Upper Bulkley River Overwintering Study
1998-2000
Interim Report

prepared by

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EXECUTIVE SUMMARY

This interim report summarizes data collected in the initial year of the upper Bulkley overwintering study, which is proposed to continue for one additional year. The study area is located primarily in the upper Bulkley watershed, upstream of the confluence of the Morice and Bulkley rivers near Houston, B.C.. Additional sites were also sampled at Toboggan Creek (near Smithers, B.C.) and Mission Creek (near Hazelton B.C.). The upper Bulkley overwintering study was initiated in November 1998, and sampling continued to the end of April 1999 for the first year of the study.

The study focused on establishing good indicators of overwintering habitat quality, and determining physical and biological factors, which may influence overwintering habitat quality. Catch per unit effort and adjusted Petersen estimates were determined for each sample site. Due to a relatively low ratio of recaptures, adjusted Petersen estimates had a large confidence intervals, and comparisons of adjusted Petersen estimates, fish density and biomass should be viewed with caution. In addition, violations of the assumptions of mark-recaptured estimates further reduce the accuracy of adjusted Petersen estimates for many of the sites sampled. Adjusted Petersen estimates were converted to measures of fish density and biomass for sites where surface area had been recorded prior to freeze up. Weight data were collected throughout the winter, and fork length was recorded for fish captured when ambient temperature had increased to above freezing. Measures of species diversity and richness were determined from the data collected.

Species captured during the overwintering study included coho, chinook, rainbow trout/steelhead, cutthroat trout, Dolly Varden, burbot and longnose dace. Dolly Varden were only captured at Toboggan Creek and Mission Creek, while chinook were only captured in the Upper Bulkley River and its tributaries. Sites exhibited some variability in measures of species abundance and density over time and between sites. Mean weight appeared to be relatively similar for species among sites and over time, although a slight decrease in mean weight was observed for some species (e.g. coho). Species richness and diversity were relatively low for all sites, with one species dominating catches at most sites.

Surface area and depth of overwintering sites appeared to have little effect on species abundance, species richness or diversity. A minimum size and depth of surface area is likely a factor in determining suitable overwintering habitat, but sites examined during this study appeared to be sufficiently large to support fish throughout the winter. Fish abundance appeared to decrease at the upper limit of surface area and depth included among the sites sampled. This may be due to a lower proportion of the surface area being utilized by salmonids, and/or decreased capture efficiency at greater surface area and depth. Low water temperatures appear to limit suitability of overwintering habitat, as no salmonids were recorded in temperatures below -0.5°C. However, moderate water temperatures (0 - 3°C) appear to have little influence on fish abundance, mean weight, or species diversity. Sites with LWD tended to have greater fish abundance than sites without LWD. This trend was also observed for coho, but was not statistically significant. Ice thickness and snow thickness appeared to have little influences on fish abundance, weight, and diversity, but these factors may influence other physical parameters which may limit habitat suitability (e.g. oxygen concentrations, water depths, useable area of the site).

In addition to data found in the initial year of the study, other parameters that may influences overwintering habitat suitability and quality are suggested. Recommendations for the continuation of the study are given.

ACKNOWLEDGMENTS

The Upper Bulkley River Overwintering study was funded by Fisheries Renewal B.C., which has proven to be an invaluable catalyst in bringing community groups together. Brenda Donas (Department of Fisheries and Oceans) designed the project. Barry Finnegan's and Greg Bonnell's assistance in the design of the project was invaluable. Field sampling was conducted by Trace Joe, Cory Koenig, Tracey De La Mare and Jim De La Mare. Data was entered by Brenda Donas, Cory Koenig and Regina Saimoto. Regina Saimoto (SKR Consultants Ltd.) conducted data analysis and reporting. Dave Bustard and Scott McKay provided useful references for the literature review portion of the report. Ron Saimoto (SKR Consultants Ltd.) and Brenda Donas provided helpful editorial comments on the report.

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1.0 INTRODUCTION

The Bulkley River is a major tributary to the Skeena River, located in north-central British Columbia. The Bulkley River drains into the Skeena River near the village of Hazelton, B.C.. The upper Bulkley River is defined as the portion of the Bulkley River upstream of the Morice River confluence, near Houston, B.C..

The upper Bulkley River drainage is characterized by a variety of land use activities, namely forestry, mining, agriculture and urbanization. In conjunction with these landuse activities and resultant habitat degradation, exploitation of salmonids in the Skeena River and Pacific Ocean have contributed to a decline in salmonid abundance in the watershed. However, no limiting factors for salmonid production in the upper Bulkley system have been conclusively identified. The quality and quantity of suitable overwintering habitat has been identified as one potential limiting factor for salmonid, and particularly coho production in the upper Bulkley River system.

The main objectives of the upper Bulkley overwintering study are to:

- determine changes in species abundance and densities during the winter,
- document changes in weight, length and condition of species at sites examined,
- document changes in species diversity and assemblages at sample sites,
- identify potential factors which may determine overwintering habitat quality,
- examine results of this overwintering study in the context of other studies conducted in the watershed,
- identify potential restoration or habitat enhancement techniques that may improve overwintering habitat quality and/or quantity, and
- present results in a format suitable for use in public education and awareness.

The interim report summarizes the results of the overwintering study from November 1998 to April 1999. The objectives of the interim report are to:

- determine which indicators are feasible and suitable in determining overwintering habitat quality,
- identify potential physical and biological factors which influence overwintering habitat quality,
- present interim results graphically, using a large variety of graphs
- discuss interim results and study design, and
- provide options for future directions of the second year of the study.

