

**Omineca Burbot Creel, Habitat and
Population Assessment Project;
Results of Surveys of Sport-Ice Fisheries
and Assessments of Burbot (*Lota lota*)
Populations in Saxton, Nukko, Eaglet,
Cluculz and Norman lakes**

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Executive Summary

Surveys of sport-ice fisheries on 5 lakes in the vicinity of Prince George (Saxton, Nukko, Eaglet, Cluculz, and Norman lakes) were undertaken from January-April 2007. Monitoring of ice fisheries consisted of roving surveys of each lake on an alternating schedule encompassing morning and afternoon periods and weekends and weekdays. Anglers encountered were interviewed as to their fishing method, the duration of their angling activity, species being targeted and their catch. Hourly counts of active fishers were also gathered by surveyors, and self-activating cameras were deployed on each study lake to gather hourly photos documenting angler effort on a portion of each study lake. Surveyors also collected aging structures and general morphological/biological information from any burbot within anglers' creels during interviews conducted. When possible, surveyors also undertook their own ice fishing activities during the survey, in an effort to catch and sample additional burbot. Post ice-off, from May-August 2007, surveyors conducted a small amount of sampling for burbot on four of the study lakes, utilizing cod and minnow traps.

Sport-ice fisheries on lakes in the Prince George area are popular activities, but limited information exists with respect to trends related to annual angler effort, the species being targeted, and the impacts of the fisheries on local fish populations, in particular, wild fish populations. Little to no information exists with respect to the number of burbot being harvested from various area lakes. Further, the life history-related habitat requirements of these burbot populations and the potential impacts of the MPB epidemic being experienced in the area are poorly understood.

A total of 16, 23, 30, 28 and 29 surveys-visits to each lake's ice fishery were completed, resulting in 61, 103, 168, 93 and 120 hourly angler counts on each of Saxton, Nukko, Eaglet, Norman and Cluculz lakes, respectively. The surveys completed resulted in 6.3%, 10.0%, 17.0%, 9.4% and 12.1% coverage of the total potential ice fishery occurring during the survey period on each of Saxton, Nukko, Eaglet, Norman and Cluculz lakes, respectively. Angler effort on Saxton and Nukko lakes was observed to be very low. Average hourly rod counts documented on Eaglet, Norman and Cluculz lakes were 0.512, 0.183 and 1.233 rods/hour, respectively. Estimated burbot CPUE was 0.046, 0.130 and 0.052 burbot/rod-hour for Eaglet, Norman and Cluculz lakes respectively. Characteristics of angler's effort and catch for each of the study lakes are presented and discussed in further detail.

Biological and life history information was collected from a total of 54 burbot during the study. While the sample size is small, population status assessment techniques indicate that all populations continue to recruit

juvenile burbot, and that increased exploitation is evident in Cluculz and Eaglet lakes, relative to Norman Lake.

Limited information is ascertainable from the project's results regarding important burbot habitats in each lake, and recommendations are provided as to a future study design that may facilitate the development of this information.

Introduction

Funding was received from the B.C. Ministry of Environment Mountain Pine Beetle Response to undertake an assessment of ice fisheries on 5 lakes containing burbot (*Lota lota*) populations in the vicinity of Prince George.

Burbot are a relatively late maturing, long-lived species, demonstrating iteroparity, and are known to spawn sporadically rather than annually after reaching the age of sexual maturity. Population health and viability are known to be sensitive to angling pressure and habitat and flow alterations (McPhail 1997).

Anecdotal information suggests that the number of anglers targeting burbot in the lakes of the Omineca Region is increasing (Williamson 2007). Further, alterations to the hydrology and thermal regimes of watersheds in the Prince George area are occurring and will continue as a result of the ongoing Mountain Pine Beetle epidemic. Given the known sensitivities of burbot populations to both harvest and physical-environmental changes, and the existing knowledge gap regarding burbot populations in this area, it is highly important that information regarding direct harvesting impacts, life history and population status, and habitat requirements be investigated. Further, most lake dwelling burbot populations in this area are suspected to be isolated and self-sustaining, and likely locally adapted to some degree, making the need for lake-specific management plans probable.

The work was led and completed by staff from the Lheidli T'enneh Band's Fisheries Program. Burbot are an important component of Lheidli T'enneh's sustenance fishery, and the Band has previously completed work on one other local lake containing a burbot population (Toth et al. 2001).

Study Area & Lakes

The five study lakes (Saxton, Nukko, Eaglet, Norman and Cluculz) are all within a 100 kilometer radius of Prince George and occur within the BC MoE Omineca Region – 7A (Figure 1). The lakes were selected based on the presence of burbot populations and their potential susceptibility to impacts

from the Mountain Pine Beetle (MPB), which are suspected to include changes in hydrology and temperature regimes in tributary and lake habitats. The lakes' identifier information and limnological/biological characteristics are provided in Tables 1 and 2. At present, anglers are restricted to a harvest of 1 burbot/day in Eaglet Lake, following management recommendations provided in Toth et al. (2001). The other four study lakes are subject to a "blanket" regional regulation that applies to all lakes within the region that are not subject to specific management recommendations, allowing the harvest of 5 burbot per day, with a two day possession limit (BC 2007).

Purpose

The intent of this work was to gather information on fishery effort and catch, and sample angler's catches to ascertain information regarding lake-specific burbot population health and life history characteristics. The work included directed sampling by the surveyors during the iced-over period, and sampling (cod traps and minnow traps) during the ice-free period (May-June). Attempts were also made to link angler effort and catch, and sampling results to areas where fish may be congregating, in an attempt to identify potential spawning areas and/or tributaries.

The main objectives of the work can be summarized as follows:

1. Analysis and comparison of burbot biological/life history data between lakes
2. Description of status of each lake's burbot population
3. Identification of burbot congregation areas and potential spawning tributaries
4. Recommendations for future management of the burbot populations within each study lake

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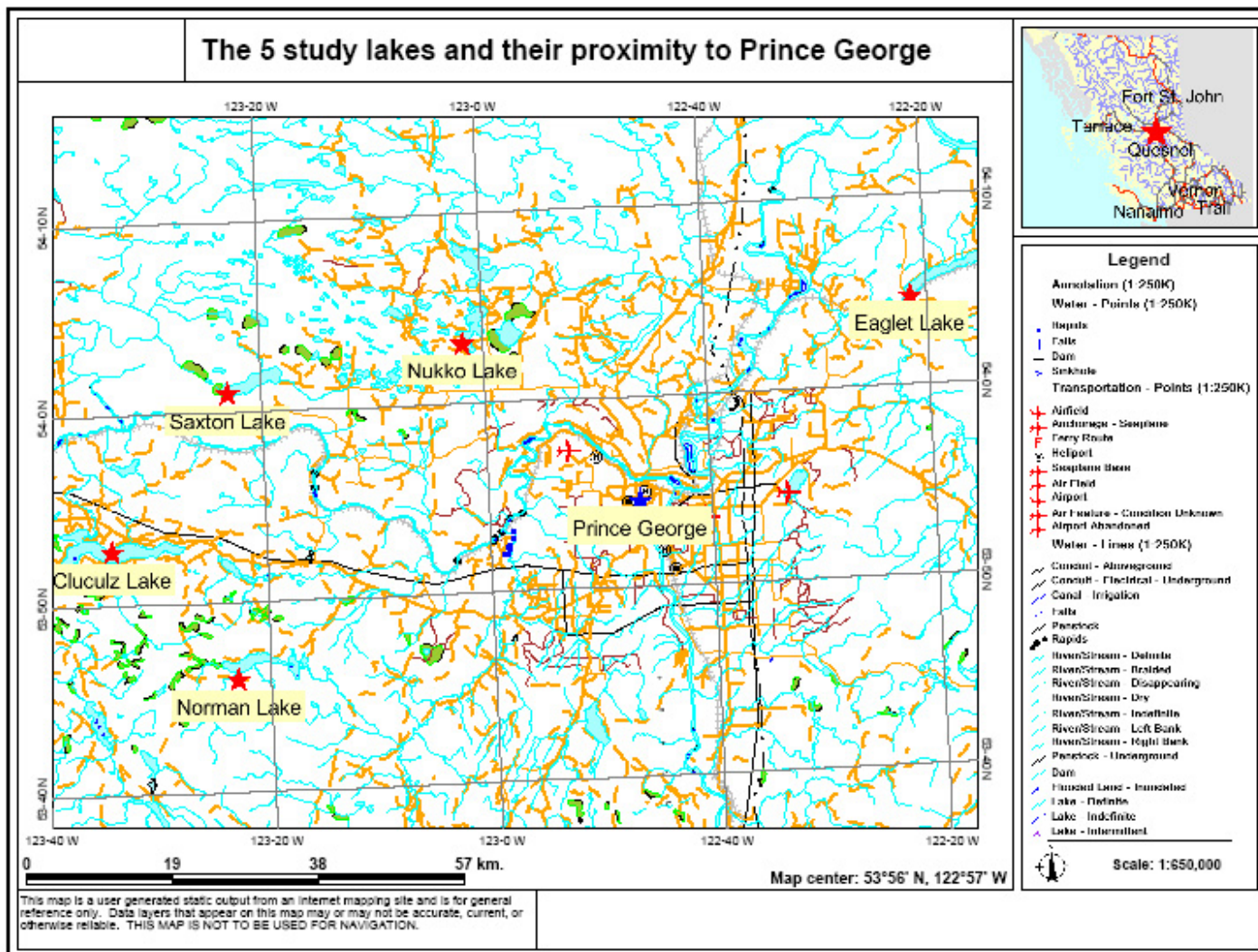


Figure 1. The Five (5) study lakes and their proximity to Prince George (from <http://srmapps.gov.bc.ca/apps/fidq/>).

Table 1. Identifier information and physical characteristics of the five (5) study lakes (from <http://www.fishwizard.com/>).

Study Lake	WSC	WBID	Surface Area (Hectares)	Surveyed Perimeter (Meters)	Volume (Cubic Meters)
Saxton	182-127900	01410STUR	434-694	153857-15484	68080794
Nukko	100-593800-25800	01254LSAL	416-607	17170-17450	43818207
Eaglet	100-596500-03300	00033WILL	831-854	23165	43152134-43152764
Norman	180-069000-20500	00587LCHL	515	14082	61896116
Cluculz	180-191300	01091NECR	2518	53108	713585187

Table 2. Limnological and biological information for the five (5) study lakes (from <http://www.fishwizard.com/>).

Study Lake	Dates of Lake Surveys on Record	Mean Depth (Meters)	Max Depth (Meters)	Out-lets	In-lets	PH (Surface)	TDS (Surface) - ppm	Secchi Depth (Meters)	Fish Species Documented
Saxton	1959, 1969, 1978	9.8	16.2	1	1	7.5-8.5	62-80	2.1-5.9	Largescale Sucker, Longnose Sucker, Mountain Whitefish, Northern Pikeminnow (formerly N. Squawfish), Redside Shiner, White Sucker, Burbot
Nukko	1960, 1970, 1977	7.2	17.1	1	0	7.8-8.0	57-79	4	Lake Whitefish, Mountain Whitefish, Northern Pikeminnow (formerly N. Squawfish), Peamouth Chub, Rainbow Trout, Largescale Sucker, Longnose Sucker, Redside Shiner
Eaglet	1969, 1992, 1999	5.0-5.1	9.5	1	8	6.0-8.1	102	0.8-1.4	Burbot, Largescale Sucker, Longnose Sucker, Northern Pikeminnow (formerly N. Squawfish), Peamouth Chub, Rainbow Trout, Redside Shiner, Mountain Whitefish, Dolly Varden, Bull Trout, White Sucker
Norman	1968-1989	12	23.8	1	2	7.9	79	3	Burbot, Lake Whitefish, Largescale Sucker, Longnose Sucker, Mountain Whitefish, Northern Pikeminnow (formerly N. Squawfish), Peamouth Chub, Rainbow Trout, Redside Shiner, Whitefish (General)
Cluculz	1958	29	60	1	2				Bull Trout, Burbot, Kokanee, Lake Chub, Lake Trout, Lake Whitefish, Largescale Sucker, Longnose Sucker, Mountain Whitefish, Northern Pikeminnow (formerly N. Squawfish), Peamouth Chub, Pygmy Whitefish, Rainbow Trout, Redside Shiner, White Sucker, Whitefish (General)

Methodology

The following describes the specific methodologies utilized by surveyors to collect data related to each study lake, and other methods used to analyze ageing structures and the data collected via this project.

