



PEACE/WILLISTON
FISH & WILDLIFE
COMPENSATION
PROGRAM

BC Hydro 



Summary Report of Arctic grayling Management and Conservation 2009: A synopsis of the information available on Arctic grayling in the Omineca region of northern British Columbia and identification of additional information needs

Sarah Ballard and J. Mark Shrimpton
March 2009

The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

**Peace/Williston Fish and Wildlife Compensation Program, 1011 Fourth Ave.
3rd Floor, Prince George B.C. V2L 3H9**

Website: www.bchydro.com/pwcp/

**This report has been approved by the Peace/Williston Fish and Wildlife
Program Fish technical Committee.**

Citation: Ballard, S and J.M. Shrimpton. 2009. Summary Report of Arctic Grayling Management and Conservation 2009. A synopsis of the information available on Arctic grayling in the Omineca region of northern British Columbia and identification of additional information needs. Peace/Williston Fish and Wildlife Compensation Program Report No. 337. 66 pp plus appendices.

Author(s): Sarah Ballard and J. Mark Shrimpton
Address(es): Ecosystem Science and Management (Biology) Program, University of Northern British Columbia. 3333 University Way, Prince George, British Columbia V2N 4Z9.

Index

Table of Contents	i
List of Tables	ii
List of Figures	iv
Introduction	1
Analytical Approach	1
1.0 Life history characteristics	3
1.1 <i>Length and Weight</i>	3
1.2 <i>Length-Weight Regression</i>	9
1.3 <i>Length Frequency</i>	11
1.4 <i>Aging Techniques</i>	19
1.5 <i>Size at Age</i>	23
1.6 <i>Von Bertalanffy Growth</i>	24
1.7 <i>Sex Ratios</i>	26
2.0 Spawner surveys	30
2.1 <i>Maturity</i>	30
3.0 Population genetics	34
4.0 Abundance estimates	34
4.1 <i>Total Arctic grayling sampled</i>	36
4.2 <i>Interspecific Interactions</i>	36
5.0 Fluvial and adfluvial population comparisons	40
6.0 Catch per unit effort (CPUE)	44
7.0 Diet	44
8.0 Survival estimates	44
8.1 <i>Tagging Data</i>	44
9.0 Physical environment surveys- areas of importance for various life stages	45
9.1 <i>Temperature</i>	45
9.2 <i>Conductivity</i>	49
9.3 <i>pH</i>	55
9.4 <i>Dissolved Oxygen</i>	56
9.5 <i>Aquatic Plants</i>	57
9.6 <i>Gravel types</i>	57
10.0 Potential areas of habitat enhancement	57
11.0 Lipid analysis	58
Data Gaps	58
Acknowledgements	61
References	61
Appendices	67

List of Tables

Table 1. Code for the sample methods used to capture Arctic grayling in all management regions of BC	4
Table 2. Mean fork length and weight for Arctic grayling sampled in the streams of the Omineca region (7A)	4
Table 3. Mean fork length and weight for Arctic grayling sampled in the streams of the Peace region (7B)	6
Table 4. Mean fork length and weight for Arctic grayling sampled in the streams of the Skeena region (6)	8
Table 5. Statistics summary for length-weight regression on Arctic grayling caught in each region	9
Table 6. Statistical summary of ANOVA length-weight regression slope (b) comparisons between management regions	10
Table 7. Length-Weight regression for all streams sampled in each major watershed in the Omineca region	11
Table 8. Statistical summary of ANOVA length-weight regression slope (b) comparisons between major watersheds of the Omineca region	11
Table 9. Aging data available where two aging structures were used to determine the age of individual Arctic grayling in the Omineca region	20
Table 10. Summary of the parameters estimation in fitting the von Bertalanffy growth function to length-at-age data of Arctic grayling of different watersheds in the Omineca region	25
Table 11. Summary of maximum likelihood model comparisons	25
Table 12. Sex ratios and mean length of Arctic grayling sampled in the Omineca region	27
Table 13. Description of Resource Inventory Committee (RIC) standards for determining maturity of specimens	30
Table 14. Mean length of Arctic grayling at different stages of maturity the Omineca region	31
Table 15. Average size of Arctic grayling for each stage of maturity identified, sampled in all watersheds of the Omineca region	33
Table 16. Abundance estimates conducted in the Omineca Region	35
Table 17. Species sampled in Omineca region that occurred with areas where Arctic grayling were also captured	37
Table 18. Abundance of all species reported in streams where Arctic grayling were captured in the Omineca region	38
Table 19. Length-weight regression for Arctic grayling sampled in streams and lakes in each region	40
Table 20. Statistics summary of ANOVA comparison of length-weight regression slopes for Arctic grayling captured in streams and lakes systems in each region	41

Table 21. Sex ratios and mean length of Arctic grayling sampled in lakes in the Skeena region	42
Table 22. Abundance of all species sampled in lakes containing Arctic grayling in the Omineca region.	43
Table 23. Average surface water temperature of Arctic grayling sampling sites in the Omineca Region	46
Table 24. Mean length of Arctic grayling sampled in various water temperatures in the Omineca region	47
Table 25. Conductivity for streams where Arctic grayling were captured in the Omineca region	50
Table 26. Conductivity of streams where Arctic grayling were captured in the Skeena Region	51
Table 27. Conductivity of streams where Arctic grayling were capture in region the Peace Region	52
Table 28. pH data available for tributaries of the Omineca region (Bruce and Starr 1985)	56
Table 29. pH of lakes where Arctic grayling were captured for all regions	56

List of Figures

Figure 1. Length-weight relationship for Arctic grayling sampled from streams in A. Omineca region (7A) B. Peace region (7B) and C. Skeena region (6)	9
Figure 2. Log transformed length and weight of Arctic grayling from A. Omineca B. Peace C. Skeena regions, with best-fit line superimposed	9
Figure 3. Log transformed length and weight of Arctic grayling sampled in the major watersheds of the Omineca region, with best-fit line superimposed. A. Parsnip B. Omineca C. Nation D. Ingenika E. Finlay.	10
Figure 4. Length-frequency analysis for Arctic grayling sampled from the Omineca region. A. All sample methods B. Separated into individual sample method.	12
Figure 5. Length-frequency analysis for Arctic grayling sampled from the Peace region. A. All sample methods B. Separated into individual sample method	13
Figure 6. Length-frequency analysis for Arctic grayling sampled from the Skeena region. A. All sample methods B. Separated into individual sample method.	14
Figure 7. Length-frequency analysis for Arctic grayling sampled from the Parsnip watershed. A. All sample methods B. Separated into individual sample method.	15
Figure 8. Length-frequency analysis for Arctic grayling sampled from the Omineca watershed. A. All sample methods B. Separated into individual sample method.	16
Figure 9. Length-frequency analysis for Arctic grayling sampled from the Finlay watershed. A. All sample methods B. Separated into individual sample method.	17
Figure 10. Length-frequency analysis for Arctic grayling sampled from the Ingenika watershed. A. All sample methods B. Separated into individual sample method.	18
Figure 11. Length-frequency analysis for Arctic grayling sampled from the Nation watershed. A. All sample methods B. Separated into individual sample method	18
Figure 12. Comparison of age estimates using two different structures; otolith and scale samples collected from each individual and separately analyzed to determine age.	22
Figure 13. Comparison of age estimates using two different structures; finray and scale samples collected from each individual and separately analyzed to determine age.	22
Figure 14. Arctic grayling length at age analysis for each region. A. Omineca Region (n=1769) B. Peace region (n=877) C. Skeena region (n=31).	23
Figure 15. Arctic grayling length at age relationships for major watersheds in the Omineca Region. A. Parsnip B. Omineca C. Finlay D. Ingenika E. Nation F. Peace	24
Figure 16. Calculated growth rates, with error bars, of Arctic grayling sampled in the major watersheds of the Omineca region compared to growth rates of other Arctic grayling populations extracted from Fishbase. The inset shows data for other salmonids and other species extracted from Fishbase	26
Figure 17. Sex ratios for Arctic grayling in region 7A plotted against the number of fish in the capture sample. A. Major watersheds B. Sampling methods	29

Figure 18. Length frequency analysis of the Arctic grayling with sex reported in the Omineca region	29
Figure 19. Number of Arctic grayling of each stage for maturity sampled in various months	33
Figure 20. Spatial and temporal sampling of Arctic grayling in the Omineca region	36
Figure 21. Length-weight relationship for adfluvial Arctic grayling sampled from lakes in the A. Omineca region B. Peace region C. Skeena region. Data for fluvial Arctic grayling shown in gray for comparison	40
Figure 22. Length frequency analysis for adfluvial Arctic grayling sampled from lakes in the A. Omineca region B. Peace region C. Skeena region	41
Figure 23. Length at age for adfluvial Arctic grayling sampled from lakes in the A. Omineca region B. Peace region C. Skeena region. Data for fluvial Arctic grayling shown in gray for comparison.	42
Figure 24. FM sex ratios for lakes in Skeena region and streams in the Omineca region.	43
Figure 25. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded surface water temperatures for fish sampling projects conducted in the Omineca region. Vertical bars represent range at each temperature.	48
Figure 26. Number of observations when Arctic grayling were reported as being captured plotted against surface water temperature for the Skeena (R6), Omineca (R7A), and Peace (R7B) Regions.	48
Figure 27. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded water conductivity ($\mu\text{S}/\text{cm}$) for fish sampling projects conducted in the Omineca region.	50
Figure 28. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded water conductivity for fish sampling projects conducted in the Skeena region.	51
Figure 29. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded water conductivity ($\mu\text{S}/\text{cm}$) for fish sampling projects conducted in the Peace region.	54
Figure 30. Number of observations when Arctic grayling were captured plotted against water conductivity ($\mu\text{S}/\text{cm}$) for the Skeena (R6), Omineca (R7A), and Peace (R7B) Regions.	55

Introduction

Arctic grayling (*Thymallus arcticus*) are widely distributed in north-western Canada and Alaska. Within the province of British Columbia, they are found in the Skeena, Omineca and Peace Regions. Arctic grayling occur throughout the headwaters of the Peace River, an area where much of the river systems have now been impounded by the WAC Bennett Dam. Despite the wide geographical range of this species much is not known about the general biology and life history of this species. It has been suggested that Arctic grayling were once abundant in the upper Peace River, Finlay River and Parsnip River watersheds prior to construction of the WAC Bennett Dam and subsequent flooding of the reservoir (Withler 1959; Blackman 2001). Arctic grayling populations within the upper Peace are now much lower than historic estimates. As a result of the decline, this species has been classified by the Conservation Data Centre of British Columbia as G1QS1/critically imperilled within the Williston watershed. The objective of this report is to summarize and review data collected for Arctic grayling populations within British Columbia and indicate where more information is required to understand the ecology and biology of this species.

Analytical Approach

The information used in this analysis was obtained from two main sources:

1. An electronic MS Access (2003) database, the result of a data consolidation of historical and recent Arctic grayling data sources in British Columbia (1956-2003), provided by the Ministry of Environment (MOE);
2. 2. More recent data (2004-2007), obtained from the Peace Williston Fish and Wildlife Compensation Program (PFWWCP) in MS Excel 2003 format.

Data provided by the MOE consisted of 49 individual worksheets, which contained a combination of: lake or stream data, all species or Arctic grayling data only, a summary of all fish sampled in a study or individual fish data and limnological data for each region (not necessarily taken when fish were sampled). The first step of this analysis was to sort the data into water body type (lake or stream) and MOE administrative management regions, Omineca (7A), Peace (7B) and Skeena (6) for each of the combinations listed above, using MOE Watershed Dictionary Watershed Code Query. The data from the PFWWCP was combined with the data on streams in the Omineca region. Compiling the data into specific groups based on the categories listed above allowed for appropriate comparisons and elimination of any replicate data in each group. Following this exercise, replicate data still existed between category groups containing information for all species, summary data and individual data, but these category groups were used for analysis of different trends and were therefore not incorporated more than once. The data for each group was further sorted into years and months to analyze temporal variation in each site and compare to other sites surveyed.

Queries were made for each trend analysis in each group, when data was available. Outliers were investigated for accuracy in the original source reports. The original reports were found through the MOE EcoCat: The Ecological Reports Catalogue. Typographical errors were noted and changed to the correct values for analysis.

The data provided for Arctic grayling age occasionally had a “+” sign associated with it (ie. 2+), indicating that the fish were at least the age provided but there was some uncertainty in the accuracy and the fish may have been older. For this analysis all “+” symbols were removed and this uncertainty was not considered in the analysis.

An overview of these data revealed spatial and temporal data gaps. The gaps in this dataset arise because information from each study was not collected with the same objectives in mind and sampling techniques and protocols were not standardized across projects.

We considered the following subject areas for Arctic grayling populations in this analysis:

1. Life history characteristics (fork length, weight, age, sex ratios);
2. Spawner surveys (fecundity, migration timing, habitats, etc.);
3. Population genetics (effective population sizes, local adaptations, bottlenecks, etc);
4. Fluvial and adfluvial population differences (geographic differences etc.);
5. Abundance estimates;
6. Catch per unit effort (CPUE);
7. Diet;
8. Survival estimates;
9. Physical environment surveys- areas of importance for various life stages;
10. Potential areas of habitat enhancement; and
11. Lipid analysis.

Although, we have a considerable amount of data from the three BC management regions where Arctic grayling have been reported, data was not available for some of these categories.

The analysis was performed primarily for Arctic grayling records from the Omineca management region and occasionally comparisons were made with data reported in the Peace and Skeena management regions. For each subject area considered data was further broken down into stream and lake data to analyze differences between fluvial and adfluvial Arctic grayling populations.

The Arctic grayling information within the provincial database was separated into fluvial and adfluvial groups based on capture location. Grayling captured in rivers or streams were classified as fluvial and grayling captured in lakes as adfluvial. The majority of Arctic grayling sampling records in the Omineca management region were classified as fluvial (97%). Similarly, in the Peace region the Arctic grayling population appears to be primarily fluvial (96%). In the Skeena region, however, 58% of the populations were fluvial and 42% were adfluvial (Miller *et al.* 2008). The following sections summarize the findings for the fluvial populations. Adfluvial populations are compared in Section 4.0 of this report.

1.0 Life History Characteristics

1.1 Length and Weight

Fork length and weight measurements comprise the largest proportion of the compiled data; in particular length measurements. There are 6334 individual records of length and 3627 individual records of weight for Arctic grayling. Of these measurements the majority were collected in the Omineca Region; 4571 lengths (72.1%) and 3259 weights (90%). In the Peace Region 1674 lengths (26.4%) and 326 weights (9%) were reported and in the Skeena Region 89 lengths (1.5%) and 42 weights (1%) were reported.

The resolution of the length data was often recorded to 1 mm, however, many records were only listed to within 10 mm. The resolution of weight data appeared to be coarser when present and in some cases the accuracy of the measurement was questioned. Generally, weight was recorded to 1 g, but values may have an accuracy that exceeds 10 g, particularly for measurements of larger fish. In the Omineca region a digital scale was used to weigh many of the adult grayling in ounces, which were then converted to grams for the records. Under field conditions it is very difficult to standardize weight. The PFWWCP field crew collected weight data as accurately as possible, weights were not recorded when it was too windy, raining or when the fish were too small. The accuracy of the weight scale was also assessed continuously during sampling and use was discontinued when accuracy was compromised (B. G. Blackman, personal communication, April 15, 2009).

All the length and weight data was sorted by sampling methods (Table 1), major watershed, year, month and individual stream for analysis, in order to ensure the best possible comparisons. In the Omineca management region mean length and weight of Arctic grayling sampled between 1956 and 2007 was determined (Table 2). Mean length and weight from the different sampling programs ranged from 13.8 – 436.7 mm and 0.3 – 570 g over the entire region. Sampling within the Omineca region, however, has been concentrated on one major watershed: most of the samples were taken from 14 individual streams in the Parsnip watershed. Arctic grayling sampled in the Parsnip watershed ranged in size from 13.8 – 366.5 mm and 0.7 – 521.2 g. These samples, however, were not taken from the same streams or in the same months from year to year. The results of this analysis should be used cautiously for it is limited temporal and spatial and represents samples taken from a number of different studies that had various objectives, which were not designed to provide a comprehensive overview of all the fish populations or long term trends.

In the Peace management region, Arctic grayling length and/or weight records were reported on 98 individual streams, from 21 major watersheds. Samples were collected between 1975 and 2005, primarily in summer and late fall (May to October). Samples were not taken, however, from each stream in each year or month. Mean length of Arctic grayling reported from an individual stream, by the same sampling method in the same month and year over the entire region ranged between 17.4 – 387.8 mm and mean weight ranged between 1.0 – 550 g (Table 3).

In the Skeena management region information on Arctic grayling size is much more limited than the Omineca and Peace regions. Length and weight data was only collected in 1997 (August and September) and 2003 (September) from 13 individual streams in 4 different major watersheds. Mean length in individual streams of this region ranged from 65.3 – 350 mm and mean weight ranged from 8.5 – 470 g (Table 4).

Table 1. Code for the sample methods used to capture Arctic grayling in all management regions of BC (RIC, 1996).

Code	Method
AG	Angling
DC	Dead capture
DN	Dip netting
EF	Electrofishing
GN	Gill netting
MT	Minnnow trapping
SN	Seining
SW	Swimming
VO	Visual observation
UN	Method unknown

Table 2. Mean fork length and weight for Arctic grayling sampled in the streams of the Omineca region (7A).

Method	Watershed	Year	Month	Stream	Mean Length (mm)	SD	n	Mean Weight (g)	SD	n
AG	Finlay	1975	July	CHOWIKA CREEK	344.0	5.7	2	400.0	42.4	2
				COLLINS CREEK	436.7	23.1	3	346.0	10.1	3
				DAVIS RIVER	347.0	21.5	3	460.0	0.0	2
				LAFFERTY CREEK	345.3	8.0	3	425.0	21.8	3
				FINLAY RIVER	220.0	-	1	-	-	-
		1985	August	FIRESTEEL RIVER	354.3	17.8	3	-	-	-
				TOODOGGONE RIVER	393.2	23.5	6	-	-	-
				FINLAY RIVER	200.0	-	1	-	-	-
				FINLAY RIVER	340.0	53.9	5	-	-	-
				FOX RIVER	292.6	68.1	7	-	-	-
		2000	August	FINLAY RIVER	329.4	65.5	101	-	-	-
				FINLAY RIVER	285.3	62.8	72	-	-	-
				INGENIKA RIVER	397.3	34.8	11	-	-	-
				INGENIKA RIVER	361.7	40.5	20	540.7	155.9	20
				MANSON RIVER	230.0	-	1	440.0	-	1
	Manson Nation	1989	August	NATION RIVER	250.0	76.6	4	212.5	136.2	4
				NATION RIVER	295.5	37.2	167	331.1	94.8	167
				NATION RIVER	227.0	59.0	9	169.4	117.1	8
				NATION RIVER	321.4	87.7	14	-	-	-
				PHILIP CREEK	254.0	55.0	5	-	-	-
	Omineca	1975	September	MESILINKA RIVER	345.0	-	1	400.0	-	1
				MESILINKA RIVER	319.2	41.2	18	379.7	143.1	18
				MESILINKA RIVER	249.1	60.4	11	262.0	197.1	10
				MESILINKA RIVER	183.3	66.6	3	-	-	-
				MESILINKA RIVER	275.5	81.4	22	328.2	149.9	17
		1994	August	MESILINKA RIVER	292.8	59.4	46	288.0	131.5	46
				MESILINKA RIVER	335.0	-	1	400.0	-	1
				MESILINKA RIVER	282.9	50.4	14	296.0	140.1	14
				MESILINKA RIVER	291.8	60.3	21	339.9	141.2	21
				MESILINKA RIVER	338.8	39.9	33	419.6	124.4	33
		1999	May	MESILINKA RIVER	332.4	54.3	104	471.4	170.9	104
				NO NAME	350.0	2.8	2	525.0	7.1	2
				OMINECA RIVER	358.0	20.3	3	552.5	74.2	2
				LAY CREEK	394.0	23.3	5	-	-	-
				MESILINKA RIVER	278.0	116.2	5	-	-	-
	Parsnip	2004	August	OMINECA RIVER	192.5	79.1	10	-	-	-
				OSILINKA RIVER	361.0	24.9	10	-	-	-
				BLACKWATER CREEK	354.0	-	1	440.0	-	1
				CUT THUMB CREEK	337.0	18.4	2	360.0	28.3	2
				IZAAC CREEK	325.0	-	1	360.0	-	1
		1993	September	PARSNIP RIVER	275.0	106.1	2	-	-	-
				TABLE RIVER	300.6	48.3	65	313.3	135.4	64
				TABLE RIVER	282.7	62.2	58	265.2	128.2	52
				ANZAC RIVER	339.7	32.7	7	412.0	115.0	7
				ANZAC RIVER	322.6	29.9	16	367.1	125.6	16
		1996	August	ANZAC RIVER	334.0	20.9	14	415.5	70.2	14
				ANZAC RIVER	344.3	26.3	41	445.7	94.0	41
				TABLE RIVER	280.8	54.4	19	255.6	114.7	19
				TABLE RIVER	315.9	17.3	11	269.8	75.4	11
				TABLE RIVER	316.9	25.5	8	365.1	66.3	8
1997	July	ANZAC RIVER	320.7	33.0	24	348.1	115.2	18		
		TABLE RIVER	322.5	29.7	20	310.1	102.2	14		
		ANZAC RIVER	328.1	33.8	45	357.1	112.2	36		
		NO NAME	312.3	28.3	3	321.3	114.9	3		
		TABLE RIVER	320.4	33.6	39	363.3	107.7	39		
September	ANZAC RIVER	336.4	26.2	28	366.7	90.1	28			
	NO NAME	360.9	20.3	9	483.3	121.6	9			
	TABLE RIVER	346.2	28.5	20	329.2	87.0	20			

Method	Watershed	Year	Month	Stream	Mean Length (mm)	SD	n	Mean Weight (g)	SD	n
		1998	July	ANZAC RIVER	318.8	22.0	9	346.2	65.9	8
				TABLE RIVER	301.6	27.0	35	285.6	66.4	35
			August	ANZAC RIVER	326.5	26.5	202	376.9	87.7	202
				MISSINKA RIVER	264.8	52.3	8	209.9	163.8	7
				TABLE RIVER	295.3	30.7	91	280.0	81.9	91
		2004	June	TABLE RIVER	324.5	46.5	22	-	-	-
			July	ANZAC RIVER	321.9	43.9	30	-	-	-
		2005	July	ANZAC RIVER	332.3	35.2	16	384.3	112.4	3
				TABLE RIVER	317.5	28.9	24	382.9	103.0	12
			August	ANZAC RIVER	341.9	35.6	12	358.6	152.8	7
				HOMINKA RIVER	362.5	10.6	2	-	-	-
				MISSINKA RIVER	340.7	32.1	12	472.9	125.8	7
				PARSNIP RIVER	362.5	10.6	2	-	-	-
				TABLE RIVER	344.4	32.4	24	408.7	92.7	23
		2007	August	ANZAC RIVER	329.1	31.4	122	-	-	-
DC	Parsnip	1998	June	TABLE RIVER	14.0	1.4	2	-	-	-
DN	Parsnip	1975	July	CUT THUMB CREEK	16.0	2.6	3	1.0	0.0	3
		1998	June	ANZAC RIVER	13.8	0.5	4	-	-	-
				TABLE RIVER	16.2	5.6	6	-	-	-
			July	ANZAC RIVER	26.0	-	1	-	-	-
				TABLE RIVER	21.7	3.0	7	-	-	-
			August	ANZAC RIVER	23.3	8.1	3	-	-	-
			September	ANZAC RIVER	25.3	4.1	4	-	-	-
EF	Finlay	1985	August	TOODOGGONE RIVER	38.0	2.6	3	-	-	-
		1988	September	TOODOGGONE RIVER	139.3	177.2	4	-	-	-
		1999	August	FOX RIVER	263.2	115.7	6	-	-	-
		2000	August	FINLAY RIVER	43.4	5.5	16	-	-	-
				NO NAME	51.8	4.6	5	-	-	-
		2001	July	FINLAY RIVER	36.7	16.4	6	-	-	-
		2004	August	FOX RIVER	70.8	29.1	25	-	-	-
		2006	August	FINLAY RIVER	51.3	18.7	88	-	-	-
		2007	August	FINLAY RIVER	43.7	11.1	31	-	-	-
	Ingenika Nation	2003	August	INGENIKA RIVER	44.8	11.5	160	1.6	1.9	74
	Omineca	1989	August	NATION RIVER	58.0	7.4	4	1.9	0.8	4
		1993	August	MESILINKA RIVER	42.8	8.0	5	0.9	0.5	5
			September	MESILINKA RIVER	62.8	5.2	9	2.3	0.6	9
		1994	August	MESILINKA RIVER	73.4	7.5	11	5.4	2.8	11
			September	MESILINKA RIVER	49.5	7.8	2	0.9	0.4	2
		2001	August	OMINECA RIVER	38.7	6.5	76	0.6	0.3	74
			September	OMINECA RIVER	42.2	9.5	198	0.9	1.0	181
				OOMINICETLA CREEK	36.0	6.2	3	0.7	0.4	3
				SILVER CREEK	60.3	6.4	4	2.2	1.1	4
		2002	August	OSILINKA RIVER	39.9	10.5	65	2.0	4.6	10
	Parsnip	1995	September	TABLE RIVER	65.2	3.7	12	2.2	0.4	12
		1996	September	TABLE RIVER	51.0	-	1	-	-	-
			November	TABLE RIVER	46.5	12.0	2	-	-	-
			December	TABLE RIVER	44.0	-	1	-	-	-
		1997	August	ANZAC RIVER	42.3	5.4	114	0.8	0.3	109
				CROCKER CREEK	41.4	2.8	17	0.7	0.2	17
		1998	August	MISSINKA RIVER	62.6	6.9	9	3.2	0.9	6
			September	MISSINKA RIVER	73.0	4.2	2	4.3	0.2	2
				TABLE RIVER	72.2	6.0	13	3.4	0.9	12
		2005	July	MISSINKA RIVER	41.9	1.5	8	-	-	-
				PARSNIP RIVER	41.0	-	1	-	-	-
			August	MISSINKA RIVER	43.4	5.5	39	-	-	-
				PARSNIP RIVER	57.8	14.1	30	-	-	-
GN	Finlay	1975	September	LAFFERTY CREEK	355.0	27.4	4	435.0	83.5	4
				OSPIKA RIVER	298.5	9.2	2	340.0	56.6	2
		1991	September	FINLAY RIVER	346.5	24.7	2	450.0	70.7	2
	Ingenika	1975	September	INGENIKA RIVER	332.5	3.5	2	415.0	21.2	2
	Manson	1975	June	MANSON RIVER	366.0	-	1	570.0	-	1
	Nation	1975	September	NATION RIVER	312.5	24.7	2	325.0	21.2	2
	Omineca	1975	September	OMINECA RIVER	310.0	-	1	310.0	-	1
	Parsnip	1975	June	BLACKWATER CREEK	184.0	-	1	77.0	-	1
				TONY CREEK	322.0	-	1	350.0	-	1
				TUTU CREEK	328.0	-	1	440.0	-	1
				WESTON CREEK	345.5	16.7	4	407.5	45.6	4
			July	MUGAHA CREEK	287.0	29.7	2	247.5	53.0	2
			November	PARSNIP RIVER	303.0	27.3	5	262.0	58.4	5
	Peace	1975	June	STRANDBERG CREEK	344.5	36.1	2	455.0	91.9	2
MT	Finlay	2000	August	FINLAY RIVER	42.5	0.7	2	-	-	-
				NO NAME	51.7	4.0	3	-	-	-
SN	Finlay	1985	August	TOODOGGONE RIVER	38.3	6.0	12	-	-	-
	Omineca	2001	August	OMINECA RIVER	73.9	37.7	23	10.8	5.3	13
				OMINICETLA CREEK	34.3	3.5	4	0.3	0.1	4
				SILVER CREEK	44.0	2.8	5	-	-	-
	Parsnip	1975	September	PARSNIP RIVER	71.0	33.1	6	6.3	8.6	6
		1996	July	TABLE RIVER	172.5	62.4	6	68.8	64.0	6
			August	TABLE RIVER	302.0	24.6	3	255.3	28.5	3
			September	TABLE RIVER	139.5	62.9	2	38.8	44.7	2
		1997	January	TABLE RIVER	83.0	-	1	6.0	-	1
		1998	July	ANZAC RIVER	47.9	19.3	42	2.7	4.1	21
				PARSNIP RIVER	89.8	49.0	339	16.9	31.2	302
			September	PARSNIP RIVER	93.0	49.4	162	17.9	56.1	162
		2005	July	PARSNIP RIVER	81.2	44.1	341	16.7	14.7	204
			August	PARSNIP RIVER	41.9	1.1	8	1.4	0.4	2
		2007	July	PARSNIP RIVER	90.3	35.5	311	12.5	17.1	218
SW	Finlay	2004	August	FOX RIVER	308.3	62.5	9	-	-	-

Method	Watershed	Year	Month	Stream	Mean Length (mm)	SD	n	Mean Weight (g)	SD	n
UN	Finlay	1975	July	CHOWIKA CREEK	359.0	12.7	2	460.0	70.7	2
				COLLINS CREEK	329.5	13.4	2	395.0	63.6	2
				LAFFERTY CREEK	345.0	7.1	2	460.0	56.6	2
	Omineca	2007	August	FINLAY RIVER	40.0	-	1	-	-	-
		1975	September	OMINECA RIVER	371.9	123.0	8	391.3	95.5	8
VO	Parsnip	1996	August	ANZAC RIVER	347.9	21.5	9	474.6	75.1	9
				PARSNIP RIVER	278.5	54.4	2	336.0	7.1	2
				TABLE RIVER	330.2	13.0	22	390.4	70.7	22
				ANZAC RIVER	345.2	20.2	53	447.8	79.3	53
				PARSNIP RIVER	323.8	22.9	24	383.5	63.6	24
				TABLE RIVER	331.6	10.9	13	389.9	81.1	13
				PARSNIP RIVER	334.4	27.7	23	431.2	81.6	23
				TABLE RIVER	327.8	9.7	4	365.3	90.5	4
				ANZAC RIVER	361.5	16.8	4	504.8	69.0	4
				PARSNIP RIVER	331.0	27.6	21	413.1	89.6	21
				TABLE RIVER	331.0	15.6	2	373.0	154.1	2
				ANZAC RIVER	366.5	16.3	2	504.0	0.0	2
				PARSNIP RIVER	333.7	31.1	17	423.2	84.1	17
				TABLE RIVER	331.7	11.1	3	384.7	110.9	3
				ANZAC RIVER	366.5	16.3	2	504.0	0.0	2
				PARSNIP RIVER	336.4	19.3	21	419.2	78.7	21
				ANZAC RIVER	365.6	12.2	7	521.2	50.6	7
				PARSNIP RIVER	335.7	20.4	32	417.3	83.9	32
				TABLE RIVER	340.0	-	1	419.0	-	1
				ANZAC RIVER	350.0	23.8	21	473.9	87.0	21
				PARSNIP RIVER	334.7	19.3	19	417.2	87.2	19
				TABLE RIVER	334.3	7.8	6	408.8	34.0	6
				ANZAC RIVER	345.0	23.8	43	447.2	93.3	43
				PARSNIP RIVER	339.6	16.2	14	441.4	64.6	14
				TABLE RIVER	329.9	9.0	10	390.1	43.3	10
				ANZAC RIVER	342.7	22.5	35	448.6	85.5	35
				PARSNIP RIVER	320.2	10.2	5	362.6	36.1	5
				TABLE RIVER	330.8	9.4	8	391.6	42.9	8
				ANZAC RIVER	341.1	21.4	11	428.3	84.8	11
				PARSNIP RIVER	314.5	3.5	2	353.5	17.7	2
TABLE RIVER	330.0	14.1	2	379.5	55.9	2				
ANZAC RIVER	340.5	22.8	11	426.4	88.7	11				
PARSNIP RIVER	327.2	13.6	5	396.5	52.5	5				
TABLE RIVER	330.0	14.1	2	379.5	55.9	2				

Table 3. Mean fork length and weight for Arctic grayling sampled in the streams of the Peace region (7B).

