in Spencer Bay.

The PIT tag antenna was reinstalled on 08/17/11 and ran uninterrupted through 12/12/11, despite Hurricane Irene dropping nearly three inches of rain during the last week of August. Twenty-nine of the 182 (16%) PIT tagged trout returned to the weir site in the fall of 2011 (Table 8). Twenty-three of these fish were likely moving upstream when they were first detected by the dataloggers. The remaining six were likely missed moving upstream and were instead picked up moving downstream in late fall of 2011. A total of 15 (52%) of the 29 PIT tagged trout that returned to the Roach River in 2011 were detected by the datalogger moving downstream after the spawning season.

Table 8. Percent of PIT tagged male Brook Trout returning to the Roach River by year.

Species	*Sex*	*Year tagged*	*Tag type*	*Percent return - 2011*	*Percent return - 2012*	*Percent return - 2013*
Brook Trout	**Male**	**2010**	**PIT**	**16%**	**8%**	**2%**
Brook Trout	**Male**	**2011**	**PIT**	**-**	**24%**	**7%**
Landlocked Salmon	**Male**	**2010**	**PIT**	**0%**	**0%**	**0%**
Landlocked Salmon	**Male**	**2011**	**PIT**	**-**	**3%**	**<1%**

Two PIT tag antennas were installed on 08/08/12 in the Roach River. One antenna was installed at the weir site and the other was installed approximately 0.5 miles downstream. Fourteen (8%) of the 182 male trout that received PIT tags in 2010 returned in 2012. All 14 fish had been detected in the river in 2011 and all of them were recorded dropping out of the river after 10/15/11. Only 3 (21%) of these fish were detected moving downstream in 2012. The antennas were removed on 11/19/12.

One antenna was installed at the weir site from 07/24/13 to 11/19/13. Four (2%) of the 182 fish tagged in 2010 returned to the river in 2013. All four had spawned in 2010, 2011, and 2012. Only 1 of these fish was detected moving downstream after 10/15/13.

None of the 139 male salmon with PIT tags were detected in 2011. One was detected returning to the river in 2012 and none in 2013.

In addition to the PIT tagged fish, we applied an adipose fin clip to 229 male trout and 353 female trout. We did not apply fin clips to the salmon because there were already fin clipped salmon of hatchery origin in the system.

Fourteen (6%) of the 229-male and eighteen (5%) of the 353 female trout with an adipose clip were recaptured in 2011. Also, eighteen (5%) of the 353 female trout with an adipose clip were recaptured in 2011. These would not represent the total return rate because the weir was left open and not capturing fish during Hurricane Irene.

<u>Roach River – 2011</u>

The weir was initially installed on 08/25/11; however, Hurricane Irene was forecasted to travel through Maine later in the week. Four sections of the weir, each measuring four feet wide, were removed and the remaining structure was stabilized with cables. The river gage initially rose 4.5 in on 8/30/11. There were a few bent pipes but the weir was cleaned and began fishing on 08/31/11. Ninety fish were taken on the first tend. More heavy rain was predicted and three sections of weir were removed, providing unfettered access to the river. The river gage rose 18 in from the 08/25/11 level. The weir was reset and began fishing again on 09/12/11 although we found the high flows had created scour holes that allowed some fish to pass through the weir. Consequently, the data collected in 2011 do not represent the entire run of spawning fish.

We captured 239 trout and 359 salmon in 2011. Daily catch data are presented in Tables 9 and 10. The trout ranged in length from 9.4 in to 19.9 in. The salmon ranged in length from 12.4 in to 20.2 in. Detailed age and growth data for the trout and salmon are presented in Tables 11 and 12.

Table 9. Total catch of Brook Trout by tending data on Roach River in 2011.

Date	Females	Males	Immature	Total
09/02/11	7	11	0	18
09/15/11	37	44	0	81
09/16/11	12	7	0	19
09/19/11	26	24	1	51
09/21/11	2	1	0	3
09/23/11	2	0	0	2
09/26/11	1	0	0	1
09/28/11	12	4	0	16
09/29/11	25	16	0	41
09/30/11	5	2	0	7
All	129	109	0	239

Table 10. Total catch of Landlocked Salmon by tending data on Roach River in 2011.

Date	Females	Males	Immature	Total
09/02/11	35	32	0	67
09/15/11	23	31	0	54
09/16/11	11	22	0	33
09/19/11	43	60	0	103
09/21/11	5	8	0	13
09/23/11	3	6	0	9
09/26/11	7	4	0	11
09/28/11	16	18	0	34
09/29/11	10	14	0	24
09/30/11	2	9	0	11
All	155	204	0	359

Table 11. Length and Fulton's K Factors for Brook Trout in the Roach River in 2011.

Age	N	Mean Length (in)	Standard Error		N	Mean K Factor	Standard Error
None	161	14.6	0.1		161	1.03	0.01
2	7	12.8	0.4		7	1.05	0.03
3	58	14.6	0.1		58	1.00	0.01
4	12	16.1	0.3		12	0.99	0.02
5	1	18.4	.		1	1.09	.
All	239	14.6	0.1		239	1.02	0.01

Table 12. Length and Fulton's K Factors for Landlocked Salmon in the Roach River in 2011.

