Yukon

SR-23-14

Lake Trout and Lake Whitefish Monitoring Program

10-year adaptive monitoring strategy (2023 – 2032)

January 2023

Lake Trout and Lake Whitefish Monitoring Program 10-year adaptive monitoring strategy (2023 – 2032)

Government of Yukon
Fish and Wildlife Branch
SR-23-14

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Suggested Citation
Sinclair, C.L., and P. Savage. 2023. Lake Trout and Lake Whitefish Monitoring Program: 10-year adaptive monitoring strategy (2023-2032), (SR-23-14). Government of Yukon, Whitehorse, Yukon, Canada.

Executive Summary

Each year the Department of Environment conducts lake trout and lake whitefish assessments across the Yukon, providing data to determine the health and sustainability of these freshwater species. Since this program began in 2010, we have generated a representative baseline of data across the Yukon. To improve on this baseline and to set out a schedule for future sampling, we have created a 10-year adaptive strategy for the Lake Trout and Lake Whitefish Monitoring Program.

The strategy aims to achieve multiple objectives, including needs-based sampling, enhanced climate change monitoring, the facilitation of comparative modelling, and an adaptive approach to data analysis.

To achieve the above objectives, we have developed selection criteria, which will be employed to determine priority lakes for sampling. Our selection criteria consist of two tiers, primary and secondary, each designed to address specific goals.

For the primary criteria, we selected lakes that are subject to conditions that require greater monitoring. These conditions include low catch rates, heavy angling pressure, and their proximity to communities. In addition, we prioritized lakes based on whether they were important to local communities or whether they may be influenced by major developments, such as hydro projects. Any lake that had two or more of our primary criteria was given sampling priority.

The secondary criteria involve key factors that may affect lakes in the future but are not of immediate concern. These factors highlight other important considerations, including lakes that might contain small-bodied lake trout, locations susceptible to climate change impacts, or are in proximity to popular recreational camping areas with high fishing pressure, and lakes identified as Special Management Areas. By considering both primary and secondary criteria, we ensure that our monitoring efforts are comprehensive and tailored to the unique challenges of the Yukon.

This report recommends a 10-year monitoring schedule that accounts for immediate program requirements but also remains adaptable to emerging trends. This flexible approach ensures that the monitoring efforts remain responsive to changing circumstances, allowing us to adapt and change, while maintaining the effectiveness of the Lake Trout and Lake Whitefish Monitoring Program.

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Introduction

Overview

The Department of Environment has been conducting yearly lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis)* monitoring surveys since 2010 (Government of Yukon, 2023). The goal of this monitoring is to provide scientific data to determine the health and sustainability of Yukon's lake trout and whitefish populations. This data allows us to conduct analyses from which regulatory actions can be developed, if required.

Since the inception of this program, we have randomly surveyed lakes, placing emphasis on achieving cross-sectional representation for the territory. While this approach allowed us to acquire good baseline data for many territorial lakes, it did not allow for intensive monitoring of individual lakes. Thus, it has made it difficult to accurately assess the long-term effects of angling pressure, human population changes and environmental changes on fish populations for single lakes. This is particularly true for lakes located near the urban Whitehorse area, which has seen a 24% population increase over the past ten years (Government of Yukon, 2022a).

To rectify this situation, Yukon Fisheries has developed a 10-year adaptive monitoring strategy for the Lake Trout and Lake Whitefish Monitoring Program. Herein, we describe our criteria and process for selecting candidate lakes that are suitable for incorporation into the strategy. We also outline our 10-year schedule for conducting assessments.

Objectives

Our objectives for this adaptive strategy are to:

1. **Increase replicate sampling for lakes of concern.** Emphasizes increased sampling for lakes where the fish populations are showing signs of population decline, or where angling pressure is high. Increasing the frequency of sampling will provide more data to better determine the underlying causes of the population declines, enabling us to devise management solutions.
2. **Improve the methods and frequency of sampling, in support of recovery planning.** Lakes with recovering lake trout populations require special attention. Intensifying our monitoring efforts allows us to assess the efficacy of our management plans, modifying our recovery strategies, as needed.
3. **Enhance monitoring to determine the influences of climate change on lake trout populations.** By expanding our monitoring to include climate-related variables, we aim to better understand and predict how climate change may affect these species.
4. **Allow for comparative modelling by sampling waterbodies of similar area, depth, and overall morphometry**. By focusing on lakes with similar features—such as size, depth, and shape—we can identify common patterns and unique trends, leading to more accurate predictions of their population dynamics.
5. **Provide an adaptive approach to integrate new data and review assessment priorities.** As added information is analyzed, or as concerns emerge, our approach ensures that the latest data is incorporated into our monitoring efforts, enabling informed decisions.

Adaptive management approach

This 10-year adaptive monitoring plan is based on our current data and program limitations. However, as the program develops, we will collect additional data which will help improve the selection process. The monitoring strategy is adaptive and an iterative process, whereby we will routinely reassess our priority lakes based on the established criteria. Over time, these reevaluations may result in demoting or removing previously prioritized lakes. In turn, this may change our assessment timelines. This process will aid in ensuring populations of concern receive appropriate attention.

Data and Limitations

To identify and prioritize lakes for inclusion in this 10-year adaptive monitoring strategy, we developed primary and secondary selection criteria based on data collected from our Lake Trout and Lake Whitefish Monitoring and Angler Survey Programs. Specifically, we used data from the Lake Trout and Lake Whitefish Monitoring Program, conducted from 2010 through 2022 and our Angler Survey Program, conducted from 1990 through 2022. Together, these two datasets represent most of the available information for Yukon's lake trout populations and its recreational fisheries. However, when prioritizing lakes for sampling, we considered certain data limitations. These limitations included:

Data limitations

- Recreational angling pressure has only been assessed for 30 of the 44 lakes in the Lake Trout and Lake Whitefish Monitoring Program.
- In the past, emphasis has not been placed on collecting biological samples; therefore, there is insufficient age, growth, and maturity data to compare within or among lake trout populations.
- The collection of data related to habitat has been scarce. Therefore, it is difficult to determine whether smaller lake trout numbers, witnessed in some lakes, exist because of heavy angling pressure or habitat limitations.

