Maritime-Maine Joint Partnership for Sustainable Border Fisheries

Project #: P2500099

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Executive Summary

The internationally situated East Grand Lake is a key site for studying the potential resistance of thiamine deficiency complex (TDC) in Lake Trout (Salvelinus namaycush). This project aims to identify seasonal Lake Trout habitats and spawning areas of global management importance and to sample eggs for thiamine analysis by capturing spawning females. It also documents the seasonal use and spawning grounds of Lake Whitefish (Coregonus clupeaformis), another vital yet understudied species.

The Maritimes' distinct populations of Lake Trout, coexisting with both anadromous and landlocked Alewife—a forage fish species linked to TDC in Lake Trout within the Great Lakes region—offer a system for studying thiaminase and thiamine dynamics in lakes and for identifying genetic markers associated with TDC resistance. These could lead to potential methods for producing thiaminase-resistant Lake Trout in the Great Lakes area.

Partnered with Acadia University, the St. Croix International Waterway Commission (SCIWC) has installed a 20-receiver acoustic telemetry array across East Grand Lake, ME/NB, and has been monitoring Lake Trout and Whitefish movements and behaviours through acoustic telemetry. They have tagged 35 fish (20 trout and 15 whitefish) to gather data on migration, habitat, and environmental responses (e.g., thermal refuge). Using these data, staff uncovered vital evidence of spawning activity in Lake Trout and collected egg samples for analysis of thiamine content during Fall 2025. Tracking data for Lake Whitefish provided valuable insights into the species' seasonal habitat use, but we were unable to determine spawning activity in 2025. Continued monitoring throughout 2026 will help reveal more about this elusive fish species.

Both Lake Trout and Lake Whitefish remain vital to East Grand Lake's ecosystem, recreation, and economy. These populations are understudied, partly due to the lake's transboundary location. An acoustic telemetry array operated by the St. Croix International Waterway Commission has helped identify important habitat and spawning behaviours, which are essential for ongoing cross-border monitoring. Continued tracking and operation of the array will help ensure both fisheries' survival in the lake and provide guidance to fisheries managers for their ongoing success.

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Introduction

Lake Trout

Since the Great Lakes were invaded by Alewife (*Alosa pseudoharengus*), some Lake Trout (*Salvelinus namaycush)* populations are unable to naturally recover, as they suffer from acute larval mortality caused by a thiamine deficiency complex (TDC). TDC stems from a parental diet heavy in thiaminase-rich, non-native Alewife. Native Lake Trout populations in the Maritime provinces of Canada (New Brunswick [NB], Nova Scotia [NS]) and the state of Maine (ME) may share a biogeographic history with native sea-run Alewife, as these forage fish are a staple food source for Lake Trout in this region. One of the few noteworthy populations exhibiting this relationship is East Grand Lake (NB/ME), wherein genetically distinct (likely native) Lake Trout prey on introduced landlocked (freshwater) Alewife.

Preliminary analyses show that Lake Trout eggs from another Maritime Lake, Sherbrooke Lake (NS), contain sufficient thiamine (8.9 ± 3.5 nmol/g) even though Alewife exhibit high thiaminase activity (16.6 ± 8.6 nmol/g/min). Despite predation on Alewife, there is regular successful Lake Trout recruitment in both East Grand and Sherbrooke Lake. Given that these Lake Trout in both lakes are highly genetically distinct from other sampled North American populations, they have the potential for local adaptation, as previously observed in smaller New York State lakes. Lake Trout in East Grand Lake may; 1) rely on Alewife as a key prey species; 2) have an adapted resistance to the effects of TDC. The reasons behind the low reproductive success of Lake Trout in much of the Great Lakes—specifically, the high prey thiaminase levels and low egg thiamine—remain unclear. As well, the mechanism of thiaminase resistance in some Lake Trout populations is unknown, as is its potential prevalence in the Maritime and New England regions. The genetically distinct Lake Trout populations in the Maritimes, and the presence of anadromous and landlocked Alewife (**Figure 1**), provide a unique system for better understanding thiaminase/thiamine dynamics in lakes and for identifying genetic markers associated with TDC resistance. Once identified, these populations could possibly provide a pathway to fostering thiaminase-resistant Lake Trout in the Great Lakes.

Figure 1 Landlocked Alewife (*Alosa pseudoharengus*; left) and Rainbow Smelt (*Osmerus mordax*; right), two heavily present forage fish species of East Grand Lake, ME/NB.

Lake Trout are an ecological, recreational, and economically significant member of East Grand Lake's fish community. Yet this population remains largely understudied, likely due to the transboundary nature of East Grand Lake, as it sits on the international Canada/USA Border. This lack of understanding of this locally important and naturally sustaining population is apparent, as it is unknown where/when these Lake Trout spawn. To ensure these fish persist in the lake, continued monitoring from interested parties on both sides of the international border is needed. These fish are a native species to the lake and may represent a genetically distinct population that appears robust and stable. The primary objective of identifying unknown spawning locations would, in addition, be to: A) collect Lake Trout eggs to test for thiamine; and B) advise and assist local fisheries managers.

Lake Whitefish

Lake Whitefish (*Coregonus clupeaformis*) occupy a sparse and inconsistent distribution across NB. In ME, biologists and researchers have been investigating potential causes to Lake Whitefish declines, such as a link between the presence of introduced Rainbow Smelt (**Figure 1**) and declining Lake Whitefish, particularly in Northern regions of the state. Although there are some targeted winter recreational fisheries for the species in NB and ME, the species remains critically understudied compared to populations in other parts of North America, like the Great Lakes. Little is understood about the ecological characteristics that make up suitable habitat for the species, specifically in this region, notably in East Grand Lake. Lake Whitefish in East Grand Lake are open to recreational sport fisheries pressures, but captures are only reported sparsely throughout the winter (via ice angling) and seldom targeted directly by anglers. East Grand Lake has a resident Rainbow Smelt population, yet Lake Whitefish in the lake appear to be stable, although they remain unmonitored outside of ME state creel surveys. There is also critical information about these Lake Whitefish that is unknown, such as spawning locations and preferred conditions. A secondary objective of this project is to document Lake Whitefish summer thermal depth/habitat use and to define spawning locations and habitat.

East Grand Lake

East Grand Lake is a large oligotrophic waterbody situated at the headwaters of the East branch of the St. Croix River (**Figures 2** and **3**). East Grand is known for its clear, deep, and cold waters, with low nutrient levels and generally excellent water quality. East Grand is further characterized by large granite boulders scattered throughout, which formed reef habitats from deposits left by receding glaciers during the last ice age. The lake's naturally bouldery substrate may provide unique spawning and foraging habitats, making it an ideal system for study. It is the ninth-largest lake in ME and the third largest in NB, and one of only thirteen lakes in NB known to support self-sustaining populations of Lake Trout (Warner et al., 2023). With a maximum depth of 39 m (128 ft) and a surface area of 16,070 acres at full pool (Maine IF&W, 1997), the lake is relatively deep and becomes thermally stratified in the summer, offering refuge for many cold-water fish that seek shelter in waters deeper than ~ 20 m. The lake's complex and bouldery shoreline seemingly offers many suitable potential spawning locations for Lake Trout. These shallow littoral zones provide newly hatched Lake Trout with plenty of space to hide from predators and feed, benefiting from warmer, safer, and more productive conditions during their early life stages (A van Leeuwen et al., 2023). Much of the lake's shoreline is now protected from development by decades of governmental and private conservation efforts, a rarity given the cascading effects that shoreline infrastructure development can have on a lake's fish communities.

