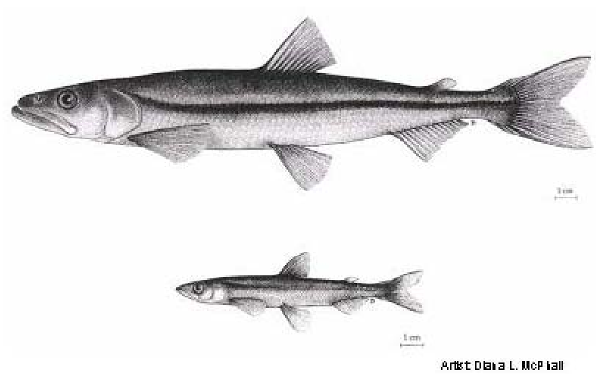
RECOVERY POTENTIAL ASSESSMENT FOR LAKE UTOPIA RAINBOW SMELT (*OSMERUS MORDAX*) DESIGNATABLE UNITS



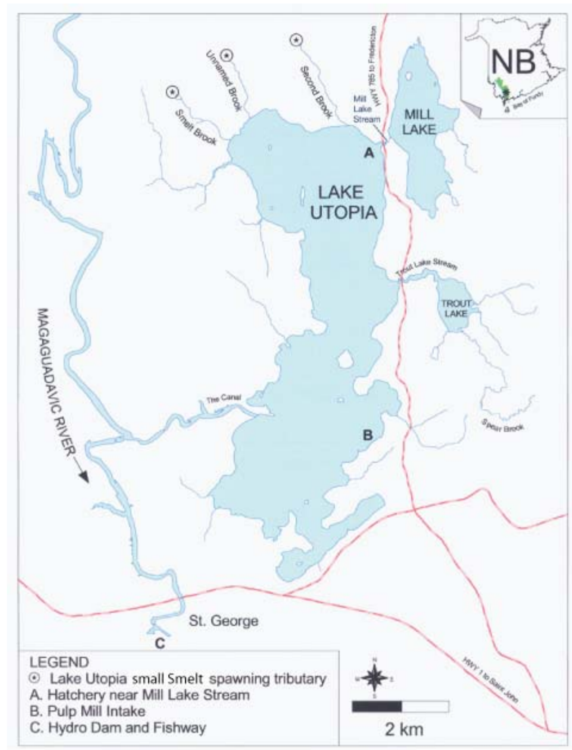


Figure 1: Map of Lake Utopia and the spawning tributaries used by Rainbow Smelt.

Context:

The native Rainbow Smelt (Osmerus mordax) inhabiting Lake Utopia, New Brunswick (Figure 1) consists of two co-existing (sympatric) morphologically, ecologically, and genetically differentiated populations (Taylor and Bentzen 1993); a small-bodied form and a large-bodied form. Each population was assessed in November 2008 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as meeting their criteria for a Designatable Unit (DU), and each DU was designated Threatened. COSEWIC (2008) represents the first assessment of the large-bodied population. The small-bodied smelt population, previously known as 'Lake Utopia dwarf smelt (LUDS)' was assessed by COSEWIC in 2000 (COSEWIC 2000) and was listed on Schedule 1 of the Species at Risk Act (SARA) as Threatened in 2003. The prohibitions associated with SARA came into force in June 2004. A draft Recovery Strategy for the LUDS has been under development since its listing, but finalization was delayed to allow for the consideration of new, additional science advice.

A Recovery Potential Assessment (RPA) was undertaken 26-27 October 2010, to provide information and advice, for both small-bodied smelt and large-bodied smelt, on current status, trends, and their potential for recovery and to propose population abundance and distribution targets for recovery. Information on habitat requirements as well the impact of human activities on both the species and their habitat, including possible alternatives and management measures to mitigate these impacts are also *included. This RPA is intended to update and consolidate existing information on both Lake Utopia Rainbow Smelt DUs to support decisions on listing of the large-bodied smelt, to support ongoing recovery planning efforts for the small-bodied smelt, and to inform decisions on permitting certain activities.*

