ESTIMATING LAKE UTOPIA RAINBOW SMELT (*OSMERUS MORDAX*) SPAWNER ABUNDANCE AND ALLOWABLE HARM

Context

Lake Utopia is part of the Magaguadavic River watershed in southwestern New Brunswick. Lake Utopia Rainbow Smelt (LURS) represent one of the only three confirmed occurrences in Canada where genetically divergent smelt populations co-exist as sympatric pairs. Two populations of smelt co-exist in Lake Utopia, a small-bodied (SbP) form and a large-bodied (LbP) form. The LURS-LbP was designated 'Threatened' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November 2008. The reason for the designation is as follows:

> *"This 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 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 lake shore and impacts of the dip-net fishery. This population is threatened by introduction of exotic species and by increasing eutrophication." (COSEWIC 2008).*

DFO conducted a Recovery Potential Assessment (RPA) in October 2010 (DFO 2011, Bradford et al. 2012). At that time, it was not possible to estimate spawner abundance. An interim (until a population estimate was available) abundance target for LURS-LbP, derived from the estimated minimum population size needed to maintain genetic diversity, was recommended at 2,000 spawners on nights of peak spawning. Pursuant to the *Species at Risk Act (*SARA), a regional listing recommendation was subsequently completed in 2013 and a final listing decision is pending.

In the past, a recreational smelt dip-net fishery occurred on the tributary streams of Lake Utopia between April 1st and May 31st. Much of the dip-netting occurred on Mill Lake Stream and Trout Lake Stream (Figure 1), owing in part to ease of access. Therefore, there was a high potential for much of the annual spawning run to be susceptible to fishing. Catch and effort data have never been gathered for this fishery; however, the historical fishing effort is considered to be low (Bradford et al. 2012). The fishery has been closed by Variation Order since spring 2011; however, there is anecdotal information to suggest illegal fishing occurs.

There is one communal Food, Social, and Ceremonial (FSC) license that allows dip-netting and angling for all smelt in Southwest New Brunswick, including the large and small-bodied forms in Lake Utopia. The bag limit for this communal licence was set at 60 fish per person per day, with the season running from April 15th to May 31st. Since 2013, the FSC licence holder has agreed to licence conditions that included a spawning season dip-netting closure within Smelt, Unnamed, and Second brooks.

If LURS-LbP is listed under SARA, activities that result in mortality of LURS-LbP, such as fishing, would not be in compliance with SARA. SARA permits cannot be issued for fisheries

targeting (directed at) listed species; however, such fisheries can be exempted in a Recovery Strategy if the activity does not jeopardize the survival or recovery of the species. Without abundance data for LURS-LbP, it is unknown whether a harvest could occur without jeopardizing survival or recovery of the species. To inform the provision of exemptions, a population abundance estimate, and a resulting updated recovery abundance objective are needed, as well as an understanding of current levels of mortality and maximum levels of allowable harm. Such information will also be needed to inform other aspects of Recovery Planning should LURS-LbP be added to Schedule 1 of SARA.

The objectives of this Science Response process are to:

- Provide a population abundance estimate for the Lake Utopia Rainbow Smelt (large-bodied) Population based on work undertaken in 2014.
- Provide an updated recovery abundance objective for the Lake Utopia Rainbow Smelt (large-bodied) Population to replace the interim recovery abundance objective proposed in the Recovery Potential Assessment (DFO 2011).
- Provide the likelihood that the updated abundance objective for the Lake Utopia Rainbow Smelt (large-bodied) Population can be achieved under current levels of mortality.
- Provide the maximum level of allowable harm that the Lake Utopia Rainbow Smelt (large-bodied) Population can sustain without jeopardizing survival or recovery.

To address these objectives, a mark-recapture study to estimate population abundance within Mill Lake Stream and Trout Lake Stream-Spear Brook, both identified as containing LURS-LbP, was initiated in 2014.

This Science Response Report results from the Science Response Process of November 19, 2015, on Estimating Lake Utopia Rainbow Smelt (Large-bodied) Population Abundance and Allowable Harm.

