Lhù'ààn Mân' (Kluane Lake) Lake Trout Diet Analysis and Juvenile Fish Sampling

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EDI Project
20Y0181
Version: 1
April 2021

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EXECUTIVE SUMMARY

This project was initiated by Kluane First Nation and Dän Keyi Renewable Resource Council in response to recent changes on Lhù'ààn Mân' (Kluane Lake). In 2016, 'Ä'äÿ Chù' (Slims River), a large tributary to the lake, was diverted to the Kaskawalsh River due to the retreat of the Kaskawalsh Glacier. As a result, Lhù'ààn Mân' (Kluane Lake) no longer receives the discharge from the 'Ä'äÿ Chù' (Slims River). Correspondingly, water levels on Lhù'ààn Mân' (Kluane Lake) have dropped by 1 – 2 m and the suitability of fish spawning areas for fish species including lake trout and chum salmon along the shoreline is currently unknown.

In addition to the changing conditions in Lhù'ààn Mân' (Kluane Lake), three large juvenile chum salmon measuring 15 – 20 cm were found in a lake trout stomach from a fish captured in Lhù'ààn Mân' (Kluane Lake) during March 2019. These fish were positively identified as chum salmon through genetic analysis by fisheries biologists at DFO in Whitehorse. Their presence suggests that chum salmon in Lhù'ààn Mân' (Kluane Lake) may have an alternative life history strategy for this species.

The project aimed to sample for young-of-the-year lake trout throughout Lhù'ààn Mân' (Kluane Lake) to assess successful spawning by lake trout and chum salmon after changes to water level in the lake. Lake trout stomach samples were also collected from local recreational and subsistence fishers to analyze stomach contents for juvenile chum salmon.

Beach seining was conducted from June 26 – 28, 2020 in an attempt to capture young-of-the-year chum salmon and lake trout throughout Lhù'ààn Mân' (Kluane Lake) to determine species presence and ultimately provide a coarse resolution of spawning aras. Sampling was done in areas known to be or have the potential to be spawning locations along the shores of Lhù'ààn Mân' (Kluane Lake) where there is groundwater upwelling. A total of 34 beach seine hauls were completed capturing 1,226 fish across 6 species. Slimy sculpin and round whitefish made up majority of the catch. A total of 85 juvenile lake trout were captured and no chum salmon were captured.

Lake trout stomach samples were collected from local anglers and subsistence fishers by the Dän Keyi Renewable Resource Council throughout the winter of 2019/2020. A total of 27 samples were collected and their contents were analyzed. Many stomachs were empty. Unknown insects, snails, and unidentified contents made up the majority of the analyzed contents. Two fish found in the lake trout stomach samples were easily identified to be a round whitefish and a slimy sculpin. Samples from 10 unidentified fish were sent to ABC and Associates for genetic testing. Five genetic tests came back as round whitefish and four were identified as lake trout. Surprisingly, one of the fish was identified as a eulachon which are not found in Lhù'ààn Mân' (Kluane Lake) and are more frequently associated with marine environments until spawning in natal streams. Further investigation and communication with the angler who submitted the sample determined that the eulachon was used as bait by the angler. No young-of-the-year or juvenile chum salmon were found in any of the lake trout stomach samples.

ACKNOWLEDGEMENTS

Input on the project design and coordination of sample collection was provided by Pauly Sias (Dän Keyi Renewable Resource Council), Kate Ballegooyen, Rachel Thom and Justin Lemphers (Kluane First Nation). The Talbot Arm Motel in Destruction Bay also assisted in storing samples from the numerous anglers who provided lake trout stomach samples for this project.

Funding for this project was provided by the Yukon Fish and Wildlife Enhancement Trust Fund.

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation/ First Nation Word	Definition
cm	Centimetre
g	Grams
m	Metre
mm	Millimetre
DFO	Department of Fisheries and Oceans Canada
DKRRC	Dan Keyi Renewable Resource Council
KFN	Kluane First Nation
YOY	Young-of-the-year
Lhù'ààn Mân'	Kluane Lake
'Ä'äy Chù'	Slims River
T'ä̀wa	Arctic grayling
Lù shäw	Lake whitefish
Cha̍ghär	Broad whitefish
Shür	Inconnu
Tà̀le	Northern pike
Mbet	Lake trout
Kwätsų	Burbot
Thì	Chum salmon
Sakay	Round whitefish
Łu	Pygmy whitefish
Tatsat	Longnose sucker

1 INTRODUCTION

Lhù'àän Mân' (Kluane Lake) is located in the White River sub-basin of the Yukon River watershed in southwest Yukon (Map 1). Much of the White River watershed, including Lhù'àän Mân' (Kluane Lake), is heavily influenced by glacial runoff. As a result of the retreat of the Kaskawalsh Glacier, the 'Ä'äÿ Chù' (Slims River) was diverted to the Kaskawalsh River; thus, Lhù'àän Mân' (Kluane Lake) no longer receives the discharge of 'Ä'äÿ Chù' (Slims River), which was a large tributary. With a 1 – 2 m drop in water level, it is conceivable that previous nearshore habitats have become exposed and the utilization of these new habitats is unknown regarding their suitability for spawning and rearing.

Fish species in Lhù'àän Mân' (Kluane Lake) form the basis of an important recreational, subsistence and commercial fisheries for local residents and visitors alike. Given the changes to water levels in recent years, there is major concern on the effects this will have on local fish populations, including lake trout and a unique population of lake spawning chum salmon. It is suspected that important lake trout spawning locations along the shore of Lhù'àän Mân' (Kluane Lake) may be exposed due to lower water levels. While it is possible that lake trout have colonized new spawning areas, this information is not known.

Table 1. Fish species present in Lhù'àän Mân' (Kluane Lake).

Species Category	Common Name	Southern Tutchone Name	Scientific Name	Code
Freshwater Game Species[1]	Arctic grayling	T'ä̀wa	*Thymallus arcticus*	GR
	Lake whitefish	Lù shäw	*Coregonus clupeaformis*	LW
	Broad whitefish	Chághär	*Coregonus nasus*	BW
	Inconnu	Shür	*Stenodus nelma*	IN
	Northern pike	Tà̀le	*Esox lucius*	NP
	Lake trout	Mbet	*Salvelinus namaycush*	LT
	Burbot	Kwätsų	*Lota lota*	BB
Salmon Species	Chum salmon	Thì	*Oncorhynchus keta*	CM
Other Fish Species	Round whitefish	Sakay	*Prosopium cylindraceum*	RW
	Pygmy whitefish	-	*Prosopium coulterii*	PW
	Least cisco	Łu	*Coregonus sardinella*	LC
	Slimy sculpin	-	*Cottus cognatus*	CCG
	Longnose sucker	Tatsat	*Catostomus catostomus*	LSU

[1] Species typically targeted by recreational or subsistence fisheries.

