Fisheries and Oceans Canada | Pêches et Océans Canada
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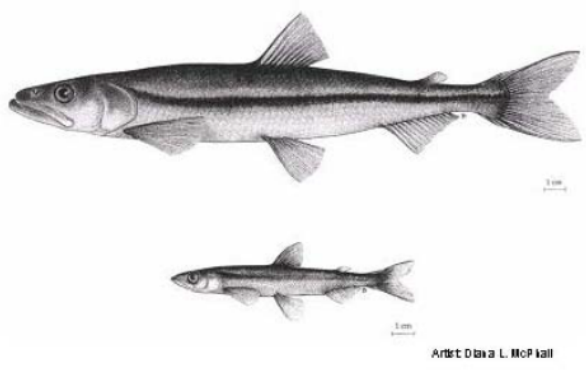
Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2026/023

UPDATED ABUNDANCE ESTIMATES OF THE SMALL-BODIED POPULATION OF LAKE UTOPIA RAINBOW SMELT (*OSMERUS MORDAX*), 2025



*Lake Utopia Rainbow Smelt (*Osmerus mordax*).*

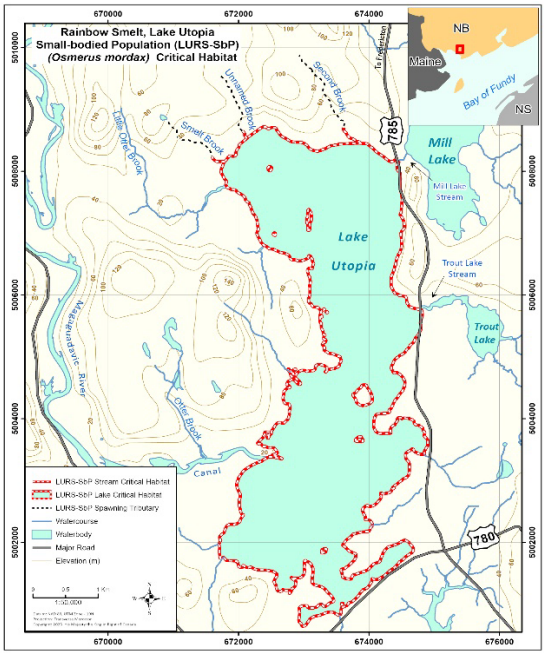


Figure 1. Areas of critical habitat identified for Lake Utopia Rainbow Smelt Small-bodied Population (LURS-SbP). Spawning streams for the SbP are located in the northern portion of the lake outlined in orange (DFO 2016).

CONTEXT

Lake Utopia is part of the Magaguadavic River watershed in southwestern New Brunswick. The native Rainbow Smelt (*Osmerus mordax*) inhabiting Lake Utopia (LURS) consists of two sympatric morphologically, ecologically, and genetically differentiated populations: a small-bodied population (SbP) and a large-bodied population (LbP). SbP and LbP were listed as threatened under the *Species at Risk Act* (SARA) in 2003 and 2019, respectively. In 2018, both populations were reassessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as endangered (COSEWIC 2018) and subsequently reclassified under SARA in 2020.

Previous Canadian Science Advisory Secretariat (CSAS) processes (DFO 2016a, DFO 2021, Themelis 2018) have reviewed the SbP abundance objectives, relative contribution of spawning streams to overall population productivity, and allowable-harm level that LURS-SbP can sustain without jeopardizing survival or recovery. The abundance objective for LURS-SbP is currently

set at 100,000 spawning fish distributed among Second Brook, Smelt Brook, and Unnamed Brook during nights of peak spawning. Available genetic information suggests that smelt occupying Second, Smelt, and Unnamed brooks during the spawning period are primarily representatives of the LURS-SbP (Themelis 2018, DFO 2021).

Quantitative mark-recapture assessments have been completed but are not available for all streams and estimates may not fully capture the peak of each spawning run. Furthermore, no simultaneous abundance estimates from all three spawning streams are available from previous work. It remains unknown if the interim abundance target has been achieved in any year since 2009.

Fisheries and Oceans (DFO) Species at Risk Program has requested from DFO Science an updated SbP population abundance estimate based on simultaneous sampling of all three spawning streams, as well as relative contribution of each stream to the overall productivity, to assess progress against the abundance objectives of 100,000 spawners outlined in the Recovery Strategy (DFO 2016b).

This Science Advisory Report is from the regional peer review of November 4-5, 2025 on Lake Utopia Rainbow Smelt, Small-bodied population (LURS-SbP) Population Abundance Estimate.

