LAKE TROUT AND LAKE WHITEFISH POPULATION ASSESSMENT

FOX LAKE 2013

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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, Renewable Resources Councils, 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 Fox 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 1994, 2001, and 2006. SPIN provides more statistically robust methods and improves confidence in survey results (Jessup and Millar 2011).

We caught 73 lake trout, resulting in a lake-wide numerical CPUE (catch per unit effort) of 0.75 lake trout per net, and a lake-wide biomass CPUE of 0.71 kg of lake trout per net. The estimated density of lake trout in Fox Lake was 3.4 lake trout per hectare. Fox Lake has a low density of large-bodied lake trout.

We also caught 261 lake whitefish, resulting in a lake-wide numerical CPUE of 1.47 lake whitefish per net, and a lake-wide biomass CPUE of 1.92 kg of lake whitefish per net. Fox Lake has a moderate relative density of lake whitefish.

The size distribution of lake trout caught in the 2013 Fox Lake SPIN survey showed fewer large lake trout than we would expect from a lake where lake trout and lake whitefish coexist, suggesting that large lake trout may have been overharvested in Fox Lake.

Key Findings

- Fox Lake has a low density of large-bodied lake trout.
- Fox Lake has a moderate relative density of lake whitefish.
- We caught fewer large lake trout than expected for a lake where lake trout and lake whitefish coexist.

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Introduction

Each year, Environment Yukon conducts assessment 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 Fox Lake using small-mesh netting in 1994, 2001, and 2006. Differences between the 2 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

Fox Lake is located approximately 60 km north of Whitehorse (Figure 1). The lake sits at an elevation of 957 m above sea level. The lake is approximately 17 km long and covers an area of 1,602 ha. It has a mean depth of 28.6 m and maximum depth of 47 m. The lake is fed by small, seasonal creeks, and drains to the south through Fox Creek into Lake Laberge. Fox Lake is relatively productive compared to other Yukon lakes, with total dissolved solids (a measure of nutrients in the water) of 228 mg/l. Fish species known in Fox Lake are lake trout, lake whitefish, round whitefish, Arctic grayling, northern pike, and burbot.

Fox Lake is easily accessed from the Klondike Highway. There are 2 boat launches, one at the south end of the lake and one at the Yukon government campground near the middle of the lake. There are also residences on the lake. Fox Lake lies within an overlap between Ta'an Kwäch'än Council and Kwanlin Dün First Nation Traditional Territories.

The recreational fishery at Fox Lake has been managed under regulations for General Waters since 1990. For lake trout, the catch limit is 3 fish per day and the possession limit is 6 fish. Only one lake trout may be over 65 cm in length.

