

Evaluation of burbot stocks and assessment of a cod trapping
technique in four small lakes of Skeena Region, BC



Paul A. Giroux
BC Min. of Environment
Environmental Stewardship Division
Fish & Wildlife Section
Skeena Region
Smithers BC

December, 2005

Skeena Fisheries Report # SK - 144

Abstract

The use of cod traps (n=10 /lake; Redden Net Comp, Richmond, BC) was assessed in four small lakes of the Skeena Region. Traps were deployed during lake trout index netting assessments to gain expense and labour efficiencies. Basic life history parameters were described for pooled samples of burbot as individual lake samples were inadequate for three of the four lakes sampled. Burbot were found to range in age from 2 – 13 years, with ages 4-6 being the most abundant. The adequacy of non-destructive fin ray aging methods remains inconclusive, and requires further investigation to determine its utility. Growth was variable among lakes, but generally described as rapid with annual rates appearing to decline after reaching 700 mm or age 6-7 years. Mortality rates were generally low, with increases corresponding with either onset of maturation or entry into the fishery. Individual populations could not be assessed for status given low sample sizes and the lack of biological reference points for burbot in small lakes. Further possible studies leading towards the development of a small lake burbot population indexing program are discussed and proposed. Cod traps were found to be easy to deploy and effective in live capturing burbot from sizes 250 mm –to- 900 mm. There was no apparent relationship between trap depth and burbot total length, whereas high catches in Maxan Lake biased the observed relationships for catch versus depth or soak time. Higher sample sizes are required to investigate the potential bias associated with trap deployment.

Acknowledgements

Skeena Region Ministry of Environment staff: Dana Atagi, Mark Beere, Karen Diemert, Darren Fillier, Tom Johnston, Jeff Lough, Tom Smith and volunteer Frank Guillon are acknowledged for their assistance with data collection. Fish aging was completed by North-South Environmental Consultants, Winnipeg Manitoba. Rob Bison, Fisheries Biologist, BC Ministry of Environment, Southern Interior Region, Kamloops, is acknowledged for his generous loan of cod traps. Colin Spence, Fisheries Biologist, BC Ministry of Environment, Kootenay Region, Nelson, is acknowledged for sharing burbot traping effort and catch results data for Region 4. Dana Atagi is acknowledged for his helpful editorial comments on the report. Funding for this project was provided by the BC Habitat Conservation Trust Fund (HCTF seed funding grant Project No. 6-152) and Skeena Region Min. of Environment, Management Team (RMT).



This project was funded by the Habitat Conservation Trust Fund and developed by personnel of the BC Ministry of Environment, Skeena Region, Fish and Wildlife Section. The Habitat Conservation Trust Fund was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia.

Anglers, hunters, trappers and guides contribute to the projects of the Trust Fund through license surcharges. Tax deductible donations to assist in the work of the Trust Fund are also welcomed.

Table of Contents

ABSTRACT	I
ACKNOWLEDGEMENTS.....	I
TABLE OF CONTENTS	II
LIST OF FIGURES	IV
LIST OF TABLES	5
LIST OF APPENDICES	5
1.0 INTRODUCTION.....	1
1.2 Study Area.....	2
1.3 Historical Fisheries Information	3
2.0 METHODS	4
2.1 Trapping and Site Selection	4
2.2 Fish Handling	5
2.3 Data Management and Analysis	5
2.3.1 Burbot Abundance.....	5
3.0 RESULTS.....	6
3.1 Water Temperature and Dissolved Oxygen	6
3.2 Effort & Habitat	7
3.3 Burbot Catch	8
3.3.1 Burbot Length, Age, Growth & Mortality	10
3.3.1.1 <i>Length</i>	10
3.3.1.2 <i>Age</i>	10
3.3.1.3 <i>Growth and Mortality</i>	12
3.4 Individual Lake Results	14
4.0 CONCLUSIONS & RECOMMENDATIONS.....	14
4.1 Burbot/Cod Trapping Methodology.....	14
4.1.1 <i>Sampling Intensity and site selection</i>	15
4.1.2 <i>Future Studies</i>	15
4.2 Burbot Exploitation and Life History	15
4.3 Conservation Management Actions.....	16
5.0 REFERENCES.....	16

APPENDIX 1: INDIVIDUAL LAKE SUMMARY ANALYSIS REPORTS	18
Doris Lake	18
Maxan Lake	23
McBride Lake:.....	28
Owen Lake	33

List of Figures

Figure 1: Location of Doris, Maxan, McBride and Owen lakes. Inset map of study area in Province of BC.	2
Figure 2: Summary of set line permits issued (Effort - top) and reported catch of burbot (Catch – bottom) for the lakes assessed, spring 2004. Source: BC Ministry of Environment, Skeena Region Fish & Wildlife files).....	3
Figure 3 Cod trap used for capture of burbot in small lakes in Skeena Region, spring 2004 (photo from Spence 2000).	4
Figure 4: Scatter plot and linear regression for burbot density (log) versus burbot hoop trap CUE (log) from Alaskan Fish and Game published reports.	5
Figure 5: Dissolved oxygen (mg/l) and temperature (°C) profiles for Doris, Maxan, McBride and Owen lakes sampled in the spring, 2004.	6
Figure 6: Mean and standard error (bars) of trap soak time for Doris, Maxan, McBride and Owen lakes, sampled spring, 2004. *** indicates significant differences between lakes soak time (one-way ANOVA, $F=2.76$, $p=0.001$).	7
Figure 7: Histogram of burbot trap frequency by depth (m) class for all lakes sampled, spring 2004.	7
Figure 8: Mean and standard error of trap depth (m) for Doris, Maxan, McBride and Owen lakes, sampled spring 2004.	8
Figure 9: Plot of burbot (BB) catch per trap against trap depth (left) and trap soak time (hours; right) for burbot trapping completed in Maxan, Doris, McBride and Doris lakes, spring 2004. *** indicates significance at $\alpha = 0.05$	9
Figure 10: Total burbot (BB) catch plotted against mean trap depth (m; left plot) and mean trap soak time (hours; right plot) for Doris, Maxan, McBride and Owen lakes sampled in spring, 2004.	9
Figure 11: Plot of burbot length (mm) against cod trap depth (m) for lakes sampled during spring 2004.	10
Figure 12: Percent frequency of total length for burbot captured in cod traps for all lakes sampled, spring 2004.	10
Figure 13: A – otolith derived burbot ages versus total length for all burbot samples on file with Skeena Region; equation for linear relationship of age-at-length displayed. B - fin ray (FR) estimated ages (grey squares) and otolith (OT) ages (circles) versus total length of burbot captured in the spring 2004 and historical samples on file. ...	11
Figure 14: Plot of fin ray determined age (y-axis) against otolith determined age (x-axis) for six burbot collected from McBride and Maxan lakes. Shaded square with x indicates removed outlier. Linear regression line (black solid line) and equation presented as well as, $x=y$ reference line (dashed line).	12
Figure 15: Percent frequency histogram for burbot ages captured in cod traps for all lakes sampled, spring 2004. Grey bars present uncorrected fin ray age results; white bars present corrected age result using <i>fin ray vs. otolith</i> regression equation.	12
Figure 16: Walford plot for burbot captured in traps in all lakes sampled in the spring of 2004. Length corrected burbot ages used.	13
Figure 17: VonBertalanffy growth curve (L_{∞} & k) for corrected ages for burbot collected from Maxan, Doris, McBride and Owen lakes, spring 2004. Grey circles represent data points removed from questionable age results.	13

Figure 18: Plot of natural log otolith and otolith corrected age frequency, linear regression line and equation for burbot captured in cod traps for all lakes sampled, spring 2004.	14
---	----

List of Tables

Table 1: Summary of physical and chemical attributes of Maxan, McBride, Owen and Doris lakes, Skeena Region. (source: BC Fisheries Data Warehouse).....	2
Table 2: Summary of burbot trap effort (soak hours), catch results (total and CUE), mean and standard error trap depth (m) and mean and standard error burbot (BB) length for Doris, Maxan, McBride and Owen lakes, spring 2004.	8
Table 3: Summary of burbot catch-per unit effort for cod traps (cod CUE), converted cod-to-hoop trap CUE, burbot density per ha, burbot abundance estimate and standard error... ..	14

List of Appendices

Appendix 1: Individual Lake Summary Analysis Reports	18
Doris Lake	18
Maxan Lake	23
McBride Lake:.....	28
Owen Lake	33

1.-1 Introduction

Recreational sport fishing for burbot (*Lota lota*) is a popular activity in Skeena Region's large and small lakes. Burbot are captured by jigging or set lining with bait in both open water and ice fisheries, slow trolling bait or hardware, or as by-catch for other targeted sport species. Burbot harvest was monitored from 1975-1985 by Skeena Region Fisheries staff through the issuance of set line permits and angler compliance with permit conditions requiring submission of catch information. However, harvest analysis or assessment of burbot population status or description of life history attributes has not been attempted. Inspection of the historical data indicates analysis and resulting conclusions would be of little management value. Presently, Skeena Region is one of three Regions within the Province that allows the use of baited set lines to capture and harvest burbot. A daily limit of five burbot and possession of ten is permitted in Skeena Region (Anon. 2005).

Burbot populations have shown susceptibility to recreational angler over-harvest and population collapse (Ahrens and Korman 2002). Population declines solely attributed to angler harvest have been noted in small lakes in Alaska (Bernard et al. 1993), whereas angler harvest has been implicated as a contributing factor along with substantial environmental changes in large river and reservoir systems (Paragamian et al. 2000, Ahrens and Korman 2002). In order to obtain base line information on some of Skeena's small lake burbot populations, a pilot program was initiated in 2004 with seed funding from Habitat Conservation Trust Fund (HCTF) to assess the feasibility of assessing burbot stocks while conducting lake trout spring littoral index netting (SLIN) surveys. The following goals and objectives were established:

Goals

- Develop scientifically defensible field methodology that can be completed while conducting lake trout SLIN that facilitates analysis for assessment of burbot stocks in small lakes;
- Contribute information towards the possible examination of fish community interactions between burbot and other species, specifically lake trout; and,
- Make recommendations for implementation of methodology/analysis into a Regional Assessment Program.

Objectives

- Randomly deploy 10-15 burbot/ cod traps per lake over 48 hour soak periods;
- Limit burbot mortality associated with trapping effort to less than 10% of catch;
- Capture and collect biological information (e.g. age, length, weight) from a sample of 20-30 burbot per lake;
- Generate estimates of basic life history parameters for each lake population sampled (e.g. mortality/survival rates, growth rates);
- Create management objectives for Skeena Region burbot populations; and,
- Evaluate individual lakes against management objectives.

1.2 Study Area

Burbot fisheries were known to occur in many of the Skeena Region's small lakes where lake trout exist. Because significant logistical and cost efficiencies could be gained by conducting burbot assessments concurrent with existing lake trout SLIN efforts, burbot trapping was initiated in lakes where lake trout SLIN efforts were previously scheduled. Lake trout assessments were conducted in small lakes where fisheries known to District Conservation Officers occur. Four lakes were scheduled for assessment in 2004; Maxan (May 12-14), Owen (May 18-20), McBride (May 26-28) and Doris (June 7-9). The latter lake is located in close proximity to Smithers, whereas the former lakes are close to the Town of Houston (Figure 1). Physical and chemical attributes for the lakes sampled collected through the Provinces Fisheries Inventory Program are summarized in Table 1.

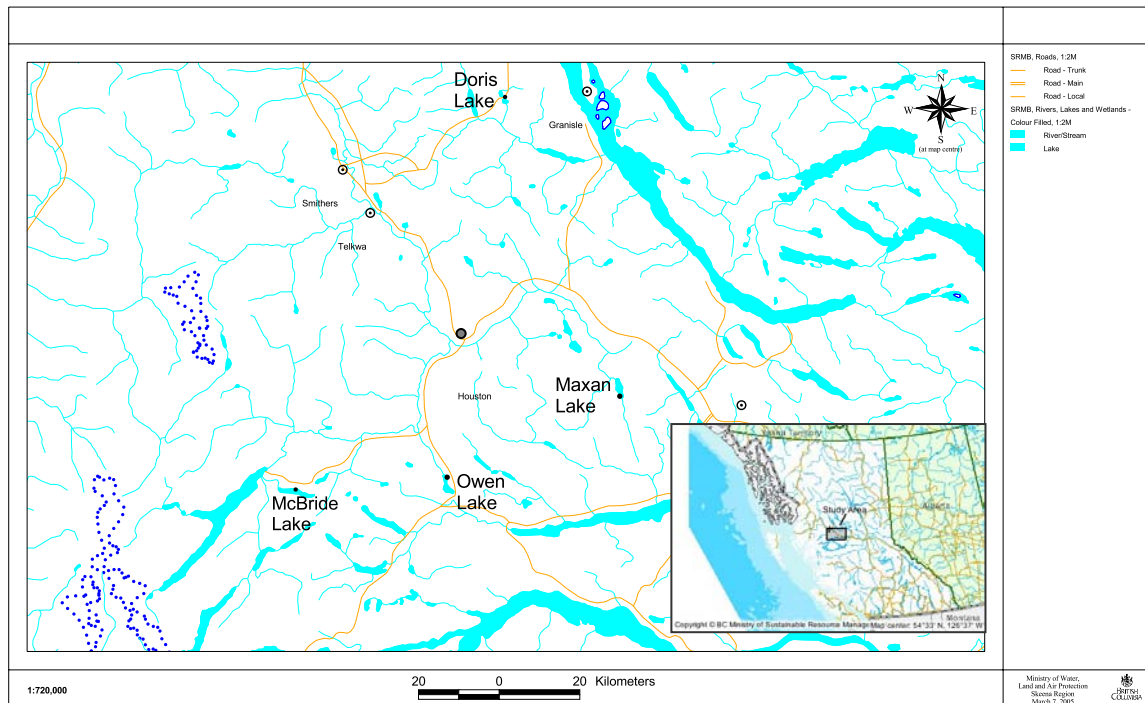


Figure 1: Location of Doris, Maxan, McBride and Owen lakes. Inset map of study area in Province of BC.

