



Kwoiek Creek Drainage

Assessment of Fish Habitat and Production

1995

by:

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ABSTRACT

Under the auspices of the Forest Renewal Program for British Columbia, an intensive assessment of fish habitat and production was completed within the Kwoiek Creek drainage in 1995. The objectives were as follows: 1) to identify existing fish and fish habitat values throughout the drainage; 2) to interpret the dynamics of fish production, and factors maintaining present abundance; 3) to quantify existing fish production (standing stock), compared to corresponding estimates of habitat capability (carrying capacity); and 4) to identify any degradation of fish habitat within the system, associated constraints to fish production, and any opportunities to mitigate for them.

All field work was conducted during October 11-26, 1995 to coincide with lower flows within the system. Principal components were: 1) 22 detailed habitat surveys of major stream components within the drainage; 2) fish sampling by electrofishing, habitat description, and water depth/velocity transects at 37 sampling sites in streams; and 3) preliminary lake surveys, including water sampling and gill netting, in 7 lakes most closely associated with the Kwoiek Creek mainstem.

Rainbow trout vastly dominated the standing stock of fish in streams in 1995. This species was found at all sampling locations in the Kwoiek Creek mainstem (and associated lakes) between the mouth of the system and cascades located 1.7 km downstream of Stukolait Lake, at the headwaters. A concrete flume, associated with a railway crossing 400 m upstream of the mouth, likely serves as a total barrier to fish passage at most (if not all) flows. Coho fry were captured in a side channel downstream of this flume, but nowhere else. There is also evidence to suggest use of this side channel by steelhead trout.

It is *conceivable* that steelhead may be able to ascend the flume, and gain access to the system as far upstream as barrier falls 3.5 km upstream of Kwoiek Lake. However, the results in October 1995 appeared to be most indicative of resident fish production, in all areas upstream of the flume. This includes a narrowly distributed bull trout population, found only in Kwoiek Lake, the 3.5 km of the Kwoiek Creek mainstem upstream of this lake (to the barrier falls), and (likely incidentally) the first reach (2 km) of the Kwoiek Creek mainstem downstream of the lake. At the same time, the capture of 3 large bull trout (659 mm to 721 mm) in Kwoiek Lake could *conceivably* indicate the presence of a fluvial-adfluvial population, associated with the Fraser River, consistent with the similar possibility for steelhead.

Most stream habitat within the system (and including the Kwoiek Creek mainstem) may be characterized as steep, bouldery and turbulent. Even at lower flows, hydraulic conditions appear to be the major constraint to the standing stock of fish in streams (ie. suitability/usability of habitat for juvenile fish). As observed in October 1995, stream production of rainbow trout was greatly concentrated in the Kwoiek Creek mainstem, and appeared to be at (or near) carrying capacity throughout its occupied length, principally governed by the availability of suitable/usable hydraulic conditions for yearlings.

In all sections of the Kwoiek Creek mainstem upstream of lakes (commencing with Kwoiek Lake), the standing stock of juvenile rainbow trout (especially yearlings) tended to be particularly high, presumably due to the production of lake recruits, in addition to stream residents. This was most strongly evidenced in Reach 6 of the Kwoiek Creek mainstem, between Kwoiek Lake and the barrier falls upstream. In addition to recruitment from/to a very substantial population of rainbow trout in Kwoiek Lake, the spawning/recruitment of bull trout is also concentrated in this reach, where spawning potential is superior to that elsewhere in the system.

Although a heavy glacial sediment load and severely limited productive capability were reported in an earlier survey of the system (1962), neither was evident in the more intensive investigations of 1995. In addition to standing stock at (or near) capacity in streams, most of the lakes investigated also appeared to contain large numbers of fish (exclusively rainbow, except in Kwoiek Lake).

In most stream sections, sediments are not abundant within the streambed materials. Although slight glacial turbidity was observed even at the flows investigated (low), it would appear that most sediments are transported out of the system, consistent with its high hydraulic energy. However, greater accumulations of fines were observed in Reach 6 of the Kwoiek Creek mainstem, upstream of Kwoiek Lake, and Reaches 10 and 11, upstream of Kha Lake. This appears to be attributable to the extensive forest harvesting along these reaches, coupled with the lower gradients of these stream sections.

Sediments are most abundant in Reaches 10 and 11. Analysis of scale samples from rainbow trout captured in Kha and Klept lakes could indicate significant reduction of recruitment, in this part of the drainage, in 1994. Although uncertainty of these analyses is acknowledged, this could reflect severe temporal sedimentation during the most recent forest harvesting activities, upstream of Kha Lake.

If the above is valid, exceptionally good recruitment of fry between Klept and Kha lakes (Reach 9) in 1995 may indicate subsequent recovery, here at least. However, much lower fry densities in Reach 10 (compared to the latter) may reflect lingering (or ongoing) effects upstream of Kha Lake. There is also reason for special concern with respect to Reach 6 of the Kwoiek Creek mainstem, downstream. Although the higher fines concentrations in this reach remain marginally good for fish production (relative to generalized criteria), at least one concentrated source of sediments was identified.

This source is a major road failure and slide on a small unnamed tributary to Reach 6 that has been severely disturbed by forest harvesting (and associated road construction). The principal concern of this, and all other sediment inputs to Reach 6, is the potential impact on bull trout spawning/recruitment, in particular. Results in October 1995 indicate that the narrowly confined bull trout population within the Kwoiek Creek drainage may be very small. If this population is entirely resident within the system (ie. lacustrine-adfluvial only), it is at the *most extreme* risk of extinction from *any* habitat disturbances (U.S. Forest Service guidelines). The population may already be in decline.

To attempt preservation of the bull trout within the system, the most urgent requirement is for the adoption of highly conservative management of *all* resources. Until such time that future monitoring enables full evaluation of the population's status and dynamics, any further disturbances to (or alterations of) habitat should be viewed as added risk to a population already highly vulnerable to extinction.

Any proposals for further development of the watershed should be placed in abeyance until all associated risks with respect to the bull trout population have been adequately resolved (including full evaluation of past and ongoing disturbances). Earlier proposals to construct hydroelectric storage dams on Kwoiek and Kokwaskey lakes seem highly inadvisable, due to potential alteration of Kwoiek Lake itself (depth profile, volume, limnology), as well as Reach 6 of the Kwoiek Creek mainstem, downstream of Kokwaskey Lake (alteration of flow patterns and associated factors, including effects on Kwoiek Lake).

In the absence of dam construction, the associated proposal for water extractions from the Kwoiek Creek mainstem downstream of North Kwoiek Creek may not be detrimental to the bull trout in the system, and could result in improved hydraulic conditions for rainbow trout. However, full consideration must be given to the possibility that fluvial-adfluvial bull trout (and/or steelhead) *could* be present within the system, with all attendant implications in terms of timing, magnitude, and duration of flows for upstream migrations, and screening to avoid intake of downstream migrations.

In terms of mitigation for past developments (ie. forest harvesting), monitoring is again required to fully evaluate the status of associated impacts (ie. ongoing or recovering). Again, the chief concern is sedimentation of Kwoiek Creek mainstem Reach 6, as well as Reaches 10 and 11 upstream. The source of concentrated inputs associated with the road failure on the small tributary to Reach 6 should be rectified, as a top priority. In addition, aerial reconnaissance should be employed to identify any other such sources, and these should also be rectified.

In terms of other impacts (problem debris, bridge failure, etc.) mitigative requirements are fairly minor. However, forest harvesting has been extensive within the drainage, much of the forest cover has been removed, and there has undoubtedly been associated alteration of runoff rates, and perhaps water temperatures, as well. Despite this, the system appears to have retained remarkable production of fish, in addition to its many other exceptional (if not unique) aesthetic features.

Above all else, the further preservation of these values should be maintained through careful management to avoid future ecological disturbances, and the provision of time, to fully recover from past disturbances.

TABLE OF CONTENTS

	Page
ABSTRACT	i
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF APPENDICES	xiv
1.0 INTRODUCTION	1
2.0 BACKGROUND	3
2.1 Study Area	3
2.2 Development and Use	4
2.3 Fish Resources	6
3.0 METHODS	7
3.1 Description and Evaluation of Stream Habitat	8
3.2 Fish Sampling in Streams	9
3.3 Estimation and Evaluation of Standing Stock Capability in Streams	9
3.4 Sampling and Evaluation of Lakes	11
4.0 RESULTS	23
4.1 Weather Conditions and Stream Discharges	11
4.2 Stream Habitat	12
4.2.1 Stream water temperatures	12
4.2.2 Kwoiek Creek mainstem downstream of Kwoiek Lake	16
4.2.3 Kwoiek Creek mainstem between Kwoiek and Kokwaskey lakes	24
4.2.4 Kwoiek Creek mainstem upstream of Kokwaskey Lake	33
4.2.5 North Kwoiek Creek	37
4.2.6 Other tributaries to Kwoiek Creek	39
4.2.7 Degradation of stream habitat	46
4.2.8 Evaluation of stream habitat limitations and constraints	49

	Page
4.3 Lake Habitat	52
4.3.1 Overview of morphology and associated habitat characteristics of investigated lakes	52
Kwoiek Lake	52
Kokwaskey Lake	55
Chochiwa Lake	57
John George Lake	60
Klept Lake	64
Kha Lake	64
Stukolait Lake	66
4.3.2 Limnology and trophic potential	69
4.3.2.1 Temperature and dissolved oxygen	69
4.3.2.2 Suspended solids (volatile and inert residues)	70
4.3.2.3 Water chemistry and trophic status	71
4.4 Species and General Distribution of Fish	73
4.5 Fish Populations in Streams	73
4.5.1 Numbers of fish captured in streams	76
4.5.2 Standing stock of fish in suitable habitat	81
4.5.3 Standing stock vs. habitat capability in the Kwoiek Creek mainstem	85
4.5.3.1 Coho salmon	88
4.5.3.2 Rainbow trout and bull trout	90
4.5.3.3 Implications with respect to steelhead	91
4.5.4 Hydraulic suitability vs. cover availability for fish in streams	92
4.6 Fish Populations in Lakes	95
4.6.1 Distribution of fish in lakes	98
4.6.2 Numbers of fish in lakes	100
4.6.3 Size of fish in lakes	101
4.6.4 Age structure of fish populations in lakes	102
4.6.5 Condition of fish in lakes	111

	Page
5.0 DISCUSSION	114
5.1 Methods Used and Reliability of Results	114
5.2 Composition and Status of Fish Populations in the Kwoiek Creek Drainage	118
5.2.1 Rainbow trout	118
5.2.2 Bull trout	120
5.3 Status of Fish Habitat and Associated Implications	122
5.3.1 Natural constraints	122
5.3.2 Effects of forest harvesting	123
5.3.3 Implications with respect to fish populations	126
5.4 Management Implications	127
5.4.1 Present values of fish production within the Kwoiek Creek drainage	127
5.4.2 Associated values of the Kwoiek Creek drainage	128
5.5 Implications of Past and Future Development of the Watershed	129
5.5.1 Forest harvesting	129
5.5.2 Hydroelectric development	130
5.6 Mitigative Requirements for Fish Production Within the Kwoiek Creek Drainage	131
6.0 SUMMARY AND CONCLUSIONS	133
6.1 Objectives and Methods of the Investigations	133
6.2 Stream Habitat and Associated Fish Populations	133
6.3 Lake Habitat and Associated Fish Populations	136
6.4 Impacts of Forest Harvesting on Fish Habitat	137
6.5 Implications With Respect to Bull Trout	138
6.6 Implications With Respect to Future Development Within the Watershed	139
6.7 Mitigation For Past Development Within the Watershed	140
ACKNOWLEDGEMENTS	141
REFERENCES CITED	141
APPENDICES	146

LIST OF TABLES

		Page
1.	Estimates of mean monthly flows from the Kwoiek Creek drainage, based on discharge records for the Nahatlatch River (WSC Sta. 08MF065)	5
2.	Summary of selected habitat survey results at sites in the Kwoiek Creek drainage, October 1995	14
3.	Summary of fish cover availability and spawning conditions at habitat survey sites in the Kwoiek Creek drainage, October 1995 (<i>weighted averages for all wetted habitat</i>)	15
4.	Evaluation/diagnosis of stream habitat condition and suitability for salmonid production in the Kwoiek Creek drainage, October 1995 (<i>following Anon., 1994</i>)	50
5.	Summary of limnological findings for investigated lakes in the Kwoiek Creek drainage, October 1995	53
6.	Water samples from lakes in the Kwoiek Creek drainage (October 1995) meeting most recent B.C. Environment water quality criteria (Nagpal, 1995) . . .	72
7.	Identification of growth limitation in lakes within the Kwoiek Creek drainage, based on ratios of total nitrogen to total phosphorus (<i>following Forsberg and Ryding, 1980</i>)	72
8.	Summary of fish species distribution, based on captures at electrofishing sites in the Kwoiek Creek drainage, October 1995	75
9.	Summary of fish numbers caught at electrofishing sites in the Kwoiek Creek drainage, October 1995	77
10.	Summary of sampled fish densities (<i>fish/m²</i>), based on the total area of electrofishing sites, in the Kwoiek Creek drainage; October 1995	79
11.	Summary of mean water depth and velocity, and associated hydraulic suitability for fish, at electrofishing sites in the Kwoiek Creek drainage; October 1995	82
12.	Summary of sampled fish densities (<i>fish/m²</i>), based on hydraulically suitable portions of electrofishing sites, in the Kwoiek Creek drainage; October 1995 . . .	84

	Page
13. Summary of mean fish weight data (g) from electrofishing captures in the Kwoiek Creek mainstem, October 1995	87
14. Summary of theoretical standing stock capability (<i>fish/m²</i>) in the Kwoiek Creek mainstem, based on October 1995 sampling results	87
15. Fish densities in suitable habitat, compared to theoretical standing stock capability, for the Kwoiek Creek mainstem, based on October 1995 sampling results	89
16. Fish densities in suitable habitat, compared to theoretical standing stock capability, for the Kwoiek Creek mainstem, based on representative sampling sites only; October 1995	93
17. Comparison of hydraulic suitability vs. total cover availability, at electrofishing sites in the Kwoiek Creek drainage; October 1995	94
18. Summary of gill netting results for investigated lakes within the Kwoiek Creek drainage, October 1995	96
19. Breakdown of rainbow trout gill netting results for investigated lakes within the Kwoiek Creek drainage, by age group of fish; October 1995	97
20. Age composition of rainbow trout recruits to lakes investigated in the Kwoiek Creek drainage in October 1995, based on scale samples from fish captured by gill netting	108

LIST OF FIGURES

	Page
1. Kwoiek Creek study area	2
2. Summary of discharges for the Nahatlatch River (WSC Sta. 08MF065), located immediately to the south of the Kwoiek Creek drainage	5
3. Location of stream habitat surveys (1-22) in the Kwoiek Creek drainage, October 1995	13

	Page
7. Gill netting fish capture results for lakes investigated within the Kwoiek Creek drainage, October 1995	221
8. Identification of char specimens captured in the Kwoiek Creek drainage in 1995, following the meristic analyses specified by Haas and McPhail (1991)	234
9. Length, weight, and condition statistics for fish captured at electro-fishing sites in streams within the Kwoiek Creek drainage, October 1995	236

1.0 INTRODUCTION

The Kwoiek Creek drainage is located approximately 150 km northeast of Vancouver. It lies between the Stein River and Nahatlatch River systems, and drains from the west into the Fraser River between the communities of Lytton and Boston Bar (Fig.1).

Road access to the system is limited, and until fairly recently, relied upon use of small aerial reaction ferries at Lytton and Boston Bar. This still applies at Lytton; however, in 1987 a permanent bridge was built at Boston Bar, greatly facilitating access to the west side of the Fraser River, in this locale. This development, and associated implications with respect to forest harvesting, other potential industry, and increased recreational opportunity, has brought attention to (and use of) affected watersheds, about which little is known; including fisheries values, dynamics, and sensitivities to development.

Accordingly, in 1994 an intensive assessment of fisheries resources was conducted in the Nahatlatch River drainage, under the direction of B.C. Environment¹ (Griffith, 1995a). Principal objectives of the study were as follows:

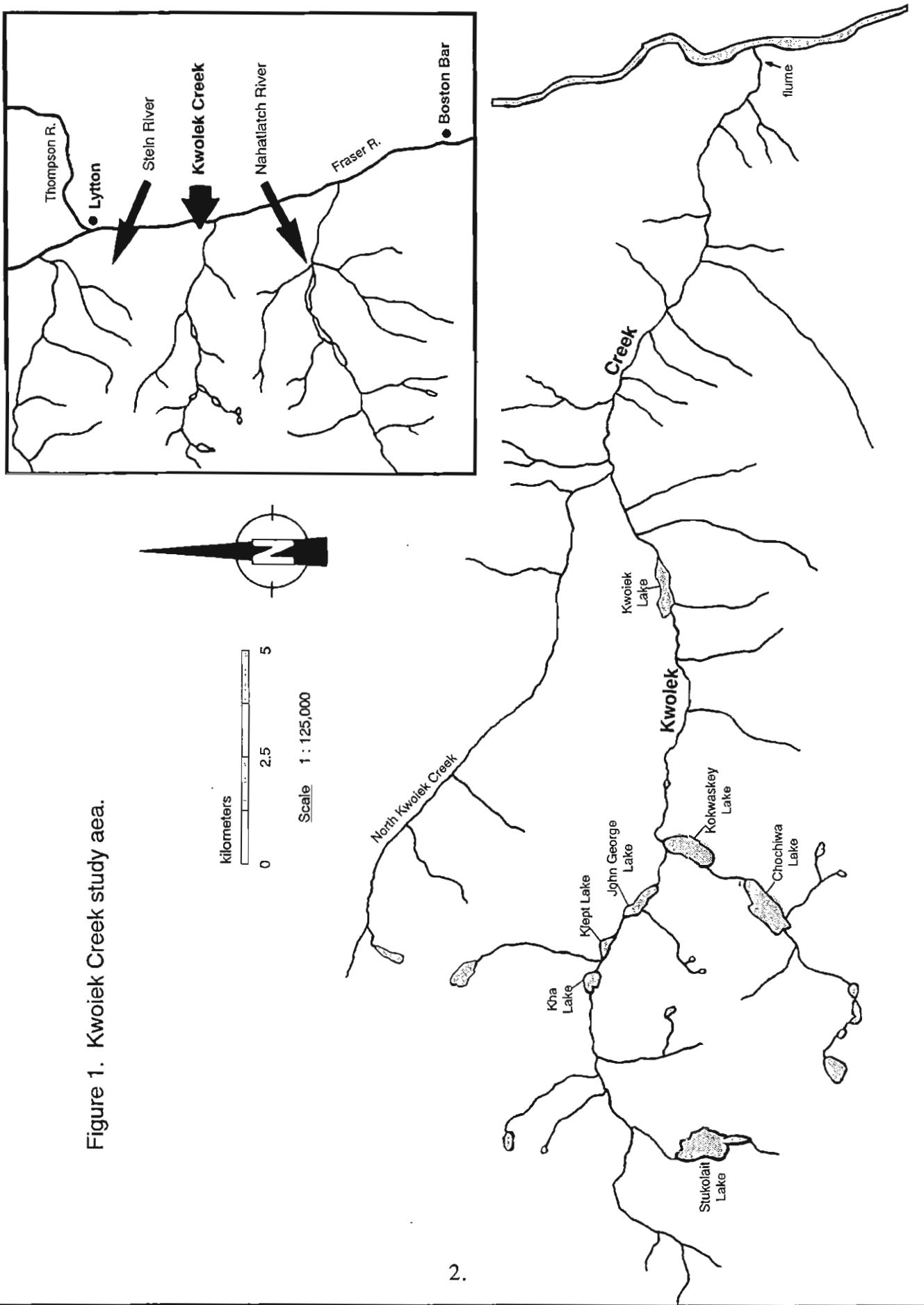
1. identify existing fish and fish habitat values throughout the drainage;
2. interpret the dynamics of fish production within the system, and identify factors maintaining present fish abundance;
3. quantify existing fish production, in terms of standing stock, by species;
4. assess present status of all fish populations, through comparison of existing standing stock to corresponding estimates of habitat capability; and
5. identify and quantify all capabilities (if any) to increase fish production within the system.

Following the above, a similar investigation was proposed for the Kwoiek Creek drainage in 1995. Since the Kwoiek watershed has been subject to substantial forest harvesting in recent years, the study was to be conducted under the provincial Forest Renewal Program (FRBC). Under this program, the assessment of fish and fish habitat has similar objectives to those listed above (Anon., 1994). However, the principal aim of the procedure is to provide answers to the following questions, specifically:

1. *what fish species are present in the watershed, where are they, and in what numbers (by life stage)?*

¹ B.C. Ministry of Environment, Lands and Parks, Kamloops.

Figure 1. Kwoiek Creek study area.



2. *what is the amount, type, actual and potential use of the habitat within the watershed (by species and life stage)?*
3. *what degraded habitats do you find, where and in what quantity (by species and life stage)?*
4. *what, where and in what quantity are the habitats that limit salmonid production?*

Like the preceding study of the Nahatlatch drainage, responsibility for the Kwoiek Creek assessment was undertaken by the British Columbia Conservation Foundation (Surrey, B.C.), on behalf of B.C. Environment. The assessment itself was completed by R.P. Griffith and Associates (Sidney, B.C.), under contract to the Conservation Foundation.

2.0 BACKGROUND

2.1 Study Area

The total length of the Kwoiek Creek system, from its origin to its mouth, is approximately 33 km. This includes the length of 6 lakes on the Kwoiek Creek mainstem (Fig. 1). In sequence, progressing upstream, these lakes are: 1) Kwoiek Lake (29 ha.); 2) Kokwaskey Lake (47 ha.); 3) John George Lake (22 ha.); 4) Klept Lake (7.5 ha.); 5) Kha Lake (12.5 ha.); and 6) Stukolait Lake (63 ha.).

There are two major tributaries to Kwoiek Creek. The first (and largest) is North Kwoiek Creek, which is approximately 14.5 km in length, and enters the Kwoiek Creek mainstem below Kwoiek Lake, 11.7 km upstream of the Fraser River (Fig. 1). The second is Chochiwa Creek, which flows into the southern end of Kokwaskey Lake. This system is 7 km in length, and drains several lakes, the largest of which is Chochiwa Lake (60 ha.), located 1 km upstream of Kokwaskey Lake (Fig. 1).

The total area of the Kwoiek Creek drainage is approximately 260 km². It is contained within the Lillooet Ranges of the Coast Mountains, in the western system of the Canadian Cordillera (Holland, 1976). Much of the topography feeding the headwaters of Kwoiek Creek, as well as North Kwoiek Creek and Chochiwa Creek, reaches 2500m (8200 ft) in elevation, or more. The origins of the Kwoiek Creek mainstem, and Chochiwa Creek, are within the extensive ice fields (ca. 25 km²) of the Rutledge, Kwoiek, and Chochiwa glaciers, on the northern slopes of Mehatl, Kwoiek, Kumkan, and Tachewana peaks. Similarly, North Kwoiek Creek originates from smaller ice fields on Skihist Mountain and Claimpost Peak.

In terms of climate, the Kwoiek Creek drainage is located within the area of transition between the Coast Forest and Dry Interior zones of British Columbia (Lyons, 1976). Dominant biogeoclimatic zones of the Kwoiek watershed are Interior Subalpine to the west (headwaters),

and Interior Douglas fir to the east (Krajina, 1975). Specific precipitation and stream discharge records are not available, but annual precipitation for the east slope of the Coast Mountains may be typified as moderate to low (Holland, *op. cit.*).

In the absence of specific records, the predominant pattern of flows in Kwoiek Creek may best be inferred by discharge data for the Nahatlatch River, immediately adjacent, to the south (Fig. 1). Flows have been monitored in this system since 1973 (Water Survey of Canada, 1991). As shown in Figure 2, peak discharges occur during May-July, as a result of initial snow melt. Generally speaking, discharges progressively decline over the rest of the summer and fall, as the snowpack at lower elevations diminishes. There is no predominance of the fall and/or winter floods, characteristic of coastal systems (eg. Griffith, 1993; 1995b). On the contrary, low flows generally develop during the fall, and extend throughout the winter (characteristic of interior drainages).

Based on the relative drainage areas of Kwoiek Creek (260 km²) and the gauging site in the Nahatlatch River (715 km²; Water Survey of Canada, 1991), gross approximations of normal monthly flows in Kwoiek Creek are provided in Table 1. On this basis, the estimate of normal mean annual discharge would be in the order of 12.5 m³/s. For minimum monthly flow, the estimate would be 3.6 m³/s, occurring in the month of February.

It must be recognized that these are *crude* estimates for Kwoiek Creek, as there may be fundamental differences in its hydrological regimen, compared to that of the Nahatlatch River, even though they are neighbouring drainages (eg. considerably greater western extent of the Nahatlatch system, and associated subjection to wetter, more coastal conditions in upper portions of the watershed; Griffith, 1995a). Earlier estimates have suggested a mean annual discharge closer to 7.7 m³/s for Kwoiek Creek (Anon., 1991). Again, this was based on records for other systems, but further details (and figures) are not provided.

2.2 Development and Use

Kwoiek Creek is located approximately 27 km north of the bridge crossing (and earlier ferry) at Boston Bar, and 15 km south of the ferry crossing at Lytton. Even at present, road conditions along the west side of the Fraser River are poor, and access to the Kwoiek system is slow and rough. As late as 1962, access was limited to foot, horseback, or float plane (Stenton and DeLair, 1963). An old road was in existence down the west side of the Fraser River from Lytton, but was impassable to vehicles. A Forest Service road allowance had been surveyed as far as Kwoiek Lake, but no construction had been initiated (*ibid.*).

At the time, it was suggested that mineral claims within the Kwoiek Creek drainage might be developed. However, no mining activity had been initiated, and there were no indications that it would (*ibid.*). It would appear that subsequent development and use of the watershed has essentially been restricted to forest harvesting (primarily) and a limited extent of public recreation (Anon., 1991).

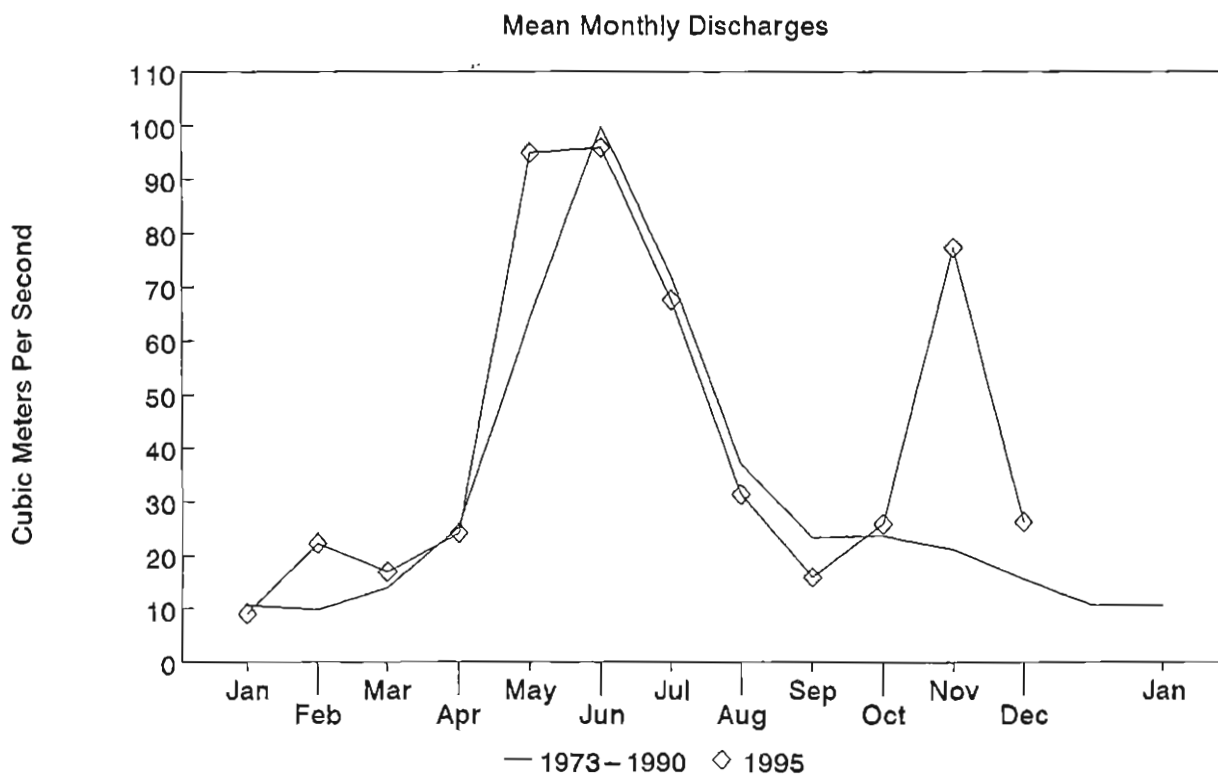


Figure 2. Summary of discharges for the Nahatlatch River (WSC Sta.08MF065), located immediately to the south of the Kwoiek Creek drainage.

Table 1. Estimates of mean monthly flows from the Kwoiek Creek drainage, based on discharge records for the Nahatlatch River (WSC Sta.08MF065).

Flow Period / Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Records for the Nahatlatch River													
Mean monthly ; 1973-1990 ¹	10.6	9.9	14.0	25.4	64.1	99.8	72.0	37.1	23.4	23.7	21.2	15.6	34.3
Mean monthly ; 1995 ²	9.1	22.3	17.0	24.2	94.9	95.9	67.5	31.4	16.0	25.9	77.4	26.3	42.4
Estimates for the Kwoiek Creek drainage													
Mean monthly; norm	3.9	3.6	5.1	9.2	23.3	36.3	26.2	13.5	8.5	8.6	7.7	5.7	12.5
Mean monthly ; 1995	3.3	8.1	6.2	8.8	34.5	34.9	24.5	11.4	5.8	9.4	28.1	9.6	15.4

¹ Water Survey of Canada (1991)

² unpublished preliminary data courtesy of Water Survey of Canada, Vancouver (Appendix 1)

In 1962, the Kwoiek valley was described as being covered with mature forest (hemlock, red cedar, spruce, and Douglas fir), unbroken except for slide areas (Stenton and DeLair, 1963). Since then, forest harvesting and associated road construction have been extensive. According to B.C. Forest Service records and mapping², road construction and harvesting had progressed to a short distance upstream of Kwoiek Lake, by the mid 1970s. The majority of harvesting, which now extends to within 1 km of Stukolait Lake (Fig. 1), appears to have occurred in the latter 1980s and early 1990s, following construction of the bridge at Boston Bar. At the time of investigation in 1995, harvesting had been terminated approximately 1 km downstream of Stukolait Lake, at the headwaters of the Kwoiek Creek mainstem, and the main forest service road had been temporarily deactivated.

However, other development of Kwoiek Creek is presently under consideration. In the late 1980s the first proposals for a small hydroelectric development were submitted to the Province of British Columbia, in the form of water licence applications (file data; B.C. Environment, Kamloops). Original proposals called only for a diversion of flows (via pipeline) from the Kwoiek Creek mainstem, downstream of North Kwoiek Creek, to a powerhouse to be constructed near the mouth of the system (*ibid.*).

In 1991, a more detailed prospectus was submitted by Western Pacific Powergen Corp. (Anon., 1991), expanding the proposal to include low level dams on both Kwoiek and Kokwaskey lakes (3 m and 6 m in height, respectively). The acceptability of any such proposal is currently under review and evaluation by relevant government agencies.

2.3 Fish Resources

The first known survey of fish populations in the Kwoiek Creek system was that conducted in 1962 (Stenton and DeLair, *op. cit.*). Angling is the only fish sampling technique referred to in the reporting. Rainbow trout (*Oncorhynchus mykiss*) were captured in Kwoiek Lake and Kokwaskey Lake, but no fish were captured or observed in Chochiwa or John George lakes; Klept, Kha and Stukolait lakes were also assumed to be barren of fish. Local residents reported the existence of Dolly Varden (*Salvelinus malma*) in Kwoiek Lake, but none were captured during the survey.

Rainbow trout were also captured or observed in Kwoiek Creek itself, from its mouth to Kokwaskey Lake. Large waterfalls between Kokwaskey Lake and both John George and Chochiwa lakes were assumed to explain the apparent absence of fish in areas further upstream. It was also assumed that North Kwoiek Creek was barren of fish, due to a series of high waterfalls near its confluence with the Kwoiek Creek mainstem (*ibid.*).

² Disturbance Records: Lillooet Forest District, Lillooet
Tenures Mapping: Resource Tenures and Engineering Branch, Victoria.

Aging of fish captured during the 1962 survey indicated that growth was very slow in the Kwoiek Creek drainage. It was concluded that this was due to glacial influences; including low water temperatures, and poor light penetration (heavy silt load).

The presence of silt was noted throughout the system, and was identified as the main constraint to fish production. Due to these natural constraints, the following was concluded: 1) the potential for fish production was very limited within the Kwoiek Creek system; 2) existing fisheries values were correspondingly low; and 3) there was no potential for improvement of these values.

However, a subsequent field investigation in August 1994 (Maricle, 1994) suggested that biological productivity in the system might be higher than expected. Although this investigation was brief, the above speculation was based on the abundance and/or large size of aquatic invertebrates that were observed. Limited electrofishing was conducted along the shore of Kwoiek Lake, and in the Kwoiek Creek mainstem upstream. Once again, rainbow trout was the only species captured, although local reports of large bull trout (*S. confluentus*)³ in Kwoiek Lake are again identified in the reporting.

The 1991 prospectus for the proposed hydroelectric development for Kwoiek Creek (Anon., 1991) suggests that there may be little production of anadromous fish within the system. Although a native food fishery occurs in the Fraser River at the mouth of Kwoiek Creek, there is no record of salmon production within Kwoiek Creek itself (*ibid.*). This is attributed to the steep gradient of the stream, as well as the presence of a culvert under a railway bridge, which is thought to act as a velocity barrier (*ibid.*). This is located just 400 m upstream of the Fraser River (Fig. 1).

Both steelhead trout (Anon., 1991) and large Dolly Varden⁴ (MacDonald, 1988) have been reported to occur in lower reaches of the Kwoiek Creek mainstem. Precise locations (ie. distances from the mouth) are not specified, but the exceptional ability of bull trout (in particular) to ascend obstructions and steep stream sections (McPhail and Baxter, 1994) is noted in one of these reports (MacDonald, *op. cit.*).

3.0 METHODS

All field work in this study of the Kwoiek Creek drainage was completed during October 11-26, 1995. Consistent with production modelling requirements (Ptolemy, 1992), timing was scheduled to coincide (hopefully) with normal base flows in the system, towards the end of the

³. In the early 1990s, it was determined that many char populations in British Columbia, previously assumed to be Dolly Varden, were in fact bull trout, a species which can be very difficult to distinguish from Dolly Varden (eg. Haas and McPhail, 1991).

⁴. Possibly bull trout (McPhail and Carveth, 1992).

growing season for fish. Accordingly, field activities were initially scheduled to commence in late September (Fig. 2). This was delayed somewhat, due to complications in preceding field commitments.

Field investigations within the Kwoiek Creek drainage consisted of three major components; 1) description and evaluation of fish habitat in streams; 2) assessment of existing fish production in streams (distribution and standing stock) relative to theoretical capability (modelling); and 3) investigation of fish populations and general habitat conditions in the major lakes within the system.

As applicable, methodologies followed new (and interim) guidelines specifically developed for the Watershed Restoration Program by B.C. Environment and the Ministry of Forests (Anon., 1994). However, more intensive methods (also developed by B.C. Environment) were required for the purposes of production modelling, and the evaluation of existing standing stock (Ptolemy, 1992). With respect to lake(s) investigations, these followed standard B.C. Environment procedures, at the preliminary level (Anon., 1995).

3.1 Description and Evaluation of Stream Habitat

Following the Watershed Restoration Guidelines (Anon., 1994), a total of 22 detailed habitat descriptions (habitat surveys) were completed, addressing the full length of Kwoiek Creek, and the first 10.5 km of North Kwoiek Creek. The distribution and stratification of these descriptions was based on the length and relative homogeneity of identifiable stream reaches. Prior to entering the field, 1:50,000 topographic mapping and recent aerial photography (1993)⁵ were used to tentatively delineate stream reaches, for subsequent ground truthing and sampling, in the field.

In addition to the above surveys, which addressed the full wetted streamwidth at all locations, descriptions were also completed for the habitat specifically sampled at all electrofishing sites in streams. In accordance with standard B.C. Environment procedures, these descriptions followed deLeeuw (1981), with some modifications associated with the modelling of standing stock capability (noted below).

Wherever possible, all habitat measurements were by tape and staff. Notable exceptions were the many areas of the Kwoiek Creek mainstem where the depth and turbulence of flows precluded such means (principally, downstream of Kwoiek Lake). In such cases, width measurements were obtained by rangefinder, and depth measurements were limited to what was safely possible.

⁵ Flight BCC93043, Maps B.C., B.C. Environment, B.C.

3.2 Fish Sampling in Streams

Fish sampling, by electrofishing, was conducted at a total of 37 different sites within the following streams: the Kwoiek Creek mainstem; North Kwoiek Creek; Chochiwa Creek; and 6 smaller tributaries. Full fish population estimates were completed at all sites, employing the 2-capture removal method, following deLeeuw (1981). Prior to sampling, all sites were reliably contained by small-mesh stopnets, installed as unobtrusively as possible, and employing anchors and/or guylines, as required by specific flow velocities and/or turbulence.

At most locations, sampling sites were selected to be as closely *representative*, as possible, of *average* habitat conditions for the given section of stream. Where feasible and beneficial (ie. conducive to efficient sampling), the full wetted width was contained and sampled. This applies to various side channel areas that were investigated, as well as some of the smaller streams. Most frequently, however, logistical constraints to the installation and maintenance of stopnet enclosures restricted sampling only to portions of the full wetted width, varying with the specific hydraulic conditions at the different sites.

At all electrofishing sites, water depth and velocity transects were completed in order to assess the hydraulic suitability (for fish) at each site. In each case, transect location/orientation was aimed at typifying the given conditions, throughout the area sampled. Orientation might be diagonal, or even longitudinal, if so required to best reflect the hydraulic makeup of the site.

Fork length and weight measurements were obtained from all fish captured by electrofishing. In order to assist age identification (and delineation) of fish captured in streams, scale samples were obtained from a total of 155 specimens, addressing all size classes. As warranted, individuals were occasionally sacrificed in order to determine the status of reproductive development, to assist in life history interpretation.

In order to positively confirm species identification and to enable most accurate age identification (by otolith), a total of 8 char specimens captured in streams were sacrificed, and were preserved by freezing, for later examination.

3.3 Estimation and Evaluation of Standing Stock Capability in Streams

The B.C. Environment standing stock capability model for juvenile salmonids (Ptolemy, 1992) was used to assess 1995 fish densities in all sampled stream sections within the Kwoiek Creek drainage (Appendix 2). All entries and results relate to conditions at low flows, and resultant standing stock capability (carrying capacity) estimates are expressed in terms of potential fish numbers per unit area of suitable/usable habitat for a given species/size of fish.

At any given sampling site, the proportion of the area that is actually usable for different species/cohorts may vary widely. Consequently, in order to compare sampling results to corresponding capability estimates, it is necessary to adjust the former, relative to the specific

degree of suitability/usability of each site, for each species/cohort of fish. This adjustment is based on probability-of-use procedures, introduced by Bovee and Cochnauer (1977), using water depth and velocity as the principal delineators of habitat partitioning (and use) for juvenile fish.

In order to express initial electrofishing results (based on total site area) as densities within *suitable habitat only* (consistent with the capability model), the mean weighted *hydraulic suitability* of each site was determined, by applying species-specific and age/size-specific probability-of-use criteria to the hydraulic transect data. This is accomplished by spreadsheet, specifically developed for salmonids in B.C. streams (Bech *et al.*, 1994)⁶.

Provided that a given transect is representative of hydraulic conditions throughout a sampling site, the mean composite (depth × velocity) probability-of-use for the transect provides the requisite estimate of the degree to which the total hydraulic habitat is actually usable for a given species/cohort of fish. Accordingly, this enables adjustment of the initial sampling results for direct comparison to capability estimates (ie. what was found in suitable/usable habitat vs. the theoretical maximum for fish, in such habitat).

All of the preceding relates specifically to the influence of water depth and velocity only. In order to assess the absolute suitability of habitat conditions at each site, an attempt was also made to evaluate any potential limitation related to the type and complexity of bed materials, and/or other cover for fish (eg. woody debris, cutbanks, vegetation, etc.). As noted above, detailed habitat descriptions were completed at each electrofishing site, concentrating on these elements.

For bed materials, an estimate was made of the proportion of total site area containing suitable sizes and complexity for salmonid fry and parr⁷ (with separate estimates for each). As a rule, suitable materials for fry (ie. cover) were deemed to range from large gravel to moderate size boulders. For parr, the general range was from large cobble to large boulders. Specific area measurements were obtained by tape. Water depth and velocity conditions, which are addressed separately by the transects, are disregarded in the cover measurements.

In order to generally assess water quality in stream habitats, and more specifically to enable capability modelling (Ptolemy, 1992), water samples were collected at 6 locations in the Kwoiek Creek mainstem, and one location in North Kwoiek Creek.

⁶. As detailed in the report addressing the 1994 assessment of the Nahatlatch River drainage (Griffith, 1995a), criteria for both bull trout and Dolly Varden were added to this spreadsheet by R.P. Griffith and Associates, in consultation with leading authorities in British Columbia, and the U.S. Fish and Wildlife Service (Fort Collins, Colorado).

⁷. The *parr* category (yearlings and older juveniles) may include small adults. However, both sampling and subsequent modelling principally relate to juvenile populations.

3.4 Sampling and Evaluation of Lakes

A total of 7 lakes within the Kwoiek Creek drainage were investigated during the 1995 field activities. This included all 6 lakes directly associated with the Kwoiek Creek mainstem (Kwoiek, Kokwaskey, John George, Klept, Kha, and Stukolait lakes). Chochiwa Lake was also included. Fish sampling was conducted in all of these lakes, employing a single standard B.C. Environment experimental gill net (Anon., 1995), and overnight set duration, in each case. In order to best evaluate the distribution of bull trout in these lakes, sinking nets were used in all cases (McPhail and Baxter, 1994). Minnow traps (baited with roe or sardines) were also installed in each lake, for the duration of the associated gill netting.

The following data were obtained from all fish captured: weight (± 0.1 g for fish < 300 g; ± 1 g for fish > 300 g), fork length, gut contents, status of reproductive development, and a scale sample for age determination and other analyses. Again, a total of 8 bull trout were preserved by freezing, for later identification, and aging by otolith.

With the exception of Stukolait Lake, the following was also completed for each lake: 1) a depth sounding transect (recorded on paper) along the main axis, to locate the deepest area (for water sampling), and to estimate maximum and mean depths; 2) at the deep water site, Secchi depth and vertical profiles of water temperature and dissolved oxygen, from the surface to near bottom (to a maximum of 30 m); 3) at a deep location, a water sample from the surface and another from near bottom (to a maximum of 30 m); and 4) a brief description of the lake's shoreline, inlet and outlet conditions, and other features relevant to fish production.

Access to Stukolait Lake entailed a steep hike of approximately 1 km, through dense bush. Accordingly, equipment was minimized, including the exclusion of the outboard motor (and fuel) for the inflatable boat. The hike was accomplished on the afternoon of October 24, at which time the gillnet was set, and general features of the lake were described, at its northeast corner. Other activities and sampling were planned for the following day, in conjunction with retrieval of the gill net. Unfortunately, however, October 25 brought blizzard conditions to Stukolait Lake, with high winds and driving snow. Conditions precluded use of the inflatable boat (relying on paddles), beyond the absolute necessity of retrieving the gill net. Accordingly, neither sounding nor limnological sampling were completed for this lake. However, a surface water sample was collected at the gill netting site, approximately 50 m from the lake's shore.

4.0 RESULTS

4.1 Weather Conditions and Stream Discharges

Water Survey of Canada records for the Nahatlatch River indicate slightly higher discharges during October 1995, compared to average years (Fig. 2; Table 1). Certainly, discharges in the Nahatlatch system were well above normal flow levels during the period of October 10-21, 1995 (Appendix 1).

According to local residents, substantial rainfall had occurred in the Lytton area during the 48 hours immediately preceding the commencement of Kwoiek Creek field activities on October 11. Based on monitoring of a benchmark established on the lower Kwoiek Creek mainstem (3 km upstream of the mouth), the water level dropped by approximately 15 cm during October 12-13 (in the absence of further precipitation, beyond the occasional light drizzle).

With heavy showers on October 15, the stream again rose by approximately 8 cm, but dropped again by October 17. For the remainder of the field program, precipitation was limited to the odd and infrequent drizzle, slight shower, or snow flurries (with the exception of the blizzard conditions at Stukolait Lake on October 25, the last day of data collection activities). During this period, the level of the Kwoiek Creek mainstem remained essentially unchanged, and on October 24, the flow was measured at 3.09 m³/s (109 cfs), at a suitable metering location (with laminar flows) approximately 1.5 km downstream of North Kwoiek Creek.

Due to the relative stability of this flow after October 17, it may have represented something close to average flows for the time of year (Griffith, 1995c). The daily discharge recorded in the Nahatlatch River on October 24, 1995 was 18.1 m³/s (Appendix 1). This was only slightly above the mean monthly flow of 16.0 m³/s for September 1995, which was considerably lower than the norm for this month (23.4 m³/s; Table 1). Furthermore, there was a delay in the recession of flows in the Nahatlatch River, compared to Kwoiek Creek (Appendix 1), which is likely attributable to the larger size and more westerly extension of the former.

As noted earlier, fish sampling and subsequent modelling methodologies are assumed to relate to (and are premised upon) low flow conditions at the end of the growing season (Ptolemy, 1992). Clearly, flows were somewhat elevated in Kwoiek Creek during the first part of the 1995 field session (ie. October 11-16). Nonetheless, it is felt that the sampled conditions were at least reasonably consistent with normal lower flows, for the given time of year.

4.2 Stream Habitat

The locations of the 22 stream habitat surveys completed during the October 1995 field investigations are shown in Figure 3. The full descriptions completed at these locations are provided in Appendix 3. Key results are summarized in Tables 2 and 3, and are discussed below. Initial comments largely concentrate on comparative conditions, within the system. Absolute evaluation is provided in later sections.

4.2.1 Stream water temperatures

As shown in Table 2, water temperatures in various parts of the Kwoiek Creek mainstem varied between 6.0°C and 8.5°C, during the October 1995 investigations. Colder temperatures further up the system were possibly influenced by later dates of investigation (Appendix 3). Studies commenced downstream, and progressed upstream, on a strategic basis.

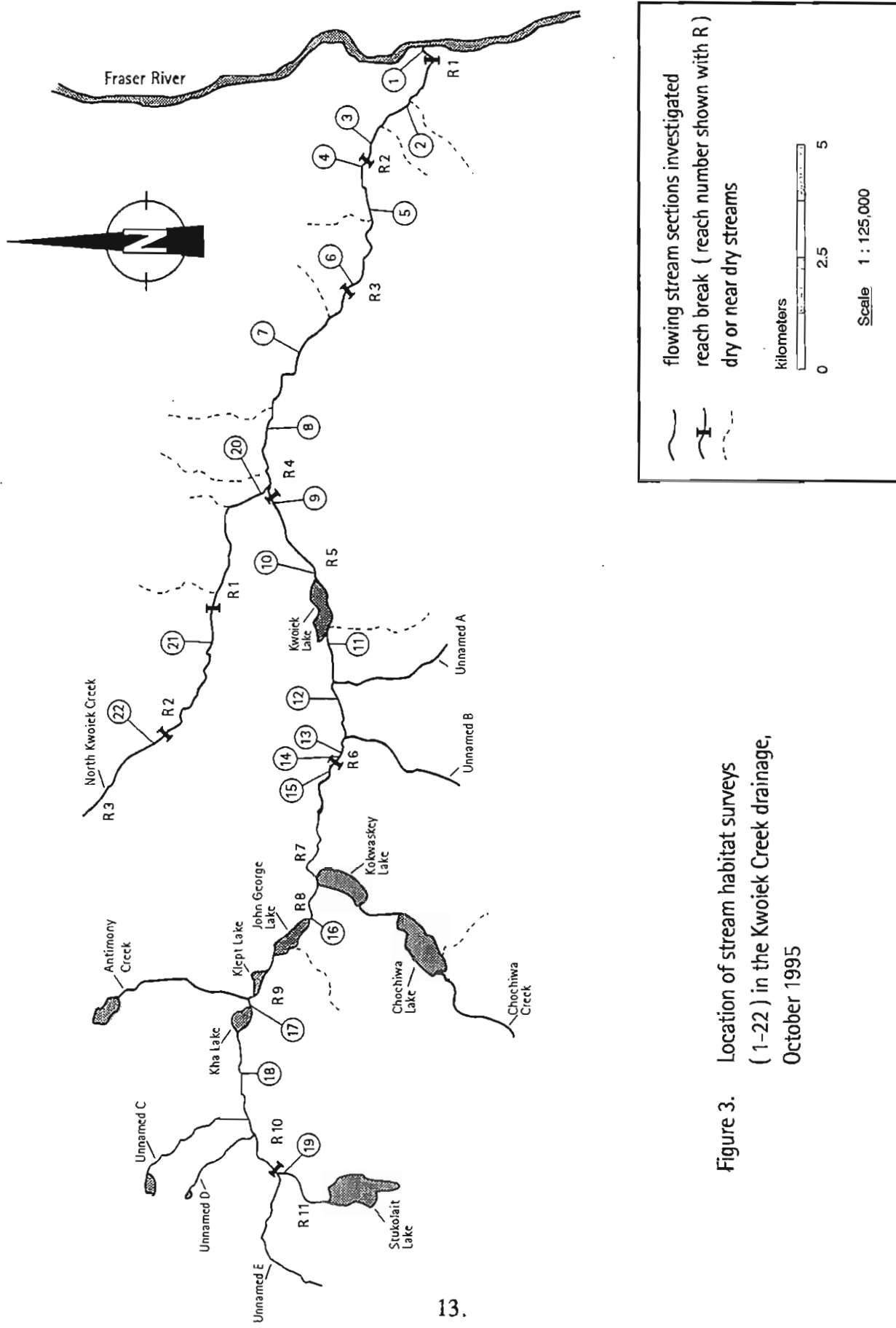


Figure 3. Location of stream habitat surveys (1-22) in the Kwoiek Creek drainage, October 1995

Table 2. Summary of selected habitat survey results at sites in the Kwoiek Creek drainage, October 1995.

Survey Site	Reach	Length (km)	Gradient (%)	Channel Width (m)	Hydraulic Habitat Types (% of wetted area)					Water Temp (°C)	Date
					Pool	Riffle	Glide	Rapids	Cascades		
Kwoiek Creek mainstem											
1.	1	0.4	9.5	14.5	5	20	15	58	2	8.5	Oct 12
2.	2	3	8	14	15	5	20	50	10	8.0	Oct 12
3.	2	—	7	12.5	5	10	10	70	5	8.0	Oct 12
5.*	3	3	11	11.5	5	20	20	45	10	7.5	Oct 13
6.	3	—	6	15	10	5	10	75	—	8.0	Oct 13
7.	4	5.5	2	14	5	25	30	40	—	8.0	Oct 13
8.	4	—	3	18.5	10	10	30	50	—	8.0	Oct 13
9.	5	2	4	21	5	40	35	20	—	7.5	Oct 13
10.	5	—	7	15.5	20	5	30	30	15	7.5	Oct 14
Mean					8.9	15.6	22.2	48.7	4.7		
Kwoiek Lake ➤											
11.	6	3.5	1	25.5	10	40	50	—	—	7.5	Oct 14
12.	6	—	1.5	18	5	50	40	5	—	8.0	Oct 15
13.	6	—	3.5	21.5	10	15	20	55	—	7.5	Oct 15
Mean					8.3	35.0	36.7	20.0	0.0		
first falls ➤											
14.	6	—	3	10.5	15	5	30	50	—	8.0	Oct 14
second falls ➤											
15.	7	—	3.5	21	7	30	15	45	3	7.0	Oct 18
Kokwaskey Lake ➤											
16.	8	0.9	3	16	10	20	40	30	—	6.5	Oct 18
John George and Klept lakes ➤											
17.	9	0.3	0.3	14	20	35	45	—	—	6.5	Oct 19
Kha Lake ➤											
18.	10	3.5	2	12.5	15	35	30	20	—	6.5	Oct 16
19.	11	1.7	2	8	15	15	45	20	5	6.0	Oct 16
Mean					15.0	25.0	37.5	20.0	2.5		
Stukolait Lake ➤											
North Kwoiek Creek											
20.	1	3.5	23	7.5	10	10	30	20	30	5.5	Oct 16
21.	2	3	2.5	10.5	10	60	30	—	—	5.5	Oct 16
22.	3	4	3.5	11.5	10	15	15	60	—	5.5	Oct 16
Mean					10.0	28.3	25.0	26.7	10.0		

* All surveys relate to mainstem habitats only; survey 4 specifically addressed side channel habitat at the bottom of Reach 3, and has been excluded

Table 3. Summary of fish cover availability and spawning conditions at habitat survey sites in the Kwoiek Creek drainage, October 1995 (*weighted averages for all wetted habitat*).

Survey Site	Reach	Total Cover Availability (% of total wetted area)		Cover Components (% of total cover)						Spawning Habitat (% of total wetted area)		Average Fines (%)
		Juveniles	Adults	Woody Debris	Streambed Materials	Riparian Vegetation		Cutbanks and Roots	Fall	Spring		
						Overstream	Instream					
Kwoiek Creek mainstem												
1.	1	27.3	<26.0 *	0.0	99.8	0.2	0.0	0.1	1.0	0.3	1.3	
2.	2	36.5	<34.3	<1.0	>98.3	0.0	0.0	<0.8	<1.0	<1.2	2.3	
3.	2	17.5	25.8	<0.4	>99.0	<0.8	0.0	<0.2	<0.4	<0.2	<0.8	
5.	3	23.5	21.8	<0.7	>98.5	0.3	0.0	<0.1	<1.5	3.7	1.3	
6.	3	28.8	23.3	<0.6	>97.8	<1.3	0.0	<0.3	<0.7	<0.3	2.1	
7.	4	37.0	28.5	<0.8	>92.0	5.0	0.0	<0.6	<2.0	<0.6	4.0	
8.	4	21.0	31.8	<1.0	>95.5	<2.0	0.0	<0.4	2.5	<0.5	5.0	
9.	5	54.3	31.5	<4.0	>85.8	<5.3	0.0	<5.0	6.3	<0.5	2.0	
10.	5	46.3	<43.3	<5.0	>95.0	0.0	0.0	0.0	<1.4	<0.2	2.5	
Mean		32.5	<29.6	<1.5	>95.7	<1.7	0.0	<0.8	<1.0	<0.8	<2.4	
Kwoiek Lake												
11.	6	27.0	11.0	<9.5	21.5	19.0	0.0	50.5	12.0	<17.0	<11.5	
12.	6	32.8	19.5	29.6	21.3	21.3	19.0	9.0	5.5	9.8	<10.8	
13.	6	34.8	43.8	<6.8	>85.5	<4.8	0.0	3.0	<2.7	<2.7	<1.5	
Mean		31.5	24.8	<15.3	>42.8	<15.0	8.3	20.8	<6.7	<9.8	<7.9	
first falls												
14.	6	33.5	43.0	<4.6	95.5	<2.3	0.0	0.0	<0.5	<0.5	2.3	
second falls												
15.	7	43.2	36.9	<3.7	>90.4	3.3	0.0	>2.4	<0.5	<0.5	1.8	
Kokwaskey Lake												
16.	8	34.5	34.0	<5.5	>85.5	4.0	0.0	<6.0	<2.5	<3.5	3.2	
John George and Klept lakes												
17.	9	45.0	22.3	35.3	54.5	7.0	<1.0	<3.3	16.8	16.3	<9.3	
Kha Lake												
18.	10	42.0	28.5	<21.3	>70.5	2.3	0.8	5.3	<5.2	<5.2	12.0	
19.	11	55.0	37.0	13.6	79.0	3.8	0.8	3.0	<1.4	<0.8	12.3	
Mean		48.5	32.8	<17.5	>74.8	3.1	0.8	4.2	<3.9	<3.0	12.2	
Stukolait Lake												
North Kwoiek Creek												
20.	1	34.5	18.0	<5.0	>90.0	<5.0	0.0	0.0	0.0	0.0	<0.4	
21.	2	51.5	21.0	23.5	44.5	22.5	0.0	9.5	8.5	7.0	13.0	
22.	3	42.3	39.3	<8.6	>87.8	2.0	0.0	<2.0	<3.4	<3.4	<4.9	
Mean		42.8	26.1	<12.4	>74.1	<9.8	0.0	<3.8	<4.0	<3.5	<6.1	

* inaccuracy (>, <) due to various limitations of parameter measurements in the field, at the given site

Temperatures appear to have been somewhat colder in North Kwoiek Creek; 5.5°C at all locations (Table 2). The timing of investigations for this stream was similar to (or prior to) most of that for the Kwoiek Creek mainstem, upstream of Kwoiek Lake (6°C to 8°C; Table 2). Chochiwa Creek, was the coolest stream encountered (5°C), but it was also the last to be investigated (October 23).

4.2.2 Kwoiek Creek mainstem downstream of Kwoiek Lake

Generally speaking, the Kwoiek Creek mainstem downstream of Kwoiek Lake may be characterized as steep, bouldery, and turbulent. The mean gradient over the 14 km of stream from the mouth to Kwoiek Lake is close to 5.5%.

Based on mapping, aerial photography, and field observations, this section of the system is viewed to consist of 5 distinct reaches. As observed in October 1995, the following generalities apply to all of these reaches: 1) rapids were the dominant hydraulic habitat type; 2) pools were few, and were principally in the form of sidepools, behind large bed and/or bank materials; 3) cover for fish was greatly dominated by boulders and other bed materials; and 4) gravel abundance, and associated spawning habitat⁸, was very limited (Tables 2 and 3).

