

Remote cellular-enabled camera monitoring of Lake Utopia Rainbow Smelt spawning streams: field trials and future application in population assessments

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ABSTRACT

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Two morphologically, ecologically, and genetically distinct populations of Rainbow Smelt (*Osmerus mordax*) coexist in Lake Utopia, southwestern New Brunswick. Effective monitoring of spawning streams is critical for managing these populations under the Species at Risk Act (SARA) and informing mark-recapture timing for population assessments. However, in-person visual monitoring is often limited by site accessibility, adverse weather conditions, and the species' nocturnal spawning behavior. This study tested the ability of remote cellular-enabled camera monitoring to enhance and supplement in-person visual assessment of spawning activity on three known spawning streams for the Small-bodied Population (SbP): Second, Unnamed, and Smelt Brooks. Six cameras captured hourly images over one month (mid-April to mid-May), alongside weekly daytime visual surveys and daily water temperature recordings. Spawning runs began shortly after ice-out at 3-7 °C and peaked between April 21–27 at 6-10 °C. Cameras detected smelt up to five days earlier and three days later than daytime in-person surveys and provided continuous daily data, compared to in-person monitoring conducted only one to two days per week. Only two of the three streams showed spawning activity in 2025. Supplementing visual surveys with remote camera data enabled accurate identification of spawning period start and end dates, confirmed the absence of spawning in Smelt Brook, and improved timing of mark-recapture efforts within the full spawning window.

RÉSUMÉ

Tsitrin, E., Broome, J., and Breen, A. 2026. Remote cellular-enabled camera monitoring of Lake Utopia Rainbow Smelt spawning streams: field trials and future application in population assessments. *Can. Tech. Rep. Fish. Aquat. Sci.* 3748: v + 9 p.
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Deux populations distinctes sur le plan morphologique, écologique et génétique d'éperlans arc-en-ciel (*Osmerus mordax*) coexistent dans le lac Utopia, au sud-ouest du Nouveau-Brunswick. Une surveillance efficace des cours d'eau de frai est essentielle pour gérer ces populations en vertu de la Loi sur les espèces en péril (LEP) et pour déterminer le moment opportun pour le marquage et la recapture aux fins de l'évaluation des populations. Cependant, la surveillance visuelle est souvent limitée par l'accès difficile, les mauvaises conditions météorologiques et le comportement reproducteur nocturne de l'espèce. Cette étude a testé la capacité de la surveillance à distance par caméra à connectivité cellulaire pour améliorer et compléter les évaluations visuelles sur terrain sur trois cours d'eau de reproduction connus pour la population de petite taille (SbP): Second, Unnamed et Smelt Brooks. Six caméras ont capturé des images toutes les heures pendant un mois (de mi-avril à mi-mai), parallèlement à des relevés visuels hebdomadaires pendant la journée et à des enregistrements quotidiens de la température de l'eau. Le frai a commencé peu après la fonte des glaces de surface, à une température de 3 à 7 °C, et a atteint son pic entre le 21 et le 27 avril, à une température de 6 à 10 °C. Les caméras ont détecté les éperlans jusqu' à cinq jours plus tôt et trois jours plus tard que les évaluations visuelles sur terrain, tout en fournissant des données quotidiennes continues, alors que le suivi sur terrain n'était effectué qu'un à deux fois par semaine. Seuls deux des trois cours d'eau ont montré une activité de frai en 2025. Le fait de compléter les relevés visuels par des données provenant de caméras à distance a permis d'identifier avec précision les dates de début et de fin de la période de frai, de confirmer l'absence de frai dans le ruisseau Smelt et d'améliorer le ciblage des efforts de marquage-recapture pendant toute la période de frai.

INTRODUCTION

The Lake Utopia Rainbow Smelt (LURS), which inhabit Lake Utopia in southwestern New Brunswick, Canada, represent a rare case of the coexistence of two morphologically, ecologically, and genetically distinct populations of Rainbow Smelt (*Osmerus mordax*) in a single lake. These populations are distinguished by genetics (DFO 2025), maximum length, spawning location and timing, relative eye and jaw length to body size, and number of gill rakers (Bradbury et al. 2011), and are referred to as the small-bodied population (SbP) and the large-bodied population (LbP). The SbP and LbP were listed as threatened under the Species at Risk Act (SARA) in 2003 and 2019, respectively. Both populations were reassessed as endangered by COSEWIC in 2018, leading to reclassification as Endangered under SARA in 2020.