SUMMARY

- 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.
- Two populations of smelt co-exist in Lake Utopia, a small-bodied form and a large-bodied form. These populations differ in physical characteristics, life history, and are reproductively isolated.
- The two populations were assessed as separate Designatable Units (DUs) by COSEWIC in 2008 and both were designated as Threatened in part because of their natural small areas of occurrence and occupancy and in part because this small area is sensitive to the effects of human activities.
- Spawning of the small-bodied form has been confirmed in only three small, vulnerable brooks (about 1 m in width and estimated to provide ≤ 500 m of accessible linear spawning habitat) at the northern end of Lake Utopia: Smelt Brook, Unnamed Brook, and Second Brook.
- The large-bodied form spawns in the two larger tributaries at the northeastern end of Lake Utopia: Mill Lake Stream and Trout Lake Stream (which outflows from Trout Lake and has Spear Brook as a tributary and which is recognized as a spawning site).
- Adult body size is recommended as the most useful, and practical criteria for the general description and operational definition of the two body forms. Small-bodied smelt would be those less than 170 mm fork length (FL) whereas the large-bodied smelt would be those ≥ 170 mm FL. A length of 170 mm FL is equivalent to 187 mm Total Length.
- Individual within-stream daily estimates of spawner abundance for small-bodied smelt have varied between 3,000 and 150,000 fish during the years that estimates have been acquired, with estimates on the order of 10^4 fish being the most frequent.
- Among-stream daily abundance estimates are typically in excess of 100,000 spawning small-bodied smelt.
- There were fewer recorded occurrences of small-bodied smelt in Scout Brook during the 2009 and 2010 spawning seasons, and when they were present they were in low numbers (<100 fish) and few egg mats were observed. There is no known natural factor as to why this occurred.
- The abundance of large-bodied Lake Utopia Rainbow Smelt (LURS) population can not be assessed with the current data.
- The presence of large-bodied spawners in Mill Lake Stream was observed to be low (few eggs and less than 20 fish) in 2010. A stream blockage resulting from the presence of a beaver dam was evident at that time.
- Recovery targets for both body forms of the Lake Utopia Rainbow Smelt can be defined on the basis of abundance and distribution.
- An interim (5 years) daily abundance target for small-bodied LURS of 100,000 spawning fish distributed among the three brooks during peak spawning period is recommended to demonstrate their continued high productivity.
- The recommended annual distribution target for small-bodied LURS is the synchronous occupation under natural conditions of the three spawning brooks, with no individual brook to be unoccupied for 2 consecutive years.

- An interim (until a population estimate is available) abundance target for the large-bodied LURS, derived from the estimated minimum population size needed to maintain genetic diversity, is recommended at 2,000 spawners.
- An interim (until more is learned about spawning in Trout Lake Stream and Spear Brook) distribution target for large-bodied LURS is the annual occupancy of Mill Lake Stream.
- Human activities have the potential to affect the LURS in the attributes of water quality, water quantity, direct mortality, and habitat impacts. Present mitigative measures, options to reduce affect, and research and monitoring proposals have been identified for all known threats under each attribute. Risks of potential effects under current management measures were ranked low, medium, or high for the individuals of both DUs of the LURS. The location of the effect (either lake or spawning streams) is also included.
- The recovery of both small-bodied and large-bodied Rainbow Smelt DUs in Lake Utopia is considered to be both biologically and technically feasible. Recovery requires maintaining self-sustaining populations for both DUs and mitigating the threats through existing regulations, education and stewardship efforts.

BACKGROUND

Rationale for Assessment

This assessment was conducted in order to meet several objectives:

- To both update and re-state to the extent possible within the Department of Fisheries and Oceans (DFO) Recovery Potential Assessment (RPA) framework (DFO 2007) information concerning the life-history, biological traits, status, trajectory, habitat requirements, threats (and alternatives and mitigation) of the small-bodied ('dwarf) Lake Utopia Rainbow Smelt for use in completion of the recovery strategy draft;
- Fulfill the science information requirements for a Recovery Potential Assessment of large-bodied Lake Utopia Rainbow Smelt; and
- Compile information that can be used to assist in identifying critical habitat for both the small- and large-bodied Lake Utopia Rainbow Smelt (LURS) designated units (DUs), and

Assess whether the concept of residence as defined under *SARA* applies to either DU.

Species Biology and Ecology

Rainbow Smelt are found in fresh and salt water along the North American coast (Scott and Crossman 1973). In New Brunswick, anadromous populations occur in most coastal streams, and Lake populations have been detected within approximately 50 inland water bodies, including the 13.8 km^2 Lake Utopia. The lake is located within a small (93 km^2) sub-drainage of the Magaguadavic River (Figure 1) in southwestern New Brunswick. Two morphologically, ecologically, and genetically differentiated populations (Taylor and Bentzen 1993) co-exist (sympatric) within Lake Utopia; a small-bodied population and a large-bodied population. Lake Utopia is one of only three lakes in Canada where genetically divergent smelt populations occur in sympatry.

Species present in Lake Utopia that can prey upon smelt include landlocked Atlantic Salmon (*Salmo salar*), Brook Trout (*Salvelinus fontinalis*), Burbot (*Lota lota*), Yellow Perch (*Perca flavescens*) (Scott and Crossman 1973), Smallmouth Bass (*Micropterus dolomieu*) and Rainbow Smelt (Currie et al. 2004).

Distinguishing Traits of Small- and Large-Bodied Lake Utopia Rainbow Smelts

Recent genetic and biological assessments have confirmed the existence of the two forms of Rainbow Smelt in Lake Utopia (Bradbury et al. in prep) that are reproductively isolated. The small-bodied form possess a larger eye and smaller upper jaw relative to their body size, and a higher number (33-38 versus 31-34) of gill rakers than the large-bodied form. The small-bodied form exhibits bi-modality in body length. These length modes do not appear to represent different age-classes but rather fish possessing differing patterns in annual body growth.

Adult body size is recommended as the most useful, and practical, criteria for the general description and operational definition of the small-bodied (< 170 mm Fork Length (FL)) and the large-bodied (≥ 170 mm FL) Lake Utopia Rainbow Smelt DUs. The 170 mm FL is equivalent to 187 mm Total Length.

