Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat
Maritimes Region **Science Response 2021/037**

LAKE UTOPIA RAINBOW SMELT, SMALL-BODIED POPULATION (LURS-SBP) POPULATION ABUNDANCE AND ALLOWABLE HARM ESTIMATE

Context

Lake Utopia is part of the Magaguadavic River watershed in southwestern New Brunswick. Two populations of Lake Utopia Rainbow Smelt (LURS) co-exist in Lake Utopia, a small-bodied form (LURS-SbP) and a large-bodied form (LURS-LbP). Lake Utopia represents one of the only three confirmed occurrences in Canada where genetically divergent smelt populations co-exist (Taylor and Bentzen 1993, Bradbury et al. 2011).

The LURS-SbP was originally designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1998 and was listed under the *Species at Risk Act* (SARA) as Threatened in June 2003. The rationale for the designation was:

> the population is part of a genetically divergent sympatric pair of Osmerus that is endemic to a single lake in Canada with an extremely small index of an area of occupancy (6 sq. km). It spawns in only three (3) small streams in the watershed and could quickly become extinct through degradation of spawning streams from increasing development around the lakeshore and impacts of the dip-net fishery. This population is threatened by the introduction of exotic species and by increasing eutrophication. (COSEWIC 2008)

A Recovery Potential Assessment (RPA) for Lake Utopia Rainbow Smelt (*Osmerus mordax*) (both SbP and LbP) was undertaken in 2010 (DFO 2011), and SbP Recovery Strategy developed (DFO 2016). LURS-SbP was re-assessed as Endangered by COSEWIC in 2018 (COSEWIC 2018). The most recent abundance estimate for the LURS-SbP is from 2009 (DFO 2011). Therefore, an update of this information, along with further investigation of new sampling information to address questions related to the relative contribution of the spawning streams to the population productivity of the LURS-SbP, is needed.

Science advice on the population status and allowable harm level for LURS-SbP was requested by the Species at Risk Program (SARP), Maritimes Region. This request intended to seek updated information on LURS-SbP abundance estimate, abundance target, and allowable harm, where available. The objectives were:

- Provide an updated population abundance estimate for LURS-SbP in Second Brook, Unnamed Brook, Smelt Brook, and Mill Lake Stream.
- Evaluate the relative contribution of each of the previously mentioned spawning streams to the overall productivity of LURS-SbP.
- Review, and update as necessary, the interim recovery-abundance target that was identified in the Recovery Strategy (DFO 2016).
- Review, and update as necessary, the current allowable-harm level that LURS-SbP can sustain without jeopardizing survival or recovery.

The request for advice submitted by SARP sought updated information on population abundance; however, it was noted that estimates of absolute population abundance were not possible and available data are not representative of the entire SbP population. Rather, the abundance estimates presented within this document represent stream specific nightly estimates of LURS-SbP abundance.

This Science Response Report results from the Regional Science Response Process of November 19, 2019, for Lake Utopia Rainbow Smelt, Small-bodied Population (LURS-SbP) Population Abundance and Allowable Harm Estimate.

Additional publications from this meeting will be posted on the DFO Science Advisory Schedule as they become available.

Background

Spawning of the LURS-SbP has been confirmed in only three small, vulnerable brooks (about 1 m in width and estimated to provide ≤ 600 m of accessible linear spawning habitat) at the northern end of Lake Utopia: Second Brook, Smelt Brook, and Unnamed Brook (DFO 2011; Figure 1). However, sporadic and minor spawning events may also occur in other streams in some years (DFO 2011). Spawning occurs in the spring, with the SbP spawning both later and over a longer period than the LbP, generally from mid-April until late May at water temperatures between 4 ^{0}C–9 ^{0}C (Curry et al. 2004, DFO 2016).

The broad recovery goal for the SbP is addressed through the following population objectives: Genetic Objective—maintenance of the genetic diversity and genetic differentiation of LURS within the Lake Utopia system; Abundance Objectives (Interim, 5-year)—100,000 spawning fish distributed among Second Brook, Smelt Brook, and Unnamed Brook during nights of peak spawning; and Distribution Objective—occupation of Lake Utopia year-round and annual, synchronous occupation of Second Brook, Smelt Brook, and Unnamed Brook for spawning, with no individual stream to be unoccupied for two consecutive years (DFO 2011, DFO 2016).