Lhù'àän Mân' (Kluane Lake) contains a unique spawning population of chum salmon which spawn along the lake shoreline where groundwater upwelling occurs, notably in the vicinity of Silver City (McKenzie and Wilson 2005, Wilson 2006). The Lhù'àän Mân' (Kluane Lake) chum salmon are very unique and do not follow the typical spawning behaviour of spawning in groundwater areas of streams and rivers. Lake spawning chum are so rare that there are only two known populations in North America, one of which are the Lhù'àän Mân' (Kluane Lake) chum (the other are in Alaska; Arostegui and Quinn 2019). The future of the unique lake

spawning population of chum salmon is currently uncertain due to large hydrological changes which have occurred in the lake during recent years. In addition to the changing conditions in Lhù'ààn Mân' (Kluane Lake), three large juvenile chum salmon measuring 15 – 20 cm were found in a lake trout stomach in Lhù'ààn Mân' (Kluane Lake) during March 2019. These fish were positively identified as chum salmon through genetic analysis by fisheries biologists at DFO in Whitehorse. These findings suggest that chum salmon in Lhù'ààn Mân' (Kluane Lake) may have an alternative life history strategy for this species, as juveniles typically migrate downstream to the ocean immediately after emergence as fry, and the presence of such large juveniles is more reminiscent of sockeye salmon life history. This potential alternative life history is very unique and given the current status of Lhù'ààn Mân' (Kluane Lake) chum salmon, an investigation of their presence is warranted. Climate change in the north is rapid and tangible, and the changes on Lhù'ààn Mân' (Kluane Lake) are an example of this. This project will provide the opportunity to document the presence of the unique lake spawning population of chum salmon under these rapidly changing conditions.

Given the changes in water levels in Lhù'ààn Mân' (Kluane Lake) and the effects it will have on fish species throughout the lake, the Kluane First Nation (KFN) in collaboration with Dän Keyi Renewable Resource Council (DKRRC) contracted EDI to initiate a research project on Lhù'ààn Mân' (Kluane Lake). One objective was to investigate juvenile fish presence along the new shoreline of Lhù'ààn Mân' (Kluane Lake) to ascertain the effects of the lower water levels on spawning success and juvenile fish populations (e.g., lake trout, chum salmon, lake whitefish). Another objective was to gather information from stomach contents of lake trout in Lhù'ààn Mân' (Kluane Lake)—this both provides valuable information on their feeding habits, as well as the added benefit of investigating the frequency of lake trout consuming juvenile chum. Furthermore, sampling juvenile chum from lake trout stomachs would provide more context on the interesting finding of large juveniles being present in previous stomach surveys, as well as provide more information on the maturity of these fish which could help explain their presence.

Map 1. Overview of Lhù'àân Mân' (Kluane Lake)

Legend

- Highway
- Secondary Road

Parks and Protected Areas

- Kluane National Park and Reserve
- Kluane Wildlife Sanctuary

Data Sources
Topographic spatial data (inset map) courtesy of Her Majesty the Queen in Right of Canada, Natural Resources Canada. All Rights Reserved.

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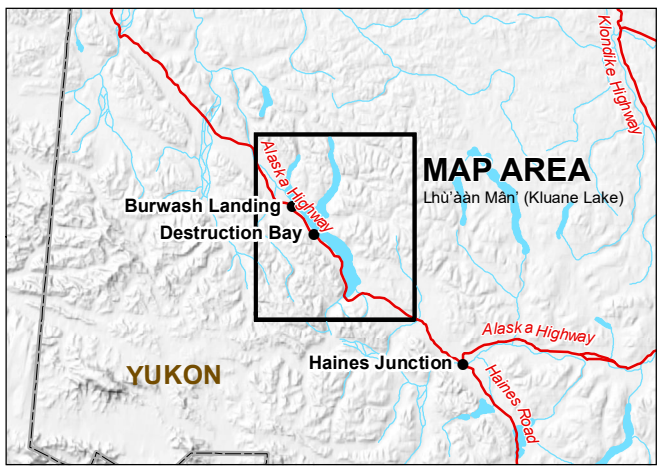

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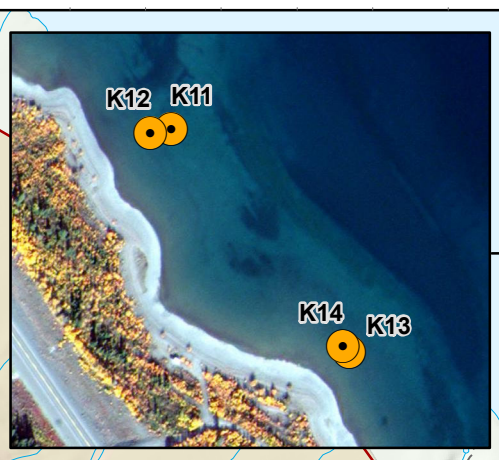
2 METHODS

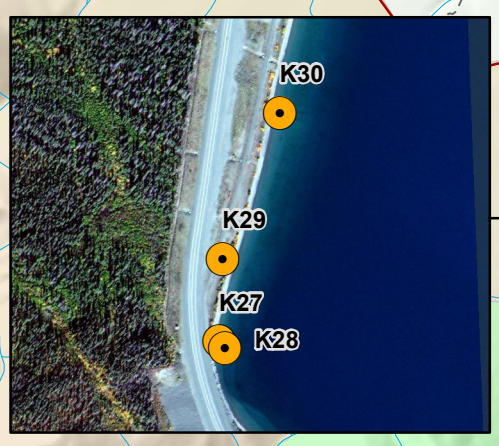
2.1 BEACH SEINING

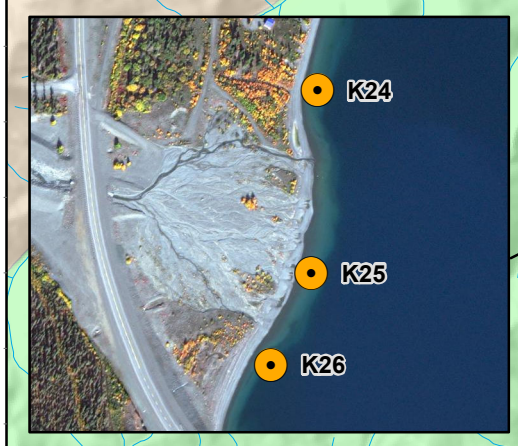
The juvenile sampling conducted in Lhù'ààn Mân' (Kluane Lake) focused on areas that are known or have the potential to be lake trout and chum salmon spawning areas as identified by Wilson (2006). Beach seining was conducted from June 26 – 28, 2020. Sites were accessed by a combination of boat and vehicle access along the shoreline of Lhù'ààn Mân' (Kluane Lake) in the vicinity of Silver City (Map 2). Two different beach seines were used; one was 10 m long by 1.5 m deep with 5 mm mesh, the other was 30 m long by 1.5 m deep with 5 mm mesh. A total of 34 sites were sampled over the three-day sampling event, ranging from 40 – 120 m in haul length (Appendix Table 1).