Program limitations

In addition to our data limitations, consideration was also given to capacity limitations in the fisheries program when setting priorities. These limitations included:

- The current staffing level only permits 3-5 lake assessments per year.
- Our current equipment inventory can only support two crews, simultaneously sampling.
- There is a limited timing window for sampling, when summer water temperatures are appropriate to sample lake trout and whitefish populations. Lakes in the Yukon typically stratify in July and begin to cool again by August. Based on our current operational capacity, this short window does not allow for more than a maximum of 2-3 large lakes (size classes E-F) or four small lakes (size classes A-D) to be sampled per season.

Selection Criteria

To select and prioritize lakes, we developed a two-staged criteria framework. We applied a primary criteria (P) to identify candidate lakes with potential vulnerable fish populations. Candidate lakes were selected based on their lake trout population density (catch-per-unit-effort), angling pressure (angling hours per hectare), proximity to human populations, and whether the lake had been identified as a waterbody of local concern (regional concern and major project areas) (Table 1).

To further prioritize the candidate lakes, we applied a secondary criterion (S). Our secondary criteria included: whether lakes contained small or large bodied lake trout, were vulnerable to long-term climate change effects, were in proximity to territorial campgrounds or if the lakes had been previously identified as having special management concerns (Table 1).

Table 1. Primary (P) and secondary (S) selection criteria used to develop a list of priority sampling lakes to enable the development of the 10-year monitoring plan.

Criteria #	Selection criteria	Details
P1	**Low catch-per-unit-effort**	Lakes where the CPUE (# fish/ 2-hour-net-set) from prior SPIN assessments were: Less than or equal to 0.25 for large-bodied Lake Trout; and Less than or equal to 2.02 for small-bodied Lake Trout.
P2	**High recreational angling pressure**	Lakes with mean estimated summer angling pressure (hours/hectare): Greater than or equal to 2.02 for large-bodied Lake Trout; and Greater than or equal to 3.51 for small-bodied Lake Trout.
P3	**Located near Yukon community**	Lakes within a 50 km radius of Yukon urban or rural areas with human populations greater than 200.
P5	**Regional concern**	Lakes identified by regional staff based on their local importance or voiced local concerns.
P4	**Major project concern**	Lakes where major projects are being conducted (e.g., hydroelectric).
S1	**Small-bodied morphology**	Lakes that have a known small-bodied Lake Trout population.
S2	**Climate concern**	Lakes where climate change may pose an increasing threat to sustainable populations or change in population structure.
S3	**Campground access with Low-moderate CPUE or high angling pressure**	Large-bodied Lake Trout lakes adjacent to a territorial campground where either low-moderate CPUE (≤0.60) or high angling pressure (>2.02) has been observed. These lakes are at higher risk of becoming vulnerable.
S4	**Special management concern**	Lakes identified in various management plans and co-management initiatives across the Yukon (e.g., Territorial Parks, Habitat Protection Areas, and Special Management Areas).

The following sub-sections detail the definitions for each criterion and the metrics we employed to prioritize the rankings.

Primary Selection Criteria

Criterion P1: Low catch-per-unit-effort (CPUE)

We chose to use Catch-per-unit-effort (CPUE) as a coarse measure for lake trout abundance. Catch-per-unit-effort (CPUE) can be defined as the number of fish caught for a unit of fishing effort. It is often used as an indirect measure of fish abundance. In general, a stable CPUE infers that the lake trout

population is stable while a declining CPUE infers that the fish population is becoming smaller or less dense.

We are aware that, in practice, there are complications with the use of CPUE because it is seldom proportional to abundance. For example, CPUE can be influenced by the ability of our sampling to capture lake trout (i.e., the catchability) and the catchability can be influenced by abiotic and biotic conditions such as water temperature, habitat types, abundance, species composition and their behaviours.

To overcome some of these difficulties, Yukon's Summer Profundal Index Netting Program (SPIN) has specific sampling protocols that standardize the inherent biases associated with the use of CPUE and the variation in catchability. For example, within a depth stratum, our nets are set randomly and proportionately to the level of abundance. Sets are standardized by both length and mesh size and are set for a standardized period (approximately 2 hours per set). In addition, the SPIN method, which was adopted from the Ontario Ministry of Natural Resources, was originally calibrated to density. As such, biases associated with CPUE are consistent across net sets and comparable within strata. Thus, it provides a coarse index of abundance (Shuter et al. 1998; Sandstrom and Lester 2009).

Metric

As previously stated, CPUE may vary depending on available habitat, lake productivity, fishing pressure and the morphology of the lake trout present (i.e., variations in density with small-bodied vs. large-bodied populations). In the Yukon, we have observed log-linear relationships between lake trout CPUE (#fish/2-hour net set) and lake size (ha). However, this relationship is influenced by the amount of angling pressure (hours/ha). Whereby, catch rates in lakes containing large-bodied lake trout tend to increase with lake size but decline where there are higher rates of angling pressure. Additionally, lakes with small-bodied lake trout tend to have higher CPUE due to their densities (i.e., the smaller bodied lake trout tend to exist at higher densities than lakes containing large-bodied lake trout). As such, we cannot directly compare CPUE measurements among all lakes; we first must separate lakes into sub-groups, based on whether they contain small-bodied and large-bodied lake trout. Then classify each sub-group as having low, moderate, or high catch rates based on their relative CPUE.

CPUE for lakes containing the large-bodied form range from 0.07 to 3.21 fish/2hr, with a median of 0.67. While lakes containing the small-bodied form range from 1.38 to 4.64 fish/2hr, with a median of 2.70. All large-bodied CPUE values were less than or equal to the lowest small-bodied CPUE value, with one exception, Dezadeash Lake which had a CPUE in 2020 of 3.21 fish/2 hrs. This large CPUE is attributable to the bathymetry and water clarity of Dezadeash Lake, which is very shallow and turbid; this in turn increased the efficiency of the nets during sampling.

We based our definitions of low, low-moderate, moderate-high, and high catch rates on the 25th, 50th, and 75th percentile groupings for each subgrouping (Table 2). **For this strategic plan, we defined Criterion P1, *low catch-per-unit-effort*, as all values ≤25th percentile.**

Table 2. The breakdown of catch-per-unit-effort (CPUE, #fish/2-hour net set) thresholds for small-bodied and large-bodied Lake Trout based on percentile groups for CPUE values calculated during Lake Trout and Lake Whitefish Monitoring Program surveys between 2010 and 2020. N = sample size, which corresponds to the number of CPUE estimates used to generate percentiles.