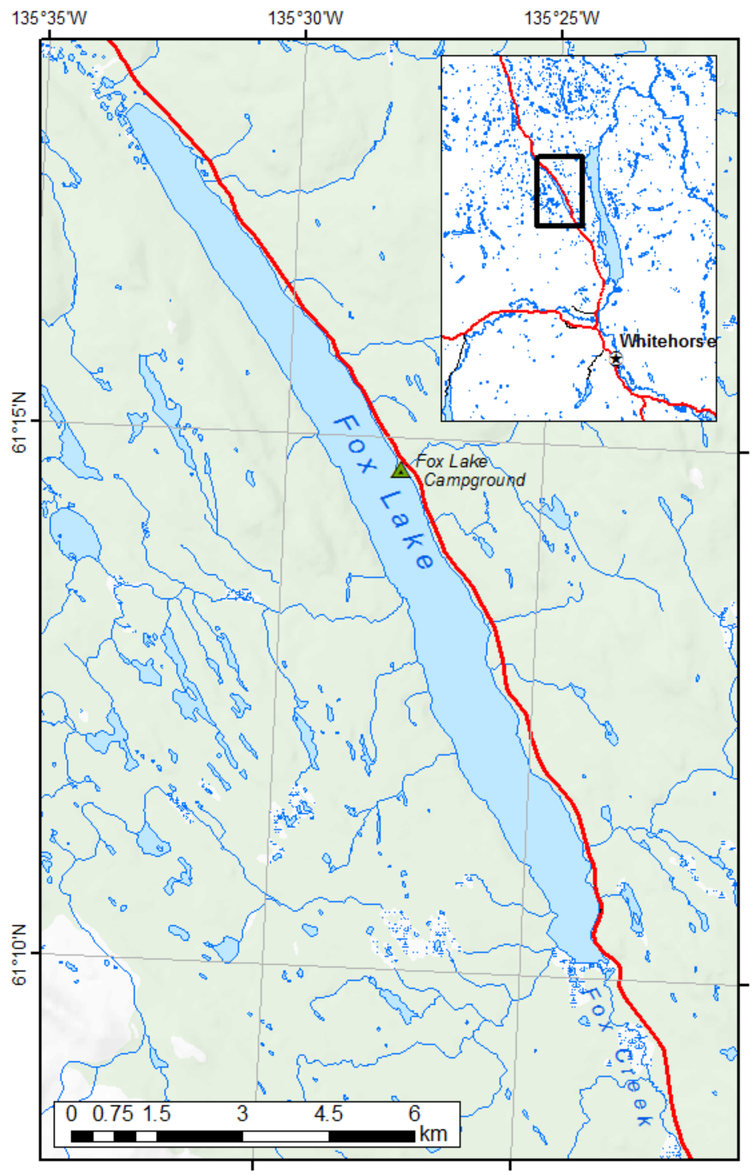

Figure 1. Location of Fox Lake, Yukon.

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 on the bottom 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.

Survey effort

We surveyed Fox Lake 3 – 5 and 10 July 2013. We set a total of 81 nets, divided among 5 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 lake trout 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, Fox Lake 2013.

Stratum	Depth range	Area (ha)	Area (%)	Nets Set	Nets Set (%)
1	**0 - 10 m**	287	18%	35	43%
2	**10 - 20 m**	212	13%	16	20%
3	**20 - 30m**	227	14%	9	11%
4	**30 - 40m**	256	16%	11	14%
5	**> 40 m**	620	39%	10	12%
Total		1,602	100%	81	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). To calculate population-wide percent volume of diet items, we examined the volume of diet items in the stomach of each fish. We also took the fullness of each stomach into account. Each stomach was weighted equally when calculating the population-wide percent volume.

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. The method excludes fish below 300 mm because they are not usually captured by anglers.

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 therefore be compared between surveys and used to detect population growth or decline.

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 (Sandstrom and Lester 2009). 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 ˚C 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 withstand higher maximum temperatures than lake trout.

We took a temperature and dissolved oxygen profile near the middle of Fox Lake on 3 July 2013. The lake was stratified, with the thermocline (zone of steep temperature gradient) between 10 m and 11 m (Figure 2). Temperatures were suitable (12 – 15 °C) between 0–7 m, and optimal (≤12 °C) below 7 m. Dissolved oxygen levels were optimal (>7 mg/L) down to the bottom at 42 m (Figure 3).

Overall, water conditions were suitable between 0 m and 42 m, and optimal between 7 m and 42 m.

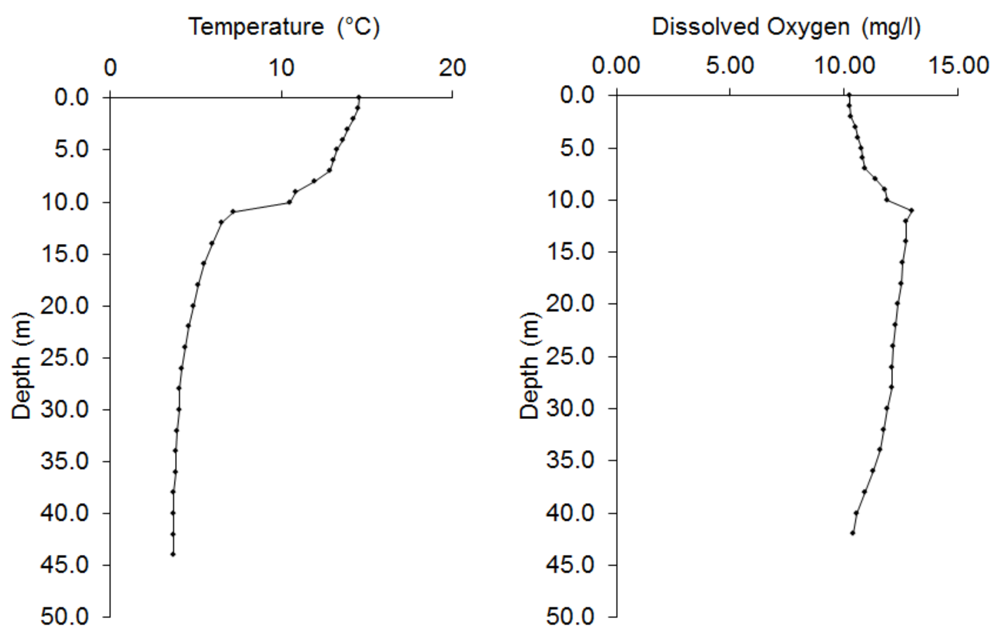

Figure 2. Temperature and dissolved oxygen profiles of Fox Lake measured 3 July 2013.