The LbP spawns primarily in Mill Lake Stream (Figure 1) from late March to mid-April, coinciding with ice break-up in Lake Utopia and stream temperatures below 6°C (Curry et al. 2004; MacDonald 2017). LbP eggs have also been reported in Trout Lake Stream and Spear Brook (Curry et al. 2004; MacDonald 2017), though no recent evidence has confirmed these locations as being established spawning habitat. The SbP spawns in three shallow (< 1m deep) and narrow (average 1 m across) streams at the north end of Lake Utopia: Smelt Brook, Unnamed Brook and Second Brook (Figure 1). Spawning occurs over a 2-4 week period from late April to early May, when stream water temperatures range from 6°C to 9°C (Curry et al 2004; MacDonald 2017). However, genetic evidence reveals some SbP spawning also occurs in Mill Lake Stream concurrently with the end of the LbP run (Themelis 2018, DFO 2024, DFO 2025).

Population assessments estimate abundance and distribution relative to objectives outlined in the Recovery strategy for Lake Utopia Rainbow Smelt (*Osmerus mordax*), SbP (sympatric with the LbP), in Canada (DFO 2016). Fisheries and Oceans Canada (DFO), responsible under SARA for updating scientific data on listed species, monitors spawning habitat and estimates population abundance for both SbP and LbP. using visual surveys to time mark-recapture efforts, which is the primary method of estimating population abundances (Bradford et al. 2013, DFO 2021). It is assumed that the mark-recapture takes place during a period of peak-spawning, as per the Recovery Strategy abundance objective, however, the temporal resolution and frequency of visual estimates may be insufficient to determine which section of the spawning run is sampled. Staffing resources and safety considerations restrict visual surveys to one to two daytime visits per week in four key streams: Mill Lake Stream for LbP, and Smelt Brook, Unnamed Brook, and Second Brook for SbP (Figure 1). Because smelt spawn at night and generally leave streams by day (Bradford et al. 2013), surveys rely on indirect evidence of smelt presence and spawning activity, such as egg mats, to identify spawning periods. As active spawning is rarely directly observed and surveys do not cover the entire spawning period, uncertainty remains whether mark recapture efforts and associated abundance estimates capture the true peak of spawning runs. For instance, a low abundance estimate may reflect poor timing of sampling (too early or too late) rather than population decline.

Remote monitoring has the potential to alleviate some of these uncertainties by providing consistent, night and day monitoring of streams throughout the entirety of the spawning run. Cameras can operate when visual surveys are impractical due to staffing or stream access issues. Direct footage of fish entering streams allows early detection of spawning runs, improving timing for mark-recapture efforts and boosting confidence in population estimate. This trial tested remote cellular-enabled camera monitoring on three of Lake Utopia's streams: Second, Unnamed and Smelt Brooks. Six cameras captured hourly photos of streambeds over a one-month period (mid-April to mid-May). The study aimed to determine the first and last smelt occurrences and overall spawning run characteristics (presence/absence, relative

abundance) in relation to two nights of mark-recapture on Second and Unnamed Brooks on April 28 and 29, 2025 (DFO, in press).