Background

Current data suggest that LURS-LbP use Mill Lake Stream and Trout Lake Stream-Spear Brook (Figure 1) for spawning (Taylor and Bentzen 1993, Curry et al. 2004, and Bradford et al. 2012). Spear Brook is a tributary of Trout Lake stream; however, these locations are described as three streams by COSEWIC (2008). Smelt Brook, Unnamed Brook, and Second Brook (Figure 1) are used by LURS-SbP for spawning (COSEWIC 2008).

Migrating from the lake where they are found during the rest of the year, LURS ascend the streams, usually at night, to spawn. Spawning for both populations occurs in the spring; LURS-LbP spawn between late-March and mid-April whereas LURS-SbP spawn later in the spring, between mid-April and late May. Surveys in 2009 and 2010 of areas adjacent to the 5 spawning tributaries revealed no evidence of shoreline spawning activity (Bradford et al. 2012).

It has been difficult to obtain spawning abundance estimates for LURS-LbP. The spawning period is of a short duration, approximately 5 days, and can begin before the ice is out of the lake. Without frequent nighttime checks for spawning activity, the spawning run would be missed. A lone spawner abundance study of LURS-LbP conducted over a single night in April 2009 at Mill Lake Stream (Bradford et al. 2012) provided a spawner abundance of 5,000 fish. In 2010, another abundance study was attempted on Mill Lake Stream but it was not successful as fewer than 20 fish were observed. At the time of the study, a beaver dam was across the mouth of a culvert under Route 785 located at the outflow of Mill Lake Stream. The beaver dam was subsequently removed by the Department of Transportation (DFO 2011).