Reach 1 extends from the mouth of the system to a railway crossing approximately 400 m upstream (Fig. 3). Gradient is moderately steep (9.5%; Table 2), large boulders dominate the bed materials, and rapids dominate the hydraulic conditions (Fig. 4). Despite the large size of the bed materials, rearing potential for both juvenile and adult⁹ fish was limited by the velocity and turbulence of flows. In addition, the abundance of viable spawning habitat was judged to be extremely low for both fall and spring spawning populations (Table 3).

However, there is some spawning potential in a side channel to Reach 1, that appears to have originated as an earlier access road. Although the lower portion of this channel is steep (> 10%) and bouldery, there are substantial gravels in the upper 80 m. Gradient is moderately low (2%), and as observed in October 1995, hydraulic conditions were dominated by riffles and glides (Fig. 5). The combination of steep gradient and relatively low flows (0.24 m³/s on October 17, 1995) may obstruct the upstream passage of fish during the fall, at least. However, access may be achieved from the Kwoiek Creek mainstem, at the upstream end of the channel.

⁸. Fall spawning habitat was directly evaluated from the conditions observed during the October 1995 field investigations. Spring spawning habitat was estimated on the basis of envisioned conditions at high flows. This included perception of altered depth/velocity conditions within the channel, as well as any additional gravel accumulations likely inundated at higher flows, but dewatered at the time of investigation.

⁹. Unless otherwise specified, evaluation for adults related to resident (nonanadromous) fish.

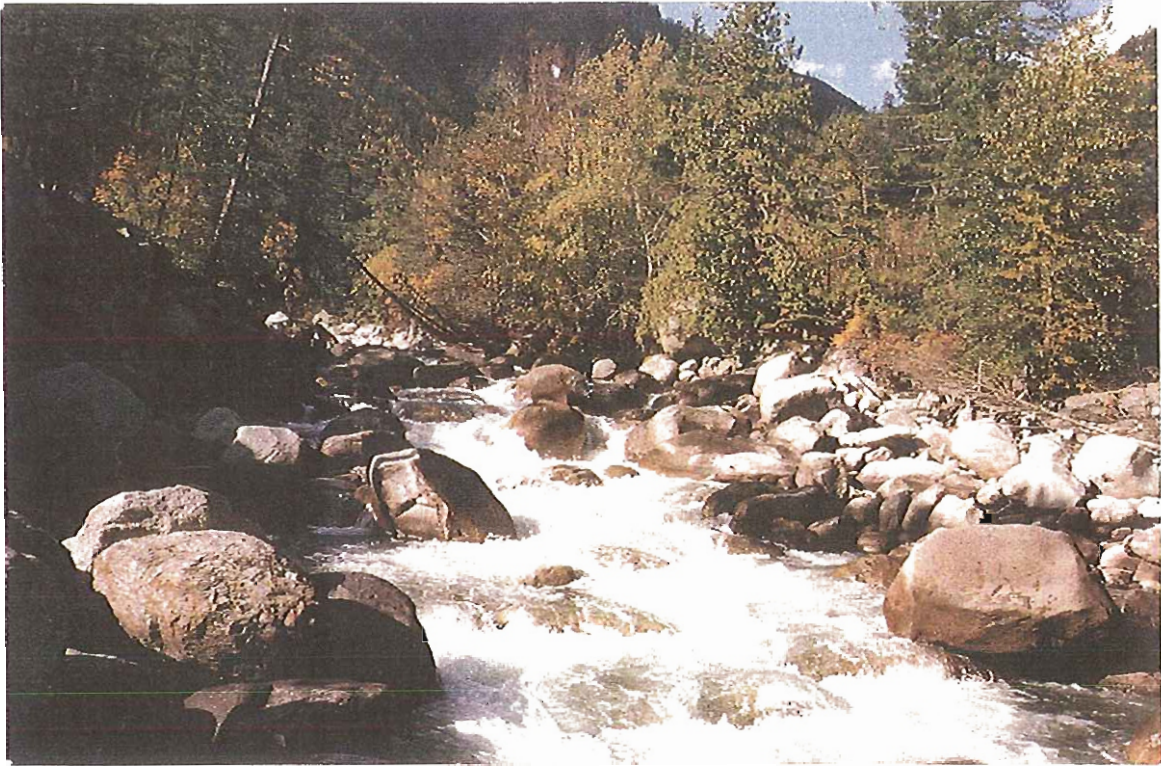


Figure 4. Kwoiek Creek mainstem, Reach 1; habitat survey 1 (vicinity of electrofishing site 1).



Figure 5. Upper end of side channel adjacent to Kwoiek Creek, Reach 1 (electrofishing site 2).

The structure under the railway bridge at the top of Reach 1 is not a culvert, as such, but rather an uncovered box-shaped concrete flume. It has a uniform gradient of approximately 3%, a flat bottom and sides, and is not baffled in any way. As observed in October 1995, it constituted 40 m of extremely difficult passage for fish, and was judged to be a very likely barrier to all species and stocks. At time of inspection, flows entered the top of the structure at an average depth of approximately 40 cm, and a velocity of 50-60 cm/s. These flows were rapidly accelerated (Fig. 6), becoming extremely swift and shallow (estimated at >2 m/s, and frequently <10 cm depth; Fig. 7).

Reach 2 of the Kwoiek Creek mainstem extends from the railway bridge and flume to another obstruction (cascades) 3 km further upstream (Fig. 3). Due to turbulence, and lack of tailhold, the cascades at this location (Fig. 8) were judged to constitute a potential barrier for smaller resident adults (at least), at the observed flows. A bypass (high water) channel is present, but was clearly impassable, due to lack of flow (Fig. 9). It is very likely, however, that the stepped profile of this channel might facilitate passage conditions at higher flows.

In Reach 2, pools are somewhat more abundant than in Reach 1 (Table 2), but remain principally confined to the stream margins, as sidepools behind large bed and/or bank materials (Figs. 10 and 11). These areas offer somewhat greater rearing potential for both juvenile and adult fish in the second reach (Table 3). Cover is greatly dominated by boulders and other bed materials. Gravels are slightly less abundant in the base flow channel of Reach 2, even compared to Reach 1. However, there are occasional high water braids in which gravel accumulations may offer additional spawning potential at higher flows (ie. in the spring).

Reach 3 extends for another 3 km upstream of the cascades at the top of Reach 2 (Fig. 3). The dominance of swift turbulent flows persists, as in Reaches 1 and 2 (Figs. 12 and 13). There are fewer pools, and rearing potential was judged to be relatively low for both juveniles (especially) and adults (Table 3). Gravels and associated spawning potential were particularly limited in this reach.

However, the upper end of the bypass channel around the falls at the top of Reach 2 offers a limited amount of superior spawning and juvenile rearing habitat, at the downstream end of Reach 3 (Fig. 14). Due to its exceptional nature, a separate survey was conducted for the habitat within this channel. Results are provided in Appendix 3 (survey 4), but have been excluded from Tables 2 and 3, which address conditions in the main channel only.

The profile of the above side channel is stepped, and pool habitat is more abundant (Table 2). Although the full channel width is 11 m, the wetted width was just 3.5 m at time of investigation in October 1995. The small volume of flow (0.08 m³/s) provided little habitat for adults (15% of wetted area with adequate depth/cover), but superior conditions for juveniles (43% of wetted area). Although there was very little viable spawning habitat at the time of investigation (<1.8% of total wetted area), substantial accumulations of gravels, in dewatered portions of the channel, were judged likely to provide considerably greater spawning opportunity at higher flows (est. 9% of total channel area).



Figure 6. Upper portion of flume under the railway crossing at the top of Kwoiek Creek Reach 1 (viewed from above).



Figure 7. Lower portion of flume under the railway crossing at the top of Kwoiek Creek Reach 1 (viewed from above).

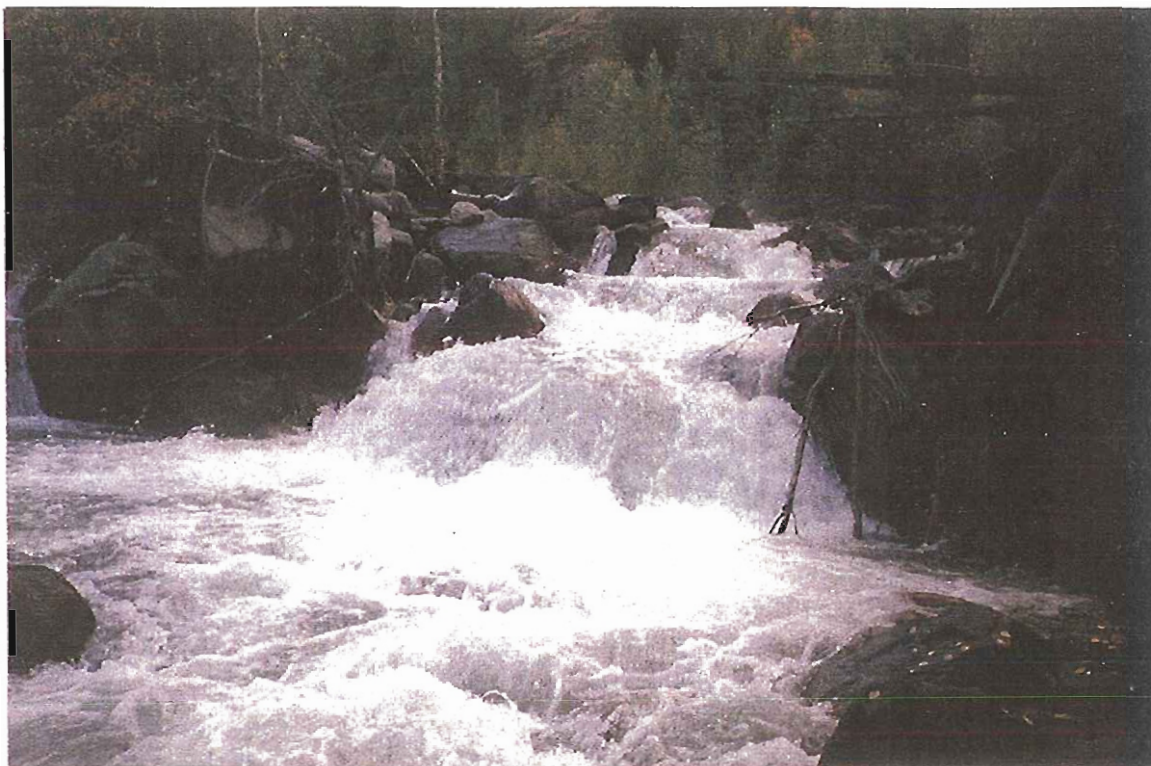


Figure 8. Cascades at the top of Kwoiek Creek mainstem, Reach 2.



Figure 9. High water bypass channel around the cascades at the top of Kwoiek Creek, Reach 2.



Figure 10. Kwoiek Creek mainstem, mid Reach 2; habitat survey 2 (electrofishing site 3 at left).



Figure 11 Kwoiek Creek mainstem. upper Reach 2; habitat survey 3



Figure 12. Kwoiek Creek mainstem, mid Reach 3; habitat survey 5 (electrofishing site 7 in foreground).

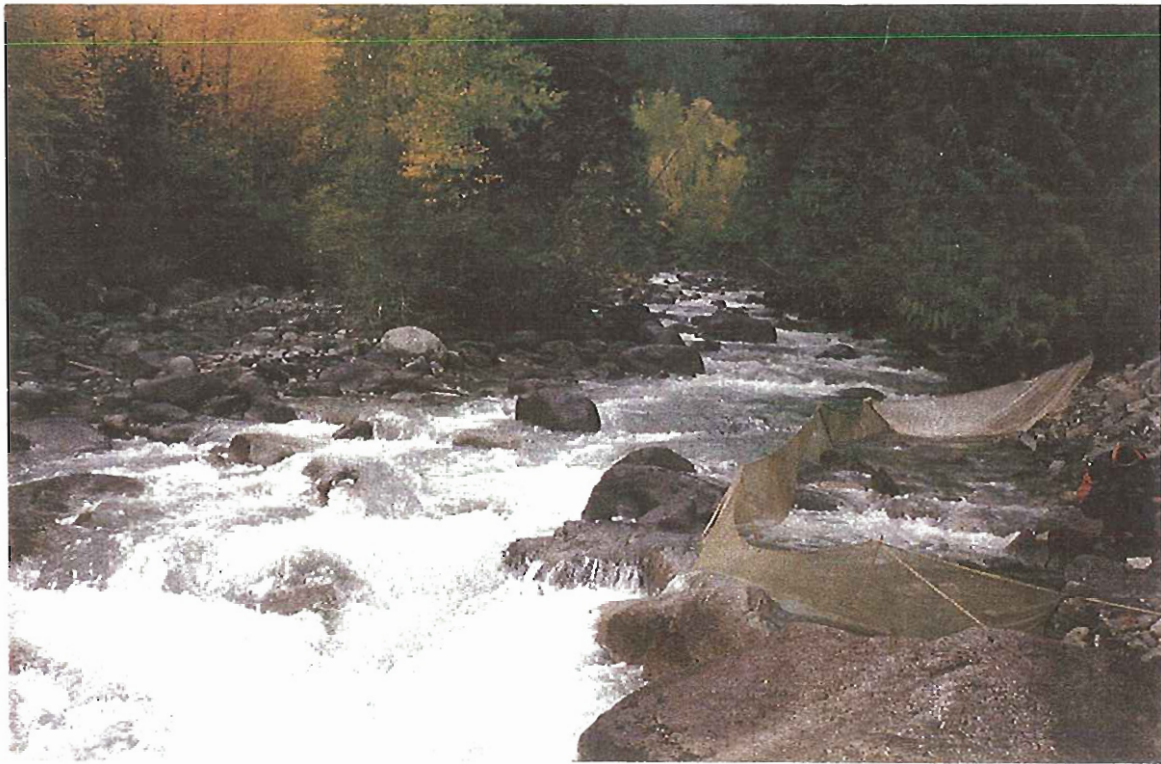


Figure 13. Kwoiek Creek mainstem, upper Reach 3; habitat survey 6 (electrofishing site 9 at right).

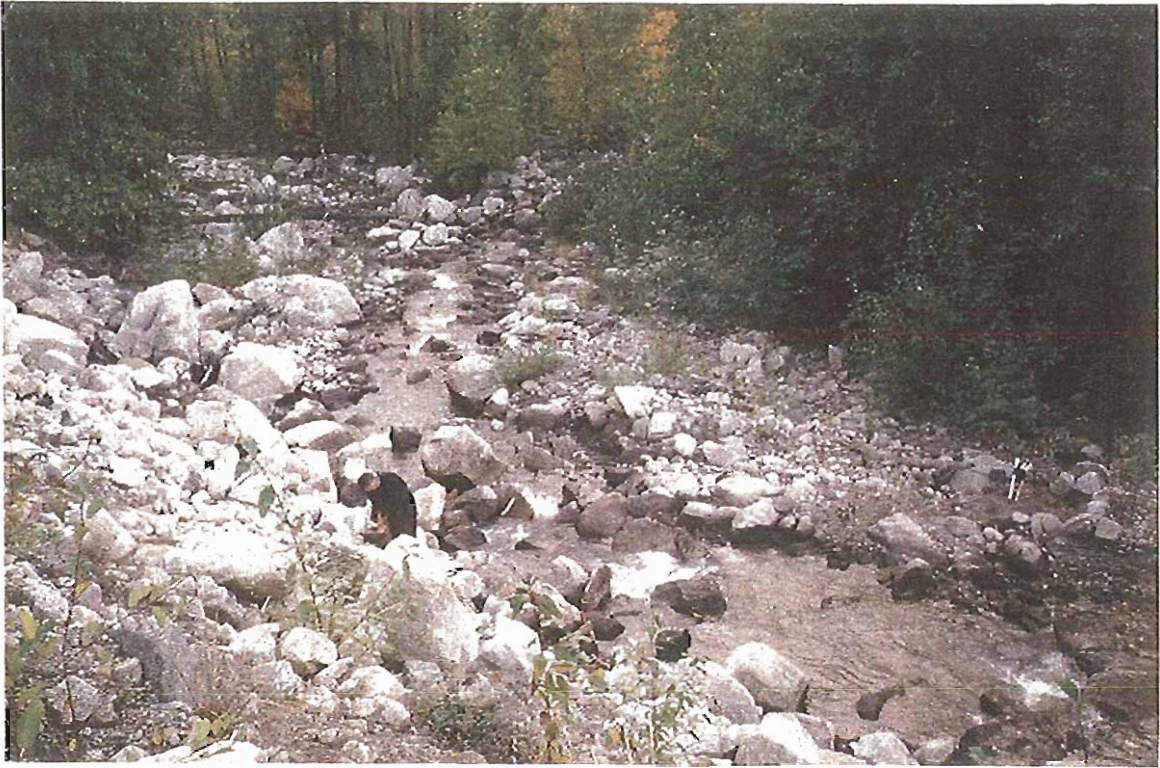


Figure 14. Side channel at the downstream end of Kwoiek Creek mainstem, Reach 3; habitat survey 4 (location of electrofishing site 5).

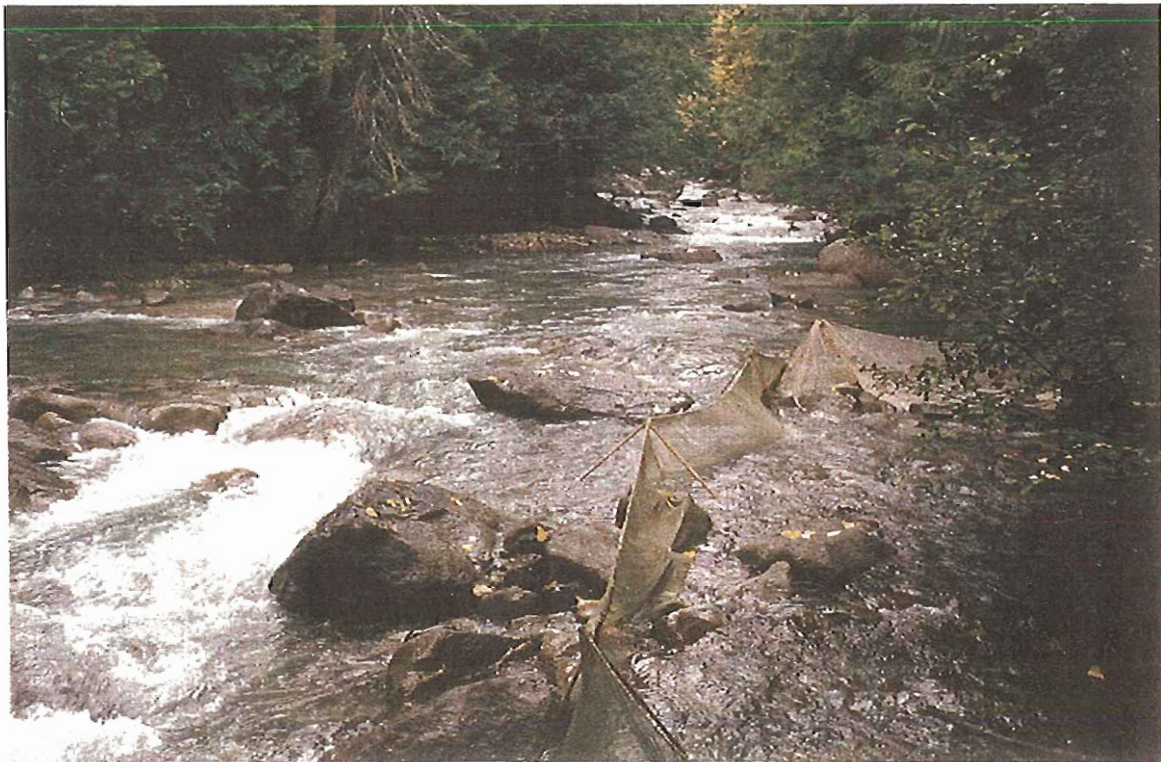


Figure 15 Kwoiek Creek mainstem, lower Reach 4; habitat survey 7 (electrofishing site 10 at right).

Reach 4 of the Kwoiek Creek mainstem is 5.5 km in length, and ends just upstream of the North Kwoiek Creek confluence (Fig. 3). In this reach, gradient drops rather abruptly, to a mean 2.2% (compared to an average of 8.1% for Reaches 1 to 3). However, this was not accompanied by any significant increase in pool area (Table 2). Rapids still predominated, to varying degrees, but there was a distinct increase in the proportion of glides (Fig. 15).

Particularly in the lower part of the reach (survey 7; Fig. 3), there was a corresponding increase in the suitability of habitat for juvenile fish (37.0% of total wetted area with suitable hydraulic conditions and cover). This declined further up the reach (survey 8; Fig. 3), where boulder sizes tended to be smaller (Fig. 16), pool habitat was more limited, and rapids were more abundant (Table 2).

For adult fish, conditions were judged to be marginally superior throughout Reach 4, compared to most areas downstream (Table 3). Perhaps most significant, however, was the increase in viable spawning habitat within the base flow channel of Reach 4. Even so, however, the absolute abundance of such habitat was not great (ca. 2-2.5% of wetted area; Table 3), and conditions suggested further limitation at higher flows (ie. for spring spawning).

Reach 5 of Kwoiek Creek is the 2 km immediately downstream of Kwoiek Lake (Fig. 3). For most of this length, gradient remains relatively low, and riffle/glide habitat predominated at the time of investigation (survey 9; Table 2; Fig. 17). Depth and cover conditions were assessed to be particularly well suited to juvenile fish, while also good for adults (Table 3). But once again, the most significant feature was the further increase in viable spawning habitat, assessed to constitute 6.3% of the total wetted area, at the flows observed (Table 3). Once again, however, channel features suggested a net decline in spawning potential at higher (spring) flows.

There is a short (100m) steeper section and series of cascades (Fig. 18) at the top of Reach 5, immediately downstream of Kwoiek Lake. Due to the stepped profile of this section, it is unlikely that the passage of most adult fish is seriously impeded, at any flow. The step pools also provide superior habitat for both juveniles and adults (survey 10; Table 3). However, as might be expected, spawning habitat (at any flow) is extremely limited within this section.

4.2.3 Kwoiek Creek mainstem between Kwoiek and Kokwaskey lakes

Reach 6 of the Kwoiek Creek mainstem extends from Kwoiek Lake to two sets of falls, commencing approximately 3 km upstream. The first are 6 m in height, in three steps (Fig. 19). They are obstructed by logs, and likely constitute a barrier to smaller adults, at least. However, once again a bypass channel is present, and should facilitate passage of fish at higher flows (judged to be inadequate at time of observation). The second falls are 7.5 m high and are near-vertical (Fig. 20). These falls constitute a most definite barrier to all upstream passage of fish, approximately 3.5 km upstream of Kwoiek Lake.



Figure 16. Kwoiek Creek mainstem, upper Reach 4; habitat survey 8 (electrofishing site 11 in foreground).



Figure 17. Kwoiek Creek mainstem, lower Reach 5; habitat survey 9.



Figure 18. Cascades below the outlet of Kwoiek Lake; top of Kwoiek Creek Reach 5.



Figure 19. First set of falls at the top of Kwoiek Creek Reach 6, 3 km upstream of Kwoiek Lake.



Figure 20. Second set of falls at the top of Kwoiek Creek Reach 6, 3.5 km upstream of Kwoiek Lake.

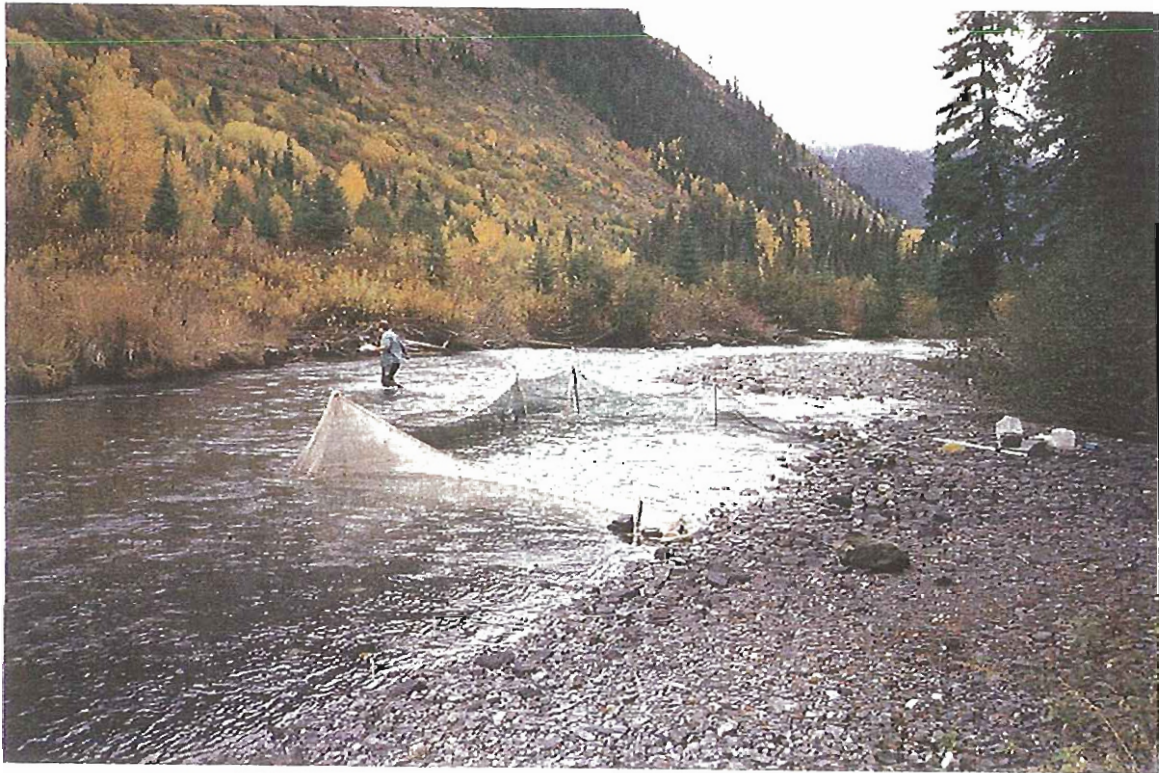


Figure 21. Kwoiek Creek mainstem, lower Reach 6; habitat survey 11 (electrofishing site 15).

Reach 6 of the Kwoiek Creek mainstem is dramatically different from the five reaches downstream of Kwoiek Lake (Tables 2 and 3). In the lowermost 2 km, gradient is predominantly low (1-1.5%), bed materials are dominated by cobbles, and hydraulic conditions by glides and riffles (Fig. 21). The bed materials offer only limited cover for fish, but the lower gradient of this reach is accompanied by a greater abundance of viable cover in the form of woody debris, cutbanks/roots, and overhanging-vegetation (Table 3; Fig. 22).

In the lower part of the reach, a greater abundance of off-channel habitat was also observed. This includes at least one small complex side channel (Fig. 23), as well as a series of isolated beaver ponds (Fig. 24), adjacent to the Kwoiek Creek mainstem, approximately 1.5 km upstream of Kwoiek Lake (survey 12; Fig. 3). At the observed flows, there was no apparent route of passage for fish between the latter ponds and the stream; however, such passage is undoubtedly possible at higher flows (eg. flood events, at least).

A substantial abundance of silts, sands, and other fine materials was also observed, consistent with the lower gradient of the first 2 km of Reach 6 (surveys 11 and 12; Table 3). However, gravels are also abundant within this section, and despite the fines, there was a substantial increase in the availability of viable spawning habitat for both fall spawning and spring spawning populations.

Towards the top of Reach 6 (survey 13; Fig. 3), gradient again increases, and there was a return to the predominance of bouldery rapids (Fig. 25) characteristic of lower Kwoiek Creek (ie. Reaches 1 to 5, downstream of Kwoiek Lake). While this provides a greater abundance of cover for fish, especially larger individuals (eg. surface turbulence), there is a corresponding decline in the abundance of gravels and associated spawning opportunity (Table 3). However, the small channel bypassing the first falls at the top of Reach 6 provides a limited amount of superior spawning and early rearing habitat (Fig. 26).

In the short section of stream between the first and second falls at the top of Reach 6 (survey 14), mainstem conditions continued to be dominated by bouldery rapids (Table 2; Fig. 27), providing good rearing potential, but extremely limited spawning opportunity. The same applied to at least the lower half of Reach 7 (survey 15; Tables 2 and 3; Fig. 28). For the purposes of this study, Reach 7 was deemed to extend from the top of Reach 6 to the outlet of Kokwaskey Lake (Fig. 3), although further delineation might be warranted for this section of stream¹⁰.

¹⁰. Mapping and aerial photography show a pond (ie. very small lake) approximately half way along Reach 7 (Fig. 3). This was not specifically investigated; nor was the section of Kwoiek Creek between this pond and the outlet of Kokwaskey Lake (constituting upper Reach 7). With a great number of drainage segments/components to be addressed during the available field time, priorities had to be established, and efforts concentrated in areas of key importance, strategically based on ongoing sampling results. This necessitated some constraint in the scope and/or detail of investigations in other areas.

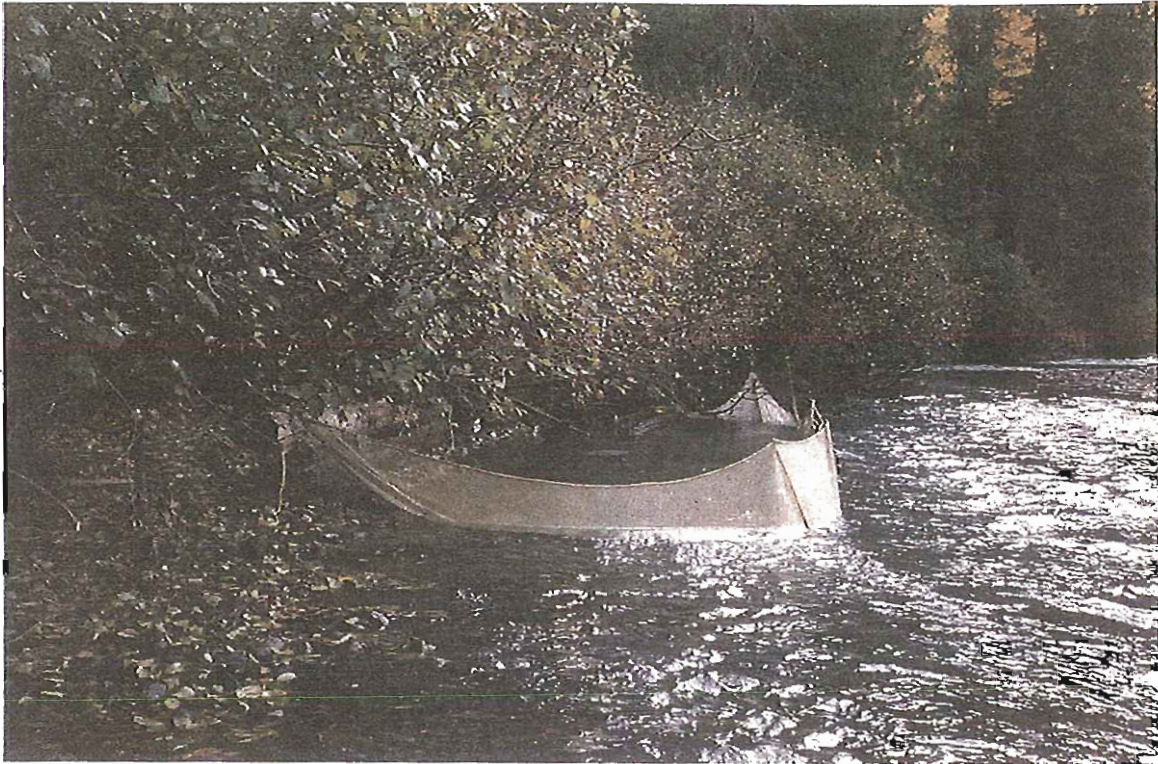


Figure 22. Kwoiek Creek mainstem, mid Reach 6; habitat survey 12 (electrofishing site 17).



Figure 23. Side channel adjacent to Kwoiek Creek mainstem Reach 6, approximately 1 km upstream of Kwoiek Lake (electrofishing site 14).



Figure 24. Beaver ponds adjacent to mid Reach 6, Kwoiek Creek mainstem.

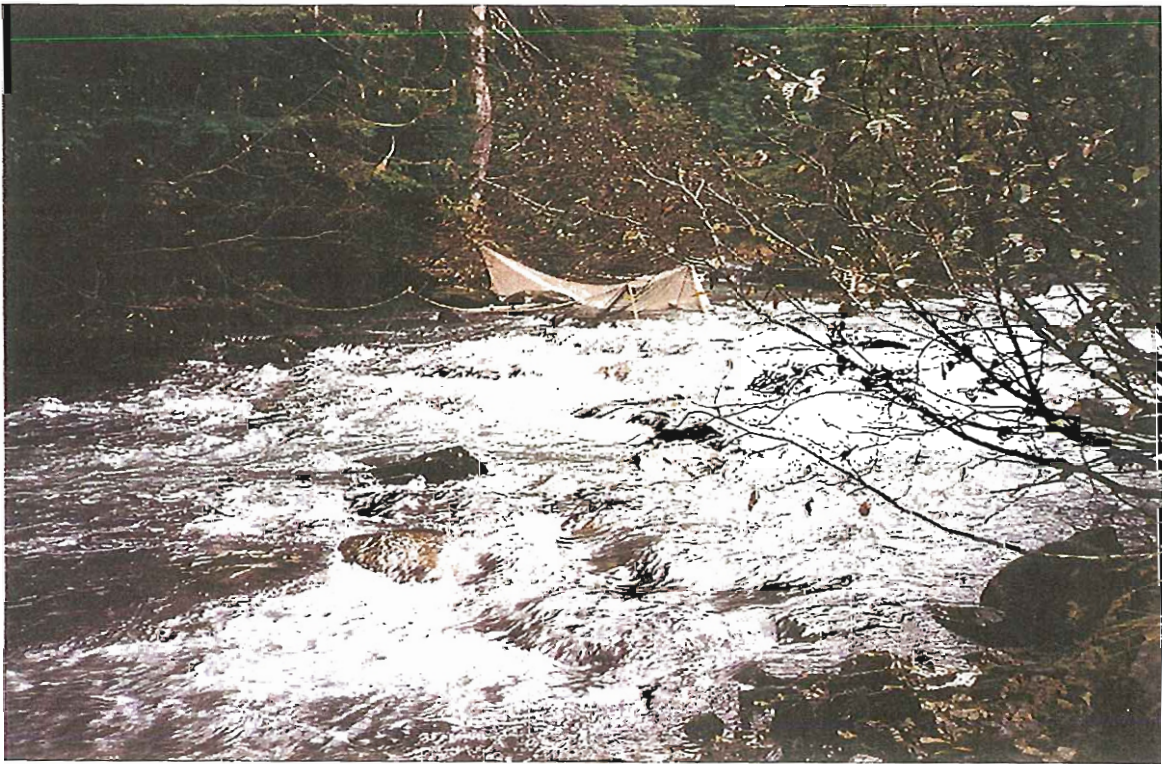


Figure 25. Kwoiek Creek mainstem, upper Reach 6; habitat survey 13 (electrofishing site 18 in background).



Figure 26. Bypass channel around the first falls at the top of Kwoiek Creek Reach 6 (electrofishing site 19).



Figure 27. Short section of Kwoiek Creek between the two sets of falls at the top of Reach 6; habitat survey 14 (electrofishing site 20).



Figure 28. Kwoiek Creek mainstem, lower Reach 7; habitat survey 15 (electrofishing site 21).



Figure 29. Kwoiek Creek mainstem, Reach 8, downstream of John George Lake; habitat survey 16.

4.2.4 Kwoiek Creek mainstem upstream of Kokwaskey Lake

For the purposes of this investigation, the 0.9 km of Kwoiek Creek between Kokwaskey and John George lakes was designated Reach 8 (Fig. 3). However, large barrier falls are present within a short steep section commencing approximately 400 m upstream of Kokwaskey Lake (Stenton and Delair, 1963)¹¹. Streamlength below these falls is discussed later, in association with Kokwaskey Lake itself.

Upstream of the falls, to the outlet of John George Lake (survey 15; Fig. 3), the Kwoiek Creek mainstem was found to be much the same as the majority of streamlength downstream (Fig. 29), but somewhat less turbulent (glides more predominant; Table 2). As in Reaches 1 to 5, and Reach 7, cover for fish was principally in the form of boulder/cobble bed materials, offering similarly good rearing potential for both juvenile and adult fish (Table 3). In association with the reduced turbulence of the section, there was an increase in the abundance of gravels and associated spawning potential, but this was only moderate.

Conditions were quite different in the two short sections of Kwoiek Creek (0.5 km and 0.3 km) between John George, Klept, and Kha lakes, respectively. These sections are very similar, and collectively constitute Reach 9 (Fig. 3). Gradient is much lower, and pool/glide habitats were dominant (65% of total wetted area), at the time of investigation (Table 2).

In general, the two short sections of stream comprising Reach 9 were judged to provide superior spawning and juvenile rearing habitat for the system (Figs. 30 and 31), although potential for adult fish was limited by channel size/depth, and the availability of suitable cover for such individuals (Table 3).

Reach 10 of the Kwoiek Creek mainstem extends from Kha Lake to major cascades (definite barrier to fish) 3.5 km upstream (Fig. 32). Although gradient remains moderately low within this section, there was a return to more turbulent riffle/rapid habitat (Table 2). This was more subdued, compared to areas downstream, due to the smaller size of bed materials (Fig. 33).

The most significant observation in this reach was the increased abundance of sands, silts, and other fine bed materials. Although gravels are moderately abundant, they tend to be smothered and consolidated by these materials (Fig. 34).

In terms of rearing potential, conditions were judged to be good for both juvenile and adult fish (Table 3). For all age groups, this was principally due to the more subdued riffle/rapid habitat, which enabled fuller exploitation of the total wetted area, while at the same time offering cover in the form of bed materials and surface turbulence. Substantial debris cover was also present (Table 3; Fig. 33).

¹¹. Consistent with the preceding footnote, these falls were not inspected in the field; however, they are clearly evident in aerial photography.



Figure 30. Kwoiek Creek mainstem, Reach 9, between Klept and Kha lakes; habitat survey 17 (electrofishing site 23).



Figure 31. Gravels in Kwoiek Creek Reach 9, upstream of Klept Lake.



Figure 32. Cascades at the top of Kwoiek Creek mainstem Reach 10, 3.5 km upstream of Kha Lake.



Figure 33. Kwoiek Creek mainstem, lower Reach 10; habitat survey 18.



Figure 34. Fines accumulations within Kwoiek Creek mainstem Reach 10, upstream of Kha Lake.



Figure 35. Kwoiek Creek mainstem, lower Reach 11; habitat survey 19 (electrofishing site 26 at right).

There is a short swampy section towards the top of Reach 10, in which a series of ponds and side channels are present, similar to those in Reach 6. However, this was the only off-channel habitat observed in Reach 10.

Reach 11 of Kwoiek Creek represents the final 1.7 km of streamlength to the outlet of Stukolait Lake (Fig. 3). At its lower end (habitat survey 19), this reach chiefly consisted of alternating glide and rapids sections, at the time of investigation. Glide habitat was dominant overall, and rearing conditions were judged to be exceptionally good for juvenile fish, in particular (Table 3). As in Reach 10, large woody debris contributed moderately to total cover availability (Fig. 35).

The abundance of fine bed materials in lower Reach 11 was slightly higher than that in Reach 10. Gravels were less abundant, and due to these conditions, spawning potential was correspondingly low (Table 3). With increasing gradient towards Stukolait Lake, the upper half of Reach 11 becomes progressively dominated by a series of bedrock falls and cascades, again constituting total barriers to the upstream migration of fish, and offering little in the way of productive rearing habitat.

4.2.5 North Kwoiek Creek

During the October 1995 field activities, the lowermost 10.5 km of North Kwoiek Creek was investigated. This streamlength was deemed to consist of 3 reaches (Table 2), although further separation might be justified with more detailed and specific assessment of this stream.

As observed in October 1995, the first reach (3.5 km) of North Kwoiek Creek was dominated by turbulent bouldery habitat (Fig. 36) not unlike that in the lowermost Kwoiek Creek mainstem (ie. Reaches 1 and 2), but smaller and considerably steeper (Table 2). Stenton and DeLair (1963) reported a series of likely barrier falls in this section of North Kwoiek Creek, and certainly, several points of difficult passage for fish were observed in the lowermost 450 m, investigated in October 1995.

The stepped profile does provide substantial rearing habitat for juvenile fish, but at the observed flows (0.49 m³/s), potential for adults was judged to be limited (Table 3). A few gravels are present, but tend to be blended with larger materials, and offer very little (if any) spawning opportunity.

However, just above the mouth of North Kwoiek Creek, there is a small side channel (120 m in length) that contains an abundance of gravels, as well as complex rearing habitat for juveniles (Fig. 37). Unfortunately, most of the gravels are highly impregnated and consolidated with fines (habitat survey 20; Appendix 3). Furthermore, there is a likely gradient barrier near the downstream end of the channel, and inflows may be too diffuse to enable fish access at the top end of the channel.



Figure 36. North Kwoiek Creek, Reach 1, 350 m upstream of the Kwoiek Creek mainstem; habitat survey 20.



Figure 37. Side channel adjacent to North Kwoiek Creek Reach 1, 200 m upstream of the Kwoiek Creek mainstem (electrofishing site 27).

After the steep 3.5 km of Reach 1, the gradient of North Kwoiek Creek drops abruptly (Table 2). For the next 3 km (Reach 2), this was reflected in the predominance of riffle/glide habitat, over cobble/gravel substrates (Fig. 38). Although there is evidence of recent and ongoing deposition of fines within this section of North Kwoiek Creek (habitat survey 21; Appendix 3), viable spawning habitat is quite abundant for both fall spawning and spring spawning populations (Table 3). With considerable diversity in cover elements for fish, including woody debris (Table 3), rearing conditions were particularly good for juveniles, under the observed conditions. Once again, however, suitable cover appeared to be more limited for adults.

Approximately 6.5 km upstream of the Kwoiek Creek mainstem, the gradient of North Kwoiek Creek increases slightly, but there is a considerable change in habitat conditions (Fig. 39). Once again, bouldery rapids were dominant at the time of observation (Table 2). Some woody debris and other forms of bank cover are present, but bed materials provide the great majority of cover for both juvenile and adult fish (Table 3). With great diversity of water depth/velocity conditions across the wetted width (Fig. 39), rearing conditions were judged to be equally good for all sizes/ages of fish, at the time of observation (Table 3).

Gravels are not as plentiful as they are in Reach 2, but still occur in sufficient abundance to provide some viable spawning potential (both fall and spring; Table 3). The influence of fines was again evident, especially in pools; however, patches of clean loose gravels were routinely found in glide habitats (habitat survey 22; Appendix 3).

4.2.6 Other tributaries to Kwoiek Creek

As noted earlier, Chochiwa Creek and numerous smaller streams tributary to Kwoiek Creek were also investigated during the October 1995 field program. Pertinent habitat data and observations were recorded, but to accommodate other data collection priorities, full habitat surveys were not conducted for these streams.

The 1 km of Chochiwa Creek between Kokwaskey and Chochiwa lakes (Fig. 3) is followed by a trail¹², and was investigated in association with the surveys of Kokwaskey and Chochiwa lakes, during the 1995 field program. As previously reported (Stenton and DeLair, 1963), barrier falls (Fig. 40) are located on this section of stream, approximately midway between the two lakes.

The stream itself is quite complex, especially downstream of the falls (Fig. 41). Gradient is relatively low (generally <2%), and at the time of observation, glide habitat was predominant. Large cobble and boulders constitute the majority of bed materials, and provide abundant cover for fish, especially juveniles. There are also frequent sidepool areas, often containing complex debris cover (Fig. 41).

¹². Kwoiek Lakes Trail, B.C. Forest Service Recreation Sites, Lillooet Forest District.



Figure 38. North Kwoiek Creek, Reach 2; habitat survey 21 (electrofishing site 29).



Figure 39. North Kwoiek Creek, Reach 3; habitat survey 22.

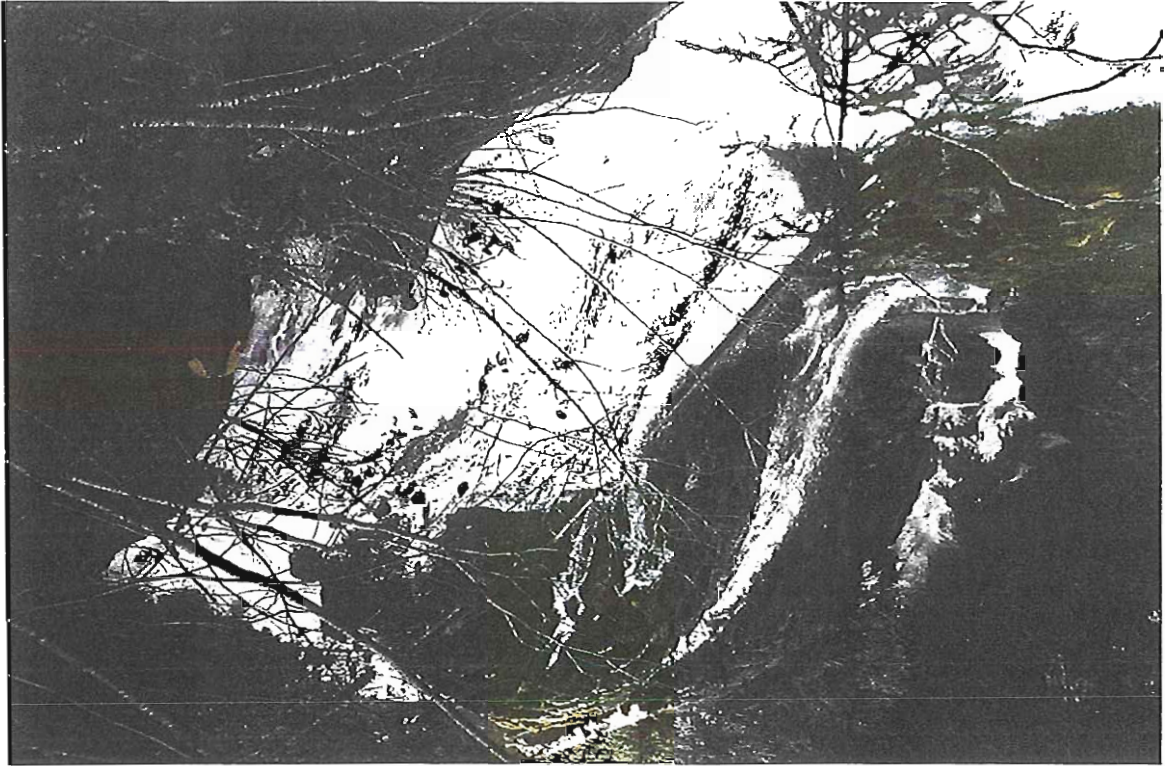


Figure 40. Barrier falls on Chochiwa Creek, approximately 500 m upstream of Kokwaskey Lake.



Figure 41. Chochiwa Creek, between Kokwaskey Lake and the barrier falls.

The major shortcoming, however, is the low abundance of gravels (<5% of substrates), and moderately high abundance of fines (*ca.* 10%). Both serve to severely restrict spawning potential. In Chochiwa Creek, a particularly high clay component was noted in the sediments. Discharge was measured at 0.41 m³/s on October 23, 1995.

Three other moderately large tributaries (for the drainage) were also investigated. The first is the unnamed stream which originates from Kwoiek Needle, to the south, and flows into the Kwoiek Creek mainstem 2.5 km upstream of Kwoiek Lake (unnamed tributary B; Fig. 3). Near its confluence with Kwoiek Creek, this stream is quite steep (> 15%), and consists of a series of step falls and pools (Fig. 42). Cover is abundant, principally in the form of boulders and woody debris. Some gravels are present (*ca.* 10% of bed materials), and are occasionally concentrated in small patches, potentially suitable for spawning. Very few fines were observed. Discharge in this stream was measured at 0.23 m³/s on October 15, 1995.

Antimony Creek originates from Antimony Lake (north of Kha Lake) and flows into the Kwoiek Creek mainstem at the point of inlet to Klept Lake (Fig. 3). Gradient is moderately steep (> 10%) in this stream as well, and there are numerous small step falls and cascades (Fig. 43). However, there are also substantial pool/glide sections providing excellent habitat for fish. Although bed materials tend to be relatively small (< 30 cm), there is a variety of other available cover, especially in the form of woody debris. Again, gravels are moderately abundant (15% of bed materials), and occur in frequent patches potentially suitable for spawning. The amount of fines is very low. Discharge was measured at 0.17 m³/s on October 17, 1995.

Another substantial tributary is the unnamed stream which drains a series of lakes to the west of Stukolait Lake, and flows into the Kwoiek Creek mainstem 1.5 km downstream of Stukolait Lake (unnamed tributary E; Fig. 3). Topographic mapping and aerial photography indicate potentially productive habitat in middle sections of this stream. However, the first 300 m consists of one major falls after another (mean gradient > 40%), with only occasional pockets of habitat suitable for fish (Fig. 44). The only possible colonization of such habitat would be by displacement of fish from areas upstream. Due to conditions, discharge could not be measured, but was estimated at 0.3 m³/s.

Most of the other streams investigated were found to be minor, and of little (if any) potential in terms of fish production. This included the outlet stream from Vesuvianite Lake (unnamed tributary Fig. 3), and the neighbouring stream draining an unnamed lake, immediately to the west (unnamed tributary D; Fig. 3). Both are small and steep (20% to 40%), and are little more than continuous cascades (Figs. 45 and 46). Several other small streams were found to be totally dry, or nearly so. This included Cedarbench Creek, and the lake headed tributary to John George Lake, flowing from the southwest (Fig. 3).

One small stream of particular importance is that which flows from the south, and enters the Kwoiek Creek mainstem approximately 1 km upstream of Kwoiek Lake (unnamed tributary A; Fig. 3). The original course of this stream is the side channel described earlier, and shown in Figure 23. A new channel, and point of entry to Kwoiek Creek, now runs down a hauling road



Figure 42. Unnamed tributary (B) draining Kwoiek Needle; electrofishing site 32 conducted immediately above mouth.



Figure 43. Antimony Creek, 200 m upstream of Kwoiek Creek mainstem (location of electrofishing site 34).



Figure 44. Unnamed tributary (E) to Kwoiek Creek Reach 11, 1.5 km downstream of Stukolait Lake.



Figure 45. Outlet stream from Vesuvianite Lake, 400 m upstream of the Kwoiek Creek mainstem.



Figure 46. Unnamed tributary (D) immediately west of Vesuvianite Lake outlet stream, 300 m upstream of the Kwoiek Creek mainstem.



Figure 47. Unnamed tributary (A) to Kwoiek Creek Reach 6, 1.2 km upstream of Kwoiek Lake.

which previously crossed the Kwoiek Creek mainstem at this location (Fig. 47). Although the new channel offers little cover for fish, it does contain substantial accumulations of gravel, potentially suitable for both fall and spring spawning. However, this is constrained by the substantial amounts of fine materials that are also present (*ca.* 15%).

4.2.7 Degradation of stream habitat

Unnamed tributary A is perhaps the worst example of deleterious impacts of forest harvesting, in the Kwoiek Creek drainage. This stream has been *severely* disturbed, including complete removal of riparian vegetation (Fig. 47). However, the most significant detail was the observation of extreme turbidity in this tributary, and a resultant brown plume in the Kwoiek Creek mainstem, following heavy rain showers on October 15. The source of this turbidity appears to be a substantial road failure and slide, towards the top of this stream¹³.

On the positive side, such extreme impacts do not appear to be widespread within the Kwoiek Creek drainage. However, the partial or complete removal of riparian vegetation is widespread. This certainly applies, most profoundly, to many small streams in harvested areas (eg. Fig. 46). However, it also applies to North Kwoiek Creek and the Kwoiek Creek mainstem.

With respect to the mainstem, some earlier disturbances of the riparian zone are evident downstream of Kwoiek Lake, especially in the vicinity of (and upstream of) the North Kwoiek Creek confluence (eg. Fig. 17; habitat surveys 9 and 10, Appendix 3). However, the most notable impacts are along Reach 6, upstream of Kwoiek Lake (Fig. 21), and Reaches 10 and 11, between Kha and Stukolait lakes (Fig. 32 and 48). It is these areas where substantial depositions of fines were observed in the Kwoiek Creek mainstem (eg. Fig. 33), during the 1995 investigations (habitat surveys 11, 12, 18 and 19; Appendix 3).

To some extent, these depositions might obviously be attributable to natural processes, especially with the lower gradient of Reaches 6, 10 and 11 (Table 2). In 1962, prior to the development of access and harvesting in the Kwoiek Creek drainage, Stenton and DeLair (1963) reported a *heavy silt load* resulting from natural causes (glaciers), affecting *the whole river and lake system*. These conditions led to the conclusion that the system was *unsuitable for the production of large quantities and size of fish*.

As will be evident from the discussion of the 1995 fish sampling results, the latter conclusion was incorrect. With respect to natural glacial siltation of the system, this certainly did not appear to be severe, based on the October 1995 observations. As would be expected, varying amounts of fines were present in stream habitat throughout the system. However, for most stream sections and hydraulic habitat types, the amount of fines was usually <5% of total bed materials,

¹³. Cleary evident in 1993 aerial photography.



Figure 48. Recent forest harvesting along Kwoiek Creek mainstem Reaches 10 and 11, upstream of Kha Lake (looking east).

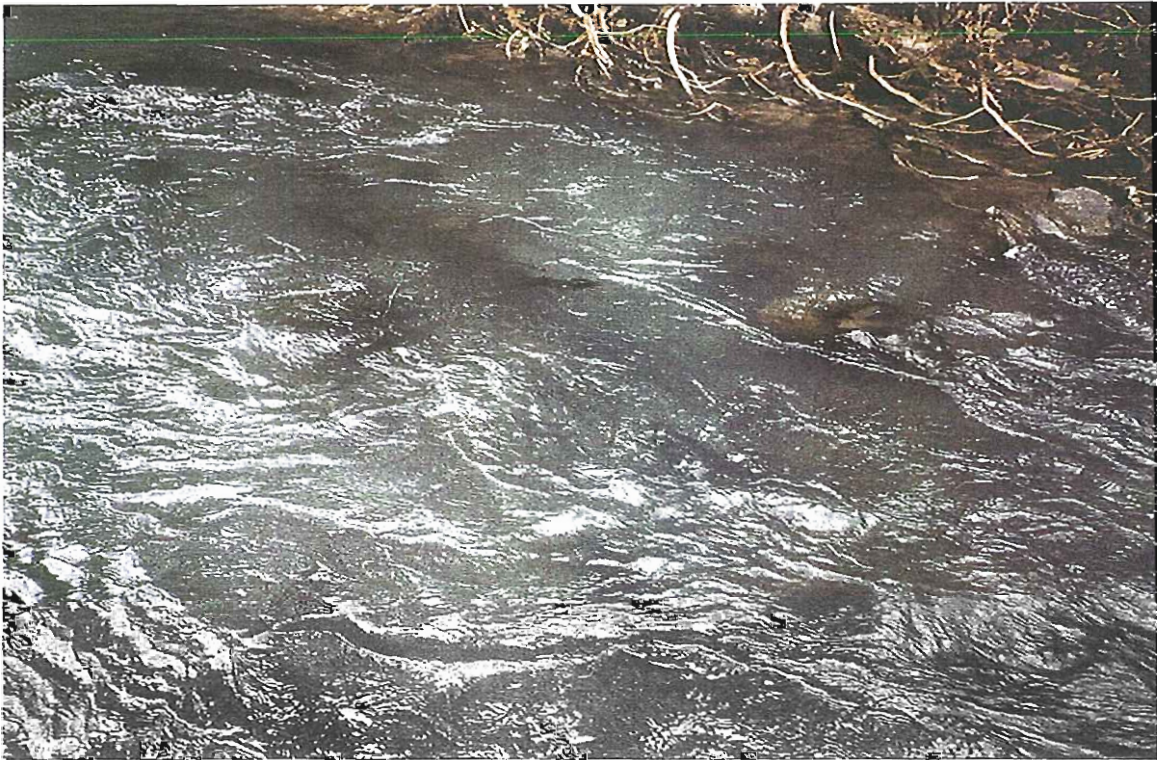


Figure 49. Glacial turbidity in Chochiwa Creek, October 23, 1995.

and frequently <1% (Appendix 3). In some stream sections other than the problem areas identified above, fines occasionally constituted 10% to 15% of bed materials in pools (*ibid.*). However, even in such cases, the overall estimate of fines content was generally <5%, when averaged (and weighted) over all hydraulic habitat types (ie. including riffles, glides, rapids, etc., Table 3).

During the October 1995 investigations, there was generally some degree of glacial turbidity (milky) in the larger streams investigated. However, in nearly all cases, this was no more than slight (Appendix 3), despite periods of heavy precipitation immediately preceding (and during) these investigations, as previously outlined. For the 7 water samples obtained over the full length of the Kwoiek Creek mainstem, and one from North Kwoiek Creek, the maximum concentration of inert suspended solids was only 4.7 mg/L (Appendix 4), and the average was just 1.9 mg/L.

Other than the severely disturbed unnamed tributary A (1 km upstream of Kwoiek Lake), Chochiwa Creek was the only stream in which higher turbidity (moderate-high) was encountered. Glacial origins were clearly evidenced by the milky blue appearance of the water (Fig. 49), consistent with the fine clay sediments observed in this stream (as previously noted).

The 1962 investigation of the Kwoiek Creek drainage was conducted during early August (Stenton and DeLair, 1963). Given the glaciers at the source of Kwoiek Creek and North Kwoiek Creek, as well as Chochiwa Creek, it is very likely that all of these streams were considerably more turbid (compared to October 1995), due to greater influence of glacial melt water during the peak of summer (eg. Fig. 2). It seems most likely that the reference to *heavy silt load*, and associated conclusions of the 1962 investigation, were primarily based on the observation of high turbidities. However, such conditions, coupled with greatly higher discharge (22.7 m³/s; *ibid.*), undoubtedly precluded direct inspection of bed materials, or any other real assessment of glacial sedimentation, and/or other influences.