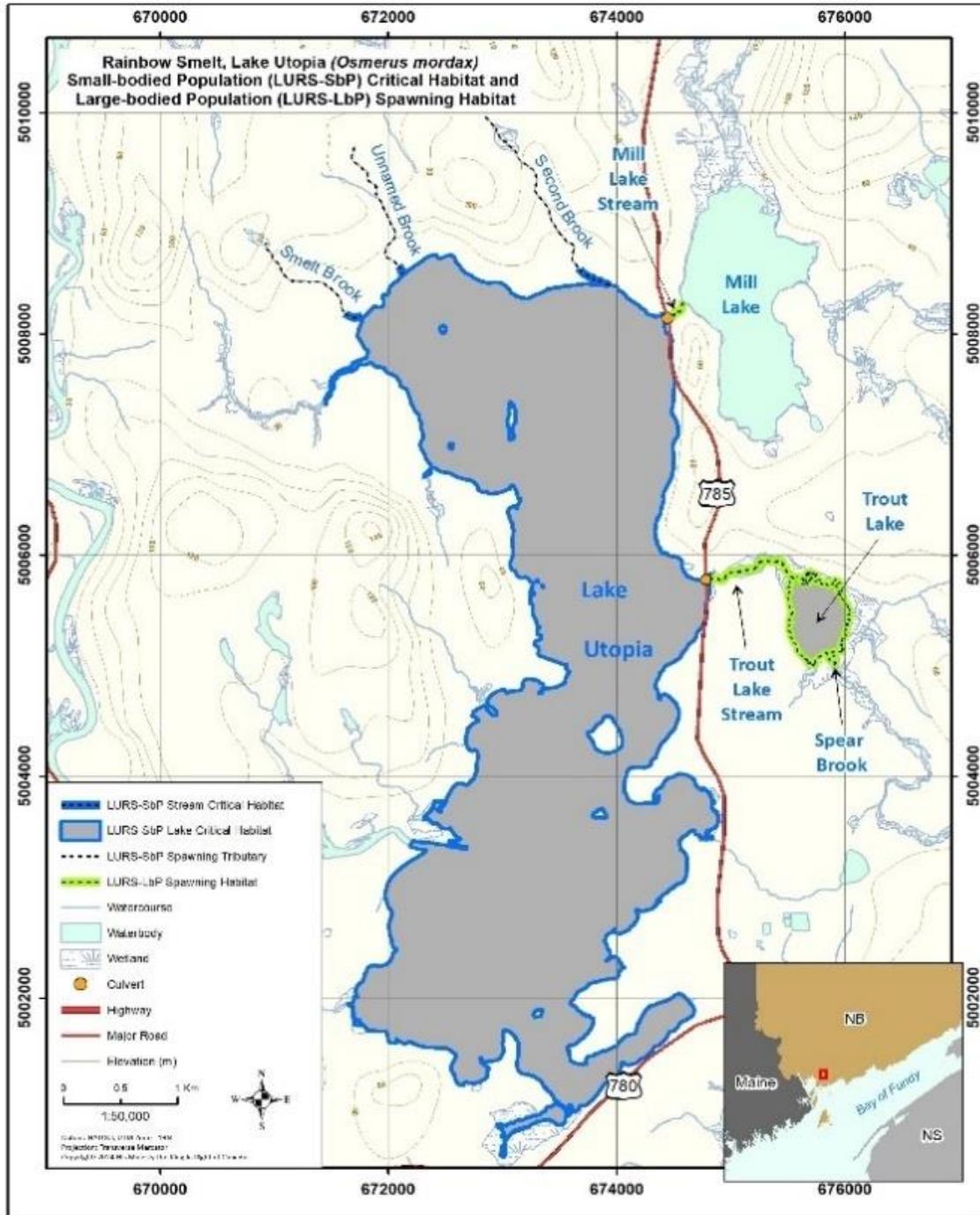


Figure 1. Areas of critical habitat identified for Lake Utopia Rainbow Smelt. Small-bodied Population (LURS-SbP) spawning streams are outlined in blue (Curry et al. 2004, DFO. 2011, Bradford et al. 2012).

MATERIALS AND METHODS

Two cellular-enabled, battery-operated VOSKER VKX (Vosker, Victoriaville, QC) cameras were installed at the downstream ends of each of Second, Unnamed, and Smelt Brooks, programmed to take one photo each hour, 24h/day, for one month (Table 1). Cameras on Second and Smelt Brooks were deployed on April 9; Unnamed Brook cameras were deployed on April 10. All cameras were retrieved on May 29, 2025, though they stopped transmitting on May 14, 2025.

Each camera was positioned at a roughly 60 degree angle relative to the ground, ~ 1 m above the stream using a manufacturer supplied swivel arm attached to a 2 m steel T-Bar post driven into the streambed and tethered on shore (Figure 2). A 40" x 24" (61 cm x 102 cm) white plastic background (Sherwood Hockey Off-Ice Practice Shooting Pad) was placed on the streambed below each camera, secured with two posts and weighed down with rocks. These pads provided a high-contrast background to improve fish visibility and counting at night (Figure 3). Cameras were powered by internal 14,000 mAh lithium batteries (V-LIT-B3), built-in solar panels, and included infrared (IR) flash for night imaging. Images were transmitted to the VOSKER mobile app using a cellular modem via the VOSKER Elite data plan.