Method	Watershed	Year	Month	Stream	Mean Length (mm)	SD	n	Mean Weight (g)	SD	n
AG	Dunedin	1997	August	NO NAME	160.8	30.9	10	52.2	22.1	9
				NO NAME	232.8	48.9	4	-	-	-
	Fort Nelson	2002	August	STANOLIND CREEK	262.5	12.0	2	-	-	-
				SOUTH GATAGA RIVER	387.8	53.4	5	-	-	-
	Gataga	2003	September	NO NAME	190.5	12.0	2	74.0	5.7	2
				NO NAME	178.5	75.7	2	70.5	71.4	2
	Kechika	2001	September	DENETIAH CREEK	294.0	-	1	250.0	-	1
				MOODIE CREEK	190.5	12.0	2	74.0	5.7	2
	Liard	2000	July	VENTS RIVER	283.1	36.0	11	-	-	-
				TRIBUTARY TO LIARD RIVER	304.8	18.7	4	-	-	-
	Muskwa	2002	August	TRIBUTARY TO LIARD RIVER	310.0	-	1	-	-	-
				TRIBUTARY TO MUSKWA RIVER	355.0	-	1	-	-	-
	Peace	1975	August	BERNARD CREEK	355.3	20.3	6	438.3	71.7	6
				CARBON CREEK	353.0	12.2	35	465.6	47.0	33
				CLEARWATER CREEK	350.0	20.0	3	425.0	50.7	3
				ELEVEN MILE CREEK	360.5	13.3	4	492.5	47.2	4
				NABESCHE RIVER	361.3	25.9	4	492.5	118.1	4
				NO NAME	350.0	-	1	440.0	-	1
				PARDONET CREEK	365.0	7.1	2	505.0	49.5	2
				POINT CREEK	375.0	-	1	550.0	-	1
SCHOOLER CREEK				357.5	17.7	2	475.0	77.8	2	
SELWYN CREEK				357.5	15.5	4	472.5	56.2	4	
WICKED RIVER				362.6	19.7	5	506.3	96.7	4	
CARBON CREEK				356.8	12.9	12	525.8	49.3	12	
PETRIE CREEK				315.0	-	1	-	-	-	
BELCOURT CREEK				340.0	0.0	2	-	-	-	
NO NAME	333.5	2.1	2	450.0	-	1				
Tsea	1997	September	THETLAANDOA CREEK	270.0	43.9	4	232.5	145.9	4	
			TSEA RIVER	292.0	22.6	3	302.3	84.2	3	
DN	Peace	1975	August	CARBON CREEK	17.4	2.3	5	1.0	-	1
EF	Beaton	1998	September	NO NAME	102.8	43.2	34	-	-	-
				JULIENNE CREEK	140.4	38.2	7	-	-	-
		2000	July	TRIB TO BEATTON RIVER	165.0	-	1	-	-	-
				TRIB TO JULIENNE CREEK	185.1	37.1	10	-	-	-
		August	TRIB TO TRIB TO BEATTON RIVER	125.0	20.0	3	-	-	-	
			BEATTON RIVER	183.5	2.1	2	-	-	-	
		1997	July	TORPID CREEK	165.3	49.2	83	72.1	71.5	80
				NO NAME	100.0	-	1	6.0	-	1
		1998	June	NO NAME	192.0	45.5	6	-	-	-
				DUNEDIN RIVER	192.6	44.6	20	72.5	41.3	8

Method	Watershed	Year	Month	Stream	Mean Length (mm)	SD	n	Mean Weight (g)	SD	n
				NO NAME	146.3	73.1	10	-	-	-
				TORPID CREEK	52.4	6.1	7	-	-	-
		1999	August	NO NAME	81.1	48.6	15	-	-	-
	Fontas	1997	August	NO NAME	100.0	-	1	-	-	-
			September	NO NAME	227.0	1.4	2	-	-	-
		2003	August	BEAVERSKIN CREEK	74.5	4.9	2	-	-	-
				FONTAS RIVER	48.5	2.1	2	-	-	-
				NO NAME	55.0	-	1	-	-	-
	Fort Nelson	1999	July	ETANE CREEK	164.3	66.5	8	-	-	-
				NO NAME	125.1	51.5	19	-	-	-
				OBOLE CREEK	125.0	44.2	22	-	-	-
		2001	September	SHUSH CREEK	130.0	121.2	3	-	-	-
		2002	August	CRIDLAND CREEK	57.8	4.5	5	-	-	-
				NO NAME	69.4	47.9	39	-	-	-
				SOUTH STANOLIND CREEK	78.6	29.6	14	-	-	-
				STANOLIND CREEK	52.0	17.5	4	-	-	-
	Frog	2001	September	KECHIKA RIVER	98.1	37.7	18	14.0	19.9	18
	Gataga	2003	September	NO NAME	71.7	16.6	32	-	-	-
				SOUTH GATAGA RIVER	71.7	10.1	6	-	-	-
				UNNAMED TRIBUTARY TO GATAGA	72.0	-	1	-	-	-
	Halfway	1997	July	DARBER CREEK	189.8	50.0	10	-	-	-
				NO NAME	194.2	47.6	28	-	-	-
			September	NO NAME	121.0	-	1	-	-	-
		1998	September	NO NAME	104.6	68.6	118	-	-	-
		2001	September	GROUND BIRCH CREEK	57.0	1.4	2	-	-	-
	Kechika	2001	September	BOYA CREEK	145.0	-	1	30.0	-	1
				DENETIAH CREEK	91.8	37.2	5	25.0	15.6	2
				HIZAZA CREEK	185.0	-	1	82.0	-	1
				HORNELINE CREEK	107.1	63.9	9	47.2	85.1	6
				MOODIE CREEK	160.0	64.6	6	69.2	80.4	6
				NO NAME	179.5	69.6	10	97.4	113.4	10
	Kiskatinaw	1997	August	NO NAME	210.0	-	1	-	-	-
		2001	August	SUNDERMAN CREEK	82.3	3.2	3	-	-	-
				UNNAMED TRIB TO KISKATINAW	66.1	5.2	7	-	-	-
			September	MINISTIK CREEK	122.5	65.8	2	-	-	-
	Liard	2000	July	VENTS RIVER	39.3	4.0	3	-	-	-
		2002	August	CRUSTY CREEK	296.5	16.2	4	-	-	-
				SULPHUR CREEK	264.0	-	1	-	-	-
				TRIBUTARY TO LIARD RIVER	246.4	51.2	9	-	-	-
			September	TRIBUTARY TO LIARD RIVER	236.0	30.5	5	-	-	-
	Milligan	2001	August	NO NAME	116.2	64.9	18	-	-	-
				TRIBUTARY TO CHINCHAGA RIVER	59.0	0.0	2	-	-	-
			September	MILLIGAN CREEK	126.0	-	1	-	-	-
				TRIBUTARY TO MILLIGAN CREEK	162.2	59.2	5	-	-	-
	Murray	2001	August	COLDSTREAM CREEK	241.7	35.4	3	-	-	-
				TRIBUTARY TO COLDSTREAM CREEK	138.1	41.1	9	-	-	-
			September	COLDSTREAM CREEK	202.0	15.5	5	-	-	-
		2005	August	WOLVERINE RIVER	327.0	-	1	439.0	-	1
	Muskwa	1999	June	NO NAME	116.9	73.6	61	-	-	-
				STEAMBOAT CREEK	80.3	10.7	13	-	-	-
		2000	August	KLEDO CREEK	49.6	6.2	14	-	-	-
				NO NAME	102.9	49.5	50	-	-	-
			September	NO NAME	101.6	32.0	17	-	-	-
		2001	July	ARNELL CREEK	272.6	47.1	7	-	-	-
				BECKMAN CREEK	132.0	-	1	-	-	-
				GATHTO CREEK	222.5	58.7	2	-	-	-
				KLUACHESI CREEK	144.8	75.3	20	-	-	-
				PUDER CREEK	214.0	27.9	4	-	-	-
				REIMER CREEK	83.5	16.3	2	-	-	-
				TIERNEY CREEK	252.0	-	1	-	-	-
				TRIBUTARY TO KLUACHESI CREEK	123.3	29.3	9	-	-	-
				TRIBUTARY TO MUSKWA RIVER	153.7	67.5	10	-	-	-
				TRIBUTARY TO VARICK CREEK	168.0	-	1	-	-	-
				VARRICK CREEK	84.0	-	1	-	-	-
				WENGER CREEK	110.0	41.0	2	-	-	-
			August	AKUE CREEK TRIBUTARY	116.7	35.5	3	-	-	-
				GAMMER CREEK	198.0	34.0	5	-	-	-
				NO NAME	161.1	56.2	9	-	-	-
				TRIBUTARY TO CREHAN CREEK	268.5	68.6	2	-	-	-
			September	GAMMER CREEK	175.0	35.4	2	-	-	-
				NO NAME	68.0	16.4	10	-	-	-
				RASPBERRY CREEK	87.9	45.3	7	-	-	-
	Peace	1975	June	CARBON CREEK	354.0	-	1	440.0	-	1
			August	SEVEN MILE CREEK	352.0	11.7	9	494.4	55.5	9
			September	SEVEN MILE CREEK	349.4	13.6	10	511.4	45.3	7
		1989	September	CLEARWATER CREEK TRIBUTARY	56.0	-	1	1.6	-	1
	Petitot	1997	September	PETITOT RIVER	95.5	3.5	2	9.0	1.1	2
		1999	October	D'EASUM CREEK	92.7	12.7	3	-	-	-
				EMILE CREEK	274.5	23.3	2	280.0	42.4	2
	Pine	1998	July	DICKEBUSCH CREEK	264.0	27.0	5	-	-	-
	Prophet	2000	August	BESA RIVER	194.5	194.5	2	-	-	-
				NEVES CREEK	323.5	18.2	8	-	-	-
				NO NAME	312.0	-	1	-	-	-
			September	BAT CREEK	184.8	10.7	5	-	-	-
	Sikanni Chief	1997	May	NITEAL CREEK	162.0	-	1	-	-	-
			August	KIRKPATRICK CREEK	156.0	-	1	-	-	-
				NO NAME	152.2	48.0	87	-	-	-

Method	Watershed	Year	Month	Stream	Mean Length (mm)	SD	n	Mean Weight (g)	SD	n
			September	TRUTCH CREEK	168.0	39.2	24	-	-	-
				NO NAME	170.5	2.1	2	-	-	-
				WEST CONROY CREEK	134.6	13.3	14	-	-	-
		1998	August	DONNIE CREEK	80.3	54.9	33	-	-	-
				NO NAME	137.1	54.8	99	-	-	-
				TEMPLE CREEK	164.0	42.0	31	-	-	-
			September	TEMPLE CREEK	203.0	53.9	4	-	-	-
		1999	July	TRIB TO KATAH CREEK	82.0	21.1	25	-	-	-
			August	KATAH CREEK	93.0	-	1	-	-	-
				NO NAME	101.8	15.4	12	-	-	-
				TRIB TO CONROY CREEK	111.7	51.3	55	-	-	-
				TRIB TO KATAH CREEK	105.2	25.2	12	-	-	-
				TRIB TO TRIB TO CONROY CREEK	43.0	-	1	-	-	-
			October	KATAH CREEK	73.3	4.0	3	-	-	-
		2001	August	BARKER CREEK	79.5	4.9	2	-	-	-
				NO NAME	99.0	28.9	5	-	-	-
		2004	August	BUCKINGHORSE RIVER	147.5	83.1	4	-	-	-
Toad		2002	September	EIGHT MILE CREEK	174.2	63.9	20	-	-	-
Tsea		1997	September	TSEA RIVER	65.4	9.2	5	2.5	1.1	5
		2002	August	NO NAME	76.4	22.9	12	-	-	-
				THETLAANDOA CREEK	136.6	67.1	13	-	-	-
(blank)		2002	August	PATRY CREEK	292.0	-	1	-	-	-
GN	Peace	1975	August	CARBON CREEK	333.3	19.4	3	453.3	80.2	3
				SEVEN MILE CREEK	346.3	28.3	4	487.5	84.2	4
			September	NABESCHE RIVER	340.0	4.2	2	530.0	14.1	2
				SEVEN MILE CREEK	343.7	20.5	3	506.7	25.2	3
		1997	September	THETLAANDOA CREEK	175.0	-	1	55.1	-	1
MT	Dunedin	1999	August	NO NAME	61.0	-	1	-	-	-
SN	Dunedin	1998	July	NO NAME	59.8	4.9	8	-	-	-
	Fontas	2003	August	FONTAS RIVER	44.0	7.1	2	-	-	-
	Fort Nelson	2001	September	SHUSH CREEK	72.9	47.1	12	-	-	-
		2002	August	CAPOT-BLANC CREEK	64.0	-	1	-	-	-
	Frog	2001	September	KECHIKA RIVER	147.5	39.3	38	37.0	27.9	37
	Kechika	2001	September	HORNELINE CREEK	123.0	2.8	2	19.0	1.4	2
	Muskwa	1999	June	STEAMBOAT CREEK	75.5	0.7	2	-	-	-
		2000	August	KLEDO CREEK	70.5	62.0	17	-	-	-
		2001	August	AKUE CREEK	98.5	2.4	4	-	-	-
				NO NAME	140.0	-	1	-	-	-
			September	RASPBERRY CREEK	65.0	-	1	-	-	-
	Petitot	1997	September	DILLY CREEK	85.0	6.5	4	6.2	2.2	4
				PETITOT RIVER	92.0	-	1	7.1	-	1
		1997	September	THETLAANDOA CREEK	68.2	16.1	6	3.1	2.6	6
	Tsea			TSEA RIVER	73.0	12.5	3	3.8	2.1	3
VO	Fort Nelson	2002	August	SOUTH STANOLIND CREEK	220.0	-	1	-	-	-
	Halfway	1998	October	NO NAME	230.0	-	1	-	-	-
UN	Beatton	1996	August	NO NAME	107.5	0.0	4	-	-	-
	Halfway	1996	August	BLAIR CREEK	195.0	-	1	-	-	-
			September	DEADHORSE CREEK	153.5	0.0	10	-	-	-
	Pine	1996	August	MARTIN CREEK	135.5	0.0	2	-	-	-
			September	HIGHHAT RIVER	258.0	-	1	-	-	-
	(blank)	1996	August	GREWATSCH CREEK	105.0	-	1	-	-	-
				LA PRISE CREEK	111.5	0.0	4	-	-	-
			September	NO NAME	103.0	-	1	-	-	-

Table 4: Mean fork length and weight for Arctic grayling sampled in the streams of the Skeena region (6).

Method	Watershed	Year	Month	Stream	Mean Length (mm)	SD	n	Mean Weight (g)	SD	N
EF	Atlin	1997	August	CANYON CREEK	182.0	-	1	41.0	-	1
				MAHAR CREEK	128.0	-	1	8.5	-	1
				O'DONNELL RIVER	172.0	-	1	-	-	-
				PIKE RIVER	65.3	0.6	3	-	-	-
				SIMPSON CREEK	170.0	-	1	-	-	-
				WILSON CREEK	81.2	68.0	15	77.3	87.3	4
	Blue	1997	September	BLUE RIVER	350.0	-	1	470.0	-	1
				CHROMITE CREEK	107.7	78.2	3	27.2	43.9	3
				NO NAME	117.5	47.4	30	20.5	26.1	29
	Dease	2003	September	SERPENTINE CREEK	104.7	39.6	3	-	-	-
	Gladys	1997	August	GLADYS RIVER	82.8	28.0	13	-	-	-
				NO NAME	110.2	83.3	6	50.0	-	1
				ZENAZIE CREEK	72.6	38.9	8	-	-	-
		2003	September	NO NAME	251.0	-	1	-	-	-
GN	Dease	1997	September	VINCENT LAKE INLET	220.0	28.3	2	75.0	35.4	2

1.2 Length-Weight Regression

Length to weight relationships were plotted for streams individually within each region as an indicator of gross changes in body shape with size for Arctic grayling in each region (Figure 1). There was a highly significant relationship between length and weight for these fish, however, it was not a linear relationship and therefore a log transformation was applied to each variable for a linear model analysis (Figure 2). The linear regression models for length-weight relationships within each region were fitted using the statistical program R version 2.10.0 (R Development Core Team 2008). For all three regions (Omineca, Peace and Skeena) the p-values indicate that the linear regression models fit the transformed data well (Table 5). An analysis of variance was used to compare the length-weight relationship of the three regions. The results indicate that there was no significant difference between the slope of the length-weight regressions for the Omineca and Peace management regions (Table 6). The slope of the length-weight regression of the Skeena region appears to be significantly different from regressions slopes of both the Omineca and Peace regions ($p < 0.05$). This difference in the Skeena region may be the result of the small sample size that was available for analysis.

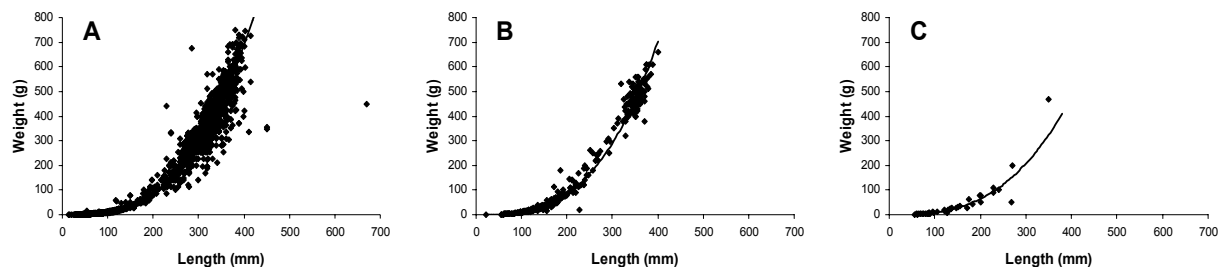


Figure 1. Length-weight relationship for Arctic grayling sampled from streams in the A. Omineca region (n=3259) B. Peace region (n=326) C. Skeena region (n=42).

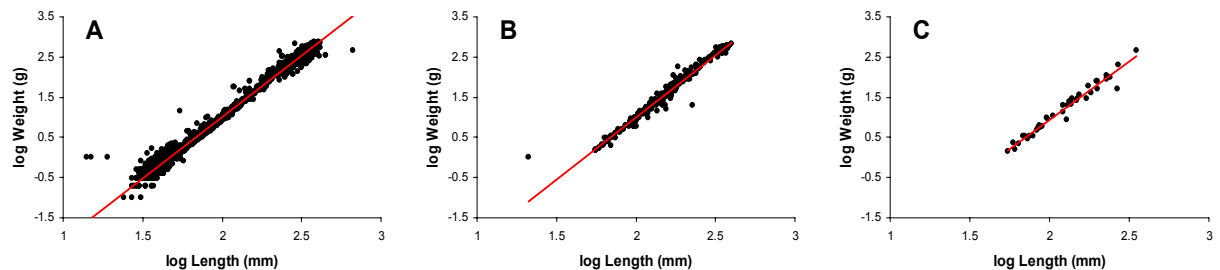


Figure 2. Log transformed length and weight of Arctic grayling from A. Omineca (n=3259) B. Peace (n=326) C. Skeena (n=42) regions, with best-fit line superimposed.

Table 5. Statistics summary for length-weight regression for Arctic grayling caught in each region (n: sample size, R^2 : coefficient of determination for the regression, b: allometric coefficient (slope), RSE: Residual standard error).

Region	n	R^2	Equation of best-fit line	b	RSE	p-value
Omineca	3259	0.9925	$\log(W) = -5.08 + 3.042 \log(L)$	3.042	0.0962	$< 2.2e-16$
Peace	326	0.9788	$\log(W) = -5.15 + 3.074 \log(L)$	3.074	0.1098	$< 2.2e-16$
Skeena	42	0.9628	$\log(W) = -4.86 + 2.896 \log(L)$	2.896	0.1192	$< 2.2e-16$

Table 6. Statistical summary of ANOVA comparing length-weight regression slopes (b) between management regions.

Compared Regions	p-value	Lower 95% CI	Upper 95% CI
Omineca : Peace	0.166*	-	-
Omineca : Skeena	0.045	-0.290	-0.003
Peace : Skeena	0.042	-0.350	-0.006

*Values were not significant (p-values >0.05).

The data from the Omineca region was filtered into finer geographic scales based on major watersheds and length-weight relationships were evaluated at this scale in the Omineca region (Figure 2). The p-values indicate that the data points for each watershed fit the linear regression model well when both length and weight were log-transformed (Table 7). Some data points did not cluster near the regression line, but no data was eliminated for this exercise as there did not seem to be a consistent bias to overestimating or underestimating the values for weight or length. The length and weight sample size for the Finlay, Manson and Peace watersheds was insufficient to apply an accurate regression model.

The length-weight regressions for each watershed in the Omineca region were compared using analysis of variance (Table 8). There appears to be a significant difference between the slope of the length-weight regressions reported for the Parsnip and Omineca watersheds, as well as between the Omineca and Nation regions (p<0.05). The regression slopes reported for the Nation and Ingenika watersheds did not differ significantly from the slope reported for the Parsnip watershed (p>0.05). Similarly, the regression slope for the Omineca watershed did not differ from the regression slope of the Nation watershed (p>0.05). Further sampling is required in the Nation and Ingenika watershed, however, to have a more accurate comparison of these watersheds. The current data is lacking for smaller grayling in the Nation watershed and larger fish in the Ingenika watershed.

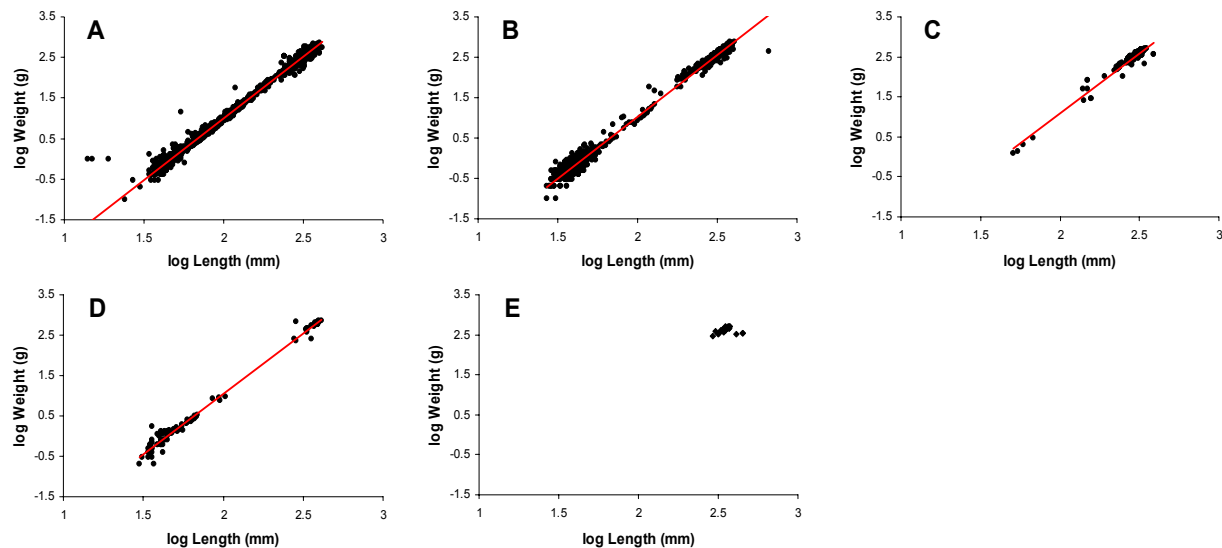


Figure 3. Log transformed length and weight data for Arctic grayling sampled in the major watersheds of the Omineca region, with best-fit line superimposed. A. Parsnip B. Omineca C. Nation D. Ingenika E. Finlay.

Table 7. Length-Weight regression for all streams sampled in the major watersheds of the Omineca region (n: sample size, R²: coefficient of determination for the regression, b: allometric coefficient (slope of regression)).

Watershed	n	R ²	Equation of best-fit line	b	RSE	p-value
Parsnip	2356	0.9928	log(W) = -5.08 + 3.038 log(L)	3.038	0.0857	< 2.2e-16
Omineca	594	0.9918	log(W) = -5.11 + 3.066 log(L)	3.066	0.1224	< 2.2e-16
Nation	185	0.9549	log(W) = -4.93 + 3.007 log(L)	3.007	0.0825	< 2.2e-16
Ingenika	96	0.9887	log(W) = -4.96 + 2.996 log(L)	2.996	0.1254	<2e-16
Finlay	24	0.0160	log(W) = 2.14 + 0.187 log(L)	0.187	0.0670	0.5563*
Manson	2	-	-	-	-	-
Peace	2	-	-	-	-	-

*Values were not significant (p-values >0.05).

Table 8. Statistical summary of ANOVA comparing length-weight regression slopes (b) between major watersheds of the Omineca region.

Compared Watersheds	p-value	Lower 95% CI	Upper 95% CI
Parsnip : Omineca	0.009	-0.048	-0.007
Parsnip : Nation	0.538*	-	-
Parsnip : Ingenika	0.079*	-	-
Omineca : Nation	0.388*	-	-
Omineca : Ingenika	0.044	0.002	0.137
Nation : Ingenika	0.868*	-	-

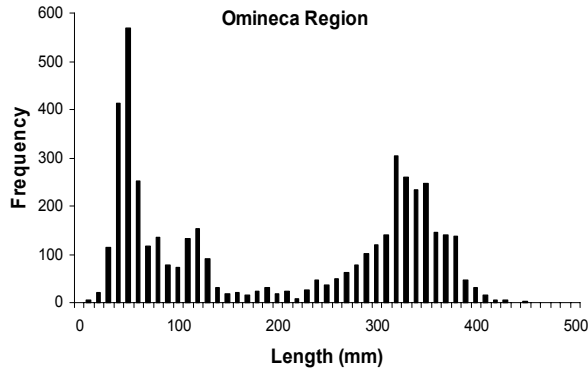
*Values were not significant (p-values >0.05).

1.3 Length Frequency

Length frequency histograms were generated for Arctic grayling sampled in each region (Figures 4A, 5A and 6A). Predominantly juveniles and adults were captured, for example, in the Omineca region the majority of Arctic grayling sampled were less than 150mm or more than 250mm (Figure 4A). The size distribution of fish sampled, however, is likely an artefact of the sampling methodologies and sampling efforts specific to each study. Therefore, each region was sorted by sample method and length frequency histograms were generated (Figure 4B, 5B, and 6B). In the Omineca region the majority of length records were taken from angling (39%), seining (28%), electrofishing (21%) and visual observation (10%). Arctic grayling sampled by angling in the Omineca region ranged in length from 30.5 - 470 mm, however only 2 juvenile fish (<100mm) were reported and the majority of fish captured by angling (68%) were greater than 300 mm in length (Figure 4B). The opposite was observed for Arctic grayling sampled by seining, the lengths ranged from 18 – 354 mm with the majority (62%) being juvenile fish (<100mm) and only 6 Arctic grayling greater than 300mm (Figure 4B). Similar trends were observed for Arctic grayling populations in the Peace and Skeena regions (Figures 5B, 6B).

The bias in fish captured is even more striking when we looked at individual watersheds (Figures 7, 8, 9, 10 and 11). Therefore, combining the results of various studies, each with independent objectives, is unlikely to reflect the overall fish population structure. This does, however, give an indication of sampling methods that would be most effective for future studies targeting a particular life history stage of Arctic grayling.

A



B

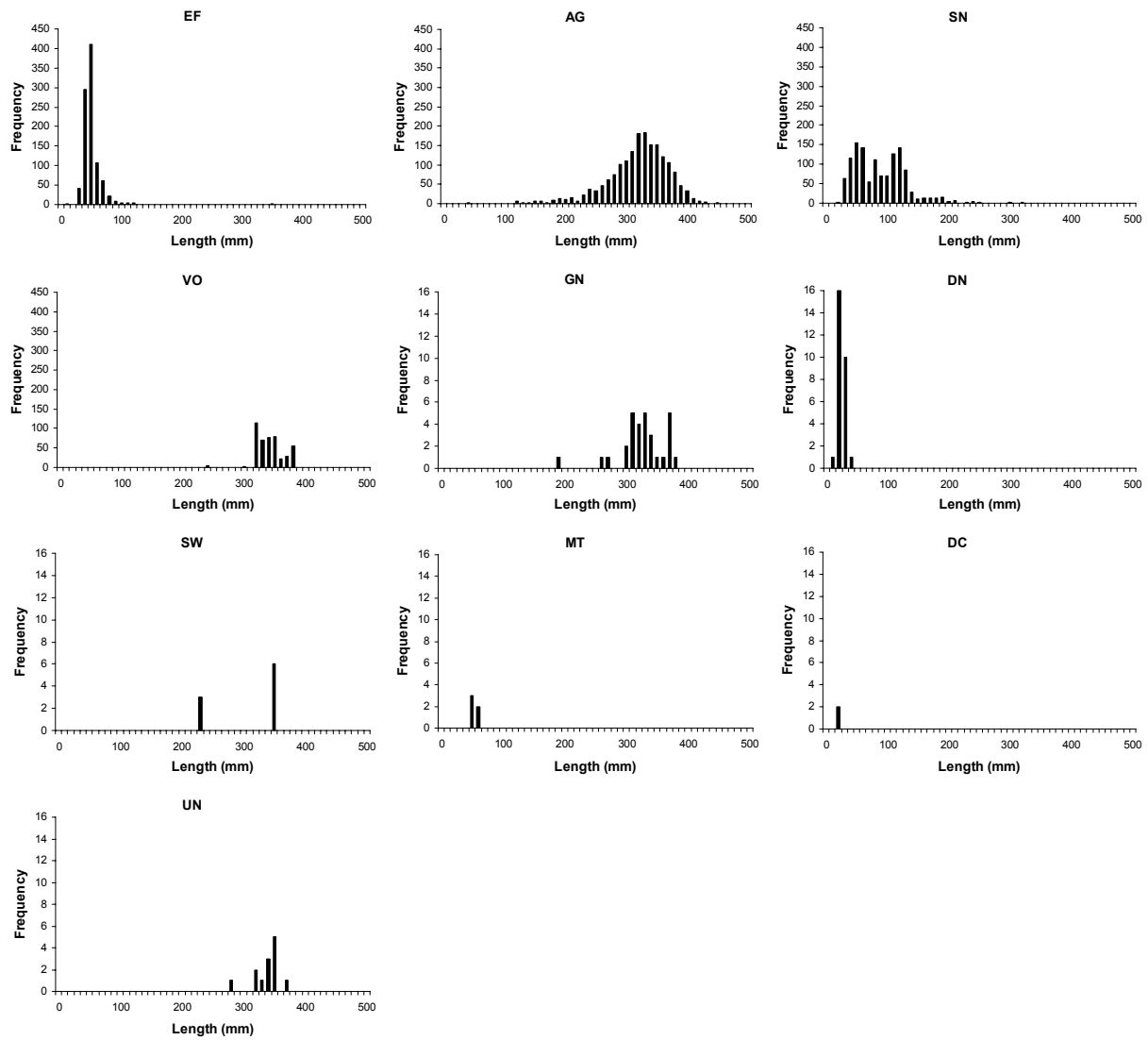
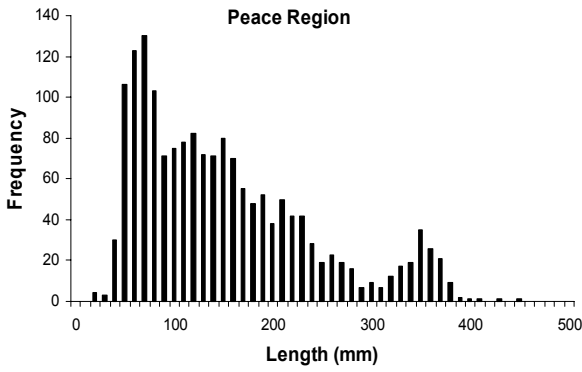


Figure 4. Length-frequency analysis for Arctic grayling sampled from the Omineca region. A. All sample methods B. Separated into individual sample method.

A



B

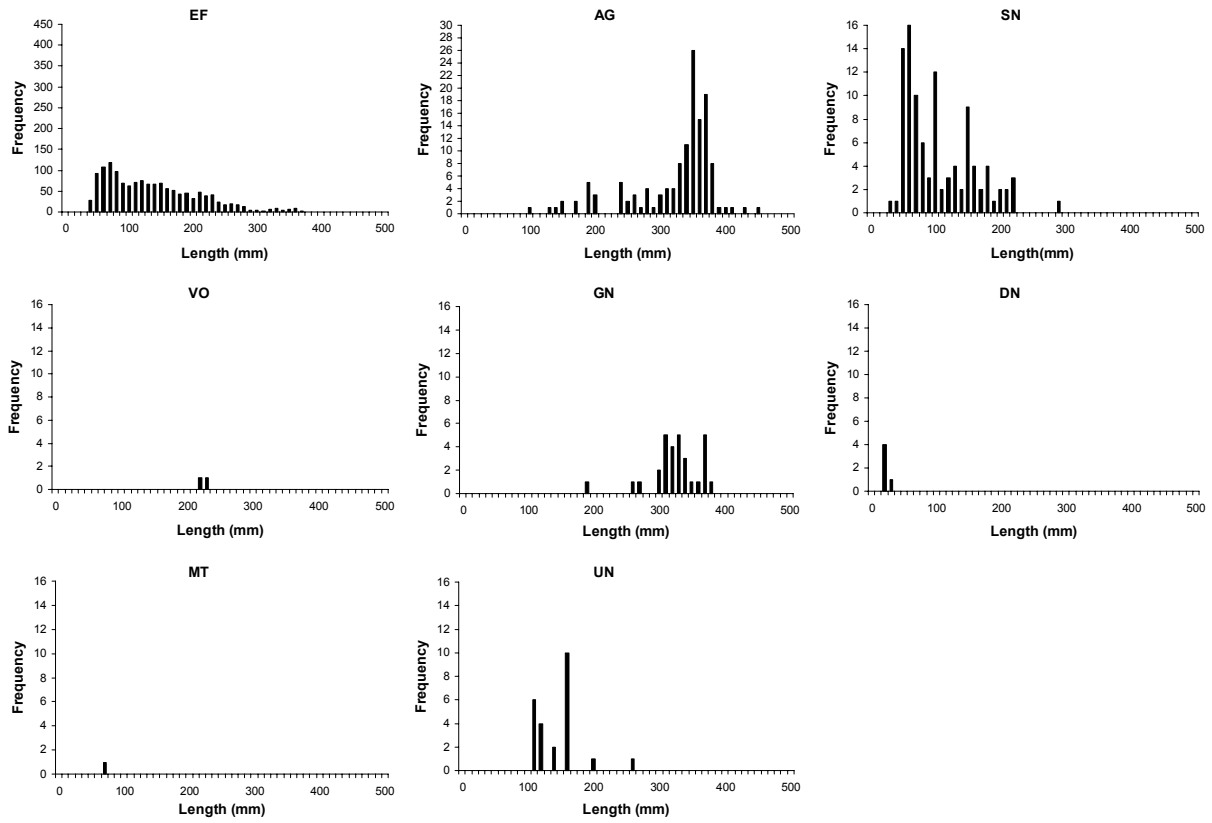
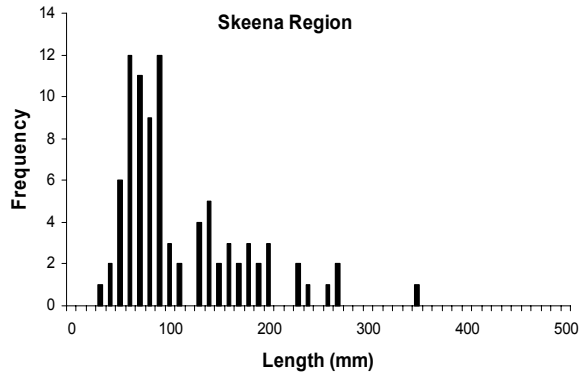


Figure 5. Length-frequency analysis for Arctic grayling sampled from the Peace region. A. All sample methods B. Separated into individual sample method.

A



B

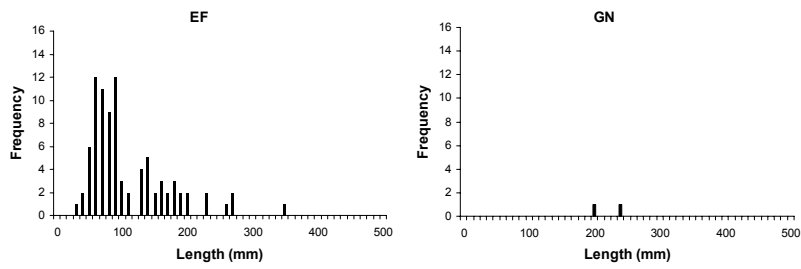
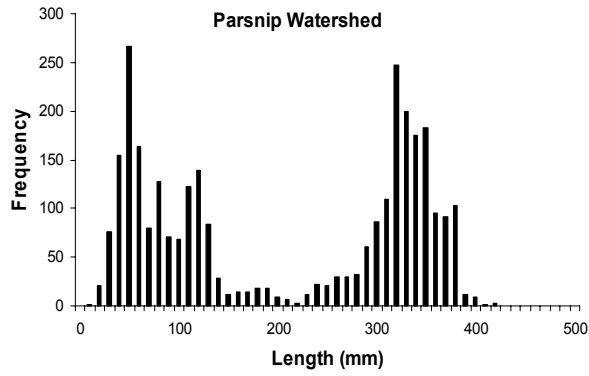


Figure 6. Length-frequency analysis for Arctic grayling sampled from the Skeena region. A. All sample methods B. Separated into individual sample method.

A



B

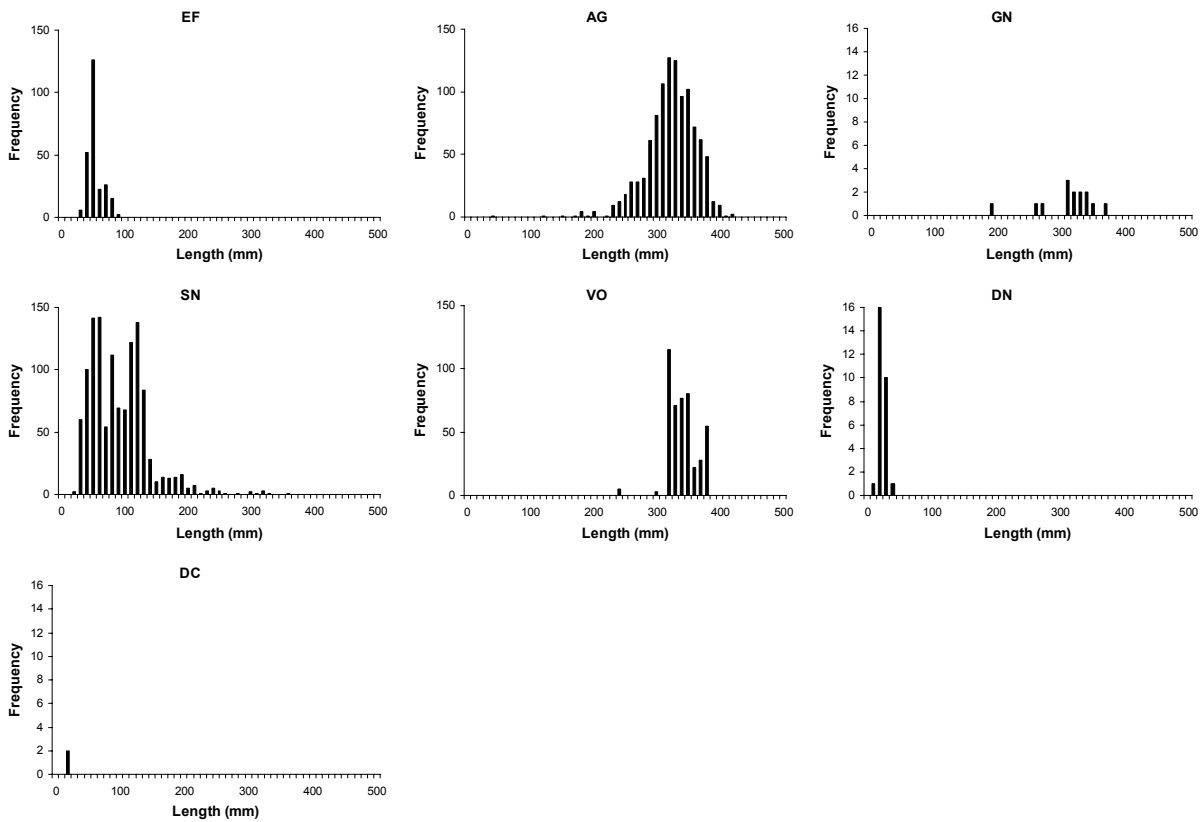
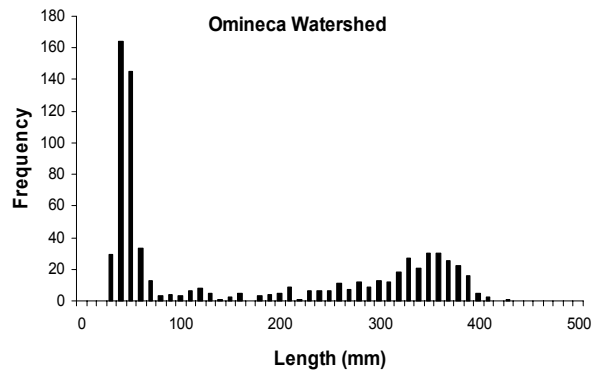


Figure 7. Length-frequency analysis for Arctic grayling sampled from the Parsnip watershed. A. All sample methods B. Separated into individual sample method.

