The distribution of introduced Rainbow Trout *(Oncorhynchus mykiss)* in the Upper Yukon River Basin 2013

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Cover Image courtesy of the 2013 Whitehorse Rapids Fishway Staff

Abstract

Aquatic Invasive Species (AIS) are of increasing national and international concern. Rainbow Trout are considered to be an Invasive Species in many countries. It is not native to the Upper Yukon River Basin. In 2013 we conducted a literature review of the introduction of Rainbow Trout to the Upper Yukon River Basin and a field program to determine the species introduction and present distribution. We found the pathway of introduction was a successful introduction to Jackson Lake in the 1950's. By the 1960s the species had colonized downstream as far as McIntyre Creek. In the 1970s it was reported from the Yukon River. In the 1990s it was documented in Croucher Creek, a tributary of the Yukon River downstream of McIntyre Creek, and a single Rainbow Trout was angled from the mouth of Laurier Creek, tributary to Lake Laberge. In the 2000s Rainbow Trout were commonly seen in the Whitehorse Rapids Fishway. The field investigation included monthly sampling in the Yukon River from the Takhini River to the Lewes River dam at the outlet of Marsh Lake. The inlet, outlet and tributaries of Lake Laberge, and the Ibex River above and below the mouth of Jackson Creek were sampled on two occasions. Sampling effort included a total of 248 minnow trap/nights. Three Rainbow Trout were captured in Laurier Creek, confirming the presence of a resident population. No Rainbows were captured in any other location. This indicates that the rate of colonization by Rainbow Trout over the past half century has been slow. Considerations for future management of Rainbow Trout and other potentially invasive non-native species include more robust Protocols for future stocking when the current moratorium is lifted, risk assessments of possible releases from present facilities and stocked lakes, the conduct of low cost surveillance programs, and an increase in directed public education programs.

Acknowledgements: This project received funding under a Contribution Agreement granted by Yukon Fish and Wildlife Enhancement Trust. Their financial support is greatly appreciated. Lawrence Vano, Operations Manager of the Whitehorse Rapids Fish Hatchery shared the observations he has made over the years at the Whitehorse Rapids Fishway. Peter Etherton, Fisheries and Oceans Canada Senior Technician and Jody Mackenzie Grieve, Federal Contaminated Sites Biologist confirmed that Rainbow Trout had not been captured in Wolf Creek. Aaron Foos, Yukon Government Fisheries Technician provided information on the initial capture of a Rainbow Trout in Laurie Creek and the YG response. Coralee Johns, Ta'an Kwäch'än Fish and Wildlife Coordinator confirmed that no Rainbows had been captured in the extensive sampling conducted by the TKC downstream from Whitehorse. Paul Sparling suggested the use of trace DNA as a future monitoring tool. Michelle McKay and the staff of the Whitehorse Rapids Fishway counted and photographed Rainbow Trout at the Whitehorse Rapid Fishway. Aaron Foos and Jody Mackenzie-Grieve reviewed a draft of this report and provided useful comments. Thank you all for your assistance.

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1.0 Introduction

The Upper Yukon River Basin is, for the purposes of this report, the Yukon River Basin upstream of the US/Canadian border. Rainbow Trout (*Oncorhynchus mykiss)* are not native to this area. They have been widely stocked by organizations, agencies and commercial interests. Most stocking was to lakes that were isolated from open drainages. Open drainages are those that have some surface connection to other streams and eventually the Yukon River. These lakes are generally referred to as “pot hole lakes” The risk of colonization from these isolated drainages is very low. The focus of this report will be on the Rainbow Trout that have colonized the open waters of the Upper Yukon River.

As of 2010 the Yukon Government considered these Rainbow Trout to be an “unplanned and unwanted introduction” and noted that there was little information available on potential and existing invasive species in the Yukon (Environment Yukon, 2010).

On May 26, 2013 the Yukon Fish and Game Association entered into a Contribution Agreement with the Yukon & Wildlife Enhancement Trust to conduct a project to address information deficiencies on the colonization of the Upper Yukon River Basin by Rainbow Trout. This included a literature review of public documents on the introduction and spread of the species to 2012, and a field investigation in 2013 to assess further colonization either upstream or downstream of the known range

The project was successfully conducted. This report will outline the nature of invasive species, and the invasive nature of Rainbow Trout. The history of the introduction of Rainbow Trout to the open waters of the Upper Yukon River Basin and subsequent colonization of waters near Whitehorse will be reported. The planning, extent, methods used and results of the 2013 Field Investigation will be described and discussed. Conclusions will be provided and will summarize the findings of the report and provide considerations for future management of invasive fish species in the Yukon.

1.1 Invasive Species

Invasive species are of increasing societal concern. The concern is broadly based and may originate in economic, ecological, aesthetic or environmental values. As the concerns are value-based, there is potential for significant conflict between communities of origin, interest or use. Many and perhaps most invasive species were consciously introduced to areas in which they were not native to satisfy the societal needs or community interests of the time. It is only later that some species are identified as invasive.

There are many definitions of “invasive species” or “invasive alien species”. The Invasive Species Specialist Group (ISSG) of the International Union for the Conservation of Nature (IUCN) current definition is:

> **“Invasive alien species”** are non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health.
> http://www.issg.org/database/welcome/content.asp

And the Yukon Government (YG) current definition is:

> An invasive species is defined as an organism (plant, animal, fungus, or bacterium) that is not native and has negative effects on our economy, our environment, or our health.
> http://www.env.gov.yk.ca/animals-habitat/invasivespecies.php

The concepts of “native” and of “harm/negative effect” are open to interpretation. Species may legally be considered to be native if they are found anywhere within a specific jurisdiction regardless of its potential to cause harm or negative effect to local economies, environment or health in another part of the jurisdiction. Similarly, harm/negative effect may be perceived by only a limited portion of the larger community. The result is that a species considered to be invasive by some may be highly valued by others. When widespread public acceptance of the invasive nature of a species has been achieved, the measures of control of the species may result in significant costs to individuals or groups.