SUMMARY

- The native Rainbow Smelt (*Osmerus mordax*) inhabiting Lake Utopia (LURS) consists of two sympatric morphologically, ecologically, and genetically differentiated populations: a Small-bodied Population (SbP) and a Large-bodied Population (LbP). Both populations were reassessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2018 as Endangered, and subsequently re-classified as Endangered under SARA in 2020.
- During the 2025 spawning season, there was evidence of spawning in all three SbP streams. However, no smelt and few eggs were observed in Smelt Brook throughout the monitoring period, despite absence of physical barriers to smelt access. Thus, only Unnamed Brook and Second Brook contributed to the estimate of the population in relation to the abundance target of 100,000 smelt.
- The total abundance of the LURS SbP over the sampling period was estimated to be 6,801 for Second Brook and 3,344 for Unnamed Brook, for a combined estimate of 10,145 for two nights.
- The estimates generated in this assessment likely underestimate overall SbP abundance during the 2025 spawning season, as mark-recapture efforts occurred near the end of the spawning runs in Second and Unnamed Brooks. Because abundance at the peak of spawning is unknown, it is uncertain whether the interim recovery target of 100,000 spawners has been achieved.
- Because estimates are limited to two sampling nights, it is unknown how many spawners each stream contributed over the course of the spawning season.
- Despite evidence of spawning activity in all three streams, the distribution target – defined as annual, synchronous occupation of Second Brook, Unnamed Brook and Smelt Brook for spawning, with no individual stream to be unoccupied for two consecutive years – was not met due to the absence of smelt from Smelt Brook in 2023 and 2024.

- Evidence of inter-stream movement, the possibility of contribution of other streams to SbP spawning habitat, the absence of smelt in Smelt Brook during the mark-recapture study, and uncertainty around the timing of peak spawning in each stream introduce complexity in accurately estimating SbP abundance and distribution.

BACKGROUND

Lake Utopia Rainbow Smelt (LURS) represent a rare occurrence in Canada where divergent smelt populations co-exist in a single lake system. There are genetic and morphological differences between the two LURS ecotypes, as well as differences in the choice of spawning streams and the timing of spawning runs: the Large-bodied Population (LbP) spawns in Mill Lake Stream between late-March and mid-April, whereas the Small-bodied Population (SbP) spawns from mid-April until mid-late May in Smelt Brook, Unnamed Brook, and Second Brook (Figure 1). The body forms of the two populations are distinguishable by their relative eye and jaw to body size ratio, number of gill rakers, and body size at maturity, with the SbP spawners generally being 130 mm or less fork length (Bradbury et al. 2011, DFO 2024). Large-bodied and Small-bodied populations are genetically distinguishable, although there is hybridization and introgression between the sympatric species pair. Gene flow is largely asymmetric, predominately from SbP to LbP, as evidenced by occurrence of ecologically “large-bodied” individuals that are genetically intermediate (DFO 2025).

Population assessments reference abundance and distribution targets outlined in the Recovery Strategy for LURS (*Osmerus mordax*), Small-bodied Population (sympatric with the Large-bodied Population), in Canada (DFO 2016). The broad recovery goals for the SbP include an abundance objective (interim, 5-year) of 100,000 spawning fish distributed among Second Brook, Smelt Brook, and Unnamed Brook during nights of peak spawning, and a distribution objective of synchronous occupation of these three streams for spawning, with no individual stream unoccupied for two consecutive years (DFO 2011, 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. Visual observations help time mark-recapture assessment efforts, which is the primary method of estimating population abundance for this species complex. Past assessments have reported individual within-stream estimates ranging from between 3,000 and 150,000 fish across the three spawning streams (Bradford et al. 2013). The most recent SbP assessment, conducted in 2018 and 2019, reported nightly abundances ranging from 1,960 to 30,109 in Second Brook and 15,996 in Unnamed Brook (DFO 2021). However, past assessments have been unable to provide an overall abundance estimate for the SbP because nightly abundance estimates have varied considerably, in part due to uneven sampling effort and timing, and marking efforts could not take place on all three spawning streams simultaneously (Bradford et al. 2013, DFO 2021).

This report provides abundance estimates for the SbP derived from concurrent mark-recapture events undertaken over two nights during spawning runs in Second and Unnamed Brook in April 2025.

ASSESSMENT

Study Area

Lake Utopia is part of the Magaguadavic River watershed in southwestern New Brunswick. The SbP spawns predominately in shallow (<1 m deep) and narrow (average 1 m across) streams

that flow out of forested areas through natural sandy beaches along the north shore of the lake (Figure 2). Spawning habitat is generally limited to the lower 100–330 m of each stream due to the presence of natural barriers such as boulders and high gradient that prevent smelt from migrating upstream (DFO 2016, MacDonald and Burbidge 2017). Spawning substrate may consist of sand, gravel, rock, aquatic vegetation, and wood debris.