	CPUE Thresholds (Percentile)			
Morph Type	**Low (≤25%)**	**Low-Moderate (>25% to 50%)**	**Moderate-High (>50% to 75%)**	**High (>75%)**
Small-Bodied N = 9	≤2.02	>2.02 to 2.70	>2.70 to 3.72	>3.72
Large-Bodied N = 47	≤0.25	>0.25 to 0.60	>0.60 to 0.88	>0.88

Criterion P2: Recreational angling pressure

To serve as an index of angling pressure we used angler effort data collected during the open water period (spring and summer months). In general, Yukon only collects recreational angling data during the summer, and therefore this data represents our most comprehensive data set. Recreational angling pressure is calculated as the total estimated recreational summer angling effort (fishing hours; McCormick and Meyer 2017) divided by lake surface area (ha). While total recreational angling effort does not allow for the distinction between hours fished for lake trout vs. other species, we assumed that an increase in total angling effort is likely to result in a higher proportion of lake trout anglers regardless of the dominant fishery type.

Like net CPUE, recreational angling pressure is lake specific and difficult to compare among waterbodies. How much angling pressure a lake can sustain is dependent on its overall productivity, size, habitat type, species composition, and population structure. However, lakes subjected to high or increasing rates of recreational angling pressure may warrant the need for increased monitoring to determine if these lake trout populations can sustain the pressure.

Metric

The Government of Yukon has collected angler survey data since 1990. This sampling program is conducted independently of the Lake Trout and Lake Whitefish Monitoring Program. Angler surveys have not been conducted equally across all Yukon lakes, resulting in differing amounts of data for individual waterbodies. In general, data sets range between one to seven years, with angling pressure varying in accordance with the survey year. Therefore, to obtain a representative value for each waterbody, an individual lake's angling pressure was averaged across all its available survey years. Resulting averages were then used for this selection criterion.

Using the data described above, we observed log-linear relationships between total angling effort (hours) and waterbody size (ha) and between angling pressure (hours/ha) and lake size. Wherein larger lakes tended to have higher total angling effort but experienced less overall angling pressure relative to smaller lakes. Given this observation, we believed it was prudent to categorize recreational angling pressure based on lake size classes. However, we found most Yukon lakes larger than 2,500 ha (size classes D, E and F) do not currently experience levels of angling pressure that influence their fish populations. We therefore decided on a different approach to categorize our lakes.

Across our sampled waterbodies, variation in angling pressure was greatest in lakes 101 to 1,000 ha in size (size class B), most of which contain large-bodied morphotypes. While small-bodied lake trout morphs can be found in the larger lakes (size classes A, B and C), all lakes less than 100 ha (size class A) contain only small-bodied lake trout. This natural divide allowed us to analyze the distribution of

recreational angling pressure by lake trout morphotype, rather than by lake size class, to account for differences in the level of pressure a small-bodied vs large-bodied population can sustain.

Recreational angling pressure on lakes with large-bodied and small-bodied morphs ranged from 0.08 to 7.40 hours/ha and 1.06 to 18.84 hours/ha, with medians of 0.39 hours/ha and 2.73 hours/ha, respectively.

We defined low, low-moderate, moderate-high, and high catch rates based on 25th, 50th, and 75th percentile recreational angling pressure values for each sub-group (Table 3). For small-bodied lakes, we had one major outlier, Louise Lake, for which angling pressure was estimated at 18.84 hours/ha. This observation was omitted from the data to generate thresholds, and Louise Lake is considered to have very high angling pressure. **For this strategic plan, we defined Criterion P2, *high recreational angling pressure*, as all values >75th percentile.**

Table 3. Breakdown of recreation angling pressure (hours/ha) thresholds for small-bodied and large-bodied lake trout based on percentile groups calculated from angler surveys conducted between 1990 and 2020. N = samples size, which corresponds to the number of angler survey estimates used to generate percentiles

	Recreational Angling Pressure Thresholds (Percentile)			
Morph Type	**Low (≤25%)**	**Low-Moderate (>25% to 50%)**	**Moderate-High (>50% to 75%)**	**High (>75%)**
Small-Bodied N = 5	≤1.72	>1.72 to 2.73	>2.73 to 3.51	>3.51
Large-Bodied N = 24	≤0.18	>0.18 to 0.39	>0.39 to 2.02	>2.02

Criterion P3: Proximity to a Yukon urban or rural population

An angler's catch rate (success) is the primary motivation behind where they choose to fish. However, studies have also shown that anglers will allocate their effort based on travel time and costs associated with accessing a fishery (Post et al. 2008). To this end, it has been shown that stock collapses are inversely proportional to travel costs, and that fishery collapses occur near urban centres where angler populations are the largest (Hunt et al. 2011). Therefore, it is important to monitor fish populations that are close to communities.

The majority of Yukon's human population resides in the Southern Lakes region, with most individuals living in the urban centre of Whitehorse (Government of Yukon, 2022a). However, angling pressures, originate from all Yukon communities. With the population of Yukon projected to increase from 1.2% to 2.2% per annum until 2040, it is anticipated this community pressure will continue to grow (Government of Yukon, 2022b). Therefore, we have defined a selection criterion to address the potential monitoring needs of lake trout populations that are near communities.

Metric

The defined distance in which a Yukon angler will travel to a fishery, while simultaneously reducing travel time and costs, may vary due to individual preference. However, to account for a lake's proximity to Yukon urban and rural populations, while minimizing an anglers travel costs to access the fishery, we arbitrarily selected a 50 km radius to define close 'proximity'. We then plotted this radius around the Yukon urban and rural areas listed below. **For this strategic plan, we defined Criterion P3, *proximity to an urban or rural population*, as any lake which was located within the plotted 50 km radius.** Table 4, Figure 1).

Table 4. Yukon urban and rural areas with populations over 200, selected for inclusion into criterion P3. Population data obtained from Yukon Bureau of Statistics (Government of Yukon, 2022a). *Rural areas of Mount Lorne and Ibex Valley were grouped within Whitehorse, as neither has a designated community centre.