Figure 2 East Grand Lake, ME/NB during October. The left-hand image is taken near Billy & Nan Islands, and the right-hand image is taken of the shoreline near Haley Cove, both areas located on the Canadian side of the lake.

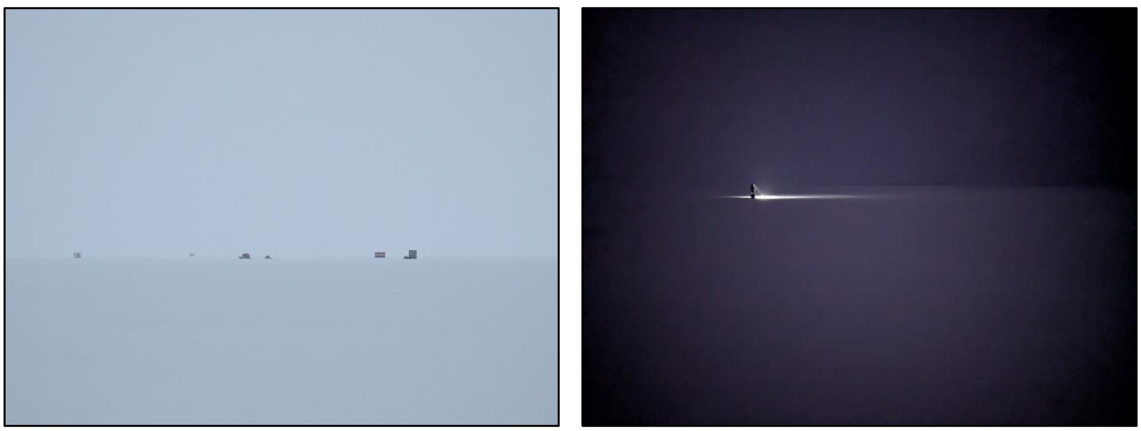

Figure 3 East Grand Lake, ME/NB, in January. The left-hand image depicts a group of ice-tents stationed at the Deep Hole area during a white-out weather event, and the right-hand image depicts SCIWC researcher Matt Warner returning to base after a day of fieldwork. Both images are taken near Greenland Point, located on the U.S. side of the lake.

The regional economy of the East Grand Lake region primarily depends on traditional activities such as fishing and hunting, which support many local businesses on both sides of the border (e.g., food, tackle, lodging, local guides, and snowmobiling). The lake once supported a native population of landlocked salmon; however, the lake struggled to sustain a fishery, leading to reliance on annual stocking. In contrast, lake trout has continued to thrive through natural reproduction; apart from 3 seasons of stocking in the early 1970s that were later deemed unnecessary (Maine IF&W, 1997). The success of these seeded introductions remains uncertain, as does the potential for these introduced fish to intermix with the pre-existing native stock (Warner et al., 2023). These salmonid species in the lake depend on abundant smelt and landlocked alewife populations for their food supply, which contributes to their continued success in the region (**Figure 1**).

Acoustic Tracking Overview

The project will employ passive acoustics, a method that uses equipment that continuously sends sound waves throughout the water and detects their echoes. These signals are sent out using biotelemetry electronic transmitters (hereafter referred to as 'tags') that are surgically inserted into the fish and are picked up by secondary receiving units placed in the environment (referred to as receivers). By analyzing return signals, researchers can determine the positioning of fish within East Grand Lake and where they reside in the water column at different times of the year. This incorporation of monitoring lacustrine ecology through a movement study increases the likelihood that conservation goals will ultimately focus on the population persistence of these native inhabitants, amid scrutiny of introduced invasive species (Tonkin et al., 2022).

Several factors must first be considered to help maximize the effectiveness of these receivers' detection ranges and their ability to detect tags. Assessment of these determined ranges is essential for long-term, large-scale deployment studies, as seasonality and differences in habitat may affect the equipment's performance (Radigan et al., 2025). Increased zooplankton and aquatic vegetation in the warmer seasons may decrease detection range, while ice cover during the Winter can amplify it, in combination with fewer macrophytes in the water column. Cold temperatures have also been shown to increase the rate at which receivers can detect tags due to lake stratification. The sound waves emitted by this equipment tend to slow or be reflected as they travel through temperature gradients that are associated with a thermocline (Scherrer et al., 2018). The depth at which receivers are placed in the water column should be similar to ensure comparable detection ranges, as performance can be influenced by how signals reflect off the water surface and the lake bottom (Radigan et al., 2025).

Project Objectives

Given its ecological similarities to the Great Lakes and its international setting, East Grand Lake has become a focal site for researchers seeking to better understand TDC and the conditions under which Lake Trout populations in North America can persist despite it. This project aims to identify seasonally specific Lake Trout habitat, locate spawning areas with international management implications, and capture spawning females to sample eggs for thiamine analysis. Concurrently, the study will document seasonal habitat use and spawning areas of Lake Whitefish (*Coregonus clupeaformis*), another essential and understudied fish species found in East Grand Lake.

Human modifications, such as habitat fragmentation and water-level regulation by dams, along with shoreline alterations, continue to threaten freshwater ecosystems across the country, with lacustrine systems among the most heavily impacted (A van Leeuwen et al., 2023). The outcomes of this project will also help inform future water-level management decisions for East Grand Lake, as the SCIWC is expected to become the future owner of the Forest City Dam located at the lake's outlet (**Figure 4**). Animal behavioural studies serve as an effective community-level indicator, guiding decisions on how best to operate these systems, with emphasis on the lake's environmental health (Hale et al., 2019). Preventing future habitat degradation will protect against changes in movement behaviours of East Grand Lake's fish communities, which could influence the overall viability of these populations (Tonkin et al., 2022). Identifying and documenting Lake Trout spawning habitat could help establish future target water levels for the fall drawdown during the species' spawning season, thereby helping safeguard the population from potential harm.

Figure 4 The Forest City Dam located at the outlet of East Grand Lake along the international boundary.

Methods

Lake Trout and Lake Whitefish Sampling and Tagging

Twenty (20) lake trout and fifteen (15) lake whitefish were captured by ice-angling from January 21 to February 27, 2025 (**Figure 5**). The fish were caught at six locations within East Grand Lake (**Table A3**), mainly near Greenland Island and the lake's deepest basin, known colloquially as the Deep Hole. The first three lake trout were caught by nearby anglers around the Deep Hole who agreed to provide caught fish for tagging, with two caught using tip-ups and one using a traditional hook-and-reel. These fish were initially placed in a lake-water-filled tote and transported by a pull-sled into the designated tagging tent to avoid prolonged exposure to the weather. The remaining 17 lake trout were caught by SCIWC and Acadia University staff inside the tagging-station tent after it was decided that longer hauls from volunteer fishing sites to the operation tent could impose unnecessary stress on the fish prior to surgery. All remaining catches were done using hook-and-reel with a variety of natural and artificial presentations.

