LAKE TROUT AND LAKE WHITEFISH POPULATION ASSESSMENT

KLUANE LAKE 2013

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Yukon
Environment
Environnement

2014

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Yukon Fish and Wildlife Branch

TR-14-04

Acknowledgements

Colin Asselstine, Crystal Beaudry, Ryan Drummond, Kelsey Kabanak, Shawn Taylor, Kelcy Tousignant and Colin Wright assisted with the survey. Jean Carey and Karen Clyde reviewed the report.

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Suggested citation:

BARKER, O.E, N.P. MILLAR AND A. FOOS. 2014. Lake Trout and Lake Whitefish Population Assessment: Kluane Lake 2013. Yukon Fish and Wildlife Branch Report TR-14-04, Whitehorse, Yukon, Canada.

Summary

Environment Yukon has been surveying important fish stocks since 1991. We use these surveys to detect population changes and monitor population health. Along with angler harvest surveys, these data are also used to assess the sustainability and impact of fisheries.

Environment Yukon works with first nations, RRCs, and user groups to determine priority lakes for surveys. Criteria for identification of priority lakes include accessibility, sensitivity, and management concern. The surveys focus on lake trout and lake whitefish, indicators of the health of northern lake ecosystems.

We surveyed Kluane Lake in 2013 using SPIN (Summer Profundal Index Netting; Sandstrom and Lester 2009). Environment Yukon previously surveyed the lake using a different netting method in 1999 and 2004. SPIN provides more statistically robust methods and improves confidence in survey results (Jessup and Millar 2011).

The 2013 SPIN survey captured 152 lake trout, resulting in a lake-wide numerical CPUE (catch per unit effort) of 1.02 lake trout per net, and a lake-wide biomass CPUE of 2.01 kg of lake trout per net. The estimated density of lake trout in Kluane Lake was 4.2 lake trout per hectare. Kluane Lake has a high density of large-bodied lake trout.

The 2013 SPIN survey also captured 471 lake whitefish, resulting in a lake-wide numerical CPUE of 2.44 lake whitefish per net, and a lake-wide biomass CPUE of 1.94 kg of lake whitefish per net. Kluane Lake has a high relative density of lake whitefish.

Key Findings

- Kluane Lake has a high density of large-bodied lake trout.
- Kluane Lake has a high relative density of lake whitefish.

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Introduction

Each year, Environment Yukon conducts assessments of fish populations, with a focus on lake trout and lake whitefish. Between 1991 and 2009, over 100 Yukon lakes were surveyed using small-mesh netting, a method based on the index netting techniques described by Lester et al. (1991). Beginning in 2010, we began to assess fish populations using a new method, Summer Profundal Index Netting (SPIN; Sandstrom and Lester 2009). SPIN provides more statistically robust data and improves confidence in survey results (Jessup and Millar 2011).

We choose lakes for assessment based on the size of the active recreational fishery, the aboriginal subsistence fishery, and the commercial and domestic fisheries, as well as other available information. Lakes with heavy harvest pressure are surveyed on a regular basis.

The SPIN assessment involves setting gillnets at various sites in the lake and recording the catch and biological information about each fish caught. The survey usually tells us:

- relative abundance and biomass of lake trout and lake whitefish as measured by an index (CPUE, or catch per unit effort);
- changes in relative abundance and biomass from previous surveys;
- for lake trout, the estimated density (number of lake trout per hectare) and abundance (number of lake trout) in the lake;
- length and weight of individual lake trout and lake whitefish, as well as other species captured; and
- age, sex, maturity, and diet of any fish killed.

Environment Yukon surveyed Kluane Lake using small-mesh netting in 1999 and 2004. Differences between the two methods mean that results from this survey cannot be compared statistically with past surveys. Here we report the 2013 results and make only subjective comparisons with previous surveys.

Study Area

Kluane Lake is located approximately 60 km northwest of Haines Junction (Figure 1). The lake sits at an elevation of 781 m above sea level. At approximately 81 km long and an area of approximately 408 km^2, Kluane Lake is the largest lake located entirely within Yukon. The lake has a mean depth of 31 m and a maximum depth of 91 m. The Alaska Highway runs along the western shore of the lake, passing through the lakeshore communities of Burwash Landing and Destruction Bay.

Kluane Lake is very large, and has four distinct zones. The first, comprising the southern end of the main basin, is heavily influenced by cold, silt-laden inflows from the A’ay Chu (Slims River), originating from the Kaskawulsh Glacier in Kluane National Park. This cold, turbid zone grades into the clearer waters of the central and northern main basin, with the extent of cold, silty waters dependent on flow volume. Conditions change again in the two northern arms, Talbot and Brooks. Talbot Arm, in the east, is narrow and deep, and is bordered by steep slopes of the Ruby Range. Talbot Arm waters are slightly warmer than those of the main basin. Brooks Arm, in the west, is shallow and relatively broad, and sits exposed in the Burwash Flats. Brooks Arm waters are warm and tannic, and are characterized by extensive macrophyte beds. The Kluane River, the main outflow of Kluane Lake, drains from Brooks Arm.

Kluane Lake is accessed from a boat launch near Horseshoe Bay in the south, and from launches in the communities of Destruction Bay and Burwash Landing.

A Yukon government campground at Congdon Creek, as well as several private campgrounds, operate along the Alaska Highway. Kluane Lake lies within the traditional territories of the Kluane First Nation and the White River First Nation, and adjacent to the traditional territory of the Champagne and Aishihik First Nations.

The recreational fishery at Kluane Lake has been managed under Conservation Waters Regulations since 2004. The catch limit for lake trout is 2 fish per day, with 2 in possession. All lake trout 65 – 100 cm total length must be released, and only one lake trout in possession can be over 100 cm total length. The catch limit for lake whitefish is 5 fish per day, with 10 in possession. There is no length restriction for lake whitefish possession. Barbless hooks are mandatory.

There are 7 commercial fishing licences for Kluane Lake, with a combined annual lake trout quota of 3,050 kg. Commercial lake whitefish harvest is not subject to quota. Commercial fishing activity is currently low, with mean lake trout and lake whitefish harvest less than 10 kg annually for each species over the past 10 years (Environment Yukon files).

Methods

We followed the Summer Profundal Index Netting (SPIN) method for lake trout and lake whitefish capture (Sandstrom and Lester 2009; Jessup and Millar 2011). Gillnets were set at different depths throughout the lake to capture lake trout and lake whitefish, and determine CPUE for both species. Each 64 m gillnet was made up of 8 panels of monofilament web with mesh sizes from 57 mm to 127 mm. We set each net for 2 hours.