Fishery Monitoring and Assessment

From January-April 2008 visits to each of the 5 study lakes were regularly undertaken. When present, surveyors tallied the number of active anglers/rods on the lake on the hour, and attempted to interview anglers to identify the species being targeted and their catch success. Surveyors also undertook their own angling/sampling efforts when it was possible. Hourly angler/rod counts, interview information, and surveyor's sampling efforts were captured on data forms developed for this purpose (Appendix 1). Observations of weather, air and water temperature and ice thickness and condition were also recorded periodically.

Effort Assessment

When present at each study lake, surveyors observed and monitored the number of active anglers on the lake and tallied them hourly. Four of five of the study lakes were too large for the purposes of allowing instantaneous angler counts, and counts were therefore conducted by either vehicle utilizing binoculars and/or snow machine. For the purposes of maintaining records of angler's spatial patterns of activity on each lake, possibly indicating fish behaviour, each lake was divided into quadrants, and angler counts were tallied hourly according to the lake quadrant. In some cases, instantaneous hourly angler counts were only collected for a portion of the lake.

To augment the surveyor's counts of active anglers, in particular during periods when the surveyors weren't present, a Scouting Camera (Cudde-back Digital No-Flash 3.0 megapixel) was deployed at each lake to collect photos hourly. Photos were later downloaded and reviewed to observe the presence of anglers.

Catch Assessment (Angler Surveys/Interviews)

When anglers were observed, they were generally approached and interviewed. Questions asked included the time they began angling that day, what method(s) they were utilizing, the species being targeted, and what they had captured (harvested and released). If they had burbot within their creel, the surveyors asked for permission to measure and collect ageing structures from the fish. In some cases, UTM coordinates for angler's fishing locations were gathered utilizing a handheld GPS unit.

Directed Sampling

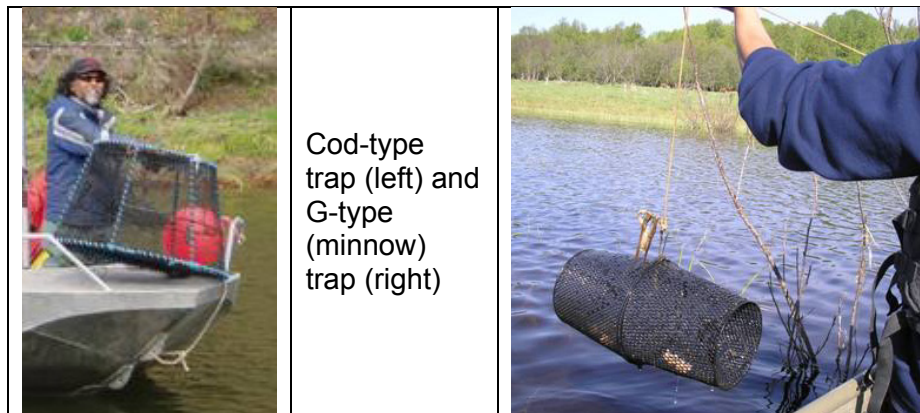
Surveyors undertook their own sampling effort on each study lake during January-April, whenever it was possible given requirements related to monitoring effort and conducting interviews. Targeted burbot sampling was also conducted in each study lake during the ice-free (May-June) period utilizing cod traps and minnow (G) traps.

Ice-on Period

Surveyors conducted their own angling activities in each study lake during the iced-over period. Effort consisted of either baited setlines or actively fished gear using either bait or jigs. Surveyor's angling efforts and catch data were recorded separately from the data relating to other anglers (see data form Appendix 1).

Ice-free Period

Surveyors sampled 4 of the 5 study lakes for 2-3 days each with a combination of up to 15 baited G-traps and 10 cod traps. The larger cod traps were set randomly throughout study lakes at a variety of depths. G-traps were generally focused in shallower littoral areas and inlet streams. Baits utilized included the flesh of peamouth chub and sockeye, as well as sockeye and Chinook roe. Traps were checked daily and records were kept of baits utilized, and trap location (UTM), depth, soak-time and catch.



Assessment of Population Status

Where possible, an assessment of the status-health of burbot populations within the study lakes is provided. This is completed through an assessment of a combination of the life history information observed and/or collected from each study lake, including the age structure and/or the length distribution. A numerical description of the health of the burbot populations was estimated using the indices of PSD (proportional stock density) and RSD (relative stock density) (Gabelhouse 1984). PSD and RSD utilize specific categories or

classes of fish length defined within the categories of S (stock), Q (quality), P (preferred), M (memorable), and T (trophy). These categories refer to the length classes of any given species of fish ranging from 20-80% of the “world-record lengths” or maximum lengths the species is known to obtain. Fisher et al. (1996) utilized the length distribution of more than 10,000+ burbot attained from 79 populations to obtain length classes specific to burbot for these categories. The burbot-specific length classes derived from this analysis were identified as 20-38cm, 38-53cm, 53-67, 67-82cm, and 82cm+ for the categories of S, Q, P, M, and T respectively (Fisher et al. 1996).

PSD is calculated as:

$$\text{PSD} = (\text{number of fish} \geq \text{minimum quality length} / \text{number of fish} \geq \text{minimum stock length}) * 100$$

RSD is calculated as:

$$\text{RSD} = (\text{number of fish of specified length range} / \text{number of fish} \geq \text{minimum stock length}) * 100$$

PSD and RSD are expressed as a unit-less value of 0-100, and provide a numerical description of the proportion of any designated length class within a sample of fish. The proportions of various size classes (P,M,Q,T) of fish within a sample provide an estimation of recruitment success, inconsistencies and/or failure, and/or over exploitation/harvest.

Assessment of Fish Condition

The condition of burbot (relative weight – Wr) collected is assessed where sufficient data relating to fish lengths and weights were collected. In order to specifically develop Wr as an assessment tool for assessing burbot condition Fisher et al. (1996) analyzed weight-length data for 10,000+ burbot from 79 North American populations. Utilizing this information, a 75th-percentile standard weight (Ws) equation was developed yielding the equation $\text{Log}_{10}Ws = -4.868 + 2.898 \log_{10}L$, which is only valid for burbot greater than 20cm, due to the variability of weight within smaller size classes. Wr values were further defined by burbot populations or stocks from differing water body types. Fisher et al. (1996) suggested a preliminary Wr objective range for burbot within small lakes to be 100+/-5.

Fish Ageing

Burbot ages were derived from otoliths collected during the course of this project, including from angler's and surveyor's catches, from heads and/or carcasses donated by anglers, and from trapping during the ice-free period. Ages were determined by Jason Yarmish (Environmental Dynamics Inc.) utilizing the “break and burn” technique.

Results

Information collected during the course of this work is developed and presented below categorized according several relevant subjects relating to the project objectives. Data forms utilized are provided in Appendix 1. Data collected is provided in:

- Appendix 2 (Hourly active angler counts for each study lake)
- Appendix 3 (Angler interviews for each study lake)
- Appendix 4 (Surveyor's angling effort for each study lake)
- Appendix 5 (Trapping results from each study lake – during the ice-free period)
- Appendix 6 (Summary bio-physical information for all burbot sampled during the study)

Ice Fishery Monitoring and Assessment

Monitoring of the ice fisheries on the 5 study lakes consisted of periodic patrols of each lake roughly twice weekly. Monitoring surveys were completed from January 4-April 7. The total number of visits to each study lake and hourly angler counts completed were as documented in Appendix 2 and summarized in Table 3 below.

Table 3. Summary information relating to ice-fishery surveys completed at each study lake.

Study Lake	Dates Surveys Completed	No. Days Surveyed (Visits)	No. Hourly Counts	*Hourly Counts Possible	% Fishery Coverage
Saxton	Jan 4-Apr 5	16	61	969	6.3%
Nukko	Jan 4-Apr 8	23	103	1035	10.0%
Eaglet	Jan 3-Apr 6	30	168	991	17.0%
Norman	Jan 5-Apr 7	28	93	986	9.4%
Cluculz	Jan 4-Apr 7	29	120	995	12.1%

**Hourly counts possible relates to the number of hourly counts possible from Jan 4-Apr 5, incorporating only daylight periods (Jan 0800hrs-1700hrs ~ 9hours of daylight/day, Feb 0700hrs-1800hrs ~ 10hours of daylight/day, March 0700hrs-1900hrs ~ 12hours of daylight/day, April 0700hrs-2000hrs ~ 13hours of daylight/day)*

Coverage of the fisheries occurring on each lake ranged from 6.3% to 17.0% of the total fishery occurring (based only on daylight hours during the surveyed period).

Effort Assessment

Effort varied substantially between the surveyed lakes (Table 4).

Table 4. Summary information relating to ice-fishery effort observed on each of the 5 study lakes.

Study Lake	No. Visits Where Angling Was Observed	No. Hourly Counts Where Anglers Were Observed	Peak No. Rods/Hr. Observed	Avg. No. Rods/Hr. Observed	Avg. No. Rods/Hr. Observed Daily	Total No. Rod Hours Observed
Saxton	0	0	0	0	0	0
Nukko	1	1	1	0.010	0.022	1
Eaglet	6	24	12	0.512	0.451	86
Norman	4	5	6	0.183	0.193	17
Cluculz	20	44	14	1.233	1.215	148

No angling effort was observed during surveys on Saxton Lake and there was very limited sign of angling activity observed. Similarly, only a single angler was observed on Nukko Lake, although signs of ice fishing activity were observed on occasion.

Estimates of total angler effort on each of the study lakes (during the survey period) were calculated by multiplying the average number of anglers or rods observed per hour at each lake by the number of hourly counts possible within the surveyed fishery, considering only daylight periods (Table 5).

Table 5. Estimates of total angler effort for each study lake's ice fishery (for the duration of the survey period – see table 3 above).

Study Lake	Avg. No. Rods/Hr. Observed	Hours w/i Survey Period	¹ Estimate of Angling Effort
Saxton	0	969	0.0
Nukko	0.009	1035	10.4
Eaglet	0.512	991	507.4
Norman	0.183	986	180.4
Cluculz	1.233	995	1226.8

¹Estimate of total rod hours of effort within the surveyed period of fishery based on average number of rods/hour observed.

As the proportion of the ice-fishery monitored was quite small in all cases, the figures in Table 5 should be considered very rudimentary estimates of total angler effort in each lake's fishery (during the period surveyed).

Other Effort Characteristics

Where the observed angler effort was substantial enough, the characteristics of the effort were assessed. The following was evident:

Cluculz Lake – Angler effort appeared to peak around noon of each day but also showed an increase in the afternoon (1600 hours) (Figures 2 and 3). The increase in effort observed to occur in the afternoon appeared to be related to lake-area residents fishing after returning home from work (based on interviews). Effort was relatively steady during the survey until mid-February, and then increased from mid-February to mid-March before declining toward the ice-off period in April (Figure 4). Average rods/hour observed for weekend periods was considerably higher (1.731 rods/hour) than weekday (0.779 rods/hour) periods during the survey (Figure 5).

Eaglet Lake – Angler effort on Eaglet Lake appeared to peak daily at 1300 hours and did not demonstrate the same increase in effort in the late afternoon period that was observed on Cluculz Lake (Figures 6 and 7). Observed effort was the highest during the latter half of January and increased again during the first half of March, before declining towards the ice-off period (Figure 8). Angler effort during weekend surveys was again observed to be much higher (1.203 rods/hour) relative to weekday surveys (0.139 rods/hour) (Figure 9).

Norman Lake – Surveys indicated that angler effort on Norman Lake was minimal (Figure 10). The effort data has therefore not been presented in graphical format. Anglers were only observed on 4 of the 28 days (5 of 93 hourly counts) when surveys were completed. All angler effort observed was during January and February. While observations were few, weekend observations indicated an average of 0.333 rods/hour (12 weekend days were surveyed) while weekday surveys indicated an average of 0.094 rods/hour (13 weeks with weekday surveys).

