



FISH AND WILDLIFE COMPENSATION PROGRAM

PEACE REGION

An Investigation of the Distribution and Relative Abundance of Arctic grayling (*Thymallus arcticus*) in the Ingenika River in 2004

D.M. Cowie and B.G. Blackman

September 2012

FWCP – Peace Region Report No. 352

The FWCP is a partnership of:



Canada



Fisheries and Oceans
Canada

Pêches et Océans
Canada

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 Investigation of the Distribution and Relative Abundance of Arctic grayling (*Thymallus Arcticus*) in the Ingenika River 2004. Fish and Wildlife Compensation Program – Peace Region Report No. 352. 20 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

ABSTRACT

In August 2004, single pass underwater counts were initiated on the Ingenika River, a relatively pristine watershed, to document the status of the Arctic grayling adult population, and to identify potential adult index sites for future underwater count assessments. The Ingenika River is 143 km in length, with five major tributaries. The Ingenika mainstem was broken into four reaches. Seventeen sites (totaling 44.7 km) were surveyed in the three lower reaches. Sites varied from 1 to 4.4 km in length. A total of 180 Arctic grayling were observed, 153 of which were > 20 cm. Numbers of all fish species were low in comparison to other watershed streams previously examined. The potential indexing sites recommended are based on a five day project plan or eight day project plan depending on time and budget constraints. A long term monitoring program on the Ingenika River may provide an index of change in adult distribution over time within this pristine watershed.

INTRODUCTION

The Ingenika River flows into Williston Reservoir, the largest body of fresh water in British Columbia, which was formed in 1968 with the construction of the W.A.C. Bennett Dam. Minimal fisheries information exists prior to the construction of the dam. Arctic grayling (*Thymallus arcticus*; hereafter grayling) were reported as the most numerous sport fish found in the tributaries surveyed along the reservoir in 1975 (Bruce and Starr 1985) and the species was also plentiful within the reservoir (Barrett and Halsey 1985). This abundance may have been artificial due to high productivity associated with the newly flooded reservoir, and displaced fluvial grayling congregating around stream mouths. In the early 1980's, grayling populations within the upper Peace River drainage dramatically declined (Northcote 1993; Blackman et al. 1990) to the extent that by the late 1980's grayling populations had disappeared from the lower reaches of all streams with a drainage area less than 1500 km² that flowed directly into the reservoir (Blackman 2001). Grayling populations appear to remain viable in six large (3,000 – 17,000 km²) systems flowing into the reservoir.

More recent research in the Williston watershed has focused on species distribution and recruitment estimates for grayling (Schell 2002, Blackman and Hunter 1998, Blackman 2002 b+c). Studies undertaken by the Fish and Wildlife Compensation Program – Peace Region (FWCP – Peace) have contributed to the available information on grayling stocks in the area (Blackman 2002, Blackman 2002 b, Northcote 2000, Stamford 2001). Results of these studies prompted the B.C. Conservation Data Centre to implement a “red listed” designation for Arctic grayling within the Williston Reservoir watershed. Regulations for catch and release of the species were also implemented to preserve remaining stocks. The Fish and Wildlife Compensation Program – Peace Region is mandated to conserve and enhance species within the watershed and to mitigate impacts of hydroelectric development on fish and wildlife within the Peace/Williston watershed. Currently the “red-listed” status of Williston Arctic grayling makes this species a priority for the Compensation program (Blackman 2002a).

Ongoing Arctic grayling studies in the Williston watershed have been conducted by the FWCP – Peace Region since 1988. By the early 1990's the disappearance of Arctic grayling from the lower reaches of 20 or more streams where they were reported as abundant in the 1970's (Bruce and Starr 1985) had been confirmed. Further projects have focused on determining current distributions, relative abundance, identifying critical habitats, factors limiting Arctic grayling, and initiating methods for long term monitoring of trends in grayling populations (Blackman 2001). An underlying goal of all projects is the conservation, enhancement, and possible restoration of Arctic grayling within the watershed (Blackman 2002).

Monitoring of grayling population trends was initiated in the Parsnip River and two of its tributaries in 1996. These populations appear to be relatively stable (Blackman et al. 2005) but very little is known about the status of the remaining grayling populations in the large remote rivers of this watershed.

The objectives for the 2004 Ingenika River project were to evaluate the potential of the Ingenika River for long term grayling population monitoring in a relatively pristine watershed by:

1. Performing underwater fish counts on the Ingenika River to document distribution and relative abundance of adult grayling in a relatively un-impacted system, and
2. To determine if and where to establish index sites on the Ingenika River for future potential indexing.

Study area

The Ingenika River (Fig. 1) has a drainage area of 5,491 km², and a length of 143.4 km (MWLAP, Watershed Code Dictionary, 1997). The Ingenika watershed is remote but can be accessed by traveling approximately 250+ km of gravel road north from Highway 97 near Mackenzie, British Columbia. Timber harvesting, mining, and other resource extraction is limited to the lower reach (river km 0 to 40.6), focusing mainly around the Swannell River at river km 4.7. While flying through the watershed in 2004, pack trails were noted in the mid and upper reaches (river km 40.6 to 110) but no roads were noted. The headwater reach (upstream of river km 110) of the watershed is pristine with no road access or other development.

Angling access is limited to the lower 40 km, as the only road access currently ends downstream of the confluence with Cutbank Creek (km 37.8). A cabin is located across from the confluence of Pelly Creek and the Ingenika River (km 40.6), but no roads were noted at the time of this survey. The river is accessible by jet boat up to a series of log jams located at km 60. Due to the limited access into the mid and upper areas of the Ingenika, angling is suspected of being mainly associated with the bridge crossing (km 5.5) at the confluence with the Swannell River and at a small bedrock outcrop on the Swannell River. Swannell logging camp (adjacent to the Swannell and Ingenika rivers confluence) is currently being decommissioned but was in operation from the early 1990's through the winter of 2002.

The Ingenika River is characterized by four main habitat types and the river was broken into four basic reaches (Table 1). The lower reach of the mainstem Ingenika River is from the Williston Reservoir confluence upstream to Pelly Creek (km 0 to 40.6). The mid-Ingenika River (km 40.6 to 89.5) has frequent log jams, with one large jam that blocks boat passage downstream of Wrede Creek at river km 60. The upper reach of the Ingenika River (km 89.5 to 109) and the headwater reach upstream of Fredrickson Creek (river km 107 to headwaters) are dominated by bedrock and boulder habitats.

Table 1. Reach description and habitat types of the Ingenika River.

