PEACE REGION

An Overview and Summary of Methodologies of Arctic grayling (*Thymallus arcticus*) Projects Conducted in the Parsnip, Table, and Anzac rivers from 1995 to 2007

D.M. Cowie and B.G. Blackman

September 2012

FWCP – Peace Region Report No. 349

The FWCP is a partnership of:

The Fish & Wildlife Compensation Program – Peace Region 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.

Fish and Wildlife Compensation Program – Peace Region

9228 – 100th Avenue, Fort St. John, BC, V1J 1X7

Website: www.fwcp.ca

This report has been approved by the Fish and Wildlife Compensation Program – Peace Region Fish Technical Committee.

Citation: Cowie D.M. and B.G. Blackman. 2012. An Overview and Summary of Methodologies of Arctic grayling (*Thymallus arcticus*) Projects Conducted in the Parsnip, Table, and Anzac Rivers from 1995 to 2007. Fish and Wildlife Compensation Program – Peace Region Report No. 349. 24 pp plus appendices.

Author(s): D.M. Cowie and B.G. Blackman

Correspondence: BC Hydro - Fish and Wildlife Compensation Program – Peace Region
9228 – 100th Avenue, Fort St. John, BC V1J 1X7

TABLE OF CONTENTS

INTRODUCTION

Fish and Wildlife Compensation Program - Peace

Williston Reservoir, the largest body of fresh water in British Columbia, was formed in 1968 when the W.A.C. Bennett Dam was constructed. Minimal information on fish resources prior to the construction of the dam exists, although Bruce and Starr reported that Arctic grayling (*Thymallus arcticus*) were the most numerous sport fish found in many tributaries of the reservoir in 1974 (Bruce and Starr 1985). The Fish and Wildlife Compensation Program - Peace (FWCP-P) is mandated to mitigate impacts of hydroelectric development on fish and wildlife within the Williston Watershed.

The British Columbia Conservation Data Centre had categorised Arctic grayling as “Red listed” since the mid 1990s, and only recently (2011) revised the status to “Yellow listed”. The status may change again; however, the species was categorized as “Red listed” and therefore an endangered species within the Watershed. The FWCP-P undertook numerous studies on the species abundance and distribution in response to the endangered status, and studies undertaken by the FWCP-P have provided information on grayling stocks in the watershed. Regulations for catch and release of the species were enacted to preserve existing stocks. The FWCP-P conducted studies of Arctic grayling in the Parsnip River Watershed from 1995 to 2007.

Parsnip, Table and Anzac River Watersheds

Since 1995, three rivers have received significant attention in relation to Arctic grayling assessments in the Williston Watershed. The focus of these projects was on the Parsnip River, which drains into Williston Reservoir near Mackenzie, B.C., and two main tributaries to the Parsnip: the Table and Anzac rivers (figure 1). The focus area on the Parsnip River was primarily between km 51 and 73, although some areas outside this were completed in certain years. The Table and Anzac rivers were sampled from the mouth upstream to barriers for Arctic grayling, as noted below depending on the sampling method employed.

In reference to kilometre locations within each of the three rivers, the kilometres were measured from the mouth of each system to the headwaters. For the Parsnip River, the kilometres were measured upstream from the mouth at the confluence with Williston Reservoir, therefore the point located 1 km upstream from the reservoir was designated as km 1. The Table and Anzac rivers were measured upstream from their confluence with the Parsnip River (at the Parsnip Rivers noted kilometre marker) to the headwater of each system. Notable features within each system are referenced to kilometre locations. It should be noted that due to the dynamic and ever changing morphology of these rivers, sections can change from year to year as the systems do (e.g. a new channel cuts through an oxbow and the old channel is abandoned) and therefore the kilometres may change if new aerial photographs were completed and measurements redone.

The 175 km long Parsnip River flows north along the west side the Rocky Mountains, 100 km northeast of Prince George to the Williston Reservoir near Mackenzie. The Parsnip River is an unconfined, low gradient (0.3%) river with a drainage area of 4,669 km^2 (Bruce and Starr 1985). Substrate is primarily fines and fluvial silts resulting in poor bank stability and low water clarity.

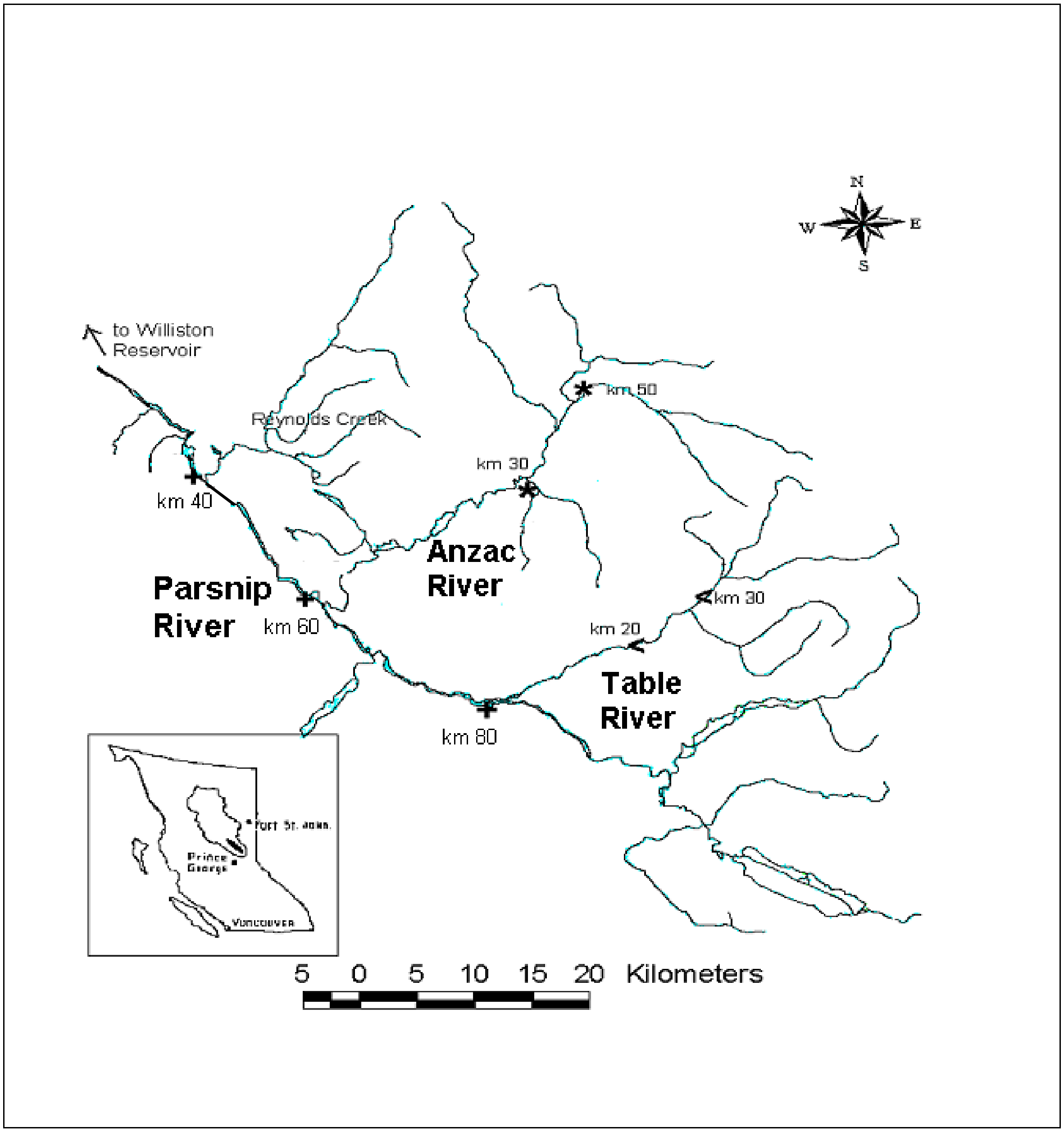

Figure 1. Map of the Parsnip, Anzac and Table rivers.

The Table River is a 56 km tributary and drains a 506 km^2 watershed into the Parsnip River at km 75 of the Parsnip. The upper reaches of the Table River have a moderate gradient of 1-2% and the channel is frequently confined, while the lower reaches (up to km 27) are a low gradient (<0.5%) that meanders over the valley floor thru oxbows, side channels, and old cut off channels. The lower Table River has areas of fluvial silt deposits, a high percentage of fines, and areas of bank instability. Forestry and a railway line development have been noted as impacting the system. A waterfall blocks Arctic grayling passage at km 37 of the Table River.

The Anzac River is 78 km long and drains a 939 km^2 watershed into the Parsnip at km 47. The average gradient varies from moderate (1-2%) in the upper reaches that flow through a bedrock canyon, to a low gradient (<0.5%) unconfined area in the valley flats. The lower reaches are similar to the Table River in that the river meanders through oxbows, side and back channels to multi-channel complex areas. The Anzac River has more bank stability as it has minimal fines and silts, and is dominated by gravel/cobble substrates. The lower reaches of the Anzac were logged in the 1940's, and road construction started in the upper reaches in the late 1990's and logging in the early 2000's. A waterfall blocks upstream passage at km 47.

Discharge flows in the Parsnip River, recorded by Water Survey Canada (WSC) at the Parsnip station, indicate a mean daily flow of 142 m^3/sec from 1985 to 1995, with a maximum daily flow rate of 824 m^3/sec (Blackman 2004). Ice off usually occurs in April with peak flows occurring in late May and into June. There is no recorded data for either the Table or Anzac rivers, however conservative estimates on the Table River indicate an average daily discharge of 12.9 m^3/sec (Langston 1998). The Anzac River Watershed is almost double the size of the Table River and flows would be expected at almost double.

Summer temperatures average a daily range from 11 to 15°C, with the Parsnip River approximately 2°C warmer than the Table and Anzac rivers.

Arctic Grayling Summary Project Objectives

Since 1995, numerous studies have taken place in the Parsnip, Table, and Anzac rivers to document distribution, relative abundance, habitat utilization and preference, and migratory patterns of Arctic grayling. The intent of this summarization process was to review projects conducted on the Parsnip, Table and Anzac rivers between 1995 and 2007, and to provide a summary of methods and results, as well as any assumptions and project revisions that occurred over the twelve years of studies that occurred in the watershed. The secondary objective of this summarization was to provide a single document of all the works completed to date, to determine if additional statistical analysis could be completed to compare data and assess trend analysis of the methods and results by a statistician.

