

Omineca Burbot Fisheries Study – Summary Report



British Columbia Ministry of Water, Land, and Resource Stewardship
Fish and Wildlife Section, Omineca Region, Prince George, BC

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Executive summary

Burbot (*Lota lota*) provides for important recreational and food fisheries in the Omineca Region (7A) of British Columbia. Burbot populations in this region are generally thought to be stable, while population data are limited; a daily limit of 5 burbot is currently in place and set-lining is permitted in lakes for this species (with some exceptions). However, burbot are difficult to study using traditional stock assessment methods, leading to a deficit of baseline knowledge about their population structure and exploitation rates. This study sought to establish methods for capturing and tagging burbot, gather data on burbot biology, and estimate fishing exploitation rate at three lakes in the Omineca Region - Carp Lake, Fraser Lake, and Cluculz Lake. We used a high-reward tagging study to assess exploitation rates for burbot at Carp Lake (2022-2023), and attempted to use the same approach at Fraser Lake (2021-2023) and Cluculz Lake (2022). We were able to estimate exploitation rates at Carp Lake, with sufficient capture rates and tag-returns at this site; additionally, we gathered information about burbot fishing at Carp Lake through creel surveys. At Fraser Lake, we were unsuccessful in estimating fishing exploitation due to a lack of tag-returns from anglers to date, despite tagging burbot throughout 2021-2023. At Cluculz Lake, our trapping efforts did not yield sufficient captures to gather any population-level information or assess the recreational fishery. At both Carp Lake and Fraser Lake, we mapped burbot capture locations from trap set data and analyzed capture success in relation to season and location. We also measured total length and weight of the tagged burbot at Carp Lake and Fraser Lake, and constructed size distributions to provide information on the size classes of burbot present at these lakes. At Cluculz Lake, we mapped and report the unsuccessful trapping locations here for future reference.

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Title image: An adult Burbot captured at Fraser Lake with a high-reward tag appended.

TABLE OF CONTENTS

Introduction 3

Background3

 Project partnerships and study context5

Project Objectives..... 5

Methods 6

Study sites.....6

 Carp Lake6

 Fraser Lake.....7

 Cluculz Lake7

Burbot capture7

Trapping locations and set duration8

Tagging and sampling8

Numbers of burbot tagged.....9

Carp Lake creel survey9

Communicating the study to fishers11

Data analyses11

 Burbot capture.....11

 Burbot biological data12

 Carp Lake creel and exploitation13

 External estimates of reporting rate13

Results 15

Burbot capture data15

 Carp Lake15

 Fraser Lake.....15

 Cluculz Lake15

Burbot biological data16

 Carp Lake16

 Fraser Lake.....16

 Inter-lake comparison.....16

Tag-reporting and exploitation data17

 Carp Lake: Estimation of exploitation rate17

 Carp Lake: Estimation of tag-reporting rate17

 Fraser Lake.....18

 Cluculz Lake18

Creel data..... 18

Discussion 19

Recreational benefits achieved as an outcome of this project 22

Acknowledgements 23

References 24

Appendices 30

INTRODUCTION

Background

Despite reports that burbot fishing effort has increased in recent years, previous work has not explicitly quantified burbot exploitation rates in the Omineca Region (Lheidli T'enneh First Nation, 2011). Data on burbot fisheries are limited, as attaining reliable information from stock assessments is challenging for this benthic species. Burbot are vulnerable to the combined impacts of harvest and environmental change and have experienced population collapse in some regions (Paragamian & Hansen, 2009; Stapanian et al., 2010). In Northern BC, historical winter creel surveys indicated a high variability in angling effort among Cluculz, Norman, Eaglet, Saxton, and Nukko Lakes (Lheidli T'enneh First Nation, 2007). However, no study in the Omineca Region to date has measured fishing exploitation rates for burbot using tag-recovery methods; quantifying exploitation rates in recreational is critical for informing management of burbot populations.

Tag-recovery models, based on reports of tagged fish from anglers, allow estimation of harvest and survival rates in recreational fisheries (Pine et al., 2003). This is because of the differences in recovery probability for fish that have been available to harvest for different lengths of time since their tagging and release. With an estimation of angler tag-reporting rate, total annual mortality can be partitioned into fishing and natural mortality (Hightower & Pollock, 2013), allowing us to quantify the role that recreational fishing plays in population dynamics. This information is useful for determining sustainable levels of fishing pressure. It is important to account for reporting rate during tagging studies, because unreported tags can lead to underestimation of harvests, potentially allowing unsustainable fishing to continue (Felts et al., 2021). High-reward tags (Nichols et al., 1991; Pollock et al., 2001) and creel surveys (Pollock et al., 1991) are two methods to estimate reporting rate to inform tag-recovery models, which both work by virtually guaranteeing reporting for some tags. Additionally, creel surveys directly involve fishers in the research process by inviting them to share experiences and thoughts about the burbot fishery (Nieman et al., 2021). These approaches are ideal for burbot because they provide baseline information about exploitation, survival, reporting rates, and fishing activity, while identifying how future studies might improve upon current methods. Additionally, creel surveys can help validate estimates obtained through tag-recovery models by providing another avenue for estimating tag-reporting rate, estimating total amounts of catch and effort, and providing qualitative information about the recreational fishery.

PROJECT OBJECTIVES

Our objectives for the Omineca Burbot Fisheries Study at the outset of the project were:

Year 1 (Fraser Lake):

1. Develop and standardize capture and tagging methods.
2. Deploy acoustic array (~40 receivers) and tag up to 20 burbot with acoustic tags.
3. Deploy ~50 high, low and no reward tags.

Year 2 (Fraser Lake, Carp Lake and Cluculz Lake)

4. Verify if methods to monitor burbot can be applied to other lakes across the region.
5. As a starting point, deploy ~50 high-reward and 50 no-reward tags at each lake (with the goal to increase this sample size in Year 3). Methods were adjusted to include only high or no-reward tag types for cost-effectiveness, based on previous research (Sackett and Catalano, 2017).
6. Determine angler use and exploitation rates at three lakes using tag-recovery.
7. Evaluate indices for signs of overfishing by method and season.

Year 3 (Fraser Lake, year 3 of 5)

8. Refine methodology and add additional tags.
9. Evaluate suitability of current angling regulations (e.g., catch limits and gear use).

Due to challenges in obtaining consistent data due to low catch rates at Cluculz Lake and Fraser Lake, we modified and focused the objectives after 2021-22 and focused on Carp Lake in 2023.

The modified 2023 objectives were to:

1. Deploy a target of approximately 150 additional tags (50% high-reward and 50% no-reward) at Carp Lake, where catch rates had been highest and some angler returns had been obtained, over an additional trapping session in Fall 2022 and intensive 4-week trapping session in Spring 2023.
2. Combine the tag-reward study with a creel survey to estimate burbot survival and exploitation rates.
3. Collect additional information on harvested burbot and burbot fishing activity at Carp Lake from anglers participating in the creel survey.

METHODS

Study sites

Carp Lake: Carp Lake is located in Carp Lake Provincial Park, in the Arctic Watershed, and entirely lacks residential development as it resides wholly within the Park. Carp Lake has a surface area of 5,580 ha and a mean depth of 16.7 m, with a max depth of 39 m. Carp Lake Provincial Park (Class A established in 1972) provides the main access point to Carp Lake for anglers during the Park’s operational period from May through September. Outside of this period, the access road is subject to snow and not maintained for vehicle access. Carp Lake is therefore only easily accessible via snowmobile during the winter months; this natural access limitation essentially buffers the amount of activity during the months when burbot are most vulnerable to exploitation (I. Spendlow personal communication). Thus, management of conservation goals for all species in Carp Lake relies on compliance with and enforcement of the freshwater fishing regulations, including all quotas and gear use restrictions. The Carp Lake Provincial Park Fisheries Management Plan (see Lewynsky 1990) notes a progression toward more restrictive angling regulations since 1975, mainly to balance rainbow trout sustainability versus increasing use following Park development. For burbot, the regional bag limit of 5 is maintained at Carp Lake. Resident fish populations, including burbot, are isolated given a barrier for upstream movement into Carp Lake from adjacent downstream McLeod River (above War Falls). In absence of recent data, management is focused on conservation to maintain sustainable use, in a key park within the BC Parks system. Excerpt of the executive summary of the Fisheries Management Plan: *“Carp Lake Provincial Park is renowned for its superb rainbow trout fishery, and of all the parks within the provincial park system, it may well be the single park most closely associated with, and dependent on, fisheries management” (Lewynsky, circa 1990).*

Fraser Lake: Fraser Lake has a surface area of 5,500 ha and a mean depth of 13 m (max depth 30 m), and is a productive mixed-species fishery. There are few highly productive lakes in such close proximity to a main highway (Highway 16) and the communities of Vanderhoof and Fraser Lake, including local Nadleh Whut’en and Stelat’en First Nations. Fraser Lake is 150 km West of Prince George and 50 km west of Vanderhoof. Furthermore, the large number of waterfront properties and a Provincial Park make Fraser Lake a recreational destination during both the summer and winter. This lake provides anglers with a desirable opportunity for large-bodied Lake trout, while harvesting highly regarded rainbow trout, kokanee, and burbot. Few lakes in the region support the co-existence of all these species of sport-fish, in conjunction with such ease of access.

Cluculz Lake: Cluculz Lake is smaller, with a surface area of 1,943 ha, yet deeper (mean depth of 29 m and max depth of 60 m), than Carp and Fraser Lakes. The greater depth may result in different behaviour, vulnerability, and mortality of burbot. Cluculz Lake has the highest number of residents of any comparable burbot lake in the region, and thus likely experiences higher burbot fishing effort. This front-country lake is habitat to a diverse array of fish species including lake

trout, rainbow trout, kokanee, burbot, and whitefish, with a prohibition on the use of setlines as a fishing method for burbot. Additional regulations allow catch and release only for lake trout since 2008. In 2007 the sport-ice fishery was estimated to be 1226 rod hours (LTN unpublished data) while the corresponding aerial boat count for 2007 accounted for 12,800 rod hours (FFSBC effort app), for a total estimate of 14,000 rod hours in 2007. In recent years, effort via boat counts on Cluculz Lake declined by 48% from 2005-2007 to 2017-19 periods (Spendlow 2020).

Burbot capture

At all three lakes, burbot were captured using cod traps manufactured by Redden Custom Nets Ltd. (Port Coquitlam, B.C; **Figure 1**). Cod traps were provided by Omineca Fisheries for use at Fraser Lake and Cluculz Lake and loaned from Lheidli T'enneh First Nation for use at Carp Lake. Burbot are able to swim into traps through a one-way narrow mesh opening in the side. We baited traps with rainbow trout to represent a burbot prey species naturally occurring in the study lakes. In 2021, we tested some commercially available bait alternatives including herring, tilapia, shrimp and bacon, but moved to the standardized use of rainbow trout in years 2-3. In 2021-2022, we sourced wild-caught rainbow trout sampled by Ministry biologists from Nulki Lake and Carp Lake as bait, and in 2023 we sourced commercially available farmed rainbow trout from a grocery store. Each trap received approximately 150 grams of bait, and we refreshed the bait every time the traps were re-set.