Community	2022 Population
Carcross	478
Carmacks	577
Dawson City	2,331
Faro	467
Haines Junction	1,012
Marsh Lake	732
Mayo	449
Old Crow	249
Pelly Crossing	382
Ross River	323
Tagish	380
Teslin	490
Watson Lake	1,491
Whitehorse*	33,966

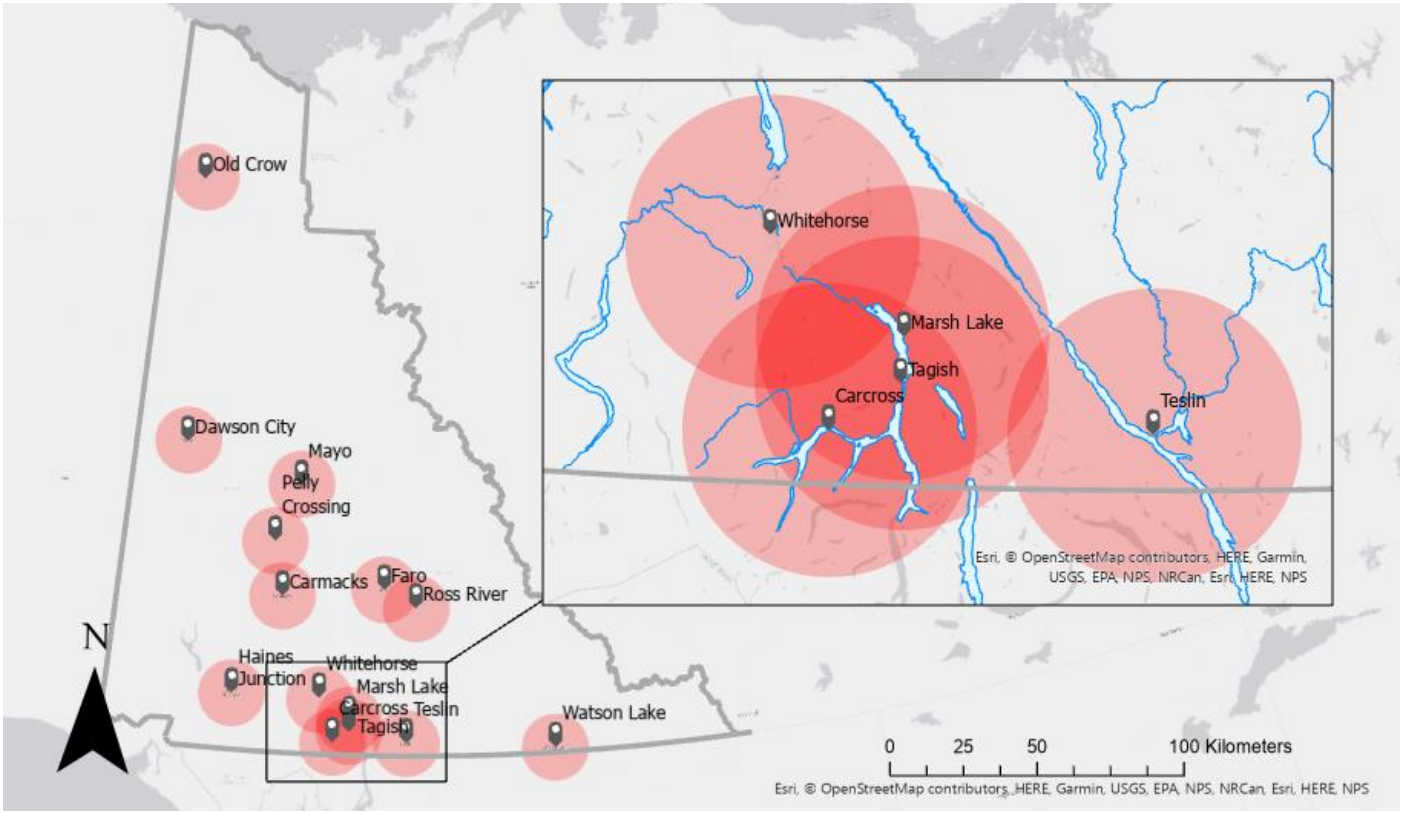

Figure 1. Yukon urban and rural areas with human populations greater than 200, with illustrated 50 km radii selection criteria. Inset depicts overlapping areas near Whitehorse, including Whitehorse, Marsh Lake, Tagish, Carcross and Teslin.

Criterion P4: Regional concern

Regional concerns regarding local lake trout populations are brought to the Department of Environment, through discussions with regional staff, Renewable Resource Councils (RRCs), licensed anglers and First Nation Governments.

Community concerns are raised by Renewable Resource Councils and are often linked to objectives specified in the *Umbrella Final Agreement* Chapter 16.1.1.1. These concerns are focused on the guiding principle *of 'ensuring conservation in the management of all fish and wildlife resources'* and are communicated to the Department of Environment, through collaboration with regional biologists or directly to the Fish and Wildlife Branch, Fisheries section.

For instance, some lakes with established regulations prohibiting lake trout harvest were originally brought to the attention of the Department of Environment by communities, through their local Renewable Resource Councils. This includes lakes such as Pine Lake, Snafu Lake, Tarfu Lake, Frenchman Lake and Twin Lakes.

Therefore, including a criterion inclusive of regional concerns allows for local regional representation in the selection process.

Metric

Using this criterion as a guideline, the list of candidate lakes was developed by requesting all Fish and Wildlife, regional team members identify lakes within their territorial management areas that have been brought to their attention by RRCs and/or First Nation Governments. **For this strategic plan, we defined Criterion P4, *a regional* concern, as any lake that has been brought to the attention of the Department of the Environment as a community concern.**

Criterion P5: Major project concerns

In the Yukon, prior to the commencement of any industrial developments, proponents must follow the environmental assessment process defined through the Y*ukon Environmental and Socio-economic Assessment Act*. This process is administered by the Yukon Environmental and Socio-economic Assessment Board, which recommends the project to proceeed, not proceed, or proceed with conditions on the degree of environmental monitoring required for each project. Typically, assessments focus on valued ecosystem components, such as fish and fish habitat, with recommendations surrounding monitoring and mitigation.

While the management of freshwater fish species is the responsibility of the Government of the Yukon, responsibility for fish habitat remains with the Government of Canada. However, there is some overlap, as developments can directly impact fish population dynamics and recreational angling.