Numerous reports were reviewed, including many that have not yet been published but are in draft submission (FWCP-P office in Prince George, B.C.) (appendix 1). Methodologies, project design, and population indexing measures were reviewed and summarized to provide one document that summarizes and details the methodologies and overall results of those projects. Two reports from surveys completed in 2005 and 2007 are in the first stage of the draft report and have therefore been referenced as data on file. Reports that have been submitted to the Technical Committee but not yet approved have been noted as such. Additional studies in the watershed that were not reviewed include Arctic grayling genetics and Arctic grayling otolith elemental signatures in the Williston Watershed.

The projects conducted between 1995 and 2007 included a variety of methods (table 1) in an attempt to determine the most economically and statistically valid option for monitoring grayling populations in the Parsnip Watershed. Overview and detailed habitat assessments were carried out during the initial years, in conjunction with fish presence, abundance, and distribution surveys which continued until 2007. The methods tested were assessed for cost, effectiveness for capturing various age classes of grayling, and the logistics of applying each method in each river system. From year to year, adjustments and/or alterations to methods (e.g. increasing number of swim crew) were sometimes made to determine if the method was feasible over the long term to detect population changes.

The sampling methods assessed have been categorized into one of three categories (table 1): comparable, incomparable, and additional methods. Methods that were classified as comparable were those that occurred in more than one sampling year, sampling sites remained the same year to year, and sampling methods did not significantly change over time. Incomparable methods were those that only occurred during one sampling season and were deemed as not being a viable sampling method for the long term monitoring. Additional methods were those that could potentially be repeated in the future but were not repeated.

The following sections outline the methods applied, the frequency of each method, and the successes and any alterations that were applied to each method for the given year it was undertaken. Methods that can potentially be assessed and/or compared for population trends include beach seining, underwater counts, and electrofishing. Numerous other methods were applied to determine their effectiveness in monitoring grayling populations in the watershed. These additional methods were either only applied once, or were found ineffective for a variety of reasons, and are therefore not suitable for use in a trend analysis of the population.

Table 1. An overview of projects conducted on the Parsnip, Table, and Anzac rivers from 1995 to 2007.

			Comparable			Incomparable		Additional Methods		
Study Year	**System**	**Project Type**	**Beach Seining**	**Underwater Counts**	**Electrofishing**	**Fyke Net**	**Pole Seine**	**Reconn**	**Habitat Preference**	**Visual**
1995	Table	Fish presence, abundance surveys, reconnaissance surveys, initial site selection/designations on Table River		X	X					
1995	Table	Habitat evaluations, Fish presence / abundance		X	X			X	X	
1996	Table	Status of on-going studies	X	X	X			X	X	
1997	Table / Anzac	Distribution and Abundance of YoY and 1+ and Habitat Use and Preference		X	X	X	X		X	X
1996-1997	Table / Anzac / Parsnip	Radio tagging and Telemetry							X	
1998	Table / Anzac / Parsnip	Life History and Habitat Utilization, preferred habitat selection	X	X	X				X	X
2000	Table Anzac / Parsnip	Distribution and Abundance	X	X						
2001	Table / Anzac / Parsnip	Distribution and Abundance	X	X	X					
2003	Table Anzac / Parsnip	Distribution and Abundance	X	X						
2005	Parsnip	Distribution and Abundance	X							
2005	Parsnip Watershed	GR Fry Distribution*			X					
2007	Table / Anzac / Parsnip	Distribution and Abundance	X	X						

* 2005 - Surveys did not include the Table and Anzac rivers, or the 50 km section of the Parsnip River covered in the other years of surveys to avoid overlap of data already available.

METHODOLOGIES AND RESULTS

Comparable Methods

Beach Seining

Beach seining was a technique applied starting in 1996 on the Table River, continued on the Anzac River in 1997 with fyke nets, and finally beach seine sampling was initiated in the Parsnip River in 1998. Beach seining was not the most effective method in the Table and Anzac rivers due to the age class of fish targeted, habitat sampled with this method, and available habitats to sample. Beach seining was effective in the larger Parsnip River for sampling 1+ and older grayling, particularly if site lengths were kept to between 60 and 100 m, but it was not an ideal method for sampling fry.

Once beach seining index sites were established on the Parsnip River (permanent sites as of 2001), data was comparable for individual sites and for the areas sampled, although site lengths varied year to year. Annual sampling would provide the most accurate estimate and may indicate a trend in grayling population status, as well as an indication of survival rates year to year within age cohorts.

Overall results of the beach seining efforts, in conjunction with telemetry and other surveys, have indicated that Table and Anzac river fish are moving into the Parsnip River for the age classes of 1+ and older. Once the grayling reach spawning age, they are returning to either of the smaller systems, and at times using both, with the Parsnip used by adults to migrate between and for overwintering. The Parsnip River has been noted as critical habitat for younger age classes within the systems, particularly age classes 1 and 2 (Blackman and Hunter, 2001, and Blackman et al, draft 2004).

1996

Beach seining was initiated in the Table River during July to September, 1996. A total of 46 sites in 3 reaches were completed. Sampling effort and results were:

- Reach 1 covering 19,850 m^2, with a catch of 13 grayling (7.4 % of the catch)
- Reach 2 covering 2,160 m^2, with no grayling caught, and
- Reach 3 covering 9,473 m^2, with 4 grayling caught (7.4% catch).

The most abundant species caught overall was mountain whitefish *(Prosopium williamsoni)*. Sediment and water clarity were noted from both natural and industry related sources (Zemlak and Langston 1998, Langston 1998, Mathias et al, 1998).

1998

The 1998 field season brought about increased beach seining, with 3 sampling sessions, covering both the lower Anzac and the Parsnip rivers. Sites on the Parsnip River were between km 63 and 71, with a primary focus of capturing young-of-the-year and 1+ grayling, as well as identifying habitat use and preference in a larger river system than the Table and Anzac rivers (refer to habitat section). All grayling caught with a fork length greater than 100 mm were fitted with a Passive Integrated Transponder tag (PIT) and received an adipose clip for a coinciding genetics study in the watershed. When the first session was completed, it was decided to conduct additional beach seining sites and to include additional PIT efforts and habitat preferences for 1+ grayling.

Sites were identified with a unique identifier (e.g. 1A, 2A, etc.) and all grayling were identified to the particular location caught. Sites ranged in length from 25 to 195 m and habitat parameters collected included length (m), velocity at 60% depth, substrate over 25 m transects at site at 1, 5, 10, 15 m from shore then substrate would be given a percentage at distance from shore then averaged for the site.

During session 1, sampling on the Parsnip River included 21 sets in 10 sites, with over 8 km sampled in a variety of habitat types. In age class 0 to 4, 164 grayling were caught, with large numbers at sites 5 and 7. Age class 1+ grayling were primarily caught in sites 9 and 10. Sampling in the Anzac River included 3 km of sampling in the lower Anzac and a total of 67 grayling were caught. Sites 1A and 3A provided 64 young-of-the-year, while site 3 was predominately 1+ grayling.

Session 2 included 23 sets in 11 sites on the Parsnip River for a total coverage of 2,285 m^2. A total of 117 grayling were caught (~50/km along 1 bank) in low velocity areas as electrofishing efforts had determined. Lineal numbers of fish caught seemed most appropriate to authors so that is the how the results were presented. In age class 2+, 54 grayling (25/km) were caught. In the Anzac sampling, 4 sets were conducted in 3 sites covering 9,500 m2. Sampling efforts resulted in 18 young-of-the-year and 1 1+ grayling.

Sampling in session 3 was conducted at the same locations as previously sampled. The Parsnip River yielded 192 young-of-the-year and 27 age class 1+, of which 188 were already PIT and adipose clipped. In the Anzac River, only site 3A could be accessed and no grayling were caught.

Overall the results of the 1998 sampling found age class 1 and 2+ grayling were only using the Parsnip River and not the Table or the Anzac rivers. As documented spawning does occur in the Table and Anzac rivers, fish are moving downstream to use the Parsnip River for age class 1 and 2, and the Parsnip River was then considered as critical habitat for those age classes. A coinciding telemetry study revealed that adult grayling from the Table and Anzac rivers would overwinter in the Parsnip River (Blackman 2002b).

Beach seining methods offer a low sensitivity to detect population changes but would capture any dramatic change, and would be more sensitive to changes if conducted annually. Seining should assist in determining an overall fry survival rate (this is where annual sampling would improve results) as each system is different. As grayling have a longer period over which they spawn, size ranges within an age class may be present.

2000

Beach seining in 2000 was only conducted in the Parsnip River between km 39 and 91, covering 3 reaches. The focus was to determine grayling distribution and abundance. A total of 90 sets in 49 sites covering 8,250 lineal m of shoreline on one bank was completed. In the sites completed, 376 young-of-the-year were caught (45.5/km), with an mean fork length of 48.7 mm. For age class 1+, 237 grayling were caught (28.7/km), which had a slightly smaller fork length than in 1998, but the variation of the population was greater in 2000 with the same condition factor. For age classes over 1+, 52 grayling were caught (63/km). All fish 1+ and older received a PIT. It was noted that spawning timing and stream temperatures may be attributed to growth differences within age classes. There was not strong relationship to any given site as indicated by sites with high numbers of fish in habitats adjacent to same habitats with no fish. It was deemed that beach seining is a reliable method for sampling the Parsnip River but is not the most suitable for fry.

2001

Beach seining was conducted on the Parsnip mainstem in mid July to early August 2001, with no seining July 19-27 due to heavy rain. Index sites were established between km 48-73 and were based on previous site selection. High water did prevent some site locations from being sampled. Sampling methods were as per preliminary habitat and distribution surveys in 1998 and 2000.