LURS have been observed in at least one of the three streams in each year in which daytime monitoring for the presence-absence of smelt or eggs has occurred (Themelis 2018). In some instances, the number of smelt present in the stream are counted/estimated during daytime monitoring. However, daytime counts are not reliable for estimating abundance due to known aspects of smelt behaviour (e.g., smelt move into and out the streams on a nightly basis, and most smelt that remain in streams during the day are male). Therefore, nighttime mark-recapture sampling is used to estimate nightly stream abundance. Mark-recapture-based abundance estimates have not been conducted since 2009 (Bradford et al. 2013). In years where mark-recapture estimates are available, individual within-stream nightly estimates of spawner abundance for LURS-SbP have varied between 3,000 and 150,000 fish, with estimates of approximately 10,000 fish being the most frequent (Bradford et al. 2013).

Monitoring and Sampling Methods (2018 and 2019 SbP Spawning Run)

Monitoring activities for 2018 and 2019 followed presence/absence protocols outlined in MacDonald and Burbidge (2017). Mark-recapture methods are described below. The timing of the SbP spawning run was determined through twice weekly visual checks for smelt and egg presence in Second Brook, Smelt Brook, and Unnamed Brook that occurred between April 23–May 16, 2018, and April 23–May 9, 2019.

Mark-recapture sampling occurred once visual surveys confirmed the presence of a spawning run. During each night of sampling, smelt were dip-netted along the stream banks at

approximately 00:00 hr. Fish were then marked by fin clipping and held in containers onshore. A unique fin clip was applied for each consecutive night of marking. After all smelt were marked, they were released and allowed to mix with other smelt present in the stream for one hour. Then, a second sample was collected, the number of marked and unmarked smelt were counted, and then all smelt were subsequently released. Unmarked smelt captured during the second sampling (recapture) event were not marked prior to release.

The length-frequency and sex ratio of the spawning run was characterized by measuring Fork Length (FL) to the nearest millimetre (mm) and sexing a sub-sample of the smelt dip-netted each night. Fin clips were preserved for potential future genetic analysis.