Table 1: Summary of physical and chemical attributes of Maxan, McBride, Owen and Doris lakes, Skeena Region. (source: BC Fisheries Data Warehouse)

Gazetted Name	Watershed Code	Waterbody Identifier	Survey Date	Surface Area (ha)	Littoral Area (ha)	Perimeter (m)	Volume (m ³)	Mean Depth (m)	Max Depth (m)	pH	TDS	Hydrogen Sulfide	Secchi Depth (m)
MAXAN LAKE	460-924300	01738BULK	1973-09-10	637.96	531.65	15703	92459340	14.5	25	7.5	77	NIL AT 10.7 m	2
MCBRIDE LAKE	460-600600-63200	01380MORR	1974-08-30	778.64	542.3	17428	83559800	10.7	26.8	6.9	42	NIL AT 80 FEET	4.6
OWEN LAKE	460-600600-23900	01248MORR	1968-08-31	296.65		16368	46340700	15.6	37.5	7.1		NIL	2.1
DORIS LAKE	480-697200-33400	00722BABL	1970-08-11	113.31		6181	7373342	6.5	13.4	6.5	47	NIL	1.8

1.3 Historical Fisheries Information

The number of burbot set line permits issued, permit information requests returned, lakes fished, number caught, weight (1974-82), and length (1982-1985) of burbot harvested was recorded by Ministry staff from burbot set line permit applications and permit information returns from 1974 –to- 1985. Inconsistencies in the data records, data collection format and the reliance on angler self-reporting limit the rigour and analysis that can be completed on the data; however, a perspective on historical set line effort and catch may prove useful in understanding present population structure and provide some insight into past and possibly present effort, harvest and catch/unit effort (CUE) results.

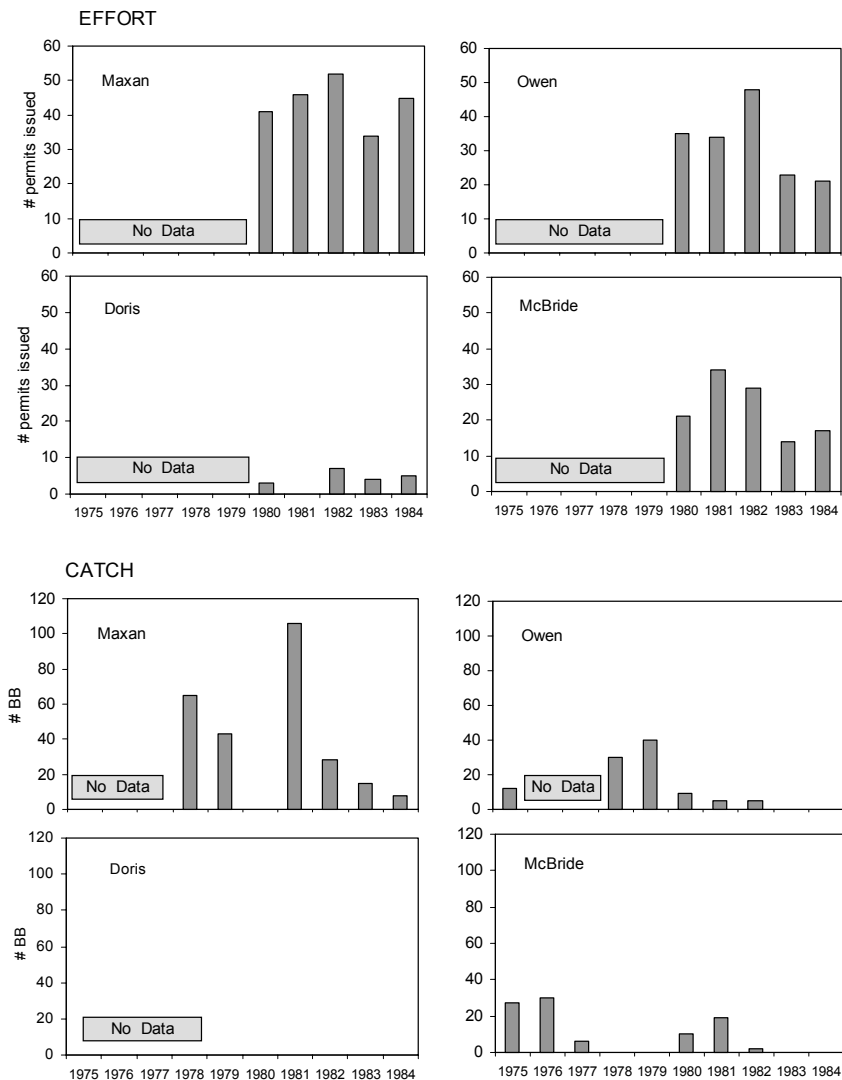


Figure 2: Summary of set line permits issued (Effort - top) and reported catch of burbot (Catch – bottom) for the lakes assessed, spring 2004. Source: BC Ministry of Environment, Skeena Region Fish & Wildlife files).

Of the lakes sampled in 2004, Maxan, Owen and McBride had a similar amount of historical permits issued, whereas Doris Lake had substantially less (Figure 2). Also of note, is the initiation of recording the number of permits issued in 1980, where they had been issued in the five previous years but, not recorded. In general, set-line anglers in Maxan Lake reported catching a greater number of burbot than the other three lakes (Figure 2). Only Owen Lake reported similar harvest levels in 1979, where reporting or harvest decreased substantially afterwards (Figure 2). Incomplete data and apparent problems with receiving consistent returns from permittees limit the utility of these data beyond gaining an understanding of permittee compliance, relative burbot set-line permits issued and harvest.

2.-1 Methods

2.1 Trapping and Site Selection

Each lake was sampled with ten (10) cod traps (manufactured by Redden Net Company, Richmond, BC). Cod traps were described in detail and demonstrated to be effective at capturing burbot by Spence (2000; Figure 3). Traps were generally set in the evening following a half day of lake trout SLIN netting where 2-4 fish suffering netting mortality were eviscerated, placed in a mesh bag and anchored to the inside of the trap as bait. Sites were selected following methods described by Bernard et al. (1993). In this method, parallel transects were numbered and superimposed over the long axis of the lakes bathymetric map, 125 m apart. Potential sites were marked and numbered along each transect at 125 m intervals where water depths were less than 15 m. Using a random number generator, transects were selected and sites were selected from each transect until all available traps were allocated. Traps were set for 48 hours prior to retrieval. Traps were identified with BC Fish & Wildlife numbered white net buoys and monitored by staff during SLIN efforts for disturbance by the public.



Figure 3 Cod trap used for capture of burbot in small lakes in Skeena Region, spring 2004 (photo from Spence 2000).

2.2 Fish Handling

Burbot captured in traps were brought to the surface and measured for total length (mm), round weight (g) using Accu-Weigh® models T-10 and T-4 spring scales. Age samples were collected by cutting a 1-2 cm section from the base of an anterior pectoral fin ray. Fish that suffered mortality or a small sub-sample (10% catch) were sacrificed to obtain estimates of maturity, gender and collection of otoliths for aging. Care was taken to process each burbot after raising the trap to the surface under a five minute period to lessen the onset of gas bubble trauma (Bernard 1993, Neufeld and Spence 2001). Burbot that exhibited initial signs of gas bubble trauma were sunk in traps for at least one hour and then released immediately after re-surfacing. Age samples were sent to North-South Consultants of Winnipeg, Manitoba for analysis.

2.3 Data Management and Analysis

Field data were collected on BC Resource Inventory Standards Committee (RISC) Field Data Information System (FDIS) fish collection forms. Data were entered into the MS Access based FDIS data entry tool for integration into the BC Ministry of Sustainable Resource Managements Fisheries Data Warehouse. Analysis was completed using MS Excel v2002.

2.3.1 Burbot Abundance

Burbot abundance was estimated through regression analysis of log transformed burbot densities and hoop trap CUE (catch per unit effort) from Alaskan lakes (Taube and Bernard 2001, Burr 1995, Bernard et al. 1993, Lafferty et al. 1992).

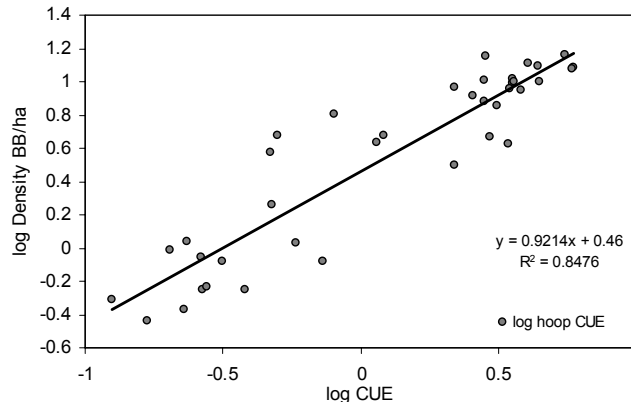


Figure 4: Scatter plot and linear regression for burbot density (log) versus burbot hoop trap CUE (log) from Alaskan Fish and Game published reports.

Equation 1 was used to predict burbot density (BB/ha) following conversion of cod trap to hoop-trap CUE. Burbot abundance was then estimated by multiplying burbot density by lake area (ha).

Equation 1:

$$10^y = \text{burbot density (BB/ha)}$$

where: $y = 0.9214(x) + 0.46$ and $x = \log \text{cod trap burbot CUE}$

Spence (2000) provided data to allow for the comparison between hoop trap and cod trap burbot CUE rates over 48 hr set periods. A cod trap –to- hoop trap correction factor was generated by applying Equation 2 from Spence’s observed catch rates. The observed CUE_{cod} from this study was converted to CUE_{hoop} and used in Equation 1 to predict burbot density and then abundance, by multiplying density by area (ha).
Equation 2:

$$CUE_{\text{hoop}} = \text{obs. } CUE_{\text{cod}} \bullet \frac{CUE_{\text{hoop}}(i)}{CUE_{\text{cod}}(i)}$$

where, i = from Spence (2000)
 48hr $CUE_{\text{cod}} = 0.047337$
 48hr $CUE_{\text{hoop}} = 0.117154$

3.1 Results

3.1 Water Temperature and Dissolved Oxygen

Dissolved oxygen concentration profiles for each lake sampled in the spring of 2004 reveal little stratification of dissolved oxygen levels, with the exception of Doris and Maxan lakes that varied by 2 mg/l from the surface to 8 m deep (Figure 5). Temperature stratification was most evident at Owen and Doris lakes. Owen Lake’s profile was taken at the end of the sampling period, which was composed of sunny and hot weather conditions in the three days preceding water sampling. Maxan and McBride lakes were 12° C or less at the surface, whereas Doris and Owen lakes were 12° C at 2 and 3 m respectively.

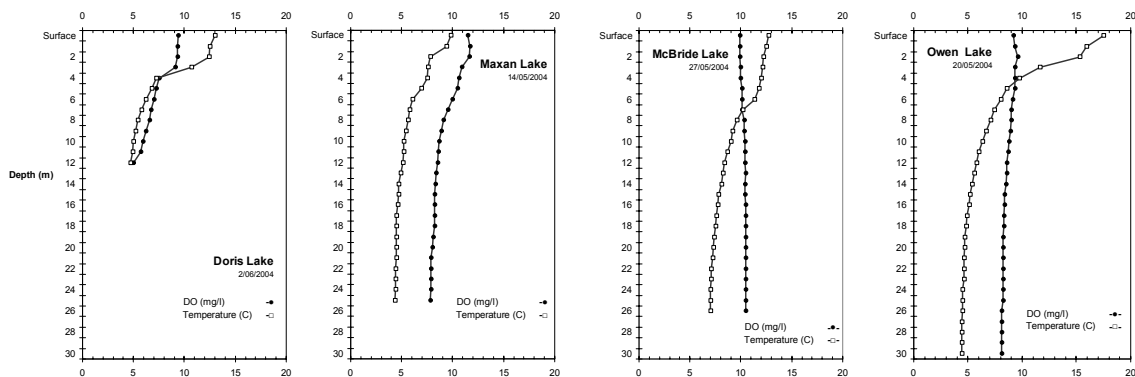


Figure 5: Dissolved oxygen (mg/l) and temperature (°C) profiles for Doris, Maxan, McBride and Owen lakes sampled in the spring, 2004.

3.2 Effort & Habitat

Mean trap soak times ranged between 38 hours and 44 hours for lakes sampled and differences between lakes were found to be significant (Figure 6; one-way ANOVA, $F=2.76$, $p=0.001$). However, the relevance of the observed difference in soak times is unclear due to bias introduced to the data set as a result of low catches among lakes (see section 3.3).

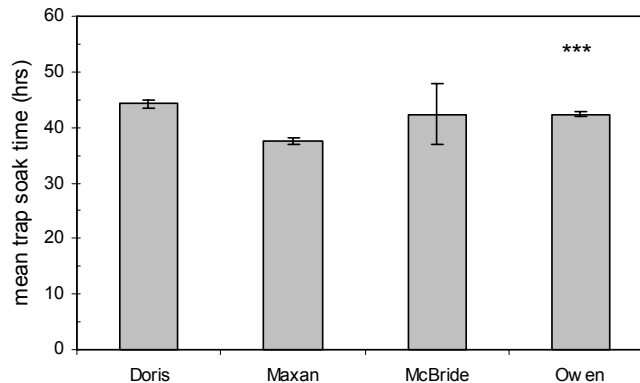


Figure 6: Mean and standard error (bars) of trap soak time for Doris, Maxan, McBride and Owen lakes, sampled spring, 2004. *** indicates significant differences between lakes soak time (one-way ANOVA, $F=2.76$, $p=0.001$)

A pooled sample of all traps revealed that depth was normally distributed through the 1.5 –to- 15 m depth range (Figure 7).