Age	N	Mean Length (in)	Standard Error		N	Mean K Factor	Standard Error
None	256	17.0	0.1		256	0.90	0.00
3	29	15.6	0.1		29	0.93	0.01
4	67	17.0	0.1		67	0.93	0.01
5	7	17.3	0.3		7	0.93	0.04
All	359	16.9	0.1		359	0.91	0.00

We implanted ATS transmitters into 43 male salmon in 2011. Many of the tagged salmon were still in the river during an early November ground check of the access sites. The ATS antenna was removed on 12/12/11. All 43 salmon were located in either November or December to determine their status prior to the 2012 ice fishing season. Nine (21%) salmon were mortalities, ten were still located in the Roach River, and the remaining 24 had dropped back into Moosehead Lake.

None of these fish were reported caught during the winter 2012 ice fishing season. We conducted aerial tracking on 04/03/12 to determine over-winter movement, mortality, and disposition at the beginning of the open water season. Twenty-one salmon were located. Three were still in the Roach River and all were emitting a mortality signal. Eight tagged salmon were in the same area that they were located prior to ice-in. Ten of the fish had changed location and one of these was a mortality. The distance traveled varied with some fish moving as far as from Rockwood to Spencer Bay. Two tagged salmon moved from Deer Island in late December to Rockwood in April.

Two ATS tagged salmon were reportedly caught by anglers during the 2012 open water season. Fish 149.043 was harvested in Rockwood in May and an ATS tagged salmon was reportedly released near the Mother Islands during the summer. This would have corresponded to fish 140.019 that was in that general area on the April flight. On the 10/18/12 flight, we detected a mortality signal from that transmitter near the Mother Islands. Only one other transmitter was located during that flight. Fish 148.083, which was last located in the Roach River on 11/13/11 was now located near Deer Island. By the end of the 2012 open water fishing season, we had 18 confirmed mortalities and there were three active transmitters in Moosehead Lake. The other 22 ATS tagged salmon were not located on an October 2012 flight. No salmon with ATS transmitters were detected at the weir site datalogger in the fall of 2012.

PIT tags

We implanted 146 PIT tags into male salmon in 2011. One salmon moved back downstream into the lake and was harvested in September 2011. Downstream movement began the week of 11/06/11 when 31 tagged salmon passed downstream through the antenna at the weir site. Sixty tagged salmon passed downstream over the next two weeks. Only one fish moved out of the Roach River and into Moosehead Lake from 11/27/11 to 12/11/11. A total of 106 (73%) PIT tagged salmon were recorded moving downstream of the weir site, presumably after spawning.

There were no reports of 2011 PIT tagged salmon harvested by anglers in 2012 or 2013. Four tagged salmon were detected on the PIT tag antennas returning to the Roach River in 2012 and just one returned in 2013.

We implanted 95 PIT tags into mature male trout in 2011. Peak post-spawning downstream movement occurred the week 10/23/11 and continued at least through the first week of December when the antenna was removed. One PIT tagged trout was harvested in Moosehead Lake in September 2012. Twenty-four (24%) of the 95 trout returned to the Roach River in 2012 and seven (7%) returned in 2013.

Discussion

For the most part, Moosehead Lake still had its native fish assemblage intact compared to when AuClair conducted his weir sampling on Socatean Stream in 1956 and 1957. Yellow Perch were first confirmed in Maine's largest lake in 1958. Yellow Perch are a major competitor with wild trout and their presence would have a severe negative impact on trout abundance in Moosehead Lake. Smallmouth Bass and White Perch were illegally introduced into Moosehead Lake in the 1970s and 1980s. While these species have become established, they are not as abundant or widespread as Yellow Perch. Other factors that could possibly cause differences in trout abundance include angling pressure and technology, as well as improved access to the lake and its tributaries. It should also be noted that Socatean Stream was actively stocked with trout until 1955, just prior to the weir sampling which could have inflated the catch in 1956 and 1957. Despite these impacts, the wild trout population in Socatean Stream is still strong. In 1956, AuClair captured 479 trout in the weir on Socatean Stream before a rain event caused a wash out and the project was abandoned for the remainder of the year. The weir was relocated in 1957 and 1,265 trout were captured. AuClair's wooden strap weir had a spacing of 3/8 in and therefore caught very small fish. The current weir has a spacing of ½ in. In the 1950s, fish were captured down to 4 in in