A



B

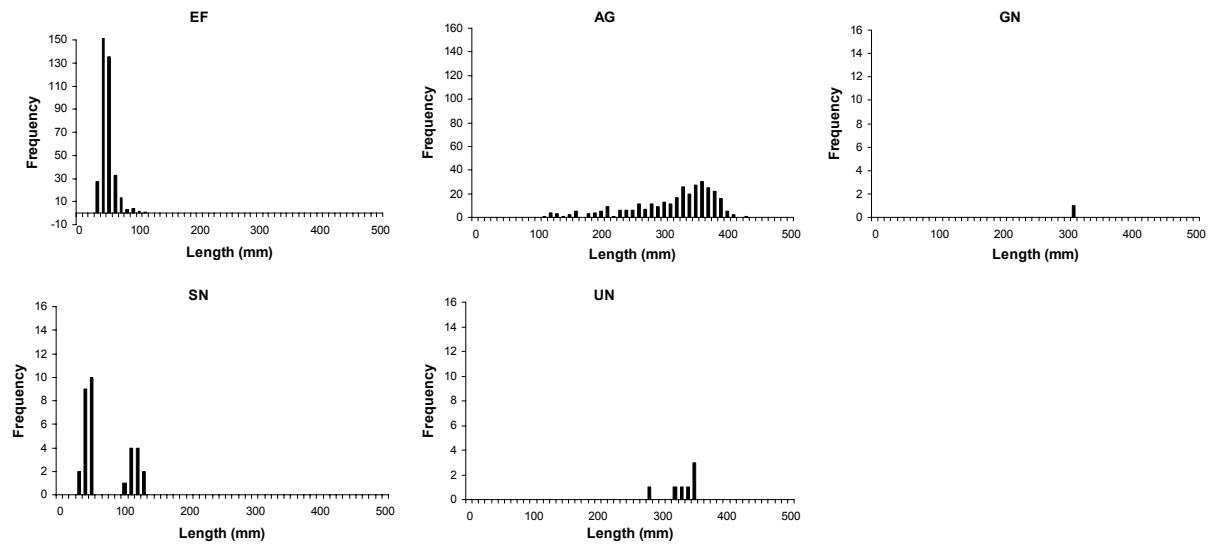
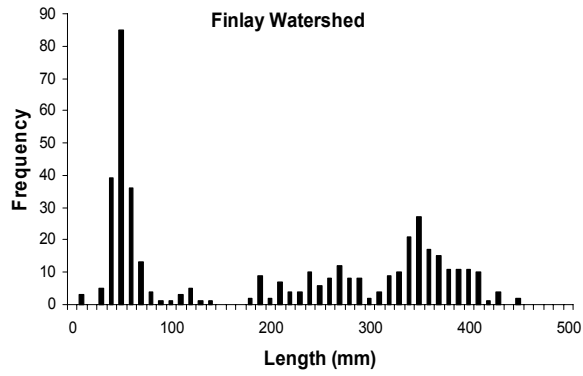


Figure 8. Length-frequency analysis for Arctic grayling sampled from the Omineca watershed. A. All sample methods B. Separated into individual sample method.

A



B

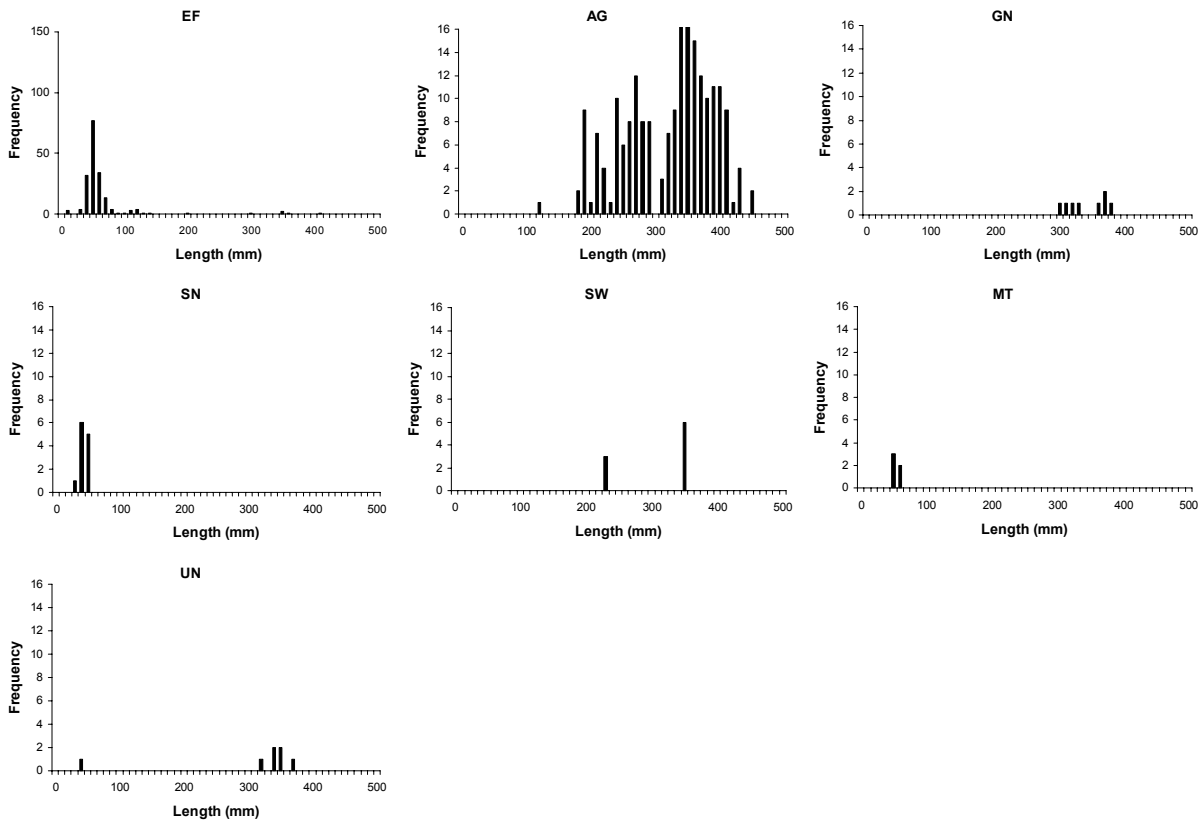


Figure 9. Length-frequency analysis for Arctic grayling sampled from the Finlay watershed. A. All sample methods B. Separated into individual sample method.

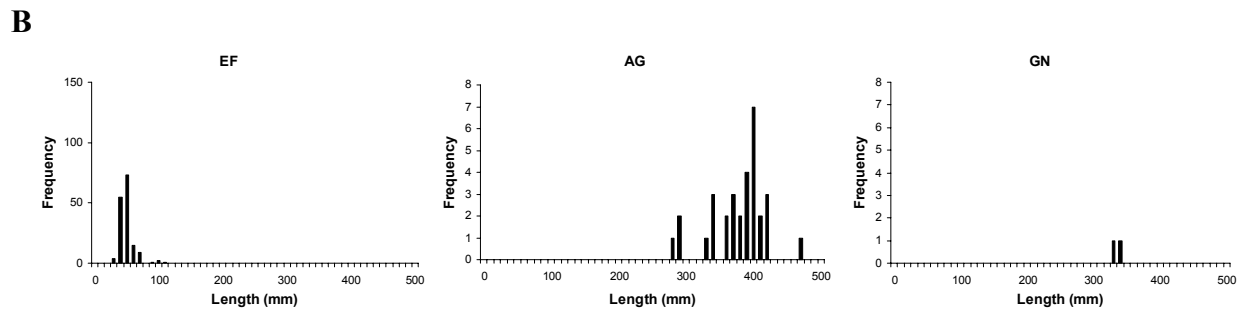
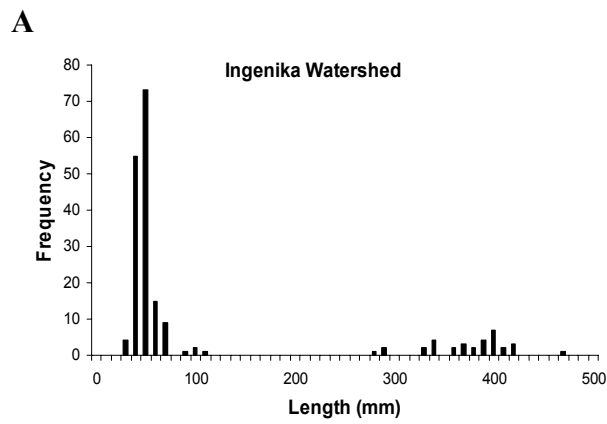


Figure 10. Length-frequency analysis for Arctic grayling sampled from the Ingenika watershed. A. All sample methods B. Separated into individual sample method.

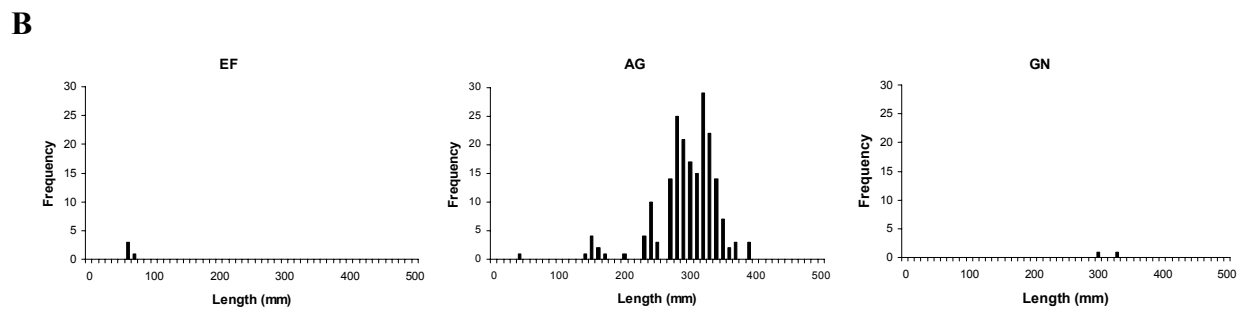
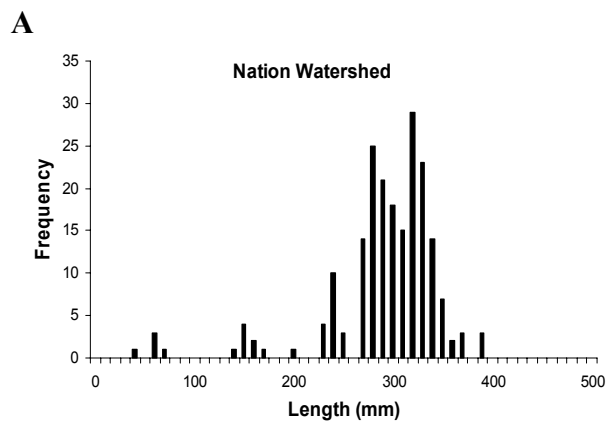


Figure 11. Length-frequency analysis for Arctic grayling sampled from the Nation watershed. A. All sample methods B. Separated into individual sample method.

1.4 Aging Techniques

Age estimates on Arctic grayling captured within their BC range have been based on three boney structures; scales, otoliths and fin rays. Recently, the validity of age estimates based on scale samples has been questioned. The standard alternative to scales has been to use otoliths, but the destructive sampling of fish to retrieve otoliths has made this approach impractical for vulnerable and threatened species. Yet the accuracy of age determination from otoliths is much better. DeCicco and Brown (2006) used oxytetracycline to mark grayling otoliths and then re-captured the fish after 4 years. The fluorescent oxytetracycline marks were clearly visible and the annuli visible beyond the mark accurately represented the years between mark and recapture. These authors also found that age estimates from scales underestimated the otolith estimated age by as much as 20 years. This study, however, was conducted on an older population of Alaskan Arctic grayling and the sample size was small (n=16). Armstrong (1986) analyzed another population of Alaskan Arctic grayling and found a slight difference between scale and otolith ages for fish up to 7 years old. For older fish in Armstrong's study, however, the scales tended to underestimate the age of the fish, similar to the study mentioned above.

Although there is evidence for the errors associated with using scales to age fish there are a number of studies suggesting that there is no difference in Arctic grayling scale and otolith ages. An earlier study conducted on a BC population Arctic grayling from Sukunka River in the Peace region found no difference between scale and otolith ages for 55 individual fish younger than 8 years old (Stuart and Chislett 1979). Another study conducted in the Peace region on Adsett Creek again found no difference in scale and otolith ages for 111 fish ages 1 to 8 years (Stewart *et al.* 1982). Silkstrom (1983) compared ageing techniques for a more northern population of Arctic grayling in the Yukon Territory from Marshall Creek. Scale ages were found to underestimate the fish age compared to the fin ray and otolith ages. Many of the individuals in this population, however, were noted to be slower growing and scale ages were accurate within 1 year for ages 1 to 8 years. The studies mentioned above appear to have found little to no difference between scale and otolith ages up to 8 years old. Similar validation of finray age estimates has not been done for Arctic grayling populations.

Most of the BC age estimates for grayling reported in the MOE provincial database have been performed on scale samples. Below is a comparison of age estimates from the different boney structures collected in the Omineca region. Figures 12 and 13 show comparisons of otolith and finray age estimates to scale age estimates. Data shown are for grayling collected in the Omineca region, where estimates of age were made using two methods for each fish. We have also differentiated data collected for fish from the different watersheds within the Omineca region. All the finray ages available in the Omineca region were determined by the PFWWCP and the otolith ages were reported in an unpublished study conducted in the summer of 2004 by Adrian Clarke, UNBC (Table 9). The findings of our analysis of the BC grayling database agree with those of DeCicco and Brown (2006); scale estimates of age may underestimate the actual age of the fish. In all cases the otolith age was greater than or equal to the scale age, except for one sample (Figure 12). Finray ages were also greater than or equal to the scale age, except for three samples (Figure 13). In some cases, scale age underestimated the otolith age by six years and scale age underestimated the finray age by up to seven years. Unfortunately, no direct comparison of otolith and finray ages was made.

Table 9. Aging data available where two aging structures were used to determine the age of individual Arctic grayling in the Omineca region (SC=Scale, FR=Finray, OT=Otolith).

Watershed	Year	Stream	Length (mm)	SC age	FR age	OT age	Sex	Reference*		
Parsnip	1997	ANZAC RIVER	330	4	4	-	F	1		
			330	4	6	-	F	1		
			335	5	6	-	M	1		
			337	6	8	-	U	1		
			340	7	8	-	M	1		
			345	6	6	-	F	1		
			350	6	7	-	U	1		
			365	6	6	-	M	1		
			370	6	8	-	U	1		
			370	7	7	-	M	1		
		385	7	9	-	F	1			
		TABLE RIVER	310	5	5	-	U	1		
			320	4	4	-	M	1		
			330	5	7	-	F	1		
			360	6	6	-	M	1		
			360	7	7	-	F	1		
			385	7	10	-	M	1		
			1998	ANZAC RIVER	311	5	5	-	F	1
					330	4	4	-	M	1
					332	6	7	-	F	1
	333				5	6	-	F	1	
	334	5			5	-	M	1		
	335	5			5	-	M	1		
	336	5			6	-	M	1		
	339	5			7	-	M	1		
	339	6			7	-	F	1		
	342	4			4	-	M	1		
	342	5			5	-	M	1		
	343	4			4	-	M	1		
	343	5			5	-	U	1		
	348	5			6	-	F	1		
	352	6			7	-	F	1		
	352	6		9	-	M	1			
	354	6		6	-	M	1			
	356	5		6	-	M	1			
	356	6		7	-	F	1			
	361	7		7	-	M	1			
	364	7		7	-	F	1			
	367	7		8	-	M	1			
	370	6		8	-	M	1			
	373	6		7	-	M	1			
	375	5		8	-	M	1			
	384	6		8	-	M	1			
	TABLE RIVER	329		5	5	-	U	1		
		332		6	6	-	U	1		
		333		6	7	-	U	1		
		336		5	6	-	U	1		
		2004	ANZAC RIVER	345	5	-	7	F	2	
				TABLE RIVER	265	3	-	3	U	2
					272	4	-	4	U	2
295			4		-	4	M	2		
297			3	-	9	F	2			
304			4	-	5	F	2			
305			4	-	7	F	2			
320			5	-	5	U	2			
325			5	-	5	U	2			
330			5	-	5	F	2			
331			5	-	8	F	2			
335	4		-	10	M	2				
345	5		-	6	M	2				
354	6		-	11	M	2				
360	7		-	10	F	2				
367	6	-	10	F	2					
372	5	-	9	M	2					
375	7	-	8	M	2					
380	6	-	9	M	2					
395	7	-	7	M	2					
2005	ANZAC RIVER	365	6	12	-	U	1			
		TABLE RIVER	315	4	4	-	U	1		
	MESILINKA RIVER	125	1	-	2	U	2			
Omineca	2004	MESILINKA RIVER	190	2	-	3	U	2		
			310	4	-	4	M	2		
			370	4	-	4	M	2		
			375	7	-	8	F	2		
			385	7	-	10	F	2		
			390	6	-	7	F	2		
			410	7	-	9	U	2		
			425	9	-	13	M	2		
			OMINECA RIVER	110	1	-	3	U	2	
				115	1	-	1	U	2	
		115		1	-	2	U	2		
		115		1	-	4	U	2		
		160		2	-	3	U	2		
		230	3	-	3	U	2			
		250	3	-	3	U	2			
	260	4	-	4	U	2				
	330	5	-	5	M	2				
	OSILINKA RIVER	330	5	-	6	F	2			

Watershed	Year	Stream	Length (mm)	SC age	FR age	OT age	Sex	Reference*
			335	6	-	5	F	2
			345	5	-	6	F	2
			345	5	-	-	M	2
			350	5	-	6	F	2
			350	6	-	6	F	2
			380	7	-	7	F	2
			390	6	-	6	M	2
			390	6	-	7	M	2
	2005	MISSINKA RIVER	310	5	5	-	U	1
			345	6	6	-	U	1
			350	7	7	-	U	1
			360	7	7	-	U	1
			365	6	6	-	U	1
			370	8	8	-	U	1
Finlay	2006	FINLAY RIVER	118	1	1	-	U	1
			186	2	2	-	U	1
			265	3	3	-	U	1
			288	4	5	-	U	1
			290	4	5	-	F	1
			313	4	4	-	F	1
			318	5	5	-	U	1
			336	6	7	-	F	1
			338	5	5	-	F	1
			341	6	8	-	F	1
			351	5	6	-	U	1
			351	6	6	-	F	1
			355	6	6	-	U	1
			361	6	6	-	M	1
			364	5	5	-	U	1
			365	6	6	-	M	1
			365	7	8	-	F	1
			370	7	7	-	M	1
			373	6	6	-	F	1
			375	6	6	-	M	1
			376	7	7	-	M	1
			378	6	6	-	U	1
			379	6	7	-	M	1
			380	7	7	-	F	1
			382	6	6	-	M	1
			384	6	6	-	M	1
			384	6	7	-	U	1
			384	7	6	-	F	1
			387	5	6	-	M	1
			388	7	7	-	U	1
			390	6	7	-	M	1
			390	6	7	-	U	1
			392	6	7	-	M	1
			392	6	8	-	M	1
			395	7	9	-	M	1
			398	5	8	-	M	1
			400	7	7	-	M	1
			403	6	6	-	M	1
			408	7	7	-	M	1
			408	8	8	-	M	1
			420	7	7	-	M	1
			421	8	8	-	M	1
			422	8	8	-	M	1
			430	8	9	-	M	1
	2007	FINLAY RIVER	352	9	9	-	M	1
			353	6	6	-	M	1
			360	7	7	-	M	1
			376	6	7	-	M	1
			394	6	7	-	M	1
Ingenika	2004	INGENIKA RIVER	286	7	-	11	U	2
			333	5	-	5	U	2
			336	5	-	6	U	2
			355	5	-	6	U	2
			366	6	-	7	U	2
			376	7	-	7	U	2
			384	6	-	6	U	2
Nation	2004	NATION RIVER	240	3	-	4	U	2
			270	3	-	3	U	2
			270	4	-	3	U	2
			320	4	-	6	U	2
			325	5	-	5	U	2
			335	6	-	6	U	2
			350	5	-	6	U	2
			350	5	-	7	U	2
			355	5	-	6	U	2
			360	6	-	6	U	2

*All aging data was collected by 1. PFWWCP or 2. An unpublished study by Adrian Clarke, UNBC.

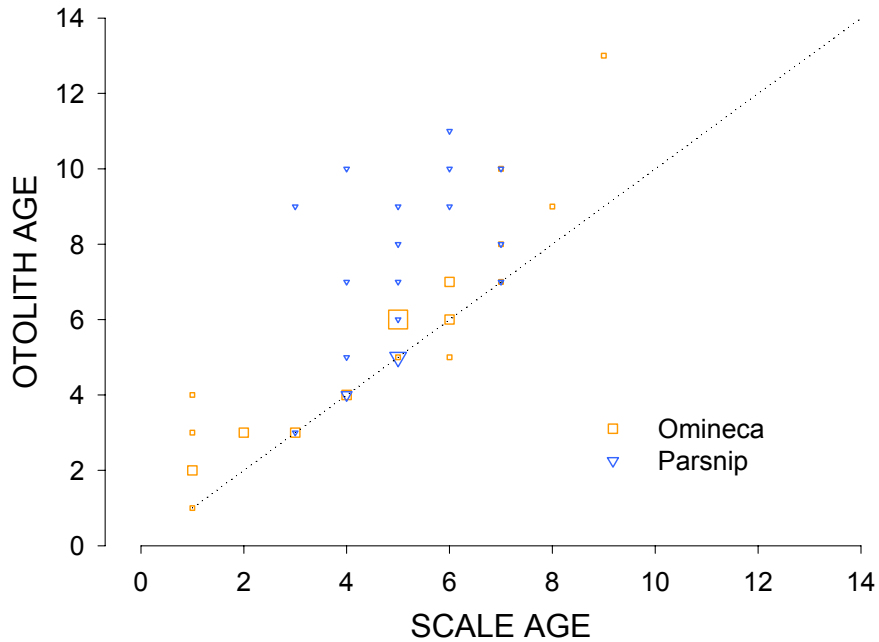


Figure 12. Comparison of age estimates using two different structures; otolith and scale samples collected from each individual and separately analyzed to determine age. Symbol size is proportional to number of samples.

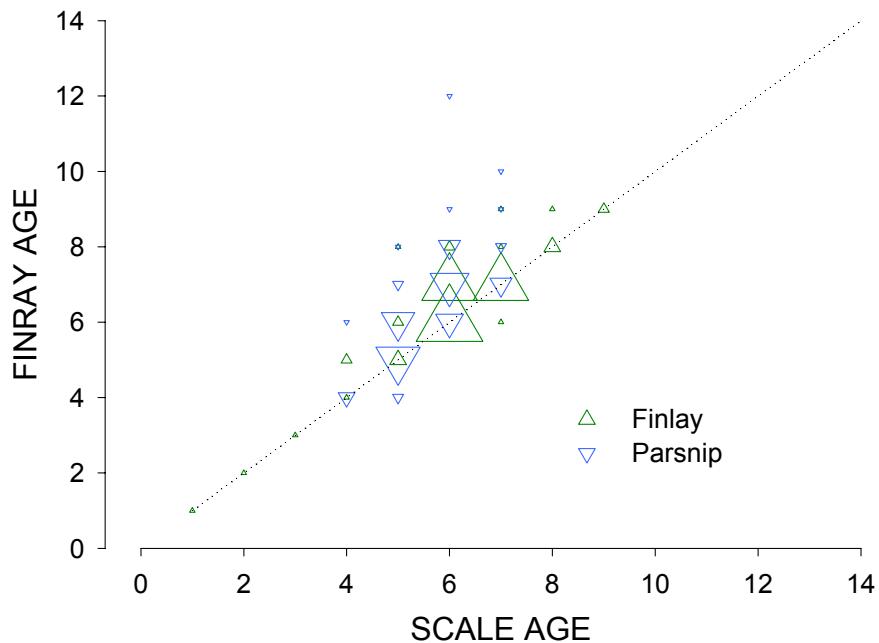


Figure 13. Comparison of age estimates using two different structures; finray and scale samples collected from each individual and separately analyzed to determine age. Symbol size is proportional to number of samples.

1.5 Size at Age

Most of the age estimates for Arctic grayling in all three management regions were determined from scale analysis; therefore all further analysis using age was done with scale ages estimates. According to the data reported, Arctic grayling ranged in age from age 0 to 9 years within the Omineca region (Figure 14A). There appears to be a considerable range in size for each age class, with considerable overlap in size between age classes. In the Peace region length at age data was available for ages 0 to 8 years, with the majority of this data being from 3 and 4 year old fish (Figure 14B). Far less length at age data was available for the Arctic grayling population in the Skeena region and it appears to be concentrated on younger fish (<5yrs) (Figure 14C). Further sampling in this region is needed to determine if the lack of older fish (>5yrs) is an artifact of sampling or a characteristic of the population.

Filtering the Omineca region into the major watersheds tended to decrease the range in sizes within each age class (Figure 15). Length at age for Arctic grayling populations in the Parsnip, Omineca and Finlay watersheds covered a range of ages including fish 0 to 9 years (Figure 15A, B, and C). In the Ingenika watershed younger fish (<3yrs) have not been reported and in the Nation watershed older fish (>5yrs) have not been reported. Only 2 length at age records were available for Arctic grayling in the Peace watershed. Therefore, further sampling of Arctic grayling populations in the Ingenika, Nation and Peace watersheds is needed to determine if these trends are due to sampling effort or if they are a characteristic of the populations.

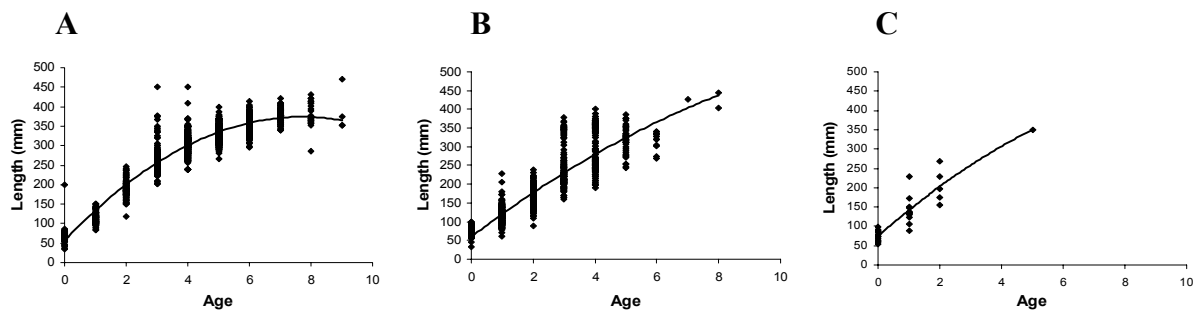


Figure 14. Arctic grayling length at age analysis for each region. A. Omineca Region (n=1769) B. Peace region (n=877) C. Skeena region (n=31).

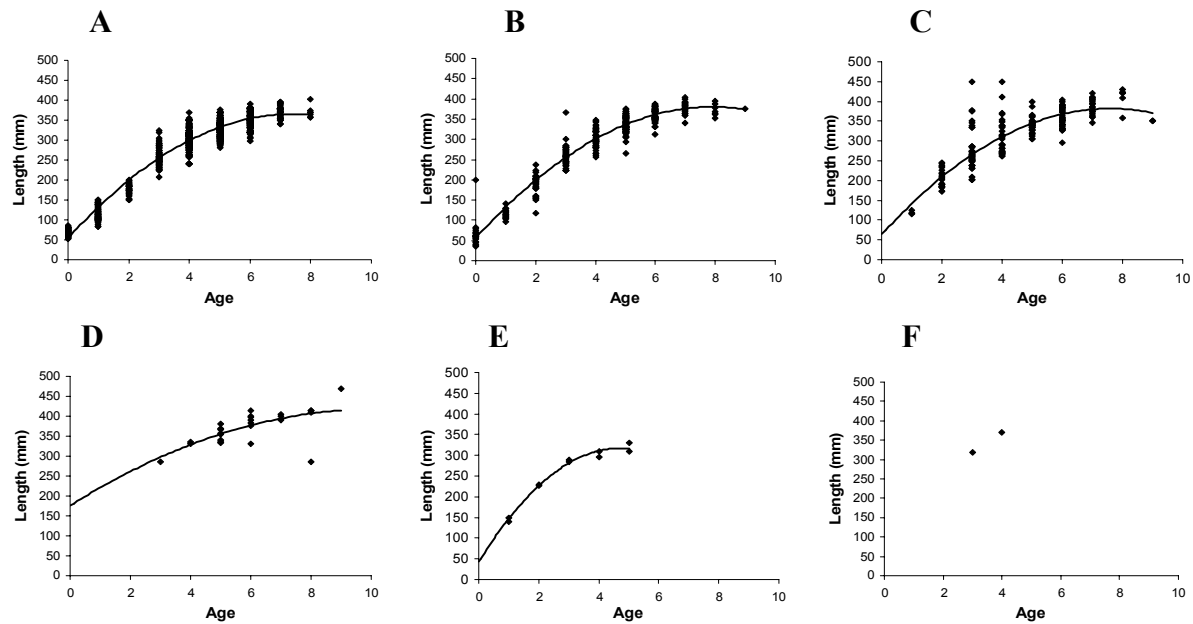


Figure 15. Arctic grayling length at age relationships for major watersheds in the Omineca Region. A. Parsnip (n=1218) B. Omineca (n=309) C. Finlay (n=203) D. Ingenika (n=27) E. Nation (n=10) F. Peace (n=2).

1.6 Von Bertalanffy growth

The Von Bertalanffy growth equation, $L_t = L_\infty(1 - e^{-K(t-t_0)})$ was used to fit curves to the Arctic grayling length at age data in different watersheds within the Omineca region. L_t is the predicted mean length of the fish of a population at age t , L_∞ is their mean asymptotic length, K is a rate of time, and t_0 is the theoretical age the fish would have at length zero, which is not a real biological parameter but rather a modeling artifact.

A non-linear three parameter model was used to calculate the von Bertalanffy growth parameters, L_∞ and K for each of the watersheds in the Omineca region using the statistical program R version 2.10.0 (R Development Core Team 2008) (Table 10). If K is large for a population then maturity will be reached at a smaller size and if K is small fish will reach a larger size. To compare the resulting growth curves we first calculated an initial value for growth rate (ω) which is representative of the growth rate near t_0 for each watershed using the biological parameters L_∞ and K , $\omega = L_\infty * K$. The Nation watershed had the highest ω value (20.52 cm/yr) almost twice that calculated for the Omineca watershed (10.67 cm/yr) (Table 10). The Nation River headwaters flow through four lakes and have been reported to have warmer temperatures compared to other watersheds where grayling have been reported (Zemlak and Langston 1998). These higher temperatures may be influencing the higher growth rates of Arctic grayling found in the Nation watershed, or this may be an artifact of the small sample size (n=10).

In order to further compare the growth curves of each watershed in the Omineca region statistically, three maximum likelihood models were considered: “All parameters vary”; “Common K”; and “Common L_{∞} ”. The AIC (Akaike's information criterion) and dAIC (AIC_i - minAIC, where AIC_i is the value for model i, and the minAIC is the value of the best model) values were calculated for each model and compared (Table 11). The “Common K” model is the best fit model (dAIC = 0) and the “Common L_{∞} ” also does not appear to differ significantly (dAIC = 4.65). The “All parameters vary (L_{∞} , K)” model, however, had a much greater dAIC value (dAIC = 55.89). This analysis suggests that Arctic grayling growth does not differ among watersheds in the Omineca region.

Table 10. Summary of the parameter estimation in fitting the von Bertalanffy growth function to length-at-age data of Arctic grayling of different watersheds in the Omineca region.

Watershed	n	L_{∞} (cm)	SE	p-value	K (yr ⁻¹)	SE	p-value	t_0	SE	p-value	ω (L_{∞} *K)
Parsnip	1226	44.11	0.61	< 2e-16	0.25	0.01	< 2e-16	-0.49	0.03	< 2e-16	11.02
Omineca	309	46.39	1.24	< 2e-16	0.23	0.01	< 2e-16	-0.53	0.06	2.86e-16	10.67
Finlay	203	40.91	1.26	< 2e-16	0.37	0.05	2.10e-13	0.08	0.20	0.665*	15.14
Ingenika	27	43.55	5.31	2.04e-08	0.32	0.25	0.219*	-0.45	2.51	0.860*	13.94
Nation	10	33.64	1.13	1.22e-08	0.61	0.09	0.00033	0.08	0.14	0.55480*	20.52
Peace	2										
Manson	2										

*Values were not significant (p-values >0.05).

Table 11. Summary of maximum likelihood model comparisons.

Model	AIC	dAIC*
Common K	3147.32	0
Common L_{∞}	3151.97	4.65
All parameters vary	3203.22	55.89

*dAIC value of 5 is considered significant.

According to information extracted from the international online database Fishbase (FishBase 2000) von Bertalanffy growth parameters calculated for populations of Arctic grayling in the Omineca region fall within the range of growth rates calculated for other populations of Arctic grayling throughout their global range (Figure 16). Although these rates appear to be similar to other populations of Arctic grayling as well as other salmonid species, there are a number of assumptions associated with this method of calculating growth rates and caution must be used when integrating these results into management decisions. For example, the rates are calculated using age data and there still appears to be some controversy with aging techniques used on certain age classes (DeCicco and Brown 2006). The age composition of each sample may also have an effect on the calculated growth rates. Errors may arise if the entire age range of a population is not represented in the data.

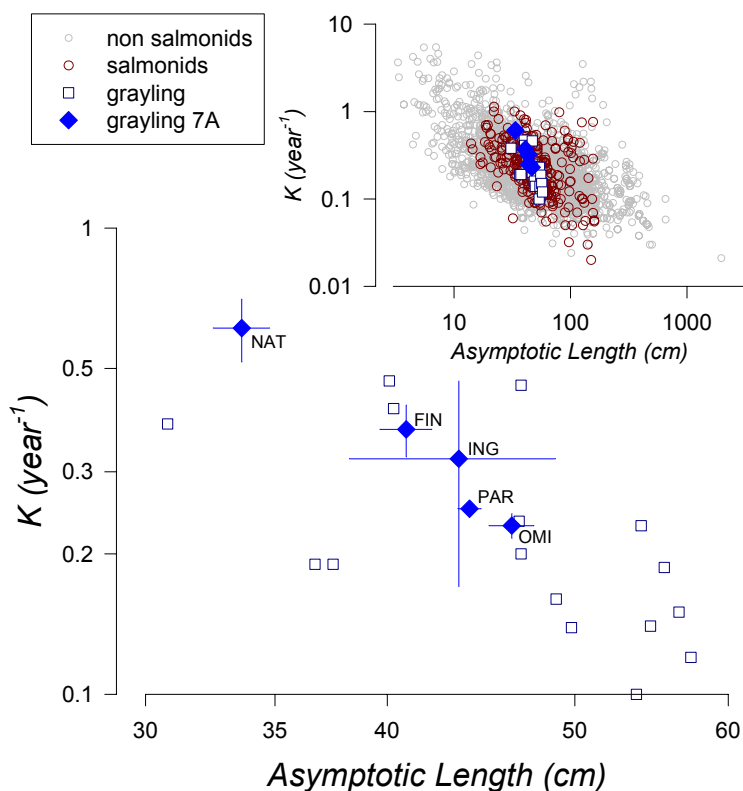


Figure 16. Calculated growth rates, with error bars, of Arctic grayling sampled in the major watersheds of the Omineca region compared to growth rates of other Arctic grayling populations extracted from Fishbase. The inset shows data for other salmonids and other species extracted from Fishbase.

1.7 Sex Ratios

Sex was not reported for all fish sampled in the Omineca region and appears to have been limited to an assessment of older fish. There are 1291 records of sex for Omineca region Arctic grayling in the provincial dataset. We used the number of males and females sampled per stream for a given date and sampling method to estimate sex ratio. Sex ratio was calculated as number of females in the sample divided by the total number of fish sampled [$F/(M+F)$]. The minimum ratio was 0 (only males) and the maximum ratio was 1 (all females in the sample) (Table 12). The range of sex ratios gives the impression that the numbers of females and males varies across the region and would have implications of genetic stability within the populations. These differences in sex ratio, however, more likely reflect sampling effort as the greatest variation was seen when sample sizes were small (Figure 17). The majority of the samples were collected by angling ($n=828$ (407 F and 421 M)), however, sex was also determined for a large portion of the Arctic grayling reported by visual observation ($n=437$ (154 F and 283 M)). The accuracy of determining Arctic grayling sex is limited by visual observation and therefore, the accuracy of these records may not be reliable compared to the accuracy of lethal sampling methods.

To minimize lethal sampling of Arctic grayling in the Omineca region, external observations were used in most cases to determine the sex of sampled Arctic grayling (B. G. Blackman,

personal communication, April 15, 2009). Arctic grayling are typically not sexually dimorphic before maturity. When they mature, however, the dorsal fin of the male is noticeably longer than that of the female, nearly reaching the adipose fin (Scott and Crossman, 1985). Therefore, using external observations to determine sex would not be valid for immature fish. For example, immature male Arctic grayling may be incorrectly reported as female when using external observations to determine sex. Within the provincial database the smallest Arctic grayling to be reported as mature was 230mm (Table 15). However, the majority of grayling sampled in the Omineca region that were less than 230 mm were not identified as male or female (Figure 18).

A difference is also seen in size of males and females captured. For example, in 85% of the sampling events conducted in the Parsnip watershed by angling males were larger in mean length than females (Table 12). The tendency for males to be larger than females was also seen in samples collected in other parts of the Williston Watershed (Table 12).

Table 12. Sex ratios and mean length of Arctic grayling sampled in the Omineca region.