Figure 1. Cod trap used for burbot capture.

Trapping locations and set duration

We selected trapping sites by randomly selecting sites within the 0-10 meter depth contour in each lake. We overlaid a grid using ArcMap 10 onto a bathymetric map of each lake; each grid area is classified into a 10-meter depth class, and areas between 0 and 10m in depth were identified as suitable trapping locations for burbot. Burbot experience barotrauma when pulled from depths greater than 10 meters, which we aimed to avoid and reduce chances of mortality or unusual behaviour after tagging (Neufeld & Spence, 2004). Within the 0-10m depth contour, we divided each lake into spatial “zones” for sampling (**Figures 2**). Within each zone, a new set of trapping points was generated randomly for each week of sampling. On each day of sampling within a session, we set 20 traps in one zone in the afternoon to be left overnight. The following morning, we pulled the traps, tagged any burbot caught and released them at the same location, pulled up all the traps from that zone and then set them in the next adjacent zone overnight, to be checked the following morning.

Since burbot are a cold-water species sensitive to warm temperatures, we measured water temperature when setting traps for burbot, using a YSI at trap-depth (about 0.5m above the lake bottom) after checking the depth using the boat’s depth sounder. We only set traps at sites with water temperature under 10° C at trap depth, to avoid subjecting burbot to heat stress while they were held in the trap overnight. This typically corresponded to sites between about 7 and 10 meters deep. If we reached a selected trapping site and the water was warmer than 10°C, we slowly navigated farther offshore toward a deeper site, checking the depth and temperature until suitable, and set the trap in this modified location. Burbot were measured and tagged in a livewell onboard the boat, while monitoring the water temperature inside the livewell. We drew water from the lake to obtain water colder than 10° C for handling burbot.

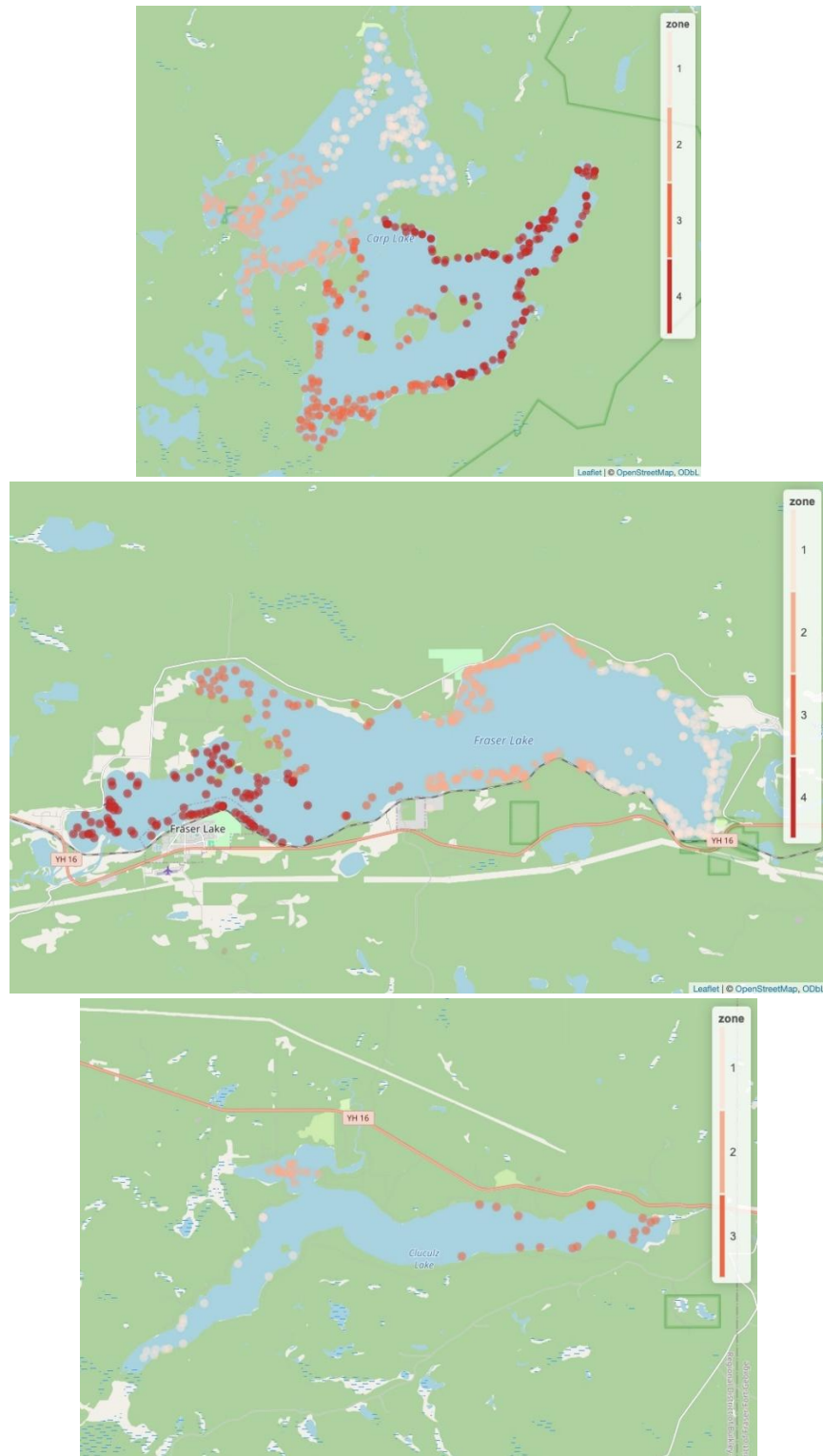


Figure 3. Traps set locations in each study lake, A) Fraser Lake, B) Carp Lake, and C) Cluculz Lake.

Tagging and sampling

Captured burbot were fitted with an external T-bar anchor tag (FD-94 Anchor Tag, *Floy Tag, Seattle WA, USA*); this is a piece of coloured vinyl tubing connected to a monofilament line with an anchor at the end (**Figure 3**). We used a tagging gun with a needle to insert the tag into the musculature of the fish just below the dorsal fin, following standard anchor-tagging protocol and location. After tagging, we placed the burbot in a livewell onboard the boat with circulating ambient water. We measured the total length of burbot in millimeters, using a tape measure while held in the water, and measured the weight in grams using a weigh-bag and scale, taking care to minimize the time held out of water. When all measurements were taken and if showing no signs of impairment, burbot were released at the capture site. Burbot handling and tagging procedures were approved by the UNBC Animal Care and Use Committee (protocol no. 2021-12).

To randomize the individuals carrying each tag type (avoiding any bias in tag type by size or capture location), we alternated between standard and high-reward with every burbot caught, resulting in approximately 50% standard tags and 50% high-reward tags among tagged burbot. Standard tags are labeled with the unique identifying 4-digit number on one side, and the phone number of the BC Ministry of Forests Omineca Regional office on the opposite side. High-reward tags are identical, except they are also marked “REWARD \$100”.



Figure 3. T-bar anchor tags (“Floy” tags).

Numbers of burbot tagged

At Carp Lake, we captured, tagged and released 91 burbot over two weeks in 2022 (May 30 – June 3 and June 20 – June 24). Following the summer open-water fishing season, in the fall of 2022 (October 24-28) we tagged and released an additional 23 burbot. Finally in May-June 2023, we put in four consecutive weeks of effort and tagged 122 more burbot. In total, over the two years of tagging and recoveries, 236 burbot were tagged and available to be caught and reported in Carp Lake: 119 with high-reward tags and 117 with standard tags.

At Fraser Lake, we tagged burbot in the spring-summer seasons of 2021, 2022, and 2023. A subset of burbot at Fraser Lake were also tagged with acoustic transmitters for a separate study on oxythermal habitat use, not discussed in this report. In 2021, we tagged 44 burbot. In 2022, we tagged 29 burbot. In 2023, we tagged 11 burbot; the 2023 season was concluded early due to rapidly warming lake water temperature.

We attempted burbot sampling at Cluculz Lake in May 2022 but were largely unsuccessful. We set 48 traps during the last week of May, and captured and tagged one burbot. Due to low capture success we excluded Cluculz Lake from the study in Year 3.

Carp Lake creel survey

We developed a burbot-specific survey at Carp Lake to increase participation in tag-reporting and to collect catch rate and qualitative information about the recreational burbot fishery at Carp Lake. Carp Lake Provincial Park was open to the public between May 20-September 15, 2023. We structured a fixed-point creel survey around this timeframe, and intercepted fishers at the main boat ramp at the end of their fishing trips. This minimally disrupts recreational fishing time, and also means that participants could answer creel questions while packing up gear, cleaning up and preparing to leave the park. Based on BC Parks rangers' observations of fishing activity at Carp Lake, fishers typically use baited set-lines to passively fish for burbot overnight, and retrieve the line the following morning. Considering this typical daily routine, we stationed ourselves at the boat launch each morning to meet fishers coming in with their catch; since we were camping at the main campground within eye and ear-shot of the boat ramp, we could identify when boats were coming in after fishing and be present to deliver surveys and sample fish at other hours.

We surveyed fishers at Carp Lake over the course of the summer park-opening season. Creels took place on an alternating week schedule (7 days on / 7 days off), with most weeks starting on Monday and ending on Sunday evening. The creel followed this schedule to capture a representative sample of the fishing season including both weekend and week days. We later expanded the number of effort-hours and tagged burbot retrieved during surveyed days across the entire fishing season using a multiplier relating the number of days sampled to the total number of available harvest days (Pollock et al., 1991). We modified the schedule a few times in response to wildfire smoke

conditions and to be present for holiday fishing activity (i.e. Canada Day weekend) – and adjusted the schedule so that we delivered surveys for the same total amount of time. However, several survey days were cancelled due to heavy wildfire smoke in the area making it unsafe to be camping outside for extended periods; we surveyed 39 days out of a potential 119 available days, and adjusted for this during analyses by adjusting our multiplier for sampled-to-total days.

When we encountered fishers going out on the water, we asked whether they were fishing for burbot, and gave them a short overview of the study. If the fisher was targeting burbot or indicated they were familiar with the species, we then asked if they would like to participate in a survey at the conclusion of their fishing trip. The survey questionnaire had four main parts: (1) fishing trip information, (2) burbot fishing at Carp Lake (more generally), (3) observations of the burbot fishery at Carp Lake, and (4) demographic information. The questionnaire was informed by prior related research projects and publications (Pumphrey, 2023, Fuentes et al., 2021, Marshall et al., 2023). It includes standard creel questions such as time spent fishing and number/species of catch, while also incorporating some Carp Lake-specific and burbot-specific questions and inviting fishers to share their own observations and concerns. We delivered surveys by either asking the questions verbally and filing out the form with the fishers' responses, or by handing the participant the questionnaire to fill out on paper, depending on their personal preference.