Lake Trout

CPUE, Density, and Population Size

We caught 73 lake trout. Of these, 72 were longer than 300 mm fork length and our analyses are based on these fish. We adjusted the catch to account for net selectivity bias based on the lengths of lake trout captured. The selectivity-adjusted total catch was 93 lake trout (Table 2). After weighting the data by catch in each strata, we found a lake-wide CPUE of 0.75 lake trout/net (SE = 0.11).

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

Stratum	Depth Range	Nets Set (%)	Lake Trout Caught	Lake Trout Caught (%)
1	**0 - 10 m**	43%	54	59%
2	**10 - 20 m**	20%	20	21%
3	**20 - 30 m**	11%	7	8%
4	**30 - 40 m**	14%	10	11%
5	**> 40 m**	12%	1	2%
Total		100%	93	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 0.71 kg/net (SE = 0.16).

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

Stratum	Depth Range	Nets Set (%)	Biomass of Lake Trout Caught (kg)	Biomass of Lake Trout Caught (%)
1	**0 - 10 m**	43%	41	53%
2	**10 - 20 m**	20%	13	16%
3	**20 - 30 m**	11%	13	17%
4	**30 - 40 m**	14%	10	13%
5	**> 40 m**	12%	1	1%
Total		100%	78	100%

Lake trout density was estimated at 3.4 lake trout/ha, giving a lake-wide abundance estimate of 5,397 lake trout (68% confidence interval: 2,763 – 8,120). Note that before full confidence can be placed on estimates of density and population size, the relationship between CPUE and density should be tested in Yukon.

Of the 73 lake trout we caught, 16 died. This represents a very small proportion of the estimated number of fish in the lake; the survey had a negligible impact on the population.

Size, Age, and Diet

Lake trout populations have different life history strategies, in part depending on the fish community in the lake. 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 whitefish are present in Fox Lake, and lake trout are of the large-bodied life history type. The lake trout caught in the 2013 Fox Lake SPIN survey were smaller than most other large-bodied lake trout in Yukon. Lake trout ranged between 232 and 730 mm, with an average fork length of 448 mm (Figure 4). The mean weight of lake trout was 1,114 g. Very few lake trout longer than 500 mm fork length were captured in this survey (Figure 4).

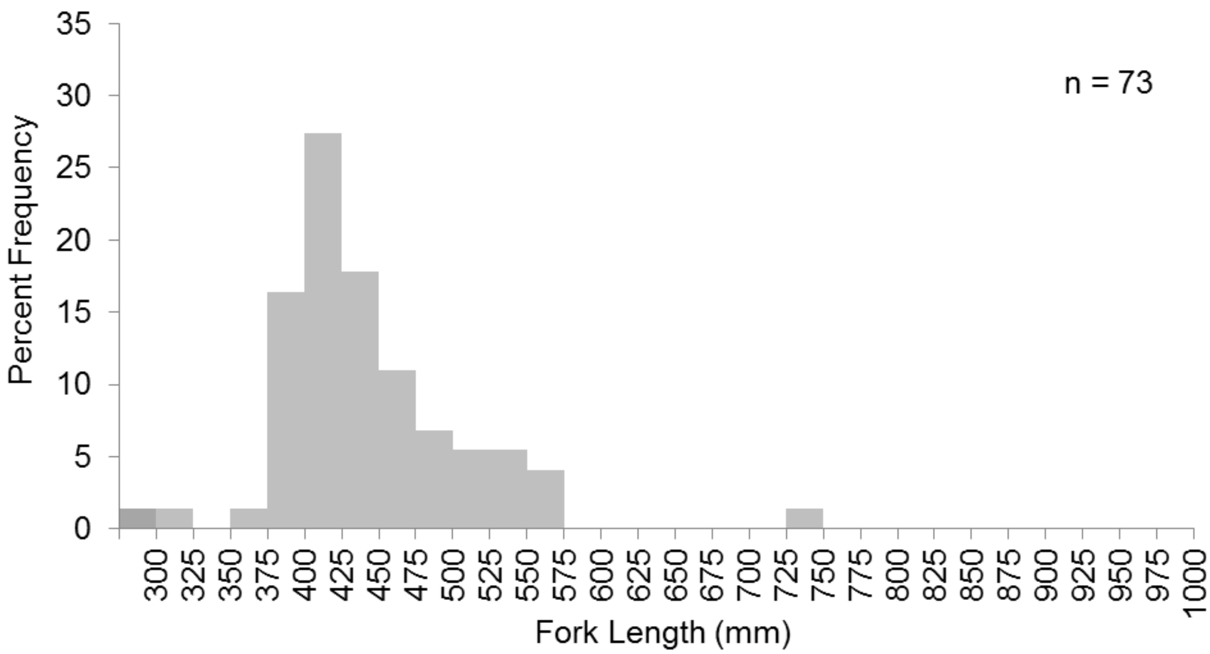

Figure 3. Length distribution of lake trout in Fox Lake, July 2013. Darker gray bar at left indicates fish below 300 mm fork length.