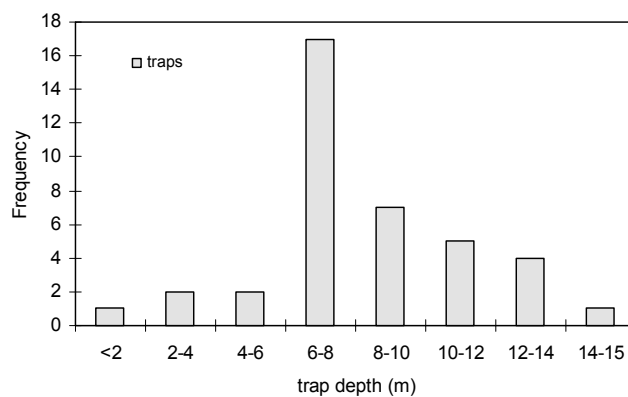


Figure 7: Histogram of burbot trap frequency by depth (m) class for all lakes sampled, spring 2004.

Maxan Lake traps were set deepest of the lakes sampled; however, differences between trap depths between lakes was not significant (Figure 8; one-way ANOVA, $F=2.86$, $p=0.16$).

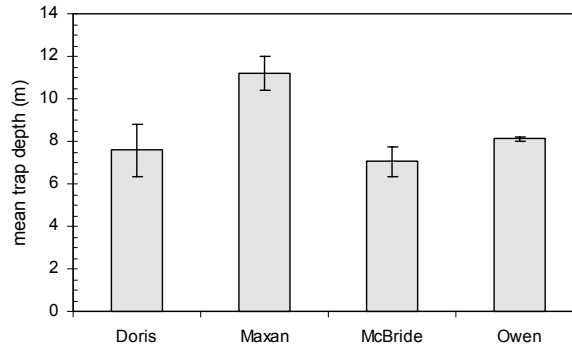


Figure 8: Mean and standard error of trap depth (m) for Doris, Maxan, McBride and Owen lakes, sampled spring 2004.

3.3 Burbot Catch

Forty-two burbot were captured in the four lakes sampled after setting and retrieving 40 traps; for an overall catch per unit effort of 1.05 BB/set or 0.03 bb/hr (Table 2). No other species of fish were captured in the traps. Maxan Lake catches exceeded the average CUE, whereas catches in McBride were average and Doris and Owen lakes were well below average (Table 2).

Table 2: Summary of burbot trap effort (soak hours), catch results (total and CUE), mean and standard error trap depth (m) and mean and standard error burbot (BB) length for Doris, Maxan, McBride and Owen lakes, spring 2004.

Lake	no. traps	total trap soak (hrs)	mean trap soak/set (hrs)	total BB trap catch	BB CUE (catch/hr)	BB CUE (catch/set)	Mean Trap Depth (m)	SE	Mean BB length (mm)	SE
Doris	10	443.16	44.19	4	0.01	0.40	7.57	1.214	428.0	33.25
Maxan	10	374.36	37.43	24	0.06	2.40	11.20	0.785	593.3	16.15
McBride	10	424.13	42.40	11	0.03	1.10	7.05	0.684	480.6	25.54
Owen	10	423.15	42.30	3	0.01	0.30	8.1	0.071	829.3	33.45
Total	40	1665	41.6	42	0.03	1.05	8.48		582.81	

Although sample size is small, trap depth and trap soak time does not exhibit a strong relationship to burbot catch rates; however, the negative relationship between burbot catch per trap and soak time was significant ($p=0.05$, $F=5.16$ $df=39$; Figure 9).

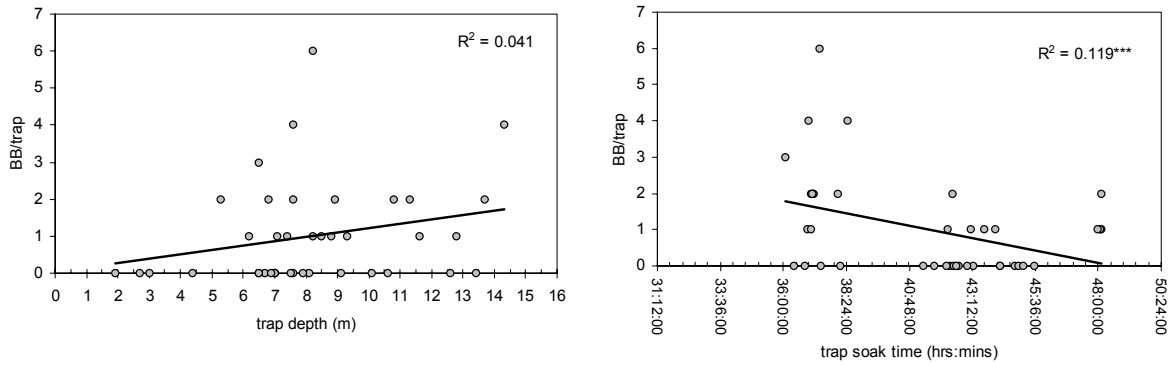


Figure 9: Plot of burbot (BB) catch per trap against trap depth (left) and trap soak time (hours; right) for burbot trapping completed in Maxan, Doris, McBride and Doris lakes, spring 2004. *** indicates significance at $\alpha = 0.05$.

The observed relationships between burbot catch and trap depth and soak time (Figure 9) were severely biased by Maxan Lake's high burbot catch and its shorter soak times and deeper average trap depth (Figure 10). Increasing sample size within lakes and sampling additional lakes would assist in determining the significance of the noted relationships.

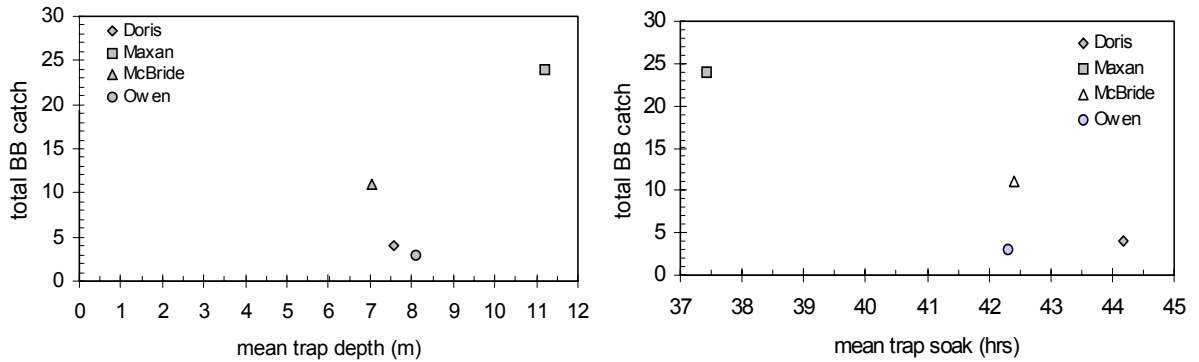


Figure 10: Total burbot (BB) catch plotted against mean trap depth (m; left plot) and mean trap soak time (hours; right plot) for Doris, Maxan, McBride and Owen lakes sampled in spring, 2004.

The relationship between burbot length and trap depth does however appear to reveal that burbot size bias is not present for trap depth (Figure 11).

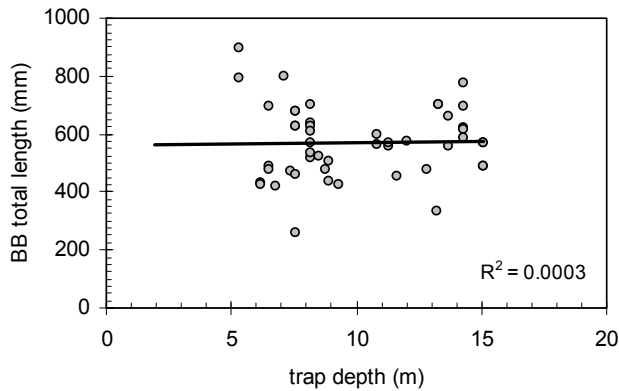


Figure 11: Plot of burbot length (mm) against cod trap depth (m) for lakes sampled during spring 2004.

3.3.1 Burbot Length, Age, Growth & Mortality

3.3.1.1 Length

Burbot total length was normally distributed for samples collected in all four lakes combined (Figure 12). Mean total length and (571.7 mm SE \pm 17.3) and the median length (570 mm) were virtually the same. Owen Lake's three burbot contributed the longest burbot in the sample, whereas Doris Lake's four burbot were the shortest (Table 2).

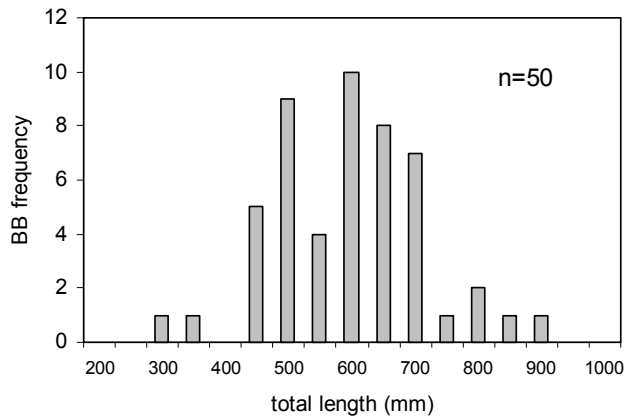


Figure 12: Percent frequency of total length for burbot captured in cod traps for all lakes sampled, spring 2004.

3.3.1.2 Age

Age was determined for 45 of the 50 burbot sampled in 2004 through the collection of pectoral fin rays (non-destructive; n=44), as well as, otolith structures from a small

sample of sacrificed burbot (n=6) where both fin rays and otoliths were collected. A comparison of the slope of burbot fin ray determined age-at-length versus samples on file of burbot otolith determined age –at- length demonstrated significant differences existed (Figure 13B; students t-test for comparison of slope: $t_{cal}=81$, 120 df $p=0.001$; Zar 1996). Further examination of ages obtained from fin rays produced results suggesting that burbot ages may be under estimated, especially for older burbot, compared to age estimates obtained from otoliths (Figure 14). Correction for this apparent bias was attempted by applying the following equation from paired burbot age samples (fin ray and otolith; n=6):

$$c_a = fr + res$$

where: C_a = corrected fin ray age

fr = fin ray age

$res = y_i - y_{ii}$

where: $y_i = 0.8478x_i - 0.587$ (y_i = predicted otolith age, x_i = fin ray age)

$y_{ii} = x_{ii}$ (y_{ii} = fin ray age, x_{ii} = otolith age)

Length –to- age correction was attempted and abandoned due to a weak linear relationship ($r^2=42$) between burbot total length and otolith ages on file for Skeena Region (Figure 13A). The weak correlation is likely a result of a high level of variation in burbot growth rates among lakes. The burbot otolith age samples on file for Skeena Region were also collected primarily in Nilkitkwa/Babine Lake.

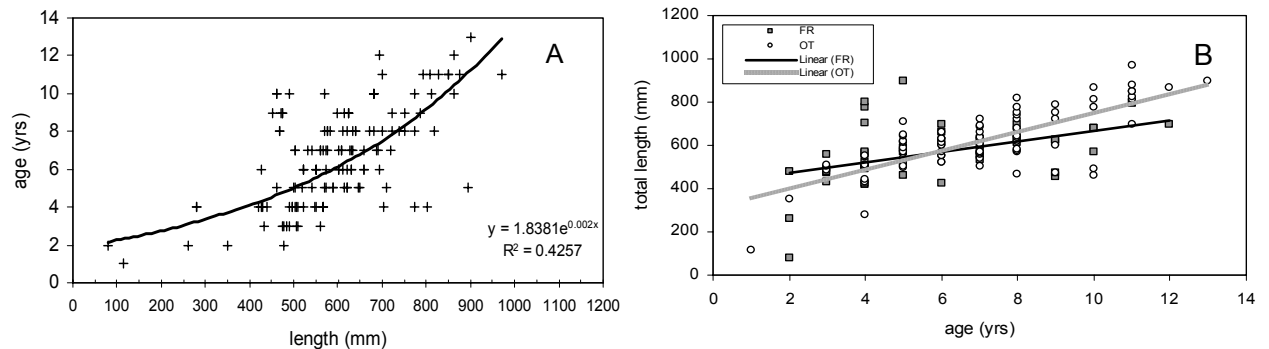


Figure 13: A – otolith derived burbot ages versus total length for all burbot samples on file with Skeena Region; equation for linear relationship of age-at-length displayed. B - fin ray (FR) estimated ages (grey squares) and otolith (OT) ages (circles) versus total length of burbot captured in the spring 2004 and historical samples on file.

Age frequency results following correction of fin ray ages using the otolith conversion method resemble uncorrected aging frequency distribution; however ages are greater by one –to- three years (Figure 15). Two year old burbot are no longer represented, whilst older age classes of burbot exist. Fin ray/otolith corrected age estimates are used for further analysis.