Spawning

Spawning occurs during spring for both DUs. Large-bodied smelt spawn early (late March-mid April), at water temperatures of 6^0C or less (Curry et al (2004), around the time of ice break-up. Small-bodied smelt spawn from mid-April until mid-late May at water temperatures ranging from 4 ^{0}C to 9 ^{0}C (Curry et al 2004). The duration of spawning in a given year is relatively brief for large-bodied smelt (e.g., 5-10 days), whereas spawning activity among small-bodied smelt can persist for 2-4 weeks.

Available data indicates that all spawning activity occurs in tributary streams. Spawning is predominately occurs in only 5 of the 14 principle tributary streams of Lake Utopia although sporadic, and minor, spawning occasionally occurs occur in other streams in some years. All 5 spawning tributaries are located within the northern basin of Lake Utopia (Figure 1).The largest tributaries, Mill Lake Stream and Trout Lake Stream, which includes Spear Brook (Figure 1), are used by large-bodied smelt. Smelt Brook, Unnamed Brook, and Second Brook (Figure 1) are used by small-bodied smelt. Both small- and large-bodied smelt ascend the streams at night when spawning occurs. Some smelt may remain in the streams during daylight.

Large-bodied smelt and small-bodied smelt larvae hatch within about 22 days and 28 days respectively after spawning. Larvae from both DUs drift downstream into the lake during periods of darkness (Curry et al. 2004).

Biological Traits

Small-Bodied Smelt

Average age of mature small-bodied smelts has been estimated as 2.8 years (Curry et al 2004). Samples collected in 2010 were estimated to be 3.3±0.7 years (n =70; range 2-5 years). The presence of two length modes, not differing in age structure (Curry et al 2004), complicates the description of size-at-age. The age frequency distribution of adult fish of 80mm-120mm FL could be expected to be similar to that of adult fish of 125mm-155mm FL.

Fecundity of the small-bodied smelts is size dependent and reported in Shaw (2006) as:

$$\text{Eggs} = 0.0003\ \text{Fork Length}^{3.465} \quad n=27,\ r^2=0.83$$

yielding estimates of eggs per female of about 2,100 at 95 mm FL to 12,000 at 155 mm FL. Females produce about 400 (range 240-600) eggs per gram of body weight (Shaw et al 2004).

Females are estimated to comprise from 10% to 64% of the spawning population on a given day, and on average less than 50% of the sample population from any year.

Large-Bodied Smelt

Fewer data concerning the biological traits of the large-bodied form are available. Curry et al (2004) reported average age of 3.1±0.7 years for the spawning population whereas Jardine and Curry (2006) estimated ages varied between 2 and 6 years of age. MacLeod (1922) reported ages of between 4 and 7 years.

There are no estimates of the fecundity of the large-bodied Lake Utopia Rainbow Smelt.

Available estimates indicate that females comprise 35% or less of the annual spawning runs.

ASSESSMENT

Trends and Current Status

Small-Bodied Smelt

Individual within-stream daily estimates of spawner abundance have varied between 3,000 and 150,000 fish during the years that estimates have been acquired, with estimates on the order of 10^4 fish being the most frequent (Figure 2). Among stream estimates are generally similar for common dates, indicating that small-bodied smelt do not exhibit a preference for one stream over the others. Summation of individual daily estimates for all three streams on common dates indicates that the number of small-bodied smelts participating in a particular spawning event can number in the 100s of thousands.

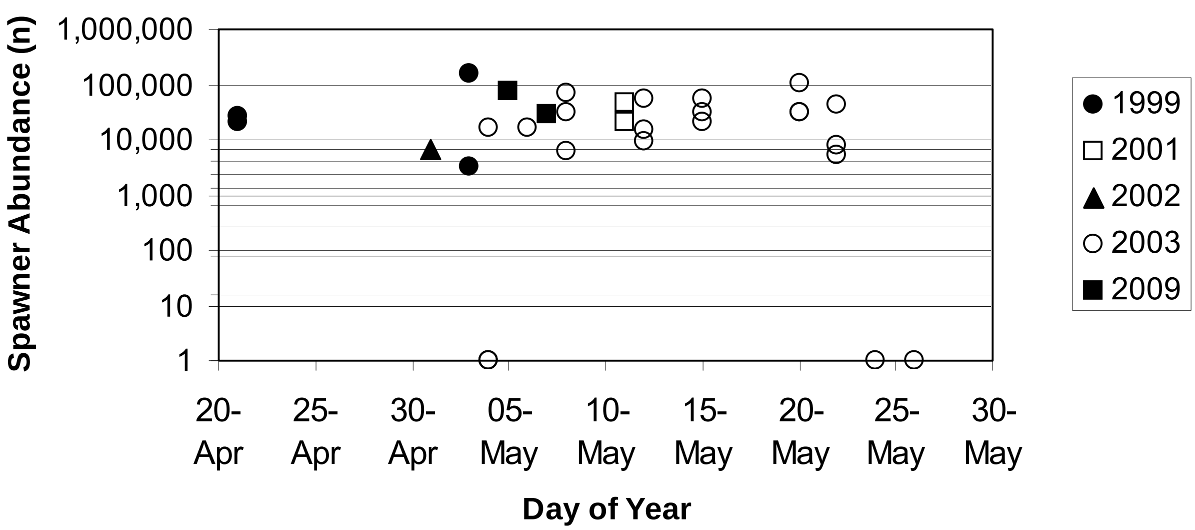


Figure 2. Daily, within-stream, spawner abundance estimates (log scale) for small-bodied Lake Utopia Rainbow Smelt by year of sampling.