While not specifically analyzed here, the numbers of anglers observed appeared to increase when weather conditions were more pleasant.

Interviews and Analysis of Reported Catch

Interviews were conducted on study lakes when anglers were observed (data in Appendix 3). Interviews were conducted while angler's were fishing, and therefore do not encompass the entire duration of their fishing effort. Total effort documented via interviews therefore varies from that documented via rod count surveys (i.e. interviewed anglers may have began their fishing activity before rod count surveys were initiated on any particular surveyed day).

Catch per unit effort (CPUE) observed between the lakes surveyed varied considerably (Table 6). Sport fish CPUE was highest in Cluculz Lake and lowest in Eaglet Lake. Overall CPUE was highest in Eaglet Lake.

Table 6. Statistics on angler interviews conducted and angler's observed catches.

Study Lake	No. Interviews	Total Effort	Avg. Effort	¹ Sport Catch	Sport CPUE (fish/hr.)	¹ Non-Sport Catch	Non-Sport CPUE (fish/hr.)	Total CPUE (fish/hr.)
Cluculz	104	231.7	2.23	88	0.380	10	0.043	0.423
Eaglet	39	65.1	1.67	6	0.092	54	0.830	0.922
Norman	19	23.1	1.22	3	0.130	7	0.303	0.433

¹ Includes catch harvested and released.

Non-sport catches were not always documented to species, but non-sport species captured were most frequently noted to include Peamouth chub on the majority of occasions. Kokanee (a sport fish) were also included in this category on two occasions in Cluculz Lake (a category for kokanee was not specifically included on the data forms and they were therefore included under the species category "Other", which in all other cases referred to non-sport species).

The breakdown of sport fish catch and CPUE observed between the surveyed lakes is provided in table 7. The burbot capture rate was considerable higher in Norman Lake relative to the other study lakes, although it should be noted that this is based on very few observations. Burbot CPUE was similar between Eaglet and Cluculz lakes. The catch rate for rainbow trout was high in Cluculz Lake, which is likely not surprising considering its relatively high stocking rate. CPUE for sport species in Eaglet Lake was very low.

Table 7. Proportional breakdown of sport species observed in catch and related CPUE.

Study Lake	Burbot H/R	Burbot CPUE (fish/hr.)	Rainbow Trout H/R	Rainbow CPUE (fish/hr.)	Lake Trout H/R	Lake Trout CPUE (fish/hr.)	Whitefish H/R	Whitefish CPUE (fish/hr.)
Cluculz	8/4	0.052	54/20	0.319	2/0	0.009	0/0	0
Eaglet	0/3	0.046	1/1	0.031	0/0	0	0/1	0.015
Norman	1/2	0.130	0/0	0	0/0	0	0/0	0

H/R – Harvested/Released

Anglers interviewed during the ice fishery were requested to indicate if they were targeting a specific fish species. Table 8 below provides the breakdown of the species anglers indicated they were targeting in each of the surveyed lakes.

Table 8. Breakdown of the species anglers interviewed indicated they were targeting.

Study Lake	Burbot	Rainbow Trout	Lake Trout	Lake Trout and Burbot	Rainbow Trout and Burbot	All Species
Cluculz	22 (21.2%)	43 (41.3%)	9 (8.7%)	23 (22.1%)	0 (0%)	7 (6.7%)
Eaglet	5 (12.8%)	14 (35.9%)	0 (0%)	0 (0%)	4 (10.3%)	16 (41.0%)
Norman	15 (78.9%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (21.1%)

Interview and catch data was assessed to determine if anglers focused on the capture of specific species obtained a higher CPUE for that species, relative to anglers that indicated they were not focused on capturing that species (Table 9). The CPUE information is presented in Figure 11. This exercise was only completed for Cluculz Lake due to the small size of the datasets available for Eaglet and Norman lakes.

Information in table 9 indicates that anglers' methods can be highly selective for the species being sought after, an important note in relation to the consideration of regulatory actions intended to reduce anglers' impacts on any particular species.

Table 9. Species-specific CPUE figures for anglers that indicated they were targeting specific species (Cluculz Lake).

Item	Targeting Burbot	Targeting Rainbow	Targeting Lake Trout	Targeting Lake Trout and Burbot	Targeting All Species
Angler Effort (hrs.)	36.9	93.9	26.3	58.6	15.9
Burbot CPUE	0.217	0.021	0	0	0.126
Rainbow CPUE	0.109	0.745	0	0	0
Lake Trout CPUE	0	0	0	0.034	0

Information related to anglers' gear was collected during the interviews on Cluculz Lake. Those targeting rainbow trout nearly exclusively were utilizing bait (%97.7), while those targeting burbot were mostly (59%) utilizing lures with no natural bait, and 100% of the anglers that indicated they were targeting lake trout were not using natural bait. While not collected, it would be assumed that there were also substantial size differences in the gear being utilized by anglers targeting these different species.

Interview data for Cluculz Lake was assessed to determine if there were species-specific seasonal trends in CPUE (Figure 12). It appears that rainbow trout and burbot CPUE was higher in January and trended down in February and March. Cluculz Lake’s angler’s indications of the species they were targeting on a monthly basis are provided in figure 13. This information suggests that rainbow trout and burbot were more susceptible to capture in January.

While not specifically assessed here, it was apparent throughout the surveys and interviews completed that a small proportion of the anglers identified (assigned and id within the survey forms) were responsible for the majority of the burbot catch documented and the burbot samples collected/provided.

Expanded Catch Estimates

The effort (rod count) surveys, in combination with angler interview and related catch and CPUE information, provides an opportunity to produce an estimate of total species-specific catch for each study lake’s ice fishery during the duration of the survey period (Table 10.). There are numerous assumptions integrated into these estimates and they should be considered rudimentary estimates of catch at best, but none-the-less provide a reasonable approximation of what catch and/or harvest may be in each situation. Saxton and Nukko lakes are excluded from this estimate due to the observation that fishing effort within the lakes was non-existent or very low during the survey period.

Table 10. Estimates of species-specific catch during the survey period (based on expansions of effort observed and CPUE observations).

Study Lake	¹ Estimate of Rod Hours Effort	Obs. Burbot CPUE (fish/hr.)	Est. Burbot Catch	Obs. Rainbow CPUE (fish/hr.)	Est. Rainbow Catch	Obs. Lake Trout CPUE (fish/hr.)	Est. Lake Trout Catch
Cluculz	1226.84	0.052	63.8	0.319	391.4	0.009	11.0
Eaglet	507.39	0.046	23.3	0.031	15.7	0	0
Norman	180.44	0.130	23.5	0	0	0	0

¹See table 5

Surveyor’s Effort

As a means of increasing the amount of effort and catch data, and the number of sampled burbot derived from each study lake, when possible surveyors applied their own fishing effort during the ice fishery survey (Table 11, complete data in Appendix 4)). Samplers typically used setlines with peamouth chub as bait, specifically targeting burbot.

Table 11. Summary of sampling and catch statistics for angling activities conducted by the survey crew during the survey period.

Study Lake	No. Sampling Events	Total Effort (rod hours)	Dates	³ Total Catch S/N-S	Burbot Catch	Burbot CPUE	Lake Trout Catch	Non-Sport Catch
Saxton	11	¹ 189.5	Feb, Mar	1/1	1	0.005	0	1
Nukko	6	26.4	Feb, Mar	0/10	0	0	0	10
Eaglet	16	² 113.0	Jan, Feb, Mar	1/10	1	0.009	0	10
Norman	6	22.0	Feb, Mar	1/0	1	0.046	0	0
Cluculz	5	12.4	Feb	3/0	2	0.161	1	0

¹Includes 7 setlines for 24 hour+ sets

²Includes 2 setlines for 24 hour+ sets

³S/N-S – Sport/Non-Sport

Sampling Post Ice-Off

Post-ice off, the survey crew returned to four of the study lakes (Eaglet, Nukko, Cluculz, and Norman) to sample for burbot utilizing baited minnow (G-type) and cod traps. Sampling was completed from May-August (Table 12, complete data in Appendix 5).

Table 12. Summary of trapping effort and catch from the four study sampled during the ice-free period during spring/summer 2007.

	Eaglet	Nukko	Cluculz	Norman
Sampling Dates	May 28 – June 30	June 18-20	June 20-23	Aug 1-4
G-Trap Hours	1563.7	462.9	0	0
Cod-Trap Hours	571.1	399.2	510.6	647.7
G-Trap Burbot Catch	0	0	n/a	n/a
¹ G-Trap Other Catch	32	36	n/a	n/a
Cod Trap Burbot Catch	4	0	4	0
² Cod Trap Other Catch	4	2	0	0

¹G-Trap Other Catch – Eaglet Lake 26 cottids, 5 reidside shiner, 1 northern pikeminnow; Nukko Lake 13 cottids, 23 reidside shiner

²Cod Trap Other Catch – Eaglet Lake 1 cottid, 2 northern pikeminnow, 1 peamouth chub; Nukko Lake 2 pike minnow

A total of 8 burbot were captured (4 from Eaglet Lake and 4 from Cluculz Lake) in cod traps. No burbot were captured in G-type minnow traps. All burbot captured in Cluculz Lake were trapped at depths greater than 30metres (100ft). In Eaglet Lake, which is much shallower on average than

Cluculz Lake, burbot were captured in traps set from 4.2 – 7.8metres (14-26ft) depth. Non-sport fish catch was substantially higher from the minnow (G) trap sampling. Data relating to trapping is available in Appendix 5.

Population Analysis and Assessment

Information relating to the biological and life history characteristics of the study lakes' burbot populations were collected through a number of manners during the course of this study.

A total of 46 aging structures (otoliths), which were subsequently successfully aged, were collected. Additionally, biological and morphological information relating to burbot captured were collected from as many burbot as possible. Information collected in this regarding is summarized in the categories and from sources as outlined below:

- Saxton Lake – A single burbot otolith was collected via crew sampling during ice fishing surveys
- Nukko Lake – No burbot samples of any nature were collected.
- Eaglet Lake – A total of 5 burbot otoliths were collected from Eaglet Lake; 1 collected by the survey crew during the ice fishery and 4 collected during trapping activities in the ice-free period. Morphological information was collected from all 5 fish; sex and maturity information was collected from the fish captured during the ice fishery.
- Norman Lake – A total of 8 burbot otoliths were collected from Norman Lake. One angler's fish was measured by the survey crew, and the head was collected. Seven otoliths and accompanying morphological and biological information from these fish were provided by Cory Williamson, Senior Fisheries Biologist, BC MoE-Omineca Region.
- Cluculz Lake – a total of 8 burbot samples that were captured prior to the initiation of the survey were provided by an angler; 6 of the 8 were provided as filleted carcasses allowing total length and sex/maturity to be assessed, and 2 of the 8 samples were only heads. An additional 7 otoliths were collected from burbot captured during the survey period (February), for which only the heads were provided by an angler. An additional 13 sets of otoliths were collected from heads were provided by anglers that were either captured just prior to or during the survey period – no morphological information is available for these fish. Morphological and in some cases sex and maturity information was collected from a total of 8 burbot during creel surveys. Four sets of otoliths were collected from Cluculz burbot during the trapping surveys conducted post-ice off.

In total, information is presented from a total of 54 burbot that were sampled in some manner. All burbot biological, life history and morphological information collected from the study lakes is provided in Appendix 6.

While the number of samples from each of the study lakes is limited, this information provides a basis from which to assess characteristics of each of the study lake's burbot populations, and in particular, Cluculz Lake.

Population Status Assessment

The size (Total Length) structure of the burbot sampled was utilized to assess the status of the target burbot populations utilizing the indices of PSD (proportional stock density) and RSD (relative stock density) developed by Gabelhouse (1984). Utilizing the Stock, Quality, Preferred, Memorable and Trophy (S, Q, P, M, T) length categories for burbot developed by Fisher et al. (1996), the RSD values evident from burbot samples collected from Norman and Cluculz lakes are provided in table 13.

Table 13. Relative stock densities (RSD) and relative weight (Wr) for samples of burbot captured during this study in total, and from Norman and Cluculz lakes. Note: "n" within each category varies slightly due to weights not being available for all fish captured.