The 2001 sampling included 34 sets in 32 sites, covering 3,750 m^2. A total of 297 grayling (30.4/km) young-of-the-year and 42.2 age class 1+ were caught. An increase in the overall mean number (total captured per total length sampled) of 1+ grayling was potentially due to the shortened site lengths. The young-of-the-year and 1+ showed a decrease in fork length since 1998. Sampling efforts indicated that distribution is clumped, which may indicate successful spawning. Overall, year to year the number of grayling is variable, but the number of grayling per km of shoreline sampled remains consistent since 1998 with young-of-the-year between 33-47/km and 1+ between 29-51/km. For future comparisons, the same 5 sections should be compared to keep the habitat parameters consistent in compared sites. It was also determined that 30 sites were required as a minimum over 25 km of river to obtain sufficient resolution to detect changes (Murphy and Blackman, draft 2004).

2003

The 2003 surveys on the Parsnip River mainstem were conducted mid July to mid August between km 51-73 at pre-established sites. The focus in 2003 was again distribution and abundance. A total of 30 sets in 30 sites covered 4,435 lineal m of shoreline.

Results for 2003 indicate 238 grayling were caught and showed a clumped distribution for young-of-the-year and 1+ and a site consistency year to year, although there was a decrease in catch per site. Sites upstream of the Anzac show a distinct age class separation in 2003, 2001, and 2000, with young-of-the-year in 2003 larger than previously.

The 2003 report indicated again that Table and Anzac young-of-the-year and 1+ fish move downstream to the Parsnip River and it should be considered as a critical area for those 2 age classes (Blackman et al, draft 2004). Telemetry showed that adult grayling from the Table and Anzac rivers are moving downstream and overwintering in the Parsnip River. Although beach seining offers a low sensitivity to change in populations, but would detect any dramatic change.

2005

The 2005 beach seining on the Parsnip River mainstem was conducted mid to late July, at pre-established sites, covering 3,216 lineal m of shoreline between km 51-73. A total of 30 sets in 30 sites caught 340 grayling, 40.9/km young-of-the-year and 56.1/km of age class 1+. Distribution along a 21 km section appears clumped without a regular pattern. In assessing the length frequency distribution, grayling downstream of the Anzac River have a smaller fork length than those upstream.

Extensive post evaluations were conducted in 2005 on sampling results from 2005 and previous years. An F-test in ANOVA for young-of-the-year showed no difference in relationship in densities of each age groups among years. To make year to year more comparable, subsamples for 2000 were used to compare with 2005 and 2001, 2003, and 1998. For the years noted, samples between km 51 and 73 were used to track population trends with relative abundance. The number of fish per 100 m was transformed to log base 10 (x+1) for statistical comparison to meet assumptions of normality and homogeneous variance. A regression analysis established significant relationships for young-of-the-year caught per 100 m, but not for 1+ per 100 m. Set length affects age class caught but there was no significant relationship between density and set length in previous sampling periods. In comparing year to year at the same site, the following was indicated:

1) preferred grayling habitat for 1+ is low velocity, shallow glides with gravel substrate,
2) sample at same time frame, and
3) sample 30 – 100 m sets in same sections as previous years.

The comparisons for 2005, 2001, 2003, and 1998 at the same km locations indicated that changing the site length could bias the capture rate (determined using a linear regression analysis). The regression analysis revealed a relationship between set length variance year to year and that the differences year to year caused the sampling bias not to remain constant (Mackay and Blackman, draft 2006). The regression analysis also indicated that stream flow/discharge may affect abundance and fish distribution, as indicated in the underwater count results.

Analysis further showed that recruitment has not dramatically changed over the time frame surveys have occurred, although the ability to detect change was limited. It was recommended to maintain sampling distribution year to year to avoid bias, and to keep site lengths fixed to between 60 and 100 m to allow for maximum capture while not compromising analysis. By targeting optimal habitats the surveys should be able to detect population changes. Using relative abundance methodology would require an increase in sampling frequency (annual) and an increase in the number of index sites (MELP 1998). An increase in the number of index sites to 300 would be required to make significant gains in the confidence of estimates (Schwarz, Pers. Comm. B.G. Blackman, 2001). Schwarz indicated that by increasing the frequency of sampling, the power of detecting populations trends and detecting trends within age cohorts between years would be possible, as well as provide an indication of survival rates year to year.

2007

The final sampling event happened in 2007 on the Parsnip River between July 17-20th, with 30 sets in 30 pre-established sites (data on file, Cowie and Blackman, 2008). A total of 2,950 lineal m of shoreline was sampled over 22 km, with a total catch of 311 grayling. This showed a decrease in young-of-the-year since 2005, but no significant difference in density in comparison to 2000, 2001, and 2003. The fork length of young-of-the-year increased over 2005 results, while the fork length for 1+ decreased. Length frequency distribution showed grayling were smaller for these age classes. The distribution remains clumped and unpredictable year to year.

To maintain comparability year to year, three assumptions were followed:

- use comparable methods;
- maintain any sample bias year to year; and
- conduct independent sampling events (MELP 1998).

As all three assumptions were met, comparability between years was maintained.

Adult Underwater Counts

Underwater counts was selected as the primary method for conducting adult enumeration, abundance, and distribution in the Table and Anzac rivers. Counts were initially conducted in the Table River in 1995 and 1996, while the Anzac River was added to the counts in 1997. Methodologies of the counts varied from year to year, with the initial years focus being on the distribution of adult grayling, and the suitability of each section as an index site for future counts. Counts were conducted using Slaney and Martin (1987) methodology and the correction factors applied for hiding and crew distraction were calculated following their outline. Mark recapture was conducted in 1995 and 1998 to assess the validity of counts and of mark recapture techniques for each system. Mark recapture techniques were determined as not being beneficial to the counts and mark recapture techniques were not applied after 1998 (Blackman and Hunter, 2001).

The counts were conducted a total of 8 times on the Table River and 6 times on the Anzac River, although not all sections were completed in any given survey year due to heavy rains and/or poor visibility. A summary of the underwater counts by project year is shown in table 2. Over the twelve year time frame the underwater counts were conducted, the population of adult grayling in the Table and Anzac rivers was noted as stable (data on file, Cowie and Blackman, 2008). As the sites completed varied from year to year, the sites that can be compared are shown in table 1. Overall, the data provided an indication of the trend in the status of the population status, while not clearly providing definitive numbers of the population, as the counts were not completed frequently enough.

Table 2. Summary of underwater counts by year, in each system.

Year	System	Km's	Number Passes	Number Crew	Comments
1995	Table	Km 35.5 to 0 (not km 29-24) Upper – km 35.5 – 32 Lower – km 9.8 - 5	1 2 2	2 2 3	Reach 1, 3, 4; Single pass to assess system for suitability; 2 pass on 2 sections selected to represent habitat types; Mark recapture assessed
1996	Table	Km 37.6 – 24.5	1	2	Reach 1, 2, 3 – only reach 3 completed; Not same sections as previous yrs but can compare Reach 3
1997	Table Anzac	N/A Km 48 – 0	0 1	N/A 3	Table River – no counts in 1997 1st time in Anzac River
1998	Table Anzac	3 sections – km 35-31, 22-18, 9-5 5 sections – km 47-45, 43-39, 34-30, 16-12, 10-6	2 2	2 to 4 2 to 4	Table - 4 km each Anzac - 4 of 4 km each and 1 of 2 km Both systems - areas of large pools received additional effort; Expanded counts; Mark recapture – fish move D/S from tagging area
1999	N/A	N/A	0	N/A	No counts conducted
2000	Table Anzac	3 sections – km 35-31, 22-18, 9-5 1 section – km 47-45	2 2	2 or 3 2 or 3	4 counts per site both systems Anzac - rained out so only the Upper Reach completed
2001	Table Anzac	2 sections – km 35-31, 22-18 4 sections – km 47-45, 43-39, 34-30, 16-12	2 2	2 2	Table – 4 km sections Anzac - 3 of 4 km each and 1 of 2 km Both systems - recount areas of large pools
2002	N/A	N/A	0	N/A	No counts conducted
2003	Table Anzac	2 sections - km 35-31, 22-18 4 sections – km 47-45, 43-39, 34-30, 16-12	3	2	Table – 4 km each Anzac – 3 of 4 km each and 1 of 2 km Both systems - each crew swim entire site = 2 passes, then divide site and each crew swim half for a total of 3 passes
2004	N/A	N/A	0	N/A	No counts conducted
2005	N/A	N/A	0	N/A	No counts conducted
2006	N/A	N/A	0	N/A	No counts conducted
2007 *	Table Anzac	2 sections – km 35-31, 22-18 2 sections - km 34-30, 16-12	3 3	2 or 3 2 or 3	Table 2 sections of 4 km each, with 3 passes completed. Anzac: km 16-12 = 2 pass, km 34-30 = 3 passes; rained out so not all sections received 3 passes

* 2007- data on file as draft report not completed (data on file, Cowie and Blackman, 2008).

1995

In the initial start-up year of underwater surveys (1995), single and 2 pass counts were conducted from early July thru mid-August on the Table River. The single pass counts were carried out by a crew of 2 from km 35.5 to km 0, the confluence with the Parsnip River (section 24-29 km was not included as numerous hazards existed). The 2 pass counts were carried out by a crew of 3 in 2 sections which are identified as 1) Upper (km 35.5-32), and 2) Lower (km 9.8-5). It was noted that there may be a bias to observation of larger fish as adults are easier to observe than juvenile and fry, which tend to use shallow areas not easily enumerated during underwater counts.

Mark recapture techniques were applied for the 2 pass counts. The number of fish actually observed versus the number tagged was only statistically valid in the Upper section, which resulted in a correction factor of 1.5 for the Upper Table River grayling (expanded counts n = 251). Wetted widths and visibility for each section was noted for count expansion factors if needed. The upper section with no expansion factor, as the entire wetted width was observed, (222 grayling observed in 2 passes for 31.7/km), while the lower section had an expansion factor (although not statistically valid) of 1.33 applied (64 grayling observed for 8.9/km expanded), as the wetted widths indicated only 21 m of 28 m were observed.

1996

During the 1996 underwater count, only one site (km 37.6 to 24.5) was enumerated in a single pass by a crew of 2. As this was not exactly the same section as conducted in 1995 a direct comparison can not be made, but reach 3 was included in both years for comparison. Expanded counts in 1996 resulted in reach 3 having 211 grayling for the 191 observed. In 1995, the expanded counts for the Upper section was 251 grayling in 2 passes, or not corrected as 222 grayling (31.7 GR/km).