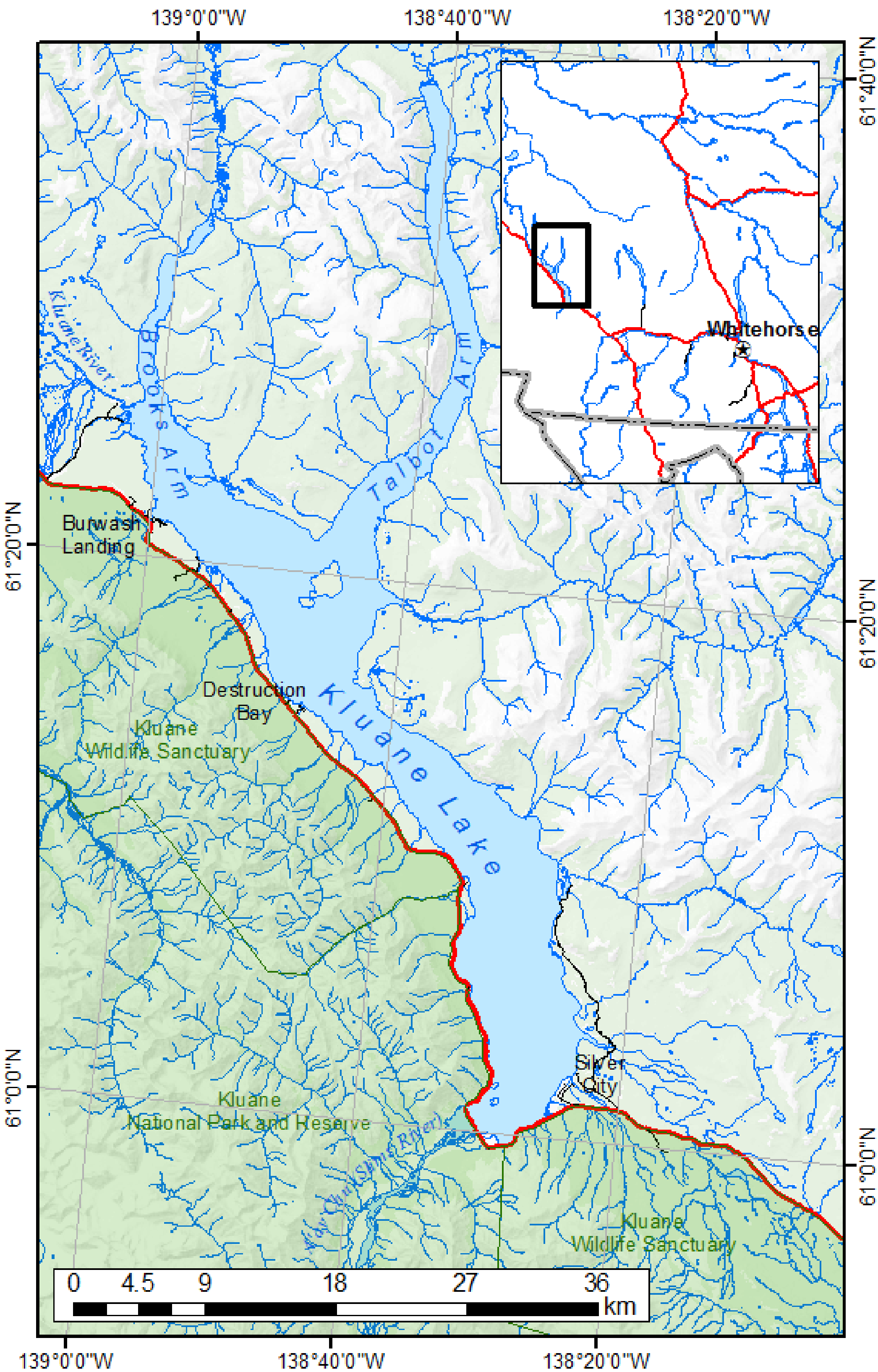

Figure 1. Location of Kluane Lake, Yukon.

Survey effort

We surveyed Kluane Lake 6 – 11 August 2013. We set a total of 129 nets, divided among 7 depth strata (Table 1, Appendix 3). We initially weighted the number of nets set in each stratum by the surface area of the stratum. After the first day, distribution of effort was adjusted by concentrating on those strata with the highest catch rates. We chose the locations for setting the nets within each stratum randomly by using random point generation in ArcGIS 10.1. Any clumped distributions of points were manually dispersed to ensure coverage of the entire lake.

Table 1. Effort breakdown by stratum, Kluane Lake 2013.

Stratum	Depth range	Area (ha)	Area (%)	Nets Set	Nets Set (%)
1	**0 - 10 m**	9,283	23%	35	27%
2	**10 - 20 m**	7,597	19%	46	36%
3	**20 - 30 m**	5,703	14%	17	13%
4	**30 - 40 m**	5,799	14%	15	12%
5	**40 - 60 m**	6,538	16%	8	6%
6	**60 - 80 m**	5,476	13%	8	6%
7	**> 80 m**	425	1%	0	0%
Total		40,821	100%	129	100%

We measured, weighed, and released all fish captured. Any fish that died was sampled for age (using otoliths or ear “bones”) and diet (stomach contents).

Lake trout

We calculated the lake-wide numerical catch per unit effort (CPUE) as the number of lake trout of “harvestable” size (300 mm and up) caught per net.

Following SPIN protocols, this numerical CPUE was calculated using catch numbers adjusted to account for net selectivity bias based on the lengths of lake trout captured (Sandstrom and Lester 2009).

CPUE is considered an index of abundance, and changes in CPUE are understood to reflect actual changes in the lake trout population. CPUE can be compared between surveys and used to detect population growth or decline. The method excludes fish below 300 mm because they are not usually captured by anglers.

We also calculated a lake-wide biomass CPUE for lake trout, as the kilograms of lake trout (300 mm and up) caught per net, using Cochran's area-weighted mean and standard deviation for random stratified samples (Cochran 1977, Krebs 1999). We did not adjust lake trout biomass CPUE for net selectivity bias.

We converted numerical CPUE to density (lake trout/ha) based on an empirical relationship between CPUE and fish density that has been established for Ontario lakes. From this, we estimated absolute abundance (i.e., the total population size) by multiplying density by lake size (number of lake trout/ha • lake area (ha) = number of lake trout in lake). Before we can be fully confident in our estimates of density and absolute abundance, the relationship between lake trout CPUE and density must be verified for Yukon lakes.

Lake whitefish

We calculated lake-wide lake whitefish CPUE both as the number of lake whitefish caught per net, and as the biomass of lake whitefish caught per net, using Cochran's area-weighted mean and standard deviation for random stratified samples (Cochran 1977, Krebs 1999).

As for lake trout, CPUE values are considered an index of lake whitefish abundance, and can be used for comparisons among surveys and to detect population growth or decline. We included all sizes of lake whitefish caught in our CPUE calculations.