Reach ID	Length (km)	River km	Habitat description	Substrate * (dominant / subdominant)	Gradient %
Lower	40.6	0 to 40.6	mean wetted width: 49 m slow velocity single-channel	finest*	0.2 %
Mid	48.9	40.6 to 89.5	mean wetted width: 40 m braided multi-channel frequent log jams	gravel finest / cobble	0.3 %
Upper	19.5	89.5 to 109	mean wetted width: 41 m ** boulder / riffle single-channel	boulder cobble	1.0 %
Headwater	36.0	109 to 143.4	mean wetted width: < 25 m bedrock step-pool entrenched	bedrock boulder / cobble	1.5 %

Cowie and Blackman 2004

* finest < 2 mm, gravel 2-64 mm, cobble 64-256 mm, boulder > 256 mm

** wetted widths in the upper reach ranged from 25 to 50 m, progressively increasing as moved downstream (Site 1 wetted width 25m, while site 3 wetted width was 50 m)

Identified fish species within the Ingenika River include: Arctic grayling, rainbow trout (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), lake whitefish (*Coregonus*

clupeaformis), mountain whitefish (*Prosopium williamsoni*), burbot (*Lota lota*), white suckers (*Catostomus commersoni*), prickly sculpins (*Cottus asper*), slimy suckers (*Cottus cognatus*), and longnose dace (*Rhinichthys cataractae*) (Bruce and Starr 1985, Cowie and Blackman 2004).

METHODS

Underwater snorkel count and angling data is on file at the Fish and Wildlife Compensation Program – Peace Region office (address on cover).

Adult abundance estimates

Site selection

Site selection for the underwater count was primarily based on experience from snorkel swims conducted in other Williston watershed systems (i.e. adult distribution patterns - larger fish upstream, preference for large pool and/or glide habitat, etc.) and previous knowledge/survey data from field investigations (grayling fry distribution, substrate composition, and habitat features) conducted in the Ingenika watershed in 2003. Sites were not selected randomly but with the intent for coverage throughout the Ingenika River and within all habitat types. Site selection was based on:

- covering a diversity of habitat types known to support grayling in other watersheds;
- helicopter and tender boat access;
- site suitability for swimmers and tender boat to operate in safe conditions; and
- previous records of grayling (adults) within the watershed.

The Ingenika River was broken into four main habitat reaches (headwaters, upper, mid, and lower) based on habitat types observed in the previous years grayling fry distribution survey (Cowie and Blackman 2004). Angling in 2003 produced adult grayling above the confluence of Fredrickson Creek (river km 107), which is upstream of an area of difficult passage (river km ~95, bedrock chute), a potential barrier to some fish species at certain flows. Underwater counts included 3 sites upstream of the potential barrier.

The Ingenika River upstream of the Fredrickson Creek confluence (river km 107) is a bedrock canyon with step-pool habitat. A small portion (1.1 km) of the Ingenika immediately upstream of Fredrickson Creek was included because adult grayling were angled there in 2003. The channel upstream of this location was confined and helicopter access was limited. Extensive electrofishing sampling in the headwater reach was conducted by Ministry of Water, Land, and Air Protection (MWLAP) staff in early August 2003 and no grayling were caught (T. Zimmerman, Omineca Fish & Wildlife Science/Allocation, MWLAP, pers. comm. 2003). Time limitations, safety logistics, and coverage of areas most suitable to adult grayling were factors that led to the elimination of most of the headwaters reach from this study. In addition, the canyon and numerous cascades may limit grayling distribution into the upper headwater area.

Helicopter landing sites often dictated the start and end points of a site (Appendix 1). Site lengths were therefore not consistent over the study area. Sites where few fish were observed were typically shorter, with the rationale that hopping downstream would provide greater overall coverage. More effort was expended in areas where grayling were more abundant.

Underwater count methodology

Underwater snorkel counts were conducted from August 10th to 14th, 2004 (Appendix 2) to estimate adult grayling abundance. Swims were conducted between 1100 hrs and 1600 hrs to optimize visibility (reducing the effects of shadows), and fish activity levels (warmest period of the day). Single-pass counts were conducted on eight sections of the Ingenika River (seventeen sites) (Fig. 2). Site lengths were determined in the office by measuring down the centre of the river from orthophotos in the B.C. Provincial base mapping (<http://srmwww.gov.bc.ca/bmgs/airphoto/IMF/Index.htm>). The counts were made by one crew of three experienced swimmers, accompanied by a fourth crew member as a tender boat operator for safety purposes. Each swimmer counted the fish in the left, right, or centre lane of the river and care was taken to stay abreast to avoid missing or double counting fish. Observer efficiency was not tested. Due to limited road access and safety concerns, a helicopter was used for all swims. Communication between swimmers ensured that double counting was minimized.

The crew started the assessment upstream of Fredrickson Creek at river km ~109 (Appendix 1). For each site, the number of each species and size of individual fish was tallied on slates and recorded by the helicopter pilot at the end of each site. Counts were segregated into 10 cm increments of 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-50 cm, and 50+ cm. Total fish numbers reported are the sum of counts made by the three swimmers in each site. No efforts were made to determine if expansion of counts were required because in most instances the entire width of the river was covered. Although untested, some areas of the river were wider than could be observed, but adult grayling are seldom found in shallow shoreline areas (Blackman 2004) so an expansion of the counts could result in an overestimate (Blackman and Hunter 2001). Water temperature was recorded for each section using a pocket thermometer. Underwater visibility was subjectively estimated by swimmers based on the horizontal distance in meters (measured with a tape measure) where a fish could be seen and identified by species. Wetted widths were recorded by the boat tender to the nearest meter with a field calibrated range finder. Several measurements were taken within the site and the average wetted width reported.

Angling and age samples

Angling was conducted opportunistically using fly rods in the middle and upper Ingenika River in order to collect scale samples for aging. Catch-per-unit-effort was not recorded as this was not a project priority but conducted opportunistically. Site locations were recorded and all grayling caught were measured to the nearest millimetre (mm) fork length and weighed to the nearest gram (g) (Appendix 3). A sub-sample of otoliths was also taken for a University of Northern British Columbia (UNBC) and FWCP – Peace Region project to determine elemental signatures of Arctic grayling in the Williston watershed (Clarke, 2004). The scales and otoliths were sent to (North/South Consultants, Winnipeg, Manitoba) for age analysis. Photomicrographs (available for viewing at the FWCP – Peace Region office) were produced from the samples and the scale ages were verified by program staff.

RESULTS

Adult abundance estimates

Seventeen single pass sites (44.7 km) in eight sections of three reaches in the Ingenika River were snorkel surveyed August 10th to 14th, 2004 (Fig. 2)(Table 2). The weather was consistent over the duration of the project with limited cloud cover. Water temperatures ranged from 10 °C in the upper reach to 15 °C in the lower reach. The overall average wetted width of the Ingenika River was 43 m. Average wetted widths varied from 25 m in site 1 to 60 m in site 17.

Underwater visibility was greater than 7 metres in sites 1-16, while visibility in site 17 (lower reach- Swannell area) was reduced to 4 m. All swimmers consistently reported high visibility conditions and the swimmer in the centre lane was able to define the left and right banks easily. The fine substrates in site 17 were easily stirred up by movement from swimmers or boat tender and the suspended materials reduced visibility to 4 m for extended periods of time.

Table 2. Summary of site data, Ingenika River, August 2004.