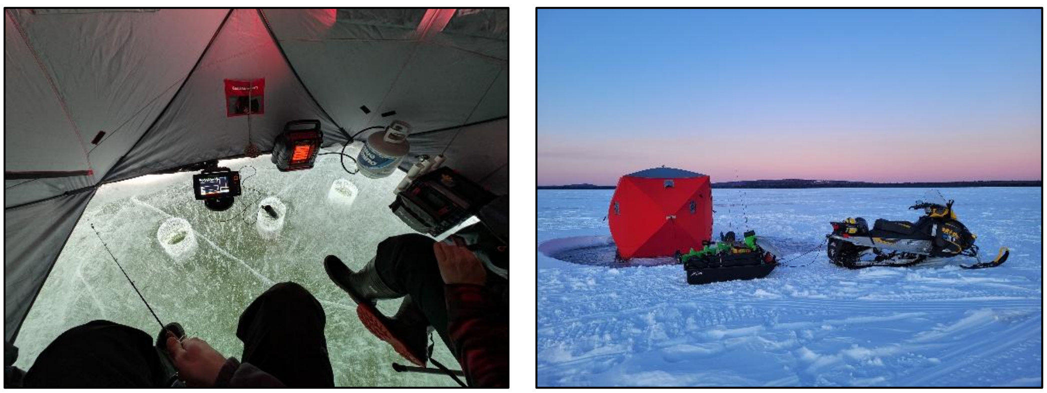

Figure 5 The ice tent tagging-station used to capture and tag Lake Trout and Lake Whitefish throughout the Winter 2025 season, taken from inside (left) and the outside (right) of the structure.

Captured fish were immediately placed into a recovery tank consisting of a 33-gallon fish tote filled with lake water while the operation station was being prepared. Fish were then anesthetized in a bath of clove oil concentrate diluted in lake water (~15-20 mg/1 L), with Aqui-S used as an alternative anesthetic during part of the tagging period in February (~15-20 mg/1 L). Once each fish had lost equilibrium, they were positioned belly-up on a neoprene-lined bump board and measured for fork and total body length. The weight of each fish was not recorded because a reliable scale was unavailable at the time. A 6 – 7 mm incision was made slightly off-centre of the ventral midline, anterior to the pelvic girdle, and the acoustic transmitter was inserted into the peritoneal cavity. The incision was subsequently closed using several medical-grade sutures. **Figures 6** and **7** provide a visual representation of the tagging surgical operation.

Figure 6 Images from tagging surgery procedures for 4 separate Lake Trout (*Salvelinus namaycush*). The far-left image shows a fish just after being anesthetized; the center-left and center-right images show the anesthetized fish undergoing tag insertion; and the far-right image shows the surgery wound being closed with sutures.

Figure 7 Lake Whitefish (*Coregonus clupeaformis*) set up for the surgery procedure just prior to tag insertion (left), and an image of a second Lake Whitefish post-surgery, just prior to release back into East Grand (right).

An external Floy anchor wire tag was inserted at the base of the dorsal fin of each lake trout to serve as a secondary visual identifier in the case of recapture, complete with contact information for Acadia University staff. Floy tags were not inserted into Lake Whitefish. Scales and anal fin clips were collected for later aging and genetic analysis purposes. Following each surgery, the fish was returned to the recovery tank containing fresh lake water and released once it had regained normal equilibrium and was observed swimming.

Each fish was given a unique identifier that matches the acoustic transmitter's ID and serial number. The tag transmitters are part of the V9TP-2x family (Innovasea, Bedford, NS, Canada) and operate at 69 kHz. Each tag measures 31 mm in length, 9 mm in diameter, and weighs 4.9 g in air (2.8 g in water). Tags are designed to operate in an aquatic environment at temperatures ranging from -5 to 35 °C and at a depth of 34 m. Each transmitter is designed to operate for 730 days and emits two consecutive ten-digit identification codes that indicate temperature and depth data. These codes were programmed to broadcast randomly at 80 – 160-second intervals (nominal delay of 120 seconds), with a transmitter output power of 146 dB.

International Public Volunteer and Engagement

Through social media and signage at lake access points (**Figure 8**), angler engagement helped staff emphasize project goals and provide updates, thereby maintaining positive relationships with the public. Public engagement took place on both sides of the border, with volunteers helping with fish capture and sharing their locally gained expertise on the most effective collection methods. Anglers who interacted with project staff were encouraged, though not required, to release tagged fish upon capture. Project staff contacted area fishing lodges and guiding services on the lake to inform them of the deployment of receiver moorings in the Spring of 2025. Discussions with locals and state and provincial agencies were held to determine the best ways to minimize public interaction with receiver moorings.

Figure 8 Signage posted on online platforms and at popular East Grand Lake boat access sites to inform the public about details of the tracking project, including the identification of tagged fish and the presence of equipment on the lake.

Acoustic Receiver Moorings Management

Monitoring was conducted using Innovasea NexTrak 69 kHz receivers deployed throughout East Grand Lake. Two receivers were initially deployed near the perimeter of the Deep Hole area on March 4, prior to spring ice-out, to detect tagged fish under late-winter conditions and to extend the data-collection window. These receivers were deployed at depths of 21 m and 26 m and were retrieved before the full array deployment later that year.

An additional 18 receivers were deployed on May 1 and 2, 2025, following ice-out at water depths ranging from 10.7 to 31.1 m. Receivers were secured to vertical mooring lines anchored with concrete blocks and positioned approximately 6 – 8 m below the water's surface. Each mooring included a subsurface buoy positioned approximately 3 – 4 m below the surface, and a select number of moorings in more heavily trafficked areas with a surface buoy to aid local anglers in avoidance and retrieval. GPS coordinates were recorded for all receiver locations during each deployment. All moorings were fitted with cautionary tags that described the project, requested that equipment remain undisturbed, and provided contact information. A diagram of the receiver mooring layout, along with a copy of the cautionary tag attached to each buoy, is shown in **Figure 9**.

Figure 9 Diagram (left) portraying the layout of each of the acoustic receiver moorings deployed across East Grand Lake, ME/NB, in addition to the signage (right) placed on each of the subsurface & surface buoys to deter public interaction with the equipment.

The array covered approximately 18 – 20 km^2 of East Grand Lake, with some overlap between the detection windows. Receivers were spaced roughly one kilometre apart to ensure effective detection coverage across the lake. Several range tests were conducted on East Grand Lake, and test tag signals were received approximately 500 m away during open-water periods, with further range increase when the lake was iced over, ensuring that the predetermined receiver placement provided full coverage. Placement focused on key lake basins with thermal stratification, targeting areas likely to support Lake Trout and Lake Whitefish during summer. Selected receivers also served as directional gates to monitor fish movements among the basins. The placement and repositioning of receivers were guided by expected fish movement patterns, previous data review, and local knowledge to optimize detections and enhance overall efficiency.

Receivers recorded tag signals containing depth and temperature data throughout the study, with in-sync timestamps, enabling later positioning via triangulation among neighbouring receivers. Data retrieval involved physically collecting the receivers, as remote downloading was not feasible. Moorings were recovered by grappling the mooring line from the surface using a boat or diver during the open-water months. A receiver-wide downloading event occurred over four separate trips from July 15 through to August 7, 2025. Each receiver was redeployed to its original position within a week of its respective retrieval. A subsequent mass download was made following the suspected fish spawning season on November 24, 2025, and the receivers were redeployed the following day, just before the water temperature approached freezing.