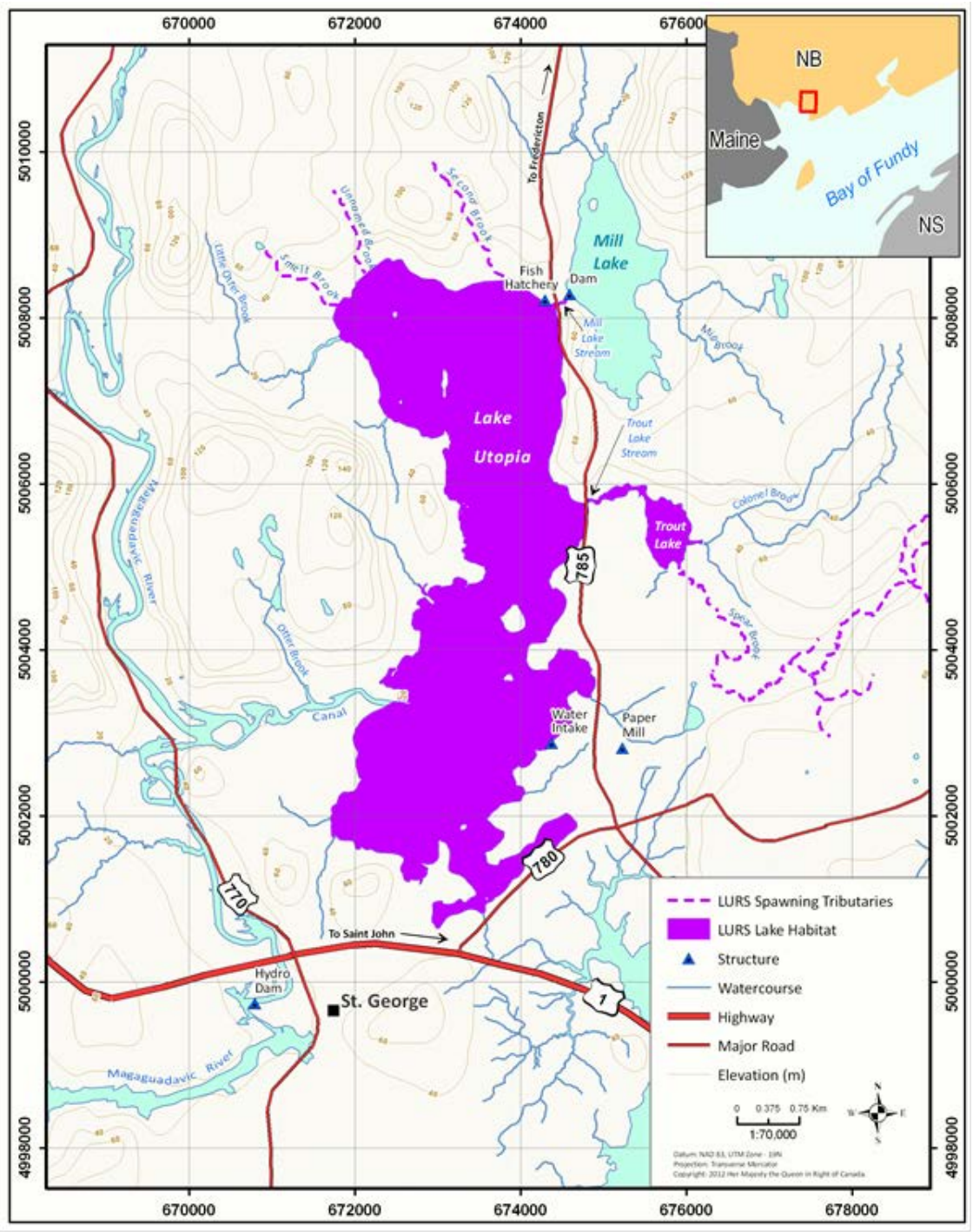

Figure 1. Lake Utopia, New Brunswick. Spawning tributaries for Lake Utopia Rainbow Smelt (LURS) are indicated by dashed lines, industrial structures by blue triangles, and roads by red lines. The spawning tributaries of the large-bodied form of LURS, Mill Lake Stream and Trout Lake Stream, are located at the northeast portion of the lake. © 2011 Her Majesty the Queen in Right of Canada.

In 2014, a mark-recapture study was undertaken by DFO to estimate abundance of LURS-LbP. At this same time, representatives from the Maritimes Aboriginal Peoples Council (MAPC) were conducting, for the second year, a presence-absence study of both populations of Lake Utopia

smelt in partnership with DFO. MAPC staff observed smelt at the mouth of Mill Lake Stream, on the Lake Utopia side of the culvert, from April 1 to April 9, 2014 (Barry Labillois, MAPC, personal communication). They were not able to check for smelt April 10th and 11th due to weather conditions. By April 12th, LURS-LbP had left the area and were not seen on subsequent nights. Through real-time reporting of the presence of smelt, DFO initiated the mark-recapture project when the smelt appeared at the mouth of Mill Lake Stream at the beginning of spawning season. More than 5,000 smelt were captured, marked and released over five nights between April 3 and April 10, 2014. Starting April 16th, smaller smelts, presumably LURS-SbP, were observed at Mill Lake Stream.

MAPC checked Trout Lake Stream during this period (April 1st, 2nd, 5th, 7th, 8th, 9th, 12th) and no smelt were sighted. DFO staff (Science and Conservation and Protection) checked both spawning tributaries for smelt and eggs both day and night during the spawning season. There was no evidence of spawning activity or migration in Trout Lake Stream in 2014, so the assessment was limited to Mill Lake Stream.

Analysis and Response

Assessment

Length Frequency Distribution

Currently, two body-forms, a large-bodied and a small bodied form are recognized as distinct populations (Bradford et al. 2012, Bradbury et al. 2011, and COSEWIC 2008). COSEWIC (2008) defines LURS-LbP as between 15 to 25 cm in total body length (equivalent to 136 to 227 mm in fork length (FL)) at maturity, while the small bodied-form ranges from approximately 8 to 15 cm. A recent genetic assessment (Bradbury et al. 2011) was used to support a definition of LURS-LbP as fish >17 cm FL and the definition of LURS-SbP as fish ≤17 cm FL (Bradford et al. 2012, DFO 2011). However, small numbers of one form can be genetically similar to the other form and hybrids of the two populations occur in detectable numbers (Bradbury et al. 2011). Therefore, gene flow between the two forms occurs.