In contrast, the much lower discharge in the system (3 m³/s), and the clarity of water, enabled close examination of streambed substrates in all stream sections, during the October 1995 investigations. Consistent with higher gradient and turbulent hydraulics, characteristic of the Kwoiek Creek system (Table 2), the 1995 results do not suggest any serious extent of glacial sedimentation, except in Chochiwa Creek, as previously noted.

It seems far more likely that the higher concentrations of fines (primarily silts and sands) observed in Reaches 6, 10 and 11 of Kwoiek Creek (and in Reach 2 of North Kwoiek Creek; Table 3), are attributable to the effects of adjacent forest harvesting, as opposed to natural causes. As noted above, unnamed tributary A, which flows into Reach 6, was the only stream (other than Chochiwa Creek) to display elevated turbidity during the 1995 investigations. This was brown in colour, and was most certainly attributable to the severe effects of forest harvesting, and associated road construction.

4.2.8 Evaluation of stream habitat limitations and constraints

Guidelines for the assessment of fish habitat under the Forest Renewal Program (Anon., 1994) provide a procedure and criteria for rating stream habitat and identifying constraints to fish production. Results for the stream habitat survey data collected in the Kwoiek Creek drainage during October 1995 (Appendix 3) are shown in Table 4.

To assist in the procedure, some numerical criteria were established in cases where they are not provided by the guidelines (*ibid.*). With respect to spawning, conditions were deemed to be *good* where the area of potential spawning habitat constituted $> 10\%$ of total wetted area in any given section of stream. Conditions were deemed to be *fair* where the proportion was between 2.5% and 10% of total area, and *poor* where it was $< 2.5\%$. For holding pools, a frequency of $> 20/\text{km}$ was deemed to be *good*; between 10/km and 20/km was *fair*; and $< 10/\text{km}$ was *poor*.

Cover availability was rated on the basis of total cover, assessed separately for juvenile and adult fish (Table 4). The ascribed rating was *good* where total cover was $> 25\%$ of wetted area; *fair* where it was 10% to 25%; and *poor* where it was $< 10\%$. Criteria for pool occurrence (% pool), abundance of woody debris, presence of off-channel habitat, and percentage of fine bed materials are provided in the guidelines (Anon., *op. cit.*).

Although the guidelines include consideration of pool frequency, relative to streamlength, this rating was not employed for the Kwoiek Creek data. Throughout the system, pool habitat was typically in the form of side pools, at the stream margins, under the flow conditions observed in October 1995. Generally speaking, these side pools tended to be small in area, but occurred fairly frequently, especially in the many stream sections with large streambed and bank materials. It was concluded that these conditions distorted the rating of pool occurrence provided in the guidelines, which appears to address traditional pools, sequenced and alternating longitudinally with other hydraulic habitat types (not common within the Kwoiek Creek drainage).

Despite the relatively high frequency of small side pools, the total area of pool habitat was rated as *poor*, at nearly every location in the Kwoiek Creek mainstem and North Kwoiek Creek (Table 4). However, since side pools were frequently deep and moderately complex (ie. large bed and bank materials), the number of holding areas for adult fish (migrant spawners) was consistently rated as *fair* or *good*.

In terms of rearing habitat, cover availability was generally rated *good* for both juvenile and adult fish, throughout the Kwoiek Creek mainstem. However, conditions were somewhat inferior (*fair*) for adults in Reaches 6 and 9 (Table 4).

Aside from the prevailing lack of pools and off-channel habitat, the low abundance of viable spawning substrates was the most widespread and universal shortcoming, throughout the system (Table 4). Only in lower Reach 6 and in Reach 9 of the Kwoiek Creek mainstem was

Table 4. Evaluation / diagnosis of stream habitat condition and suitability for salmonid production in the Kwoiek Creek drainage, October 1995 (following Anon., 1994).

Stream / Reach	Site No.	Percent Pool Habitat	Abundance of Woody Debris	Cover Availability		Off-Channel Habitat	Spawning Habitat		Percent Fines	Holding Pools (adults)
				Juveniles	Adults		Fall	Spring		
Kwoiek Creek mainstem										
1.	1.	Poor	Poor	Good	Good	Fair	Poor	Poor	Good	Good
2.	2.	Poor	Poor	Good	Good	Poor	Poor	Poor	Good	Good
	3.	Poor	Poor	Fair	Good	Poor	Poor	Poor	Good	Poor
3.	5.	Poor	Fair	Fair	Fair	Poor	Poor	Fair	Good	Good
	6.	Poor	Poor	Good	Fair	Poor	Poor	Poor	Good	Good
4.	7.	Poor	Fair	Good	Good	Poor	Poor	Poor	Good	Fair
	8.	Poor	Poor	Good	Good	Poor	Fair	Poor	Good	Good
5.	9.	Poor	Poor	Good	Good	Poor	Fair	Poor	Good	Fair
	10.	Fair	Poor	Good	Good	Poor	Poor	Poor	Good	Good
Predominant Rating		Poor	Poor	Good	Good	Poor	Poor	Poor	Good	Good
Kwoiek Lake ➤										
6.	11.	Poor	Fair	Good	Fair	Fair	Good	Good	Good	Fair
	12.	Poor	Good	Good	Fair	Fair*	Fair	Fair	Good	Fair
	13.	Poor	Fair	Good	Good	Fair	Fair	Fair	Good	Good
Predominant Rating		Poor	Fair	Good	Fair	Fair	Fair	Fair	Good	Fair
first falls ➤										
6.	14.	Poor	Fair	Good	Good	Poor	Poor	Poor	Good	Fair
second falls ➤										
7.	15.	Poor	Poor	Good	Good	Poor	Poor	Poor	Good	Good
Kokwaskey Lake ➤										
8.	16.	Poor	Fair	Good	Good	Poor	Poor	Fair	Good	Fair
John George and Klept lakes ➤										
9.	17.	Poor	Good	Good	Fair	Poor	Good	Good	Good	Good
Kha Lake ➤										
10.	18.	Poor	Good	Good	Good	Poor	Fair	Fair	Fair	Poor
11.	19.	Poor	Good	Good	Good	Poor	Poor	Poor	Fair	Fair
Predominant Rating		Poor	Good	Good	Good	Poor	-	-	Fair	-
Stukolait Lake ➤										
North Kwoiek Creek										
1.	20.	Poor	Fair	Good	Fair	Poor	Poor	Poor	Good	Good
2.	21.	Poor	Fair	Good	Fair	Poor	Fair	Fair	Fair	Fair
3.	22.	Poor	Good	Good	Good	Poor	Fair	Fair	Good	Poor
Predominant Rating		Poor	Fair	Good	Fair	Poor	Fair	Fair	Good	-

* beaver activity precludes access to most of the off-channel habitat in this area

spawning potential rated *good*. In the majority of areas, the rating was *poor* for both fall and spring spawning potential. As emphasized earlier, in most stream sections this is attributable to a lack of gravel substrates, as opposed to the influence of fines. In fact, the rating for fines abundance was *good* (< 12%; Anon., *op. cit.*) at nearly all sites inspected.

Exceptions were Kwoiek Creek mainstem Reaches 10 and 11 (upstream of Kha Lake), and Reach 2 in North Kwoiek Creek, where the abundance of fines was rated *fair*. However, in each of these cases, this rating was extremely marginal (12.0% to 13.0% fines; Table 3). Similarly, the *good* rating for lower Reach 6 of the Kwoiek Creek mainstem (10.8% to 11.5%; Table 3) was also marginal.

As discussed in the preceding section, the greater abundance of fines in all of the latter areas seems attributable to adjacent forest harvesting. To some extent, this has likely affected local spawning potential, especially in Reaches 10 and 11 of the Kwoiek Creek mainstem, where gravels are not highly abundant (Table 4). Although the *good* rating for fines in lower Reach 6 is borderline, gravels are sufficiently abundant here that spawning potential remains *good*, at least at the lowermost site inspected (habitat survey 11; Table 4).

In terms of other impacts, there can be little doubt that forest harvesting has led to changes in runoff rates and discharge patterns within the system (eg. Fig. 48). While the abundance of woody debris is not a problem in most areas (Table 4)¹⁴, it may contribute to fish passage difficulties at some locations (eg. Fig. 19), and occasional accumulations may lead to bank erosion at others (habitat survey 19; Appendix 3).

Consistent with all of the above, it seems safe to conclude the following as a general evaluation and diagnosis of stream habitat (and associated fish production potential), in the drainage as a whole:

1. although glacial influences do not appear to be as deleterious as previously suggested (Stenton and DeLair, 1963), the main constraints to stream production of fish *are* natural, and are related to the characteristic steepness and turbulence of streams within the system;
2. low abundance of gravels, and associated spawning potential, applies to most of the system;
3. numerous barriers (and/or obstructions) to fish passage isolate various stream sections, and drainage components;

¹⁴. Habitat assessment procedures (Anon., 1994) attach a superior rating to increasing abundances of woody debris, due to its value as fish cover. The *poor* ratings in Table 4 actually reflect a *low* abundance of woody debris in most stream habitat within the Kwoiek Creek drainage.

4. except for alterations of runoff/flow patterns, the impacts of forest harvesting appear to be localized, at present, and principally relate to increased introduction and deposition of fines;
5. these introductions/depositions of fines have likely degraded conditions in areas of key importance with respect to spawning potential; and
6. in all respects, the effects of forest harvesting (including the disturbance or removal of riparian vegetation, obstruction/instability due to debris, etc.) should be viewed as an additional aggravation to a system already subject to severe natural constraints.

4.3 Lake Habitat

A summary of morphological and limnological findings for the 7 lakes investigated in October 1995 is provided in Table 5. Further details are provided in Appendix 4 (water quality analyses) and Appendix 5 (field limnology and depth sounding). Due to blizzard conditions, habitat investigations at Stukolait Lake were restricted to the northeast quadrant (including the outlet; Fig. 3), and the collection and analysis of a surface water sample only (as previously noted).

4.3.1 Overview of morphology and associated habitat characteristics of investigated lakes

In addition to the collection of specific limnological and depth data (Appendix 5), observations were recorded with respect to the general morphology and characteristics of lakes investigated. This was aided by the completion of the depth sounding transect (recorded on paper) along the main axis of each lake, except Stukolait Lake (*ibid.*). In addition, inlets and outlets were inspected, with specific respect to fish migration and spawning potential. Any other features and/or factors of potential significance/importance to fish production were also duly noted.

Kwoiek Lake

Kwoiek Lake is approximately 1.4 km in length, and 29 ha in area. It is orientated east-west (Fig. 3), and is closely bordered by the main Kwoiek Creek Forest Service Road, along its northern shore. The maximum and mean depths appear to be 6.7 m and 3.6 m, respectively (Table 5). The shallowest areas are at the western end (Appendix 5), where Reach 6 of Kwoiek Creek flows into the lake (Fig. 50). Kwoiek Lake was the shallowest of the 7 lakes investigated in 1995, and had the highest proportional area with depths <2 m (ie. 15.8%; Table 5). Furthermore, unlike any of the other lakes investigated, the bottom of Kwoiek Lake appears to be highly irregular, presumably due to large rock materials (Appendix 5).

Table 5. Summary of limnological findings for investigated lakes in the Kwoiek Creek drainage, October 1995.

Parameter	Kwoiek	Kokwaskey	Chochiwa	John George	Klept	Kha	Stukolait
Sampling date	Oct 20	Oct 24	Oct 23	Oct 21	Oct 18	Oct 19	Oct 24
Surface area ¹ (ha)	29.3	47.0	60.3	21.5	7.5	12.8	62.5
Mean depth ² (m)	3.6	31.9	34.0	8.2	5.0	6.8	—
Maximum depth ² (m)	6.7	52.5	52.2	12.5	7.2	8.3	—
Percent <2m deep ² (%)	15.8	3.1	4.3	1.8	14.5	6.6	—
Secchi depth (m)	2.3	2.1	1.6	2.3	2.1	2.1	—
Sampling station :							
Bottom depth (m)	4.4	47.5	51.3	10.7	6.7	7.6	—
Sample depth (m)	4.0	30.0	30.0	10.0	6.0	7.0	—
Temperature (°C)							
surface sample	7.1	7.0	5.0	6.0	7.0	5.9	5.1
deep sample	7.1	6.5	5.0	5.0	6.2	5.6	—
Dissolved oxygen (mg / L)							
surface sample	9.2	7.9	7.4	9.4	8.2	8.2	9.5
deep sample	9.0	6.5	7.9	8.7	7.9	8.0	—
Dissolved solids (mg / L)							
surface sample	15.4	7.90	5.00	13.6	15.7	13.0	5.30
deep sample	15.6	7.60	4.90	13.9	17.3	13.0	—
Inert residues (mg / L)							
surface sample	2.67	3.00	9.33	2.33	2.33	4.00	2.33
deep sample	2.67	2.00	4.33	1.33	8.00	4.33	—
Volatile residues (mg / L)							
surface sample	ND	ND	ND	ND	0.667	ND	0.667
deep sample	ND	ND	0.333	ND	ND	ND	—
pH							
surface sample	7.28	6.84	6.66	7.21	7.29	7.15	6.76
deep sample	7.23	6.88	6.69	7.30	7.32	7.12	—
Alkalinity (mg / L)							
surface sample	15.0	6.5	5.5	13.0	13.5	11.0	4.5
deep sample	17.5	8.0	6.0	15.5	15.5	12.5	—
Nitrite nitrogen (ug / L)							
surface sample	ND	ND	0.296	ND	ND	ND	ND
deep sample	0.601	1.21	ND	ND	ND	ND	—
Nitrate nitrogen (ug / L)							
surface sample	29.5	23.6	25.8	12.1	29.1	40.1	63.6
deep sample	13.2	25.3	24.4	14.6	29.1	49.5	—
Ammonia nitrogen (ug / L)							
surface sample	2.98	2.98	6.01	6.01	5.00	2.98	3.99
deep sample	2.98	3.99	7.02	9.04	8.03	5.00	—
Kjeldahl nitrogen (mg / L)							
surface sample	0.397	0.224	0.303	0.407	0.388	0.309	0.188
deep sample	0.249	0.200	0.194	0.224	0.303	0.388	—
Total phosphorus (ug / L)							
surface sample	2.65	3.78	10.9	5.78	6.06	6.35	1.51
deep sample	3.21	2.65	2.93	4.35	5.49	6.06	—

¹ approximate: from aerial photography

² approximate: from single longitudinal sounding transect

ND none detected



Figure 50. The western end of Kwoiek Lake, showing the inlet at centre; viewed from the north shore of the lake.

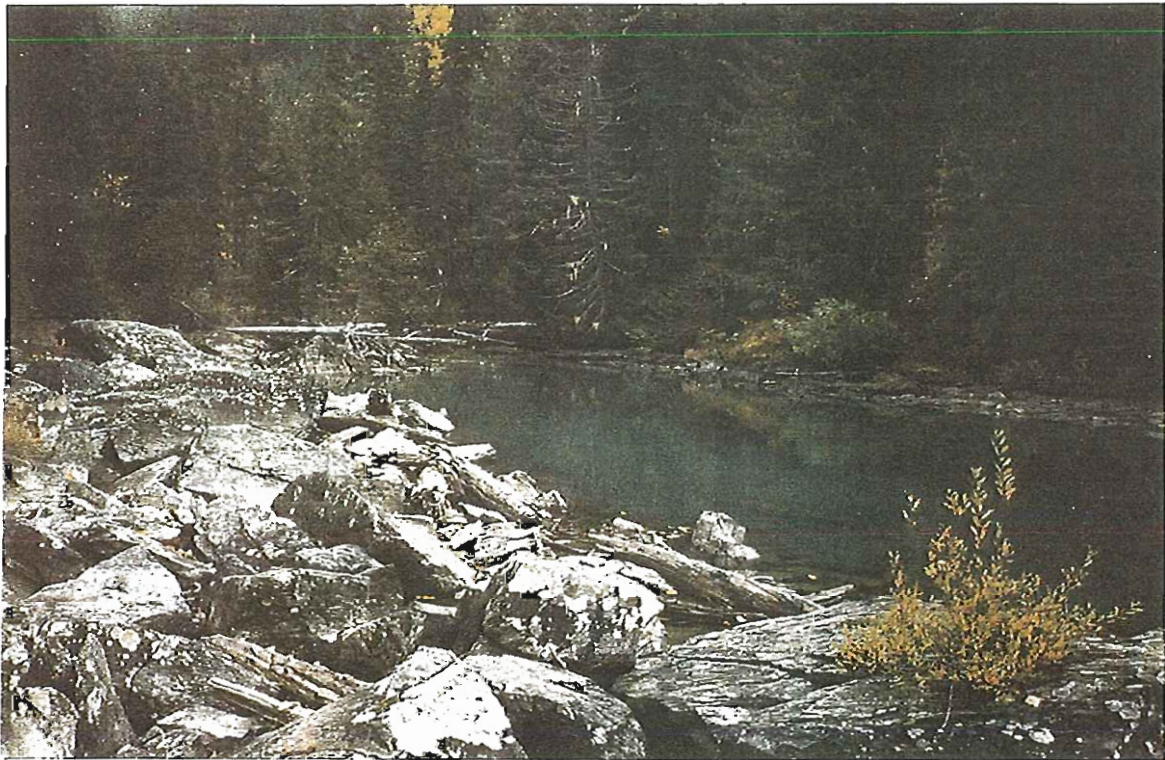


Figure 51. Bouldery shoreline of Kwoiek Lake near the outlet, at the eastern end of the lake.

Aside from the western end of the lake, the shoreline is dominated by angular cobble/boulder rubble, increasing in size towards the eastern (outlet) end of the lake (Fig. 51). Sediments are dominated by silts and sands, but tend to be minor around most of the lake's perimeter. In contrast, the western end is principally mud, extensively colonized by sedges and rushes. Even in this area, however, extremely little submerged vegetation was observed (ie. almost none), during the October 1995 investigations. The same also applies to all other lakes investigated.

The sedges and rushes cause the inlet of Kwoiek Creek to be somewhat diffuse, but no serious obstructions to fish passage were observed. Similarly, the outlet (giving rise to Kwoiek Creek Reach 5, Fig. 3) is unobstructed. A small set of cascades is present (Fig. 18), as previously noted. These are stepped, and should not pose a problem to the passage of adult fish. However, success in the upstream passage of juveniles would be doubtful (especially for fry and yearlings).

A low to moderate amount of woody debris is present around the lake's perimeter, but there was no significant accumulation at the outlet when investigated in October 1995 (Fig. 51). The extent of debris in Kwoiek Lake may be viewed as beneficial to fish production (cover availability), without detriments in any other respects (eg. aesthetics, access, etc.).

With respect to spawning, stream investigations (previously discussed) revealed exceptional availability of suitable substrates (for the system) in Reach 6 of Kwoiek Creek, immediately upstream of Kwoiek Lake (Table 4). Potential is for more limited in Reach 5 of Kwoiek Creek, downstream of the lake (*ibid.*). In the section of stream between these cascades and the lake (30 m), and at the outlet itself, there are only a few small gravel accumulations that might support some spawning/recruitment of lake fish. Approximately 150 m below the lake outlet there is a brief widening of the Kwoiek Creek channel, resulting in a pond-like pool, in which suitable spawning substrates are somewhat more abundant (Fig. 53). However, as noted above, the subsequent recruitment of juveniles to the lake (from this site), would be doubtful, due to the cascades immediately upstream (Fig. 52).

Kokwaskey Lake

At the time of investigation, Kokwaskey Lake could only be accessed by foot, along the Kwoiek Lakes Trail (B.C. Forest Service), which continues to Chochiwa Lake, and beyond. Except for this trail, and limited forest harvesting high on the valley walls to the west, there was essentially no development of the Kokwaskey Lake watershed, in October 1995.

The main axis of Kokwaskey Lake is oriented north-south, with Kwoiek Creek entering and exiting at the north end, and Chochiwa Creek entering at the south end. Kokwaskey Lake is somewhat larger than Kwoiek Lake (47 ha; Table 5), but most notably, it is greatly deeper, with mean and maximum depths appearing to be 31.9 m and 52.5 m, respectively (*ibid.*).



Figure 52. Electrofishing site 13, immediately downstream of the outlet of Kwoiek Lake.



Figure 53. Kwoiek Creek mainstem, immediately downstream of the cascades below the outlet of Kwoiek Lake (note large pool in background).

The basin is bowl-shaped (Appendix 5), and based on the single sounding transect, depths <2m appear to constitute just over 3% of the lake's surface area. Depths tend to be shallower at the northern end of the lake (*ibid.*), in association with the inflow (and exit) of Kwoiek Creek. Muddy sediments (primarily silts and sands) are most abundant in this part of the lake (Fig. 54). Otherwise, shoreline bed materials are dominated by rubble (angular cobble and small boulders; also evident in Fig. 54), as at Kwoiek Lake, but generally smaller in size.

Kwoiek Creek enters through dense mature forest, which extends to the lakeshore. There is no marsh associated with it. Unfortunately, however, there is a major debris jam on this stream, just 25 m upstream of the lake (Fig. 55). It is uncertain as to whether this is entirely natural, or precipitated by forest harvesting. As noted above, there was clearcutting to the west, but this was high up the valley walls, and remote from the lake itself.

In any event, the debris jam is a certain barrier to upstream migration of fish, from the lake. A smaller bypass channel has formed, but this too is choked with debris, and was judged to be impassable at the time of inspection. In terms of spawning potential, there is only a limited abundance of suitable substrates in the short accessible length of the stream, and in the fan at its mouth.

Chochiwa Creek enters Kokwaskey Lake at a gradient of 1.5%, and again there is no associated marsh (Fig. 56). Consistent with the higher energy of this entry, there is a fan of cobbles and small boulders, that drops off abruptly (Appendix 5). The features of Chochiwa Creek in the 500 m between the lake and the barrier falls (Fig. 40) have previously been outlined. The combination of low gravel abundance and glacial sedimentation (including clay materials) serve to restrict spawning potential in this stream, as well.

The outlet area of Kokwaskey Lake may offer greater spawning potential. Although the entire northern tip of the lake (giving rise to the outlet; Fig. 3) is spanned by a low level debris jam, with scattered materials thereafter, frequent pockets of gravels were observed in this area (Fig. 57). Presumably, these result from scouring, caused by the debris at higher flows. Under such circumstances (ie. spring and/or summer; Fig. 2), viable spawning might result. However, the success of it would depend on subsequent flow levels, relative to egg incubation/oxygenation, survival/release of fry, etc.

Chochiwa Lake

Chochiwa Lake is one of the largest lakes in the drainage (60.3 ha), and aside from the access trail, it remained totally undeveloped at the time of investigation in 1995. Like Kokwaskey Lake, its main axis is roughly north-south, with Chochiwa Creek entering at the south, and exiting (to Kokwaskey Lake) at the north.



Figure 54. Kokwaskey Lake, looking south from the north end; inlet of Kwoiek Creek to the right (foreground).



Figure 55. Debris jam in Kwoiek Creek, 25 m upstream of its entry to Kokwaskey Lake.



Figure 56. Entry of Chochiwa Creek to the southern end of Kokwaskey Lake (looking north).



Figure 57. Debris accumulation spanning the northern tip of Kokwaskey Lake, near its outlet (looking east from the western shore).

Maximum depth (52.2 m) appears to be similar to that of Kokwaskey Lake, but the mean depth appears to be slightly greater (34.0 m; Table 5). The lake is surrounded by extremely steep terrain, on all sides (Fig. 58), and again the basin is bowl-shaped (Appendix 5), with very little area <2m deep (4.3%; Table 5).

The entire shoreline is dominated by cobble/boulder rubble. There is a prominent fan, largely composed of sands, silts, and clays, at the inlet of Chochiwa Creek. However, very little sediment was observed in other areas of the lake.

Chochiwa Creek enters the lake at moderately high gradient (>10% within 100 m), which increases to a series of barrier falls, commencing approximately 300 m upstream of the lake (Fig. 58). In the accessible portion, downstream of these falls, gravels are again low in abundance, and are consolidated with clays and other fine materials, limiting spawning potential.

The outlet of Chochiwa Lake is totally obstructed by a substantial debris jam. In the absence of any development, this is entirely natural, and is attributable to the many slide areas around the lake's perimeter (Fig. 58). Such slides were also evident at Kokwaskey Lake (Fig. 54), suggesting that the debris accumulations (Figs. 55 and 57) were likely natural, in this case as well. At the outlet of Chochiwa Lake, the debris jam is immediately followed by a series of bedrock cascades, totalling 5 m in height, and including a single drop of 1.8 m. These would certainly preclude any potential juvenile recruitment of Chochiwa Lake from outlet spawning.

John George Lake

Access to John George Lake is by wading the short length of Kwoiek Creek (200 m) upstream from a crossing of the main Kwoiek Creek Forest Service Road, just downstream of the lake (Fig. 3). After this crossing, the road continues at high elevation along the south side of John George Lake. There has been considerable forest harvesting in this area, and upstream.

The main axis of John George Lake is southeast-northwest, with Kwoiek Creek entering at the western end, and exiting at the eastern end (Fig. 3). This lake is similar to Kwoiek Lake, both in size (21.5 ha) and general appearance (Fig. 60). The bottom profile is also similar (Appendix 5), but the depth is somewhat greater (mean 8.2 m; maximum 12.5 m). Based on the single longitudinal sounding transect, the proportion of area <2 m deep may be particularly low (1.8%; Table 5). However, a number of small marshy areas on both the north and south shore (Fig. 60) suggest that the transect may have missed much of the shallow habitat in this lake.

Unlike Kwoiek Lake, there is no major marsh associated with the inlet of Kwoiek Creek to John George Lake. The stream enters directly into the lake, at a gradient < 1%, and contains abundant gravels suitable for spawning (Fig. 61). Furthermore, there are substantial gravel accumulations at the lake outlet, prior to narrowing of the stream channel (Fig. 62).

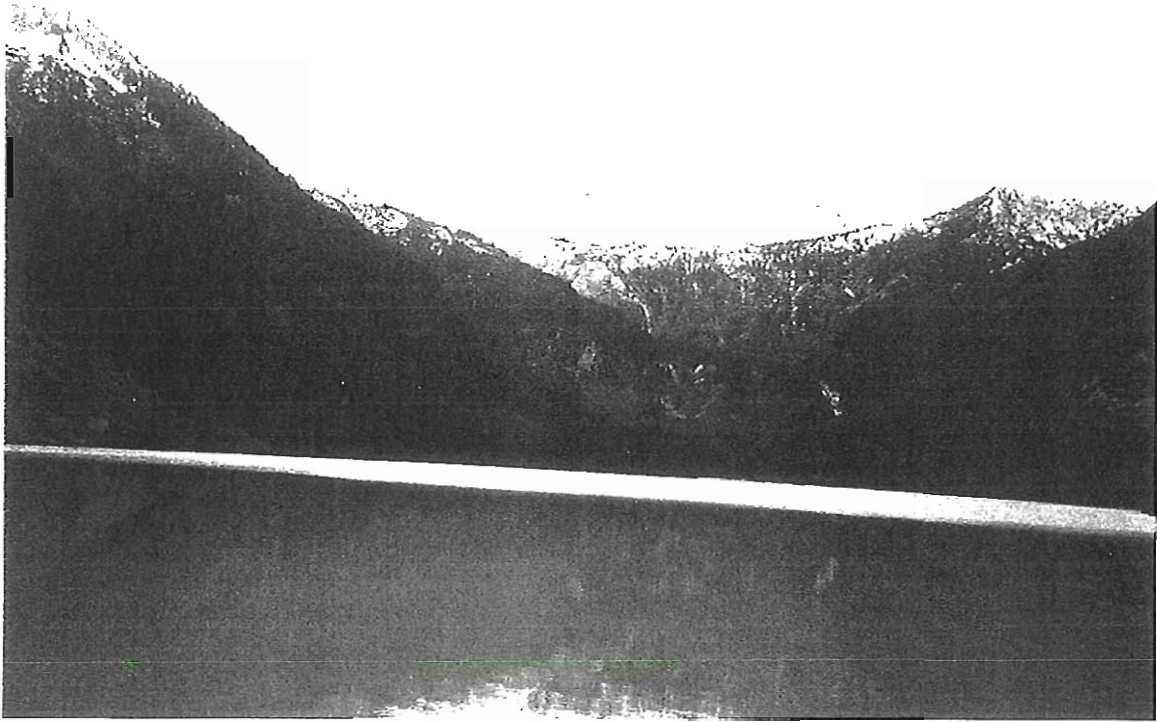


Figure 58. Chochiwa Lake, looking south; barrier falls on Chochiwa Creek can be seen at right centre (note natural slide to left).



Figure 59. Debris jam at the outlet of Chochiwa Lake.



Figure 60. John George Lake, looking towards the northwest end; viewed from the eastern end, near the outlet.



Figure 61. Gravels in Kwoiek Creek, immediately upstream of its entry to John George Lake.



Figure 62. Vicinity of John George Lake outlet; Kwoiek Creek channel in background (note abundance of gravels in foreground).



Figure 63. Klept Lake, looking east from the western shore, near the inlet of Kwoiek Creek.

Aside from some minor debris accumulations, there are no obstructions at the outlet of John George Lake, or in Kwoiek Creek immediately downstream. However, as noted earlier, major barrier falls are present approximately 500 m further downstream (400 m upstream of Kokwaskey Lake).

Klept Lake

From John George Lake, the main Kwoiek Creek Forest Service Road continues (at high elevation) along the south side of Klept Lake, and then crosses Kwoiek Creek just downstream of Kha Lake (Fig. 3). Access to Klept Lake is by boating the short distance of Kwoiek Creek (250 m) from this crossing.

Klept Lake is only 7.5 ha in area, and was the smallest of the lakes investigated in 1995. Unlike any of the lakes downstream, the shoreline of Klept Lake is distinctly muddy. Marshy areas, with sedges and grasses, are present along much of the shoreline, especially at the western end, where Kwoiek Creek enters the lake (Fig. 63). Sedimentation is also reflected in the particularly smooth and distinctly conical depth profile, along the main axis (Appendix 5). Most significant, the proportion of total area with depths < 2 m (14.5%) was close to that of Kwoiek Lake (Table 5). Nonetheless, Klept Lake appears to be surprisingly deep for its size (mean 5.0 m, maximum 7.2 m; Table 5).

With respect to spawning potential, the section of Kwoiek Creek immediately upstream of Klept Lake is dominated by glide habitat over small bed materials (Fig. 64). Although fines (sands, silts) are abundant, there are also substantial amounts of gravels suitable for spawning. The outlet is partially obstructed by a small debris accumulation, and boulders from an apparent slide, at the southeast corner of the lake. Successful recruitment from outlet spawning may be doubtful; however, opportunities in the inlet were judged to be excellent.

Kha Lake

Kha Lake is accessed by a short trail commencing at the bridge crossing of Kwoiek Creek just downstream of the lake outlet. This lake is also small in size (12.8 ha), but is again quite similar to Kwoiek Lake (Fig. 65).

Muddy sediments are moderately abundant, especially at the western (inlet) end. Extensive marshes are associated with the inflow of Kwoiek Creek, which is again diffuse, though not obstructed. In other areas of the lake, shoreline materials largely consist of cobble/boulder rubble, as for all other lakes investigated.

In contrast to Klept Lake, the basin is bowl-shaped (Appendix 5), possibly reflecting less sedimentation of the lake bottom. Based on soundings along the main axis, depths < 2m constitute far less of Kha Lake's total area (6.6%), compared to Klept Lake (Table 5). On the other hand, Kha Lake appears to be only marginally deeper (mean 6.8; maximum 8.3 m).

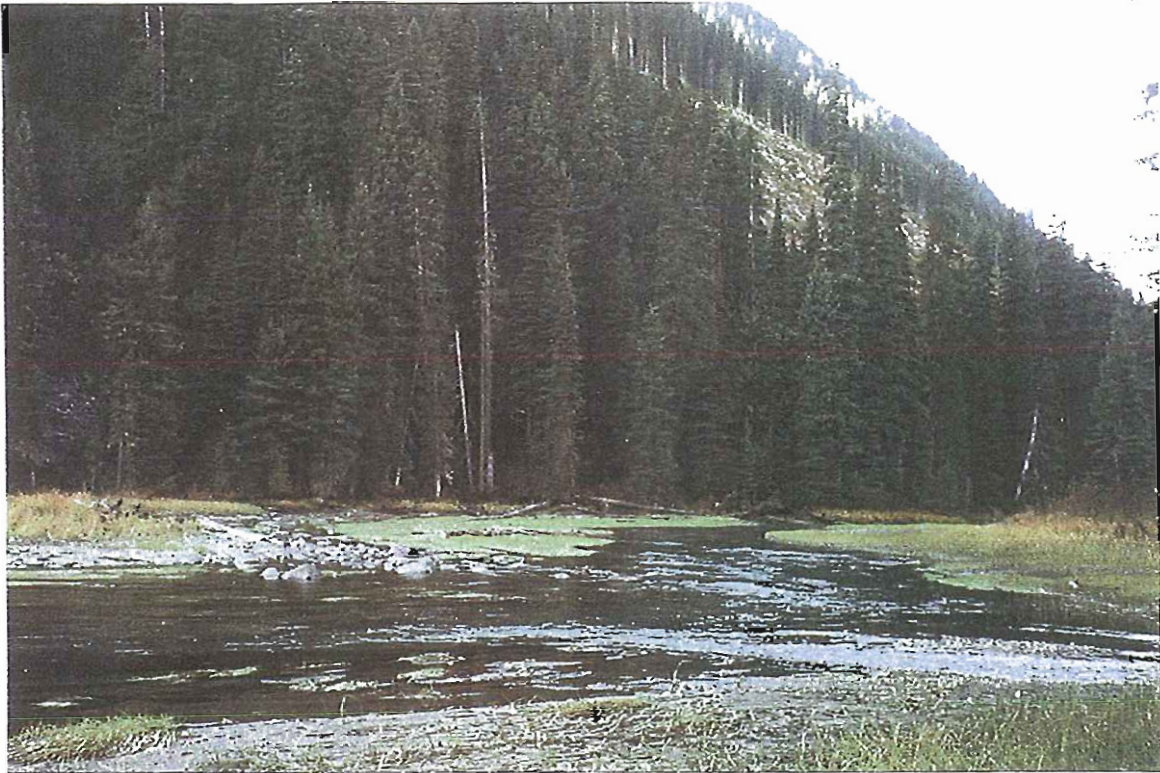


Figure 64. Kwoiek Creek, near its point of entry to Klept lake.



Figure 65. Kha Lake, looking west from the eastern end, near the outlet; inlet of Kwoiek Creek (Reach 10) near centre.

In terms of spawning potential, conditions in Reach 10 of Kwoiek Creek (commencing immediately upstream of Kha Lake) were judged to be fair to poor, as previously outlined (Table 4). However, conditions immediately downstream of Kha Lake were judged to be good, for both fall and spring spawning (habitat survey 17; Table 4). Furthermore, similar to John George Lake, there are abundant gravels in the immediate outlet area, which might provide additional spawning/recruitment potential. A substantial amount of debris is present at the outlet, but in this case it represented no impediment to fish passage (adult or juvenile), at the time of observation.

In terms of forest harvesting, Kha Lake has suffered the most severe effects, of any of the lakes investigated. Although much of the shoreline vegetation remains intact (Fig. 65), a major clearcut on the southern shore extends to the water's edge at some locations (Fig. 66). Fortunately, however, this has not resulted in the introduction of excessive woody debris. Even at Kha Lake, the abundance of such debris along the shoreline was relatively low, and not detrimental in any respect.

Stukolait Lake

In October 1995, access to Stukolait Lake entailed a steep 1 km hike through mature forest, as previously noted. This commenced at the end of the Kwoiek Creek Forest Service Road, and associated clearcut (Fig. 32).

Without a doubt, Stukolait Lake is the most interesting of the 7 lakes that were investigated during the 1995 field activities. It can only be described as spectacular (Fig. 67). Its southwest side is dominated by snowfields and glaciers, some of which are blue and iridescent. These give rise to extensive talus slopes that extend to the lake's shoreline. Judging by the northeast quadrant, the lake shore is dominated by frequently large angular rubble, and firm sediments of sands, silts, and clays.

There was a surprising amount of debris along the shoreline (Fig. 68), again attributable to natural slides. There was no significant accumulation of debris at the outlet (Fig. 67), but there are a series of falls (Fig. 69) that preclude any possibility in spawning/recruitment in the outlet stream (Kwoiek Creek Reach 11). Due to blizzard conditions on October 25 (Fig. 68), the inlet stream, at the southern tip of the lake (Fig. 3), could not be investigated. However, given the direct glacial origins (Fig. 67), it is unlikely that this would provide any significant spawning potential.

In the absence of a sounding transect (also due to conditions on October 25), nothing can be said about the lake's overall depth, or its bottom profile. However, there are extensive shallows (< 1m) in the vicinity of the outlet area, at least.



Figure 66. Clearcut extending to the shore, at the southeast corner of Kha Lake.



Figure 67. Stukolait Lake, looking south from the northern end of the lake, near the outlet (October 24, 1995).



Figure 68. Stukolait Lake, looking south from the northeast shore, under blizzard conditions on October 25, 1995.

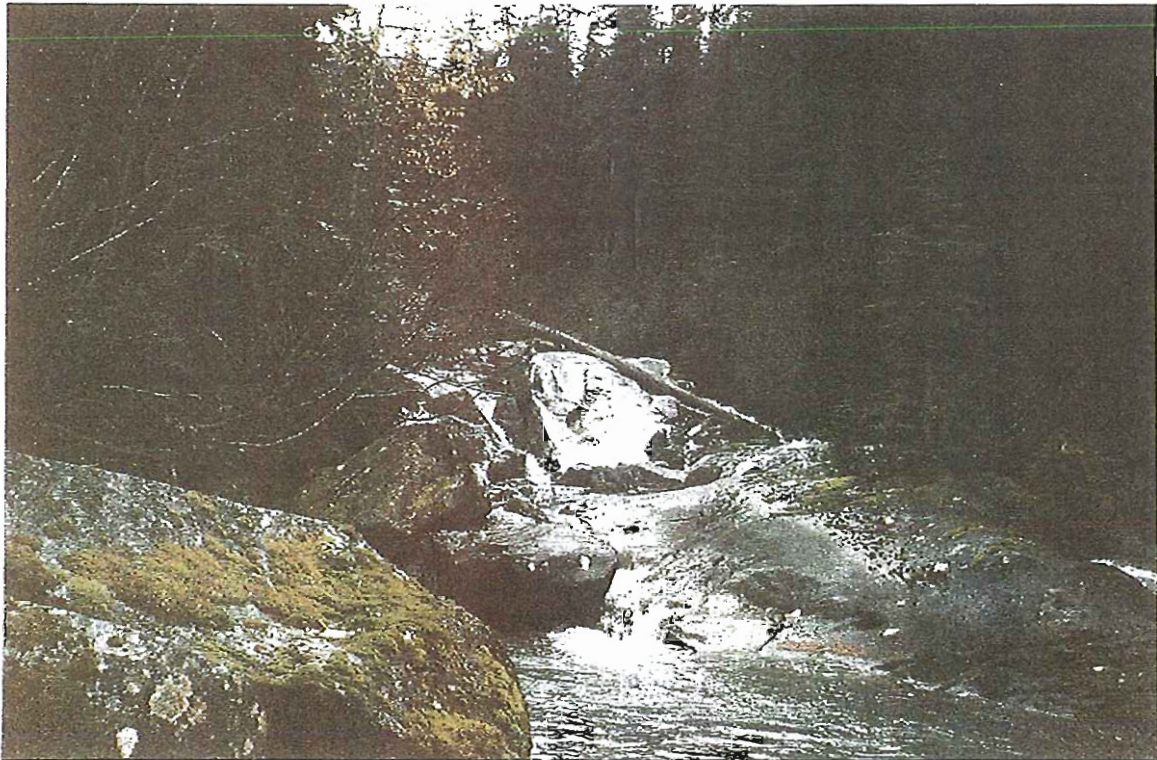


Figure 69. One of the series of barrier falls on Kwoiek Creek, immediately downstream of Stukolait Lake.

4.3.2 Limnology and trophic potential

Results of water quality analyses (Appendix 4) for all lakes investigated are also given in Table 5. For Chochiwa and Kokwaskey lakes, deep water samples were obtained from a depth of 30 m, the full capability of the sampling equipment. Limnological field data, including temperature and dissolved oxygen profiles, are provided in Appendix 5. Determinations for surface and deep water samples are also given in Table 5.

4.3.2.1 Temperature and dissolved oxygen

The temperature and oxygen data should be viewed with some reservation. The behaviour of the meter (YSI Model 57) was occasionally erratic, especially for oxygen determinations. In some cases, temperature readings were low by nearly 1°C. The latter were calibrated and adjusted, as required for each lake, by comparison to 2 pocket thermometers. New membranes were installed in the probe, in attempts to maintain consistently stable oxygen readings. It was later determined (on return from the field) that loose connections, within the probe itself, were the cause of the intermittent difficulties.

Notwithstanding the above, all 6 lakes for which profiles were obtained (ie. excluding Stukolait Lake) were isothermal, or close to it, at time of investigation in October 1995 (Appendix 5; Table 5). Again, the specific timing of the investigations of different lakes (Table 5) likely influenced the relativity of temperatures from lake to lake. The chief significance of the data is the similar coolness of all lake bodies, consistent with the stream results.

The combined (lakes, streams) results also indicate progressive cooling of the system during the course of the October 11-26 field program. For instance, temperatures in Reach 1 to 5 of Kwoiek Creek, downstream of Kwoiek Lake, ranged between 7.5°C and 8.5°C at the time of stream habitat surveys, October 12-14 (Table 2). Similarly, temperatures in Reach 6 of Kwoiek Creek, upstream of Kwoiek Lake, were 7.5°C to 8.0°C on October 14-15 (*ibid.*). By October 20, Kwoiek Lake was isothermal at 7.1°C (Table 5).

As would be expected, cooling was most advanced in upstream areas (eg. Chochiwa and Stukolait lakes; Table 5), with progressive cooling downstream, over the course of the field investigations. The imminence of dramatic (harsh) climatic changes was not only demonstrated by the blizzard at Stukolait Lake on October 25, but also the earlier formation of ice along the shoreline of Kha Lake, during its investigation on October 18-19.

Consistent with the temperature data, oxygen profiles were fairly uniform for all lakes investigated (Appendix 5), although concentrations appeared rather low, given the cool water temperatures. This may have been attributable to defective equipment, as noted above. The same likely applies to various aberrations in some of these profiles.

For example, higher oxygen concentrations in the surface waters of Kokwaskey and John George lakes (Appendix 5) might be attributable to cooler temperatures at the surface (relative to those below), or to the photosynthesis of phytoplankton (Wetzel, 1975). The first possibility does not apply (Table 5). Furthermore, analysis of water samples revealed no detectable volatile residues (suspended organic matter) in either of these lakes (Table 5). However, in the case of Kokwaskey Lake, which was calm at the time of investigation, the higher oxygenation of the uppermost surface waters may have been due to substantial breezes the previous day (experienced in the sampling of Chochiwa Lake; Appendix 5).

In John George Lake, the apparent peak just below the surface (1 m to 2 m; Appendix 5) may have been due to the influence of colder water from areas upstream, acknowledging the later sampling of this lake (Table 5).

4.3.2.2 Suspended solids (volatile and inert residues)

While volatile (organic) residues were non-detectable for nearly all water samples taken, inert (inorganic) residues were present, without exception (Table 5). For Kwoiek, Kokwaskey and Chochiwa lakes, the milky aqua appearance of the water (*ibid.*) clearly suggested *some* glacial influences (ie. fine clays). Not surprisingly, concentrations were highest in Chochiwa Lake (Table 5), consistent with the clearly evident transport of glacial materials observed in Chochiwa Creek (Fig. 49).

Conditions were somewhat different in lakes further up the Kwoiek Creek system. Although the waters of John George, Klept and Kha lakes were also milky, the colour was distinctly green, as opposed to aqua (Table 5). In the single sample obtained from Stukolait Lake, the concentration of inert residues was considerably lower than those obtained from Chochiwa Lake (Table 5). More significantly, it was also less than the concentrations in Kha Lake. These were second only to Chochiwa Lake. Levels progressively diminished in Klept and John George lakes, downstream (Table 5)¹⁵. All of these phenomena might be explained by the introduction of coarser materials (eg. silts) between Stukolait and Kha lakes, and their more immediate deposition (due to size/weight) in areas downstream (Dunne and Leopold, 1978).

In all of the lakes investigated, the presence of inert residues resulted in Secchi depths of only 1.6 m to 2.3 m (Table 5). As noted earlier, suspended organic matter was below detectable limits in nearly all samples. Consistent with the higher concentration of inerts, the Secchi depth was shallowest in Chochiwa Lake (1.6 m). Downstream, it improved in Kokwaskey Lake (2.1 m) and again in Kwoiek Lake (2.3 m).

¹⁵. The strangely high concentration of inert residues near the bottom of Klept Lake (Table 5) could reflect concentrated settling in this lake, as evidenced by the morphological data. It could also be attributable to disturbance of the lake bottom with the boat anchor, or the sampling equipment.

Similar results were obtained for Kha (2.1 m), Klept (2.1 m), and John George lakes (2.3 m). However, once again, a faster rate of settling is suggested. Furthermore, the results are consistent with the higher rate of sedimentation in Klept Lake, in particular, evidenced by the morphological investigations, addressed earlier (and, perhaps the deep water sample; Table 5).

In the final analysis, however, the Secchi depth data serve to indicate significant restriction of light penetration in all lakes investigated. Assuming greater turbidity accompanying the higher discharges of summer (as previously discussed), it is likely that the photic zone in all of these lakes would be restricted to <2 m during most of the growing season, at least.

4.3.2.3 Water chemistry and trophic status

In Table 6, the results of various water analyses for the 7 investigated lakes are compared to the most recent criteria for freshwater aquatic life (and/or salmonids, in particular), established by B.C. Environment (Nagpal, 1995).

For all samples from John George, Klept and Kha lakes, all analyses meet the specified criteria. However, in various samples, only moderate suitability is suggested for oxygen and alkalinity. As noted earlier, all oxygen data are subject to uncertainty, due to problems with instrumentation. On the other hand, some deficiency in alkalinity was universal to all lakes investigated (Table 6). The results suggest that, at best, these lakes would only have a moderate capability to buffer acid inputs (Nagpal, *op. cit.*). Such capabilities would be particularly poor for Kokwaskey, Chochiwa and Stukolait lakes (Table 6).

While all pH results meet the specified criteria (Table 6), actual determinations were close to (or below) neutrality, in every case (Table 5). Consistent with the findings with respect to alkalinity, Kokwaskey, Chochiwa and Stukolait lakes were all slightly acidic, at time of investigation (*ibid.*).

Results for all nitrogen fractions (including ammonia) were below specified limits, in every case (Table 6). However, total phosphorus was deficient in the surface samples from Chochiwa, John George and Stukolait lakes, and both samples from Kwoiek and Kokwaskey lakes (Table 6). Phosphorus was particularly low in surface waters of Stukolait Lake, but was surprisingly high in those of Chochiwa Lake.

Based on criteria provided by Forsberg and Ryding (1980), Chochiwa, Kokwaskey and Stukolait lakes are all clearly oligotrophic (ie. total phosphorus < 15 μ g/L, total nitrogen < 400 μ g/L; Table 6). For the other 4 lakes, total nitrogen falls marginally within the mesotrophic range, in one sample or the other (surface or deep). As might be expected, phosphorus appears to be the limiting nutrient in all lakes investigated. This conclusion is based on the ratio of total nitrogen to total phosphorus (Forsberg and Ryding, *op. cit.*), and applies to all water samples obtained from the lakes investigated in October 1995 (Table 7).

Table 6. Water samples from lakes in the Kwoiek Creek drainage (October 1995) meeting most recent B.C. Environment water quality criteria (Nagpal, 1995).

Water Quality Parameter	Criterion ¹ (Nagpal, 1995)	Water Samples Meeting Specified Criteria						
		Kwoiek	Kokwaskey	Chochiwa	John George	Klept	Kha	Stukolait ²
Dissolved oxygen	> 8.8 mg / L (desirable)	<i>both</i>	<i>neither</i>	<i>surface</i>	<i>surface</i>	<i>neither</i>	<i>neither</i>	<i>yes</i>
	> 6.75 mg / L (moderate)	–	<i>surface</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	–
Non-filterable residues	< 10 mg / L	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>yes</i>
pH	6.5 – 9	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>yes</i>
Alkalinity	> 20 mg / L (desirable)	<i>neither</i>	<i>neither</i>	<i>neither</i>	<i>neither</i>	<i>neither</i>	<i>neither</i>	<i>no</i>
	10 – 20 mg / L (moderate)	<i>both</i>	<i>neither</i>	<i>neither</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>no</i>
Nitrites	< 0.06 mg / L	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>yes</i>
Nitrates	< 200 mg / L (maximum)	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>yes</i>
	< 40 mg / L (average)	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>yes</i>
Ammonia	1.9 – 2.0 mg / L	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>both</i>	<i>yes</i>
Total phosphorus	5 – 15 ug / L	<i>neither</i>	<i>neither</i>	<i>surface</i>	<i>surface</i>	<i>both</i>	<i>both</i>	<i>no</i>

¹. For freshwater aquatic life and salmonids in particular, if given

². Sample obtained from surface only

Table 7. Identification of growth limitation in lakes within the Kwoiek Creek drainage, based on ratios of total nitrogen to total phosphorus (*following* Forsberg and Ryding, 1980).

Parameter	Sample	Kwoiek	Kokwaskey	Chochiwa	John George	Klept	Kha	Stukolait
Total nitrogen ¹	(ug / L) surface	426.5	247.6	329.1	419.1	417.1	349.1	251.6
	deep	262.8	226.5	218.4	238.6	332.1	437.5	–
Total phosphorus	(ug / L) surface	2.65	3.78	10.9	5.78	6.06	6.35	1.51
	deep	3.21	2.65	2.93	4.35	5.49	6.06	–
Ratio (Total N / Total P)	surface	160.9	65.5	30.2	72.5	68.8	55.0	166.6
	deep	81.9	85.5	74.5	54.9	60.5	72.2	–
Limiting nutrient ²	all	Phosphorus	Phosphorus	Phosphorus	Phosphorus	Phosphorus	Phosphorus	Phosphorus

¹. Nitrite-N + Nitrate-N + Kjeldahl N

². Phosphorus limiting if *Total N / Total P* > 17

4.4 Species and General Distribution of Fish

Results of fish sampling within the Kwoiek Creek drainage in October 1995 (Appendices 6 and 7) revealed a much wider distribution of fish than was suggested by investigations in 1962 (Stenton and DeLair, 1963). At that time, rainbow trout were captured in Kwoiek and Kokwaskey lakes, but no fish were captured (or observed) in Chochiwa or John George lakes.

In contrast, all of the lakes investigated in 1995, except Stukolait Lake, were found to contain rainbow trout. Furthermore, the reported (but not documented) presence of char in Kwoiek Lake (Stenton and DeLair, *op. cit.*; Maricle, 1994) was also confirmed in 1995. As detailed in a later section, this included some of the very large fish said to be present in this lake (*ibid.*).

Without exception, all char specimens subjected to detailed meristic analyses (Haas and McPhail, 1991) proved to be bull trout (*S. confluentus*). Full data and analytical results are provided in Appendix 8¹⁶.

Juvenile bull trout were also captured in Reaches 5 and 6 of Kwoiek Creek, immediately downstream and upstream of Kwoiek Lake, respectively (Fig. 3). The species was not captured anywhere else in the drainage. Rainbow trout were captured in Reaches 1 to 10 (inclusive) of the Kwoiek Creek mainstem, but not upstream of the cascades at the top of Reach 10 (Fig. 32). This species was present in various tributary streams, including Chochiwa Creek (between Chochiwa and Kokwaskey Lakes) and lowermost North Kwoiek Creek; however, no fish of any species were captured in Reaches 2 or 3 of North Kwoiek Creek.

Juvenile coho salmon (*Oncorhynchus kisutch*) were the only other fish captured within the Kwoiek Creek drainage, during the October 1995 investigations. These were only encountered in the side channel to Reach 1 (Fig. 5), just above the mouth, and downstream of the railway crossing and associated flume (habitat survey 1; Fig. 3).

4.5 Fish Populations in Streams

Full data regarding electrofishing captures in streams are provided in Appendix 6, along with corresponding water depth/velocity transects, and other habitat data. The location of all sampling sites in streams is shown in Figure 70. A summary of sampling locations, site types, and capture results (by species), is provided in Table 8.

¹⁶. Analyses conducted by Dr. Ivan Stefanov, I.D. Stefanov and Associates, Victoria, B.C.

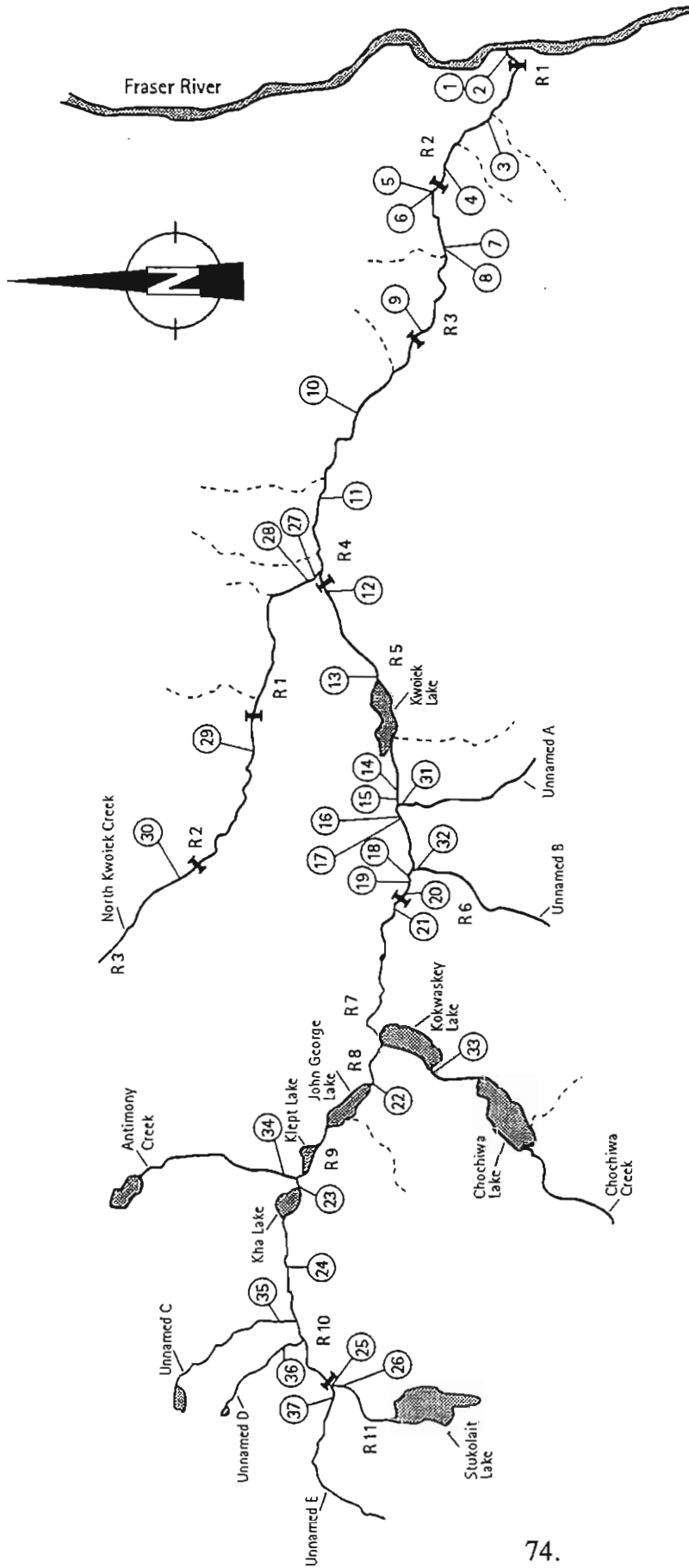


Figure 70. Location of electrofishing sites (1-37)
in the Kwoiek Creek drainage,
October 1995

Table 8. Summary of fish species distribution, based on captures at electrofishing sites in the Kwoiek Creek drainage, October 1995.

Stream and Sampling Location	Reach	Site No.	Site Type / Description	Rainbow Trout	Bull Trout	Coho Salmon
Kwoiek Creek mainstem						
90 m upstream of mouth	1	1	mainstem – representative	◆		
50m upstream of mouth	1	2	side channel – representative	◆		◆
Railway flume						
1.5 km upstream of mouth	2	3	mainstem – representative	◆		
3 km upstream of mouth	2	4	mainstem – complex braid with debris	◆		
3.5 km upstream of mouth	3	5	side channel – representative	◆		
3.5 km upstream of mouth	3	6	side channel – superior fry habitat	◆		
4.5 km upstream of mouth	3	7	mainstem – representative	◆		
4.5 km upstream of mouth	3	8	mainstem – quiet braid	◆		
6 km upstream of mouth	3	9	mainstem – representative	◆		
8 km upstream of mouth	4	10	mainstem – representative	◆		
10.3 km upstream of mouth	4	11	mainstem – representative	◆		
12 km upstream of mouth	5	12	mainstem – representative	◆	◆	
outlet of Kwoiek Lake	5	13	mainstem – complex side pool above falls	◆	◆	
Kwoiek Lake						
1 km upstream of Kwoiek Lake	6	14	side channel – representative	◆	◆	
1.2 km upstream of Kwoiek Lake	6	15	mainstem – representative	◆	◆	
1.5 km upstream of Kwoiek Lake	6	16	mainstem – superior side pool with debris	◆	◆	
1.5 km upstream of Kwoiek Lake	6	17	mainstem – representative	◆	◆	
2.8 km upstream of Kwoiek Lake	6	18	mainstem – representative	◆		
3 km upstream of Kwoiek Lake	6	19	side channel – representative	◆		
First falls						
3.2 km upstream of Kwoiek Lake	6	20	mainstem – representative	◆		
Second falls						
4 km upstream of Kwoiek Lake	7	21	mainstem – representative	◆		
Kokwaskey Lake						
160 m downstream of John Geoge Lake	8	22	mainstem – representative	◆		
John George and Klept lakes						
120 m downstream of Kha Lake	9	23	mainstem – representative	◆		
Kha Lake						
1.3 km upstream of Kha Lake	10	24	mainstem – superior debris habitat	◆		
Cascades						
3.7 km upstream of Kha Lake	11	25	mainstem – complex side pool			
3.8 km upstream of Kha Lake	11	26	mainstem – complex debris habitat			
North Kwoiek Creek						
150 m upstream of Kwoiek Creek	1	27	side channel – complex debris habitat			
400 m upstream of Kwoiek Creek	1	28	mainstem – superior glide/pool habitat	◆		
4.6 km upstream of Kwoiek Creek	2	29	mainstem – superior glide/pool habitat			
7 km upstream of Kwoiek Creek	3	30	mainstem – superior glide/pool habitat			
unnamed tributary A	–	31	optimum habitat present			
unnamed tributary B	–	32	stepped pocket water near mouth	◆		
Chochiwa Creek	–	33	complex side pool near Kokwaskey Lake	◆		
Antimony Creek	–	34	superior complexity of cover	◆		
unnamed tributary C	–	35	optimum habitat – 400 m upstream of Kwoiek Creek			
unnamed tributary D	–	36	optimum habitat – 300 m upstream of Kwoiek Creek			
unnamed tributary E	–	37	optimum habitat – 200 m upstream of Kwoiek Creek			

Clearly, rainbow trout was the most widely distributed species, as previously described. These fish were captured at 28 sites (76%) of the total 37 completed. Without exception, rainbow trout were present at all sampling locations in Reaches 1 to 10 of the Kwoiek Creek mainstem.