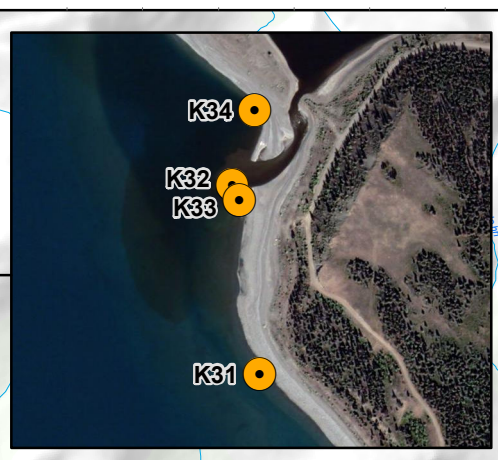
Captured fish were identified to species, enumerated, and subsamples (n = 10) of each species/life stage were measured to fork length (FL). Information collected at each site included: UTM coordinates, date and time, weather conditions, photo documentation, bed material type, water temperature, dissolved oxygen concentration, and sample area dimensions (length, width, and depth).

Map 2. Beach Seining Sites on Lhù'àän Mân' (Kluane Lake)









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Lhù'àän Mân' (Kluane Lake)

Slums River

Kluane National Park and Reserve

Kluane Wildlife Sanctuary

N

Legend

- Beach Seining Site

Parks and Protected Areas

- Kluane National Park and Reserve
- Kluane Wildlife Sanctuary

Data Sources
Topographic spatial data (inset map) courtesy of Her Majesty the Queen in Right of Canada, Natural Resources Canada. All Rights Reserved.

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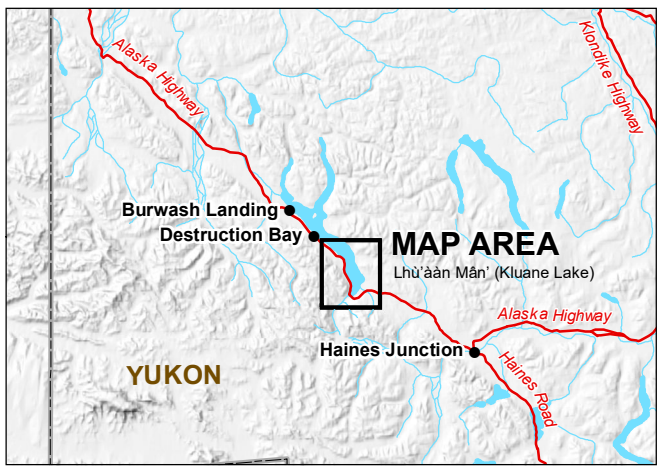

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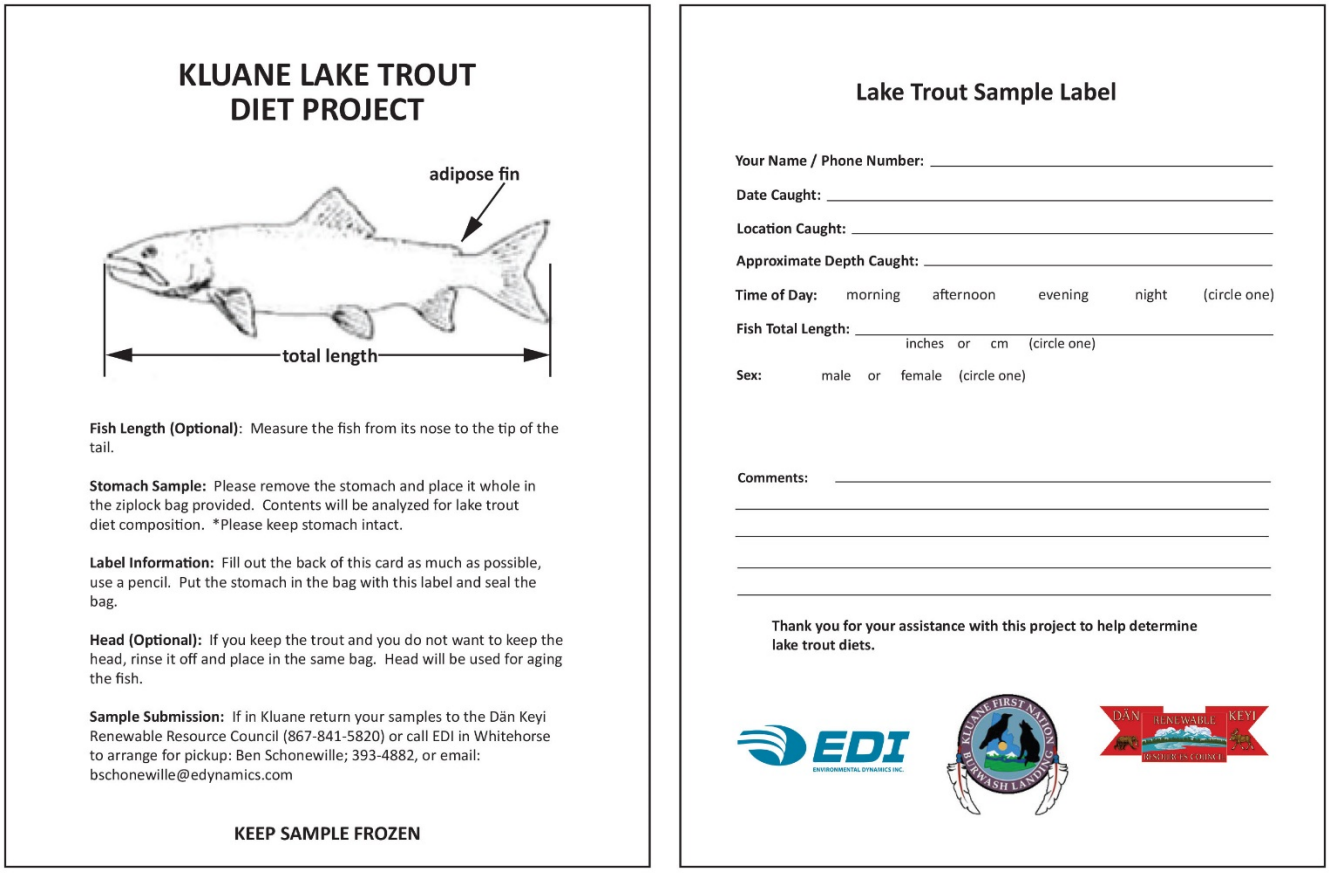
2.2 LAKE TROUT DIET ANALYSIS