We do not have sufficient data to calculate reliable net selectivity relationships for lake whitefish; we did not adjust lake whitefish catches based on net selectivity.

A relationship between lake whitefish CPUE and absolute density has not been established; we present relative abundance data only for lake whitefish.

Results and Discussion

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen (DO) are water quality variables critical to lake trout, and they determine suitable and optimal habitats within a lake. Lake trout habitat has been defined as *suitable* where temperatures are below 15°C and dissolved oxygen is above 4 mg/L (Clark et al. 2004).

Outside these levels (i.e., temperature above 15°C and dissolved oxygen below 4 mg/L) the habitat is *unsuitable* for lake trout.

The *optimal* temperature range for Yukon lake trout is between 2 and 12°C (Mackenzie-Grieve and Post 2006). The *optimal* dissolved oxygen level for lake trout is ≥7 mg/L (Evans 2005).

Less is known about suitable and optimal habitat for lake whitefish, though they are often found in shallower and warmer parts of lakes and are able to tolerate higher maximum temperatures than lake trout.

We took temperature and dissolved oxygen profiles in 2 locations: the main basin of Kluane Lake and Talbot Arm.

We measured temperature and dissolved oxygen in the main basin on 9 August 2013. The profile location was beyond the zone of direct influence of the cold, silty A'ay Chu (Slims River) inflow. Temperatures and dissolved oxygen were optimal for lake trout from the surface to a depth of 60 m (Figure 2). The main basin was unstratified. Profile depth was limited to 60 m depth by the length of instrument cable; the lake bottom in this location was at 75 – 80 m.

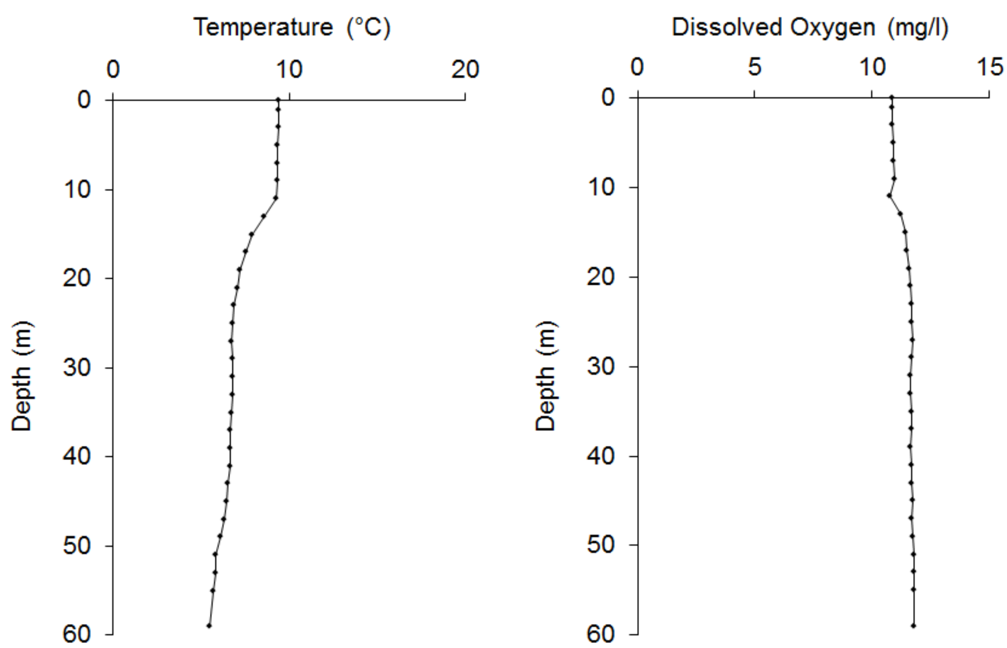

Figure 2. Temperature and dissolved oxygen profiles of the main basin of Kluane Lake, measured 9 August 2013.

We measured temperature and dissolved oxygen in Talbot Arm on 7 August 2013. Water temperatures declined steadily from 14°C at the surface to just over 6°C at the bottom; no thermocline was evident (Figure 3). Dissolved oxygen levels were high and relatively constant from surface to bottom. Lake trout habitat was suitable throughout the entire water column, and optimal between 12 m depth and the bottom.

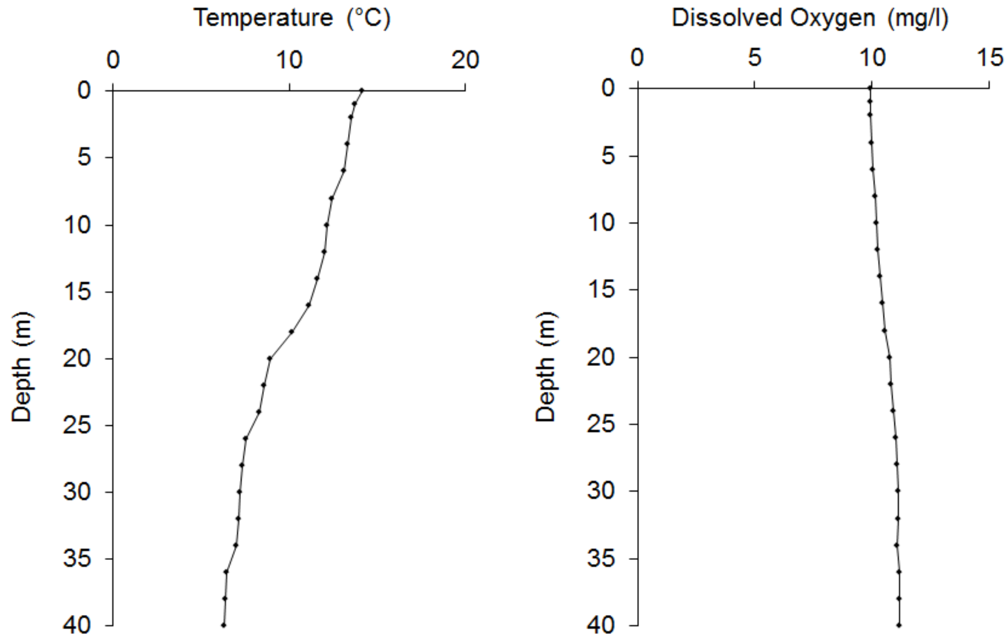

Figure 3. Temperature and dissolved oxygen profiles of Talbot Arm, Kluane Lake, measured 7 August 2013.

Lake Trout

Catch (CPUE), Density, Biomass, and Population Size

We captured 168 lake trout (not including 8 fish <300 mm) in 2013. The mortality rate for lake trout was 31% (54 fish) and we kept stomachs and otoliths from all of these fish. Rough water causing difficult net-handling conditions contributed to higher-than-average lake trout mortality on this survey.