Many fish sampled between April 3-10, 2014 were smaller in length (Figure 2) than the length minimum for LURS-LbP suggested by Bradbury et al. (2011), Bradford et al. (2012), or COSEWIC (2008) (3% and 90% depending on whether 136 mm or 170 mm FL is used, respectively) suggesting that the fish sampled were a mix of small- and large-bodied LURS. Further analysis of genetic samples and meristic measurements collected during this study is required to determine to which population each fish belong.

The sample of fish measured during April 3-10, 2014 ranged from 125 to 190 mm FL (Figure 2). Specimens as large as 300 mm (DFO, unpublished data[1]) were also observed on each night, but being few in number, did not form part of the random samples collected for detailed sampling. After an interval of several days, a second spawning period of smaller LURS was observed in the area (Figure 2). This group was comprised of smaller fish, presumably LURS-SbP.

1 DFO. 2013. Recovery Strategy for the Lake Utopia Rainbow Smelt (*Osmerus mordax*), Small-bodied Population (sympatric with the Large-bodied Population), in Canada [DRAFT]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada. Ottawa viii + 57 pp

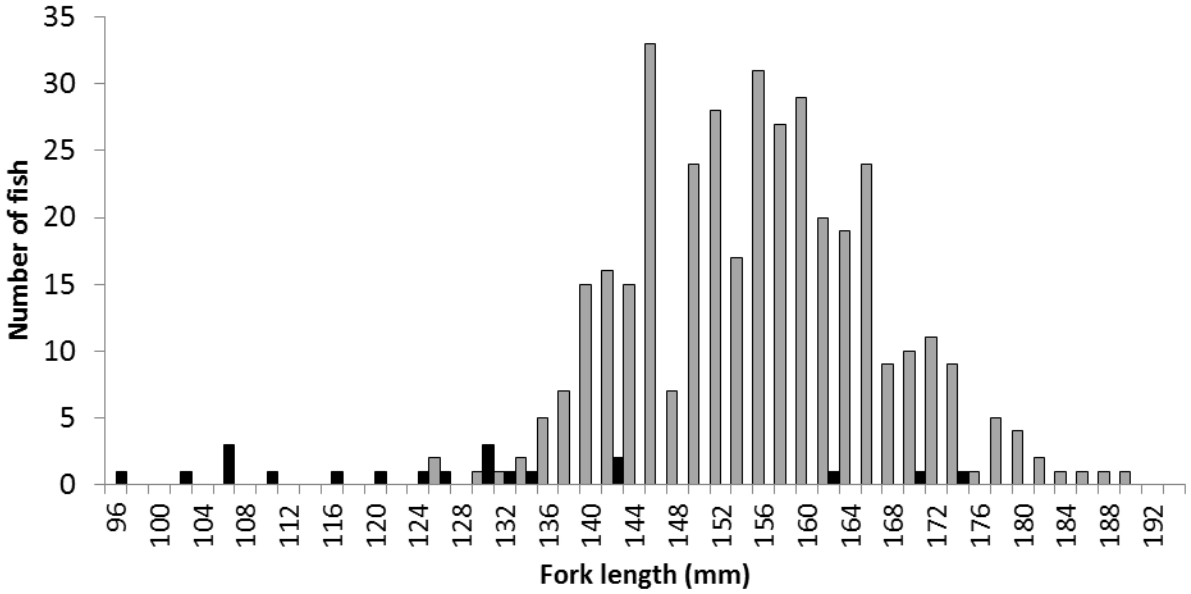

Figure 2. Length frequency of LURS sampled during an abundance study of the early spawners (n=378; April 2-10th) at Mill Lake Stream is represented by the grey bars. The black bars represent length frequency of individuals collected during a subsequent LURS spawning run on April 22nd (n=19). X axis label indicates upper limit of length for each 2 mm bin (length group).