Method	Watershed	Year	Month	Stream	Sex	Total	FM Ratio	Mean Length (mm)	SD	n			
AG	Finlay	1975	July	CHOWIKA CREEK	M	1	0	340.0	-	1			
				COLLINS CREEK	F	2	0.67	430.0	28.3	2			
					M	1		450.0	-	1			
				DAVIS RIVER	F	1	0.33	325.0	-	1			
					M	2		358.0	14.1	2			
				LAFFERTY CREEK	F	1	0.33	353.0	-	1			
			M	2		341.5	6.4	2					
		1985	August	FIRESTEEL RIVER	F	2	0.67	352.5	24.7	2			
					M	1		358.0	-	1			
		2006	August	FINLAY RIVER	F	28	0.45	327.8	38.9	28			
					M	34		387.1	25.9	34			
					U	39		280.3	64.7	39			
		2007	August	FINLAY RIVER	F	28	0.58	276.9	44.3	28			
					M	20		347.3	31.8	20			
	Ingenika	2003	August	INGENIKA RIVER	F	3	0.60	426.7	37.9	3			
					M	2		390.0	0.0	2			
	Manson Nation	1975	June	MANSON RIVER	M	1	0	230.0	-	1			
		1992	July	NATION RIVER	F	56	0.44	292.4	23.9	56			
	M				70		313.0	27.3	70				
	2004	July	NATION RIVER	F	3	0.43	335.0	15.0	3				
				M	4		268.8	156.6	4				
				U	7		345.7	41.2	7				
					F	1	0.33	270.0	-	1			
					M	2		255.0	21.2	2			
					U	2		245.0	106.1	2			
				Omineca	1975	September	MESILINKA RIVER	M	1	0	345.0	-	1
								F	2	1	350.0	2.8	2
					2001	August	OMINECA RIVER	M	3	0	358.0	20.3	3
								F	2	0.40	382.5	10.6	2
	2004	August	LAY CREEK		M	3		401.7	28.4	3			
					F	2	0.67	382.5	3.5	2			
				M	1		310.0	-	1				
				M	1	0	330.0	-	1				
	Parsnip	1975	June	BLACKWATER CREEK	M	1	0	354.0	-	1			
					F	2	1	337.0	18.4	2			
		July	CUT THUMB CREEK	F	2	1	325.0	-	1				
				F	1	1	325.0	-	1				
		September	IZAAC CREEK	F	1	1	325.0	-	1				
				F	1	0.33	328.0	-	1				
		1996	April	ANZAC RIVER	F	1	0.33	328.0	-	1			
					M	2		375.0	7.1	2			
		May	ANZAC RIVER	F	3	0.33	342.3	26.4	3				
				M	6		341.2	20.7	6				
	June	ANZAC RIVER	F	1	0.11	341.0	-	1					
			M	8		337.0	13.7	8					
	August	ANZAC RIVER	F	3	0.33	325.0	13.2	3					
			M	6		359.3	14.0	6					
TABLE RIVER			F	5	0.71	303.5	37.8	5					
			M	2		324.5	0.7	2					
1997	February	TABLE RIVER	F	5	0.50	310.0	17.3	5					
			M	5		324.0	17.1	5					
May	TABLE RIVER		M	1	0	310.0	-	1					
			F	8	0.50	302.5	33.1	8					
July	ANZAC RIVER		M	8		332.4	30.8	8					
			F	8	0.73	319.8	30.0	8					
August	ANZAC RIVER		M	3		360.0	21.8	3					
			F	13	0.68	321.9	29.3	13					
NO NAME			M	6		354.2	27.1	6					
			M	1	0	345.0	-	1					
TABLE RIVER			F	5	0.38	332.4	9.0	5					
			M	8		339.3	12.4	8					

Method	Watershed	Year	Month	Stream	Sex	Total	FM Ratio	Mean Length (mm)	SD	n	
			September	ANZAC RIVER	F	14	0.50	323.9	23.8	14	
					M	14		353.1	17.5	13	
				NO NAME	F	4	0.44	352.5	10.4	4	
					M	5		367.6	24.9	5	
				TABLE RIVER	F	12	0.67	348.6	27.4	12	
					M	6		355.0	19.7	6	
		1998	August	ANZAC RIVER	F	104	0.53	315.0	23.8	104	
					M	91		339.4	24.0	91	
				MISSINKA RIVER	M	1	0	383.0	-	1	
					U	7		247.9	23.1	7	
				TABLE RIVER	F	7	0.58	308.3	23.2	7	
					M	5		323.6	12.4	5	
		2004	June	TABLE RIVER	F	12	0.60	309.9	35.0	12	
					M	8		359.5	35.3	8	
					U	1		325.0	-	1	
			July	ANZAC RIVER	F	4	0.50	338.8	17.5	4	
					M	4		347.5	45.7	4	
					U	20		318.8	45.3	20	
		2005	July	ANZAC RIVER	F	7	0.64	321.0	28.5	7	
					M	4		357.5	38.0	4	
				TABLE RIVER	F	8	1	300.1	15.1	8	
			August	ANZAC RIVER	F	3	1	323.0	19.3	3	
				HOMINKA RIVER	F	1	0.50	370.0	-	1	
					M	1		355.0	-	1	
				PARSNIP RIVER	F	1	0.50	370.0	-	1	
					M	1		355.0	-	1	
		2007	August	ANZAC RIVER	F	37	0.34	315.3	23.9	37	
					M	72		343.8	26.0	72	
EF	Finlay	1999	August	FOX RIVER	F	1	0.25	295.0	-	1	
					M	3		350.3	7.5	3	
					U	2		116.5	0.7	2	
GN	Finlay	1975	September	LAFFERTY CREEK	F	1	0.25	315.0	-	1	
					M	3		368.3	7.6	3	
				OSPIKA RIVER	F	1	0.50	292.0	-	1	
					M	1		305.0	-	1	
		1991	September	FINLAY RIVER	M	2	0	346.5	24.7	2	
	Ingenika	1975	September	INGENIKA RIVER	F	2	1	332.5	3.5	2	
	Manson	1975	June	MANSON RIVER	M	1	0	366.0	-	1	
	Nation	1975	September	NATION RIVER	F	2	1	312.5	24.7	2	
	Omineca	1975	September	OMINECA RIVER	F	1	1	310.0	-	1	
	Parsnip	1975	June	BLACKWATER CREEK	F	1	1	184.0	-	1	
				TONY CREEK	M	1	0	322.0	-	1	
				TUTU CREEK	F	1	1	328.0	-	1	
				WESTON CREEK	F	4	1	345.5	16.7	4	
			July	MUGAHA CREEK	F	2	1	287.0	29.7	2	
			November	PARSNIP RIVER	M	5	0	303.0	27.3	5	
	Peace	1975	June	STRANDBERG CREEK	M	2	0	344.5	36.1	2	
SN	Parsnip	1998	September	PARSNIP RIVER	F	3	0.60	287.7	36.2	3	
					M	2		325.5	40.3	2	
VO	Parsnip	1996	August	ANZAC RIVER	F	3	0.33	325.0	13.2	3	
					M	6		359.3	14.0	6	
				PARSNIP RIVER	F	1	0.50	240.0	-	1	
					M	1		317.0	-	1	
				TABLE RIVER	F	9	0.56	326.6	13.1	9	
					M	7		340.1	12.4	7	
			September	ANZAC RIVER	F	15	0.28	336.1	17.4	15	
					M	38		348.8	20.3	38	
				PARSNIP RIVER	F	10	0.48	315.9	32.1	10	
					M	11		330.4	12.3	11	
				TABLE RIVER	F	4	0.50	333.1	6.2	4	
					M	4		340.3	14.2	4	
			November	PARSNIP RIVER	F	10	0.43	325.1	33.9	10	
					M	13		341.6	20.5	13	
				TABLE RIVER	F	1	0.50	342.0	-	1	
					M	1		324.0	-	1	
			December	ANZAC RIVER	M	4	0	361.5	16.8	4	
				PARSNIP RIVER	F	9	0.45	321.1	34.9	9	
					M	11		340.5	18.3	11	
				TABLE RIVER	F	1	1	342.0	-	1	
			1997	February	ANZAC RIVER	M	2	0	366.5	16.3	2
					F	7	0.41	316.4	37.6	7	
				PARSNIP RIVER	M	10		345.8	19.6	10	
					F	1	0.50	342.0	-	1	
					M	1		333.0	-	1	
			March	ANZAC RIVER	M	2	0	366.5	16.3	2	
				PARSNIP RIVER	F	8	0.38	326.3	16.3	8	
					M	13		342.6	18.9	13	
			April	ANZAC RIVER	M	7	0	365.6	12.2	7	
				PARSNIP RIVER	F	12	0.38	324.2	13.8	12	
					M	20		342.7	20.8	20	
				TABLE RIVER	F	1	1	340.0	-	1	
			May	ANZAC RIVER	F	4	0.19	317.5	2.9	4	
					M	17		357.6	19.5	17	
				PARSNIP RIVER	F	5	0.26	318.4	6.7	5	
					M	14		340.5	19.0	14	
				TABLE RIVER	F	4	0.67	335.0	10.0	4	
					M	2		333.0	0.0	2	
			June	ANZAC RIVER	F	13	0.30	320.3	5.9	13	
					M	30		355.7	20.4	30	
				PARSNIP RIVER	F	2	0.14	312.0	0.0	2	
					M	12		344.2	12.2	12	

Method	Watershed	Year	Month	Stream	Sex	Total	FM Ratio	Mean Length (mm)	SD	n
				TABLE RIVER	F	7	0.70	328.6	10.7	7
				TABLE RIVER	M	3		333.0	0.0	3
			July	ANZAC RIVER	F	9	0.26	317.4	5.1	9
				ANZAC RIVER	M	26		351.5	19.3	26
				PARSNIP RIVER	F	1	0.20	312.0	-	1
				PARSNIP RIVER	M	4		322.3	10.5	4
				TABLE RIVER	F	6	0.75	330.0	11.0	6
				TABLE RIVER	M	2		333.0	0.0	2
			August	ANZAC RIVER	F	2	0.18	321.5	9.2	2
				ANZAC RIVER	M	9		345.4	21.1	9
				PARSNIP RIVER	F	1	0.50	312.0	-	1
				PARSNIP RIVER	M	1		317.0	-	1
				TABLE RIVER	F	2	1	330.0	14.1	2
			October	ANZAC RIVER	F	3	0.27	321.0	6.6	3
				ANZAC RIVER	M	8		347.8	22.6	8
				PARSNIP RIVER	F	1	0.20	312.0	-	1
				PARSNIP RIVER	M	4		331.0	12.2	4
				TABLE RIVER	F	2	1	330.0	14.1	2
UN	Finlay	1975	July	CHOWIKA CREEK	M	1	0	350.0	-	1
				COLLINS CREEK	F	2	1	329.5	13.4	2
				LAFFERTY CREEK	F	2	1	345.0	7.1	2
	Omineca	1975	September	OMINECA RIVER	F	5	0.63	403.0	149.9	5
				OMINECA RIVER	M	3		320.0	39.1	3

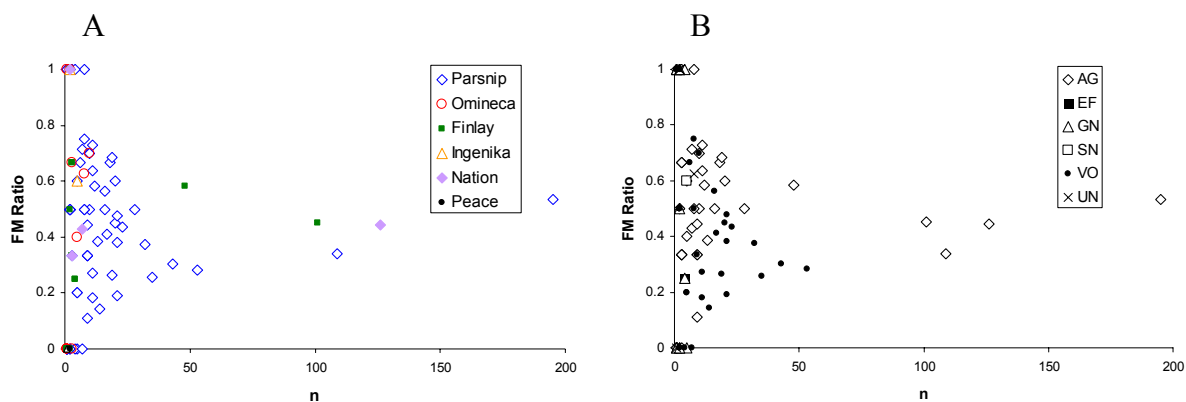


Figure 17. Sex ratios for Arctic grayling in region 7A plotted against the number of fish in the capture sample. A. Major watersheds B. Sampling methods.

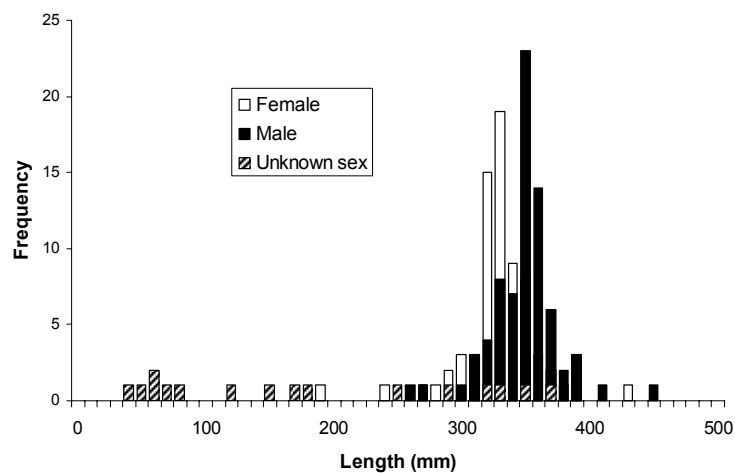


Figure 18. Length frequency analysis of the Arctic grayling with sex reported in the Omineca region.

2.0 Spawner surveys

In the Omineca region few studies have been conducted to locate spawning habitat, determine timing of spawning, or estimate fecundity. A radiotelemetry study conducted by the PFWWCP in 1996 and 1997 did track 55 Arctic grayling from summer feeding grounds in the Table and Anzac Rivers, to overwintering areas, and documented their movement to spawning areas. Spawning date and area in this study were based on water temperature, incubation and hatchery calculated growth rates determined in previous hatchery studies. Potential spawning habitat was characterized as shallow gravel riffles or glides; however, no grayling were tracked to these habitats during the estimated spawning dates. The results of this study suggest that the radiotagged Arctic grayling preferred multi channeled areas of the Anzac and Parsnip Rivers for spawning during May and June. Unfortunately, the survival rate for tagged fish in this study was low and limited the interpretation of the results (Blackman 2002a).

The MOE provincial database has limited additional information on Arctic grayling spawning details. Information available is limited to maturity stage of Arctic grayling sampled and is described below.

2.1 Maturity

Maturity was recorded for a small proportion of all the Arctic grayling sampled. Length-weight relationships and condition factors are influenced by the stage of sexual maturity of each fish. Sexual maturity of Arctic grayling can be determined directly by gonad observations or by external observation of secondary sexual characteristics. For this analysis it was assumed that each study determined maturity using Resource Inventory Committee (RIC) standards (Table 13) (RIC, 1996).

Table 13: Description of Resource Inventory Committee (RIC) standards for determining maturity of specimens (RIC, 1996).

Stage	Description
Immature (IM)	Young individuals that have not yet reproduced; fish with underdeveloped gonads.
Maturing (MT)	Ovaries and testes begin to fill out and take up a large part of the body cavity; eggs distinguishable to the naked eye.
Mature (M)	Fish in full spawning colours; gonads at maximum size; body cavity feels full, especially females; roe or milt is not produced if the body cavity is lightly squeezed.
Spawning (SP)	Fish in full spawning colours; eggs and milt are expelled when body cavity is lightly squeezed (also referred to as gravid).
Spent (ST)	Still have spawning colours; eggs and sperm totally discharged; body cavity feels empty and genital opening is inflamed; gonads empty except for a few remaining eggs or residual sperm.
Resting (R)	Adult sized fish; spawning colours not as apparent; gonads are very small and eggs may be present.

Determining stage of maturity was attempted for less than 16% (n=761) of the Arctic grayling sampled in the Omineca region. Immature, maturing, mature, spawning, and spent were all stages observed for the Omineca region populations and no grayling were reported as resting

(Table 14). The stage of maturity data was sorted into the various sampling methods, major watersheds, years, months and streams. It is unclear from the records if maturity was determined by lethal sampling or external observation, therefore caution must be taken when interpreting this data.

The average Arctic grayling in the provincial database was reported as mature at 337.9 mm (Table 15). The majority of these Arctic grayling (99%), however, were assessed by visual observation. Therefore, there may be considerable uncertainty associated with the assignment of maturity according to the RIC standards listed above. Most of the Arctic grayling (59%) reported in the Omineca region were identified as mature and were sampled in all months of the year except January (Figure 19). Immature, maturing, spawning and spent Arctic grayling were primarily sampled in the summer months (June-September). The timing of the stage of maturity represented by this analysis is most likely an artefact of sampling effort and the potential inaccuracy of assessing stage of maturity based on external observations.

Table 14. Mean length of Arctic grayling at different stages of maturity in the Omineca region.

Method	Maturity*	Watershed	Year	Month	Stream	n	Mean Length (mm)		SD	n	Mean Weight (g)		SD	n
AG	IM	Nation	1992	July	NATION RIVER	20	245.2	59.0	20	216.4	120.6	20		
			2004	August	MESILINKA RIVER	2	157.5	46.0	2	-	-	-		
		Omineca	2004	July	OMINECA RIVER	9	177.2	66.4	9	-	-	-		
				June	TABLE RIVER	1	220.0	-	1	-	-	-		
		Parsnip	2004	July	ANZAC RIVER	2	268.5	4.9	2	-	-	-		
				June	MANSON RIVER	1	230.0	-	1	440.0	-	1		
	M	Manson	1975	June	MANSON RIVER	1	230.0	-	1	440.0	-	1		
				July	COLLINS CREEK	1	450.0	-	1	355.0	-	1		
	MT	Finlay	2004	August	FOX RIVER	7	292.6	68.1	7	-	-	-		
				August	INGENIKA RIVER	20	361.7	40.5	20	540.7	155.9	20		
		Ingenika	2004	August	MESILINKA RIVER	1	345.0	-	1	400.0	-	1		
				September	OMINECA RIVER	1	340.0	-	1	-	-	-		
		Omineca	2001	August	OMINECA RIVER	1	340.0	-	1	-	-	-		
				September	IZAAC CREEK	1	325.0	-	1	360.0	-	1		
		1998	August	MISSINKA RIVER	7	266.9	56.2	7	209.9	163.8	7			
				July	CHOWIKA CREEK	1	340.0	-	1	370.0	-	1		
		ST	Finlay	1975	July	COLLINS CREEK	2	430.0	28.3	2	341.5	9.2	2	
					July	DAVIS RIVER	2	358.0	14.1	2	460.0	0.0	2	
	Parsnip		1975	June	LAFFERTY CREEK	3	345.3	8.0	3	425.0	21.8	3		
				July	BLACKWATER CREEK	1	354.0	-	1	440.0	-	1		
	U		Finlay	2000	August	CUT THUMB CREEK	2	337.0	18.4	2	360.0	28.3	2	
					August	FINLAY RIVER	1	200.0	-	1	-	-	-	
	Omineca	2001	July	FINLAY RIVER	5	340.0	53.9	5	-	-	-			
August				NO NAME	2	350.0	2.8	2	525.0	7.1	2			
1998		August	OMINECA RIVER	2	367.0	18.4	2	552.5	74.2	2				
			MISSINKA RIVER	1	250.0	-	1	-	-	-				
DC	IM	Parsnip	1998	June	TABLE RIVER	2	14.0	1.4	2	-	-	-		
DN	IM	Nation	1998	August	SYLVESTER CREEK	1	-	-	-	-	-	-		
			July	CUT THUMB CREEK	3	16.0	2.6	3	1.0	0.0	3			
		Parsnip	1998	June	ANZAC RIVER	4	13.8	0.5	4	-	-	-		
				July	TABLE RIVER	7	16.2	5.6	6	-	-	-		
		July	1998	July	ANZAC RIVER	1	26.0	-	1	-	-	-		
				August	TABLE RIVER	9	21.7	3.0	7	-	-	-		
	August	1998	ANZAC RIVER	3	23.3	8.1	3	-	-	-				
			September	ANZAC RIVER	5	25.3	4.1	4	-	-	-			
	M	Parsnip	1998	June	TABLE RIVER	1	-	-	-	-	-	-		
				June	TABLE RIVER	1	-	-	-	-	-	-		
	EF	IM	Finlay	1988	September	TOODOGGONE RIVER	1	-	-	-	-	-	-	
				1999	August	FOX RIVER	2	116.5	0.7	2	-	-	-	
			2000	August	FINLAY RIVER	5	40.6	3.6	5	-	-	-		
NO NAME					5	51.8	4.6	5	-	-	-			
2001			July	FINLAY RIVER	6	36.7	16.4	6	-	-	-			
				August	FOX RIVER	23	63.1	7.4	23	-	-	-		
Nation			1998	August	MONRO LAKE OUTLET	1	-	-	-	-	-	-		
				August	RAINBOW CREEK	1	-	-	-	-	-	-		
Parsnip			1996	September	SYLVESTER CREEK	1	-	-	-	-	-	-		
				September	TABLE RIVER	2	51.0	-	1	-	-	-		
November		1996	TABLE RIVER	3	46.5	12.0	2	-	-	-				
			December	TABLE RIVER	7	44.0	-	1	-	-	-			
1998		August	MISSINKA RIVER	8	63.9	6.1	8	3.2	0.9	6				
			September	MISSINKA RIVER	2	73.0	4.2	2	4.3	0.2	2			
M		Finlay	1988	September	TOODOGGONE RIVER	1	405.0	-	1	-	-	-		
MT		Finlay	1999	August	FOX RIVER	4	336.5	28.3	4	-	-	-		
				August	FOX RIVER	2	159.0	46.7	2	-	-	-		
U	Parsnip	1998	August	MISSINKA RIVER	1	52.0	-	1	-	-	-			
			August	FINLAY RIVER	11	44.7	5.9	11	-	-	-			
Omineca	2001	August	FINLAY RIVER	13	37.2	7.9	13	0.4	0.3	13				
			OMINECA RIVER	13	37.2	7.9	13	0.4	0.3	13				

Method	Maturity*	Watershed	Year	Month	Stream	n	Mean Length (mm)	SD	n	Mean Weight (g)	SD	n					
GN	M	Parsnip	1975	November	PARSNIP RIVER	2	315.0	7.1	2	287.5	17.7	2					
				September	LAFFERTY CREEK	4	355.0	27.4	4	435.0	83.5	4					
	MT	Finlay	1975	September	OSPIKA RIVER	2	298.5	9.2	2	340.0	56.6	2					
					INGENIKA RIVER	2	332.5	3.5	2	415.0	21.2	2					
		Omineca	1975	September	OMINECA RIVER	1	310.0	-	1	310.0	-	1					
					Parsnip	1975	June	BLACKWATER CREEK	1	184.0	-	1	77.0	-	1		
			Parsnip	1975	July	MUGAHA CREEK	1	266.0	-	1	210.0	-	1				
					November	PARSNIP RIVER	3	295.0	35.0	3	245.0	74.7	3				
	SP	Parsnip	1975	June	TONY CREEK	1	322.0	-	1	350.0	-	1					
					TUTU CREEK	1	328.0	-	1	440.0	-	1					
		ST	Manson	1975	June	WESTON CREEK	1	368.0	-	1	470.0	-	1				
						MANSON RIVER	1	366.0	-	1	570.0	-	1				
			Nation	1975	September	NATION RIVER	2	312.5	24.7	2	325.0	21.2	2				
						Parsnip	1975	June	WESTON CREEK	3	338.0	8.9	3	386.7	22.5	3	
			Peace	1975	June	MUGAHA CREEK	1	308.0	-	1	285.0	#DIV/0!	1				
						STRANDBERG CREEK	2	344.5	36.1	2	455.0	91.9	2				
	MT	IM	Finlay	2000	August	FINLAY RIVER	2	42.5	0.7	2	-	-	-				
						NO NAME	3	51.7	4.0	3	-	-	-				
	SN	IM	Parsnip	1975	September	PARSNIP RIVER	6	71.0	33.1	6	6.3	8.6	6				
						U	Omineca	2001	August	OMINECA RIVER	23	73.9	37.7	23	10.8	5.3	13
				OMINICETLA CREEK	4	34.3				3.5	4	0.3	0.1	4			
					SILVER CREEK	5	44.0	2.8	5	-	-	-					
SW	MT	Finlay	2004	August	FOX RIVER	9	308.3	62.5	9	-	-	-					
VO	M	Parsnip	1996	August	ANZAC RIVER	9	347.9	21.5	9	474.6	75.1	9					
					PARSNIP RIVER	2	278.5	54.4	2	336.0	7.1	2					
					TABLE RIVER	22	330.2	13.0	22	390.4	70.7	22					
						September	ANZAC RIVER	53	345.2	20.2	53	447.8	79.3	53			
							PARSNIP RIVER	24	323.8	22.9	24	383.5	63.6	24			
						November	TABLE RIVER	13	331.6	10.9	13	389.9	81.1	13			
							PARSNIP RIVER	23	334.4	27.7	23	431.2	81.6	23			
						December	TABLE RIVER	4	327.8	9.7	4	365.3	90.5	4			
							ANZAC RIVER	4	361.5	16.8	4	504.8	69.0	4			
							Parsnip	1997	February	PARSNIP RIVER	21	331.0	27.6	21	413.1	89.6	21
										TABLE RIVER	2	331.0	15.6	2	373.0	154.1	2
							ANZAC RIVER	2	366.5	16.3	2	504.0	0.0	2			
															PARSNIP RIVER	17	333.7
							TABLE RIVER	3	331.7	11.1	3	384.7	110.9	3			
															ANZAC RIVER	2	366.5
						March	PARSNIP RIVER	21	336.4	19.3	21	419.2	78.7	21			
							ANZAC RIVER	7	365.6	12.2	7	521.2	50.6	7			
							Parsnip	April	PARSNIP RIVER	32	335.7	20.4	32	417.3	83.9	32	
									TABLE RIVER	1	340.0	-	1	419.0	-	1	
						May	ANZAC RIVER	21	350.0	23.8	21	473.9	87.0	21			
							PARSNIP RIVER	19	334.7	19.3	19	417.2	87.2	19			
							TABLE RIVER	6	334.3	7.8	6	408.8	34.0	6			
															ANZAC RIVER	43	345.0
						June	PARSNIP RIVER	14	339.6	16.2	14	441.4	64.6	14			
							TABLE RIVER	10	329.9	9.0	10	390.1	43.3	10			
						July	ANZAC RIVER	35	342.7	22.5	35	448.6	85.5	35			
							PARSNIP RIVER	5	320.2	10.2	5	362.6	36.1	5			
							TABLE RIVER	8	330.8	9.4	8	391.6	42.9	8			
															ANZAC RIVER	11	341.1
						August	PARSNIP RIVER	2	314.5	3.5	2	363.5	17.7	2			
							TABLE RIVER	2	330.0	14.1	2	379.5	55.9	2			
						October	ANZAC RIVER	11	340.5	22.8	11	426.4	88.7	11			
PARSNIP RIVER	5	327.2	13.6	5			396.5	52.5	5								
		TABLE RIVER	2	330.0	14.1	2	379.5	55.9	2								
UN	MT	Finlay	1975	July	COLLINS CREEK	1	339.0	-	1	440.0	-	1					
				September	OMINECA RIVER	8	371.9	123.0	8	391.3	95.5	8					
	ST	Finlay	1975	July	CHOWIKA CREEK	1	350.0	-	1	410.0	-	1					
					COLLINS CREEK	1	320.0	-	1	350.0	-	1					
		LAFFERTY CREEK	2	345.0	7.1	2	460.0	56.6	2								

*Refer to Table 7 for description of each stage of maturity.

Table 15. Average size of Arctic grayling for each stage of maturity identified, sampled in all watersheds of the Omineca region.

Maturity	Method	n	Mean		n	Min		Max	
			Length (mm)	SD		Length (mm)	Length (mm)		
IM	AG	34	222.7	66.3	34	110	329		
	DC	2	14.0	1.4	2	13	15		
	DN	34	19.6	5.8	28	10	32		
	EF	68	58.4	17.3	55	29	117		
	MT	5	48.0	5.8	5	42	54		
	SN	6	71.0	33.1	6	45	121		
	Total	149	92.5	87.2	130	10	329		
MT	AG	38	331.8	63.7	38	210	450		
	EF	7	245.1	122.6	7	52	359		
	GN	14	309.1	50.1	14	184	375		
	SW	9	308.3	62.5	9	225	350		
	UN	9	368.2	115.5	9	275	670		
	Total	77	321.3	79.4	77	52	670		
M	AG	1	230.0	-	1	230	230		
	DN	1	-	-	-	-	-		
	EF	1	405.0	-	1	405	405		
	GN	2	315.0	7.1	2	310	320		
	VO	456	338.1	22.6	456	240	380		
	Total	461	337.9	23.4	460	230	405		
SP	GN	3	339.3	25.0	3	322	368		
ST	AG	11	361.8	36.6	11	324	450		
	GN	9	333.6	24.9	9	295	370		
	UN	4	340.0	14.1	4	320	350		
Total	24	347.6	31.7	24	295	450			
U	AG	11	325.8	62.5	11	200	390		
	EF	24	40.7	7.9	24	27	53		
	SN	32	64.3	35.5	32	28	124		
	Total	67	98.7	107.7	67	27	390		

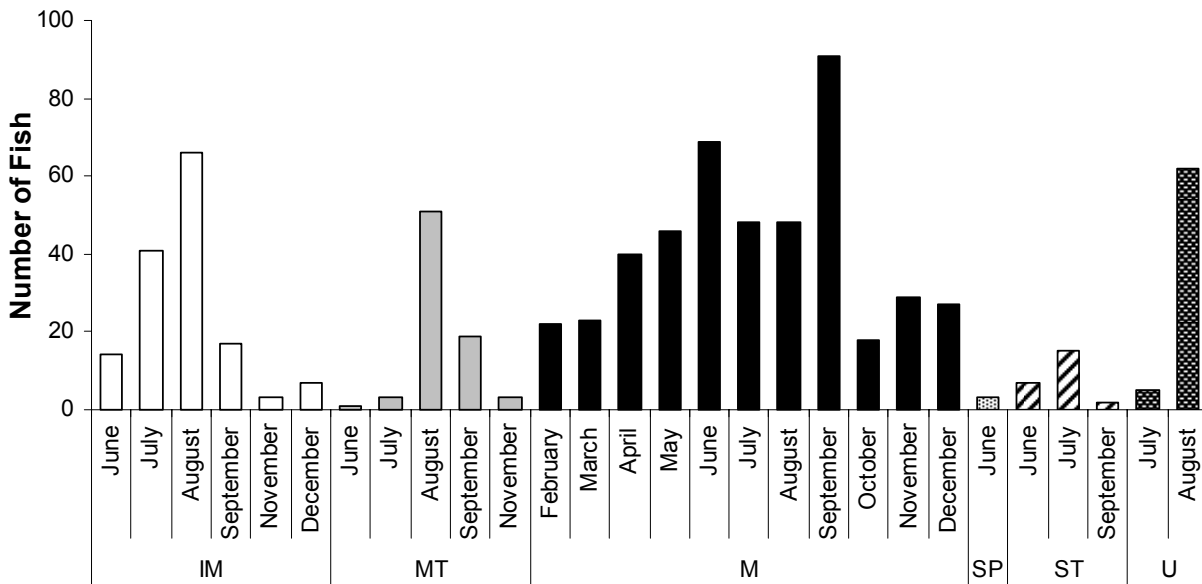


Figure 19. Number of Arctic grayling of each stage for maturity, sampled in various months.

3.0 Population genetics

Population genetics have been examined for Arctic grayling within the Williston Watershed and were summarized in the following reports and publications. Extant North American Arctic grayling show a high level of diversity phylogeographically and consist of at least three major lineages that originated from distinct Pleistocene glacial refugia (Stamford 2001; Stamford and Taylor 2004). Findings from the genetic studies specific to the Williston Watershed indicate that allele frequencies for Arctic grayling differed across the watershed and that there were significant genetic differences among major watersheds. A highly significant isolation-by-distance relationship was also found indicating that fish from neighboring watersheds were more closely related than to populations further away (Stamford and Taylor 2005; Shrimpton et al. 2007; Shrimpton and Clarke 2008). Work by Stamford and Taylor (2005) suggested, based on coalescent analyses, that current Arctic grayling population sizes are less than 1% of historical sizes. Their calculations estimated that the decline may have occurred relatively recently (i.e., < 300 years ago), although, the timeline suggests that the bottleneck predates any anthropogenic disturbance in the system.

4.0 Abundance estimates

Abundance estimates of Arctic grayling in the Omineca region have been limited to tributaries of the Parsnip watershed, a single study on the Ingenika River, and single study on the Mesilinka Rivers (Table 16). Since 1995, the PFWWCP has conducted several surveys to determine the abundance of juvenile and adult Arctic grayling in the Table and Anzac Rivers (Zemlak and Langston 1998). In these studies, seine netting was used to estimate juvenile abundance and swim counts were used to estimate abundance of adults. Early studies used mark recapture in combination with the swim count methods but this was discontinued when Blackman and Hunter (2001) found that adult Arctic grayling are migrating out of the systems too quickly to get accurate counts (Blackman 2002a; Murphy and Blackman 2004; Blackman et al. 2004; Mackay and Blackman 2005). In 2004, swim count methods used in the Parsnip watershed were applied to estimate adult Arctic grayling abundance in the Ingenika River (Cowie and Blackman 2006). In 2005, abundance in km 73-51 of the Parsnip River was estimated to be 41 young-of-the-year (<7.7 cm) grayling, and 56 one year old (7.8-15.3 cm) grayling per kilometer of shoreline sampled (Mackay and Blackman 2005). The highest abundance estimate for young-of-the-year (<7.7 cm) grayling was reported in 1998 at km 9.8 of the Table river and the highest abundance of adults was reported in the Anzac river in 1998 between km 45 and 47 (Blackman and Hunter 2001).

Table 16. Abundance estimates conducted in the Omineca Region.

Stream Name	Year	Location	Method	Stage	Fish per km	Reference	
Table River	1995	km 35.5-32.0	SW	>20cm	32	Zemlak and Langston 1998	
		Km 9.8-5.0	SW	>20cm	7	Zemlak and Langston 1998	
	1998	km 9.8	SN	<7.7cm	80	Blackman and Hunter 2001	
		km 22	SN	<7.7cm	40	Blackman and Hunter 2001	
		km 9-5	SW	>20cm	1	Blackman and Hunter 2001	
		km 22-18	SW	>20cm	17	Blackman and Hunter 2001	
	2000	km 35-31	SW	>20cm	34	Blackman and Hunter 2001	
		km 9-5	SW	>20cm	3	Blackman 2002b	
		km 22-18	SW	>20cm	9	Blackman 2002b	
		km 35-31	SW	>20cm	31	Blackman 2002b	
Anzac River	1998	km 10-6	SW	>20cm	4	Blackman and Hunter 2001	
		km 16-12	SW	>20cm	2	Blackman and Hunter 2001	
		km 34-30	SW	>20cm	23	Blackman and Hunter 2001	
		km 42-39	SW	>20cm	33	Blackman and Hunter 2001	
	2000	km 47-45	SW	>20cm	82	Blackman and Hunter 2001	
Parsnip River	2000	km 47-45	SW	>20cm	34	Blackman 2002b	
		km 39	SN	<7.7cm	1	Blackman 2002b	
		km 40-44	SN	<7.7cm	7	Blackman 2002b	
		km 40-44	SN	7.8-15.3cm	2	Blackman 2002b	
		km 45-49	SN	<7.7cm	12	Blackman 2002b	
		km 45-49	SN	7.8-15.3cm	3	Blackman 2002b	
		km 45-49	SN	>15.4cm	1	Blackman 2002b	
		km 50-54	SN	<7.7cm	5	Blackman 2002b	
		km 50-54	SN	7.8-15.3cm	5	Blackman 2002b	
		km 50-54	SN	>15.4cm	1	Blackman 2002b	
		km 55-59	SN	<7.7cm	14	Blackman 2002b	
		km 55-59	SN	7.8-15.3cm	10	Blackman 2002b	
		km 55-59	SN	>15.4cm	3	Blackman 2002b	
		km 60-64	SN	<7.7cm	13	Blackman 2002b	
		km 60-64	SN	7.8-15.3cm	12	Blackman 2002b	
		km 60-64	SN	>15.4cm	3	Blackman 2002b	
		km 65-69	SN	<7.7cm	17	Blackman 2002b	
		km 65-69	SN	7.8-15.3cm	8	Blackman 2002b	
		km 65-69	SN	>15.4cm	2	Blackman 2002b	
		km 70-74	SN	<7.7cm	9	Blackman 2002b	
		km 70-74	SN	7.8-15.3cm	11	Blackman 2002b	
		km 70-74	SN	>15.4cm	1	Blackman 2002b	
		km 75-79	SN	<7.7cm	9	Blackman 2002b	
		km 85-89	SN	<7.7cm	8	Blackman 2002b	
		km 85-89	SN	7.8-15.3cm	8	Blackman 2002b	
		km 85-89	SN	>15.4cm	1	Blackman 2002b	
		km 90-91	SN	<7.7cm	1	Blackman 2002b	
		km 90-91	SN	7.8-15.3cm	1	Blackman 2002b	
		km 90-91	SN	>15.4cm	4	Blackman 2002b	
		km 73-51	SN	<7.7cm	39	Mackay and Blackman 2005	
		km 73-51	SN	7.8-15.3cm	30	Mackay and Blackman 2005	
		2001	km 73-51	SN	<7.7cm	31	Mackay and Blackman 2005
		km 73-51	SN	7.8-15.3cm	46	Mackay and Blackman 2005	
2003	km 73-51	SN	<7.7cm	17	Mackay and Blackman 2005		
	km 73-51	SN	7.8-15.3cm	30	Mackay and Blackman 2005		
2005	km 73-51	SN	<7.7cm	41	Mackay and Blackman 2005		
	km 73-51	SN	7.8-15.3cm	56	Mackay and Blackman 2005		
Mesilinka River	1992	Control reach	SW	>20cm	10	Wilson <i>et al.</i> 2008	
	1993	Control reach	SW	>20cm	5	Wilson <i>et al.</i> 2008	
	1994	Control reach	SW	>20cm	10	Wilson <i>et al.</i> 2008	
	1995	Control reach	SW	>20cm	11	Wilson <i>et al.</i> 2008	
	1997	Control reach	SW	>20cm	10	Wilson <i>et al.</i> 2008	
	1999	Control reach	SW	>20cm	5	Wilson <i>et al.</i> 2008	
Ingenika River	2004	km 3-45	SW	>20cm	1	Cowie and Blackman 2005	
	2004	km 60-89	SW	>20cm	4	Cowie and Blackman 2005	
	2004	km 89-109	SW	>20cm	6	Cowie and Blackman 2005	

4.1 Total Arctic grayling sampled

Records of Arctic grayling sampling in the Omineca Region are available for over 50 years, from 1956 to 2007 (Figure 20). There are few documented records of scientific collection of Arctic grayling within the early years (1956-1991), but following the inception of the Peace / Williston Fish & Wildlife Compensation Program in 1988, sampling activities have increased dramatically. The sampling effort has focused on specific watersheds during a year or over several years; for example the sampling activity on the Parsnip River watershed from 1995 to 1998, and then subsequent sampling in the Omineca watershed (Figure 20).