	S 20-38cm	Q 38-53cm	P 53-67cm	M 67-82cm	T 82cm+
No. Burbot Total	0	12	13	6	0
No. Burbot Norman	0	2	3	3	0
No. Burbot Cluculz	0	6	8	3	0
RSD Total	0	38.7	41.9	19.4	0
RSD Norman	0	25.0	37.5	37.5	0
RSD Cluculz	0	35.3	47.1	17.6	0
Norman W _r	na	(n=2) 94.6	(n=3) 92.6	(n=2) 91.9	na
Cluculz W _r	na	Na	(n=1) 145.5	(n=3) 95.1	na

While the available samples (combined and for individual lakes) are very small, the following is evident:

- The relatively high RSD-Q values would appear to indicate that the juvenile recruitment has been successfully occurring and that a good "supply" of fish suspected of being of pre-spawning-age and/or the age-of-first maturity are present within the lakes.

- The range of RSD-P values fall within or are above the mean range documented by Fisher et al. (2000). The higher RSD-P value (47.1) from Cluculz Lake may indicate a reduced abundance of larger, older age classes of burbot within the lake.
- The RSD-M value for Cluculz Lake falls within the mean ranged reported by Fisher et al. (2000).
- The RSD-M value for Norman Lake is based on a sample size of only 8 fish but is approximately twice the mean value reported by Fisher et al. (2000), suggesting the population consists of a high proportion of larger, older age classes of fish, and that perhaps the lake has experienced a lower level of exploitation relative to Cluculz Lake, which is supported by the angler effort data.
- The absence of any burbot in the trophy (T) length class is not unexpected, as Fisher et al. reported a mean range of 0-4 for RSD-M.
- The RSD-P, M and T values obtained for the combined sample from this study are skewed towards a higher proportion of larger, older age classes of burbot relative to the sample collected from Eaglet Lake utilizing similar methodologies and timing, suggesting that the burbot populations in these study lakes have been subject to less exploitation. The small sample of burbot collected (5) from Eaglet Lake during this study are not presented in the table above, but their sizes support the findings that the lake has been subject to a high rate of exploitation (Toth et al. 2001).

The PSD measure for the sample of burbot from all study lakes combined is 100 due to the fact that the sample did not include any fish less 38cm total length, a reflection of the capture methods utilized. Toth et al. (2001) demonstrated that burbot do not fully recruit to the angling gear utilized during ice fisheries targeting burbot until a length of 40cm is obtained.

The distribution of burbot ages observed from fish captured during this study would appear to confirm the RSD values reported above, with an apparent higher frequency of older and younger individuals from Norman and Cluculz lakes respectively (Figure 14). The length distribution of the sample also supports this trend (Figure 15).

The length at age relationship for the burbot sampled from three of the study lakes suggests similar growth rates (Figure 16). Toth et al. (2001) documented that burbot from Eaglet Lake demonstrated similar growth

(length at age) to burbot populations from other areas in Canada and North America.

Fish Condition Assessment

The physical condition of burbot sampled from Norman and Cluculz lakes was assessed utilizing the relative weight (W_r) measure for burbot developed by Fisher et al. (1996) utilizing the equation $Log_{10}W_s = -4.868 + 2.898 \log_{10}L$, which is only valid for burbot greater than 20cm. The W_r values for burbot from Norman and Cluculz lakes are provided in table 13, presented according to the appropriate length categories of Q, P, M or T.

Fisher et al. (1996) suggested a preliminary W_r objective range for burbot within lakes to be 100 ± 5 . The small samples available from this study for the purposes of assessing this measure indicated that burbot from both Norman and Cluculz lakes correspond well to the suggested target range, exceeding it in some cases. Burbot from both Norman and Cluculz lakes exceed the W_r measures previously observed for burbot from Eaglet Lake east of Prince George, where W_r measures for a sample of burbot captured during the winter period were <90 for the Q, P, and M length categories (Toth et al. 2001).

Additional Biological/Life History Information

While based on very few samples, the data collected suggests the following additional information. Female burbot tended to be larger than males of the same age, a trait that is generally recognized in other Gadidae species (Figure 17). This has major implications for interpreting angler's catch data (in the absence of sex determinations) for the purposes of assessing population's statuses. It also has implications for the selectivity of ice fisheries targeting burbot which appear to select for larger size classes of fish. The youngest fish observed to be mature (classified as "code" 3 or 4) were a 7 year old male and 7 year old female. The smallest fish observed to be mature was a 43cm male. The smallest female classified as mature was 51cm. Two males that would almost certainly have reached the age/size of sexual maturity (60 & 75 cm – age 11 & 13) were classified (code 2) as non-mature during the pre-spawn period, likely confirming males do not spawn every year. Nearly twice as many mature males as females were captured, suggesting earlier maturation and/or more frequent years of maturation for males. Almost all fish that were assigned maturity class 1 were either of unknown or indeterminable sex.

Discussion and Conclusions

Given the timing and design of this study, little information could be ascertained about the nature of important spawning or rearing habitats and the potential implications of habitat alterations stemming from pine canopy loss related to the Mountain Pine Beetle epidemic. Anecdotal information collected during the study from some of the more successful burbot anglers indicated that burbot do indeed congregate prior to spawning, but that congregations move around the lake prior to spawning. Further, the spawning period is not the preferred angling period as the catchability of burbot during their spawning period is known (by anglers) to decrease. If these assumptions are correct, it is not likely possible to determine the locations of spawning areas by focusing on angler congregations.

A viable option for monitoring burbot movements and spawning locations would likely require the use of acoustic tagging and tracking methods. Radio telemetry was previously utilized on Eaglet Lake with some success but was hampered during ice cover periods, and the method's use for refining specific habitats is limited (Van Schubert and Newman 2000).

Observed angler effort levels varied substantially between study lakes with Saxton and Nukko lakes receiving negligible levels of effort, Norman Lake receiving moderate effort, and Eaglet and Cluculz lakes receiving the highest levels of angler effort. Expansion of observed angler effort during the period of the ice fisheries surveyed indicated total estimated effort levels of 180.4, 507.4 and 1226.8 rod-hours for Norman, Eaglet and Cluculz lakes respectively.

The characteristics of angler effort were unique to each study lake, but in general were at their highest levels on weekends. Effort was at its strongest in January on Eaglet Lake and at its highest levels on Cluculz Lake at the end of February and first week of March.

Catch statistics observed also varied substantially between the study lakes. The highest CPUE was observed on Eaglet Lake (0.92 fish/rod-hour) with similar rates of catch documented for Cluculz and Norman lakes (0.42 and 0.43 fish/rod-hour). Sport fish catch rates were highest in Cluculz Lake and were comprised mostly of rainbow trout. Sport fish catch in Eaglet Lake was very low (0.09 sport fish/rod-hour). Burbot catch rates were highest in Norman Lake (0.13 burbot/rod-hour) and similar between Cluculz and Eaglet lakes (0.05 burbot/rod-hour).

Anglers interviewed were most commonly focused on the capture of a specific species. Nearly 80% of the anglers interviewed on Norman Lake were targeting burbot, while only 21% of Cluculz Lake anglers and 13% of Eaglet

Lake anglers were specifically targeting burbot. Angler's indications of the species they were targeting and the corresponding CPUE data indicated that anglers could be highly selective for the species being targeted, and in particular, burbot. These factors should be taken into consideration when interpreting and expanding angler effort and catch data.

Seasonal trends in burbot CPUE from Cluculz Lake indicated a decreasing susceptibility to capture from January to March, which supported the anecdotal information provided by anglers.

Estimates of total catch produced from expanded effort and catch data collected indicated an approximate total harvest of 64, 23 and 24 burbot from Cluculz, Eaglet and Norman lakes respectively (during the duration of the ice fishery surveys). Other notable expanded total catch estimates included 391 rainbow trout and 11 lake trout from Cluculz Lake.

While the overall size of the sample of biological and morphological information collected from individual burbot from the study lakes is small, the health-status of populations from Cluculz and Norman lakes appears to be generally good. The sample of burbot from Norman Lake appeared to indicate a lower level of exploitation relative to Cluculz Lake, which is supported by the catch and effort data. Length at age data indicated similar growth rates between the lake's populations. Very limited data collected from Eaglet Lake suggested that the burbot population still reflects a heavily exploited population structure.

Sampling conducted during the ice-free period indicated that cod traps can be an effective sampling method for capturing burbot.

Recommendations

It is clear that additional information regarding the health and status of Central Interior burbot populations is required before fishery and environmental impacts can be fully understood. Monitoring ice fisheries (in some cases) may serve as a useful tool for providing some of the required information.

In the interim, there may be value in implementing management measures that assist in ensuring that harvest impacts are suitably precautionary, including reducing daily limits and/or imposing slot limits. For instance, implementing a harvest slot of 40-55cm would continue to allow some harvesting opportunities for anglers while helping to ensure an ongoing source of larger, older age classes of fish to facilitate recruitment. Such a measure may be particularly applicable to lakes receiving substantial effort, such as Cluculz Lake.

For the purposes of continuing to develop information regarding burbot populations in the area, and their health-status, the following measures are suggested for consideration:

1. Where they can be identified, engage and utilize local angling expertise to collect samples from area burbot populations during their angling activities. Indications are that a very small number of anglers are highly proficient at harvesting burbot. Engaging anglers that can participate in the development of short and longer-term datasets relating to the size and age composition of burbot catches from area lakes would be highly valuable and likely cost effective. These anglers are also likely a potential source of non-traditional ecological information about burbot.
 - a. Implement other measures to monitor angler effort and harvest on area burbot lakes.
2. Identify a single research lake in the Prince George area containing a burbot population known to receive little or known harvest pressure. Identify and implement a long-term baseline study where information regarding biological/life history parameters can be developed and the various sampling methodologies necessary to effectively assess the species and its habitat requirements can be refined.
3. Identify two lake dwelling burbot populations in the area with differing degrees of access to tributary habitats. Capture fish within the older age classes in both populations and deploy a number of long-term acoustic tags for the purposes of tracking seasonal movements and behaviour. Monitor the physical characteristics of the lakes and their tributaries to aid in interpreting burbot movement and behaviour information.

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Figures 2-17

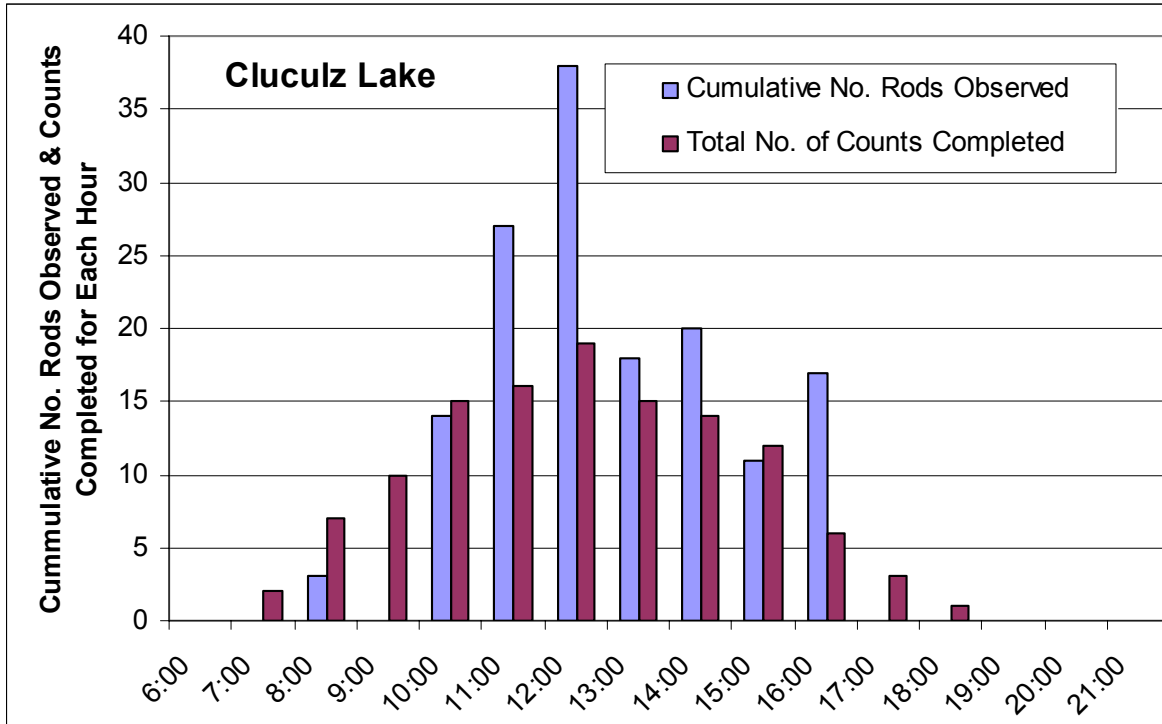


Figure 2. Cumulative number of anglers-rods observed per hour and the total number of counts that were completed for each hour (Cluculz Lake).