Major projects in the Yukon, which may have the potential to affect freshwater fish populations, are related to the development and operation of hydroelectric facilities (Figure 2). These projects can alter natural water levels and flow, which may affect freshwater fish migration, spawning habitat, juvenile rearing habitat, and overwintering habitat. Therefore, we selected hydroelectric projects as a criterion because they can alter natural water regimes.

Metric

To narrow the focus for what projects should be included in this criterion, we focused on large-scale hydroelectric projects that may have a predicted effect on freshwater fish populations. This includes lakes that are impacted directly through the construction and operation of hydroelectric control facilities, as well as lakes in the downstream and upstream systems that may also be impacted by changes in water flows and levels. **For this strategic plan, we defined Criterion P5, (*major project***

***concerns)*, as lakes within the footprint of a hydroelectric project, which may have the potential to impact freshwater fish populations through the alteration of habitat or water regime.**

Figure 2. Current Yukon major hydroelectric project example: Whitehorse Hydro Plant (Yukon Energy).

Secondary Selection Criteria

Criterion S1: Small-bodied morphology

The Lake Trout and Lake Whitefish Monitoring Program has identified two distinct body morphologies for lake trout in the Yukon. They include the small and large-body forms. Researchers have attributed the differences between these morphotypes to variations in their growth rates as a function of food availability (Trippel and Beamish 1989). That is, large-bodied lake trout are piscivorous (diet primarily consisting of prey fish), while the small-bodied form are non-piscivorous (diet not focused on prey fish), feeding primarily on invertebrates.

In the Yukon, large-bodied lake trout are typically found in lakes that contain resident populations of lake cisco (*Coregonus artedi*) and lake whitefish, their preferred prey. We find small-bodied lake trout in lakes that have simple fish assemblages, void of whitefish species or only containing round whitefish (*Prosopium cylindraceum*). Nevertheless, we can find both morphotypes within the same watershed and lake, occupying distinct trophic niches.

Current Yukon Fishing Regulations do not account for the growth differences between the two morphologies, with all current regulations solely based on the growth of the large-bodied morph. In some instances, this regulative oversight has led to inadequate harvest slot sizes, which fail to protect the small-bodied morph. To rectify this situation, going forward, we have given lakes containing the small-bodied morph a higher priority ranking for sampling.

Metric

To determine adequate regulations for small-bodied lake trout, we require analysis of growth (age-at-length) data, which for many small-bodied lakes is currently deficient. Improving data collection and analysis of age and growth for small-bodied populations will improve our ability to determine appropriate regulations, ensuring sustainability of these populations while maintaining recreational angling. **Therefore, for the purpose of this strategic plan, we defined Criterion S1 (*small-bodied morphology)*, as lakes with currently known populations of small-bodied lake trout.**

Criterion S2: Climate concern

The Government of Yukon's current mandate is guided by *Our Clean Future* Strategy (Government of Yukon 2020a), which prioritizes responding to the impacts of climate change on wild species and their habitats. From a freshwater fisheries perspective, this involves monitoring Yukon lakes and their fish populations for changes related to climate. Specifically, we will prioritize lakes we have identified as being particularly susceptible to the influences of climate warming. Once identified, these lakes will be monitored for changes to their habitat quality, species composition, prey availability, and population age and size structures.

Lake trout are a cold cline species, with known optimal thermal temperature preferences between 8°C and 12°C (Christie and Regier 1988). As lake temperatures increase with climate change, this temperature range, known as their thermal habitat volume, is predicted to diminish through time (MacKenzie-Grieve and Post 2006). For example, we have identified Dezadeash Lake as being a waterbody that is particularly vulnerable to the influences of climate change. Dezadeash Lake is a monomictic, shallow water lake (maximum depth of 7m), which can warm quickly (Figure 3). This warming and the effects of climate change affect lake trout habitat availability, and thus their population health.

Metric

Using archived bathymetric measures, taken during past lake trout surveys, we will identify and prioritize lakes for sampling that are vulnerable to the influences of climate warming. While it could be argued that monitoring lakes for climate change influences can be warranted across all Yukon lakes, due to capacity limitations, it is not practical. Therefore, we will focus on monitoring using criteria based on the following metric.

For this strategic plan, we defined Criterion S2, climate concerns, as lakes which have a high potential for impacts to their thermal habitat availability due to changes in known lake processes resulting in a shift in habitat and/or a lowering of water levels; lakes with known cold-water refugia; and lakes with known limited thermal volume in peak summer months.

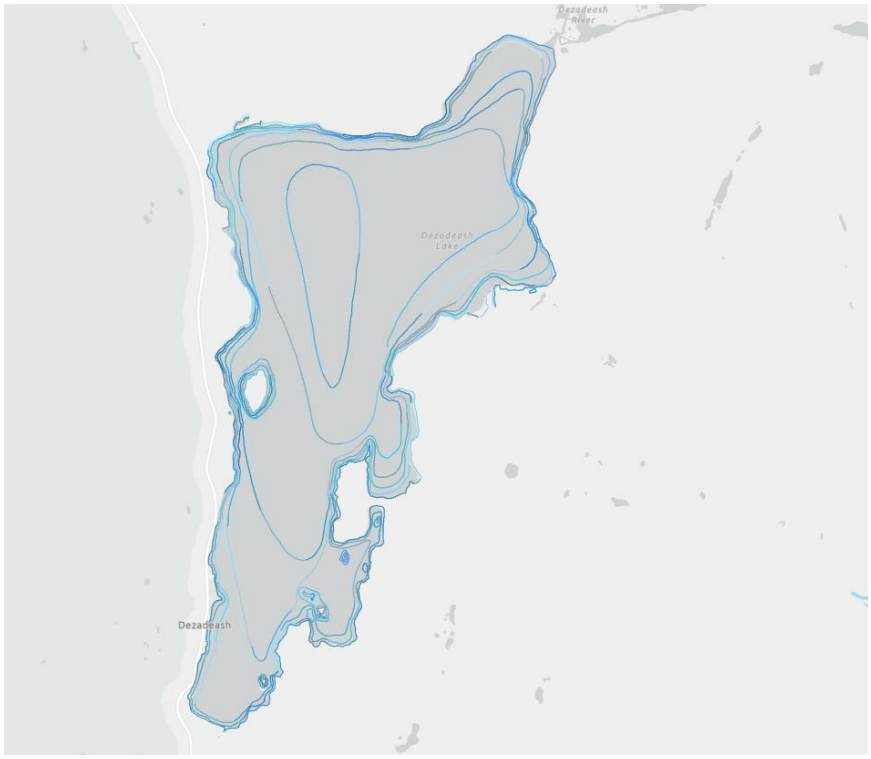

Figure 3. Bathymetric profile of Dezadeash Lake, illustrating 1m isolines (blue).