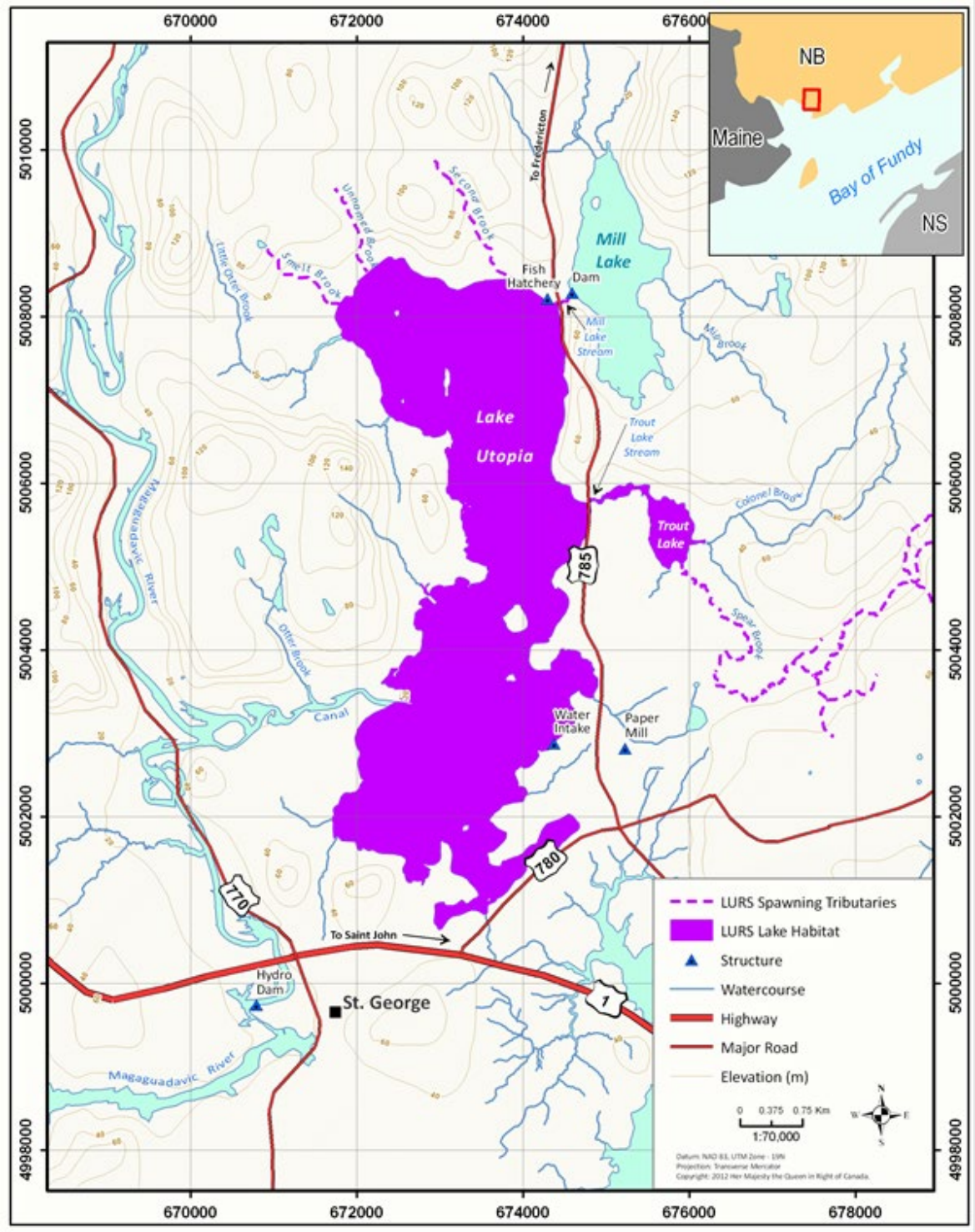

Figure 1. Lake Utopia, New Brunswick. The dashed line indicates spawning tributaries for the LURS; blue triangles indicate industrial structures, and roads are highlighted in red. The spawning tributaries of LURS-SbP—Second Brook, Smelt Brook, and Unnamed Brook—are located in the northern portion of the lake. The spawning tributaries of LURS-LbP—Mill Lake Stream, Trout Lake Stream, and Spear Brook—are located in the northeast portion of the lake.

Analysis and Response

Summary of 2018 SbP Monitoring

The timing of the SbP spawning run was determined through visual surveys for smelt and egg presence in Second Brook, Smelt Brook, and Unnamed Brook that occurred between April 23–May 16, 2018 (Table 1). Monitoring efforts could not be fully executed during this time due to spring flood conditions, which made it unsafe to access LURS spawning streams. Because of this, the peak spawning period, which was estimated to have occurred on May 2, 2018, was missed. On May 3, 2018, under high water conditions, both Second Brook and Smelt Brooks were checked by boat, and small numbers of smelt and eggs were observed in each stream. No spawning fish were observed in Smelt or Unnamed Brooks during further monitoring events (Table 1). Visual monitoring of Second Brook for the presence of smelt and eggs continued once conditions permitted, and a single night mark-recapture event was conducted on May 5, 2018. Monitoring effort confirmed the presence of both smelt and eggs in Second, Smelt, and Unnamed Brooks in 2018 (Tables 1 and 2).

Due to spring flood conditions, monitoring of Mill Lake Stream was delayed and extended further into the spring than normal. Through this extended monitoring effort, a late run of smelt was observed in Mill Lake Stream that was consistent with the timing of spawning in the traditional SbP spawning brooks.

Summary of 2019 SbP Monitoring

Conditions in spring 2019 were more favourable for monitoring activities than 2018. The timing of the SbP spawning run was determined through visual surveys for smelt and egg presence in Second Brook, Smelt Brook, and Unnamed Brook that occurred between and April 23–May 9, 2019 (Table 1). Monitoring effort was also conducted in Mill Lake Stream to determine the presence of a second run of smelt, consistent with the timing of LURS-SbP spawning, as was observed in 2018 (Table 1).

Monitoring effort confirmed the presence of both smelt and eggs in Second Brook, Smelt Brook, and Unnamed Brook (Table 1 and Table 2). The monitoring effort in Mill Lake Stream did not observe the presence of smelt or eggs during the SbP spawning period (Table 1). Three sequential nights of mark-recapture sampling were conducted in Second Brook on May 2–4, 2019, and a single night mark-recapture sampling event was conducted on May 5, 2019, in Unnamed Brook.