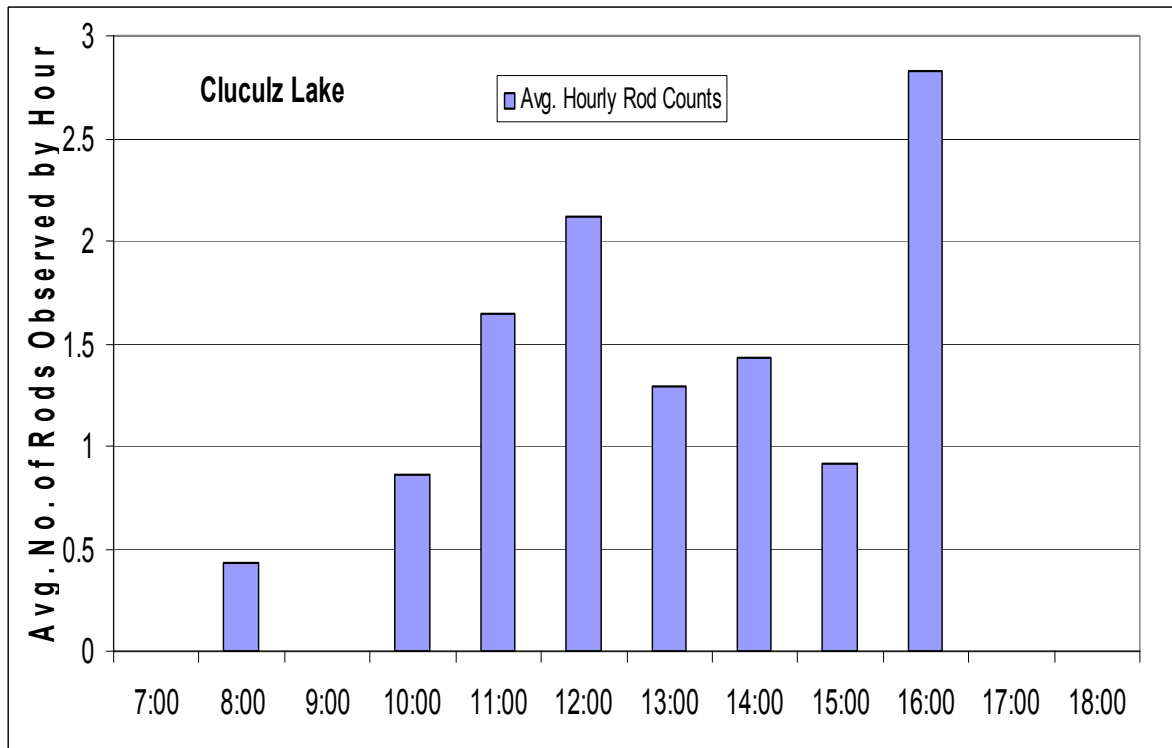


Figure 3. Average number of anglers-rods observed per hour (Cluculz Lake).

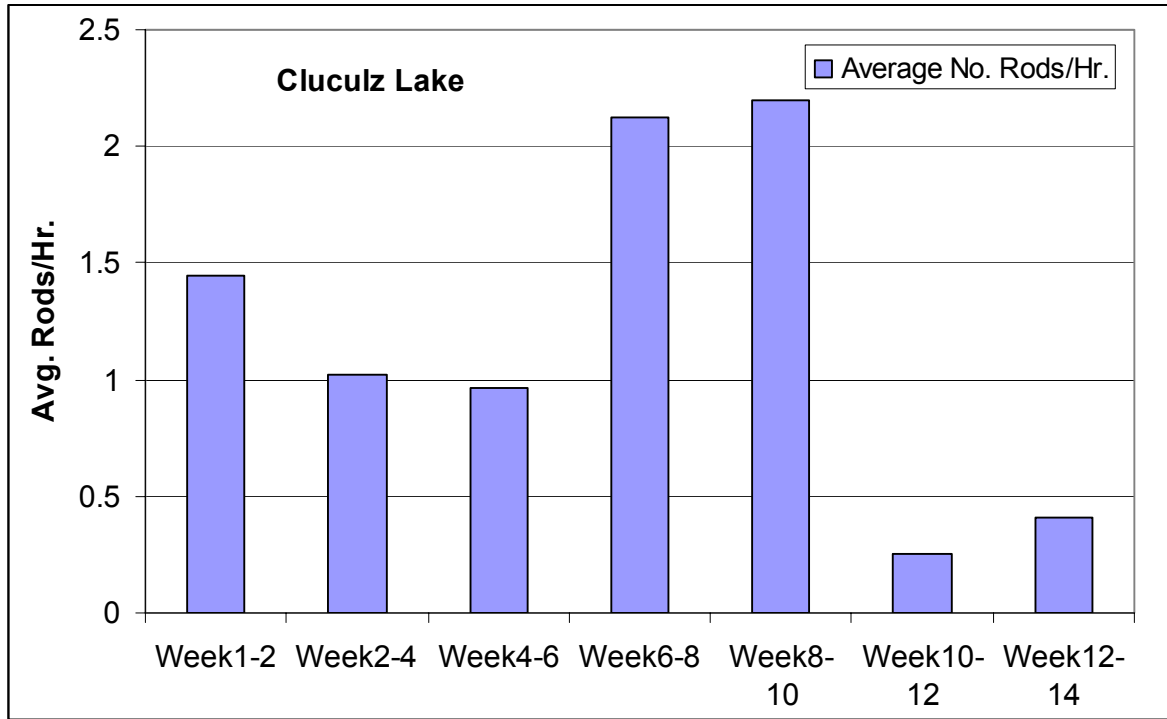


Figure 4. Averaged daily effort observed bi-weekly during the survey period (beginning in January and ending in April) on Cluculz Lake.

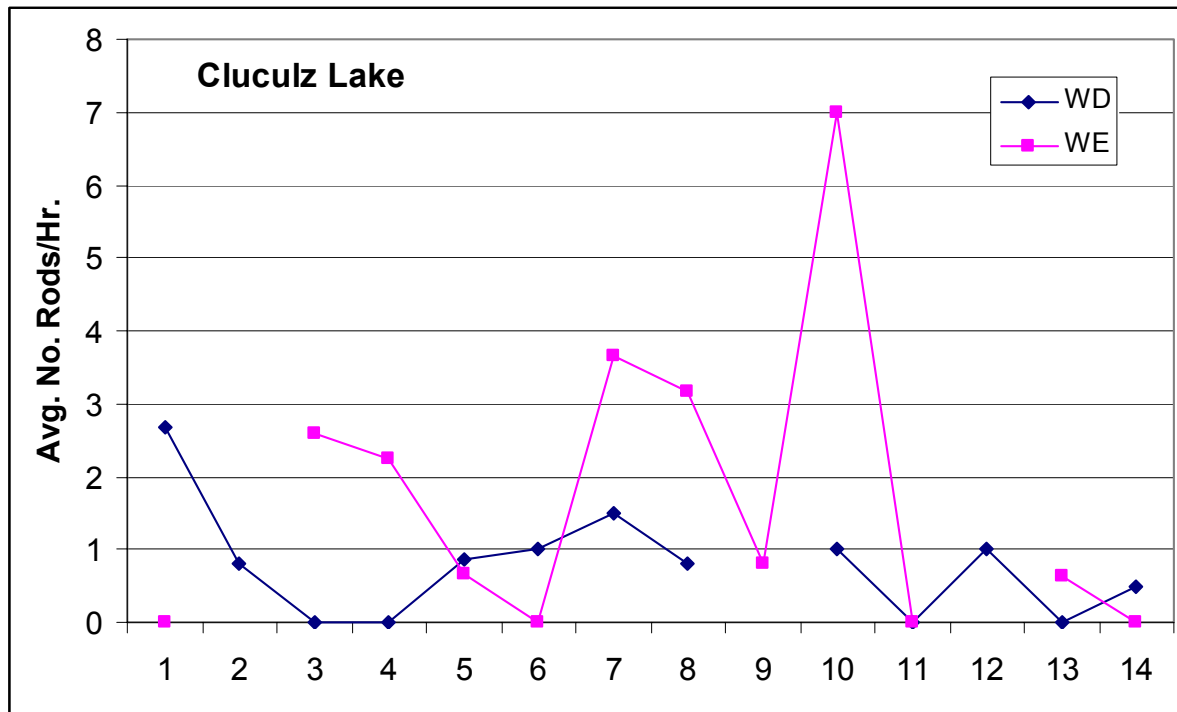


Figure 5. Average daily effort observed on weekends (WE) and weekday (WD) periods on Cluculz Lake.

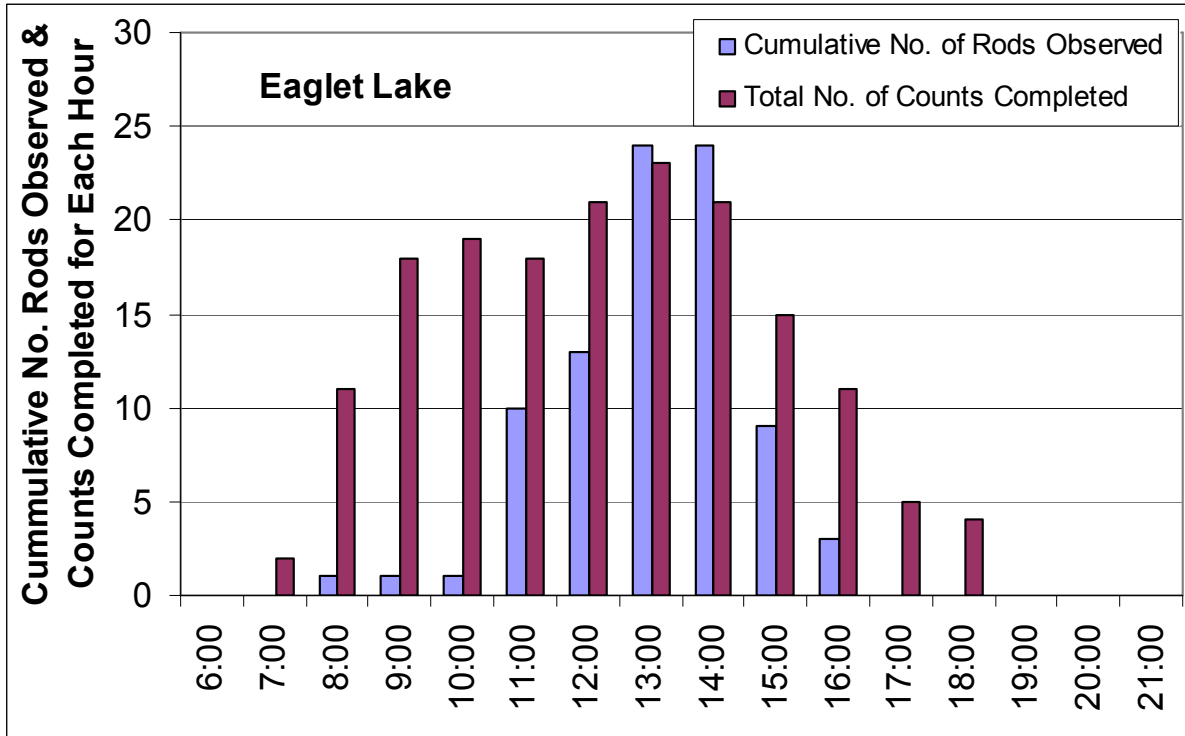


Figure 6. Cumulative number of anglers-rods observed per hour and the total number of counts that were completed for each hour (Eaglet Lake).