As noted in the previous section, no rainbow trout (or any other species of fish) were captured in Reach 11 of Kwoiek Creek, or its tributary (unnamed tributary E; Table 8). The absence of fish in this tributary is not surprising, given the extremely steep and falls-dominated habitat (Fig. 44). For similar reasons (Figs. 45 and 46), it is not surprising that no fish were captured in unnamed tributaries C and D (Table 8), tributary to Kwoiek Creek Reach 10 (Fig. 70).

Other absences are more surprising. Firstly, while parr (yearlings and older juveniles) might not be expected in the cobble/gravel habitat of unnamed tributary A (Fig. 47), the same would not apply to fry; even acknowledging the alternative spawning habitat in Reach 6 of Kwoiek Creek, into which this stream flows. Given the presence of fish at all neighbouring sampling locations, including unnamed tributary B (Table 8; Fig. 70), the high turbidity observed in this stream, and the substantial presence of fines (both previously discussed) likely provide the best explanation for the absence of fry in this stream (ie. spawning deterred and/or unsuccessful).

Given the substantial size of North Kwoiek Creek (eg. Figs. 36, 38 and 39), the apparent absence of fish in Reaches 2 and 3 of this stream (Table 8) is also surprising. A total of only 3 fish were captured in North Kwoiek Creek, all from site 28, just 400 m upstream of the mouth (Fig. 70). These were rainbow trout aged 3+ and 4+ (Appendix 6); one was a mature and near ripe female (202 mm); the two others were both mature males (213 mm, 230 mm).

It can only be assumed that these were immigrants (presumably spawning or pre-spawning) from the Kwoiek Creek mainstem, perhaps seeking the gravelly side channel associated with Reach 1 of North Kwoiek Creek (Fig. 37). However, no fish (juvenile or adult) were captured in this channel, despite the sampling of particularly complex habitat (site 27; Table 8). This result may be due to difficulties of access (to the side channel), and/or the influence of sediments on spawning success (habitat survey 20; Appendix 3).

4.5.1 Numbers of fish captured in streams

In Table 9, the actual number of fish captured at the October 1995 electrofishing sites in streams is provided for all relevant species and age groups of fish. In most cases, these numbers are low. Obviously, the most extreme case was for coho, where only 3 fry of this species were captured, and only at a single site (in the the side channel downstream of the railway flume). Bull trout numbers were also very low, and were restricted to Reaches 5 and 6 of the Kwoiek Creek mainstem, as noted above.

Table 9. Summary of fish numbers caught at electrofishing sites in the Kwoiek Creek drainage, October 1995.

Stream and Type of Site	Reach	Site No.	Area (m ²)	Rainbow Trout					Bull Trout		Coho
				Age 0+	Age 1+	Age 2+	Age 3+	Age 4+	Age 0+	Age 1+	Age 0+
Kwoiek Creek mainstem											
mainstem – representative	1	1	30.4	3	1	1	–	–	–	–	–
side channel – representative	1	2	37.2	12	1	–	–	–	–	3	
Railway flume											
mainstem – representative	2	3	38.6	1	2	1	–	–	–	–	
mainstem – braid with debris	2	4	50.5	2	2	2	–	–	–	–	
side channel – representative	3	5	39.0	1	2	1	–	–	–	–	
side channel – superior for fry	3	6	24.5	6	–	–	–	–	–	–	
mainstem – representative	3	7	34.9	3	2	1	–	–	–	–	
mainstem – quiet braid	3	8	44.5	8	8	5	2	–	–	–	
mainstem – representative	3	9	34.7	1	3	–	1	–	–	–	
mainstem – representative	4	10	43.7	3	1	–	–	–	–	–	
mainstem – representative	4	11	30.4	2	3	–	–	–	–	–	
mainstem – representative	5	12	29.7	4	4	3	2	–	1	–	
mainstem – complex side pool	5	13	22.1	7	5	–	–	–	1	–	
Kwoiek Lake											
side channel – representative	6	14	53.4	8	13	1	3	–	3	–	
mainstem – representative	6	15	47.5	4	–	–	–	–	2	3	
mainstem – side pool with debris	6	16	43.2	5	4	2	–	–	3	1	
mainstem – representative	6	17	40.3	9	–	–	–	–	4	–	
mainstem – representative	6	18	42.9	3	1	2	1	–	–	–	
side channel – representative	6	19	29.8	–	2	1	2	–	–	–	
First falls											
mainstem – representative	6	20	40.4	9	5	1	–	–	–	–	
Second falls											
mainstem – representative	7	21	59.2	3	13	3	2	–	–	–	
Kokwaskey Lake											
mainstem – representative	8	22	23.8	–	3	–	–	–	–	–	
John George and Klept lakes											
mainstem – representative	9	23	52.4	53	19	–	–	–	–	–	
Kha Lake											
mainstem – superior debris	10	24	21.1	5	2	1	–	–	–	–	
Cascades											
mainstem – complex side pool	11	25	32.1	–	–	–	–	–	–	–	
mainstem – complex debris	11	26	49.1	–	–	–	–	–	–	–	
North Kwoiek Creek											
side channel – complex debris	1	27	35.5	–	–	–	–	–	–	–	
mainstem – superior glide/pool	1	28	45.3	–	–	–	2	1	–	–	
mainstem – superior glide/pool	2	29	47.0	–	–	–	–	–	–	–	
mainstem – superior glide/pool	3	30	50.9	–	–	–	–	–	–	–	
unnamed tributary A	optimum	31	66.5	–	–	–	–	–	–	–	
unnamed tributary B	above mouth	32	60.7	–	4	2	1	–	–	–	
Chochiwa Creek	complex pool	33	23.8	1	3	–	–	–	–	–	
Antimony Creek	superior cover	34	44.9	–	–	–	1	–	–	–	
unnamed tributary C	optimum	35	44.1	–	–	–	–	–	–	–	
unnamed tributary D	optimum	36	27.6	–	–	–	–	–	–	–	
unnamed tributary E	optimum	37	46.8	–	–	–	–	–	–	–	

Although rainbow trout were present at nearly all sampling locations, numbers of these fish were frequently low, as well. However, numbers of yearlings and/or older fish were high, generally speaking, relative to the numbers of fry (Table 9). The outstanding exception was at site 2, in the side channel downstream of the railway flume.

By far the highest number of rainbow fry were captured at site 23, in the short section of Kwoiek Creek between Klept and Kha lakes (Fig. 70). However, this site also produced an extraordinary number of yearlings (Table 9). Exceptional numbers of rainbow yearlings were also captured at sites 14 (lowermost Reach 6, upstream of Kwoiek Lake) and 21 (lowermost Reach 7, upstream of barrier falls at the top of Reach 6; Fig. 20).

While the results in Table 9 do provide some indication of relative fish abundance at different sampling locations, they do not account for the variation in the actual area sampled at each site (ie. within the net enclosures). These areas are indicated in Table 9.

To standardize between all sites, Table 10 expresses the capture results in terms of the specific area sampled ($fish/m^2$), at each site. Results for rainbow fry are most interesting. Clearly, the density of these fish at site 23, between Klept and Kha lakes ($1.11\text{ fry}/m^2$), was greatly higher than at any other location sampled; and this result relates to *representative* (average) habitat for the given stream section (Fig. 30).

The next highest density of rainbow fry was only $0.32\text{ fish}/m^2$. This occurred at two locations: 1) in the side channel habitat at site 2, downstream of the railway flume; and 2) at site 13, above the small cascades at the top of Kwoiek Creek Reach 5, 20 m downstream of the outlet of Kwoiek Lake (Fig. 70). This may suggest concentrated spawning/recruitment in these areas. However, it should be noted that the results pertain to side channel habitat, on the one hand, and a complex side pool on the other (Table 10). In the case of site 13, there is only a limited abundance of gravels in this area, as previously noted.

A higher density of rainbow fry ($0.25\text{ fish}/m^2$) was also obtained in superior fry habitat at site 6, within the side channel at the bottom of Kwoiek Creek Reach 3 (Fig. 70). However, surprisingly few fry were captured at site 5 (Table 10), representative of this side channel, as a whole (Fig. 14).

Once again, there was a parallel further upstream. At site 24, in the Kwoiek Creek mainstem upstream of Kha Lake, the sampled density of rainbow fry was also $0.25\text{ fish}/m^2$. However, this again related to superior habitat (above average for the reach), in the form of complex debris (Table 10).

Very similar results ($0.22\text{ fry}/m^2$) were obtained in the representative habitat, containing debris (Appendix 3), at site 17 in Kwoiek Creek Reach 6 (Fig. 70). It is most interesting that the same density of rainbow fry was also found at site 20 (Fig. 47), between the two sets of falls at the top of Reach 6 (Table 10).

Table 10. Summary of sampled fish densities (*fish / m²*), based on the total area of electrofishing sites, in the Kwoiek Creek drainage; October 1995.

Stream and Type of Site	Reach	Site No.	Rainbow Trout					Bull Trout		Coho
			Age 0+	Age 1+	Age 2+	Age 3+	Age 4+	Age 0+	Age 1+	Age 0+
Kwoiek Creek mainstem										
mainstem – representative	1	1	0.10	0.03	0.03	--	--	--	--	--
side channel – representative	1	2	0.32	0.03	--	--	--	--	0.08	
Railway flume										
mainstem – representative	2	3	0.03	0.05	0.03	--	--	--	--	
mainstem – braid with debris	2	4	0.04	0.04	0.04	--	--	--	--	
side channel – representative	3	5	0.03	0.05	0.03	--	--	--	--	
side channel – superior for fry	3	6	0.25	--	--	--	--	--	--	
mainstem – representative	3	7	0.09	0.06	0.03	--	--	--	--	
mainstem – quiet braid	3	8	0.20	0.18	0.12	0.04	--	--	--	
mainstem – representative	3	9	0.03	0.09	--	0.03	--	--	--	
mainstem – representative	4	10	0.07	0.02	--	--	--	--	--	
mainstem – representative	4	11	0.07	0.10	--	--	--	--	--	
mainstem – representative	5	12	0.15	0.13	0.10	0.07	--	0.03	--	
mainstem – complex side pool	5	13	0.32	0.24	--	--	0.05	--	--	
Kwoiek Lake										
side channel – representative	6	14	0.15	0.24	0.02	0.06	--	0.06	--	
mainstem – representative	6	15	0.09	--	--	--	0.04	0.08	--	
mainstem – side pool with debris	6	16	0.12	0.09	0.05	--	0.09	0.02	--	
mainstem – representative	6	17	0.22	--	--	--	0.10	--	--	
mainstem – representative	6	18	0.07	0.02	0.05	0.02	--	--	--	
side channel – representative	6	19	--	0.07	0.03	0.07	--	--	--	
First falls										
mainstem – representative	6	20	0.22	0.12	0.02	--	--	--	--	
Second falls										
mainstem – representative	7	21	0.05	0.23	0.05	0.03	--	--	--	
Kokwaskey Lake										
mainstem – representative	8	22	--	0.17	--	--	--	--	--	
John George and Klept lakes										
mainstem – representative	9	23	1.11	0.38	--	--	--	--	--	
Kha Lake										
mainstem – superior debris	10	24	0.25	0.09	0.05	--	--	--	--	
Cascades										
mainstem – complex side pool	11	25	--	--	--	--	--	--	--	
mainstem – complex debris	11	26	--	--	--	--	--	--	--	
North Kwoiek Creek										
side channel – complex debris	1	27	--	--	--	--	--	--	--	
mainstem – superior glide/pool	1	28	--	--	--	0.04	0.02	--	--	
mainstem – superior glide/pool	2	29	--	--	--	--	--	--	--	
mainstem – superior glide/pool	3	30	--	--	--	--	--	--	--	
unnamed tributary A optimum		31	--	--	--	--	--	--	--	
unnamed tributary B above mouth		32	--	0.07	0.03	0.02	--	--	--	
Chochiwa Creek complex pool		33	0.04	0.13	--	--	--	--	--	
Antimony Creek superior cover		34	--	--	--	0.02	--	--	--	
unnamed tributary C optimum		35	--	--	--	--	--	--	--	
unnamed tributary D optimum		36	--	--	--	--	--	--	--	
unnamed tributary E optimum		37	--	--	--	--	--	--	--	

With respect to rainbow parr, higher sampled densities (ie. >0.2 fish/m²) tend to correspond with greater densities of fry: ie. above the cascades at the outlet of Kwoiek Lake (site 13); Kwoiek Creek Reach 6, above Kwoiek Lake (site 14); and, most emphatically, the short section of Kwoiek Creek between Klept and Kha lakes (site 23; Table 10).

At some sites, however, moderate densities of rainbow yearlings (ie. >0.1 fish/m²) were not explained by higher fry densities at the given site, or those nearby (if applicable). The best example is site 22, in Kwoiek Creek just downstream of John George Lake (Fig. 70). Although the density of rainbow yearlings was 0.17 fish/m², no fry were captured at this site (table 10). At site 21, above the second (barrier) falls at the top of Kwoiek Creek Reach 6, the sampled density of rainbow fry was only 0.05 fish/m²; for yearlings, it was 0.23 fish/m². In both cases, results pertain to representative (average) habitat for the relevant stream sections (Table 10).

At site 33, in Chochiwa Creek just upstream of Kokwaskey Lake (Fig. 70), the density of rainbow yearlings was 0.13 fish/m², although it was only 0.04 fish/m² for fry. In this case, results pertain to the superior habitat of a complex pool with abundant debris (Appendix 6).

To some extent, all of the latter results might be attributable to the fact that each of the relevant sites was the only one completed for the given stream section. Obviously, variable densities of rainbow trout were found where multiple sites were completed, in other stream sections (notably, Kwoiek Creek Reaches 3, 5 and 6; Table 10). In such cases, however, sites containing lower densities of fry also *tended* to contain lower densities of parr (Table 10).

Results at four other sampling sites warrant specific mention with respect to rainbow trout. The first two are sites 8 and 12, in the Kwoiek Creek mainstem, downstream of Kwoiek Lake (Fig. 70). In both cases, moderate densities of all rainbow trout age groups (to age 3+) were present (Table 10).

In the first instance, results at site 8, in Reach 3, appear to demonstrate the particular value (ie. degree of exploitation) of quiet complex habitat (Appendix 6), generally lacking in the Kwoiek Creek mainstem, as a whole. Even in the side channel at the bottom of Reach 3, velocities averaged in excess of 0.3 m/s (site 5; Appendix 6). Furthermore, depths in this channel were somewhat restrictive for parr (ave. 25 cm), especially in the superior fry habitat at site 6 (ave. 6 cm; Appendix 6).

The results at site 12 relate to representative habitat in lower Reach 5 of the Kwoiek Creek mainstem (Table 10; Fig. 70). The abundance and diversity of fish at this site may simply reflect the somewhat superior spawning and rearing potential in this stream section (habitat survey 9; Table 3). However, it might also reflect outlet spawning of Kwoiek Lake fish; ie. downstream of the cascades just below the lake outlet (Fig. 18), and/or displacement of recruits from spawning above the cascades (site 13; Table 10).

The last two sites of particular interest, with respect to rainbow trout, are sites 14 and 19, both located in side channel habitat associated with Kwoiek Creek Reach 6 (Table 10), upstream

of Kwoiek Lake (Fig. 70). Several age groups of rainbow were well represented at these sites as well. It is interesting to note, however, that while rainbow fry were moderately abundant at the lower site (site 14), none were captured at the upper site (site 19).

This is strange, given that gravels were abundant, cover was complex, velocities were low (ave. 12 cm/s; Appendix 6), and a considerable density of fry (0.22 fish/m²) was encountered at site 20, just upstream (Table 10). The latter site is also located above the first falls at the top of Reach 6. If anything, site 19 would be expected to contain more fry than site 20, given its provision of alternate spawning opportunity, immediately downstream of these falls.

Finally, relatively little can be said about the electrofishing results for bull trout. Numbers of fish were universally low (Table 10). It is notable, however, that yearlings appear to have been more abundant downstream, and fry more abundant upstream, over the range of sites at which the species was captured in Reach 6, upstream of Kwoiek Lake. Furthermore, this distribution extended only as far upstream as site 17, approximately half way up the reach (Fig. 70). With respect to captures in Reach 5, downstream of Kwoiek Lake, results in Table 10 actually relate to the capture of a single fish, both at site 12 and at site 13 (Table 9). These captures may be no more than incidental, perhaps reflecting limited spawning of this species downstream of Kwoiek Lake, and/or displacement of fish from the lake outlet.

4.5.2 Standing stock of fish in suitable habitat

For the sake of simplicity, and most pragmatic evaluation of the electrofishing results, the preceding discussion is based on the full area of habitat sampled at each site. However, due to hydraulic constraints in particular (ie. water depth and velocity), only a portion of a given site may actually be usable (suitable) for any given species/age group of fish (eg. Stalnaker and Arnette, 1976; Bovee and Cochnauer, 1977; Bech *et al.*, 1994).

Particularly with the frequently swift and turbulent hydraulic conditions sampled within the Kwoiek Creek drainage (eg. Figs. 12, 13, 15, 16 etc.), the results in Table 10 include the influence of variation in the specific degree of habitat usability/suitability at each site, as well as variation in fish distribution and abundance.

In order to provide a more definitive evaluation, the results in Table 10 were adjusted to express all capture results in terms of *usable habitat* only, as previously outlined. Site-specific water depth/velocity transect data (Appendix 6) were employed to derive corresponding species/size-specific probability-of-use estimates, for each site, following Bech *et al.* (1994).

Results are provided in Table 11, and represent the proportion of total site area where hydraulic conditions were actually suitable for a given species and age/size class of fish, at any given site. Each value is weighted on the basis of the specific degree of usability (for depth and velocity combined) for each cell (between measurement stations) along the transect completed at the site. In the procedure, yearling and older fish are collectively addressed as *parr* (Bech *et al.*; *op. cit.*).

Table 11. Summary of mean water depth and velocity, and associated hydraulic suitability for fish, at electrofishing sites in the Kwoiek Creek drainage; October 1995.

Stream and Type of Site	Reach	Site No.	Hydraulic Means		Weighted Hydraulic Suitability (Probability of Use)				
			Depth (m)	Velocity (m/s)	RB Fry	RB Parr	BT Fry	BT Parr	CO Fry
Kwoiek Creek mainstem									
mainstem – representative	1	1	0.14	0.20	0.655	0.404	0.640	0.151	0.166
side channel – representative	1	2	0.15	0.44	0.462	0.201	0.523	0.072	0.011
		Mean	0.15	0.32	0.559	0.303	0.582	0.112	0.089
mainstem – representative	2	3	0.12	0.22	0.854	0.302	0.772	0.044	0.075
mainstem – braid with debris	2	4	0.32	0.31	0.422	0.743	0.551	0.384	0.177
side channel – representative	3	5	0.25	0.31	0.560	0.476	0.663	0.285	0.205
side channel – superior for fry	3	6	0.06	0.05	0.896	0.137	0.866	0.009	0.046
mainstem – representative	3	7	0.28	0.39	0.509	0.467	0.590	0.236	0.159
mainstem – quiet braid	3	8	0.33	0.11	0.673	0.772	0.830	0.504	0.444
mainstem – representative	3	9	0.38	0.26	0.515	0.771	0.670	0.459	0.228
mainstem – representative	4	10	0.18	0.22	0.782	0.486	0.735	0.195	0.204
mainstem – representative	4	11	0.15	0.20	0.632	0.333	0.699	0.160	0.161
mainstem – representative	5	12	0.34	0.28	0.528	0.641	0.627	0.412	0.333
mainstem – complex side pool	5	13	0.19	0.17	0.798	0.552	0.802	0.229	0.273
		Mean	0.24	0.23	0.652	0.516	0.710	0.285	0.210
side channel – representative	6	14	0.23	0.10	0.888	0.712	0.880	0.360	0.354
mainstem – representative	6	15	0.16	0.41	0.335	0.354	0.495	0.095	0.011
mainstem – side pool with debris	6	16	0.09	0.06	0.733	0.268	0.739	0.064	0.114
mainstem – representative	6	17	0.27	0.52	0.307	0.286	0.408	0.139	0.029
mainstem – representative	6	18	0.20	0.24	0.573	0.521	0.624	0.253	0.248
side channel – representative	6	19	0.14	0.12	0.856	0.433	0.876	0.139	0.214
		Mean	0.18	0.24	0.615	0.429	0.670	0.175	0.162
mainstem – representative	6	20	0.19	0.14	0.814	0.614	0.846	0.240	0.288
		Second falls							
mainstem – representative	7	21	0.29	0.19	0.636	0.742	0.755	0.463	0.436
		Kokwaskey Lake							
mainstem – representative	8	22	0.41	0.31	0.402	0.600	0.561	0.421	0.281
		John George and Klept lakes							
mainstem – representative	9	23	0.36	0.16	0.623	0.663	0.767	0.461	0.400
		Kha Lake							
mainstem – superior debris	10	24	0.16	0.11	0.836	0.485	0.830	0.149	0.219
		Cascades							
mainstem – complex side pool	11	25	0.29	0.05	0.737	0.836	0.906	0.526	0.578
mainstem – complex debris	11	26	0.23	0.09	0.879	0.703	0.923	0.351	0.351
		Mean	0.26	0.07	0.808	0.770	0.915	0.439	0.465
North Kwoiek Creek									
side channel – complex debris	1	27	0.18	0.21	0.772	0.580	0.803	0.148	0.129
mainstem – superior glide/pool	1	28	0.38	0.20	0.443	0.720	0.619	0.527	0.398
mainstem – superior glide/pool	2	29	0.26	0.46	0.301	0.337	0.407	0.175	0.049
mainstem – superior glide/pool	3	30	0.38	0.15	0.508	0.614	0.702	0.536	0.469
		Mean	0.30	0.26	0.506	0.563	0.633	0.347	0.261
unnamed tributary A optimum		31	0.08	0.36	0.725	0.089	0.687	0.011	0.018
unnamed tributary B above mouth		32	0.19	0.26	0.633	0.454	0.629	0.196	0.163
Chochiwa Creek complex pool		33	0.16	0.11	0.976	0.530	0.933	0.180	0.207
Antimony Creek superior cover		34	0.20	0.19	0.831	0.597	0.806	0.212	0.194
unnamed tributary C optimum		35	0.07	0.36	0.491	0.114	0.615	0.008	0.003
unnamed tributary D optimum		36	0.05	0.16	0.979	0.101	0.835	0.000	0.016
unnamed tributary E optimum		37	0.14	0.08	0.823	0.417	0.835	0.166	0.228
		Mean	0.13	0.22	0.780	0.329	0.763	0.110	0.118

The final adjustment of the sampling results (Table 10) is provided in Table 12. In one case, the result is the same in both tables; rainbow fry at site 33, in Chochiwa Creek. This is due to the nearly total suitability of the hydraulic conditions for rainbow fry at this site (0.976; Table 11).

Generally speaking, the suitability of hydraulic conditions in sampled stream habitat in the Kwoiek Creek drainage tended to be far more limited, for all species and age groups of fish (mean values; Table 11). Consequently, most values in Table 12 are correspondingly (and variably) higher than those in Table 10.

Nonetheless, Table 12 generally supports all of the indications previously identified from Table 10. However, some differences clearly stand out, and are of utmost significance. The first (and most obvious) applies to the coho fry captured at site 2, in the side channel downstream of the railway flume (7.27 fish/m²; Table 12). Due to its shallow depth (ave. 15 cm) and relatively high water velocity (ave. 0.44 m/s), this site had an exceptionally low suitability (0.059) for coho fry (Bech *et al.*, 1994). Accordingly, the presence of *any* fish, though few in number (Tables 9 and 10), represented *extreme* exploitation of the very limited usable habitat (for the species) at this site.

It should also be noted that, when adjusted on the basis of usable habitat only, the density of rainbow fry at this site (0.69 fish/m²; Table 11) was also substantially higher than the initial estimate in Table 10 (0.32 fish/m²). For both coho and rainbow (especially the former), the inference is a concentrated demand for (and exploitation of) suitable fry habitat, downstream of the railway crossing and flume.

It is also interesting that, aside from the extreme results for rainbow fry at site 23, between Klept and Kha lakes (Table 10 and 12), the adjusted values (Table 12) reveal the highest density of rainbow fry (0.72 fish/m²) at site 17, in Reach 6 of Kwoiek Creek, upstream of Kwoiek Lake. This was masked by assessment on the basis of total site area (Table 10).

At site 13, upstream of the cascades at the outlet of Kwoiek Lake, the adjusted values further suggest considerably higher concentration of both rainbow fry and yearlings, compared to all sites downstream (except for the rainbow fry at site 2, downstream of the railway crossing and flume; Table 12). Generally speaking, parr densities in Table 12 are considerably higher than those in Table 10, due to the predominantly lower degree of habitat suitability, for these fish, at most locations sampled (mean values; Table 11). To some extent, the latter may reflect constraints to netting and sampling capabilities (ie. restriction to shallower habitats) in the predominantly swift and turbulent stream habitat within the Kwoiek Creek drainage.

Other implications of habitat suitability relate to bull trout. Generally speaking, hydraulic conditions at sampling sites were less suitable (often greatly) for this species, than they were for rainbow trout; more important, this applies most particularly (for both fry and parr) in Reaches 5 and 6 of the Kwoiek Creek mainstem, to which the stream distribution of bull trout in the Kwoiek Creek drainage appears to be limited (Table 12).

Table 12. Summary of sampled fish densities ($fish/m^2$), based on hydraulically suitable portions of electrofishing sites, in the Kwoiek Creek drainage; October 1995.

Stream / Site Type	Reach	Site No.	Rainbow Trout					Bull Trout		Coho Age 0+
			Age 0+	Age 1+	Age 2+	Age 3+	Age 4+	Age 0+	Age 1+	
Kwoiek Creek mainstem										
mainstem – representative	1	1	0.15	0.07	0.07	–	–	–	–	–
side channel – representative	1	2	0.69	0.15	–	–	–	–	–	7.27
Railway flume										
mainstem – representative	2	3	0.04	0.17	0.10	–	–	–	–	–
mainstem – braid with debris	2	4	0.09	0.05	0.05	–	–	–	–	–
side channel – representative	3	5	0.05	0.11	0.06	–	–	–	–	–
side channel – superior for fry	3	6	0.28	–	–	–	–	–	–	–
mainstem – representative	3	7	0.18	0.13	0.06	–	–	–	–	–
mainstem – quiet braid	3	8	0.30	0.23	0.16	0.05	–	–	–	–
mainstem – representative	3	9	0.06	0.12	–	0.04	–	–	–	–
mainstem – representative	4	10	0.09	0.04	–	–	–	–	–	–
mainstem – representative	4	11	0.11	0.30	–	–	–	–	–	–
mainstem – representative	5	12	0.28	0.20	0.16	0.11	–	–	0.07	–
mainstem – complex side pool	5	13	0.40	0.43	–	–	–	0.06	–	–
Kwoiek Lake										
side channel – representative	6	14	0.17	0.34	0.03	0.08	–	–	0.17	–
mainstem – representative	6	15	0.27	–	–	–	–	0.08	0.84	–
mainstem – side pool with debris	6	16	0.16	0.34	0.19	–	–	0.12	0.31	–
mainstem – representative	6	17	0.72	–	–	–	–	0.25	–	–
mainstem – representative	6	18	0.12	0.04	0.10	0.04	–	–	–	–
side channel – representative	6	19	–	0.16	0.07	0.16	–	–	–	–
First falls										
mainstem – representative	6	20	0.27	0.20	0.03	–	–	–	–	–
Second falls										
mainstem – representative	7	21	0.08	0.31	0.07	0.04	–	–	–	–
Kokwaskey Lake										
mainstem – representative	8	22	–	0.28	–	–	–	–	–	–
John George and Klept lakes										
mainstem – representative	9	23	1.78	0.57	–	–	–	–	–	–
Kha Lake										
mainstem – superior debris	10	24	0.30	0.19	0.10	–	–	–	–	–
Cascades										
mainstem – complex side pool	11	25	–	–	–	–	–	–	–	–
mainstem – complex debris	11	26	–	–	–	–	–	–	–	–
North Kwoiek Creek										
side channel – complex debris	1	27	–	–	–	–	–	–	–	–
mainstem – superior glide/pool	1	28	–	–	–	0.06	0.03	–	–	–
mainstem – superior glide/pool	2	29	–	–	–	–	–	–	–	–
mainstem – superior glide/pool	3	30	–	–	–	–	–	–	–	–
unnamed tributary A	optimum	31	–	–	–	–	–	–	–	–
unnamed tributary B	above mouth	32	–	0.15	0.07	0.04	–	–	–	–
Chochiwa Creek	complex pool	33	0.04	0.25	–	–	–	–	–	–
Antimony Creek	superior cover	34	–	–	–	0.03	–	–	–	–
unnamed tributary C	optimum	35	–	–	–	–	–	–	–	–
unnamed tributary D	optimum	36	–	–	–	–	–	–	–	–
unnamed tributary E	optimum	37	–	–	–	–	–	–	–	–

When adjusted on the basis of usable habitat only, most of the sampled densities of bull trout (Table 10) are substantially increased (Table 12). Most interesting, the progressive increase in fry abundance between sites 15 and 17 (Table 10) becomes accentuated (Table 12), further suggesting concentrated spawning/recruitment of the species in mid Reach 6 (Fig. 70).

This appears to be followed by a movement/concentration of yearlings, further down the reach (sites 15 and 16; Table 12). The lower abundance of bull trout yearlings in the side channel habitat at site 14 is likely attributable to the substantial numbers of rainbow parr at this site (Table 12)¹⁷.

A final point relates to the bull trout in Reach 5 of Kwoiek Creek, downstream of Kwoiek Lake. Although values in Table 12 are higher than those in Table 10, the results still indicate minor (likely incidental) utilization of this reach, by this species.

4.5.3 Standing stock vs. habitat capability in the Kwoiek Creek mainstem

While standardization of sampling results on the basis of usable habitat enables direct comparisons between fish numbers at different sites, the ultimate evaluation of existing standing stock is that relative to site capability (carrying capacity). In the B.C. Environment model to estimate juvenile salmonid standing stock capability in streams (Ptolemy, 1992), fish size is a critical criterion. For all fish captured by electrofishing in the Kwoiek Creek drainage in 1995, size data are summarized in Appendix 9.

In the capability modelling, separate estimates are generated for distinctly different *size* classes of juvenile salmonids, as opposed to individual species (Ptolemy, *op. cit.*). These classes are based on fish weights, and correspond to successive age groups (Table 13). Where the size classes of different species broadly overlap, these species are dealt with collectively within the relevant size classes. As shown in Figure 71 and Table 13, this applies to the populations of juvenile rainbow trout and bull trout in Kwoiek Creek, especially in Reach 6 of the mainstem, where production of bull trout juveniles appears to be concentrated.

Coho are addressed by a specific and exclusive model component (Appendix 2), providing a totally separate capability estimate for this species. This is due to the more specialized and restricting habitat requirements of these fish (ie. pools or glides with complex bank cover), and their surface orientation (Ptolemy, *op. cit.*).

¹⁷. Although little is known, specifically, about the interactions of juvenile bull trout with other juvenile fish (Rieman and McIntyre, 1993), studies addressing Dolly Varden suggest sub-dominance of char juveniles to other salmonids, including rainbow trout (eg. Armstrong and Elliott, 1972).

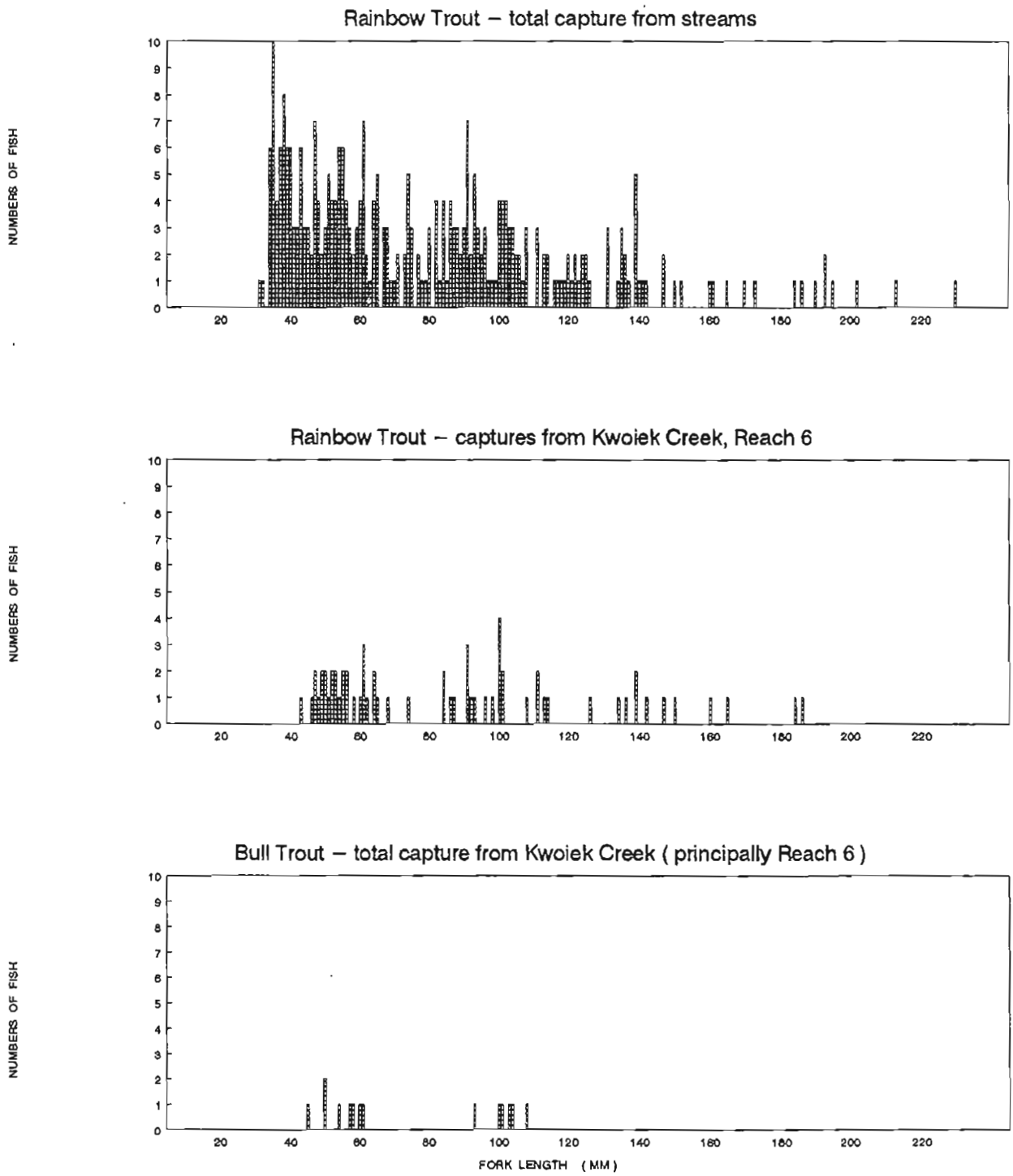


Figure 71. Length frequency distribution of rainbow trout and bull trout in the Kwoiek Creek drainage, October 1995.

Table 13. Summary of mean fish weight data (g) from electrofishing captures in the Kwoiek Creek mainstem, October 1995.

Stream Component	Rainbow Trout		Bull Trout		Coho Age 0+		
	Age 0+	Age 1+	Age 2+	Age 3+		Age 0+	Age 1+
Kwoiek Creek mainstem							
Downstream of Kwoiek Lake	1.9	10.1	23.3	55.3	2.1	9.4	4.5
Kwoiek Lake to Kokwaskey lake	1.7	9.3	24.9	52.6	1.6	8.8	-
Upstream of Kokwaskey Lake	1.0	8.3	24.5	-	-	-	-

Table 14. Summary of theoretical standing stock capability (fish / m²) in the Kwoiek Creek mainstem, based on October 1995 sampling results.

Stream Component	Alkalinity (mg/L)	Rainbow Trout and Bull Trout Combined			Coho Age 0+	
		Age 0+	Age 1+	Age 2+		Age 3+
Kwoiek Creek mainstem						
Downstream of North Kwoiek Creek	22.0 *	0.896	0.169	0.073	0.031	0.765
North Kwoiek Creek to Kwoiek lake	19.8 *	0.850	0.160	0.069	0.029	-
Kwoiek Lake to Kokwaskey Lake	15.0	0.827	0.151	0.056	0.027	-
Upstream of Kokwaskey Lake (excluding Reach 11)	14.0	1.358	0.164	0.055	-	-

* Average of upstream and downstream samples

For different sections of the Kwoiek Creek mainstem, the resultant estimates of theoretical standing stock potential (habitat capability) are provided in Table 14. All estimates are based on the relevant mean size (weight) data for rainbow trout (Table 13). No adjustment has been made for the specific weights of bull trout (if applicable), given the extremely low representation of this species in the total sample, as well as the relatively minor differences of these weights, compared to those of rainbow (Table 13).

The resultant habitat capability estimates (Table 13) represent maximum standing stock potential for each size class of fish, in habitat that is *fully suitable* for such fish (Ptolemy, *op. cit.*). As emphasized earlier, Table 12 expresses the 1995 sampling results (existing standing stock) in similar terms; ie. densities of fish in hydraulically suitable habitat only. Accordingly, values in Tables 12 and 13 may be directly compared to assess the status of 1995 standing stock, relative to the theoretical capability (capacity) of the sites sampled, and the system as a whole.

This comparison is made in Table 15. Attention is restricted to the Kwoiek Creek mainstem, due to its vast dominance of accessible and/or occupied stream habitat (Table 12). For obvious reasons, Reach 11 has been excluded, due to the absence of any fish captures in this reach, during the October 1995 investigations.

4.5.3.1 Coho salmon

At first inspection, various results in Table 15 appear to be highly inordinate. The prime example is the result for coho fry at site 2, in side channel habitat of Reach 1, downstream of the railway crossing and flume (Table 15). This result suggests that the standing stock, at time of investigation in 1995, represented nearly 10 times the theoretical capability for the site.

To some extent, the accuracy of the result is highly questionable, given the very few coho fry that were actually captured (3; Table 9), and the associated potential for distortion. On the other hand, the value in Table 15 is directly attributable to the exceptionally low suitability of hydraulic conditions, for coho fry, at the site in question (0.075 probability of use; Table 11). Consistent with earlier consideration of this site, the presence of any fish at all may best be explained by excessive fish densities (and associated competition) in areas with more suitable hydraulic conditions, forcing sub-dominant individuals into areas with inferior conditions (eg. Glova and Mason, 1977).

Comparable results for coho fry (greatly in excess of capability estimates), have also been observed in other systems where population levels were high, and/or suitable habitat was severely limited (Griffith, 1995*d*). Assuming that upstream passage of adult coho in Kwoiek Creek is precluded by the concrete flume at the top of Reach 1 (as supported by the 1995 sampling results), and given the dominance of steep and turbulent habitat in the short length of the Kwoiek Creek mainstem downstream (Fig. 4), recruitment and production of coho may be highly reliant

Table 15. Fish densities in suitable habitat, compared to theoretical standing stock capability, for the Kwoiek Creek mainstem, based on October 1995 sampling results.

Site	Reach	Site No.	Rainbow Trout and Bull Trout Combined				Coho Age 0+	
			Age 0+	Age 1+	Age 2+	Age 3+		
Percent of Theoretical Standing Stock Capability								
Kwoiek Creek mainstem								
mainstem – representative	1	1	16.7	41.4	95.9	–	–	
side channel – representative	1	2	77.0	88.8	–	–	950	
		Railway flume	Mean	46.9	65.1	47.9	0.0	475.2
mainstem – representative	2	3	4.5	100.6	137.0	–	–	
mainstem – braid with debris	2	4	10.0	29.6	68.5	–	–	
side channel – representative	3	5	5.6	65.1	82.2	–	–	
side channel – superior for fry	3	6	31.3	–	–	–	–	
mainstem – representative	3	7	20.1	76.9	82.2	–	–	
mainstem – quiet braid	3	8	33.5	136.1	219.2	161.3	–	
mainstem – representative	3	9	6.7	71.0	–	129.0	–	
mainstem – representative	4	10	10.0	23.7	–	–	–	
mainstem – representative	4	11	12.3	177.5	–	–	–	
mainstem – representative	5	12	32.9	168.8 *	231.9	379.3	–	
mainstem – complex side pool	5	13	54.1 *	268.8	–	–	–	
		Kwoiek Lake	Mean	20.1	101.6	74.6	60.9	0.0
side channel – representative	6	14	20.6	337.7 *	53.6	286.3	–	
mainstem – representative	6	15	42.3 *	556.3 *	–	–	–	
mainstem – side pool with debris	6	16	33.9 *	430.5 *	339.3	–	–	
mainstem – representative	6	17	117.3 *	–	–	–	–	
mainstem – representative	6	18	14.5	26.5	178.6	148.1	–	
side channel – representative	6	19	–	108.0	125.0	592.6	–	
		First falls	Mean	38.1	242.8	116.1	172.6	0.0
mainstem – representative	6	20	32.6	132.5	53.6	–	–	
		Second falls						
mainstem – representative	7	21	9.7	205.3	125.0	148.1	–	
		Kokwaskey Lake						
mainstem – representative	8	22	–	170.7	–	–	–	
		John George and Klept lakes						
mainstem – representative	9	23	131.1	347.6	–	–	–	
		Kha Lake						
mainstem – superior debris	10	24	22.1	115.9	181.8	–	–	
		Mean	39.1	194.4	72.1	29.6	0.0	

* Bull trout present, and included (all other entries rainbow trout only)

on (and concentrated in) the limited side channel habitat that is available. Under such circumstances, highly excessive densities of coho fry might be expected (even in inferior habitats), particularly with reduction of total habitat area, during low flows (as investigated in October 1995).

4.5.3.2 Rainbow trout and bull trout

With respect to rainbow trout and bull trout, the most extreme results pertain to Reach 6, upstream of Kwoiek Lake. With one exception (site 17), the 1995 densities of parr (one or more age groups) were well in excess of theoretical capability at all sampling sites in this reach (Table 15). The most extreme case was for age 3+ fish at site 19 (100% rainbow; Table 12), in the side channel adjacent to the first set of falls, near the top of the reach.

One of these fish was a female (150 mm) with fully developed eggs, as was also encountered in lowermost North Kwoiek Creek (previously noted). As in the neighbouring Nahatlatch River (Griffith, 1995a), spawning or pre-spawning behaviour of rainbow trout appears to extend into the fall months, within the Kwoiek Creek system. Although the actual capture of age 3+ fish at site 19 was only 2 individuals (Table 9), the resultant super-saturation evidenced by the modelling (nearly 600%; Table 15) may reflect upstreaming of small mature fish (spawners or pre-spawners), and subsequent concentration below obstructions to further passage (ie. the first falls on the mainstem, and inadequate flows in the side channel bypassing these falls).

Needless to say, the same explanation does not apply to the comparable results for age 1+ fish at sites 15 and 16, lower in the reach (Table 15). Furthermore, at site 15 all fish of this age group were bull trout; and at site 16, roughly half of the yearlings were bull trout (Table 12). At the latter site, the age 1+ standing stock of each species, relative to theoretical capability, was 225% for rainbow trout, and 205% for bull trout (ie. proportionality in Table 12 applied to Table 15). The standing stock of age 2+ fish was also greatly in excess of theoretical capability at site 16 (339%), and in this case, consisted entirely of rainbow trout (Table 12).

Similar results pertain to site 14, completed in side channel habitat in the same vicinity (Fig. 70). In this case, the standing stock of rainbow yearlings (specifically) represented 150% of the theoretical capability for such fish, at this site; bull trout represented an additional 75% of this capability (proportionality in Table 12). Age 2+ and 3+ fish were exclusively rainbow trout; and at this site, none of the age 3+ fish were mature (3 captured and inspected; Table 9).

In general, the results in Table 15 suggest almost universal super-saturation of parr habitat in Reach 6, by one or more age groups of one or both species present. In light of this, it is most interesting that, with the exception of site 23 between Klept and Kha lakes, site 17 in mid Reach

6 was the only sampling location theoretically saturated with trout/char fry, at the time of investigation (117%; Table 15). In this case, the standing stock of these fish consisted of 74% rainbow trout and 26% bull trout (Table 12).

Table 15 also indicates super-saturation of parr habitat by at least one age group of fish at all sampling locations in Kwoiek Creek, upstream of Reach 6 (sites 21 to 24). Rainbow trout was the only species present at any of these locations (Table 12). As noted above, one of these sites was also theoretically saturated with rainbow fry (site 23); but in most cases, fry densities were well below corresponding capability estimates (Table 15). The same also applies to Reach 6, which seems to suggest great specificity (and concentration) in the selection of spawning/recruitment sites by both rainbow trout and bull trout, in the Kwoiek Creek system, upstream of Kwoiek Lake.

Results in Table 15 also indicate frequent saturation of parr habitat, by one or more age groups, at sampling sites in Kwoiek Creek downstream of Kwoiek Lake. This is most pronounced at the two uppermost sites, in Reach 5 (sites 12 and 13), and in the superior (less turbulent) braid habitat at site 8, in Reach 3. Fry densities at all of these sites were also somewhat higher, relative to corresponding capability, than at other sites downstream of Kwoiek Lake (except site 2 below the railway crossing and flume, near the mouth of the system).

Excluding the coho at site 2, and the minor contribution of the single bull trout yearling at site 12 and single fry at site 13 (Table 12), all other results downstream of Kwoiek Lake relate exclusively to rainbow trout (Table 15). The somewhat higher density of fry at site 2, relative to corresponding capability (Table 15), could indicate the spawning/recruitment of steelhead in the side channel habitat downstream of the flume, as evidenced for coho.

4.5.3.3 Implications with respect to steelhead

As noted earlier, steelhead have been reported to utilize lower sections of the Kwoiek Creek system (Anon., 1991). However, in the absence of information specific to flow conditions in the flume, at the time of potential ascent of adult steelhead, it is not possible to realistically assess the likelihood of success, and associated access to (and utilization of) areas upstream.

Certainly, under the conditions observed at lower flows, in October 1995 (velocities > 2m/s; depths < 10 cm), possibilities of successful fish passage would seem very remote, for any species. However, given adequate water depth, adult steelhead are reported to be capable of maintaining swimming speeds > 2m/s for extended periods, and close to 5m/s over short distances, at least (Wightman and Taylor, 1976).

Accordingly, there is the *possibility* that steelhead could ascend the flume at higher flows. If such is the case, the less challenging falls at the top of Reach 2 (Fig. 8) would likely represent little impediment, particularly with the bypass channel present (Fig. 9). Similarly, the cascades below Kwoiek Lake (Fig. 18) would probably cause little (if any) obstruction to the upstream

passage of steelhead. The same likely applies to the first falls at the top of Reach 6 (Fig. 19), which may also be bypassed at higher flows. However, the second falls at the top of Reach 6 would certainly seem to constitute a total barrier to *all* further passage of fish, including steelhead (Fig. 20).

Consequently, it is conceivable that the apparently greater standing stock of rainbow trout juveniles (relative to theoretical capability; Table 15) in Reach 6 of Kwoiek Creek, in October 1995, may reflect superimposition of steelhead production on stocks of rainbow trout resident within the system. The same might apply to the apparent concentration of rainbow juveniles in Reach 5 (sites 12 and 13; Table 15).

On the other hand, results at the uppermost sites in the drainage (ie. sites 21 to 24; Table 15) may suggest otherwise. Due to the barrier falls at the top of Reach 6, the standing stock of fish (exclusively rainbow) at all of these sites undoubtedly consists of resident production only. Although the frequency of occurrence and abundance of age 2+ and 3+ fish was lower at these sites, compared to areas downstream (reduction of stream proportions; Appendix 3), fry and yearling results were highly comparable (Table 15).

In fact, as shown by the mean values in Table 15, fry and yearling results at the uppermost sites were highly comparable, on average, to those in Reach 6. The similarities are even more pronounced if attention is restricted to results for representative (average) habitats only (Table 16). Also evident, in both Table 15 and Table 16, is the lower abundance, on average, of fry and yearlings (relative to capability) downstream of Kwoiek Lake, compared to all areas upstream. The influence of lake populations (production of recruits) seems to provide the best explanation of these relationships. As noted earlier, and as evidenced by the presence of bull trout in particular, it could also explain the superior results in Reach 5, immediately downstream of Kwoiek Creek.

4.5.4 Hydraulic suitability vs. cover availability for fish in streams

All adjustment of sampled fish densities (and subsequent comparisons to theoretical capabilities) is based on the mean weighted suitability of hydraulic conditions, at each site, for each species/age group of fish. However, equivalent cover availability must also be present, to constitute *fully suitable* habitat, in compliance with the standing stock capability estimates (Ptolemy, 1992).

In Table 17, the total availability of all fish cover for trout and char, at each electrofishing site, is compared to the corresponding hydraulic suitability results. Separate estimates of cover for fry and parr are based on the abundance (area) of suitably-sized bed materials for each, plus all other cover elements present (woody debris, cutbanks/roots, overhanging vegetation, etc.; Appendix 6). For ease of comparison, the hydraulic suitability estimates in Table 17 are expressed as percentages of total site area, consistent with those of available cover.

Table 16. Fish densities in suitable habitat, compared to theoretical standing stock capability, for the Kwoiek Creek mainstem, based on representative sampling sites only; October 1995.

Site	Reach	Site No.	Rainbow Trout and Bull Trout Combined				Coho Age 0+
			Age 0+	Age 1+	Age 2+	Age 3+	
Percent of Theoretical Standing Stock Capability							
Kwoiek Creek mainstem							
mainstem – representative	1	1	16.7	41.4	95.9	–	–
side channel – representative	1	2	77.0	88.8	–	–	950
		Mean	46.9	65.1	47.9	0.0	475.2
Railway flume							
mainstem – representative	2	3	4.5	100.6	137.0	–	–
side channel – representative	3	5	5.6	65.1	82.2	–	–
mainstem – representative	3	7	20.1	76.9	82.2	–	–
mainstem – representative	3	9	6.7	71.0	–	129.0	–
mainstem – representative	4	10	10.0	23.7	–	–	–
mainstem – representative	4	11	12.3	177.5	–	–	–
mainstem – representative	5	12	32.9	168.8 *	231.9	379.3	–
		Mean	13.2	97.6	76.2	72.6	0.0
Kwoiek Lake							
side channel – representative	6	14	20.6	337.7 *	53.6	296.3	–
mainstem – representative	6	15	42.3 *	556.3 *	–	–	–
mainstem – representative	6	17	117.3 *	–	–	–	–
mainstem – representative	6	18	14.5	26.5	178.6	148.1	–
side channel – representative	6	19	–	106.0	125.0	592.6	–
		Mean	38.9	205.3	71.4	207.4	0.0
First falls							
mainstem – representative	6	20	32.6	132.5	53.6	–	–
Second falls							
mainstem – representative	7	21	9.7	205.3	125.0	148.1	–
Kokwaskey Lake							
mainstem – representative	8	22	–	170.7	–	–	–
John George and Klept lakes							
mainstem – representative	9	23	131.1	347.6	–	–	–
		Mean	43.3	214.0	44.6	37.0	0.0

* Bull trout present, and included (all other entries rainbow trout only)

Table 17. Comparison of hydraulic suitability vs. total cover availability, at electrofishing sites in the Kwoiek Creek drainage; October 1995.

Stream and Type of Site	Reach	Site No.	Weighted Hydraulic Suitability (% of site)				Total Cover (% of site)	
			RB Fry	RB Parr	BT Fry	BT Parr	Fry	Parr
Kwoiek Creek mainstem								
mainstem – representative	1	1	65.5	40.4	64.0	15.1	65	80
side channel – representative	1	2	46.2	20.1	52.3	7.2	86	46
		Mean	55.9	30.3	58.2	11.2	75.5	63.0
mainstem – representative	2	3	85.4	30.2	77.2	4.4	93	73
mainstem – braid with debris	2	4	42.2	74.3	55.1	38.4	92	87
side channel – representative	3	5	56.0	47.6	66.3	28.5	85	70
side channel – superior for fry	3	6	89.6	13.7	88.6	0.9	100	56
mainstem – representative	3	7	50.9	46.7	59.0	23.6	80	65
mainstem – quiet braid	3	8	67.3	77.2 *	83.0	50.4	75	55
mainstem – representative	3	9	51.5	77.1	67.0	45.9	90	80
mainstem – representative	4	10	78.2	48.6	73.5	19.5	91	71
mainstem – representative	4	11	63.2	33.3	69.9	16.0	100	81
mainstem – representative	5	12	52.8	64.1	62.7	41.2	85	75
mainstem – complex side pool	5	13	79.8	55.2	80.2	22.9	95	80
		Mean	65.2	51.8	71.0	26.5	89.6	72.1
side channel – representative	6	14	88.8	71.2 *	88.0	36.0	100	32
mainstem – representative	6	15	33.5	35.4	49.5	9.5 *	86	6
mainstem – side pool with debris	6	16	73.3 *	26.8	73.9 *	6.4	60	45
mainstem – representative	6	17	30.7	28.6	40.8	13.9	100	43
mainstem – representative	6	18	57.3	52.1	62.4	25.3	77	62
side channel – representative	6	19	85.6	43.3	87.6	13.9	58	43
		Mean	61.5	42.9	67.0	17.5	80.2	36.5
mainstem – representative	6	20	81.4	61.4	84.6	24.0	85	90
		Second falls						
mainstem – representative	7	21	63.6	74.2	75.5	46.3	85	65
		Kokwaskey Lake						
mainstem – representative	8	22	40.2	60.0 *	56.1	42.1	85	55
		John George and Kept lakes						
mainstem – representative	9	23	62.3	66.3	76.7	46.1	100	81
		Kha Lake						
mainstem – superior debris	10	24	83.6	48.5	83.0	14.9	100	80
		Cascades						
mainstem – complex side pool	11	25	73.7	83.6	90.6	52.6	100	100
mainstem – complex debris	11	26	87.9	70.3	92.3	35.1	70	60
		Mean	80.8	77.0	91.5	43.9	85.0	80.0
North Kwoiek Creek								
side channel – complex debris	1	27	77.2	58.0	80.3	14.8	77	62
mainstem – superior glide/pool	1	28	44.3	72.0	61.9	52.7	90	85
mainstem – superior glide/pool	2	29	30.1	33.7	40.7	17.5	70	40
mainstem – superior glide/pool	3	30	50.8	61.4	70.2	53.6	90	75
		Mean	50.6	56.3	63.3	34.7	81.8	65.5
unnamed tributary A	optimum	31	72.5	8.9	68.7	1.1	90	30
unnamed tributary B	above mouth	32	63.3	45.4	62.9	19.6	100	95
Chochiwa Creek	complex pool	33	97.6	53.0	93.3	18.0	100	100
Antimony Creek	superior cover	34	83.1	59.7	80.6	21.2	100	90
unnamed tributary C	optimum	35	49.1	11.4	61.5	0.8	100	81
unnamed tributary D	optimum	36	97.9	10.1	83.5	0.0	100	100
unnamed tributary E	optimum	37	82.3	41.7	83.5	16.6	72	67
		Mean	78.0	32.9	76.3	11.0	94.6	80.4

* Fish in this category captured at the site

The objective of Table 17 is to evaluate the validity of using the hydraulic suitabilities, alone, to adjust the fish capture results for comparisons between them, and to corresponding capability estimates. The underlying rationale is that a given hydraulic suitability estimate (and associated standing stock estimate; Table 12) is only valid if it is matched by at least equal cover availability. In Table 17, all cases have been boxed where this does *not* apply. Since cover was recorded to the nearest 1%, differences $< 1\%$ have been discounted.

The number of such cases is 15, out of a total 148 comparisons (ie. 10.1%). Of these cases, only 6 (4%) relate to instances where there were captures of fish within the relevant category. In these instances, most of which relate to Reach 6 of the Kwoiek Creek mainstem (Table 17), the standing stock of the given category may have been *under*-estimated. In the vast majority of cases, however, the preceding adjustments (and associated discussions) appear to be justified. The mean values in Table 17 clearly show that cover availability was generally superior to hydraulic conditions (often substantially) in stream habitat sampled throughout the Kwoiek Creek drainage, in October 1995.

As a final note, the results in Table 17 should not be confused with the earlier estimates of cover availability associated with the stream habitat surveys (Table 3). The latter were based on the inspection of lengthy stream sections, and addressed the full wetted width. Furthermore, in these surveys the suitability of hydraulic conditions was intrinsic to the identification (and estimation) of suitable/usable cover. In the modelling process (Table 17), the two parameters are assessed and compared separately, and address sampled habitat specifically. This was frequently restricted to only a portion of the full wetted width, and accordingly, conditions were generally more conducive to juvenile fish.