Table 1. Observed occurrences of Lake Utopia Rainbow Smelt (LURS) and eggs in Second Brook, Smelt Brook, Unnamed Brook, and Mill Lake Stream for 2018 and 2019 during daytime monitoring effort (0 = absence, 1 = presence, "–" denotes no monitoring occurred on that day). Nighttime mark-recapture events (M) indicate the confirmed presence of smelt.

	Second Brook				Smelt Brook				Unnamed Brook				Mill Lake Stream			
	2018		2019		2018		2019		2018		2019		2018		2019	
Date	**Smelt**	**Eggs**	**Smelt**	**Eggs**	**Smelt**	**Eggs**	**Smelt**	**Eggs**	**Smelt**	**Eggs**	**Smelt**	**Eggs**	**Smelt**	**Eggs**	**Smelt**	**Eggs**
Apr-23	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0
Apr-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr-26	-	-	0	0	-	-	0	0	-	-	0	1	-	-	0	0
Apr-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr-29	-	-	1	1	-	-	0	0	-	-	0	1			0	0
Apr-30	1	1	-	-	1	1	-	-	1	1	-	-	0	0	-	-
May-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-02	-	-	M	-	-	-	1	0	-	-	-	-	-	-	0	0
May-03	1	1	M	-	1	1	-	-	0	1	-	-	0	0	-	-
May-04	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-
May-05	M	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-
May-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-07	-	-	1	1	-	-	0	0	-	-	-	-	-	-	0	0
May-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-09	1	1	0	1	0	1	0	1	0	1	-	-	0	0	-	-
May-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-16	0	1	-	-	0	1	-	-	0	1	-	-	-	-	-	-

Table 2. Summary of yearly (2015–2019) 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.

	Second Brook		Smelt Brook		Unnamed Brook	
Year	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

Abundance Estimates

The interim abundance objective for the LURS-SbP is 100,000 smelt distributed among Second Brook, Smelt Brook, and Unnamed Brook during nights of peak spawning (DFO 2011, DFO 2016). Available genetic information suggests that smelt occupying Second, Smelt, and Unnamed Brooks during the spawning period are representatives of the LURS-SbP (DFO 2018, Themelis 2018, [1]Bentzen 2019).

Smelt that were sub-sampled during mark-recapture events on April 30–May 4, 2019, had a mean FL of 124.3 mm (±SD = 12.8, n = 597, Table 3 and Figure 2). Due to the presence of outliers (Figure 2), the median FL of 125 mm (IQR = 117–131) is also reported. Nightly abundance estimates for LURS were calculated using the adjusted Petersen (Chapman) method and are summarized in Table 4. Each night was treated as a separate mark-recapture event, and only fish marked that night were counted in the nightly estimate. Note that nightly estimates should not be summed to provide an overall abundance estimate because fish could be counted twice. A different fin was clipped during each night, and, based on these marks, some of the same fish were seen on multiple nights. Unmarked fish captured during the recapture phase (second nightly dipping) were not marked prior to release.

Table 3. Mean length, indicated by sex, of Lake Utopia Rainbow Smelt examined during mark-recapture sampling of spawning runs in 2019.

Date	Brook	Number Males	Mean Length (mm) (±SD)	Number Females	Mean Length (mm) (±SD)	Proportion Female
Apr-30	Unnamed	131	127.1 (± 14.8)	69	127.0 (± 12.3)	0.35
May-02	Second	116	123.3 (± 11.0)	8	124.0 (± 10.8)	0.06
May-03	Second	117	120.8 (± 12.1)	18	116.0 (± 12.1)	0.13
May-04	Second	104	125.3 (± 10.6)	34	125.1 (± 10.7)	0.25

[1] Bentzen, P. (2019). Results from genetic analyses of 2017–2018 Lake Utopia smelt tissue samples. Unpublished manuscript. Dalhouise University.