Reach	Section	Date Swim was Conducted	Site	Length (km)	Average wetted width (m)	Visibility (m)	Temp (°C)	
UPPER	A	August 10	1	1.1	25	7+	10	
		August 10	2	4.4	45	7+		
		August 10	3	2.2	50	7+		
	B	August 11	4	2.2	45	7+	10	
		August 11	5	3.1	40	7+		
		C	August 11	6	2.6	40		7+
August 12	7		1.9	30	7+			
August 12	8		3.2	50	7+			
August 12	9		3.8	40	7+			
August 12	10		1.5	40	7+			
MID	D	August 13	11	4.1	35	7+	12	
		August 13	12	3.2	45	7+		
	LOWER	E	August 13	13	2.9	40	7+	15
		F	August 14	14	2.1	45	7+	14.5
August 14			15	1.8	50	7+		
G		August 14	16	2.3	50	7+		
H	August 14	17	2.3	60	4+	15		

Mountain whitefish were the most numerous species followed by Arctic grayling (Table 3, Appendix 2) (Figure 3). Arctic grayling were more numerous in the upper section but mountain whitefish were 10 times more numerous than grayling overall. A total of 180 adult grayling were counted and 153 were over 20 cm fork length (Table 4). Mountain whitefish accounted for 1,758 of fish observed, with 976 over 20 cm.

Table 3. Total number of all fish observed in the underwater counts in the Ingenika River, 2004.

Reach	Section	Approximate River km	Species							
			Site	Site Length (km)	GR (/km)	MW	BT	RB	SU	KO
UPPER	A	109 - 101	1	1.1	0	49	0	4	0	0
			2	4.4	9 (2.0)	98	1	3	0	0
			3	2.2	1 (0.5)	58	3	5	0	0
	B	95 - 89	4	2.2	41 (18.6)	111	0	1	0	0
			5	3.1	33 (10.6)	176	3	3	0	0
Upper	Total		13	84 (6.5)	492 (37.8)	7 (0.5)	16 (1.2)	0	0	
MID	C	89 - 75.5	6	2.6	6 (2.3)	144	0	0	0	0
			7	1.9	12 (6.3)	100	1	1	0	0
			8	3.2	11 (3.4)	160	1	0	0	0
			9	3.8	17 (4.5)	130	1	3	0	0
			10	1.5	6 (0.4)	45	0	1	0	0
	D	67 - 60	11	4.1	17 (4.1)	87	4	2	0	0
Mid	Total		20.3	80 (3.9)	799(39.9)	8 (0.4)	7 (0.3)	0	0	
LOWER	E	44.5 - 42	13	2.9	10 (3.4)	224	1	1	13	0
	F	34 - 30	14	2.1	1 (0.5)	131	2	0	19	0
			15	1.8	1 (0.6)	16	3	0	7	0
	G	24.5 - 22	16	2.3	4 (1.7)	1	1	0	0	0
	H	5.5 - 3.0	17	2.3	0	95	1	0	0	1
Lower	Total		11.4	16 (1.4)	467 (40.9)	8 (0.7)	1 (0.1)	39 (3.4)	1 (0.1)	
Grand Total			44.7	180 (4.0)	1,758	23	24	39	1	

* River km are approximations based on Watershed Code Dictionary Report 1997.

Numbers in brackets () denote number of grayling per kilometre

Table 4. Number of fish > 20 cm fork length observed in the underwater counts in the Ingenika River, 2004.

Section km	Site	Length (km)	#> 20 cm				#>20 cm / km				Average No. Observed per kilometre by Section				
			No. of fish Observed >20 cm F.L.				No. Observed per kilometre								
			GR	MW	BT	RB	GR	MW	BT	RB	GR	MW	BT	RB	
A 109-101	1	1.1	0	28	0	3	0.0	25.5	0.0	2.7					
	2	4.4	8	60	1	2	1.8	13.6	0.2	0.5					
	3	2.2	1	26	3	1	0.5	11.8	1.4	0.5	8	1.2	14.8	0.5	0.8
B 95-89			<i>area of difficult passage</i>												
	4	2.2	40	46	0	1	18.2	20.9	0.0	0.5					
	5	3.1	23	58	3	0	7.4	18.7	1.0	0.0	5	11.9	19.6	0.6	0.2
C 89-74	6	2.6	6	84	0	0	2.3	32.3	0.0	0.0					
	7	1.9	10	56	1	1	5.3	29.5	0.5	0.5					
	8	3.2	11	90	1	0	3.4	28.1	0.3	0.0					
	9	3.8	17	81	1	1	4.5	21.3	0.3	0.3					
	10	1.5	6	33	0	0	4.0	22.0	0.0	0.0	13	3.4	20.0	0.2	0.2
D 67-60	11	4.1	14	55	4	2	3.4	13.4	1.0	0.5					
	12	3.2	11	47	1	0	3.4	14.7	0.3	0.0	7	3.4	14.0	0.7	0.3
E 45-42	13	2.9	6	157	1	1	2.1	54.1	0.3	0.3	3	2.1	54.1	0.3	0.3
F 34-30	14	2.1	0	79	2	0	0.0	37.6	1.0	0.0					
	15	1.8	0	0	3	0	0.0	0.0	1.7	0.0	4	0.0	20.3	1.3	0.0
G 25-22	16	2.3	0	0	1	0	0.0	0.0	0.4	0.0	2	0.0	0.0	0.4	0.0
H 6-3	17	2.3	0	76	1	0	0.0	33.0	0.4	0.0	2	0.0	33.0	0.4	0.0
Total		44.7	153	976	23	12					3.4	21.8	0.5	0.3	

Angling and age composition

Twenty adult grayling were angled from three sections (A-C) (Appendix 3) in the Ingenika River. Fork lengths ranged from 279 to 414 mm, and weights ranged from 227 to 726 g (Appendix 3). Angling was opportunistic and was not conducted through all sections where underwater counts were completed, nor was catch-per-unit-effort recorded. Scale structures were taken from 20 grayling, and otoliths were taken from 10. Ages were determined for 15 grayling from the scales (age 4-8), and 8 from otoliths (age 5-11).

DISCUSSION

Adult abundance estimates and distribution

A total of 44.7 km (17 sites) was surveyed by single pass underwater counts in three reaches of the Ingenika and 180 grayling (153 over 20 cm) were observed. The overall adult grayling distribution within the lower to the upper reaches was similar to that seen in other Williston watersheds (Table & Anzac rivers, Parsnip River tributaries, and Mesilinka River) (Table 5). The adult grayling concentrate in the upper reaches and density declines to the point where there are few adult grayling over 20 cm using the lower reaches (Fig. 4).

Mountain whitefish counts were 37.9/km in the upper section, 39.4/km in the mid section, and 41/km in the lower section of the Ingenika for all fork lengths (Fig. 3), and 16.8/km, 22/km, and 27.4/km respectively for mountain whitefish > 20 cm. The Ingenika River has 10 times more mountain whitefish than grayling. Bull trout and rainbow trout numbers were low with only 23 and 24 observed respectively in the 44.7 km. Suckers were only observed in the lower section and one kokanee was observed near Swannell River.

The grayling in the Ingenika River do not appear to follow the size stratification of larger fish upstream and smaller fish downstream that has been observed in the Table and Anzac rivers (Blackman 2004, Blackman et al. 2005, Mathias et al. 1998) and some Alaskan streams (Hughes 1999).