4.6 Fish Populations in Lakes

Fish capture data for the 7 lakes investigated in October 1995 are provided in Appendix 7. Key results for the full samples, from all lakes, are summarized in Table 18, and are specified by age group in Table 19. All fish captures were by gill net, except for two rainbow yearlings (107 mm, 110 mm) captured by minnow trap in Klept Lake.

In viewing and evaluating the fish capture results, and all associated data and implications, it must be recalled that all survey and sampling of these lakes was at the *preliminary* level only (Anon., 1995). Following standard procedures (*ibid.*), only one gill net was employed for each lake. In all cases, this was a sinking net, to best assess the distribution of bull trout, as previously noted.

To varying degrees these limitations likely precluded full representation of fish populations in resultant captures. Greatest shortcomings in sampling efficiency (and associated distortion of results) might be expected for Kokwaskey and Chochiwa lakes, due to their considerably larger size, and much greater depth, compared to all other lakes sampled (Table 5; Appendix 5).

Table 18. Summary of gill netting results for investigated lakes within the Kwoiek Creek drainage, October 1995.

Sampling Result	Bull Trout		Rainbow Trout					
	Kwoiek L.		Kwoiek L.	Kokwaskey L.	Chochiwa L.	John George L.	Klept L.	Kha L.
Netting duration (net hours)	18.25		18.25	19.5	20.75	22.25	24.75	19.5
Number captured	8		73	42	19	57	152	69
Number / net hour	0.44		4.00	2.15	0.92	2.56	6.14	3.54
Fork length (mm)								
mean	423.9		198.7	145.5	141.8	187.0	182.1	187.0
minimum	187		113	86	102	103	108	107
maximum	721		244	223	228	416	392	361
S.D.	208.5		29.8	30.9	42.4	57.1	76.2	69.6
Weight (g)								
mean	1,375.0		95.4	35.8	41.6	96.4	94.3	94.4
minimum	62.8		12.7	6.9	13.5	13.3	13.3	11.9
maximum	3,778		155.7	112.9	135.4	788	460	376
S.D.	1,504.8		33.7	23.5	37.2	113.3	125.9	105.9
Condition ¹ ($\times 10^{-5}$)								
mean	0.97		1.14	1.03	1.18	1.12	1.04	1.05
minimum	0.85		0.88	0.91	0.98	0.98	0.72	0.80
maximum	1.05		1.30	1.17	1.34	1.42	1.39	1.19
S.D.	0.06		0.07	0.06	0.08	0.09	0.09	0.09
Rainbow < 160 mm (% of catch)	—		11.0	64.3	68.4	29.8	49.3	39.1

1. Condition Factor k , in: $Weight_g = k (Fork\ Length_{mm})^3$

Table 19. Breakdown of rainbow trout gill netting results for investigated lakes within the Kwoiek Creek drainage, by age group of fish; October 1995.

Age Group	Sampling Result	Rainbow Trout											
		Kwoiek L.	Kokwaskey L.	Chochiwa L.	John George L.	Klept L.	Kha L.						
Age 1+	Mean length (mm)	121.0	7.6	118.2	8.9	110.0	9.4	117.3	7.9	116.1	8.5	117.7	8.2
	Mean weight (g)	19.4	6.0	17.6	3.6	16.6	4.4	18.6	3.7	16.8	3.0	17.8	4.2
	Mean condition ¹ . ($\times 10^{-5}$)	1.06	0.13	1.05	0.04	1.22	0.04	1.14	0.04	1.07	0.06	1.08	0.08
	n (% of capture in brackets)	4 (5.5)	16 (38.1)	8 (42.1)	15 (26.3)	16 (10.5)	13 (18.8)	16 (10.5)	13 (18.8)				
Age 2+	Mean length (mm)	167.5	22.7	149.2	19.5	131.7	21.3	170.4	19.6	149.0	26.5	156.3	16.6
	Mean weight (g)	57.9	21.7	35.1	12.7	28.6	15.2	58.1	19.4	38.8	21.3	42.8	12.9
	Mean condition ($\times 10^{-5}$)	1.16	0.07	1.02	0.06	1.17	0.08	1.14	0.08	1.06	0.07	1.08	0.05
	n (% of capture in brackets)	13 (17.8)	18 (42.9)	6 (31.8)	9 (15.8)	91 (59.9)	32 (46.4)	91 (59.9)	32 (46.4)				
Age 3+	Mean length (mm)	208.1	12.8	192.6	17.5	190.7	13.7	217.1	27.7	214.7	45.5	237.1	43.8
	Mean weight (g)	104.5	17.2	75.3	21.1	79.3	15.5	122.1	62.3	119.3	77.4	145.5	66.6
	Mean condition ($\times 10^{-5}$)	1.15	0.08	1.01	0.07	1.13	0.05	1.11	0.10	1.05	0.06	1.03	0.10
	n (% of capture in brackets)	47 (64.4)	7* (19.0)	3 (15.8)	32 (56.1)	26* (17.1)	17 (24.6)	26* (17.1)	17 (24.6)				
Age 4+	Mean length (mm)	229.6	10.4	226.5	1.5	226.5	1.5	—	—	349.1	34.4	330.8	22.9
	Mean weight (g)	136.1	16.8	123.8	11.8	123.8	11.8	—	—	381.3	87.1	333.7	55.3
	Mean condition ($\times 10^{-5}$)	1.12	0.05	1.06	0.08	1.06	0.08	—	—	0.89	0.10	0.92	0.10
	n (% of capture in brackets)	9 (12.3)	0	2 (10.5)	0	17 (11.2)	6 (8.7)	0	0	17 (11.2)	6 (8.7)	6 (8.7)	6 (8.7)
Age 5+	Mean length (mm)	—	—	—	—	—	—	416	6.0	373.0	6.0	357	357
	Mean weight (g)	—	—	—	—	—	—	788	18.0	475.0	18.0	438	438
	Mean condition ($\times 10^{-5}$)	—	—	—	—	—	—	1.09	0.08	0.92	0.08	0.96	0.96
	n (% of capture in brackets)	0	0	0	0	1 (1.8)	2 (1.3)	1 (1.4)	1 (1.4)	2 (1.3)	1 (1.4)	1 (1.4)	1 (1.4)

1. Condition Factor k , in: $Weight_g = k (Fork\ Length\ mm)^3$ * Includes one fish for which scales were unreadable, and age was assumed

Given the shallower depths of all other lakes investigated (Table 5), sinking nets would sample much greater proportions of the water column, in each case (2.4 m panel height extending up from the lake bottom). With the smaller area of these lakes, the nets would also span variably greater proportions of total surface area. Obviously, this would be most applicable to Klept and Kha lakes, but would also apply to John George and Kwoiek lakes, compared to Kokwaskey and Chochiwa lakes (Table 5).

4.6.1 Distribution of fish in lakes

Rainbow trout were caught in all lakes except Stukolait Lake, in which no fish (of any species) were captured (Appendix 7). Bull trout were captured in Kwoiek Lake only (Table 18). This included 3 very large fish (Figs. 72 and 73), in the size range of 659 mm to 721 mm (3.0 kg to 3.8 kg); however, the total capture of this species, including smaller individuals, was only 8 fish (Appendix 7).

A very interesting observation, of potential significance to the distribution of bull trout within the system, was the severely kinked spine of the largest specimen captured (Fig. 73). This fish appeared to be recently spawned, but there were no external signs of injury accompanying the spinal distortion. Whether by injury, or defective development, the condition appeared to have originated much earlier. This observation may be of key importance in defining the life history and associated distribution of bull trout, within the Kwoiek Creek system.

The absence of any juvenile bull trout at electrofishing sites in the Kwoiek Creek mainstem, except those immediately upstream and downstream of Kwoiek Lake (principally the former; Tables 8 and 9), suggests a lacustrine-adfluvial population associated with Kwoiek Lake (McPhail and Baxter, 1994). On the other hand, the large size of some individuals caught in the lake could equally suggest an additional fluvial-adfluvial component, potentially involving migration of fish from the Fraser River (*ibid.*).

Although it seems unlikely, it is conceivable that large bull trout, known for their exceptional ability to ascend barriers (*ibid.*), might also (ie. as previously considered for steelhead) successfully negotiate the flume near the mouth of Kwoiek Creek (perhaps over a specific range of fall flows). As noted earlier, large Dolly Varden (> 3 kg) have been reported for the *lower creek* (specific location not given; MacDonald, 1988), and these fish may well have been bull trout¹⁸. If such fish could negotiate the flume, the additional obstructions in Kwoiek Creek downstream of Kwoiek Lake should pose little difficulty to ongoing passage, even during low flows, like those observed in October 1995 (Figs. 8 and 18).

¹⁸. The distinction between Dolly Varden and bull trout, and their distributions, was not fully understood or documented when these observations were reported.



Figure 72. One of the large bull trout in the gill netting capture from Kwoiek Lake, October 1995 (note distorted spine).

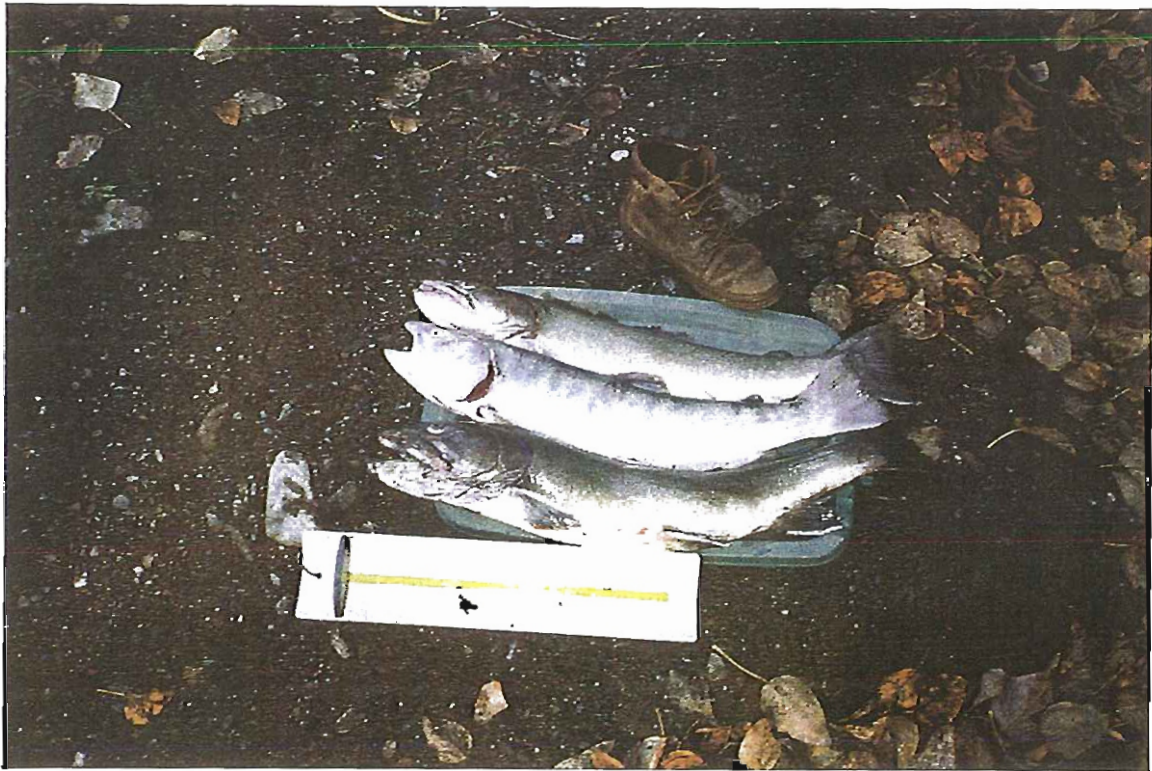


Figure 73. Three large bull trout captured by gill netting in Kwoiek Lake, October 1995 (again, note distorted spine of individual at bottom).

Given the superior spawning potential in Reach 6 of Kwoiek Creek, upstream of Kwoiek Lake (Table 3), this might easily be the destination of such fish, known for their long migrations and finite homing to isolated spawning/rearing sites (McPhail and Baxter, 1994). Some individuals might also utilize the above average spawning potential (for the system) in some areas of Reach 5, downstream of Kwoiek Lake (Table 3), as may be evidenced by the capture of juveniles (in extremely low numbers) at electrofishing sites in this reach (Table 9).

Acknowledging the exceptional difficulties (and low efficiency) of electrofishing for bull trout juveniles (eg. Maricle, 1994), it is possible that such fish were present at sites lower in the Kwoiek Creek mainstem, but simply avoided capture. However, if this were the case, at least a chance capture would be expected at one or more of the 11 electrofishing sites lower in the system (Table 9).

On the other hand, the absence of bull trout juveniles at all such sites (as suggested by the electrofishing results) need not indicate the absence of a fluvial-adfluvial population. Such a population might *exclusively* utilize only Kwoiek Lake and Reaches 5 and 6 of the Kwoiek Creek mainstem, until ready for emigration (McPhail and Baxter, *op. cit.*).

Ultimately, it may be the deformed specimen noted above that provides the best indicator as to whether a migratory stock is present, or not. Certainly, such a fish would seem to have no chance of ascending *any* serious obstructions, let alone the flume near the mouth of the system. Given that the condition appeared to be old, it seems most likely that this fish, at least, was resident within Kwoiek Lake, as part of a lacustrine-adfluvial population.

4.6.2 Numbers of fish in lakes

Although the gill net sets in the investigated lakes were all of similar duration, and extended overnight, the exact number of hours varied from lake to lake, as dictated by circumstances (Table 18). To standardize the results as much as possible, captures are expressed in terms of *fish/net hour* (Neuman, 1992). However, in addition to the previously noted limitations of gill netting, specific to the lakes investigated here, all gill netting results are subject to some degree of chance, as well as bias due to selectivity, location, weather conditions, etc. (eg. Hamley, 1975). Accordingly, all results and interpretation must be viewed with reservation.

With the exception of the bull trout in Kwoiek Lake, all capture rates relate entirely to rainbow trout. The highest rate (6.14 fish/net hour) was in Klept Lake, and the lowest in Chochiwa Lake (0.92 fish/net hour; Table 18). Following Klept Lake, fish appeared to be most abundant in Kwoiek Lake (4.44 fish/net hour, total), with the great majority being rainbow trout (4.00 fish/net hour). Given the apparently low numbers in Chochiwa Lake, the catch rate was surprisingly high in Kokwaskey Lake (2.15 fish/net hour). Conversely, the rate in John George Lake (2.56 fish/net hour), comparable to that in Kokwaskey, was rather low in view of the much higher capture rate in Klept Lake (Table 18), just upstream (Fig. 70). The rate in Kha Lake (3.54 fish/net hour) was just in excess of the overall mean (3.29 fish/net hour).

The large capture of fish (all rainbow trout) in Klept Lake is consistent with the exceptionally high densities of rainbow fry and yearlings captured at electrofishing site 23 (Tables 12 and 15), in the short length of Kwoiek Creek between Klept and Kha lakes (Fig. 70). The same applies to the capture in Kwoiek Lake, and the superior densities of juveniles at electrofishing sites in Reach 6 of Kwoiek Creek, immediately upstream (Tables 12 and 15).

At the other extreme, the indication of low numbers in Chochiwa Lake is consistent with the particular lack of spawning habitat associated with this lake. By the same token, the higher numbers in Kokwaskey Lake (relative to Chochiwa Lake) correspond with somewhat greater spawning potential (collectively) in Chochiwa Creek, the inlet section of Kwoiek Creek (below the debris jam), and gravels in the outlet area of the lake itself (Fig. 57). However, it should be reiterated that the lower numbers of fish captured in Kokwaskey and Chochiwa lakes could be directly attributable to differences in size and morphometry, and associated sampling efficiency/coverage, compared to the other lakes.

The relatively low catch rate in John George Lake (2.56 fish/net hour) is more surprising, given the excellent spawning opportunity in the inlet section of Kwoiek Creek (Fig. 61), as well as at the outlet area of the lake (Fig. 62). The indication of moderate fish numbers in Kha Lake (Table 18) is consistent with the moderate fry densities sampled in Reach 10 of Kwoiek Creek, upstream (Tables 12 and 15). Presumably, the high densities of rainbow juveniles in Kwoiek Creek, below the outlet of Kha Lake (site 23; Tables 12), principally recruit to Klept Lake, downstream.

In terms of comparison to other B.C. systems, even the catch rate for Chochiwa Lake was higher than might be expected, given the greater glacial influences evidenced in this case (eg. Griffith, 1994a; 1994b). Certainly, the results for all other lakes (including Kokwaskey Lake) seem to be excellent, especially under the harsh environmental conditions (and constraints) throughout the Kwoiek Creek drainage, as a whole (eg. Griffith, 1994c). Most significantly, the catch rates in Kwoiek, Klept, and Kha lakes appear to be very good, even compared to lakes in more temperate parts of British Columbia (*ibid.*).

4.6.3 Size of fish in lakes

Fork length statistics for the full samples from all lakes investigated in October 1995 are provided in Table 18. Obviously, by far the largest fish were the bull trout from Kwoiek Lake. The largest rainbow were captured in John George (max. 416 mm), Klept (max. 392 mm), and Kha lakes (max. 361 mm; Table 18). The maximum length of rainbow in Kwoiek Lake was only 244 mm; in view of this, it may be surprising that the mean length was 198.7 mm, the largest for any of the lakes sampled (Table 18).

This is undoubtedly related to the presence of bull trout in this lake. In two of the three large individuals caught in October 1995, gut contents were found to contain rainbow trout of 120 mm to 160 mm (Appendix 7). A smaller individual (352 mm) also contained fish remains.

Although rainbow trout as small as 113 mm were captured in Kwoiek Lake (Table 18), the total number of fish < 160 mm (8 fish; Appendix 7) represented only 11.0% of the total capture (73 fish). In comparison, the range was 29.8% to 68.4% for the other lakes investigated (Table 18), with a mean of 50.2%.

A very obvious (and likely) explanation of this would be predation of smaller rainbow trout by the bull trout in Kwoiek Lake, consistent with the traditional feeding behaviour reported for the latter species (McPhail and Baxter, 1994).

Although the mean fish length for the entire sample of rainbow trout from Kwoiek Lake was greater than those for all other lakes investigated (Table 18), this does not apply to older/larger age groups in the sample (ie. Ages 3+ and 4+; Table 19). In fact, acknowledging the skewed results for Kwoiek Lake, the mean length of rainbow trout was actually greatest in John George, Klept, and Kha lakes, consistent with the larger *maximum* lengths in the samples from these lakes (Table 18).

The somewhat smaller mean length of rainbow trout in Klept Lake, compared to John George and Kha lakes, may be related to the much greater number of fish captured in Klept Lake, compared to the other two (Table 18). However, the results for Klept Lake are the only suggestion of any inverse relationship between catch rate and mean length of fish (ie. numbers vs. size). In fact, results for all other lakes investigated suggest the reverse, if anything (Fig. 74).

For all samples, including Klept Lake, stronger relationships (direct) are evidenced between mean length of fish and water chemistry, as reflected by total dissolved solids, and total alkalinity (Fig. 74). Nonetheless, the sample from Klept Lake does convey a particular influence of catch rate (population size) on mean length, when compared to the results for all other lakes investigated (*ibid.*).

The smallest mean lengths of rainbow trout were obtained from Chochiwa and Kokwaskey lakes (Table 18). Results were highly similar for these two lakes (141.8 mm and 145.5 mm, respectively), and were substantially lower than all others (Table 18). This is likely due to particular constraints of water chemistry and relative potential for fish production (Tables 6 and 7; Fig. 74). Colder water temperatures are another likely factor, as evidenced for Chochiwa Lake, at least (Table 5; Appendix 5).

4.6.4 Age structure of fish populations in lakes

The oldest fish captured in any of the lakes investigated were the 3 large bull trout from Kwoiek Lake (Figs. 72 and 73). Although otoliths from the largest specimen (721 mm) were difficult to read, this fish appeared to be age 10+. The others (659 mm, 665 mm) were both age 8+. Two individuals close to 350 mm appeared to be age 6+ (Appendix 8).

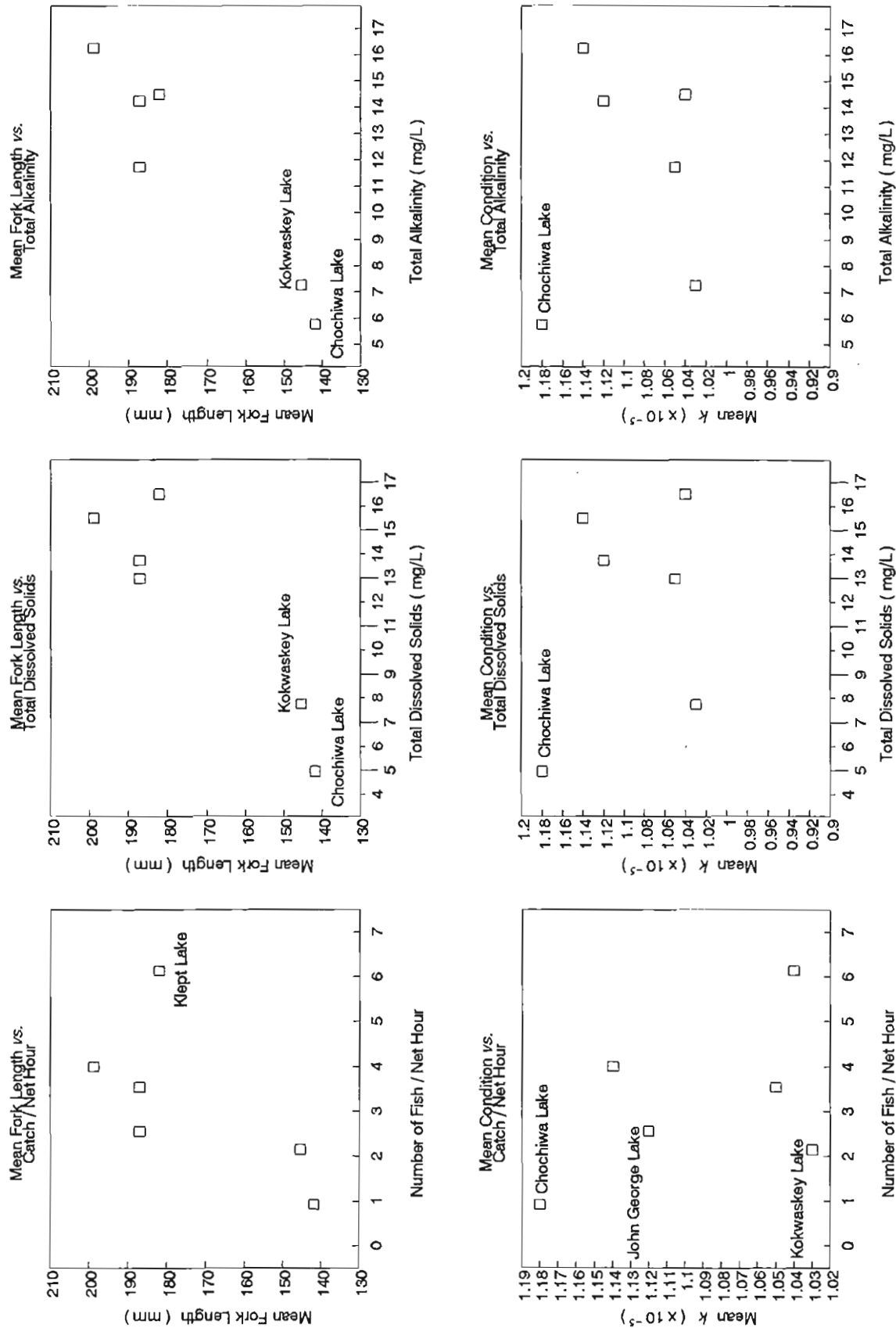


Figure 74. Relationship between the length and condition of rainbow trout and other variables, for captures from lakes investigated within the Kwoiek Creek drainage, October 1995.

Significant difficulties were experienced in the determination of age for rainbow trout (from scale samples), both from streams and lakes, within the Kwoiek Creek drainage. However, for stream samples the delineation of age groups was generally (and clearly) aided by length frequency distributions (eg. Fig. 71). In areas upstream of Kwoiek Lake, comparison of these distributions with relevant scale samples frequently revealed the presence of a first annulus after as few as 2 or 3 circuli. In some cases, it seemed likely that a first year's annulus was totally absent. This was evidenced in the scale samples from some older parr, but most frequently raised doubts in the delineation between fry and yearlings in the size range of 70 mm to 80 mm (total capture; Fig. 75).

The reduced or absent first annulus for some individuals is likely explained by the small size of many rainbow fry found in the Kwoiek Creek drainage, towards the end of October, in 1995 (Appendix 6). This was most pronounced in Reaches 7 to 10 of the Kwoiek Creek mainstem, upstream of the second (barrier) falls above Kwoiek Lake. In these reaches, the great majority of fry were <40 mm in length (Fig. 75).

Difficulties in aging rainbow trout from lake samples was further complicated by the overlap of age group size ranges, both within lakes (eg. age at recruitment), and between lakes (variable growth rates). This is shown in the top part of Figure 76, where initial inspection might lead to the conclusion that fish to 250 mm in length fell into 2 principal age groups. However, as shown in the more detailed plot, at the bottom of the figure, 3 major age groups were actually represented within this size range.

Notwithstanding a certain level of uncertainty, it would appear that a total of five different age groups were present in the rainbow trout samples from the lakes investigated; age 1+ to 5+ (Table 19). No fry were captured in any lake (including minnow trapping, which only produced 2 yearlings in Klept Lake, as previously noted).

For each lake investigated, the suspected age composition of gill net captures is provided in Table 19. For ages 1+ to 4+, these results are also illustrated in Figure 77. The variation in the results is quite remarkable. The most obvious anomaly was the extremely low proportion of age 1+ and 2+ fish in the sample from Kwoiek Lake.

Table 20 provides an interpretation of lake recruitment, based on further scale analyses. A combination of age 0 to age 3 recruits is suggested for Kwoiek Lake. All indications from survivorship suggest similar predominance of age 1 and 2 recruits. The very low numbers of age 1+ and 2+ fish in the total capture itself (Table 20) may directly reflect predation by large bull trout, as previously discussed.

However, this would not account for the obvious survivorship to age 3+, which dominated the capture (Table 19; Fig. 77). It may be more likely that, at the time of sampling, age 1+ and 2+ rainbow were more abundant in the pelagic zone (and/or other areas of the lake), due to the presence of the large bull trout at the netting location. Such avoidance/segregation has been observed for rainbow trout and Dolly Varden in B.C. lakes (Nilsson and

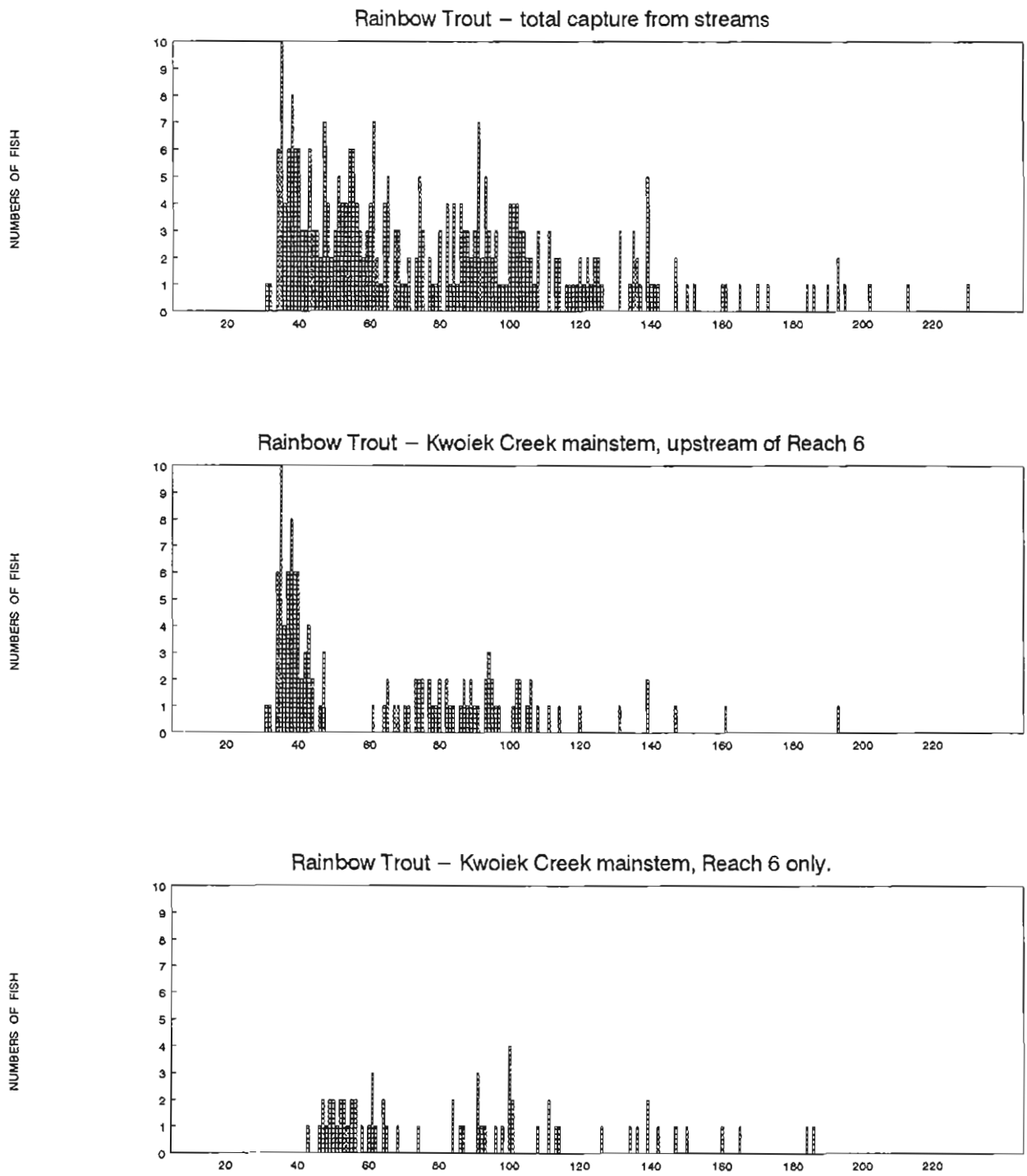


Figure 75. Length frequency distribution of rainbow trout captured in stream habitat within the Kwoiek Creek drainage, October 1995.

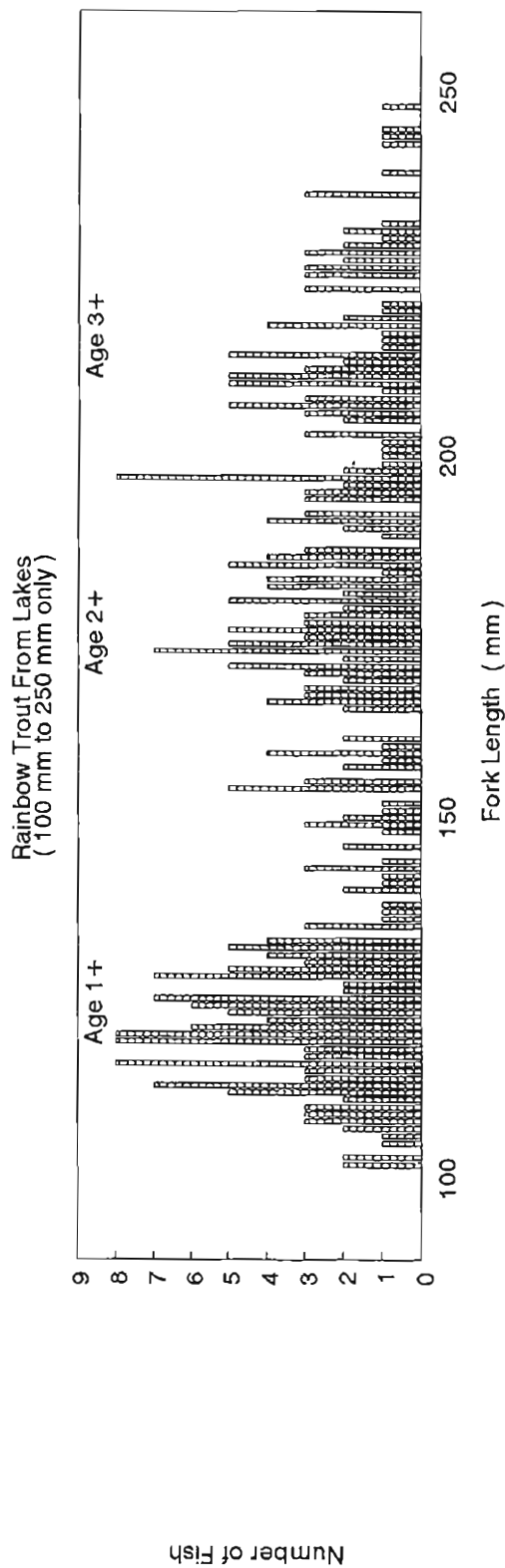
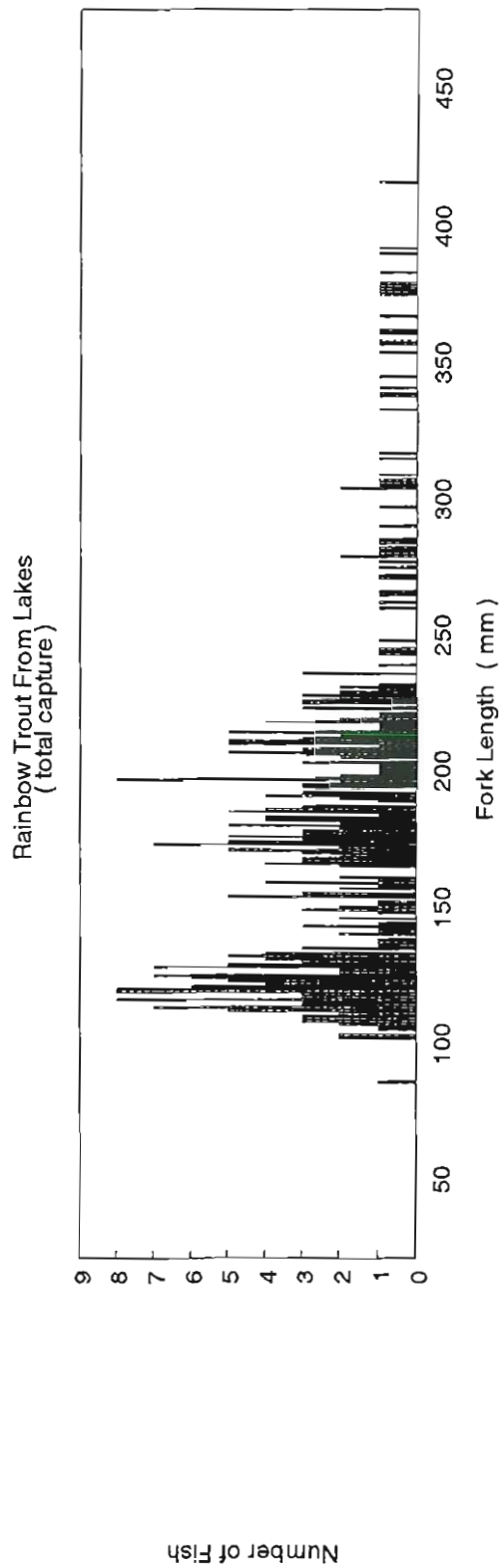


Figure 76. Length frequency distribution of rainbow trout from all lakes investigated within the Kwoiek Creek drainage, October 1995.

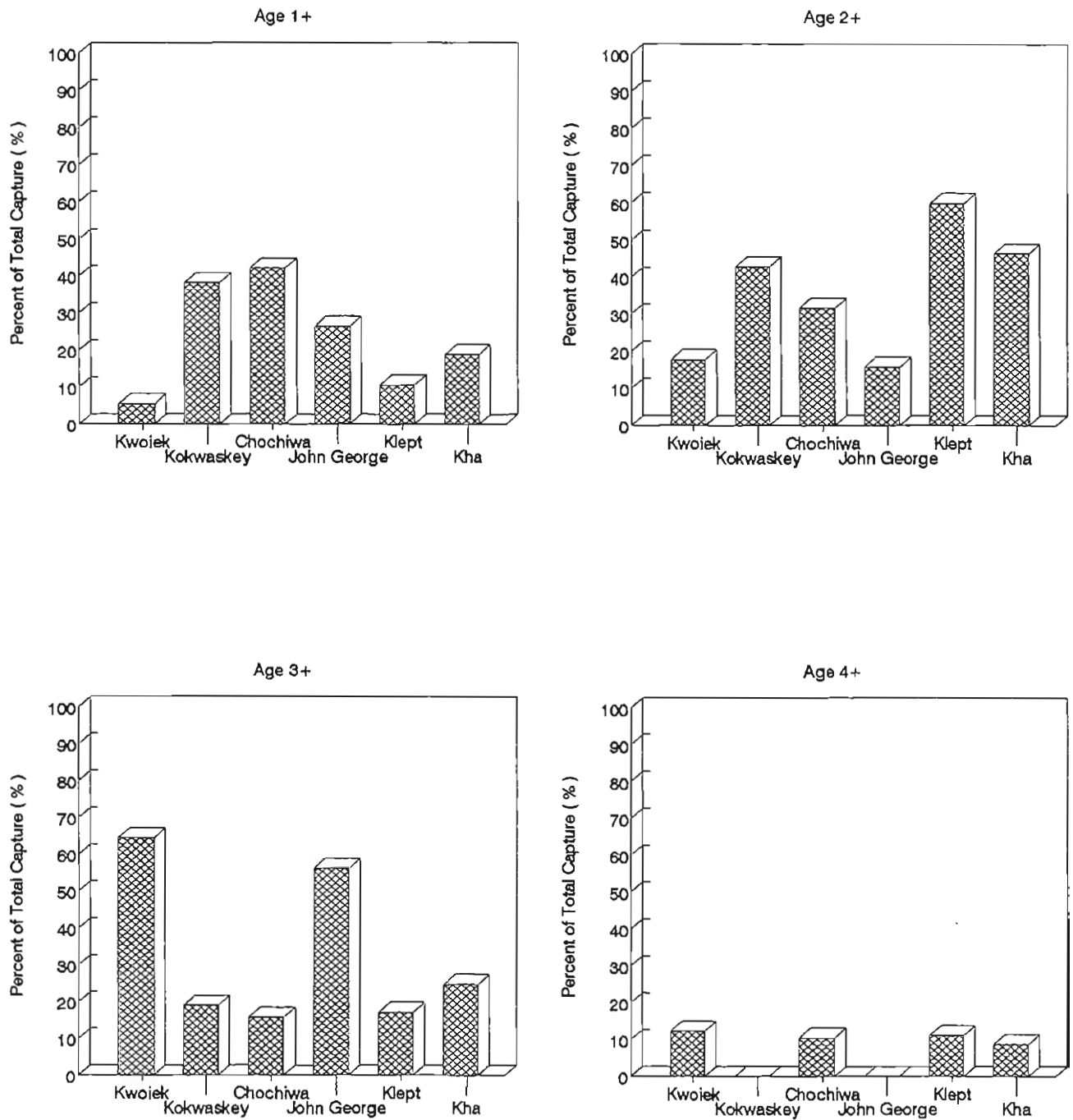


Figure 77. Composition of rainbow trout captures, by age group, in lakes investigated within the Kwoiek Creek drainage, October 1995.

Table 20. Age composition of rainbow trout recruits to lakes investigated in the Kwoiek Creek drainage in October 1995, based on scale samples from fish captured by gill netting.

Sampling Result	Rainbow Trout					
	Kwoiek L.	Kokwaskey L.	Chochiwa L.	John George L.	Klept L.	Kha L.
Age range of recruits	Ages 0-3	Ages 0-2	Ages 0-2	Ages 0-2	Ages 0-3	Ages 0-3
Age 1+ captures						
Readable samples	4	16	8	15	16	13
Percent Age 0 recruits	0.0	56.3	62.5	53.3	68.8	46.2
Percent Age 1 recruits	100.0	43.8	37.5	46.7	31.3	53.8
Age 2+ captures						
Readable samples	13	18	6	9	90	32
Percent Age 0 recruits	7.7	33.3	16.7	44.4	24.4	15.6
Percent Age 1 recruits	46.2	50.0	33.3	44.4	28.9	56.3
Percent Age 2 recruits	46.2	16.7	50.0	11.1	46.7	28.1
Age 2+ and older captures						
Readable samples	-	25	11	41	-	-
Percent Age 0 recruits	-	28.0	36.4	39.0	-	-
Percent Age 1 recruits	-	60.0	36.4	53.7	-	-
Percent Age 2 recruits	-	12.0	27.3	7.3	-	-
Age 3+ and older captures						
Readable samples	56	-	-	-	45	24
Percent Age 0 recruits	3.6	-	-	-	6.7	0.0
Percent Age 1 recruits	46.4	-	-	-	44.4	41.7
Percent Age 2 recruits	35.7	-	-	-	31.1	50.0
Percent Age 3 recruits	14.3	-	-	-	17.8	8.3

Northcote, 1981). In Kwoiek Lake, different results may well have been obtained with additional sampling, in a different area of the lake, and use of a floating net.

Anomalies in Klept, John George, and (to a lesser extent) Kha lakes are more difficult to rationalize. Based on analysis of scale samples, age 2+ fish appear to have constituted 60% of the total catch in Klept Lake. This included all individuals displaying one of the following: 1) a distinct annulus after 5 to 8 circuli; 2) a suspected annulus after 2 to 3 circuli; or 3) the likely absence of the first year's annulus (ie. first apparent annulus at > 10 circuli). The latter 2 were common, consistent with the particular predominance of small rainbow fry at electrofishing site 23, just upstream of Klept Lake in October 1995 (Appendix 6).

In contrast to the scale analyses, the length frequency distribution of the catch from Klept Lake suggests a more normal combination of ages 1+ and 2+ (Fig. 78). In the capture from John George Lake, a combination of age 2+ and 3+ fish appears to have constituted the majority (*ibid.*). Similar to Klept Lake, however, scale analyses suggested a great dominance of age 3+ fish for John George Lake (Fig. 77).

Scale samples obtained from these lakes were analysed using a variety of different criteria, in attempts to resolve these differences. This resulted in broader areas of doubt, and further confusion, prompting ultimate adherence to the initial criteria. It seems more logical that populations in Klept Lake would have an age structure more similar to the length frequency distribution shown in Figure 78, and aging of some scale samples may have been erroneous, as outlined above. The same also applies to results for John George Lake, and to a lesser extent, the apparent dominance of age 2+ fish in the sample from Kha Lake, as well (Fig. 77).

However, it should be noted that the age determination in the present study (relative to fish size) is generally consistent with that of the 1962 survey of the system (Stenton and DeLair, 1963), acknowledging that data were very limited in the latter investigation (16 fish from Kokwaskey Lake). If anything, a slightly smaller mean size per age group is evidenced by the 1962 aging (ie. supporting interpretations regarding designation of first annuli in the 1995 samples).

If the aging of 1995 specimens was correct, and age structures of the various lakes were actually as depicted in Figure 77 (ie. on the basis of scale analyses), this may reflect abrupt reduction of recruitment for the 1994 brood year. The suggested predominance of age 3+ fish in John George Lake possibly indicates an earlier (perhaps routine) surplus of fish in Klept Lake, as suggested for age 2+ fish in 1995 (and consistent with extremely high densities of juveniles in the short section of Kwoiek Creek, upstream).

This is highly speculative, of course, and is subject to a variety of sampling and analytical constraints, as previously outlined. Nonetheless, it is important to consider that all of these findings could indicate impacts on recruitment to John George, Klept, and Kha lakes for the 1994 brood year (at least), as a result of the substantial disturbances in this part of the watershed, from recent forest harvesting (eg. Fig. 48).

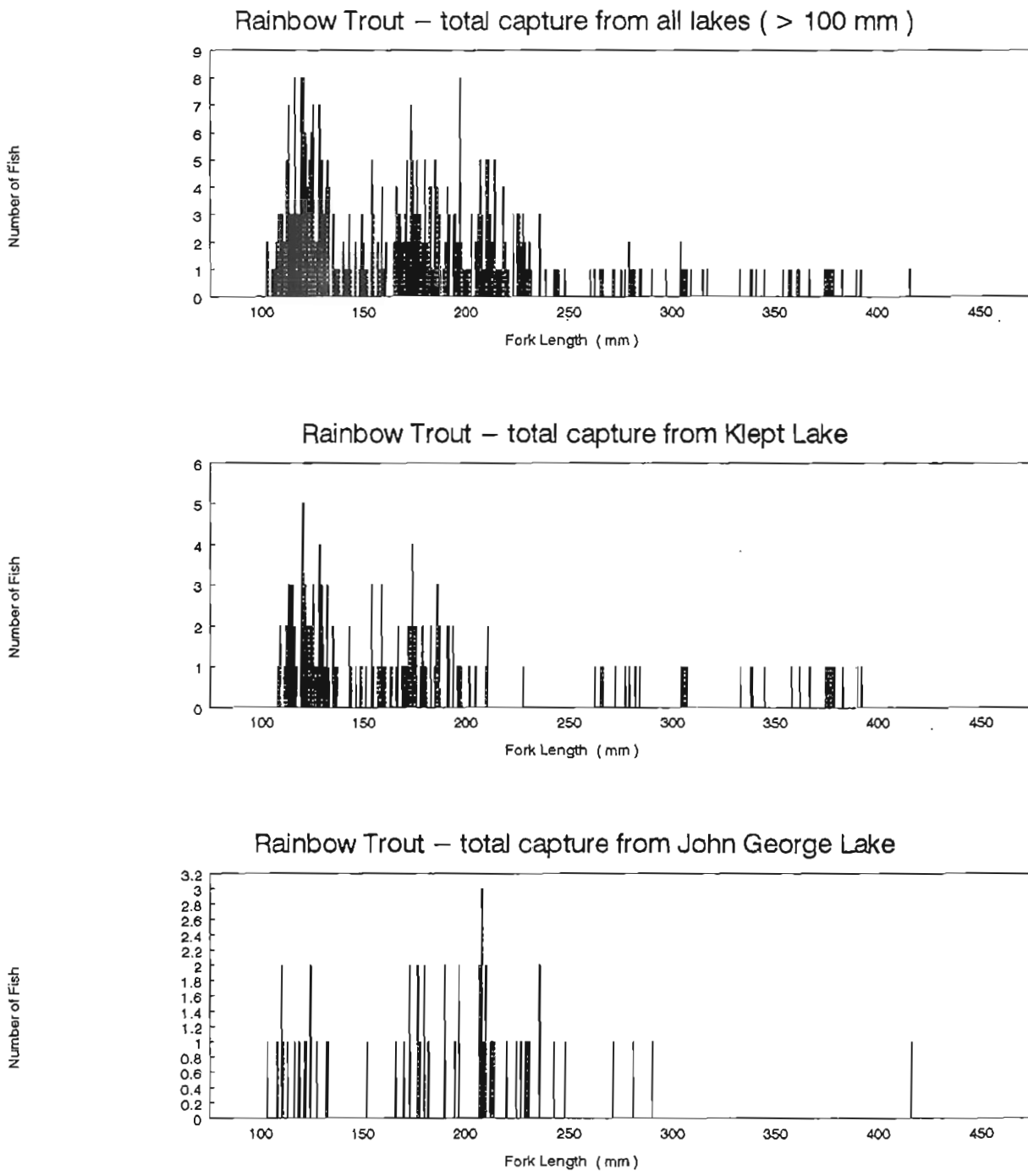


Figure 78. Length frequency distribution of rainbow trout in Klept and John George lakes, compared to collective results for all lakes investigated, October 1995.

As a footnote to this, the age structure of the captures from Kokwaskey and Chochiwa lakes appeared to be most consistent with age structure in a normal population (Krebs. 1972). This was particularly so for Chochiwa Lake (Fig. 77), the only lake investigated whose watershed remained *totally* undisturbed. As a final note with respect to the age interpretation by scale analyses (key to these discussions), some support is also provided by the logical and reconcilable agreement in the mean sizes for age groups identified as 1+ to 3+, for all lakes investigated (Table 19; Fig. 79).

Unlike Kwoiek Lake, all of the other investigated lakes indicate a significant reliance on age 0 recruits, especially for age 1+ populations (Table 20). Accordingly, disturbances of the watershed could result in the dramatic impacts on populations of age 1+ fish suggested for Klept and Kha lakes (Fig. 77), with associated downstream effects (potentially) on John George Lake.

While this might be suggested for the 1994 brood year, the electrofishing data may indicate a recovery in 1995. This is certainly suggested by the high densities of rainbow fry at electrofishing site 23, between Klept and Kha lakes (Tables 12 and 15). On the other hand, the relatively high abundance of fines in Kwoiek Creek upstream of Kha Lake (Fig. 34), and the greatly lower densities of fry (Tables 12 and 15), possibly indicate ongoing impacts here, at least.

4.6.5 Condition of fish in lakes

Table 18 provides the mean condition factor (index of weight as a function of length; defined in Table 18) for the full captures of fish from all lakes investigated. The results for Kokwaskey, Klept, and Kha lakes (1.03×10^{-5}) may be viewed as average, to slightly below average, compared to other lakes in British Columbia (eg. Griffith, 1994c). However, results for John George Lake and Kwoiek Lake (1.12×10^{-5} and 1.14×10^{-5} , respectively) seem well above average.

Most notably, the result for Chochiwa Lake (1.18×10^{-5}) is exceptionally good, and is very surprising, given the earlier suggestion of suppressed fish length, as a result of water chemistry and temperatures. While some relationship between water chemistry and the condition of rainbow trout is evidenced for the other lakes, the same does not apply to Chochiwa Lake (Fig. 74).

Detailed analysis and evaluation of diet and condition are beyond the scope of this investigation, and the associated sampling limitations. However, some general trends are evident in the results, and warrant consideration here.

An interesting phenomenon is the apparent decline of condition in successive age groups of rainbow trout, in all lakes investigated, except Kwoiek Lake (Table 19). This could reflect limited abundance of increasingly larger food items, most conducive to the shifting diet of growing rainbow trout (eg. Scott and Crossman, 1973).

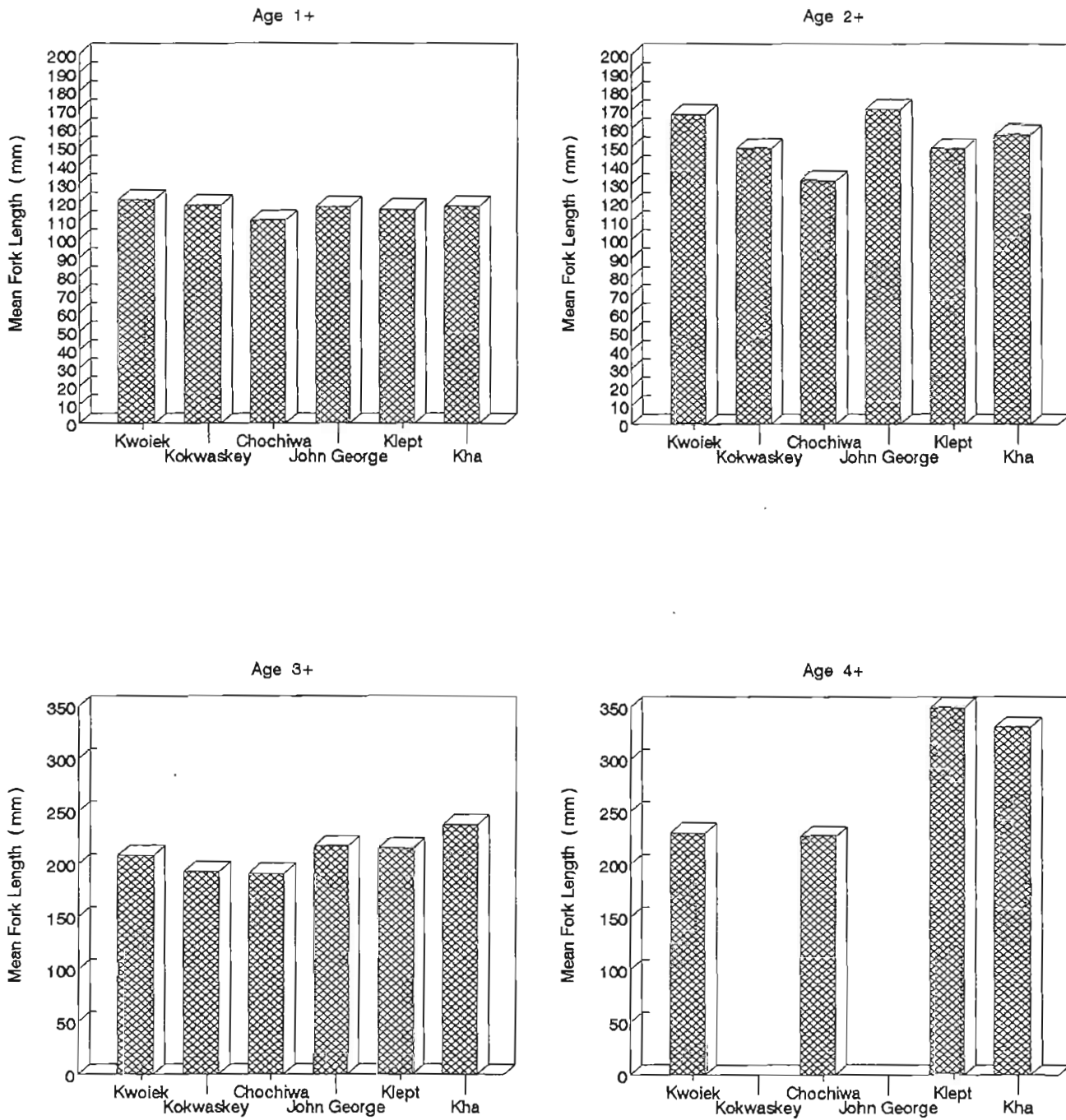


Figure 79. Mean length of rainbow trout, by age group, from gill netting captures in lakes investigated within the Kwoiek Creek drainage, October 1995.

For most lakes investigated (excluding Kokwaskey and Chochiwa lakes) gut contents of captured rainbow largely consisted of aquatic insect larvae and other benthos (Appendix 7). Both the abundance and diversity of such organisms, in all lakes investigated, may be constrained by the lack of light penetration (Secchi depths; Table 5), if only indirectly (Russel-Hunter, 1970). Reduction of both Secchi depth and benthic production in lakes has been shown to accompany increased inorganic sedimentation, due to forest harvesting in associated watersheds (Parkinson *et al.*, 1977).

There was no evidence of fish in the diet of any rainbow trout captured. However, one specimen from Kwoiek Lake was found to contain small frogs. Based on concentrations of volatile solids (Appendix 4), there was no detectable organic matter (ie. phytoplankton or zooplankton) in the water samples from most of the lakes investigated. Only minor amounts were indicated for the surface waters of Klept and Stukolait lakes, and the deeper waters (30 m) of Chochiwa lake.

The latter findings are most interesting, in that zooplankton appeared to constitute a substantial proportion of the gut contents of captures from Chochiwa and Kokwaskey lakes. Many fish contained unidentifiable pink matter (Appendix 7) believed to indicate feeding on copepods, as observed in other cold and glacially influenced lakes (Griffith, 1994*b*; 1994*d*).

This being the case, it is most interesting that fish from Chochiwa Lake displayed such exceptional condition (Tables 18 and 19), although water analyses suggest that the abundance of such food was likely low. This may be further evidence of a very small population of fish in this lake, consistent with the gill netting results.

Fish in Kokwaskey Lake evidenced similar feeding on suspected zooplankton, but to a lesser degree than those in Chochiwa Lake. There appeared to be a greater reliance on terrestrial insects (eg. ants) in the samples from Kokwaskey Lake (Appendix 7). In any event, the indication of substantially larger numbers of fish in this lake, compared to Chochiwa Lake, could explain the consistently poorer condition of fish (Tables 18 and 19).

The superior condition of the capture from John George Lake is most intriguing. Gut contents indicated substantial reliance on benthic organisms, as evidenced for Klept, Kha, and Kwoiek lakes (Appendix 7). However, the gut contents of several fish from John George Lake included remains (carapaces and appendages) that appeared to be those of *Gammarus sp.*. The same applies to Kwoiek Lake, where the condition of rainbow trout was also superior (Tables 18 and 19), despite the added presence of bull trout in this lake.

In addition to being highly piscivorous, bull trout also feed on benthic organisms (Rieman and McIntyre, 1993; McPhail and Baxter, 1994). Given the dominance of such food in the gut contents of rainbow trout from Kwoiek Lake (Appendix 7), some level of inter-specific competition would be expected, in addition to the intra-specific competition suggested by the results for Kokwaskey Lake (fish condition) and Klept Lake (fish length), at least.

In the absence of detailed data and analyses, the particularly shallow depth of Kwoiek Lake (Table 5; Appendix 5) appears to provide the most plausible explanation for both the presence (and maintenance) of the bull trout population, and the apparently superior condition of rainbow trout, despite this presence. It also seems likely that the predation of bull trout on smaller rainbow may be related to the maintenance of superior condition in older age groups of the latter species (ie. reduction of intra-specific competition through control of small competitors, and/or more intensive partitioning of habitat). The poorer condition of the age 1+ rainbow sample from Kwoiek Lake (Table 19) may also reflect the exertion of such controls (ie. restricted access to benthic feeding areas inhabited by bull trout).

The exceptionally poor condition of age 4+ and 5+ fish from Klept and Kha lakes (Table 19) also reflects extraordinary conditions. In this case, it was the influence of reproductive status. In these lakes, a broad spectrum of development was exhibited by the sample of age 3+ and older fish obtained in October 1995 (Appendix 7).

Some individuals were at or near maturity, for presumed spawning the following spring (Fig. 80). Others were dark and depleted, and gave all indications of recent spawning (*ibid.*). In the sample from Klept Lake, 3 females were fully ripe (or over ripe), with eggs loose within the body cavity, and many atrophying (Fig. 81). Residual eggs (and egg casings) were also found in one specimen from Kha Lake (Appendix 7).