Criterion S3: Campground access with low-moderate CPUE OR high angling pressure

The long-term objectives of the Yukon Park Strategy include protecting the ecological integrity of Yukon parks while providing opportunities for the public to experience and enjoy Yukon's biodiversity (Government of Yukon 2020b). During the past ten years, use of Yukon's parks has increased by approximately 80% (Government of Yukon 2020b). We anticipate that this may lead to increased angling pressure in lakes adjacent to campgrounds. Therefore, to ensure the long-term sustainability of these fisheries, we have assigned a sampling priority to lakes adjacent to campgrounds.

Metric

The Lake Trout and Lake Whitefish Monitoring Program and angler survey programs have assessed 24 lakes located at territorial campgrounds. While the presence of a campground alone does not automatically elicit the need for further lake trout monitoring, the data suggests that waterbodies with easy access, coupled with low to moderate densities of large-bodied lake trout, may be vulnerable to over-exploitation. As such, these lakes warrant increased monitoring to ensure they remain sustainable.

Small-bodied lake trout are not included within this secondary selection criteria, as all known small-bodied populations are addressed under criterion S1.

For this strategic plan, we define Criterion S3, campground access with low-moderate CPUE or high angling pressure, as lakes with large-bodied morphs located at a territorial campground with a low-moderate CPUE (≤ 0.60, Table 2) OR high angling pressure (>2.02, Table 3).

Criterion S4: Special management concern

The Government of Yukon has collaborated with Yukon First Nation governments to establish several Territorial Parks, Habitat Protection Areas, and Special Management Areas across the Yukon. In these plans, regional lakes have been identified as priorities for protection. Specifically, these plans have outlined sampling of freshwater fish populations as a priority and have cited the analysis and population status of lake trout as key planning metrics to ensure cultural and conservation values are protected.

Currently, lake trout has been identified for monitoring in the lake management plans for Mandanna Lake (Mandanna Lake Planning Team, 2013) and Ta'tla Mun (Government of Yukon and Selkirk First Nation, 2013). Lake trout has also been identified in the recent Tagish River Habitat Protection Area (Tagish River Habitat Protection Area Steering Committee, 2022).

Therefore, to meet plan goals and commitments, continued monitoring to ensure protection of lake trout populations in these specified areas is warranted. Any new protected areas or management plans will be assessed for inclusion in our strategic plan, through the adaptive approach previously discussed.

Metric

The Yukon currently has eight Territorial Parks, nine Habitat Protection Areas and three Special Management Areas (

Table 5). **For this plan's purposes, we define Criteria S4, special management concern, as lakes found within the boundaries of any territorial park, habitat protection areas, or special management areas, are included in this criterion.**

Table 5. Current Yukon Territorial Parks, Habitat Protection Areas, and Special Management Areas.

Protected Area Type	Name
Territorial Park	Agay Mene Territorial Park
	Asi Keyi Territorial Park
	Coal River Springs Territorial Park
	Dàadz**ii V**àn Territorial Park
	Hershel Island Qikiqtaruk Territorial Park
	Kusawa Territorial Park
	Ni'iinlii Njik Territorial Park
	Tombstone Territorial Park
Habitat Protection Area	Ch'ihilii Chik Habitat Protection Area
	Ddhaw Ghro Habitat Protection Area
	Devils' Elbow and Big Island Habitat Protection Areas
	Ni'iinlii Njik Habitat Protection Area
	Nuna K'óhonete Yédäk Tah'é Habitat Protection Area
	Pickhandle Lakes Habitat Protection Area
	Tagish River Habitat Protection Area
	Tsâwnjik Chu Habitat Protection Area
	Lútsäw Wetland Habitat Protection Area
Special Management Area	Mandanna Lake
	Ta'tla Mun Special Management Area
	Van Tat K'atr'anahtii Special Management Area

Selection Process

Priority Ranking

To identify priority lakes, the selection criteria is applied to each lake, following a hierarchical stepwise approach (Figure 4). Using this approach, lakes are subsequently classified into the sampling categories of high, moderate, and low priority. By doing so, we ensured lakes requiring greater attention will be sampled in a timely manner. We scheduled all high or moderately ranked lakes for sampling within a 10-year monitoring cycle.

The ranking categories are as follows:

- **High Ranking Lakes:** Lakes that have met more than two primary selection criteria.
- **Moderate Ranking Lakes**: Lakes that have met two or less of the primary selection criteria and one or more of the secondary selection criteria.
- **Low Ranking Lakes**: Lakes that have met two or less primary selection criteria and no secondary selection criteria.