Several adjustments were made to the moorings throughout the open-water season to accommodate changes in lake water level and public interaction with the equipment. The 2025 season was characterized by severe drought, with low precipitation and high air temperatures. As water levels declined throughout the year, SCWIC staff visited each station monthly to shorten the moorings if needed, ensuring the receivers remained at a similar depth below the surface and preventing the public from interacting with subsurface buoys.

Temperature Data Management

In addition to monitoring fish movements with a static receiver array, the project also collected water-temperature data to monitor thermal stratification. By establishing the extent of the waterbody's hypolimnion, staff were able to determine how Lake Trout in East Grand can withstand limits on ideal temperature and oxygen levels. This was accomplished through several deployments of an In-Situ water-quality device that monitored selected parameter changes throughout the water column. In conjunction with in-field water-column profiling, staff used passive water-quality monitoring methods, including long-term loggers that measured temperature, light, and pressure conditions. One mooring with several loggers distributed throughout the water column was deployed on May 27, 2025, the same day the acoustic receivers were installed.

The logger string was placed in 35 m of water in the Deep Hole area, approximately 800 m northwest of Greenland Island. This was equipped with 15 separate loggers, beginning at 4 m below the surface and spaced every 2 m to the lake bottom. The loggers consist of HOBO Pendant loggers at 4 m to 22 m and HOBO Tidbit-400 loggers at 24 m to 32 m. The two Pendant loggers closest to the surface, at 4 m and 6 m, were equipped with additional light-level sensors.

The temperature logger-string recorded data hourly from deployment through to the date it was retrieved, along with the acoustic receivers, on November 24, 2025. The Deep Hole temperature string was redeployed on November 25, 2025, at the same location. The first logger on the mooring string was positioned 5 m from the lake's surface, with no light-sensing logger equipped at the subsurface buoy for the redeployment.

Lake Trout Spawning Site Identification and Egg Sampling

To identify Lake Trout spawning sites and to capture eggs for thiamine analysis, tagged Lake Trout were actively tracked using a VR-100-300 unit, and suspected spawning shoals were gill-netted over a four-night period from October 20-25, 2025. A 1.5-inch mesh gill net was used to angle the fish, which was set in approximately 30-minute interval deployments. The captured fish were carefully dip-netted from the gillnet mesh and manually carried aboard to prevent unnecessary damage. Fish were placed into a holding tank until the net was fully brought in and redeployed, then weighed, measured for fork and total length, and sexed. If fish were identified as male, fin and scale samples were collected and then immediately released. Identified females were stripped of approximately 10 grams of eggs, then fin-clipped, scale-sampled, and released.

Results and Discussion

Lake Trout

Depth/Temperature Residency

All acoustically tagged Lake Trout (n = 20) displayed a hypolimnetic (~20 m and deeper) depth residency for the majority of the 2025 summer season, while East Grand Lake was thermally stratified before fall turnover (early June to mid-October 2025; **Figure 10**). Cold, hypolimnetic water temperatures that likely drive depth residency of Lake Trout during this warm-water, summer period reached a minimum temperature of ~11 °C (**Figure 11**), making this the coldest available habitat in the lake.

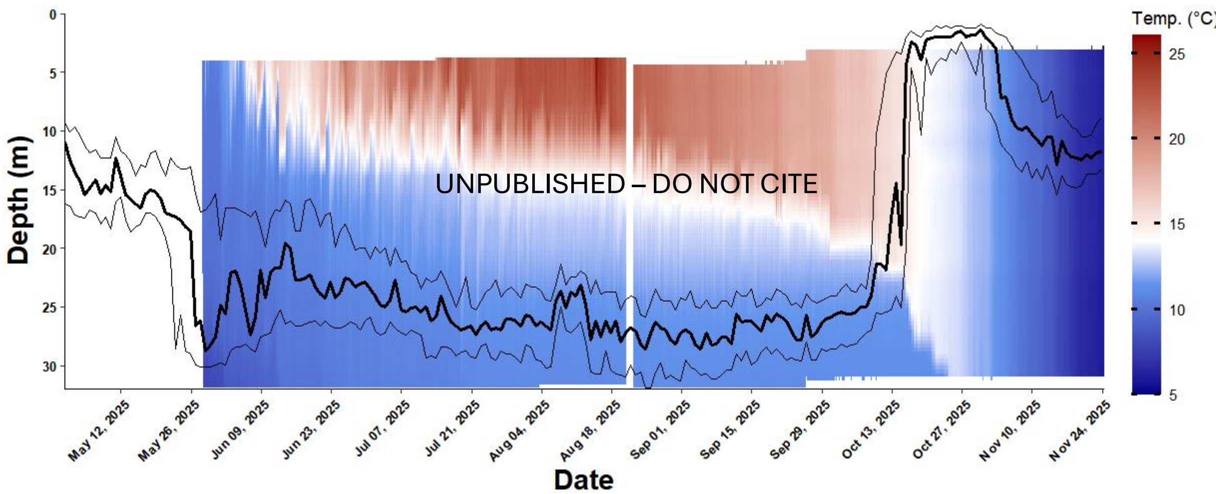

Figure 10 Water column temperature as recorded for the deepest part of East Grand Lake (NB/ME) from May 1 to Nov. 24, 2025, overlaid with the median (solid black line), and the 25th and 75th quartiles (upper and lower gray lines) of the daily depth residency of n = 20 acoustically tagged Lake Trout (*Salvelinus namaycush*) from May 1 to Nov. 24, 2025.

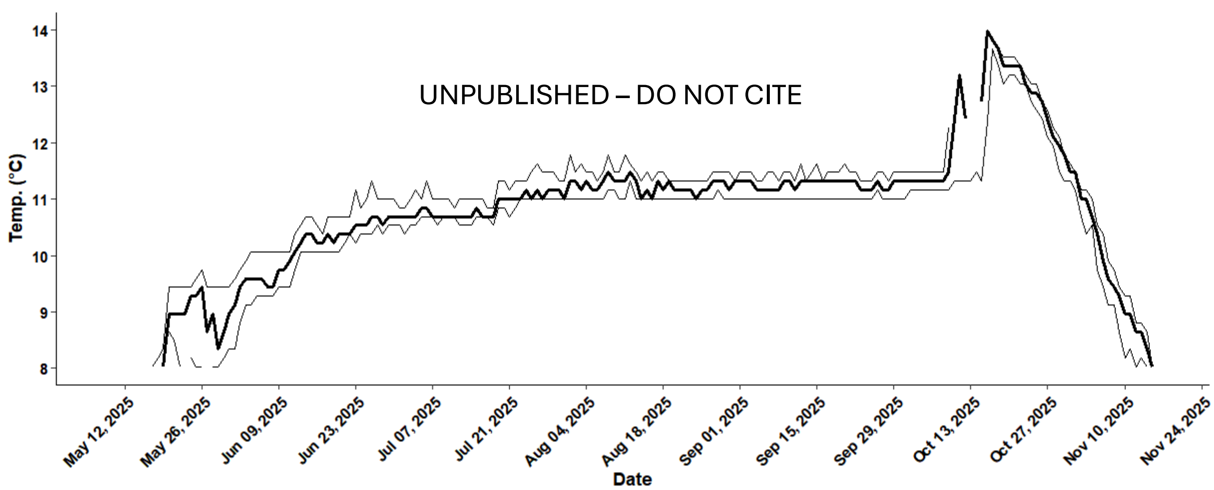

Figure 11 Median (solid black line), and 25th and 75th quartiles (upper and lower gray lines) of the daily temperature residency of n = 20 acoustically tagged Lake Trout (*Salvelinus namaycush*) from May 1 to Nov. 24, 2025.