Abundance comparison to other Watersheds

Table 5 provides a simple comparison of relative numbers of grayling encountered in other Williston watershed streams. The data presented for the Mesilinka River is a pre-enhancement count, collected during a mark recapture study as part of a long term (1991-1999) stream fertilization project. The Ingenika and Mesilinka rivers are colder and appear to be less productive than the Table and Anzac rivers, which are located roughly 300 km further south. Underwater counts have been conducted since 1995 on the Table River and since 1997 on the Anzac River. The initial surveys tested different index methodologies (mark recapture, expanded counts, simple counts, multiple counts, etc.) in order to find a cost effective adult index method. These surveys determined adult grayling distribution patterns vary throughout the season, and are affected by water levels, and that grayling tend to move downstream after being marked (spaghetti tagged), but that the degree and distance of movement varies with habitat. Grayling appear to be easier to count than rainbow and bull trout because of habitat selection and with good water clarity (>5 m) over 80% (up to 96% at one site) of the marked grayling were observed. In comparison, only a maximum of 50% of marked rainbow trout were observed in the same sites (Blackman and Hunter 2001). Multiple counts in the Table and Anzac rivers in 2003 in sites where underwater visibility was greater than 4 meters (2 sites) provided 95% confidence intervals in the counts of grayling (>20 cm) that averaged $\pm 12\%$. When the visibility dropped to less than 4 m (4 sites) the average 95% confidence interval rose to $\pm 21\%$. Hagen and Baxter (2004) also found the precision of underwater counts was higher with better underwater visibility. Although the single pass swim method does not provide for statistical analysis, under clear water conditions and with experienced swimmers the numbers of fish observed does provide a quick and relatively inexpensive index of abundance. The water in most of the Ingenika River was so clear that the grayling counts are probably very close to the actual numbers.

Table 5. A comparison of grayling (larger than 20 cm fl) observed during underwater counts in various Williston watershed systems.

Stream	Accessible Length (km)	Count Location	Mean Count GR > 20 cm per km
Ingenika	119*	Lower km 3-45	0.5
		Mid km 60-89	3.7
		Upper km 89-109	5.5
Table ***	37 **	km 5 - 9	< 1
		km 18-22	17 (+2)
		km 31-35	34 (+1)
Anzac ***	47 ***	km 6-10	4
		km 12-16	6 (+2)
		km 30-34	23 (+)4
		km 39-43	41 (+5)
		km 45-47	39 (+8)
Mesilinka ****	140*	T2 km 23-31	4.7
		T1 km 55-62	11.1
		Control km 93-100	7.4

* Bruce and Starr 1985.

** Zemlak and Langston 1998.

*** Blackman and Hunter 2001, Blackman et al. 2005.

**** Mean based on 1992-93 data from Wilson et al. 2002. Prior to stream fertilization program.

Age composition

Otoliths were collected from a small sample of adult Arctic grayling for a University of Northern British Columbia (UNBC) elemental signatures research project (Clarke 2004). In three of the seven otolith /scale ages the otolith was one year older, and the otolith age for one fish was given as eleven but the scale age was greater than seven. As previously reported by Blackman and Hunter (2001), underestimates occur in the scale ages (compared to ages from fin rays) of fish older than 5 years in Williston Reservoir watershed streams because growth is frequently much slower after this age. Most grayling populations that have been sampled in Williston Reservoir watershed are dominated by fish which are five years of age or younger (data on file) and so scale ages are acceptable, but the grayling from the Ingenika River appear to live longer and so scale ages may not be suitable for describing this population.

RECOMMENDATIONS

The intent of this study was to determine if the Ingenika River could be used as an index stream to monitor Arctic grayling population trends in a relatively un-impacted system. The single pass underwater count method allowed for coverage of a larger area and provides a basic picture of grayling relative numbers and distribution pattern. The fact that the populations in this watershed are relatively un-impacted and the water clarity is so excellent favours the use of the Ingenika as an index system. However, this system appears to be cold, clear, very sterile, and less productive than most watershed streams. The very low numbers of fish could be a handicap because any small counting errors would result in much higher variability in the fish counts. The limited access, particularly to the mid and upper reaches, may have reduced impacts from angling on the grayling populations using these sections; however any access development could have a dramatic affect on this sparse population.

Normally index sites should not be conducted in the “high density” areas such as the site immediately downstream from the area of difficult passage at km 95. FWCP – Peace Region staff and Ministry representatives discussions have determined that due to the low numbers of grayling in the river, this high density area should be included. The downstream areas where visibility is poor should be avoided; getting reliable counts will be much more difficult and for the most part this is not the type of habitat grayling use, so changes in the population would not necessarily be reflected in the numbers of fish in this type of habitat. Surveys should be conducted in mid to late August to reduce the effects of seasonal movement patterns and operate under low flow conditions,

In order to provide higher confidence in the counts, more detailed surveys will be necessary. Whether multiple pass counts, mark recapture, or observer efficiency methodologies are used, considerably more time will be required per area surveyed. Based on the distribution patterns observed in this survey it should be possible to collect reliable data on a sub sample of habitat types which should reflect any changes in the population. Given the clumped distribution patterns, with adult grayling concentrating in large pools, and dramatic changes in distribution patterns between years, observed in other watershed streams (Blackman 2004), site selection should be stratified by habitat type and abundance patterns. Logistically some compromise may be necessary between the statistical confidence in the counts and number of areas sampled (confidence that the counts are representative of the population). The selection of sites should be re-examined after five years when a better idea of yearly variations is possible.

Considerations for future indexing in the Ingenika River

Logistically, this is a very expensive system to work in because of its remoteness (2004 costs were \$32,000 not including staff time). The wetted width of the Ingenika requires a minimum crew of three swimmers. As the mid and lower reaches are wider, the potential to include an additional observer could be considered. In addition, as per BC Hydro/FWCP – Peace Region Safe Work Procedures (SWP) 2004, a tender boat and operator is required for swimmer safety. With a crew of four (3 observers and a boat operator) and a small inflatable boat, helicopter access (using a Bell 206 jet ranger) to the swim locations requires 2 trips each way. In the upper sections, water temperatures can be cold (<10 °C) and there is a significant amount of shallow, high velocity, boulder riffle habitat. To avoid swimmer fatigue, swims should be kept to less than 8 km per day particularly later in the week.

At least one site from each stream reach should be sampled and sites should be a minimum of 2 and preferably 4 kilometres in length. This would account for seasonal changes in distribution

within the system or possible changes in distribution related to discharge. By keeping the sites longer this will reduce the potential problems which arise from changes in distribution caused by natural river processes (channel movement).

The following are planning and logistical considerations for conducting long-term monitoring index sites on the Ingenika River:

1. BC Hydro and FWCP – Peace Region safe work procedures must be met to conduct underwater counts, which would include a minimum crew of two observers and an inflatable tender boat with operator.
2. Mobilization to/from the Ingenika River requires 1 day each way.
3. An awareness that this is a remote and difficult system to access.
4. That each crew can conduct 6-8 km of underwater counts per day (maximum distance per day per swimmer).
5. To minimize budget requirements of chartering flights (via NT Air or another Williston airline company) the project described below will be designed as 5 days (including 2 mobilization days and 3 days to conduct underwater counts). As an alternative, by designing this project to run from Monday to Monday (8 days), the project could include 2 days for mobilization and 5 days to conduct underwater counts, thereby increasing coverage of the Ingenika River and reducing potential swimmer fatigue caused by pushing limits to conduct as many passes in as many areas as possible.