We adjusted the catch to account for net selectivity bias based on the lengths of lake trout captured. The selectivity-adjusted total catch was 180 lake trout (Table 2). After weighting the data by catch in each stratum, we found a lake-wide numerical CPUE of 1.02 lake trout/net (SE = 0.12).

Table 2. Selectivity-adjusted lake trout catch (no. of fish) by stratum, Kluane Lake 2013.

Stratum	Depth Range	Nets Set (%)	Lake Trout Caught	Lake Trout Caught (%)
1	**0 - 10 m**	35%	29	16%
2	**10 - 20 m**	46%	105	58%
3	**20 - 30 m**	17%	35	19%
4	**30 - 40 m**	15%	11	6%
5	**40 - 60 m**	8%	0	0%
6	**0 - 80 m**	8%	0	0%
7	**> 80 m**	0%	0	0%
Total		100%	180	100%

We calculated a biomass CPUE for lake trout without adjusting catch for net selectivity (based on information in Table 3). After weighting the data by catch in each stratum, we found a lake-wide biomass CPUE for lake trout of 2.01 kg/net (SE = 0.04).

Table 3. Non-selectivity-adjusted lake trout catch (biomass in kg) by stratum, Kluane Lake 2013.

Stratum	Depth range	Nets Set (%)	Biomass of Lake Trout Caught (kg)	Biomass of Lake Trout Caught (%)
1	**0 - 10 m**	35%	102.7	28%
2	**10 - 20 m**	46%	202.5	54%
3	**20 - 30 m**	17%	57.9	16%
4	**30 - 40 m**	15%	10.0	3%
5	**40 - 60 m**	8%	0.3	0%
6	**60 - 80 m**	8%	0	0%
7	**> 80 m**	0%	0	0%
Total		100%	373.4	100%

Lake trout density was estimated at 4.2 lake trout / ha, giving a lake-wide abundance estimate of 168,712 lake trout (68% confidence interval: 99,487 – 240,691). Note that before full confidence can be placed on estimates of density and population size, the relationship between CPUE and density should be verified in Yukon.

Size, Age, and Diet

Lake trout populations have different life history strategies, in part depending on the fish community they coexist with. Lake trout in lakes with lake whitefish tend to be larger, on average, than lake trout in lakes without lake whitefish. These large-bodied lake trout populations also tend to mature at a larger size, have a larger maximum size, and have lower population densities than small-bodied lake trout populations (typically found in lakes without lake whitefish).

Lake trout in Kluane Lake coexist with lake whitefish, and are of the large-bodied life history type. Lake trout caught in the 2013 Kluane Lake SPIN survey ranged between 240 and 950 mm, with an average fork length of 552 mm (Figure 4). The mean weight of lake trout was 2,348 g.

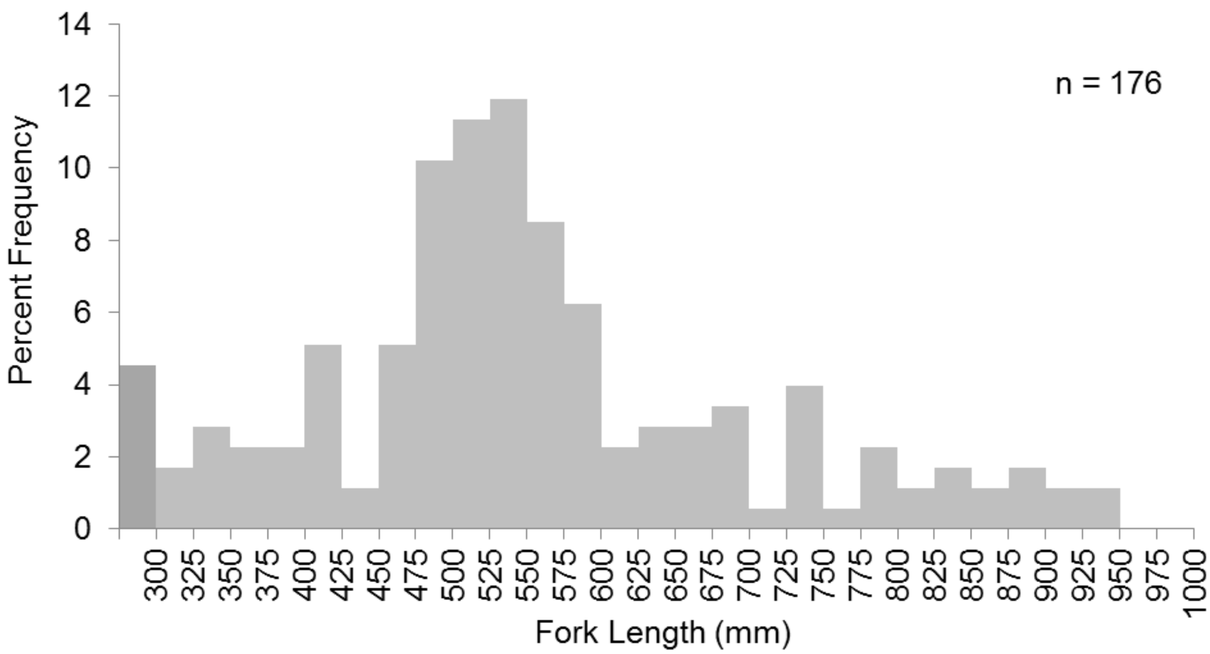

Figure 4. Length distribution of lake trout caught in the Kluane Lake SPIN survey, August 2013. The darker bar on the far left represents 8 fish that were all less than 300 mm.

The lake trout that we aged were 4 – 38 years old, with a mean age of 12 (Figure 5). Length-at-age data from this subset of lake trout indicate steady growth in length until about age 15, after which growth appears to slow considerably (Figure 6). Interpretation of these data are hampered by low sample sizes of trout >15 years old (Figures 5 and 6); large trout tend to have a low mortality rate in SPIN surveys.