Despite East Grand Lake being a large, deep lake, hypolimnetic summer thermal refuge was restricted by deep stratification, limiting Lake Trout depth residency to depths greater than 20 m. Historic temperature data from East Grand Lake suggest these are annually regular conditions. For other lakes in ME, State agencies have noted that narrow summer deep-water thermal refuges (6–13 °C, >6 mg/L DO) are a constraint on carrying capacity for Lake Trout in small lakes (Snucins and Gunn, 1995; Maine IF&W, 1997).

Spawning and Egg Sampling

The Lake Trout fall vertical spawning migration (~ 25 m median daily depth to ~2 m median daily depth over ~5 days) began before fall turnover, and when surface water temperatures dropped to ~14 °C (**Figures 10** and **11**). This migration was confirmed to be for spawning, as an active-tracking VR100-300 unit was used to locate shallow-spawning individuals for egg collection from October 22 – 25, 2025. There was a higher proportion of captured males (25) to females (11) across all sampled sites. A small number of post-spawn females were captured at each of the three successful netting sites, which had a slender appearance and were unable to produce the required amount of eggs when stripped (**Figure 12**).

Figure 12 Sampled post-spawn female Lake Trout (*Salvelinus namaycush*; Top), a pre-spawned female (middle), and a notably colourful male (bottom left) caught on East Grand Lake, ME/NB, October 2025. The bottom right shows a vial of sampled Lake Trout eggs.

Of several zones sampled using gill nets to capture females for egg sampling, one considerable Lake Trout aggregation was located, which included at least three tagged Lake Trout (**Figure 13**). Using active tracking with a VR100-300 unit to detect nearby fish signals and headlamps to navigate the lake's shoreline, researchers uncovered a large aggregation of Lake Trout at depths of 1 – 1.5 m. Although only five females were sampled at the aggregation site, >15 unsexed individuals were released without sampling, and >200 were observed in the water using lights. It is unknown if this site is used annually as a spawning site; future surveys will seek to confirm this, as this may be critical habitat. From this site and two others, 10 female Lake Trout were sampled, with 10 g of eggs from each, to be tested for total thiamine by Dr. Jacques Rinchard from the State University of New York.

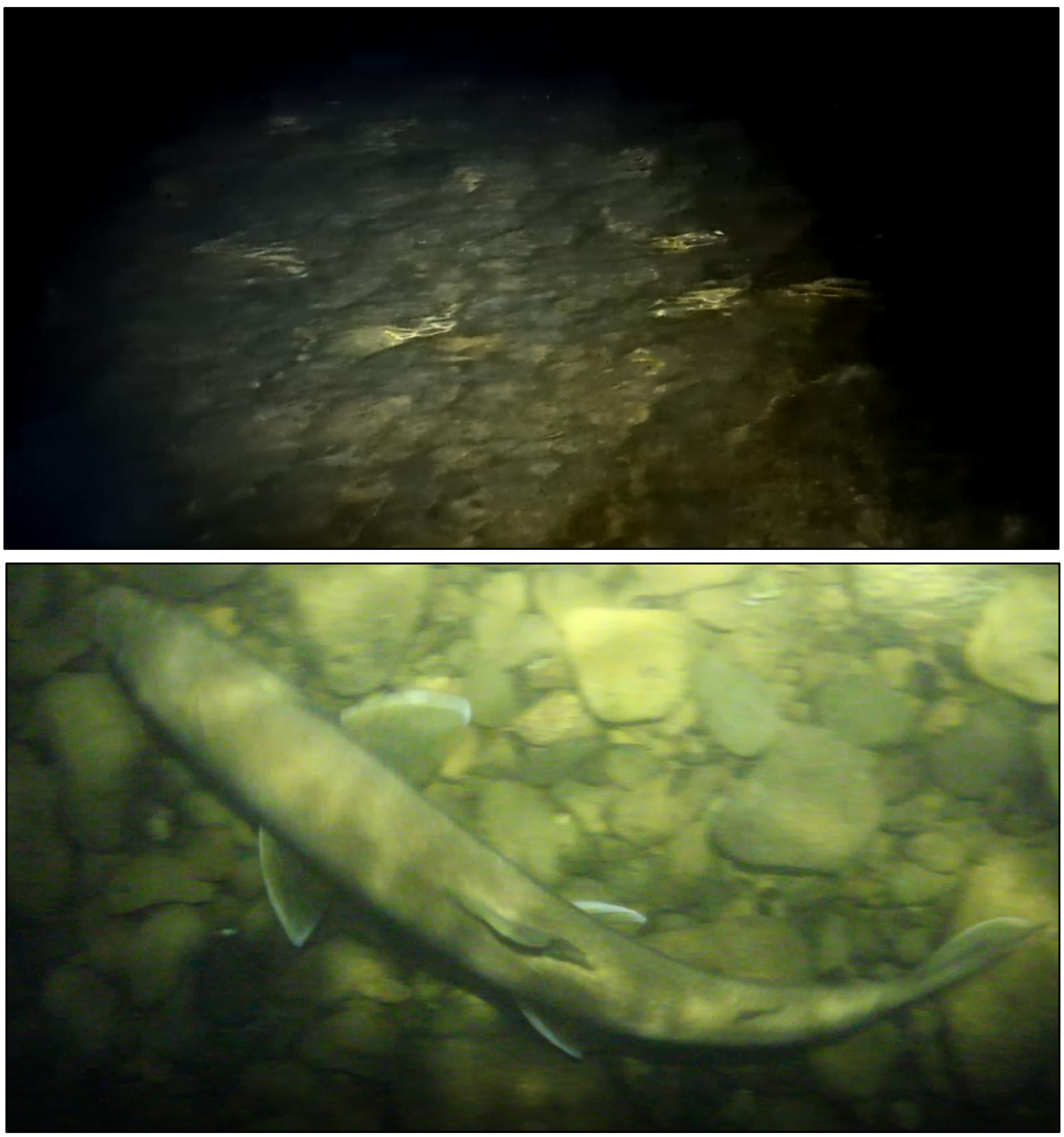

Figure 13. A large aggregation of Lake Trout (*Salvelinus namaycush*) co-located by actively tracking 3+ acoustically tagged Lake Trout along the shoreline of East Grand Lake, ME/NB – October 2025.

Lake Whitefish

Depth/Temperature Residency

Acoustically tagged Lake Whitefish (n=9) displayed a hypolimnetic (23 m and deeper) depth residency for much of the 2025 summer season while East Grand Lake was stratified before fall turnover (early June to mid-October, 2025; **Figure 14**). These data do not include any from the 6 Lake Whitefish that went missing from the array or died during the study period. Cold, hypolimnetic water temperatures that likely drive depth residency of Lake Whitefish during this warm-water, summer period were not lower than ~11 °C (**Figure 15**), making this the coldest available habitat in the lake.