1997

In the 1997 field season, sites were only conducted on the Anzac River. The entire system was surveyed in a single pass with a crew of 3. Habitat use was assessed by a crew of 2 at eight locations that adults were inhabiting. Underwater counts resulted in 533 grayling being observed (4.21/km). As in the Table River, there was not an even distribution of grayling, and larger fish were in the upstream locations. Grayling were again noted as using deeper water near the thalweg. As clarity increased, the fish tended to move into deeper pools. The timing of grayling distribution appears to be slightly behind the Table system, in that fish were still moving into upstream locations when the Table fish would already be in the upper reaches. Flows and system temperatures may be causing seasonal differences in the migration pattern for each system for this species. Overall, underwater counts was determined as an effective method for adult enumeration. It should be noted that fish move according to flows and water levels year to year, so additional index sites may be required to provide an accurate estimate of grayling in each system.

1998

The 1998 project included counts in both the Table and Anzac rivers. In the Table River, three sections were completed, km 9 to 5, 22 to 18, and 35 to 31. In the Anzac River, five sections were completed, km 10 to 6, 16 to 12, 34 to 30, 43 to 39, and 47 to 45. A crew of 3 was used in both systems, with areas such as large pools receiving extra effort by the crew walking back upstream and swimming the pool until consensus of numbers were reached.

Mark recapture techniques were used to assess the validity of counts and if expansion factors should be applied. Within a 4 km site, the middle 2 km were used as the tagging area. Standard expansion factors indicate counts by a crew of 2 in the Anzac River would be above the estimate from mark recapture as the wetted width is narrower. By using a crew of 3, the entire width was observed and no expansion factor was required. Mark recapture results also indicated that once grayling were tagged, they moved downstream of the tagging area. This movement resulted in the potential that an overestimate of grayling abundance could occur if expansion factors were applied and tagged fish had moved out the index sites.

In the Table River, 56% of tags were observed (68 of 122 tags), while 18% of tags had moved out of 2 km tag area. In the Anzac, 76% of tags were observed (153 of 206 tags), while 17% of tags had moved out of the tag area. In the Upper Anzac (canyon area with large pools), tagged fish did not move out the tagging area, but were deeper. In reach 3 of the Anzac River and reaches 2 and 3 in the Table River, the mark recapture estimates would almost double the counts, which indicate a positive bias to fish movement or to fish being missed altogether. Tag observation seems variable due to factors such as fish movement out of the site, fish moving into deeper areas which may cause fish not being observed, and crew experience. Both systems have higher numbers of grayling in the upper reaches.

Recommendations in 1998 for future underwater counts included expanding sites to 6 km if a mark recapture program is included in the project design, to ensure fish that move downstream would remain in the site, or to not do a mark recapture program and to conduct a 3 pass enumeration. A three pass assessment would not require expansion factors if visibility was greater than 4.5 m.

2000

Underwater counts in 2000 were conducted on the Table River, 3 sections with 2 passes, and in the Anzac River, 1 section at km 47-45. The Anzac River was not completed due to heavy rains which reduced visibility. A total of 4 counts per section was completed with either a 2 or 3 person crew, depending on wetted widths.

The upper Table River results were 123 grayling, which is similar to 1998 (136) and 1995 (127). Counts in the middle sections of the Table River were similar to previous years but with more variability, and numbers were down from previous counts in the lower Table River.

The single section completed in the Anzac River (the upper canyon section) was down from 82/km in 1998 to 34/km. Adult grayling distribution varies from year to year, and may be affected by water levels and temperature. Overall, grayling have been noted as becoming concentrated in the upper reaches as water levels drop over the summer season. If water levels do not drop, it is speculated that more adults will remain in the lower and middle reaches, which may account for the reduction in counts in the upper section in 2000 (Blackman 2002).

Mark recapture techniques were not applied in 2000, as previous surveys in the Table and Anzac rivers indicated that up to 40% of grayling moved post tagging. As an alternative to tagging, multiple counts with a suitable crew size for the section wetted width was selected. In narrow sections, 2 crews of 2 were used, while in wider sections, a crew of 3 and a crew of 2 were used for a total of 4 counts per section. No obvious bias was detected in crew counts for different crew sizes, but project costs increased with more crew as additional helicopter moves were required to move crew to sites. No obvious bias was detected between crew sizes to data from the crews was treated as the same regardless of crew size. No expansion factors were applied to counts as in 1998, as it was found that an over estimate of the population could occur due to fish movement post tagging and missed fish in the crew observations. Observation of fish was directly related to visibility being greater than 3 m and crew experience.

2001

In the Table River 2 sections were conducted, and 4 sections were conducted on the Anzac River. Counts were conducted with 2 crews of 2 conducting 2 passes per site for a total of a 4 pass count. Sites that previously had very low numbers of grayling (less than 2 grayling/km) were dropped from the counts to reduce costs and time requirements.

Methods that were assessed in 1998 and 2000 (mark recapture and additional crew and/or passes) were noted as not being beneficial to counts so were not applied in 2001. Difficulty in capturing 20% of the population to tag, as required for statistically valid results in a mark recapture program, was noted so mark recapture techniques were abandoned. Additional crew and/or passes did not provide improved counts but did increase project costs. Effectiveness of the counts appears to be more dependant on visibility and crew experience. Abundance estimates from expanded counts and mark recapture efforts provided different population estimates (Mathias et al 1998, Blackman and Hunter 2001). In order to compare year to year counts, it was decided to compare simple counts from each site.

Visibility in the upper Anzac River was 3-4 m, which was reduced from previous years and may have resulted in fewer fish observations. The Table River results of 22.7 grayling/km have remained consistent with a slight downward trend (Murphy and Blackman, draft 2004) since counts began in 1995 (2000, 1998, and 1995 counts averaged are 32 grayling/km). The Anzac River counts indicate more variability of numbers and it appears to have a slight downward trend, although the Anzac River was only added in 1997 (single pass entire system). Counts in 1998 were mark recapture efforts, and in 2000 crews were rained out so the system was not completed. Counts in 2001 on the Anzac River put grayling estimates at 21/km. Upper reach counts for both systems remained consistent in showing that the larger grayling tend to move to upstream reaches. Areas of deep pools or with large numbers of fish were recounted.

2003

The Table River surveys included 2 sections, and the Anzac River included 4 sections in 2003. Counts were conducted by 2 crews of 2. Each crew completed one pass, then the site was divided into two, and each crew swam ½ the site for a total of 3 passes per site. Counts increased from 2000 and 2001 in both systems. The Table River counts increased to 26/km, while the Anzac River counts increased to 15.5/km. The population is appearing to be stable overall as numbers are not continually on the decline. Age analysis conducted on samples from angling show that Anzac River grayling are older and larger at age than Table River fish.

The larger grayling are residing in the upstream reaches as in previous surveys, as the adults move upstream as flows decrease and the season progresses. Large pools are being selected as primary habitats for adults and if visibility was reduced, counts would be affected negatively. Continued indexing would potentially detect a change in the adult population if a minimum of 3 passes was conducted to allow for statistical power analysis. No trend in population is statistically evident at this point, but the population since the inception of the project in 1995 does appear to show it as stable (Blackman et al, draft 2004).

2007

The final counts were conducted in 2007 (data on file, Cowie and Blackman, 2008). Due to policy and safety related changes, a boat tender followed swim crews on all sections conducted except the upper Anzac canyon. The Table River surveys included 2 sections, km 22-18 and 35-31, with 3 passes in each. Counts on the Anzac River included 2 sections, km 16-12 with 2 passes and km 34-30 with 3 passes. The remaining sections of the Anzac were not completed due to rains and poor visibility. Results indicated a decline from the prior surveys, with the Table River counts showing a decrease to 20/km, while the Anzac River counts decreased to 13/km.

Electrofishing

Electrofishing (EF) was used over the time frame of the studies for a variety of purposes, but was mainly for the initial habitat assessments and in determining fish presence/absence in the Table, Anzac and associated tributaries of these two systems. Methodologies varied from open to closed sites, with random site selection to targeting specific habitats. If the same sites were conducted under the same conditions (open or closed site), the individual site could be compared to previous surveys.

1995

The initial surveys on the Table River and tributaries in 1995 included 40 mainstem sites from July to late September. The intent of the open sites was to determine presence/absence of fish and species present. The only successful way that young-of-the-year were caught was using open sites. Of the 40 mainstem sites, 16 were open for a total area sampled of 15,198 m^2. Grayling (n=13) were only caught in open sites and only in section km 27-26. The habitat grayling were caught in (shallow, small cobble, and with no flow) was not typical to literature reviews of grayling habitat. The study ended prior to additional sites of this habitat being sampled.

In the tributaries, 24 sites were conducted for a total area sampled of 39,983 m^2. Tributary sites were conducted using closed sites with 2 passes for fish density. No grayling were caught in closed sites or in any tributary sampled.

1996

Additional effort was put into electrofishing and conducting habitat typing in the Table River in 1996 from July to mid-September for juvenile grayling distribution. Sampling was conducted at 35 sites, 22 mainstem sites and 13 sites in 7 tributaries, and was conducted using open sites. Habitat typing was assessed using methods from Reconnaissance and Fish Habitat Level 1 surveys. Habitat typing had good distribution within the sampling area.

In the mainstem, 65 grayling were caught in 12 of the 22 sites, with an overall of 92% of sites having grayling present. No sampling effort or coverage was recorded. It was noted that site selection was biased based on young-of-the-year that were caught the previous year in one location. The habitat type (shallow, small cobble, and with no flow) was referred to as the grayling young-of-the-year preferred habitat. Sampling conducted in the tributaries, 13 sites on 7 tributaries, yielded no grayling. As the surveys did not commence until July, no fry emergence was noted as they would have already moved from hatch areas.

1997

Surveys conducted in 1997 included sampling using single pass sites with no stop nets on both the Table and Anzac rivers in July and August. Young-of-the-year habitat use and habitat preference was added to sampling efforts. A four person crew would walk out from shore until the depth was too deep (~60-80 cm), and mark all locations fish were caught with a metal washer for habitat parameters to be collected. Habitat parameters collected are detailed in the habitat preference section contained in the Incomparable Methods presented later in this report.