In Canada non-native species of plants, invertebrates or fish living predominantly or totally in water are generally considered to be Aquatic Invasive Species (AIS). AIS determinations may be made at a national, provincial/territorial or local level. An aquatic species native to one geographical area of Canada may be considered invasive when released or otherwise transported to another area. Modes of transportation depend to a great extent on the type of organism. Certain invertebrates and aquatic plants may be transported inadvertently as “hitch hikers” on or in watercraft, sports equipment or water fowl. Fish are almost always transported deliberately by people and are either introduced to open systems or escape from confinement. The exceptions are when headwater streams are diverted from one watershed to another due to natural process or human action.

Species that are introduced or escape are often those that are valued for recreational angling or commercial purposes. Rainbow Trout is an example.

1.2 Rainbow Trout

Rainbow Trout are native to western North America and north-east Asia. It is an extremely plastic species. Life histories and body shapes and sizes are highly variable, and reflect the great degree of variation in habitats utilized by the species (Scott and Crossman, 1979). This complexity complicated determination of the taxonomy of the species. In Canada the species was generally named *Salmo gairdneri,* and it is referred to as such in older documents. More recently, genetic analysis determined that Rainbow Trout are more closely related to the Pacific Salmon. The species name is now *Oncorhynchus mykiss.*

The species has long been valued as a sports fish and to a lesser degree as a farmed food fish. It has been cultivated in fish hatcheries since the late nineteenth century. The development of refrigeration and steam driven ships allowed eggs and fish to be transported to distant lands including those colonized by Europeans. The present distribution in New Zealand, Australia, South Africa and India reflect this. Wherever released, the plasticity of the species allowed introduced populations to colonize all available and suitable waters. The ability of the species to move from fresh to salt water and back allowed it to colonize rivers from the mouth. Self-sustaining Rainbow Trout populations are now present on every continent save Antarctica, and on many islands.

Rainbow Trout are generally associated with clear, cold, unpolluted waters. However, the species can tolerate a wide range of environmental conditions (Molony, 2001). Distribution of the anadromous form of Rainbow Trout is limited by marine water temperatures (Welch et al, 1998). Main determinants of distribution in fresh water are considered to be related to elevated water temperatures and reduced stream flow (McCrimmon, 1971).

Rainbow Trout are aggressive as individuals and as a species. Population growth and rate of colonization may be rapid where environmental conditions and ecosystem structure are favourable. Introduction and subsequent colonization by the species has generally been followed by reductions in the populations of native species (Korsu et al, 2010). In some cases native species were extirpated from portions of their range, resulting in fragmentation of populations (Crowl et al, 1999).

An emerging societal interest in biodiversity has resulted in changing attitudes regarding the value of native fish species and of other ecosystem components such as amphibians. In the post-colonial world, introduced Rainbow Trout have increasingly been considered an invasive species of global importance. The species is currently listed by the IUCN as one of the "100 of the World's Worst Invasive Species". It is one of only eight fish species on the list. The list may be found at http://www.issg.org/database/species/ecology.asp?si=103&fr=1&sts=&lang=EN

Attempts to control rates of invasion or to remove populations of Rainbow Trout are not well documented in the scientific literature. The popular press and web, however, is well stocked with articles on local initiatives or the actions of operational (ie non-research) government or quasi-governmental agencies. For examples see: http://theconversation.com/rabbits-of-the-river-trout-are-not-native-to-australia-14115 http://www.mylfrog.info/threats/introducedfish.html

2.0 Rainbow Trout in the the Upper Yukon River Basin

In this document, "open waters" will refer to those waters which have direct surface flows to the Yukon River or any tributary thereof. The distinction is important as almost all fish stocking has taken place in lakes and more rarely lake-stream complexes that flow significant distances as ground water before entering open waters. An example is McLean Lake and Creek in Whitehorse, which enters the ground in a small lake between Ear Lake and the Alaska Highway.

Rainbow Trout appear to have been first stocked in the Upper Yukon River Basin by the Hon. George Black, MP. Prior to the Second World War he planted 25,000 eggs in the Klondike River (Wynne-Edwards, 1947). The history of Rainbow Trout stocking from 1945 to 1973 is summarized in Walker et al (1973). There were further attempts to establish a population in the Klondike River. Christal and Hanson Lakes, both tributaries to the South McQuesten River were also stocked. Both have intermittent or constant surface connections to open waters. By 1969 stocking of open systems had ceased.

As of 2012, the distribution of Rainbow Trout in the Upper Yukon River Basin was limited to the Yukon River below the Whitehorse Rapids Dam, McIntyre Creek and Croucher Creek. All Rainbow Trout were considered to be descendants of fish stocked in Jackson Lake.

2.1 Jackson Lake/Porter Creek/McIntyre Creek

The first Rainbow Trout were stocked in Jackson Lake by the Yukon Fish and Game Association. The date of the first stocking is not known. Walker et al (1973) imply that stocking occurred prior to the first documented release in 1956. Rainbow Trout were stocked in 1956 – 59 by the Department of Fisheries (now Fisheries and Oceans Canada). No documentation of stocking after this date was found. Small fry (25 mm fork length) were captured on July 7, 1960. This indicated that successful spawning had occurred. It also established that the stock was spring spawning and provided insight into the size of the fry at emergence from the spawning gravels.

Jackson Lake is part of Yukon Electrical Company Limited's (YECL) Fish Lake Hydro Project. This project diverted Fish Creek from the Ibex/Takhini River drainage basin to Jackson/Louise Lakes and then to the Porter Creek drainage. Porter Creek was subsequently diverted above the Pueblo Mine to McIntyre Creek (Wright and Whyard, 1991).

Over the life of the Fish Lake Hydro Project the majority of the volume of flow from Fish Lake has been directed toward McIntyre Creek. This flow pathway includes both Jackson and Louise Lakes and other inflows such as the headwaters of Porter Creek. These provide refuge areas during periods when Fish Lake flows are returned to Jackson Creek. The flow pathway to lower McIntyre Creek includes two hydro-electrical generating plants. Each plant has a head pond. Each head pond is a small reservoir controlled by a low dam. Water from each dam either feeds its generating plant through penstocks or discharges over a spillway. Fish travelling through the generating plants would not be expected to survive. Flows from the spillways bypass the generating stations. At least some fish exiting the head pond and being carried through the spillways have survived to colonize the creek downstream.