The lake trout that we aged were 3 – 24 years old, with a mean age of 13 (Figure 5). Length-at-age data from this subset of lake trout indicate relatively little growth in length beyond age 10, though interpretation of these data are hampered by low sample sizes of trout <10 years old and >17 years old (Figures 4 and 5); large trout tend to have a low mortality rate in SPIN surveys.

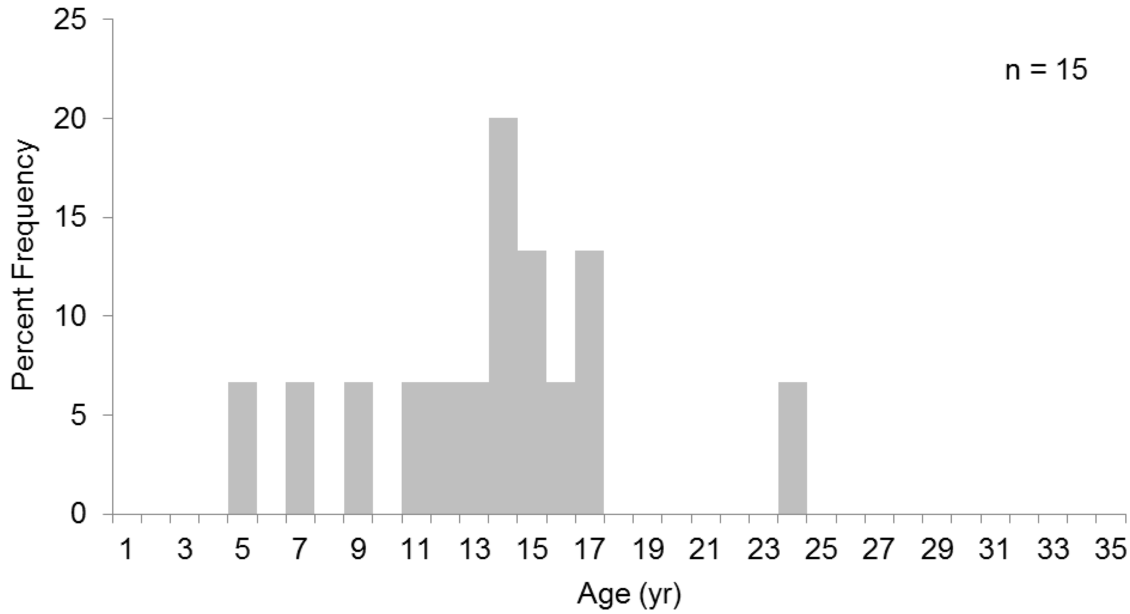

Figure 4. Age distribution of lake trout capture mortalities from Fox Lake SPIN survey, July 2013.