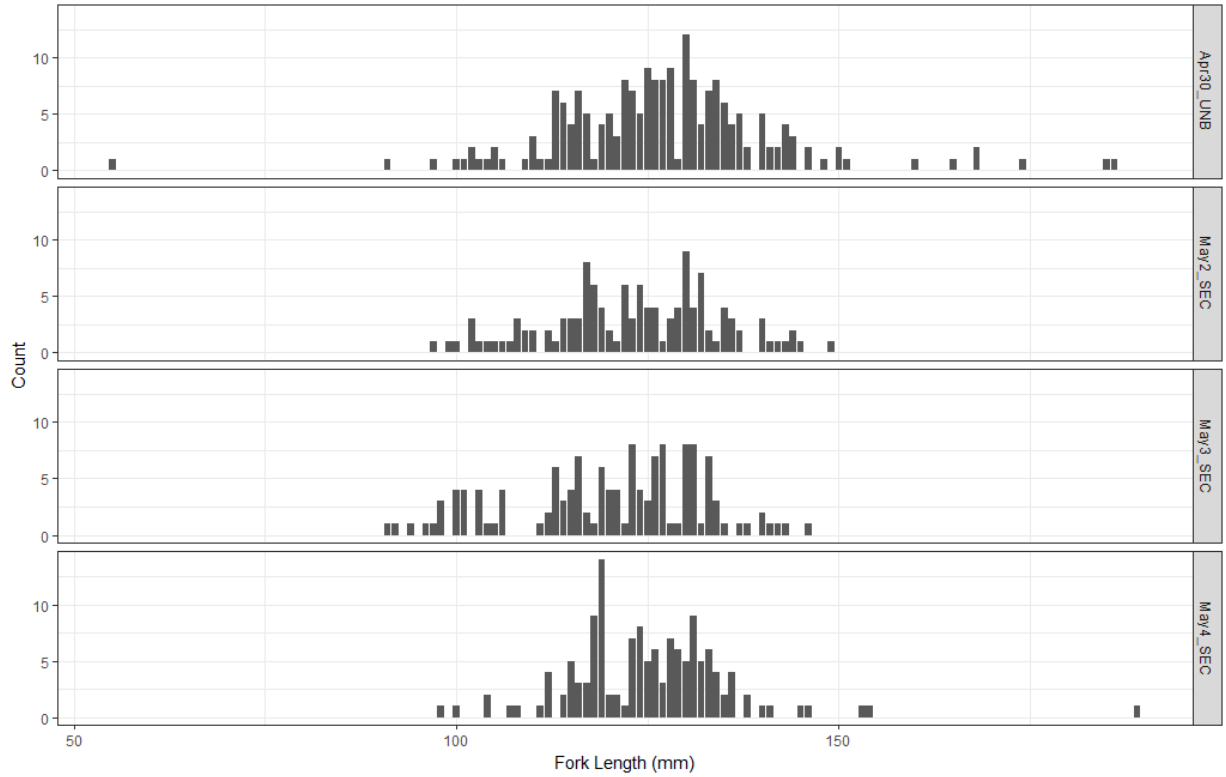

Figure 2. Length frequency distribution of Lake Utopia Rainbow Smelt (LURS) sampled from Unnamed Brook (UNB) on April 30, 2019 (upper panel, n = 200), and Second Brook (SEC) for May 2–4, 2019 (lower panels, n = 124, n = 135, n = 138, respectively).

Second Brook

On May 5, 2018, a single night of mark-recapture sampling was conducted on Second Brook (Table 4). The estimated number of LURS was 1,960 (95% CI = 1,695–2,284). Note that this mark-recapture event occurred after the estimated peak spawning of May 2, 2018.

In 2019, three sequential nights of mark-recapture sampling occurred May 2–4 on Second Brook (Table 4). Nightly estimates of LURS abundance were 12,404 (95% CI = 8,621–18,481), 30,109 (95% CI = 16,648–58,861), and 9,196 (95% CI = 6,572–13,259) for May 2–4, respectively (Table 4). Although mark-recapture events occurred on sequential nights, the unmarked fish captured during the recapture phase were not marked prior to release, and, therefore, further mark-recapture estimation methods were not calculated.

Smelt Brook

Smelt Brook was not surveyed using mark-recapture techniques in 2018 or 2019. A single night of mark-recapture sampling was planned for Smelt Brook in 2018, but it could not be completed because the brook was made inaccessible by flood conditions. A single night of mark-recapture sampling was planned for Smelt Brook in 2019; however, insufficient numbers of smelt were present to proceed.