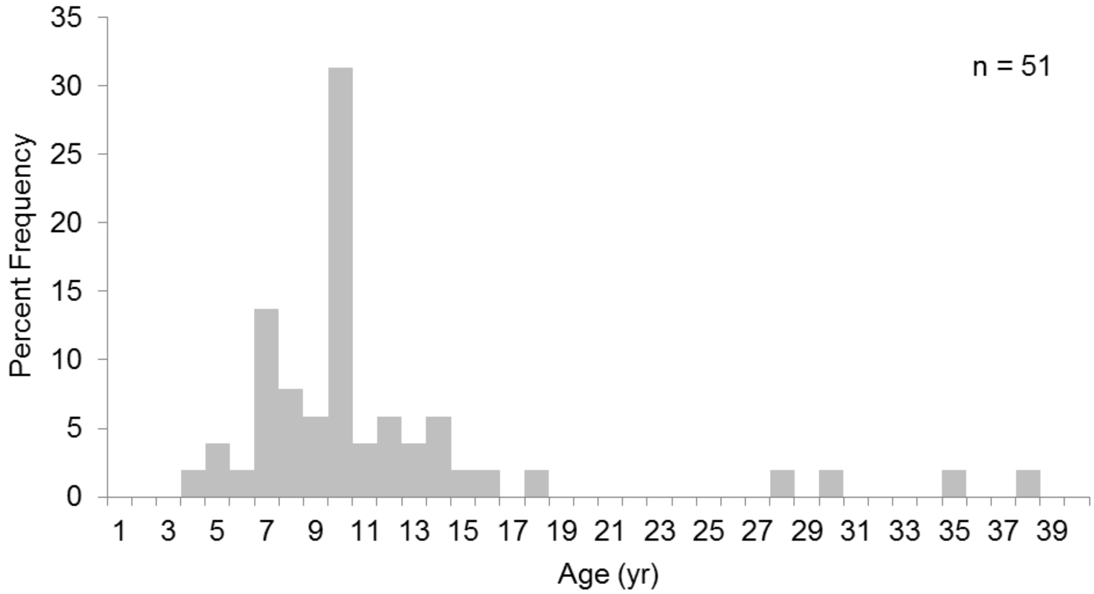

Figure 5. Age distribution of lake trout capture mortalities from Kluane Lake SPIN survey, August 2013.

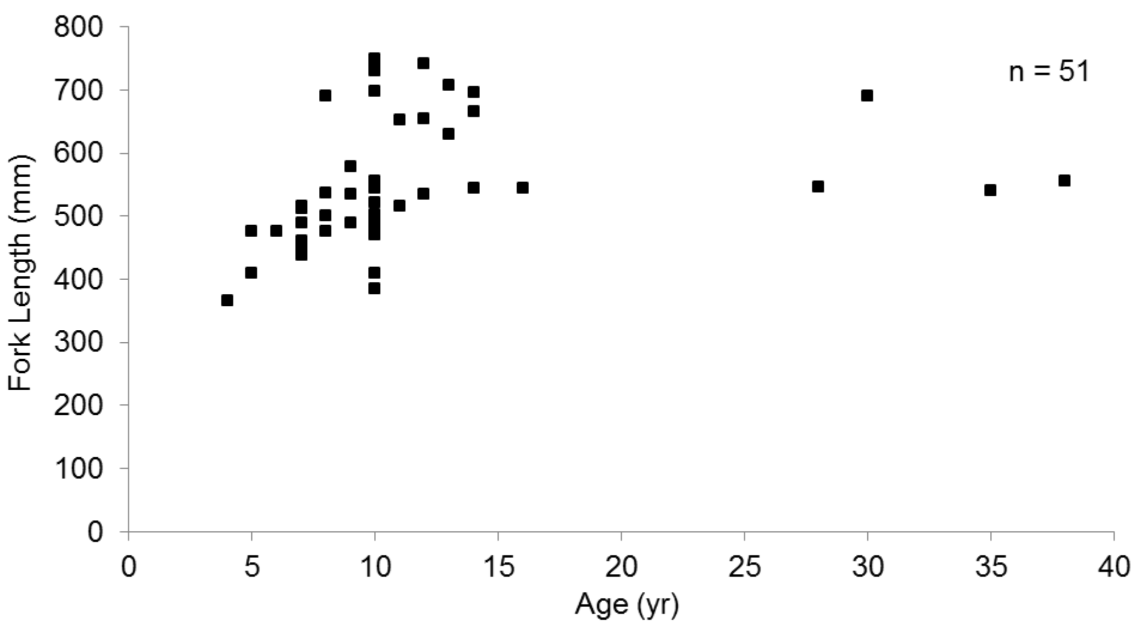

Figure 6. Length at age of lake trout in Kluane Lake, August 2013.

Lake trout in Kluane Lake fed on both invertebrates and fish. We examined stomachs of 52 lake trout, which averaged 25% full. Snails, sculpins, caddisflies and non-biting midges formed the highest proportion of stomach contents, with fish cumulatively comprising 28.9% of diet volume (Table 4).

Table 4. Sampled lake trout stomach contents, Kluane Lake 2013.

Stomach Content	Frequency of Occurrence	Percent volume
Pond snails	13.5%	33.3%
Slimy sculpin	11.5%	14.9%
Caddisflies	19.2%	13.0%
Non-biting midges	32.7%	12.3%
Scuds, sideswimmers	13.5%	7.8%
Unidentified fish	11.5%	7.6%
Unidentified whitefish	3.8%	5.1%
Unidentified invertebrates	11.5%	2.3%
Copepods	5.8%	1.5%
Round whitefish	1.9%	1.3%
Unknown	9.6%	0.8%
Unidentified mammal	1.9%	trace
Unidentified vegetation	3.8%	trace

Lake Whitefish

Catch (CPUE), Density, Biomass, and Population Size

We captured 471 lake whitefish in 2013. The mortality rate for lake whitefish was 54% (252 fish) and we kept stomachs and otoliths from all of these fish. Rough water causing difficult net-handling conditions contributed to higher-than-average lake whitefish mortality on this survey.

We calculated numerical and biomass CPUE for lake whitefish without adjusting for net selectivity (Table 5). After weighting the data by catch in each stratum, we found a lake-wide numerical CPUE of 2.44 lake whitefish/net (SE = 0.36), and a lake-wide biomass CPUE of 1.94 kg lake whitefish/net (SE = 0.16).

Table 5. Non-selectivity-adjusted lake whitefish catch by stratum, Kluane Lake 2013.

Stratum	Depth Range	Nets Set (%)	No. Lake Whitefish Caught	Lake Whitefish Caught (%)	Biomass of Lake Whitefish Caught (kg)	Biomass of Lake Whitefish Caught (%)
1	**0 - 10 m**	29%	50	11%	27.0	7%
2	**10 - 20 m**	35%	322	68%	259.1	69%
3	**20 - 30 m**	13%	83	18%	76.3	20%
4	**30 - 40 m**	11%	16	3%	10.9	3%
5	**40 - 60 m**	6%	0	0%	0	0%
6	**60 - 80 m**	7%	0	0%	0	0%
7	**80 + m**	0%	0	0%	0	0%
Total		100%	471	100%	373.2	100%

Size, Age, and Diet

Lake whitefish caught in the 2013 Kluane Lake SPIN survey were 217 - 545 mm in length (fork length), with an average of 376 mm (Figure 7). The average weight of lake whitefish was 792 g. Lake whitefish 250 – 475 mm fork length were numerous, with few fish falling outside of this range (Figure 7). Kluane Lake lake whitefish were of intermediate length when compared to mean lake whitefish fork lengths from other Yukon lakes (Appendix 2).