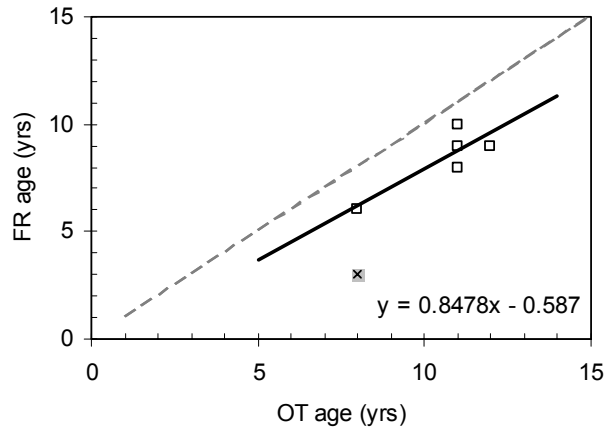


Figure 14: Plot of fin ray determined age (y-axis) against otolith determined age (x-axis) for six burbot collected from McBride and Maxan lakes. Shaded square with x indicates removed outlier. Linear regression line (black solid line) and equation presented as well as, x=y reference line (dashed line).

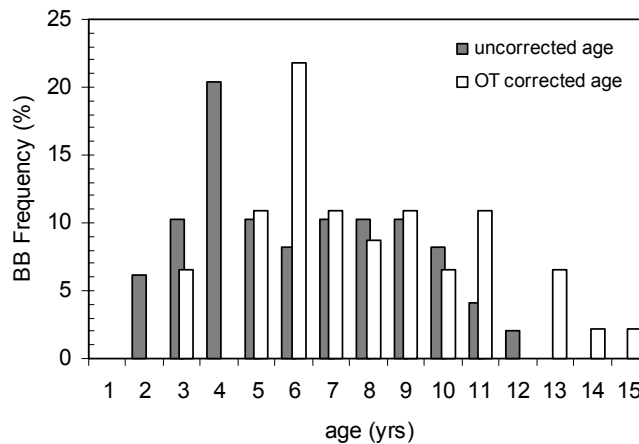


Figure 15: Percent frequency histogram for burbot ages captured in cod traps for all lakes sampled, spring 2004. Grey bars present uncorrected fin ray age results; white bars present corrected age result using *fin ray vs. otolith* regression equation.

3.3.1.3 Growth and Mortality

Burbot growth appears to be rapid and linear for the first 5-7 years (Figures 15 & 16). Asymptotic length (L_{∞}) for the pooled sample of burbot was 650 mm as determined from a Walford plot (Ricker 1958; Figure 15) and 896 mm using longest burbot in catch (L_{∞}). Annual growth (K) was estimated at 0.2830 from the Walford plot. Removal of outliers (large, young fin-ray aged burbot) from the age at length calculation was completed to obtain a more representative growth curve (Figure 17).

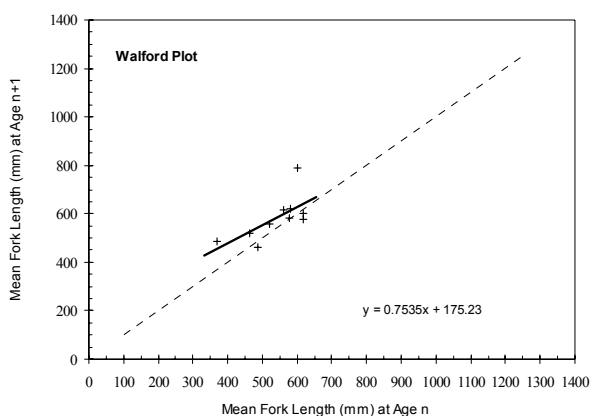


Figure 16: Walford plot for burbot captured in traps in all lakes sampled in the spring of 2004. Length corrected burbot ages used.

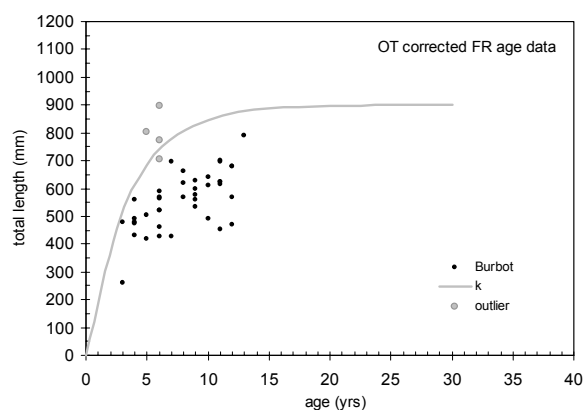


Figure 17: VonBertalanffy growth curve (L_{∞} & k) for corrected ages for burbot collected from Maxan, Doris, McBride and Owen lakes, spring 2004. Grey circles represent data points removed from questionable age results.

Natural log transformed age frequency plot of otolith and otolith corrected age data depicts a low instantaneous mortality rate ($Z=0.16$) for the pooled sampled of burbot captured in all four lakes (Figure 18). Only a modest increase in mortality is observed after age five. Dramatic increases in mortality occur at age eleven, where burbot are fully recruited to the fishery and 100 percent of the population would be mature. Maximum life expectancy for burbot in the small lakes assessed appears to be between 12 –to- 15 years.

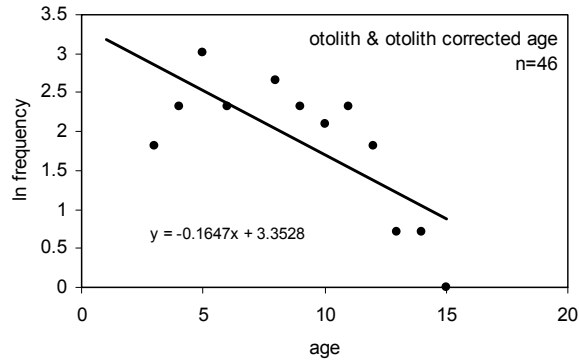


Figure 18: Plot of natural log otolith and otolith corrected age frequency, linear regression line and equation for burbot captured in cod traps for all lakes sampled, spring 2004.

3.4 Individual Lake Results

Catch results for individual lakes were generally insufficient to assess the basic life history parameters of asymptotic length, annual growth and mortality. Maxan Lake was the only lake to provide a sample size suitable for description of the lakes population. Detailed analysis for each lakes population is presented in Appendix 1.

Burbot abundance estimates using Spence's (2000) data to formulate a hoop trap conversion, provided a wide range of densities per lake (Table 3). A higher level of effort would most likely decrease the amount of uncertainty surrounding the predicted abundance levels.

Table 3: Summary of burbot catch-per unit effort for cod traps (cod CUE), converted cod-to-hoop trap CUE, burbot density per ha, burbot abundance estimate and standard error.

Lake	Area (ha)	BB _{cod} CUE	BB _{cod→hoop} CUE	predicted BB/ha	predicted BB abundance	± SE BB Abundance
Maxan	638.0	2.4	1.0	2.8	1788.5	287.0
Doris	104.0	0.4	0.2	0.5	55.9	5.1
Owen	296.0	0.3	0.1	0.4	122.1	9.8
McBride	778.0	1.1	0.4	1.4	1062.9	137.7

4.1 Conclusions & Recommendations

4.1 Burbot/Cod Trapping Methodology

The use of cod traps for capturing burbot was not evaluated in this report; however, their ease of deployment and lack of direct burbot mortalities due to handling was evident. Cod traps did catch burbot as small as 250 mm, indicating their effectiveness at assessing adult populations.

4.1.1 Sampling Intensity and site selection

The deployment of 10 traps for a single 48 hour soak did not provide adequate sample size for the majority of the lakes sampled. Assuming 30 or more burbot are necessary for describing a lakes population, and applying the observed mean catch rate of 1.05 burbot per set, 25-30 trap sets would be the minimum effort requirement. Burbot capture results in this pilot study were inconclusive in determining if the site selection guidelines or trap soak times used in this study introduced significant bias. However, burbot length does not appear to be influenced by trap depth. Zero immediate mortality was observed for burbot captured in cod traps. However, a small 250 mm burbot was sampled following regurgitation from a larger burbot and may indicate an issue exists with in-trap cannibalism. Therefore, relying on the capture of burbot less than 400 mm for a sampling program requires some caution or further evaluation. Changes to the site selection methodology are not recommended until the within and among lake sample size can be increased.

4.1.2 Future Studies

The catch and effort data provided by Spence (2000) to generate the cod trap –to- hoop trap conversion is based on the capture of less than 20 burbot and therefore lacks rigour. Furthermore, the generation of density estimates applying methods similar to those used by Bernard et al. (1993) require catchability coefficients for the gear used, which does not exist for cod traps. Future studies that compare the efficiency rate of cod traps versus hoop traps and improve on the Spence (2000) data set will be beneficial towards confirming the use cod traps as an efficient burbot capture technique. A mark-recapture experiment for an accessible small lake population of burbot, similar to studies completed by the Alaskans (Bernard et al. 1993, Lafferty et al. 1992; Burr 1994; Taube and Bernard 2002) will assist in generating catchability coefficient for cod traps. By deploying both hoop and cod trap gear types, the confidence of the mark-recapture estimate will be increased, as well as, developing a data set from which a cod –to- hoop trap conversion can be determined. Generation of density estimates for burbot in small lakes will be useful in converting cod trap CUE to abundance estimates and application in a Region wide population monitoring program.

Burbot biological reference points from which to compare burbot life history parameters and abundance estimates are also necessary. This would require a large commitment of funding from the Province or an outside funding body, and most likely academic or Ministry of Environment, Research Section involvement.

4.2 Burbot Exploitation and Life History

Early attempts to manage and monitor burbot effort and harvest in Skeena Region relied on a permit process requiring voluntary angler participation. The number of set-line permits issued remained relatively stable between 1980-84, whereas permit information returns gradually declined and dropped dramatically over the final two years for recorded information. The permit process was discontinued in 1984. The collected information revealed that the number of permits issued were similar for the larger lakes sampled in this report, but harvest was heavily biased towards Maxan Lake. It is not clear that Maxan Lake burbot harvest is a result of abundant burbot, a compliant angling community or, actual harvest. What is clear, is that attempts at long term angler reporting in Skeena Region was inconsistent, with periods of low reporting and eventual non-compliance. A lack of Ministry reporting on the results of data collected to user

groups may have contributed to the lack of compliance as the permittees would not see the value in submitting in the requested information.

From the permit return information, as many as 100 burbot were harvested from Maxan Lake in 1981. McBride (1971) Owen Lake (1977-78) were the only other waterbodies with a harvest of approximately 20 burbot. Without limit reference point information on sustainable yields for burbot populations, it unknown if these harvest levels are excessive. A monitoring program may assist in addressing the question of sustainable harvest by detecting changes in long-term CUE; however, it is likely that harvest levels observed were not excessive.

Burbot in Skeena Region small lakes appear to conform to growth descriptions provided by McPhail (1997), where burbot are described as growing rapidly prior to maturation, which occurs at age 4-7 for northern populations. Growth rates generally slow after maturation where maximum ages to 20-22 years are known, but 8-12 constitute the average age for adults (McPhail 1997). Referring to Figure 17, linear growth of the VonBertalanffy growth curve ends at approximately age 4-5. This suggests that a reduction of growth may be due to the onset of maturation. The mortality curve presented in Figure 17, also supports the notion of maturation initiating at age 5, as this is the point where catch abundances begin to decline.

4.3 Conservation Management Actions

Insufficient sample sizes and a subsequent lack of data preclude the submission of recommendations for management objectives or action on any of the lakes studied or lakes throughout the Region. Generation of biological reference points for burbot yield and abundance should be considered a priority for conservation and management of small lake populations.

Management objectives for burbot were primarily chosen for ease of measurement and remain extremely subjective until such a time that a greater sample of Regional populations can be gathered and analysed. Six categories for burbot management objectives were placed in the Skeena Region Burbot Assessment Reports (Appendix 1). 1) Asymptotic length ($L_{\infty} = 750$ mm); 2) instantaneous mortality ($Z = 0.50$); 3) large bodied/rapid growth category; 4) cod trap CUE ≥ 0.04 /hr; 5) 40% cod trap catch survival to 10 yrs; and 6) 80% catch survival to maturity. Refinement of the objectives is recommended following consultations with fisheries biologists, client groups and Ministry representatives.

5.-1 References

Ahrens, R. and J. Korman 2002. What happened to the West Arm burbot stock in Kootenay Lake? Use of an age-structured population model to determine the possible causes for recruitment failure. Unpublished manuscript prepared for: BC Min. of Water, Land and Air Protection, Nelson BC.

Anonymous. 2005. BC Freshwater Fishing Regulations Synopsis. BC Ministry of Environment, Victoria, BC.

Bernard, D.R., J.F. Parker and R. Lafferty, 1993. Stock Assessment of Burbot Populations in Small and Moderate-Size Lakes. NA Journal of Fisheries Management 13:657-675.

Burr, J.M. 1995. Lake trout studies in the AYK Region, and burbot index of abundance in Galbraith Lake, 1994. Fishery Data Series No. 95-30. Alaska Department of Fish and Game, Anchorage, Alaska.

Lafferty, J., J. Parker and D.R. Bernard. 1992. Stock Assessment and biological characteristics of burbot lakes of Interior Alaska during 1991. Fishery Data Series No. 92-20. Alaska Department of Fish and Game, Anchorage, Alaska.

McPhail, J.D. 1997. A review of burbot (*Lota lota*) life history and habitat use in relation to compensation and improvement opportunities. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2397. Dept. of Fisheries and Oceans, Vancouver, BC.

Neufeld, M. and C. Spence, 2001. A simple decompression procedure to reduce gas bubble trauma in trap caught burbot. Unpublished manuscript prepared

Paragamian, V., V. Whitman, J. Hammond and H. Andrusak, 2000. Collapse of burbot fisheries in the Kootenai River, Idaho, USA. pp. 155-164. In: Paragamian, V.L. and D. W. Wells, 2000. Burbot: Biology, Ecology and Management. Publication Number 1, Fisheries Management Section of the American Fisheries Society.