Recommended Ingenika River underwater count index locations

The recommended sections below are more than one crew could cover in a 3 day time frame if conducting a three pass assessment in the 5 day project format. The sections would need to be broken back down into the individual sites and the above considerations factored into the planning stages to determine which sites are best suited for the long-term monitoring of grayling in the Ingenika River.

The long-term monitoring index sections and/or specific sites recommended, based on the distribution, relative abundance of Arctic grayling seen in the 2004 assessment, and to provide coverage in all three reaches, are as follows (Table 7):

1. 5 day project plan:
 - a. UPPER REACH: Section A, site 2 (river km 103-107.5, see table 7 note RE: dividing site 2).
 - b. Section B site 4 and possibly part of site 5 (river km 95-92)
 - c. MID REACH: Section D, site 12 (river km 60-63.5).
2. 8 day project plan would include above plus:
 - a. Mid reach: Section C (river km 75-89). Either site 6 (2.6 km) or site 10 (1.5 km). or:
Lower reach: Section E, site 13 (river km 42-45.5).
 - The addition of one or both sites would increase the sampling effort in the multi-channel braided habitat.
 - The addition of these sites would provide greater river coverage but increase the required project budget and time allotment.

Table 7. Recommended locations for future indexing of Arctic grayling in the Ingenika River.

Section	Site	Site length (km)	Comments	Start location	End location
A	2*	see comment below	single channel boulder/riffle upstream of potential barrier at ~ km 95	Fredrickson Creek	halfway downstream to Flameau Creek (if site 2 divided into 2 new sites)
B	4	2.2	below barrier	Falls	2-3 km downstream
D	12	3.2	multi-channel braided gravel/fines	~ 4 km downstream of Wrede Creek	log jam
Optional sites (if planning for more than a 5 day project)					
C	6	2.6	start of multi-channel braided habitat	~ 6 km downstream of pool at potential barrier chute	
	10	1.5	heavily braided upstream of Wrede Creek	~ 10 km upstream of Wrede Creek confluence	
E	13	2.9	single channel low velocity fines	~ 4 km upstream of Pelly Creek	upstream of cabins across from Pelly Creek confluence

* Site 2 is 4.4 km in length but could be divided into 2 sites of 2.2 km each. The upper most of these would start at Fredrickson Creek.

Including an additional site from the lower reach downstream of Pelly Creek was not considered, as the numbers of grayling observed there were low. In the 8.5 km (Sites 14-17) where counts were conducted, only 6 grayling were observed. It was felt that a change in the grayling population may not be detected by conducting counts in this area. Observer efficiency, water clarity, channel width are among factors that could allow for fish not being accounted for. Errors in observations could potentially be reduced if a multi-pass method was used by experienced swimmers.

CONCLUSIONS

Implementing long-term indexing on the Ingenika River may provide biologists and resource managers trend data in Arctic grayling populations in a relatively pristine watershed. The preservation and conservation of Arctic grayling over the long-term would benefit both the natural resources and generations to come.

ACKNOWLEDGEMENTS

The authors would like to thank Pelly Lake Lodge for the gracious hospitality, stories, and a place to remember. Review of this report was completed by R. Pillipow.

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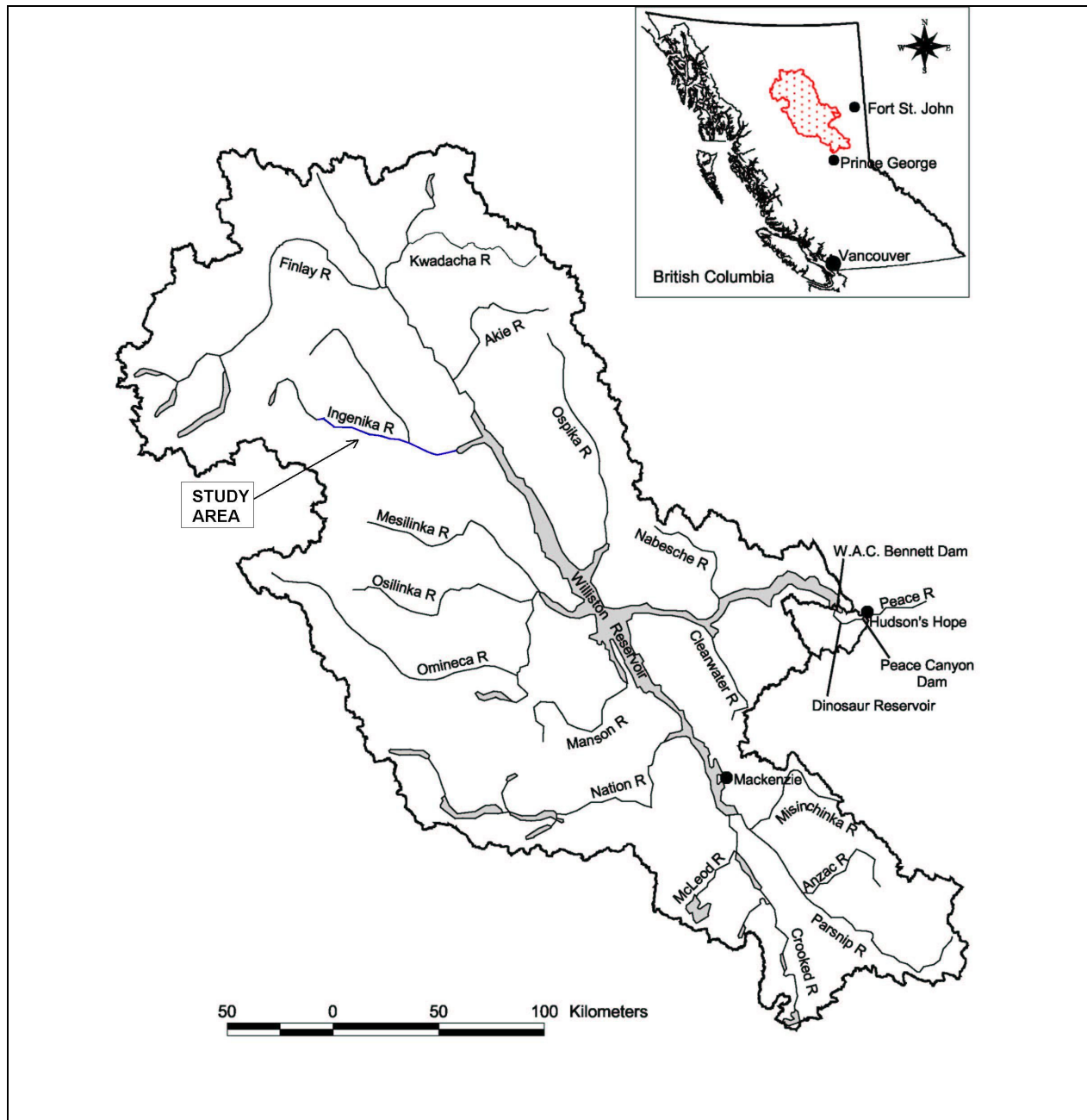


Figure 1. The Ingenika River: study area.