There were fewer recorded occurrences of small-bodied smelt in Second Brook during the 2009 and 2010 spawning seasons, and when they were present they were in low numbers (<100 fish) and few egg mats were observed. There is no known natural factor as to why this occurred, attraction flow and stream depth through the section of barrier beach at the stream mouth were considered to be adequate for smelts to ascend.

Large-Bodied Smelt

Daily spawner abundance has been estimated quantitatively for large-bodied smelt on one occasion, the evening of 17 April, 2009, at Mill Lake Stream. Median spawner abundance was estimated to be 5,000 fish. Attempts during 2010 to sample large-bodied smelts on Mill Lake Stream, beginning March 22nd, were not successful; fewer than 20 fish in total were observed. It was noted on March 20th that a beaver dam was in place across the mouth of a culvert at the outflow of Mill Lake Stream. The dam was removed by the Department of Transportation some time before March 29th.

Current status of large-bodied Lake Utopia Rainbow Smelt, in the context of spawner abundance, cannot be assessed with the data currently available. Inference concerning change in status with time is also not possible.

Small- and Large-Bodied Smelt Sympatry

Genetic analyses indicate the recurring presence of hybrid individuals and gene flow from the large to small forms suggesting that the stability of the pair will likely depend on the persistence of suitable local environmental conditions Bradbury et al. 2010). Therefore, statements on the general status of Lake Utopia Rainbow Smelt will need to consider as factors environmental stability within Lake Utopia and the tributary streams used by smelt, as well as the selective mechanisms within the ecosystem that maintain smelt diversity. Neither factor is well understood at the present time. Indications of a recent, much reduced use of one brook (Second) by small-bodied smelt, and evidence of potential for disruption of both access to, and availability of, spawning habitat for large-bodied smelt lend uncertainty to the stability of the production potential for both members of the species pair.

Habitat Requirements and Residence

Characteristics of Spawning Habitat

Spawning substrates are similar for both DUs. They consist of one or more of the following: sand, gravel, rock, aquatic vegetation, and wood debris. Smelt generally ascend, and occupy, the stream between the mouth (above the beaches at the lake shore) and either an obstruction or abrupt increase in stream gradient. Areas immediately downstream of obstructions can contain high densities of eggs.

Characteristics of Spawning Tributaries

Large-Bodied Smelt

The spawning tributaries used by the large-bodied smelt DU contains lakes and are larger than those used by small-bodied smelt. The two known spawning tributaries are Mill Lake Stream and Trout Lake Stream which includes Spear Brook, a tributary to Trout Lake (Figure 1).

Mill Lake Stream averages 4 m wide and less than 1 m deep (Curry *et al* 2004). Water velocities in Mill Lake Stream may reach 1 m/sec (Curry et al. 2004). A small (~0.5 m) waterfall that can probably not be ascended in most years by large-bodied smelt limits the available spawning habitat to the 10 - 30 m stretch immediately below the waterfall.

Trout Lake Stream has been described as being about 10 m wide with slow-moving water and deeper pools (Curry *et al*. 2004). The only known report of the presence of eggs within the stream is within the culvert under the road that crosses the stream at its mouth.

Spear Brook (Figure 1) is a 3-5 m in width low gradient stream with an outlet to Trout Lake that has become extensively braided from extensive damming activity by beavers. Both adult smelt and eggs have been observed in Spear Brook.

Neither the relative importance to spawning of Mill Lake Stream versus Trout Lake Stream nor Trout Lake Stream versus Spear Brook is understood.

Characteristics of Spawning Tributaries

Small-Bodied Smelt

Small-bodied smelt spawn in 3 small vulnerable brooks at the northern end of Lake Utopia; : Smelt Brook, Unnamed Brook, and Scout Brook (Figure 1). These streams are smaller (1-2 m wide), and generally run cooler water than the streams used by large-bodied smelt. Flow rates in these brooks have been estimated as <10 cm/s (Curry et al. (2004). In combination the three streams have been estimated to provide 500 meters or less of accessible linear habitat for spawning (Curry *et al*. 2004).

Use of the Lake

Small-bodied Lake Utopia Rainbow Smelt larvae can be found throughout the surface waters of Lake Utopia, at night (Shaw 2006) at lengths ranging between 20 to 25 mm at the end of June to between 20 to 30 mm at the end of July (Shaw 2006). The distribution of older smelt larvae within Lake Utopia is not well known. Metamorphosis is thought to occur by October. The extent to which habitat usage varies with life stage is not known. The distribution of large-bodied Lake Utopia Rainbow Smelt larvae is not known.