If the participant consented to their harvested burbot being sampled, we measured the burbot's length, weight, and extracted otoliths for age analysis. Otoliths from the Carp Lake creel were processed by North/South Consultants Inc. Ageing Lab, Winnipeg MB, for age data. We also processed otoliths from Fraser Lake, which had been sampled from mortalities that occurred during tagging and handling in 2021 and 2022, and from burbot captured by Ministry biologists during a 2016 SPIN survey. Although the burbot sampled for age data were captured through different means at Carp Lake and Fraser Lake (angler harvests vs samples from surveys), they both provided age data in a study that mainly consisted of live-captures and therefore limited gathering of burbot age data. We used this data to summarize the ages of burbot harvested at Carp Lake, and to relate burbot age to burbot length and weight.

Communicating the study to fishers

We placed posters (Figure 4) in prominent locations around Carp Lake Provincial Park and Fraser Lake (Beaumont Provincial Park and at White Swan and Peterson’s Beach boat ramps) to explain the study to anglers. The study was not widely advertised outside the parks, so as not to attract additional fishing pressure to the lakes. Posters were hung beside boat launches and fish-cleaning station, in outhouses and on bulletin boards. On the posters, we clarified that some burbot have a reward for reporting their tag. Posters also stated that anglers may keep or release their tagged burbot, are asked to keep the tag, and should call the phone number on the tag to provide information about their catch. In 2023, we posted additional posters at Carp Lake explaining the purpose of the creel survey to notify anglers that they may be asked to participate in an academic research survey.

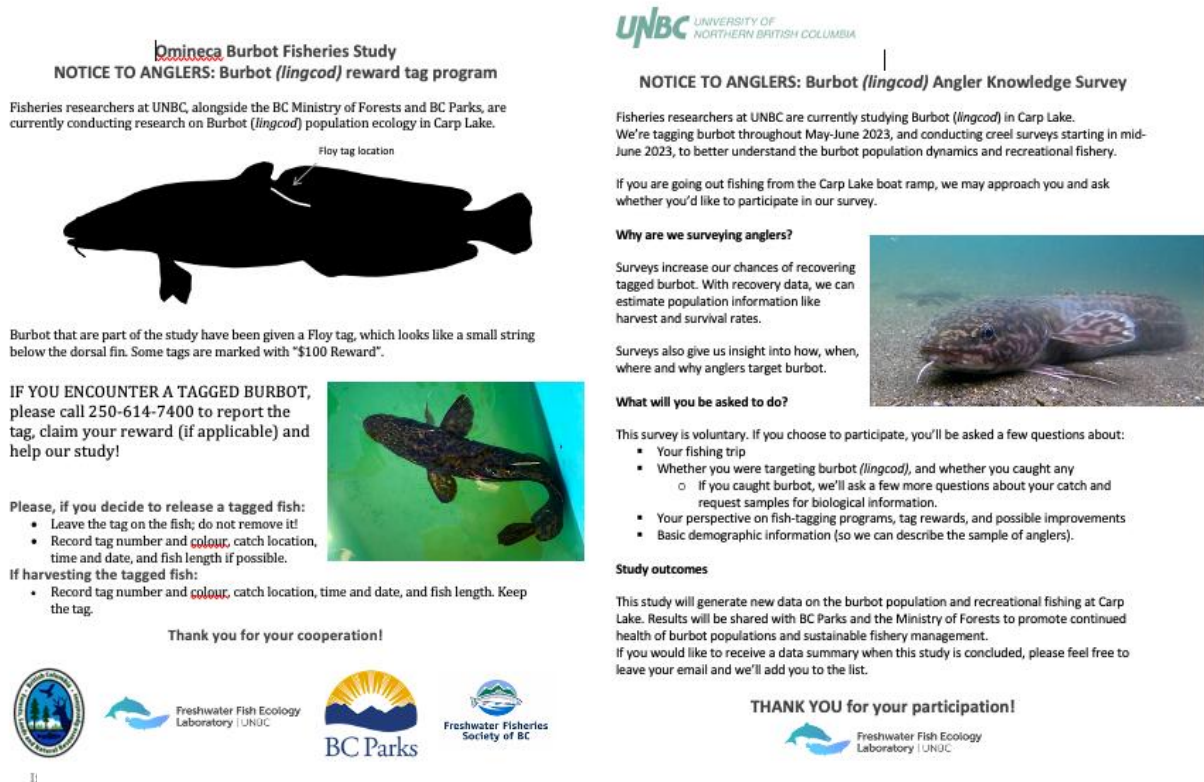


Figure 4. Posters describing the burbot tagging study (left) and creel survey (right).

Data Analyses

Burbot capture

We calculated burbot catch-per-unit effort, or CPUE, for each trap-set as the number of burbot captured per trap hour. The duration of each trap-set was first calculated in hours as the difference between the set time and the pull time; then the number of burbot captured in that trap was divided by the trap duration.

A one-way ANOVA test was used to compare CPUE, in terms of catch-per-unit effort, between Zones within each lake, and between sampling occasions within each lake. This was done to assess whether there were any spatial patterns in burbot capture success (potentially indicating differences in burbot density between zones in the study lakes), and whether burbot capture success depends on season, which might suggest optimal timing for future burbot capture efforts. All statistical analyses and figures were done using R programming software (v4.3.2; R Core Team 2023). CPUE statistics were summarized in a table using the package *gt* (v0.10.1; Iannone et al 2024). Burbot trap and catch location data were recorded in latitude/longitude coordinates and mapped using the *leaflet* package (v2.2.1; Cheng et al 2023). We plotted CPUE by Zone and by season using the package *ggplot2* in R (v3.4.4; Wickham 2016).

Burbot biological data

We measured and compared burbot length, weight, and ages from Carp Lake and Fraser Lake to identify signs of overexploitation by examining size structure, and potentially characterize population-level response to exploitation. We created length and weight frequency histograms, as well as scatterplots of the length-weight relationship, for Carp Lake and Fraser Lake burbot based on measurements of the burbot captured for tag-recovery. We also used age data from otolith samples to create age frequency histograms for Carp Lake and Fraser Lake burbot. We compared the length, weight, and age of burbot between Carp Lake and Fraser Lake using two-sample t-tests in R.

Carp Lake creel and exploitation

We estimated exploitation, survival, and reporting rates for burbot using tag-recovery model implemented using Bayesian inference. Tag-recovery models were originally developed by Brownie (1985) to analyze annual tag recovery data. They are based on the premise that, when individuals are tagged and released at known dates and recovered at a known date in any subsequent year, differences in the number of recoveries of animals tagged from each annual cohort can yield information about the annual mortality rate. When reporting rate is known, it is possible to partition mortality into harvest and natural mortality, because total recovery rate is the product of exploitation rate and reporting rate.

The Brownie model was adapted for twice-a-year tagging by Hearn et al (1998). This model is advantageous because it allows us to estimate reporting rate, as well as exploitation and survival rates, directly from the tag-recovery data, rather than relying on external estimates of tag reporting. Furthermore, the twice-a-year study design requires fewer years of tag returns to estimate parameters accurately, making it better suited to short studies. In the twice-a-year formulation, part of the year is open to harvest and the remainder of the year is closed to harvest. The model assumes no harvest in the winter season in order to separate fishing and natural mortality. In our study in Carp Lake, we believe this is a reasonable assumption because of the inaccessibility of Carp Lake to automobiles in winter; however we are aware that some, likely lower, rate of harvest does occur in winter. A simulation modelling study is in progress to examine how a low level of winter harvest could affect model accuracy and precision.

Burbot tagged in the spring (May – June) each year are considered “pre-harvest season” tags, and burbot tagged in the fall (October) are “post-harvest season” tags. Pre-harvest-season-tagged individuals are subject to harvest and natural mortality in the same year they are tagged, as well as both harvest and natural mortality in every subsequent year. Post-season-tagged individuals are only exposed to natural mortality in the first year, since, they are tagged after harvests end for the season, but experience both harvest and natural mortality in all following years. Throughout each harvest season, tagged burbot may survive the harvest season, be harvested and reported by an angler (i.e. recovered), or be harvested but not reported by an angler. Through our tag-recovery process, we observe only the recoveries – individuals that are both caught and reported via the phone line or creel survey. Because burbot is typically a harvested species, targeted mainly using set-lines in the summer (Barker et al., 2014), we assumed that 100% of burbot that are caught by anglers are harvested, therefore catch rate and harvest rate are equal.

We implemented the tag-recovery model using R and JAGS (R Core Team 2023, Plummer 2003). Tag-recovery data from Carp Lake was formatted as an m-array, with rows representing cohorts of tagged burbot from each tagging session (spring 2022, fall 2022, and spring 2023), and columns representing the number of burbot from that cohort recovered during each subsequent harvest season (summer 2022 or summer 2023). We created a Bayesian model to define the cell probabilities in the m-array; these are the expected numbers of tag returns for each harvest season, as described by Hearn et al (1998). Expected numbers of tag returns are defined based on the premise that individuals from each tagged cohort have a different probability of being caught and recovered during each harvest period, given their differences in time-at-large.

We modified the model to explicitly include two tag types with different reporting rates: no-reward and high-reward tags. We could then specify the number of each tag type deployed in each sampling session, and account for the difference in reporting rates between tag type. We used vague priors modelled by a beta distribution with an interval between 0 and 1 for reporting rate, harvest rate and survival rate.

External estimates of reporting rate

To estimate reporting rate independent of the tag-recovery model, we used the high-reward tagging method (Pine et al., 2003), with \$100-reward tags and standard (no-reward) tags deployed throughout the two years of tagging. This allowed us to estimate reporting rate of standard tags under the assumption that 100% of high-reward tags are reported voluntarily. Previous literature has shown that \$100 is sufficient to result in near-complete reporting of tags (Nichols et al., 1991), although the necessary reward to attain 100% reporting may vary over space and time, and the accuracy of exploitation and mortality rates are sensitive to errors in reporting rate estimation (Brenden et al., 2010). We therefore wanted to evaluate the effectiveness of reward tags using creel surveys as an additional method. Using the creel survey approach, tag-reporting rate is assumed 100% during times when the survey is taking place. Similar to the high-reward method, the rate of tag returns within survey times is compared with the rate of tag-returns outside the survey times. We utilized the equations from Pollock et al (1991) to separately estimate reporting rate based on the ratio of tags returned through the creel survey and through the phone line (Appendix 2).

We took the mean of the two estimates of reporting rate – (1) from reward tags and (2) from the creel survey for a mean reporting rate estimate. We calculated the overall variance as the mean of the variance of two random variables.