It is not known why such conditions should be exhibited by rainbow populations from Klept and Kha lakes, given the superior spawning potential in Kwoiek Creek, between these lakes (habitat survey 17; Table 3). However, with the indication of first spawning predominantly at age 4 or 4+¹⁹, the above conditions pertained to the majority of age 4+ fish, and all age 5+ fish, in the samples from both lakes (Appendix 7). This resulted in the exceptionally low condition factors shown in Table 19.

5.0 DISCUSSION

5.1 Methods Used and Reliability of Results

There are inherent limitations to any single point-in-time assessment of freshwater fish populations and their habitat. In the 1995 study of the Kwoiek Creek drainage, the scope and depth of data collection were extensive. However, many estimates had to be made, and even though the data are numerous and diverse, they are no more than a collection of samples and observations from a broad continuum in time and conditions. In addition, all methods of data collection and analysis are subject to their own constraints, and none are perfect, nor totally accurate. Furthermore, no matter how extensive the data base, there is always the risk that

¹⁹. Based on analysis of scale samples, and subject to the same uncertainties with respect to age, previously discussed.

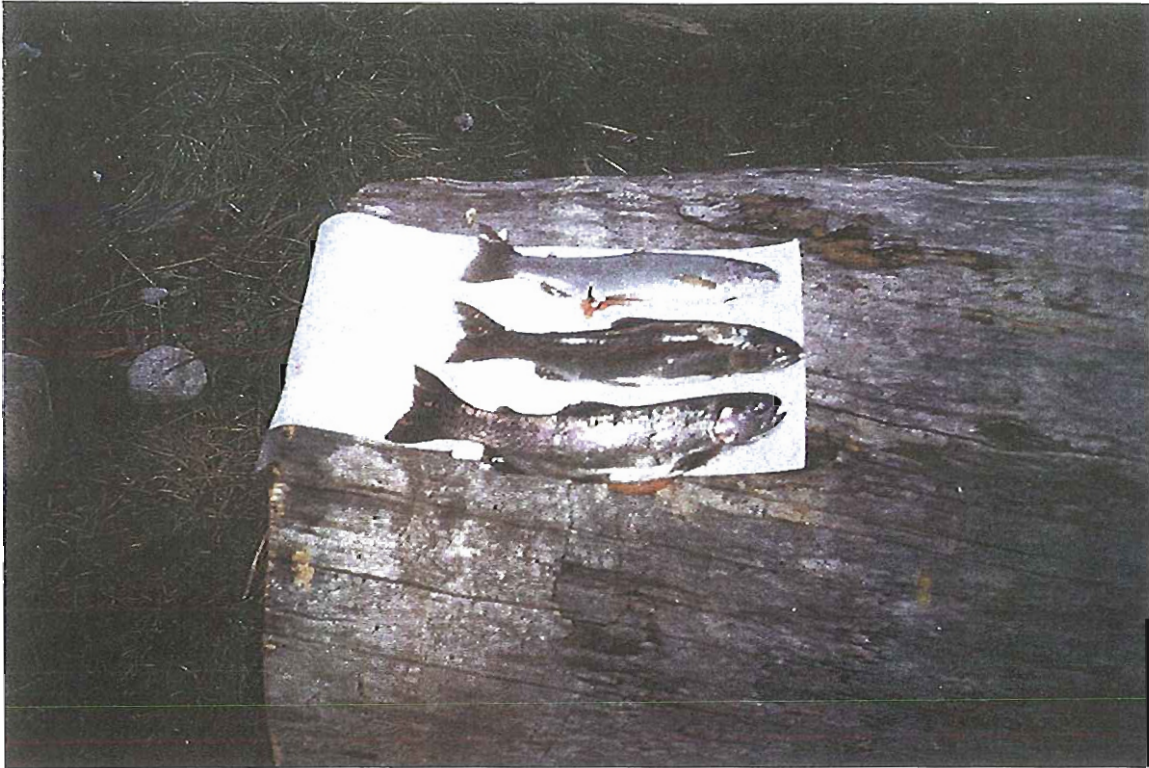


Figure 80. Array of sexual development in female rainbow trout captured in Kha Lake, October 1995.



Figure 81. Over-ripe female rainbow trout captured in Klept Lake, October 1995 (note atrophying eggs).

various considerations may be overlooked, under-estimated, or misinterpreted during either the collection or analysis of the data.

However, the reality of resource management is that decisions must be made despite such limitations. The investigator's responsibility is to provide the best possible interpretation and understanding of key issues and dynamics, in order to enable the most appropriate management decisions, based on the information at hand. In terms of the information itself, the ideal is a balanced compromise between detail (fullest information with respect to each issue), precision (absolute accuracy of all estimates), and scope (ensuring attention to all key issues). By virtue of necessity, one is usually at the expense of another.

In the case of the Kwoiek Creek study, it is felt that an adequate balance was achieved, although it may always be argued that more information would be most desirable, or that any given estimate (or methodology) may not be entirely accurate. The key point is that the methodologies used in this study have enabled an understanding and interpretation of fish production in the system, that would not have been possible in their absence. The fact that the various approaches to different issues logically converge on similar conclusions may be the ultimate testament to their value.

A key component of this study was the application of a standing stock capability model for fish in stream habitats (Ptolemy, 1992). This resulted in a variety of anomalies (ie. routine indications of *super*-saturation in 1995). This may reflect particular inaccuracy (or distortion) of the model, in its specific application to the Kwoiek Creek system. The legitimacy of the results and associated conclusions hinge as much on the reliability of the capability model itself, as on the data collected in the field.

With respect to the model, it is based on thousands of data sets specific to B.C. streams. For rainbow trout, the vastly dominant species in the Kwoiek Creek drainage, the same applies to the probability-of-use data used in association with the model (Bech *et al.*, 1994). Both are based upon (and address) a wide range of stream sizes, and relate to habitat usability (as opposed to preferences) under an even greater range of conditions. They are based on actual fish densities sampled over this broad range, and thus provide the most useful measure of habitat capability, across a broad spectrum, but specific to British Columbia.

Unfortunately, less confidence can be attached to the modelling results for bull trout. In the absence of probability-of-use curves specific to B.C., modelling of this species relied heavily (by necessity) on very limited data from other geographic regions, and other species of char (eg. Anon., 1981; Pratt, 1984). It is also acknowledged that even for rainbow trout, it is unlikely that modelling (or sampling) results are *precisely* accurate, in any given case, or overall.

With respect to the field data, the degree to which they *do* accurately reflect the true conditions and dynamics, of any given system, hinges on the manner in which they are collected. In highly intensive investigations of salmonids and their habitat, the desire for results of maximum possible resolution may necessitate exhaustive and detailed sampling procedures, at

any given site (eg. Bovee, 1994). From a program perspective, such intensity directly limits the number of sites that may be addressed within the resources (time, budget) available for any given investigation. The trade-off between sampling intensity and *scope* is particularly critical in the assessment of entire drainages, such as that conducted for Kwoiek Creek.

The first objective must be a strategic inventory to identify, as fully as possible, all important fish populations and habitat resources within the system. Hence, the scope of the investigation is of key importance. Although tributaries to Kwoiek Creek were not investigated in detail, Figures 3 and 70 clearly demonstrate a wide distribution of sampling effort within the drainage. These figures also indicate the intensity of sampling, focusing on the Kwoiek Creek mainstem, and branching out strategically.

In terms of intensity (ie. in any given locale), a second trade-off must be made between diversification and replication of sampling. As indicated in Table 8, the emphasis in fish sampling was within the Kwoiek Creek mainstem, and on sites representative of *average* habitat conditions within the given stream section. As warranted, specific habitats were sampled to address specific issues; notably, to determine differences (if any) in fish use of the limited side channels, other less turbulent habitats, and tributary streams (including North Kwoiek and Chochiwa creeks). Although site-specific replication was sacrificed, in order to maximize the scope of the investigation, the spacing of representative sampling was kept as close as possible, in order to provide a *continuum* of replicates (of average conditions), throughout the system.

Obviously, conditions and influences vary from site to site, even within distinct stream reaches. Accordingly, differences would be expected between representative sites at any different locations. However, in the assessment of stream populations, as employed for the Kwoiek Creek system, results are ultimately standardized on the basis of *usable habitat*, by virtue of the modelling process. Consequently, results should directly reflect the broad issues of population dynamics (ie. recruitment/exploitation of suitable habitat) equally, at all sites. The inferred dynamics should make sense, with results at one site supporting the next, progressively, throughout the drainage. The closer the spacing between sites, the more they should support each other, as a continuum, and more accurately reflect the associated dynamics (Poole, 1974).

As outlined in preceding sections, results of the 1995 investigation of the Kwoiek Creek drainage reflect the above, and display a high degree of consistency both within and between different data sets. Generally speaking, data are mutually supportive, and enable logical interpretation of the dynamics of fish production (as sampled) within the system. It is fully acknowledged, however, that such interpretation is greatly limited by the restriction of most data to a single point in time.

Lastly, a very critical issue in the collection of field data, particularly by electrofishing, is the care with which the sampling is actually conducted. For any site where reliable population estimates are to be derived, the most important factor is the efficient and *unobtrusive* installation of stopnets. This involves careful selection of the site to be sampled, ensuring the ability to

successfully install and maintain nets, while adequately addressing representative habitat conditions. In the Kwoiek Creek drainage, this was particularly critical, due to the swift and turbulent hydraulic conditions characteristic of the system. Electrofishing sites were selected with extreme care, to best reconcile logistical constraints with investigative objectives.

Stopnets were always fed out from the downstream end of sites; were quietly extended from the shore, and then upstream; were sealed across the top end; and were pinned closely to the stream bottom with rocks, in addition to lead lines. To favour speed and efficiency in this process (as well as capture efficiency), site area was kept relatively small (primarily 25-50m²), as long as all requisite habitat features were adequately represented. This approach does not only ensure utmost confidence in the capture results at all sites, it also enables the greatest number of sites, and utmost confidence in the results overall (as outlined above).

With respect to lakes, it is fully acknowledged that the preliminary investigations conducted in 1995 provide only a cursory and instantaneous overview of conditions and implications. The very limited water sampling, at a single point in time, can only provide the most general indications of limnology and associated potential for fish production. In addition, fish sampling by gill net is subject to particular chance and/or bias, due to a variety of potential influences. Accordingly, resultant capture data (and their interpretation) are subject to corresponding uncertainty. Due to the subjectivity of (and complications in) various scale analyses, the same applies to the interpretation of associated life history events.

However, notwithstanding these limitations, a great volume of data were obtained from the lakes investigated in October 1995. Though data sets are far from complete, individually, they also appear to be mutually supportive, and are highly consistent with data and implications from the investigations of associated stream habitat.

Any data are subject to a variety of inaccuracies and limitations. This is especially true for biological studies in the wild, where a great multitude of factors come into play, but few can be addressed. As suggested above, the ultimate value of *any* volume of data is the degree to which it enables meaningful interpretation, by means of logical analyses. To this end, it is believed that such results were achieved in the 1995 investigation of the Kwoiek Creek system.

5.2 Composition and Status of Fish Populations in the Kwoiek Creek Drainage

5.2.1 Rainbow trout

Rainbow trout clearly constitute the vast majority of fish production within the Kwoiek Creek drainage. This species is concentrated within the Kwoiek Creek mainstem and associated lakes. In October 1995, rainbow trout were found in all reaches of Kwoiek Creek, except the uppermost 1.7 km (above major cascades; Fig. 32), and Stukolait Lake, located at the headwaters.

Although concentrations of rainbow fry appeared to be highly localized and specific in October 1995, parr densities were frequently above theoretical capability levels (often greatly) in most sections of the Kwoiek Creek mainstem (Table 16)²⁰. In the adjacent Nahatlatch River drainage, high densities of rainbow parr were interpreted as an indication of steelhead production (Griffith, 1995a). However, this applied to the lowermost sections of this system.

In lower Kwoiek Creek (ie. downstream of Kwoiek Lake) rainbow parr densities were high (very close to theoretical saturation, on average; Table 16), but they were not as high as they were above barriers to fish passage, further up the system. It is *conceivable* that steelhead might be able to ascend the flume (under the railway crossing) at the top of Reach 1, and ascend the Kwoiek Creek mainstem as far as the second falls upstream of Kwoiek Lake. However, it seems extremely unlikely that these falls could be ascended, even by steelhead (Fig. 20). This speculation is supported by the absence of bull trout in any sampling upstream of these falls, despite the presence of very large individuals in Kwoiek Lake (Figs. 72 and 73), the exceptional ability of such fish to ascend natural obstructions (McPhail and Baxter, 1994), and the characteristic behaviour of the species to utilize headwater areas, if accessible (*ibid.*; Rieman and McIntyre, 1993).

While the presence of steelhead juveniles at the time of sampling in 1995 cannot conclusively be denied, the data appear to be most indicative of *resident* rainbow trout, with greatest concentrations in stream sections upstream of Kwoiek Lake, due to the production of recruits to the chain of lakes on the Kwoiek Creek mainstem, in addition to resident populations within Kwoiek Creek itself. This seems most evident in the extremely high densities of rainbow fry and yearlings at electrofishing site 23, between Klept and Kha lakes (Table 16), and the apparently high numbers of fish in Klept Lake, itself (Table 18). The same also applies to Kwoiek Lake, and densities of juvenile fish in Kwoiek Creek Reach 6 (*ibid.*).

As noted earlier, the widespread super-saturation that is indicated by the capability modelling for streams (Tables 15 and 16) may raise doubts about the model's accuracy, in its specific application to the Kwoiek Creek system. However, for results addressing representative (average) habitat only, *mean* standing stock estimates were generally below corresponding capability estimates (Table 16). The major exceptions again apply to parr (yearlings in particular) in mainstem sections upstream of Kwoiek Lake (including areas above barrier falls). On average, all standing stock of juveniles was below corresponding capability estimates downstream of Kwoiek Lake, with the notable exception of the coho fry in the side channel associated with Reach 1 (Table 16).

²⁰. Results in Table 16 relate to size/age groups of rainbow trout and bull trout combined. However, bull trout were present at sites 12 to 17 only. With the further exception of coho fry at site 2, all other results relate *exclusively* to rainbow trout.

It is most interesting that the mean estimates of standing stock for all age groups of parr downstream of Kwoiek Lake (and upstream of the flume at the top of Reach 1) were close to corresponding capability estimates (again, especially for yearlings; Table 16). In the absence of lake-related production (except perhaps in Reach 5), this may be the best indicator that the standing stock of fish in Kwoiek Creek was actually at capacity (or close to it), at time of investigation, in October 1995. The governing factor appeared to be the availability of suitable hydraulic conditions for yearlings, in particular.

In addition to even greater saturation of stream habitat by juveniles in mainstem sections upstream of Kwoiek Lake, the indication that the system was at (or near) capacity for rainbow trout in 1995 is also suggested by the impressive catch rates in the lakes investigated (Table 18). Some of these rates were excellent (notably in Kwoiek, Klept and Kha lakes), even compared to lakes in more temperate regions of British Columbia. In all cases, they were surprisingly good given the cold glacial origins and influences of the Kwoiek Creek system.

5.2.2 Bull trout

The preceding consideration as to the presence of steelhead (or not), in the Kwoiek Creek system, has far greater implications with respect to bull trout. As concluded for steelhead, the presence of a migratory population (or sub-population) of fluvial-adfluvial bull trout cannot be conclusively denied on the strength of the October 1995 findings. At least two of the three large specimens captured in Kwoiek Lake (Figs. 72 and 73) could *conceivably* have been migrants from the Fraser River (hinging on negotiability of the flume near the mouth of the system). Certainly, a migratory component (sub-population) of this sort is characteristic of the species, even if a lacustrine-adfluvial population is also present (Rieman and McIntyre, 1993).

This issue is critically important to bull trout in general, and *extremely* so for the population(s) in the Kwoiek Creek system, specifically. Due to the broadly endangered status of bull trout populations throughout western North America, coupled with (and related to) the particular sensitivity of this species to habitat conditions, the U.S. Forest Service has prepared a compendium of information, aimed at conservation of the species throughout its range (Rieman and McIntyre, *op. cit.*).

The document emphasizes the extraordinary risks of extinction of bull trout populations (and history of it), as a result of habitat disruption and/or fragmentation. As alluded to above, the regional persistence of the species has been attributed to its broad migrations between systems, its network of recruitment/production within these systems, and the multiplicity of its life history strategies encompassing both.

The specific habitat requirements of bull trout appear to be more restrictive than those of other salmonids. Typically, spawning and recruitment of the species is in discrete sections of smaller streams, normally towards the headwaters of any given system. In addition to migratory

fish (fluvial-adfluvial and/or lacustrine-adfluvial), stream resident populations (or sub-populations) may also be present in such areas.

These characteristics expose bull trout populations (or sub-populations) to very special risks of extinction. Firstly, since recruitment areas tend to be isolated and discrete, any and all of them (and the populations or sub-populations they contain) are particularly subject to localized disruption of habitat, natural and/or otherwise. Similarly, the overall (regional) population is at corresponding risk, due to the high vulnerability of all of the small isolated sub-populations it is comprised of.

On top of this, bull trout demonstrate a particularly high sensitivity to habitat disruptions, in general (due to their more restrictive habitat requirements). Furthermore, in the Kwoiek Creek system specifically, juvenile bull trout may be subject to competitive pressures from the high densities of rainbow trout also present (ie. at or near capacity for the species).

Results of the 1995 investigations indicate that the *pocket* of bull trout production in the Kwoiek Creek system is limited to Kwoiek Lake, the 3.5 km of Kwoiek Creek between this lake and barrier falls upstream (Reach 6), and to a much lesser extent (likely incidental), the upper 2 km (\pm) of the Kwoiek Creek mainstem, downstream of Kwoiek Lake (Reach 5). Although the narrow limits of this distribution are consistent with the reported behaviour of the species, its location within central portions of the system (and in the *mainstem*) appears to be quite unusual (Rieman and McIntyre, 1993; McPhail and Baxter, 1994).

Otherwise, the 1995 findings would be totally consistent with either fluvial-adfluvial and/or lacustrine-adfluvial production within the system, as far upstream as it is accessible. It is unknown whether a natural obstruction (or barrier) existed at the location of the present railway flume near the mouth of Kwoiek Creek, or when the first obstruction (or barrier) was created at this site (perhaps as early as the late 1800s, when the railway was first constructed). Consequently, it cannot be determined with any certainty that a fluvial-adfluvial population was *ever* present in the system, upstream of the existing flume.

In the absence of definitive data either way, the balance of probabilities for the 1995 findings seems to suggest restriction to a lacustrine-adfluvial bull trout population, at the *present* time. If this is so, it places this population at the highest possible risk of extinction, especially in terms of habitat disturbances (Rieman and McIntyre, *op. cit.*).

Not only are bull trout narrowly distributed within the Kwoiek Creek system, they also appear to be low in number. In addition to the very few electrofishing captures (Table 9), which are subject to doubt due to the inherent constraints to electrofishing for this species, population size may be best reflected in the small capture of bull trout in the gill netting of Kwoiek Lake (Table 18).

Relevant to all types of risk (including genetic factors), small isolated populations of bull trout are *the* most severely jeopardized by *any* environmental change (*ibid.*). Especially in the

absence of a fluvial-adfluvial component to promote maintenance of bull trout recruitment to Kwoiek Creek, *any* disruption of habitat should be viewed as a threat to the persistence of the population in this system (*ibid.*). Even if a fluvial-adfluvial component *is* present, this may not persist, unless the integrity and productive capability of habitat (that supports it) is maintained.

5.3 Status of Fish Habitat and Associated Implications

5.3.1 Natural constraints

In addition to the falls 3.5 km upstream of Kwoiek Lake, and other natural barriers in the system, fish production in the Kwoiek Creek drainage is constrained (or at least influenced) by other natural habitat limitations. In the detailed surveys of stream habitat within the system (Appendix 3), a lack of viable spawning substrates was identified for most stream sections investigated; especially in the Kwoiek Creek mainstem, downstream of Kwoiek Lake (Table 3).

Certainly, there appeared to be a general relationship (direct) between the availability of spawning habitat (Table 3), and the standing stock of fish in various stream sections (Table 5), during the 1995 investigations. However, even in stream sections where spawning habitat was severely limited, and fry numbers were accordingly low, parr populations generally remained high, relative to theoretical capability (Tables 15 and 16).

The results of water depth and velocity analyses at all electrofishing sites indicate that hydraulic conditions may be the most universal constraint to fish production in stream habitat within the system (Table 11). Since fish results are based on suitable/usable habitat only, this conclusion is not influenced by higher discharges that were experienced in the initial days of the 1995 field activities. Although spawning habitat is widely limited, and fry numbers tend to be low (relative to theoretical capability), recruitment is apparently adequate to saturate (or even super-saturate) suitable/usable stream habitat for parr, especially yearlings (Table 16).

The availability of pool habitats, most conducive to such fish (eg. Hartman, 1965), was *poor* throughout the drainage, even during the low flows observed in October 1995 (Table 4). Rapids and other swift and/or turbulent hydraulics greatly dominated the wetted habitat in most stream sections, under the observed conditions (Table 2). Even at electrofishing sites, generally constrained to quieter areas at the stream margins (due to logistical factors), water velocities were frequently high (ie. 40 cm/s to > 1m/s; Appendix 6). While fry may utilize extremely shallow depths in order to avoid excessive velocities, the same does not apply to yearlings and/or older fish (eg. Bech *et al.*, 1994).

Based on the probability-of-use data available, hydraulic conditions appear to have been particularly limiting for bull trout juveniles, especially in Reach 6 of the Kwoiek Creek mainstem (Table 11). Although these results are subject to greater uncertainty than those for rainbow trout, due to the absence of in-depth data for B.C., they are consistent with the greater specificity in habitat requirements reported for this species (Rieman and McIntyre, 1993).

In contrast, the availability of suitable cover elements for juvenile fish is generally *good* (Table 4), or very good (Table 17), throughout the Kwoiek Creek system. With the exception of the Kwoiek Creek mainstem immediately upstream of Kwoiek Lake (Reach 6), and upstream of John George Lake (Reaches 9 to 11), cover for fish is almost exclusively in the form of streambed materials. In the latter reaches, there are greater contributions of woody debris and other bank cover, in sections with lower stream gradients (Appendix 3).

Although a heavy glacial silt load was earlier reported for the Kwoiek Creek system (Stenton and DeLair, 1963), this did not appear to be the case with closer investigation in 1995. In nearly all stream habitat investigated within the drainage, the degree of sedimentation on the streambed was judged to be *good* for fish production (Table 4).

Exceptions were in Reaches 10 and 11 of the Kwoiek Creek mainstem, upstream of Kha Lake, and the second reach of North Kwoiek Creek, where fines were more abundant, and the rating (Anon., 1994) for fish was *fair*. Higher abundances of fines were also noted in the lower half of Reach 6, immediately upstream of Kwoiek Lake (Table 3); according to rating criteria (*ibid.*), conditions remained *good* for fish, but only marginally so.

With respect to lake habitat, however, the suspension and transport of glacial materials was sufficient to reduce Secchi depths to between 1.6 m and 2.1 m in Chochiwa and Kokwaskey lakes, respectively (Table 5). Secchi depths were similarly low (2.1 m to 2.3 m) in all other lakes investigated (excluding Stukolait Lake, where assessment was precluded by weather). However, water analyses suggest that conditions in Kha, Klept, and John George lakes may be more attributable to inputs downstream of Stukolait Lake (ie. from Reaches 10 and 11 of the Kwoiek Creek mainstem). Conditions in Kwoiek Lake (2.3 m Secchi depth) are obviously dependent on combined influences from areas upstream (ie. Chochiwa drainage and Kwoiek Creek upstream of Kokwaskey Lake).

Notwithstanding the above, the accumulation of sediments did not appear to be excessive in the lakes investigated. A possible exception is Klept Lake. This particular water body may serve as a sediment trap, due to reduced hydraulic energy from the presence of Kha Lake, just 300 m upstream (Dunne and Leopold, 1978). With this exception, as well as the higher accumulations of fines in some lower gradient stream sections, identified above (notably Kwoiek Creek Reaches 6, 10 and 11), it would appear that the majority of fine materials are flushed out of the system, by its prevailing high energy, that was clearly evident even at low flows (*ibid.*).

5.3.2 Effects of forest harvesting

Forest harvesting has been extensive and widespread within the Kwoiek Creek drainage, especially (and most recently) in portions of the watershed upstream of Kwoiek Lake (eg. Fig. 82, as well as Figs. 21, 32, 33 and 48). This has resulted in the removal of riparian vegetation along many small tributaries (eg. Figs. 46 and 47), as well as various sections of the Kwoiek Creek mainstem itself (Figs. 17, 21, 32, 33 and 48).



Figure 82. View of forest harvesting along Reaches 10 and 11 of the Kwoiek Creek mainstem, upstream of Kha Lake.

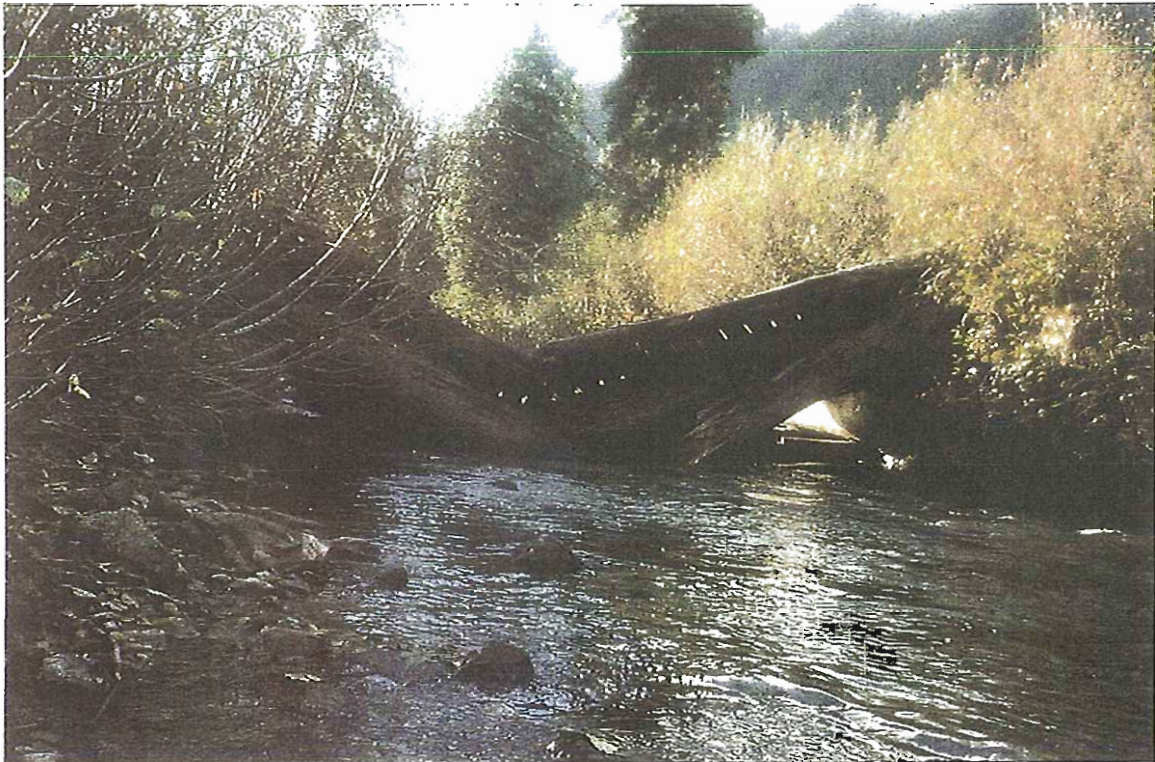


Figure 83. Collapsed bridge on Kwoiek Creek mainstem, approximately 1.5 km upstream of Kha Lake.

However, there appears to be little problem with instream debris, except minor complications to fish passage at some natural obstructions (Fig. 19), and bank instability associated with small accumulations in lower gradient sections of the Kwoiek Creek mainstem (Fig. 30). The introduction of debris to streams appears to have been low, and/or it has been transported out of the system, due to the prevalence of steeper stream gradient (Table 2), and associated hydraulic energy.

Substantial debris accumulations are present at the outlets of Kokwaskey and Chochiwa lakes (Figs. 57 and 59). However, for the latter lake, whose watershed has not been subjected to any forest harvesting or road construction, the debris can only be attributed to natural causes (eg. slides). The same may also apply to Kokwaskey Lake (Fig. 54); however, a large debris jam on Kwoiek Creek, at its point of entry to this lake (Fig. 55), could be related (directly or indirectly) to forest harvesting further upstream.

At one location, a collapsed bridge seriously plugs the Kwoiek Creek mainstem (Fig. 83). This is located in Reach 10, approximately 1.5 km upstream of Kha Lake. Otherwise, bridge crossings appear to be in good repair, or have been removed altogether.

However, one such crossing of the Kwoiek Creek mainstem (now removed) has contributed to the *severe* disturbance of a small tributary to Reach 6, upstream of Kwoiek Lake (unnamed tributary A; Fig. 70). The lower channel of this stream now follows the hauling road which previously crossed the Kwoiek Creek mainstem (Fig. 47).

Most important, however, was the extreme turbidity of this small stream that was observed after heavy rain showers, and the resultant plume of sediments (silts) entering Reach 6 of the Kwoiek Creek mainstem. This is undoubtedly attributable to the major road failure (and slide) towards the top of this tributary.

Based on observations in October 1995, sedimentation of Kwoiek Creek mainstem Reaches 6, 10 and 11 was the most evident impact of forest harvesting, detrimental to fish production within the system.

Recent and extensive forest harvesting along Reaches 10 and 11 (Fig. 82) appears to provide the best explanation for the higher abundance of suspended inert (inorganic) solids in Kha Lake, compared to Stukolait Lake, at the time of investigation (Table 5). The same applies to the substantial accumulations of silts and sands observed in Reaches 10 and 11 of the Kwoiek Creek mainstem itself (Fig. 34).

In Reach 6 of the mainstem, upstream of Kwoiek Lake, unnamed tributary A (noted above) is undoubtedly indicative of other sediment inputs to this reach, which has also been subjected to extensive forest harvesting (eg. Fig. 21). As noted earlier, the abundance of fines was considerably higher in the lower half of this reach (surveys 11 and 12; Table 3), compared to most other stream sections investigated within the drainage.

5.3.3 Implications with respect to fish production

Interpretation of scale samples from rainbow trout captured in Klept and Kha lakes, during the October 1995 investigations, suggests that there *may* have been a dramatic decline in the 1994 recruitment in this part of the drainage (ie. age 1+ in 1995; Fig. 77). These results are subject to doubt, due to various uncertainties in the analyses themselves; however, if the results are accurate, this may reflect severe temporal effects (eg. sediment loading) from the extensive forest harvesting along Reaches 10 and 11 of the Kwoiek Creek mainstem (Figs. 82).

Assuming the above is valid, the exceptionally high densities of rainbow fry at electrofishing site 23, between Klept and Kha lakes in October 1995 (Fig. 70), may indicate subsequent recovery, at this location at least (Table 16). However, the considerably lower abundance of fry at site 24, in superior habitat within Reach 10 of Kwoiek Creek (Table 15), likely indicates lingering (and/or ongoing) effects of sedimentation, upstream of Kha Lake; again, consistent with the abundance of fines observed in this part of the system (Fig. 34), and the higher concentration of suspended solids in Kha Lake, compared to Stukolait Lake (Table 5).

The validity of these suggestions should be determined with future monitoring. In any event, both stream populations and lake populations of rainbow trout appear to remain remarkably strong (overall) in all areas occupied by fish upstream of Kokwaskey Lake (Tables 15 and 18).

Implications may be far more serious for Reach 6 of the Kwoiek Creek mainstem. Once again, the principal concern is for bull trout. As emphasized earlier, this species appears to be particularly sensitive to *all* changes in habitat (Rieman and McIntyre, 1993). With respect to sediments in spawning substrates, recent studies indicate that *any* increase leads to reduced survival of bull trout embryos (*ibid.*).

As in other aspects of habitat use, bull trout demonstrate great specificity in their selection of spawning sites. In the Kwoiek Creek drainage, this is likely demonstrated in the containment of nearly all bull trout fry captures to three consecutive electrofishing sites in October 1995, all in the lower half of Reach 6 of the Kwoiek Creek mainstem (sites 15 to 17; Table 12).

Even here, however, the actual numbers of bull trout fry (and parr) appeared to be low (Table 9), consistent with the small population size indicated by the gill netting results in Kwoiek Lake (Table 18). As noted earlier, the production of bull trout juveniles may also be subject to special constraints in Reach 6, specifically, due to natural hydraulic conditions (Table 11).

Whether or not the present population of bull trout in the Kwoiek Creek system still includes (or *ever included*) a fluvial-adfluvial component, the superior spawning opportunity in lower Reach 6 (Table 3) is undoubtedly the key factor to the presence and persistence of the species, within the drainage.

Accordingly, the indication of increased sedimentation in Reach 6 is of great concern, even though levels may remain marginally *good* for fish production (Table 4), relative to general criteria (Anon., 1994). Rieman and McIntyre (1993) conclude the following: *any increase in the proportion of fines in substrates should be considered a risk to productivity of an environment and to the persistence of associated bull trout populations*. And once again, the population in the Kwoiek Creek system should be viewed as subject to the *most extreme* vulnerability, especially if it is entirely isolated (*ibid.*).

As a final note, the specific distribution of bull trout juveniles in Reach 6 of the Kwoiek Creek mainstem, in October 1995, may indicate a direct response to sediments. Acknowledging that numbers of captures were low at all sites (and differences slight; Table 9), fry densities in usable habitat appeared to increase with upstream progression to site 17, in mid Reach 6 (Table 12; Fig. 70). This may reflect some trade-off between the abundance of spawning substrates (greater downstream), and the proportion of fines (also greater downstream, if only marginally; survey sites 11 and 12; Table 3).

Although the homing of bull trout is highly specific, their selection of actual spawning sites may shift, in order to acquire the most advantageous conditions (Rieman and McIntyre, *op. cit.*). It may be more than coincidence, for example, that electrofishing site 17 was located upstream of unnamed tributary A (Fig. 70).

5.4 Management Implications

5.4.1 Present values of fish production within the Kwoiek Creek drainage

Most emphatically, the results of the October 1995 investigation of the Kwoiek Creek drainage confirm suspicions reported by Maricle (1994), that fish production and associated values of the system are considerably greater than was earlier reported (Stenton and DeLair, 1963). In terms of stream production, all indications are that the system may be operating at (or near) productive capacity for rainbow trout, where they are present (Table 15).

A much wider distribution of this species was identified in 1995, compared to that initially reported, following a survey of the system in 1962 (Stenton and DeLair, *op. cit.*). This could be attributable to unauthorized movements of fish, with progressive and extensive development of the watershed, since that time. On the other hand, fish sampling appears to have been limited to angling in 1962, and the reported distribution of fish was largely based on visual observations only.

Conditions at the time of investigation in 1962 (early August) may have suggested severe glacial constraints to fish production within the system; ie. influences of glacial meltwater, and associated turbidity, may be high in early August (Fig. 2). However, all results of the intensive investigations at lower flows in October 1995 clearly indicated otherwise. It would appear that glacial inputs are principally flushed from the system, due to its high hydraulic energy.

From the standpoint of fish production, in general, the Kwoiek Creek system should be viewed as truly exceptional; ie. as one of the dwindling number of systems in British Columbia that may still be operating at (or near) its productive potential. The abundance of rainbow trout in inhabited sections of the Kwoiek Creek mainstem (ie. the majority of it), and its associated lakes (excluding Sukolait Lake), may be viewed as extraordinary, compared to the Nahatlatch River drainage, at least (Griffith, 1995a).

No doubt, the maintenance of such values in Kwoiek Creek is greatly attributable to its relative inaccessibility, even at the present time. In particular, the apparently large populations of rainbow trout in most of the lakes investigated in 1995 (Table 18) likely reflect low levels of angling pressure, as observed in other naturally recruited lakes in remote or thinly populated areas of British Columbia (eg. Griffith, 1986; 1992).

The narrow pocket of bull trout production, in the central portion of the system, is a very intriguing phenomenon. Although it cannot *conclusively* be determined on the basis of information to date, the balance of probabilities suggests that this may consist solely of lacustrine-adfluvial production, centered in Kwoiek Lake.

If this is the case, the population might be expected to rapidly succumb to angling pressure (in the absence of specially conservative regulations), especially if accompanied by habitat disturbances from watershed development (Rieman and McIntyre, 1993).

This poses a great challenge to future management of the system, especially if access is improved. Persistence of the population, in general, and the presence of some very large individuals, in particular (assuming they are lacustrine-adfluvial), undoubtedly attests to very limited exploitation by angling, to the present time. From any perspective, the presence of these fish must be viewed as an extraordinary (and likely fortuitous) resource, demanding utmost conservation.

5.4.2 Associated values of the Kwoiek Creek drainage

In addition to exceptional fish values, the Kwoiek Creek drainage offers an extraordinary wealth and variety of outdoor recreational opportunities, and aesthetic values. Despite the visual impacts of forest harvesting, the entire drainage remains very scenic, due to its confinement and high relief (Fig. 82). All of the lakes investigated in 1995 offer a great array of camping opportunities, in very pleasant surroundings (Figs. 50, 54, 56, 58, 60, 63, 65 and 67).

Kokwaskey and Chochiwa lakes, and the Kwoiek Lakes Trail provide an excellent opportunity for canoeing and/or hiking into a pristine sub-alpine environment (Fig. 58). Similarly, a relatively short (if arduous) hike through mature old growth forest provides access to the alpine splendour of Stukolait Lake (Fig. 67). No doubt, the many other alpine and sub-alpine lakes in the drainage, that were *not* investigated in 1995, offer comparable opportunities and rewards.

Wildlife appears to be both abundant and diverse. Notable observations during the October 1995 field activities were two cinnamon black bears (sow and cub) and a cougar. In all respects, the Kwoiek Creek drainage must be recognized as an extremely valuable public resource. Particularly in view of its fish resources, it may even be unique. Accordingly, it should be afforded all requisite care in future management, to promote its full recovery from past disturbances, and its ongoing preservation.

5.5 Implications of Past and Future Development of the Watershed

5.5.1 Forest harvesting

Despite the extensive forest harvesting that has taken place within the Kwoiek Creek drainage, rainbow trout populations have apparently remained strong. In addition to whatever mitigative steps that were taken during the harvesting, this is undoubtedly due to the nature of the system itself; ie. flushing of sediment and debris from most stream sections, and lakes; maintenance of channel stability by large rock materials in most stream sections (Appendix 3); principal reliance on (and abundance of) fish cover in the form of streambed materials; and, apparent dominance of natural constraints in the production of fish within this system (ie. hydraulic conditions, as observed even at low flows in October 1995).

Notwithstanding the above, sedimentation may have resulted in significant temporal impacts on the recruitment of rainbow trout in areas upstream of Kokwaskey Lake, in 1994. It is very likely that past and/or ongoing inputs of silts and sands continue to suppress the recruitment of rainbow fry, upstream of Kha Lake. No doubt, there have been attendant changes in seasonal flow patterns and temperatures (Dunne and Leopold, 1972), that were beyond the scope (and capability of detection) of the investigation in 1995. Certainly, monitoring of the system is warranted, if only to ensure maintenance of current rainbow trout values.

Again, however, implications are far more severe for the bull trout population within the system. Based on all indications of the October 1995 investigations, and information assembled by the U.S. Forest Service (Rieman and McIntyre, 1993), it should be assumed that this population has been put at *extreme* risk of extinction, with past forest harvesting. Given the low numbers of fish captured during the 1995 investigations (Table 18), especially juveniles (Tables 9 and 12), the population may already be in a state of decline, as a result of past habitat disturbances (*ibid.*).

To hopefully avoid all possibilities of the population becoming extinct, the first step must be to ensure that all future management of the Kwoiek Creek drainage is fully conducive to the maintenance and/or restoration of the ecological features and processes that are necessary for the long-term persistence of the population (*ibid.*). Secondly, detailed monitoring of the system should most definitely be initiated to more fully appreciate the status of bull trout production within the system, and all associated dynamics and implications (*ibid.*).

Most emphatically, any proposals for *future* forest harvesting in the Kwoiek Creek watershed should be placed in abeyance, pending such monitoring, and the provision of full assurances that proposed activities will not further jeopardize the conservation of the bull trout population (*ibid.*).

5.5.2 Hydroelectric development

Terms of reference for the October 1995 investigation of the Kwoiek Creek drainage did not include specific assessment of potential impacts related to the hydroelectric development under consideration (Anon., 1991). This issue is being addressed by other studies (*ibid.*).

However, if only due to the very key significance and vulnerability of the bull trout population, cautionary comments are clearly warranted here. If the population of this species in the Kwoiek Creek system is exclusively lacustrine-adfluvial, the extraction of flows from the mainstem downstream of Kwoiek Lake (original proposal) may be of little significance.

On the other hand, if a fluvial-adfluvial component is involved, any such extractions would have to ensure maintenance of suitable passage conditions (timing, magnitude, and duration of mainstem flows) for upstreaming adults. Similarly, diversion intakes should be equipped with sufficiently sophisticated screens to efficiently prevent intake and mortality of downstreaming fish.

Again, if fluvial-adfluvial bull trout *are* present within the system, they are undoubtedly critical to the maintenance of the overall population (Rieman and McIntyre, 1993); and accordingly, their passage requirements must be fully addressed, and assured, in any alteration of mainstem flows.

Needless to say, the same implications also apply to steelhead. Although the balance of probabilities (based on the October 1995 findings) suggests that rainbow trout are resident throughout the Kwoiek Creek system, upstream of the flume, it is *conceivable* that steelhead production may also be present (ie. by the same token that fluvial-adfluvial bull trout *may* be present).

However, regardless of whether migratory fish are present or not, any consideration of damming Kwoiek Lake and/or any other lake on the system (expanded proposal; Anon., 1991) would seem highly threatening to the maintenance of bull trout production (consistent with preceding discussions related to forest harvesting). With respect to Kwoiek Lake, the existing depth profile, volume and/or area are likely vital to the balance and maintenance of the existing bull trout production (as well as that of the rainbow trout which serve as forage).

In the compendium of information on bull trout assembled by the U.S. Forest Service (Rieman and McIntyre, 1993) it is clearly stated that managers must consider *any* disruption in important habitat characteristics a threat to the persistence of a bull trout population. With respect

to developing storage on any other lake in the system, this would obviously affect flow patterns in Reach 6 of the Kwoiek Creek mainstem, in which spawning/recruitment of bull trout is concentrated. It might also affect the limnology of Kwoiek Lake, as well (eg. flushing rate, heat budget, nutrient cycling, etc.).

If the bull trout population in the Kwoiek Creek drainage is already suffering from habitat disturbances associated with forest harvesting (which may be the case), the added stress of any detrimental impacts from the proposed hydroelectric development could greatly accelerate the demise of this population (*ibid.*).

On the other hand, and notwithstanding possible implications in terms of fish passage (ie. fluvial-adfluvial bull trout and/or steelhead, if present), the extraction of flows downstream of North Kwoiek Creek (original proposal) might actually improve habitat conditions for rainbow trout (including juvenile steelhead, *if they are present*). Even at the low flows observed in October 1995, pool habitats were extremely limited in Kwoiek Creek, especially downstream of Kwoiek Lake (Table 2). Hydraulic conditions were predominantly swift and turbulent (Figs. 4, 10, 11, 12, 13, 15, 16 and 17). These conditions resulted in relatively low suitability/usability of available habitat (ie. *ca.* 50% to 70%, on average), even in the quieter conditions of electrofishing sites (Table 11).

It is quite possible that a reduction in flows, compared to those observed in October 1995, could actually benefit both juvenile and adult rainbow trout, within the lower Kwoiek Creek mainstem. Specific analyses in other B.C. streams (eg. Wightman and Ptolemy, 1989; Griffith, 1990; 1996) have indicated significant increases in *total usable area*, with reduction of stream discharges to some threshold level (ie. decreases in total wetted width offset by increases in the proportion of usable width).

Obviously, the applicability of this to Kwoiek Creek would have to be ascertained by specific transect analyses, as in the above investigations of other systems. Furthermore, consideration would also have to be given to passage flows for resident trout, which may have to undergo migrations (possibly involving obstructions; eg. Figs. 8 and 9) in order to find suitable spawning substrates, within the Kwoiek Creek mainstem, downstream of Kwoiek Lake (Table 3).

5.6 Mitigative Requirements for Fish Production Within the Kwoiek Creek Drainage

Given that the October 1995 standing stock of rainbow trout appeared to be at (or near) productive capability, in most inhabited portions of the Kwoiek Creek drainage (Tables 15 and 16), mitigative action may not seem warranted. However, reversible impacts of past forest harvesting should nonetheless be addressed, if only to minimize any future degradation of the system.

Obvious examples include the collapsed bridge on the Kwoiek Creek mainstem upstream of Kha Lake (Fig. 83), and debris accumulations complicating fish passage at natural obstructions (eg. the first falls on the Kwoiek Creek mainstem upstream of Kwoiek Lake; Fig. 19). Whether it is entirely natural or not, the debris jam on Kwoiek Creek at its point of inlet to Kokwaskey Lake (Fig. 55) should be removed, to promote greater recruitment of rainbow trout to Kokwaskey Lake.

In addition, it may be advisable to consider removal of some debris accumulations in other parts of the Kwoiek Creek mainstem, if they are causing severe erosion and/or channel instability. This would only apply to lower gradient sections, where bank materials are smaller, and less stable (notably Reaches 6 and 9). However, any such work must be highly selective, and constrained to problem debris only. Despite the past forest harvesting in the watershed, debris is not abundant in streams. Most of the debris that is present is beneficial in its provision of fish cover, especially in lower gradient sections, such as Reaches 6 and 9 of the Kwoiek Creek mainstem.

A far more pressing issue is the road failure and slide on unnamed tributary A, and its input of fines to Reach 6 of the Kwoiek Creek mainstem. As previously discussed, this may have a very direct influence on the present and future status of the bull trout population within the system. If at all possible, this area should be stabilized. In addition, aerial reconnaissance should be conducted to identify any other such failures, and these should also be stabilized.

However, above all else, the *most* pressing need for fish production within the Kwoiek Creek drainage is the adoption of adequately conservative management for *all* resources and uses, to attempt maintenance of the unusual and highly vulnerable bull trout population within the system. Failure to do so may result in its extinction. This process may have been initiated already, due to past effects of forest harvesting.

Before any further development takes place within the drainage, sufficient monitoring should be conducted to fully clarify the ongoing dynamics and status of all fish populations in the system, and most notably that of bull trout. Specific investigations should be initiated to fully evaluate the present and/or historic use of the system by fluvial-adfluvial bull trout, and/or steelhead.

With documentation of either, consideration might be given to baffles or other means of facilitating upstream passage of fish in the flume under the railway crossing near the mouth of the system (Figs. 6 and 7). Needless to say, this should include full consideration of all implications with respect to existing production in areas upstream.

However, with any indication of present or historic fluvial-adfluvial bull trout in the system, improvement of the flume might be vital to the long-term preservation of the species within the system (Rieman and McIntyre, 1993). Needless to say, these (and associated) issues must be addressed and evaluated in any consideration of further developments, including manipulation/extraction of flows.

6.0 SUMMARY AND CONCLUSIONS

6.1 Objectives and Methods of the Investigations

1. During October 11-26, 1995 an intensive assessment of fish habitat and production was completed within the Kwoiek Creek drainage.
2. Although difficult to access, even at present, this watershed has been subject to extensive forest harvesting, since the early 1970s.
3. In view of this, the objectives of the 1995 assessment were as follows: i) to identify existing fish and fish habitat values throughout the drainage; ii) to interpret the dynamics of fish production, and factors maintaining present abundance; iii) to quantify existing fish production (standing stock), compared to corresponding estimates of habitat capability (carrying capacity); and iv) to identify any degradation of fish habitat within the system, associated constraints to fish production, and any opportunities to mitigate for them.
4. The assessment addressed the following drainage components: i) the full length of the Kwoiek Creek mainstem; ii) the first 10.5 km of North Kwoiek Creek (the main tributary); iii) lowermost Chochiwa Creek; iv) 6 smaller tributary streams; and v) 7 lakes most closely associated with the Kwoiek Creek mainstem (Kwoiek, Kokwaskey, Chochiwa, John George, Klept, Kha, and Stukolait lakes).
5. The investigation of stream habitats was most intense, and involved the following: i) 22 detailed habitat surveys in the Kwoiek Creek mainstem and North Kwoiek Creek; and ii) fish capture results, habitat descriptions, and water depth/velocity transects at 37 different electrofishing sites, addressing all streams identified in 4., above.
6. Lake investigations were conducted at the preliminary level only, involving basic evaluation of lake morphometry and limnology (including water analyses), and a single overnight gill net set to sample fish populations (sinking, so as best to assess for the presence of bull trout in all lakes investigated).

6.2 Stream Habitat and Associated Fish Populations

1. Although stream discharges were somewhat elevated during the initial days of the field investigations (October 11-16), they subsequently dropped and stabilized, and are deemed to have been reasonably close to lower flows for the system, for the time of year (measured at 3.09 m³/s, in the Kwoiek Creek mainstem, downstream of North Kwoiek Creek, on October 24).

2. During the field program, stream temperatures ranged from 6°C to 8.5°C in the Kwoiek Creek mainstem; North Kwoiek Creek appeared to be slightly colder, at 5.5°C; Chochiwa Creek was the coldest, at 5.0°C.
3. The first 5 reaches of Kwoiek Creek, from the mouth to Kwoiek Lake, may be characterized as steep, bouldery, and turbulent; at the observed flows, rapids habitat was dominant; pool area was particularly low, and was principally restricted to the stream margins (ie. sidepools); cover for fish was principally in the form of streambed substrates, and was abundant; spawning habitat (gravel abundance) is limited in all reaches of Kwoiek Creek, downstream of Kwoiek Lake.
4. A box-shaped concrete flume is present on the mainstem, associated with a railway crossing, 400 m upstream of the mouth; under the observed conditions, this structure appeared to constitute a barrier to any (and all) upstream passage of fish (ie. velocities > 2 m/s and depths < 10 cm, over a length of approximately 40 m).
5. A small side channel is present, adjacent to the mainstem downstream of the flume, and was found to contain a very high concentration of coho salmon fry in usable habitat for such fish; coho were not found in the adjacent mainstem, nor any portion of the drainage upstream of the flume.
6. A somewhat higher density of rainbow fry, in the above side channel, may indicate its use by steelhead trout, as well; perhaps at flows different from those observed in October 1995, it is *conceivable* that steelhead may also ascend the flume, and extend upstream within the Kwoiek Creek system, as far as barrier falls approximately 3.5 km upstream of Kwoiek Lake; however, on the balance of probabilities (based on all 1995 findings), it seems most likely that the existing production of rainbow trout is resident, in all areas occupied by fish upstream of the flume.
7. Rainbow trout were found at all electrofishing sites within the first 5 reaches of the Kwoiek Creek mainstem (ie. downstream of Kwoiek Lake); in fact, rainbow trout were found at *all* electrofishing sites in the mainstem, except in the uppermost 1.7 km, immediately downstream of Stukolait Lake (Reach 11).
8. Bull trout juveniles were found in very low numbers at 2 sampling sites in Reach 5, immediately downstream of Kwoiek Lake (a single fish at each site).
9. Generally speaking, densities of rainbow fry were low in all reaches downstream of Kwoiek Lake, but numbers of parr appear to have been close (on average) to corresponding estimates of habitat capability.
10. This was particularly evident for yearlings, and water depth/velocity analyses indicate that the availability of suitable/usable hydraulic conditions for yearlings (ie. sufficient depths with adequately low velocities) may be the chief constraint to stream production within the system.

11. The same also applies to most of the Kwoiek Creek mainstem upstream of Kwoiek Lake (Reaches 6 to 10); with some notable exceptions, and reduction of scale, habitat in these reaches is much like that in the mainstem downstream of Kwoiek Lake (Reaches 1 to 5).
12. In all areas upstream of the barrier falls at the top of Reach 6 (approx. 3 km upstream of Kwoiek Lake) rainbow trout was the only species encountered; in most of these areas (as in Reach 6), the standing stock of rainbow trout appeared to be at (or above) theoretical capability, especially in the case of yearlings (as downstream); higher densities in these areas (and Reach 6) are undoubtedly attributable to the production of recruits to the series of associated lakes, in addition to stream residents.
13. Recruitment/production of bull trout juveniles appears to be concentrated in the lower and middle sections of Reach 6, immediately upstream of Kwoiek Lake; numbers of these fish appear to be very low, although the particular difficulty in capturing bull trout by electrofishing may have contributed to these results.
14. There was some indication of higher densities of bull trout fry towards the middle of Reach 6, compared to sites further down the reach.
15. The concentration of bull trout juveniles in Reach 6 is undoubtedly attributable to the much greater availability of suitable spawning habitat in this stream section, compared to all areas downstream; the same likely applies to the exceptional standing stock of yearling and older rainbow trout, which was well above corresponding capability estimates (on average), in this reach.
16. Stream production of fish within the drainage appears to be highly concentrated within the Kwoiek Creek mainstem; most of North Kwoiek Creek appears to be barren of fish, due to extreme gradients near its mouth; its use and value for fish production may be insignificant; similarly, fish use of other tributaries appears to be very limited, largely due to steep gradients.
17. Rainbow trout are present in Chochiwa Creek, but in low numbers; this seems most attributable to the greater abundance of natural sediments (including clays) in this stream, and/or other glacial influences most evident in the Chochiwa drainage (including colder temperatures, noted above).
18. Otherwise, there is little evidence of the severe glacial impacts and associated constraints to fish production that were earlier reported for the system, as a whole.
19. Generally speaking, the abundance of sediments was low in most stream sections investigated; although the system is undoubtedly subject to substantial glacial inputs at some times of the year, these are presumably transported out of the system, due to its prevailing steepness, and associated hydraulic energy.

20. Again, the same hydraulic energy (and associated conditions for fish) appears to be the principal constraint to stream production of fish within the system; and, as observed in October 1995, existing standing stock of rainbow trout appeared to be at (or near) productive capability throughout inhabited reaches of the Kwoiek Creek mainstem.

6.3 Lake Habitat and Associated Fish Populations

1. All lakes investigated were found to contain rainbow trout, except Stukolait Lake, which appears to be barren of fish (as also applies to Reach 11 of the Kwoiek Creek mainstem, immediately downstream).
2. Based on gill net capture results, the number of rainbow trout appeared to be excellent in most of the lakes investigated (most notably in Kwoiek, Klept and Kha lakes); Chochiwa and Kokwaskey lakes appear to contain lower numbers, consistent with the limited availability of spawning habitat, in both cases.
3. Results for the latter lakes may also reflect (or may have been influenced by) their larger size and/or much greater depths, compared to all other lakes investigated (except Stukolait, perhaps, which could not be fully investigated, due to weather conditions).
4. Based on a depth sounding transect along its main axis, Kwoiek Lake appears to be particularly shallow (maximum 6.7 m; mean 3.6 m); it was also the only lake found to contain bull trout, in addition to rainbow trout.
5. Despite the relatively small size of this lake (29.3 ha), 3 large bull trout (659 mm to 721 mm) were caught in the gill net sample; very low representation of rainbow < 160 mm in the capture from this lake (compared to all other lakes) likely reflects predation by the bull trout.
6. However, the total number of bull trout captured in Kwoiek Lake was also small, consistent with the electrofishing results in Reach 6 of the Kwoiek Creek mainstem, upstream of the lake (as well as Reach 5, downstream of the lake).
7. Conversely, numbers of rainbow trout (ie. > 160 mm) appeared to be exceptionally good (second only to Klept Lake); again, this is undoubtedly attributable to the superior spawning habitat in Reach 6 of the Kwoiek Creek mainstem, immediately upstream, coupled with the nature and productivity of Kwoiek Lake itself.
8. The same applies to superior spawning habitat in the Kwoiek Creek mainstem upstream of Klept Lake (Reach 9), and the very high numbers of fish indicated by the gill netting results for this lake.

9. In this case, however, there was an indication of reduced mean length of fish, due to high numbers; for all other lakes investigated, including Kwoiek Lake, mean length appeared to be more directly related to water chemistry, as indicated by total dissolved solids and alkalinity.
10. All of the lakes investigated may be viewed as oligotrophic, although nitrogen concentrations were marginally mesotrophic for Kwoiek, John George, Klept and Kha lakes, at the time of investigation in October 1995.
11. Consistent with findings for stream populations, the overall abundance, size, and condition of fish in these lakes was surprisingly good, especially for a system subject to cold glacial influences, and other natural constraints, in addition to extensive forest harvesting.

6.4 Impacts of Forest Harvesting on Fish Habitat

1. Aside from unknown effects on seasonal stream flow patterns and water temperatures (beyond the scope of the investigation), increased sedimentation of some sections of the Kwoiek Creek mainstem appears to be the most serious impact of past forest harvesting within the drainage.
2. As noted earlier, natural inputs of glacial materials appear to be largely flushed out of the Kwoiek Creek system, due to its prevailing steepness and associated hydraulic energy; in most stream sections, the abundance of fine materials is low.
3. However, proportions of fine materials were considerably higher in Reach 6 of the Kwoiek Creek mainstem, upstream of Kwoiek Lake, and Reaches 10 and 11, between Kha and Stukolait lakes.
4. Each of these reaches has been affected by extensive forest harvesting, which (coupled with lower stream gradient) appears to explain the greater abundance of fines observed in October 1995.
5. Analysis of scales from rainbow trout captures from Klept and Kha lakes suggests that recruitment of rainbow fry may have been greatly interrupted in this part of the system in 1994; the analyses are subject to uncertainty, but if accurate, may reflect a severe temporal disturbance (ie. heavy sedimentation) during recent forest harvesting upstream of Kha Lake.
6. The October 1995 capture of exceptionally high densities of rainbow fry in the Kwoiek Creek mainstem between Klept and Kha lakes may indicate subsequent recovery here, at least; however, lower densities of fry may indicate lingering (and/or ongoing) effects in Reach 10 of the Kwoiek Creek mainstem, upstream of Kha Lake.