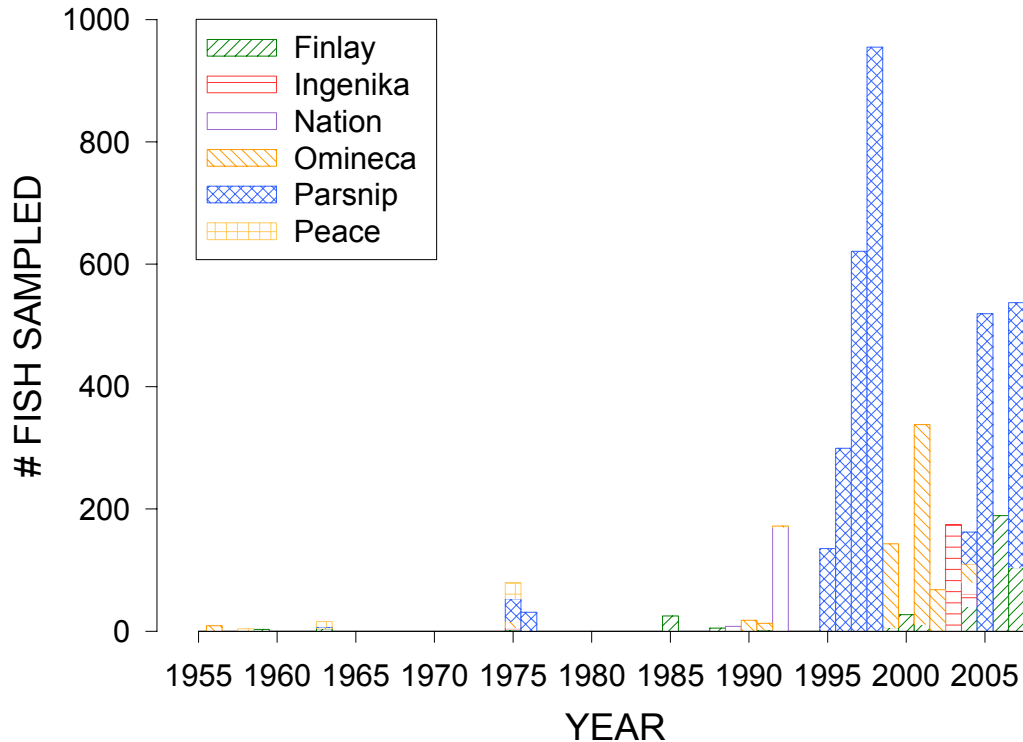


Figure 20. Spatial and temporal sampling of Arctic grayling in the Omineca region.

4.2 Interspecific Interactions

In the Omineca management region a number of species have been reported to inhabit streams where Arctic grayling have been captured (Table 17), however, the present investigation found no literature directly addressing the interaction between Arctic grayling and other species. Competition for resources and predation on juveniles are potential interactions between Arctic grayling and other species that may be limiting their abundance in a system. In an evaluation of Arctic grayling enhancement in Alaska it was noted that rainbow trout, large stickleback and large grayling preyed on juvenile grayling (Skaugstad 1988). Bull trout, northern pike minnow and burbot are also known to prey on other fish species (Scott and Crossman 1973). The creation of the Williston reservoir may have also initiated new interactions between species. For example the PFWWCP started stocking the Williston reservoir with kokanee from the Columbia River in

1990, after the reservoir was flooded (Blackman *et al.* 1990). It is speculated that Arctic grayling extinction in Michigan can be greatly attributed to competition and predation from introduced salmonid species (Hubbs and Lagler 1958; Vincent 1962).

Bull trout, mountain whitefish and rainbow trout have been the dominant species present in streams that reported Arctic grayling (Table 18). Kokanee was the only other salmonid species reported where Arctic grayling were sampled. A snorkel survey conducted in August 1998 on the Manson River reported 1900 kokanee, 1522 mountain whitefish, 183 rainbow trout and only one Arctic grayling observation. In the following year snorkel surveys reported 113 kokanee, 779 mountain whitefish, 185 rainbow trout, 8 bull trout and again only one Arctic grayling (Phillipow 2002).

It is difficult to interpret interactions between Arctic grayling and other species from the current available data as the species composition results presented in this analysis most likely reflect the sampling objectives, sampling methods and effort of each specific study. Other species may have been present where Arctic grayling were reported but not necessarily recorded. Certain sampling methods may also be bias toward particular size ranges and habitat excluding some fish species or life history stages when sampling.

Table 17. Species sampled in Omineca region that occurred with areas where Arctic grayling were also captured (RIC, 1996).

Species Code	Common Name	Scientific Name
BB	Burbot	<i>Lota lota</i>
BT	Bull Trout	<i>Salvelinus confluentus</i>
CAS	Prickly Sculpin	<i>Cottus asper</i>
CCG	Slimy Sculpin	<i>Cottus cognatus</i>
CSU	Largescale Sucker	<i>Catostomus macrocheilus</i>
DV	Dolly Varden	<i>Salvelinus malma</i>
GR	Arctic grayling	<i>Thymallus arcticus</i>
KO	Kokanee	<i>Oncorhynchus nerka</i>
LNC	Longnose Dace	<i>Rhinichthys cataractae</i>
LSU	Longnose Sucker	<i>Catostomus catostomus</i>
LT	Lake Trout	<i>Salvelinus namaycush</i>
MW	Mountain Whitefish	<i>Prosopium williamsoni</i>
NSC	Northern Squawfish	<i>Ptycheilus oregonensis</i>
PCC	Peamouth Chub	<i>Mylocheilus caurinus</i>
RB	Rainbow Trout	<i>Oncorhynchus mykiss</i>
WSU	White Sucker	<i>Catostomus commersoni</i>
LW	Lake Whitefish	<i>Coregonus clupeaformis</i>
RSC	Redside shiner	<i>Richardsonius balteatus</i>
BT/DV	Unable to distinguish between Bull trout and Dolly Varden	
SM	Smelts	
SU	Suckers	

Table 18. Species abundance for streams where grayling were captured in the Omineca region.

Method	Month	Year	Watershed	Stream	Species	N				
AG	July	2001	Finlay	FINLAY RIVER	GR	5				
					BT	1				
	August	1996	Omineca	KLIYUL CREEK	GR	2				
					MW	6				
					RB	2				
					GR	8				
					BT	12				
					MW	1				
		1998	Parsnip	MISSINKA RIVER	RB	8				
					NSC	1				
					GR	1				
					RB	1				
					GR	2				
					GR	3				
		2000	Finlay	FINLAY RIVER	BT/DV	2				
					GR	7				
					BT	2				
					RB	3				
					GR	20				
					GR	2				
2001	Omineca	NO NAME OMINECA RIVER	GR	10						
			MW	1						
			RB	13						
			GR	1						
			RB	1						
			RB	1						
September	1996	Ingenika Omineca	INGENIKA RIVER LAY CREEK MESILINKA RIVER	GR	20					
				GR	2					
				GR	10					
				MW	1					
				RB	13					
				GR	1					
				RB	1					
				1997	Omineca	MESILINKA RIVER	GR	1		
							RB	1		
							RB	1		
GR	1									
BT	2									
RB	3									
CCG	1									
LSU	7									
RSC	1									
GR	6									
EF	July	1996	Peace	FRIES CREEK	GR	1				
					BT	2				
					RB	3				
					SM	1				
					GR	6				
					RB	1				
					CCG	1				
					LSU	1				
					August	1998	Parsnip	MISSINKA RIVER	GR	9
									BT	17
	MW	49								
	RB	32								
	BB	9								
	CCG	180								
	LKC	58								
	LNC	1								
	LSU	7								
	RSC	1								
	September	1999	Finlay	FOX RIVER	GR	6				
					BT	5				
MW					23					
RB					2					
GR					16					
CCG					6					
LSU					1					
GR					5					
BT					1					
BT/DV					31					
DV	43									
2000	Finlay	FINLAY RIVER	NO NAME	MW	2					
				RB	9					
				BB	1					
				CCG	13					
				LSU	3					
				GR	9					
				BT	2					
				MW	8					
				BB	3					
				CCG	10					
LNC	1									
2001	Omineca	OMINECA RIVER	LSU	6						
			GR	25						
			BT	1						
			MW	76						
			RB	6						
			BB	2						
			CCG	21						
			WSU	1						
			GR	5						
			BT	43						
1996	Omineca	NO NAME	MW	5						
			RB	37						
			BB	2						
			CCG	22						
			LSU	7						
			PCC	8						
			GR	1						
			BT	1						
			MW	5						
			RB	3						
1997	Omineca	ABRAHAM CREEK MESILINKA RIVER	CAS	4						
			GR	1						
			BT	6						
			MW	18						
			RB	10						

Method	Month	Year	Watershed	Stream	Species	N
					BB	11
					CAS	7
					CCG	51
		1998	Parsnip	MISSINKA RIVER	LSU	3
					GR	2
					MW	1
					RB	3
					CCG	41
					LSU	27
MT	August	2000	Finlay	FINLAY RIVER	GR	2
				NO NAME	GR	3
					BT	1
					BT/DV	1
					DV	3
					LSU	2
SN	August	2001	Omineca	OMINECA RIVER	GR	22
					BT	2
					MW	142
					CCG	35
				OMINICETLA CREEK	GR	4
					MW	26
					CCG	8
					LSU	1
				SILVER CREEK	GR	5
					MW	32
					RB	4
					CCG	4
	September	1996	Omineca	MESILINKA RIVER	GR	8
					BT	1
					MW	418
					RB	3
		1997	Omineca	MESILINKA RIVER	GR	4
					BT	3
					MW	8
SW	August	1998	Parsnip	MISSINKA RIVER	GR	50
					BT	45
					MW	587
					RB	43
					NSC	9
		2002	Ingenika	INGENIKA RIVER	GR	7
					BT	1
					MW	41
		2004	Finlay	FOX RIVER	GR	9
					BT	1
					MW	65
			Ingenika	INGENIKA RIVER	GR	189
					BT	22
					KO	1
					MW	1625
					RB	24
					SU	39
VO	July	1995	Parsnip	TABLE RIVER	GR	165
					BT	22
		1996	Parsnip	TABLE RIVER	GR	165
					BT	54
		1998	Parsnip	TABLE RIVER	GR	133
					BT	34
	August	1989	Nation	NATION RIVER	GR	42
					DV	26
					MW	561
					RB	184
					LT	1
					CSU	229
					LNC	14
					NSC	13
					SU	9
		1992	Omineca	MESILINKA RIVER	GR	62
					BT	18
					RB	99
		1993	Omineca	MESILINKA RIVER	GR	49
					BT	17
					RB	66
		1995	Parsnip	TABLE RIVER	GR	401
					BT	68
		1998	Manson	MANSON RIVER	GR	1
					BT	22
					KO	1900
					MW	1522
					RB	183
			Parsnip	ANZAC RIVER	GR	1137
					BT	169
				TABLE RIVER	GR	277
					BT	275
		2002	Manson	MANSON RIVER	GR	1
					BT	8
					KO	113
					MW	779
					RB	185
	September	1998	Parsnip	MISSINKA RIVER	GR	2
					BB	1
					CCG	11

5.0 Fluvial and adfluvial population comparisons

Throughout their range Arctic grayling appear to demonstrate both fluvial and adfluvial life history forms. Using the data collected in the provincial database, a recent report by Miller *et al.* (2008) found that only 3% of the Arctic grayling records in the Omineca region suggested an adfluvial life history. Similarly, in the Peace region only 4% of the grayling populations were adfluvial, however, in the Skeena region 42% of the populations were considered adfluvial. The adfluvial populations in the Omineca region are represented by samples collected in 1997 from only two lakes, both in the Finlay watershed. Therefore, the interpretation of any comparisons between life history types made with the Omineca region data are not reliable due to the insufficient sample size of adfluvial Arctic grayling (n=9). In the Peace and Skeena regions a greater number of putative adfluvial populations have been sampled and were included to supplement comparisons where Omineca adfluvial populations were lacking. The information that has been gathered on the adfluvial populations may be useful as an initial overview of the potential differences and similarities to fluvial populations in the region.

The log transformed length-weight regression relationships for adfluvial populations in each region were plotted and compared to the results found for fluvial populations (Figure 21, Table 19). Although the number of Arctic grayling sampled in lake systems in the Omineca region is small the results of an analysis of variance comparing length-weight regression slopes for adfluvial and fluvial populations suggests that there is no significant difference between life history types ($p>0.05$). Similarly, in the Peace region the slope of the adfluvial and fluvial length-weight regressions appear not to differ significantly ($p>0.05$). However, in the Skeena region, where the most data is available for adfluvial populations and the least data is available for fluvial populations, the results suggest that there is a significant difference ($p=0.002$) between the slopes of the length-weight regressions of two life history types (Table 20).

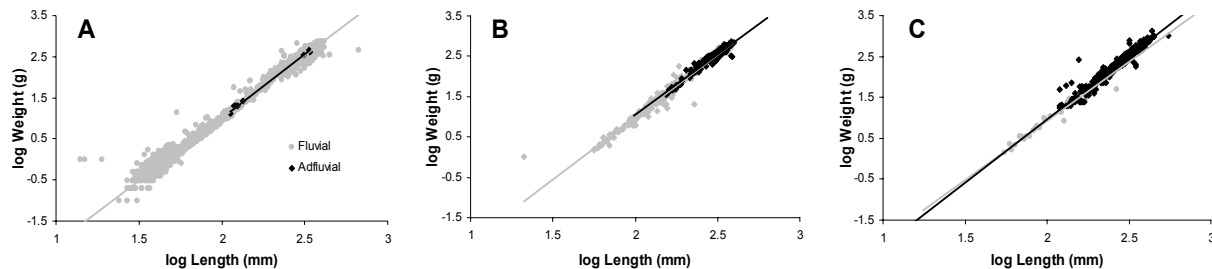


Figure 21. Length-weight relationship for adfluvial Arctic grayling sampled from lakes in the A. Omineca region (n=9) B. Peace region (n=173) C. Skeena region (n=697). Data for fluvial Arctic grayling shown in gray for comparison.

Table 19. Length-weight regression for Arctic grayling sampled in streams and lakes of BC.

Region	n	R ²	Equation of best fit line	b	RSE	p-value
Streams						
Omineca	3259	0.9925	Log(W) = -5.08 + 3.042 log(L)	3.042	0.0962	< 2.2e-16
Peace	326	0.9788	Log(W) = -5.15 + 3.074 log(L)	3.074	0.1098	< 2.2e-16
Skeena	42	0.9628	Log(W) = -4.86 + 2.896 log(L)	2.896	0.1192	< 2.2e-16
Lakes						
Omineca	9	0.9976	Log(W) = -5.12 + 3.073 log(L)	3.073	0.035	1.977e-10
Peace	173	0.9469	Log(W) = -4.96 + 3.004 log(L)	3.004	0.075	< 2.2e-16
Skeena	698	0.9478	Log(W) = -5.25 + 3.109 log(L)	3.109	0.080	< 2.2e-16

Table 20. Statistics summary of ANOVA comparison of length-weight regression slopes for Arctic grayling captured in streams and lakes systems of BC.

Region	p-value	Lower 95% CI	Upper 95% CI
Omineca	0.474*	-	-
Peace	0.354*	-	-
Skeena	0.002	0.077	0.348

*Values were not significant (p-values >0.05).

Length frequency histograms for adfluvial Arctic grayling sampled in each management region are shown in Figure 22. The adfluvial Arctic grayling sampled appear to cover a narrower range than was seen for the fluvial populations reported in Section 1.3 Length Frequency. For example no adfluvial Arctic grayling less than 120mm in the Peace region and 160mm in the Skeena region were reported. This is most likely due to sampling effort and a lack of juvenile assessments in these regions. Adfluvial Arctic grayling were primarily sampled by gillnetting, with the exception of a few samples (n=36) collected by angling in the Skeena region. The selectivity of these sampling methods most likely excluded smaller grayling. The length distribution of Arctic grayling sampled in the Omineca region is limited but it does reveal that both juveniles and adults were reported and present in lakes.

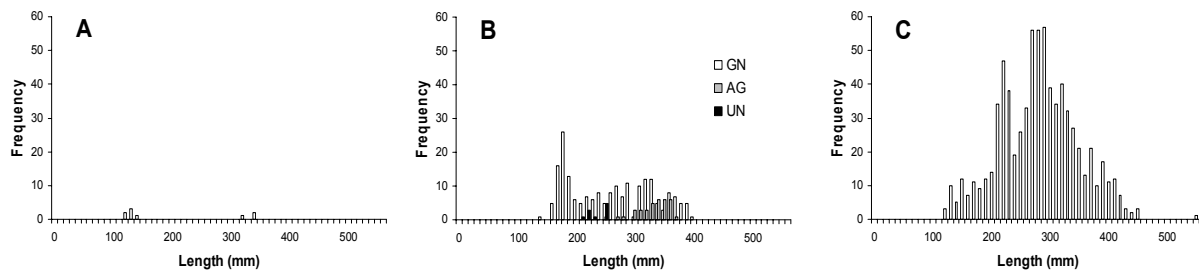


Figure 22. Length frequency analysis for adfluvial Arctic grayling sampled from lakes in the A. Omineca region (n=9) B. Peace region (n=249) C. Skeena region (n=742).

In the Omineca region very little variation in size at age was reported for adfluvial samples (Figure 23), which is most likely reflective of the small sample size. Scale or finray estimates of age indicated that adfluvial Arctic grayling were 1, 2, 4, or 5 years old within the Omineca region. In the Peace and Skeena regions adfluvial populations were aged by scale, finray or otolith analysis and ages ranged from 1 to 6 years. The majority of age estimates for adfluvial Arctic grayling in all regions were determined by scale analysis. There were no reports of cases where more than one structure was used to age one fish, therefore aging technique comparisons can not be made for the adfluvial samples.

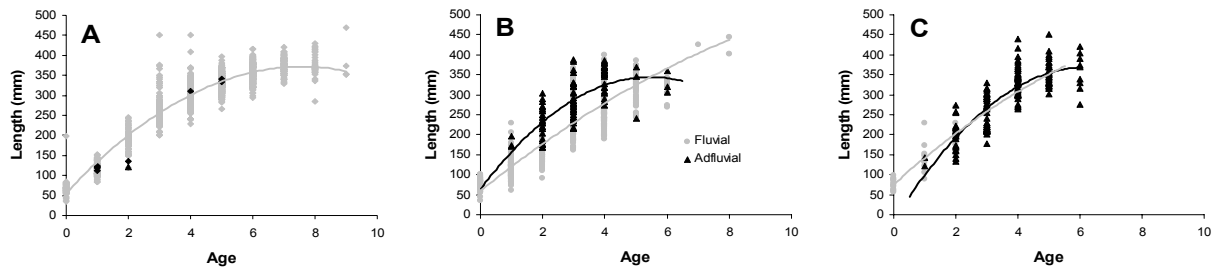


Figure 23. Length at age for adfluvial Arctic grayling sampled from lakes in the A. Omineca region (n=9) B. Peace region (n=93) C. Skeena region (n=166). Data for fluvial Arctic grayling shown in gray for comparison.

Sex was determined for less than half (44%) of the adfluvial Arctic grayling in the two lakes sampled in the Omineca region. The sex ratio was 2:1 in Fishing Lakes “a” and in Fishing Lakes “b” sex was only reported for a single male Arctic grayling. More data was available for lakes in the Skeena region and the average sex ratio in each year and month of sampling was calculated to be 0.49 (Table 21). Similar to the sex ratios for fluvial Arctic grayling sampled in the Omineca region, the range of sex ratios for adfluvial populations in the Skeena region gives an impression of variation across the region. It is more likely, however, that the differences in sex ratio is reflecting sampling effort, as the greatest variation once again was seen when sample sizes were small (Figure 24).

Table 21. Sex ratios and mean length of Arctic grayling sampled in lakes in the Skeena region.

Waterbody	Year	Month	Lake	Sex	n	Sex Ratio	Mean Length (mm)	SD
Atlin	1980	May	SURPRISE LAKE	F	63	0.44	262.7	21.9
				M	79		281.7	48.2
	1997	July	DIXIE LAKE	F	5	0.5	283.0	12.5
				M	5		283.8	13.3
				U	12		275.5	25.7
Blue	1996	May	FRANK'S LAKE	F	1	1	314.0	0.0
				F	23		292.5	32.0
		August	FRANK'S LAKE	M	21	318.9	43.9	
				U	11	197.7	42.1	
Cry	1985	September	CRY LAKE	M	1	0	261.0	0.0
				F	3		370.0	0.0
				U	3		215.0	0.0
Dease	1986	August	ED ASP LAKE	F	16	0.52	289.4	53.4
				M	15		310.0	57.2
				U	31		274.3	63.5
	1986	August	LITTLE DEASE LAKE	F	3	0.6	409.3	16.2
				M	2		402.0	11.3
	1980	August	MOOSE LAKES	F	9	0.33	266.1	266.1
				M	18		277.8	277.8
	1980	August	EAGLEHEAD LAKE	F	1	0.33	298.0	0.0
				M	2		276.5	135.1
	1980	August	SWINTON LAKE	F	18	0.46	225.6	39.0
				M	21		243.5	30.1
	1980	July	FISH LAKE	F	9	0.38	301.1	30.4
M				15	282.7		49.9	
1980	August	SERPENTINE LAKE	F	3	0.75	314.3	35.9	
			M	1		204.0	0.0	
			U	1		200.0	0.0	
1997	September	VINCENT LAKE	M	1	0.5	240.0	0.0	
			U	1		200.0	0.0	
			F	16		209.1	6.3	
Gladys	1997	August	LAIDLAW LAKE	M	17	0.48	216.7	7.8
				U	23		211.8	21.1
				F	15		263.9	39.2
Jennings	1996	September	MINOTAUR	M	10	0.6	288.8	64.9
				U	2		164.5	6.4
				M	3		421.7	16.1
				U	1		450.0	0.0
				F	1		340.0	0.0
Spatzizi	1976	January	COLD FISH LAKE	F	1	1	340.0	0.0
				F	16		355.0	27.7
Swift	1996	July	PLATE LAKE	M	13	0.55	360.4	24.8
				F	1		222.0	0.0
		September	SWIFT LAKE	F	3	0.42	325.0	325.0
				M	4		400.0	400.0
				U	2		130.5	14.8

Waterbody	Year	Month	Lake	Sex	n	Sex Ratio	Mean Length (mm)	SD
Teslin	1996	August	MELGARD LAKE	F	7	0.42	378.1	29.9
				M	10		376.9	32.2
Tutshi	1987	September	TUTSHI LAKE	F	1	0.25	371.0	0.0
				M	3		334.7	24.8
Tuya	1986	August	TUYA LAKE	F	18	0.67	284.9	71.2
				M	9		374.0	100.9
				U	6		214.5	62.4
			TACHILTA LAKES	F	2	0.4	224.5	51.6
				M	3		278.7	55.8
				U	2		176.5	40.3
Butte Lake	1996	August	BUTTE LAKE	F	12	0.44	322.3	15.0
				M	15		336.6	28.1
				U	15		187.9	48.6
Little Rancheria	1996	July	UPPER TOOTSEE LAKE	F	2	0.22	340.0	14.1
				M	7		360.0	20.2
Nakina	1997	August	NAKINA LAKE	F	17	0.45	289.9	26.7
				M	19		322.8	31.6

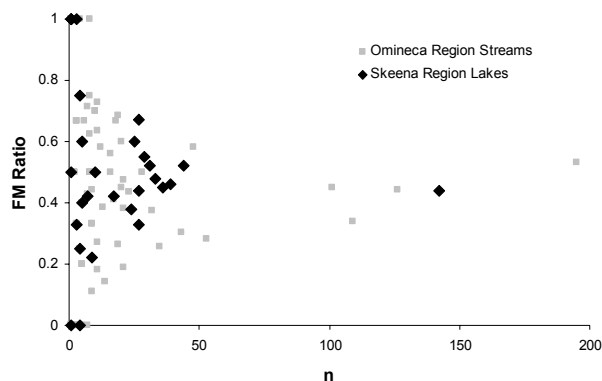


Figure 24. FM sex ratios for lakes in Skeena region and streams in the Omineca region.

Lake trout, lake whitefish, mountain whitefish, rainbow trout, bull trout, longnose suckers and prickly sculpins were the other species sampled in the two lakes in the Omineca region where Arctic grayling were sampled. The most abundant fish species was mountain whitefish in both lakes (Table 22). The range of fish species reported in lakes of the Omineca region where Arctic grayling were sampled showed a similar range to that found in tributaries of the Finlay watershed, lake trout and lake whitefish were the only exceptions.

Table 22. Abundance of all species sampled in lakes containing Arctic grayling in the Omineca region.

Year	Month	Waterbody ID	Lake	Species	n
1997	August	00770TOOD	FISHING LAKE a	GR	5
				LSU	13
				LT	7
				LW	41
				MW	76
1997	August	00841TOOD	FISHING LAKE b	RB	5
				GR	4
				BT	4
				CAS	1
				LSU	11
				LW	18
				MW	32
RB	2				

6.0 Catch per unit effort (CPUE)

The present Arctic grayling data was not sufficient to calculate Catch per- unit- effort (CPUE). Effort was not recorded for the sampling records in the provincial database therefore we were unable to calculate CPUE for Arctic grayling sampled in the Omineca region. CPUE is a good index of stock abundance for fish and is commonly used to highlight regional and temporal trends in abundance (Simonson and Lyons 1995; Harley *et al.* 2001).

7.0 Diet

To date, no assessment of Arctic grayling diet has been conducted for populations in the Omineca Region. In the Peace region, an early study, limited to the Sukunka drainage, used stomach content analysis to reveal that Arctic grayling fry fed primarily on bottom prey, such as aquatic invertebrate larvae (ie. Chironomid larvae). In contrast, juveniles and adults fed primarily on surface prey, such as adult Chironomids and flies in the summer months and bottom prey over winter (Stuart and Chislett 1979). In the Skeena region stomach contents were determined for Arctic grayling sampled in Surprise Lake (Envirocon Limited 1980). Fish were sampled from various locations in the lake and stomach contents showed a wide range of taxa consumed by grayling. Composition of stomach contents from individual fish ranged from 3 – 65% Trichoptera larvae, 0 – 15% Diptera larvae, 2 – 74% Plecoptera larvae and 5 – 82% Copepoda, depending on the locations (Envirocon Limited 1980). This study also found variation in prey items in May compared to July, the two times in the year when samples were collected, suggesting not only a geographical variation in prey items, but also temporal variation (Envirocon Limited 1980). Further investigation of the literature has revealed a number of consultant reports and reconnaissance surveys completed in the Skeena region, which list stomach content for the Arctic grayling sampled similar to the studies listed above (Coombes 1986; SKR Consultants 1997a; SKR Consultants 1997b; SKR Consultants 1997c; Beere 2002). Arctic grayling diet could be a good indicator of population health and may increase our understanding of interspecies interactions.

8.0 Survival estimates

8.1 Tagging Data

All tagging data was obtained from studies conducted by the PFWWCP and has been analyzed in PFWWCP reports. This data is not sufficient to calculate survival estimates. Arctic grayling were primarily tagged with floy tags for Peterson mark-recapture population estimates (Zemlak and Langston 1998; Blackman and Hunter 2001). One study by the PFWWCP used radiotelemetry tags to track movement of Arctic grayling in the Table and Anzac rivers to winter and spawning areas. These tagging studies were not designed to address survival estimates and therefore analysis of this data can not accurately predict survival estimates.

9.0 Physical environment surveys- areas of importance for various life stages

9.1 Temperature

Surface water temperatures have been recorded for streams where Arctic grayling have been captured in the Finlay, Omineca and Parsnip Watersheds. These sampling activities occurred from March to December, in 1975-1977, 1995, 1996, 1998-2001 and 2004 but the majority of measurements (more than half) were collected in August (Table 23). It is surprising that given the importance of temperature, little effort has been made to collect temperature measurements for locations where Arctic grayling are found. Between the months of March and December, Arctic grayling were recorded to have been in waters ranging in temperature from 2.5 – 14.5 °C in the Omineca Region (Table 24). These data, however, must be again be interpreted with caution. It is unlikely that water temperatures in the Parsnip River were 12 °C in March, 1977 or 10 °C in June, 1977. The temperature measurements recorded in the database, therefore, do not appear to reflect the seasonal variation characteristic of rivers in this region. In the Williston watershed the water temperature of major watersheds where hydrometric stations are installed ranged from 0 to ~25 °C (WSC, 2010).

Many of the temperature records also had corresponding length measurements of the Arctic grayling captured. We examined this data visually to see if there were any trends in fish size in relation to water temperature. Figure 25A is a plot of mean length of fish sampled against water temperature. There is no pattern. There is also a paucity of information on Arctic grayling temperature requirements in the literature. According to Humpesch (1985) the optimum temperature range of incubation for European grayling (*Thymallus thymallus*) is 7-11 °C. In BC, the optimum temperature for spawning Arctic grayling is suggested to range between 4 and 9 °C (Northcote 1993). Given the northerly distribution of grayling throughout North America, Europe and Asia, however, these values appear high. Our examination of the temperature records for Arctic grayling in the Omineca region indicates that the number of fish captured as a function of water temperature tends to be greater at intermediate water temperature (Figure 25B); but little can be determined from this data due to uneven effort as 16 of 33 measurements were reported from August. It would appear that grayling distributions are limited to cooler waters as fish were not captured in water recorded to be greater than 14.5 °C in the Omineca Region.

Water temperature records for the Skeena Region are few, limited to summer months (July, August and September), but there is a considerable record of water temperatures associated with grayling sample collection from the Peace Region. Arctic grayling have been captured in the Peace Region from March to October. The range in water temperatures where grayling have been found is much wider than documented for the Omineca Region; range from 1 °C in October to 25 °C in August. Figure 26 shows the number of records where grayling were observed to be in waters of different temperatures for the three different regions included in the provincial dataset. The observations refer to a single record for a given river, not the number of fish that were caught. It is clear that the majority of sampling programs have been conducted when the water temperature were between 8 and 14 °C. Without a more extensive sampling effort throughout the year, it is not possible to determine ranges for temperature tolerance or ranges for temperature preference of Arctic grayling.

Table 23. Mean surface water temperature of Arctic grayling sampling sites in the Omineca Region.

Watershed	Stream	Ref*	Year	Mean Surface Water Temperature (°C) ± SE (n)								
				Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Parsnip	ANZAC RIVER	7	1977			10.5 (1)		12 (1)				
	COLBOURNE CREEK	7	1977					12 (1)				
	DESTILIDA CREEK	7	1977		10±0 (2)							
	FERN CREEK	7	1977			12 (1)						
	HOMINKA RIVER	7	1976					9±1.15 (4)				
	MISSINKA RIVER	10	1998					14.2±0.33 (13)	11.8±0.35 (2)			
	NO NAME	7	1977					12.5±0.71 (2)				
	PARSNIP RIVER	6	1975							2.5 (1)		
		7	1977	12 (1)	10 (1)	13.3±1.77 (2)				6.3 (1)		
	REYNOLDS CREEK	7	1977		8.5 (1)	13 (1)		12±0 (2)				
TABLE RIVER		7	1977			7 (1)	10±0 (2)					
		8	1995						9±0 (12)			
		9	1996			10.3±0.35 (2)		13±0 (3)	9 (1)		8.5±0.71 (2)	9±0 (2)
		5	2001					9.41±1.42 (39)				
		5	2001					7±0 (4)				
Omineca	OMINECA RIVER	5	2001					14±0 (5)				
	OMINICETLA CREEK	5	2001					5±0 (2)				
	SILVER CREEK	5	2001					5±0 (2)				
Finlay	NO NAME	5	2001					9.46±1.47 (19)				
	FINLAY RIVER	1	2000									
		2	2001			10.7±0 (11)						
	FOX RIVER	3	1999					11±0 (6)				
		4	2004					12±0.16 (41)				
	1	2000					9.5±0.28 (8)					

* See Appendix 8 for reference details.

Table 24. Mean length of Arctic grayling sampled in various water temperatures in the Omineca region.

Method	Watershed	Year	Month	Stream	Temperature (°C)	n	Mean Length (mm)	SD	n			
AG	Finlay	2000	August	FINLAY RIVER	10.2	1	200.0	-	1			
		2001	July	FINLAY RIVER	10.7	5	340.0	53.9	5			
		2004	August	FOX RIVER	11	1	400.0	-	1			
	Omineca	2001	August	NO NAME	5	2	274.7	53.6	6			
				OMINECA RIVER	8	1	350.0	2.8	2			
					9	2	340.0	-	1			
		Parsnip	1998	August	MISSINKA RIVER	13.5	1	367.0	18.4	2		
						14	5	243.0	-	1		
						14	5	248.4	28.2	5		
EF	Finlay	1999	August	FOX RIVER	11	6	263.2	115.7	6			
				FINLAY RIVER	6.7	2	40.5	6.4	2			
		Omineca	2000		NO NAME	10.2	14	43.9	5.5	14		
					9.2	5	51.8	4.6	5			
					10.7	6	36.7	16.4	6			
	Parsnip		2001	August	FOX RIVER	12	25	70.8	29.1	25		
					OMINECA RIVER	9	13	37.2	7.9	13		
						9	12	65.2	3.7	12		
			1995	September	TABLE RIVER	8	1	38.0	-	1		
						9	1	-	-	-		
						9	2	-	-	-		
	1996	November	TABLE RIVER	14	1	65.0	-	1				
				14.5	6	64.8	6.4	6				
				11.5	1	76.0	-	1				
		December	TABLE RIVER		12	1	70.0	-	1			
					6.7	2	42.5	0.7	2			
					8.6	2	50.5	4.9	2			
	MT	Finlay	2000	August	FINLAY RIVER	9.2	1	54.0	-	1		
					8.6	2	50.5	4.9	2			
					9.2	1	54.0	-	1			
SN		Omineca	2001	August	OMINECA RIVER	8	1	28.0	-	1		
						9	18	85.3	34.6	18		
						13.5	4	34.0	1.2	4		
			Parsnip			OMINICETLA CREEK	7	4	34.3	3.5	4	
						SILVER CREEK	14	5	44.0	2.8	5	
						PARSNIP RIVER	2.5	1	-	-	-	
				1996	July	TABLE RIVER		10	1	258.0	-	1
								10.5	1	96.0	-	1
								13	3	302.0	24.6	3
	August	TABLE RIVER				9	1	95.0	-	1		
						9	1	-	-	-		
						9	1	-	-	-		
	SW UN	Finlay	2004	August	FOX RIVER	12	9	308.3	62.5	9		
						8	2	-	-	-		
						10	2	-	-	-		
		Parsnip	1976	August	HOMINKA RIVER	12	1	-	-	-		
						10	2	-	-	-		
						12	1	-	-	-		
1977			March	PARSNIP RIVER	10	2	-	-	-			
					10	1	-	-	-			
					10	1	-	-	-			
June			DESTILIDA CREEK		8.5	1	-	-	-			
					10.5	1	-	-	-			
					12	1	-	-	-			
			July	REYNOLDS CREEK		12	1	-	-	-		
						12	1	-	-	-		
						12	1	-	-	-		
			August	ANZAC RIVER		12	1	-	-	-		
						12	1	-	-	-		
						12	1	-	-	-		
COLBOURNE CREEK		14.5		1	-	-	-					
		13		1	-	-	-					
		7		1	-	-	-					
August	ANZAC RIVER		12	1	-	-	-					
			12	1	-	-	-					
			12	1	-	-	-					
October	NO NAME		12	1	-	-	-					
			13	1	-	-	-					
			13	1	-	-	-					
October	REYNOLDS CREEK		12	2	-	-	-					
			10	2	-	-	-					
			6.3	1	-	-	-					

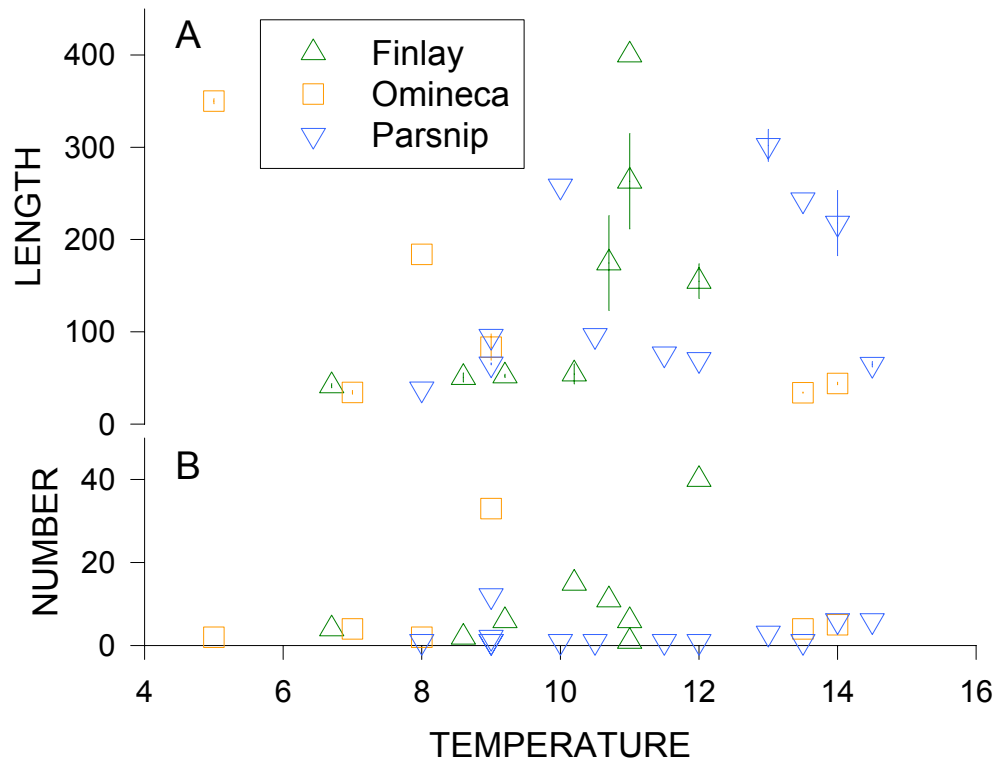


Figure 25. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded surface water temperatures for fish sampling projects conducted in the Omineca region.