In the fall of 2019, the DKRRC, in support of KFN, began to engage local anglers and subsistence fishers to provide lake trout stomachs for analysis. During an RRC meeting in early 2020, an EDI biologist gave a brief presentation and proposed project summary to community members and addressed any questions or concerns. An annual lake trout ice fishing derby held on Lhù'ààn Mân' (Kluane Lake) was identified to promote the project and encourage anglers to provide samples for this project.

To encourage local fishers to provide stomach samples for the project, a double-sided sampling card was prepared and printed on waterproof paper for ease of participation (Figure 1). Each sampling card was prepared in a large Ziplock bag with a pencil to facilitate data collection. Fishers were asked to provide the following information along with the samples: name, date caught, location caught, fish total length, kept or released, male or female, and any other relevant comments. In addition to providing the stomachs, fishers were also given the option of providing the head for the collection of ageing structures (otoliths). Fishers were provided with sampling kits during the February 11, 2020 public information session and through personal contact with other fishers and DKRRC members. Efforts were made to ensure that fishers who are active in different areas of the lake were provided with sampling kits.

Submitted lake trout head and stomach samples were processed at EDI's Whitehorse office. All data submitted with the sample was recorded. Otoliths were collected from lake trout heads and a small genetic sample was collected and stored in a vile of 95% ethanol with a unique identification number. Stomach contents were removed from the stomach, and a total weight (g) was recorded. Stomach contents were then divided by identifiable species and had weight (g) for each species recorded. If species could not be identified, a sample was taken and stored in 95% ethanol with a unique identification number for genetic analysis by ABC and Associates.



KLUANE LAKE TROUT
DIET PROJECT

adipose fin

total length

Fish Length (Optional): Measure the fish from its nose to the tip of the tail.

Stomach Sample: Please remove the stomach and place it whole in the ziplock bag provided. Contents will be analyzed for lake trout diet composition. *Please keep stomach intact.

Label Information: Fill out the back of this card as much as possible, use a pencil. Put the stomach in the bag with this label and seal the bag.

Head (Optional): If you keep the trout and you do not want to keep the head, rinse it off and place in the same bag. Head will be used for aging the fish.

Sample Submission: If in Kluane return your samples to the Dän Keyi Renewable Resource Council (867-841-5820) or call EDI in Whitehorse to arrange for pickup: Ben Schonewille; 393-4882, or email: bschonewille@edynamics.com

KEEP SAMPLE FROZEN

Lake Trout Sample Label

Your Name / Phone Number: _____

Date Caught: _____

Location Caught: _____

Approximate Depth Caught: _____

Time of Day: morning afternoon evening night (circle one)

Fish Total Length: _____
inches or cm (circle one)

Sex: male or female (circle one)

Comments: _____

Thank you for your assistance with this project to help determine lake trout diets.

Figure 1. Sampling card used to facilitate the collection of biological samples from the lake trout captured by recreational and subsistence fishers on Lhù'àän Mân' (Kluane Lake) during 2020.

3 RESULTS

3.1 BEACH SEINING

A total of 1,226 fish were captured during the beach seining program over 34 seine hauls from June 26 – 28, 2020 (Table 2; Appendix Table 2). Slimy sculpin were the most frequently captured species accounting for 45.3 % (n = 555) of the catch followed by round whitefish (45.0 %; n = 552). A total of 85 lake trout were also captured, accounting for 6.9% of the total catch. Small numbers of Arctic grayling, longnose sucker, lake whitefish, and unidentified whitefish made up the remainder of the catch (Table 2). The unidentified whitefish were small larval juveniles which cannot be identified to species with confidence in the absence of genetic identification.

Table 2. Summary of fish captured during the 2020 beach seining sampling program on Lhù'ààn Mân' (Kluane Lake), June 2020.

Species	Number Captured	Average Fork Length (mm ± SE)	Fork Length Range (mm)
Slimy sculpin	555	-	-
Arctic grayling	2	106.0 ± 2.0	104 – 108
Longnose sucker	17	47.4 ± 1.0	40 – 52
Lake trout	85	35.2 ± 2.7	24 – 170
Lake whitefish	2	24.0 ± 1.0	23 – 25
Round whitefish	552	101.2 ± 3.6	60 – 195
Whitefish species	13	20.5 ± 1.5	13 – 26
Total	**1,226**	**-**	**-**

Of the 85 captured lake trout, seven of them were believed to be 1+ or 2+ year old fish based on fork length. Six of the lake trout believed to 1+ ranged in fork length from 70 to 94 mm and one was 170 mm, compared to the rest of the lake trout catch, believed to be YOY, which ranged from 24 to 33 mm and averaged 29 mm. No YOY or juvenile chum salmon were captured during the beach seining sampling event despite 34 seine hauls including of number of which were located at the well documented spawning area near Silver City.

Map 3. Lake Trout Beach Seining Results

Legend

Beach Seining Results

- Young of Year Lake Trout Captured
- No Captures

Parks and Protected Areas

- Kluane National Park and Reserve
- Kluane Wildlife Sanctuary

Data Sources
Topographic spatial data (inset map) courtesy of Her Majesty the Queen in Right of Canada, Natural Resources Canada. All Rights Reserved.