Electrofishing effort in the Table River included 29 sites at 4 road access locations, for 9.1 km (31,839 m^2) of coverage, with habitat use being assessed at 1,100 points (2,245 m of shoreline). Sampling resulted in 114 grayling caught at 67 points. In the Anzac River, 25 mainstem sites (6,881 m shoreline) throughout the system were sampled, with 3,500 habitat points being completed. Sampling in the Anzac River resulted in 353 grayling at 276 points. All grayling caught were young-of-the-year, while all other species were age class 1-2.

1998

Electrofishing was again used in 1998 for assessment in the Table River in early September. Stop nets were used at road access sites previously sampled (km 9.8 and km 22) with known grayling fry presence. The sites included 24 mainstem sites measuring 3 x 25 m, with an additional 4 whole river and 2 side channels being assessed. Stop nets were installed using rebar and set 3 hours prior to any sampling being conducted. A minimum of 2 passes was completed, with a 3rd pass if grayling were caught in pass 2. Microfish 3 software was used to determine abundance estimates for the 850 m (4,629 m^2) of habitat sampled.

Results of sampling were 29 young-of-the-year grayling with a mean fork length of 72.2 mm, and mean weight of 2.42 g. The density for grayling and total fish caught were greater at km 9.8 than km 22. The estimated number of grayling fry was up to 40/km (two banks) at km 22 and 80/km at km 9.8. Arctic grayling were the most numerous sport fish and no young-of-the-year bull trout were caught.

2001

The final electrofishing surveys were conducted in 2001 in late August using closed sites. Sites in the Table River were at 2 pre-established locations: 10 sites at km 22.8 covering 722 m^2 and 12 sites at km 9.8 covering 897 m^2, for a total coverage of 1,619 m^2 (Blackman 2002). In total, 21 grayling were caught for 34 grayling fry/km. These numbers are comparable to the 1998 assessment with an increase at the lower site, and a decrease at upper location.

Sampling in the Anzac River was at newly established sites covering 894 m^2. Site selection and distribution included 6 sites at a bridge at km 6 (414 m^2), where no grayling were caught, 14 sites at 2 locations at cabins located at km 8 (480 m^2), where 5 grayling were caught for 5.2 grayling fry/km. Of the grayling caught, 20 of 26 were in 4 of 27 sites.

In discussing the effectiveness of electrofishing for sampling long-term to track populations in these systems, it was suggested that if fish distribution was clumped, it may be tough to get a precise measurement in a small area in which to detect change. Sites would need to cover a much larger area to reflect changes in population.

2005

An additional unrelated electrofishing project was conducted in the Parsnip Watershed in 2005, with a primary focus on the distribution and abundance of Arctic grayling fry in the Parsnip River and all tributaries within the Parsnip River Watershed (data on file, Sherstone and Blackman, 2008). Sites for this project were not randomly selected, but were selected in the field with a focus on habitat types that have been previously identified as being preferenced by grayling fry in other Williston Watersheds.

A total of 101 open electrofishing sites were conducted, covering 10,420 m of shoreline. From 22 of the sites, 78 Arctic grayling fry were caught, with 6 of the 13 tributaries sampled containing grayling. A 51 km section of the Parsnip River (km 39 to km 90) and two major tributaries, the Table and Anzac rivers, were not included in the sampling effort as the areas have been previously sampled in other projects and the focus was on areas not previously sampled.

Incomparable Methods

Fyke Nets

1997

Netting with fyke nets was conducted on the Anzac River in July, 1997. The nets were set for 48 hours at km 3 in a riffle downstream of a previously documented fry location. The 3 fyke nets were a fine mesh (<1 mm) net that covered a 50 x 50 cm area, and were set 1, 5, and 10 m from shore to a depth of 10-25 cm depth. The nets were checked three times per day. No fry were caught in any of the sets. Problems reported included the net mesh being plugged too quickly and they therefore needed constant and continuous cleaning to avoid mortalities. This method was determined not to be an optimal method for the system due to nets plugging and needing constant attention.

Pole Seining

1997

Both the Table and Anzac rivers were assessed with visual observations (as outlined in a section below), which included 2 crews of 3 using a fine mesh pull seine (4 mm mesh) and aquarium nets to collect fry observed for positive identification. This method had a high mortality rate, especially in silted areas. Numerous voucher samples were collected for species verification. Stamford (Stamford, Pers. Comm. 1999) indicated that a valid field identification between longnose suckers and grayling fry post emergence is not possible and the method would be unreliable.

Additional Surveys

During the period of 1995 to 1998, various types of habitat surveys were conducted on the Table, Anzac, and Parsnip rivers, although not all systems every year. Methodologies varied from overview to detailed and followed a variety of survey types available such as:

- Level 1 and 2 Fish Habitat (FHA), Department of Fisheries and Oceans Canada (DFO),
- Reconnaissance surveys, Ministry of Environment (MOE), and
- Detailed assessments that targeted young-of-the-year habitat use and preferences.

Surveys had various levels of data collected and coverage ranged from the entire length of the system to spot sampling as access allowed, depending on survey type and focus. The habitat surveys were able to assist in identifying areas that were in higher use by grayling of a certain age class, and of areas that could be considered critical habitat as the habitat type may be limited within the system(s). If future surveys were conducted using the same inventory method and in the same locations, the habitat data could be compared to assess the stability of habitats in each system.

Reconnaissance Surveys

1996

Reconnaissance (MOE) and Department of Fisheries and Oceans (DFO) Level 1 Fish Habitat surveys were conducted in 1996. The Table River was divided into kilometre sections and sites selected based on access to surveys sites and maintaining a good overall site distribution. The Reconnaissance electrofishing surveys included 11 sites on 6 tributaries but no mainstem sites. Results can be found in the electrofishing section of this report.

Habitat and Habitat Preference Surveys

1995

Level 2 Fish Habitat surveys (FHA) were completed on the Table River upstream to falls at km 37. Results indicate that grayling tended to use areas immediately adjacent to debris and log jams but were not typically found in the debris. Grayling were tending to use the thalweg and pools, residing roughly 10 cm off the bottom, in an average velocity of 0.36 m/sec. Post peak spawning surveys showed the highest concentration of grayling at a pool (tributary 605), an area which was identified as representing optimal adult summer feeding/rearing habitat. Grayling distribution was ordered in a migratory sequence, with larger fish residing upstream and juveniles in the downstream reaches (Northcote 1993).

1996

Reconnaissance (MOE) and Department of Fisheries and Oceans (DFO) Level 1 Fish Habitat surveys were conducted in 1996. The Table River was divided into km sections and three mainstem sites were selected based on access to surveys sites and maintaining a good overall site distribution.

Fish habitat typing from the Level 1 surveys rate habitat based on criteria for Coastal regions, as no interior ratings have yet been established. There are limits to this rating systems, for example there is no category for a channel width greater than 15 m, which is common in sections of the Table River mainstem. The Table River has a mean channel width of 18.1-48.7m in reaches 1-4.

As no alternative habitat rating system was identified, Level 1 survey methodology was selected as the rating system that would be used. The results from the Level 1 surveys indicate that there is less fry habitat than parr/adult habitats available in the mainstem and tributaries, which led to the assumption that fry habitat may be the limiting factor for Table River salmonid populations. Reach 1 to 3 had more adult habitat, while reach 4 and 6 had greater parr habitat.

Results of the FHA surveys found that the Table River had the following habitat ratings:

- Poor percentage of pools overall and poor pool frequency except in reach 6 which rated as fair;
- Fair to good for large woody debris (LWD), while the over cover was rated poor but this would be due to the wide channel widths;
- Reach 1 to 3 had the highest percentage adult rearing habitat in relation to fry and parr rearing habitat;
- Reach 4 and 6 was rated as parr dominated habitats; and
- In tributaries, 13 of 16 had a higher percentage of parr habitat, while 3 of 16 tributaries were rated as having more adult habitats.

Overall, the Table River appears to have less fry habitat available in the mainstem and tributaries than parr and adult habitat. This is supported in that no grayling were caught in tributaries and no grayling were caught upstream of km 37.6 at the falls or in side or back channel habitats. It was also noted that increased sediments, occurring from natural and industry related activities, potentially reduce visibility and impair feeding and young-of-the-year survival. Logging in the watershed has resulted in cover loss, bank instability, and the potential of increased daily and annual temperatures. Beavers, which are active in the watershed, may cause migration issues.

In 1996, grayling habitat preference was added to underwater adult counts. Sites were selected for distribution, access, and reach representation, and therefore the survey had a bias to the accuracy of the representation of habitats in the system as sites were not selected randomly. The site selection did appear the same as in 1995 for comparability. The authors noted that the habitat description is observer dependant and that conditions and life stages vary by species, which are factors that need to be considered when using the habitat preference rating system.

1997

Surveys were conducted on grayling young-of-the-year habitat use and preferences. All locations of fish caught were marked with a metal washer for a subsequent crew to follow and survey for habitat parameters. A four person crew waded out from shore until the depth was too deep (60-80 cm) to collect habitat parameters at marked locations. All grayling caught were young-of-the-year.

Habitat parameters were then assessed using a logistic regression analysis (Statistix 7.0) to determine if there was a significant relationship of habitat variables and the distribution of fry, which was in turn used to develop preference graphs per species per system. Grayling fry showed an affinity to shallow (mean 12 cm), low velocity (<0.1 m/s) habitats. The logistic regression analysis for the Anzac grayling showed a negative relation to depth, velocity, percent cobble, and a positive relation to percent fines, while in the Table River similar results but only in relation to depth and velocity.

The Table River assessment included 29 electrofishing sites, covering 9.1 km (31,839 m^2) at 4 road access sites. The habitat use included 2,245 m shoreline with 1,100 habitat points. A total of 114 grayling were caught in 67 points. The Anzac River assessment included 25 mainstem electrofishing sites through the system, covering 6,881 m of shoreline. A total of 3,500 habitat points were completed, and 353 grayling were noted at 276 points.

Habitat data from previous years underwater counts was pooled for the Table River (1995-1996) with habitat data for the Anzac River. Results indicated that 63% of grayling use pools in both systems, while there was a slight difference in velocity and depth. Position appears to be determined by feeding efficiency and that the key position is near the thalweg. As the water clarity increases, grayling move to deeper locations. Extreme low flows could result in competition for feeding locations and crowding in pools as these areas are considered optimal grayling habitat.