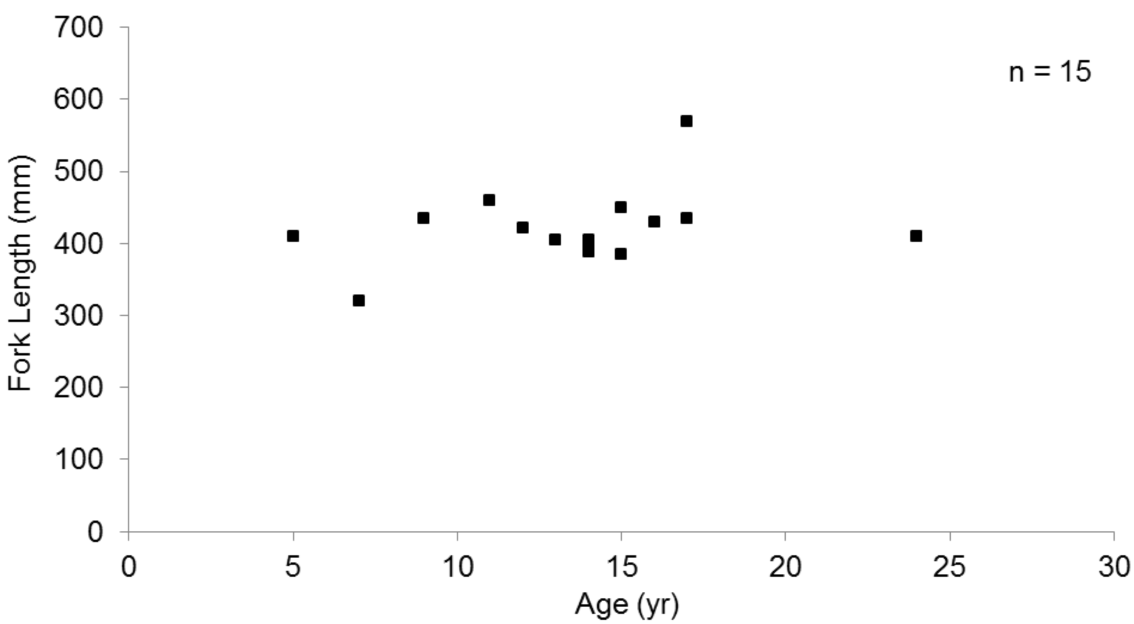

Figure 5. Length at age of lake trout in Fox Lake, July 2013.

We examined 11 lake trout stomachs, which averaged 22% full. Non-biting midges, scuds, and sideswimmers formed the largest proportion of lake trout stomach contents (Table 3).

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

Stomach Content	Frequency of Occurrence	Percent volume
Non-biting midges	78%	55%
Scuds, sideswimmers	44%	17%
Unidentified invertebrates	33%	13%
Caddisflies	33%	7%
Water mites	44%	3%
Unidentified fish	22%	3%
Slimy sculpin	11%	2%
Unidentified vegetation	22%	1%
Orb snails	11%	trace

Lake Whitefish

CPUE, Density, and Population Size

We caught 261 lake whitefish in 2013. 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 1.47 lake whitefish/net (SE = 0.19), and a lake-wide biomass CPUE of 1.92 kg lake whitefish/net (SE = 0.12).

Table 5. Lake whitefish catch by stratum, Fox 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**	43%	224	86%	303	88%
2	**10 - 20 m**	20%	35	13%	41	12%
3	**20 - 30 m**	11%	2	1%	2	1%
4	**30 - 40 m**	14%	0	0%	0	0%
5	**> 40 m**	12%	0	0%	0	0%
Total		100%	261	100%	346	100%

Size, Age, and Diet

Lake whitefish caught in the 2013 Fox Lake SPIN survey were 173 – 565 mm in length (fork length), with an average of 469 mm (Figure 6). The average weight of lake whitefish was 1,328 g. The length distribution was strongly unimodal, with nearly all lake whitefish caught falling between 425 and 550 mm fork length (Figure 6). Fox Lake lake whitefish were relatively large when compared to lake whitefish from other Yukon lakes (Appendix 2).