The McIntyre Creek pathway provided the most viable pathway to the Yukon River drainage. The rate of colonization was not monitored by agencies. However, the Rainbow Trout in McIntyre Creek supported an accessible fishery for local youth, including the author. In 1965 Rainbow Trout were angled at the confluence of the YECL diversion channel and Porter Creek. In 1968 Rainbow Trout were angled in the "Pumphouse Pond" the local name for the head pond of Hydro #2. At the time all the stream dwelling Rainbow Trout had small body sizes. At least some spawned prior to reaching 8 inches in length, which was the legal size for retention.

2.2 Jackson Creek/Ibex River

Water from Fish Lake was, and continues to be, periodically returned to Jackson Creek and then to the Ibex River drainage. This is done to allow maintenance or reconstruction of structures or physical plant, or to discard water surplus to electrical generating requirements or capacities. Such releases are the exception rather than the rule. During periods when flows are diverted to the McIntyre Creek system upper Jackson Creek is dewatered. When multi-year dry periods occur, the channel may be dry for a significant distance downstream of Franklin Lake (Jang and von Finster, 1999).

Rainbow Trout have colonized Fish Creek upstream to the control structure at the outlet of Fish Lake. They can enter the Jackson Creek system either from a bypass gate on the YECL diversion channel between Fish and Jackson Lake, from a control structure in the YECL dam to the South west of Jackson Lake, or as a result of a failure of the west wall of the YECL diversion channel. In every case, the outflows enter Franklin Lake prior to Jackson Creek. This reduces the risk of Rainbow Trout being carried all the way to lower Jackson Creek and then the Ibex River. Rainbow Trout have been reported in Franklin Lake (AECOM, 2010).

Prior to 2010, only limited sampling had taken place in Lower Jackson Creek or in the adjacent waters of the Ibex River. Additional sampling was conducted in 2011 and 2012 in preparation for re-licensing of the Fish Lake Hydro-electrical Project, however no RBT were captured (Bachman & Grieve 2012).

2.3 Yukon River below Whitehorse Rapids Dam

Rainbow Trout were reported in the Yukon River near Whitehorse In 1976. However, none were captured during intensive sampling conducted by the Fisheries and Marine Service of Environment Canada (now Fisheries and Oceans Canada) between April and July of 1973. Methods used included box traps, inclined plane traps, Wolf traps (a form of inclined plane trap), Fyke nets and gill nets. Sampling was conducted between the approximate site of the current Millennium Bridge and the upstream end of Miles Canyon, and included the Whitehorse Rapids Fishway (Brown et al, 1976).

The Whitehorse Rapids Fishway allows fish passage over Yukon Energy Corporations Whitehorse Rapids Dam and serves as a tourist attraction. The Fishway operates annually from June to early September. It includes viewing windows and is staffed by summer students. The first observation of Rainbow Trout in the Fishway was not documented. However, they have been there for at least a decade. Fishway staff members were informed of the 2013 Field Investigation. They were asked to take photos of Rainbow Trout through the viewing windows. They did so, and counted a total of 26 Rainbow Trout (Michelle McKay, personal communication).

Whitehorse Rapids Fish Hatchery staff members have collected Chinook Salmon brood stock from the Fishway since the hatchery commenced operations. They have observed an apparent increase in both length and girth of the Rainbow Trout visible in the viewing chamber (L. Vano, personal communication).

Rainbow Trout spawning has not been observed in the Yukon River downstream of the Whitehorse Rapids Dam. The persistent observation of adult-sized Rainbow Trout in the Fishway implies a resident population in this area. The river channel(s) between the Dam and downstream Whitehorse is more complex than any other portion of the river between Marsh Lake and Lake Laberge. It is the only part of the river that is not subject to deposition of sand and coarse silt from upstream bank and escarpment erosion, as these sediments settle in Schwatka Lake. The complex channel and clean substrate would result in scattered areas of suitable spawning habitat for small-bodied adult Rainbows such as those seen in the Fishway. It is likely that Rainbow Trout successfully spawn in these areas during some or most years.

2.4 Croucher Creek

Croucher Creek is an east bank tributary of the Yukon River, entering 2.2 km downstream of the mouth of McIntyre Creek. In 1993, Rainbow Trout were captured in the creek as incidentals (i.e., non-target species) in a juvenile Chinook Salmon habitat utilization study. Catches of Rainbow were greatest at the furthest upstream sampling station, which was located 4.3 km upstream from the mouth (Moodie, 1993). Rainbow trout were captured by DFO in juvenile Chinook Salmon studies in 2000 (Bradford et al 2001), 2005 (von Finster and MacKenzie-Grieve, 2006) and 2006 (von Finster and MacKenzie-Grieve, 2007). Spawning has not been observed in the creek. Young-of-year Rainbow Trout and individuals as large as 139 mm fork length and 25.2 g in weight (Moodie, 1993) have been captured. Larger Rainbows are captured in a sports fishery upstream. It is almost certain that a spawning population has formed in Croucher Creek.

2.5 Inlet, Outlet and Tributaries of Lake Laberge

No Rainbow Trout have been reported in Lake Laberge, the Yukon River upstream and downstream of the lake, or in any tributary to the lake with the exception of Laurier Creek. Laurier Creek is an east shore tributary of Lake Laberge, entering approximately 17 km from the inlet and 32 km from the outlet. It is approximately 49 km downstream of the mouth of McIntyre Creek. Capture of a single Rainbow Trout was reported by a sports angler at or near the mouth of Laurier Creek in 1997. This raised concerns by the Yukon Territorial Government Renewable Resources (now Environment Yukon) Fisheries that Rainbow Trout were colonizing new areas. In response, the Section conducted sampling of the Laurier Creek, the Yukon River between Lake Laberge and Hootalinqua and the lower reaches of tributaries to the lake and river.   No Rainbow Trout were captured (Aaron Foos, YG Fisheries Technician, personal communication).

The single Rainbow Trout captured could either have strayed from the Whitehorse area populations or could have been a resident of Laurier Creek. The subsequent lack of captures by YTG staff did not answer this question. It did, however infer that any population existing in Laurier Creek was very small.