7. In the case of Reach 6, upstream of Kwoiek Lake, the proportion of fines was somewhat lower than in Reaches 10 and 11, and relative to generalized criteria, conditions may still be viewed as good for fish production; but only marginally so.
8. A specific concern in this reach was the high turbidity observed in unnamed tributary A (following heavy rain showers), and the resultant inputs to Reach 6 of the Kwoiek Creek mainstem; this small tributary has been severely impacted as a result of forest harvesting, and a major road failure and slide appears to be the major source of the sediment inputs.

6.5 Implications With Respect to Bull Trout

1. Based on all findings of the 1995 investigations, it seems most probable that the bull trout population in the Kwoiek Creek drainage is entirely resident (lacustrine-adfluvial) and confined to Kwoiek Lake, the 3.5 km of the Kwoiek Creek mainstem to barrier falls upstream (Reach 6), and to a lesser extent (likely incidental), Reach 5 of the Kwoiek Creek mainstem, downstream.
2. As noted earlier, the production of bull trout juveniles appears to be concentrated in lower and middle Reach 6 of Kwoiek Creek, consistent with the greater availability of spawning habitat, immediately upstream of Kwoiek Lake.
3. As a species, bull trout are highly sensitive to any changes in environment, and many populations have apparently become extinct due to habitat disruptions from forest harvesting and other watershed development.
4. If the bull trout in the Kwoiek Creek drainage *are* entirely resident, they are undoubtedly at *extreme* risk of extinction from habitat disturbances, especially as the population appears to be small.
5. Since bull trout display high specificity in spawning requirements, as well as direct vulnerability to sedimentation (ie. reduced survival of embryos), conditions in Reach 6 of the Kwoiek Creek mainstem may be of great concern to the preservation of the species, in this system.
6. It is possible that the lower numbers of fish captured in October 1995 may reflect existing and ongoing decline of the population, as a result of past disturbances.
7. As noted above for steelhead, it is *conceivable* that migratory (fluvial-adfluvial) bull trout may also be present within the Kwoiek Creek drainage; in such case, the demise of production in this system could result in impacts to a much broader (regional) population of bull trout.

6.6 Implications With Respect to Future Development Within the Watershed

1. To best attempt preservation of the bull trout population and other exceptional fish values of the Kwoiek Creek drainage, any proposals for future development of the watershed should be placed in abeyance, until the status and dynamics of the populations (bull trout, in particular) are fully understood.
2. Monitoring should be initiated, not only to determine the above, but also the ongoing impacts of past forest harvesting, and associated implications, especially for bull trout (notably, sedimentation in the mainstem).
3. *Any* environmental disturbances associated with future development of the watershed, and potentially affecting bull trout production in any way, should be viewed as additional threats to a population already at extreme risk of extinction (and perhaps in a state of ongoing decline).
4. While proposed hydroelectric water extractions from the Kwoiek Creek mainstem downstream of Kwoiek Lake may not pose any significant threat to bull trout production in the system, the same does not apply to accompanying proposals to construct dams on Kwoiek and Kokwaskey lakes.
5. Any alteration of the depth profile and/or limnology of Kwoiek Lake could upset the balance which currently supports the bull trout production in the system, including the accompanying production of rainbow trout, upon which the bull trout are reliant.
6. Similarly, no other lake in the drainage should be developed for hydroelectric purposes, due to resultant changes in streamflow patterns (and associated conditions) within Reach 6 of the Kwoiek Creek mainstem, as well as potential changes in the limnology of Kwoiek Lake.
7. In addition, if further investigations reveal that migratory (fluvial-adfluvial) bull trout and/or steelhead *are* present in the Kwoiek Creek system upstream of the railway crossing (and flume) near the mouth, any proposal of water extractions would have to give full consideration to all fish passage requirements (eg. specific timing, magnitude, and duration of flows); intakes should also be equipped with efficient screens, to avoid all losses of downstreaming fish.
8. If fluvial-adfluvial bull trout *are* present, they are likely critical to the maintenance of the population (as a whole) within a system; and once again, any change affecting these fish should be viewed as a threat to their preservation, and (potentially) that of the entire population within the Kwoiek Creek system, and perhaps a wider (regional) population as well.

6.7 Mitigation For Past Development Within the Watershed

1. Clearly, the most pressing need at this time is for monitoring to *fully* evaluate the effects of past development within the Kwoiek Creek watershed, including various possibilities suggested by the 1995 investigations (notably, the status and dynamics of bull trout production; but also, the spawning/recruitment of rainbow trout in the upper mainstem, especially).
2. Without such monitoring, it is not possible to fully identify or appreciate the actual needs for mitigation.
3. Certainly, a number of minor undertakings are warranted to rectify site-specific impacts, as a matter of course (identified in the discussion).
4. Furthermore, the input of sediments from unnamed tributary A (to Reach 6 of the Kwoiek Creek mainstem) should most definitely be eliminated; similarly, any other concentrated inputs should be identified and rectified.
5. The flume near the mouth of the system may represent a very critical issue; if this constitutes a man-made barrier (or obstruction) to fish passage, it should likely be modified (eg. with baffles) to facilitate ascent of fish, if only for the sake of bull trout production within the system.
6. Needless to say, sound judgement in this respect could only follow further investigations confirming the presence (current and/or historical) of fluvial-adfluvial bull trout, and assurances that the proposed modifications would not impact on other aspects of fish production within the system.
7. In the same vein, if such modifications were proposed for the purposes of steelhead production (or that of any other migratory species), consideration would have to be given to all attendant implications with respect to bull trout, most specifically; this includes all indications of the 1995 investigations, that the Kwoiek Creek system may already be operating at (or near) capability for rainbow trout, especially in Reach 6 of the Kwoiek Creek mainstem, also vital to bull trout spawning and recruitment.
8. In all respects, the Kwoiek Creek system is intriguing and perhaps unique; in order to attempt the preservation of its fish resources, and restoration of its many other aesthetic values, the most important mitigation will be the adoption of conservative management, monitoring of conditions and dynamics, avoidance of all further impacts, and time, to allow the watershed to recover from past disturbances.

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Appendix 1.

Unpublished preliminary stream discharge data for the Nahatlatch River, 1995.
(Environmental Services and Applications, Water Survey of Canada, Vancouver)

~~(PRELIMINARY)~~ DAILY DISCHARGE IN CUBIC METRES PER SECOND FOR 1995

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
10.8												
9.75 B	51.9	16.8	21.2	49.8	129 E	118	36.5	16.2	15.9	12.4	81.4	1
8.85 B	33.9	15.5	20.7	53.8	126 E	117	38.2	16.2	13.5	12.0	61.3	2
8.58 B	25.7	14.8	28.0	56.2	123 E	101	35.3	16.5	15.0	11.7	58.5	3
8.28 B	22.1	14.0	26.0	49.7	120 E	84.0	36.8	18.4	13.7	11.5	43.4	4
7.98 B	19.6	12.8	26.7	49.7	100 E	75.9	41.5	20.8	11.9	11.4	36.7	5
7.80 B	20.7	12.5	23.4	57.3	84.0 E	65.8	38.3	18.4	13.1	11.2	32.8	6
7.70 B	23.6	11.8	23.5	67.5	68.2 A	63.9	58.4 A	17.0	12.8	11.1	29.8	7
7.80 B	21.1	11.6	24.5	79.7	100	66.5	43.8 E	17.2	17.5	156	24.1 A	8
8.30 B	18.8	13.6	22.3	95.8	121	77.8	37.2 E	17.6	18.0	95.4	25.7 E	9
9.80 B	17.3	21.1	20.5	117	123	106	38.5 A	17.9	56.8	45.5	27.3 E	10
9.48	16.4	20.5	19.3	91.4	124	69.7	43.3	17.7	39.0	36.3	28.9 A	11
9.86	14.6	20.5	18.3	67.1	94.6	54.5	38.4	16.7	28.6	38.6	26.8	12
8.72	12.6	18.7	18.0	68.3	83.1	52.9	32.6	16.4	22.5	38.0	26.5	13
8.45	12.2 B	21.2	16.9	104	64.9	49.4	38.5	16.2	33.5	153	25.7	14
8.36	12.3 B	22.0	15.9	126	63.1	58.7	40.1	16.3	48.1	124	24.1	15
7.89	12.8 B	19.7	15.2	136	76.1	56.1	34.8	15.7	86.1	99.1	22.5	16
7.66	11.9 B	18.6	14.9	119	84.8	62.3	29.1	14.7	56.9	104	21.1	17
7.74	12.3 B	19.0	14.4	89.5	82.2	67.5	34.4	15.4	43.1	241	20.7	18
7.84	14.4 B	19.9	14.1	73.5	64.5	67.8	37.2	18.9	38.8	98.7	20.1	19
7.57	36.8	20.4	14.0	74.2	73.3	69.8	31.6	16.5	27.3	63.7	19.1	20
7.28 B	47.1	19.9	14.0	73.6	98.7	73.8	28.0	13.1	24.3	58.1	18.3	21
7.00 B	31.3	18.5	14.9	76.9	106	67.5	27.3	11.5	21.5	44.1	17.8	22
6.80 B	25.2	17.1	17.9	84.5	104	54.7	25.2	11.0	19.4	104	17.8	23
6.78 B	24.8	15.9	24.1	98.6	102	49.8	25.2	11.1	18.1	121	15.9 B	24
6.68 B	25.0	15.1	29.8	116	94.6	46.8	21.2	10.9	18.8	109	14.7 B	25
6.58 B	22.2	14.3	35.2	119	97.0	103	19.5	11.8	28.0	73.4	14.5 B	26
6.48 B	19.8	14.0	42.9	127	83.5	72.4	18.1	12.8	18.2	56.3	14.4 B	27
6.38 B	18.4	14.2	51.4	143	83.7	42.8	18.8	25.8	16.3	56.9	14.2 B	28
16.4		15.2	53.8	143 A	100	40.8	17.8	14.6	15.1	212	14.0 B	29
21.3		17.3	51.9	105 E	112	33.8	17.7	17.6	14.0	136	13.0 B	30
25.7		19.8		150 E		31.9	16.9		13.3		12.0 B	31
283.47	624.0	526.3	724.9	2942.1	2878.3	2893.9	974.6	488.9	882.3	2321.4	814.3	TOTAL
9.14	22.3	17.0	24.2	94.9	95.9	67.5	31.4	16.0	25.9	77.4	26.3	MEAN
24500	53900	45500	62600	254000	249000	181000	84200	41500	69300	201000	78400	DAM3
25.7	51.9	22.0	53.0	105	129	118	58.4	25.8	86.1	241	81.4	MAX
6.38	11.9	11.6	14.0	49.7	63.1	31.9	16.9	10.9	11.9	11.1	12.0	MIN

RY FOR THE YEAR 1995

MEAN DISCHARGE, 42.4 M3/S

TOTAL DISCHARGE, 1348800 DAM3

MAXIMUM DAILY DISCHARGE, 241 M3/S ON NOV 18

MINIMUM DAILY DISCHARGE, 6.38 M3/S ON JAN 28

MAXIMUM INSTANTANEOUS DISCHARGE, 334 M3/S AT 7:42 ON NOV 18

~~MINIMUM INSTANTANEOUS DISCHARGE, 6.63 M3/S AT 5:13 ON JAN 28~~

PREPARED BY/DATE: *J. Stewart Jan 25/96*

CHECKED BY/DATE: *J. Stewart Jan 25/96*

APPROVED BY/DATE: *[Signature] Jan 25/96*

A-MANUAL GAUGE
 B-ICE CONDITIONS
 E-ESTIMATED

365 DAY(S) WITH DATA
 32 DAY(S) WITH ICE
 6 DAY(S) MANUAL DATA
 12 DAY(S) ESTIMATED
 8 DAY(S) WITH NO DATA

66 #13 used JAN 01 - DEC 31

Appendix 2.

Notes and explanations: standing stock capability model for juvenile salmonids in streams (Ptolemy, 1992).

Equations for standing stock capability estimates used in this study (Ptolemy, 1982):

Trout and Char

$$\text{FPU} = 36.3 \times (\text{Alk})^{0.5} \times (\text{Size})^{-1}$$

Coho Salmon

$$\text{FPU} = 100 \times (\text{Alk})^{0.4} \times (\text{Size})^{-1}$$

Where:

FPU = numbers of fish/100m², at capacity

Alk = total alkalinity (mg/L) for late summer/fall
base flow period

Size = mean fish size (g) for cohort

Notes:

1. An optional expression addressing inert (non-filterable) residues is required if levels are > 40 mg/L (eg. glacial streams); however, water samples from the Kwoiek Creek drainage were all << 40 mg/L.
2. Cohort-specific fish sizes (g) are computed on a stream-specific and/or section-specific basis, as allowed / warranted by the data.
3. All total alkalinity values were based on analyses of water samples collected during the October 1995 field session, in the Kwoiek Creek drainage.

Appendix 3.

Stream habitat survey data: Kwoiek Creek drainage, October 1995.

Fish Habitat Survey Data

Site No.: 1
 Stream Name : **Kwoiek Creek mainstem** Reach No.: 1 Date : October 12, 1995
 Location : immediately upstream of the Fraser River
 Reach length : 0.4 km Survey length : 100 m Stream gradient : 9.5 %
 Channel width : 14.5 m Wetted width : 10 m Water temperature : 8.5 °C

Habitat Features	Pool	Riffle	Glide	Rapids	Casacades	Side Channel
% of total wetted area	5	20	15	58	2	10
Mean depth (m)	0.5	0.2	0.4	0.6	0.3	0.25
Maximum depth (m)	>1	0.4	0.8	?	?	0.7
Residual depth (m)	>0.5					
Dominant substrates type	boulders	boulders	boulders	boulders	boulders	boulders
%	60	80	75	90	>95	45
Subdominant substrates type	cobble	cobble	cobble	cobble	cobble	cobble
%	20	10	20	5	<5	25
Spawning gravels (%) fall	<5	0	<5	0	0	10
spring	<5	0	0	0	0	10
Fines (%)	5	<5	?	?	0	10
Compaction	moderate	high	high	high	high	high
Total cover (% total wetted area)						
juveniles	60	40	70	10	?	70
adults	40	<10	50	25	?	20
Components (% total cover)						
large woody debris	0	0	0	0	0	10
small woody debris	0	0	0	0	0	10
substrates	95	100	100	100	100	60
overstream vegetation	3	0	0	0	0	10
instream vegetation	0	0	0	0	0	0
cutbanks, roots	2	0	0	0	0	10
Canopy (%)	10					60
Pieces LWD per channel width						
10 – 20 cm	0					0.2
20 – 50 cm	0					0.3
> 50 cm	0					0

Dominant channel type : boulder-step-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 4 Mean area (m²) 15
 Off-channel habitat : features side channel appears to have been an old road; greater abundance of gravels
 access gradient barrier in lower half of side channel; access from upstream
 Bank condition / channel stability : principally boulders; 85 % stable
 Surrounding terrain, and other : riparian vegetation dominated by older second growth; mixed deciduous and conifers;
 mainstem gradient/turbulence may impede fish passage at some flows (influenced by
 Turbidity : slight the level of the Fraser River, as well)

Fish Habitat Survey Data

Site No.: **3**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **2** Date: **October 12, 1995**
 Location: **upstream of bridge crossing near the top of Reach 2; 3 km upstream of the Fraser River**
 Reach length: **3 km** Survey length: **100 m** Stream gradient: **7 %**
 Channel width: **12.5 m** Wetted width: **10.5 m** Water temperature: **8.0 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Casacades	Side Channel
% of total wetted area	5	10	10	70	5	—
Mean depth (m)	0.4	0.2	0.3	?	0.2	
Maximum depth (m)	0.85	0.4	0.5	?	?	
Residual depth (m)	0.5					
Dominant substrates type	boulders	boulders	boulders	boulders	boulders	
%	50	80	65	90	>95	
Subdominant substrates type	cobble	cobble	cobble	cobble	cobble	
%	20	15	20	<10	<5	
Spawning gravels (%) fall	<5	0	<1	0	0	
spring	<1	0	<1	0	0	
Fines (%)	<5	0	<5	0	0	
Compaction	moderate	high	high	high	high	
Total cover (% total wetted area)						
juveniles	60	50	60	5	?	
adults	35	5	60	25	?	
Components (% total cover)						
large woody debris	<1	0	0	0	0	
small woody debris	<5	0	0	0	0	
substrates	>90	100	>95	100	100	
overstream vegetation	<5	0	<5	0	0	
instream vegetation	0	0	0	0	0	
cutbanks, roots	<1	0	<1	0	0	
Canopy (%)	15					
Pieces LWD per channel width						
10 – 20 cm	0.1					
20 – 50 cm	0.3					
> 50 cm	0.2					

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 0 Mean area (m²) —
 Off-channel habitat : features no off-channel habitat in this section
 access _____
 Bank condition / channel stability : principally boulders; 95 % stable
 Surrounding terrain, and other : riparian vegetation includes some mature (old growth) conifers; other features similar to habitat survey site 2, downstream
 Turbidity : very slight

Fish Habitat Survey Data

Site No.: **5**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **3** Date: **October 13, 1995**
 Location: **mid Reach 3, 1 km upstream of falls at the top of Reach 2**
 Reach length: **3 km** Survey length: **100 m** Stream gradient: **11 %**
 Channel width: **11.5 m** Wetted width: **8.5 m** Water temperature: **7.5 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Cascades	Side Channel
% of total wetted area	5	20	20	45	10	—
Mean depth (m)	0.3	0.2	0.4	0.4	0.25	
Maximum depth (m)	0.6	0.4	0.7	?	0.5	
Residual depth (m)	0.2					
Dominant substrates type	boulders	boulders	boulders	boulders	boulders	
%	60	70	65	90	>95	
Subdominant substrates type	cobble	cobble	cobble	cobble	cobble	
%	15	10	10	5	<5	
Spawning gravels (%) fall	5	<1	<5	0	0	
spring	5	<1	<5	5	0	
Fines (%)	5	0	5	0	0	
Compaction	moderate	high	high	high	high	
Total cover (% total wetted area)						
juveniles	50	20	40	20	?	
adults	30	5	40	25	?	
Components (% total cover)						
large woody debris	3	0	<1	0	0	
small woody debris	2	0	<1	0	0	
substrates	>90	100	>95	100	100	
overstream vegetation	<5	0	0	0	0	
instream vegetation	0	0	0	0	0	
cutbanks, roots	<1	0	0	0	0	
Canopy (%)	15					
Pieces LWD per channel width						
10 – 20 cm	0.6					
20 – 50 cm	1.1					
> 50 cm	0.3					

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 7 Mean area (m²) <10
 Off-channel habitat : features no off-channel habitat in this section
 access
 Bank condition / channel stability : primarily large boulders; 90 % stable; some instability due to debris
 Surrounding terrain, and other : riparian vegetation dominated by young deciduous and coniferous second growth;
 substantial debris accumulations, and associated pools (atypical for reach)
 Turbidity : very slight

Fish Habitat Survey Data

Site No.: **6**
 Stream Name : **Kwoiek Creek mainstem** Reach No.: **3** Date : **October 13, 1995**
 Location : **top of Reach 3; 400 m downstream of Reach 4**
 Reach length : **3 km** Survey length : **300 m** Stream gradient : **6 %**
 Channel width : **15 m** Wetted width : **12 m** Water temperature : **8.0 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Side Channel
% of total wetted area	10	5	10	75	—
Mean depth (m)	0.5	0.1	0.6	?	
Maximum depth (m)	>1	0.3	>1	?	
Residual depth (m)	0.6				
Dominant substrates type	boulders	cobble	boulders	boulders	
%	60	60	50	95	
Subdominant substrates type	cobble	boulders	cobble	cobble	
%	20	30	30	5	
Spawning gravels (%) fall	<5	<1	<1	0	
spring	<1	<1	<1	0	
Fines (%)	10	1	10	0	
Compaction	low	moderate	moderate	moderate	
Total cover (% total wetted area)					
juveniles	80	30	80	15	
adults	40	5	40	20	
Components (% total cover)					
large woody debris	<1	0	0	0	
small woody debris	<5	0	0	0	
substrates	>85	>95	>95	100	
overstream vegetation	<5	<5	<5	0	
instream vegetation	0	0	0	0	
cutbanks, roots	<1	<1	<1	0	
Canopy (%)	20				
Pieces LWD per channel width					
10 – 20 cm	<0.1				
20 – 50 cm	<0.1				
> 50 cm	<0.1				

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 16 Mean area (m²) 20
 Off-channel habitat : features no off-channel habitat; however, dry braids within main channel (same characteristics)
 access higher water only
 Bank condition / channel stability : primarily large boulders; 90 % stable; some instability due to road encroachment
 Surrounding terrain, and other : small mixed second growth dominates riparian zone; surrounding terrain steep, rocky, and sparsely vegetated
 Turbidity : near clear

Fish Habitat Survey Data

Site No.: **8**
 Stream Name : **Kwoiek Creek mainstem** Reach No.: **4** Date : **October 13, 1995**
 Location : **upper Reach 4; 500 m upstream of Cedarbench Creek**
 Reach length : **5.5 km** Survey length : **250 m** Stream gradient : **3 %**
 Channel width : **18.5 m** Wetted width : **16.5 m** Water temperature : **8.0 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Side Channel
% of total wetted area	5	15	30	50	-
Mean depth (m)	0.4	0.15	0.4	0.35	
Maximum depth (m)	0.9	0.25	0.7	0.6	
Residual depth (m)	0.7				
Dominant substrates type	boulders	cobble	boulders	boulders	
%	40	60	50	80	
Subdominant substrates type	cobble	boulders	cobble	cobble	
%	20	30	30	20	
Spawning gravels (%) fall	5	5	5	0	
spring	<5	0	0	0	
Fines (%)	15	5	10	0	
Compaction	moderate	high	high	high	
Total cover (% total wetted area)					
juveniles	50	10	40	10	
adults	25	10	30	40	
Components (% total cover)					
large woody debris	<5	0	<5	0	
small woody debris	<5	0	<1	0	
substrates	>85	100	>90	100	
overstream vegetation	5	0	<5	0	
instream vegetation	0	0	0	0	
cutbanks, roots	<1	0	<1	0	
Canopy (%)	10				
Pieces LWD per channel width					
10 – 20 cm	0.3				
20 – 50 cm	0.1				
> 50 cm	0				

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 13 Mean area (m²) 30
 Off-channel habitat : features no off-channel habitat in this section
 access
 Bank condition / channel stability : primarily large boulders and roots of large trees; 90 % stable
 Surrounding terrain, and other : mature conifers in riparian zone important to channel stability; present along both banks of channel
 Turbidity : slight

Fish Habitat Survey Data

Site No.: **9**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **5** Date: **October 13, 1995**
 Location: **lower Reach 5; 500 m upstream of North Kwoiek Creek**
 Reach length: **2 km** Survey length: **175 m** Stream gradient: **4 %**
 Channel width: **21 m** Wetted width: **18 m** Water temperature: **7.5 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Side Channel
% of total wetted area	5	40	35	20	-
Mean depth (m)	0.4	0.2	0.3	0.3	
Maximum depth (m)	0.9	0.35	0.5	0.5	
Residual depth (m)	0.6				
Dominant substrates type	boulders	boulders	boulders	boulders	
%	50	75	70	90	
Subdominant substrates type	cobble	cobble	cobble	cobble	
%	15	15	20	5	
Spawning gravels (%) fall	15	5	10	0	
spring	10	0	0	0	
Fines (%)	5	0	<5	0	
Compaction	moderate	high	high	high	
Total cover (% total wetted area)					
juveniles	60	50	75	25	
adults	25	20	35	50	
Components (% total cover)					
large woody debris	<5	0	<5	0	
small woody debris	5	0	<5	0	
substrates	>75	90	>80	>90	
overstream vegetation	10	5	5	<5	
instream vegetation	0	0	0	0	
cutbanks, roots	5	5	5	<5	
Canopy (%)	5				
Pieces LWD per channel width					
10 – 20 cm	0.2				
20 – 50 cm	0.5				
> 50 cm	<0.1				

Dominant channel type: boulder-cascade-pool Aggrading / degrading / stable? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 3 Mean area (m²) 8
 Off-channel habitat: features no off-channel habitat in this section
 access
 Bank condition / channel stability: primarily large boulders and roots of deciduous shrubs; 95 % stable
 Surrounding terrain, and other: riparian zone dominated by small second growth, largely deciduous; obviously clear-cut to the edge of the stream, along both banks, in earlier logging
 Turbidity: very slight

Fish Habitat Survey Data

Site No.: **10**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **5** Date: **October 14, 1995**
 Location: **uppermost Reach 5, 100 m downstream of Kwoiek Lake**
 Reach length: **2 km** Survey length: **100 m** Stream gradient: **7 %**
 Channel width: **15.5 m** Wetted width: **9 m** Water temperature: **7.5 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Cascades	Side Channel
% of total wetted area	20	5	30	30	15	-
Mean depth (m)	0.5	0.05	0.6	0.4	?	
Maximum depth (m)	>1	0.2	>1	?	?	
Residual depth (m)	0.8					
Dominant substrates type	boulders	cobble	boulders	boulders	boulders	
%	50	80	50	90	>95	
Subdominant substrates type	cobble	boulders	cobble	cobble	cobble	
%	40	20	40	10	<5	
Spawning gravels (%) fall	<5	<1	<5	0	0	
spring	<1	0	0	0	0	
Fines (%)	5	0	5	0	0	
Compaction	moderate	mod. - high	moderate	mod. - high	mod. - high	
Total cover (% total wetted area)						
juveniles	80	5	70	30	0	
adults	50	<5	60	50	0	
Components (% total cover)						
large woody debris	<5	0	<5	0	0	
small woody debris	<5	0	<5	0	0	
substrates	>90	100	>90	100	100	
overstream vegetation	0	0	0	0	0	
instream vegetation	0	0	0	0	0	
cutbanks, roots	0	0	0	0	0	
Canopy (%)	15					
Pieces LWD per channel width						
10 - 20 cm	0.3					
20 - 50 cm	0.2					
> 50 cm	<0.1					

Dominant channel type : block-step-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 5 Mean area (m²) 15
 Off-channel habitat : features no off-channel habitat; some bouldery high water braids (dry at time of investigation)
 access higher water only
 Bank condition / channel stability : primarily large boulders; >95 % stable
 Surrounding terrain, and other : riparian zone dominated by small second growth, largely deciduous; obviously clear-cut to the edge of the stream, along both banks, in earlier logging
 Turbidity : very slight

Fish Habitat Survey Data

Site No.: **11**
 Stream Name : **Kwoiek Creek mainstem** Reach No.: **6** Date : **October 14, 1995**
 Location : **downstream of earlier bridge crossing (now gone), approx. 1 km upstream of Kwoiek Lake**
 Reach length : **3 km** Survey length : **200 m** Stream gradient : **1 %**
 Channel width : **25.5 m** Wetted width : **14 m** Water temperature : **7.5 °C**

Habitat Features	Pool	Riffle	Glide				Back channel
% of total wetted area	10	40	50				<5
Mean depth (m)	0.45	0.25	0.45				0.2
Maximum depth (m)	>1	0.5	0.65				0.45
Residual depth (m)	0.6						
Dominant substrates type	fines	cobble	cobble				gravel
%	60	50	50				55
Subdominant substrates type	gravel	gravel	gravel				cobble
%	15	20	20				35
Spawning gravels (%) fall	5	10	15				35
spring	10	15	20				35
Fines (%)	45	<5	10				10
Compaction	low	moderate	moderate				low
Total cover (% total wetted area)							
juveniles	35	15	35				40
adults	15	5	15				20
Components (% total cover)							
large woody debris	15	5	10				30
small woody debris	5	0	<1				10
substrates	10	20	25				10
overstream vegetation	30	15	20				25
instream vegetation	0	0	0				10
cutbanks, roots	40	60	45				15
Canopy (%)	5						10
Pieces LWD per channel width							
10 – 20 cm	0.9						2.1
20 – 50 cm	0.3						1.3
> 50 cm	0.3						0.7

Dominant channel type : debris-cobble-cascade-pool Aggrading / degrading / stable ? aggrading
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 4 Mean area (m²) <10
 Off-channel habitat : features originally the bottom end of a tributary stream, which now flows down an earlier road
 access unobstructed at bottom; not linked to mainstem at top
 Bank condition / channel stability : banks principally composed of fines and gravels; 70 % stable
 Surrounding terrain, and other : surrounding terrain has been extensively logged; riparian zone along north bank has
 been removed (primarily shrub growth at present); old growth strip left along portions
 Turbidity : very slight of the south bank (not continuous)

Fish Habitat Survey Data

Site No.: **12**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **6** Date: **October 15, 1995**
 Location: **mid Reach 6; 1.5 km upstream of Kwoiek Lake**
 Reach length: **3 km** Survey length: **250 m** Stream gradient: **1.5 %**
 Channel width: **18 m** Wetted width: **14.5 m** Water temperature: **8.0 °C**

Habitat Features	Pool	Riffle	Glide	Rapids		Ponds
% of total wetted area	5	50	40	5		15
Channel widths per pool	0.3					
Mean depth (m)	0.2	0.2	0.4	0.2		0.2
Maximum depth (m)	0.4	0.5	0.8	0.3		0.45
Residual depth (m)	0.2					
Dominant substrates type	gravel	cobble	cobble	boulders		fines
%	50	70	60	50		80
Subdominant substrates type	fines	boulders	boulders	cobble		gravel
%	40	15	10	40		10
Spawning gravels (%) fall	20	5	5	0		0
spring	15	10	10	0		0
Fines (%)	40	<5	15	<5		80
Compaction	low	moderate	moderate	moderate		muddy
Total cover (% total wetted area)						
juveniles	25	40	45	15		20
adults	10	15	25	30		<10
Components (% total cover)						
large woody debris	25	15	25	0		5
small woody debris	35	10	10	0		60
substrates	5	20	15	100		0
overstream vegetation	15	25	20	0		25
instream vegetation	10	25	15	0		15
cutbanks, roots	10	5	15	0		15
Canopy (%)	10					<5
Pieces LWD per channel width						
10 – 20 cm	2.1					0.3
20 – 50 cm	1.2					0.1
> 50 cm	0.2					<0.1

Dominant channel type : debris – cobble – cascade – pool Aggrading / degrading / stable ? aggrading
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 5 Mean area (m²) 20
 Off – channel habitat : features series of beaver ponds / channels in swampy area adjacent to mainstem
 access access at higher water only (ie. flooding)
 Bank condition / channel stability : banks principally composed of fines and gravels; 50 % stable; 50 % unstable
 Surrounding terrain, and other : valley bottom totally logged; leave strip along southern bank; no leave strip on northern bank, resulting in considerable instability; valley walls also heavily logged on both sides of the system
 Turbidity : slight

Fish Habitat Survey Data

Site No.: **14**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **6** Date: **October 14, 1995**
 Location: **lowermost Reach 7; bridge crossing 150 m upstream of falls at top of Reach 6**
 Reach length: **3 km** Survey length: **200 m** Stream gradient: **3 %**
 Channel width: **10.5 m** Wetted width: **9.5 m** Water temperature: **8.0 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Side Channel
% of total wetted area	15	5	30	50	-
Mean depth (m)	0.3	0.05	0.4	0.3	
Maximum depth (m)	0.5	0.15	0.8	0.6	
Residual depth (m)	0.35				
Dominant substrates type	boulders	cobble	boulders	boulders	
%	50	90	55	90	
Subdominant substrates type	cobble	boulders	cobble	cobble	
%	30	10	30	5	
Spawning gravels (%) fall	<1	<1	<1	0	
spring	<1	<1	<1	0	
Fines (%)	5	1	5	0	
Compaction	moderate	high	moderate	high	
Total cover (% total wetted area)					
juveniles	40	20	55	20	
adults	30	0	45	50	
Components (% total cover)					
large woody debris	<5	0	<5	0	
small woody debris	<5	0	<5	0	
substrates	90	100	90	100	
overstream vegetation	<5	0	<5	0	
instream vegetation	0	0	0	0	
cutbanks, roots	0	0	0	0	
Canopy (%)	25				
Pieces LWD per channel width					
10 – 20 cm	0.8				
20 – 50 cm	0.3				
> 50 cm	0				

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 2 Mean area (m²) 20
 Off-channel habitat : features no off-channel habitat in this section
 access
 Bank condition / channel stability : large bank materials and tree roots; >90 % stable
 Surrounding terrain, and other : surrounding valley walls have been heavily logged; however, a substantial leave strip has been left along both banks of the stream, in this area
 Turbidity : slight

Fish Habitat Survey Data

Site No.: **15**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **7** Date: **October 18, 1995**
 Location: **mid Reach 7, 1 km upstream of falls at the top of Reach 6**
 Reach length: **3 km** Survey length: **250 m** Stream gradient: **3.5 %**
 Channel width: **21 m** Wetted width: **17 m** Water temperature: **7.0 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Cascades		Side Channel
% of total wetted area	7	30	15	45	3		—
Mean depth (m)	0.5	0.2	0.4	0.5	0.2		
Maximum depth (m)	0.8	0.35	0.7	0.8	?		
Residual depth (m)	0.4						
Dominant substrates type	boulders	boulders	boulders	boulders	bedrock		
%	45	60	55	95	100		
Subdominant substrates type	gravel	cobble	cobble	cobble	—		
%	30	25	20	<5	—		
Spawning gravels (%) fall	<1	<1	<1	0	0		
spring	<1	<1	<1	0	0		
Fines (%)	10	1	5	0	0		
Compaction	low	moderate	moderate	high	—		
Total cover (% total wetted area)							
juveniles	60	70	75	15	0		
adults	30	20	40	50	10		
Components (% total cover)							
large woody debris	5	5	5	0	0		
small woody debris	5	0	<5	0	0		
substrates	70	>85	>80	100	100		
overstream vegetation	15	5	5	0	0		
instream vegetation	0	0	0	0	0		
cutbanks, roots	5	<5	<5	0	0		
Canopy (%)	10						
Pieces LWD per channel width							
10 – 20 cm	0.2						
20 – 50 cm	0.2						
> 50 cm	0.3						

Dominant channel type: boulder-cascade-pool Aggrading / degrading / stable? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 11 Mean area (m²) 25
 Off-channel habitat: features no off-channel habitat in this section
 access
 Bank condition / channel stability: primarily large boulders and bedrock; 90 % stable
 Surrounding terrain, and other: extensive logging along both sides of river; narrow leave strip along both banks
 Turbidity: slight

Fish Habitat Survey Data

Site No.: **16**
 Stream Name : **Kwoiek Creek mainstem** Reach No.: **8** Date : **October 18, 1995**
 Location : **uppermost 170 m, immediately upstream of bridge crossing downstream of John George Lake**
 Reach length : **0.9 km** Survey length : **170 m** Stream gradient : **3 %**
 Channel width : **16 m** Wetted width : **13.3 m** Water temperature : **6.5 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Side Channel
% of total wetted area	10	20	40	30	-
Mean depth (m)	0.3	0.2	0.4	0.3	
Maximum depth (m)	0.8	0.45	0.7	0.6	
Residual depth (m)	0.35				
Dominant substrates type	boulders	boulders	boulders	boulders	
%	40	65	50	90	
Subdominant substrates type	cobble	cobble	cobble	cobble	
%	30	35	25	5	
Spawning gravels (%) fall	5	0	<5	0	
spring	5	<5	5	0	
Fines (%)	10	1	5	0	
Compaction	moderate	high	high	high	
Total cover (% total wetted area)					
juveniles	45	50	35	20	
adults	20	10	30	60	
Components (% total cover)					
large woody debris	10	0	5	0	
small woody debris	5	0	<5	0	
substrates	70	>90	>80	>95	
overstream vegetation	10	5	5	0	
instream vegetation	0	0	0	0	
cutbanks, roots	5	<5	<5	<5	
Canopy (%)	10				
Pieces LWD per channel width					
10 – 20 cm	0.6				
20 – 50 cm	0.3				
> 50 cm	0.2				

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 3 Mean area (m²) 12
 Off-channel habitat : features no off-channel habitat in this section
 access
 Bank condition / channel stability : primarily boulders, large cobble and bedrock; 90 % stable
 Surrounding terrain, and other : stream largely bordered with old growth forest, along both banks; some logging of
 south side, with very sparse leave strips; very few spawning gravels at the outlet of
 John George Lake
 Turbidity : slight

Fish Habitat Survey Data

Site No.: **17**
 Stream Name: **Kwoiek Creek mainstem** Reach No.: **9** Date: **October 19, 1995**
 Location: **between outlet from Kha Lake and inlet to Klept Lake**
 Reach length: **0.3 km** Survey length: **300 m** Stream gradient: **1.5 %**
 Channel width: **14 m** Wetted width: **13 m** Water temperature: **6.5 °C**

Habitat Features	Pool	Riffle	Glide	Side Channel
% of total wetted area	20	35	45	-
Mean depth (m)	0.4	0.2	0.4	
Maximum depth (m)	0.7	0.35	0.7	
Residual depth (m)	0.35			
Dominant substrates type	gravel	boulders	gravel	
%	40	60	45	
Subdominant substrates type	cobble	cobble	cobble	
%	30	25	35	
Spawning gravels (%) fall	30	5	20	
spring	30	10	15	
Fines (%)	15	<5	10	
Compaction	low	moderate	low	
Total cover (% total wetted area)				
juveniles	25	50	50	
adults	15	10	35	
Components (% total cover)				
large woody debris	35	10	25	
small woody debris	25	5	15	
substrates	20	80	50	
overstream vegetation	15	5	5	
instream vegetation	<5	0	0	
cutbanks, roots	<5	0	5	
Canopy (%)	10			
Pieces LWD per channel width				
10 – 20 cm	2.3			
20 – 50 cm	3.4			
> 50 cm	0.4			

Dominant channel type : debris-cobble-cascade-pool Aggrading / degrading / stable ? aggrading
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 14 Mean area (m²) <10
 Off-channel habitat : features no off-channel habitat in this section
 access
 Bank condition / channel stability : 75 % stable; maintained by boulders; 25 % unstable, due to fine materials, and debris
 Surrounding terrain, and other : extensive logging on both sides of stream, with very sparse leave strip; excellent spawning habitat in this section
 Turbidity : slight

Fish Habitat Survey Data

Site No.: **18**
 Stream Name : **Kwoiek Creek mainstem** Reach No.: **10** Date : **October 16, 1995**
 Location : **downstream of collapsed bridge approx. 1.5 km upstream of Kha Lake**
 Reach length : **3.5 km** Survey length : **300 m** Stream gradient : **2 %**
 Channel width : **12.5 m** Wetted width : **12 m** Water temperature : **6.5 °C**

Habitat Features	Pool	Riffle	Glide	Rapids		Side Channel
% of total wetted area	15	35	30	20		-
Mean depth (m)	0.4	0.1	0.3	0.2		
Maximum depth (m)	0.7	0.3	0.6	0.4		
Residual depth (m)	0.4					
Dominant substrates type	cobble	cobble	boulder	boulder		
%	40	60	50	80		
Subdominant substrates type	finer	gravel	cobble	cobble		
%	20	20	30	10		
Spawning gravels (%) fall	<1	10	5	0		
spring	<1	10	<5	0		
Fines (%)	20	10	15	5		
Compaction	high	high	high	high		
Total cover (% total wetted area)						
juveniles	60	40	50	20		
adults	25	5	40	55		
Components (% total cover)						
large woody debris	35	10	10	<5		
small woody debris	25	5	10	0		
substrates	5	85	70	>95		
overstream vegetation	15	0	0	0		
instream vegetation	5	0	0	0		
cutbanks, roots	15	0	10	0		
Canopy (%)	<5					
Pieces LWD per channel width						
10 – 20 cm	0.9					
20 – 50 cm	1.6					
> 50 cm	0.4					

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? aggrading
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 1 Mean area (m²) 12
 Off-channel habitat : features no off-channel habitat in this section
 access _____
 Bank condition / channel stability : >90 % stable; maintained by boulders
 Surrounding terrain, and other : extensive logging on both sides of stream; leave strip often lacking on both banks; thin where present; noticeable increase in fines within channel
 Turbidity : clear

Fish Habitat Survey Data

Site No.: **20**
 Stream Name: **North Kwoiek Creek** Reach No.: **1** Date: **October 16, 1995**
 Location: **at bridge crossing, 300 m upstream of the confluence with the Kwoiek Creek mainstem**
 Reach length: **3.5 km** Survey length: **150 m** Stream gradient: **23 %**
 Channel width: **7.5 m** Wetted width: **7.2 m** Water temperature: **5.5 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	cascades		Side Channel
% of total wetted area	10	10	30	20	30		<2
Mean depth (m)	0.3	0.1	0.2	0.25	0.2		0.15
Maximum depth (m)	0.6	0.2	0.5	0.6	0.4		0.55
Residual depth (m)	0.4						
Dominant substrates type	boulder	boulder	boulder	boulder	boulder		gravel
%	75	85	85	90	95		65
Subdominant substrates type	cobble	cobble	cobble	cobble	cobble		finer
%	10	10	5	5	5		30
Spawning gravels (%) fall	0	0	0	0	0		5
spring	0	0	0	0	0		10
Fines (%)	<1	0	<1	0	0		30
Compaction	mod. - high	high	high	high	high		high
Total Cover (% total wetted area)							
juveniles	70	30	75	10	0		55
adults	40	0	20	25	10		15
Components (% total cover)							
large woody debris	10	0	5	0	0		>35
small woody debris	5	<5	<5	0	0		20
substrates	80	>90	>85	>95	>95		10
overstream vegetation	5	5	5	<5	<5		15
instream vegetation	0	0	0	0	0		<5
cutbanks, roots	0	0	0	0	0		15
Canopy (%)	15						45
Pieces LWD per channel width							
10 - 20 cm	0.7						1.3
20 - 50 cm	0.5						1.0
> 50 cm	0.1						0.3

Dominant channel type : boulder-step-pool Aggrading / degrading / stable ? stable
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 7 Mean area (m²) <10
 Off-channel habitat : features 120 m in length; abundant gravels, but mostly consolidated / embedded with fines
 access suspected gradient barrier at bottom end of channel
 Bank condition / channel stability : primarily large boulders; >95 % stable
 Surrounding terrain, and other : logging on both sides of stream; leave strip of small mature trees along both banks;
 thick growth of deciduous shrubs along the stream margins
 Turbidity : clear

Fish Habitat Survey Data

Site No.: **21**
 Stream Name : **North Kwoiek Creek** Reach No.: **2** Date : **October 16, 1995**
 Location : **lower Reach 2; bridge crossing 4.8 km upstream of the confluence with Kwoiek Creek**
 Reach length : **3 km** Survey length : **175 m** Stream gradient : **2.5 %**
 Channel width : **10.5 m** Wetted width : **8.7 m** Water temperature : **5.5 °C**

Habitat Features	Pool	Riffle	Glide	Side Channel
% of total wetted area	10	60	30	—
Mean depth (m)	0.35	0.25	0.4	
Maximum depth (m)	0.7	0.4	0.7	
Residual depth (m)	0.3			
Dominant substrates type	fines	cobble	cobble	
%	55	80	55	
Subdominant substrates type	cobble	gravel	gravel	
%	30	15	25	
Spawning gravels (%) fall	10	5	15	
spring	10	5	10	
Fines (%)	55	5	15	
Compaction	moderate	high	moderate	
Total Cover (% total wetted area)				
juveniles	35	60	40	
adults	15	20	25	
Components (% total cover)				
large woody debris	30	15	20	
small woody debris	10	5	5	
substrates	25	50	40	
overstream vegetation	15	25	20	
instream vegetation	0	0	0	
cutbanks, roots	20	5	15	
Canopy (%)	5			
Pieces LWD per channel width				
10 – 20 cm	0.4			
20 – 50 cm	0.6			
> 50 cm	<0.1			

Dominant channel type : rifle-pool Aggrading / degrading / stable ? aggrading
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 3 Mean area (m²) <10
 Off-channel habitat : features no off-channel habitat in this section
 access
 Bank condition / channel stability : primarily cobble / gravel banks; 80 % stable
 Surrounding terrain, and other : logging on either side of channel; narrow leave strips only; recent fines deposits on streambed; some infilling of cobbles and gravels
 Turbidity : slight

Fish Habitat Survey Data

Site No.: **22**
 Stream Name : **North Kwoiek Creek** Reach No.: **3** Date : **October 16, 1995**
 Location : **lower Reach 3; bridge crossing 7 km upstream of the confluence with Kwoiek Creek**
 Reach length : **4 km** Survey length : **150 m** Stream gradient : **3.5 %**
 Channel width : **11.5 m** Wetted width : **10.2 m** Water temperature : **5.5 °C**

Habitat Features	Pool	Riffle	Glide	Rapids	Side Channel
% of total wetted area	10	15	15	60	-
Mean depth (m)	0.35	0.1	0.3	0.3	
Maximum depth (m)	0.7	0.25	0.6	0.5	
Residual depth (m)	0.3				
Dominant substrates type	boulder	boulder	boulder	boulder	
%	60	85	75	90	
Subdominant substrates type	fines	gravel	gravel	cobble	
%	20	10	15	5	
Spawning gravels (%) fall	5	<5	10	<1	
spring	5	<5	10	<1	
Fines (%)	20	<5	10	<1	
Compaction	moderate	high	high	high	
Total Cover (% total wetted area)					
juveniles	70	75	80	20	
adults	40	20	55	40	
Components (% total cover)					
large woody debris	15	<5	10	<5	
small woody debris	10	0	5	0	
substrates	>60	>90	>75	>95	
overstream vegetation	5	5	5	0	
instream vegetation	0	0	0	0	
cutbanks, roots	<5	<5	<5	0	
Canopy (%)	<5				
Pieces LWD per channel width					
10 – 20 cm	0.8				
20 – 50 cm	1.3				
> 50 cm	0.2				

Dominant channel type : boulder-cascade-pool Aggrading / degrading / stable ? aggrading
 Number of adult holding pools (> 1m, complex cover, cool, etc.) 0 Mean area (m²) -
 Off-channel habitat : features no off-channel habitat in this section
 access
 Bank condition / channel stability : banks composed of boulders (primarily), cobble and fines; 75 % stable
 Surrounding terrain, and other : extensive logging on both sides of stream; sparse leave strips in some areas; other-wise none; ongoing deposition of fines evident
 Turbidity : slight

Appendix 4.

Results of laboratory analyses for water samples obtained from streams and lakes in the Kwoiek Creek drainage, October 1995.

Client/Code

R.P. Griffith & Associates
1237 Munro Road
Sidney, B.C.
V8L 3R9

Date 11/08/95
Source lake/stream
Type of Sample water
No. of Samples 21

No. W27702

Comments

MPLE		Alkalinity (mg/L CaCO ₃)	NH ₃ -N (ug/L)	TKN (mg/L)	NO ₃ -N (ug/L)	NO ₂ -N (ug/L)
oiek Cr-at train crossing	250ct95	23.0	n/a	n/a	16.3	ND
oiek Cr-1st bridge d/s N.Kwojek	250ct95	21.0	n/a	n/a	23.1	ND
oiek Cr-d/s of Kwojek Lake	250ct95	18.5	n/a	n/a	16.3	ND
oiek Cr-u/s of Kwojek Lake	250ct95	15.0	n/a	n/a	16.7	ND
oiek Cr-d/s of John George Lake	250ct95	14.0	n/a	n/a	13.0	0.296
oiek Cr-u/s of Kha Lake	250ct95	14.0	n/a	n/a	44.0	ND
permost Kwoiek Cr-above logging	250ct95	6.50	n/a	n/a	75.9	ND
rth Kwoiek Cr	250ct95	29.0	n/a	n/a	16.7	ND
oiek Lake-surface 0.5 m	200ct95	15.0	2.98	0.397	29.5	ND
oiek Lake 0.4 m	200ct95	17.5	2.98	0.249	13.2	0.601
kwaskey Lake-surface 0.5 m	240ct95	6.50	2.98	0.224	23.6	ND
kwaskey Lake 30.0m	240ct95	8.00	3.99	0.200	25.3	1.21
ochiwa Lake-surface 0.5 m	230ct95	5.50	6.01	0.303	25.8	0.296
ochiwa Lake 30.0m	230ct95	6.00	7.02	0.194	24.4	ND
hn George Lk-surface 0.5 m	210ct95	13.0	6.01	0.407	12.1	ND
hn George Lake 10.0m	210ct95	15.5	9.04	0.224	14.6	ND
ept Lake-surface 0.5 m	180ct95	13.5	5.00	0.388	29.1	ND
ept Lake 6.0 m	180ct95	15.5	8.03	0.303	29.1	ND
a Lake-surface 0.5 m	190ct95	11.0	2.98	0.309	40.1	ND
a Lake 7.0 m	190ct95	12.5	5.00	0.388	49.5	ND
ukolait Lake-surface 0.5 m	250ct95	4.50	3.99	0.188	63.6	ND
		0.100	0.254	0.0115	0.167	0.100
F. VALUE		100	20.0	1.00	15.0	4.60
D ± 2SD		97.6 ± 12.0	20.2 ± 2.2	1.02 ± 0.10	15.2 ± 1.8	4.67 ± 0.

= standard deviation

D = secondary standard calibrated to primary standard reference material

= standard deviation at zero analyte concentration

= none detected

.... /pg 2

Client/Code

C.F. Griffith & Associates
 1237 Munro Road
 Sidney, B.C.
 V8L 3R9

Date 11/08/95
 Source lake/stream
 Type of Sample water
 No. of Samples 21

Comments

SAMPLE		pH	TP (ug/L)	TDS (ug/L)	TSS (ug/L)	INERT (ug/L)	VOLATILE (ug/L)
Wick Cr-at train crossing	250ct95	7.58	n/a	27.3	5.33	4.67	n/a
Wick Cr-1st bridge d/s N.Kwojek	250ct95	7.52	n/a	26.1	1.67	1.67	n/a
Wick Cr-d/s of Kwojek Lake	250ct95	7.33	n/a	20.8	2.67	2.67	n/a
Wick Cr-u/s of Kwojek Lake	250ct95	7.18	n/a	16.6	2.33	1.67	n/a
Wick Cr-d/s of John George Lake	250ct95	7.22	n/a	14.4	1.67	1.00	n/a
Wick Cr-u/s of Kha Lake	250ct95	7.18	n/a	13.5	1.00	1.00	n/a
Westmost Kwojek Cr-above logging	250ct95	6.81	n/a	6.80	1.33	1.33	n/a
North Kwojek Cr	250ct95	7.62	n/a	34.2	1.33	1.33	n/a
Wick Lake-surface 0.5 m	200ct95	7.28	2.65	15.4	2.67	2.67	ND
Wick Lake 4.0 m	200ct95	7.23	3.21	15.6	2.67	2.67	ND
Waskey Lake-surface 0.5 m	240ct95	6.84	3.78	7.90	3.00	3.00	ND
Waskey Lake 30.0m	240ct95	6.88	2.65	7.60	2.00	2.00	ND
Schiwa Lake-surface 0.5m	230ct95	6.66	10.9	5.00	9.33	9.33	ND
Schiwa Lake 30.0m	230ct95	6.69	2.93	4.90	4.67	4.33	0.333
John George Lk-surface 0.5 m	210ct95	7.21	5.78	13.6	2.33	2.33	ND
John George Lake 10.0m	210ct95	7.30	4.35	13.9	1.33	1.33	ND
Sept Lake-surface 0.5 m	180ct95	7.29	6.06	15.7	3.00	2.33	0.667
Sept Lake 6.0m	180ct95	7.32	5.49	17.3	8.00	8.00	ND
Wick Lake-surface 0.5 m	190ct95	7.15	6.35	13.0	4.00	4.00	ND
Wick Lake 7.0 m	190ct95	7.12	6.06	13.0	4.33	4.33	ND
Wickolait Lake-surface 0.5 m	250ct95	6.76	1.51	5.30	3.00	2.33	0.667
			0.050	0.700	0.200		
F. VALUE		7.00	25.0	50.0	5.00		
SD ± 2SD		7.01 ± 0.84	25.4 ± 2.6	50.6 ± 4.4	4.86 ± 0.60		

- = standard deviation
- SD = secondary standard calibrated to primary standard reference material
- = standard deviation at zero analyte concentration
- = none detected

R. Jones
 Supervisor

H. Hartmann
 H. Hartmann
 Analytical Chemist

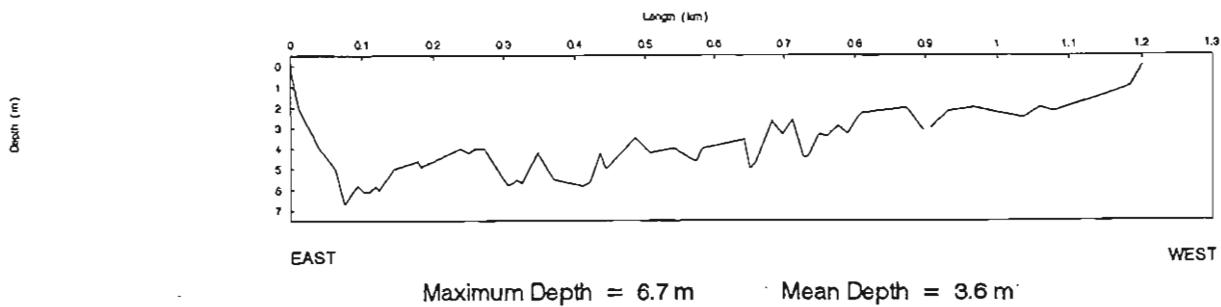
Appendix 5.

Limnological data for lakes in the Kwoiek Creek drainage investigated during October 1995.