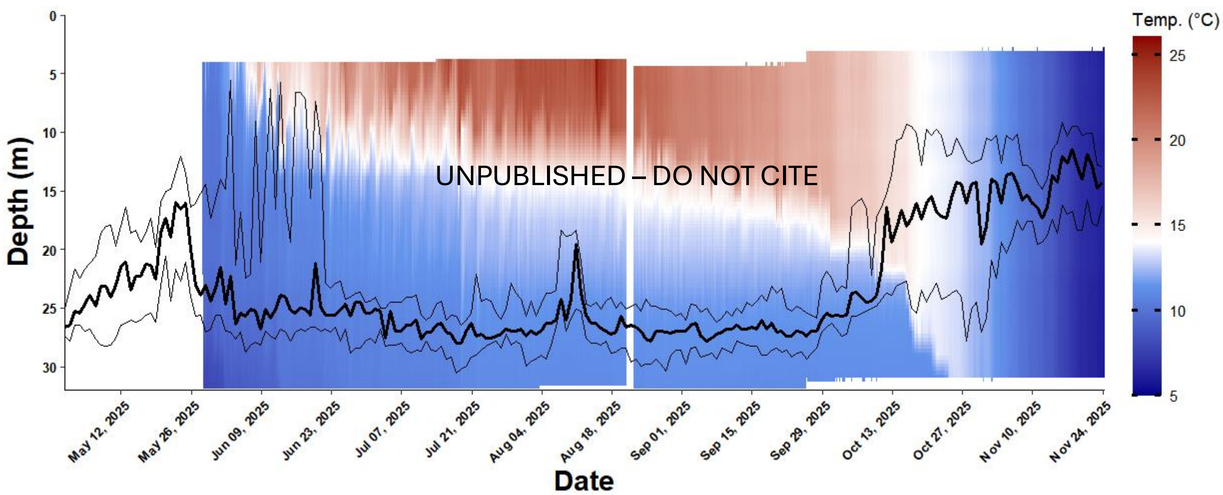

Figure 14 Water column temperature as recorded for the deepest part of East Grand Lake (NB/ME) from May 1 to Nov. 24, 2025, overlaid with the median (solid black line), and the 25th and 75th quartile (upper and lower gray lines) of the daily depth residency of n = 9 acoustically tagged Lake Whitefish (*Coregonus clupeaformis*) from May 1 to Nov. 24, 2025.

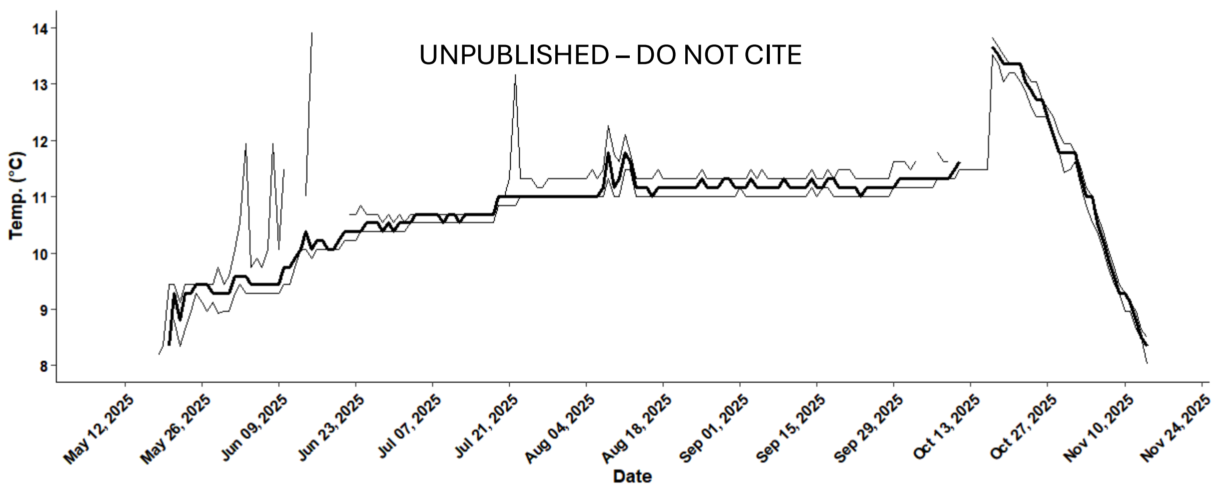

Figure 15 Median (solid black line), and 25th and 75th quartiles (upper and lower gray lines) of the daily

temperature residency of n = 9 acoustically tagged Lake Whitefish (*Coregonus clupeaformis*) from May 1 to Nov. 24, 2025. N = 6 Lake Whitefish that have gone missing from the array or confirmed dead at any time before Nov. 24 are not included in any part of the depth residency.

Variance in Lake Whitefish daily depth residency was widest (~5 – 25 m) during the summer, greatest between early May and late June, 2025, just as the lake began to stratify. This is explained by discernibly differing depth/temperature occupancy habits displayed by two groups of Lake Whitefish during this time period; a representative individual Lake Whitefish displaying each habit is shown in **Figure 16**. There were no identifiable physical features between these groups, and they shared the same depth/temperature residency after late June and into the fall. It is unclear if these are two separate strategies by individuals within the same population, or if genetic analysis of these fish will reveal a separation.

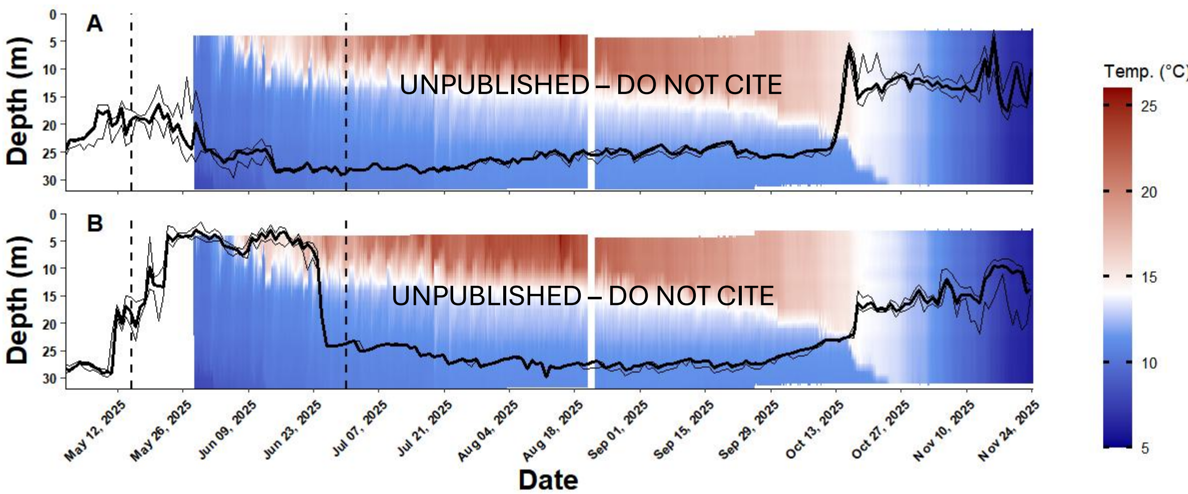

Figure 16 Water column temperature as recorded for the deepest part of East Grand Lake (NB/ME) from May 1 to Nov. 24, 2025, overlaid with the median (solid black line), and the 25th and 75th quartiles (upper and lower gray lines) of the daily depth residency of 2 separate (A and B) acoustically tagged Lake Whitefish (*Coregonus clupeaformis*) from May 1 to Nov. 24, 2025. A is the depth residency of a representative individual Lake Whitefish (39 cm total length) that displayed a deeper early spring residency (within the period between the dashed line). B is the depth residency of a representative individual Lake Whitefish (37.7 cm total length) that displayed a shallower early spring residency (within the period between the dashed line).