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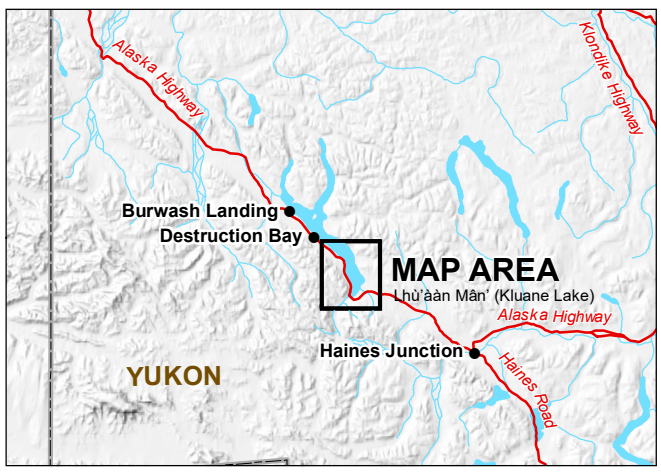

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3.2 LAKE TROUT DIET ANALYSIS

Anglers and local fishers provided samples from 27 lake trout captured in Lhù'ààn Mân' (Kluane Lake) during 2020. Unfortunately, due to COVID-19 the 2020 lake trout ice fishing derby and the school group gillnetting were both cancelled. The cancellation of these two events substantially reduced the number of anticipated samples submitted.

Of the submitted samples, 11 had empty stomachs, 6 stomachs contained fish, with most also containing snails or unknown insects (Appendix Table 3). Unidentified insects made up majority of the contents from the remaining 16 stomach samples. A total of 12 fish were found in 6 lake trout stomachs, with 2 of them easily identified as a round whitefish and slimy sculpin. Samples from the remaining 10 stomachs were sent to ABC and Associates for genetic testing. Five of genetic tests came back as round whitefish and four were identified as lake trout (Appendix Table 3). One of the fish was identified as a eulachon (*Thaleichthys pacificus*) which are not found in Lhù'ààn Mân' (Kluane Lake). No YOY or juvenile chum salmon were found in any of the lake trout stomach samples.

The 11 empty stomachs and the single stomach containing the eulachon were not included in analysis. Of the 15 remain stomach samples with contents insects were found most frequently in 35.7 % of the stomachs (Table 3). Round whitefish and snails were the next most frequent accounting for 28.6 and 21.4 %, respectively. Surprisingly, juvenile lake trout were found in 14.3 % of the analyzed stomachs. Insects also had the highest average percent volume with 6.4 %. Snails had the second highest average volume at 5.1 % followed closely by round whitefish at 5.1 %.

Table 3. Summary of stomach contents found in sampled lake trout.

Stomach Contents	Frequency of Occurrence (%)	Average Percent Volume+/- SE (%)
Snails	21.4	5.1 ± 3.3
Unknown contents	7.1	0.5 ± 0.5
Insects	35.7	6.4 ± 2.7
Round whitefish	28.6	5.1 ± 3.8
Lake trout	14.3	4.5 ± 3.5
Slimy sculpin	7.1	0.02 ± 0.02

Notes – the empty stomachs (11) and the single eulachon are not included in this analysis.

4 DISCUSSION

The beach seining component of the work was successful in capturing juvenile fish of a number of species including lake trout. Young-of-the-year (YOY) lake trout were captured at a number of sites sampled on the west shoreline of the south end of Lhù'ààn Mân' (Kluane Lake) and provide an indication that successful lake trout spawning is occurring under the altered water levels on the lake. Lhù'ààn Mân' (Kluane Lake) appears to have extensive lake trout spawning and a much large scaler sampling program would be required to provide greater context regarding the current status of lake trout spawning in the lake. The capture of large juvenile lake trout (1 or 2 years old) was also notable given that juvenile lake trout are typically only located near spawning areas for a short time period after emergence (Schonewille and Costello 2018, EDI 2020). Beach seining on other Yukon lakes for juvenile lake trout have very rarely captured these larger juvenile lake trout compared to the 2020 sampling on Lhù'ààn Mân' (Kluane Lake).

No juvenile chum salmon were captured by beach seining and this could be attributed to a number of factors. Chum salmon returns to the Yukon River watershed have been relatively low in recent years and therefore the numbers of spawning chum in Lhù'ààn Mân' (Kluane Lake) during the fall of 2019 could have been very low. This could have resulted in very low numbers of juveniles present, thus reducing the overall potential for capturing them. The beach seining for chum salmon was first focused in the vicinity of Silver City where lake spawning by chum salmon is known to occur (McKenzie and Wilson 2005, Wilson 2006). It was hoped that the capture of juvenile chum at this known location could be used to confirm the method and sampling timing before the method was used to locate other unknown spawning areas elsewhere in the lake. The timing of sampling could also be an important variable which may influence the catchability of juvenile chum salmon near the spawning area. The specific life history of lake spawning chum salmon – including timing of emergence and residence time near spawning areas – is unknown and additional sampling should focus on repeat sampling events at known spawning sites (Silver City) before more widespread sampling is conducted.

The lake trout stomach contents analysis did not detect the presence of juvenile chum salmon in the stomachs sampled; however, there were some notable findings from this sampling and the associated analysis. Firstly, there was a single eulachon identified using DNA analysis in a trout stomach from Lhù'ààn Mân' (Kluane Lake). Eulachon are not found in Lhù'ààn Mân' (Kluane Lake) and are more frequently associated with marine environments until spawning in natal streams. Further investigation and communication with the angler who submitted the sample determined that this was bait the angler was using during fishing.

There were also findings of juvenile lake trout in adult lake trout stomachs, suggesting intercohort cannibalism (i.e., eating of juvenile fish by adult fish of the same species). The literature suggests that in wild populations the occurrence of this is fairly low (< 2% of their diet; Morissette et al. 2018). While it is inadvisable to draw concrete conclusions from a small sample size, juvenile lake trout were captured in 14.3 % of stomachs assessed. This is an interesting and unexpected finding and will be a consideration in future sampling

The lack of lake whitefish in the lake trout stomach contents was an unexpected finding given that this species typically constitutes an important prey item for lake trout in Yukon lakes where both species occur. Juvenile lake whitefish were captured during the beach seining component of the work indicating that there is at least

some successful spawning occurring by this species under the altered water levels on Lhù'ààn Mân' (Kluane Lake). These patterns may be a result of the relatively low sample size of lake trout stomachs analyzed and additional sampling in future years may be required to confirm this pattern.