Unnamed Brook

Unnamed Brook was not sampled using mark-recapture techniques in 2018 due to flood conditions, but a single night mark-recapture sampling event occurred on Unnamed Brook in

2019 (Table 4). The abundance of LURS in Unnamed Brook on April 30, 2019, was estimated as 15,996 (95% CI = 10,077–26,804).

Table 4. Nightly abundance estimates for 2018 and 2019 spawning Lake Utopia Rainbow Smelt (LURS) in Unnamed and Second Brook. A unique fin clip was applied in each consecutive marking event (ADF = adipose fin, UCC = upper caudal fin, RPL = right pectoral fin, LPL = left pectoral fin). Unmarked fish collected in the recapture event (i.e., second nightly capture) were not marked prior to release.

Year	Date	Brook	Clip	Marked	Caught	Recaptures	Estimate	95% CI
2018	**May-05**	**Second**	**ADF**	**500**	**500**	**127**	**1,960**	**1,695–2,284**
2019	Apr-30	Unnamed	UCC	525	516	16	15,996	10,077–26,804
2019	May-02	Second	ADF	575	602	27	12,404	8,621–18,481
2019	May-03	Second	RPL	600	500	9	30,109	16,648–58,861
2019	May-04	Second	LPL	525	576	32	9,196	6,572–13,259

Relative Contribution of Spawning Streams

Yearly monitoring indicates that Second Brook, Smelt Brook, and Unnamed Brook are occupied frequently by LURS, and each stream contributes to the population as evidenced by the presence of eggs in most years (Table 1 and Table 2; Themelis 2018). Additional information is required to quantitatively address the relative contribution of each spawning stream to the overall productivity of the LURS-SbP. Concurrent nightly mark-recapture estimates of abundance from each of the three streams, including unique marking to enable examination of the level of immigration/emigration between streams during the spawning period, and repeated across consecutive seasons, would be required to address this question quantitatively.

Recovery Abundance Target

LURS have been observed in at least one of the three streams in each year in which daytime monitoring for the presence-absence of smelt or eggs has occurred (Themelis 2018). The mark-recapture abundance estimates for 2018 and 2019 presented in this document are the first conducted since 2009 (DFO 2011). However, abundance estimates are not available for all streams, and the available estimates may not fully capture the peak of each spawning run. Estimates for individual streams reported for 2018 and 2019 fall within the range of past estimates reported in Bradford et al. (2013), but it remains unknown if the interim abundance target has been achieved in any year since 2009.

Presently, there are insufficient data available to evaluate the interim abundance target. As stated in the previous section, concurrent nightly mark-recapture estimates of abundance from each of the three streams, repeated across consecutive seasons to enable the evaluation of inter-annual variability in spawning run size, would be required to quantitatively evaluate the current interim abundance target.

Allowable Harm

Human activities that may contribute to mortality or harm to LURS were reviewed and evaluated in the 2010 Recovery Potential Assessment (DFO 2011, DFO 2016). The Lake Utopia watershed supports or has supported, forestry, agriculture, a pulp mill, aquaculture, year-round and seasonal human settlement, recreational use (e.g., boating, all-terrain vehicle use, hunting and fishing), linear developments (e.g., roads, railways and transmission lines) and water storage for hydroelectric power generation (DFO 2011). The Maguadavic River watershed,

including Lake Utopia and its tributaries, has been subject to the deliberate or accidental introduction of Aquatic Invasive Species (AIS) (DFO 2016). Although unquantified, the introduction and establishment of Chain Pickerel (*Esox niger*) is most concerning (DFO 2011). The ranking of the relative threat posed by Chain Pickerel is expected to differ between the SbP and the LbP, where the threat of predation pressure is considered to be of medium concern to the SbP and of high concern to the LbP (DFO 2011, 2016).

The current levels of natural- or human-induced mortality are unknown, and the paucity of mark-recapture-based abundance estimates does not permit evaluation of abundance trends for the LURS-SbP. The level of allowable harm that the LURS-SbP can sustain without jeopardizing survival or recovery cannot be quantified. As stated in the previous sections, concurrent nightly mark-recapture estimates of abundance from each of the three streams, repeated across consecutive seasons to enable the evaluation of inter-annual variability in spawning run size, would be required to quantitatively address the level of allowable harm that could be sustained by the LURS-SbP. Increased variability in environmental conditions due to climate change will act to further increase uncertainty, particularly in the absence of the aforementioned data.