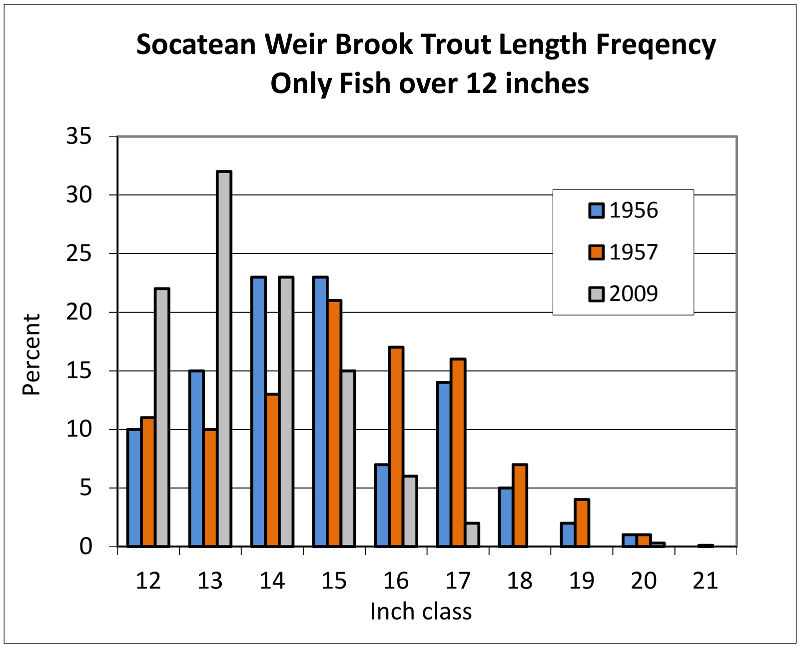

Figure 233. Brook Trout length frequency comparison from Socatean Stream.

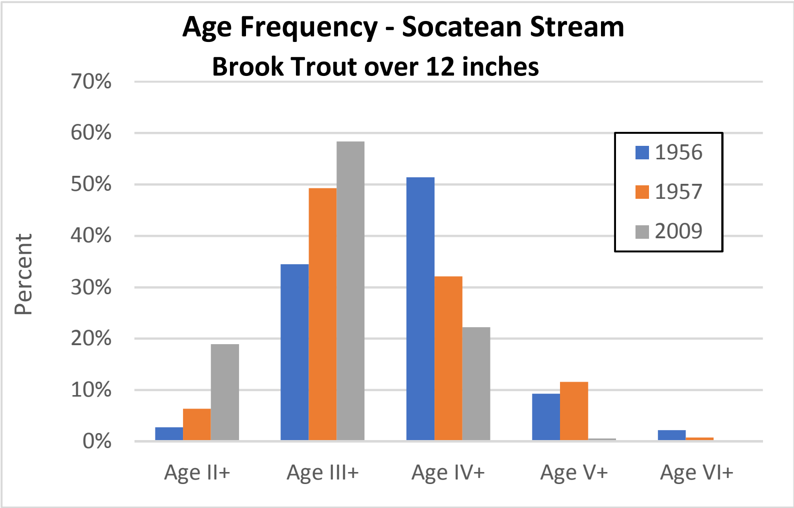

Figure 24. Brook Trout age frequency comparison from Socatean Stream.

length while the smallest trout captured in 2009 was 9.1 in. In 2009, we captured 370 trout of all sizes in Socatean Stream. Several washouts occurred from heavy rain events; therefore, we did not capture the entire run of spawning fish. We can compare catches of trout exceeding 12 in to eliminate any bias in the differences in the weir gap and to focus on mature trout moving upstream from Moosehead Lake. AuClair took 232 trout over 12 in in 1956 and 787 fish in 1958 compared to 308 in 2009. There were fewer larger fish in 2009 than either of the earlier years (Figure 23). Only 8% of the trout sampled in 2009 exceeded 16 in compared to 29% and 45% in 1956 and 1957. The primary reasons for this are the lack of older fish (Figure 24) and slower growth rate. Just one fish age V+ or older was taken in 2009. Trout in 1957 exhibited the best growth in terms of mean length at age for all three years except for age VI+ fish when compared to 1956 (Figure 25). Yet, the 1956 fish had the best overall K factors (Figure 26). Analysis of covariance for the length/weight relationship (Figure 27) shows that all three years are significantly different (Pr>0.0001). Therefore, growth is ranked best to worst: 1956, 1957, and 2009. There are no growth data for salmon or Lake Trout during the late 1950s for Moosehead Lake, however the K-factors for trout taken in the weir and the analysis of covariance indicate that growth was much better than in 2009. We do have extensive data from 2009 and all years after the Moosehead Lake Project was initiated in 1967. Data clearly show that there were severe growth issues in Moosehead Lake in 2009. Smelt abundance was low and growth rates for Lake Trout, Landlocked salmon, and trout were poor (Obrey, unpublished data) which could also impact survival.

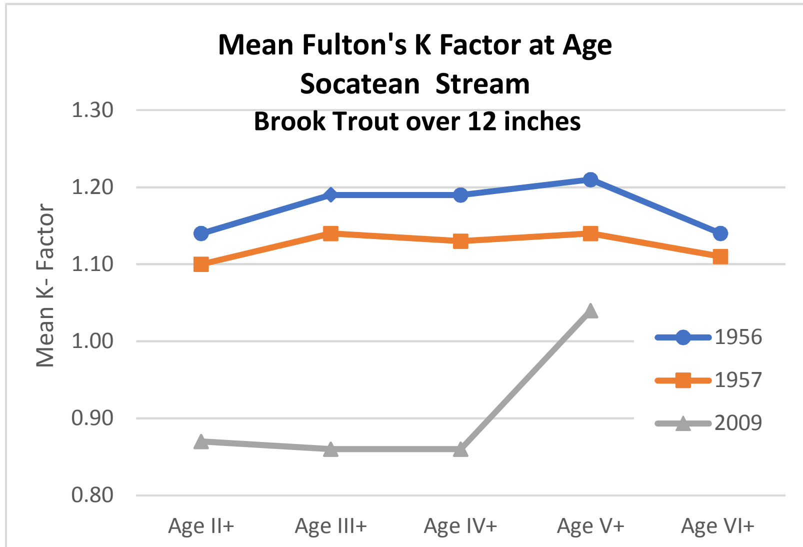

Figure 24. Brook Trout K Factor comparison from Socatean Stream.