In-person, daytime visual surveys of smelt spawning streams were conducted 1-2 days a week by staff of the Passamaquoddy Recognition Group Inc. (PRGI) before and during smelt spawning season, according to methodology described in MacDonald and Burbidge (2017). Water temperature in streams was monitored hourly with HOBO Pendant Temperature/Light 64K Data Loggers, deployed and downloaded annually by PRGI staff.

Table 1. Locations and timing of remote monitoring cameras on Lake Utopia Rainbow Smelt SbP spawning streams.

Camera Locations	Deployment Lat	Deployment Long	Deployment Date	Recovery Date
Second Brook cam 1	45.208595	-66.787502	April 9, 2025	May 29, 2025
Second Brook cam 2	45.208788	-66.787502	April 9, 2025	May 29, 2025
Smelt Brook cam 1	45.205900	-66.813700	April 9, 2025	May 29, 2025
Smelt Brook cam 2	45.206046	-66.813920	April 9, 2025	May 29, 2025
Unnamed Brook cam 1	45.209819	-66.808208	April 10, 2025	May 29, 2025
Unnamed Brook cam 2	45.209946	-66.808363	April 10, 2025	May 29, 2025

A



B



Figure 2. Camera deployments on Second Brook (A) and Unnamed Brook (B), upstream (left) and downstream (right) locations.



Figure 3. Sample photos from Second Brook (A) and Unnamed Brook (B) cameras, upstream (left) and downstream (right) locations.

RESULTS

Smelt were first detected on cellular-enabled camera images on April 14 in Second Brook and April 17 in Unnamed Brook (Table 2), with observations primarily occurring between 23:00 and 03:00. Fish counts remained low (<100 per night) until April 21-25, when smelt were consistently observed on both Smelt Brook cameras and the downstream Unnamed Brook camera between roughly 22:00 and 04:00. The upstream Unnamed Brook camera failed to detect any smelt because it was mistakenly positioned above a riffle barrier that limits spawning access (MacDonald and Burbidge 2017). Smelt were last detected on camera in Unnamed Brook on April 30, while they continued to be observed in Second Brook until May 3.

In contrast, daytime on-site monitoring by PRGI first recorded evidence of smelt presence on April 15 in Second Brook, based on observation of eggs and seven adult mortalities, while no evidence of smelt presence was observed in Unnamed Brook until several live and dead smelt were observed on April 22 (Table 2). Large numbers (>100) of adults, eggs, and mortalities were noted on April 22 and 25 in both streams. On April 29, the next in-person monitoring day, smelt remained abundant in Second Brook but only a single adult was seen in Unnamed Brook, coinciding with the second night of mark-recapture sampling when fewer smelt were available for capture, particularly in Unnamed Brook (DFO, in press). Smelt were last observed in-person on April 29 in Unnamed Brook and May 2 in Second Brook. Notably, no smelt were ever recorded on cameras or observed in-person in Smelt Stream during the monitoring period, despite the absence of physical barriers to access (DFO, in prep).

The first in-person visual survey during which no ice was observed on Lake Utopia occurred on April 17. Water temperatures in Second Brook averaged 3 °C when smelt were first observed on April 14-15, while in Unnamed Brook, temperatures reached 6-7 °C at first detection on April 17-18. (Figure 4). Peak spawning is assumed to have occurred around April 21–27, based on smelt

abundances present in camera footage and field observations of adults and eggs. During this period, water temperatures in Second Brook ranged from 6 to 7 °C, and from 8 to 10 °C in Unnamed Brook. At the time of mark-recapture sampling (April 28 and 29), temperatures were 7–8 °C in Second Brook and 10 °C in Unnamed Brook, remaining within this range until the last smelt were observed on May 2. Temperatures in Smelt Brook were comparable to Second Brook over the study period, despite no smelt being observed.