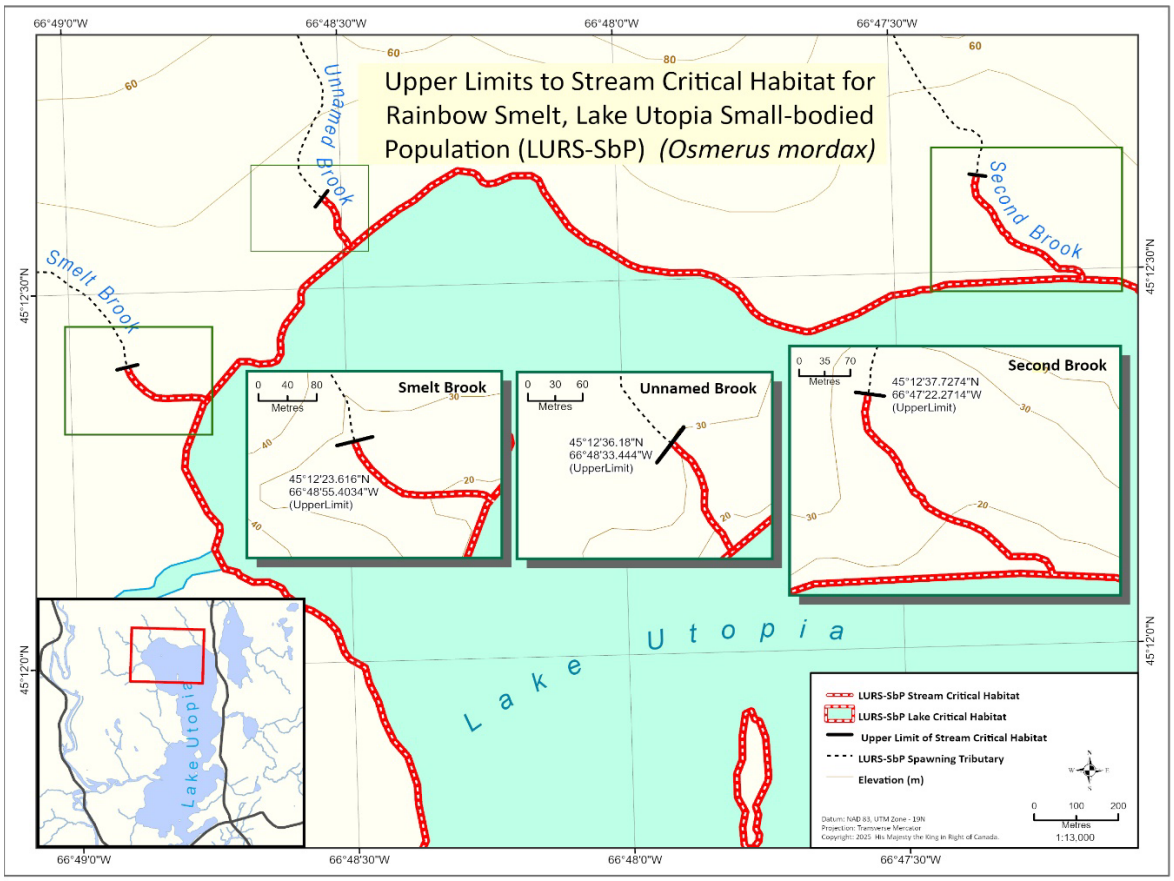


Figure 2. Areas identified as critical stream habitat for Lake Utopia Rainbow Smelt, Small-bodied Population (LURS-SbP). A portion of each of Smelt Brook, Unnamed Brook, and Second Brook are highlighted in orange to emphasize the linear extent of critical habitat within the stream (DFO 2016). The width in each stream that constitutes critical habitat is not represented on this map. The inset map shows the general location of the identified critical habitat within Lake Utopia.

Sampling Methods and Data Analysis

Timing of spawning runs were assessed using remote stream monitoring cameras (Tsitrin et al. In review) in combination with daytime visual surveys made 1–2 days a week between April 11 to May 2, 2025, by members of the Passamaquoddy Recognition Group Inc. (PRGI). Cameras operated from April 10 through to May 14, 2025, taking photos hourly. Photos were checked nightly for presence of smelt. Sampling was undertaken when LURS were observed in abundance within the streams (i.e., consistent overnight periods of hundreds of fish seen on cameras). The first night when smelt were observed in abundance in more than one stream (Unnamed and Second Brook) was April 21. However, due to scheduling conflicts, mark-recapture sampling was undertaken on the nights of April 28 and 29, 2025, between 11 pm and 7 am. No smelt were observed on camera (April 10 to May 14, 2025) in Smelt Brook throughout the monitoring period, despite absence of physical barriers to smelt access. Visual

surveys (April 11 to May 2, 2025) also did not find any live smelt, although some exposed (dead) eggs and one small cluster of submerged eggs were noted on the last day of visual surveys (May 2). Thus, mark-recapture efforts took place on Unnamed Brook and Second Brook only.

On the first night of sampling, 300 smelt from each of Unnamed and Second Brook were dip-netted along the stream banks and held in 66 L containers on shore. Smelt were marked by Passive Integrated Transponder (PIT) FDX tags (8.5 by 2.12 millimeters, VodaIQ, Ferry, ID, USA) inserted by 15-gauge needle into the body cavity. No anesthesia was used for tagging. Individual sex, fork length (FL, mm) and weight (g) were recorded. Marked smelt were held for recovery in aerated holding containers on shore until all smelt from the capture group were marked. At this time, all smelt were released together and allowed one hour to mix with other smelt present in the stream. A second sample of 300 was then captured, the number of marked and unmarked smelt counted, all unmarked smelt were tagged, and all fish released. The same protocols were followed on the second night of sampling. However, due to low numbers of smelt in Unnamed Stream, only approximately 170 individuals were captured in each of the mark and recapture samples.

A small portion of the caudal fin was clipped from recaptured smelt, as well as some of the newly marked fish from the recapture group, and preserved in 95% ethanol for future genetic analysis. Fin clipping for genetic sampling continued for each stream until 100 samples were collected.

Nightly abundance estimates were calculated with the R package *fishmethods* (Nelson 2023) using the adjusted Petersen method (Chapman estimator), and total abundance over the sampling period was estimated using the adjusted Schnabel method.