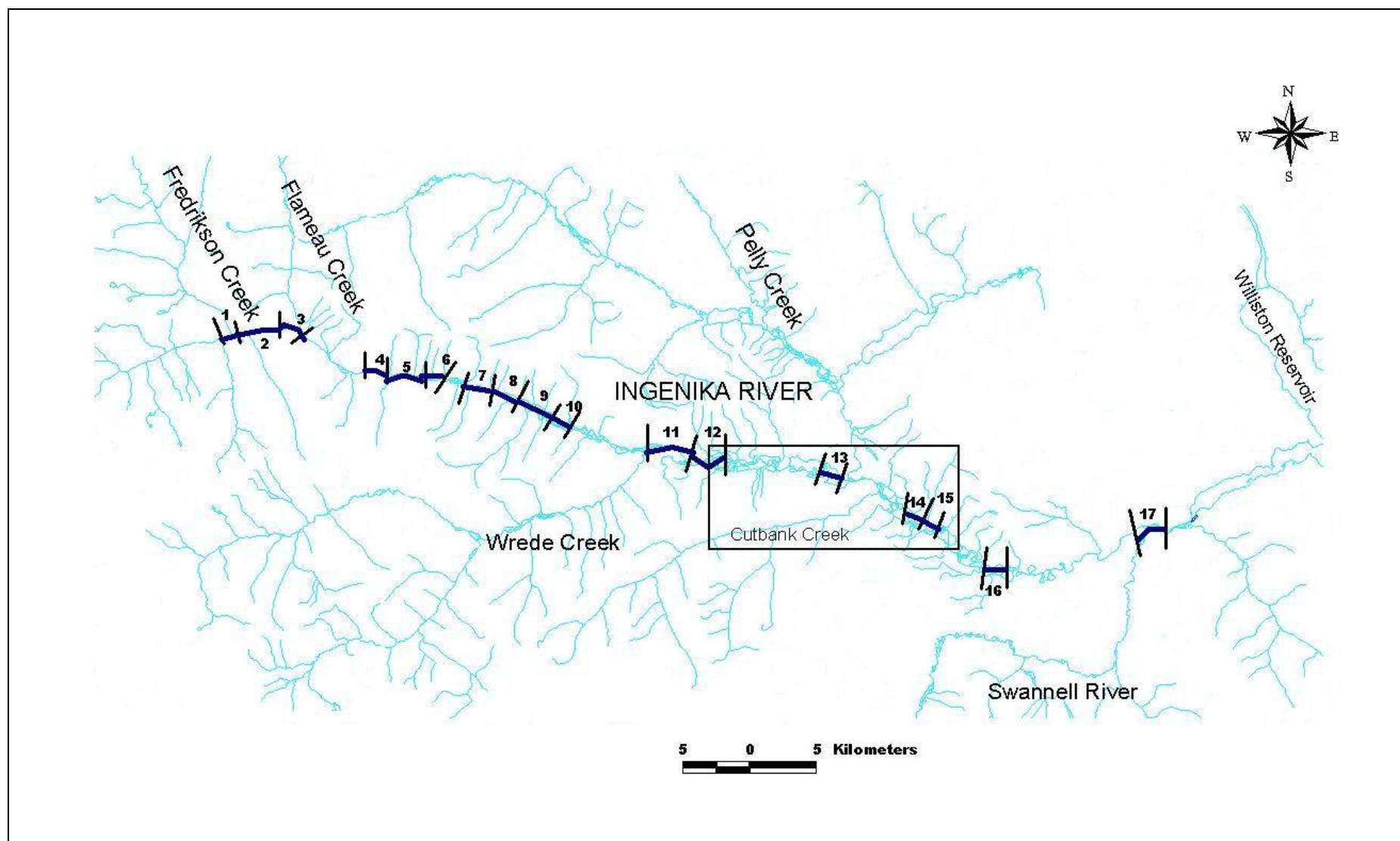


Figure 2. Location and general distribution of sites where underwater counts were conducted in the Ingenika River, 2004.