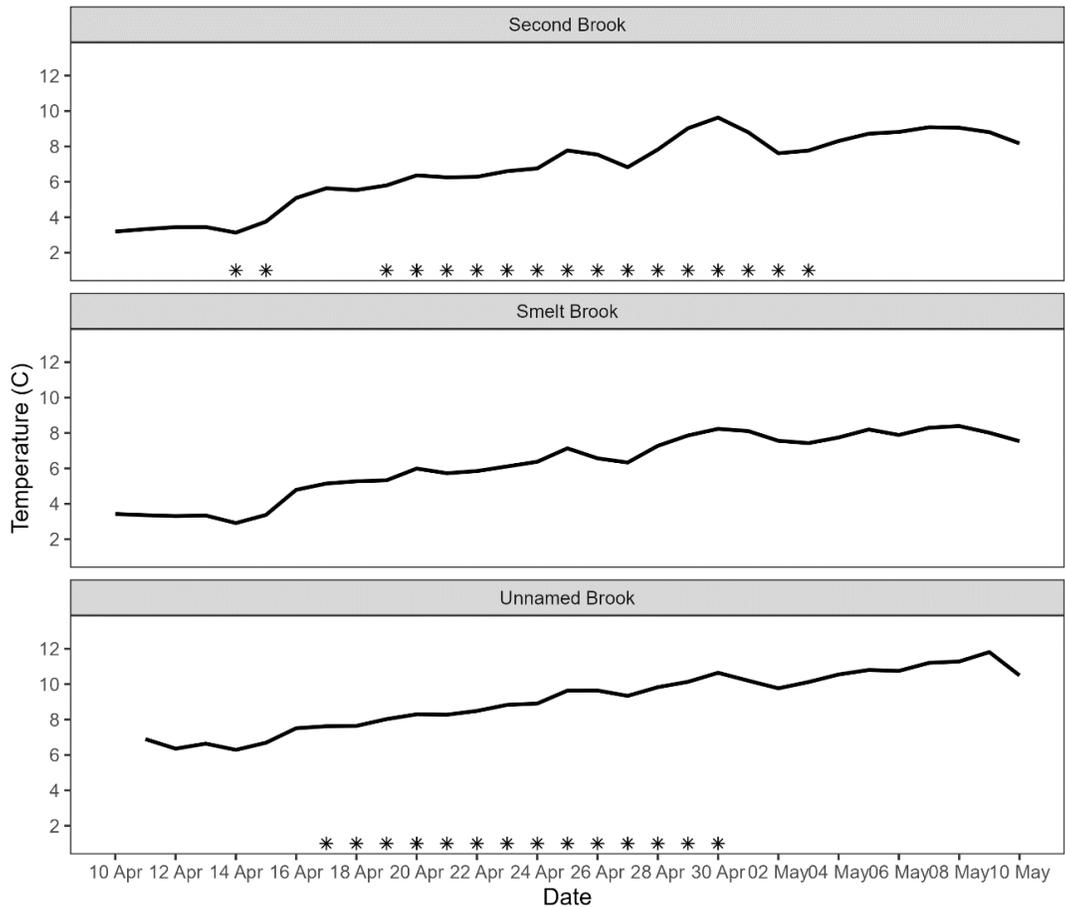


Figure 4. Average daily water temperature (°C) in LURS-SbP spawning streams from April 10, 2025, until May 10, 2025. Asterix along the bottom of each graph represent days on which smelt were observed on remote-monitoring cameras within a 24h period. Mark-recapture sampling took place on April 28 and 29 between about 22:00 to 07:00 on the following day.

Table 2. Abundance estimates and observed mortalities of Lake Utopia Rainbow Smelt in Second Brook, Smelt Brook and Unnamed Brook between April 9 and May 14, 2025, based on visual surveys and remote camera monitoring. Live counts are approximate, as cameras provide a limited field of view and visibility during visual surveys was often hindered by high water. “morts” indicates observed mortalities and “-” indicates no monitoring. Camera counts combine hourly photos from 22:00 to 03:00, when smelt are expected to be most active in the streams (Curry et al. 2004).