3.0   2013 Field Investigation

3.1 Planning

Planning for the project took place during the winter of 2012/13 as part of the Yukon Fish and Wildlife Enhancement Trust (YFWET) application process. The plan was included in the application and became part of the contract for the Contribution Agreement between the YF&GA and the YFWET.

The plan for the Field Investigation was based on three assumptions. They were:

- that the weather and stream and river flows in the subject waters would not negatively affect the success of sampling;
- that a sampling method appropriate for the capture of Rainbow Trout would be applied;
- that, where captures did occur, the numbers and sizes of Rainbow Trout captured would be sufficient to support meaningful speculation as to whether a spawning population existed in the area sampled.

The Investigation was planned to survey a wide geographical area in a safe and cost effective manner.

A Scientific Collection License was applied for from Fisheries and Oceans Canada.   License XR 93 2013 was issued on May 7, 2013.

3.2 Methods

The target was juvenile, sub-adult or dwarf adult Rainbow Trout. Larger fish are more difficult to capture and require the use of gillnets, trap nets or electrofishing. These methods are generally more hazardous to samplers and require multi-person crews with comprehensive skills certification to meet Yukon Occupational Health and Safety standards.   The methods are also potentially hazardous to the target species and to other species incidentally captured or effected. Direct and delayed mortality from gill nets and electrofishing may be significant (Baker et al, 2013, Dalbey and McMahon, 1996: Holmes et al, 1990).

Younger fish are almost always more numerous than older fish due to age-related mortality. Captures of more than one age class at a sampling location would imply spawning at or near that location.

Modified G-Type Minnow Traps were used throughout the study. All traps had ¼ inch (6.35 mm) mesh. The entry holes were increased from ~15 mm to ~30 mm. This allowed the capture of Rainbow Trout up to a fork length of about 170mm.

Rainbow Trout are vulnerable to capture in these traps. The 1999 version of the "DFO Protocol for the baiting of G-Type minnow traps…in the Yukon River Drainage Basin" was followed. This Protocol was developed from methods used by BC Ministry of Environment staff in the 1970s to capture salmoninae (salmon, trout and charr). In the Yukon, minnow trapping techniques were further developed to allow the effective, efficient and safe capture of juvenile Chinook Salmon. Rainbow Trout are also captured in the traps. Central to the technique is the use of salmon roe in a perforated plastic bag as bait and a nominal 24 hour set time. Other salmonids such as grayling or the various whitefish species are seldom captured in traps. Experienced personnel can efficiently transport, deploy, and retrieve the traps at little risk to themselves or to the fish captured. Mortality of captured fish is generally less than 1%. The traps are light in weight and designed to be easily transported. This allows large numbers of traps to be carried in a small boat or on an ATV.

Methods to access sampling areas varied depending on location. A 19 foot Lund Jon Boat was used in the Yukon River and a 19 foot Harber Craft on Lake Laberge. The Ibex River valley was accessed by a Toyota 4X4 pickup and a Yamaha ATV.

Stations were determined in the field. Locations were chosen that were easily accessible to increase sampler safety and efficiency and that had favorable physical characteristics such as sufficient water depth and low current velocity. Numbers of traps set at each Station varied. Traps were generally set from shore, although some were set in the middle of smaller streams. All Stations were geo-referenced.

All fish captured were enumerated by species. Non-target species were immediately released. Rainbow Trout were blotted to remove surface water and then weighed to the nearest 0.1 g with an Ohaus HH120D digital scale. The scale was calibrated before use and placed on a level surface. Fork lengths were measured to the nearest millimeter on a smolt measuring board. One Rainbow Trout was retained for confirmation of the field identification. Captures were reported to Fisheries and Oceans in compliance with the Scientific Collection License.

Observations were noted of fish seen but not captured.

3.3 Sampling areas and dates of sampling

The sampling was conducted in three main geographical areas. The areas and the dates of sampling for each were:

3.3.1 Yukon River Upstream and Downstream of Whitehorse

This area was located between the YEC Lewes River Dam and the confluence of the Yukon and Takhini Rivers. The Upstream Sampling Section extended from the downstream end of Miles Canyon to a point approximately 500 meters below the Lewes River Dam. The Downstream Sampling Section extended from the City of Whitehorse Force Main crossing to the downstream end of the erosion bank at the mouth of the Takhini River. Sampling occurred on June 18 – 19, July 17 – 18, August 14 – 15 and September 4 – 5. In the June and July sampling, 20 traps were set in 10 Stations in each of the Upstream- and the Downstream Sampling Sections. In the August sampling, 20 traps were set in each Section, with 10 Stations in the Upstream and 7 Stations in the Downstream Section. The reduction in numbers of Stations downstream in August and September was a result of very high water which reduced the number of adequate sampling sites. In September, 20 traps were set in each Section with 10 Stations in the Upstream and 6 Stations in the Downstream Section.

3.3.2 Ibex River Sampling Area.

This Area included the Ibex River from the lowest Station, located 13.25 km (straight line) upstream from the mouth, to a point 9.25 km further upstream. The two furthest upstream Stations were above the mouth of Jackson Creek. The Area included a Station on Jackson Creek located approximately 500 meters from its mouth. Sampling occurred on July 4 – 5 and September 2 – 3. In the June sampling 28 traps were set at 7 Stations on the Ibex River and 4 at 1 Station on Jackson Creek. In the September sampling 16 traps were set at 6 stations on the Ibex River and 4 traps were set at 1 Station on Jackson Creek. The reduction of traps in September was a result of the very poor condition of the Ibex River Road. An ATV was required as the road was too difficult for the 4X4 pickup.

3.3.3 Lake Laberge Inlet, Outlet and Tributaries

This area included the Yukon River extending approximately 5.3 km upstream of Lake Laberge, Lower Laurier Creek, the lower section of an un-named tributary entering from the east located 11 km from the outlet, and the Yukon River extending approximately 2.5 km downstream of Lake Laberge. It did not include Laberge Creek or Joe Creek. Sampling occurred on June 22 -23 and September 15 – 17 and 22 - 23. In the June sampling 6 traps were set at 3 Stations upstream of Lake Laberge; 4 traps in 2 Stations in Laurier Creek; 4 traps in 2 Stations in the Un-named Creek and 6 traps in 3 Stations downstream of Lake Laberge. On September 15 six traps were set at 3 Stations downstream of Lake Laberge. On September 22 eight traps were set at 4 Stations in Laurier Creek. No traps were set upstream of Lake Laberge due to very high water levels and sediment load in the Yukon River. No traps were set in the Un-named creek as flows were low and the water was very warm during the summer.