Spawning

No discernible shallow-water (<5 m) Lake Whitefish spawning migration or aggregation was observed through depth residency analysis (**Figure 14**). Unless these Lake Whitefish spawn between ~10 and 17 m, Lake Whitefish did not reside regularly above 10 m before Nov. 24, when receivers were most recently downloaded. Data after late November may reveal a shallow-water vertical migration, and fine-scale positioning analysis across the lake may identify spawning aggregation locations.

Lessons Learned

Whitefish Capture & Surgery Complications

During the Winter 2025 season, one of the main issues SCIWC staff encountered was tagging Lake Whitefish during their fish capture efforts. Lake Whitefish turned out to be a more complicated fish to perform the tag insertion surgery, namely because their overly thin skin proved difficult to suture, post-insertion, and the inability of the fish to expel excess gas from their swim bladders, a condition known as barotrauma. Lake Whitefish are physostomous and can generally expel excess gas from their swim bladders when brought up from deep water (>15 m). However, the fish SCIWC staff had captured struggled to expel gas, and almost all Lake Whitefish captured exhibited severe barotrauma.

For these reasons, four Lake Whitefish did not survive the tagging procedure. Two post-surgery mortalities were reported shortly after the tagging procedure, determined by reading acoustic tag depth data using a VR100-300. One of these post-surgery mortalities was recovered in an unlikely situation: the fish had remained under the ice, leaving the staff to retrieve it several weeks later by tracking its general location. This recovered tag was then placed into another Lake Whitefish. The two remaining mortalities occurred during the tagging procedure, with barotrauma-caused complications during the surgery. These two fish required euthanasia via a swift concussive blow to the top and base of the head. They were then sampled for tissue later used for DNA analysis, while the remaining fish were donated to Maine IF&W biologists for their ongoing Lake Whitefish otolith/age monitoring program.

To reduce barotrauma and physical stress from handling Lake Whitefish, the tagging procedure was modified post-capture. The use of floy dart tags as secondary identifiers was discontinued due to the large size of the tag, which could potentially hinder the fish's ability to swim freely. To address the issue of expanded gas bladders during the study, an improvised experimental holding method was used for fish caught from depths greater than 9 m (~2 atmospheres of pressure). Whitefish were rarely caught in shallower waters (less than 9 m) during the project. Immediately after capture, these fish were placed in a lobster crate (1 m x 0.15 m plastic tote) and suspended underwater from a rope attached to the ice surface. The crate was lowered back to the fish's catch depth to help it rest, preventing the gas bladder from overexpanding. After an hour, the crate was raised to depths greater than 9 m, or approximately 1 atmosphere, where it stayed for several hours during the day or overnight. This gradual ascent in a stable lacustrine environment was intended to promote natural acclimation to shallower depths, thereby reducing the risk of gas-bladder complications during surgery.

This holding method provided some relief by preventing further mortalities during surgery but did not fully cure the barotrauma issue. Gas bladder pressure was somewhat reduced, making tag insertion and suturing slightly easier. After surgery, regardless of the depth at which the fish were captured, Lake Whitefish were unable to swim downward against their own buoyancy. Using the same crate-holding method, tagged Whitefish recovered at their respective capture depths to minimize stress, avoiding freezing temperatures while at the surface, and overinflation. After an hour, they were released and seemed to regain enough energy to swim down successfully. All descended to depths of 15 – 25 m, with no further mortalities as indicated by collected tracking data during the remainder of the capture portion of the project.

Tag Detections for Lake Trout and Lake Whitefish

As of the last data offload on November 24, 2025, unique detections across all tagged Lake Trout totalled 1,294,983, including temperature and pressure signals. All were last detected on the same day as receiver retrieval and appear active, except for two fish that have not been detected in the array since late May and mid-July 2025. It is unknown whether they remain in the water body; it can be theorized that they may have been angled or left the lake naturally through the outlet stream.

For surviving Lake Whitefish, there have been a total of 711,651 temperature and depth-pressure detections as of the last data offload. By late November 2025, the number of active Lake Whitefish had decreased from 15 to 9. One fish was confirmed dead shortly after tagging and could not be recovered. Two fish have been missing from the array detections since early Spring 2025, possibly because they were caught by anglers or left the lake entirely. The remaining three Lake Whitefish are still detected by our receivers but are considered mortalities due to the absence of depth signal changes over several months. This delayed mortality may be due to the size of the tags used (V9TP). For future tagging projects involving Lake Whitefish, staff will use smaller tags rather than the V9 tags, which are better suited for larger bodied fish.

Array Management

Of the 20 receivers deployed throughout the lake, one receiver mooring has gone missing from its deployment location, leaving staff to reason it may have been tampered with. The Big English Cove (S/N: 801562) site was first reported missing by SCIWC staff on August 7, 2025, and on October 3, 2025, it was confirmed that the subsurface buoy was no longer in its original location. Detections from neighbouring receivers and active tracking with a VR100-300 confirmed that the receiver was still present in the area and transmitting signals. Several attempts to pinpoint the receiver within the cove were made, but as of Winter 2026, the mooring remains undiscovered. Once the ice is out and the water is warm enough for divers to enter the lake, further attempts to locate the missing receiver in 2026 will be made.

Staff and project partners have discussed the most effective way to keep deployed receiver moorings in place at their respective locations without unnecessary public interaction. Namely, whether to keep moorings connected to solely sub-surface buoys (3 – 4 m below the surface) or surface buoys visible along the water line. Throughout the monitoring period, many of the moorings were connected to sub-surface buoys, except for the receivers located around the heavily trafficked Deep Hole area. This method proved mostly successful, with the main issue being the need to shorten the subsurface buoys due to the drought conditions throughout 2025, especially mid-Summer and early-Fall. Communications will continue in 2026 to transition all moorings to surface buoys this upcoming Spring after ice-out on East Grand Lake, based on the lack of tampering with the buoys in the Deep Hole area, to streamline future data retrieval.

Future Research Objectives

One of the main project objectives for the 2026 fieldwork season is to continue and complete the collection of East Grand Lake's bathymetry data. SCIWC staff are on track to map the remaining lake areas (~50% of the lake surface area) by Fall 2026, before the Lake Trout and Lake Whitefish spawning season. As data collection continues, staff will correct and display bathymetry information alongside the fieldwork. Finalized map data are intended for calculating summer thermal-habitat volume and for future spawning-habitat discovery for both fish species. Completed maps will also be provided to outside parties interested in the data, in yet-to-be-determined formats.

Moving forward, for the 2026 season, staff will replicate the Summer and Fall tracking conducted in 2025 for Lake Trout, as well as the egg sampling efforts during the Fall spawning season window. Throughout the season, staff will also collect Alewife (~ 20 samples) from East Grand to have them analyzed for thiaminase concentration. Samples will be sent to Dr. Freya Rowland of the Columbia Environmental Research Center once collected. This Alewife collection will be conducted in tandem with a large-scale food web analysis to determine diet and decipher the Lake Trout's resistance to TDC and its potential genetic distinction.