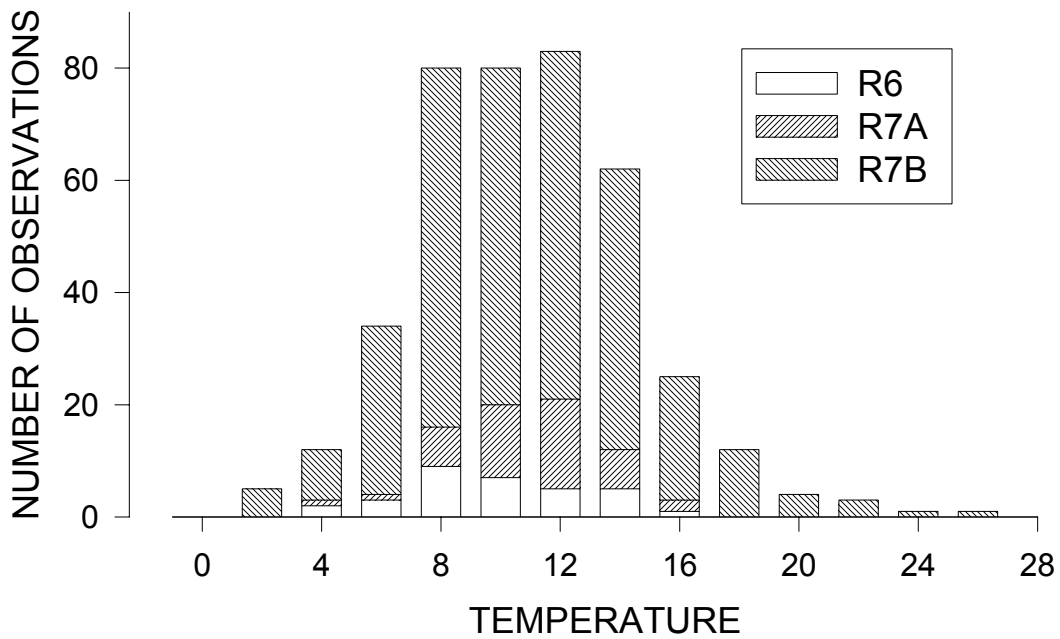


Figure 26. Number of observations when Arctic grayling were reported as being captured plotted against surface water temperature for the Skeena (R6), Omineca (R7A), and Peace (R7B) Regions.

9.2 Conductivity

Conductivity of surface water has been recorded for rivers where Arctic grayling have been captured in the Omineca region (Table 25). Water conductivity naturally varies between 50 and 1500 $\mu\text{S}/\text{cm}$, although commonly interior streams of BC range up to 500 $\mu\text{S}/\text{cm}$ and coastal streams have lower conductivity, around 100 $\mu\text{S}/\text{cm}$ (MOE 2010). In the Omineca region water conductivity samples were collected in July, August and September. There are only 19 records of water conductivity for the Omineca region, but where measurements have been made they range from 40 to 320 $\mu\text{S}/\text{cm}$ (Table 25). Mean sizes of the fish captured where conductivity of water samples were measured ranged from 34 mm to 400 mm. There is no apparent pattern between conductivity and fish size, although no small fish (<100 mm) were captured in waters with a conductivity greater than 200 $\mu\text{S}/\text{cm}$, but this is limited to just 3 observations above 200 $\mu\text{S}/\text{cm}$ (Figure 27). The number of samples collected from water with low conductivity is much more extensive, however, and only three water conductivity measurements were made in water with conductivity above 200. There is insufficient data for us to infer that grayling are selecting water with lower conductivity. Recent work on Interior Fraser Coho has demonstrated that adults select areas with lower conductivity for spawning (McRae, Warren and Shrimpton, unpublished data). Whether a similar relationship exists for Arctic grayling or salmonids in general is not clear.

Conductivity measurements have been collected for water where grayling were captured in the Skeena and Peace regions. We examined the data from these two other regions to see if a similar trend was apparent. Conductivity measurements in the Skeena region tend to be low with 18 of 28 measurements below conductivity of 100 $\mu\text{S}/\text{cm}$ (Table 26). The smallest fish sampled were captured in water with the lowest conductivity, but small fish (<100 mm) were also captured in water with conductivity over 300 $\mu\text{S}/\text{cm}$ (Figure 28). From our analysis of the dataset, it is not clear whether the low number of grayling collected in higher conductivity water is related to sampling effort, low values of conductivity within this region in general, or selection.

There is a considerable amount of data on conductivity from the Peace region where water measurements have been collected from June to October (Table 27). The range in conductivity recorded from rivers within the Peace region is much greater than the Omineca or Skeena regions; 20 – 877 $\mu\text{S}/\text{cm}$. Mean sizes of the fish captured where conductivity of water samples were measured ranged from 39 mm to 333 mm. The majority of measurements were collected from waters with conductivity below 400 $\mu\text{S}/\text{cm}$ and fish of all sizes were captured in these waters (Figure 29). It does not appear, however, that many small grayling (<100mm) were collected in water with conductivity greater than 400 $\mu\text{S}/\text{cm}$ in the Peace region (Figure 29). Whether this is due to sampling effort or selection is difficult to interpret from the current data available.

The number of records where Arctic grayling were observed to be in waters of different conductivity levels for the Skeena, Omineca and Peace regions is shown in Figure 30. Observations refer to the number of records in the dataset, not the number of fish that were caught. It is clear that the majority of Arctic grayling sampling was conducted in waters with conductivity less than 300 $\mu\text{S}/\text{cm}$. Without a more extensive sampling effort throughout the year, it is difficult to determine preferences or tolerance ranges for conductivity in Arctic grayling for different life stages.

Table 25. Conductivity of streams where Arctic grayling were captured in the Omineca Region.

Year	Month	Stream Name	Conductivity (µS/cm)	n	Mean Length (mm)	Length SD	Ref*
Finlay							
1999	August	FOX RIVER	320	6	263.2	115.7	3
2000	August	FINLAY RIVER	80	15	54.3	40.7	1
		NO NAME	100	4	41.5	3.9	1
			40	6	52.2	4.2	1
			70	2	50.5	4.9	1
2001	July	FINLAY RIVER	85	11	174.5	162.4	2
2004	August	FOX RIVER	190	5	67.8	4.8	4
			210	35	167.2	121.0	4
			220	1	400.0	0.0	4
Omineca							
2001	August	NO NAME	118	2	350.0	2.8	5
		OMINECA RIVER	62	2	184.0	220.6	5
			72	2	367.0	18.4	5
			79	4	34.0	1.2	5
			82	18	50.9	29.1	5
			84	13	84.8	35.9	5
		OMINICETLA CREEK	102	4	34.3	3.5	5
		SILVER CREEK	111	5	44.0	2.8	5
Parsnip							
1998	August	MISSINKA RIVER	154	6	64.8	6.4	10
	September	MISSINKA RIVER	124	1	76.0	0.0	10

* See Appendix 8 for reference details.

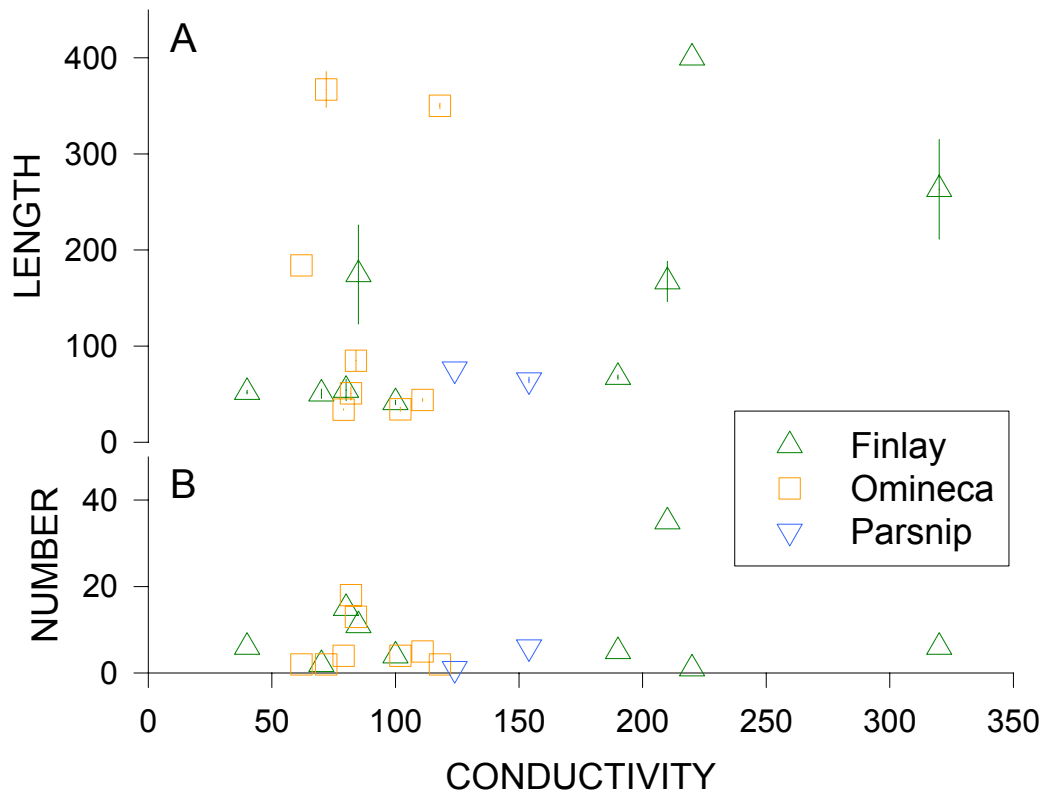


Figure 27. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded water conductivity (µS/cm) for fish sampling projects conducted in the Omineca region.

Table 26. Conductivity of streams where Arctic grayling were captured in the Skeena Region.

Watershed	Year	Month	Stream Name	Conductivity (µS/cm)	n	Mean Length (mm)	SD	Ref*
Atlin	1997	August	CANYON CREEK	62	1	182.0	0.0	11
			MAHAR CREEK	33	1	128.0	0.0	11
			O'DONNELL RIVER	38	1	172.0	0.0	11
			PIKE RIVER	47	3	65.3	0.6	11
			SIMPSON CREEK	47	1	170.0	0.0	11
			WILSON CREEK	49	7	65.3	31.6	11
				52	8	95.1	89.0	11
				173	1	350.0	0.0	12
Blue	1997	September	BLUE RIVER	103	3	107.7	78.2	12
			CHROMITE CREEK	31	1	185.0	0.0	12
			NO NAME	35	2	228.5	0.7	12
				126	3	139.3	7.6	12
				177	1	151.0	0.0	12
				254	7	91.4	13.7	12
				306	1	68.0	0.0	12
				348	4	119.5	44.8	12
				370	11	102.6	40.5	12
				200	3	104.7	39.6	13
Dease Gladys	2003 1997	September August	SERPENTINE CREEK	40	10	79.3	5.8	12
			GLADYS RIVER	42	3	94.3	65.5	11
			NO NAME	7	1	140.0	0.0	11
				16	1	59.0	0.0	11
				34	1	268.0	0.0	11
				36	3	64.7	7.0	11
				6	2	131.0	35.4	11
				8	2	47.5	3.5	11
				14	4	56.0	6.7	11
				190	1	251.0	0.0	13

*See Appendix 8 for reference details.

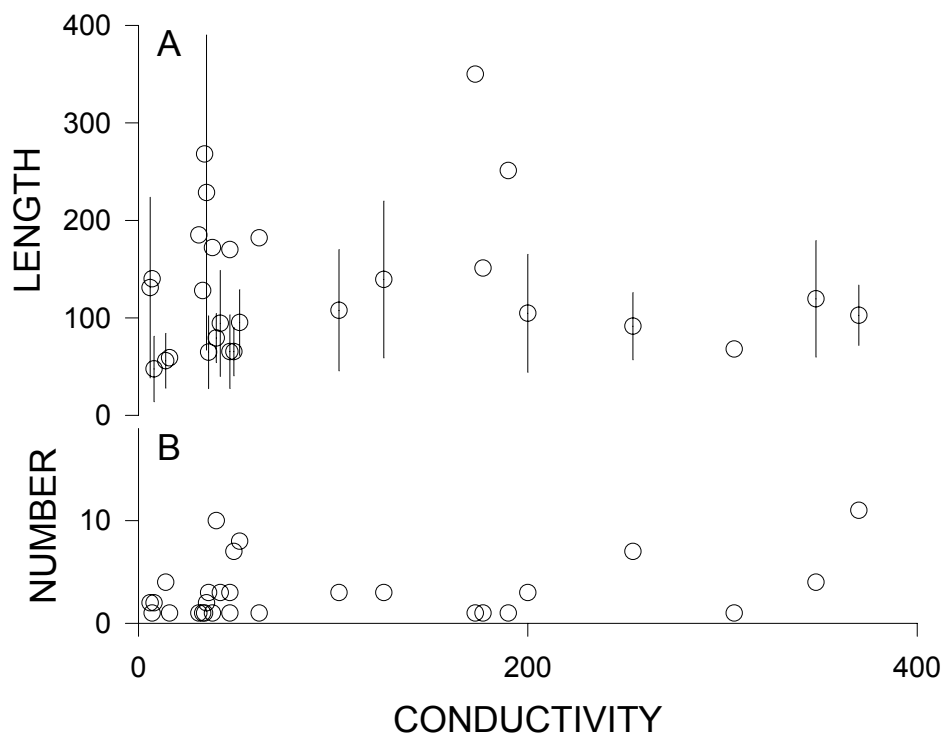


Figure 28. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded water conductivity for fish sampling projects conducted in the Skeena region.

Table 27. Conductivity of streams where Arctic grayling were captured in the Peace Region.

Watershed	Year	Month	Stream Name	Conductivity (μ S/cm)	n	Mean Length (mm)	SD	Ref*		
Beatton	1996	August	GREWATSCH CREEK	157	1	105.0	0	14		
			LA PRISE CREEK	55	4	111.5	0	14		
	1998	September	NO NAME	52	4	107.5	0	14		
			NO NAME	326	5	86.6	3.6	15		
			NO NAME	690	1	201.0	0	15		
Dunedin	2000	July	TRIB TO TRIB TO BEATTON RIVER	62	2	125.0	28.3	16		
	1997	July	TORPID CREEK	50	3	117.7	13.7	17		
Dunedin				60	45	160.5	51.9	17		
				70	9	147.6	45.6	17		
				80	4	177.8	10.9	17		
				90	8	212.5	38.9	17		
				100	5	182.6	48.8	17		
				120	9	166.0	37.9	17		
				30	1	189.0	0	17		
				90	1	100.0	0	17		
				110	8	153.9	30.9	17		
				120	1	188.0	0	17		
	1998	June		NO NAME	110	4	201.3	53.1	18	
					200	1	194.0	0	18	
					230	1	153.0	0	18	
					210	2	162.5	2.1	18	
					260	1	180.0	0	18	
		July	DUNEDIN RIVER	300	17	196.8	47.1	18		
				60	9	60.6	5.2	18		
				230	3	98.7	103.4	18		
				250	4	169.3	28.4	18		
				260	6	225.7	40.8	18		
	1999	August		TORPID CREEK	120	7	52.4	6.1	18	
					NO NAME	100	1	61.0	0	19
					NO NAME	110	2	104.5	47.4	19
					140	2	74.5	4.9	20	
					130	4	46.3	5.0	20	
Fontas	2003	August	BEAVERSKIN CREEK	190	1	55.0	0	20		
			FONTAS RIVER	150	5	120.4	27.0	21		
Fort Nelson	1999	July		180	3	237.3	34.5	21		
				NO NAME	120	6	108.3	72.0	21	
				160	12	135.8	40.4	21		
				520	1	96.0	0	21		
				OBOLE CREEK	190	6	100.0	8.4	21	
				310	6	103.5	8.4	21		
				420	2	226.5	9.2	21		
				510	8	134.6	42.1	21		
				370	15	84.3	66.4	22		
				210	1	64.0	0	23		
	2002	August		CRIDLAND CREEK	70	1	58.0	0	24	
					170	4	57.8	5.2	24	
					60	1	292.0	0	23	
					PATRY CREEK	10	1	220.0	0	25
					STANOLIND CREEK	110	3	196.3	114.9	25
					210	3	48.0	19.1	25	
					240	14	78.6	29.6	25	
					60	1	75.0	0	23	
					110	2	139.0	14.1	24	
					140	1	200.0	0	23	
					190	26	61.5	48.1	25	
					210	6	64.0	4.7	24	
	Frog	2001	September	KECHIKA RIVER	260	3	57.0	1.0	23	
				298	34	148.4	38.6	26		
	Gataga	2003	September	NO NAME	351	1	197.0	0	26	
220					2	61.0	4.2	27		
260					25	69.6	9.7	27		
300					1	144.0	0	27		
310					4	72.0	14.8	27		
Halfway	1996	August	SOUTH GATAGA RIVER	240	3	74.3	10.1	27		
				300	8	268.3	170.0	27		
				240	1	72.0	0	27		
				184	1	195.0	0	28		
				371	10	153.5	0	28		
	1998	September		DEADHORSE CREEK	361	1	103.0	0	28	
					NO NAME	430	16	114.8	68.3	29
					GROUND BIRCH CR	279	2	57.0	1.4	30
					BOYA CREEK	708	1	145.0	0	26
					DENETIAH CREEK	337	6	125.5	89.0	26
Kechika	2001	September	HIZAZA CREEK	356	1	185.0	0	26		
				HORNELINE CREEK	714	11	110.0	57.5	26	
				MOODIE CREEK	542	3	192.3	70.7	26	
				607	3	127.7	48.0	26		
				611	2	190.5	12.0	26		

Watershed	Year	Month	Stream Name	Conductivity ($\mu\text{S/cm}$)	n	Mean Length (mm)	SD	Ref*
			NO NAME	384	1	267.0	0	26
				464	1	303.0	0	26
				479	6	172.0	51.4	26
				544	1	132.0	0	26
				622	3	139.3	53.7	26
Kiskatinaw	1997	August	NO NAME	425	1	210.0	0	31
	2001	August	SUNDERMAN CREEK	219	3	82.3	3.2	32
			UNNAMED TRIB TO KISKATINAW	224	7	66.1	5.2	32
		September	MINISTIK CREEK	329	2	122.5	65.8	32
Liard	2000	July	VENTS RIVER	270	11	283.1	36.0	33
				290	3	39.3	4.0	33
	2002	August	TRIB TO LIARD	710	2	292.0	17.0	34
		September	TRIB TO LIARD	646	3	251.0	20.5	34
				795	1	310.0	0	34
				877	2	213.5	34.6	34
Muskwa	1999	June	NO NAME	30	2	74.5	7.8	35
				40	9	74.8	4.9	35
				60	6	62.7	28.4	35
				110	4	89.5	17.7	35
				120	3	131.3	90.6	35
				130	8	237.1	26.4	35
				140	18	84.8	53.8	35
				150	4	112.0	62.4	35
				200	7	186.7	69.3	35
			STEAMBOAT CREEK	130	14	79.4	10.4	35
				170	1	83.0	0	35
	2000	August	KLEDO CREEK	210	18	72.6	58.9	36
				270	13	45.1	7.4	36
			NO NAME	90	3	156.7	47.3	36
				100	7	39.1	3.0	36
				120	3	110.0	10.0	36
				130	1	48.0	0	36
				170	8	133.5	34.3	36
				200	11	64.4	42.4	36
				240	8	126.4	17.4	36
				250	1	176.0	0	36
				270	1	114.0	0	36
				400	7	135.0	31.6	36
		September	NO NAME	20	1	165.0	0	36
				40	11	95.8	34.2	36
				50	1	115.0	0	36
				70	1	105.0	0	36
				80	1	95.0	0	36
				90	2	96.5	2.1	36
	2001	August	AKUE CREEK	180	4	98.5	2.4	37
			AKUE CREEK TRIB	260	3	116.7	35.5	37
			GAMMER CREEK	170	5	198.0	34.0	37
			NO NAME	80	1	50.0	0	37
				100	3	160.0	26.5	37
				180	5	172.0	49.7	37
				300	1	200.0	0	37
		September	GAMMER CREEK	120	2	175.0	35.4	37
			NO NAME	150	1	70.0	0	37
				160	1	60.0	0	37
				180	7	63.6	11.8	37
				210	1	105.0	0.0	37
			RASPBERRY CREEK	110	7	87.9	45.3	37
				190	1	65.0	0	37
Murray	1996	August	MARTIN CREEK	223	2	135.5	0	28
		September	HIGHHAT RIVER	232	1	258.0	0	28
	1998	July	DICKEBUSCH CREEK	320	5	264.0	27.0	38
	2000	July	NO NAME	280	2	333.5	2.1	33
	2002	September	EIGHT MILE CREEK	398	3	162.7	58.3	39
				523	10	227.1	27.7	39
				850	7	103.6	9.4	39
		August	NO NAME	50	1	61.0	0	40
				80	1	65.0	0	40
	2005	August	WOLVERINE RIVER	403	1	327.0	0	41
				110	1	58.0	0	41
Petitot	1997	September	PETITOT RIVER	190	1	93.0	0	42
	1999	October	D'EASUM CREEK	260	3	92.7	12.7	43
			EMILE CREEK	216	2	274.5	23.3	43
Sikanni Chief	1997	August	NO NAME	23	5	230.0	25.6	44
				58	8	151.3	10.2	44
				154	5	46.4	4.6	44
	1998	August	DONNIE CREEK	136	33	80.3	54.9	45
			NO NAME	90	14	166.7	50.3	45
				119	2	144.5	20.5	45
				192	19	114.9	72.4	45

Watershed	Year	Month	Stream Name	Conductivity ($\mu\text{S/cm}$)	n	Mean Length (mm)	SD	Ref*	
				198	6	158.5	39.9	45	
				205	4	146.5	8.5	45	
				224	7	108.4	63.2	45	
			TEMPLE CREEK	259	15	168.1	47.2	45	
		September	TEMPLE CREEK	243	4	203.0	53.9	45	
		July	TRIB TO KATAH CR	182	8	86.1	17.3	46	
		August	KATAH CREEK	212	1	93.0	0	46	
			TRIB TO CONROY CR	217	21	120.0	74.0	47	
				383	9	98.3	24.4	47	
			TRIB TO KATAH CR	204	3	133.7	40.1	46	
			TRIB TO TRIB TO CONROY CR	217	1	43.0	0	47	
				130	5	94.4	24.8	47	
				160	3	62.7	14.7	47	
				190	1	73.0	0	47	
		2002	August	THETLAANDOA CR	80	6	150.0	70.4	48
				90	2	192.0	0	48	
				110	1	206.0	0	48	
				170	4	71.5	8.7	48	

* See Appendix 8 for reference details.

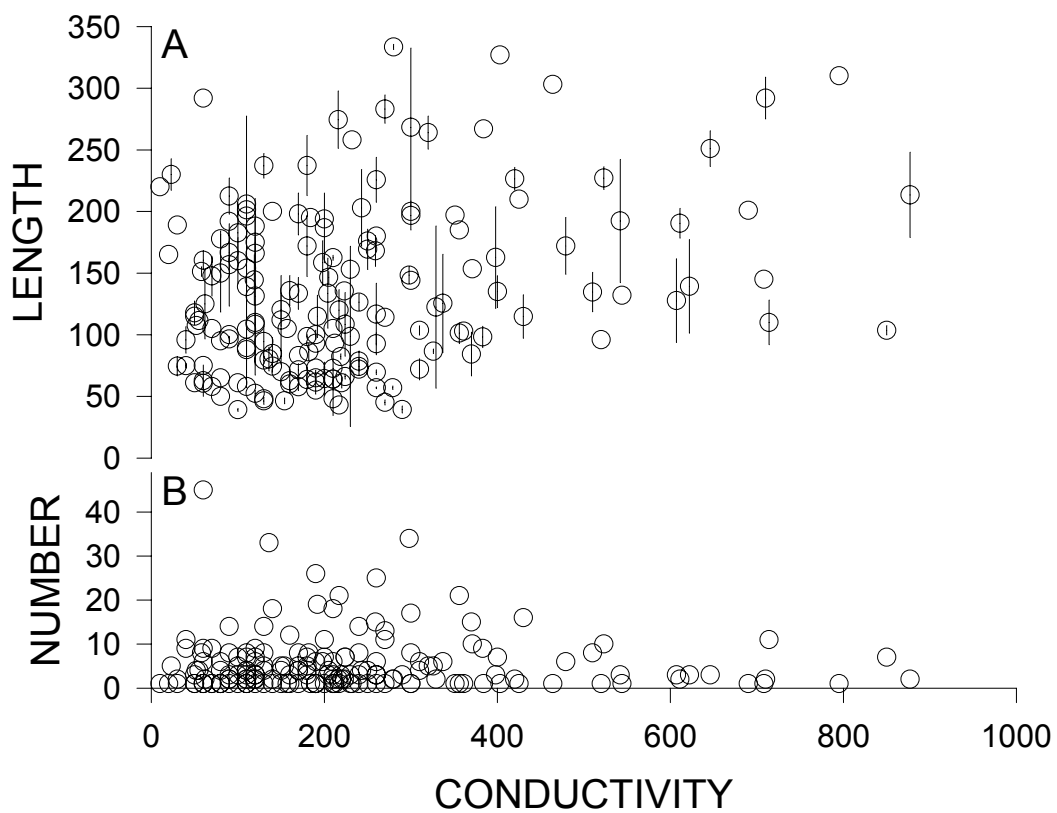


Figure 29. Mean length (A) and number of observations (B) for Arctic grayling plotted against the recorded water conductivity ($\mu\text{S/cm}$) for fish sampling projects conducted in the Peace region.

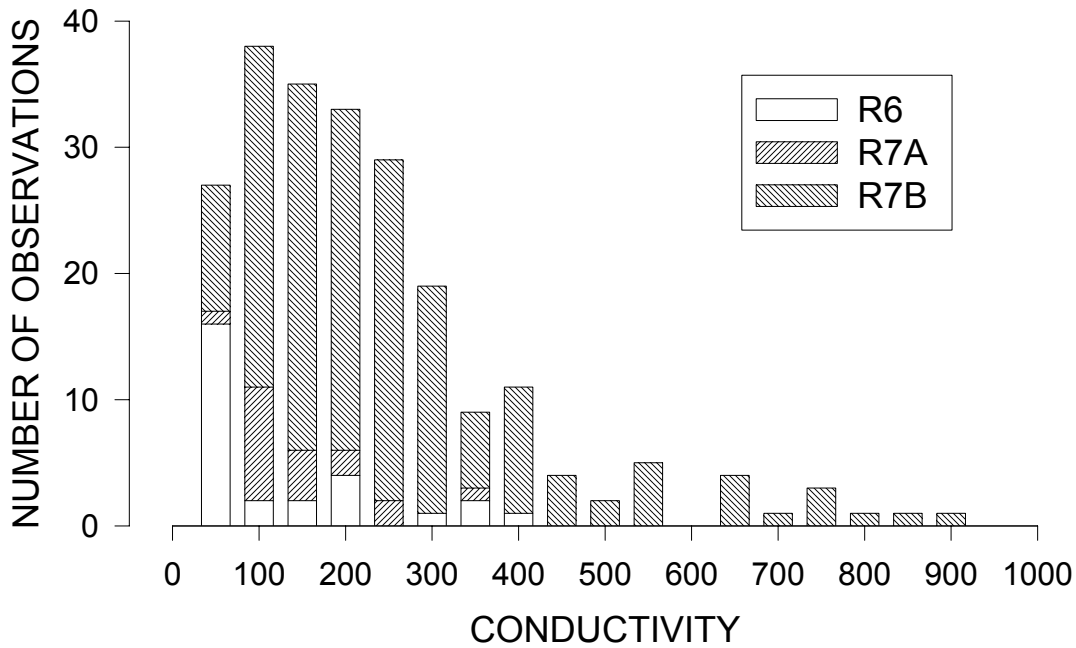


Figure 30. Number of observations when Arctic grayling were captured plotted against water conductivity ($\mu\text{S}/\text{cm}$) for the Skeena (R6), Omineca (R7A), and Peace (R7B) Regions.

9.3 pH

The pH data available for streams in the Omineca region where Arctic grayling have been sampled is limited. An early study by Bruce and Starr (1985) reported pH for streams where Arctic grayling had been sampled, but not necessarily at the time of sampling, ranging from 6.7 to 8.2 (Table 28). There is also limited pH data available for the lakes where Arctic grayling have been sampled in the Omineca region as well as for the Peace and Skeena regions (Table 29). In August 1997 the pH at the surface of both Fishing Lakes a and b in the Omineca region was 8.1. At the bottom of Fishing Lake “a” the pH was 7.5 and at the bottom of Fishing Lake “b” the pH was 7.6. In the Peace region, pH data is available from 1997, 1999, and 2003. The pH ranged from 7.8 – 8.1 at the surface and 7.6 – 7.8 at the bottom of these lakes. In the lakes of the Skeena region, surface pH ranged from 6.7 – 8.7 and bottom pH from 6.6 – 7.9. No size data is available for the specific Arctic grayling captured at the sites where pH was recorded.

Table 28. pH data for streams in the Omineca region (Bruce and Starr 1985).

Watershed	Stream Name	Month	pH	
Parsnip	BLACKWATER CREEK	June	7.2	
			7.3	
				7.2
		CLEARWATER CREEK	September	8.1
		CUTTHUMB CREEK	June	6.9
		KIMTA CREEK	June	8.0
		LIGNITE CREEK	September	7.7
		MISCHINSINLIKA CREEK	September	7.4
		MISINCHINKA RIVER	September	7.8
		MUGAHA CREEK	June	7.9
		PACK RIVER	September	7.7
		PARSNIP RIVER	September	7.8
		PATSUK CREEK	June	8.0
		SCOTT CREEK	June	8.0
		SCOVIL CREEK	September	7.9
		SIX MILE CREEK	June	8.1
		TONY CREEK	June	7.7
		TUTU CREEK	June	7.9
		WESTON CREEK	June	8.1
				8.0
	UNNAMED "B"	June	7.3	
	UNNAMED "C"	June	8.0	
Peace	STRANDBERG CREEK	June	6.7	
	STRANDBERG CREEK	June	7.0	
	ECKLUND CREEK	June	7.0	
	CENTENNIAL CREEK	June	7.0	
Finlay	OSPIKA	September	8.2	
			8.2	
Manson Nation	MANSON RIVER	June	7.6	
	NATION RIVER	September	7.8	

Table 29. pH of lakes where Arctic grayling were captured in BC lakes.

Region	Waterbody	Year	Month	Lake Name	Surface pH	Bottom pH	Depth (m)
Omineca	Finlay	1997	August	FISHING LAKESa	8.1	7.6	14
				FISHING LAKESb	8.1	7.5	25
Peace	Turnagain	1997	September	SANDPILE LAKES	8.1	7.6	24
				NO NAME	7.8	7.6	4.5
Skeena	Gataga	2003	September	NO NAME	8	7.8	22
				NO NAME	8	7.2	22
	Atlin	1997	July	DIXIE LAKE	8	7.7	40
				NAKINA LAKE	8.3	7.7	10
	Gladys	1997	August	LAILAW LAKE	6.7	7.7	26
				TROUT LAKE	7.1	6.6	20
Dease	1997	September	VINCENT LAKE	8.7	7.9	30	
Cry	1997	September	CRY LAKE	8	7.9	30	

9.4 Dissolved Oxygen

No information is available in the provincial database for dissolved oxygen levels of streams at the time of Arctic grayling sampling. However, Arctic grayling have been reported to have a greater tolerance for low dissolved oxygen compared to most salmonid species (Northcote 1995). Feldmuth and Eriksen (1978, cited in Hubert *et al.* 1985) found that a Montana population of Arctic grayling at an acclimated temperature of 13 °C had a critical oxygen maximum ranging from 1.4 mg/l at 8 °C to 1.8 mg/l at 20 °C. Other Montana population have been reported in waters with dissolved oxygen ranging from 7.2 -11.6 mg/l in spring and summer months (Nelson 1954; Liknes and Gould 1987). Even though Arctic grayling are often noted to have a high tolerance for low dissolved oxygen compared to other salmonid species (Hubert *et al.* 1985;

Northcote 1993; Birtwell *et al.* 2005) the documentation of studies to support this claim are limited or nonexistent.

9.5 Aquatic Plants

No information is available in the Arctic grayling database on aquatic vegetation. Reed (1964) did reported Arctic grayling in streams with heavy riparian vegetation rich in terrestrial insects. Aquatic vegetation does play an important role in fish habitat and can have large effects on a number of environmental variables which limit fish distribution (Owen and Karr 1978).

9.6 Gravel types

No information is available in the provincial database on Arctic grayling substrate preference. Gravel type is an important substrate characteristic for stream fish and preference may depend on fish species and/or life stage. This preference can change depending on life history stage, season and available habitat. According to Stewart *et al.* (1982) Arctic grayling spawning habitat in Adsett creek was coarse gravel (2-4cm). Similarly, Alaskan populations of Arctic grayling have been reported spawning over gravel and rocky bottom substrate as well as occasionally sandy bottoms (Reed 1964; Beauchamp 1990). Adult European grayling preferred boulder substrate in the summer and smaller gravel and pebbles in autumn (Nykanen *et al.* 2004).

10.0 Potential areas of habitat enhancement

Although the data available for Arctic grayling in British Columbia provides a large amount of information on geographic distribution and size ranges, it does not provide adequate information required to assess potential areas of habitat enhancement. Habitat enhancement projects in the Omineca region have been limited to a fertilization project on the Mesilinka River. This project was initiated in 1991 to determine if stream fertilization would enhance Arctic grayling stocks in the area. Monitoring results revealed that Arctic grayling abundance in the system only increased modestly and that Rainbow trout and Mountain Whitefish abundance increased substantially (Larkin *et al.* 1999).

A transplant experiment was attempted in 1992. The objective of this study was to create a “genetic reserve” for Nation River Arctic grayling. Adult Arctic grayling were transplanted into Little Calais Lake in 1992 and 1993. No natural populations of Arctic grayling were sampled in this lake. Surveys of the lakes were conducted to determine the success of the transplant and no Arctic grayling were captured (Langston 1999).

Logging and mining activities in the Omineca region have occurred in the past and are ongoing. The impact of these activities has not been documented to our knowledge. Sites need to be identified and proper habitat enhancements need to be made where potential Arctic grayling habitat has been altered. Arctic grayling are included in the list of species assessed by the Fish

Passage - Culvert Inspection Procedures (FPCI). This program assesses fish passage at culverts and other known barriers that limit fish movement (Parker 2000). The results of FPCI are used to prioritize watersheds and species for support under Forest Renewal British Columbia's (FRBC) Watershed Restoration Program (WRP).

11.0 Lipid analysis

No lipid analysis is available in the provincial database for Arctic grayling populations. Lipid content of individual fish can be used as an indicator of fish health and future population success (Adams 1999). This is especially the case for northern temperate fish populations that experience low resource winters and therefore must maximize energy storage in order to survive. A study on rainbow trout reported that small fish with low lipid content depleted lipids early and experienced an increasing in mortality compared to larger fish with larger lipid reserves (Post and Parkinson 2001). The survival of fish during the winter depends on lipid reserves and the length of the winter season (Post and Parkinson 2001; Biro *et al.* 2004). No analysis of lipid content has been attempted for Arctic grayling populations in the Omineca region to assess population health and overall fish condition.

Data Gaps

A considerable amount of data on Arctic grayling in BC has been consolidated and considered for this report. It is evident, however, from the analysis above that gaps within this data exist, limiting our understanding of Arctic grayling populations in the Omineca region. Gaps in the data limit our understanding of basic demographic information and life history details, which are important for management approaches. There is also a paucity of information describing habitat use and selection by Arctic grayling and what their tolerance is to physical and chemical parameters that affect water quality. We suggest that further investigation of the identified data gaps should be addressed and subsequently integrated into the Arctic grayling provincial management plan. An overview of the data gaps that have been identified is provided below.