Neither the beach seining or lake trout stomach contents analysis documented the presence of large juvenile chum salmon comparable to the 15-20 cm individuals found in a lake trout stomach during 2019. The presence of chum salmon of this size in Lhù'ààn Mân' (Kluane Lake) may be a rare occurrence, despite there being three individuals identified in a single lake trout stomach during 2019. In addition to their absence in current sampling, their presence during 2019 sampling poses even more questions regarding what these large juveniles were doing in Lhù'ààn Mân' (Kluane Lake). Chum salmon typically out-migrate to the ocean immediately following emergence and exceptions of rearing in a lake are rare (Arostegui and Quinn 2019). There is a population in Russia that feed in lakes after emergence, though they out-migrate to the sea within the same year (Zhivotovsky et al. 2012, Zelennikov et al. 2016). There are accounts of Chinook salmon precocious males (i.e., juvenile but sexually mature) in several rivers in the Yukon (e.g., Nisutlin, Morley rivers; Szekeres. 2021)) and elsewhere. These males elect to not migrate to the ocean and instead remain rearing in freshwater streams and rivers for 2 – 3 years, which is considered an alternative mating strategy. They are able to fertilize female eggs during spawning season without having migrated to the ocean and back. Though without more sampling it is impossible to determine if this was the case with the three juvenile chum analyzed by DFO, it is a possibility. Future sampling at different time points could begin to explain some of these unknowns.

5 CONCLUSION

Beach seining targeted known or potential spawning areas for lake trout and chum salmon; juvenile lake trout were captured, although no chum salmon were captured. The project was successful in obtaining and analyzing stomach samples from lake trout in Lhù'ààn Mân' (Kluane Lake). Unfortunately, due to COVID-19, the ability to obtain more lake trout samples was less than expected. Recommendations for future years of this project include:

- Increase the number of beach seining events – with a focus on the known chum lake spawning area at Silver City – beginning immediately at ice out.
- Conduct more widespread beach seining to determine lake trout spawning areas and important lake rearing areas for other fish species, including lake whitefish.
- Engage more anglers and subsistence fishers to submit additional lake trout stomach samples from as many areas of Lhù'ààn Mân' (Kluane Lake) and from varying times of years.

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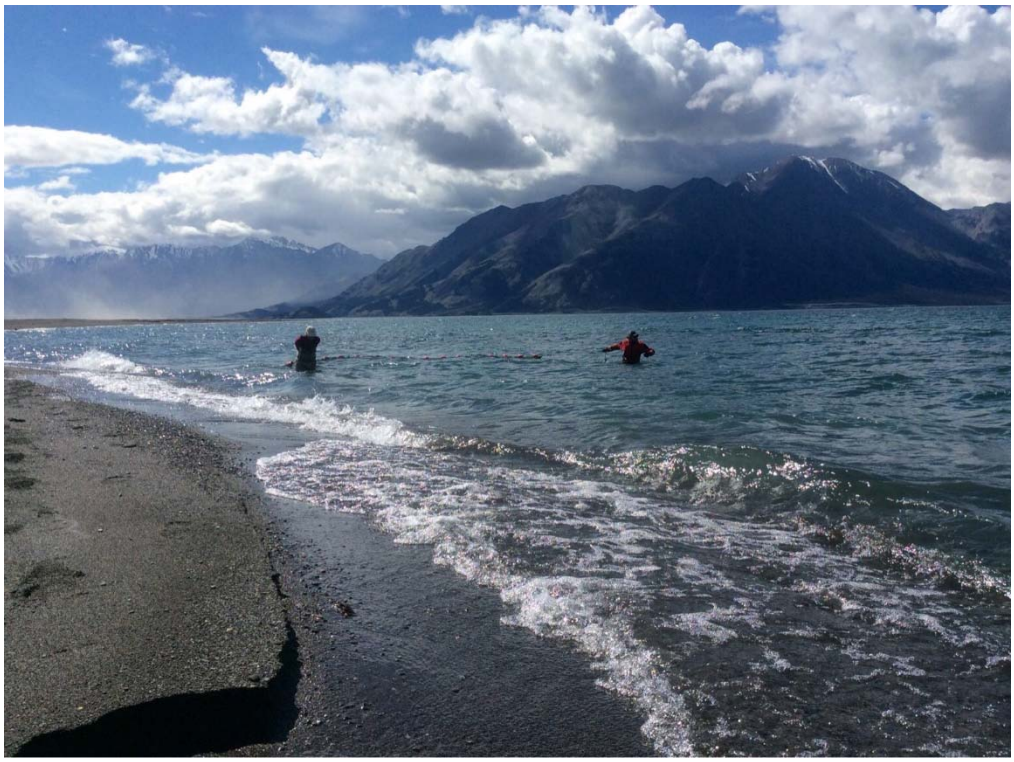
APPENDICES

APPENDIX A PHOTOGRAPHS

Appendix Photo 1. Beach seining at site K02 on Lhù'ààn Mân' (Kluane Lake).



Appendix Photo 2. Beach seining at K05 on Lhù'ààn Mân' (Kluane Lake).

Appendix Photo 3. Young of the year lake trout captured during beach seining in Lhù'ààn Mân' (Kluane Lake).

Appendix Photo 4 Large juvenile lake trout captured during beach seining in Lhù'ààn Mân' (Kluane Lake).

Appendix Photo 5. Eulachon found in lake trout stomach sample as determined by DNA identification (EDI2020DNA276).

Appendix Photo 6. Round whitefish found in lake trout stomach sample with species identification by DNA analysis (EDI2020DNA267).

APPENDIX B BEACH SEINING DATA

Appendix Table 1. Beach seining sample site data from Lhù'ààn Mân' (Kluane Lake).