RESULTS

Length Frequency Distribution

Smelt that were sampled from Second Brook during mark-recapture on April 28–29, 2025, had a mean FL of 115 mm (±SD = 12.6, n = 1,113, Figure 3). There was no statistically significant difference in length between sexes (two-sided Welch's t-test, t = −1.31, df = 1,081.8, p-value = 0.191). The log-log length-weight relationship for Second Brook spawners can be described with a linear model ($y = 4.05 + 0.31x$, $R^2 = 0.76$ for males; $y = 4.16 + 0.25x$, $R^2 = 0.52$ for females; Figure 4). Weight data recorded for smelt sampled from Unnamed Brook on April 28 were deemed unreliable due to scale malfunction, and no weights were sampled on April 29. The mean FL of smelt sampled from Unnamed Brook was 112 mm (±SD = 10.7, n = 840, Figure 3).

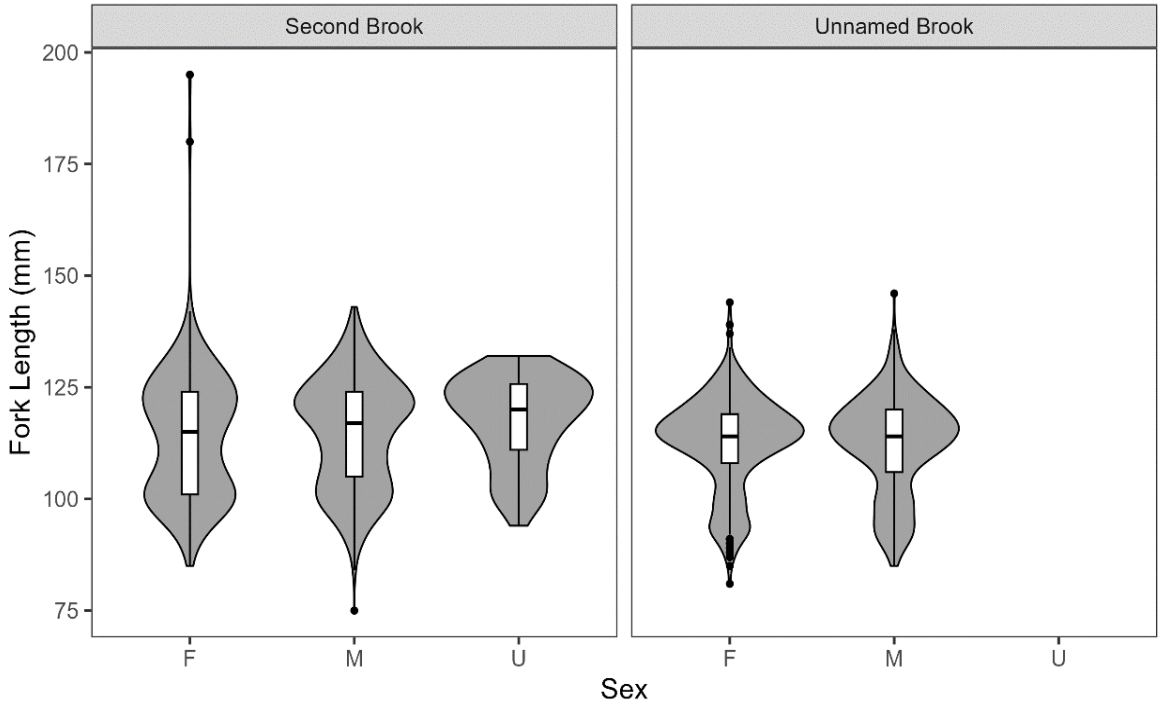


Figure 3. Distribution of fork lengths (mm) of Lake Utopia Rainbow Smelt sampled during mark-recapture from Second Brook and Unnamed Brook on the nights of April 28 and 29, 2025. Data separated by stream and sex, with M = male, F = female, and U = unidentified.