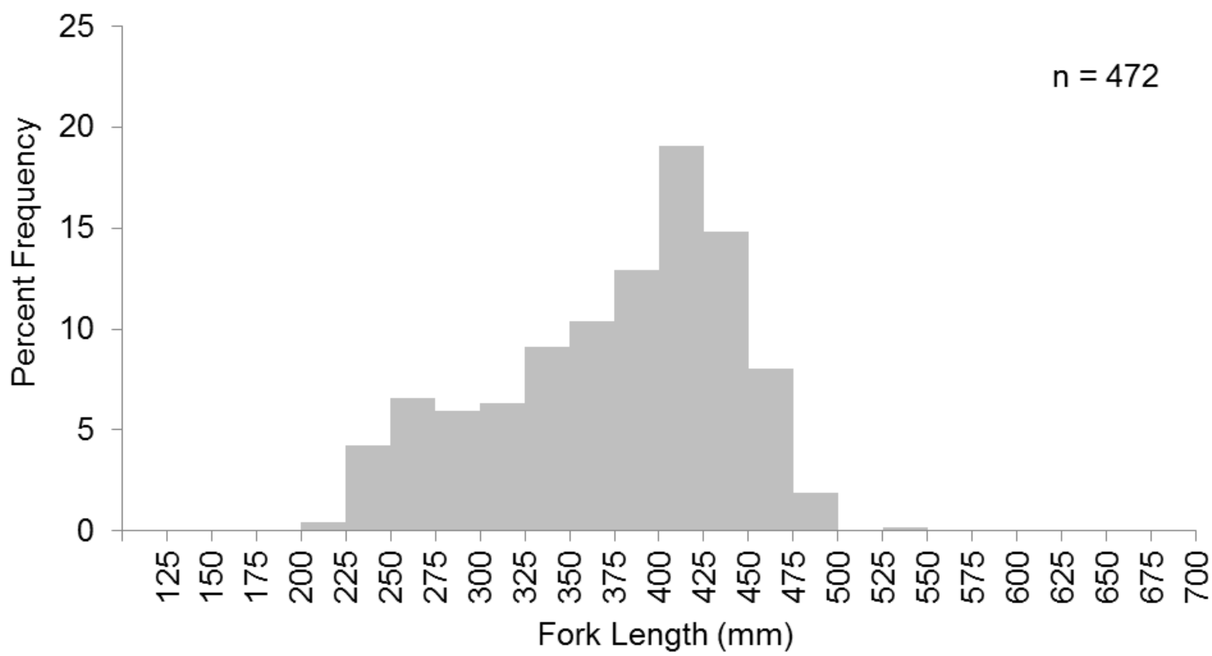

Figure 7. Length distribution of lake whitefish in Kluane Lake, August 2013.

The lake whitefish we aged were 3 – 37 years old, with a mean age of 11 (Figure 8). Length-at-age data from these lake whitefish indicate rapid growth until ages 11 – 14, after which growth slows considerably (Figure 9). Lake whitefish in Kluane Lake appear to reach a maximum fork length of 375 – 475 mm (Figure 9).

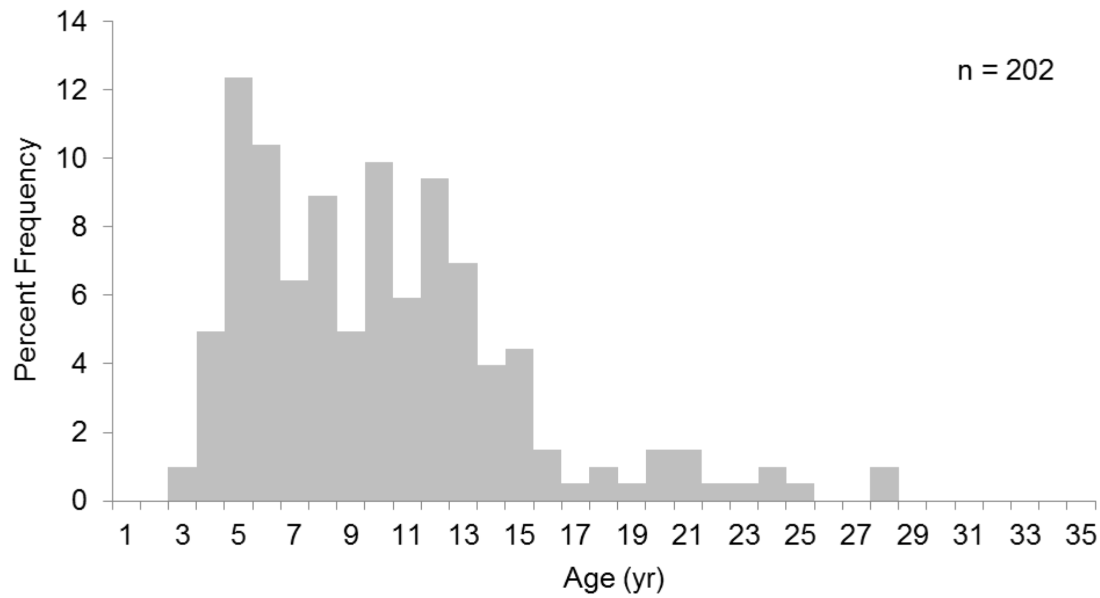

Figure 8. Age distribution of lake whitefish capture mortalities from Kluane Lake SPIN survey, August 2013.

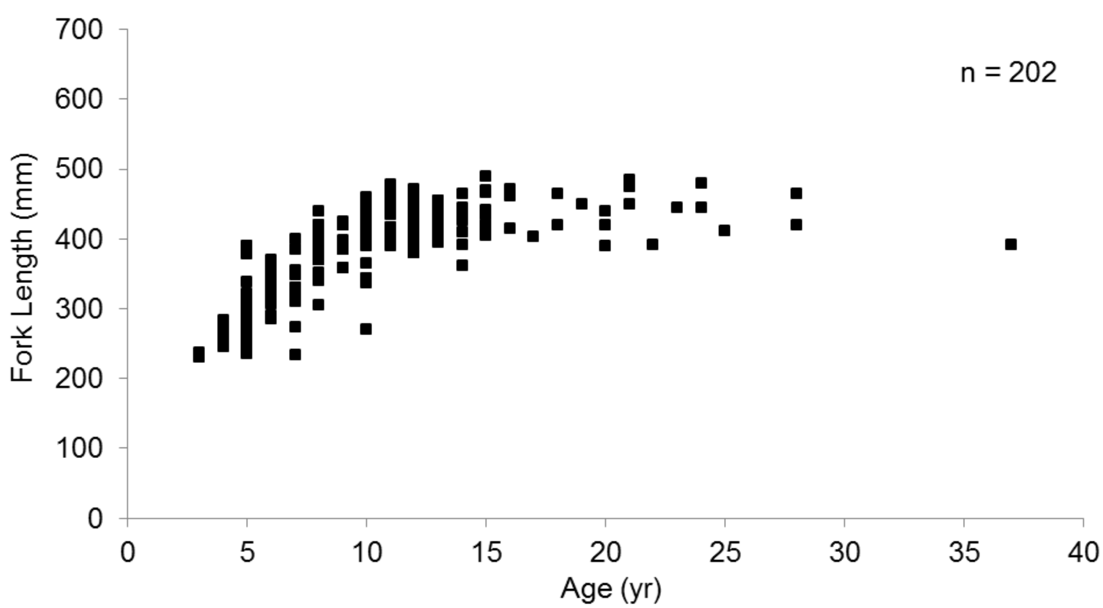

Figure 9. Length at age of lake whitefish in Kluane Lake, August 2013.