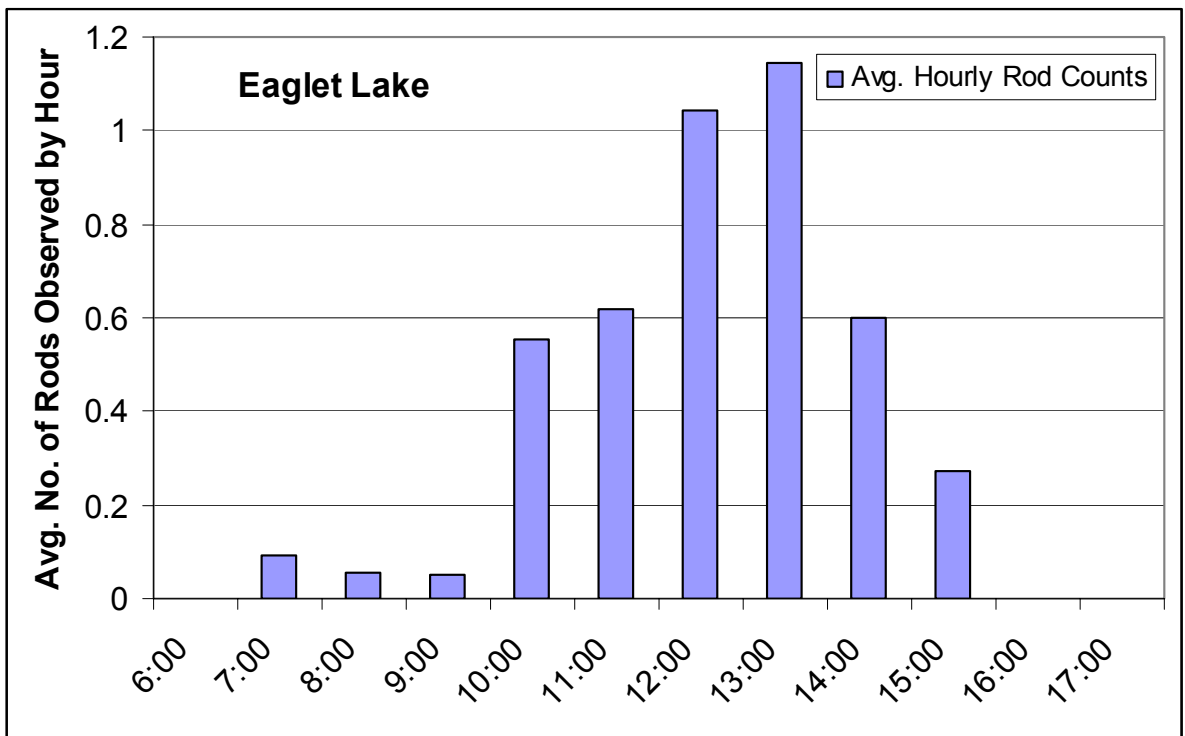


Figure 7. Average number of anglers-rods observed per hour (Eaglet Lake).

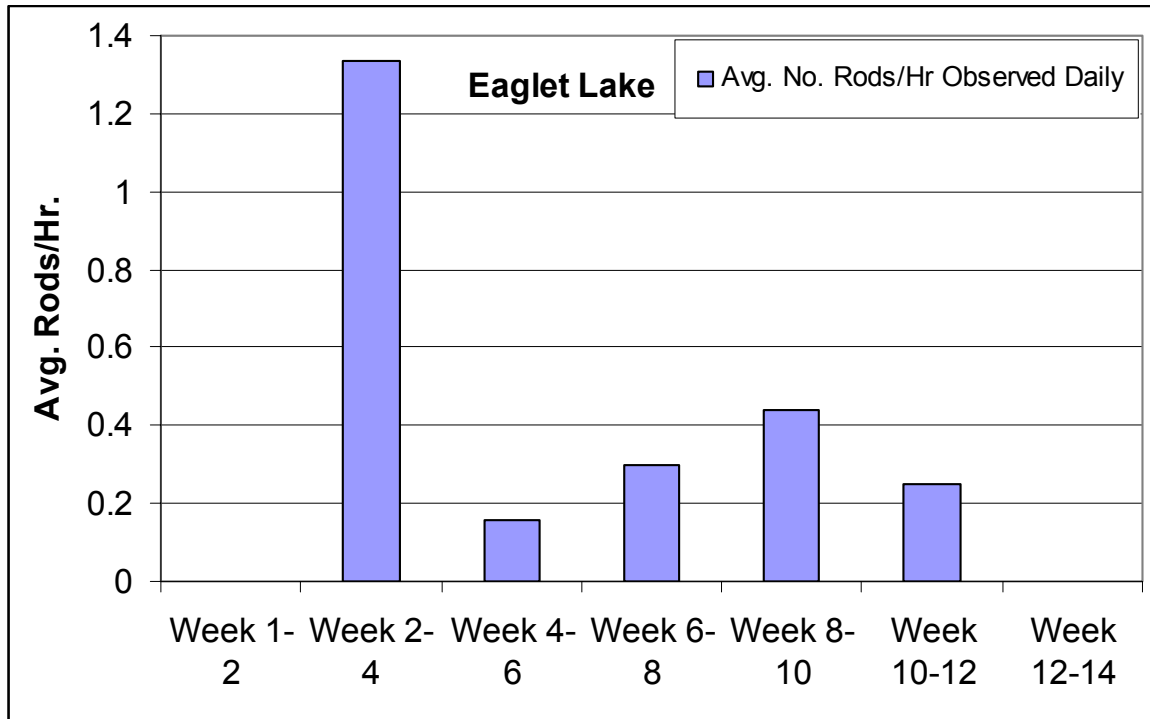


Figure 8. Averaged daily effort observed bi-weekly during the survey period (beginning in January and ending in April) on Eaglet Lake.

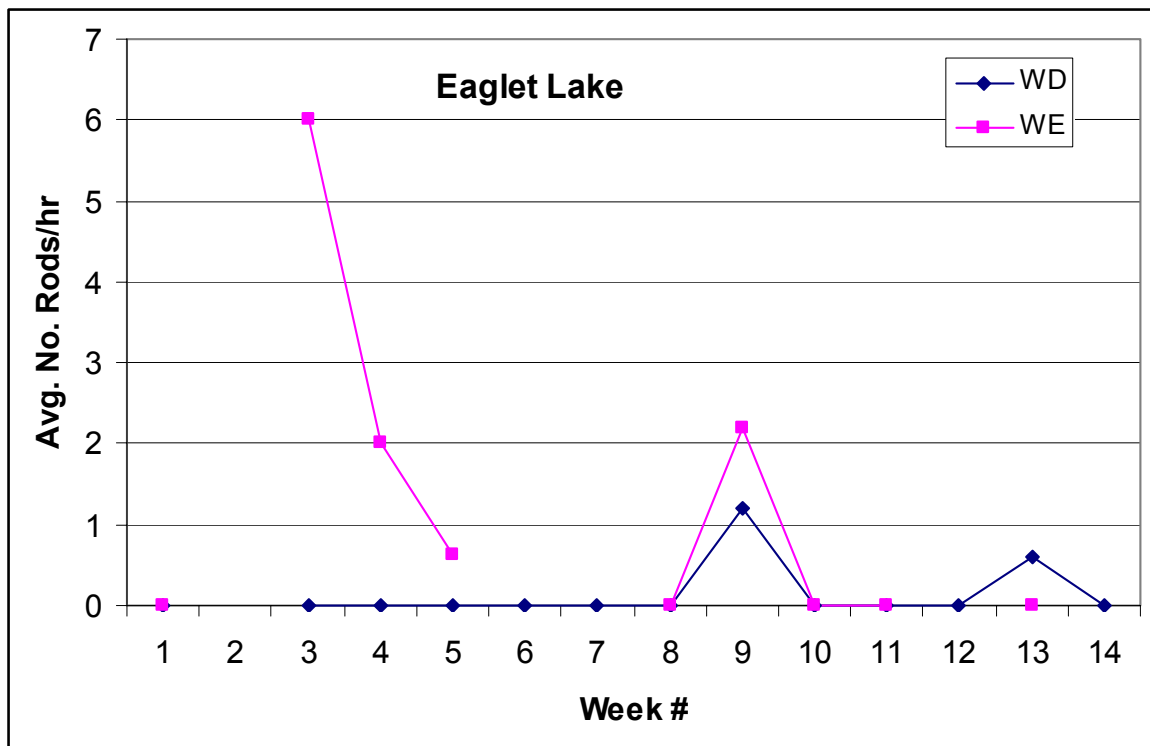


Figure 9. Average daily effort observed on weekends (WE) and weekday (WD) periods on Eaglet Lake.

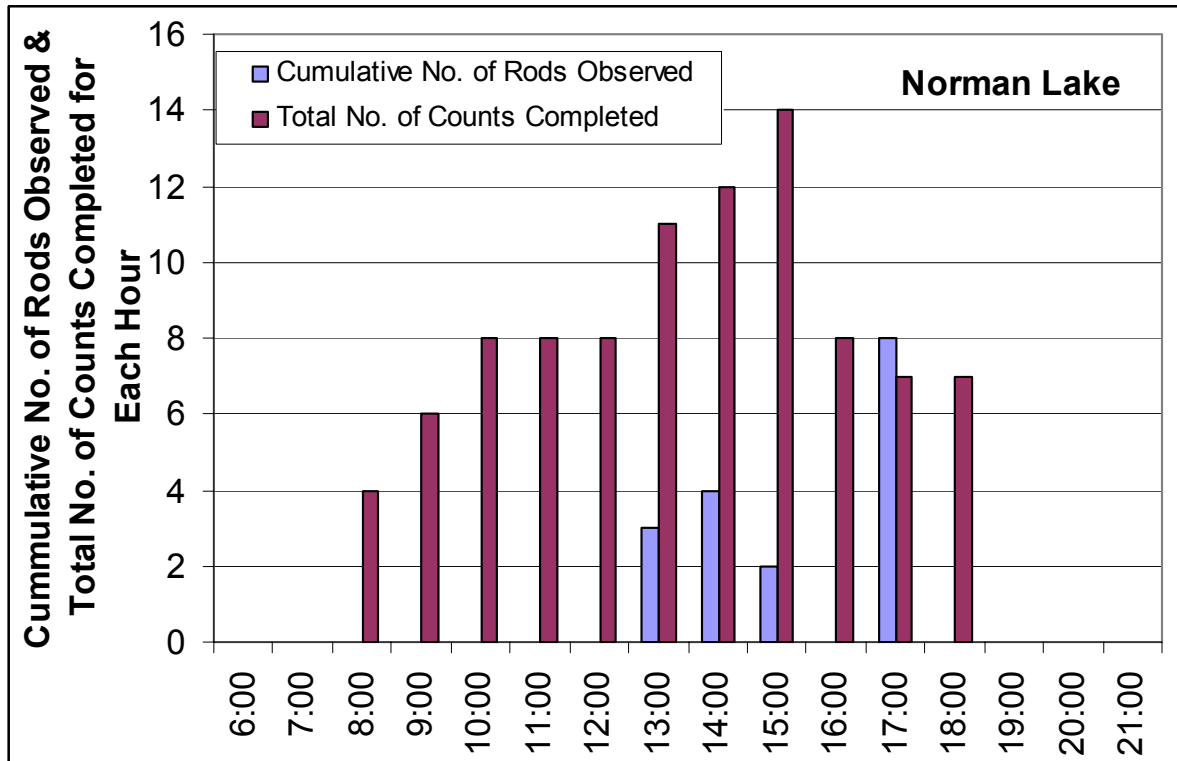


Figure 10. Cumulative number of anglers-rods observed per hour and the total number of counts that were completed for each hour (Norman Lake).