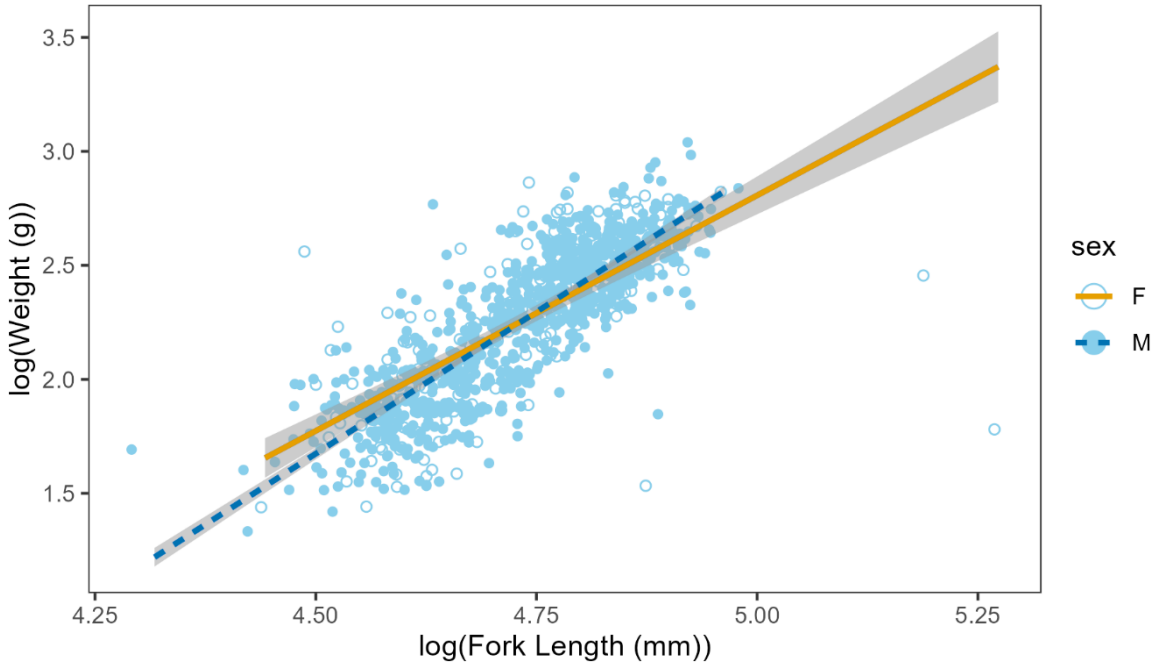


Figure 4. Length-weight relationship of Lake Utopia Rainbow Smelt males (filled circles, blue dashed line: $y = 4.05 + 0.31x$, $R^2 = 0.76 \pm 95\%$ CI in grey shading) and females (open circles, solid orange line: $y = 4.16 + 0.25x$, $R^2 = 0.52 \pm 95\%$ CI in grey shading) sampled during mark-recapture from Second Brook on the nights of April 28 and 29, 2025 (n = 1,113).

Population Estimate

A total of 1,118 individual smelt were captured from Second Brook and 841 from Unnamed Brook. Nightly marking and recapture data are summarized in Table 1. Sex ratios varied between streams and across nights: females comprised 13–34% of captures in Second Brook and 39–52% in Unnamed Brook (Table 2). Among recaptured individuals, females represented 9–22% in Second Brook and 51–62% in Unnamed Brook.

Using the Schnabel method (input data Table 1), total abundance over the sampling period was estimated to be 6,801 (95% CI = 4,982 to 10,711) for Second Brook and 3,344 (95% CI = 2,511 to 5,004) for Unnamed Brook. Nightly estimates calculated using the adjusted Petersen method, in which each night was treated as a separate mark-recapture event and only fish marked that night were counted in the nightly estimate, were 3,527 (95% CI = 2,577 to 5,475) and 2,092 (95% CI = 1,648 to 2,817) in Second Brook, and 4,145 (95% CI = 2,923 to 6,472) and 534 (95% CI = 438 to 691) in Unnamed Brook for April 28 and 29, respectively (Table 3). These estimates exclude five individuals recaptured on the second night in Unnamed Brook that carried no tags but showed evidence of having been tagged previously (i.e., puncture wounds), as well as one fish in Second Brook whose tag ID could not be linked to the marking metadata due to recording errors. Including these individuals in the Schnabel analysis did not meaningfully affect results: 6,808 (95% CI = 4,988 to 10,723) for Second Brook and 3,208 (95% CI = 2,424 to 4,739) for Unnamed Brook. When included in the second-night Petersen estimate for Unnamed Brook, the abundance was 490 (95% CI = 407 to 616).

Table 1. Summary of mark-recapture data for Lake Utopia Rainbow Smelt Small-bodied Population in Second and Unnamed Brooks during each study night, including total number of fish captured during each event, number of recaptures, number of newly marked fish, and total number of marked fish available for recapture from all previous periods (NA = not applicable; M1 = first marking event, R1 = first recapture event, M2 = second marking event).

Study night	Stream	Event	Total catch	New marked	Recaptures Total (M1, R1, M2)
1	Second	Marking	299	299	*NA*
1	Second	Recapture	293	269	24 (24, *NA, NA*)
1	Unnamed	Marking	301	301	*NA*
1	Unnamed	Recapture	301	280	21 (21, *NA, NA*)
2	Second	Marking	303	294	9 (4, 4, *NA*)[2]
2	Second	Recapture	299[1]	256	43 (0,2,41)
2	Unnamed	Marking	166	149	17 (8,8, *NA*)[3]
2	Unnamed	Recapture	170	111	59 (8,5,42) [3]

[1]300 fish were captured; however, one had been tagged in Unnamed brook and was, therefore, not counted in estimates for Second Brook.

[2]One ID was not recorded during tagging, and was not counted in estimates due to the inability to be traced to a marking event.

[3]A total of five recaptured individuals had evidence of being marked (puncture wound) but carried no tag. These were not counted in estimates due to the inability to trace them to specific marking events.

Table 2. Nightly sex ratios amongst marking and recapture groups of Lake Utopia Rainbow Smelt Small-bodied Population in Second and Unnamed Brooks.

Study night	Stream	Event	New marks applied	Proportion females	Total recaptured IDs	Proportion females in recaptures
1	Second	Marking	299	0.13	*NA*	*NA*
1	Second	Recapture	269	0.13	24	0.09
1	Unnamed	Marking	301	0.39	*NA*	*NA*
1	Unnamed	Recapture	280	0.49	21	0.62
2	Second	Marking	294	0.13	9	0.22
2	Second	Recapture	256	0.34	43	0.14
2	Unnamed	Marking	149	0.52	17	0.56
2	Unnamed	Recapture	111	0.44	59	0.51

Table 3. Abundance estimates of Lake Utopia Rainbow Smelt Small-bodied Population for two nights of mark-recapture effort on Second Brook and Unnamed Brook (CI – 95% confidence intervals).