Site	Date	Time	Temperature (°C)	Dissolved Oxygen (mg/L)	Water Clarity	Weather	Substrate	Wind Direction	Wind Intensity	Haul Number	Length (m)	Width (m)	Depth (m)	Effort (m²)
K01	26-Jun-20	14:00	10.7	8.82	Clear	Overcast	Gravel	None	None	1	75	20	1.4	1500
K02	26-Jun-20	14:15	10.8	10.5	Clear	Sunny	Gravel	North	Light	1	100	25	1.4	2500
K03	26-Jun-20	14:50	9.4	10.93	Clear	Overcast	Gravel, Sand, Fines	North	Light	1	95	25	1.2	2375
K04	26-Jun-20	15:05	10.6	9.76	Clear	Sunny	Gravel, Sand, Fines	West	Light	1	100	20	1.2	2000
K05	26-Jun-20	15:50	7.7	10.65	Clear	Overcast	Sand, Gravel	West	Light	1	75	8	1.4	600
K06	26-Jun-20	16:00	7.8	10.06	Clear	Sunny	Gravel, Cobble	West	Moderate	1	60	7	1.3	420
K07	26-Jun-20	16:10	8.9	10.85	Clear	Sunny	Gravel, Cobble	West	Moderate	1	105	8	1.3	840
K08	26-Jun-20	16:30	9.3	10.55	Clear	Sunny	Gravel, Cobble	West	Moderate	1	80	7	1.3	560
K09	26-Jun-20	16:45	9.2	10.58	Clear	Sunny	Gravel, Cobble	West	Moderate	1	95	7	1.2	665
K10	26-Jun-20	16:55	9.9	10.31	Clear	Sunny	Gravel, Cobble	West	Moderate	1	85	7	1.2	595
K11	27-Jun-20	10:00	8.6	10.99	Clear	Sunny	Gravel, Cobble	West	Moderate	1	105	7	1	735
K12	27-Jun-20	10:30	10.7	10.39	Clear	Sunny	Gravel, Cobble	West	Moderate	1	120	7	1	840
K13	27-Jun-20	11:00	10	10.46	Clear	Sunny	Gravel, Cobble	West	Moderate	1	100	8	1	800
K14	27-Jun-20	11:15	10.9	10.26	Clear	Sunny	Gravel, Cobble	West	Moderate	1	100	8	1.1	800
K15	27-Jun-20	12:10	8.5	11.55	Clear	Overcast	Cobble, Boulders	East	Light	1	60	3	1.3	180
K16	27-Jun-20	12:25	8.5	11.55	Clear	Overcast	Cobble, Boulders, Gravel	East	Light	1	65	6	1.3	390
K17	27-Jun-20	12:40	7.1	11.73	Clear	Sunny	Cobble, Boulders, Gravel	East	Light	1	70	6	1.3	420
K18	27-Jun-20	12:55	7.6	11.56	Clear	Sunny	Cobble, Boulders	East	Light	1	40	4	1.3	160
K19	27-Jun-20	13:05	9.8	11	Clear	Sunny	Cobble, Boulders, Gravel	East	Light	1	70	5	1.2	350
K20	27-Jun-20	14:35	8.6	11.72	Clear	Sunny	Gravel, Fines	East	Moderate	1	40	5	1.3	200
K21	27-Jun-20	15:00	7.5	11.65	Clear	Sunny	Gravel	East	Light	1	85	5	1.2	425
K22	27-Jun-20	15:30	7.5	11.7	Clear	Sunny	Gravel, Cobbles	East	Light	1	75	6	1.2	450
K23	27-Jun-20	16:15	7.7	11.37	Clear	Overcast	Gravel, Cobbles	West	Light	1	100	7	1.2	700
K24	27-Jun-20	16:40	8	11.01	Clear	Rainy	Gravel, Cobbles	West	Light	1	105	8	1.2	840
K25	27-Jun-20	17:00	7.3	11.3	Clear	Overcast	Gravel, Cobbles	West	Light	1	100	7	1.2	700
K26	27-Jun-20	17:20	7.5	11.46	Clear	Sunny	Gravel, Cobbles	West	Light	1	100	8	1.2	800
K27	27-Jun-20	17:55	8.5	11.36	Clear	Sunny	Gravel	None	None	1	100	8	1.2	800
K28	27-Jun-20	18:10	8.6	11.4	Clear	Overcast	Cobble, Gravel	None	None	1	100	8	1.2	800
K29	27-Jun-20	18:20	8.3	11.26	Clear	Overcast	Cobble	None	None	1	100	8	1.3	800
K30	27-Jun-20	18:35	8.9	11.19	Clear	Sunny	Cobble	East	Light	1	150	8	1.3	1200
K31	28-Jun-20	11:35	8.5	10.79	Clear	Overcast	Cobble, Gravel	East	Moderate	1	100	8	1	800
K32	28-Jun-20	12:20	8.7	11.16	Clear	Overcast	Cobble, Gravel	East	Moderate	1	100	8	1.2	800
K33	28-Jun-20	12:30	8.6	10.77	Clear	Overcast	Cobble, Gravel	East	Moderate	1	100	8	1.3	800
K34	28-Jun-20	12:45	6.9	11.53	Clear	Overcast	Cobble	East	Moderate	1	120	8	1.2	960

Appendix Table 2. Beach seining fish capture data.

ID	Date	Species	Life Stage	Number Captured	Number of Mortalities
K01	26-Jun-20	CCG	Adult	22	0
K02	26-Jun-20	CCG	Adult	246	0
K02	26-Jun-20	RW	Juvenile	11	0
K02	26-Jun-20	LW	Juvenile	1	1
K03	26-Jun-20	CCG	Adult	53	0
K04	26-Jun-20	NFC			
K05	26-Jun-20	NFC			
K06	26-Jun-20	RW	Juvenile	2	0
K07	26-Jun-20	LT	Juvenile	2	0
K08	26-Jun-20	LT	Juvenile	2	0
K09	26-Jun-20	LT	Juvenile	1	0
K09	26-Jun-20	RW	Juvenile	2	0
K10	26-Jun-20	NFC			
K11	27-Jun-20	RW	Juvenile	35	0
K11	27-Jun-20	CCG	Adult	12	0
K12	27-Jun-20	CCG	Adult	18	0
K12	27-Jun-20	GR	Juvenile	2	0
K12	27-Jun-20	RW	Juvenile	413	10
K13	27-Jun-20	CCG	Adult	4	0
K14	27-Jun-20	RW	Juvenile	11	0
K14	27-Jun-20	CCG	Adult	11	0
K16	27-Jun-20	LT	Juvenile	1	1
K16	27-Jun-20	CCG	Adult	1	1
K17	27-Jun-20	NFC			
K18	27-Jun-20	NFC			
K19	27-Jun-20	CCG	Adult	1	0
K20	27-Jun-20	CCG	Adult	10	0
K20	27-Jun-20	LT	Juvenile	7	1
K21	27-Jun-20	CCG	Adult	25	0
K21	27-Jun-20	LT	Juvenile	18	0
K22	27-Jun-20	LT	Juvenile	19	4
K22	27-Jun-20	CCG	Adult	4	1
K23	27-Jun-20	LT	Juvenile	9	0
K23	27-Jun-20	WF	Juvenile	1	0
K24	27-Jun-20	CCG	Adult	27	0
K24	27-Jun-20	LT	Juvenile	9	0
K25	27-Jun-20	LT	Juvenile	11	4
K25	27-Jun-20	WF	Juvenile	3	2
K25	27-Jun-20	CCG	Adult	25	14