Population Abundance Estimate

This spawning abundance study occurred over five nights between April 3 and April 10, 2014. Each night there was a marking and a recapture event, separated by an hour to allow time for marked fish to mix with the remainder of the population. During the recapture event, unmarked fish were marked. All marking and recapture events occurred at the mouth of Mill Lake Stream (45˚ 12' 31.6"N, 66˚ 46' 72.1" W) just below the culvert running under Route 785. Each marking event was completed using a unique fin clip for each night (Table 1). On nights where smelt were abundant, a dip net was used to capture fish along the banks; otherwise a beach seine net was used. A summary of the numbers caught on each sampling night is presented in Table 1.

Table 1. Summary of mark-recapture study data. Clip types are UCC = Upper Caudal fin, LCC = Lower Caudal fin, ADF = Adipose fin, RPF = Right Pelvic fin and LPF = Left Pelvic fin. Dates indicate the trip date. Search 1 represents the marking event, and Search 2 represents the recapture event. The second sampling event (Search 2) each night was after midnight, so on the date following the marking event. N/A = not applicable.

		April 3, 2014	April 4, 2014	April 5, 2014	April 6, 2014	April 10, 2014	Total
	Clip Type	**UCC**	**LCC**	**ADF**	**RPF**	**LPF**	
Number of unmarked Caught	**Start of Night**	277	334	1200	661	355	2827
	End of Night	26	40	885	815	658	2424
Total Newly Caught/Night		303	374	2085	1476	1013	5251
UCC303+4 Recaptures	**Search 1**	N/A	4	8	15	1	28
	Search 2	4	1	15	12	2	34
LCC Recaptures	**Search 1**	N/A	N/A	6	16	8	30
	Search 2	N/A	4	22	11	2	39
ADF Recaptures	**Search 1**	N/A	N/A	N/A	85	30	115
	Search 2	N/A	N/A	82	126	30	238
RPF Recaptures	**Search 1**	N/A	N/A	N/A	N/A	16	16
	Search 2	N/A	N/A	N/A	55	28	83
LPF Recaptures	**Search 1**	N/A	N/A	N/A	N/A	N/A	0
	Search 2	N/A	N/A	N/A	N/A	10	10
Total Recaptures		4	9	133	320	127	593

Using an adjusted Schnabel method (input data in Table 2) to estimate total abundance over the spawning period, the early spawning population of LURS at Mill Lake Stream was estimated as 22,803 (95% confidence intervals of 21,107-24,724). Nightly estimates were also calculated using the adjusted Petersen method and are summarised in Table 3. Each night was treated as a separate mark-recapture event and only fish marked that night were counted in the nightly estimate. The abundance ranged from approximately 1,700 to 23,700, generally increasing with time. The nightly estimate should not be summed to provide an overall abundance estimate because fish would 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. However, the increase in nightly spawner abundance between the first and last day of sampling suggests that there is immigration and the system may not be closed, a violation of the assumptions of the Schnabel method, which would result in a less precise estimate.

Table 2. Summary of field data for LURS abundance study including recaptures of marked fish for a given period, unmarked fish captured minus mortalities during a given period, total fish caught (recaptures+unmarked) in a given period, and marked fish available for recapture from all previous periods.

Start Date	Phase	Search #	Recaptures	Unmarked	Total Caught	Marked
April 3, 2014	Marking	1	0	277	277	0
	Recap	2	4	26	30	277
April 4, 2014	Marking	3	4	333	337	303
	Recap	4	5	40	45	636
April 5, 2014	Marking	5	14	1200	1214	676
	Recap	6	119	885	1004	1876
April 6, 2014	Marking	7	116	657	773	2761
	Recap	8	204	815	1019	3418
April 10, 2014	Marking	9	55	355	410	4233
	Recap	10	72	658	730	4588
		Total	593	5246	5839	18768

Table 3. Estimates of spawning fish in Mill Lake Stream based on mark-recapture study.

Nightly Population Estimates	
April 3, 2014	1,724
April 4, 2014	3,082
April 5, 2014	14,542
April 6, 2014	12,058
April 10, 2014	23,658

Abundance Target

Recovery objectives for a species are set out in the Recovery Strategy and are informed by science advice. Information about the life history of the species and its historical status provides a starting point for estimating population sizes and potential ranges, as well as the associated timescales for these estimates.