1998

During the 1998 field season, young-of-the-year and 1+ habitat use and preferences were assessed with beach seining. A series of 3 beach seining sessions were conducted in the Parsnip and Anzac rivers. A variety of habitats over 8 km was assessed. All fish with a fork length greater than 100 mm were fitted with a passive integrated transponder (PIT) and received an adipose clip for a coinciding genetics study.

Habitat preference and use parameters surveyed included length (m), velocity (at 60% depth), and substrate (% at distance from shore then averaged for site) over 25 m transects at each site at 1, 5, 10, 15 m from shore. A habitat preference histogram (using methods similar to Baxter 1997) was created by calculating a weighted amount of habitat for each site by dividing individual site length by total length surveyed, then the number of grayling for each site was divided by the total number of grayling caught. The range of bins selected (Sturges) for depth and velocity at each distance from shore was then calculated for a total habitat in each bin range. The habitat use was then standardized to get the highest preference value, with a value of 1 being the most used, while 0 was the most unused. A descriptive index for grayling habitat selection was developed but only from shore to 5 m for young-of-the-year as they prefer shallow, and for 1+ to 15 m in the Parsnip River.

Radio Telemetry of Arctic Grayling Migrations to Overwinter, Spawning, and Summer Feeding Areas, August 1996 through October 1997

A radio telemetry program was carried out during the period of August 1996 until October 1997 (Blackman 2002b). The intent was to surgically fit radio tags into numerous Arctic grayling in both the Table and Anzac rivers, and track these marked fish to determine migration routes, overwintering habitats, and potentially identify spawning areas. A total of 55 adults (25 from the Table, 30 from the Anzac) were angled and surgically implanted with radio transmitters, 18 of which were confirmed to survive to spawning season the following year.

The Table River fish moved downstream to overwintering areas by late September, while the Anzac fish did not move from tagging sites until early November. Locational tracking during the winter occurred on a monthly basis, and the sites were noted so that habitat parameters could be assessed in the following field season. Grayling moved an average of 55 km downstream to overwinter sites (Blackman 2002b). The selection of habitats in the overwintering areas were highly variable and included shallow higher velocity areas, which are typically noted as feeding locations. Movement over the winter did occur.

The rising of water temperatures and ice off in late April coincided with the spring migration to spawning areas. Poor visibility and high flows did not allow for observation of spawning activities, but fry emergence indicates spawning to have occurred from late May to mid June. The range of movement to spawning areas was 9 to 71 km (mean of 33 km). Males tended to move to spawning areas first (up to a month earlier than females), while females moved slowly upstream. Multi-channelled areas of the mainstem Parsnip and Anzac rivers were the selection of many grayling during the spawning period, while 1/3 of the tagged fish were not in the same river they had been tagged in. Spawning was completed in late June and grayling moved to summer feeding areas, most of which were back to the location where they were tagged the previous year. Grayling started to move back to overwinter areas by early October.

The average movement of the one year tracking period was 126 km, with a range of 67 to 245 km. There was insufficient tagged grayling to identify numerous areas of spawning activity within the system. The poor survival rate of tagged fish (only 18 of 55 were confirmed to survive to spawning) was probably a combination of issues including small size of fish tagged, natural high mortality rates, inexperience of tagging crew, and common issues encountered with telemetry projects such as fish move out of study area, tag failure or shedding, and predation (Blackman 2002b). As an alternative to radio telemetry (a high cost program) fry distribution surveys, as noted in previous sections, were recommended.

Visual Observations

Visual observations were used during two years of the initial studies (1997 and 1998) to assess the method in determining if it could be used as a reliable technique to:

1. locate spawning locations;
2. identify spawning areas by locating emerging fry; and
3. determine a rough distribution of fry.

None of the visual observations were highly successful methods in the purpose they were intended for various reasons. Overall it was recommended that the method was not a cost effective technique in the watershed.

1997

Both the Table and Anzac rivers were assessed with visual observations in 1997. The method involved 2 crews of 3 being moved upstream with a helicopter (as road access is limited) with sites every 1-2 km. The type of habitats targeted included gravel bars or side channels, as literature reviews indicated that as a preferred habitat for grayling fry (Blackman 2004). Crews wore polarized glasses and walked upstream along the shoreline counting any fry observation made within 1 m. A fine mesh pull seine and aquarium nets were used to collect fry observed for positive identification, with numerous vouchers collected for species verification.

A total of 33 sites were conducted on the Table River between km 0 and 31. A total of 58 fry were observed, although none were observed upstream of km 29. The only location where a group of more than 10 fry were observed was at the mouth of the Table River.

A total of 37 sites were conducted on the Anzac River between km 0 and 47. A total of 144 fry were observed and 106 were caught for species verification. No fry were observed upstream of km 34. Three main locations (km 0.7, 2.4, 27) had groups of fry (n= 31, 20, 15). Crocker Creek, a tributary to the Anzac River at km 35.6, had fry in the first 300 m.

No large schools of fry were noted in either system. The upper limits of fry distribution coincided with a change of substrates from gravel to cobble. High waters were present in the watershed in 1997 and may have led to poor fry survival, lower success with spawning or potentially both (Blackman 2004).

Visual observations has limitations as a reliable method. Poor visibility caused by wind or rain would make this method highly ineffective. Fry species identification can be difficult, as longnose suckers *(Catostomus catostomus)* and Arctic grayling fry are hard to differentiate at the fry stage. A valid field identification between longnose suckers and grayling fry post emergence is not reliable (Stamford, Pers. Comm. 1999). Grayling fry are only surface orientated for approximately 10 days then hide, so the method would become ineffective if timing was off fry emerging.

1998

In 1998, two types of visual observations were undertaken, egg deposition and young-of-year (YoY). Egg deposition visuals were conducted on the Table River at km 28, and the Anzac River at km 5-6. Crews observed 300 m x 3 m wide shoreline habitat to look for spawning evidence. In total, 60 random sites on the Anzac River were examined for eggs. An oar was used to disturb gravel in a 1 m^2 area and a 0.5 mm fyke net on the downstream end to collect anything dislodged from the site. Grayling eggs are only at a depth of 2-3 cm (Van Whye 1962). The sites had a mean depth of 0.1-0.5 m, and a mean velocity of 0.2-0.75m/s. Surveys were conduced at previously identified spawning areas on a date known as spawning periods (Blackman 2002b). No egg deposition sites were found in the Anzac River. During the Table River surveys, new fry were observed and it was assumed fry were emerged and the surveys were ceased.

For the young-of-year surveys, visuals were carried out by a 2 person crew walking upstream counting fry with polarized glassed. A total of 31 index sites (100-200 m in length) were conducted and 3 fry/ 50 m of stream bank were observed. Of the fry observed, grayling were 10-15 mm fork length, while mountain whitefish were 20-28 mm fork length. In the 31 sites, the Table River observations were 791 fry, while the Anzac River 40 fry were observed. The Anzac River had low fry numbers in km 0-20. Large numbers of new fry (600) were noted at km 1 on the Table River, using the margins of a shallow riffle and drifting downstream.

The second visual survey in 1998 was more detailed than the earlier one noted above. The lower 32 km of the Table were started on June 30th, and the Lower Anzac at km 20, started on July 7th. All walkable areas were searched with special attention given to already identified fry habitat.

On June 30th, 3 fry sizes were observed in the Table River. The fry were noted as the following:

1) 11-14 mm fork length, with 2 eyes and a thread, fish were in a dense school in shallow, low velocity as expected of new grayling fry (Armstrong 1986);
2) 15-25 mm fork length, fish were active, slightly higher velocity than smaller fry, 25 mm could be identified as grayling by dorsal fin; and
3) >25 mm - identified as Mountain Whitefish in Table River with larger fish in the lower reach; while 1 week later Anzac River fish were fork length 16-32 mm.

It should be noted that post analysis of fry vouchers indicated that size 15-25 mm were grayling fry but fish 11-14 mm were longnose suckers (Stamford, Pers. Comm. 1999). Since fry schools mix and the notes were not detailed enough to separate data apart, counts can not be determined to numbers by species.

The second survey in the Table River found fry upstream to km 32 in alcoves and back and side channels. Groups of 200+ fry and 5 schools of 500-1000 fish were observed. Smaller groups of 2-10 fish per school were observed in slow moving water along the shores of gravel bars. The highest numbers of fry were observed in km 17-20, while km 12, 15, 25-26, and 29 had spikes in the observations. A morphology analysis indicated that upstream of km 25.5, fry were not suckers, and therefore the counts of 2,000 fry between km 25.5 and 33 are probably grayling fry. In the Anzac River, 5,278 fry were observed with the highest numbers at km 1, 11, and 14-20. The area in km 14-20 is a multi-channelled habitat. In telemetry studies conducted in 1997, the area was noted as a main spawning area. No further upstream areas were completed due to time and budget constraints.

Additional Data Collection

Length at Age

Length at age information within a watershed can often be used to help classify a fish into an age class based on fork length. As different species grow at varied rates depending on numerous factors such as geographical location, annual and daily water temperatures, timing of fry emergence, and timing of spawning, identifying the range of an age class for a given species within a watershed can be a useful tool in both field and initial analysis.

Arctic grayling in the Williston Watershed are at the species most southern distribution in the Parsnip drainage (Blackman 2002a) , which may mean that they have different growth rates than numerous published literature from other more Northern areas in which they are more common, such as Alaska, USA. Grayling in the Parsnip Watershed have been assessed over a number of years and an attempt to determine a length at age classification was undertaken in conjunction with other ongoing studies in the watershed. Ageing analysis was conducted by North/South Consulting Inc, Winnipeg.