Ricker, W.E. 1958. Handbook of computations for biological statistics of fish populations. Fisheries Research Board of Canada Bulletin No. 119.

Spence, C. 2000. A comparison of catch success between two styles of burbot traps in lakes. pp. 165-170. In: Paragamian, V.L. and D.W. Willis. 2000. Burbot. Biology, Ecology, and Management. Publication Number 1. Fisheries Management Section of the American Fisheries Society

Taube, T.T. and D.R. Bernard. 2001. Stock Assessment and biological characteristics of burbot in Tolsona Lake, 2000. Fishery Data Series No. 01-26. Alaska Department of Fish and Game, Anchorage, Alaska.

Zar, J.H. 1996. Biostatistical Analysis. Prentice-Hall Publishers, New Jersey, USA. 3rd Edition.

Appendix 1: Individual Lake Summary Analysis Reports

Doris Lake

SKEENA REGION BURBOT ASSESSMENT REPORT

LAKE NAME: DORIS **ALIAS:** **BC WBID:** 00722BABL

LAKE LOCATION: Nearest town: SMITHERS Drainage: SKEENA

LAKE USE: Rec. sites: 1 Cabins:
 Native Netting: no Lodge:
 yes
 unknown

POPULATION MANAGEMENT GOAL:
Maintain fishery/natural population

POPULATION MANAGEMENT OBJECTIVES:

1. $L_{\infty} \geq 750$	4. CUE $\geq 0.04/\text{hr}$
2. $Z \leq .5$	5. 40% catch survival to 10 yrs
3. Large: Rapid growth category	6. 80% catch survival to maturity

MANAGEMENT/SURVEY HISTORY:
 Previous survey(s): no yes reconn. 1970's
 Previous burbot assessment(s): no yes

SURVEY METHODS:

Method	Date (yy.mm.dd)	Area (ha)	Crew	
Fish	cod traps	2004-06-14	104	Giroux, P. Atagi, D. Beere, M. Lough, J.

Trap Specs:
 # Sets: 11 Total Effort (hrs): 443:10:00
 Mean Effort (hrs): 44:19:00

trap mesh: trap mean depth (m): 09/01/1900

Burbot Abundance, Survival & Mortality Analysis

Total Catch: 4
 CUE: 0.4 BB/set 0.01 BB/hr
 Survival to Maturity: n/a
 % Catch Survival to age 10 years: 100

Mortality Estimates:

Z' (p-250mm)	Z (Ricker)	M	F	A250	L_{∞} (mm)	k'
0.98	0.02	0.32	0.66	2.10	502	0.69

Z = Beverton-Holt

Burbot Growth Analysis

Growth:Size Slow:Small Rapid:Small
 Slow:Large Rapid:Large

SURVEY CONCLUSIONS:

	Goal/Objectives Achieved		Reason
	Yes	No	
Natural Population	<input type="checkbox"/>	<input checked="" type="checkbox"/>	insufficient sample to determine pop'n status
$L_{\infty} \geq 750$	<input type="checkbox"/>	<input checked="" type="checkbox"/>	-
$Z \leq .5$	<input type="checkbox"/>	<input checked="" type="checkbox"/>	-
Large: Rapid growth category	<input type="checkbox"/>	<input checked="" type="checkbox"/>	-
CUE $\geq 0.04/\text{hr}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>	-
40% catch survival to 10 yrs	<input type="checkbox"/>	<input checked="" type="checkbox"/>	-
80% catch survival to maturity	<input type="checkbox"/>	<input type="checkbox"/>	not measured

RECOMMENDATIONS:

Assessment: Re-assess for BB ASAP w/ greater amount of trap effort
 integrate BB with LT weekend and holiday creel survey to estimate yield (1 priority)

Other: defer regulation changes following completion of Regional BB pop'n status review

COMMENTS:

Uncertainties: sample size inadequate to generate accurate β using Walford method
 small sample size negatively effects mortality estimate calculations
 small sample size bias' survival estimate

Reported by: P.A. Giroux
 Date: 21-Feb-05

Acknowledgements:

This project was funded by the Habitat Conservation Trust Fund and developed by personnel of the Ministry of Water Land and Air Protection. The Habitat Conservation Trust Fund was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia.

Anglers, hunters, trappers and guides contribute to the projects of the Trust Fund through license surcharges. Tax deductible donations to assist in the work of the Trust Fund are also welcomed.



Survival:

LAKE NAME: Doris SAMPLE DATE: 2004 6 2
 YY MM DD

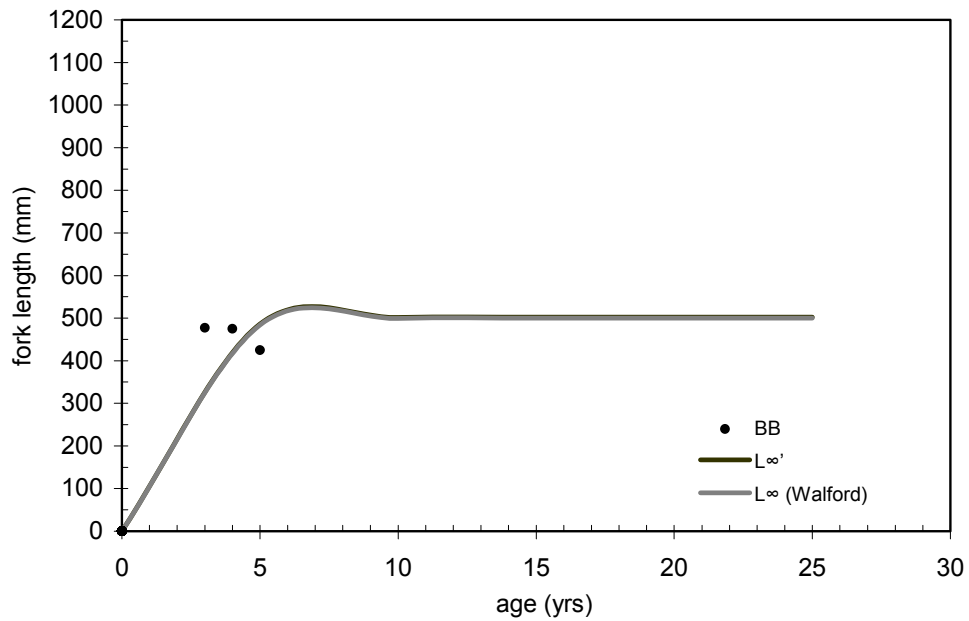
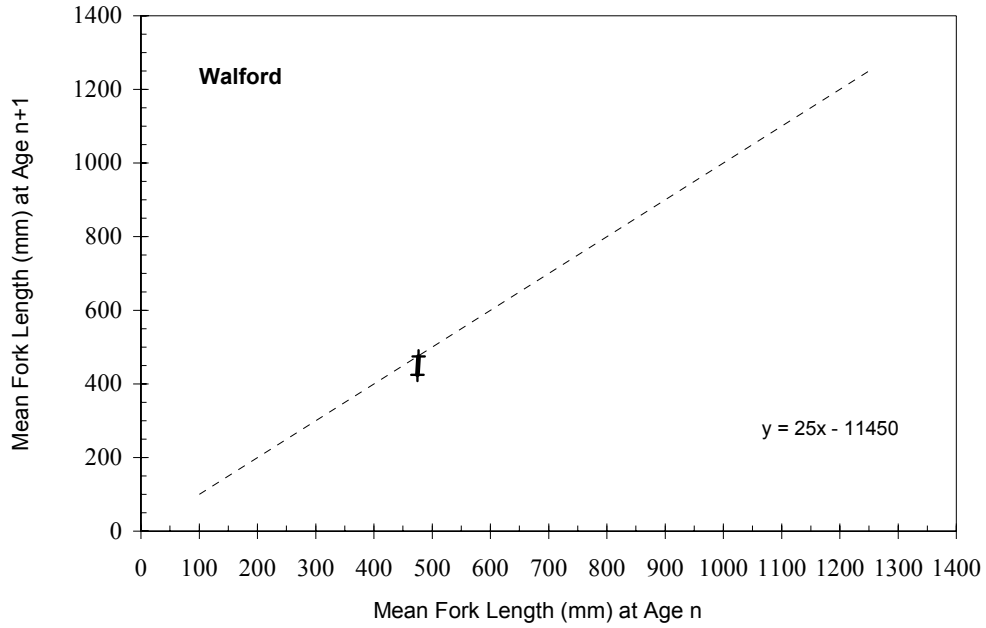
Age	N	(%)	Cumulative		Mean Fork Length (mm)
			N	%	
1	0	0.0	0	0	#DIV/0!
2	1	33.3	1	33	477
3	1	33.3	2	67	475
4	1	33.3	3	100	425
5	0	0.0	3	100	#DIV/0!
6	0	0.0	3	100	#DIV/0!
7	0	0.0	3	100	#DIV/0!
8	0	0.0	3	100	#DIV/0!
9	0	0.0	3	100	#DIV/0!
10	0	0.0	3	100	#DIV/0!
11	0	0.0	3	100	#DIV/0!
12	0	0.0	3	100	#DIV/0!
13	0	0.0	3	100	#DIV/0!
14	0	0.0	3	100	#DIV/0!
15	0	0.0	3	100	#DIV/0!
16	0	0.0	3	100	#DIV/0!
17	0	0.0	3	100	#DIV/0!
18	0	0.0	3	100	#DIV/0!
19	0	0.0	3	100	#DIV/0!
20	0	0.0	3	100	#DIV/0!
21	0	0.0	3	100	#DIV/0!
22	0	0.0	3	100	#DIV/0!
23	0	0.0	3	100	#DIV/0!
24	0	0.0	3	100	#DIV/0!
25	0	0.0	3	100	#DIV/0!
26	0	0.0	3	100	#DIV/0!
27	0	0.0	3	100	#DIV/0!
28	0	0.0	3	100	#DIV/0!
29	0	0.0	3	100	#DIV/0!
30+	0	0.0	3	100	#DIV/0!
Total	3	100	3	100	

Objective: 40% SURVIVAL TO AGE 10 YRS

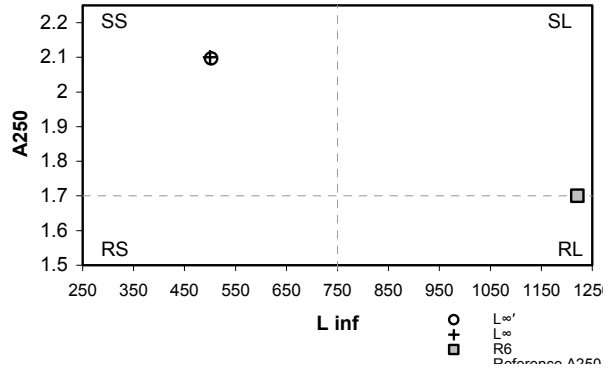
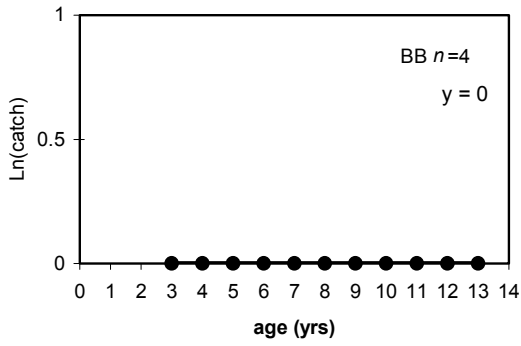
yes
 no

Von Bertalanffy Growth Parameters					
Lake	Age Class	β	k'	L_{∞} (mm)	L_{∞}' (mm)
Doris	BB 2 - 12 yrs	0.5	0.693147	500	502

*** $L_{\infty}' = .95 \times \text{longest BB}$



Mortality:

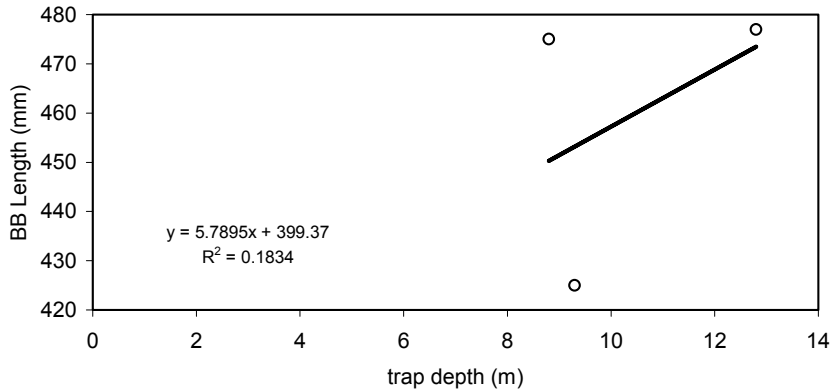


Mortality Summary Table

Doris	L_{∞}' (mm)	K'	Z	M	F	A250
Z' (>250)	502	0.69	0.98	0.32	0.66	2.10
Z' (smallest)	502	0.69	1.25	0.32	0.93	
Z Walford (>250)	500	0.69	0.97	0.32	0.97	2.10
Z Walford (smallest)	500	0.69	1.23	0.32	1.23	
Ricker			0.02	0.32	-0.30	

Trap Effort:

Lake	total trap soak (hrs)	mean trap soak/set (hrs)	total BB trap catch	BB CUE (catch/hr)	BB CUE (catch/set)	Mean Trap Depth (m)	SE	Mean BB Length (mm)	SE
Doris	443:10:00	44:19:00	4	0.01	0.4	7.57	1.214	428	33.25



Raw Data:

	Length (mm)	Weight (g)	Age	Structure	OT Corrected Age	Entered Age	Sex	Maturity	Capture
Lake	335	280							Cod trap
Doris	425	640	4	FR	5	5			Cod trap
	475	775	3	FR	4	4			Cod trap
	477	750	2	FR	3	3			Cod trap
Area (ha)									
104									

Date Sampled
14/06/2004

Maxan Lake

SKEENA REGION BURBOT ASSESSMENT REPORT

LAKE NAME: MAXAN ALIAS: BC WBID: 00722BULK

LAKE LOCATION: Nearest town: BURNS LAKE Drainage: SKEENA

LAKE USE: Rec. sites: 1 Cabins:
Native Netting: no Lodge:
yes
unknown

POPULATION MANAGEMENT GOAL:
Maintain fishery/natural population

POPULATION MANAGEMENT OBJECTIVES:
1. $L_{\infty} \geq 750$ 4. CUE $\geq 0.04/hr$
2. $Z \leq .5$ 5. 40% catch survival to 10 yrs
3. Large growth category 6. 80% catch survival to maturity

MANAGEMENT/SURVEY HISTORY:
Previous survey(s): no yes recon. 1970's
Previous burbot assessment(s): no yes

SURVEY METHODS:

Method	Date (yy.mm.dd)	Area (ha)	Crew	
Fish	cod traps	2004-05-13	0	Giroux, P. Smith, T. Beere, M. Guillon, F.
Trap Specs:				
# Sets:	10	Total Effort (hrs):	374:22:00	
		Mean Effort (hrs):	37:26:12	
trap mesh:		trap mean depth (m):	9.9	

Burbot Abundance, Survival & Mortality Analysis

Total Catch: 34
CUE: 2.4 BB/set 0.06 BB/hr
Survival to Maturity: n/a
% Catch Survival to age 10 years: 79

Mortality Estimates:

Z' ($>250mm$)	Z (Ricker)	M	F	A250	L_{∞} (mm)	K'
3.22	0.03	0.54	2.68	1.81	816	1.87

Z' = Beverton-Holt

Burbot Growth Analysis

Growth: Size Slow: Small Rapid: Small
Slow: Large Rapid: Large

SURVEY CONCLUSIONS:

Goal	Goal/Objectives Achieved		Reason
	Yes	No	
1. Natural Population	<input checked="" type="checkbox"/>	<input type="checkbox"/>	↓ LT population ???, ↑ abundance of non-sport species forage?
Objectives			
$L_{\infty} \geq 750$	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
$Z \leq .5$	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Large growth category	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
CUE $\geq 0.04/hr$	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
40% catch survival to 10 yrs	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
80% catch survival to maturity	<input type="checkbox"/>	<input type="checkbox"/>	not measured

RECOMMENDATIONS:

Assessment: Re-assess BB w/ 5 yrs
integrate BB with LT weekend and holiday creel survey to estimate yield (↓ priority)

Other: defer regulation changes following completion of Regional BB pop'n status review
possible candidate for mark-recapture experiment to evaluate trap effectiveness

COMMENTS:

Uncertainties: need to refine BB reference for growth parameters (i.e. SL, SS, LR, LS)

Reported by: P.A. Giroux
Date: 21-Feb-05

Acknowledgements:

This project was funded by the Habitat Conservation Trust Fund and developed by personnel of the Ministry of Water Land and Air Protection. The Habitat Conservation Trust Fund was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia.

Anglers, hunters, trappers and guides contribute to the projects of the Trust Fund through license surcharges. Tax deductible donations to assist in the work of the Trust Fund are also welcomed.



Survival:

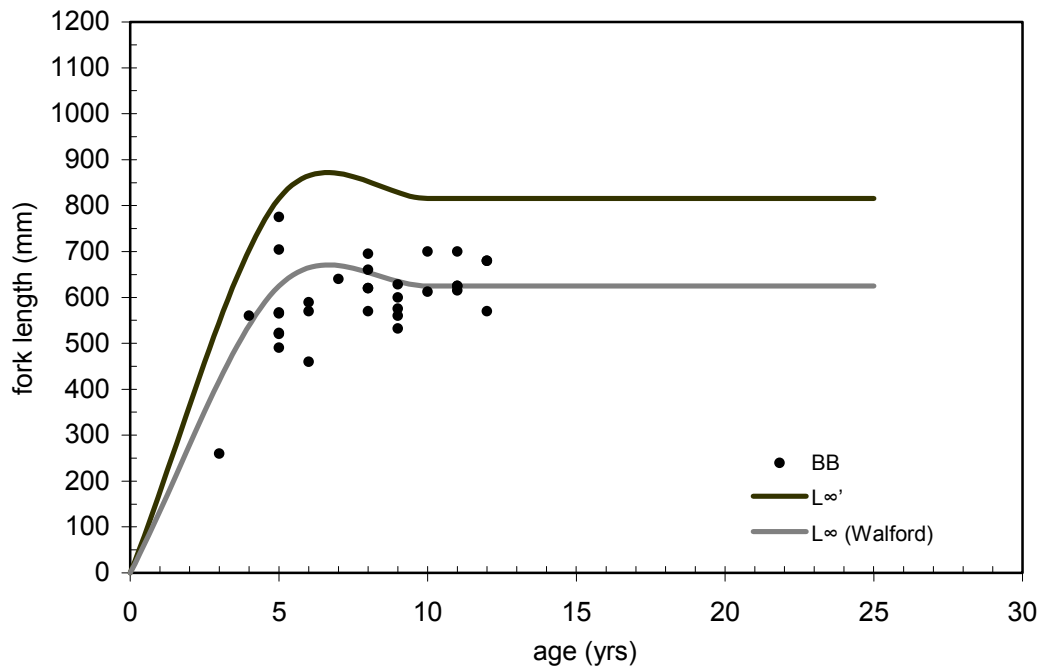
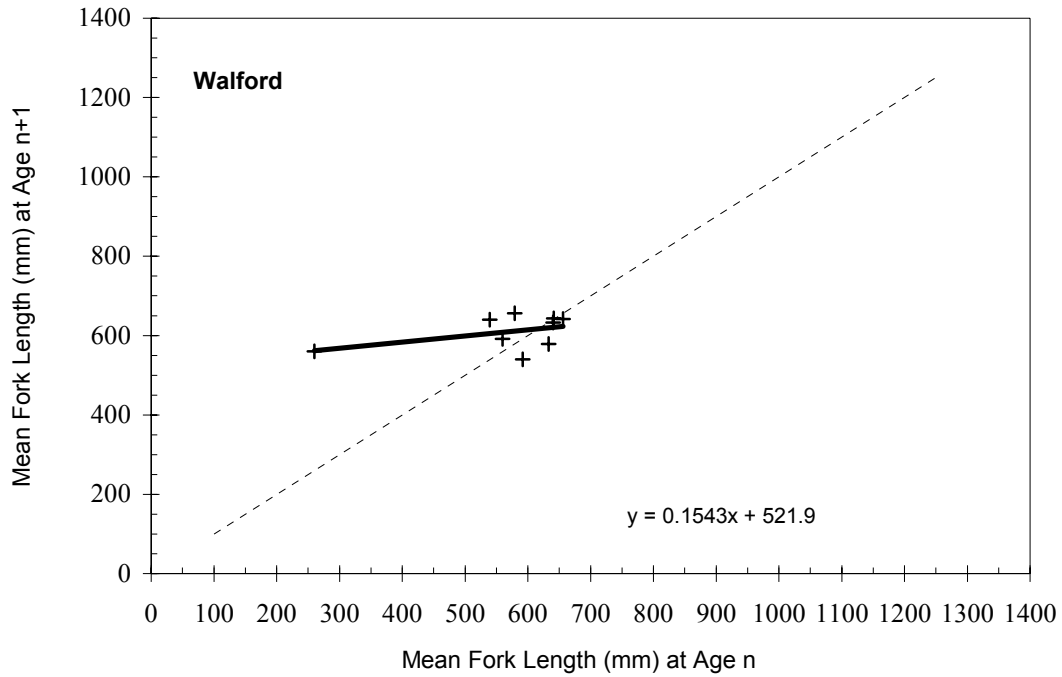
LAKE NAME: Maxan SAMPLE DATE: 2004 6 2
 YY MM DD

Age	N	(%)	Cumulative		Mean Fork Length (mm)
			N	%	
1	0	0.0	0	0	#DIV/0!
2	0	0.0	0	0	170
3	2	5.9	2	6	560
4	1	2.9	3	9	604
5	7	20.6	10	29	535
6	3	8.8	13	38	658
7	1	2.9	14	41	579
8	5	14.7	19	56	628
9	5	14.7	24	71	622
10	3	8.8	27	79	605
11	4	11.8	31	91	700
12	3	8.8	34	100	#DIV/0!
13	0	0.0	34	100	#DIV/0!
14	0	0.0	34	100	#DIV/0!
15	0	0.0	34	100	#DIV/0!
16	0	0.0	34	100	#DIV/0!
17	0	0.0	34	100	#DIV/0!
18	0	0.0	34	100	#DIV/0!
19	0	0.0	34	100	#DIV/0!
20	0	0.0	34	100	#DIV/0!
21	0	0.0	34	100	#DIV/0!
22	0	0.0	34	100	#DIV/0!
23	0	0.0	34	100	#DIV/0!
24	0	0.0	34	100	#DIV/0!
25	0	0.0	34	100	#DIV/0!
26	0	0.0	34	100	#DIV/0!
27	0	0.0	34	100	#DIV/0!
28	0	0.0	34	100	#DIV/0!
29	0	0.0	34	100	#DIV/0!
30+	0	0.0	34	100	#DIV/0!
Total	34	100	34	100	

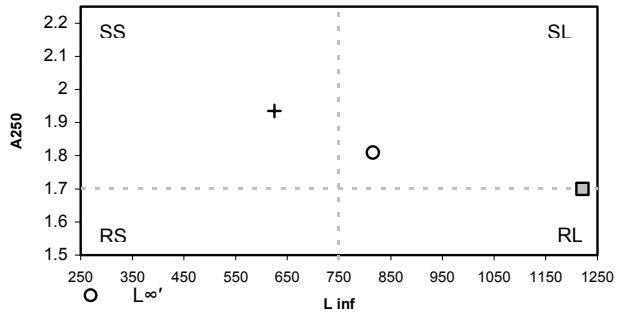
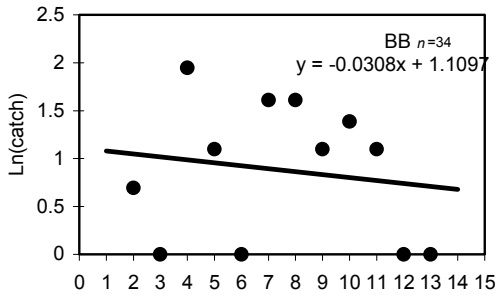
Objective: 40% SURVIVAL TO AGE 10 YRS

yes
 no

Lake	Von Bertalanffy Growth Parameters				
Maxan	Age Class	β	k	L_{∞} (mm)	L_{∞}' (mm)
	BB 2 - 12yrs	0.1543	1.868857	625	816
*** $L_{\infty}' = .95 \times \text{longest BB}$					



Mortality:

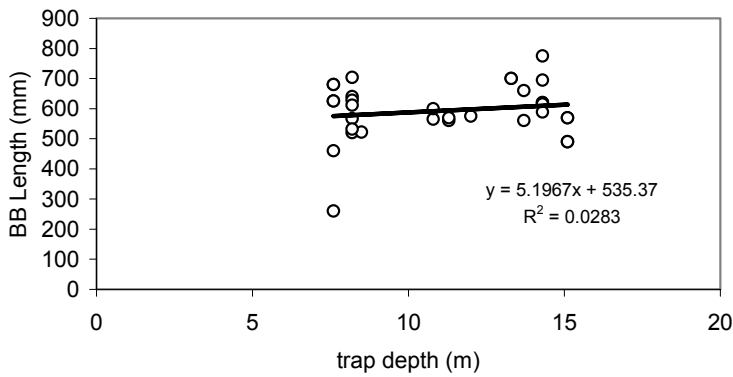


Mortality Summary Table

Maxan	L_{∞}' (mm)	K'	Z	M	F	A250
$Z' (>250)$	816	1.87	3.22	0.54	2.68	1.81
$Z' (\text{smallest})$	816	1.87	2.76	0.54	2.22	
Z Walford (>250)	625	1.87	2.14	0.54	2.14	1.93
Z Walford (smallest)	625	1.87	2.04	0.54	2.04	
Ricker			0.03	0.54	-0.51	

Trap Effort:

Lake	total trap soak (hrs)	mean trap soak/set (hrs)	BB trap catch	BB CUE (catch/hr)	BB CUE (catch/set)	Mean Trap Depth (m)	SE	Mean BB Length (mm)	SE
Maxan	374:22:00	37:26:12	24	0.06	2.4	11.20	0.785	593.3	16.15



Conclusion: no apparent site depth : BB length bias

Maxan Lake Raw Data:

	Length (mm)	Weight (g)	Age	Structure	OT		Sex	Maturity	Capture
					Corrected Age	Corrected Age Values			
Maxan	80			2 FR	3	3			CT
	260	80		2 FR	3	3			CT
	460	580		5 FR	6	6			CT
	490	650		10 OT	10	10			CT
	490	650		4 FR	5	5			CT
	520	780		5 FR	6	5			CT
	522	830		4 FR	5	5			CT
	532	750		7 FR	9	9			CT
	560	1180		7 FR	9	9			CT
	560	970		3 FR	4	4			CT
	565	950		4 FR	5	5			CT
	567	900		4 FR	5	5			CT
	570	700		8 OT	8	8			CT
	570	700		5 FR	6	6			CT
	570	1300		10 FR	12	12			CT
	575	1150		7 FR	9	9			CT
	589	1150		5 FR	6	6			CT
	600	1050		7 FR	9	9			CT
	612	1000		8 FR	10	10			CT
	615	1400		9 FR	11	11			CT
	620	1680		8 OT	8	8			CT
	620	1680		6 FR	8	8			CT
	625	1430		9 FR	11	11			CT
	625	1430		9 FR	11	11			CT
	628	1500		7 FR	9	9			CT
	640	1900		8 FR	7	7			CT
	660	2030		6 FR	8	8			CT
	680	1680		10 FR	12	12			CT
	680	1680		10 FR	12	12			CT
	695	2100		6 FR	8	8			CT
	700	2380		11 OT	11	11			CT
	700	2380		8 FR	10	10			CT
	704	2875		4 FR	5	5			CT
	775	2950		4 FR	5	5			CT

McBride Lake:

SKEENA REGION BURBOT ASSESSMENT REPORT

LAKE NAME: McBRIDE ALIAS: _____ BC WBID: 01380MORR

LAKE LOCATION: Nearest town: HOUSTON Drainage: SKEENA

LAKE USE: Rec. sites: 2 Cabins: 1
Native Netting: no Lodge:
yes
unknown

POPULATION MANAGEMENT GOAL:
Maintain fishery/natural population

POPULATION MANAGEMENT OBJECTIVES:
1. $L_{\infty} \geq 750$ 4. CUE $\geq 0.04/\text{hr}$
2. $Z \leq .5$ 5. 40% catch survival to 10 yrs
3. Large: Rapid growth category 6. 80% catch survival to maturity

MANAGEMENT/SURVEY HISTORY:
Previous survey(s): no yes recon. 1970's
Previous burbot assessment(s): no yes

SURVEY METHODS:
Method Date (yy.mm.dd) Area (ha) Crew
BB Sampling: cod traps 2004-05-26 778.6 Giroux, P.
Diemert, K.
Beere, M.
Johnston, T.
Trap Specs:
Sets: 10 Total Effort (hrs): 424:08:00
Mean Effort (hrs): 42:24:48
trap mesh: trap mean depth (m): 7.14

Burbot Abundance, Survival & Mortality Analysis

Total BB Catch: 11
BB CUE: 1.1 /trap set 0.03 /trap hr
Survival to Maturity: n/a
% Catch Survival to age 10 years: 70

Mortality Estimates:

Z' ($>250\text{mm}$)	Z (Ricker)	M	F	A250	L_{∞}' (mm)	k'
0.60	0.09	0.17	0.43	1.85	732	0.29

Z' = Beverton-Holt

Burbot Growth Analysis

Growth: Size Slow: Small Rapid: Small
Slow: Large Rapid: Large

SURVEY CONCLUSIONS:

Goal	Objectives Achieved		Reason
	Yes	No	
Maintain Fishery & Natural Population	<input type="checkbox"/>	<input checked="" type="checkbox"/>	insufficient sample size to assess pop'n

Objectives

$L_{\infty} \geq 750$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
$Z \leq .5$	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Large: Rapid growth category	<input type="checkbox"/>	<input type="checkbox"/>
CUE $\geq 0.04/\text{hr}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
40% catch survival to 10 yrs	<input type="checkbox"/>	<input checked="" type="checkbox"/>
80% catch survival to maturity	<input type="checkbox"/>	<input type="checkbox"/>

RECOMMENDATIONS:

Assessment: Re-assess for BB ASAP w/ greater amount of trap effort
integrate BB with LT weekend and holiday creel survey to estimate yield (↓ priority)
Other: defer regulation changes following completion of Regional BB pop'n status review

COMMENTS:

Uncertainties: sample size inadequate to generate accurate β using Walford method
? β directly effects mortality estimate calculations
high uncertainty on Objectives conclusions

Reported by: P. A. Giroux
Date: 21-Feb-05

Acknowledgements:

This project was funded by the Habitat Conservation Trust Fund and developed by personnel of the Ministry of Water Land and Air Protection. The Habitat Conservation Trust Fund was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia.

Anglers, hunters, trappers and guides contribute to the projects of the Trust Fund through license surcharges. Tax deductible donations to assist in the work of the Trust Fund are also welcomed.



Survival:

LAKE NAME: McBride

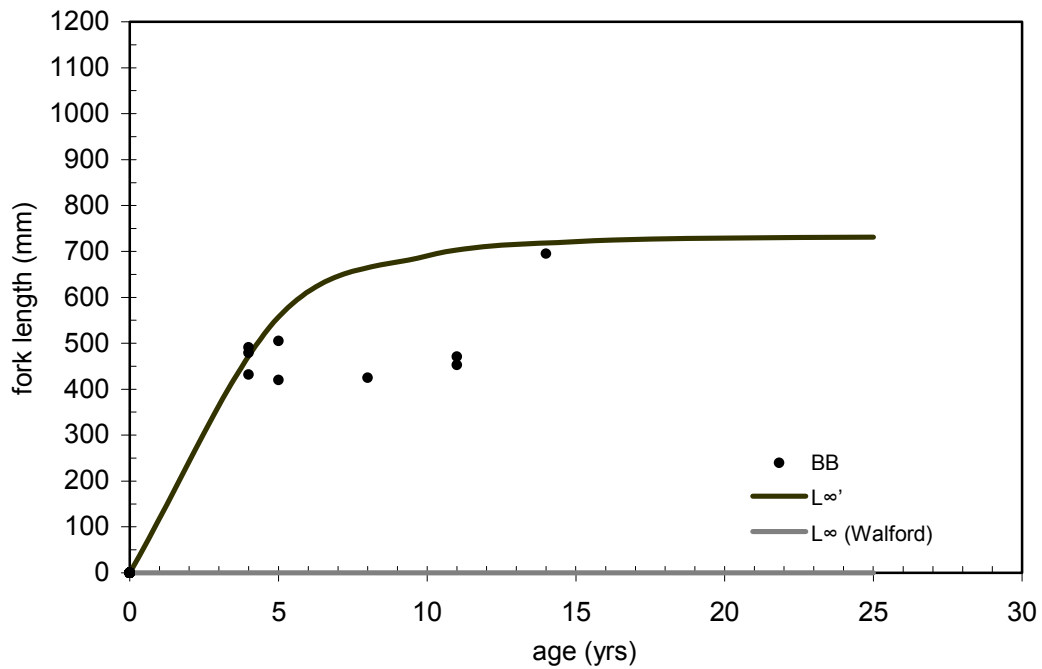
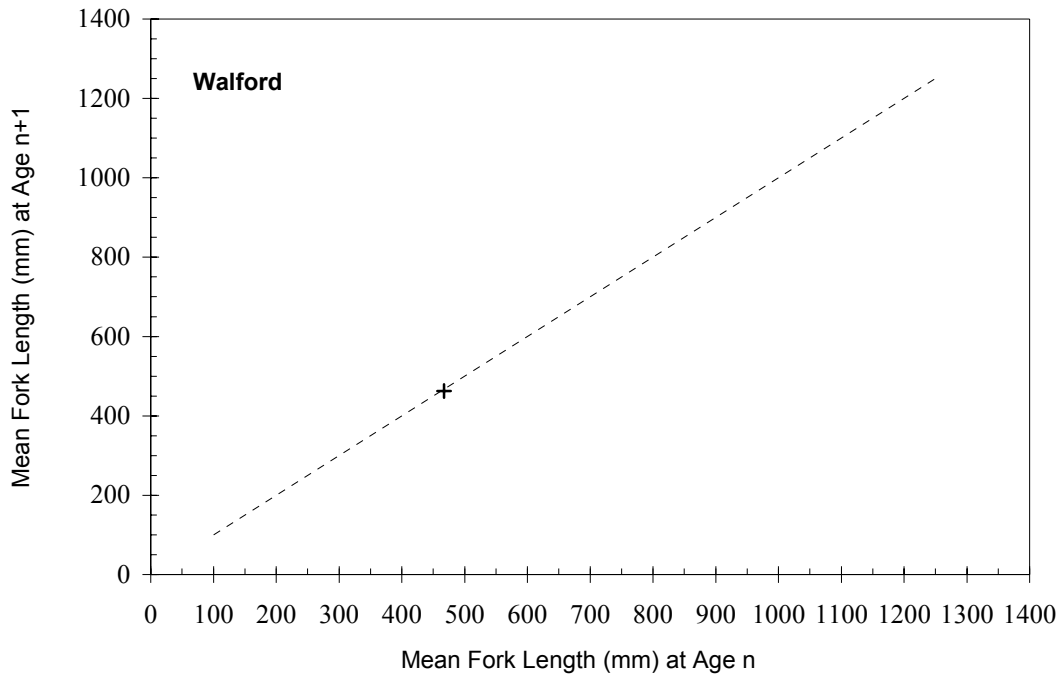
SAMPLE DATE: 2004 6 2
 YY MM DD

Age	N	(%)	Cumulative		Mean Fork Length (mm)
			N	%	
1	0	0.0	0	0	#DIV/0!
2	0	0.0	0	0	#DIV/0!
3	0	0.0	0	0	467
4	4	40.0	4	40	463
5	2	20.0	6	60	#DIV/0!
6	0	0.0	6	60	425
7	0	0.0	6	60	#DIV/0!
8	1	10.0	7	70	#DIV/0!
9	0	0.0	7	70	462
10	0	0.0	7	70	#DIV/0!
11	2	20.0	9	90	#DIV/0!
12	0	0.0	9	90	695
13	0	0.0	9	90	#DIV/0!
14	1	10.0	10	100	#DIV/0!
15	0	0.0	10	100	#DIV/0!
16	0	0.0	10	100	#DIV/0!
17	0	0.0	10	100	#DIV/0!
18	0	0.0	10	100	#DIV/0!
19	0	0.0	10	100	#DIV/0!
20	0	0.0	10	100	#DIV/0!
21	0	0.0	10	100	#DIV/0!
22	0	0.0	10	100	#DIV/0!
23	0	0.0	10	100	#DIV/0!
24	0	0.0	10	100	#DIV/0!
25	0	0.0	10	100	#DIV/0!
26	0	0.0	10	100	#DIV/0!
27	0	0.0	10	100	#DIV/0!
28	0	0.0	10	100	#DIV/0!
29	0	0.0	10	100	#DIV/0!
30+	0	0.0	10	100	#DIV/0!
Total	10	100	10	100	

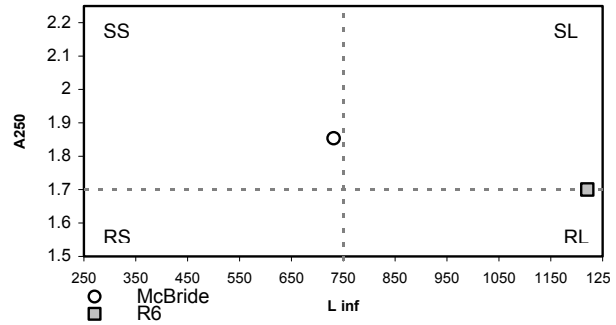
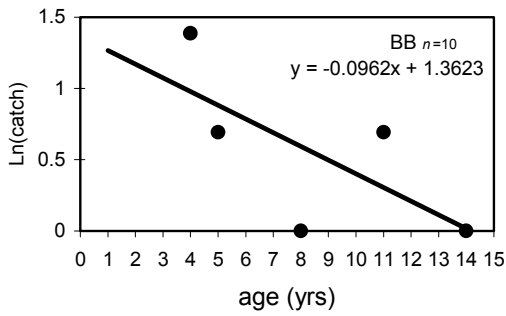
Objective: 40% SURVIVAL TO AGE 10 YRS

yes
 no

Lake	Von Bertalanffy Growth Parameters				
McBride	Age Class	β	k'	L_{∞} (mm)	L_{∞}' (mm)
	BB na	0.75	0.287682	0	732
*** $L_{\infty}' = .95 \times \text{longest BB}$					



Mortality:



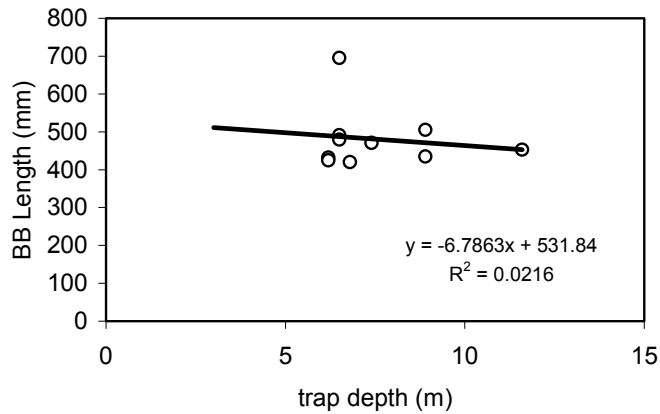
Mortality Summary Table

McBride	L_{∞}' (mm)	K'	Z	M	F	A250
$Z' (>250)$	732	0.29	0.60	0.17	0.43	1.85
$Z' (\text{smallest})$	732	0.29	1.48	0.17	1.31	
Z Walford (>250)	0	0.29	-0.31	0.17	-0.31	
Z Walford (smallest)	0	0.29	-1.99	0.17	-1.99	
Ricker			0.09	0.17	-0.08	

Effort:

BB Trap Summary

total trap soak (hrs)	mean trap soak/set (hrs)	BB trap catch	BB trap catch/hr	BB CUE	Mean Trap Depth (m)	SE	Mean BB length (mm)	SE
424:08:00	42:24:48	11	0.03	1.1	7.14	0.684	480.6	25.54



McBride Lake Burbot Raw Data:

	Length (mm)	Weight (g)	Age	Structure	OT Corrected Age	Corrected Age Values	Sex	Maturity	Capture
Lake	420	380	4	FR	5	4			cod trap
McBride	425	410	6	FR	8	4			cod trap
	432	570	3	FR	4	4			cod trap
	435			OT	4	4			cod trap
Area (ha)	453	480	9	FR	11	4			cod trap
778.6	471	420	9	FR	11	5			cod trap
	479	500	3	FR	4	5			cod trap
	491	0	3	FR	4	6			cod trap
Date	505	570	4	FR	5	7			cod trap
26/05/2004	695	1375	12	FR	14	8			cod trap

Owen Lake

SKEENA REGION BURBOT ASSESSMENT REPORT

LAKE NAME: OWEN ALIAS: BC WBID: 01248MORR

LAKE LOCATION: Nearest town: HOUSTON Drainage: SKEENA

LAKE USE: Rec. sites: 1 Cabins: 2+
Native Netting: no Lodge: 1 (closed)
yes
unknown

POPULATION MANAGEMENT GOAL:
Maintain fishery/natural population

POPULATION MANAGEMENT OBJECTIVES:
1. $L_{\infty} \geq 750$ 4. CUE $\geq 0.04/\text{hr}$
2. $Z \leq .5$ 5. 40% catch survival to 10 yrs
3. Large: Rapid growth category 6. 80% catch survival to maturity

MANAGEMENT/SURVEY HISTORY:
Previous survey(s): no yes recon. 1970's
Previous burbot assessment(s): no yes

SURVEY METHODS:
Method Date (yy.mm.dd) Area (ha) Crew
Fish cod traps 2004-05-18 279.9 Giroux, P.
Fillier, D.
Beere, M.
Lough, J.