Sources of Uncertainty

Variability in environmental conditions (i.e., ice break-up, water temperature, water levels) can impact the timing of the peak spawning run and may also result in significant portions of the spawning period being unavailable for observation due to areas of the stream being inaccessible or unsafe to conduct monitoring activities. The potential impact of increased variability in environmental conditions on stream occupancy, spawning success, and subsequent recruitment to the LURS-SbP is unknown.

The number of recent abundance estimates are limited overall and are not available for all streams (i.e., no recent abundance estimates for Smelt Brook). The frequency of monitoring effort is limited, and available abundance estimates may not fully capture the peak of each spawning run. Further, mark-recapture sampling does not survey the full length of linear habitat available with each spawning stream. Therefore, nightly abundance estimates should be considered with caution as a conservative estimate of the nightly stream abundance.

Nightly immigration/emigration within the spawning streams can cause violations of the assumptions of mark-recapture estimates and consequently influence the precision of the estimates. To help alleviate this concern, mark-recapture sampling is conducted near 00:00 hr as peak migration into the stream is thought to have occurred by this time. In previous sampling events, barrier nets were installed at the stream mouth prior to collecting fish to further ensure that the population was closed at the time of sampling; however, barrier nets were not deployed as part of 2018 or 2019 mark-recapture sampling.

Recommendations

Annual monitoring to ensure that the LURS-SbP streams are free of barriers to allow upstream access for spawning, and to determine stream occupancy (i.e., presence/absence of smelt and/or eggs), should be continued. The feasibility of conducting concurrent mark-recapture sampling across all LURS-SbP spawning streams should be evaluated. Recent attempts to conduct mark-recapture estimates from all LURS-SbP spawning streams within a single season have been hampered by a combination of adverse environmental conditions (i.e., flooding) and limited by a lack of personnel to simultaneously survey more than a single stream per night.

During mark-recapture sampling activities, all fish captured should be tagged before release. Marking of unmarked individuals that are collected during the second nightly sample (recapture

phase) would serve to increase the robustness of mark-recapture estimates by avoiding potential bias induced by repeated spawning movements of individual smelt. Marking of all smelt handled during a mark-recapture period would also permit further evaluation of immigration/emigration that could assist in evaluating the relative contribution of each spawning stream to the LURS-SbP. Ensuring that the section of the stream being monitored for the mark-recapture study has temporary, removable barriers to prevent the fish from leaving that section during the study period would also help to improve confidence in the resulting nightly abundance estimates.

Late season monitoring of Mill Lake Stream should be evaluated. Monitoring of Mill Lake Stream should be considered a supplementary activity, and it should not be completed if it impacts upon monitoring effort and data collection within the three primary LURS-SbP spawning streams.

Conclusions

Monitoring effort in 2018 and 2019 confirmed the presence of both smelt and eggs in Smelt Brook, Second Brook, and Unnamed Brook. Available data suggest that the LURS-SbP continues to meet the distribution objective identified in the Recovery Strategy. Monitoring effort in Mill Lake Stream that coincided with the spawning run timing of LURS-SbP in the known SbP spawning streams did not detect smelt or eggs in 2019.

Quantitative mark-recapture estimates were conducted in both 2018 and 2019; however, in these years, estimates are not available for all streams and available estimates may not fully capture the peak of each spawning run. Nightly mark-recapture-based abundance estimates indicated a peak spawning run size of 30,109 for Second Brook in 2019. It remains unknown if the interim abundance target has been achieved in any year since 2009.

Presently there are insufficient data available to address the relative contribution of the spawning streams to the LURS-SbP, to evaluate the interim LURS-SbP abundance target, or to estimate the level of allowable harm that can be sustained by the LURS-SbP. To address these knowledge gaps, additional information is required. Further biological sampling and concurrent nightly mark-recapture estimates of abundance from each of the three streams, including unique marking to enable examination of the level of immigration/emigration between streams during the spawning run, repeated across consecutive seasons to enable the evaluation of inter-annual variability in spawning run size, would be required to quantitatively address these knowledge gaps.