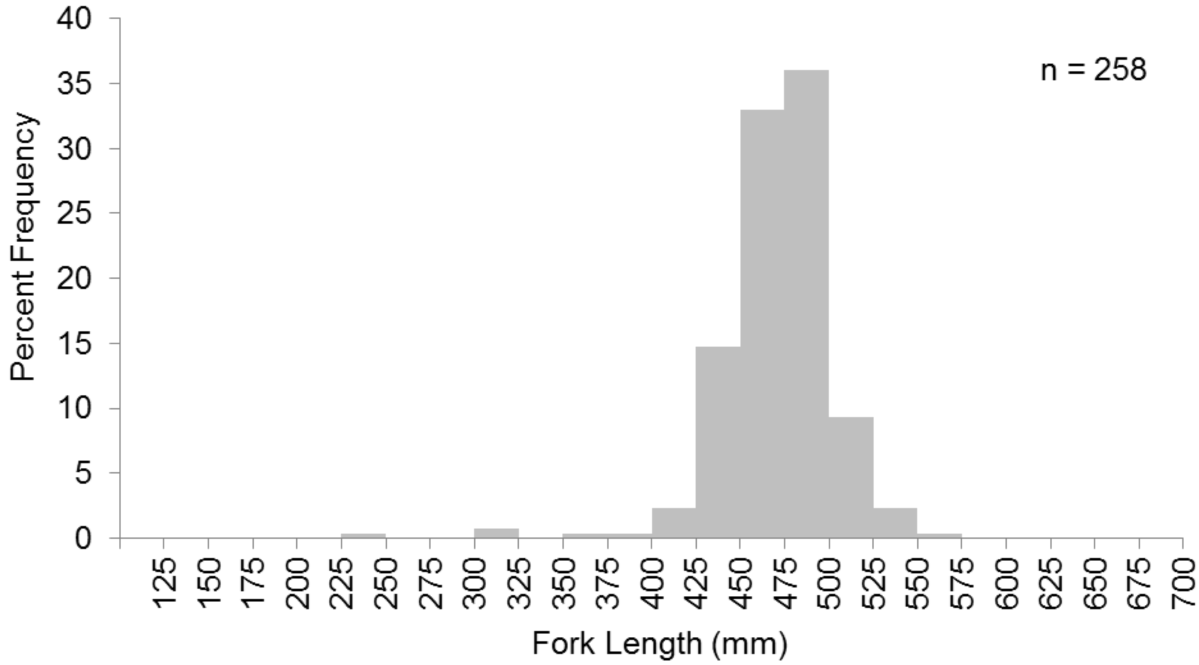

Figure 6 . Length distribution of lake whitefish in Fox Lake, July 2013.

The lake whitefish we aged were 4 – 38 years old, with a mean age of 21 (Figure 7). Length-at-age data from these lake whitefish indicate rapid growth until ages 4 - 5, after which growth slows considerably (Figure 8). Lake whitefish in Fox Lake appear to reach a maximum fork length of 450 – 550 mm (Figure 8).

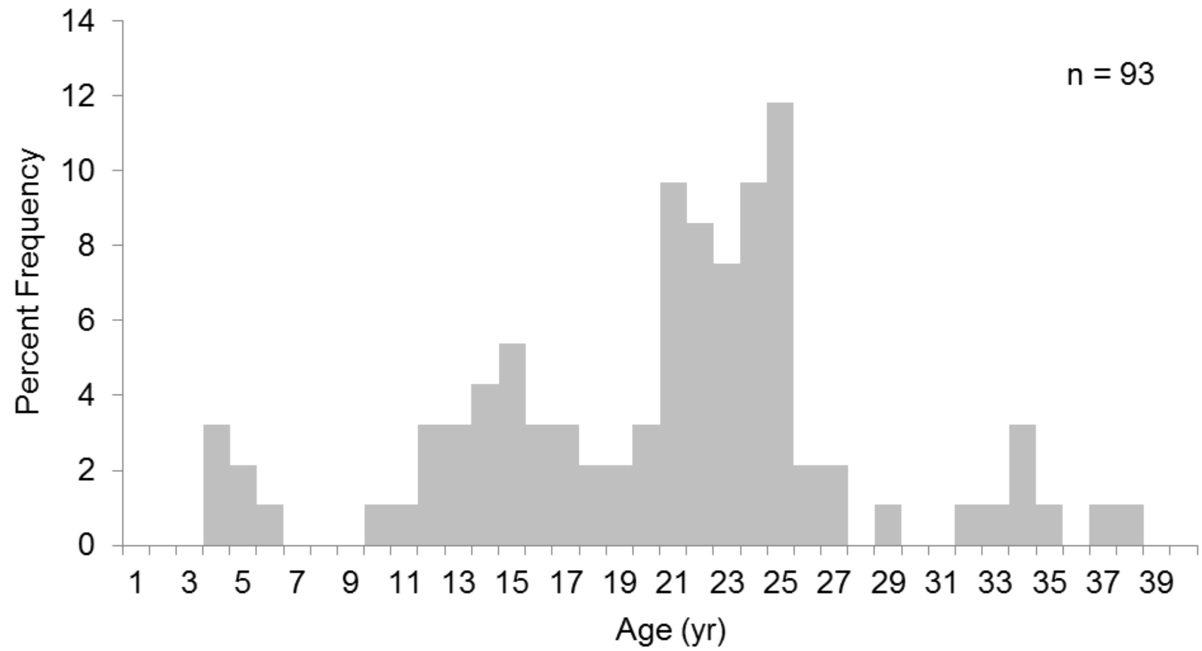

Figure 7. Age distribution of lake whitefish capture mortalities from Fox Lake SPIN survey, July 2013.