Trap Specs:
Sets: 11 Total Effort (hrs): 423:09:00
Mean Effort (hrs): 42:18:54
trap mesh: trap mean depth (m): 8.10000014

Burbot Abundance, Survival & Mortality Analysis

Total Catch: 3
CUE: 0.3 BB/set 0.01 BB/hr
Survival to Maturity: n/a
% Catch Survival to age 6 years: 67

Mortality Estimates:

Z' ($>250\text{mm}$)	Z (Ricker)	M	F	A400	L_{∞} (mm)	k'
0.28	0	0.15	0.13	1.76	943	0.24

Z' = Beverton-Holt

Burbot Growth Analysis

Growth:Size Slow:Small Rapid:Small
Slow:Large Rapid:Large

SURVEY CONCLUSIONS:

	Goal/Objectives Achieved		Reason
	Yes	No	
Natural Population	<input type="checkbox"/>	<input type="checkbox"/>	insufficient sample to determine pop'n status
$L_{\infty} \geq 750$	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
$Z \leq .5$	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Large: Rapid growth category	<input type="checkbox"/>	<input type="checkbox"/>	
CUE $\geq 0.04/\text{hr}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
40% catch survival to 10 yrs	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
80% catch survival to maturity	<input type="checkbox"/>	<input type="checkbox"/>	not measured

RECOMMENDATIONS:

Assessment: Re-assess for BB ASAP w/ greater amount of trap effort
integrate BB with LT weekend and holiday creel survey to estimate yield (1 priority)

Other: defer regulation changes following completion of Regional BB pop'n status review

COMMENTS:

Uncertainties: sample size inadequate to generate accurate β using Walford method
small sample size negatively effects mortality estimate calculations
steep sided/narrow basin shape makes unbiased spatial sampling difficult

Reported by: P.A. Giroux
Date: 21-Feb-05

Acknowledgements:

This project was funded by the Habitat Conservation Trust Fund and developed by personnel of the Ministry of Water Land and Air Protection. The Habitat Conservation Trust Fund was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia.

Anglers, hunters, trappers and guides contribute to the projects of the Trust Fund through license surcharges. Tax deductible donations to assist in the work of the Trust Fund are also welcomed.



Survival:

LAKE NAME: Owen

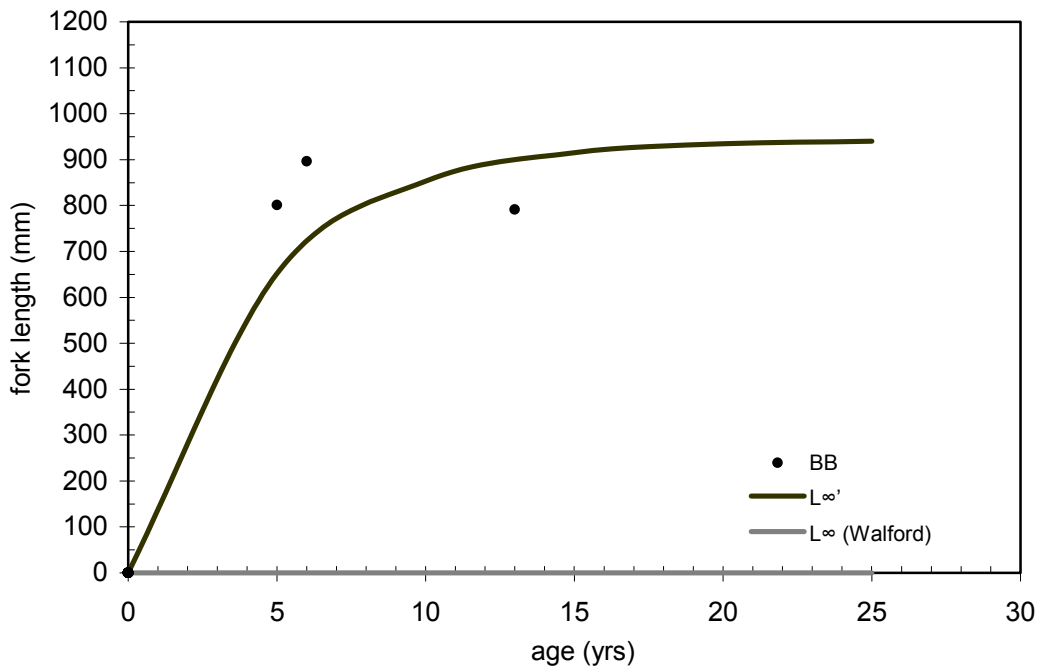
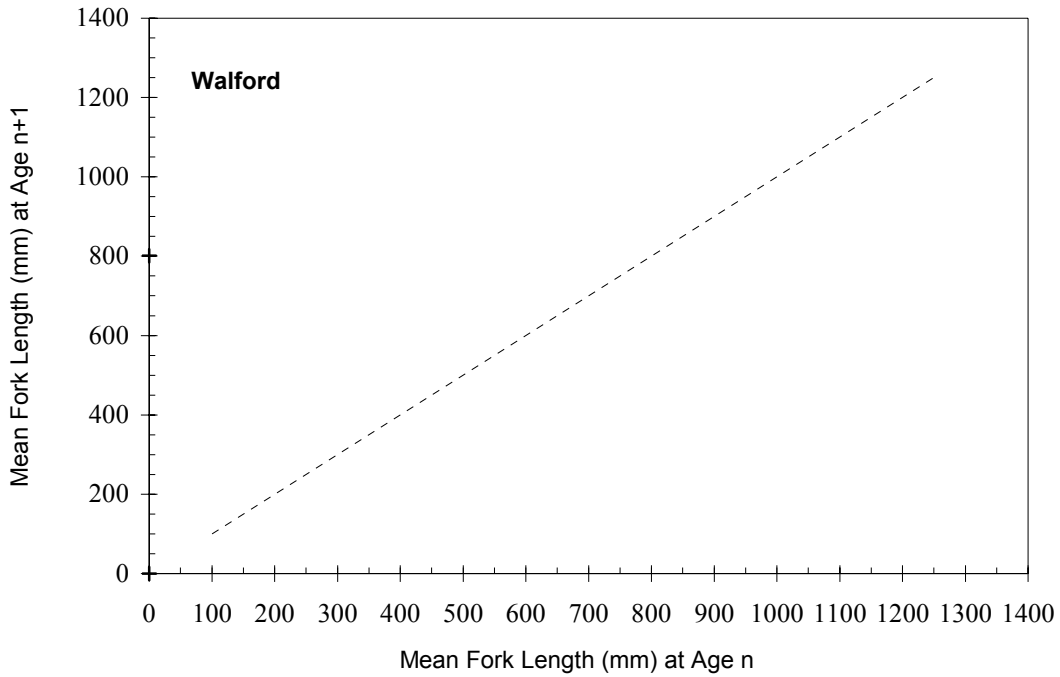
SAMPLE DATE: 18/05/2004

Age	N	(%)	Cumulative		Mean Fork Length (mm)
			N	%	
1	0	0.0	0	0	#DIV/0!
2	0	0.0	0	0	#DIV/0!
3	0	0.0	0	0	#DIV/0!
4	0	0.0	0	0	#DIV/0!
5	1	33.3	1	33	801
6	1	33.3	2	67	896
7	0	0.0	2	67	#DIV/0!
8	0	0.0	2	67	#DIV/0!
9	0	0.0	2	67	#DIV/0!
10	0	0.0	2	67	#DIV/0!
11	0	0.0	2	67	#DIV/0!
12	0	0.0	2	67	#DIV/0!
13	1	33.3	3	100	791
14	0	0.0	3	100	#DIV/0!
15	0	0.0	3	100	#DIV/0!
16	0	0.0	3	100	#DIV/0!
17	0	0.0	3	100	#DIV/0!
18	0	0.0	3	100	#DIV/0!
19	0	0.0	3	100	#DIV/0!
20	0	0.0	3	100	#DIV/0!
21	0	0.0	3	100	#DIV/0!
22	0	0.0	3	100	#DIV/0!
23	0	0.0	3	100	#DIV/0!
24	0	0.0	3	100	#DIV/0!
25	0	0.0	3	100	#DIV/0!
26	0	0.0	3	100	#DIV/0!
27	0	0.0	3	100	#DIV/0!
28	0	0.0	3	100	#DIV/0!
29	0	0.0	3	100	#DIV/0!
30+	0	0.0	3	100	#DIV/0!
Total	3	100	3	100	

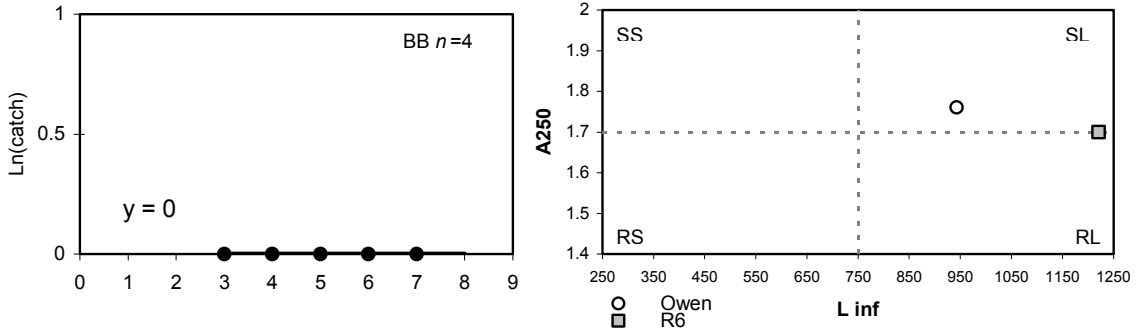
Objective: 40% SURVIVAL TO AGE 10 YRS

yes
no

Lake	Von Bertalanffy Growth Parameters				
Owen	Age Class	β'	k'	L_{∞} (mm)	L_{∞}' (mm)
	BB 5 - 13 yrs	0.79	0.235722	0	943
*** $L_{\infty}' = .95 \times$ longest BB, β' = estimated					



Mortality:

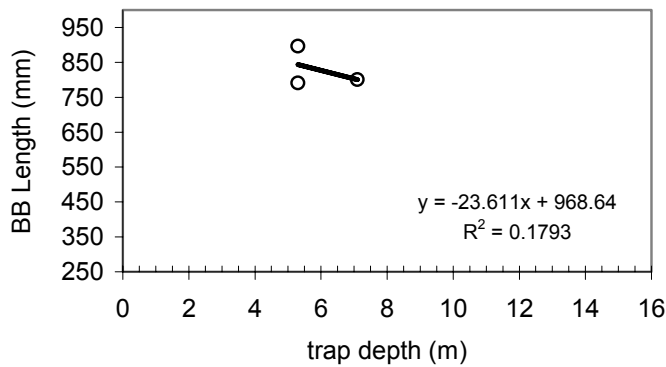


Mortality Summary Table

Owen	L_{∞}' (mm)	K'	Z	M	F	A250
$Z'_{(>250)}$	943	0.24	0.28	0.15	0.13	1.76
$Z'_{(smallest)}$	943	0.24	0.94	0.15	0.79	
Z Walford _(>250)	0	0.24	-0.10	0.15	-0.10	#DIV/0!
Z Walford _(smallest)	0	0.24	-4.86	0.15	-4.86	
Ricker			0	0.15	-0.15	

Trap Effort:

total trap soak (hrs)	mean trap soak/set (hrs)	total BB trap catch	BB trap catch/hr	BB CUE	Mean trap depth (m)	SE	Mean BB length (mm)	SE
423:09:00	42:18:54	3	0.01	0.3	8.10	0.0713	829.3	33.45



Raw Data:

	Length (mm)	Weight (g)	Age	Structure	Corrected Age	Corrected Age Values	Sex	Maturity	Capture
Lake	791	2900	11	FR	13	13			cod trap
Owen	801	2850	4	FR	5	5			cod trap
	896	4750	5	FR	6	6			cod trap

Area (ha)
279.9

Date Sampled
18/05/2004