- Physical and chemical factors affecting Arctic grayling distribution

The range in abiotic factors that Arctic grayling can tolerate and preference ranges are not known for Arctic grayling in the Omineca region. It can not be assumed that knowledge of abiotic tolerance levels for other species of salmonids or even other grayling populations is transferable to fish found in the Williston watershed (Brett 1956). Based on our knowledge of salmonid biology, temperature, dissolved oxygen, pH, flow, slope and gradient are undoubtedly important for grayling (Gunn 1986; Mathews and Berg 1997; Deegan *et al.* 1999; Adams *et al.* 2000). Some of these variables are known to show considerable temporal and spatial variation that may have a profound influence on Arctic grayling distribution.

Measurements of physical factors, such as outlined above, across a broad geographic region in concert with grayling distribution will provide insight into the effect of these variables on grayling habitat use or avoidance. It is important to understand what factors

affect distribution positively and negatively to develop an understanding of how habitat changes may impact grayling populations. The creation of the Williston Reservoir altered Arctic grayling habitat, yet very limited information has been documented on the physical and environmental requirements for these populations. Temperature and conductivity measurements have been limited to the sampling sites in Finlay, Omineca and Parsnip watersheds, primarily in the summer months. The intervals of these measurements were not consistent and reflected a lack of sampling effort throughout the winter months. No documentation is available for dissolved oxygen, pH, flow, slope or gradient at Arctic grayling sampling sites in the Omineca region.

Few environmental factors have a larger influence on animal energetics and metabolism than temperature. For fish a change in environmental temperature will directly affect all aspects of their physiology, such as enzyme function, growth, metabolism and locomotion. A change of a few degrees Celsius in ambient temperature can have profound effects on fish, especially in developing animals because this temperature effect is cumulative (Elliott, 1981). Because animals have evolved to deal with specific temperature regimes, relatively small temperature changes can have measurable effects on community and population structure, largely rooted in the direct effect of temperature on the physiology of the individual organisms. For example, Konecki *et al.* (1995) suggested that juvenile Coho salmon (*Oncorhynchus kisutch*) may prefer temperatures to optimize growth, even if they can tolerate or utilize food more efficiently at much higher temperatures.

Increasingly in fisheries management the laboratory-based estimates of thermal preference and field estimates of a species thermal ranges are combined to investigate population demographics. Integrating these two techniques is a robust approach to understanding temperature requirements for a species. The information can then be used to establish criteria useful in assessing distribution of fish in field studies, modeling potential loss or gain of critical habitat, or defining critical thermal thresholds for regulation and interspecific species interactions (Welsh *et al.*, 2001). We recommend that determination of temperature tolerance and preference is a key step to understanding Arctic grayling habitat requirements for the Omineca region. This work should compare grayling from different rivers to assess if differences exist among populations and expand on our knowledge of the range of temperature preference in this species.

- Demographic information for Arctic grayling

Characteristics of Arctic grayling populations such as size, growth, density, distribution, age, age at maturity, sex ratios, recruitment variability, and maximum age are vital for understanding population demographics necessary for conservation management. Components of demographic information needed to fully understand Arctic grayling populations are not clearly defined in the Omineca region. Many of the individual level statistics have been collected such as range of lengths and weights. All size classes, however, must be captured to understand population demographics. Growth estimates have been made based on the age analysis and the preliminary analysis of growth rate suggests little difference among watershed. Given the uncertainty that exists in determining fish age from scales, further work is required accurately assess age and then to validate growth rates for all populations.

At present, the information regarding abundance estimates is limited to the Parsnip watershed and the Ingenika River. Monitoring of other populations in the Omineca region is needed to provide estimates of the number of Arctic grayling returning to each watershed and changes in those numbers over time. There is a fairly comprehensive understanding of relative densities among rivers flowing into the Williston Reservoir. Our calculation of sex ratios suggests that males and females are similar in abundance, but it is not clear at what age fish become mature and how long they live. We also recommend that a sampling program be conducted to fully characterize population demographics within the major tributaries to the Williston Reservoir.

- Critical habitat assessment

Relatively few studies have examined the extent of movement by Arctic grayling in the Williston watershed, but it is likely that most fish are constrained to particular tributaries of the Williston reservoir (Clarke et al. 2005). On a watershed level, information has not been collected/reported in a manner suitable to analyze what habitat is critical for specific life history stages of Arctic grayling. Selection of suitable spawning sites is often considered to be critical because the highest rate of mortality in salmonids generally occurs during the incubation period, and this mortality is closely related to the features of the spawning/incubation site. Few areas have been identified as potential spawning areas for grayling in the Omineca region. Spawning habitats need to be identified, which will help to focus habitat protection and restoration projects. It is also not known if spawners exhibit site fidelity, observed in other salmonid populations (Bahr and Shrimpton 2004), or select different locations for each spawning event. It has been suggested that Arctic grayling have a strong affinity for site fidelity, but they frequently are found in different streams for different stages of life history (Tack 1980, Armstrong 1986, Ridder 1994). However, Blackman (2002) noted that 6 out of 18 tagged fish did not return to streams they were tagged in to spawn. Identification of spawning habitat is important for successful protection of Arctic grayling.

Sampling effort has been focused in the summer months and very little is known about overwintering movements and habitat use.

With the flooding of the Upper Peace River following construction of the WAC Bennett Dam, fluvial habitat was lost. Adfluvial and fluvial life history types have been speculated to exist within the Omineca region, but presence of the two life history types needs to be confirmed.

- Interspecific interactions

The extent and impacts of interspecific competition and predation have also not been defined. It is difficult to identify what resources other species share with Arctic grayling and what factors limit overlap, for example: temperature, flow, slope, gradient, stream order, prey type, aggressiveness. The overlap of specific life stages of other species that prey on juvenile Arctic grayling has not yet been investigated.

The environmental changes in tributaries of the Williston reservoir have made it difficult to restore fish habitats to their original conditions, especially given the lack of information available before the creation of the reservoir. Therefore, rather than attempting to restore the fish habitat in the Omineca region to its original conditions, it is useful to compare healthy populations of

Arctic grayling to the red-listed populations in the Omineca region. This analysis overall has revealed that there does not seem to be a consistent approach to monitoring Arctic grayling populations within the Omineca region or between the management regions of BC. This inconsistency makes it difficult to assess the health of the red-listed populations of Arctic grayling in the Omineca region because comparisons between populations and over time are difficult, if not impossible.

Acknowledgements

Funding for this report was provided by the Peace/Williston Fish and Wildlife Compensation Program and a Natural Sciences and Engineering Research Council (NSERC) Industrial Postgraduate Scholarship (IPS). We would like to thank Brian Blackman (PFWWCP), Ray Pillipow (MOE), Elizabeth Miller (MOE) and Brenden Anderson (MOE) for reviewing and providing comments on a first draft of this report. Also we would like to thank Susanne Williamson (MOE) for providing us with and explaining the provincial database used in the analysis.

References

Adams SM 1999 Ecological role of lipids in the health and success of fish populations. In: Lipids in Freshwater Ecosystems (M. T. Arts & B. C. Wainman, eds), pp. 132-160. Springer-Verlag, New York.

Adams SB Frissell CA Rieman BE 2000 Transactions of the American Movements of nonnative brook trout in relation to stream channel slope. Transactions of the American Fisheries Society, 129: 623-638.

Armstrong RA 1986 A Review of Arctic Grayling Studies in Alaska 1952-1982. Biological Papers of the University of Alaska. 23:3-17.

Bahr MA and Shrimpton JM 2004 Spatial and quantitative differences in movement of large bull trout (*Salvelinus confluentus*) from a watershed in northwestern British Columbia, Canada, are due to habitat selection and not differences in life history. Ecology of Freshwater Fish 13:294–304.

Beauchamp DA 1990 Movements, habitat use, and spawning strategies of Arctic grayling in a subalpine lake tributary. Northwest Science, 64:195-207.

Beere MC 2002 A Reconnaissance of Tuya Lake. British Columbia Ministry of Water, Land and Air Protection Fisheries Branch. Smithers, B.C. Skeena Fisheries Report #135

Biro PA Morton AE Post JR and Parkinson EA 2004 Over-winter lipid depletion and mortality of age-0 rainbow trout (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 61(8):1512-1519.

Birtwell IK Samis SC and Khan NY 2005 Commentary on the Management of Fish Habitat in Northern Canada: Information Requirements and Policy Considerations Regarding Diamond, Oil Sands and Placer Mining – Summary Report. Canadian Technical Report of Fisheries and Aquatic Sciences 2607: xii + 65.

Blackman BG Jesson D Ableson D and Down T 1990 Williston Lake Fisheries Compensation program management plan. Peace/Williston Fish and Wildlife Compensation Program Report No. 58, 38pp.

Blackman BG 2001 A strategic plan for the conservation and restoration of Arctic grayling in the Williston Reservoir watershed. Peace/Williston Fish and Wildlife Compensation Program Report no. 241, 17 pp.

Blackman BG Hunter MJ 2001 1998 Arctic grayling (*Thymallus arcticus*) Surveys in the Table Anzac and Parsnip Rivers. Peace/Williston Fish and Wildlife Compensation Program, Report No. 237. 39pp plus appendices.

Blackman BG 2002a Radio Telemetry Studies of Arctic Grayling Migrations to Overwinter, Spawning and Summer Feeding Areas in the Parsnip River Watershed 1996-1997. Peace/Williston Fish and Wildlife Compensation Program, Report No. 263. 26pp plus appendices.

Blackman BG 2002b The distribution and relative abundance of Arctic grayling (*Thymallus arcticus*) in the Parsnip, Anzac, and Table Rivers. Peace/Williston Fish and Wildlife Compensation Program. Report No.254 15pp

Blackman BG Murphy EB Cowie DM 2004 Relative abundance of Arctic grayling (*Thymallus arcticus*) in the Parsnip, Table and Anzac rivers 2003. Peace/Williston Fish and Wildlife Compensation Program Report, 19pp plus appendices. Unpublished report.

Brett JR 1956 Some Principles in the Thermal Requirements of Fishes. The Quarterly Review of Biology, 31(2):75-87.

Bruce PG and PJ Starr 1985 Fisheries resources and fisheries potential of Williston Reservoir and its tributaries streams. Vol. II. Fisheries resources potential of Williston Lake tributaries – a preliminary overview. Prov. B.C. Fish. Tech. Circ. No. 69:100 pp.

Coomes DMV 1986 A Reconnaissance Survey of Ed Asp Lake. Recreational Fisheries Branch Ministry of Environment and Parks.

Cowie DM Blackman BG 2006 An Investigation of the Distribution and Relative Abundance of Arctic grayling (*Thymallus arcticus*) in the Ingenika River 2004. Peace/Williston Fish and Wildlife Compensation Program Report No. 21 pp plus appendices.

DeCicco AL Brown RJ 2006 Direct validation of annual growth increments on sectioned otoliths from adult Arctic grayling and a comparison of otolith and scale ages. North American Journal of Fisheries Management 26, 580–586.

Deegan LA Golden HE Harvey CJ and Peterson BJ 1999 Influence of Environmental Variability on the Growth of Age-0 and Adult Arctic Grayling. Transactions of the American Fisheries Society, 128: 1163-1175.

Elliott JM 1981 Some aspects of thermal stress on freshwater teleosts. 209-245 pp. In: Stress and fish. A.D. Pickering (ed.). Academic Press.

Envirocon Limited 1980 Arctic Grayling Spawning and Production in Surprise Lake: A Preliminary Discussion of the Effects of Hydro Electric Power Development. Placer development LTD.

Feldmuth CR and Eriksen CH 1978 A hypothesis to explain the distribution of native trout in a drainage of Montana's Big Hole River. Verh. Internat. Verein. Limnol. 20:2040-2044.

FishBase 2000 Froese R Pauly D (Eds.), World Wide Web electronic publication. Retrieved April 23, 2009, from FishBase 2000 database: <http://www.fishbase.org>

Gunn JM 1986 Behaviour and ecology of salmonid fishes exposed to episodic pH depressions. Environmental Biology of Fishes, 17(4):241-252.

Harley SJ Ransom A Myers and Dunn A 2001 Is catch-per-unit-effort proportional to abundance? Canadian Journal of Fisheries and Aquatic Sciences 58(9): 1760–1772.

Hubbs CL and Langler KF 1958 Fishes of the Great Lakes Region. Cranbrook Institute of Science, Bulletin No.26, Bloomfield Hills, Michigan.

Humpesch U 1985 Inter- and intra-specific variation in hatching success and embryonic development of five species of salmonids and *Thymallus thymallus*. Polish Archives of Hydrobiology. 104:129-144.

Konecki JT Woody CA and Quinn TE 1995 Critical thermal maxima of coho salmon (*Oncorhynchus kisutch*) fry under field and laboratory ac-climation regimes. Canadian Journal of Zoology, 73: 993-996.

Langston AR 1999 Evaluation of the 1992 and 1993 Arctic grayling (*Thymallus arcticus*) transplants to Little Calais Lake and current fish population status, 1998. Peace/Williston Fish and Wildlife Compensation Program, Report No. 199. 11pp plus appendices.

Larkin GA Wilson GA Ashley KI Slaney PA Land RW Biancolin S 1999 Development of a premier northern river fishery: Mesilinka River, the fourth year of fertilization Peace/Williston Fish and Wildlife Compensation Program, Report No. 197. 27pp plus appendices.

Liknes GA and Gould WR 1987 The Distribution, Habitat and Population Characteristics of Fluvial Arctic Grayling (*Thymallus arcticus*) in Montana. Northwest Science 61(2).

Mackay CA Blackman BG 2005 Relative abundance of Arctic grayling (*Thymallus arcticus*) in the Parsnip River in 2005. Peace/Williston Fish and Wildlife Compensation Program Report 18 pp. Unpublished report.

Mathews KR and Berg NH 1997 Rainbow trout responses to water temperature and dissolved oxygen stress in two southern California stream pools. *Journal of Fish Biology* 50:50–67.

Miller EF Williamson S Blouw L Clarke A 2008 British Columbia Arctic Grayling Information Synopsis. Ministry of Environment, Environmental Stewardship Division Fish and Wildlife section.

MOE (Ministry of Environment) 2010 Guidelines for Interpreting Water Quality Data. Resources Inventory Committee Publication. Version 1.0. British Columbia, Canada.
<http://srmwww.gov.bc.ca/risc/pubs/aquatic/interp/>

Murphy EB Blackman BG 2004 Relative abundance trends in Arctic grayling (*Thymallus arcticus*) populations of the Parsnip, Table, and Anzac Rivers in 2001. Peace/Williston Fish and Wildlife Compensation Program. Report No. 293 27pp.

Nelson P 1954 Life history and management of the American grayling tricolor. (*Thymallus signifer*). *Montana Journal of Wildlife Management* 18(3):324-342.

Northcote TG 1993 A review of management and enhancement options for the Arctic grayling (*Thymallus arcticus*) with special reference to the Williston Reservoir watershed in British Columbia, B.C. Ministry of Environment, Lands and Parks, Fisheries Branch, Fisheries Management Report No. 101.

Nykanen M Huusko A and Lahti 2004 Changes in movement, range and habitat preferences of adult grayling from late summer to early winter. *Journal of Fish Biology*, 64(5):1386-1398.

Owen TG and Karr JR 1978 Habitat Structure and Stream Fish Communities. *Ecology*, 59(3): 507-515.

Parker MA 2000 Fish Passage – Culvert Inspection Procedures. Ministry of Environment, Lands and Parks, Watershed Restoration Technical Circular No. 11.

Pillipow R 2002 Manson River snorkel surveys conducted 1998 and 2002 by MWLAP staff, unpublished data. Province of BC, Ministry of Water, Land and Air protection.

Post JR and Parkinson EA 2001 Energy allocation strategy in young fish: Allometry and survival. *Ecology* 82(4): 1040-1051.

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org>.

Reed RJ 1964 Life history and migration patterns of Arctic grayling. Alaska Dept. Fish and Game, Res. Rep. 2:30p.

RIC (Resources Inventory Committee) 1996 Fish Collection Methods and Standards. Prepared by the B.C. Ministry of Environment, Lands and Parks, Fish Inventory Unit for the Aquatic Ecosystems Task Force. pp

Ridder WP 1994 Contributions of Arctic grayling from Caribou Creek to the Richardson Clearwater River and Shaw Creek, 1980 through 1988. Fisheries Data Report Series No. 94-49 Alaska Dept of Fish and Game.

Scott WB and EJ Crossman 1973 Freshwater Fishes of Canada. Fisheries Research Board of Canada, Bulletin 184. Ottawa, ON, Canada.

Shrimpton JM Roberts SL Clarke AD 2007 Genetic analysis of Arctic grayling population structure in the Williston Watershed. Peace/Williston Fish and Wildlife Compensation Program Report No. 311. 12 pp.

Shrimpton JM Clarke AD 2008 Genetic analysis of Arctic grayling population structure in the Williston Watershed: samples from the Finlay River. Peace/Williston Fish and Wildlife Compensation Program Report, 12pp. Unpublished report.

Silkstrom CB 1983 Otolith, pectoral fin ray and scale age determinations for Arctic grayling. Prog. Fish-Cult. 45(4).

Simonson TD and Lyons J 1995 Comparison of Catch per Effort and Removal Procedures for Sampling Stream Fish Assemblages. North American Journal of Fisheries Management, 15: 419-427.

Skaugstad C 1988 Evaluation of Arctic grayling enhancement in Alaska during 1987. Alaska Department of Fish and Game, Fisheries Data Series No. 48, Fairbanks.

SKR Consultants Ltd. 1997a A Reconnaissance Inventory Of Butte Lake (650-8625-561-01) Prepared for Ministry of Environment. Smithers, B.C. by SKR Consultants Ltd. Smithers, BC.

SKR Consultants Ltd. 1997b A Reconnaissance Inventory of Unnamed Lake (alias Frank's Lake) (218-1779-852-03) approximately 20 km east of Tuya Lake. Prepared for Ministry of Environment. Smithers, B.C. by SKR Consultants Ltd. Smithers, BC.

SKR Consultants Ltd. 1997c A Reconnaissance Inventory of Unnamed Lake (alias Minotaur Lake) (819-0952-03) approximately 15 km south of Swift Lake. Prepared for Ministry of Environment. Smithers, B.C. by SKR Consultants Ltd. Smithers, BC.

Stamford MD 2001 Mitochondrial and microsatellite DNA diversity throughout the range of a cold adapted freshwater salmonid: Arctic grayling (*Thymallus arcticus*). Peace/Williston Fish and Wildlife Compensation Program Report No. 248. 90pp.

Stamford MD Taylor EB 2004 Phylogeographical lineages of Arctic grayling (*Thymallus arcticus*) in North America: divergence, origins and affinities with Eurasian *Thymallus* Molecular Ecology 13, 1533-1549.

Stamford MD Taylor EB 2005 Population subdivision and genetic signatures of demographic changes in Arctic grayling (*Thymallus arcticus*) from an impounded watershed. Canadian Journal of Fisheries and Aquatic Sciences 62, 2548-2559.

Stewart RJ McLenehan RE Morgan JD and Olmsted WR 1982 Ecological studies of Arctic grayling (*Thymallus arcticus*), Dolly Varden Char (*Salvelinus malma*), and mountain whitefish (*Prosopium williamsoni*) in the Liard River drainage B.C. E.V.S Consultants Ltd. for Westcoast transmission Company Ltd. and Foothills Pipe Lines (North B.C.) Ltd.

Stuart KM and Chislett GR 1979 Aspects of the life history of Arctic grayling in the Sukunka drainage. Prov. Province of BC Fisheries Branch, Prince George, Internal Report, 111p.

Tack SL 1980 Migrations and distributions of Arctic grayling in interior and Arctic Alaska. Alaska Dept Fish and Game , Ann. Rep. of Prog. 1979-1980, Proj. F-9-12 (R-I):32p.

Vincent RE 1962 Biogeographical and ecological factors contributing to the decline of Arctic grayling, *Thymallus arcticus* Pallas, in Michigan and Montana. Doctoral dissertation. The University of Michigan, Ann Arbor.

Welch HH Hodgson GR and Harvey BC 2001 Distribution of Juvenile Coho Salmon in Relation to Water Temperatures in Tributaries of the Mattole River, California. North American Journal of Fisheries Management, 21:464-470.

Wilson GA Ashley KI, Slaney PA and Land RW 2008 Williston Reservoir River Fisheries Restoration: The Mesilinka River Fertilization Experiment, 1992-99. Peace/Williston Fish and Wildlife Compensation Program Report No. 319. 95 pp. plus appendices.

Withler IL 1959 Fisheries problems associated with development of the Peace River and its upper tributaries for hydroelectric purposes. Province of BC Fisheries Management Report, no. 31, Victoria, BC, Canada, 19 pp.

Zemlak RJ and Langston AR 1998 Fish species presence and abundance of the Table River, 1995. Peace/Williston Fish and Wildlife Compensation Program, Report No. 173. 28pp plus appendices.

Appendices

Appendix 1. Number of Arctic grayling sampled in streams of the Omineca region (7A).

Major Watershed	Waterbody ID	Stream Name	Watershed Code	N	
Finlay	00000FINL	AKIE RIVER	239-083100-00000-00000-0000-0000-000-000-000-000-000-000	1	
		FINLAY RIVER	239-000000-00000-00000-0000-0000-000-000-000-000-000-000	330	
	00000FIRE	FIRESTEEL RIVER	239-821700-00000-00000-0000-0000-000-000-000-000-000-000	3	
		NO NAME	239-727000-00000-00000-0000-0000-000-000-000-000-000-000	8	
	00000FOXR	FOX RIVER	239-350100-00000-00000-0000-0000-000-000-000-000-000-000	47	
		KWADACHA RIVER	239-333700-00000-00000-0000-0000-000-000-000-000-000-000	1	
	00000OSPK	OSPIKA RIVER	230-935100-00000-00000-0000-0000-000-000-000-000-000-000	2	
		TOODOGONE RIVER	239-667500-00000-00000-0000-0000-000-000-000-000-000-000	26	
	Ingenika	00000TOOD	INGENIKA RIVER	230-991300-00000-00000-0000-0000-000-000-000-000-000-000	197
		00000INGR	SWANNELL RIVER	230-991300-03200-00000-0000-0000-000-000-000-000-000-000	1
Nation	00000NATR	MONRO LAKE OUTLET	237-238200-00000-00000-0000-0000-000-000-000-000-000-000	1	
		NATION RIVER	237-000000-00000-00000-0000-0000-000-000-000-000-000-000	203	
Omineca	00000LOMI	PHILIP CREEK	237-131300-00000-00000-0000-0000-000-000-000-000-000-000	6	
		RAINBOW CREEK	237-272900-00000-00000-0000-0000-000-000-000-000-000-000	2	
	00000MESI	SUSCHONA CREEK	237-372000-00000-00000-0000-0000-000-000-000-000-000-000	1	
		SYLVESTER CREEK	237-331000-00000-00000-0000-0000-000-000-000-000-000-000	4	
	00000UOMI	NINA CREEK	238-251600-00000-00000-0000-0000-000-000-000-000-000-000	1	
		OSILINKA RIVER	238-024000-00000-00000-0000-0000-000-000-000-000-000-000	87	
		ABRAHAM CREEK	230-925900-74900-00000-0000-0000-000-000-000-000-000-000	1	
		AMBER CREEK	230-925900-45000-00000-0000-0000-000-000-000-000-000-000	1	
		CARINA CREEK	230-925900-34800-00000-0000-0000-000-000-000-000-000-000	1	
		CONTROL CREEK	230-925900-12300-00000-0000-0000-000-000-000-000-000-000	1	
CULVERT CREEK		230-925900-09000-00000-0000-0000-000-000-000-000-000-000	1		
KLIYUL CREEK		230-925900-81200-00000-0000-0000-000-000-000-000-000-000	1		
LAY CREEK		230-925900-75700-00000-0000-0000-000-000-000-000-000-000	5		
MESILINKA RIVER		230-925900-00000-00000-0000-0000-000-000-000-000-000-000	339		
Parsnip	00000PARA	NO NAME	230-925900-50000-00000-0000-0000-000-000-000-000-000-000	1	
		CARRUTHERS CREEK	238-772600-00000-00000-0000-0000-000-000-000-000-000-000	1	
	00000PARS	OMINECA RIVER	238-000000-00000-00000-0000-0000-000-000-000-000-000-000	321	
		OMINICETLA CREEK	238-621000-00000-00000-0000-0000-000-000-000-000-000-000	9	
		SILVER CREEK	238-485600-00000-00000-0000-0000-000-000-000-000-000-000	9	
		NO NAME	238-878500-00000-00000-0000-0000-000-000-000-000-000-000	2	
		BLACKWATER CREEK	230-913400-00000-00000-0000-0000-000-000-000-000-000-000	2	
		CUT THUMB CREEK	230-903300-00000-00000-0000-0000-000-000-000-000-000-000	5	
		IZAAC CREEK	230-906500-33600-00000-0000-0000-000-000-000-000-000-000	1	
		MISCHINSINLIKA CREEK	230-906500-00000-00000-0000-0000-000-000-000-000-000-000	1	
MORFEE CREEK		230-905100-04500-00000-0000-0000-000-000-000-000-000-000	1		
MUGAHA CREEK		230-905100-00000-00000-0000-0000-000-000-000-000-000-000	2		
00000FINA	SCOTT CREEK	230-901900-00000-00000-0000-0000-000-000-000-000-000-000	2		
	TONY CREEK	230-904500-00000-00000-0000-0000-000-000-000-000-000-000	1		
	TUTU CREEK	230-904600-00000-00000-0000-0000-000-000-000-000-000-000	1		
	WESTON CREEK	230-901500-00000-00000-0000-0000-000-000-000-000-000-000	4		
	ANZAC RIVER	236-313100-00000-00000-0000-0000-000-000-000-000-000-000	955		
	COLBOURNE CREEK	236-101400-00000-00000-0000-0000-000-000-000-000-000-000	4		
	CROCKER CREEK	236-313100-42700-00000-0000-0000-000-000-000-000-000-000	17		
	DESTILIDA CREEK	236-313100-15400-00000-0000-0000-000-000-000-000-000-000	4		
	FERN CREEK	236-358400-00000-00000-0000-0000-000-000-000-000-000-000	1		
	HOMINKA RIVER	236-545600-00000-00000-0000-0000-000-000-000-000-000-000	10		
Peace	00000FINA	MISINCHINKA RIVER	236-073000-00000-00000-0000-0000-000-000-000-000-000-000	5	
		MISSINKA RIVER	236-614900-00000-00000-0000-0000-000-000-000-000-000-000	78	
	PARSNIP RIVER	236-000000-00000-00000-0000-0000-000-000-000-000-000-000	1442		
	REYNOLDS CREEK	236-220100-00000-00000-0000-0000-000-000-000-000-000-000	6		
	TABLE RIVER	236-450800-00000-00000-0000-0000-000-000-000-000-000-000	594		
	NO NAME	236-313100-60100-00000-0000-0000-000-000-000-000-000-000	12		
		236-313115-44700-00000-0000-0000-000-000-000-000-000-000	1		
		236-783100-00000-00000-0000-0000-000-000-000-000-000-000	2		
		236-903300-00000-00000-0000-0000-000-000-000-000-000-000	2		
		230-986000-00000-00000-0000-0000-000-000-000-000-000-000	5		
	230-958300-00000-00000-0000-0000-000-000-000-000-000-000	5			
	230-966200-00000-00000-0000-0000-000-000-000-000-000-000	4			
	230-950000-00000-00000-0000-0000-000-000-000-000-000-000	9			
	230-916700-00000-00000-0000-0000-000-000-000-000-000-000	2			
	230-918800-00000-00000-0000-0000-000-000-000-000-000-000	2			

Appendix 2. Number of Arctic grayling sampled in streams of the Peace region (7B).

Waterbody ID	Stream Name	Watershed Code	N	
00000DUNE	LA BICHE RIVER	210-319000-00000-00000-0000-000-000-000-000-000-000	9	
	DUNEDIN RIVER	210-364400-00000-00000-0000-000-000-000-000-000-000	20	
	ODAYIN CREEK	210-364400-38000-00000-0000-000-000-000-000-000-000	10	
	TORPID CREEK	210-364400-33700-00000-0000-0000-000-000-000-000-000	83	
	TOT-2	210-364400-33700-46900-0000-0000-000-000-000-000-000	7	
	NO NAME	210-364400-06400-00000-0000-0000-000-000-000-000-000	1	
		210-364400-06400-47000-0000-0000-000-000-000-000-000	1	
		210-364400-08600-00000-0000-0000-000-000-000-000-000	8	
		210-364400-08600-18800-0000-0000-000-000-000-000-000	6	
		210-364400-14900-00000-0000-0000-000-000-000-000-000	4	
		210-364400-30700-00000-0000-0000-000-000-000-000-000	4	
		210-364400-33700-08300-0000-0000-000-000-000-000-000	1	
		210-364400-33700-17800-5950-0000-000-000-000-000-000	1	
		210-364400-33700-34200-0000-0000-000-000-000-000-000	1	
		210-364400-33700-58200-0000-0000-000-000-000-000-000	9	
		210-364400-33700-63400-0000-0000-000-000-000-000-000	12	
		210-364400-33700-73200-0000-0000-000-000-000-000-000	4	
		210-364400-33700-73200-2600-0000-000-000-000-000-000	4	
		210-364400-38000-03800-0000-0000-000-000-000-000-000	17	
		210-364400-38000-30700-0000-0000-000-000-000-000-000	1	
		210-364400-38000-45700-0000-0000-000-000-000-000-000	6	
		210-364400-38000-45700-4590-0000-000-000-000-000-000	5	
		210-371400-00000-00000-0000-0000-000-000-000-000-000	14	
		210-371400-42400-00000-0000-0000-000-000-000-000-000	2	
	00000FONT	BEAVERSKIN CREEK	212-999400-65400-28000-0000-0000-000-000-000-000-000	2
		FONTAS RIVER	212-999400-00000-00000-0000-0000-000-000-000-000-000	4
		NO NAME	212-999400-04400-00000-0000-0000-000-000-000-000-000	2
		212-999400-06800-00000-0000-0000-000-000-000-000-000	1	
		212-999400-85500-00000-0000-0000-000-000-000-000-000	1	
00000FROG	KECHIKA RIVER	217-000000-00000-00000-0000-0000-000-000-000-000-000	56	
00000GATA	SOUTH GATAGA RIVER	217-625100-62700-00000-0000-0000-000-000-000-000-000	11	
	UNNAMED TRIBUTARY TO GATAGA	217-625100-59200-00000-0000-0000-000-000-000-000-000	1	
	NO NAME	217-625100-52600-00000-0000-0000-000-000-000-000-000	26	
		217-625100-62700-43300-0000-0000-000-000-000-000-000	2	
		217-625100-62700-68600-0000-0000-000-000-000-000-000	4	
00000KISK	BRASSEY CREEK	232-485800-00000-00000-0000-0000-000-000-000-000-000	2	
	KISKATINAW RIVER	232-000000-00000-00000-0000-0000-000-000-000-000-000	4	
	MINISTIK CREEK	232-751200-00000-00000-0000-0000-000-000-000-000-000	2	
	SUNDERMAN CREEK	232-832400-00000-00000-0000-0000-000-000-000-000-000	3	
	UNNAMED TRIBUTARY TO GATAGA	232-826100-00000-00000-0000-0000-000-000-000-000-000	7	
	WEST KISKATINAW RIVER	232-646800-00000-00000-0000-0000-000-000-000-000-000	9	
00000LFRT	NO NAME	232-646800-48900-02700-0800-0000-000-000-000-000-000	1	
	CAPOT-BLANC CREEK	212-022800-00000-00000-0000-0000-000-000-000-000-000	1	
	ETANE CREEK	212-158200-00000-00000-0000-0000-000-000-000-000-000	8	
	OBOLÉ CREEK	212-152500-00000-00000-0000-0000-000-000-000-000-000	22	
	PATRY CREEK	212-022800-24900-00000-0000-0000-000-000-000-000-000	1	
	TSOO CREEK	212-208400-00000-00000-0000-0000-000-000-000-000-000	4	
	NO NAME	212-022800-16300-00000-0000-0000-000-000-000-000-000	3	
		212-022800-24900-37200-0000-0000-000-000-000-000-000	1	
		212-022800-59000-00000-0000-0000-000-000-000-000-000	1	
		212-158200-05600-00000-0000-0000-000-000-000-000-000	1	
00000LHAF	NO NAME	212-158200-56000-00000-0000-0000-000-000-000-000-000	12	
		212-158200-62200-00000-0000-0000-000-000-000-000-000	6	
		212-208400-94000-00000-0000-0000-000-000-000-000-000	4	
	BLAIR CREEK	235-141600-51500-00000-0000-0000-000-000-000-000-000	7	
	DARBER CREEK	235-141600-69500-00000-0000-0000-000-000-000-000-000	10	
	GROUND BIRCH CREEK	235-174800-00000-00000-0000-0000-000-000-000-000-000	2	
	NO NAME	233-702900-32300-00000-0000-0000-000-000-000-000-000	1	
		235-141600-63900-00000-0000-0000-000-000-000-000-000	1	
		235-141600-66300-00000-0000-0000-000-000-000-000-000	27	
		235-141600-74300-00000-0000-0000-000-000-000-000-000	52	
		235-141600-74300-72400-0000-0000-000-000-000-000-000	1	
		235-141600-76500-00000-0000-0000-000-000-000-000-000	25	
		235-141600-51500-28200-0000-0000-000-000-000-000-000	7	
		235-259400-60900-00000-0000-0000-000-000-000-000-000	1	
00000UHAF	NO NAME	235-141600-79000-00000-0000-0000-000-000-000-000-000	41	
	GEESDALE CREEK	235-141600-51500-83400-0000-0000-000-000-000-000-000	5	
	NO NAME	235-492500-43800-00000-0000-0000-000-000-000-000-000	2	
		235-430800-05100-21900-0000-0000-000-000-000-000-000	1	
		235-430800-05100-21900-2830-0000-000-000-000-000-000	1	
00000LIAR	NO NAME	235-430800-56400-00000-0000-0000-000-000-000-000-000	1	
	CRUSTY CREEK	210-467900-00000-00000-0000-0000-000-000-000-000-000	4	
	DEADHORSE CREEK	235-141600-07300-00000-0000-0000-000-000-000-000-000	18	
	SULPHUR CREEK	210-490800-00000-00000-0000-0000-000-000-000-000-000	1	
	TRIBUTARY TO LIARD RIVER	210-473800-00000-00000-0000-0000-000-000-000-000-000	1	
		210-480300-00000-00000-0000-0000-000-000-000-000-000	2	
	210-482100-00000-00000-0000-0000-000-000-000-000-000	2		