LURS-LbP was designated as 'Threatened' by COSEWIC, not because of a decline in abundance, but in part because of their restricted distribution. The distribution-based criterion that COSEWIC uses to designate a species as 'Threatened' specifies an index of area of occupancy less than 20 km or with few locations (fewer than 5). LURS-LbP is found only in one lake; further, spawning is only known in three tributaries to this lake. The COSEWIC index of area of occupancy was estimated as 6 km^2 (COSEWIC 2008). Considering the rationale for the 'Threatened' designations, the broad goal of the draft Recovery Strategy for LURS (DFO, unpublished manuscript) is to maintain the current population distribution and abundance of the small-bodied and large-bodied populations of Lake Utopia Rainbow Smelt and the genetic diversity of the Lake Utopia Rainbow Smelt sympatric species pair. Essentially, the persistence of the LURS sympatric species pair, in the face of threats and the precarious nature of its unique, singular, and limited occurrence, is what represents survival in the draft Recovery Strategy (DFO, unpublished manuscript).

The proposed interim recovery abundance was based on the population size required to maintain genetic diversity, which is estimated to be in the vicinity of 550–2,000 mature individuals (DFO 2011). It was suggested that the upper value of 2,000 mature individuals be used due to the vulnerability of the population to catastrophic events and/or environmental variability (i.e., very small index of area of occupancy, in a single location), an estimated potential annual harvest from a directed recreational dip-net fishery (closed since 2011) of approximately 1,250 adults, and evidence for hybridization with the smaller form of smelt (Bradford et al. 2012). This target was surpassed by the 2009 estimate of 5,000 fish in a single night. It may have been surpassed on several nights in 2014 (nightly estimates range between 1,724 and 23,658 and total spawning population estimate of 22,741 at Mill Lake Stream), but the uncertainty around assignation of the fish sampled to a specific designated unit make it difficult to draw conclusions.

An abundance estimate for Trout Lake Stream-Spear Brook cannot be provided because no fish were observed. In addition, the use of Trout Lake Stream-Spear Brook as spawning habitat for LURS-LbP productivity requires further investigation.

Given the uncertainty of population membership (i.e. large- or small-bodied) of spawning LURS sampled at Mill Lake Stream, an updated abundance objective, and the likelihood of achieving it, cannot be provided for LURS-LbP using these data.

Allowable Harm

The maximum human-induced mortality that LURS-LbP can sustain without jeopardizing its survival or recovery cannot be determined without information on trends in abundance and levels of mortality. Given the vulnerability of the population to catastrophic events and environmental variability, it is recommended that allowable harm should be determined in terms of nightly spawner abundance rather than overall population size, which is consistent with the proposed interim recovery targets developed after the RPA for inclusion in the draft Recovery Strategy.

A number of potential sources of direct mortality were identified in Bradford et al. (2012) including entrainment at industrial intakes, i.e., paper mill and hatchery, directed fisheries, bycatch fisheries, increased predation through human actions (e.g. introduction of predatory species), and scientific research. For many of these ongoing human-induced threats, the level of mortality is likely low (Bradford et al. 2012) and would, thus, not have a measureable effect on survival or recovery.

There is one communal FSC license that allows dip-netting and angling for all smelt in Southwest New Brunswick, including the large- and small-bodied forms found in Lake Utopia. The bag limit for this communal licence was set at 60 fish per person per day, with the season running from April 15th to May 31st. Since 2013, the FSC licence holder has agreed to licence conditions that included a spawning season dip-netting closure within Smelt, Unnamed, and Second brooks.

In 9 years of data, LURS-LbP have been recorded only once in Mill Lake Stream later that April 15th (April 17, 2003), despite continued monitoring as late as mid-May. LURS-LbP spawning appears to end prior to the opening of the FSC fishing season. Provided the spawning season and fishery remain separated in time, there is low potential for the FSC fishery to jeopardize the survival or recovery of LURS-LbP.