Smelt of both DUs are generally pelagic and schooling fish that occupy the mid-depth and deeper cool waters of Lake Utopia (Curry et al 2004). The diet of smaller smelt (e.g., all small-bodied smelts and the young of the larger form) in Lake Utopia consists primarily of small zooplankton. The diet of the larger members of the large-bodied form can contain larger prey items like fish, including smaller smelt (Curry et al 2004).

The process of gonad maturation for Lake Utopia smelts is not known. How inter-annual variability in both the climate and productivity of the lake may influence age at maturity, spawner potential, and partial recruitment is therefore uncertain.

There are no indications that the lake shoreline is used by either DU for spawning.

Residence

The *Species at Risk Act* defines residence as a: "a d*welling place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*".

Residency for the Lake Utopia Rainbow Smelt DUs will require additional consideration once guidelines and criteria to identify residences for aquatic species are established. The egg masses resulting from spawning activity might be considered at that time, as they fulfill the crucial function of breeding and are geographically predictable in their distribution.

Recovery Targets

The Threatened designations of the small-bodied and large-bodied Lake Utopia Rainbow Smelt DUs are not a result of either demonstrated declines in abundance to below a critical threshold, or contractions in range. Rather, they are a result, of firstly, their natural small areas of occurrence (29 km^2 – the area of the lake) and area of occupancy (6 km^2 – the spawning streams; COSEWIC 2008) for both forms, and secondly, concerns that threats related to habitat degradation, directed fishing, Aquatic Invasive Species, and lake eutrophication if not effectively mitigated could have detrimental negative impacts on the species and their habitats (COSEWIC 2008). The effectiveness of mitigative measures can be evaluated against the following population abundance and distribution targets.

The abundance of large-bodied Lake Utopia Rainbow Smelt (LURS) population can not be assessed with the current data.

Population Abundance Targets

Small-Bodied Smelt

An interim (5 years) daily abundance target for small-bodied Lake Utopia Rainbow Smelt of 100,000 spawning fish distributed among the three brooks during peak spawning period is recommended to demonstrate their continued high productivity.

An accurate estimate of total spawner abundance will need to be developed to replace the interim target. Information on the rates of immigration to and emigration from the spawning tributaries will be required.

Large-Bodied Smelts

There is insufficient data with which to establish a quantitative abundance target for large-bodied smelt relative to productive capacity. The minimum population size needed to maintain genetic diversity, estimated as 2,000 spawners, is the recommended interim population abundance target. This value is derived by dividing an assumed effective population size (Ne) of 500 mature individuals by an Ne/Ncensus ratios of 0.26, a value associated with self-sustaining salmonid populations.

As is the case with small-bodied smelt an accurate estimate of total spawner abundance should be developed to replace the interim target.

Distribution Targets

Small-Bodied Smelt

The recommended annual distribution target for small-bodied smelt is the synchronous occupation under natural conditions of the three spawning brooks, with no individual brook to be unoccupied for 2 consecutive years. This target has the aim of accommodating the effects of interannual variability of brook use resulting from natural factors associated with climate variability and variability in total spawner abundance.

Large-Bodied Smelt

The relative dependence of annual large-bodied smelt productivity on use of the Trout Lake Stream-Spear Brook Stream system for spawning is not well understood. A distribution target that can act as an indicator of production relative to production potential is; therefore, not possible at present. Until more is learned about the use of the Trout Lake-Spear Brook Stream system, an interim distribution target for large-bodied Smelt is; therefore, recommended as the annual occupancy of Mill Lake Stream for spawning.

Threats, Alternatives and Mitigation Measures

The Lake Utopia watershed supports forestry, agriculture, year-round and seasonal human settlement, heavy industry (e.g. a pulp mill), aquaculture, recreational use (e.g. boating, ATV use, hunting and fishing), linear developments (roads, railways and transmission lines) and water storage for hydroelectric power generation. The LURS are subject to a directed recreational dip-net fishery. Recreational angling fisheries for land-locked Atlantic Salmon and Brook Trout are enhanced by stocking. Lake Utopia and its waterways are susceptible and vulnerable to Aquatic Invasive Species (AIS) which may arrive either through deliberate (authorized and unauthorized) or accidental (entrance into the Magaguadavic River from tidal waters) pathways.

Blue-green algae (Division Cyanophyta) blooms, which have resulted in the production of detectable levels of phytotoxins in some years, have been a recurrent phenomenon since 2000 (Hanson 2003).

Threats resulting from human activities were grouped into 4 main categories of attributes (water quality, water quantity, direct mortality, and impacts on habitat) and reviewed to assess their potential to affect the Lake Utopia Rainbow Smelt sympatric pair. All have the potential to negatively impact on Rainbow Smelt production within Lake Utopia either directly to the species or to their habitat within the lake itself or in the tributary streams that support spawning. The relative likelihood of a negative effect for each threat, if not mitigated, was ranked as either low, or medium, or high for both DUs in Appendix 1.

Also presented in Appendix 1 are the present mitigative measures, options to reduce affect, and research and monitoring proposals identified with each human-induced threat, and the location of the effect (either lake or spawning streams). Instances where the potential for a specific threat to affect one DU differentially than the other DU may indicate potential for a change in the conditions that sustain sympatry.