The fact that fewer trout were taken in 2009 is not surprising. The establishment of non-native species, especially Yellow Perch, has caused a significant reduction in wild trout abundance in Moosehead Lake since 1957.

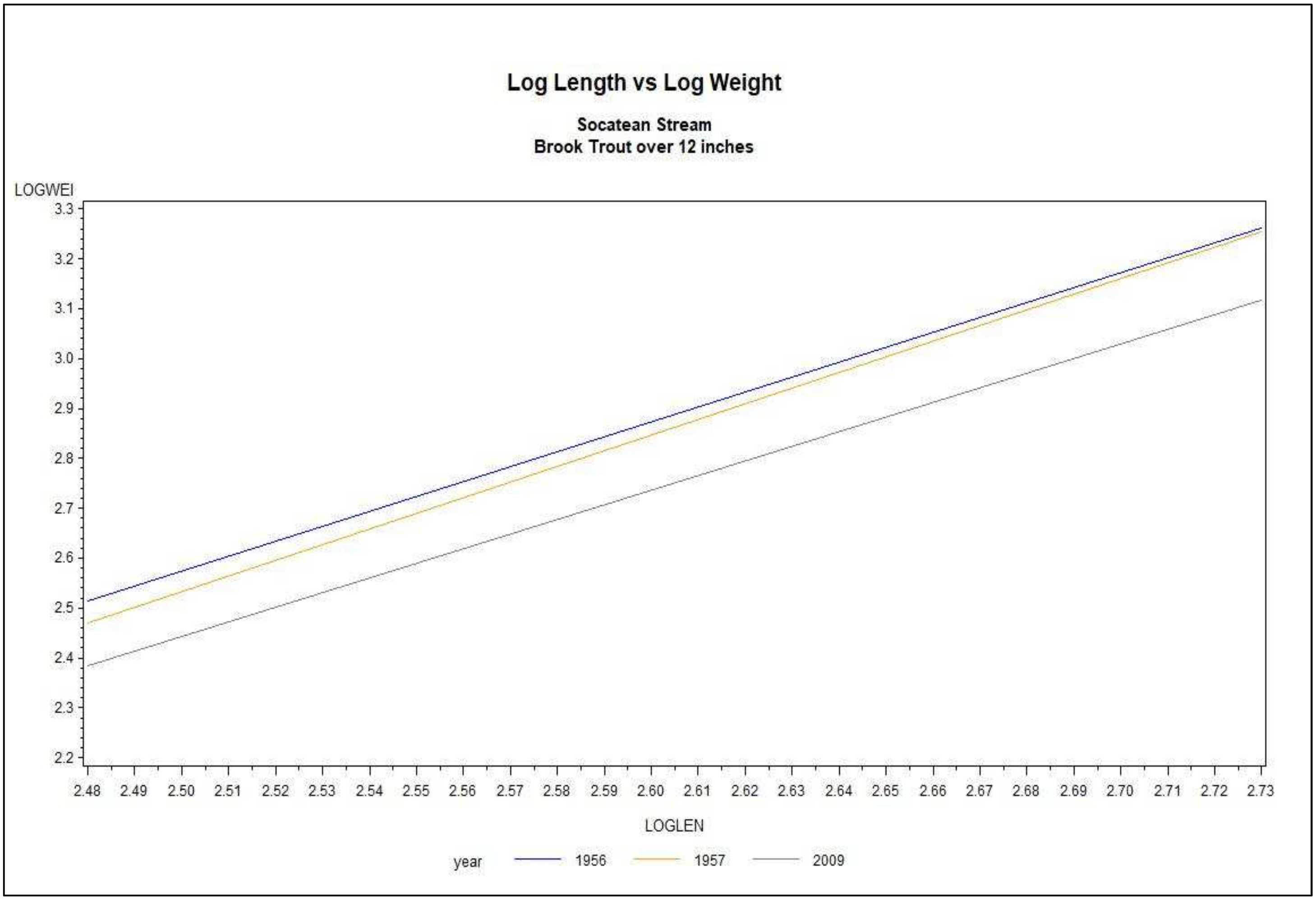

Figure 25. Analysis of covariance for the length – weight relationship for Brook Trout in Socatean Stream.

AuClair (1982) noted that trout spawning was finished by November 10 on Socatean Stream. This correlated with data collected in 2009 in which peak downstream movement of PIT tagged males occurred on Nov 4 and the last fish was recorded moving downstream on November 27.

AuClair (1982) tagged 449 male trout traveling upstream in 1957. He estimated 286 (64%) died in the stream based on downstream recaptures. In 2009, we estimated that 57% of the male PIT tagged and 63% of the ATS tagged trout from Socatean Stream had perished in late fall and early winter. Post-spawning mortality was slightly lower on the Roach River. In 2010, we estimated 51% mortality for both the PIT tagged and ATS tagged trout. In 2011, we estimated 44% mortality among the PIT tagged trout in the Roach River. Theses mortality figures are all relatively close and comparable to results from a similar study conducted on Chamberlain Lake, another large oligotrophic wild trout water in northern Maine (Obrey 2018). We might expect better survival in the Roach River because its larger which could enhance escapement from predators.