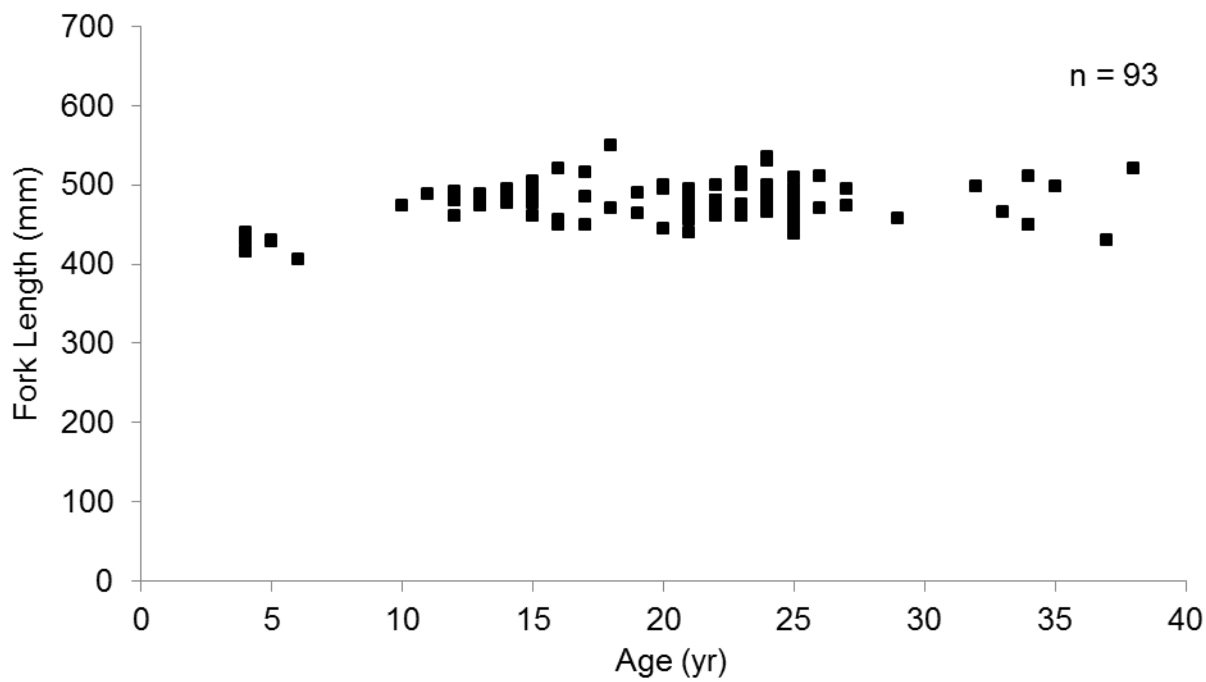

Figure 8. Length at age of lake whitefish in Fox Lake, July 2013.

We examined the stomachs of 69 lake whitefish. They averaged 43% full and were mostly full of snails, scuds, and sideswimmers (Table 6).

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

Stomach Content	Frequency of Occurrence	Percent volume
Pond snails	43%	30%
Orb snails	51%	20%
Scuds, sideswimmers	40%	18%
Caddisflies	26%	7%
Non-biting midges	26%	6%
Slimy sculpin	9%	4%
Unidentified invertebrates	9%	3%
Water mites	17%	2%
Snails	5%	2%
Unidentified vegetation	19%	2%
Water fleas	2%	2%
Unknown items	8%	1%
Unidentified fish	3%	1%
Leeches	6%	1%

Other Species

The majority of fish caught in the 2013 Fox SPIN survey were lake trout and lake whitefish. Other species captured were round whitefish (n = 137), Arctic grayling (n = 15), and northern pike (n = 3). Of these fish, 35 round whitefish and one Arctic grayling were retained as capture mortalities.

Round whitefish ranged from 245 mm to 410 mm in fork length, with an average of 357 mm. The round whitefish we aged were 4 – 24 years old, with a mean age of 10. Diet data are recorded in the Department of Environment's database.

Arctic grayling ranged from 130 mm to 395 mm in fork length, with an average of 327 mm. Diet and age data recorded in the Department of Environment's database.

Burbot, while known to be present in Fox Lake, were not caught in this survey. Burbot are not highly susceptible to capture in gillnets used for SPIN surveys.

Results from Previous Surveys

Lake Trout

In small-mesh netting surveys we caught more lake trout in 2006 than in 2001, though slightly fewer than in the first survey in 1994 (Table 7). Small-mesh CPUE was higher than the Yukon average for productive lakes (those lakes with total dissolved solids of greater than 100 mg/L) with large-bodied lake trout (0.46 lake trout/net) in 2006, much lower than the average in 2004, and close to the average in 1994. 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. The power of small-mesh netting surveys to accurately reflect population abundance of lake trout is limited; we consider SPIN survey results to be more reliable indicators of lake trout abundance (Jessup and Millar 2011).

Lake Whitefish

We caught fewer lake whitefish per net in small-mesh netting surveys in 2006 than we did in 2004, and many fewer than in 1994 (Table 7). The small-mesh netting method, however, was not designed specifically to determine relative abundance of lake whitefish, 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 all small-mesh surveys was higher than the Yukon average for productive lake whitefish lakes (1.56 lake whitefish/net).