We grouped responses to creel survey questions into categories, to summarize percentages of participants giving each response for questions such as type of method used, bait used, and time spent fishing. For open-ended questions, we identified common themes or repeated responses among participants, and summarize these to provide context for tag-recovery results.

RESULTS

Burbot capture data

A summary of burbot capture effort, number of captures, and catch-per-unit effort is presented in **Figure 5**. At Carp Lake, we deployed a total of 559 traps-sets (11,102 total trap hours). This was comprised of 159 trap-sets (3,155 hours) in the spring of 2022, 80 trap-sets (1,619 hours) in the fall of 2022, and 320 trap-sets (6,328 hours) in the spring of 2023. A total of 251 burbot were captured including 95 in spring 2022, 23 in fall 2022, and 133 in spring 2023. Mean catch-per-unit-effort overall at Carp Lake was 0.023. At Fraser Lake, we set a total of 388 trap-sets (22,159 total trap hours). Of these, 198 (16,098 hours) were in the spring-summer of 2021, 141(4,621 hours) in the spring-summer 2022, and 60 (1,440 hours) in the spring of 2023. A total of 83 burbot were captured with 42 in 2021, 30 in 2022, and 11 in 2023. Mean CPUE at Fraser Lake was considerably lower at 0.0001.

Burbot capture effort at Carp Lake, Fraser Lake, and Cluculz Lake					
	Number of traps set	Trap hours	Total burbot caught	Mean CPUE	SD of CPUE
Carp Lake					
Spring 2022	159	3,155	95	0.0299	0.0378
Fall 2022	80	1,619	23	0.0145	0.029
Spring 2023	320	6,328	133	0.021	0.0314
Cluculz Lake					
Spring 2022	49	1,125	1	0.0009	0.0061
Fraser Lake					
2021	198	16,098	42	0.0001	0.0004
2022	141	4,621	30	0.0001	0.0003
2023	60	1,440	11	0.0001	0.0003

Figure 5. Summary of burbot capture effort and success rates by lake and year, for Carp Lake, Cluculz Lake, and Fraser Lake.

Carp Lake

A map of Carp Lake showing the locations where traps were set and where burbot were captured vs. no burbot were captured is shown in (**Figure 6**); we successfully captured burbot in all four zones of Carp Lake. Using one-way ANOVA, we observed no significant difference in burbot CPUE (number of burbot per trap hour) by zone in Carp Lake using cod traps ($F_{3, 273} = 0.841, P = 0.473$). (**Figure 7**).

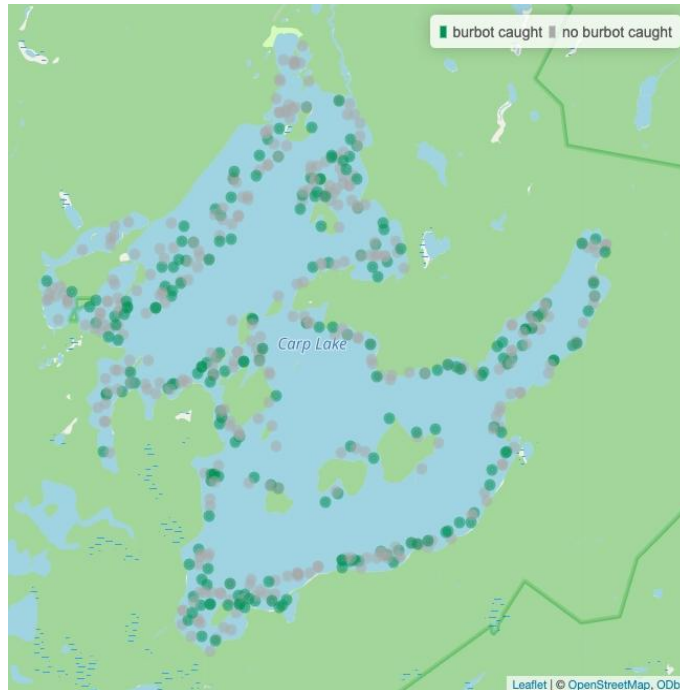


Figure 6. Map showing the sites at Carp Lake where at least one burbot was captured (green) and where traps were set but no burbot were caught (grey).

Sampling season did appear to influence CPUE for burbot using cod traps (**Figure 8**). We observed similar CPUE in both spring tagging occasions (May-June 2022 and May-June 2023), and lower median CPUE in the fall (October) week of tagging. We used a one-way ANOVA to determine any statistical difference in burbot CPUE in relation to trapping season. There was a statistical difference in burbot catch per unit effort between seasons ($F_{2, 273} = 7.78, P = 0.0005$).

In our trapping efforts, we typically captured one burbot (22.75%) or no burbot (72.44%) per trap set; though occasionally, we encountered two burbot in a trap (3.71%) and on rare occasions, we captured three burbot in a trap (1.10%) (**Figure 7**).

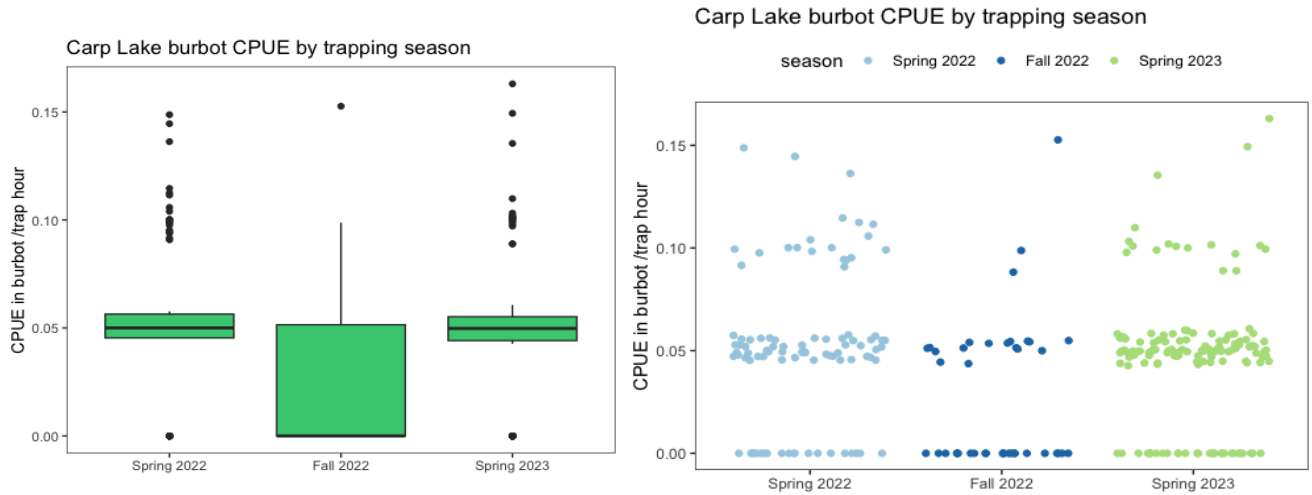


Figure 7. Burbot CPUE in burbot/hour (left) and total number of burbot caught per trap (right), by season of tagging at Carp Lake.

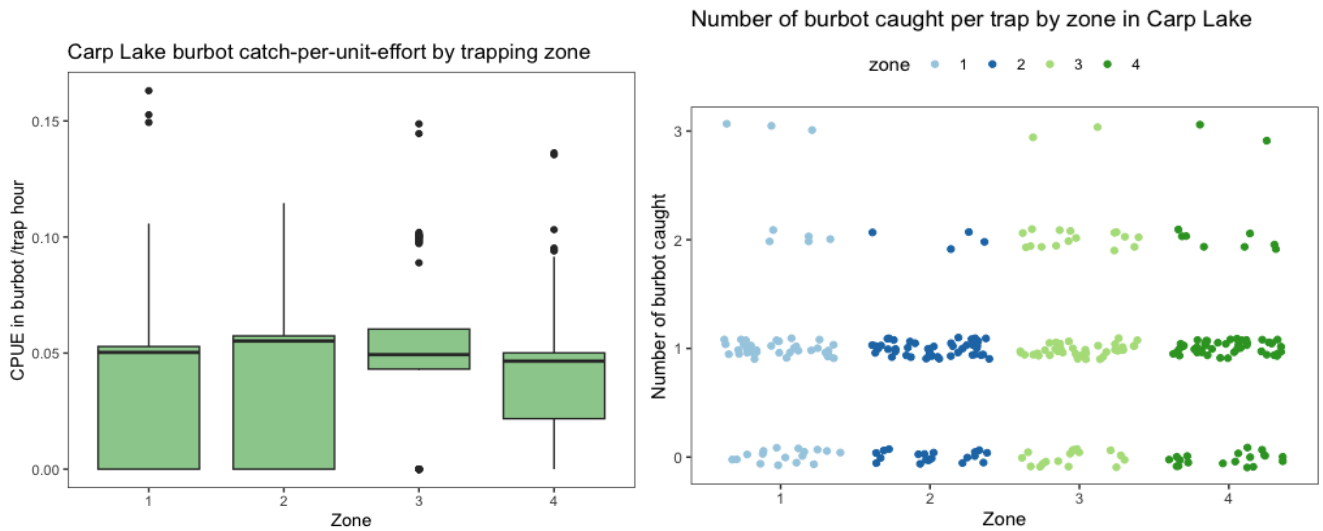


Figure 8. Burbot CPUE in burbot/hour (left) and total number of burbot caught per trap (right), by zone in Carp Lake.

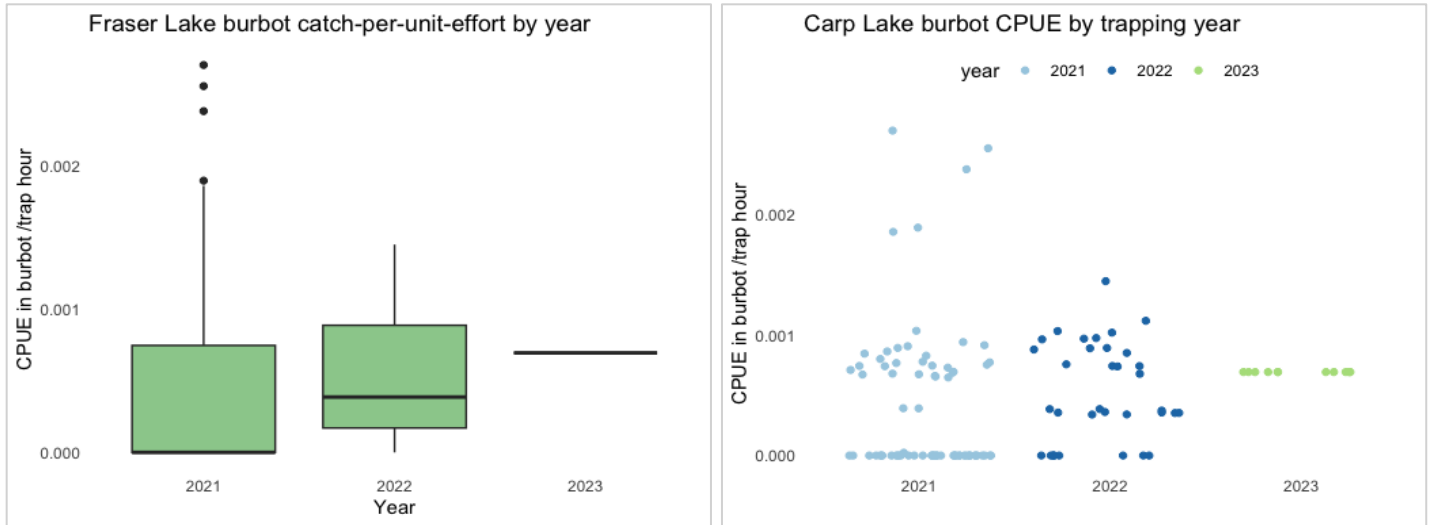


Figure 11. Burbot CPUE in burbot/hour (left) and total number of burbot caught per trap (right), by year of tagging at Fraser Lake.