Date (year=2025)	Second Brook Camera	Second Brook Visual	Unnamed Brook Camera	Unnamed Brook Visual	Smelt Brook Camera	Smelt Brook Visual
9-Apr	0	-	-	-	0	-
10-Apr	0	-	0	-	0	-
11-Apr	0	0	0	0	0	0
12-Apr	0	-	0	-	0	-
13-Apr	0	-	0	-	0	-
14-Apr	<10	-	0	-	0	-
15-Apr	<10	7 morts	0	0	0	0
16-Apr	0	-	0	-	0	-
17-Apr	0	3 morts	<10	0	0	0
18-Apr	0	-	<50	-	0	-
19-Apr	50-100	-	<50	-	0	-
20-Apr	>100	-	50-100	-	0	-
21-Apr	>100	-	50-100	-	0	-
22-Apr	>1000	>1000 (+69 morts)	>100	130 (+17 morts)	0	0
23-Apr	>1000	-	>100	-	0	-
24-Apr	>1000	-	>1000	-	0	-
25-Apr	>1000	>1000 (+315 morts)	>1000	300 (+650 morts)	0	0
26-Apr	>1000	-	>1000	-	0	-
27-Apr	>1000	-	>100	-	0	-
28-Apr	>1000	-	50-100	-	0	-
29-Apr	>100	>1000 (+113 morts)	50-100	1 (+6 morts)	0	0
30-Apr	50-100	-	<50	-	0	-
1-May	50-100	-	0	-	0	-
2-May	<50	14 (+82 morts)	0	0	0	0
3-May	<10	-	0	-	0	-
4-May	0	-	0	-	0	-
5-May	0	-	0	-	0	-
6-May	0	-	0	-	0	-
7-May	0	-	0	-	0	-
8-May	0	-	0	-	0	-
9-May	0	-	0	-	0	-
10-May	0	-	0	-	0	-
11-May	0	-	0	-	0	-
12-May	0	-	0	-	0	-
13-May	0	-	0	-	0	-
14-May	0	-	0	-	0	-

DISCUSSION

This pilot study demonstrates the effectiveness of using remote cameras to monitor the spawning runs of SbP Lake Utopia Rainbow Smelt compared to visual surveys, which are constrained by the remote nature and limited accessibility of the spawning habitat, and the largely nocturnal timing of spawning activity. These limitations reduce the ability of daytime surveys to accurately identify the onset, peak, and duration of spawning runs, particularly for the small-bodied population. Deploying cameras prior to the spawning season enables continuous, non-invasive monitoring that supplements and augments traditional visual surveys. The Recovery Strategy for LURS emphasizes the need for recurring population estimates, yet abundance data for the small-bodied population remain sparse and inconsistent across streams and years. Coordinated mark-recapture efforts across all small-bodied population streams are therefore critical for improving population estimates, but the brief two- to three-week spawning period requires accurate and timely detection of peak spawning. Current monitoring frequency is insufficient to reliably capture peak activity or ensure timely deployment of field crews, and it remains unclear how representative past abundance estimates have been. Remote camera monitoring addresses these gaps by providing continuous data on stream occupancy and spawning activity across the full spawning period.

Challenges encountered during this study included variable water clarity, cellular signal interruptions, and difficult early-season access, particularly where ice and snow impeded both boat and land entry. Changes in water level and clarity, particularly after rainfall, meant that not all images were clear enough to count fish, and some hourly data were lost due to equipment or transmission failures. Despite these issues, remote cameras substantially improved data quantity and quality for the 2025 season. First, camera footage confirmed that no spawning occurred in Smelt Brook, an important consideration for assessing the distribution objective for LURS-SbP identified in the Recovery Strategy (see DFO 2016). Second, the flexible deployment schedule allowed cameras to be operational before the predicted start of spawning, which, when combined with in-stream environmental data, enhanced our understanding of factors triggering the spawning season. Finally, the timing of mark-recapture efforts was shown to coincide with the end of the spawning period, providing important context for interpreting abundance estimates.

While camera data provides a more precise view of spawning run timing, in-person visual surveys remain important for monitoring Lake Utopia smelt streams. On-site presence extends observation beyond the camera's limited field of view, allowing staff to identify and remove potential obstructions to smelt passage (e.g., fallen logs), verify spawning habitat conditions, and collect additional biological information such as eggs and adult mortalities. We recommend continued use of remote cameras in conjunction with traditional methods to improve the timing and reliability of mark-recapture estimates and to enhance understanding of spawning timing, duration, and the relative contribution of individual streams to critical SbP habitat. The feasibility of remote camera use in Mill Lake Stream should also be investigated. In addition to confirming smelt presence, streamside cameras have potential applications in population estimates, behavioral studies, and early detection of water-level declines that could result in adult mortality or egg stranding (Alexa Meyer, personal communication). Overall, remote cameras offer a cost-effective and practical tool to support ongoing assessment and recovery of Lake Utopia Rainbow Smelt populations.

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