Method	Second Brook	Unnamed Brook
Schnabel	6,801 (4,982 – 10,711)	3,344 (2,511 – 5,004)
1st night Petersen	3,527 (2,577 – 5,475)	4,145 (2,923 – 6,472)
2nd night Petersen	2,092 (1,648 – 2,817)	534 (438 – 691)

Sources of Uncertainty

The interim abundance target specified in the LURS SbP Recovery Strategy (DFO 2016b) is based on estimates captured at the peak of the spawning run. To better determine the timing of peak spawning, a combination of visual and remote monitoring methods was used. Fish numbers increased during April 20 to 25, 2025, but due to scheduling conflicts, mark-recapture work was delayed until the following week, when spawning activity in Second and Unnamed Brooks was already declining. The mark-recapture based abundance estimates are expected to under-represent the overall 2025 spawning run because the peak of the run was missed. It is unknown if the interim abundance target was achieved because the mark-recapture effort did not align with peak spawning.

Another source of uncertainty arises from the recapture of five individuals with signs of a puncture wound but no detectable tag. While a few instances of a faulty tag injector resulting in a tag failing to leave the needle were noted during sampling, tag IDs were typically verified immediately after insertion by scanning each fish. This suggests that these cases likely represent tag loss rather than tagging failure. While internal tagging reduces the likelihood of tag shedding compared to external tags, it does not eliminate it, and some tag loss can still occur (e.g., Wilder et al. 2016). If not all recaptures are counted, the number of marked fish in the population would appear lower, thereby inflating abundance estimates. To address this, abundance estimates based on PIT tagging should be adjusted for tag loss. It is possible that other instances of tag loss occurred during this study but were missed due to the small size of the incision site and reduced visibility at night. Tag retention trials specific to Rainbow Smelt in Lake Utopia could be used to assess the extent of this potential bias.

The detection of an individual tagged in Unnamed Brook on the first night and recaptured in Second Brook on the second night provides evidence that inter-stream movement occurs, though the frequency of such movement is unknown. While it is possible that this represents an

isolated event, it may also represent a broader behavioral tendency of smelt to utilize multiple spawning sites within a season, or to explore different sites before initiating spawning. If such movement is common, it violates a core assumption of the mark-recapture model: that marked and unmarked individuals mix randomly within a closed population. Unaccounted inter-stream dispersal could result in either over- or underestimates of stream-specific population sizes, depending on movement patterns. Further studies capturing a greater portion of the spawning season would be needed to assess whether this behavior is atypical or more widespread. Individual preference for specific spawning streams could also be assessed through recaptures of individuals marked with PIT tags from previous years.

The spawning run in Smelt Brook appears to have been small, as only one egg cluster was found and no adult smelt were observed on cameras or during visual surveys. No physical barriers to access were observed prior to or during the expected timing of the spawning run. One possible explanation is residual avoidance of a beaver dam that blocked access in 2023–2024; although it was removed in fall 2024, smelt may have continued to avoid the stream or responded to altered habitat conditions. The absence may also reflect natural interannual variation driven by factors such as fluctuations in annual recruitment, water flow, upstream access, spawning densities, or habitat quality. Annual day-time visual surveys show that smelt numbers are typically lower in Smelt Brook than in Second Brook, with no smelt observed in 2020 and 2016 (see Appendix A). Continued monitoring is essential to determine whether the absence of smelt from Smelt Brook is part of normal variation or indicates a longer-term shift in spawning habitat that could affect the Recovery Strategy distribution objective.

The role of other streams in supporting the Small-bodied Population spawning run remains poorly understood, as only the three streams are named in the Recovery Strategy (DFO 2016b) as critical spawning habitat and regularly monitored. Mill Lake Stream is assessed only as a spawning site for the Large-bodied Population, yet evidence of genetic mixing (DFO 2024, DFO 2025) and reports of a late-season run of smaller smelt after the typical LbP spawning period (Themelis 2018) suggest it also supports SbP spawning. Its contribution to overall SbP spawning habitat, however, has not been evaluated. Including Mill Lake Stream in monitoring during the SbP spawning period, particularly with the use of remote cameras, could provide an efficient and minimally invasive method to supplement this monitoring without requiring additional in-person field presence. Incorporating Mill Lake Stream into regular monitoring is critical to accurately estimate the total spawning population of Small-bodied Rainbow Smelt in Lake Utopia.

CONCLUSIONS AND ADVICE

The total estimated abundance of the Lake Utopia Rainbow Smelt Small-bodied Population was 6,801 in Second Brook and 3,344 in Unnamed Brook, for a combined two-night estimate of 10,145. Because mark-recapture occurred after the peak of spawning, these values likely underestimate the true 2025 abundance, leaving it uncertain whether the interim recovery target of 100,000 spawners was met. Although spawning activity was documented in all three streams in 2025, the distribution target – defined as annual, synchronous spawning in Second Brook, Unnamed Brook, and Smelt Brook, with no stream unoccupied for two consecutive years – was not met, owing to the absence of smelt in Smelt Brook during 2023 and 2024. The possibility of inter-stream movement, unknown contribution of Mill Lake Stream, and the absence of smelt in Smelt Brook during the mark-recapture study introduce further complexity in accurately estimating SbP abundance and distribution. These findings highlight the need for cautious interpretation of current estimates and emphasize the importance of continued, coordinated monitoring across all known spawning streams.