1996

During the surveys conducted, samples were collected to assess the length at age of Arctic grayling in the watershed, and to compare to previous studies in other Williston Watershed as follows:

- Table and Anzac rivers – August - September 1996 during radio tagging efforts
- Mesilinka River - 1990-1992 – stream fertilization
- Nation River – 1992 – grayling transplant
- Parsnip River – 1974 – historic files

The comparison found no difference for ages 3 to 6 in the Table River in 1995/96, and no difference in ages 3 to 4, and 6 in the Table and Anzac rivers. Age 5 Anzac River grayling were significantly larger than the Table River grayling. The age 7 age class did not have a large enough sample size to compare. The Mesilinka River grayling in age class 2 to 6 and the Nation

River age class 2 to 4 were larger than the 1995 Table River grayling. There was no difference in age classes 2 and 3 for Parsnip grayling and the 1995 Table River, but the Table River grayling were significantly longer at age 4 to 5.

1998

Additional length at age surveys were completed to compare scales and fin rays. A total of 90 samples from 1997 and 1998 were included in the comparison. The fish ranged in fork length from 311 to 400 mm. Results indicated that 33 fish were the same age using both sample types, while 45 fish were within the same 1 year. Scale ages tended to underestimate older larger fish. It was also noted that it appears PIT tags appear not to affect growth. Fish were larger than in previous years, with 1998 being noted as having a longer growth season and warmer temperatures. The Parsnip River temperature records indicate it is warmer earlier than the Table River and therefore it can be expected that fry would emerge earlier.

Age class distribution assessments combined with other surveys, indicate that the Anzac River has a higher percentage of larger and older individuals, that are also larger at age than the Table River population. The Table River population is a mix of mature and immature fish. The Parsnip River adult grayling is not effectively sampled with techniques applied to date. The surveys do show that the Parsnip is dominated with a younger age class and is used for rearing of immature fish from all 3 systems. Telemetry records show that adult grayling caught in the Anzac River have spawned in all 3 systems and are therefore using all the systems.

2007

In 2007, the final year of assessments, grayling caught were not assessed for ages, but rather length at age data from previous years and the length frequency distribution was used to categorize grayling into age classes (table 3) (data on file, Cowie and Blackman, 2008). The length frequency showed a slight decrease from previous years.

The age classes used based on previous age analysis conducted within the same systems, resulted in the following age categories:

- Young-of-the-year a fork length of <u><</u>70 mm,
- 1+ a fork length between <u>></u>70 mm and <u><</u>150 mm, and
- 2+ and older a fork length of >150 mm.

The mean fork length for young-of-the-year was 48.3 mm, and 103 mm for 1+ grayling.

Table 3. Average fork length (mm) and weight (g) of grayling captured by beach seine in the Parsnip River from 1998 to 2007.

	Young-of-the-year						One year old**					
	2007*	**2005**	**2003**	**2001**	**2000**	**1998**	**2007***	**2005**	**2003**	**2001**	**2000**	**1998**
Mean FL (mm)	48.3	44.5	56.9	45.2	48.7	49.8	103	133.7	97.5	98.3	100	113.9
St. Deviation	10.3	14.0	15.2	15.8	14	5.9	14.4	15.1	18.2	15.9	16.2	10.9
Range	22-68*	22-77	26-77	20-76	20-74	34-67	72-140**	80-151	78-145	78-144	78-152	90-145
Number of Fish	94	117	81	117	383	192	202	164	129	143	240	109
Mean Wt (g)	1.4	2.5	2.9	2.4	2.6	1.3	10.5	16.6	10	10.4	10.6	14.9
St. Deviation	0.8	1.5	0.8	0.9	0.9	0.5	4.7	6.7	6.8	8.5	6.2	6.2
Range	0.3-4.1	1.0-6.8	0.4-4.6	0.3-5.0	0.5-4.7	0.3-2.8	3.4-27.3	4.1-39	2.8-31	4.1-83	4.4-39	6.0-55
Number of Fish	25	44	58	53	150	151	183	146	109	143	224	109

* The 2007 is data on file (Cowie and Blackman, 2008) but the data comparison was conducted. The 1998 – 2005 portion of the table is in a draft submitted report (Mackay C.A. and B.G. Blackman 2006)

** During the 1998 sampling session, numerous sites were done multiple times over the dates noted. The data presented is a summary from the complete data set for that time frame within the range of km 48-73. I.E. Sites outside the range of km 48-73 were not included.

Passive Integrated Transponder (PIT) Tagging

A useful tool in on-going surveys is to mark fish with an unique identifier for tracking parameters such as location, fork length, weight, etc.. In some survey years, Arctic grayling greater than 100 mm had a passive integrated transponder tag (PIT) inserted immediately behind the dorsal fin. This tag has a remote readable individual code for re-identification purposes. Whenever grayling were caught, they needed to simply be scanned to determine if a PIT had been applied and note the identifier number to later retrieve past data on the individual fish. This data is noted in all field data collected and remains on file.

As PIT tags were not applied in all survey years but rather opportunistically, there is little consistency in the application of the tags. Data from fish that were tagged and were re-caught in subsequent surveys are noted in the raw data which was not reviewed for this summary.

SUMMARY OF COMPARABLE METHODS

There were three methods that would be considered comparable: beach seining, underwater counts, and electrofishing. Over the period of the projects conducted, 1995 to 2007, each of these methods was adjusted to best suit the site, method, costs, etc. over the project years. Adjustments to a method included setting site lengths to 100 m for beach seining, adjusting crew numbers for underwater counts depending upon section and budget, and comparing open to closed electrofishing efficiency in grayling fry capture.

Beach seining could be compared over the long term as sites are noted by river km and keeping in mind that river morphology year to year may differ (channel shift, oxbows, etc.), the location could be maintained, re-sampled and compared to previous survey years data. Underwater counts could potentially be compared as again sites were based on river km and features such as waterfalls and canyons noted. Electrofishing is a repeatable method as the locations are identifiable, accessible, and relatively easy to replicate. All of the habitat surveys could be repeated and the sites compared for changes to habitat as would be expected.

The frequency of the surveys that were completed, typically on a bi-annual basis, was beneficial in determining factors such as the habitats grayling were selecting the Parsnip, Table, and Anzac rivers, estimates of the population both in distribution and abundance by age class, and providing a series of data that spans over more than 10 years. Subsequent future surveys in the watershed could provide indications of changes to the species in both distribution and abundance.

ACKNOWLEDGMENTS

The primary author would like to acknowledge the many years of dedication and perseverance that Brian G. Blackman gave to the Arctic grayling species in the Williston Watershed, and to the Fish and Wildlife Compensation Program. Brian has left a long trail of surveys and many angled fish, including some that could still be PIT tagged and growth information retrieved should surveys occur in the next few years. Brian, I wish you many years of nice pools and calm waters to throw out a line.

REFERENCES

Armstrong, R.H. 1986. A review of Arctic grayling studies in Alaska 1952-1982. Biol. Pap. Univ. Alaska No. 23.

Baxter J.S. 1997. Summer Daytime microhabitat use and preference of bull trout fry and juveniles in the Chowdale River, British Columbia. B.C. Environment Fisheries Management Report No. 107: 36pp.

Blackman, B.G. and M.J. Hunter 2001. 1998 Arctic grayling (*Thymallus arcticus*) surveys in the Table, Anzac and Parsnip Rivers. Peace/Williston Fish and Wildlife Compensation Program. Report No. 237.

Blackman, B.G. 2002a. 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.

Blackman B.G. 2002b. 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.

Blackman, B.G., E.B. Murphy, and D.M Cowie. 2004. Relative abundance of Arctic grayling (*Thymallus arcticus)* in the Parsnip, Table and Anzac rivers in 2003. Peace/Williston Fish and Wildlife Compensation Program. Draft 2008.

Blackman B.G. 2004. 1997 Arctic grayling habitat use in the Table and Anzac Rivers with ancillary information on other associated species. Peace/Williston Fish and Wildlife Compensation Program Report No. 296.

Bruce, P.G., 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.

Data on File, 2008. Cowie, D.M. and B.G. Blackman. Relative Abundance of Arctic grayling (*Thymallus arcticus*) in the Parsnip, Table and Anzac rivers in 2007. Peace/Williston Fish and Wildlife Compensation Program Report.

Data on File, 2008. Sherstone T.W. and B.G. Blackman. 2005 Arctic grayling (*Thymallus arcticus*) Fry Distribution Surveys in the Parsnip River. Peace/Williston Fish and Wildlife Compensation Program Report.

Langston, A.R. 1998. A reconnaissance survey of the Table River: 1995 status report. Peace Williston Fish and Wildlife Compensation Program, Report No. 178.

Mackay C.A. and B.G. Blackman. 2006. Relative Abundance of Arctic grayling *(Thymallus arcticus)* in the Parsnip River in 2005. Peace/Williston Fish and Wildlife Compensation Program Report. Draft 2006.

Mathias K. L., A. R. Langston and R. J. Zemlak. April 1998. A summary report of the Table River surveys 1996 status report. Peace/Williston Fish and Wildlife Compensation Program, Report No. 180. 62pp plus appendices.

Ministry of Environment, Lands and Parks (MELP). 1998. Species inventory fundamentals: Standards for components of British Columbia's biodiversity No. 1, Version 2.0. Resources Inventory Committee, Province of British Columbia, Victoria, B.C.

Murphy, E.B. and B.G. Blackman. 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. No.293. 18 pp plus appendices. Draft 2004.

Northcote, T.G. 1993. A Review of Management and Enhancement Options for Arctic grayling *(Thymallus arcticus)* with Special Reference to Williston Reservoir Watershed in British Columbia. Fish Management Report, Province of British Columbia, Ministry of Environment, Lands, and Parks, Fisheries Branch. Report #101, 69p.

Schwarz, C., Simon Fraser University, 2001. Personal Communication with B.G. Blackman. RE: Beach Seining Sample Sizes.

Slaney, P.A., and A.D. Martin. 1987. Accuracy of underwater census of trout populations in a large stream in British Columbia. North Amer. J. Fish. Man. 7: 117-122.

Stamford, M., University of British Columbia, 1999. Personal Communication with B.G. Blackman. Arctic Grayling *(Thymallus arcticus)* Fry Identification. May, 1999

Van Whye, G. 1962. Inventory and cataloguing of sport fish and sport fish waters of the Cappoe River and Prince William Sound drainages. Alaska Dept. Fish and Game, Ann. Rep. Of Prog. 1961-1962, Proj. F-5-R-3, 3(II-A):227-243.

Zemlak, R. J. and A. R. Langston. March 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. Summary and status of reports reviewed for this summary report.