We examined 208 lake whitefish stomachs, which averaged 62% full. Snails, clams and mussels, and unidentified invertebrates formed the largest proportion of lake whitefish stomach contents (Table 6).

Table 6. Sampled lake whitefish stomach contents, Kluane Lake 2013.

Stomach Content	Frequency of Occurrence	Percent volume
Orb snails	56.7%	32.4%
Clams, mussels	75.5%	30.6%
Unidentified invertebrates	73.6%	26.2%
Pond snails	20.2%	3.8%
Non-biting midges	51.9%	3.5%
Unknown	47.1%	2.4%
Water mites	36.5%	0.6%
Unidentified vegetation	23.6%	0.4%
Scuds, sideswimmers	9.1%	0.2%
Copepods	3.4%	0.1%
Water fleas	1.9%	0.1%
Unidentified fish	0.5%	trace
Caddisflies	1.4%	trace

Other Species

The majority of fish caught in the 2013 Kluane SPIN survey were lake trout and lake whitefish. Other species captured were longnose sucker (n = 15), round whitefish (n = 11), northern pike (n = 1) and burbot (n = 1). Of these fish, only 4 round whitefish were retained as capture mortalities; age and stomach contents data are not presented.

Inconnu, while known to be present in Kluane Lake, were not caught in this survey.

Results from Previous Surveys

Lake Trout

We caught the same number of lake trout per net in 2004 as in 1999 in small-mesh netting surveys (Table 7). Small-mesh CPUE was slightly lower than the Yukon average for unproductive lakes (total dissolved solids of less than 100 mg/l) with large-bodied lake trout (0.33 lake trout/net) in all years surveyed. These surveys used a method that is quite different from the current method. Nets were set from shore out into the lake only sampling the littoral (nearshore) zone, mesh material and mesh sizes were different, and set duration was only one hour.

Lake Whitefish

We caught fewer lake whitefish per net in 2004 than we did in 1999 in small-mesh netting surveys (Table 7). The small-mesh netting method, however, was not designed specifically to determine lake whitefish relative abundance, and provided low statistical power for detecting changes. A decline in CPUE may not be a statistically different decline and is not a reliable indicator of decline in the lake whitefish population. The lake whitefish CPUE for both small-mesh surveys was higher than the Yukon average for unproductive lake whitefish lakes (0.86 lake whitefish/net).

Table 7. Results of small-mesh netting surveys of Kluane Lake.

	2004	1999
Nets set	271	226
Lake trout caught	69	64
Lake trout numerical CPUE (No. fish / net)	0.25	0.28
Lake whitefish caught	458	581
Lake whitefish numerical CPUE (No. fish / net)	1.69	2.57

Population Status and Conclusions

Lake Trout

Unproductive lakes like Kluane usually have lower lake trout densities than more productive lakes (Burr 1997). As well, lake trout tend to be large-bodied and exist at lower densities in lakes with lake whitefish, compared to lakes where lake whitefish are absent; there they tend to exist at high densities and are small-bodied.

We found that Kluane Lake had a high density of large-bodied lake trout, compared to other large, low-productivity Yukon lakes with lake whitefish populations (Appendix 1). Only one other large-bodied lake trout lake – Dezadeash Lake, a lake with considerably higher estimated productivity – had a higher estimated density of large-bodied lake trout (Appendix 1). Survey results for Kluane Lake indicate a healthy population of large-bodied lake trout for a lake of its size, fish community and productivity.

Previous small-mesh netting surveys found a slightly lower-than-average relative abundance of large-bodied lake trout. Higher results in this survey could indicate a positive response by the lake trout population to more conservative angling regulations introduced in 2004. The power of small-mesh netting surveys to accurately reflect population abundance of lake trout, however, is limited; relative results may have differed between small-mesh and SPIN surveys for methodological reasons alone. We consider SPIN survey results to be more reliable indicators of lake trout abundance (Jessup and Millar 2011).

Recreational and commercial fishing efforts on Kluane Lake are low, and both have decreased over the past decade (Foos 2007, Environment Yukon files). Harvest of lake trout by recreational anglers and commercial fishers has also declined since the early 2000s, and remains much lower than the optimal sustainable yield (Foos 2007, Environment Yukon files).

Lake Whitefish

Unproductive lakes, like Kluane Lake, also tend to have lower lake whitefish densities than more productive lakes. The same is true of lakes that have a low proportion of appropriate lake whitefish habitat (lake areas <20 m deep). We found that Kluane Lake had a high density of lake whitefish compared to other lakes with similar productivity and proportion of lake whitefish habitat (Appendix 2).

Previous small-mesh netting surveys also found higher-than-average abundance of lake whitefish compared to other unproductive lakes.

Lake whitefish harvest on Kluane Lake is primarily through commercial and subsistence fisheries. The commercial lake whitefish harvest is very small, averaging less than 10 kg annually over the past decade (Environment Yukon files). Subsistence harvest levels are unknown.

We do not currently have enough information to determine a sustainable harvest level for lake whitefish. The current low level of harvest, however, is likely well below sustainable limits.

Future Surveys

At the current sample size (n = 129 nets set) and variability of the data, our predicted power to detect changes of 25% in the lake trout relative abundance in Kluane Lake is 0.79 (i.e., if there is a change of 25% or more in the lake trout population, we will detect it 79% of the time). This level of power is appropriate for informing management decisions regarding lake trout populations.

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Appendix 1 – Characteristics of lake trout populations for Yukon lakes.

Lakes are arranged in descending order of estimated lake trout density. Information on lake productivity, fish community, lake trout body size and SPIN survey sample details are included. Lake productivity refers to the annual maximum sustainable yield of all fish and is estimated from physical and chemical information on each lake, independently of fish information. It is estimated following the method proposed by Schlesinger and Regier (1982) of relating mean annual air temperature to the morphoedaphic index (Ryder, 1965). This information is presented so that comparisons can be made between lakes with similar characteristics. Density estimates are based on a relationship between CPUE and lake trout density developed for lakes in Ontario; before full confidence can be placed on estimates of density and population size, the relationship between CPUE and density should be established in Yukon.