Cluculz Lake

The research team attempted to trap burbot at Cluculz Lake during the 2022 field season. Over three days of effort (49 trap-sets; map shown by **Figure 12**), only one burbot was captured, providing insufficient data to analyze burbot catch rates.



Figure 12. Map showing the trapping locations at Cluculz Lake, 2022, where at least one burbot was caught vs where no burbot were caught.

Burbot biological data

Carp Lake

At Carp Lake, the median length of burbot captured for tagging was 632.5 mm (IQR 585 - 715 mm). The median weight was 1800 g (IQR 1350 – 2825 g). Most burbot fell within the 1000 – 1500g weight class. The weight distribution of burbot was right-skewed with some individuals weighing up to 6000 g (**Figures 13-14**). Age of burbot sampled during the creel ranged from 6 years to 19 years, with a mean of 14 years (**Figure 15**).

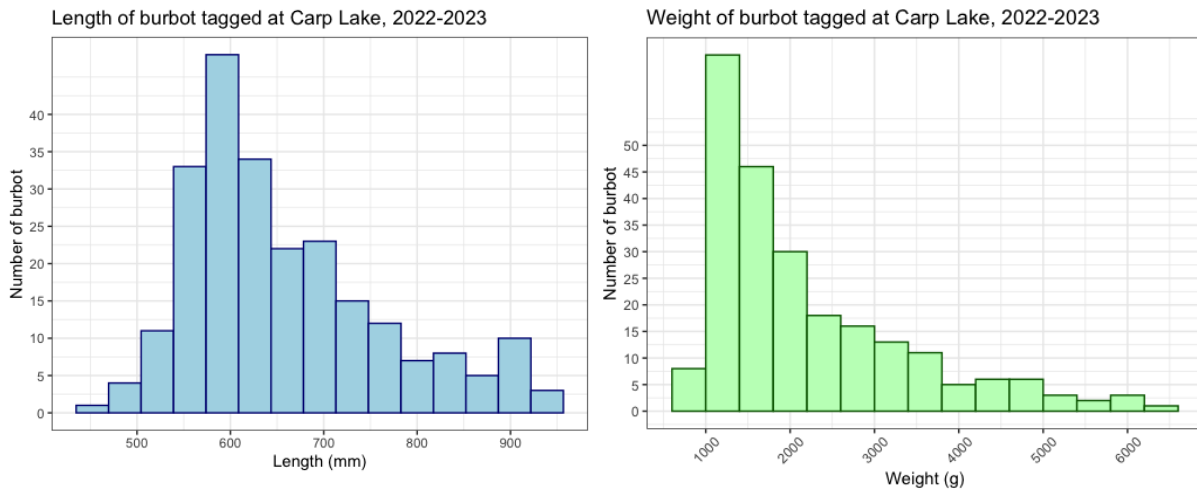


Figure 13. Length frequency histogram for tagged burbot at Carp Lake in 2022 and 2023 (right); weight frequency histogram for tagged burbot at Carp Lake in 2022 and 2023

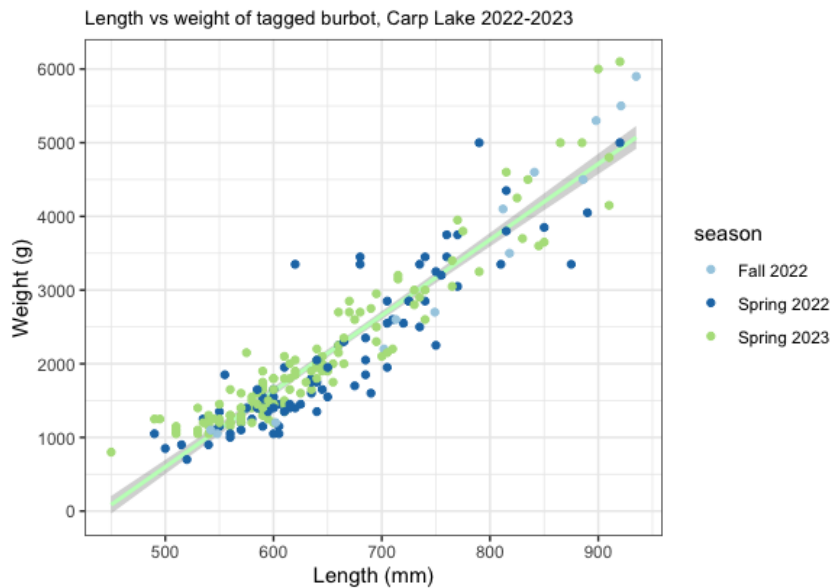


Figure 14. Length – weight relationship for burbot tagged at Carp Lake in 2022 and 2023.

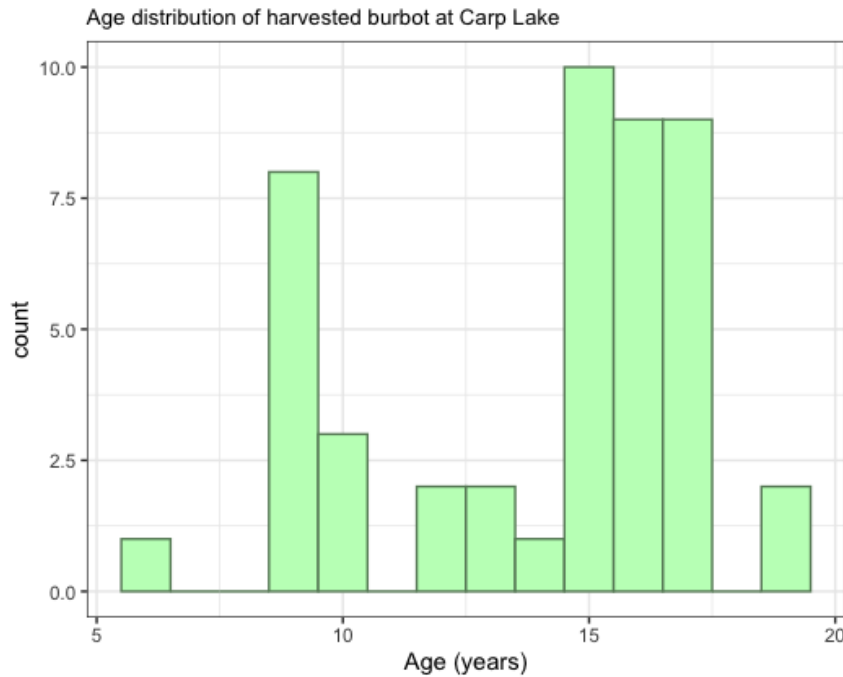


Figure 15. Age distribution of the burbot sampled for otoliths at Carp Lake.

Fraser Lake

The median length of burbot captured in Fraser Lake was 595 mm (IQR 470 – 650 mm), whereas their median weight was 1050 g (IQR 650 – 1300 g). Tagged burbot length and weight frequency distributions (**Figure 16**) showed a left skew in burbot lengths, while weights were more normally distributed with a mode around 1000-1200 g. The relationship between burbot length and weight appeared linear (**Figure 17**). Mean age was about 10 years at Fraser Lake, with a range of 5 years to 15 years (**Figure 18**).

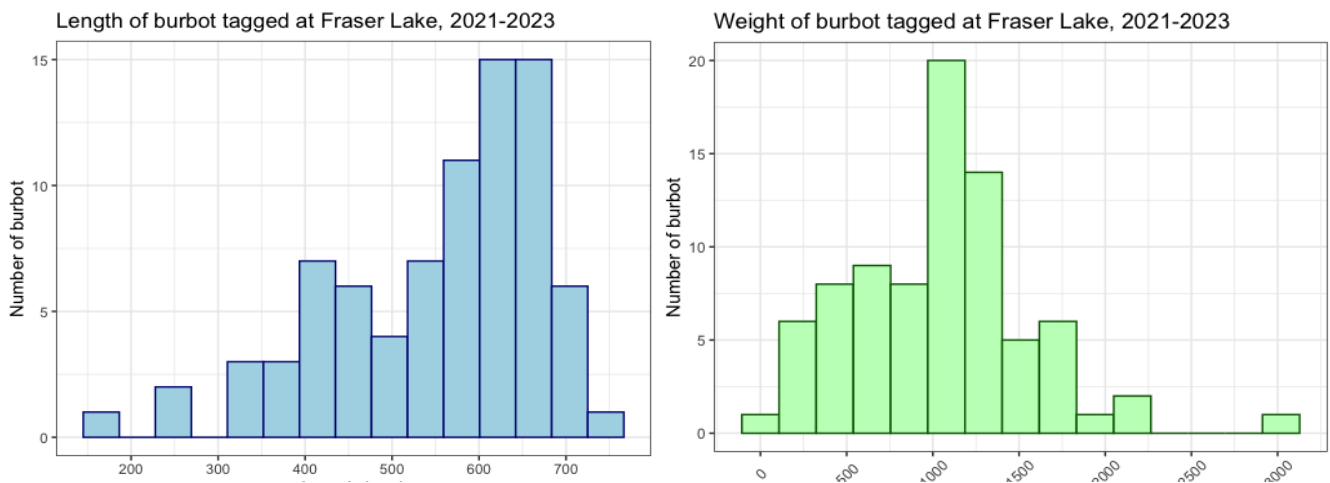


Figure 16. Length frequency histogram for tagged burbot at Fraser Lake across 2021, 2022 and 2023 (right); weight frequency histogram for tagged burbot at Fraser Lake across 2021, 2022 and 2023 (left).