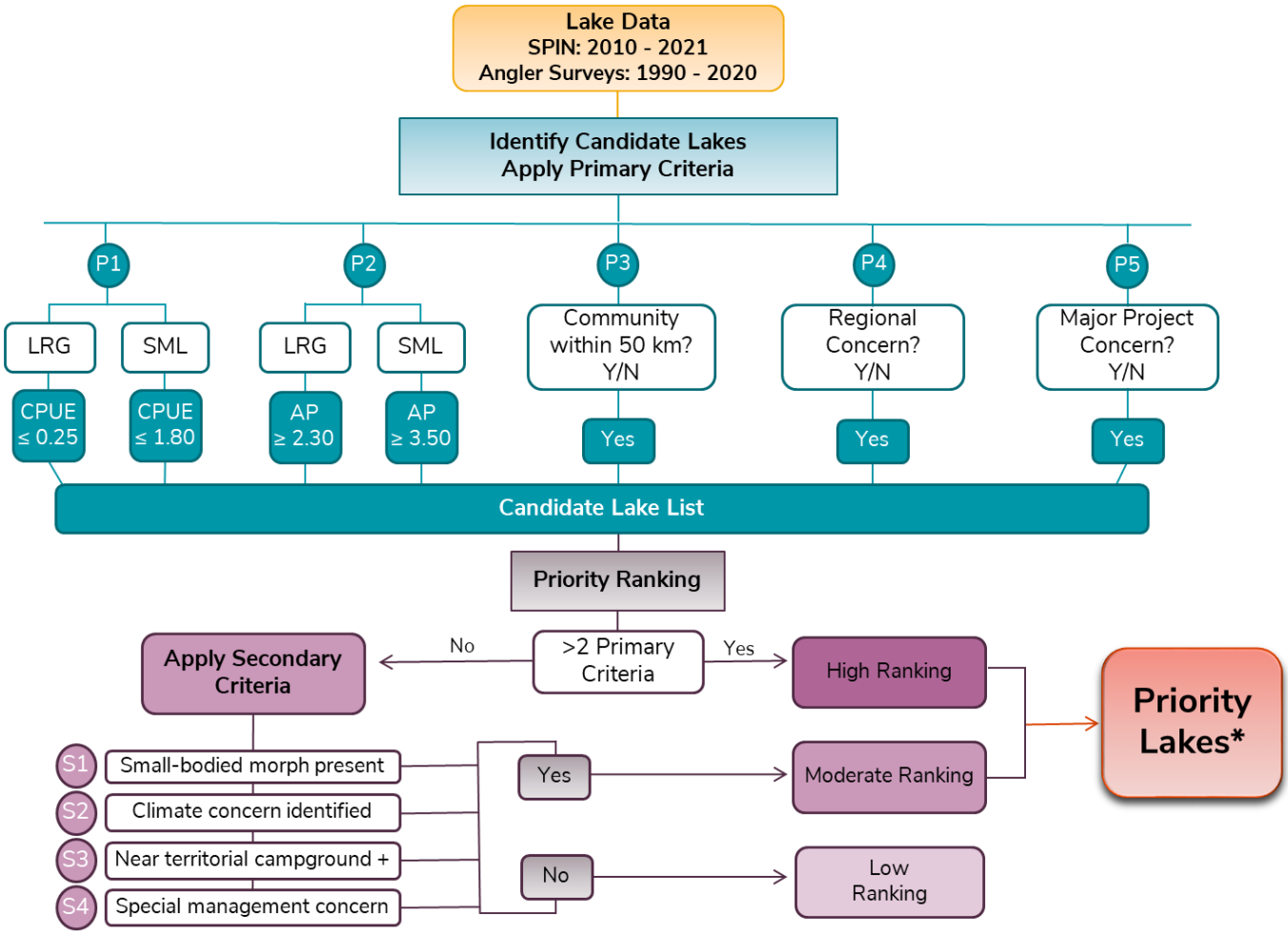

Figure 4. Flow diagram of the selection approach developed for the 10-year monitoring plan. AP = angler pressure, CPUE = catch-per-unit-effort, LRG = large-bodied, S = secondary, SML = small-bodied, P = Primary. *Priority lakes are subject to further scrutiny based on program capacity (time, staff, and budget) and prior knowledge of the system.

Assessment Timing

When ranking lakes, it is important to define the frequency and timing of sampling associated with its ranking. To define the frequency of assessments, we created three distinct timing categories with specific criteria (Table 6). Defining the timing helps ensure we meet the objectives of our strategic plan and ensures we assess lakes at an appropriate level.

Table 6. Timing categories, assessment frequency, and criteria for lake assessment timing.

Timing Category	Assessment frequency	Criteria
Category A	Once every 5 years	• High-ranking lakes; and • Moderate-ranking lakes with selection criteria S2 (climate concerns).
Category B	Once every 10 years	• Moderate-ranking lakes; • High-ranking lakes where additional sampling is ongoing because of a major project; and • Lakes with low lake trout population numbers based upon limited habitat availability.
Category C	Two consecutive surveys followed by 8-years of non-sampling	• Lakes with recovering lake trout populations, where there is currently insufficient data necessary to support the development of regulations (i.e., age and growth factors).

Results

Lake Selection

Fifty-three lakes were identified as either having been surveyed in prior years (i.e., Lake Trout and Lake Whitefish Monitoring Program data) or identified by regional Fish and Wildlife Branch staff as important (Table 7). Through the application of the selection process, 46 of these lakes were considered candidate lakes for future sampling (meeting a primary criteria), among these, 26 were selected for priority sampling. They were categorized as either high-ranking or moderate ranking in status. For a full summary of the selection results see Table 7.

Removed Lakes

In reviewing the list of priority lakes (Table 7), four lakes were identified for removal. The reasoning behind the removals is detailed below. Though these lakes have been removed, it should be noted that our plan is adaptive, allowing us to revisit our decisions throughout the course of the next ten years. As this plan continues past 2032, each of the lakes should be reassessed for potential monitoring needs.

Snafu Lake

Due to Snafu Lake having four primary criteria, it was identified as a high priority lake for assessment, falling in timing category C (two consecutive years of sampling, followed by eight years of non-sampling). Following the 2015 regulatory change, which restricted all lake trout harvest in Snafu, the lake was reassessed in 2021 to determine the population's status. Our results indicate that the population has not recovered, and that available lake trout habitat is limited. Bathymetric data, indicates this lake would not be classified as optimal lake trout habitat. Therefore, we removed Snafu Lake from our 10-year schedule (Table 8).

Ethel Lake

Ethel Lake met two of the priority criteria and one secondary, therefore it was identified as a moderate priority for assessment. Specifically, it fell in timing category B (once every 10 years) by meeting criteria P3, P4 and S3. Ethel Lake, however, was sampled in 2022, during the development of this adaptive plan. During this assessment, the population of large-bodied lake trout was found to have a high CUE of ~1.85 (> 75th percentile, > 0.88). This assessment also addressed a regional concern, to monitor this population. Therefore, Ethel Lake has been removed from this initial 10-year plan.

Fish Lake

Fish Lake was identified as a moderate-ranking lake for assessment falling into timing category B (once every 10 years). It met selection criteria P3, P4 and S1. However, Fish Lake was sampled in 2021. During this assessment, CPUE was high ~2.52 fish /hr (> 75th percentile, > 0.88), suggesting this population is currently stable. This survey was successful in collecting data related to this small-bodied population. Our survey met the needs of this monitoring plan and under our timing criteria the lake is not in line for sampling during the next 10 years. Therefore, Fish Lake was removed from this initial 10-year adaptive schedule (Table 8), to ensure the schedule addresses all identified lakes.