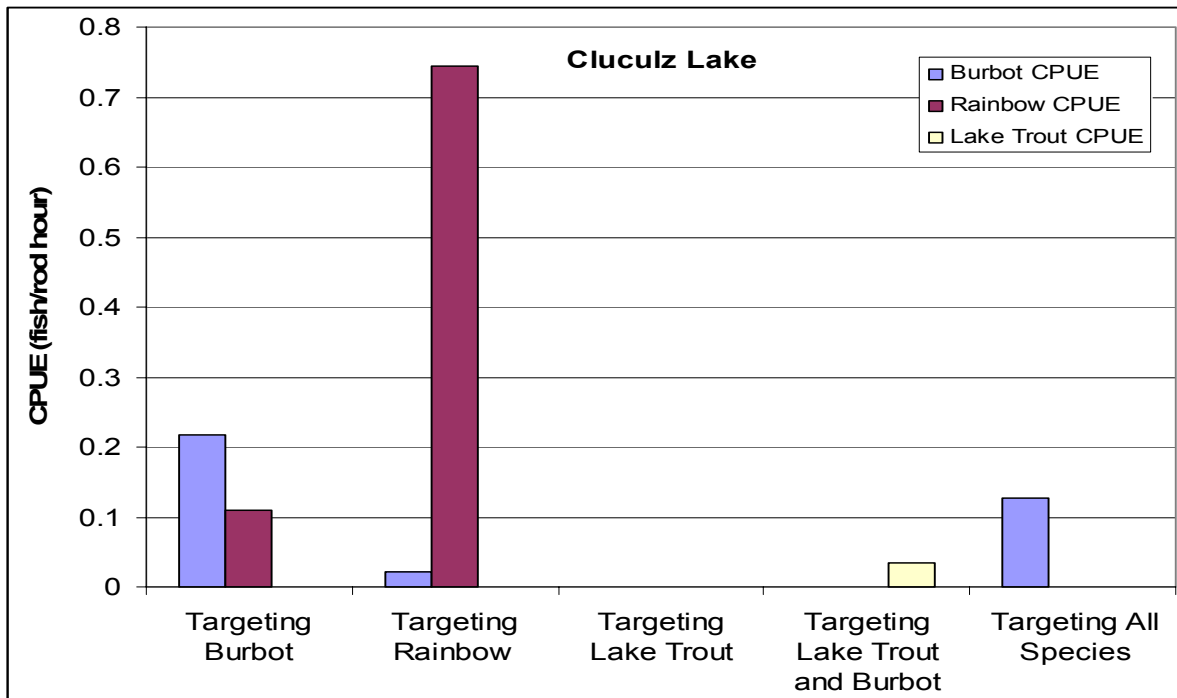


Figure 11. Observed species-specific CPUE figures for anglers that indicated they were targeting specific species.

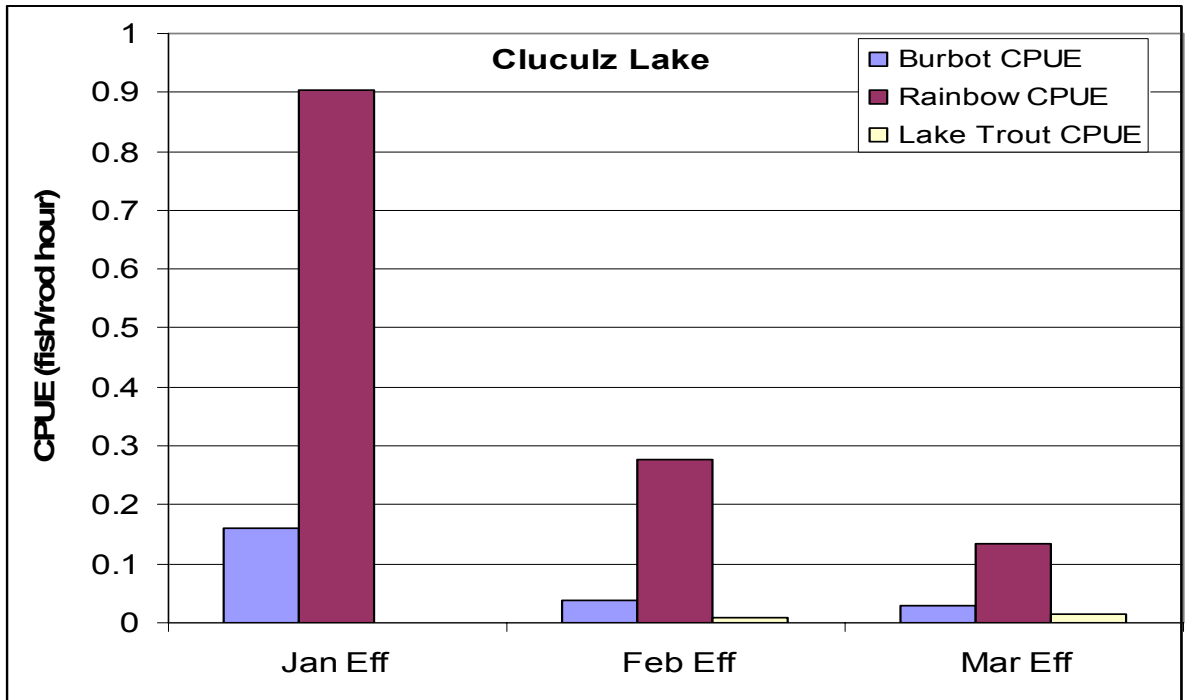


Figure 12. Observed species-specific CPUE figures for angler effort and catch information monthly (January-31.0 hours of effort, February-133.1 hours of effort, March-67.6 hours of effort).

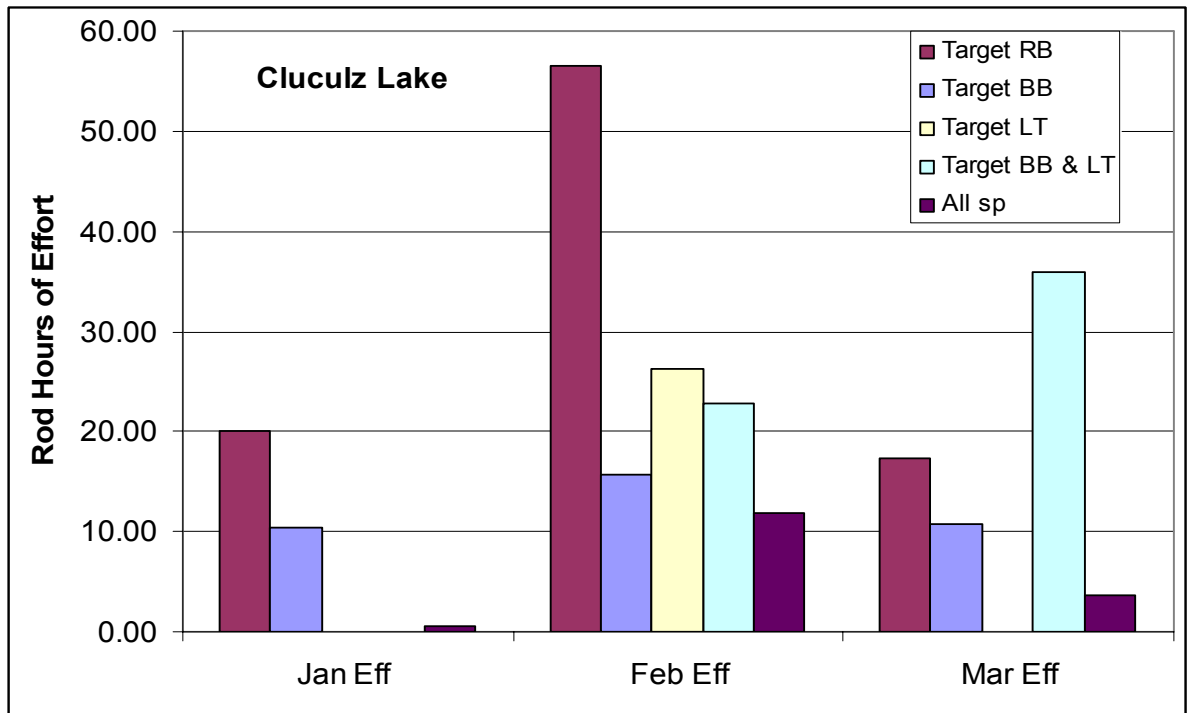


Figure 13. Proportional species-specific directed effort as indicated by interviewed anglers (by month) from Cluculz Lake.

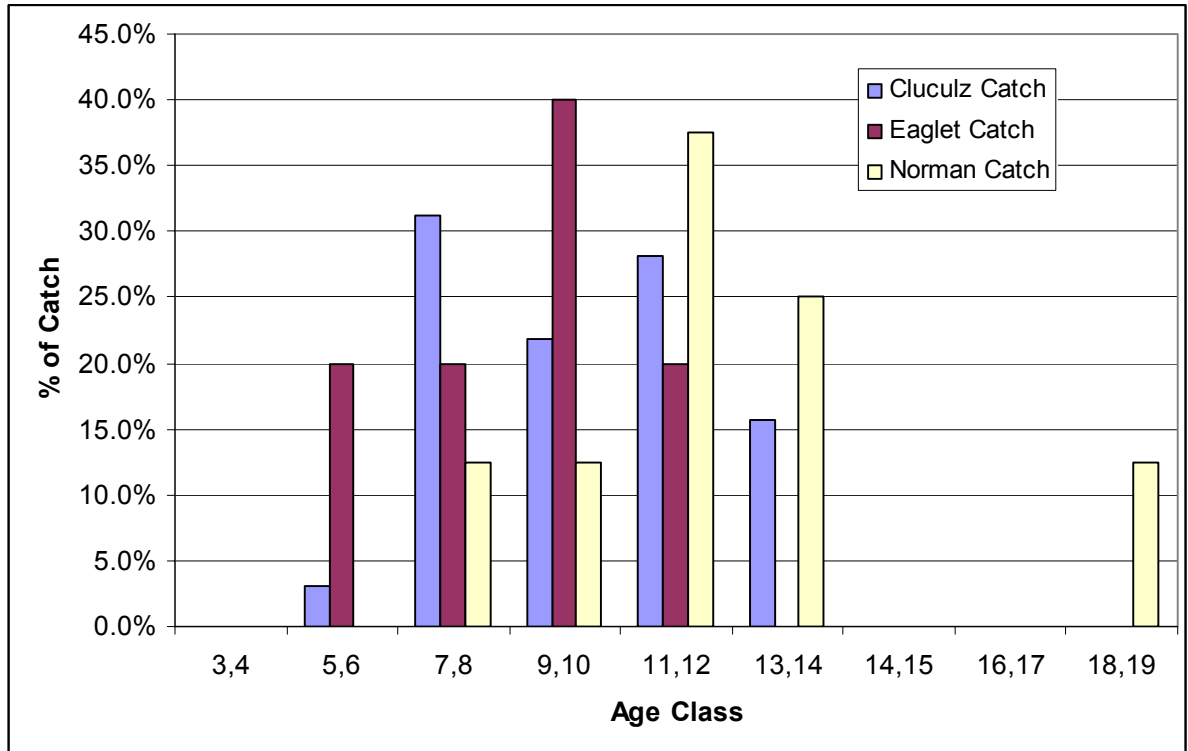


Figure 14. Distribution of age classes within burbot catches from 3 study lakes (Cluculz n=32; Eaglet n=5; Norman n=8).