ID	Date	Species	Life Stage	Number Captured	Number of Mortalities
K26	27-Jun-20	LT	Juvenile	4	0
K26	27-Jun-20	CCG	Adult	48	1
K27	27-Jun-20	CCG	Adult	6	0
K27	27-Jun-20	WF	Juvenile	6	5
K28	27-Jun-20	LW	Juvenile	1	0
K28	27-Jun-20	WF	Juvenile	2	1
K28	27-Jun-20	CCG	Adult	2	0
K29	27-Jun-20	NFC			
K30	27-Jun-20	WF	Juvenile	1	0
K31	28-Jun-20	LSU	Juvenile	1	0
K31	28-Jun-20	RW	Juvenile	78	0
K31	28-Jun-20	LT	Juvenile	1	0
K31	28-Jun-20	CCG	Adult	23	7
K32	28-Jun-20	CCG	Adult	6	0
K32	28-Jun-20	LSU	Juvenile	6	0
K33	28-Jun-20	CCG	Adult	6	3
K33	28-Jun-20	LSU	Juvenile	6	0
K34	28-Jun-20	LT	Juvenile	1	0
K34	28-Jun-20	LSU	Juvenile	4	0
K34	28-Jun-20	CCG	Adult	5	0

Notes:

Fish species codes: CCG – slimy sculpin, GR – Arctic grayling, LSU – longnose sucker, LT – lake trout, LW – lake whitefish, RW – round whitefish, WF – whitefish species, NFC – no fish caught.

APPENDIX C LAKE TROUT STOMACH ANALYSIS

Appendix Table 3. Lake trout stomach content analysis from sampling conducted on Lhù'ààn Mân' (Kluane Lake) in 2020.

Fish ID	Date Caught	Fork Length (mm)	Sex	Stomach Contents								
				Total Stomach Contents Weight (g)	Species	Content Weight (g)	Content Genetic ID	Species	Content Weight (g)	Content Genetic ID	Species	Content Weight (g)	Content Genetic ID
1	21-Mar-20	600	Male	33.2	Snails	31.5	-	Slimy sculpin	0.3	-	Round whitefish	1.4	EDI2020DNA277
2	21-Mar-20	565	Male	0	Empty	-	-	-	-	-	-	-	-
3	20-Mar-20	600	Female	0	Empty	-	-	-	-	-	-	-	-
4	21-Mar-20	550	Male	3.9	Snails	3.9	-	-	-	-	-	-	-
5	21-Mar-20	540	Male	7.3	Unknown contents	7.3	-	-	-	-	-	-	-
6	21-Mar-20	620	Female	40	Eulachon	40	EDI2020DNA276	-	-	-	-	-	-
7	20-Mar-20	590	Female	0	Empty	-	-	-	-	-	-	-	-
8	20-Mar-20	630	Male	0	Empty	-	-	-	-	-	-	-	-
9	-		-	52.7	Round whitefish	48.8	EDI2020DNA275	Round whitefish	3.9	EDI2020DNA274	-	-	-
10	16-Jul-20	560	Male	6.7	Diptera	6.7	-	-	-	-	-	-	-
11	20-Mar-20	640	Male	2.6	Round whitefish	2.6	EDI2020DNA273	-	-	-	-	-	-
12	20-Mar-20	530	Male	15	Lake trout	15	EDI2020DNA272	-	-	-	-	-	-
13	20-Mar-20	620	-	0	Empty	-	-	-	-	-	-	-	-
14	21-Mar-20	600	Male	0	Empty	-	-	-	-	-	-	-	-
15	20-Mar-20	580	Female	0	Empty	-	-	-	-	-	-	-	-
16	21-Mar-20	645	Male	0	Empty	-	-	-	-	-	-	-	-
17	20-Mar-20	590	Male	0	Empty	-	-	-	-	-	-	-	-
18	21-Mar-20	580	Female	0	Empty	-	-	-	-	-	-	-	-
19	16-Jul-20	560	Female	14	Diptera	14	-	-	-	-	-	-	-
20	15-Jul-20	600	Male	20.6	Unknown insects	20.6	-	-	-	-	-	-	-
21	16-Jul-20	560	Female	18.3	Unknown insects	18.3	-	-	-	-	-	-	-
22	15-Jul-20	560	Female	30.4	Unknown insects	30.4	-	-	-	-	-	-	-
23	15-Jul-20	580	Female	14	Unknown insects	14	-	-	-	-	-	-	-
24	20-Mar-20	640	Female	47.7	Lake trout	32.6	EDI2020DNA271	Lake trout	13.3	EDI2020DNA270	Lake trout	1.8	EDI2020DNA269
25	-		-	0	Empty	-	-	-	-	-	-	-	-
26	13-Jul-20	560	Female	14.36	Round whitefish	3.06	EDI2020DNA268	Round whitefish	11.3	EDI2020DNA267	-	-	-
27	16-Jul-20	600	Male	36.2	Snails	36.2	-	-	-	-	-	-	-

APPENDIX D GENETIC ANALYSIS RESULTS

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ANALYSIS

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Genetic Species Identification of Unknown Fish Samples Collected from the Stomachs of Lake Trout in Kluane Lake, YT.

Date: December 1, 2020

Background

Ten genetic samples of unknown prey items (unidentified fish) were collected from the stomachs of lake trout and submitted for identification using genetic testing. These methods employ known fixed size or sequence-based differences between species to unambiguously determine genetic species ID (i.e., genetic barcoding).

Methods and Materials

The 5' end of the mitochondrial cytochrome oxidase 1 gene (COI_3) was barcoded as per Ivanova (2007). Sequence data for the test samples was aligned to and compared against known voucher sequences to confirm species ID.

Results

Sample ID	Confirmed SPP ID	Diagnostic Markers
EDI2020DNA267	Round Whitefish - *Prosopium cylindraceum*	COI_3
EDI2020DNA269	Lake Trout - *Salvelinus namaycush*	COI_3
EDI2020DNA270	Lake Trout - *Salvelinus namaycush*	COI_3
EDI2020DNA271	Lake Trout - *Salvelinus namaycush*	COI_3
EDI2020DNA272	Lake Trout - *Salvelinus namaycush*	COI_3
EDI2020DNA273	Round Whitefish - *Prosopium cylindraceum*	COI_3
EDI2020DNA274	Round Whitefish - *Prosopium cylindraceum*	COI_3
EDI2020DNA275	Round Whitefish - *Prosopium cylindraceum*	COI_3
EDI2020DNA276	Eulachon - *Thaleichthys pacificus*	COI_3
EDI2020DNA277	Round Whitefish - *Prosopium cylindraceum*	COI_3

Literature Cited

Ivanova, N. V., T. S. Zemlak, R. H. Hanner, and P. D. N. Hebert. 2007. Universal primer cocktails for fish DNA barcoding. Molecular Ecology Notes 7(4):544-548.