3.4 Results

With the exception of the September 22- 23 sampling of Laurier Creek the number of fish captured was very low at all Stations throughout the study (Table 1).

Table 1 - 2013 Fish captures by sampling area, date and species

<u>Primary Focus Area - Upstream Section</u>								
Date	Trap/nights	RBT	CN	CCG	LNS	BB	LKC	NP
June 18 - 19	20	0	0	1	0	0	0	0
July 17 - 18	20	0	11	6	0	0	0	1
August 14 - 15	20	0	0	1	2	0	0	1
September 4 - 5	20	0	0	0	1	0	0	0
Total	**80**	**0**	**11**	**8**	**3**	**0**	**0**	**2**
<u>Primary Focus Area - Downstream Section</u>								
June 18 - 19	20	0	4	4	1	0	0	0
July 17 - 18	20	0	12	12	1	0	0	0
August 14 - 15	20	0	5	1	0	0	0	0
September 4 - 5	20	0	1	5	0	0	0	1
Total	**80**	**0**	**21**	**22**	**2**	**0**	**0**	**1**
<u>Ibex River Area</u>								
Date	Trap/nights	RBT	CN	CCG	LNS	BB	LKC	NP
July 4 - 5	34	0	0	31	0	0	0	0
September 2 - 3	20	0	2	55	0	0	0	0
Total	**54**	**0**	**2**	**86**	**0**	**0**	**0**	**0**
<u>Yukon River Up- and downstream of Lake Laberge</u>								
Date	Trap/nights	RBT	CN	CCG	LNS	BB	LKC	NP
June 22 - 23	12	0	0	1	1	0	1	0
September 15 -17 (d/s only)	6	0	12	0	1	1	0	0
Total	**18**	**0**	**12**	**1**	**2**	**1**	**1**	**0**
<u>Un-named tributary to Lake Laberge</u>								
Date	Trap/nights	RBT	CN	CCG	LNS	BB	LKC	NP
June 22 - 23	4	0	0	1	3	0	2	0
Total	**4**	**0**	**0**	**1**	**3**	**0**	**2**	**0**
<u>Laurier Creek</u>								
Date	Trap/nights	RBT	CN	CCG	LNS	BB	LKC	NP
June 22 - 23	4	1	5	0	0	0	0	0
September 22 - 23	8	2	111	0	0	1	0	0
Total	**12**	**3**	**116**	**0**	**0**	**1**	**0**	**0**

RBT–Rainbow Trout
CN–Chinook Salmon
CCG–Slimy Sculpin
LNS–Long Nosed Sucker
BB- Burbot
LKC- Lake Chub
NP-Northern Pike

Rainbow Trout were captured only in Laurier Creek. The first was captured on June 21 (Table 1) in a trap set approximately 100 meters upstream from the mouth. The Rainbow had a fork length of 119 mm and weighed 15.2 grams. This fish was sacrificed, preserved in formalin and presented to Aaron Foos, Yukon Government Fisheries Technician and Jody MacKenzie-Grieve, DFO Federal Contaminated Sites Program Biologist. Both confirmed that the fish was a Rainbow Trout.

Two more Rainbow Trout were captured on September 23 (Table 1). The first was 109 mm fork length and weighed 12.0 grams (Photo 1), and the second was 165 mm fork length and weighed 43.6 grams (Photo 2) . Both fish were returned unharmed to Laurier Creek after measurements had been taken.

Photo 1. Rainbow Trout captured in Laurier Creek, September 23, 2013. Note how dark this individual is.

Photo 2. The largest Rainbow Trout captured in Laurier Creek in 2013. This fish had a fork length of 165 mm and weighed 43.6 gm. This was almost certainly an adult fish. If it survives the winter of 2013/14 it will probably spawn in spring of 2014.

Fish observed but not captured included an unexpected abundance of Arctic Grayling in the Upstream Sampling Section in July through September. Arctic Grayling were seen at all sampling Stations. They were remarkably naive and could be approached to within less than 1 meter before they moved. Individuals over approximately 150 mm could be positively identified. Most were 200 – 250 mm in length. No large grayling (>300 mm) were seen. Juvenile northern pike were very numerous in July in the Upstream Sampling Section and were distributed along gently sloping shorelines. All appeared to be 100 – 200 mm in length.

Arctic Grayling were observed at the furthest downstream Station of the Downstream Sampling Section in the July, August and September sampling. Several appeared to be greater than 300 mm in length.

Arctic Grayling were observed in the furthest downstream Station of the Ibex River Area in June and September. The fish were wary and sizes could not be determined.

3.5 Discussion – 2013 Field Investigation

The assumption that weather and flows would be normal in 2013 was invalid. There was heavy snow fall in late winter and the spring was delayed. On May 1, 2013 the water equivalent of the snow pack in the Whitehorse area was in excess of 250% of normal (Environment Yukon Water Resources Branch, May 1, 2013). The effects of the abnormal flows varied and will be discussed as they relate to specific sampling areas.

3.4.1 Yukon River Upstream and Downstream of Whitehorse

The late melt and high snowpack resulted in a rapid rise in the Yukon River in June and high river levels through the remainder of the Field Investigation period. Steeper river banks eroded. The river flooded back into the riparian vegetation in most areas with more gentle banks. This reduced the number of suitable trapping areas. The Yukon River was turbid during the June sampling but was nearly clear during the July sampling. By the August sampling it had cleared, and it remained so in September.

It is likely that the late spring and high river levels negatively affected sampling success throughout this area. Catches of fish of any species in the traps were extremely low.

It is unlikely that a spawning population of Rainbow Trout exists in the Upstream Sampling Section. In support of this statement, no Rainbow Trout have been captured in Wolf Creek in a juvenile Chinook Salmon sampling project which has just completed its third year (P. Etherton, personal communication) or recent investigations of habitat utilization by Slimy Sculpin (J. MacKenzie-Grieve, personal communication).