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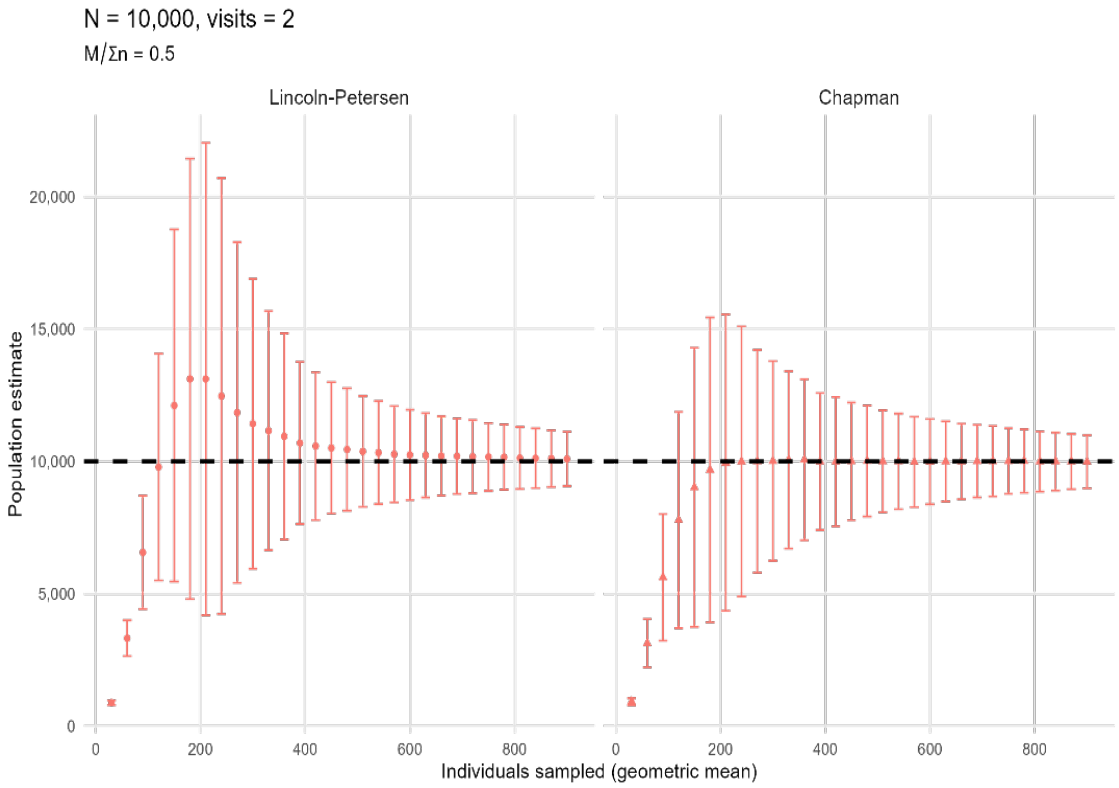
APPENDIX A – VISUAL MONITORING OF LURS – SBP SPAWNING STREAMS

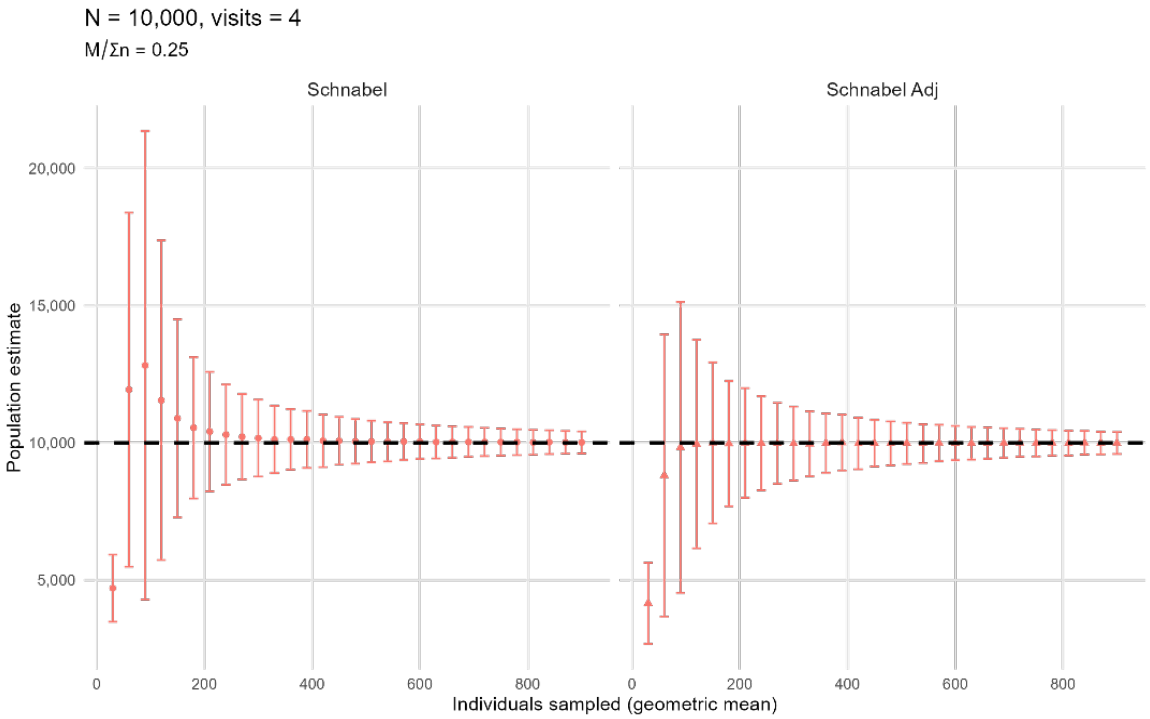
Appendix A. Summary of yearly (2015–2025) day-time observations of Lake Utopia Rainbow Smelt (LURS) and egg presence in Second Brook, Smelt Brook, and Unnamed Brook (0 = not observed, 1 = observed). Monitoring dates and total effort varied between years.