As for Lake Whitefish, similar methods will be replicated to continue tracking these fish throughout the 2026 season. Fine-scale positioning using the proprietary Innovasea software Fathom Connect will be used in the future to identify more precise locations indicative of Lake Whitefish spawning. The data collected post-ice-out in Spring 2026 will provide evidence of spawning activity by these fish in early December 2025. Determining this window will allow staff to better understand spawning activity and accommodate fieldwork schedules later in the year, if ice formation on the lake allows. The receiver array data will continue to track the surviving Lake Whitefish throughout the 2026 season.

Maine IF&W has approached SCIWC and discussed potentially using the receivers to conduct similar habitat research on the East Grand Lake's Burbot/Cusk (Lota lota) community, another understudied fish species. As of the writing of this report, no objectives have been confirmed for this potential study. However, staff will continue to encourage like-minded agencies and organizations to use the existing acoustic array for research on this treasured lake and its robust fisheries (**Figure 17**).

Figure 17 Looking North from near Forest City on East Grand Lake, ME/NB – March 2025

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Finally, we are grateful for the individual anglers and East Grand Lake residents who donated their time, knowledge, guidance, and efforts in support of this project. Thank you, from the researchers of the SCIWC.

Figure 18 SCIWC researchers involved in the project, from left to right: Marshall Elsemore, B.Sc., Neal Berry, B.Sc., and Matthew G. Warner, M.Sc.

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Appendix

Table A1. Metadata of Captured and Tagged Lake Trout (*Salvelinus namaycush*).

ID	Name	Fork Length (cm)	Total Length (cm)	Tag ID (temp)	Tag ID (depth)	Tag Serial #	Floy Tag ID	Tagged Date	Catch Depth (m)	Tagging/Release Site
EGL-02-LT1	*CLICee*	57.0	65.1	235	236	1621242	4087	2025-01-21	33.8	*Deep Hole*
EGL-03-LT2	*Notorious 14*	78.5	84.0	231	232	1621240	4092	2025-01-22	33.8	*Deep Hole*
EGL-05-LT3	*Annette*	64.0	69.0	227	228	1621238	4066	2025-01-25	33.8	*Deep Hole*
EGL-08-LT4	*Mr. Worldwide*	70.0	76.0	259	260	1621254	4069	2025-01-31	25.3	*Border*
EGL-10-LT5	*Felix*	61.0	67.5	247	248	1621248	4062	2025-02-03	25.3	*Border*
EGL-11-LT6	*Lauren*	62.0	68.0	249	250	1621249	4057	2025-02-03	25.3	*Border*
EGL-12-LT7	*Hoyt*	61.5	65.5	257	258	1621253	4091	2025-02-04	22.9	*Border 2*
EGL-13-LT8	*Pat*	56.5	60.0	253	254	1621251	4085	2025-02-04	22.9	*Border 2*
EGL-14-LT9	*Precious*	51.0	55.5	241	242	1621245	4064	2025-02-04	25.3	*Border*
EGL-15-LT10	*Fluke*	47.5	52.0	261	262	1621245	4095	2025-02-04	25.3	*Border*
EGL-16-LT11	*Aqui*	57.0	62.0	245	246	1621247	4079	2025-02-05	25.3	*Border*
EGL-17-LT12	*Overlook*	52.5	57.5	255	256	1621252	4090	2025-02-05	25.3	*Border*
EGL-18-LT13	*Emma*	51.5	56.0	237	238	1621243	4084	2025-02-05	25.3	*Border*
EGL-19-LT14	*Lily*	63.5	68.5	239	240	1621244	4052	2025-02-05	25.3	*Border*
EGL-20-LT15	*Kristine*	70.0	76.5	281	282	1621580	4070	2025-02-08	25.3	*Border*
EGL-21-LT16	*Fontaine*	64.0	68.5	285	286	1621582	4094	2025-02-12	25.3	*Border*
EGL-24-LT17	*Ellie*	67.5	72.5	267	268	1621573	4075	2025-02-18	25.3	*Border*
EGL-25-LT18	*Mung*	69.5	75.5	287	288	1621583	4098	2025-02-18	25.3	*Border*
EGL-26-LT19	*Wes*	67.5	70.0	271	272	1621575	4068	2025-02-26	25.3	*Border*
EGL-27-LT20	*Squirrel*	49.5	53.5	269	270	1621574	4054	2025-02-27	25.3	*Border*

Table A2. Metadata of Captured and Tagged Lake Whitefish (*Coregonus clupeaformis*).

ID	Name	Fork Length (cm)	Total Length (cm)	Tag ID (temp)	Tag ID (depth)	Tag Serial #	Floy Tag ID	Tagged Date	Catch Depth (m)	Tagging/Release Site
EGL-01-LW1	Christy	31.5	35.0	223	224	1621241	4058	15-Jan-25	15	*Greenland Cove*
EGL-04-LW2	Johnny	33.0	36.8	229	230	1621239	NA	24-Jan-25	14	*Greenland Point*
EGL-06-LW3	Hope	35.5	39.7	263	264	1621256	NA	29-Jan-25	25.3	*Border*
EGL-07-LW4	Scar	36.2	40.5	265	266	1621257	NA	29-Jan-25	25.3	*Border*
EGL-09-LW5	U-Boat	34.8	38.7	243	244	1621246	NA	31-Jan-25	25.3	*Border*
EGL-22-LW6	Wind Waker	35.0	38.7	851	852	1621250	NA	14-Feb-25	25.3	*Border*
EGL-23-LW7	Roxanne	34.6	39.0	273	274	1621576	NA	16-Feb-25	25.3	*Border*
EGL-28-LW8	Muncher	38.0	40.5	291	292	1621585	NA	28-Feb-25	25.3	*Border*
EGL-29-LW9	Lil' Grant	30.5	34.0	277	278	1621578	NA	1-Mar-25	14	*Greenland Point*
EGL-30-LW10	Lucky	34.5	38.0	289	290	1621584	NA	19-Mar-25	19.2	*Forest City Cove*
EGL-31-LW11	Sunny	34.5	38.0	279	280	1621579	NA	14-Mar-25	19.2	*Forest City Cove*
EGL-32-LW12	Mudkip	31.7	35.6	275	276	1621577	NA	14-Mar-25	19.2	*Forest City Cove*
EGL-33-LW13	Finner	34.5	37.5	295	296	1621587	NA	16-Mar-25	19.2	*Forest City Cove*
EGL-34-LW14	Pete	33.0	36.2	283	284	1621581	NA	17-Mar-25	19.2	*Forest City Cove*
EGL-35-LW15	Dandelion	33.7	37.5	293	294	1621586	NA	17-Mar-25	19.2	*Forest City Cove*

Table A3. Tagging/Capture site locations during the Winter 2025 season, displaying the number of fish caught at each station per species.

Site #	Site Name	Latitude (degrees)	Longitude (degrees)	Depth (m)	# Lake Trout Tagged	# Lake Whitefish Tagged	Total Fish Tagged
1	Greenland Cove	45.66966	-67.79885	15.2	0	1	1
2	Deep Hole (south)	45.67556	-67.80103	33.8	3	0	3
3	Greenland Island (north)	45.67383	-67.79522	14	0	2	2
4	Border	45.67822	-67.79173	25.3	15	6	21
5	Border 2	45.68009	-67.79565	22.3	2	0	2
6	Forest City Cove	45.66236	-67.74498	19.2	0	6	6