Lewes Lake

Lewes Lake was ranked as a moderate-priority lake, to be placed in timing category B (once every 10-years). It met selection criteria P3, P4 and S1. Lewes Lake, however, was sampled in 2022, during the development of this adaptive plan. The results of this survey addressed our concerns and demonstrated this small-bodied population was currently stable. Our survey met the needs of this

monitoring plan and therefore, the lake is not scheduled for monitoring for another 10 years. Therefore, Lewes Lake was removed from this 10-year adaptive schedule (Table 8).

Data Gaps

During the selection process, we identified 23 lakes that did not have data related to recreational angling pressure and nine lakes which lacked CPUE data. These data gaps highlight the importance of applying an adaptive management approach.

10-Year Monitoring Schedule

The last step in this adaptive plan was the creation of the 10-year monitoring schedule (Table 8). As previously discussed, the development of this schedule attempts to accommodate current data and program limitations. Due to the number of lakes and our capacity limitations, the timing categories, as applied, do not take into consideration the gap between previous surveys.

Conclusion

Overall, the 10-year adaptive strategy not only enhances our ability to collect relevant and accurate data, but also positions us to address evolving changes facing Yukon lake trout populations. Through our application of our defined selection criteria and adaptive framework, we are positioned to meet the goals of this program and improve our monitoring of these populations.

It is our aim to re-evaluate this plan and proposed schedule on a regular basis, ensuring input from stakeholders is evaluated, allowing our schedule to adapt if required. However, in its current state, this plan provides us with a roadmap for the next 10 years of sampling, helping to ensure the long-term monitoring and sustainability of Yukon's lake trout and lake whitefish populations.

Table 7. The results matrix indicates which priority lakes were identified through the multi-step selection process. Lakes in the table have been surveyed or identified as lakes of regional concern. Candidate lakes identified through the application of primary (P) criteria are highlighted in blue and those identified by the secondary (S) criteria are striped. The shades of purple correspond to the level of priority ranking from high to low (dark to light). AP = angler pressure, Climate = climate concern, ND = no data, Near TC+ = near territorial campground and high angling pressure or low-moderate CPUE, Regional = regional concern, SML = small-bodied, Sp. Mgmt. = special management concern.

Lake	Step 1: Candidate Lakes					Step 2: Ranking						
	Criterion P1 Low CPUE	**Criterion P2** High AP	**Criterion P3** Within 50 km	**Criterion P4** Regional Concern	**Criterion P5** Major Projects	**High Ranking** >2 Primary Criteria	**Moderate Ranking** ≤2 Primary Criteria + Secondary Criteria				**Low Ranking**	**Priority Lakes**
							Criterion S1 SML	**Criterion S2** Climate	**Criterion S3** Near TC+	**Criterion S4** Sp. Mgmt.		
Aishihik												
Atlin												
Bennett		*ND*										
Braeburn												
Canyon	*ND*	*ND*										
Caribou												
Chadburn		*ND*										
Dezadeash												
Dragon	*ND*	*ND*										
Ethel												
Fish												
Fox												
Frances												
Frenchman												
Granite	*ND*	*ND*										
Janet	*ND*	*ND*										
Kathleen (Stewart)												
Kloo	*ND*	*ND*										
Kluane												
Klukshu												
Kusawa												

Lake	Step 1: Candidate Lakes					Step 2: Ranking						Priority Lakes
	Criterion P1 Low CPUE	**Criterion P2** High AP	**Criterion P3** Within 50 km	**Criterion P4** Regional Concern	**Criterion P5** Major Projects	**High Ranking** >2 Primary Criteria	**Moderate Ranking** ≤2 Primary Criteria + Secondary Criteria				**Low Ranking**	
							Criterion S1 SML	**Criterion S2** Climate	**Criterion S3** Near TC+	**Criterion S4** Sp. Mgmt.		
Laberge												
Ladue		*ND*										
Lewes		*ND*										
Little Atlin												
Little Fox												
Little Salmon												
Louise												
Mandana		*ND*										
Marsh												
Mayo												
Michie		*ND*										
Minto		*ND*										
Moraine	ND	*ND*										
Morley		*ND*										
Nesketahin	*ND*	*ND*										
Pine												
Quiet												
Sekulmun		*ND*										
Simpson												
Snafu												
Snafu (gaz)		*ND*										
Tagish												
Tarfu												
Ta'tla Mun		*ND*										
Ten Mile		*ND*										
Teslin												

Lake	Step 1: Candidate Lakes					Step 2: Ranking						Priority Lakes
	Criterion P1 Low CPUE	**Criterion P2** High AP	**Criterion P3** Within 50 km	**Criterion P4** Regional Concern	**Criterion P5** Major Projects	**High Ranking** >2 Primary Criteria	**Moderate Ranking** ≤2 Primary Criteria + Secondary Criteria				**Low Ranking**	
							Criterion S1 SML	**Criterion S2** Climate	**Criterion S3** Near TC+	**Criterion S4** Sp. Mgmt.		
Toobally		*ND*										
Twin Lakes (W)												
Watson												
Wellesley	*ND*	*ND*										
Williamson	*ND*	*ND*										
Wolf		*ND*										

Table 8. 10-year lake trout assessment schedule, including selection process ranking and timing category (T1: back-to-back, followed by 8-year break, T2: approximately 10 years, T3: approximately 5 years, T4: approximately 10 years) by lake and assessment year. (* indicates scheduling options to be finalized with major project partners)

Lake Name	Lake Size (ha)	Ranking	Timing Category	Year									
				2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Dezadeash	7968	Moderate	A										
Kluane	40821	Moderate	A										
Laberge	20099	High	A										
Little Atlin	4032	High	A										
Marsh	9554	High	A										
Teslin	37720	High	A										
Canyon*	870	High	B										
Caribou	51	Moderate	B										
Chadburn	144	Moderate	B										
Kusawa	14018	Moderate	B										
Little Salmon	6321	Moderate	B										
Louise	51	Moderate	B										
Mayo*	9963	High	B										
Mandanna	786	Moderate	B										
Ta'tla Mun	3141	Moderate	B										
Tagish	35458	Moderate	B										
Twin(s)	61 (e), 150 (w)	High	B										
Watson	1410	Moderate	B										
Frenchman	1441	High	C										
Pine	603	High	C										
Tarfu	404	High	C										

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