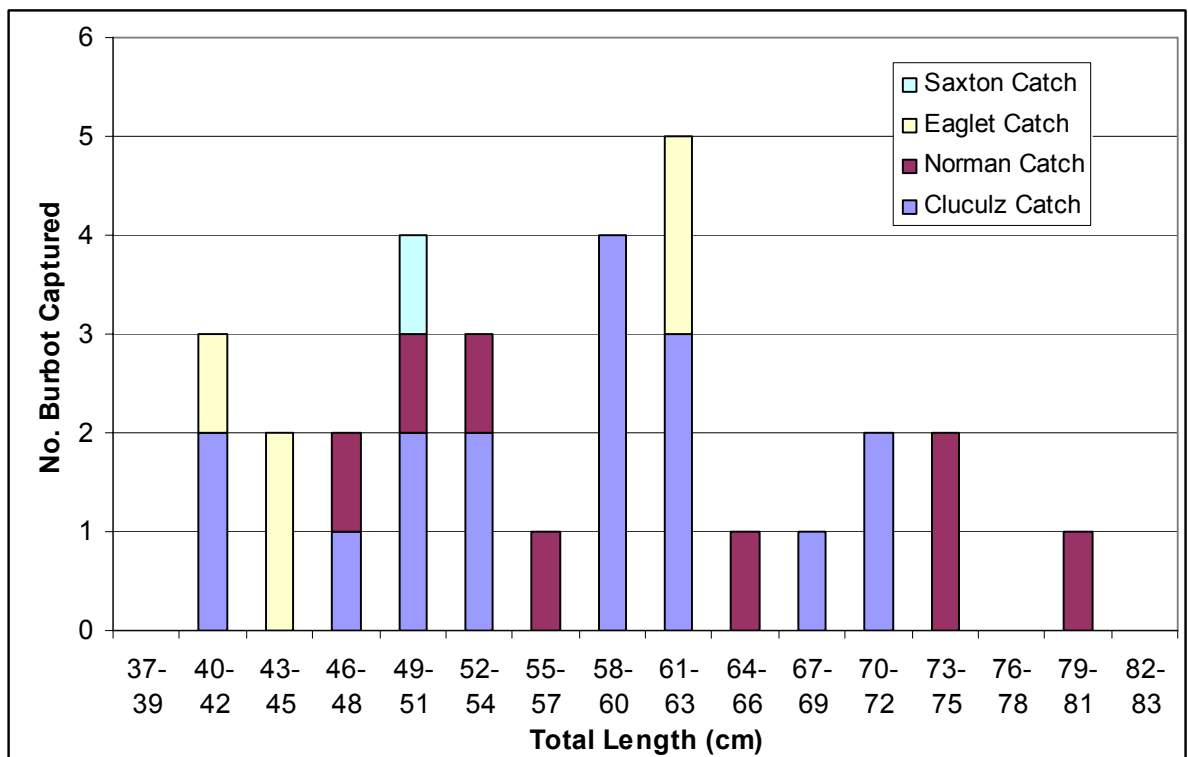


Figure 15. Length distribution of burbot (31) captured from four study lakes.

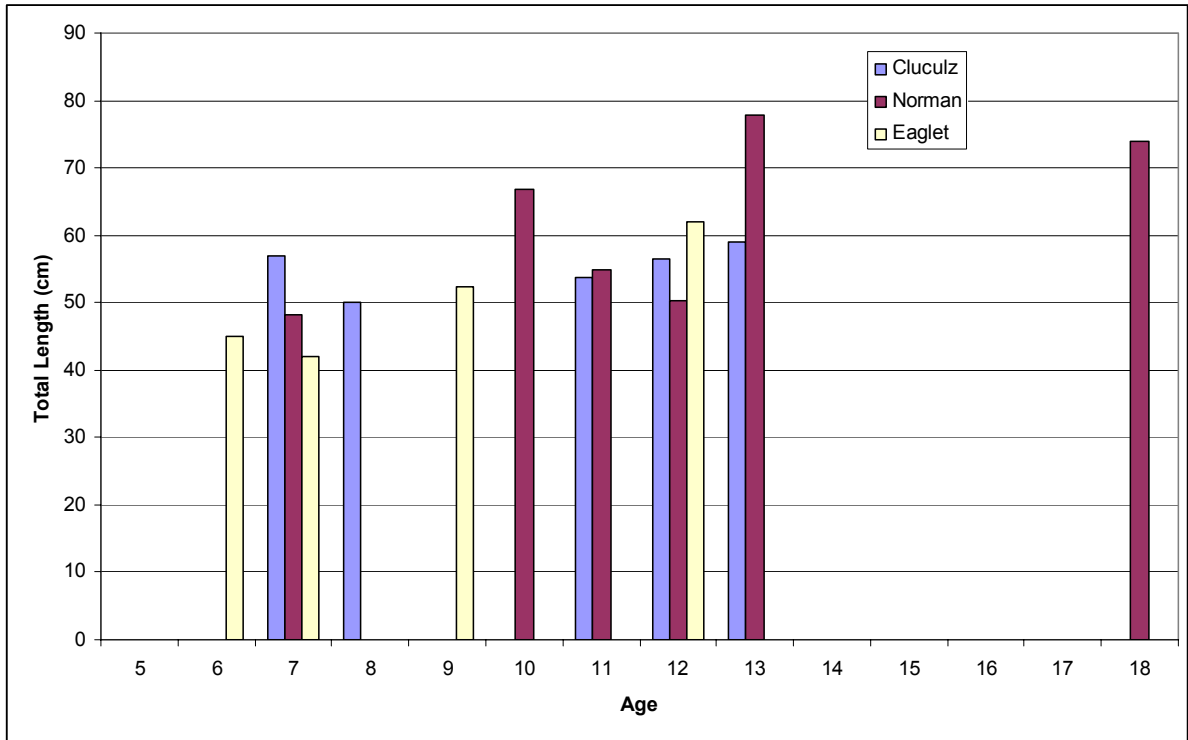


Figure 16. Length at age for burbot sampled from Cluculz (n=5), Norman (n=6) and Eaglet (n=4) lakes.

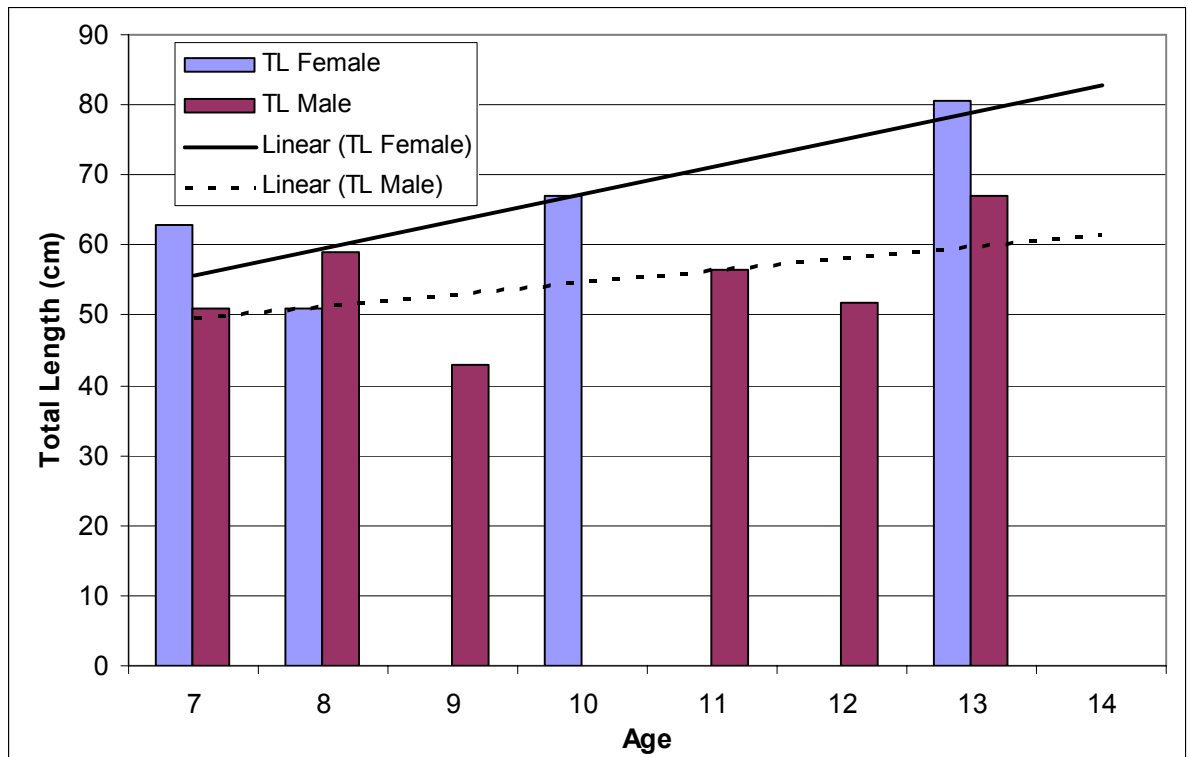


Figure 17. Length at age for male and female burbot sampled during this study.

Appendix 1 – Data Forms

Omineca Burbot Creel, Habitat and Population Assessment Project; 2007
BC Ministry of Environment, Mountain Pine Beetle Response

Omineca Burbot Project; Winter 2007

Angler Count (Effort) Form

Lake _____ Date _____ Crew _____

Time Arrived _____ hrs Time Leave _____ hrs

Time	No. Rods/Anglers	Details (entire or partial count/method)	Angler breakdown by area/quadrant
0700			
0800			
0900			
1000			
1100			
1200			
1300			
1400			
1500			
1600			
1700			
1800			

Weather Conditions _____

Air Temperature ___ C Ice Thickness ___ cm Water Temperature ___ C Water Clarity C L M T

Comments (details about angler distribution, ice condition) _____

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Omineca Burbot Project; Winter 2007

Sampler's CPUE Form

Lake _____ **Date** _____

Time Line In	Time Line Out	Fishing Method (bait used)	Lake Area/Quadrant	Catch Killed							Catch Released						
				Burbot	Rainbow	Whitefish	Lake Tr.	Brook Tr	Dolly/BT	Other	Burbot	Rainbow	Whitefish	Lake Tr.	Brook Tr	Dolly/BT	Other

Note: Information from each hole/line fished is entered on a separate line

Specific Coordinates of Fishing Locations

_____	_____
_____	_____
_____	_____
_____	_____

Crew _____

Page __ of __ for the day

Omineca Burbot Creel, Habitat and Population Assessment Project; 2007
 BC Ministry of Environment, Mountain Pine Beetle Response

Omineca Burbot Project; Winter 2007

Burbot Sampling Form

Lake Captured From _____ Date of Capture _____

Location Captured (area/quad)	Sample from Angler or Crew (A/C)	Angler ID	*Fish ID No.	TL (mm)	Girth (mm)	Weight (g)	**Sex (Na/M/F/Unk)	*** Maturity Class (1-6 or Na/Unk)	Pectoral Ray Collected (Y/N)	Otolith Collected (Y/N)	Photos (File #)

*From Interview Form (last four digits of angler's phone #)
 **Suggest using numbering system starting (Nu, No, C, S, E for lake of capture) and three digit number (e.g. 001, 002 etc.)
 ***Na – sex determination not attempted; Unk – internal exam completed but sex not determined; M – Male; F – Female
 ****Class 1-6, see descriptions in Maturity Classification Directions; Na – maturity determination not attempted; Unk – attempted but could not be determined

Comments (sex and maturity) _____

Crew _____

Burbot Maturity Classification Directions

The following Maturity Classes (1-6) and associated descriptions will be utilized to describe the state of gonad development of burbot captured. This table was developed and previously utilized by Evenson (2000). It was also used for the Eaglet Lake study.

Class	Maturity Stage	Description
Burbot that will not spawn in the current year		
1	Immature	Gonads of very small size. Testes and ovaries transparent, flesh colored, and thread-like. Sex not easily discernable with naked eye. Ovaries rounded and testes angular.
2	Immature and Developing	Gonads of very small size, although some development is apparent. Sex can positively be identified with the naked eye. Ovaries are pale yellow and rounded. Testes are milky and angular.
Burbot that will spawn, or have spawned in the current year		
3	Mature and Developing	Gonads large and occupying at least half the body cavity. Ovaries are round in cross section and color varies from pale yellow to orange. Eggs are indistinguishable to the naked eye. Testes are angular and milky white. Ovaries are typically broader for their length than testes.
4	Gravid	Gonads large, filling the ventral cavity. Testes white, drops of milt fall with pressure, Eggs completely developed and ripe however they cannot be stripped readily.
5	Spawning	Roe and milt run with slight pressure. Weight of gonads decreases rapidly from the start of spawning to its completion.
6	Spent	Sexual products have been discharged; genital aperture is inflamed. Ovaries have the appearance of deflated sacs, and usually contain few retained eggs. Testes typically have some residual sperm. Bluish blotches are associated with partially spawned testes. By summer, gonads are small translucent, and are difficult to differentiate from immature and developing gonads.

Burbot are generally known (suspected) to be winter spawners (January-April) in this region. As all of the fish we will be sampling will be captured during this period, this fact should be kept in mind (i.e. it may limit the occurrence of some maturity classes and make others more common). Determining maturity (and even sex in some cases) proved to be challenging during the Eaglet Lake study. Take photos where possible when completing internal examinations for maturity so that we can continue to refine this process.