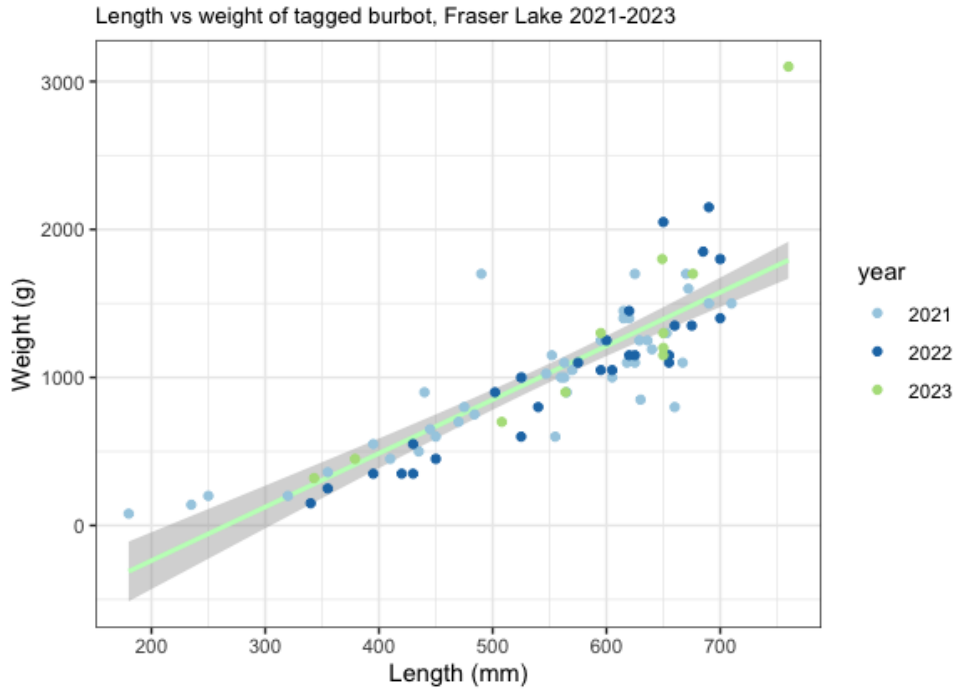


Figure 17. Length – weight relationship for burbot tagged at Fraser Lake in 2021, 2022 and 2023.

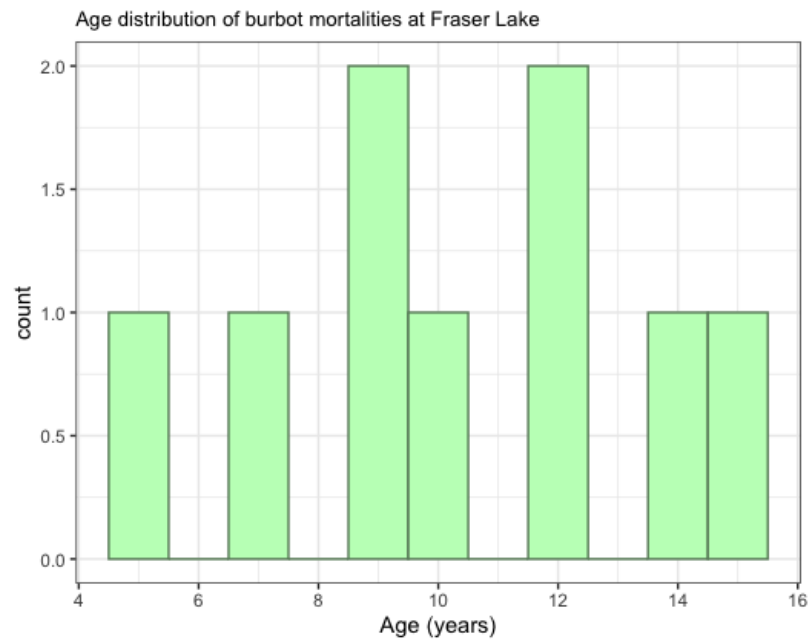


Figure 18. Age distribution of burbot sampled for otoliths at Fraser Lake.

Inter-lake comparison (Carp Lake vs Fraser Lake)

Burbot captured at Carp Lake were older (Mean \pm 1 SD = 14 \pm 3.29 years; $t_{11.4} = 3.084$, $P = 0.01$), longer (658.6 \pm 107.5 mm; $t_{124.6} = 6.99$, $P < 0.001$), and heavier (2,227 \pm 1,207 g; $t_{297.5} = 12.13$, $P < 0.001$) than those captured at Fraser Lake (10.33 \pm 3.24 years; 551.3 \pm 122.9 mm; 1036 \pm 528 g) (Figures 19-21).

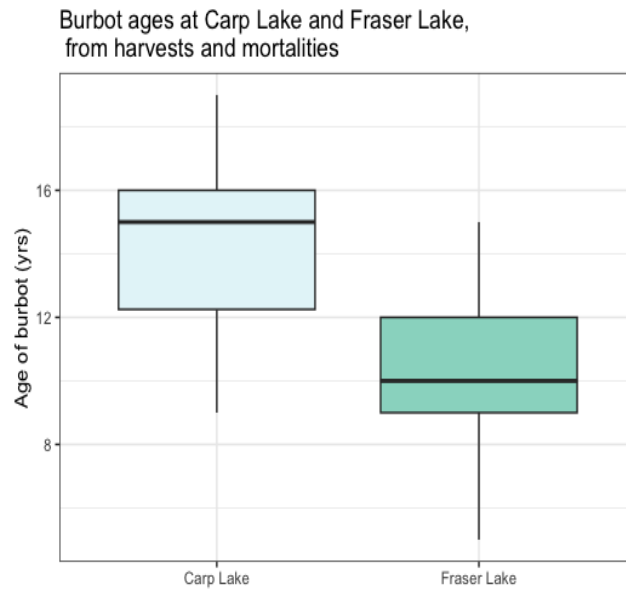
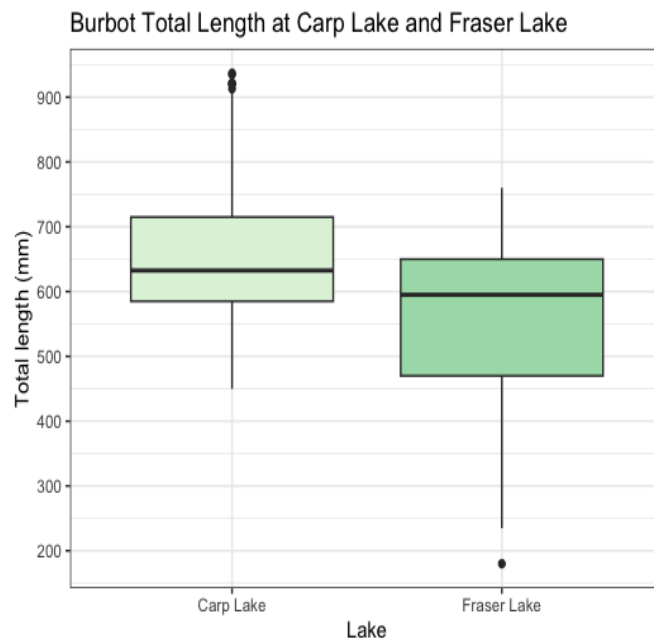


Figure 21. Ages of burbot sampled for otoliths at Carp Lake and Fraser Lake.



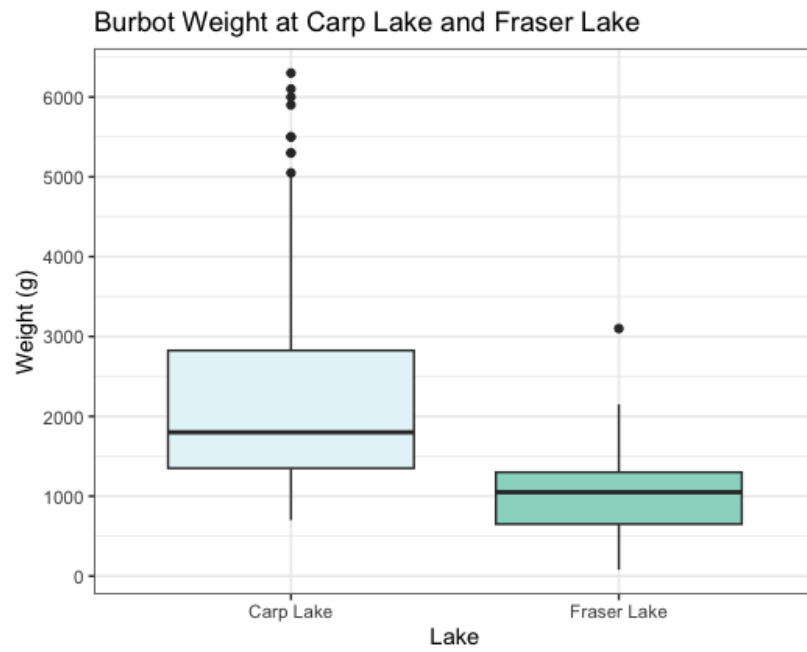


Figure 23. Burbot weights at Carp Lake and Fraser Lake.

Tag-reporting and exploitation data*Carp Lake: Estimation of exploitation rate*

In the 2022 fishing season following our first tagging occasion, there were 91 tags at-large in Carp Lake. Two tags were recovered and returned by fishers in 2022. In the 2023 fishing season, before accounting for natural mortality, 89 tags from Year 1 were still at large, as well as an additional 23 tags deployed during the fall 2022 post-season tagging, and 122 tagged in spring 2023. We received a total of 15 tag reports in 2023: 8 via phone and 7 via creel surveys.

Out of all 17 tagged burbot caught and reported by anglers (via phone or creel, across both years), all were harvested. Out of the 17 tags returned, 10 were high-reward tags and 7 were standard tags. Creel survey data also showed that all but one (out of 56) of the burbot caught during the 2023 season were harvested, as per responses to the question asking whether any burbot caught were released or kept

Using the tag-recovery model, mean harvest rate (or fishing mortality rate, F) was estimated at 0.074 or 7.4% (SD = 0.019). Reporting rate for standard tags was estimated at 0.697 or 69.7% (SD = 0.126). Survival rate was estimated at 0.690 or 69% (SD = 0.197); this can also be stated as the inverse: the natural mortality rate N was estimated at 31%.

Carp Lake: Estimation of tag-reporting rate

We compared reporting rate to the estimate calculated using the equations from Pollock et al (2001, 1991). Over both harvest seasons, 10 high-reward tags (out of 119) and 7 standard tags (out of 117) were reported by anglers. Using the high-reward method, we estimated reporting rate as 0.71 or 71% with a variance of 0.115. We recovered 7 burbot via the creel survey and 10 via the phone line, with a total of 39 days surveyed out of a possible 119 summer season days in 2023. The total number of tags recovered expanded across the whole season (\hat{R}) was estimated at 21.35 ($\widehat{var}(\hat{R}) = 65.1$). Using the creel survey method, we then estimated reporting rate at 0.70 or 70%, with a variance of 0.019. The mean reporting rate from both equations is then about 70.5% with a variance of 0.134. This is very similar to the reporting rate of 69.7% estimated by the model.