Clearly, the rigors of spawning play a significant role in the survival of wild trout and there are important management implications. It would be a useful exercise on large wild trout waters to compare mortality rates resulting from angler harvest to natural mortality associated with post-spawning. In some cases, it may be difficult to improve the size quality of the catch simply by manipulating fishing regulations because most fish are lost to the system during the spawning process. These high rates of natural mortality also demonstrate the fragile state of wild trout at the cessation of the annual spawning activity. This is important in the discussion regarding extended fishing seasons and/or year-round fishing. Currently, in Maine, the fishing season in most streams and rivers containing wild trout ends on September 30. Therefore, the fish are undisturbed by anglers for just one to three weeks prior to the act of spawning. The fishing season does not open until April 1 the following year and, in most cases in northwestern Maine, the ice does not retreat until late April or early May. This ensures that the post-spawning fish that remain in the tributaries are allowed a period of recovery and that eggs deposited in redds in October are not crushed by wading anglers.

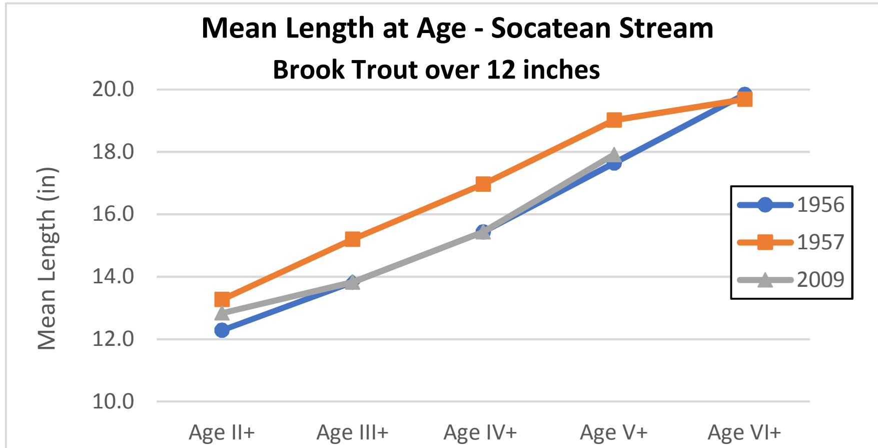

Figure 26. Brook Trout mean length at age comparison from Socatean Stream.

No salmon were taken in Socatean Stream in 2009, yet several dozen were captured in 1958 and 1959(MDIFW unpublished data). Stocking records indicate the stream was stocked with salmon in the early 1900s, but it is unclear when that stocking ceased because stocking records are sparse and incomplete prior to 1954. There is very little nursery habitat for young salmon in Socatean Stream. The substrate is primarily gravel/sand and the stream has many slow meandering sections that are often choked with beaver dams. Without stocking and the associated homing instinct, it is not surprising that there were no salmon captured in 2009.

There were higher percentages of trout between 14 in and 17 in in the Roach River runs than the Socatean Stream run (Figure 28). Some of this may be growth related. In 2009, the lake was still suffering from excessive Lake Trout abundance and a lack of smelt as forage. In 2008, several management strategies were implemented to reduce Lake Trout density in Moosehead Lake. Although Lake Trout and salmon are more reliant on smelt to maintain growth, we documented improvements in trout growth as the smelt population rebounded in Moosehead Lake. The mean K-factor for adult trout in 2009 in Socatean Stream was 0.88. The mean K-factors for Roach River trout were 0.90 in 2010 and 1.02 in 2011. We documented similar trends in mean length at age over this period. It is also very likely that survival has improved for all three of the major coldwater game species in the lake as forage increased.

The lack of large trout (exceeding 18 in) in both Socatean Stream and the Roach River is noteworthy. We know these fish exist and they are observed in our winter creel surveys, reported in the Roach River voluntary box survey in September, and seen in social media reports. We anticipated capturing some larger trout in these two major spawning tributaries. We did capture salmon exceeding 18 in, therefore the weir should have been an effective sampling tool for large trout as well. These weir studies indicate that the larger trout are either spawning in other locations or spawning at dates later than we sampled.