Contributors

Name	Affiliation
Jeremy Broome	DFO Science Maritimes Region
Tara McIntyre (chair)	DFO Science Maritimes Region
Samantha Fulton	DFO Science Maritimes Region
Rod Bradford	DFO Science Maritimes Region
Caira Clark	DFO Science Maritimes Region
Danielle MacDonald	DFO Science Maritimes Region
Daphne Themelis	DFO Science Maritimes Region
Katelynn Crawford	DFO Science Maritimes Region
Ree Brennin Houston	DFO Species at Risk Management Division Maritimes Region
Kimberly Robichaud-Leblanc	DFO Species at Risk Management Division Maritimes Region

Approved by

Alain Vézina
Regional Director of Science, DFO Maritimes Region
Dartmouth, Nova Scotia
Ph. 902-426-3490
Date: February1, 2021

Sources of Information

Bradbury, I.R., R. Bradford, and P. Bentzen. 2011. Genetic and Phenotypic Diversity and Divergence in Sympatric Lake Utopia Rainbow Smelt (*Osmerus mordax)*. DFO Can. Sci. Advi. Res Doc. 2011/008: vi + 28p.

Bradford, R.G., Bentzen, P., and Bradbury, I. 2013. Lake Utopia Rainbow Smelt (*Osmerus mordax*) Status, Trends, Habitat Considerations and Threats. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/124. iv + 42 p

COSEWIC (Committee on the Status of Endangered Wildlife in Canada*)*. 2008. COSEWIC Assessment and Update Status Report on the Rainbow Smelt, Lake Utopia Large-bodied Population and Small-bodied Population *Osmerus mordax* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 28 pp.

COSEWIC. 2018. COSEWIC assessment and status report on the Rainbow Smelt *Osmerus mordax*, Lake Utopia large-bodied population and the Lake Utopia small-bodied population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 40 pp.

Curry, R.A., S.L. Currie, L. Bernatchez, and R. Saint-Laurent. 2004. The Rainbow Smelt, *Osmerus mordax*, Complex of Lake Utopia: Threatened or Misunderstood? Environmental Biology of Fishes 69: 153–166.

DFO. 2011. Recovery Potential Assessment for Lake Utopia Rainbow Smelt (*Osmerus mordax*) Designatable Units. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/004.

DFO. 2016. Recovery Strategy for thenLake Utopia Rainbow Smelt (*Osmerus mordax*), Small-bodied Population (sympatric with the Large-bodied Population), in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada. Ottawa viii + 57 pp.

DFO. 2018. Updated Estimate of Lake Utopia Rainbow Smelt (*Osmerus mordax*), Large-bodied Population, Spawner Abundance and Allowable Harm. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/019.

MacDonald, D. and Burbidge, C. 2017. Protocols for monitoring spawning populations of Lake Utopia Rainbow Smelt (*Osmerus mordax*). Can. Tech. Rep. Fish. Aquat. Sci. 3195. iv + 51 pg.

Taylor, E.B., and Bentzen, P. 1993. Molecular genetic evidence for reproductive isolation between sympatric populations of smelt Osmerus in Lake Utopia, South-western New Brunswick, Canada. Molecular Ecology 2. 345–357.

Themelis, D. 2018. Pre-COSEWIC Assessment for Lake Utopia Rainbow Smelt (*Osmerus mordax*) Small-bodied and Large-bodied Populations. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/025. v + 27 p

This Report is Available from the:

Center for Science Advice (CSA)
Maritimes Region
Fisheries and Oceans Canada
Bedford Institute of Oceanography
1 Challenger Drive, PO Box 1006
Dartmouth, Nova Scotia B2Y 4A2

Telephone: 902-426-7070
E-Mail: MaritimesRAP.XMAR@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769
ISBN 978-0-660-40216-1 Cat. No. Fs70-7/2021-037E-PDF
© Her Majesty the Queen in Right of Canada, 2021

Correct Citation for this Publication:

DFO. 2021. Lake Utopia Rainbow Smelt, Small-bodied Population (LURS-SbP) Population Abundance and Allowable Harm Estimate. DFO Can. Sci. Advis. Sec. Sci. Resp. 2021/037.

Aussi disponible en français :

MPO. 2021. Population d'éperlans arc-en-ciel de petite taille du lac Utopia – Estimation de l'abondance et des dommages admissibles. Secr. can. de consult. sci. du MPO. Rép. des Sci. 2021/037.