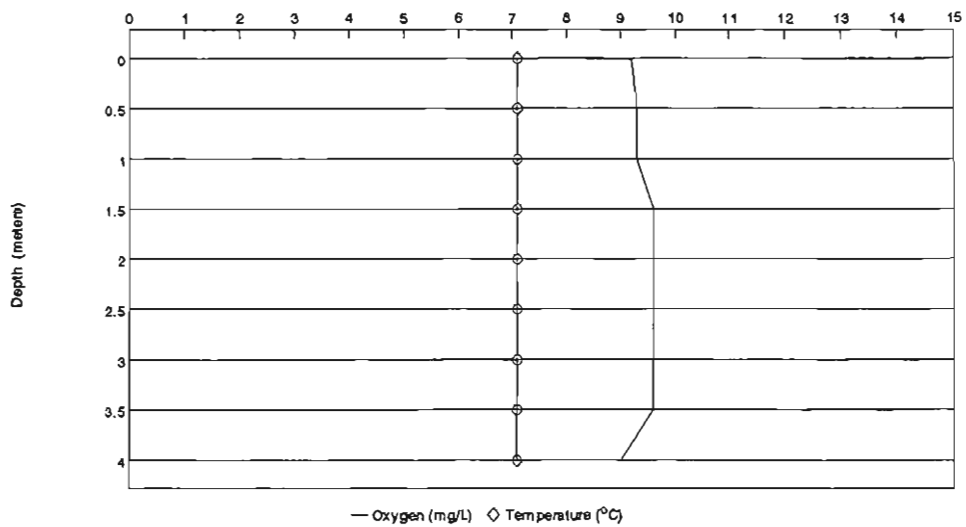
Limnology Summary

Water body :	Kwoiek Lake	Bottom depth (m) :	4.4
Date :	October 20, 1995	Time :	12:15 hrs.
Wind velocity (km/hr) :	10 – 25	Wind direction :	W
Cloud cover (%) :	60	Surface condition :	choppy
Secchi depth (m) :	2.3	Water colour :	milky aqua
Field pH (surface) :	7.0	Field H ₂ S (surface) :	0.0 mg/L
Field pH (1m from bottom) :	6.5	Field H ₂ S (1m from bottom) :	0.0 mg/L

Longitudinal Depth Profile



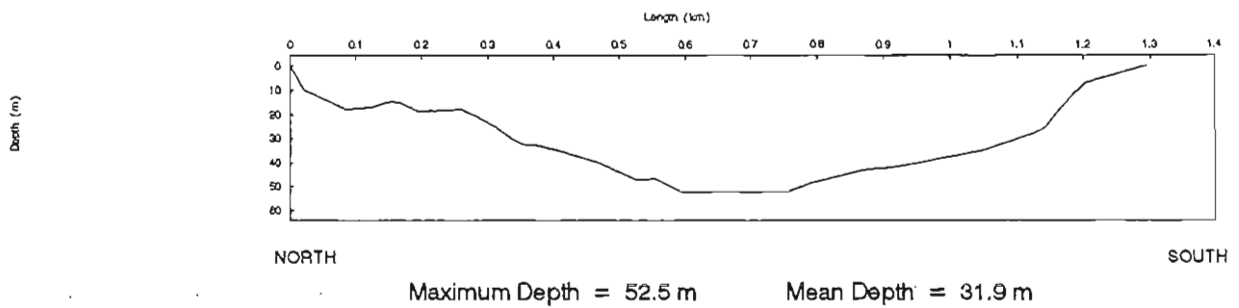
Dissolved Oxygen and Temperature Profile



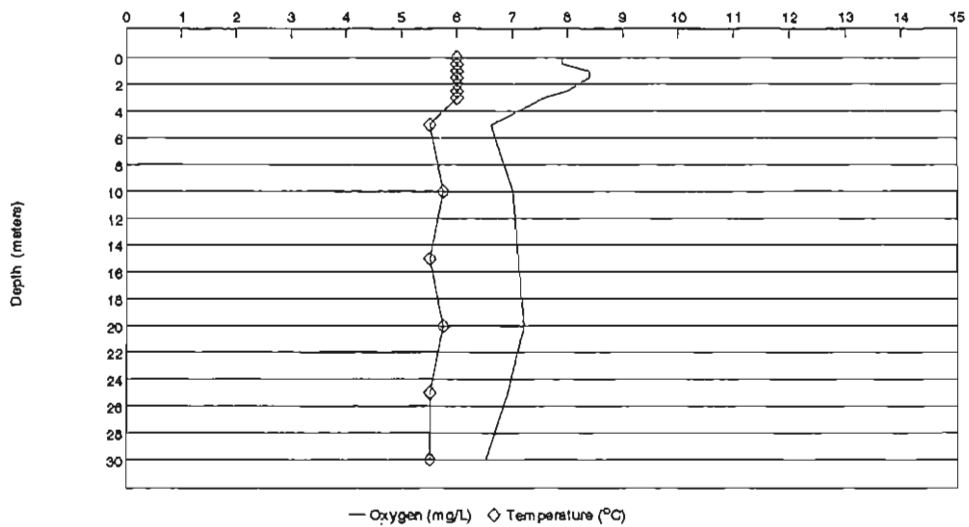
Limnology Summary

Water body :	Kokwaskey Lake	Bottom depth (m) :	47.5
Date :	October 24, 1995	Time :	12:00 hrs.
Wind velocity (km/hr) :	near still	Wind direction :	SE
Cloud cover (%) :	95	Surface condition :	smooth
Secchi depth (m) :	2.1	Water colour :	milky aqua
Field pH (surface) :	6.5	Field H ₂ S (surface) :	0.0 mg/L
Field pH (1m from bottom) :	6.5	Field H ₂ S (1m from bottom) :	0.0 mg/L

Longitudinal Depth Profile



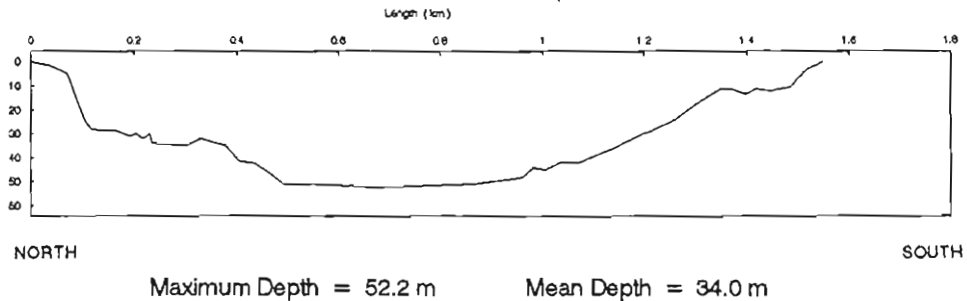
Dissolved Oxygen and Temperature Profile



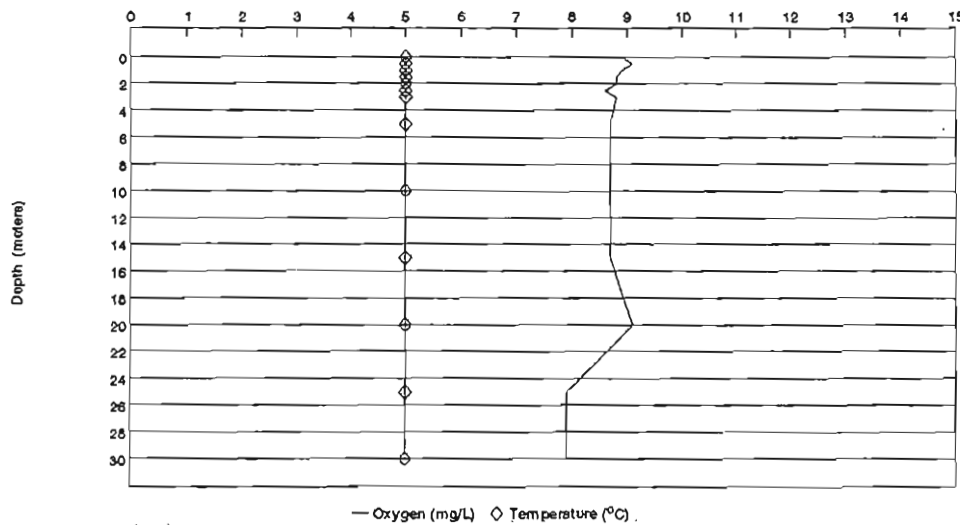
Limnology Summary

Water body :	Chochiwa Lake	Bottom depth (m) :	51.3
Date :	October 23, 1995	Time :	12:30 hrs.
Wind velocity (km/hr) :	10 - 25	Wind direction :	N
Cloud cover (%) :	70	Surface condition :	rippled
Secchi depth (m) :	1.6	Water colour :	milky aqua
Field pH (surface) :	6.5	Field H ₂ S (surface) :	0.0 mg/L
Field pH (1m from bottom) :	6.5	Field H ₂ S (1m from bottom) :	0.0 mg/L

Longitudinal Depth Profile



Dissolved Oxygen and Temperature Profile



Limnology Summary

Water body : **John George Lake**

Bottom depth (m) : **10.7**

Date : **October 21, 1995**

Time : **13:00 hrs.**

Wind velocity (km/hr) : **5 - 20**

Wind direction : **SE**

Cloud cover (%) : **80**

Surface condition : **rippled**

Secchi depth (m) : **2.3**

Water colour : **milky green**

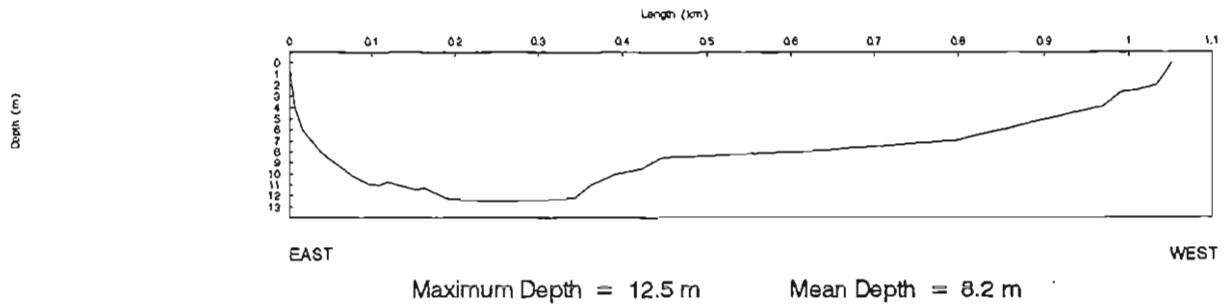
Field pH (surface) : **7.0**

Field H₂S (surface) : **0.0 mg/L**

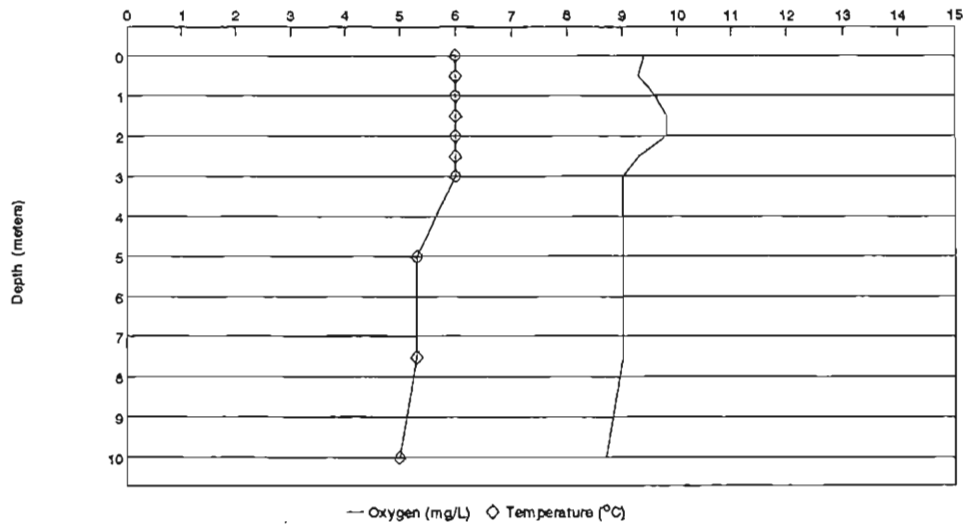
Field pH (1m from bottom) : **7.0**

Field H₂S (1m from bottom) : **0.0 mg/L**

Longitudinal Depth Profile



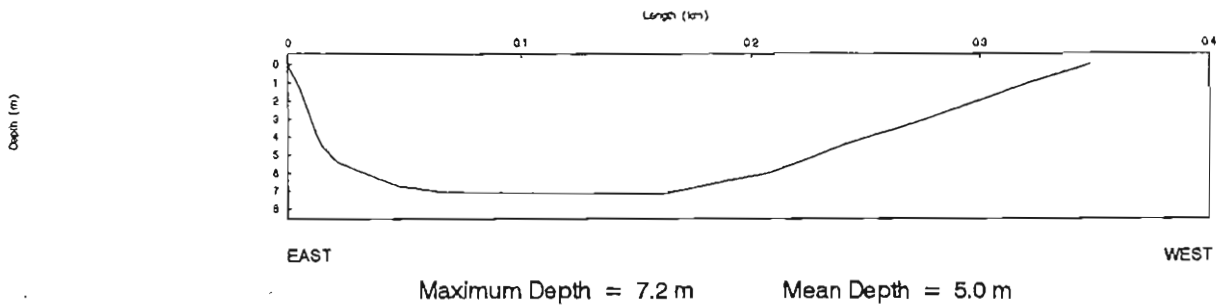
Dissolved Oxygen and Temperature Profile



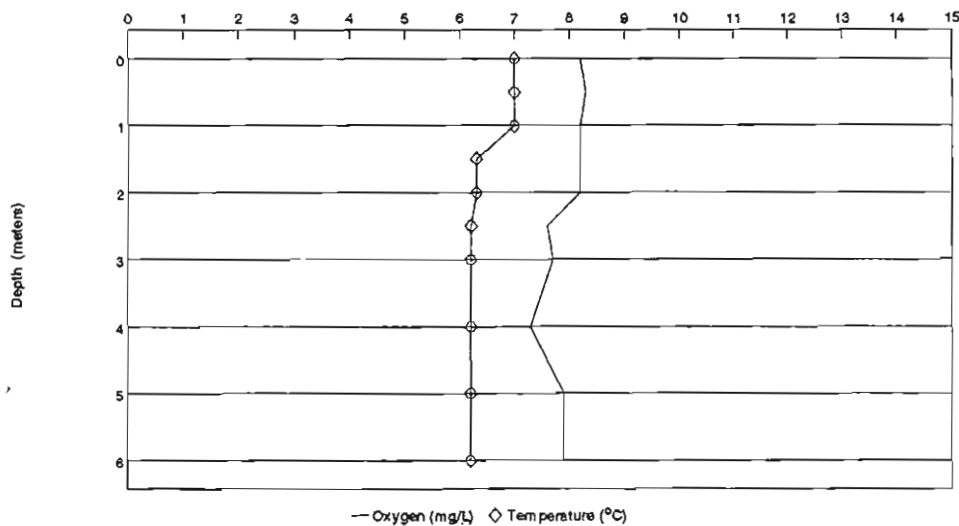
Limnology Summary

Water body :	Klept Lake	Bottom depth (m) :	6.7
Date :	October 18, 1995	Time :	14:15 hrs.
Wind velocity (km/hr) :	0 – 5	Wind direction :	SE
Cloud cover (%) :	< 5	Surface condition :	slight ripple
Secchi depth (m) :	2.1	Water colour :	milky green
Field pH (surface) :	7.0	Field H ₂ S (surface) :	0.0 mg/L
Field pH (1m from bottom) :	7.0	Field H ₂ S (1m from bottom) :	0.0 mg/L

Longitudinal Depth Profile



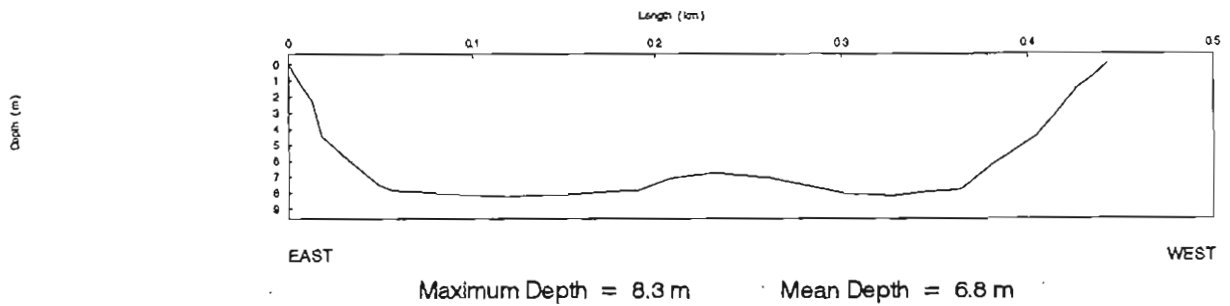
Dissolved Oxygen and Temperature Profile



Limnology Summary

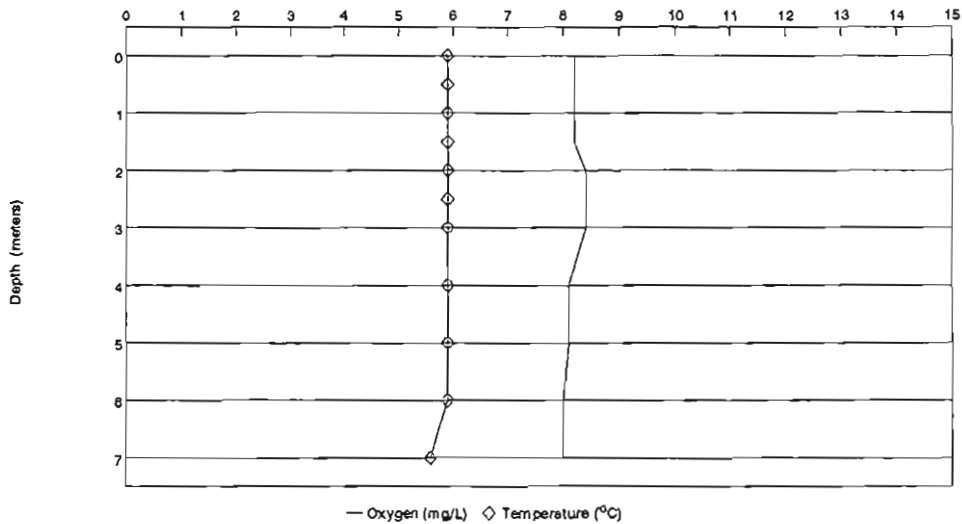
Water body :	Kha Lake	Bottom depth (m) :	7.6
Date :	October 19, 1995	Time :	11:45 hrs.
Wind velocity (km/hr) :	still	Wind direction :	n / a
Cloud cover (%) :	50	Surface condition :	smooth
Secchi depth (m) :	2.1	Water colour :	milky green
Field pH (surface) :	7.0	Field H ₂ S (surface) :	0.0 mg/L
Field pH (1m from bottom) :	7.0	Field H ₂ S (1m from bottom) :	0.0 mg/L

Longitudinal Depth Profile



Maximum Depth = 8.3 m Mean Depth = 6.8 m

Dissolved Oxygen and Temperature Profile



Appendix 6.

Fish captures, habitat descriptions, and water depth/velocity transects
at electrofishing sites in the Kwoiek Creek drainage, October 1995.

Key to Species:

BT = bull trout
CO = coho salmon
RB = rainbow trout

Appendix 7.

Gill netting fish capture results for lakes investigated within the Kwoiek Creek drainage, October 1995.

Key: Status of Reproductive Development

imm = immature; no significant development of organs

mg = maturing; fish likely to spawn within 12 months

kelt = recovering from recent spawning

mat = mature; fully developed, but not in spawning condition

ripe = full developed, and in spawning condition

s (followed by year) = spawning indicated by scale sample

Gill Netting Fish Capture Data

Sinking Net (dry; periodic sun; breezy)

Kwoiek Lake

Set: 16:45 hrs. October 19, 1995
Retrieved: 11:00 hrs. October 20, 1995

Shallow End: 0.6 m
Deep End: 2.6 m

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	113	12.7	1 +	F	imm	empty	1	19
Rainbow	116	15.3	1 +	F	imm	empty	1	1
Rainbow	116	18.3	2 +	M	imm	empty	2	30
Rainbow	122	21.2	1 +	F	imm	half full	1	2
Rainbow	128	21.0	2 +	?	imm	full	2	67
Rainbow	133	28.3	1 +	M	imm	partially full	1	59
Rainbow	154	43.0	2 +	F	imm	partially full	2	52
Rainbow	155	40.8	2 +	F	imm	full	2	66
Rainbow	168	51.0	2 +	M	imm	half full	0	54
Rainbow	173	59.6	2 +	F	imm	half full	2	28
Rainbow	174	59.6	2 +	F	imm	empty	2	18
Rainbow	178	67.3	2 +	M	imm	empty	1	24
Rainbow	181	73.1	2 +	M	imm	partially full	1	26
Rainbow	182	65.7	2 +	F	imm	partially full	1	34
Rainbow	183	74.7	3 +	M	mg	half full	3	29
Rainbow	183	78.1	3 +	M	mat	empty	2	8
Rainbow	184	80.9	2 +	F	imm	half full	1	70
Rainbow	185	65.8	3 +	F	imm	empty	3	43
Rainbow	185	74.2	3 +	M	mg	half full	1	12
Rainbow	185	79.9	3 +	M	mat	half full	3	53
Rainbow	187	77.3	2 +	F	imm	empty	1	14
Rainbow	192	80.8	3 +	F	mg	full	2	58
Rainbow	194	86.6	3 +	F	mg	full	1	21
Rainbow	195	91.6	3 +	M	imm	full	2	51
Rainbow	197	83.4	3 +	F	mg	partially full	1	9
Rainbow	197	85.0	3 +	M	imm	empty	2	71
Rainbow	197	91.5	3 +	F	mg	full	3	56
Rainbow	198	94.8	2 +	F	imm	half full	1	45
Rainbow	199	90.5	3 +	F	s 3	empty	1	57
Rainbow	200	94.1	3 +	M	mat	partially full	1	65
Rainbow	201	100.6	3 +	F	s 3	full	2	40
Rainbow	203	97.6	3 +	F	mg	empty	2	16
Rainbow	203	99.1	3 +	M	mg	empty	2	23
Rainbow	203	101.1	3 +	M	s 3	half full	2	55
Rainbow	205	92.6	3 +	M	mg	empty	3	3
Rainbow	206	99.9	4 +	F	mg	partially full	3	64
Rainbow	206	103.9	3 +	F	mg	half full	1	38
Rainbow	207	97.2	3 +	F	mat	empty	2	13
Rainbow	207	103.0	3 +	F	s 3	half full	3	27
Rainbow	207	113.4	3 +	F	s 3	partially full	2	41

* rainbow trout gut contents: caddis and stonefly larvae, other benthos, surface insects, and one fish with frogs (scale sample 46.)

(cont'd)

Gill Netting Fish Capture Data

Sinking Net					Kwoiek Lake			
Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	210	107.0	3 +	F	mat	empty	2	61
Rainbow	211	104.3	3 +	M	mg	full	2	72
Rainbow	211	105.6	3 +	M	s 3	half full	1	69
Rainbow	211	113.1	3 +	F	s 3	empty	1	42
Rainbow	212	103.5	3 +	F	ripe	empty	2	25
Rainbow	212	106.5	3 +	M	s 3	empty	1	63
Rainbow	213	110.9	3 +	F	mg	full	0	4
Rainbow	214	106.2	3 +	F	mg	empty	2	62
Rainbow	214	108.5	3 +	M	mat	partially full	1	44
Rainbow	214	112.4	3 +	F	s 3	partially full	1	22
Rainbow	214	118.9	3 +	M	mat	empty	1	5
Rainbow	216	113.8	3 +	F	mg	empty	1	32
Rainbow	217	110.1	3 +	M	imm	empty	1	11
Rainbow	218	118.3	3 +	M	mg	empty	2	31
Rainbow	218	121.1	3 +	F	mg	partially full	3	17
Rainbow	218	122.8	3 +	M	s 3	partially full	1	60
Rainbow	219	114.9	3 +	F	mg	empty	2	35
Rainbow	219	135.5	3 +	F	s 3	half full	1	15
Rainbow	221	115.3	3 +	F	mg	partially full	1	36
Rainbow	223	116.3	4 +	M	s 3, 4	half full	1	48
Rainbow	223	128.5	4 +	M	s 4	empty	1	10
Rainbow	226	127.2	3 +	M	mg	partially full	0	6
Rainbow	226	127.7	3 +	F	s 3	partially full	1	39
Rainbow	226	138.2	4 +	F	s 3	empty	2	20
Rainbow	227	127.3	4 +	M	s 3	half full	2	7
Rainbow	228	136.9	3 +	F	near ripe	empty	1	37
Rainbow	229	126.9	3 +	M	imm	empty	3	50
Rainbow	231	141.2	3 +	F	s 3	full	1	46
Rainbow	232	139.7	4 +	F	s 4	empty	1	33
Rainbow	233	128.8	4 +	F	ripe / s 3	empty	1	47
Rainbow	236	149.6	4 +	M	s 3, 4	half full	2	68
Rainbow	239	157.6	4 +	F	s 4	full	2	73
Rainbow	244	155.7	4 +	F	s 4	empty	1	49
Bull Trout	187	62.8	3 +	M	imm	empty	-	Otolith 8.
Bull Trout	203	78.5	3 +	F	imm	half full / worms	-	Otolith 7.
Bull Trout	246	126.2	4 +	M	imm	empty	-	Otolith 6.
Bull Trout	352	410	6 +	M	kelt	fish (unidentifiable)	-	Otolith 4.
Bull Trout	358	450	6 +	M	imm	full / frogs & stoeflies	-	Otolith 5.
Bull Trout	659	3016	8 +	F	kelt	2 rainbow (120-160 mm)	-	Otolith 3.
Bull Trout	665	3078	8 +	M	kelt	1 rainbow (150 mm)	-	Otolith 2.
Bull Trout	721	3778	10 +	M	kelt	empty	-	Otolith 1.

Gill Netting Fish Capture Data

Sinking Net (occasional snow showers; moderate breeze)

Kokwaskey Lake

Set: 16:00 hrs. October 23, 1995

Shallow End: 0.8 m

Retrieved: 11:30 hrs. October 24, 1995

Deep End: 14 m

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	86	6.9	1 +	M	imm	empty	1	9 - 3
Rainbow	112	14.3	1 +	M	imm	empty	0	4 - 3
Rainbow	112	15.0	1 +	F	imm	empty	0	5 - 1
Rainbow	116	16.0	1 +	M	imm	partially full	0	9 - 2
Rainbow	116	18.3	1 +	M	mat	half full	1	5 - 4
Rainbow	117	16.4	1 +	M	imm	-	0	9 - 1
Rainbow	118	17.3	1 +	M	imm	partially full	1	4 - 4
Rainbow	119	18.2	1 +	M	imm	partially full	1	7 - 3
Rainbow	119	18.3	2 +	F	imm	half full	2	5 - 5
Rainbow	120	17.5	1 +	M	imm	partially full	1	5 - 2
Rainbow	120	18.0	1 +	M	imm	empty	0	4 - 5
Rainbow	121	17.9	1 +	F	imm	half full	0	2 - 4
Rainbow	121	18.5	1 +	F	imm	partially full	0	6 - 4
Rainbow	123	20.1	2 +	M	imm	full	1	8 - 1
Rainbow	125	20.0	1 +	M	imm	partially full	1	3 - 4
Rainbow	125	21.7	2 +	M	mat	near empty	2	6 - 3
Rainbow	126	20.1	2 +	F	imm	partially full	1	6 - 2
Rainbow	129	21.8	1 +	M	imm	partially full	1	8 - 2
Rainbow	129	23.3	1 +	F	imm	empty	0	7 - 2
Rainbow	130	21.8	1 +	F	imm	half full	0	8 - 4
Rainbow	131	22.1	2 +	F	imm	empty	1	6 - 1
Rainbow	133	23.3	2 +	M	imm	empty	1	3 - 5
Rainbow	135	26.0	2 +	F	imm	near empty	1	8 - 3
Rainbow	149	32.1	2 +	M	imm	empty	2	3 - 3
Rainbow	150	31.5	2 +	F	imm	partially full	0	7 - 5
Rainbow	150	34.8	2 +	F	imm	partially full	0	4 - 1
Rainbow	155	40.2	2 +	F	imm	half full	0	2 - 2
Rainbow	161	45.7	2 +	F	imm	partially full	0	1 - 4
Rainbow	165	43.0	2 +	M	imm	half full	1	2 - 5
Rainbow	167	47.4	2 +	F	mat	half full	0	1 - 3
Rainbow	168	44.3	2 +	F	kelt	near empty	1	3 - 2
Rainbow	169	47.6	2 +	M	mat	partially full	1	2 - 3
Rainbow	170	46.6	3 +	M	kelt	near full	1	7 - 1
Rainbow	171	55.2	3 +	F	near ripe	partially full	1	5 - 3
Rainbow	177	51.8	2 +	M	imm	partially full	1	4 - 2
Rainbow	182	61.9	2 +	F	imm	partially full	0	1 - 1
Rainbow	186	68.8	3 +	M	mat	empty	1	7 - 4
Rainbow	189	61.2	?	M	kelt	near full / regen. scales	?	6 - 5
Rainbow	195	76.9	3 +	M	mg	partially full	1	1 - 5
Rainbow	197	71.6	3 +	F	kelt	spring/summer spawner	1	2 - 1
Rainbow	206	95.4	3 +	M	mat	empty	0	3 - 1
Rainbow	223	112.9	3 +	M	imm	empty	1	1 - 2

* gut contents: principally insects (primarily ants); some unidentifiable pink mush (suspected copepods)

Gill Netting Fish Capture Data

Sinking Net (occasional snow showers; moderate breeze)

Chochiwa Lake

Set: 14:45 hrs. October 22, 1995
Retrieved: 11:30 hrs. October 23, 1995

Shallow End: 1.2 m
Deep End: 23 m

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	102	13.5	1 +	F	imm	full	1	4
Rainbow	102	13.5	1 +	M	imm	partially full	0	7
Rainbow	103	13.4	1 +	M	mg	partially full	1	19
Rainbow	105	14.3	1 +	M	imm	partially full	0	2
Rainbow	106	16.0	2 +	M	mg	partially full	2	1
Rainbow	109	16.2	1 +	M	mat	full	1	10
Rainbow	110	15.6	1 +	M	mat	near full	0	17
Rainbow	118	19.0	1 +	F	imm	full	0	8
Rainbow	119	18.7	2 +	F	imm	half full	2	16
Rainbow	120	18.9	2 +	F	imm	empty	2	15
Rainbow	131	27.3	1 +	M	mat	partially full	0	12
Rainbow	132	26.3	2 +	F	imm	empty	1	18
Rainbow	140	31.4	2 +	F	imm	empty	1	3
Rainbow	173	60.5	2 +	M	imm	half full	0	9
Rainbow	180	70.5	3 +	F	kelt	spring/summer spawner	1	13
Rainbow	182	66.2	3 +	F	kelt	spring/summer spawner	1	5
Rainbow	210	101.1	3 +	F	kelt	spring/summer spawner	0	14
Rainbow	225	112.1	4 +	F	kelt	spring/summer spawner	0	11
Rainbow	228	135.4	4 +	F	kelt	spring/summer spawner	0	6

* gut contents: principally unidentifiable pink mush (suspected copepods); some ants

Gill Netting Fish Capture Data

Floating Net (retrieved under blizzard conditions)

Stukolait Lake

Set: 16:00 hrs. October 24, 1995
Retrieved: 12:30 hrs. October 25, 1995

Shallow End: 1.7 m
Deep End: 4.3 m

No FISH CAPTURED

Gill Netting Fish Capture Data

Sinking Net (snow flurries; freezing rain; occasional sun; strong breezes)

John George Lake

Set: 14:45 hrs. October 20, 1995

Shallow End: 0.8 m

Retrieved: 13:00 hrs. October 21, 1995

Deep End: 4.7 m

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	103	13.3	1 +	?	imm	full	1	56
Rainbow	108	13.6	1 +	M	imm	partially full	1	45
Rainbow	110	14.8	1 +	M	imm	partially full	1	34
Rainbow	110	15.4	1 +	F	imm	empty	1	54
Rainbow	111	15.3	1 +	F	imm	empty	1	36
Rainbow	113	16.6	1 +	F	imm	empty	1	46
Rainbow	116	17.5	1 +	F	imm	empty	0	52
Rainbow	118	19.8	1 +	M	imm	empty	0	50
Rainbow	119	19.0	1 +	M	imm	partially full	1	35
Rainbow	121	18.9	1 +	M	imm	empty	0	32
Rainbow	122	20.7	1 +	F	imm	full	0	29
Rainbow	124	22.4	1 +	M	mat	empty	0	47
Rainbow	124	22.4	1 +	M	imm	full	0	42
Rainbow	127	23.1	1 +	M	imm	half full	0	43
Rainbow	132	30.2	2 +	F	imm	half full	0	53
Rainbow	133	26.2	1 +	M	imm	half full	0	48
Rainbow	152	38.3	2 +	M	imm	partially full	1	37
Rainbow	166	48.1	2 +	M	imm	half full	1	26
Rainbow	170	51.0	2 +	F	imm	half full	1	49
Rainbow	173	57.2	3 +	F	imm	half full	2	44
Rainbow	173	58.6	2 +	F	imm	full	0	38
Rainbow	177	60.8	2 +	M	imm	full	2	57
Rainbow	177	67.6	2 +	F	imm	full	0	41
Rainbow	178	66.3	2 +	M	imm	full	1	15
Rainbow	180	57.0	3 +	F	imm	partially full	1	33
Rainbow	180	63.3	3 +	F	imm	half full	1	31
Rainbow	182	64.0	3 +	F	imm	half full	1	40
Rainbow	190	69.1	3 +	M	imm	full	1	18
Rainbow	190	74.1	3 +	M	imm	partially full	1	20
Rainbow	195	86.0	3 +	M	imm	half full	1	51
Rainbow	197	77.1	3 +	M	imm	full	1	39
Rainbow	197	93.0	3 +	F	mat	full	0	13
Rainbow	207	94.1	3 +	M	imm	partially full	1	16
Rainbow	207	97.0	3 +	M	imm	half full	1	28
Rainbow	208	94.7	3 +	M	imm	half full	1	30
Rainbow	208	101.5	3 +	M	mat	half full	0	25
Rainbow	208	118.8	3 +	M	mat	half full	1	4
Rainbow	209	101.8	2 +	M	imm	empty	0	21
Rainbow	210	94.2	3 +	M	imm	full	1	22
Rainbow	210	105.5	3 +	M	imm	full	1	24

* principal gut contents: Caddis and mayfly larvae, other benthos, and surface insects (*Gammarus* remains suspected)

(cont'd)

Gill Netting Fish Capture Data

Sinking Net

John George Lake

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	212	96.3	3 +	F	imm	near full	0	19
Rainbow	213	97.7	3 +	F	imm	half full	1	14
Rainbow	214	109.5	3 +	M	mat	full	0	12
Rainbow	220	121.1	3 +	F	imm	full	2	23
Rainbow	225	117.1	3 +	F	imm	full	1	17
Rainbow	227	129.4	3 +	F	imm	full	1	55
Rainbow	229	139.3	3 +	M	mat	partially full	1	5
Rainbow	230	129.8	3 +	F	imm	half full	0	8
Rainbow	231	123.9	3 +	F	imm	full	0	7
Rainbow	236	144.7	3 +	F	mat	half full	0	27
Rainbow	236	146.4	3 +	M	imm	full	0	11
Rainbow	243	186.2	3 +	M	imm	half full	1	6
Rainbow	248	155.1	3 +	M	imm	first annulus regenerated	?	10
Rainbow	271	250	3 +	M	mat	full	0	9
Rainbow	281	268	3 +	M	mat	partially full	0	3
Rainbow	290	346	3 +	M	imm	near full	0	2
Rainbow	416	788	5 +	F	ripe	empty	0	1

Gill Netting Fish Capture Data

Sinking Net (dry; sunny; slight breeze)

Klept Lake

Set: 14:00 hrs. October 18, 1995
 Retrieved: 14:45 hrs. October 19, 1995

Shallow End: 0.6 m
 Deep End: 5.5 m

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	108	13.3	1 +	M	imm	empty	1	80
Rainbow	109	14.4	1 +	F	imm	half full	1	111
Rainbow	109	14.6	1 +	F	imm	half full	0	122
Rainbow	111	14.7	1 +	M	imm	full	0	90
Rainbow	112	14.5	2 +	M	imm	half full	2	78
Rainbow	112	16.2	1 +	M	imm	empty	0	33
Rainbow	113	14.9	2 +	F	imm	empty	1	34
Rainbow	113	15.6	2 +	F	imm	partially full	0	46
Rainbow	113	16.5	1 +	F	imm	empty	0	1
Rainbow	114	13.6	1 +	F	imm	empty	1	52
Rainbow	114	15.3	1 +	F	imm	full	0	139
Rainbow	114	15.8	1 +	M	imm	empty	0	76
Rainbow	115	15.4	1 +	F	imm	empty	0	79
Rainbow	115	16.0	2 +	M	imm	half full	2	82
Rainbow	115	16.3	1 +	M	imm	partially full	0	37
Rainbow	116	16.7	2 +	M	imm	partially full	2	130
Rainbow	116	16.9	2 +	M	imm	empty	2	74
Rainbow	117	15.9	2 +	F	imm	half full	2	104
Rainbow	119	16.5	2 +	M	imm	empty	1	133
Rainbow	119	16.7	2 +	M	imm	full	2	116
Rainbow	119	17.7	1 +	M	imm	empty	1	94
Rainbow	119	17.8	2 +	F	imm	partially full	2	83
Rainbow	120	17.4	2 +	M	imm	empty	2	125
Rainbow	120	17.7	2 +	F	imm	partially full	1	66
Rainbow	120	20.1	2 +	M	imm	full	2	87
Rainbow	120	20.4	2 +	M	imm	empty	2	88
Rainbow	120	22.8	2 +	F	imm	full	2	123
Rainbow	121	17.5	2 +	F	imm	empty	2	85
Rainbow	121	18.5	2 +	F	imm	full	1	129
Rainbow	121	19.3	2 +	M	imm	empty	2	149
Rainbow	122	18.5	1 +	M	imm	full	0	45
Rainbow	122	18.7	2 +	M	imm	full	1	77
Rainbow	123	17.8	2 +	F	imm	empty	1	47
Rainbow	123	20.8	2 +	F	imm	empty	2	81
Rainbow	124	19.3	2 +	M	imm	partially full	2	89
Rainbow	124	20.1	1 +	M	imm	half full	1	110
Rainbow	125	19.0	2 +	M	imm	half full	0	127
Rainbow	125	19.6	2 +	F	imm	partially full	2	84
Rainbow	125	21.0	2 +	M	imm	half full	0	50
Rainbow	126	21.5	2 +	F	imm	empty	2	91

* principal gut contents: caddis, stonefly and mayfly larvae, other benthos, and surface insects

(cont'd)

Gill Netting Fish Capture Data

Sinking Net					Klept Lake			
Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	127	22.3	2 +	F	imm	full	2	148
Rainbow	128	21.2	2 +	F	imm	half full	2	90
Rainbow	128	22.1	1 +	M	imm	empty	0	124
Rainbow	128	22.7	2 +	F	imm	partially full	2	99
Rainbow	128	23.3	2 +	M	imm	partially full	2	103
Rainbow	129	18.5	2 +	F	imm	empty	2	86
Rainbow	129	21.7	2 +	M	imm	empty	1	72
Rainbow	129	23.0	2 +	F	imm	partially full	1	62
Rainbow	130	21.1	2 +	F	imm	partially full	2	107
Rainbow	130	24.6	1 +	F	imm	partially full	0	73
Rainbow	131	26.7	2 +	F	imm	partially full	2	93
Rainbow	132	23.3	2 +	M	imm	empty	2	98
Rainbow	132	24.3	2 +	M	imm	partially full	0	128
Rainbow	132	24.9	2 +	F	imm	half full	1	134
Rainbow	133	21.7	2 +	F	imm	partially full	2	75
Rainbow	135	23.1	2 +	F	imm	empty	1	35
Rainbow	135	27.0	2 +	F	imm	half full	2	92
Rainbow	136	24.8	2 +	F	imm	half full	2	106
Rainbow	137	26.0	2 +	M	imm	partially full	2	132
Rainbow	143	32.3	2 +	M	imm	half full	1	38
Rainbow	143	40.6	2 +	F	imm	half full	2	96
Rainbow	144	31.9	2 +	M	imm	empty	2	108
Rainbow	146	33.0	2 +	F	imm	half full	1	42
Rainbow	148	34.6	2 +	M	imm	empty	1	138
Rainbow	149	36.0	2 +	F	imm	full	0	59
Rainbow	151	37.3	2 +	F	imm	empty	1	51
Rainbow	154	37.8	2 +	M	imm	empty	2	119
Rainbow	154	40.9	2 +	M	imm	half full	1	41
Rainbow	154	42.4	2 +	M	mg	full	2	95
Rainbow	155	40.9	2 +	M	imm	full	1	121
Rainbow	157	43.7	3 +	F	imm	full	3	100
Rainbow	158	42.8	2 +	F	imm	empty	2	101
Rainbow	159	41.6	2 +	M	imm	half full	1	65
Rainbow	159	44.9	2 +	M	imm	full	2	147
Rainbow	159	45.7	2 +	M	imm	partially full	1	64
Rainbow	160	43.4	3 +	M	imm	empty	1	28
Rainbow	161	43.9	2 +	F	imm	half full	2	105
Rainbow	163	47.2	2 +	M	imm	empty	0	40
Rainbow	164	46.2	2 +	M	imm	half full	1	142
Rainbow	166	45.9	2 +	M	imm	empty	1	54
Rainbow	167	47.2	2 +	M	imm	empty	0	71
Rainbow	167	50.5	2 +	F	imm	empty	1	141
Rainbow	169	52.8	2 +	F	imm	full	2	102

(cont'd)

Gill Netting Fish Capture Data

Sinking Net

Klept Lake

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	170	51.2	3 +	F	imm	partially full	3	117
Rainbow	171	53.5	2 +	M	mg	empty	1	39
Rainbow	172	50.1	3 +	F	imm	partially full	2	70
Rainbow	172	59.7	2 +	M	imm	partially full	1	126
Rainbow	173	48.9	2 +	M	imm	partially full	0	56
Rainbow	173	53.0	2 +	M	imm	full	0	44
Rainbow	174	54.1	?	M	imm	all scales regenerated	?	32
Rainbow	174	56.3	2 +	M	mg	partially full	0	144
Rainbow	174	57.3	3 +	M	imm	full	3	146
Rainbow	174	57.3	3 +	F	imm	empty	1	68
Rainbow	175	58.1	2 +	F	imm	half full	0	135
Rainbow	175	58.4	3 +	F	imm	partially full	2	140
Rainbow	176	50.9	3 +	M	imm	half full	3	97
Rainbow	176	58.8	2 +	M	imm	half full	1	152
Rainbow	178	61.4	2 +	M	imm	near full	0	69
Rainbow	179	57.1	3 +	F	imm	half full	2	49
Rainbow	179	59.8	2 +	F	imm	full	0	151
Rainbow	180	57.6	2 +	M	imm	half full	0	131
Rainbow	181	67.1	2 +	M	imm	half full	2	113
Rainbow	183	65.4	2 +	M	imm	empty	0	43
Rainbow	183	67.5	2 +	F	imm	full	0	29
Rainbow	185	66.6	2 +	M	mg	full	1	63
Rainbow	186	67.3	2 +	F	imm	empty	0	136
Rainbow	186	71.6	3 +	F	imm	full	2	48
Rainbow	186	72.7	2 +	M	imm	empty	2	114
Rainbow	187	64.9	2 +	F	imm	full	2	115
Rainbow	187	65.4	3 +	F	imm	half full	1	27
Rainbow	191	70.1	3 +	M	imm	partially full	3	118
Rainbow	191	73.1	2 +	F	imm	partially full	0	67
Rainbow	192	73.2	2 +	M	imm	empty	0	145
Rainbow	192	77.3	2 +	M	imm	full	2	109
Rainbow	194	73.9	2 +	F	imm	half full	0	57
Rainbow	194	76.9	3 +	M	imm	full	1	55
Rainbow	196	87.7	2 +	M	imm	half full	2	120
Rainbow	197	82.6	2 +	M	mg	full	0	61
Rainbow	198	91.3	2 +	M	imm	empty	0	58
Rainbow	202	97.2	2 +	M	mg	half full	1	36
Rainbow	205	92.5	3 +	M	imm	half full	3	112
Rainbow	210	94.4	3 +	F	imm	empty	1	143
Rainbow	211	97.0	3 +	M	mg	partially full	1	60
Rainbow	211	98.2	3 +	F	imm	half full	1	31
Rainbow	228	128.7	3 +	M	mg	empty	1	26
Rainbow	262	186.5	3 +	F	mat	partially full	0	19

(cont'd)

Gill Netting Fish Capture Data

Sinking Net

Klept Lake

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	265	232	3 +	F	mat	empty	1	16
Rainbow	266	202	3 +	F	mat	empty	1	23
Rainbow	272	200.0	4 +	F	ripe	many eggs atrophying	2	137
Rainbow	277	232	3 +	F	mat	empty	1	20
Rainbow	279	232	3 +	M	imm	empty	1	24
Rainbow	282	236	3 +	M	mg	partially full	1	17
Rainbow	284	230	3 +	F	mat	empty	1	150
Rainbow	304	308	4 +	M	s 4 (kelt)	empty	2	15
Rainbow	305	282	4 +	F	ripe	most eggs atrophying	1	21
Rainbow	306	286	3 +	M	imm	full	1	53
Rainbow	307	280	4 +	F	ripe	partially full	2	18
Rainbow	333	324	4 +	F	mat	empty	2	6
Rainbow	338	342	4 +	F	s 4 (kelt)	partially full	0	13
Rainbow	339	362	4 +	F	ripe	some eggs atrophying	1	14
Rainbow	345	370	4 +	M	s 4 (kelt)	empty	1	12
Rainbow	358	352	4 +	M	s 4 (kelt)	near empty	2	7
Rainbow	362	432	4 +	M	s 4 (kelt)	empty	2	10
Rainbow	367	494	5 +	F	s 4,5 (kelt)	empty	1	2
Rainbow	375	418	4 +	M	mg	empty	2	8
Rainbow	376	490	4 +	F	mat	empty	3	4
Rainbow	377	386	4 +	F	s 4 (kelt)	empty	2	11
Rainbow	378	494	4 +	M	s 4 (kelt)	empty	2	25
Rainbow	379	456	5 +	M	s 5 (kelt)	empty	2	22
Rainbow	383	438	4 +	M	s 3, 4 (kelt)	empty	1	3
Rainbow	390	544	4 +	M	s 3, 4 (kelt)	empty	0	9
Rainbow	392	460	4 +	F	mat	empty	3	5

Gill Netting Fish Capture Data

Sinking Net (dry; periodic sun; breezy)

Kha Lake

Set: 15:45 hrs. October 18, 1995
 Retrieved: 11:15 hrs. October 19, 1995

Shallow End: 0.4 m
 Deep End: 4.1 m

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	107	11.9	1 +	?	imm	empty	1	29
Rainbow	107	14.1	1 +	M	imm	half full	0	64
Rainbow	108	13.6	1 +	M	imm	full	0	56
Rainbow	112	15.2	1 +	?	imm	half full	0	68
Rainbow	113	15.4	1 +	F	imm	empty	1	44
Rainbow	113	16.3	1 +	F	imm	full	1	57
Rainbow	116	16.8	1 +	?	imm	empty	0	52
Rainbow	117	17.6	1 +	M	imm	empty	1	49
Rainbow	123	20.0	2 +	M	imm	empty	2	60
Rainbow	123	21.0	1 +	M	imm	half full	1	65
Rainbow	124	20.4	1 +	F	imm	empty	0	48
Rainbow	124	21.8	1 +	M	imm	half full	0	24
Rainbow	125	19.2	1 +	M	imm	partially full	1	45
Rainbow	125	20.0	2 +	?	imm	empty	2	28
Rainbow	128	21.4	2 +	F	imm	full	2	67
Rainbow	128	23.4	2 +	F	imm	empty	2	61
Rainbow	131	26.5	2 +	M	imm	full	2	51
Rainbow	138	27.1	2 +	M	imm	half full	1	46
Rainbow	140	30.4	2 +	M	imm	full	1	47
Rainbow	141	28.5	1 +	M	imm	empty	0	17
Rainbow	142	29.3	2 +	M	imm	empty	0	53
Rainbow	143	31.4	2 +	F	imm	half full	2	50
Rainbow	146	31.6	2 +	F	imm	full	1	66
Rainbow	149	34.1	2 +	M	imm	full	2	23
Rainbow	154	39.2	2 +	M	imm	half full	2	62
Rainbow	157	41.4	2 +	F	imm	empty	1	20
Rainbow	159	45.7	2 +	F	imm	empty	2	19
Rainbow	162	46.6	2 +	M	imm	partially full	1	59
Rainbow	163	51.5	2 +	F	imm	empty	1	63
Rainbow	164	45.3	2 +	M	imm	full	0	54
Rainbow	164	47.6	2 +	F	imm	full	1	15
Rainbow	164	50.3	2 +	M	imm	half full	1	14
Rainbow	164	50.7	2 +	F	imm	partially full	1	21
Rainbow	165	49.2	2 +	M	imm	full	1	25
Rainbow	166	48.0	2 +	M	imm	partially full	1	22
Rainbow	166	49.8	2 +	F	imm	full	1	55
Rainbow	168	52.7	2 +	M	mg	full	1	42
Rainbow	171	51.0	2 +	F	imm	half full	1	18
Rainbow	171	53.4	2 +	M	imm	full	0	27
Rainbow	171	54.0	2 +	M	imm	full	1	16

* principal gut contents: mayfly, caddis and stonefly larvae, other benthos, and surface insects

(cont'd)

Gill Netting Fish Capture Data

Sinking Net

Kha Lake

Species	Fork Length (mm)	Weight (g)	Age	Sex	Status of Reproductive Development	Degree of Gut Contents and Comments	Age at Lake Entry	Scale Sample No.
Rainbow	173	51.5	2 +	F	imm	near empty	1	12
Rainbow	175	61.5	2 +	F	imm	half full	0	26
Rainbow	176	59.5	3 +	F	imm	full	2	3
Rainbow	176	60.1	2 +	F	imm	full	1	4
Rainbow	176	60.2	2 +	F	imm	half full	1	13
Rainbow	180	64.2	2 +	F	imm	empty	0	58
Rainbow	185	64.3	3 +	M	imm	full	2	5
Rainbow	191	77.9	3 +	M	imm	partially full	2	9
Rainbow	191	80.5	3 +	M	imm	half full	2	2
Rainbow	196	86.0	3 +	M	mg	half full	2	11
Rainbow	197	83.0	3 +	M	mat	full	2	6
Rainbow	215	103.9	3 +	M	mg	empty	3	8
Rainbow	218	114.4	3 +	F	mat	full	2	10
Rainbow	225	120.6	3 +	F	imm	full	2	7
Rainbow	245	166.1	3 +	M	s 3	half full	2	1
Rainbow	260	170.3	3 +	F	s 3 (kelt)	empty	1	69
Rainbow	275	177.5	3 +	M	mg	full	2	43
Rainbow	279	176.0	3 +	F	imm	near empty	1	41
Rainbow	280	208	3 +	F	s 3	resid. eggs in body cavity	1	40
Rainbow	285	234	3 +	M	s 3 (kelt)	empty	1	35
Rainbow	297	284	4 +	M	s 4 (kelt)	empty	1	30
Rainbow	304	282	3 +	M	mat	empty	1	39
Rainbow	309	270	3 +	F	mat	empty	2	36
Rainbow	315	260	4 +	M	s 4	partially full	1	38
Rainbow	317	322	4 +	M	s 4 (kelt)	half full	2	31
Rainbow	341	334	4 +	M	s 4 (kelt)	empty	1	33
Rainbow	354	426	4 +	M	s 4 (kelt)	near empty	1	34
Rainbow	357	438	5 +	M	s 4, 5 (kelt)	empty	3	32
Rainbow	361	376	4 +	F	s 4	half full	1	37

Appendix 8.

Identification of char specimens captured in the Kwoiek Creek drainage in 1995, following the meristic analyses specified by Haas and McPhail (1991).

identification of char from the Kwoiek Creek drainage, based on the linear discriminant function (LDF) formula given by Haas and McPhail (1991); LDF < 0 = Dolly Varden (*Salvelinus malma*); > 0 = bull trout (*S. confluentus*).

$$\text{LDF} = (0.629 \times \text{branchiostegal ray number}) + (0.178 \times \text{anal fin ray number}) + (37.310 \times \text{upper jaw length / standard length}) - 21.8$$

Specimens captured in Kwoiek Lake :

Fork Length (mm)	Standard Length (mm)	Age (by otolith)	Number of Anal Fin Rays	Upper Jaw Length (mm)		Number of Branchiostegals	LDF Value	Species
				Left	Right			
712	642	10+ *	12	117	113	26	3.37	Bull Trout
665	605	8+	13	96	96	25	2.16	Bull Trout
659	587	8+	12	84	85	26	2.06	Bull Trout
358	322	6+ *	12	47	47	25	1.51	Bull Trout
352	317	6+	12	45	44	27	2.56	Bull Trout
246	217	4+	12	30.5	31	25	1.35	Bull Trout
203	179	3+	12	24.5	25	26	1.85	Bull Trout
187	168	3+	11	23	23	25	0.99	Bull Trout

* otoliths not clear; aging aided by scale analyses

Specimens captured in Kwoiek Creek :

Fork Length (mm)	Standard Length (mm)	Age (by otolith)	Number of Anal Fin Rays	Upper Jaw Length (mm)		Number of Branchiostegals	LDF Value	Species
				Left	Right			
108	98	1+	11	12.5	12	25	0.55	Bull Trout
104	94	1+	11	12.5	13	26	1.57	Bull Trout
103	92	1+	11	12	12	26	1.38	Bull Trout
101	90	1+	10	12.5	13	26	1.62	Bull Trout
100	89	1+	11	12	12	25	0.91	Bull Trout
100	89	1+	12	12	12	25	1.09	Bull Trout
93	84	1+	10	11	11	26	1.22	Bull Trout
61	54	0+	? *	6	6	27	-	Bull Trout

* fin damaged during preservation; identification based on other criteria

Appendix 9.

Length, weight, and condition statistics for fish captured at electrofishing sites in streams within the Kwojek Creek drainage, October 1995.

Summary of fork length statistics from fish captured at electrofishing sites in the Kwoiek Creek drainage, October 1995.

Source of Fish	Length Statistic	Rainbow Trout				Bull Trout		Coho
		Age 0+	Age 1+	Age 2+	Age 3+	Age 0+	Age 2+	Age 0+
Entire capture	Mean (mm)	49.3	94.4	132.3	176.1	56.0	100.3	70.3
	Min. (mm)	31	67	118	147	45	93	67
	Max. (mm)	74	131	147	213	62	108	72
	S.D. (mm)	10.9	13.3	8.1	19.3	5.3	4.8	2.4
	<i>n</i>	152	103	27	17	10	8	3
<hr/>								
Kwoiek Creek mainstem All mainstem sites	Mean (mm)	49.3	94.2	132.2	170.5	56.0	100.3	70.3
	Min. (mm)	31	74	118	147	45	93	67
	Max. (mm)	74	131	147	195	62	108	72
	S.D. (mm)	10.9	11.9	8.4	16.9	5.3	4.8	2.4
	<i>n</i>	151	96	25	13	10	8	3
Downstream of Kwoiek Lake	Mean (mm)	55.2	96.2	129.5	174.0	60	103	70.3
	Min. (mm)	41	74	118	152	60	103	67
	Max. (mm)	71	131	141	195	60	103	72
	S.D. (mm)	6.6	13.1	8.3	17.3	0.0	0.0	2.4
	<i>n</i>	53	34	14	5	1	1	3
Kwoiek Lake to Kokwaskey Lake	Mean (mm)	52.3	95.2	136.1	168.3	55.6	99.9	-
	Min. (mm)	35	74	120	147	45	93	-
	Max. (mm)	74	114	147	193	62	108	-
	S.D. (mm)	9.8	11.2	7.4	16.2	5.4	5.1	-
	<i>n</i>	41	38	10	8	9	7	-
Upstream of Kokwaskey Lake	Mean (mm)	42.0	89.8	131	-	-	-	-
	Min. (mm)	31	74	131	-	-	-	-
	Max. (mm)	73	111	131	-	-	-	-
	S.D. (mm)	10.6	10.0	0.0	-	-	-	-
	<i>n</i>	58	24	1	-	-	-	-
<hr/>								
Tributary streams All sites in tributaries	Mean (mm)	38	97.6	133.0	194.5	-	-	-
	Min. (mm)	38	67	131	173	-	-	-
	Max. (mm)	38	125	135	213	-	-	-
	S.D. (mm)	0.0	25.4	2.0	14.8	-	-	-
	<i>n</i>	1	7	2	4	-	-	-

Summary of body weight statistics from fish captured at electrofishing sites in the Kwoiek Creek drainage, October 1995.

Source of Fish	Weight Statistic	Rainbow Trout				Bull Trout		Coho
		Age 0+	Age 1+	Age 2+	Age 3+	Age 0+	Age 2+	Age 0+
Entire capture	Mean (g)	1.47	9.53	24.03	63.75	1.67	8.85	4.47
	Min. (g)	0.3	3.7	15.7	35.3	0.9	6.9	4.0
	Max. (g)	4.2	25.1	29.4	125.9	2.1	10.5	5.1
	S.D. (g)	0.98	4.18	4.22	25.00	0.41	1.14	0.46
	<i>n</i>	152	103	27	17	10	8	3
Kwoiek Creek mainstem All mainstem sites	Mean (g)	1.47	9.34	23.98	53.64	1.67	8.85	4.47
	Min. (g)	0.3	3.7	15.7	35.3	0.9	6.9	4.0
	Max. (g)	4.2	25.1	29.4	77.9	2.1	10.5	5.1
	S.D. (g)	0.98	3.75	4.37	14.42	0.41	1.14	0.46
	<i>n</i>	151	96	25	13	10	8	3
Downstream of Kwoiek Lake	Mean (g)	1.87	10.14	23.28	55.34	2.1	9.4	4.47
	Min. (g)	0.7	4.3	15.7	36.7	2.1	9.4	4.0
	Max. (g)	4.1	25.1	29.4	77.9	2.1	9.4	5.1
	S.D. (g)	0.70	4.46	4.78	15.93	0.0	0.0	0.46
	<i>n</i>	53	34	14	5	1	1	3
Kwoiek Lake to Kokwaskey Lake	Mean (g)	1.68	9.31	24.92	52.58	1.62	8.77	-
	Min. (g)	0.4	3.7	16.3	35.3	0.9	6.9	-
	Max. (g)	4.1	16.4	29.3	69.0	2.1	10.5	-
	S.D. (g)	0.88	3.38	3.76	13.29	0.40	1.20	-
	<i>n</i>	41	38	10	8	9	7	-
Upstream of Kokwaskey Lake	Mean (g)	0.98	8.25	24.5	-	-	-	-
	Min. (g)	0.3	4.6	24.5	-	-	-	-
	Max. (g)	4.2	15.6	24.5	-	-	-	-
	S.D. (g)	1.04	2.79	0.0	-	-	-	-
	<i>n</i>	58	24	1	-	-	-	-
Tributary streams All sites in tributaries	Mean (g)	0.6	12.13	24.65	96.63	-	-	-
	Min. (g)	0.6	3.7	23.7	62.1	-	-	-
	Max. (g)	0.6	21.5	25.6	125.9	-	-	-
	S.D. (g)	0.0	7.54	0.95	23.75	-	-	-
	<i>n</i>	1	7	2	4	-	-	-

Summary of fish condition statistics from captures at electrofishing sites in the Kwoiek Creek drainage, October 1995.

Source of Fish	Condition Factor ¹ ($\times 10^{-5}$)	Rainbow Trout				Bull Trout		Coho Age 0+
		Age 0+	Age 1+	Age 2+	Age 3+	Age 0+	Age 2+	
In-stream capture	Mean	1.05	1.07	1.03	1.12	0.94	0.88	1.28
	Min.	0.70	0.88	0.87	0.85	0.77	0.83	1.15
	Max.	1.63	1.38	1.13	1.32	1.13	0.97	1.37
	S.D.	0.12	0.09	0.07	0.14	0.12	0.04	0.09
	<i>n</i>	152	103	27	17	10	8	3
Kwoiek Creek mainstem All mainstem sites	Mean	1.05	1.07	1.03	1.07	0.94	0.88	1.28
	Min.	0.70	0.88	0.87	0.85	0.77	0.83	1.15
	Max.	1.63	1.38	1.13	1.25	1.13	0.97	1.37
	S.D.	0.13	0.09	0.08	0.12	0.12	0.04	0.09
	<i>n</i>	151	96	25	13	10	8	3
Downstream of Kwoiek Lake	Mean	1.06	1.08	1.06	1.03	0.97	0.86	1.28
	Min.	0.83	0.96	0.96	0.90	0.97	0.86	1.15
	Max.	1.27	1.24	1.11	1.15	0.97	0.86	1.37
	S.D.	0.10	0.06	0.04	0.09	0.00	0.00	0.09
	<i>n</i>	53	34	14	5	1	1	3
Kwoiek Lake to Kokwaskey Lake	Mean	1.06	1.03	0.99	1.09	0.94	0.88	—
	Min.	0.73	0.88	0.87	0.85	0.77	0.83	—
	Max.	1.28	1.21	1.13	1.25	1.13	0.97	—
	S.D.	0.13	0.09	0.09	0.13	0.12	0.05	—
	<i>n</i>	41	38	10	8	9	7	—
Upstream of Kokwaskey Lake	Mean	1.04	1.11	1.09	—	—	—	—
	Min.	0.70	0.96	1.09	—	—	—	—
	Max.	1.63	1.38	1.09	—	—	—	—
	S.D.	0.14	0.11	0.00	—	—	—	—
	<i>n</i>	58	24	1	—	—	—	—
Tributary streams All sites in tributaries	Mean	1.09	1.13	1.05	1.28	—	—	—
	Min.	1.09	0.98	1.04	1.20	—	—	—
	Max.	1.09	1.28	1.05	1.32	—	—	—
	S.D.	0.00	0.10	0.01	0.05	—	—	—
	<i>n</i>	1	7	2	4	—	—	—

¹ Condition factor, k , in : $Weight_g = k (Fork\ Length_{mm}^3)$