Fraser Lake

No tags (out of 83 tagged burbot) have been returned by anglers at Fraser Lake during the study period up to the reporting date. Consequently we are unable to estimate exploitation rate of the Fraser Lake fishery.

Cluculz Lake

We were unable to estimate exploitation at Cluculz Lake as we were only able to capture and tag one burbot in 49 trap sets (CPUE = 0.0009).

Creel data

We asked anglers which method they used to target burbot: set-lining, jigging, both, or another method. Out of 38 fishing trips from 35 anglers/groups, 35 respondents (92.1%) reported using a set-line to target burbot. 2 respondents (5.3%) reported actively fishing for burbot by jigging. 1 respondent (2.6%) used both set-line and jigging methods on their trip. To summarize start and end times for anglers’ set-lining activity, we categorized set times into three main “blocks”: morning (before 11:00 AM), mid-day (after 11:00 AM but before 5:00 PM) and evening (between 5:00 PM and midnight). A total of 58.3% of respondents reported setting their line in the evening, 22.2% of respondents reported setting their line in the morning, and 19.4% set their line during the mid-day time block.

We asked fishers how likely they would be to report a tagged burbot given no reward, and then given a reward of \$100 (**Figure 22**). Answer choices were on a scale from “very unlikely” to “very likely”. For standard (non-reward) tags, 57.6% of respondents said they would be “likely” to report a tagged burbot, 27.3% of respondents said their likelihood to report a tagged fish would be “neutral”, 6% (two anglers) said they would be unlikely to report, and another 6% said they would be “very unlikely” to report. Only 3% of respondents (one angler) responded “very likely” to report a tagged fish without a reward. For \$100 reward tags, 75.8% of respondents responded “very likely” to report a tagged burbot and 21.2% responded “likely” to report a tagged burbot. Fewer anglers indicated neutral-unlikely responses. No angler responded “neutral” or “unlikely”, and 3% (one angler) responded “very unlikely”.

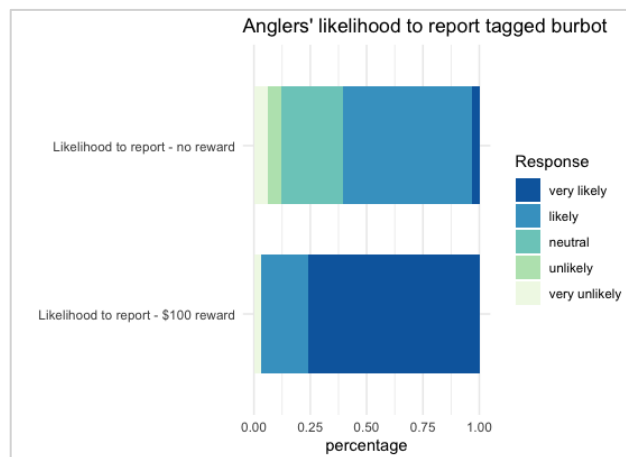


Figure 24. Responses for fishers’ likelihood to report a tagged burbot, given no reward or a \$100 reward.

In terms of awareness of the tagging study, a total of 58.8% of respondents replied that they knew a burbot tagging program was taking place at Carp Lake before being approached for the survey. 41.1% of respondents replied they were not aware that there was a tag-recovery study happening at Carp Lake.

DISCUSSION

To date, the burbot study at Carp Lake suggests an annual fishing mortality rate of about 7.4%. The 2023 fishing season likely provided more robust data due to the larger sample size of tagged burbot at-large in Carp Lake, and the presence of a creel agent collecting data on tagged and untagged burbot for approximately one-third of Carp Lake Park's opening dates. The presence of a creel agent collecting tagged burbot also may have increased the reporting rate of non-reward tags for 2023. Burbot fishing activity still could have been underestimated in 2023, as some groups of anglers brought their fish back via smaller docks and small trails directly to their campsite, making it difficult to survey these people or determine if they had caught any fish. Overall participation rate was high, but there were a couple of isolated instances when anglers declined to participate in the survey, due to time constraints or other undisclosed reasons.

Spatial data from cod trap catch rates showed relatively equal capture success across the four "zones" of Carp Lake. However, from field observations we did experience lower burbot capture success in some of the bays that we sampled. For instance, Kettle Bay (north-east corner of the lake), in close proximity to the main boat launch, yielded few burbot, as did Sekani Bay, the northwest "arm" of Carp Lake. This may have been due to the shallower depth in these bays. Burbot are known to occupy deeper waters within lakes, though they exhibit diel bank migration for feeding at night (Cott et al., 2015). Kettle Bay also appeared to experience much higher fishing pressure relative to the rest of the lake, according to our creel survey responses, which may have caused a behavioural response (burbot avoid this area) or lower burbot abundance in this area due to fishing. Sekani Bay is nearly separated from the main lake by a shallow, narrow channel, which could limit burbot movement into and out of the bay during low-water periods. Burbot CPUE was relatively high at Carp Lake overall, around 0.05 burbot per trap-hour. Using overnight sets of about 18-20 hours, we can therefore expect about 1 burbot per trap set (on average) for this lake specifically. Capture success did differ by season, with higher CPUE observed in the spring trapping efforts compared to our one fall trapping effort. This observation is interesting given that burbot have been shown to occupy shallower depths as summer progresses into fall, a movement likely associated with changes in the amount of light entering the water column (Cott et al. 2015). Changes in burbot catch rates could perhaps result from seasonal changes in burbot activity level due to their life-history (with spawning occurring in late winter), water temperature, or resource partitioning with other species (Guzzo et al. 2016). Taken together, the catch rates at Carp Lake in 2022-2023 suggest cod traps are an effective method for burbot live-capture, and that resources may be better placed sampling for burbot in the spring (post-ice-off), rather than in the fall.

Some possible explanations for the low catch rate using cod traps at Cluculz Lake include the unique bathymetry of the waterbody, warm water temperatures, potentially higher fishing pressure in the shallow parts of the lake, or time of year. Cluculz Lake has a steep drop-off near the shoreline, with only a small proportion of the lake being shallower than 10m. This shallow area

rapidly drops to ~25 meters, and the lake has a maximum depth of about 60 meters. To trap within the 10-meter depth contour (following protocols to avoid barotrauma), we needed to set traps very shallow and close to shore. It is possible that burbot did not encounter our traps if they congregated in the deeper areas of the lake; furthermore, the presence of waterfront properties around the shoreline of Cluculz Lake might influence burbot habitat use if fishing pressure is high in these areas. Alternatively, water temperatures appear to affect catch rates for burbot. Cluculz Lake sampling was done in late May, when water temperature is starting to increase and burbot potentially move toward deeper, colder waters. We observed decreasing catch rates throughout the spring seasons at Fraser Lake in 2021 and 2022 as temperatures warmed. The highest catch rates for burbot seem to be just after ice-off. Therefore, it may be worthwhile to attempt sampling Cluculz Lake again in the future very early in the spring season, and perhaps at slightly deeper depths, with modified methods from those deployed in this study. For example, a baro-descender or other method of mitigating barotrauma such as pulling traps up from depth over two days, could be used. As we deployed consistent and standardized methods that yielded reasonable catch rates in Fraser and Carp Lakes, but not in Cluculz Lake, our results could also suggest that Cluculz Lake burbot have a different life-history and/or habitat use, which may be the result of the differing habitat. Standardizing burbot assessments is challenging due to these knowledge gaps in lake-specific habitat use. It may be necessary to cater burbot monitoring methods to be lake-specific.

Anecdotally, we are aware that the burbot fishery at Cluculz Lake is popular and productive, particularly in the winter months. This suggests that cod trap results presented here likely do not reflect a low abundance of burbot in Cluculz Lake, rather that methods need to be better calibrated to assess this lake. For example, a winter creel survey may yield information on the fishery.

The Carp Lake creel survey provided information about the typical fishing practices used for burbot at Carp Lake. Responses regarding fishing method to target burbot were fairly consistent with our assumption that most anglers set lines overnight, though there was substantial variation in the time of day participants started fishing. The majority of fishers checked or pulled their line in the morning, though a substantial proportion checked or pulled their line during the daytime or in the evening. Many fishers said that they check their lines in both the morning and evening, and re-set their line with new bait if they did not catch a burbot on their first attempt, if staying longer on their visit.

Following the first burbot-tagging effort at Carp Lake in spring 2022, angler participation in tag reporting was low: we received two tag-reports in the summer of 2022, while 91 tagged burbot were at-large. The creel survey appeared to improve these return rates. Furthermore, by asking anglers for their opinions regarding tagging studies and their experience fishing at Carp Lake, we identified some limitations to tag-recovery methods and potential improvements for future studies. A few survey responses indicated that the study needed additional clarity that anglers may keep their tagged fish. This confusion may be a response to past studies having requirements to catch-

and-release fish with tags. As a result, some tagged burbot could have been caught and immediately released once the angler noticed a tag; or, anglers may not report tagged burbot that they harvest if they believe harvesting the fish is not allowed.

Some different methods of reporting could work better for fishers, including an online form or app, or having a drop-box at the fish-cleaning station. Fishers might not want to complete additional tasks (calling, filling out forms, etc) after they complete their trip, which points to a drop-box as a solution when creel survey agents cannot be present at all hours. The creel survey generally appeared to improve reporting rates, as we were able to clarify how the tag-recovery program worked when talking with anglers, and explain what the tags look like and why reporting them can help provide population information about burbot. Additionally, many anglers did not know about the tagging study prior to participating in the survey. The question regarding likelihood to report tagged burbot, with and without rewards, indicated that most anglers are very likely to report a fish with a \$100 reward, while more anglers responded with a lower likelihood (likely, neutral, or unlikely) when asked about non-reward tags. It is probably advantageous then, to invest money into reward-tag programs to ensure accurate harvest data and avoid underestimation of burbot catches.

There were a few general complaints from anglers about regulations being “confusing”, which may be a comment regarding species-specific and waterbody-specific differences in catch limits and gear restrictions. Any lack of clarity on burbot regulations could cause reluctance in participating in surveys; anglers may feel less inclined to allow a researcher to sample their catch or ask questions about their fishing activity. The recent installation of a large sign outlining burbot limits and gear restrictions at Carp Lake likely helps with this issue, and similar signage could be put in at other popular burbot-fishing lakes. But generally, anglers showed a high level of enthusiasm to participate in the survey, an interest in burbot conservation, and expressed that burbot management is important work.