It is also unlikely that a spawning population of Rainbow Trout exists in the Downstream Sampling Section of the main stem Yukon River. With the known exceptions McIntyre and Croucher Creeks, it is believed that Rainbows have not established populations in any of the tributaries to this Section. In support of this statement, the Ta'an Kwachan Community Stewardship Project sampled all other tributaries in 2007 (Anderton, 2008), 2008 (Marjanvovic, 2008) and 2009 (Marjanvovic, 2009). No Rainbow Trout were captured, or have been captured in subsequent sampling.

3.4.2 Ibex River Sampling Area

The Ibex River Sampling Area also experienced higher and later flows than usual in 2013. The early July sampling took place near the end of the 2013 spring freshet. The river was turbid and water levels appeared high and were falling. There was considerable evidence of very high flows in the recent past. The early September sampling followed a period of rain. The river was clear, at a moderate level and rising.

It is likely that the late spring and high flows in the Ibex River negatively affected sampling success. No fish were captured in the Stations located up- and downstream of the mouth of Jackson Creek. This section has relatively steep gradients and a boulder substrate. Small numbers of Slimy Sculpin were captured in the low gradient lower reaches of Jackson Creek. The greater numbers of Slimy Sculpin captured in the two lower gradient downstream Ibex River Stations were as was expected.

No Rainbow Trout were captured in the Ibex River Sampling Area. However, Yukon Electrical Company Limited recently diverted flows into Jackson Creek for extended periods of time. The flows have at times reached the Ibex River (Bachman and Grieve, 2013). It is possible that low numbers of Rainbow Trout have travelled downstream in Jackson Creek If so, it would have been unlikely that they would have been captured in this study. If they are in the Ibex River it is possible that they are in the process of establishing a spawning population in the Ibex River.

3.4.3 Lake Laberge Inlet, Outlet and Tributaries

The Lake Laberge Sampling Area comprised the Yukon River up- and downstream of the Lake and two of the east bank tributaries. The Yukon River upstream of Lake Laberge is backwatered from the lake at moderate to high lake levels. During the July 5 sampling the river was turbid and rising quickly. On September 22 the lake was at near record high levels and the river was extensively backwatered. Most low-lying riparian areas were flooded, and steep river banks were eroding. The Yukon River downstream of Lake Laberge was slightly turbid in early July and clear in mid-September. The river was at medium stage in July and was high in mid-September.

The late spring and high river levels in the Yukon River upstream of the Lake Laberge would have had similar effects on sampling effectiveness as in the Upstream and Downstream Sampling Areas. More fish were captured downstream of Lake Laberge.

It is unlikely that a spawning population of Rainbow Trout exists in the Yukon River immediately upstream or downstream of Lake Laberge.

The east bank tributaries include both the un-named tributary near the north end of the lake and Laurier Creek. On June 23 the un-named tributary was clear and at a low stage. The creek was visited in mid-July. It was very warm had almost ceased to flow. The lack of flow indicated that overwintering flows would not be present and that Rainbow Trout could not become established in the creek. Sampling was therefore not conducted in September.

On June 23 Laurier Creek was within the range of normal summer flows. The waters of the creek were clear but stained. Young-of-year Chinook Salmon were just starting to enter the creek, and not all 1+ (overwintered) Chinook had emigrated from the creek. Stream flow and clarity was similar in September. Young-of-year Chinook were relatively numerous in the portion of the creek sampled. This was confined to the lower 200 meters of the creek. Sampling did not take place above this as the creek entered private property.