Waterbody ID	Stream Name	Watershed Code	N
		210-483200-00000-00000-0000-0000-000-000-000-000-000	2
		210-494400-00000-00000-0000-0000-000-000-000-000-000	6
		210-496200-00000-00000-0000-0000-000-000-000-000-000	2
		210-504700-00000-00000-0000-0000-000-000-000-000-000	1
		210-508300-00000-00000-0000-0000-000-000-000-000-000	3
00000MMUS	VENTS RIVER	210-547000-00000-00000-0000-0000-000-000-000-000-000	14
00000LMUS	TETSA RIVER	212-580800-30200-00000-0000-0000-000-000-000-000-000	17
	AKUE CREEK	212-580800-16000-00000-0000-0000-000-000-000-000-000	4
	AKUE CREEK TRIBUTARY	212-580800-16000-30200-0000-0000-000-000-000-000-000	3
	GAMMER CREEK	212-580800-16000-74100-0000-0000-000-000-000-000-000	7
	KLEDO CREEK	212-580800-20200-00000-0000-0000-000-000-000-000-000	31
	MUSKWA RIVER	212-580800-00000-00000-0000-0000-000-000-000-000-000	169
	RASPBERRY CREEK	212-580800-19500-00000-0000-0000-000-000-000-000-000	8
	STEAMBOAT CREEK	212-580800-20200-05500-0000-0000-000-000-000-000-000	15
	NO NAME	212-580800-16000-13000-0000-0000-000-000-000-000-000	1
		212-580800-16000-23100-0000-0000-000-000-000-000-000	1
		212-580800-16000-33500-0000-0000-000-000-000-000-000	4
		212-580800-16000-33500-1020-0000-000-000-000-000-000	1
		212-580800-16000-58300-0000-0000-000-000-000-000-000	8
		212-580800-19500-18500-0000-0000-000-000-000-000-000	1
		212-580800-19500-44500-0000-0000-000-000-000-000-000	7
		212-580800-19500-50100-0000-0000-000-000-000-000-000	1
		212-580800-20200-05500-5690-0000-000-000-000-000-000	2
		212-580800-20200-05500-6250-0000-000-000-000-000-000	7
		212-580800-20200-05500-6250-6400-000-000-000-000-000	7
		212-580800-20200-05500-6330-0000-000-000-000-000-000	6
		212-580800-20200-05500-6839-0000-000-000-000-000-000	9
		212-580800-20200-05500-6920-0000-000-000-000-000-000	17
		212-580800-20200-05500-7170-2986-000-000-000-000-000	4
		212-580800-20200-05500-8220-0000-000-000-000-000-000	8
		212-580800-20200-05500-9030-0000-000-000-000-000-000	1
		212-580800-20200-43000-0000-0000-000-000-000-000-000	22
		212-580800-20200-43000-1010-0000-000-000-000-000-000	1
		212-580800-20200-43000-2350-0000-000-000-000-000-000	5
		212-580800-20200-43000-4090-0000-000-000-000-000-000	16
		212-580800-20200-43000-6100-0000-000-000-000-000-000	1
		212-580800-20200-43000-6313-0000-000-000-000-000-000	8
		212-580800-20200-43000-6430-0000-000-000-000-000-000	9
		212-580800-20200-43000-6430-0490-000-000-000-000-000	1
		212-580800-20200-43000-6430-3120-000-000-000-000-000	1
		212-580800-20200-43000-6430-4710-000-000-000-000-000	2
		212-580800-20200-43000-6430-6720-000-000-000-000-000	1
		212-580800-44100-00000-0000-0000-000-000-000-000-000	2
00000LPCE	PEACE RIVER	230-000000-00000-00000-0000-0000-000-000-000-000-000	3
00000UPCE	NO NAME	230-744800-79100-00000-0000-0000-000-000-000-000-000	3
00000LPET	D'EASUM CREEK	211-107100-00000-00000-0000-0000-000-000-000-000-000	3
	DILLY CREEK	211-290100-00000-00000-0000-0000-000-000-000-000-000	4
	EMILE CREEK	211-132100-00000-00000-0000-0000-000-000-000-000-000	2
	PETTIT RIVER	211-000000-00000-00000-0000-0000-000-000-000-000-000	3
	NO NAME	211-107100-11800-00000-0000-0000-000-000-000-000-000	1
00000LSIK	GUTAH CREEK	212-998700-13500-00000-0000-0000-000-000-000-000-000	17
	KATAH CREEK	212-998700-15500-07700-0000-0000-000-000-000-000-000	4
	NITEAL CREEK	212-998700-04900-00000-0000-0000-000-000-000-000-000	1
	TRIB TO CONROY CREEK	212-998700-15500-29200-0000-0000-000-000-000-000-000	6
		212-998700-15500-29200-3000-0000-000-000-000-000-000	17
		212-998700-15500-29200-4650-0000-000-000-000-000-000	5
		212-998700-15500-29200-5500-0000-000-000-000-000-000	9
		212-998700-15500-29200-7240-0000-000-000-000-000-000	19
	TRIB TO KATAH CREEK	212-998700-15500-07700-0240-0000-000-000-000-000-000	3
		212-998700-15500-07700-0620-0000-000-000-000-000-000	7
		212-998700-15500-07700-0740-0000-000-000-000-000-000	2
		212-998700-15500-07700-1150-0000-000-000-000-000-000	8
		212-998700-15500-07700-1300-0000-000-000-000-000-000	2
		212-998700-15500-07700-2930-0000-000-000-000-000-000	12
		212-998700-15500-07700-4830-0000-000-000-000-000-000	3
	WEST CONROY CREEK	212-998700-15500-57900-0000-0000-000-000-000-000-000	14
	NO NAME	212-998700-15500-29200-7240-1130-000-000-000-000-000	12
		212-998700-15500-57900-6350-0000-000-000-000-000-000	2
		212-998700-13500-18100-0000-0000-000-000-000-000-000	6
		212-998700-13500-23500-0000-0000-000-000-000-000-000	8
		212-998700-13500-30500-0000-0000-000-000-000-000-000	10
		212-998700-13500-43900-0000-0000-000-000-000-000-000	32
		212-998700-13500-52900-0000-0000-000-000-000-000-000	1
00000MFRT	CRIDLAND CREEK	212-548200-00000-00000-0000-0000-000-000-000-000-000	5
	ONION CREEK	212-418900-00000-00000-0000-0000-000-000-000-000-000	2
	SHUSH CREEK	212-458700-00000-00000-0000-0000-000-000-000-000-000	15
	SOUTH STANOLIND CREEK	212-294900-25100-00000-0000-0000-000-000-000-000-000	15
	STANOLIND CREEK	212-294900-00000-00000-0000-0000-000-000-000-000-000	6
	NO NAME	212-294900-25100-54900-0000-0000-000-000-000-000-000	26
		212-400300-00000-00000-0000-0000-000-000-000-000-000	2
		212-423800-00000-00000-0000-0000-000-000-000-000-000	2

Waterbody ID	Stream Name	Watershed Code	N
		212-474900-00000-00000-0000-000-000-000-000-000-000	44
		212-520400-00000-00000-0000-000-000-000-000-000-000	18
		212-548200-59600-00000-0000-000-000-000-000-000-000	6
		212-548200-74100-00000-0000-000-000-000-000-000-000	2
		212-563500-00000-00000-0000-000-000-000-000-000-000	2
00000MILL	MILLIGAN CREEK	233-309300-00000-00000-0000-000-000-000-000-000-000	1
	TRIBUTARY TO CHINCHAGA RIVER	228-962600-00000-00000-0000-000-000-000-000-000-000	2
	TRIBUTARY TO MILLIGAN CREEK	233-309300-81800-00000-0000-000-000-000-000-000-000	4
		233-309300-86800-00000-0000-000-000-000-000-000-000	1
	NO NAME	228-962600-25900-00000-0000-000-000-000-000-000-000	11
		228-962600-46200-00000-0000-000-000-000-000-000-000	5
		228-962600-70800-00000-0000-000-000-000-000-000-000	2
00000MURR	BABCOCK CREEK	234-323950-93990-00000-0000-000-000-000-000-000-000	1
	BARBOUR CREEK	234-323962-50000-00000-0000-000-000-000-000-000-000	4
	COLDSTREAM CREEK	234-323900-01600-00000-0000-000-000-000-000-000-000	8
		234-323901-60000-00000-0000-000-000-000-000-000-000	4
	COWIE CREEK	234-323912-20000-00000-0000-000-000-000-000-000-000	2
	FLATBED CREEK	234-323950-90000-00000-0000-000-000-000-000-000-000	5
	GWILLIM RIVER	234-323926-00000-00000-0000-000-000-000-000-000-000	7
	KINUSEO CREEK	234-323970-90000-00000-0000-000-000-000-000-000-000	7
	MEIKLE CREEK	234-323926-06380-00000-0000-000-000-000-000-000-000	5
	MOOSE CREEK	234-323926-03530-00000-0000-000-000-000-000-000-000	2
	MURRAY RIVER	234-323900-00000-00000-0000-000-000-000-000-000-000	20
	SUPRENANT CREEK	234-323926-06410-00000-0000-000-000-000-000-000-000	4
	TRAPPER CREEK	234-323926-05820-00000-0000-000-000-000-000-000-000	2
	TRIBUTARY TO COLDSTREAM CREEK	234-323900-01600-50300-0000-000-000-000-000-000-000	7
		234-323900-01600-54400-0000-000-000-000-000-000-000	2
	WATERFALL CREEK	234-323961-70000-00000-0000-000-000-000-000-000-000	2
	WOLVERINE RIVER	234-323900-49400-00000-0000-000-000-000-000-000-000	7
00000PCEA	BERNARD CREEK	230-878100-00000-00000-0000-000-000-000-000-000-000	6
	CARBON CREEK	230-846900-00000-00000-0000-000-000-000-000-000-000	57
	CLEARWATER CREEK	230-870800-00000-00000-0000-000-000-000-000-000-000	3
	CLEARWATER CREEK TRIBUTARY	230-870800-11500-00000-0000-000-000-000-000-000-000	1
	ELEVEN MILE CREEK	230-846900-10700-00000-0000-000-000-000-000-000-000	4
	LOST CABIN CREEK	230-894900-00000-00000-0000-000-000-000-000-000-000	1
	NABESCHE RIVER	230-860500-00000-00000-0000-000-000-000-000-000-000	8
	PARDONET CREEK	230-861500-00000-00000-0000-000-000-000-000-000-000	2
	POINT CREEK	230-871600-00000-00000-0000-000-000-000-000-000-000	1
	SCHOOLER CREEK	230-846600-00000-00000-0000-000-000-000-000-000-000	2
	SELWYN CREEK	230-885500-00000-00000-0000-000-000-000-000-000-000	4
	SEVEN MILE CREEK	230-847000-00000-00000-0000-000-000-000-000-000-000	27
	STOTT CREEK	230-831800-00000-00000-0000-000-000-000-000-000-000	1
	WICKED RIVER	230-891000-00000-00000-0000-000-000-000-000-000-000	5
	NO NAME	230-840500-00000-00000-0000-000-000-000-000-000-000	1
00000PINE	BURNT RIVER	234-443931-30000-00000-0000-000-000-000-000-000-000	2
	CALLAZON CREEK	234-875500-00000-00000-0000-000-000-000-000-000-000	2
	CENTURION CREEK	234-478000-00000-00000-0000-000-000-000-000-000-000	4
	COMMOTION CREEK	234-564000-00000-00000-0000-000-000-000-000-000-000	2
	CRASSIER CREEK	234-687000-00000-00000-0000-000-000-000-000-000-000	1
	DICKEBUSCH CREEK	234-443900-07600-00000-0000-000-000-000-000-000-000	9
	FALLING CREEK	234-708400-00000-00000-0000-000-000-000-000-000-000	2
	HASLER CREEK	234-593000-00000-00000-0000-000-000-000-000-000-000	2
	HIGHHAT RIVER	234-443900-08000-00000-0000-000-000-000-000-000-000	3
	JOHNSON CREEK	234-593008-50000-00000-0000-000-000-000-000-000-000	2
	MARTIN CREEK	234-443900-14100-00000-0000-000-000-000-000-000-000	5
	PINE RIVER	234-000000-00000-00000-0000-000-000-000-000-000-000	14
	STONE CREEK	234-536700-00000-00000-0000-000-000-000-000-000-000	1
	SUKUNKA RIVER	234-443900-00000-00000-0000-000-000-000-000-000-000	17
00000SMOK	BELCOURT CREEK	231-336900-64000-00000-0000-000-000-000-000-000-000	2
00000TOAD	EIGHT MILE CREEK	214-315100-00000-00000-0000-000-000-000-000-000-000	20
	NO NAME	214-785100-00000-00000-0000-000-000-000-000-000-000	2
00000TSEA	THETLAANDOA CREEK	211-380400-02800-00000-0000-000-000-000-000-000-000	24
	TSEA RIVER	211-380400-00000-00000-0000-000-000-000-000-000-000	11
	NO NAME	211-380400-02800-02800-0000-000-000-000-000-000-000	1
		211-380400-02800-02800-6220-0000-000-000-000-000-000	4
		211-380400-02800-55000-0000-000-000-000-000-000-000	2
		211-380400-02800-55000-0120-0000-000-000-000-000-000	1
		211-380400-02800-55000-2170-0000-000-000-000-000-000	3
		211-380400-02800-66000-0000-000-000-000-000-000-000	1
		211-380400-19100-00000-0000-000-000-000-000-000-000	3
		211-380400-19100-14800-0000-0000-000-000-000-000-000	1
00000TURN	SETTEA CREEK	217-291397-30000-00000-0000-000-000-000-000-000-000	3
	TURNAGAIN RIVER	217-291300-00000-00000-0000-000-000-000-000-000-000	6
00000UBTN	BEATTON RIVER	233-000000-00000-00000-0000-000-000-000-000-000-000	2
	JULIENNE CREEK	233-826200-00000-00000-0000-000-000-000-000-000-000	7
	TRIB TO BEATTON RIVER	233-791200-00000-00000-0000-000-000-000-000-000-000	1
	TRIB TO JULIENNE CREEK	233-826200-12000-00000-0000-000-000-000-000-000-000	1

Waterbody ID	Stream Name	Watershed Code	N
		233-826200-50900-00000-0000-0000-000-000-000-000-000-000	1
		233-826200-65000-00000-0000-0000-000-000-000-000-000-000	8
	TRIB TO TRIB TO BEATTON RIVER	233-791200-22700-00000-0000-0000-000-000-000-000-000-000	1
		233-791200-61400-00000-0000-0000-000-000-000-000-000-000	2
	NO NAME	233-750300-00000-00000-0000-0000-000-000-000-000-000-000	18
		233-750300-46400-00000-0000-0000-000-000-000-000-000-000	4
		233-808100-00000-00000-0000-0000-000-000-000-000-000-000	1
		233-840500-00000-00000-0000-0000-000-000-000-000-000-000	11
00000UKEC	BOYA CREEK	217-301200-00000-00000-0000-0000-000-000-000-000-000-000	1
	DENETIAH CREEK	217-590300-00000-00000-0000-0000-000-000-000-000-000-000	6
	HIZAZA CREEK	217-554000-00000-00000-0000-0000-000-000-000-000-000-000	1
	HORNELINE CREEK	217-406300-00000-00000-0000-0000-000-000-000-000-000-000	11
	MOODIE CREEK	217-431900-00000-00000-0000-0000-000-000-000-000-000-000	8
	NO NAME	217-431900-43400-00000-0000-0000-000-000-000-000-000-000	3
		217-431900-50800-00000-0000-0000-000-000-000-000-000-000	1
		217-474000-00000-00000-0000-0000-000-000-000-000-000-000	1
		217-590300-29300-00000-0000-0000-000-000-000-000-000-000	1
		217-611200-00000-00000-0000-0000-000-000-000-000-000-000	6
00000UMUS	ARNELL CREEK	212-580800-44400-31200-0000-0000-000-000-000-000-000-000	7
	BECKMAN CREEK	212-580800-44400-05700-0000-0000-000-000-000-000-000-000	1
	GATHTO CREEK	212-580800-44400-00000-0000-0000-000-000-000-000-000-000	2
	KLUACHESI CREEK	212-580800-48300-00000-0000-0000-000-000-000-000-000-000	20
	PUDER CREEK	212-580800-64700-00000-0000-0000-000-000-000-000-000-000	4
	REIMER CREEK	212-580800-64400-00000-0000-0000-000-000-000-000-000-000	2
	TIERNEY CREEK	212-580800-48300-62200-0000-0000-000-000-000-000-000-000	1
	TRIBUTARY TO CREHAN CREEK	212-580800-71000-47800-0000-0000-000-000-000-000-000-000	1
		212-580800-71000-77600-0000-0000-000-000-000-000-000-000	1
	TRIBUTARY TO KLUACHESI CREEK	212-580800-48300-19500-0000-0000-000-000-000-000-000-000	9
	TRIBUTARY TO MUSKWA RIVER	212-580800-55600-00000-0000-0000-000-000-000-000-000-000	8
		212-580800-62000-00000-0000-0000-000-000-000-000-000-000	1
		212-580800-77600-00000-0000-0000-000-000-000-000-000-000	1
		212-580800-86800-00000-0000-0000-000-000-000-000-000-000	1
	TRIBUTARY TO VARICK CREEK	212-580800-54700-74200-0000-0000-000-000-000-000-000-000	1
	VARRICK CREEK	212-580800-54700-00000-0000-0000-000-000-000-000-000-000	1
	WENGER CREEK	212-580800-60500-00000-0000-0000-000-000-000-000-000-000	2
00000UPRO	BAT CREEK	212-580800-04700-59000-0000-0000-000-000-000-000-000-000	5
	BESA RIVER	212-580800-04700-66500-0000-0000-000-000-000-000-000-000	2
	NEVES CREEK	212-580800-04700-66500-2760-0000-000-000-000-000-000-000	8
	PETRIE CREEK	212-580800-04700-66500-5420-0000-000-000-000-000-000-000	1
	NO NAME	212-580800-04700-66500-6380-0000-000-000-000-000-000-000	1
00000USIK	BARKER CREEK	212-998700-62700-00000-0000-0000-000-000-000-000-000-000	2
	BUCKINGHORSE RIVER	212-998700-48600-00000-0000-0000-000-000-000-000-000-000	4
	DONNIE CREEK	212-998700-42300-00000-0000-0000-000-000-000-000-000-000	33
	KIRKPATRICK CREEK	212-998700-37600-42900-0000-0000-000-000-000-000-000-000	1
	TEMPLE CREEK	212-998700-34000-00000-0000-0000-000-000-000-000-000-000	35
	TRUTCH CREEK	212-998700-37600-00000-0000-0000-000-000-000-000-000-000	24
	NO NAME	212-998700-34000-26100-0000-0000-000-000-000-000-000-000	19
		212-998700-34000-26100-3620-0000-000-000-000-000-000-000	12
		212-998700-34000-46600-0000-0000-000-000-000-000-000-000	6
		212-998700-34000-49600-0000-0000-000-000-000-000-000-000	1
		212-998700-34000-67500-0000-0000-000-000-000-000-000-000	18
		212-998700-34000-67500-0870-0000-000-000-000-000-000-000	2
		212-998700-34000-70200-0000-0000-000-000-000-000-000-000	13
		212-998700-34000-76000-0000-0000-000-000-000-000-000-000	6
		212-998700-34000-82400-0000-0000-000-000-000-000-000-000	1
		212-998700-34000-89900-0000-0000-000-000-000-000-000-000	1
		212-998700-37600-67300-0000-0000-000-000-000-000-000-000	5
		212-998700-37600-73200-0000-0000-000-000-000-000-000-000	8
		212-998700-37600-78700-0000-0000-000-000-000-000-000-000	5
		212-998700-37600-78800-0000-0000-000-000-000-000-000-000	23
		212-998700-37600-78800-1810-0000-000-000-000-000-000-000	1
		212-998700-37600-78800-2270-0000-000-000-000-000-000-000	2
		212-998700-37600-78800-6300-0000-000-000-000-000-000-000	5
		212-998700-37600-78800-6300-1832-000-000-000-000-000-000	2
		212-998700-37600-81400-0000-0000-000-000-000-000-000-000	6
		212-998700-37600-81900-0000-0000-000-000-000-000-000-000	1
		212-998700-37600-87700-0000-0000-000-000-000-000-000-000	3
		212-998700-37600-90900-0000-0000-000-000-000-000-000-000	25
		212-998700-42300-14100-0000-0000-000-000-000-000-000-000	2
		212-998700-42300-34100-0000-0000-000-000-000-000-000-000	4
		212-998700-42300-53900-0000-0000-000-000-000-000-000-000	14
		212-998700-52100-00000-0000-0000-000-000-000-000-000-000	3
		212-998700-53900-00000-0000-0000-000-000-000-000-000-000	2
		212-999400-06765-00000-0000-0000-000-000-000-000-000-000	1
00000SAHD	SAHDOANAH CREEK	211-401900-00000-00000-0000-0000-000-000-000-000-000-000	12

Appendix 3. Number of Arctic grayling sampled in streams of the Skeena region (6).

Waterbody ID	Stream Name	Watershed Code	N
00000ATLL	CANYON CREEK	837-446100-51300-00000-0000-0000-000-000-000-000-000-000	1
	MAHAR CREEK	837-446100-55200-00000-0000-0000-000-000-000-000-000-000	1
	O'DONNELL RIVER	837-446100-00000-00000-0000-0000-000-000-000-000-000-000	1
	PIKE RIVER	837-560100-00000-00000-0000-0000-000-000-000-000-000-000	3
	SIMPSON CREEK	837-560100-74200-00000-0000-0000-000-000-000-000-000-000	1
00000BLUR	WILSON CREEK	837-446100-17800-00000-0000-0000-000-000-000-000-000-000	15
	BLUE RIVER	218-177900-00000-00000-0000-0000-000-000-000-000-000-000	1
	CHROMITE CREEK	218-177900-72500-00000-0000-0000-000-000-000-000-000-000	3
	NO NAME	218-177900-41700-00000-0000-0000-000-000-000-000-000-000	15
		218-177900-57400-00000-0000-0000-000-000-000-000-000-000	1
		218-177900-57400-45300-0000-0000-000-000-000-000-000-000	7
		218-177900-60900-00000-0000-0000-000-000-000-000-000-000	3
		218-177900-76700-00000-0000-0000-000-000-000-000-000-000	1
		218-177900-85200-00000-0000-0000-000-000-000-000-000-000	3
		218-177900-85200-97900-0000-0000-000-000-000-000-000-000	1
00000DEAL	SERPENTINE CREEK	218-964400-00000-00000-0000-0000-000-000-000-000-000-000	3
00000DEAR	VINCENT LAKE INLET	218-154900-37100-00000-0000-0000-000-000-000-000-000-000	2
00000GLAR	GLADYS RIVER	817-000000-00000-00000-0000-0000-000-000-000-000-000-000	13
	ZENAZIE CREEK	817-579900-00000-00000-0000-0000-000-000-000-000-000-000	8
	NO NAME	218-996367-00000-00000-0000-0000-000-000-000-000-000-000	1
		817-529100-00000-00000-0000-0000-000-000-000-000-000-000	3
		817-531700-00000-00000-0000-0000-000-000-000-000-000-000	1
00000UJER	JENNINGS RIVER	817-579900-71600-00000-0000-0000-000-000-000-000-000-000	1
	NO NAME	837-446100-26151-00000-0000-0000-000-000-000-000-000-000	1
		819-000000-00000-00000-0000-0000-000-000-000-000-000-000	1
		819-632100-00000-00000-0000-0000-000-000-000-000-000-000	2
		819-633400-00000-00000-0000-0000-000-000-000-000-000-000	2
00000JENR	NO NAME	819-633900-00000-00000-0000-0000-000-000-000-000-000-000	3
		819-095200-00000-00000-0000-0000-000-000-000-000-000-000	2
		819-418500-70100-00000-0000-0000-000-000-000-000-000-000	8
		819-418500-70100-41100-0000-0000-000-000-000-000-000-000	7
00000MDEA	EAGLE RIVER	218-654600-00000-00000-0000-0000-000-000-000-000-000-000	8
	NO NAME	218-654661-90000-00000-0000-0000-000-000-000-000-000-000	2
00000NAHR	NAHLIN RIVER	788-000000-00000-00000-0000-0000-000-000-000-000-000-000	2
00000NAKR	NAKINA RIVER	790-000000-00000-00000-0000-0000-000-000-000-000-000-000	2
00000LRAN	NO NAME	219-479500-70600-00000-0000-0000-000-000-000-000-000-000	2
		219-479500-70600-00000-0000-0000-000-000-000-000-000-000	2
		219-479500-70600-00000-0000-0000-000-000-000-000-000-000	2
00000SWIR	NOME CREEK	818-579500-55200-00000-0000-0000-000-000-000-000-000-000	5
	NO NAME	818-000000-00000-00000-0000-0000-000-000-000-000-000-000	2
		818-202300-00000-00000-0000-0000-000-000-000-000-000-000	7
		818-579500-55200-58600-0000-0000-000-000-000-000-000-000	1
		818-792600-92900-00000-0000-0000-000-000-000-000-000-000	1
00000TESR	NO NAME	810-860200-89600-00000-0000-0000-000-000-000-000-000-000	1
		810-879300-00000-00000-0000-0000-000-000-000-000-000-000	2
		810-883500-00000-00000-0000-0000-000-000-000-000-000-000	1
		810-885100-00000-00000-0000-0000-000-000-000-000-000-000	1
		810-886400-00000-00000-0000-0000-000-000-000-000-000-000	1
		217-291397-30000-00000-0000-0000-000-000-000-000-000-000	3
00000TURN	SETTEA CREEK	217-291397-30000-00000-0000-0000-000-000-000-000-000-000	3

Appendix 4. Number of Arctic grayling sampled in lakes of the Omineca region (7A).

Waterbody ID	Lake	Watershed Code	Total
00770TOOD	FISHING LAKES	239-608600-00000-00000-0000-000-000-000-000-000-000	5
00841TOOD		239-617500-00000-00000-0000-000-000-000-000-000-000	4

Appendix 5. Number of Arctic grayling sampled in lakes of the Peace region (7B).

Waterbody ID	Lake	Watershed Code	Total
00321PINE	JACKFISH LAKE	234-478000-00000-00000-0000-000-000-000-000-000-000	10
00864TURN	THREE KETTLE LAKE	217-291300-00000-00000-0000-000-000-000-000-000-000	26
00435TURN	DALL LAKE	217-291300-32100-00000-0000-0000-000-000-000-000-000	6
01149COAL	NETSON LAKE	216-514400-00000-00000-0000-0000-000-000-000-000-000	31
00112UMUS	KLUACHESI LAKE	212-580800-48300-00000-0000-0000-000-000-000-000-000	55
01251LKEC	DEADWOOD LAKE	217-140000-37100-00000-0000-0000-000-000-000-000-000	1
01088LIAR	LONG MOUNTAIN LAKE	210-547000-78200-30400-0000-0000-000-000-000-000-000	26
00071TURN	SANDPILE LAKES	217-291300-10500-00000-0000-0000-000-000-000-000-000	8
00493MURR	NO NAME	234-323900-73500-00000-0000-0000-000-000-000-000-000	1
00264GATA	MAYFIELD LAKE	217-625100-52600-00000-0000-0000-000-000-000-000-000	83

Appendix 6. Number of Arctic grayling sampled in lakes of the Skeena region (6).

Waterbody ID	Lake	Watershed Code	Total GR
00204TUYSR	BUTTE LAKE	650-862500-56100-00000-0000-0000-000-000-000-000-000	42
00523CRYL	CARIBOU LAKE	218-417300-00000-00000-0000-0000-000-000-000-000-000	6
00051SPAT	COLD FISH LAKE	690-342900-00000-00000-0000-0000-000-000-000-000-000	1
00394CRYL	CRY LAKE	218-417300-00000-00000-0000-0000-000-000-000-000-000	1
01095ATLL	DIXIE LAKE	837-446100-33400-00000-0000-0000-000-000-000-000-000	22
01240MDEA	EAGLEHEAD LAKE	218-654600-00000-00000-0000-0000-000-000-000-000-000	3
00512DEAL	ED ASP LAKE	218-696100-43300-00000-0000-0000-000-000-000-000-000	63
01314MDEA	FISH LAKE	218-654600-50600-44300-0000-0000-000-000-000-000-000	24
00975BLUR	FRANK'S LAKE	218-177900-85200-00000-0000-0000-000-000-000-000-000	58
00260MSTR	HLUEY LAKES	600-438100-34900-29900-0000-0000-000-000-000-000-000	10
00903TESR	KEDAHDA LAKE	810-806700-00000-00000-0000-0000-000-000-000-000-000	1
00026GLAR	LIDLAW LAKE	817-425700-93000-75400-0000-0000-000-000-000-000-000	56
01733DEAL	LITTLE DEASE LAKE	218-904800-00000-00000-0000-0000-000-000-000-000-000	34
00215JENR	LONG LAKE	819-418500-70100-00000-0000-0000-000-000-000-000-000	4
01178TESR	MELGARD LAKE	810-860200-00000-00000-0000-0000-000-000-000-000-000	17
00026JENR	MINOTAUR LAKE	819-095200-00000-00000-0000-0000-000-000-000-000-000	27
01121MDEA	MOOSE LAKES	218-654600-50600-20700-0000-0000-000-000-000-000-000	27
01234NAKR	NAKINA LAKE	790-000000-00000-00000-0000-0000-000-000-000-000-000	36
01218SWIR	NO NAME	818-579500-55200-00000-0000-0000-000-000-000-000-000	10
00181SWIR	PLATE LAKE	818-792600-00000-00000-0000-0000-000-000-000-000-000	29
01400MDEA	SERPENTINE LAKE	218-654600-83100-00000-0000-0000-000-000-000-000-000	4
00492ATLL	SURPRISE LAKE	837-174200-00000-00000-0000-0000-000-000-000-000-000	142
00334SWIR	SWIFT LAKE	818-000000-00000-00000-0000-0000-000-000-000-000-000	1
01281MDEA	SWINTON LAKE	218-654600-50600-32500-0000-0000-000-000-000-000-000	39
01683TUYSR	TACHILTA LAKES	650-480800-00000-00000-0000-0000-000-000-000-000-000	12
00007TESR	TESLIN LAKE	810-000000-00000-00000-0000-0000-000-000-000-000-000	25
00051TUTR	TUTSHI LAKE	836-000000-00000-00000-0000-0000-000-000-000-000-000	4
00373TUYSR	TUYA LAKE	650-000000-00000-00000-0000-0000-000-000-000-000-000	33
00354LRAN	UPPER TOOTSEE LAKE	219-479500-70600-00000-0000-0000-000-000-000-000-000	9
00809DEAR	VINCENT LAKE	218-154900-37100-00000-0000-0000-000-000-000-000-000	2

Appendix 7. Corrections in original database incorporated into analysis.

Datasheet	Study	Correction	Confirmed	
BC lakes IND UTMS SPP-GR_LB+_GR	A FISH COLLECTION RECORD FOR JACKFISH LAKE	Weight: 2126→212.6mm	Y	
		Weight: 2126→212.6mm	Y	
		Weight: 2126→212.6mm	Y	
		Weight: 2126→212.6mm	Y	
		Weight: 2126→212.6mm	Y	
		Weight: 2126→212.6mm	Y	
		Weight: 2126→212.6mm	Y	
		Weight: 2126→212.6mm	Y	
		A RECONNAISSANCE SURVEY OF COLD FISH LAKE	0→No weight recorded	Y
		A RECONNAISSANCE SURVEY OF LITTLE DEASE LAKE	Weight: 0→No weight recorded	N
		A RECONNAISSANCE SURVEY OF TACHILTA LAKES	Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
			Weight: 0→No weight recorded	Y
		PROVINCE OF BRITISH COLUMBIA, SKEENA REGION LAKE TROUT ASSESSMENT	Weight: 0→No weight recorded	N
		A RECONNAISSANCE INVENTORY OF UNNAMED LAKE (ALIAS FRANK'S	Weight: 0→No weight recorded	Y
		ARCTIC GRAYLING SPAWNING AND PRODUCTION IN SURPRISE LAKE:	Weight: 1040→No change	Y
			Length: 35→350mm	Y
		A RECONNAISSANCE SURVEY OF NETSON LAKE	Length: 35→350mm	Y
			Length: 36→360mm	Y
			Length: 36→360mm	Y
Length: 36→360mm	Y			
Length: 36→360mm	Y			
Length: 36→360mm	Y			
Length: 36→360mm	Y			
Length: 36→360mm	Y			
Length: 37→370mm	Y			
Length: 44→440mm	Y			
A RECONNAISSANCE INVENTORY OF UNNAMED LAKE (ALIAS MELGARD LAKE)	Length: 31.8→318mm	Y		
A RECONNAISSANCE INVENTORY OF UNNAMED LAKE (ALIAS MINOTAUR	Length: 15.7→157mm	Y		
DPG_database_GR	Fish Species Presence and Abundance of the Table River, 1995 (no. 173)	Length: 30.5→305mm	N	
		Length: 34.5→345mm	N	
		Length: 30.5→305mm	N	
FHIIP GR projects_all spp	7 - Finlay	Dissolved Oxygen: 0→No value recorded	N	
		pH: 0→No value recorded	N	
		0→No value recorded	N	

Appendix 8. References for temperature, conductivity and pH data collected at Arctic grayling sampling sites in the Omineca Region.

Reference	Author	Project Title	Year	Database Reference Name
1	RL&L Environmental Services Ltd. (Prince George)	Reconnaissance (1:20,000) Fish and Fish Habitat Inventory	2000	DFB Mackenzie District Fish Inventory - 2000
2	RL&L Environmental Services Ltd. (Prince George)	Reconnaissance (1:20,000) Fish and Fish Habitat Inventory	2001	Mackenzie TSA Fish Inventory - 2000 & 2001
3	RL&L Environmental Services Ltd. (Prince George)	Reconnaissance (1:20,000) Fish and Fish Habitat Inventory	1999	Peace River Fish Inventory (RL&L)
4		Reconnaissance (1:20,000) Fish and Fish Habitat Inventory	2004	Fox River Overview FFHI - 2004
5	Chris Schell Consulting	Overview (1:50,000) Inventory of the Upper Omineca Watershed Atlas Group (UOMI)	2001	Upper Omineca Watershed Atlas Group Overview Inventory
6	Bruce PG and Starr PJ, 1985	Fisheries resources and fisheries potential of Williston Reservoir and its tributary streams volume II: Fisheries resources potential of Williston Lake Tributaries - A preliminary overview.	1975	Bruce and Starr 1985
7			1977	RAB by WSC_GR_streams_known
8	Peace Williston Fish and Wildlife Compensation Program-Randy Zemlak, A.R. Langston	Fish Species Presence and Abundance of the Table River, 1995 (no. 173)	1995	Fish Species Presence and Abundance of the Table River, 1995 (no. 173)
9	Peace Williston Fish and Wildlife Compensation Program-K.L. Mathias, A.R. Langston, and R.J. Zemlak	A Summary Report of the Table River Surveys 1996 Status Report (No. 180)	1996	A Summary Report of the Table River Surveys 1996 Status Report (No. 180)
10	Triton Environmental Consultants Ltd.	Reconnaissance (1:20,000) Fish and Fish Habitat Inventory of the Missinka River Watershed WSC:236-614900	1998	Missinka Fish Inventory - 1998
11			1997	Atlin Fish Inventory - 1997
12			1997	Blue River Stream Inventory - 1997
13			2003	Highway 37 Fish and Fish Habitat Inventory - 2003
14	Diversified Environmental Services	FHIIP GR projects_all spp	1996	7-Beaton
15		Canfor Beatton River Fish Inventory - 1998	1998	Canfor Beatton River Fish Inventory - 1998
16		Beatton Watershed Fish Inventory (Julienne) - 2000	2000	Beatton Watershed Fish Inventory (Julienne) - 2000
17		Dunedin River Fish Inventory (Torpid) - 1997	1997	Dunedin River Fish Inventory (Torpid) - 1997
18		Dunedin River Fish Inventory - 1998	1998	Dunedin River Fish Inventory - 1998
19		Fort Nelson Fish Inventory (Unnamed) - 1999	1999	Fort Nelson Fish Inventory (Unnamed) - 1999
20		Fontas river 1:50000 overview	2003	Fontas river 1:50000 overview
21		Fort Nelson Fish Inventory (Obole) - 1999	1999	Fort Nelson Fish Inventory (Obole) - 1999
22		Overview in Raspberry & Akue & Shush Watersheds - 2001	2001	Overview in Raspberry & Akue & Shush Watersheds - 2001
23		Ft. Nelson FFHIP (Capot-Blanc) - 2002	2002	Ft. Nelson FFHIP (Capot-Blanc) - 2002
24		Ft. Nelson FFHIP (Cridland) - 2002	2002	Ft. Nelson FFHIP (Cridland) - 2002
25		Ft. Nelson FFHIP (Stanolind) - 2002	2002	Ft. Nelson FFHIP (Stanolind) - 2002
26		UKEC Overview Inventory - 2001	2001	UKEC Overview Inventory - 2001
27		Gataga River 1:50000 FFHI Overview - 2003	2003	Gataga River 1:50000 FFHI Overview - 2003
28		FHIIP GR projects_all spp		
29		Canfor Cameron River Fish Inventory - 1998	1998	Canfor Cameron River Fish Inventory - 1998
30		Canfor/FRBC Fish Inventory (Ground Birch) - 2001	2001	Canfor/FRBC Fish Inventory (Ground Birch) - 2001
31		Pine River (Drainages) Fish Inventory - 1997	1997	Pine River (Drainages) Fish Inventory - 1997
32		Kiskatinaw Headwaters Fish Inventory - 2001	2001	Kiskatinaw Headwaters Fish Inventory - 2001
33		Toad/Vents Fisheries Overview - 2000	2000	Toad/Vents Fisheries Overview - 2000

Reference	Author	Project Title	Year	Database Reference Name
34		Liard Tribs and Eight Mile Creek Overview - 2002	2002	Liard Tribs and Eight Mile Creek Overview - 2002
35		Fort Nelson Fish Inventory (Steamboat) - 1999	1999	Fort Nelson Fish Inventory (Steamboat) - 1999
36		Slocan - Fort Nelson Division Fish Inventory - 2000	2000	Slocan - Fort Nelson Division Fish Inventory - 2000
37		Overview in Raspberry & Akue & Shush Watersheds - 2001		Overview in Raspberry & Akue & Shush Watersheds-2001
38		Pine Murray Fish Inventory (Lower Sucnunka) - 1998	1998	Pine Murray Fish Inventory (Lower Sucnunka) - 1998
39		CARBON CREEK ENVIRONMENTAL STUDIES 1975 VOLUME I AND II	1975	CARBON CREEK ENVIRONMENTAL STUDIES 1975 VOLUME I AND II
40		Ft. Nelson FFHIP (Thetlaandoa) - 2002	2002	Ft. Nelson FFHIP (Thetlaandoa) - 2002
41		Wolverine Fish Population & Fish Habitat Inventories - 2005	2005	Wolverine Fish Population & Fish Habitat Inventories - 2005
42		Hay - Petitot Overview Inventory - 2000	2000	Hay - Petitot Overview Inventory - 2000
43	RL & L Environmental Services Ltd. (Prince George)	TransCanada Transmission Fish Inventory - 1999		TransCanada Transmission Fish Inventory - 1999
44		Beaton, Fontas, Halfway and Sikanni Chief Rivers FFHI 1997	1997	Beaton, Fontas, Halfway and Sikanni Chief Rivers FFHI 1997
45		Canfor Sikanni Chief River Fish Inventory - 1998	1998	Canfor Sikanni Chief River Fish Inventory - 1998
46		Canfor/FRBC Fish Inventory (Katah) - 1999	1999	Canfor/FRBC Fish Inventory (Katah) - 1999
47		Canfor/FRBC Fish Inventory (Conroy) - 1999	1999	Canfor/FRBC Fish Inventory (Conroy) - 1999
48		Ft. Nelson FFHIP (Thetlaandoa) - 2002	2002	Ft. Nelson FFHIP (Thetlaandoa) - 2002