Measures to Increase Productivity or Survivorship

There are opportunities to increase productivity for both small-bodied smelt and large-bodied smelt.

Small-Bodied Smelt

The brooks used for spawning by small-bodied smelt are susceptible to inter-annual variability in the amount of accessible spawning habitat through the deposition of organic debris (logs, accumulation of detritus around stones, tree branches etc.) downstream of the natural limit to fish passage. Surveys to clear the streams of potential blockages, prior to the arrival of the smelts, could be effective at maintaining high production potential.

The discovery in 2010 of spawning activity at the mouth of a small brook not previously known to be attractive for spawning by small-bodied smelt suggests there is potential to increase the absolute quantity of spawning habitat with relatively minor alterations to the lower stretch of this brook. The desirability of doing so will however need to be evaluated in the context of fitness consequences for the sympatric species pair, and land-owner acceptance.

Large-Bodied Smelt

Mill Lake Stream, upstream of the small falls that acts as the natural barrier to fish passage in most years, potentially possesses more spawning habitat for large-bodied Lake Utopia Rainbow Smelt than there is presently available in this stream. Access to this potential additional spawning habitat could be enabled with relatively minor alterations to the stream. Evidence abounds upstream of the falls of the extensive historical alteration of the stream bed to facilitate human use, likely saw-milling. It is feasible that the present barrier to upstream passage is a consequence of the early stream alterations.

Recovery Potential

The recovery of both small-bodied smelt and large-bodied smelt in Lake Utopia is considered to be both biologically and technically feasible. A strong, multi-jurisdictional regulatory framework exists to enforce compliance of existing activities with existing regulations, mitigate threats and support recovery actions. These regulatory frameworks can be applied to maintain, and increase where required, the level of protection of these fish, and their supporting habitat in both Lake Utopia and the tributary streams they use for reproduction. The time frame for recovery -- that is the time before both populations of smelt can be declared as maintaining self-sustaining levels and meeting the ecological requirements that promote and maintain sympatry -- will depend upon several factors. The first is continued compliance with regulations that can be demonstrated to be effective in protection of fish and fish habitat. The second is the speed that the responsible jurisdictions work to address existing threats through stronger application of the regulatory framework, particularly where the potential for harm is significant. The third is the speed that knowledge gaps are addressed, particularly where the potential for harm appears to be high, but where essential information needs to be gathered before effective mitigation can be applied and the response of the population measured. A fourth factor is the willingness of the local public to engage in effective local stewardship and monitoring of both the smelt and their habitat.

Research and Monitoring

An assessment of large-bodied Lake Utopia Rainbow Smelt status is required to both help prioritize, and to support implementation of, recovery activities. The assessment will need to define current abundance, the age and sex composition of the adult population, and the timing, duration and distribution of spawning activity among spawning tributaries.

Further estimates of spawner abundance for both small-bodied smelt and large-bodied smelt are needed to set more accurate population recovery targets.

The tasks of understanding the mechanisms contributing to hybridizing between the two DUs, and the fitness consequences for each DU from hybridization, will benefit from the creation of an archive for genetic and biological materials that would be gathered periodically.

The temporal and spatial use of Lake Utopia by both DUs needs to be quantified.

The influence of water supply management within Lake Utopia for hydroelectric power generation on Rainbow Smelt production in the lake and both the suitability and accessibility of spawning habitat located in the tributaries needs to be understood.

Reference lake water levels that can facilitate migration to and from the spawning tributaries by adult members (both DUs), that can enable drifting larvae to enter Lake Utopia (both DUs), and can maximize the amount of spawning habitat available to the large-bodied DU need to be developed.

Several of the issues identified in this assessment could be more efficiently and effectively addressed through research directed at other populations of the same species occurring elsewhere. These issues include the response of the Lake Utopia Rainbow Smelt DUs to the eventual appearance and naturalization of chain pickerel to Lake Utopia, and identification of the specific characteristics of smelt spawning habitat that establish viability. Explicit provisions within the present funding formulas to enable species at risk science to incorporate the gathering of data on populations of the same species not presently at risk would help to enable meta-analytical solutions.

The science and monitoring requirements to support the management objectives defined to meet recovery targets that are specific, measurable, achievable, relevant and results-focused, and time-bound (SMART) need to be defined.

Sources of Uncertainty

The geographic scale of the individual spawning tributaries used by small-bodied smelt is small. The spawning habitat is accordingly susceptible to cumulative effects arising from the pursuit of two or more human activities. An accurate weighting of overall risk is difficult in the absence of site-specific information, and in the absence of effects-focused data that may be available from comparable physical settings.

OTHER CONSIDERATIONS

Trends toward later lake-ice formation and earlier ice-melt, since 1971 and 1961 respectively, have been demonstrated for Lake Utopia (Duguay et al 2006). The consequences of a shorter period of ice cover on the productive potential of the lake for both DUs are not known. The extent, or whether, the trends in ice-cover indicate a potential for change in the hydrological and temperature cycles of the tributaries used for spawning is not known.