Report # on BCH website *	Study year	System	Title of Electronic File	Author(s)	Comments
173	1995	Table		Langston & Zemlak	
178	1995	Table		Langston	
180	1996	Table		Mathias et al	
296	1997	Table / Anzac		Blackman	
237	1998	Table/ Anzac / Parsnip		Blackman & Hunter	
263	1998	Table/ Anzac / Parsnip		Blackman	Telemetry
254	2000	Table/ Anzac / Parsnip		Blackman	
293**	2001	Table/ Anzac / Parsnip		Murphy & Blackman	waiting TC approval
N/A	2003	Table/ Anzac / Parsnip	2004 – (2003PA~1)	Blackman, Murphy & Cowie	waiting TC approval, no report #
N/A	2005	Parsnip	2006	Mackay & Blackman	waiting TC approval, no report #
N/A	2005	Parsnip and all tribs	2005 ARCTIC GRAYLING SEPT 06	Sherstone & Blackman	Data on file as report incomplete, errors noticed
N/A	2007	Table/ Anzac / Parsnip	(2007 P~1)	Blackman & Cowie	Data on file as report incomplete, errors noticed

* BCH website for reports as of January 2012: http://www.bchydro.com/pwcp/reports.html
* * Report number assigned as 293 although the report is not yet approved.

Appendix 2. Excerpt from Schwarz personal communication with B. Blackman, 2001.

Greetings again Brian:

I had a look at the sample size problem. Unfortunately, you are in a "worse case" scenario - low average abundance but tremendous variance among the sets. These are very difficult to monitor effectively because you have to select enough sets to ensure that you get enough large counts to get an overall mean that is reasonable robust to being influenced by a single rogue high set.

If often turns out in these very skewed distributions that a transformation is appropriate - often log(x+1) : the "+1" is used to adjust for sets with 0 counts. When applied to the beach seine data, the mean of the transformed values was about .4 and the standard deviation was also about 4.

A change of 50% downwards corresponds to a change of about .-3 on the log scale; a doubling upwards corresponds to a positive change of .3. JMP v.4 has a sample size/power platform that can be used to "guess-timate" the required sample sizes to detect changes say between two years. This gives a power/sample size curve.

When investigating sample size, power is also a concern. Power is the ability to detect a change, usually 80% (.8 on the left axis) is the minimum power that would be of interest. Reading across the curve we get a TOTAL sample size of around 60, i.e. about 30/year. This looks as if it might be feasible to do. More samples would be required to detect a 25% downward change. Sample size requirements increase dramatically - now an 80% power to detect a 25% drop over two years needs over 300 sets - about 150/year! I don't think this is feasible at all!

These are only approximate - some of the 2000 seines were taken from the same location which tends to reduce the variation over sets which would imply yet a larger sample size would be needed than the above seems to indicate. Similarly, the log transform (with the +1 added) tends to "reduce" apparent sample sizes as well.

I'm also unsure how to treat the recruitment from the other rivers. Wouldn't this tend to drive up abundances immediately downstream from these tributaries or have these fish distributed them selves up and down the river?

If you are interested in detecting trends over many years, the situation gets more complicated as you need fewer sets each year, but now can't detect a trend until several years have passed.

If you want to spread the sampling out over three sites, there are two conflicting goals operating. To compare the index between years, all sites would somehow be pooled into one overall index and the sample size requirements above would likely be suitable. If you are interested in comparing within a year, then each of the sites would need the above sample size requirements which would imply a tripling of effort in any one year.

The situation for the 0+ is worse - the distribution of recoveries is even more skewed. However, after taking a log transform, the standard deviation of the log(x+1) is only slightly larger. This implies slightly more samples than for the 1+ group, but not a doubling or anything like that.

When I looked at the comparison of the 1998 vs. 2000 data collected at the same locations, there doesn't seem to be any relationship between the two counts so I don't think you can reduce the sample sizes by taking repeated measurements at the same site over different years.

Hope this helped. Please don't hesitate to contact me if you need further help.

Carl Schwarz.

Appendix 3. Stamford personal communication with B. Blackman, 1999.

Arctic Grayling *(Thymallus arcticus)* Fry Identification
Mike Stamford, UBC
10 May, 1999

During June and July of 1998, samples of larval fish were collected from the Table River and the Anzac River for potential use as Arctic grayling DNA samples. These samples were identified as Arctic grayling in the field by roughly scanning their size and gross morphology by eye (Brian Blackman pers. com.). Given their small size and early stages of development, it would have been nearly impossible to identify characters that are unique to Arctic grayling larvae. Identification would have been easier if field personal had the use of a taxonomic key that could focus their attention on specific features. The purpose of this study was to identify morphological features of larval Arctic grayling that can be used for identification in the field. Morphological and molecular genetic analyses were used as two independent (double blind) techniques to identify Arctic grayling larvae from the batch of samples. The identity of the other species (morphologically) was not confirmed with molecular genetic evidence.

Arctic grayling versus Mountain Whitefish *(Prosopium williamsoni)*

Arctic grayling *(Thymallus arcticus')* and whitefish *(Prosopium spp., Coregonus spp,* and *Stenodus* spp.) are closely related (Stearly 1993) so they have similar morphologies. Further, the mountain whitefish *(Prosopium williamsoni)* occurs in similar habitats with Arctic grayling in streams, especially at earlier life history stages (pers. obs.). Consequently these two similar looking species tend to be sampled together and their identity is often confused (Gordon Haas, pers. com.). There are 3 obvious morphological features that can be used to distinguish Arctic grayling from other species of fish (Scott and Crossman 1973). The presence of an adipose fin distinguishes northern fish fauna as salmonids (Salmonidae) or trout perch (Percopsidae). From this taxonomic level, grayling and whitefish can be readily distinguished because they have significantly larger scales and their caudal fin is relatively forked. Finally, fully developed Arctic grayling can be distinguished from whitefish because their dorsal fin has more than 17 principle rays and the base is longer than the length of the head. Whitefish (and all other salmonids) have fewer than 17 dorsal fin rays and the fin base is shorter than the length of the head (Figure 1).

In samples collected early in the spring, mountain whitefish larvae (0+) are expected to be larger and further developed than Arctic grayling fry. This is because mountain whitefish spawn in the fall (Arctic grayling spawn in the spring) and most likely emerge from the gravel earlier than Arctic grayling (Scott and Crossman 1973). Underdeveloped Arctic grayling larvae are likely to be found at the same time as fully developed (all their fins have formed) mountain whitefish larvae but not with underdeveloped mountain whitefish larvae. Morphological examination of the samples collected from the Table and the Anzac showed the above expectation (Figure 1). All of the mountain whitefish in the samples had fully developed fins while the Arctic grayling were smaller and many of them had not yet developed their dorsal or anal fins. Genetic analysis revealed that only some of the underdeveloped larvae were Arctic grayling. Further examination under the microscope was done to find morphological structures that distinguish between the remaining underdeveloped larvae in the sample.

Arctic Grayling versus Longnose Suckers *(Catasotmus catastomus)*

Distinguishing between species of fishes that are at an early larval stage of development is especially difficult. This is partly because of their small size, but also because related taxa tend to follow similar ontogenic pathways (i.e. they look more similar at earlier stages of development; Moser et. al. 1984). Different species of early larvae tend to be sampled together when these different species spawn in similar habitats at similar times of the year. Arctic grayling and longnose suckers *(Catasotmus catastomus)* start their spawning migration into streams at similar water temperatures in early spring (Scott and Crossman 1973, McPhail and Lindsey 1970). It is not surprising, therefore, those larvae of these two species were found foraging in the same areas when these samples were collected. Further, the larvae of these two species were found to be remarkably similar in the length between the tip of the head and the anus, relative to the total length. This feature has been used to identify longnose sucker larvae from other species (Stamford, Pers. Comm. 1999).

The most obvious morphological differences between the larvae of the two species were determined through examination under the microscope. It was first noticed that Arctic grayling were larger than longnose suckers (Figure 2). Arctic grayling larvae that were nearly the same size as the sucker larvae had yellow-orange yolk sacks located in the gut cavity while all of the sucker larvae had fully absorbed yolk sacks. Arctic grayling larvae had apparent premaxillary bones while the longnose sucker larvae had terminal mouths with small more delicate bony structures around the mouth (Figure 3). Finally, the melanophores of the longnose suckers extended equally along the whole length of the body both dorsally and ventrally. Arctic grayling larvae have melanophores running the length of the body dorsally in a similar pattern to the suckers, but ventrally pigmentation is constrained to the anterior region around the belly (Figure2).

Conclusion

Morphological differences between the larvae of mountain whitefish and Arctic grayling were most significant in these samples because underdeveloped whitefish were not found with underdeveloped grayling. Even the least developed whitefish that were sampled could be distinguished from grayling by the morphology of their dorsal fin. The growth rate of Arctic grayling fry relative to whitefish fry should be investigated further because both species appear to exploit similar habitats throughout their life history. How they partition the resources might have something to do with their size at age. If Arctic grayling hatch later but grow faster than mountain whitefish fry then there must be some period in the summer when they are very similar in size and competition for resources reaches a peak.

The most useful distinguishing features of the larvae of longnose suckers and Arctic grayling were the difference in size and the different pattern of pigmentation along the belly. The different structures on the mouth might prove difficult to assess in the field without the use of a hand lens, owing to the size of the larvae. Further investigation into the spawning and rearing habitats exploited by Arctic grayling and longnose suckers is needed to reveal how interactions between these species affects their abundance. Alteration of habitat may swing the balance so conditions become more beneficial for one species relative to the other.

References

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fish. Res. Bd. Can. Bull. 173.

Moser, H.G., D.M. Cohen, M.P. Fahay, A.W. Kendall Jr., W.J. Richards and S. L. Richardson (eds). 1984. Ontogeny and systematics of fishes. Special Publication no. 1. Arner.Ichthyol. Herpetol., Lawerence, KS, USA.

Stearley, R.F, and Smith, G.R. 1993. Phylogeny of the Pacific trouts and salmons *(Oncorhynchus)* and geners of the family Salmonidae. Trans. Arner. Fish. Soc. 122: 1 - 33. Scott, W. B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. Can. Bull. 184.