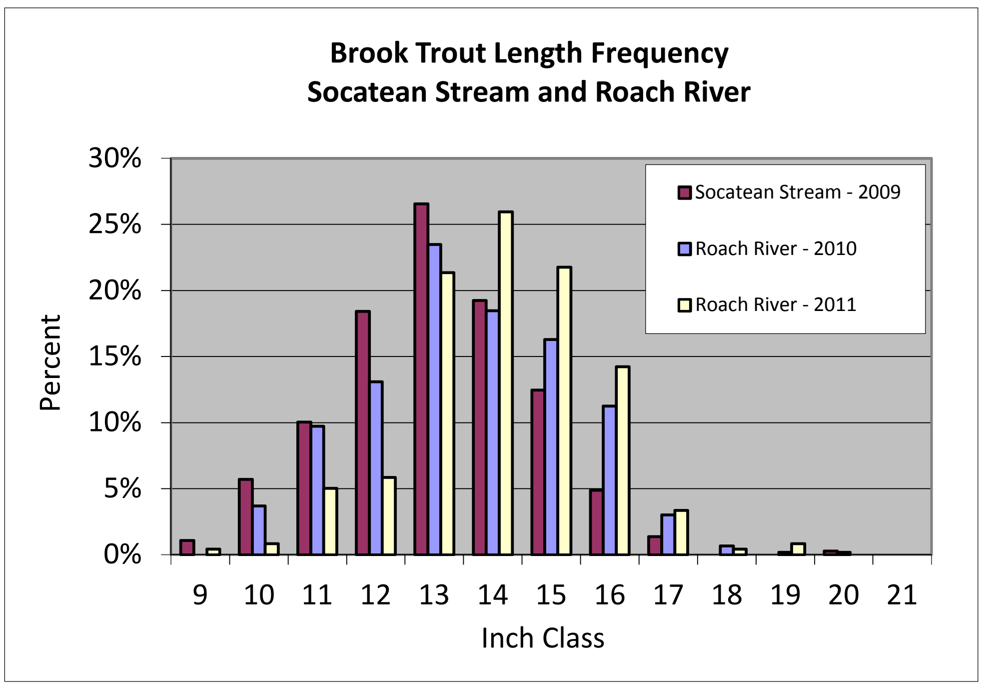

Figure 27. Comparison of Brook Trout length frequencies from Socatean Stream and the Roach River.

The catch at Socatean Stream was highly correlated with flow in the stream (Figure 29). Rain events or the removal of upstream beaver dams resulted in increased stream flow, which was followed by an increase in the catch of trout. It was interesting that the increase in catch occurred very soon after the increase in flow, suggesting that the adult trout must be near the mouth of the stream in the fall.

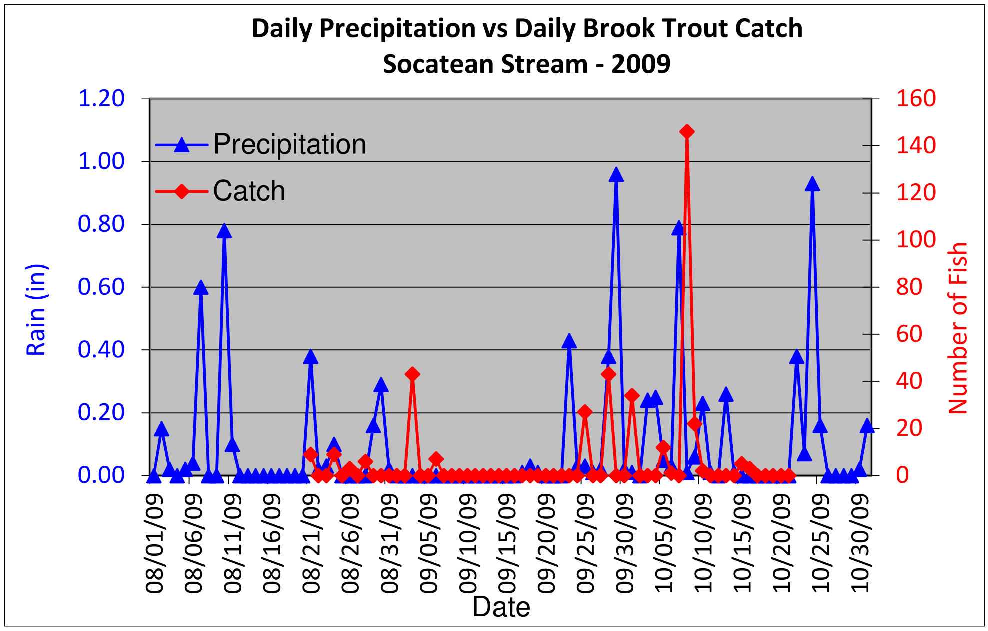

Figure 28. The relationship between precipitation (flow) and Brook Trout catch in the weir at Socatean Stream.

There was very little rain during the month of September 2009. This is a period when we would expect peak upstream fish movement, yet very little occurred until a major rain event on 09/23/09. Trout delayed entry to the stream until flows increased. This improved their ability to pass upstream over the numerous obstacles including falls and beaver dams.

Flows in the Roach River are regulated by the DIFW operated dam at the outlet First Roach Pond. There are just two tributaries to the Roach River below the dam that contribute natural flows, Lazy Tom Stream and Jewett Brook. Fish began moving upstream as soon as the dam was opened and continued throughout the month of September.

Data from the PIT tag antennas in 2011, 2012, and 2013 shed light on time and speed of movement of trout in the Roach River (Figure 30). Both trout and salmon preferred to move after sundown and prior to sunrise. Eighty percent of the total recorded hits on the antennas occurred between the 1800 hours and 0600 hours.

In 2012, a lower antenna was installed near the confluence of the river with Moosehead Lake. Another antenna was installed just below the weir site 0.5 miles upstream. Fish could move upstream unimpeded from the lower antenna to the upper antenna since the weir and collection box were further upstream. Many fish lingered around the antennas making it difficult to ascertain the direction of travel. The data were sorted to include the last hit on the lower antenna and the subsequent earliest hit on the upstream antenna for an individual fish to evaluate the average time of travel for fish moving upstream during the spawning run. Fifteen of 21 fish moving upstream took less than two hours to make the half mile journey (Figure 31).