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Attributes	Human Induced Threats	Effect to be Mitigated	Present Mitigation	Options to Reduce Effect	Monitoring and/or Research Activities to Help Assess Effects	Effect Under Current Management Strategies			
						Small-bodied		Large-bodied	
						Individuals	Location of Effect	Individuals	Location of Effect
Water Quality	Hatchery Effluent (Inside Lake Utopia)	Increased nutrient load causing trophic status change (eutrophication); other contamination. Accumulation of nutrients in the sediment.	Compliance with existing standards and regulations as set out in the Clear Water Act and Pesticide Control Act. Reduced nutrient load of hatchery effluent and recent (July 2008) incorporation of a low phosphorous feed (Lake Utopia facility).	"Treat, reduce, or eliminate effluent. Regulate for Reduced Nutrient Load. Dredging and chemically neutralizing. "	Research and monitoring to help assess impacts on trophic structure of the lake.	Medium	Lake	Medium	Lake
Water Quantity	Hatchery Effluent (outside Lake Utopia)	Increased nutrient load causing trophic status change (eutrophication); other contamination.	Compliance with existing standards and regulations as set out in the Clear Water Act and Pesticide Control Act	"Treat, reduce, or eliminate effluent. Manage Flows to and from Lake Utopia to promote flushing. Regulate for Reduced Nutrient Load "	Hydrological study required to support development of a management strategy.	Low	Lake	Low	Lake
Water Quantity	Inputs from Magaguadavic River (non-point sources)	Increased nutrient load causing trophic status change (eutrophication); other contamination.	Compliance with existing regulations	Manage Flows to and from Lake Utopia to promote flushing. Stewardship programs and public awareness	Hydrological study required to support development of a management strategy. Investigate impacts of agri-chemical use.	Low	Lake	Low	Lake
Water Quantity	Residential and Recreational Inputs (non-point sources)	Increased nutrient load causing trophic status change (eutrophication); other contamination.	"Compliance with existing regulations as set out in the Clean Water Act, Pesticide Control Act and Clean Environment Act "	Divert domestic waste water away from the lake. Continue to conduct shoreline audits to assess change in inputs with time. Stewardship programs and public awareness.		Medium	Lake	Medium	Lake
Water Quantity	Agriculture/silviculture (Herbicides and pesticides)	Unknown health effects	Legislation (Pesticide Control Act) to control	Organic control of undesirable vegetation and/or insects.	Monitor for presence of herbicides/	Low	Lake/Stream	Low	Lake/Stream

Attributes	Human Induced Threats	Effect to be Mitigated	Present Mitigation	Options to Reduce Effect	Monitoring and/or Research Activities to Help Assess Effects	Effect Under Current Management Strategies			
						Small-bodied		Large-bodied	
						Individuals	Location of Effect	Individuals	Location of Effect
			spraying around watercourses is currently in place.		pesticides in spawning streams.				
Water Quantity	Cumulative Effluent (all Sources)	Increased nutrient load causing trophic status change (eutrophication); other contamination.	All the above	All the above plus adopting a watershed management approach	Develop a nutrient load model for the lake.	Medium	Lake	Medium	Lake
Water Quantity	Water Level Fluctuations due to hydro-electric dam operation	Impede access to spawning sites; submergence of spawning sites; stranding and drying out of eggs	Operational definitions of water levels are identified in Fisheries Management Plan for the hydroelectric generating facility in St. George	Assess spawning habitat requirements and current availability and use under present water level management plan. Manage lake levels to match biological requirements of smelt.	Establish lake level targets relative to stream elevations during spawning.	High	Stream	High	Stream
Water Quantity	Water Level Fluctuations due to hydro-electric dam operation	Potential of flushing of larvae from the lake.	None	Water management considerations in a fisheries management plan if required.	Research to develop requirements to assess potential for larval flushing.	Low	Lake	Low	Lake
Water Quantity	Water Withdrawal for Paper Mill	Impede access to spawning sites.	None	Alternative water supply. Reduce water withdrawal.	Determine impact of water withdrawl on access to spawning sites.	Low	Lake	Low	Lake
Direct Mortality	Entrainment at Intakes for Paper Mill and Hatchery	Direct mortality	Compliance with DFO's "Freshwater Intake End-of-Pipe Fish Screen Guideline".	Alternative water supply.	Monitor water supplies for entrained smelt.	Low	Lake	Low	Lake
Direct Mortality	Directed Fisheries	Direct mortality on Adults. Destruction of egg mats while dipnetting.	Compliance with existing regulations as set out under the Fisheries Act and the Fish and Wildlife Act. Smelt	Close directed fishery.	Assess status of Lake Utopia rainbow smelt and fishery.	Low	Stream	Medium	Stream