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

	2006	**2001**	**1994**
Nets set	12	12	24
Lake trout caught	8	2	10
Lake trout numerical CPUE (No. fish/net)	0.67	0.17	0.42
Lake whitefish caught	20	23	71
Lake whitefish numerical CPUE (No. fish/net)	1.67	1.92	2.96

Population Status and Conclusions

Lake Trout

The lake trout population in Fox Lake is likely depleted. This appears particularly true for larger lake trout in Fox Lake, which were caught much less frequently than would be expected. Multiple lines of evidence (low lake trout density compared to other similar lakes, smaller-than-expected fish, high angler effort and harvest, and regulations that allow for harvest of large fish) support this conclusion.

Lake trout in lakes where lake whitefish are present tend to be large-bodied, and exist at lower densities, compared to lakes where lake whitefish are absent. Where lake whitefish are absent, lake trout tend to exist at high densities and are small-bodied. Productive lakes like Fox Lake, however, usually have higher lake trout densities than less productive lakes (Burr 1997).

When compared to other lakes that also have lake whitefish, Fox Lake had a lower than expected density of large-bodied lake trout (Appendix 1). Dezadeash, Mandanna, Kluane, Tetl'ámän, and Sekulmun lakes are all less productive than Fox Lake but all have a higher density of lake trout (Appendix 1). A number of other lakes with large-bodied lake trout (Frenchman, Tarfu, West Twin, Pine, Snafu) have lower lake trout densities than Fox Lake despite being similarly productive. However, the lake trout population in each of these lakes shows signs of being depleted.

The size distribution of lake trout caught in the 2013 Fox Lake SPIN survey showed a smaller mean fork length, and fewer large lake trout, than would be expected of a Yukon lake where lake trout coexist with lake whitefish (Appendix 1, Environment Yukon files). This scarcity of large lake trout, compared to other similar Yukon lakes, could indicate that harvest pressure has disproportionately affected large lake trout in the Fox Lake population. From other studies we know that anglers catch large lake trout in greater proportion than they exist in the population (Millar et al. 2014). General Waters regulations on Fox Lake allow anglers to harvest lake trout >65 cm total length (compared to regulations for Conservation Waters where all lake trout 65 – 100 cm total length must be released, and many waterbodies managed as Special Management Waters where all lake trout >65 cm total length must be released).

Recreational fishing effort on Fox Lake is very high, and shows a trend of rapid increase over the past decade (Foos et al. *in prep.*, Environment Yukon files). Harvest of lake trout by recreational anglers nearly doubled between 2001 and 2013, and exceeded sustainable levels in 2013 (Foos et al. *in prep.*, Environment Yukon files). Harvest above sustainable levels can lead to depletion of lake trout populations. In addition, this harvest pressure, combined with regulations allowing for harvest of large lake trout, may have altered the size distribution of the Fox Lake lake trout population through selective harvest of large fish.

Lake Whitefish

Productive lakes, like Fox Lake, also tend to have higher lake whitefish densities than less productive lakes. Lakes with a lower proportion of preferred lake whitefish habitat (lake areas < 20 m deep), however, tend to have lower lake whitefish densities than those with a higher proportion of appropriate habitat. We found that Fox Lake had a moderate density of lake whitefish, compared to other lakes with similar productivity and proportion of lake whitefish habitat (Appendix 2).

In our previous small-mesh netting surveys we found a higher-than-average abundance of lake whitefish, compared to other productive lakes.

Recreational lake whitefish harvest on Fox Lake is very small, estimated at 17 kg annually in the most recent angler harvest survey (Foos et al. *in prep.*, Environment Yukon files). Subsistence harvest levels are not known.

Future Surveys

At the current sample size (n = 81 nets set) and variability of the data, our predicted power to detect changes of 25% in the lake trout relative abundance in Fox Lake is 0.62 (i.e., if there is a change of 25% or more in the lake trout population, we will detect it 62% of the time). In order to detect change with a power of 80% (a common management goal), sample size would need to be increased to an estimated 126 sets. Increasing sample size to this level would represent a significant increase in effort, and is not recommended.

The power to detect change provided by SPIN surveys of Yukon lakes with depleted lake trout densities has generally been poor (Environment Yukon files). Recovery of lake trout populations in these lakes to a non-depleted state, however, often requires an increase of greater than 25%; a repeat SPIN survey in future would likely be powerful enough to detect such an increase without a substantial increase in sample size (number of nets set).

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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	1,449	1.11	1.41	4.4	6.4	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'ámān̈	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 preferred 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)
Tetl'ámā̲n	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 – Fox Lake 2013 SPIN set locations.