The importance of Trout Lake Stream-Spear Brook system for LURS-LbP productivity is not well understood (Bradford et al. 2012). Although no obstructions are present at the entrance of this stream, given the absence of any evidence of spawning in 2014 in Trout Lake Stream, it is

recommended that LURS-LbP mortality be minimized until there is evidence to suggest that it is sustainable.

Sources of Uncertainty

The timing of the run and presence of large-sized LURS individuals sampled between April 3-10, 2014 were consistent with membership to LURS-LbP. However, length-frequency data indicated that the run was comprised of both the large-bodied and the small-bodied forms. The length of spawners has been used to assign membership to either LURS-LbP or LURS-SbP (Bradford et al. 2012, Bradbury et al. 2011, COSEWIC 2008, and DFO 2011); however, the minimum length limit is not absolute. Further analysis of genetic samples and meristic measurements collected during this study is required to determine to which population the fish belong.

There was an increase in nightly spawner abundance between the first and last day of sampling, which suggests that there is immigration and the system may not be closed, a violation of the assumptions of the Schnabel method.

MAPC checked Trout Lake Stream during the 2014 LURS spawning period (April 1st, 2nd, 5th, 7th, 8th, 9th, 12th) and no smelt were sighted. DFO staff (Science and Conservation and Protection) also checked both LURS-LbP spawning tributaries for smelt spawners and eggs both day and night during the 2014 spawning season. There was no evidence of spawning activity or migration in Trout Lake Stream in 2014. It is not known if LURS are still using this location for spawning.

The absence of observed LURS eggs or individuals above the Mill Lake Stream culvert in 2014 suggests that the water velocity through the culvert acted as an impediment to the passage of LURS into Mill Lake Stream in 2014. This observation, in conjunction with the low number of individuals (few eggs and fewer than 20 fish) observed in 2010 due to a stream blockage (a beaver dam), demonstrate the vulnerability of LURS to habitat changes. Whether the LURS were able to find alternate suitable habitat for egg deposition is not known. Given that evidence of spawning by LURS-LbP (either fish in spawning condition or eggs) has only been found in two tributaries, this does not seem likely. The effect of these types of events on the likelihood that current population levels can be maintained and recovery targets achieved is unknown.

Recommendations

Further biological sampling (i.e., genetics, size at age) and monitoring of LURS spawner use and abundance in Mill Lake Stream and Trout Lake Stream-Spear Brook to identify trends and estimates of human-induced mortality, are required to provide a more precise LURS-LbP abundance estimate and advice on allowable harm.

Conclusions

A mark-recapture study to estimate population abundance was initiated by DFO in 2014. The overall population for LURS spawning at Mill Lake Stream during the study period was estimated as 22,741 (95% confidence intervals of 21,052-24,724). Based on length of the fish tagged, it is believed that this represents a mix of both small- and large-bodied populations of LURS. Nightly estimates were also calculated. The increase in nightly abundance estimates over the study period suggests that individuals were immigrating to the population. Abundance estimates ranged from approximately 1,700 on the first night to 23,700 on the last night. A different fin was clipped during each night, and based on these marks, the same fish were seen on multiple nights. The nightly estimate should, therefore, not be summed to provide an overall abundance estimate because fish could be counted more than once. This violates one of the

assumptions of a closed population of the Schnabel method. Therefore, the LURS spawner abundance estimate in Mill Lake Stream should be interpreted with caution.

No fish or eggs were seen at Trout Lake Stream-Spear Brook in 2014. Due to the limited nature of this study (a point estimate based on a single spawning season in one of three spawning locations) a quantitative estimate of allowable harm cannot be provided. Further biological sampling (i.e., genetics, size at age) and monitoring of spawner abundance to identify trends and estimates of human-induced mortality is required to provide a more precise LURS-LbP abundance estimate and advice on allowable harm. Given the uncertainty of population membership (i.e. large- or small-bodied) and abundance estimates, an updated abundance objective, and the likelihood of achieving it, cannot be provided.

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Sources of Information

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