Attributes	Human Induced Threats	Effect to be Mitigated	Present Mitigation	Options to Reduce Effect	Monitoring and/or Research Activities to Help Assess Effects	Effect Under Current Management Strategies			
						Small-bodied		Large-bodied	
						Individuals	Location of Effect	Individuals	Location of Effect
			dip net fishery has season and gear restrictions and a daily bag limit.						
Direct Mortality	Bycatch in Recreational Angling Fishery	Handling mortality	Compliance with existing regulations as set out under the Fisheries Act and the Fish and Wildlife Act.	Varied season closures or gear restrictions.	Assess status of Lake Utopia rainbow smelt and fishery.	Low	Lake	Low	Lake
Direct Mortality	Predation (stocked fish)	Increase in rate of predation on Lake Utopia smelt.	Stocking at a rate designed to minimize impact on the smelt population.	Stop stocking.	Assess status of Lake Utopia rainbow smelt and fishery.	Low	Lake	Low	Lake
Direct Mortality	Predation (aquaculture escapees)	Increase in rate of predation on Lake Utopia smelt.	I&T regulations and provincial regulations	Implement escapement reduction techniques at all hatcheries located within the Magaguadavic River drainage.	Monitor effectiveness of escapement reduction techniques at hatcheries.	Low	Lake	Low	Lake
Direct Mortality	Aquatic Invasive Species (Chain Pickerel Esox niger; naturalized in the Magaguadavic system)	"Competition, predation, displacement, community shift"	Regulations as set out under the Fisheries (General) Regulations	Eradicate non-indigenous species	Acquire information on Chain Pickerel-Smelt interactions in other systems	Medium	Lake	High	Lake/Stream
Direct Mortality	Aquatic Invasive Species (Largemouth Bass and others; non-naturalized)	"Competition, predation, displacement, community shift"	Regulations as set out under the Fisheries (General) Regulations	Control access at fishway.	Acquire information on Smelt-Largemouth Bass and other(s) interactions in other systems	Low	Lake	Low	Lake
Direct Mortality	Aquatic Invasive Species (Smallmouth Bass; naturalized)	"Competition, predation, displacement, community shift"	Regulations as set out under the Fisheries (General) Regulations	Reduce and control numbers	Acquire information on Smelt-Smallmouth Bass within Lake Utopia	Low	Lake	Low	Lake

Attributes	Human Induced Threats	Effect to be Mitigated	Present Mitigation	Options to Reduce Effect	Monitoring and/or Research Activities to Help Assess Effects	Effect Under Current Management Strategies			
						Small-bodied		Large-bodied	
						Individuals	Location of Effect	Individuals	Location of Effect
Direct Mortality	ATV and foot traffic in/around spawning areas	Destruction of eggs. Introduction of deleterious substances.	"Compliance with existing legislation as set out in the Off-Road Vehicle Act, Clean Water Act, Fisheries Act, and SARA"	"Enforcement of current legislation. Signage, education and targeted public awareness initiatives.Increase presence of enforcement personnel"		Low	Stream	Low	Stream
Direct Mortality	Scientific Research	Lethal sampling and/or incidental harm results in mortality.	"Sampling authorized under Section 52 F(G)R, \section 73(SARA). "	"Do not authorize lethal sampling. Archived collections available at the Atlantic Resource Center, Huntsman Marine Science Center. 'Low' number of removals. Review all proposed research programs, incorporate conditions on Section 73 (SARA) permits. "		Low	Stream	Low	Stream
Direct Mortality	Hatchery Effluent (Inside Lake Utopia)	Increased parasite load; disease transfer	Fisheries Act - Fish Health Protection Regulations	Treat effluent; recirculation facility	Monitor fish health	Low	Lake	Low	Lake
Impacts on Habitat	Forestry on Crown and Private land	"Increased siltation, flow alterations, reduced water quality, reduce food supply. Altered water temperatures in spawning tributaries. Change in timing of water discharge patterns (seasonal)."	Compliance with existing legislation as set out under the Crown Land and Forest Act and Fisheries Act and best management practices	Stop or reduce activity. Alternative harvest options. Develop and distribute best management practices. Education of land owners.	Assess effectiveness of existing regulations as applied to small streams.	High	Stream	Low	Stream
Impacts on Habitat	Stream Blockages associated with man-made structures	Alteration of spawning habitat.	Ad Hoc: Debris cleared from structures when noted	Replace culverts with a bridge. Remove beaver colonies. Monitoring through increased stewardship		Low	Stream	High	Stream

Attributes	Human Induced Threats	Effect to be Mitigated	Present Mitigation	Options to Reduce Effect	Monitoring and/or Research Activities to Help Assess Effects	Effect Under Current Management Strategies			
						Small-bodied		Large-bodied	
						Individuals	Location of Effect	Individuals	Location of Effect
				to identify stream blockages.					
Impacts on Habitat	ATV and foot traffic in/around spawning areas	Alteration of spawning habitat.	"Compliance with existing legislation as set out in the Off-Road Vehicle Act, Clean Water Act, Fisheries Act, and SARA"	"Enforcement of current legislation. Signage, education and targeted public awareness initiatives. Increase presence of enforcement personnel"	Monitoring through stewardship and reporting of activities	Low	Stream	Low	Stream
Impacts on Habitat	Residential/urban development within the watersheds	"Increased siltation, flow alterations, reduced water quality, reduce food supply. Altered water temperatures in spawning tributaries. Change in timing of water discharge patterns (seasonal)."	"Compliance with existing legislation as set out under the Fisheries Act, Canadian Environmental Assessment Act, and Clean Environment Act"	Watershed management. Education of land owners.	Assess spawning and rearing habitat requirements and current effectiveness of existing regulatory frameworks to protect fish habitat.	High	Stream	Low	Stream

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