Inter-lake comparison

Burbot captured and tagged at Carp Lake had both higher median length and weight than burbot from Fraser Lake. Burbot sampled for ageing structures from Carp Lake were on average older than those sampled from Fraser Lake. Carp Lake burbot showed a right skew in their weight distribution, while burbot from Fraser Lake had more normally distributed weights. We observed much higher maximum values for both length and weight at Carp Lake. Additionally, catch rates were higher at Carp Lake than Fraser Lake; together these observations suggest a potentially healthier burbot stock at Carp Lake compared to Fraser Lake in terms of population structure and abundance. Additional years of data from both lakes would be helpful to better understand the population structure with a larger sample size. The absence of any tag-returns to date at Fraser Lake, compared to the 17 tag returns obtained at Carp Lake in two years, suggests potentially lower levels of burbot fishing at Fraser Lake, or some difficulty in fishers accessing burbot at this site.

RECREATIONAL BENEFITS ACHIEVED AS AN OUTCOME OF THIS PROJECT

To date there has been little focus on burbot population monitoring, despite the potential sensitivity of burbot to overharvest and changes in lake habitat. Burbot is a popular harvest species in our region with relatively liberal fishing regulations (set-lining is allowed with some exceptions) and more information on burbot fisheries benefits how these fisheries can be managed sustainably.

The project supplies current information about burbot fishing activity at Carp Lake Provincial Park. Our results indicate a relatively low harvest rate of 7.4% for burbot at Carp Lake, while survival rate was estimated at 69% (natural mortality rate of 31%), meaning that harvest mortality comprises about 24% of total mortality. Since this is within precautionary limits ($F < 0.5-0.7M$, where F is fishing mortality and M is total mortality), it appears that burbot in Carp Lake are not currently at risk of over-exploitation (Warnock 2022). We also provide the first estimates of reporting rate for burbot using a tag-recovery approach.

This project also has helped identify methods for effectively capturing and tagging burbot, a historically under-studied species in the Omineca Region. We utilized cod traps for burbot capture at both Carp Lake and Fraser Lake with good success at both lakes, while success at Cluculz Lake was limited and results indicate additional work using an alternate approach to study the fishery may be required. The use of reward tags yielded success at Carp Lake, while no reports were received at Fraser Lake, despite successful tagging efforts.

Cod traps present a relatively cost-effective, reliable, and safe method for trapping live burbot; most burbot tagged after being held in cod traps recovered very quickly and were released immediately. The tag-recovery results to date show that tagging live burbot is a viable method for estimating exploitation in a recreational fishery, especially when tag-reporting is incentivized using rewards and/or a creel survey.

MANAGEMENT RECOMMENDATIONS

For Carp Lake, our estimates of harvest and survival from the tag-return study show that fishing exploitation rate (also referred to as harvest mortality) appears to be a small (24%) proportion of total mortality. We therefore recommend no change to current recreational fishing regulations for Carp Lake at the time of this study. These analyses are not finalized as the tag-recovery model will still be adjusted for tag loss, and simulation modelling will inform us as to how violation of the assumption of no winter harvest affects model accuracy. These adjustments are being made as part of the Master's thesis with expected completion in 2024. In future research, it would be useful to gather population demographic information, using live mark-recapture techniques which estimate abundance. This would put the exploitation rate information into the context of burbot population size and better indicate the sustainability of the fishery.

It is unclear how much winter ice-fishing harvest takes place at Carp Lake, and how any winter harvest rate contributes to total annual harvest. Additionally, burbot fishing methods likely differ between summer and winter, with set-lining being dominant in the summer while jigging might play a bigger role in winter fishing activity. This could lead to different catch rates; jigging may make fishers more likely to reach the daily limit of five burbot. Finally, burbot spawning activity during the ice-fishing season could make burbot more susceptible to overharvest in winter, and it is worth examining how much fishing pressure is applied during this important season. We therefore believe conducting a winter creel survey, or other monitoring approach such as trail cameras, would provide useful information on year-round burbot fishing at Carp Lake.

At Cluculz Lake, we recommend further efforts to trap and tag burbot using adjustments to the methods used in this study. Future trap-setting should include deeper sets (deeper than 10 m) with use of a descender device or multi-day pulls to mitigate barotrauma. This might resolve low catch rates if burbot in Cluculz Lake are inhabiting the deeper areas. We also recommend implementing a burbot-specific creel survey at this lake, ideally in both the summer and winter, to investigate the level of fishing pressure burbot are experiencing at this front-country lake.

At Fraser Lake, it is not clear whether the absence of tag reports in the exploitation study was a result of low fishing effort, low catch success rates, or low tag-reporting rate. Given this lack of information about the recreational fishing activity occurring at Fraser Lake, we recommend a burbot creel survey be implemented at this fishery as well. Monitoring recreational fishing activity will yield information about how much burbot harvest is taking place at Fraser Lake, how fishing activity is distributed seasonally, and indicate the sustainability of the fishery. In addition, the results from the parallel oxythermal habitat and seasonal habitat use study of Burbot and white sturgeon should be considered when considering burbot management actions at Fraser Lake.

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Appendix 1: TAG-REPORTING RATE EQUATIONS

Using the high-reward tag approach (Pollock et al., 2001) based on our reward-tag program in 2022-2023, we estimated angler reporting rate for tagged burbot with the following equation:

$$\lambda = \frac{R_s N_r}{R_r N_s}$$

where R_s is the number of standard tags returned, N_s is the number of standard tags released, R_r is the number of high-reward tags returned, and N_r is the number of high-reward tags released (Pollock et al., 2001).

The variance of the reporting rate using reward tags is given by:

$$var(\lambda) = \lambda^2 \frac{N_s - R_s}{N_s R_s} + \frac{N_r - R_r}{N_r R_r}$$

Using the creel survey method, reporting rate is given by the following equation (Pollock et al., 1991):

$$\lambda = \frac{R_h}{R - R_s}$$

where R_h is the number of tags recovered by anglers that are reported in the absence of the creel (in our study, this is the number of tags reported via the phone line). \widehat{R} is an estimate of the total number of tags recovered by anglers (the number we would expect to encounter if creel surveys took place over the entire season, or a complete census of the fishery was carried out). R_s is the number of tags recovered by anglers that were solicited during the creel.

We estimated \widehat{R} by first calculating the ratio between the total number of days surveyed, and the total number of available days that could have been surveyed throughout the 2023 season. We then used this multiplier to expand the number of tags recovered during our surveys across the whole season.

The variance of the reporting rate using creel surveys is given by:

$$\widehat{var}(\hat{\lambda}) = \frac{\hat{\lambda}(1 - \hat{\lambda})}{\widehat{R} - R_s} + \frac{\hat{\lambda}(1 - \hat{\lambda})\widehat{var}(\widehat{R})}{(\widehat{R} - R_s)^3}$$

Appendix 2: CREEL SURVEY QUESTIONNAIRE

Carp Lake Angler Knowledge Survey

Survey number: _____ Surveyor Code: _____

Date: _____ Time: _____

Angler Code: _____ No. in Party: _____

Part A: Fishing trip information

1. Did you go fishing out on the lake today?
 Yes No (*skip to Part B*)
2. What time did you start fishing today? _____
3. If you're not done fishing for the day, about how long do you think you'll spend fishing today (total number of hours)? _____
4. Did you fish for burbot (*lingcod*) today?
 Yes No (*skip to Part B*)
5. I) Did you release or keep any burbot/lingcod?
Released: _____ Kept: _____
II) Do any of your burbot have a tag that looks like this? [*example anchor tag*]
 Yes No
Number of tagged burbot:

III) Do you have any burbot that you'd let us measure today?
 Yes No
Total length (mm): _____
Weight (g): _____
IV) We're looking at the sizes and ages of burbot in Carp Lake and need burbot heads to estimate age. Would you be willing to give us any today?
 Yes (*sample collected Y/N*) No
6. What kind of fishing gear are you using for burbot today? (*circle all that apply*)
 Set-line Jigging

- Other: _____
- 7. (If set-lining) At what time of day do you typically:
 - a. Set your line? _____
 - b. Check your line? _____
 - c. Leave the water? _____
- 8. What kind of bait are you using?

- 9. Roughly where on the lake did you catch burbot today?

Part B: Burbot fishing at Carp Lake

- 10. About how often do you fish for burbot at Carp Lake each year?
 - Once a year or less
 - Between 2-5 times per year
 - More than 5 times per year
 - I come here regularly (e.g. once a month or more)
 - Other: _____
- 11. Before we began this survey, were you aware there is a burbot tagging program happening at Carp Lake?
 - Yes
 - No
- 12. Because we have little information on burbot at this lake, we're trying to access fisher knowledge about burbot, and figure out how to encourage fishers to share what they know. We're looking at different ways to get people involved in reporting the tagged fish they catch. The next few questions are about that:
 - I) How likely do you think people fishing at Carp Lake are to report a tagged burbot by calling a phone number on a tag, if no reward is involved?
 - Very unlikely
 - Unlikely
 - Neutral
 - Likely
 - Very likely
 - II) How likely do you think people would be to report a tagged burbot if there is a \$100 reward on the tag, awarded to you when you call the phone number?

- Very unlikely
- Unlikely
- Neutral
- Likely
- Very likely

III) Can you think of other ways to report tagged burbot that would work better, or different rewards that would encourage reporting?

Part C: Observations of the burbot fishery

1. How long have you been fishing for burbot at Carp Lake?

- 1 year or less
- 2-5 years
- 5-10 years
- 10-20 years
- More than 20 years

2. Have you ever heard concerns about fish or fishing at Carp Lake?

3. Have you noticed any changes in burbot during the time you've been fishing at Carp Lake?

Part D: Demographic information

1. Which age range do you belong to?

- 18-34 years old
- 35-49 years old
- 50-64 years old
- 65-79 years old
- 80 years or older
- I prefer not to say

2. About how long does it take you to drive to Carp Lake from your place of residence?

- Less than 1 hour
- 1-3 hours
- More than 3 hours
- I prefer not to say

3. Are you a member of a First Nation?

- Yes
 - No
 - I prefer not to say
4. What gender do you identify as?
- Female
 - Male
 - Non-binary
 - Transgender
 - Two-Spirit
 - I prefer not to say
 - Other: _____

5. Please choose the highest level of education that you have completed.
- Some high school
 - High school diploma
 - Some university or college or trade school
 - Bachelor's degree or college diploma or trades certificate
 - Master's degree
 - Some graduate school
 - Ph.D/doctoral degree or equivalent
 - I prefer not to say
6. What is your estimated annual household income?
- Under \$15,000
 - Between \$15,000 and \$29,999
 - Between \$30,000 and \$49,000
 - Between \$50,000 and \$74,999
 - Between \$75,000 and \$99,999
 - Between \$100,000 and \$150,000
 - Over \$150,000
 - I prefer not to say

Thank you for taking the time to participate in our study. We could not do this research without you! If you would like to receive a summary of results, or if you have any questions or concerns about burbot research at Carp Lake, please contact Liz Hirsch (ehirsch@unbc.ca).