Lake	Lake Area (ha)	Lake Productivity (kg fish/ha)	Lake whitefish present?	Lake Trout Morphology	Survey Year	No. of Trout Caught*	Mean Fork Length (mm)*	Mean Weight (g)*	Mean No. of Trout per Net (Numerical CPUE)	Mean Weight of Trout per Net (Biomass CPUE; kg)	Estimated Density (No./ha)	Estimated Density (kg/ha)	Population Estimate
Caribou	51	3.89	No	Small body	2012	84	388	630	3.81	1.71	55.9	35.2	2,851
Fish	1,386	2.44	No	Small body	2012	122	390	720	3.71	2.18	54.4	39.2	75,562
Caribou	51	3.89	No	Small body	2011	89	390	654	3.63	1.18	53.2	34.8	2,716
Lewes	131	3.17	No	Small body	2010	92	358	543	3.31	1.35	48.6	25.9	6,369
Fish	1,386	2.44	No	Small body	2009	66	431	†	2.64	†	38.9	-	53,870
Kathleen	3,398	1.87	No	Small body	2012	188	466	†	2.18	†	‡	-	‡
Kathleen	3,398	1.87	No	Small body	2011	194	448	†	2.14	†	‡	-	‡
Louise (Jackson)	68	3.27	No	Small body	2011	41	409	971	2.02	1.39	29.8	28.9	2,024
Fish	1,386	2.44	No	Small body	2010	53	426	946	2.01	1.46	29.7	28.1	41,787
Kathleen	3,398	1.87	No	Small body	2013	194	480	†	1.86	†	‡	-	‡
Kathleen	3,398	1.87	No	Small body	2010	121	474	†	1.96	†	‡	-	‡
Dezadeash	7,968	3.18	Yes	Large body	2013	228	641	3,323	1.73	4.92	6.3	20.9	50,590
Mush	1,888	2.25	No	Small body	2012	132	436	†	1.18	†	‡	-	‡
Mandanna	786	2.44	Yes	Large body	2013	58	487	1,439	1.11	1.42	4.4	6.3	3,487

Appendix 1- Continued

Lake	Lake Area (ha)	Lake Productivity (kg fish/ha)	Lake whitefish present?	Lake Trout Morphology	Survey Year	No. of Trout Caught*	Mean Fork Length (mm)*	Mean Weight (g)*	Mean No. of Trout per Net (Numerical CPUE)	Mean Weight of Trout per Net (Biomass CPUE; kg)	Estimated Density (No./ha)	Estimated Density (kg/ha)	Population Estimate
Kluane	40,821	1.64	Yes	Large body	2013	176	552	2,348	1.02	2.01	4.2	9.9	168,712
Tetl'ámā̄n	3,141	2.05	Yes	Large body	2011	65	671	4,235	1.00	3.67	4.1	17.4	12,937
Sekulmun	4,985	1.16	Yes	Large body	2010	60	536	2,345	0.88	1.80	3.7	8.7	18,651
Fox	1,602	2.56	Yes	Large body	2013	73	448	1,114	0.75	0.70	3.4	3.8	5,397
Quiet	5,441	1.47	Yes	Large body	2012	170	517	1,781	0.73	1.07	3.3	5.8	17,865
Mayo	9,963	1.20	Yes	Large body	2013	123	456	1,261	0.35	0.14	2.1	2.7	21,229
Frenchman	1,441	2.60	Yes	Large body	2012	15	533	2,475	0.31	0.68	2.0	5.0	2,891
Ethel	4,610	1.42	Yes	Large body	2011	31	573	3,333	0.30	0.71	2.0	6.7	9,102
Tarfu	405	2.74	No (least cisco)	Large body	2010	8	567	2,338	0.20	0.28	1.7	4.0	680
West Twin	153	2.50	Yes	Large body	2013	7	432	1,125	0.15	0.18	1.5	1.7	234
Pine	603	2.87	Yes	Large body	2010	2	503	1,600	0.07	0.11	1.3	2.1	764
Snafu	284	3.58	Yes	Large body	2010	0	-	-	0.00	0.00	-	-	-

* Number of lake trout caught, mean fork length and mean weight all reflect measures for all lake trout (including those <300 mm fork length), without adjusting for net selectivity.

† Data collected on these surveys were insufficient to accurately determine lake trout weight parameters.

‡ Data not available. Contact Parks Canada for more information on Kathleen and Mush lakes.

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Appendix 2 – Characteristics of lake whitefish populations in Yukon lakes.

Lakes are arranged in descending order of numerical lake whitefish CPUE. Lake area less than 20 m in depth is considered potential lake whitefish habitat in Yukon lakes, based on distribution of lake whitefish catches observed in netting surveys. Lake productivity refers to the annual maximum sustainable yield of all fish, and is estimated following the method proposed by Schlesinger and Regier (1982) of relating mean annual air temperature to the morphoedaphic index (Ryder, 1965). This information is presented so that comparisons can be made among lakes.

Lake	Lake Area (ha)	Lake Area <20 m deep (%)	Lake Productivity (kg fish/ha)	Survey Year	No. Lake Whitefish Caught	Mean Fork Length (mm)	Mean Weight (g)	Mean No. of Lake Whitefish per Net (Numerical CPUE)	Mean Weight of Lake Whitefish per Net (Biomass CPUE; kg)
Tatlmain	3,141	39%	2.05	2011	650	335	539	10.14	5.38
Snafu	284	100%	3.54	2010	96	340	572	5.38	3.06
Dezadeash	7,968	100%	3.18	2013	630	307	386	4.36	1.67
Frenchman	1,441	65%	2.60	2012	136	303	427	2.71	1.14
Kluane	40,821	41%	1.64	2013	471	376	792	2.44	1.94
Pine	603	65%	2.87	2010	66	529	2,287	2.32	5.37
West Twin	153	61%	2.50	2013	26	418	1,021	1.49	1.59
Fox	1,602	31%	2.56	2013	261	471	1,324	1.47	1.92
Mandanna	786	52%	2.44	2013	31	491	1,693	0.90	1.53
Mayo	9,963	22%	1.20	2013	52	428	1,176	0.20	0.23
Ethel	4,610	28%	1.42	2011	15	416	1,178	0.18	0.24
Quiet	5,441	13%	1.47	2012	42	454	1,270	0.15	0.19
Sekulmun	4,985	26%	1.16	2010	1	480	1,500	0.01	0.02

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Appendix 3 – Kluane Lake 2013 SPIN set locations.

August 6-11 2013
N = 129 nets set