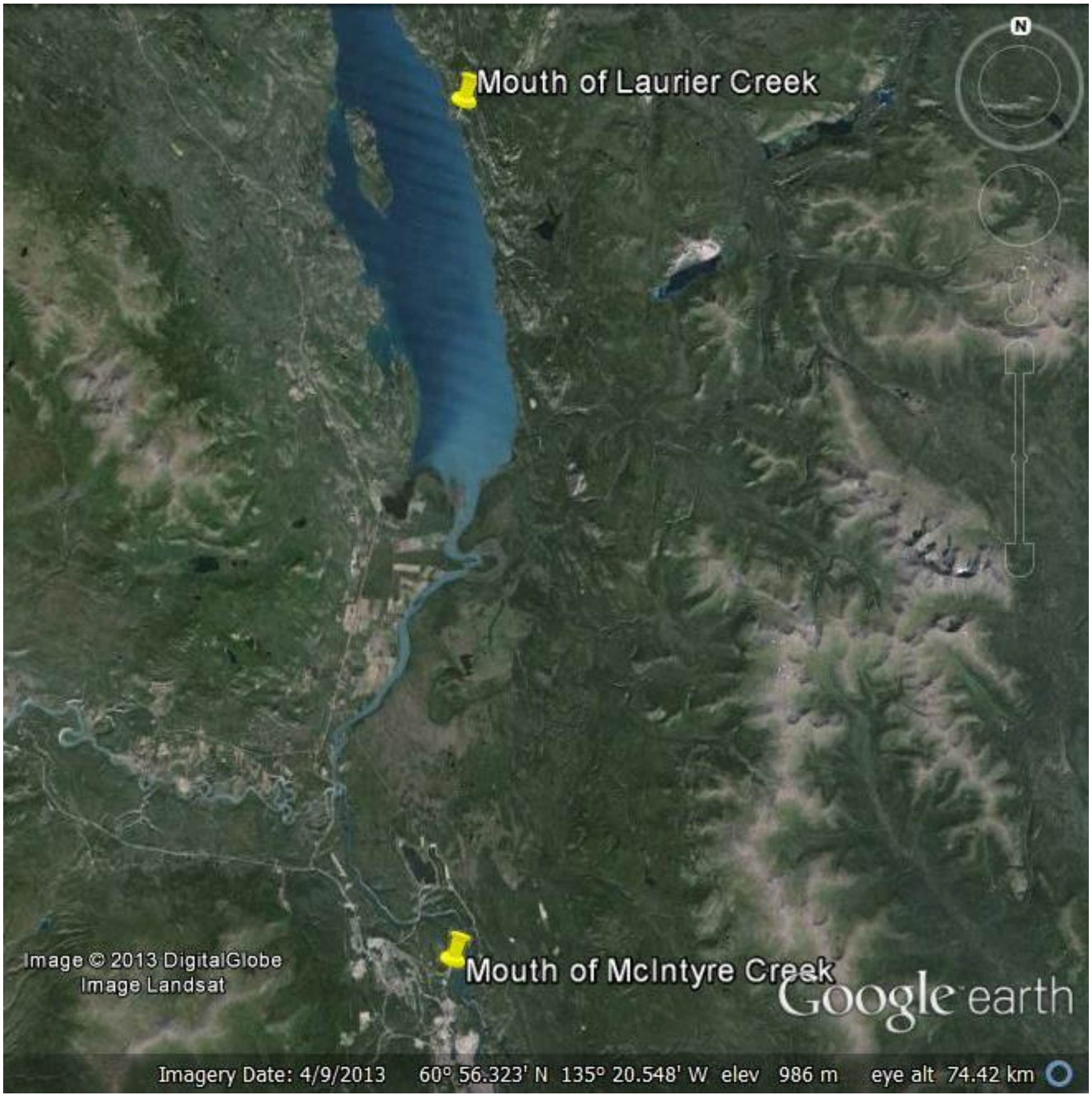

Photo 3. Indicates the distance between the mouth of McIntyre Creek and the mouth of Laurier Creek. Note the lighter coloured Yukon River water flowing north along the East (right) shore of Lake Laberge and past the mouth of Laurier Creek. This image was taken on September 4, when the Yukon River was cooling. Earlier in the summer the effect would have been greater as the Yukon River was warmer.

The three Rainbow Trout captured in Laurier Creek are considered sufficient to strongly infer that a spawning population exists in the creek. This statement is supported by the report of a Rainbow Trout angled from the creek in 1997. Assuming that parties unknown did not stock the creek in the past, the Rainbows in the creek would be descendants of fish that had travelled downstream about 50 km from one or more of the known or suspected spawning populations in the Whitehorse area. In spring and most of the summer the Yukon River is turbid and significantly warmer than Lake Laberge. The river enters the lake and flows down the east shoreline and immediately in front of the mouth of Laurier Creek.

The Laurier Creek watershed was investigated by DFO in 1990 for the purposes of Placer Classification under the Yukon Placer Authorization (Dept. of Fisheries and Oceans Canada, 1990). No fish were captured in the creek upstream of a set of waterfalls near the mouth. The highest of the set of waterfalls appeared to be impassable to fish. As the placer mining area was in the creek headwaters, the distance from the lake to the falls was not important to the task of classification and was not noted. The existing Rainbow Trout population is confined to a section of creek unlikely to be more than 1 km long. The population is therefore likely to be small and recruitment low.

A contributing factor to an expected low annual recruitment of Rainbow Trout to Laurier Creek is the use of the lower creek by juvenile Chinook Salmon. These fish migrate downstream from spawning areas in the Upper Lakes area and then up suitable non-natal streams such as Laurier Creek to rear and overwinter. In September, 2013, far more juvenile Chinook Salmon were captured than Rainbow Trout in the lower creek. The number of salmon entering the creek in any given year will in part be a reflection of the number of adults that had spawned upstream in the previous year. The 2012 Chinook escapement was low, and the 111 juvenile Chinook that were captured in the 8 minnow traps should be considered to be correspondingly low. A greater Chinook escapement could result in more juvenile Chinook in Laurier Creek in the following year. Young-of-year Chinook are also larger than young-of-year Rainbows at any given date and may be more aggressive. Assuming that Rainbow Trout fry emerge from the gravel at a fork length of 25 mm in early July, overwintering juvenile Chinook Salmon that have not yet left the creek could be large enough to prey on them.

Recruitment to the Laurier Creek Rainbow population may be from spawning in areas of the creek that juvenile Chinook Salmon cannot reach. Young-of-year Rainbows in such an area would have a much greater chance of successfully growing to be an adult. The size-at-maturity in small streams tends to be as little as 150 mm fork length (Scott and Crossman, 1979).

4.0 Conclusions and considerations for future management of potentially invasive fish species

This project provides a benchmark against which the future distribution of Rainbow Trout can be measured. The benchmark is supported by the history of introduction in Jackson Lake and subsequent colonization of McIntyre Creek, the Yukon River below the Whitehorse Rapids Dam and Croucher Creek. The presence of Rainbow Trout in Laurier Creek was confirmed and a spawning population strongly inferred. No Rainbow Trout were captured in the Ibex River or the lower reaches of Jackson Creek, the tributary that would be the pathway to the Creek.

The Rainbow Trout populations in the Yukon River, McIntyre Creek and Croucher Creek are likely to be too expensive to extirpate. The population in Laurier Creek is in a confined area and could be economically extirpated. Such a project would take several years and would require the permission of the owner of the land through which the creek flows. Rainbow Trout were not captured in the Ibex River watershed.

The risk of further colonization of the Upper Yukon River basin by Rainbow Trout remains. The risk of other potentially invasive species also exists. Arctic Charr have escaped from an aquaculture facility and appear to have established a spawning population in McIntyre Creek (Environment Yukon, 2010). Gold Fish were released to the Takhini Hot Springs discharge pond and posed the risk of entering the Takhini River when the pond was periodically partially drained.

Arctic Charr, Kokanee Salmon and Rainbow Trout are widely stocked in pot hole lakes by the Yukon Government for the recreational fishery and by commercial fish farmers. The Yukon Government has applied a moratorium on the issuing of new licenses to stock fish since 2000. Existing licenses are renewed. All the pothole lakes were assessed at the time of first stocking to determine whether they had surface water connections to open systems. In some cases this was more than 50 years ago, and reflected the hydrological and climatological conditions and land forms of the time and the capacities of the assessors. The older, and possibly certain of the more recent assessments, did not account for changes in precipitation and particularly multi-year high precipitation periods related to what we now know as Climate Change. A result of such wet periods is an increase in ground water levels and in surface water elevations of pothole lakes connected to ground water. If the terrain separating a stocked lake from open drainages is low lying an outflow channel may develop. Additionally, the rapid melting of permafrost in ice rich ground can result in significant ground subsidence and development of stream channels or, in extreme cases, catastrophic lake drainage. Either process, or both in concert, could result in potentially invasive fish in the pot hole lake emigrating to open systems downstream down.