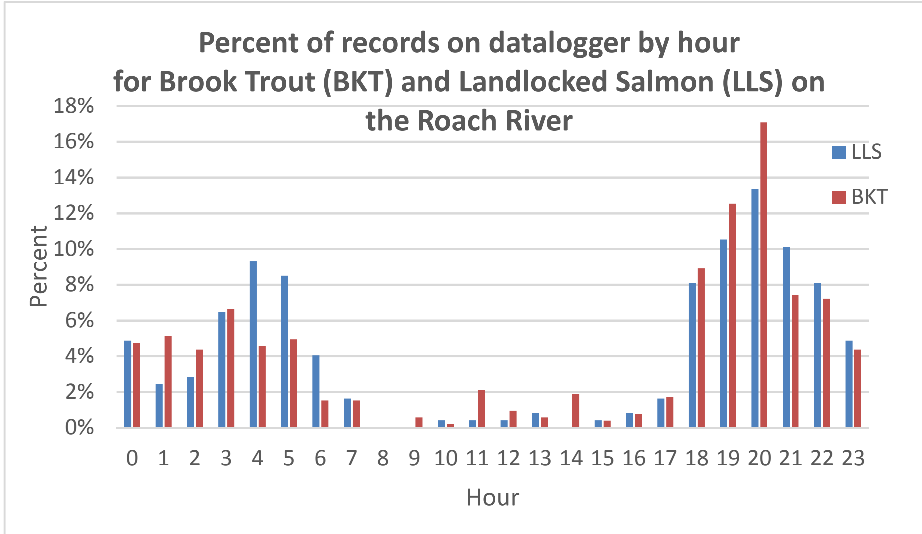

Figure 29. Time of movement for Brook Trout and Landlocked Salmon in the Roach River.

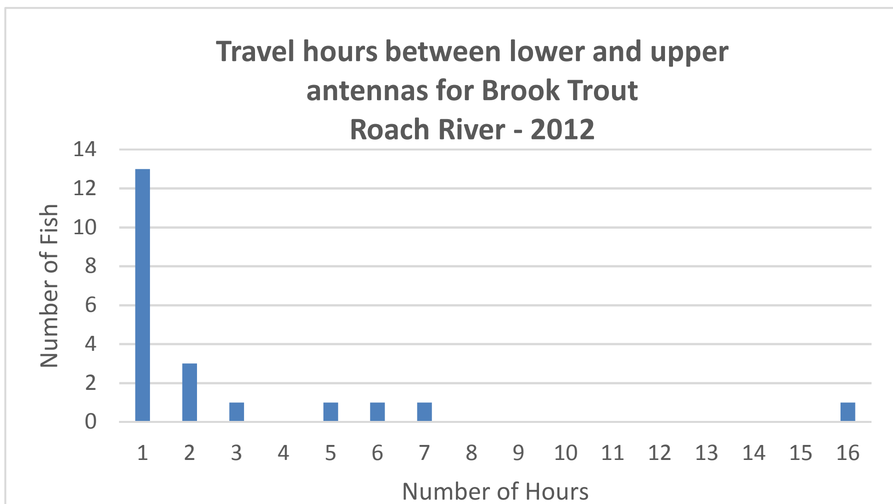

Figure 31. Travel time for Brook Trout in the Roach River.

We used radio telemetry to track the surviving post-spawning trout and evaluate the refuge areas that were established decades ago. In the winter of 2010, there were 15 active transmitters from the Socatean Stream tagging the previous fall. Two of the transmitters were still in the stream and 13 were in Moosehead Lake. Five (38%) of the ATS tagged fish in the lake were inside the protected area at the mouth of Socatean Stream and one other fish had made its way to the Spencer Bay refuge area. Seven of the tagged trout were alive in the lake in areas where they were vulnerable to ice fishing.

Three of these fish (43%) were harvested and another was caught and released. It subsequently died, likely from the hooking incident. Therefore, 57% of the vulnerable fish were lost due to fishing mortality. We located 19 active trout transmitters in the winter of 2011 from the Roach River tagging in the fall of 2010. Twelve of these fish (63%) were in Spencer Bay and protected from angling. Three fish were in streams or the Roach River which are closed to ice fishing. Four ATS tagged fish were in the lake in areas open to ice fishing. One of these fish was detected with a live signal in December and February; however, it was emitting a mortality signal on the April flight. It is possible the fish died as a result of a hooking injury although it was never reported caught. Another tagged trout that was caught on 01/08/12 was released and survived to return to the Roach River in the fall of 2012. A third fish in the lake was located near Rockwood and was detected throughout the winter and into April, but was never located after ice out. Clearly, the refuge areas at the mouth of Socatean Stream and Spencer Bay are still very important refuge areas for wild trout with 31% and 63% of the lake dwelling fish from Socatean Stream and the Roach River utilizing these sanctuaries. There were no other concentrations of post-spawning adult trout located during any of these radio telemetry studies. In general, we found that trout exited the stream or river in late October or early November, moved to a location in the lake, and remained there until ice out. Even more importantly, those few fish that were not present in the refuge areas exhibited high rates of hooking the following winter, indicating that the density of adult trout in Maine's largest lake is not very high. This correlates with data collected on Chamberlain Lake (Obrey 2018).