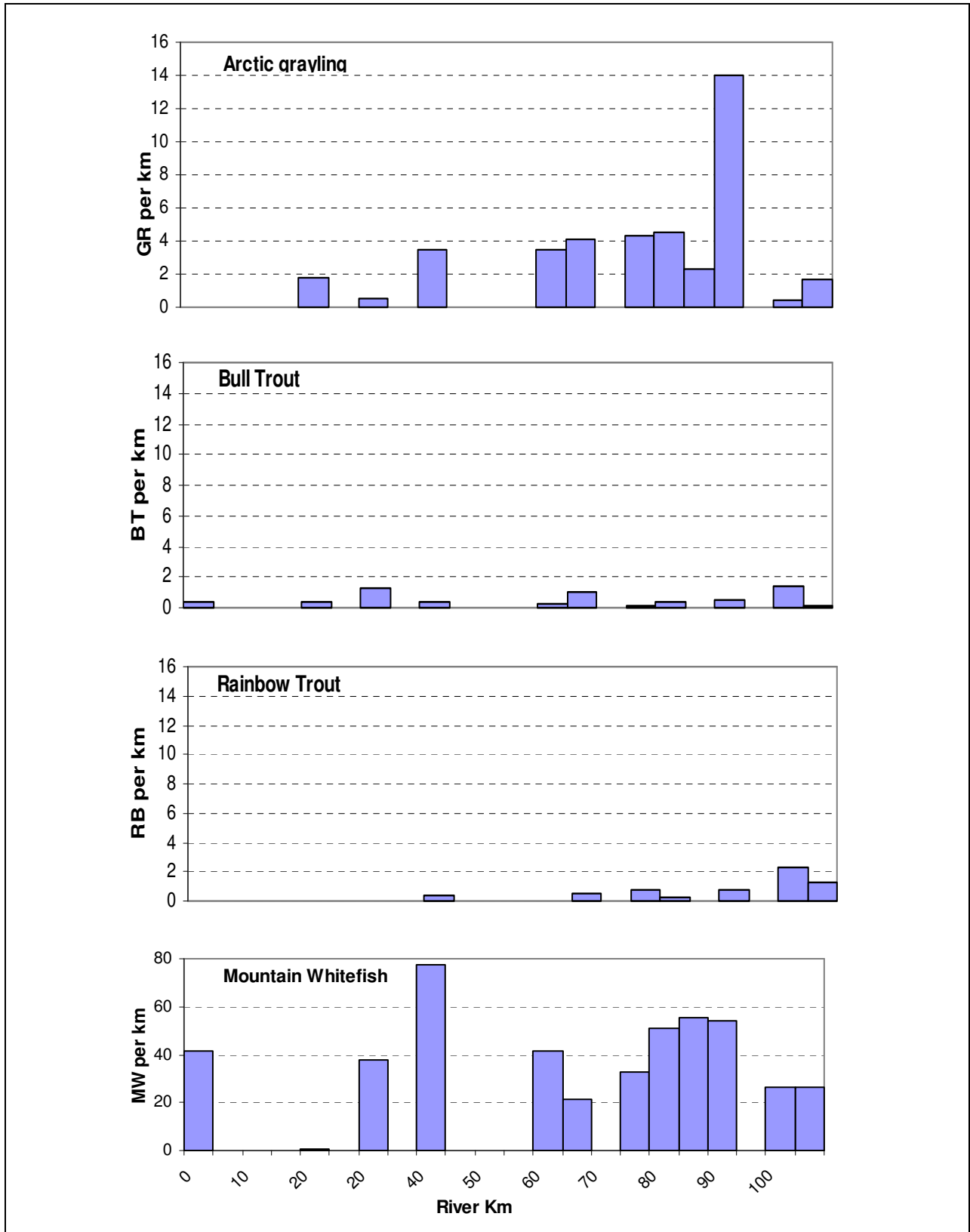
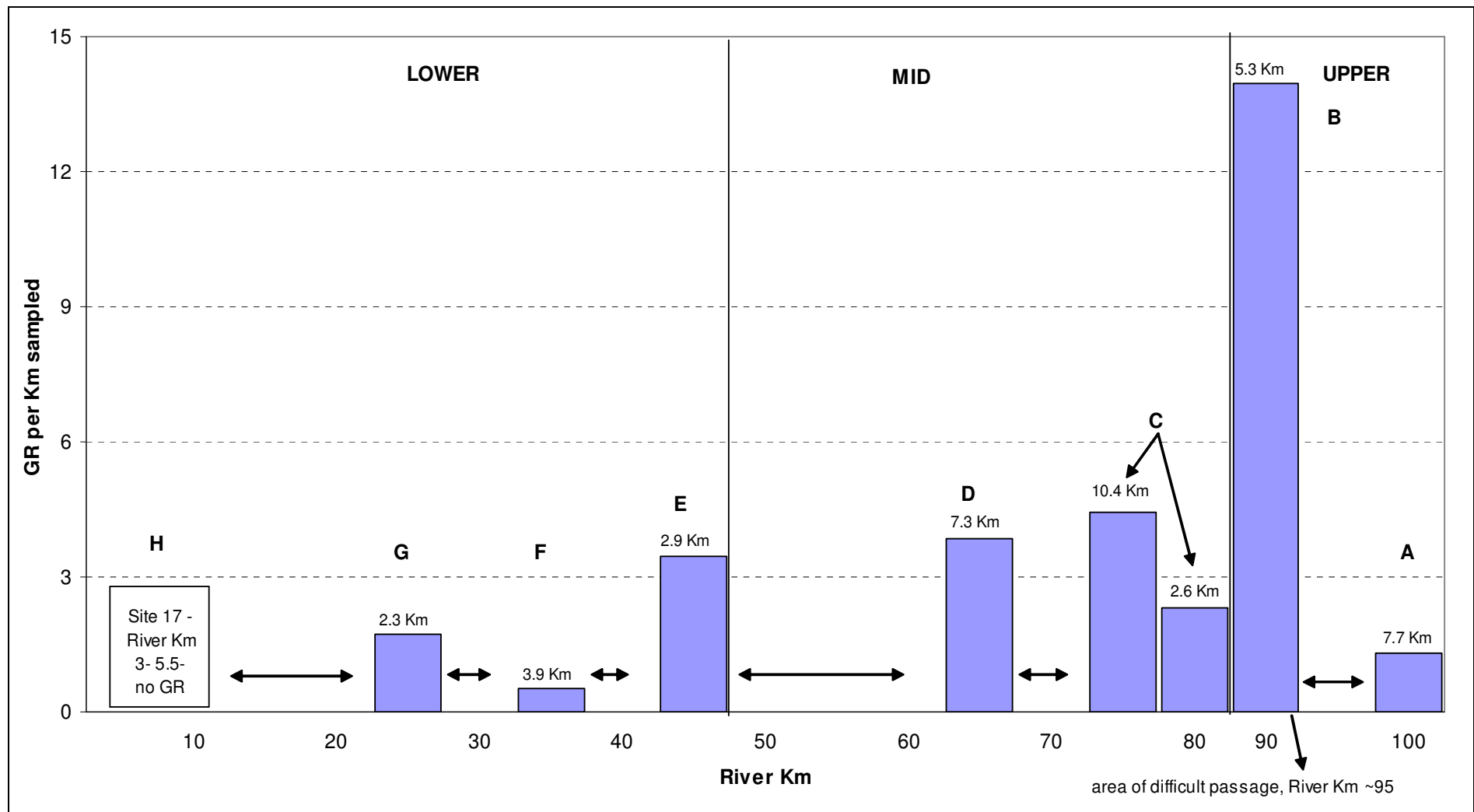


Figure 3. Relative abundance estimates of all species (all fork lengths) observed per river km. Note that the y-axis of Mountain whitefish is a different scale than the charts for Arctic grayling, bull trout and rainbow trout.



* River km are approximations based on Watershed Code Dictionary Report 1997.

Figure 4. Overview of overall distribution Arctic grayling (all fork lengths) observed per km of river sampled by underwater counts in the Ingenika River, 2004. The X axis is the distance upstream from the mouth to the start of the upper section, river km 110. Areas not surveyed are identified with the dark double arrow. The kilometre notations are the length per section. Each bar represents a section within a reach (2 bars represent section C; no bar for section H as no grayling were observed).

Appendix 1

Waypoint ID for underwater counts: start and end locations in the Ingenika River, 2004

Start UTM		End UTM		Site *	Section ID	Reach		
9	669111	6305246	9	670023	6305468	1		
9	670023	6305468	9	674019	6306234	2	A	
9	674019	6306234	9	675729	6305367	3		Upper
9	680290	6303324	9	682082	6303047	4	B	
9	682082	6303047	10	318826	6303156	5		
10	318826	6303156	10	320900	6302557	6		
10	321830	6302034	10	323501	6301602	7		
10	323501	6301602	10	326145	6300796	8	C	
10	326145	6300796	10	328380	6298870	9		Mid
10	328380	6298870	10	329536	6298417	10		
10	335051	6297215	10	338115	6295663	11	D	
10	338115	6295663	10	340708	6295357	12		
10	348193	6294284	10	349265	6293381	13	E	
10	354137	6290508	10	355572	6290260	14	F	
10	355572	6290260	10	356773	6289814	15		Lower
10	359849	6287111	10	361195	6286946	16	G	
10	371054	6289308	10	373100	6289067	17	H	

*** Site breakdown:**

Sites 1-3 consecutive sites, upstream Fredrickson Creek to downstream of Flameau Creek