This issue could be addressed by assessing pothole lakes currently stocked to determine the degree of risk of the lakes establishing surface drainage to open systems due to rising lake levels or thermokarst related outflows. The assessors should have the skills necessary to interpret landforms and to predict potential risks resulting from high precipitation, thermokarst, or river channel migration. It is likely that the risk for most currently stocked lakes will be absent or minimal and that stocking can continue. If a credible risk exists, stocking could cease. If the stocked population is not self-sustaining the risk will decline and end as the fish age and die. If the population is self-sustaining consideration could be given to active removal.

The moratorium on issuing new fish farm licenses is an opportunity to address present and emerging areas of concern. These include the Climate Change related issues described above.

Another issue is the use of dug-outs or other water bodies adjacent to rivers or streams that are subject to ice dams or in-channel icing to such a degree that surface waters enter the dug-out or water bodies. If surface waters can enter, the stocked fish can leave the stocked area and enter open systems.

The release of problematic invasive species, such as Asian Carp, to open waters due to unforeseen environmental and related site security issues at hatcheries and pond based aquaculture facilities has repeatedly occurred (Naylor et. al. 2005, Irons et. al. 2007) . Three hatcheries in the Upper Yukon River Basin currently incubate and rear non-native species. Two are private and one is public. The public hatchery was originally planned to incubate and rear native species. It was subsequently modified and has since incubated and reared fish species that are non-native to the Upper Yukon basin, including Rainbow Trout and Kokanee Salmon. It is located near the bank of the Yukon River downstream of the Whitehorse Rapids Dam. The original hatchery is 30 years old. The facilities have been modified and additional structures built. These include outdoor tanks in which non-native (to the Upper Yukon River Basin) fish species are held. The facility is secured by a chain link fence. There have been no escapes of these non-native fish species from the Hatchery. However, it bears the intrinsic risk of being an an aging facility, with limited physical security, located very close to a major river and downstream of a dam.

It would be prudent to require that an assessment of the risk of release of non-native species from the hatchery and associated grow out and brood stock holding facilities be conducted. If the degree of risk warrants, any shortcomings could be addressed over a reasonable period of time. Given the importance of the facility and its ownership by a Crown Corporation, it is possible that federal funds could be directly or indirectly secured to contribute to structural improvements. Options could include the transfer of the non-native species to a more secure location.

In a global context, invasion has been found to be a process rather than an event. Introduction of alien species is generally followed by a period when the species is confined to a small area. Depending on the reproductive capacity of the species and the degree to which environmental and ecosystem factors favour or limit survival and growth of the young, this period may be short or protracted. Environments and ecosystems are not static, and conditions affecting reproduction and recruitment of an non-native species may rapidly change from adequate to favourable. The population, or colony size, may grow quickly and – if the conditions are highly favourable – very quickly. The risk of a non-native species becoming invasive increases with the size of the colony. Past performance of a non-native species is therefore a poor predictor of invasive potential (Crooks and Soule, 2001).

The spread of Rainbow Trout (from Jackson Lake) and Arctic Charr (from an aquaculture facility adjacent to McIntyre Creek) in the Upper Yukon River Basin has been slow. It implies that there has been some form of environmental or ecosystem related containment. This may not continue, and it would be prudent for fishery managers to design, implement and maintain a low cost surveillance program to track the progress of each species. The program could be carried out by government or could enlist non-governmental resources.

An emerging and potentially economically attractive technology is the use of Environmental DNA (eDNA). Samples of water from potentially invaded streams are taken and analysed for traces of DNA from target species, or from a number of target species (Goldberg et.al., 2013) The species may be plants, invertebrates or vertebrates. The technique is developing more rapidly than it is being reported in the scientific literature. At present it appears to be expensive and to require a significant investment in skills development to ensure quality assurance/control during sampling and sample preparation (Wilson and Wright, 2013). It is likely that costs will decline rapidly and that the sampling will be simplified as commercial laboratories develop and standardize the methodology. Managers should maintain a watching brief on the development of eDNA. When it becomes standardized, simplified and acceptably inexpensive it should be considered as a primary surveillance tool for all Aquatic Invasive Species in areas where introduction is most likely.

In the interim, the use and encouragement of non-governmental resources could assist to continue to educate the public, gain information for government agencies and sustain political support for AIS management. This could include:

- the staff of the Whitehorse Rapids Fishway. At a minimum, the staff could count and photograph each Rainbow Trout observed in the fish way. They could also trap Rainbow Trout in the fishway prior to the Chinook Salmon in modified minnow traps, obtain length and weight measurements and take digital images. Individual Rainbow Trout have unique markings and multi-year identification of individuals is possible;
- sports anglers. The Yukon Fishing Regulations Summary is published annually. The present Aquatic Invasive Species section of the Summary could be modified to ask for anglers' assistance. Most anglers have the ability to acquire digital images either though cameras or smart phones, and many have GPS enabled devices to allow locations to be geo-referenced. Anglers could be asked to photograph each potentially invasive species they capture (or any they cannot identify) and provide the location information and photograph to an email address.

Either in partnership between governments or with Non-Governmental Organizations, signage could be installed on access routes to fishing areas where there is a risk that non-native species will spread. This would include the two accesses to the Ibex River, the Rotary Park Boat Launch, and the Deep Creek Boat Launch. The signage would make the same request as in the Regulations Summary.

The Yukon Government characterization of Rainbow Trout and Arctic Charr as "unplanned and unwanted" species is robust. It more accurately describes the species than the term "invasive", as no harm or negative effects have as yet been determined in the areas that they have colonized. Consideration should be using "unplanned and unwanted" in educational products such as pamphlets, posters etc. The material could provide information on the potential negative effects of introduced species on the aquatic ecosystems of the Upper Yukon River. This would have the benefit of educating people of the present distribution of the species. It could also prepare people for the actions that would be required if the present apparent containment of the species ends and one or both become invasive.

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