We know that Socatean Stream and the Roach River are two of the major spawning tributaries for wild trout in Moosehead Lake. We approximate both the Roach River run and the Socatean Stream run around 600 adult trout in each, based on the weir studies and attempting to account for missed fish. The Moose River is another large tributary with a significant spawning run that has not been evaluated. Other smaller tributaries include North and South Brook in Lily Bay. Adult trout have been observed in each of these in the fall, but they have not been evaluated with the weir yet. The weir was setup on Williams Brook and Tomhegan Stream in 2015 and only a handful of trout were captured in each. The East Outlet of the Kennebec River is a large outflowing river with a limited amount of suitable spawning habitat that is dominated by salmon. The number of wild trout moving upstream through the fishway trap at the outlet indicates that this river contributes a relatively small number of trout to the lake. Therefore, if we assume that the spawning run in the Moose River is similar to the Roach

River and all the other tributaries and outlets have smaller runs, then the overall population of stream-spawning adult trout from Moosehead Lake is likely just a few thousand fish.

Basley (DIFW, unpublished data) reported population estimates for trout greater than 12 in in the range of 0.13 - 0.30 fish per surface acre on Big Eagle Lake in the Allagash Wilderness Waterway. Obrey (2018) reported estimates of 0.24 - 0.28 for similar sized trout in nearby Chamberlain Lake. Bonney (2006) stated that population estimates from 24 trout ponds less than 200 acres ranged for 0.62 – 60.93 fish per surface acre. Chamberlain Lake and Big Eagle Lake are large oligotrophic lakes in the Allagash Wilderness Waterway located in northwestern Maine. For the most part, these waters have escaped the consequences of illegal fish introductions and the fisheries are dominated by wild trout, native Lake Trout, and native Lake Whitefish (*Coregonus clupeaformis*). Therefore, we would expect the density of trout in these waters to be higher than Moosehead Lake, where numerous warmwater species have been illegally introduced. Using the catch figures from the weir studies on Socatean Stream and the Roach River, along with the previously mentioned assumptions, a rough estimate of pre-spawning adults in Moosehead Lake that utilize these tributaries and outlet might be in the range 0.03 – 0.04 fish per surface acre. These estimates seem low in relation to annual harvest estimates of trout on Moosehead Lake, but they do not include immature fish or shore-spawning trout which are also known to occur in Moosehead Lake.

Very few salmon spawn more than once in the Roach River. None of the ATS tagged fish returned in 2012 or 2013. We documented 3% of the PIT tagged salmon returned in 2012 and less than 1% in 2013. Boucher and Warner (2006) reported that most repeat spawning occurred in alternate years for salmon in the Fish River chain. Most salmon spawning in the Roach River for the first time were age IV+ and V+. No older fish were taken. Therefore, wild Moosehead Lake salmon are not surviving long enough (age VI+ and age VII+) to return for a second spawning.

Recommendations

1. The weir will continue to be a very valuable tool to sample spawning runs of Landlocked Salmon and Brook Trout in the future.
2. Future sampling should be focused on the Roach River because we can gather information from large numbers of both Landlocked Salmon and Brook trout, where Socatean Stream is exclusively Brook Trout.
3. The smaller tributaries to Moosehead Lake should be sampled with the weir as time permits.
4. Activity that increases stress and mortality on wild Brook Trout and Landlocked Salmon during the fall spawning season should be avoided.

Funding Acknowledgment

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Current and past Fisheries Staff (left to right) at the Socatean Weir site in 2009: Assistant Regional Biologist Jeff Bagley, Fisheries Specialist Stephen Seeback, Fisheries Director Peter Bourque, retired Regional Fisheries Biologist Paul Johnson, retired Regional Fisheries Biologist Roger AuClair, retired Hatchery Supervisor (and former Assistant Regional Biologist) David Locke, Regional Fisheries Biologist Tim Obrey.

COOPERATIVE

STATE FEDERAL

PROJECT

This report has been funded in part by the Federal Aid in Sport Fish Restoration Program. This is a cooperative effort involving federal and state government agencies. The program is designed to increase sport fishing and boating opportunities through the wise investment of angler's and boater's tax dollars in state sport fishery projects. This program which was founded in 1950 was named the Dingell-Johnson Act in recognition of the congressmen who spearheaded this effort. In 1984 this act was amended through the Wallop Breaux Amendment (also named for the congressional sponsors) and provided a threefold increase in Federal monies for sportfish restoration, aquatic education and motorboat access.

The program is an outstanding example of a "user pays-user benefits" or "user fee" program. In this case, anglers and boaters are the users. Briefly, anglers and boaters are responsible for payment of fishing tackle, excise taxes, motorboat fuel taxes, and import duties on tackle and boats. These monies are collected by the sport fishing industry, deposited in the Department of Treasury, and are allocated the year following collection to state fishery agencies for sport fisheries and boating access projects. Generally, each project must be evaluated and approved by the U.S. Fish and Wildlife Service (USFWS). The benefits provided by these projects to users complete the cycle between "user pays – user benefits."

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