Sites 4-6 consecutive sites, Site 4 starts at chute at River km ~95

Site 6 is start of braided mid reach in Section C

Site 7-10 consecutive sites

Site 11-12 consecutive sites, Wrede Creek downstream to logjam

Site 13 independent site, upstream of Pelly Creek

Sites 14-15 consecutive sites, downstream Cutbank Creek

Site 16 independent site

Site 17 independent site, includes confluence of Swannell Creek

Appendix 2 2004 Adult Counts

		Ingenika	Date	Aug 10 2004		Ingenika	Date	Aug 10 2004		Ingenika	Date	Aug 10 2004	
	UTM	9		km		9		km		9		km	
Start		669111	6305246	WP001		669991	6305447	WPOO2		674019	6306234	WP003	
Finish		669991	6305447	WP002		674019	6306234	WPOO3		675747	6305425	WP004	
Distance		880	201	1.1		4028	787	4.4		1728	-809	2.2	
Water Temperature			10										
Underwater Visibility (m)			7+										
Average Wetted Width m			25				45				50		
Comments		SITE 1;upstream from Fredrickson				SITE 2; D/S Fredrickson				SITE 3; U/S to D/S Flameau			
Swimmer		M	L	B	Total	M	L	B	Total	M	L	B	Total
Species	Size Range (cm)				Total				Total				Total
MW	0-10	13	2		15		20		20		10		10
	10-20	6			6	10	5	3	18	8	5	9	22
	20-30	20		8	28	11	5	35	51	3		21	24
	30-40				0	9			9			2	2
	40-50				0				0				0
	50+				0				0				0
	Total				49				98				58
	Total >20 cm				28				60				26
GR	0-10				0				0				0
	10-20				0		1		1				0
	20-30				0	1	1	1	3			1	1
	30-40				0	2	1	2	5				0
	40-50				0				0				0
	50+				0				0				0
	Total				0				9				1
	Total >20 cm				0				8				1
BT	0-10				0				0				0
	10-20				0				0				0
	20-30				0				0				0
	30-40				0				0				0
	40-50				0				0				0
	50+				0		1		1		1	2	3
	Total				0				1				3
	Total >20 cm				0				1				3
RB	0-10				0				0		3		3
	10-20	1			1			1	1	1			1
	20-30	1	1	1	3			2	2	1			1
	30-40				0				0				0
	40-50				0				0				0
	50+				0				0				0
	Total				4				3				5
	Total >20 cm				3				2				1

		Ingenika	Date	11-Aug-04		Ingenika	Date	11-Aug-04		Ingenika	Date	11-Aug-04	
	UTM	9		km		10		km					
Start		680289	6303324	WP 005		682082	6303047	WP 006		318826	6303156	WP 007	
Finish		682082	6303047	WP 006		318826	6303156	WP 007		320900	6302557	WP 008	
Distance		1793	-277	2.2		-363256	109	3.1		2074	-599	2.6	
Water Temperature													
Underwater Visibility (m)			7+										
Average Wetted Width m			45				40				35-40		
Comments		Site #4; start at chute				SITE 5; End of upper river section				SITE 6; start mid section; heavy braiding			
Swimmer		L	B	M		L	B	M		L	B	M	
	Size Range				Total				Total				Total
Species	(cm)												
MW	0-10	20		2	22	20		25	45	17			17
	10-20	30	13		43	8	22	43	73	24	7	12	43
	20-30	25	16		41	4	27	24	55	10	43	30	83
	30-40		5		5		2	1	3	1			1
	40-50				0				0				0
	50+				0				0				0
	Total				111				176				144
	Total >20 cm				46				58				84
GR	0-10				0				0				0
	10-20	1			1		10		10				0
	20-30	8	11	1	20	6	2	1	9		2		2
	30-40		18	2	20	4	0	10	14	1	3		4
	40-50				0				0				0
	50+				0				0				0
	Total				41				33				6
	Total >20 cm				40				23				6
BT	0-10				0				0				0
	10-20				0				0				0
	20-30				0				0				0
	30-40				0				0				0
	40-50				0				0				0
	50+				0	1	2		3				0
	Total				0				3				0
	Total >20 cm				0				3				0
RB	0-10				0				0				0
	10-20				0	2		1	3				0
	20-30				0				0				0
	30-40				0				0				0
	40-50	1			1				0				0
	50+				0				0				0
	Total				1				3				0
	Total >20 cm				1				0				0

		Ingenika	Date	12-Aug-04		Ingenika	Date	12-Aug-04		Ingenika	Date	12-Aug-04		Ingenika	Date	12-Aug-04
	UTM	10		km		10		km		10		km				km
Start		321830	6302034	WP 009		323500	6301602	WP 010		326146	6300796	WP 011		328380	6298870	WP 012
Finish		323500	6301602	WP 010		326146	6300796	WP 011		328380	6298870	WP 012		329537	6298416	WO 013
Distance		1670	-432	1.9		2646	-806	3.2		2234	-1926	3.8		1157	-454	1.5
Water Temperature			10.8													
Underwater Visibility (m)																
Average Wetted Width m			30				50				40				40	
Comments		Site #7; multi-channel				SITE 8				SITE 9				SITE 10		
Swimmer		B	M	L		B	M	L		B	M	L		B	M	L
	Size Range				Total				Total				Total			
Species	(cm)															
MW	0-10			2	2				0		1		1	2		2
	10-20	35	5	2	42	27	33	10	70	34	10	4	48	2	3	5
	20-30	38	14	3	55	26	56	5	87	8	54	8	70	16	2	14
	30-40			1	1		2	1	3		11		11			1
	40-50				0				0				0			0
	50+				0				0				0			0
	Total				100				160				130			45
	Total >20 cm				56				90				81			33
GR	0-10				0				0				0			0
	10-20			2	2				0				0			0
	20-30	3		1	4	1	3		4	1	3		4			0
	30-40	2	3	1	6	2	5		7	5	6	2	13	4	2	6
	40-50				0				0				0			0
	50+				0				0				0			0
	Total				12				11				17			6
	Total >20 cm				10				11				17			6
BT	0-10				0				0				0			0
	10-20				0				0				0			0
	20-30				0				0				0			0
	30-40				0				0				0			0
	40-50				0			1	1				0			0
	50+		1		1				0		1		1			0
	Total				1				1				1			0
	Total >20 cm				1				1				1			0
RB	0-10				0				0				0			0
	10-20				0				0	1		1	2		1	1
	20-30	1			1				0			1	1			0
	30-40				0				0				0			0
	40-50				0				0				0			0
	50+				0				0				0			0
	Total				1				0				3			1
	Total >20 cm				1				0				1			0

Appendix 3

Summary of Arctic grayling angling capture data from the Ingenika River, 2004

Site order from upstream to downstream is: A3 – A4 – A1 – A5 – A6 – A2

Site	Zone	UTM		Species	Fork length (mm)	Weight (g)	Age		Comments
		Easting	Northing				OT	SC	
A1	9	669111	6305246	GR	336	470	6	5	top of swim site 1; river km ~109 scale possible age 6
A2	10	326819	6299953	GR	279	258	n/a	n/a	
				GR	333	377	5	5	
				GR	397	722	n/a	6	
				GR	369	523	n/a	5	
				GR	366	534	7	6	scale possible 7
A3	9	680290	6303324	GR	384	634	6	6	
				GR	392	694	n/a	n/a	Chute pool at river km ~95; start of swim site 4 scale possible 6
				GR	355	255	6	5	
A4	10	317443	6303088	GR	376	630	7	7	
				GR	286	677	11	7+	older than 7
				GR	387	590	7	n/a	Large pool at river km ~ 91; in swim site 5
				GR	391	590	n/a	n/a	Scale regenerated; unageable
				GR	356	545	n/a	5	
				GR	394	636	n/a	n/a	Scale regenerated; unageable
				GR	400	681	n/a	7	
A5	10	319860	6302783	nfc	n/a	n/a		In swim site 6; river km ~ 88	
A6	10	326197	6300701	GR	393	590	n/a	6	At end of swim site 8, start of site 9; river km ~ 81
				GR	285	227	n/a	4	