Year	Second Brook		Smelt Brook		Unnamed Brook	
	Smelt	Eggs	Smelt	Eggs	Smelt	Eggs
2015	1	0	1	0	1	0
2016	1	1	0	0	1	0
2017	1	1	0	1	0	1
2018	1	1	1	1	1	1
2019	1	1	1	1	1	1
2020	1	1	0	0	1	1
2021	1	1	1	1	1	1
2022	1	1	1	1	1	1
2023	1	1	0	0	1	1
2024	1	1	0	0	1	1
2025	1	1	0	1	1	1

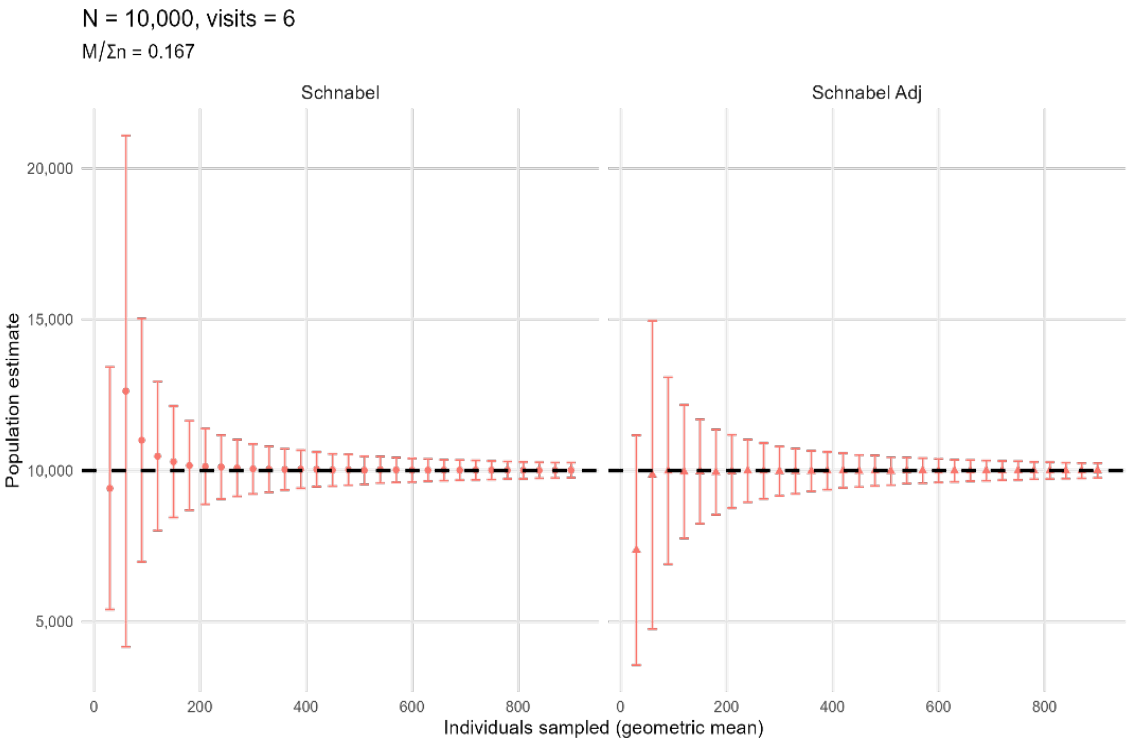
APPENDIX B – POWER ANALYSIS



Appendix B-1. Predicted estimates of population size (±SE) for a population of 10,000 individuals under varying sample sizes assuming two sampling events (i.e., one night of mark-recapture). Results presented for unadjusted Lincoln-Petersen and adjusted Chapman estimators.



Appendix B-2. Predicted Schnabel estimates of population size (±SE) for a population of 10,000 individuals under varying sample sizes assuming four sampling events (i.e., two nights of mark-recapture).



Appendix B-3. Predicted estimates of population size (±SE) for a population of 10,000 individuals under varying sample sizes assuming six sampling events (i.e., three nights of mark-recapture).

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