2.0 MATERIALS AND METHODS

2.1 Site Selection

Sites were selected by Brenda Donas. All sites were selected in eight distinct sections of the drainage (Table 1, Figure 1). The majority of sites were located in portions of the upper Bulkley drainage that is known to be accessible to salmonids, particularly coho. In addition

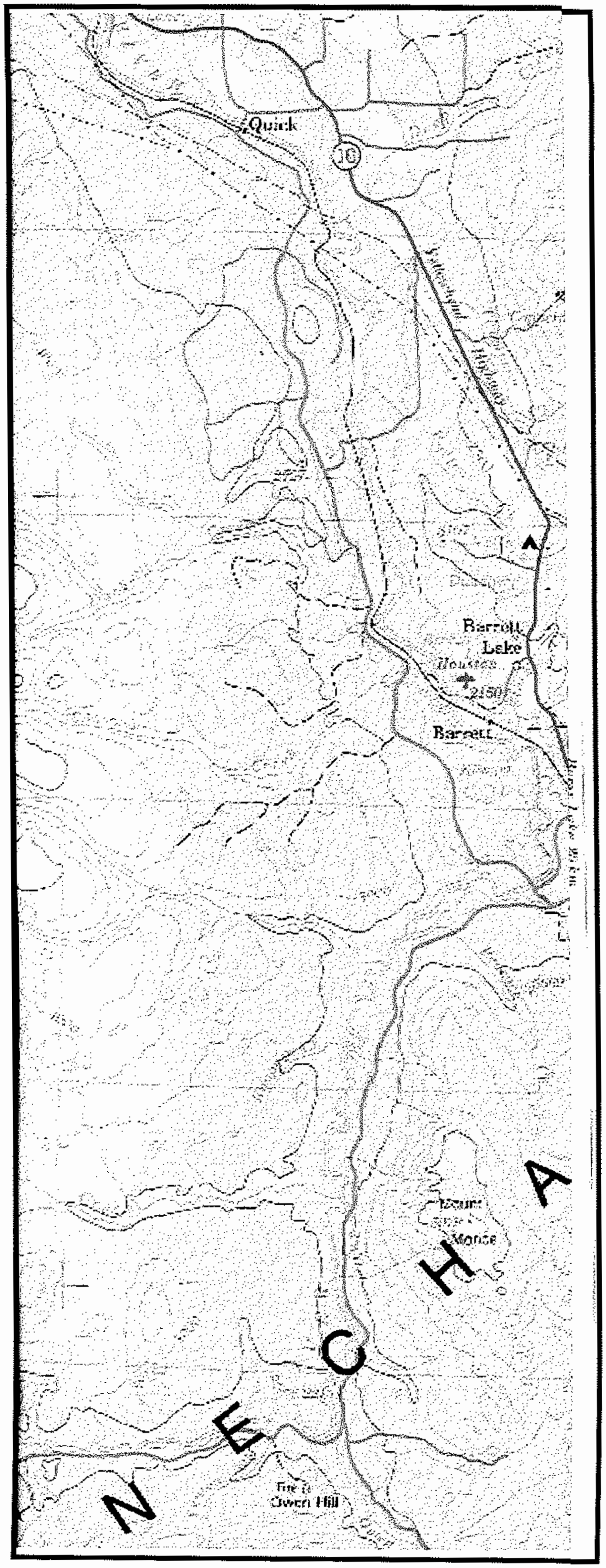


Figure 1.

Locations
of sites sampled
in the

Upper Bulkley Watershed
during the
Upper Bulkley Overwintering Study

conducted

November 1998
to
April 1999

(Mission and Toboggan creek sites
are not shown on the map)

Sample Sites

Ba	1-3	Barren Creek
Bu	1-6	Buck Creek
By	1-2	Byman Creek
Q	1	Mc Quarrie Creek
R	1- 4	Richfield Creek
UB	1-8	Upper Bulkley River

1:200,000 Scale excerpt
from
1:250,000 Scale NTS Map 93L

Table 1. Site description and duration of sampling during the upper Bulkley River overwinter study, November 1998 – April 1999.

	Site #	Location (km are distances along FSR)[1]	Habitat	Surface Area	Sample Dates
Upper Bulkley River	UB 1	just downstream of Richfield Creek confluence	pool with LWD	117.8 m^2	Nov 98 – Apr 99
	UB 2	at confluence with Byman Creek	log jam	477.1 m^2	Nov 98 – Apr 99
	UB 3	near McQuarrie Creek confluence	pool with LWD	-	Nov 98 – Jan 99
	UB 4	downstream of McQuarrie Creek confluence	log jam	53.2 m^2	Nov 98 – Jan 99
	UB 5	just downstream of Barren Creek confluence	pool	2533.8 m^2	Nov 98 – Apr 99
	UB 6	downstream of Barren Creek	log jam	-	Nov 98 – Apr 99
	UB 7	just upstream of McKilligan Road Bridge	pool with LWD	97.8 m^2	Nov 98 – Jan 99
	UB 8	just downstream of McKilligan Road Bridge	LWD	10 m^2	Nov 98 – Apr 99
Richfield	R 1	downstream of CNR bridge (0.5 km u/s of mouth)	pool, no LWD	15.5 m^2	Nov 98 – Apr 99
	R 2	100 m downstream of R 1 (0.4 km u/s of mouth)	LWD	30.8 m^2	Nov 98 – Apr 99
	R 3	upstream of Highway 16 crossing	LWD	43.9 m^2	Nov 98 – Apr 99
	R 4	approximately 300 m downstream of R 3	pool, no LWD	60 m^2	Nov 98 – Apr 99
McQuarrie	Q 1	at highway 16 crossing	culvert pool	34.5 m^2	Nov 98 – Apr 99
Byman	By 1	approximately 0.5 km downstream of CNR crossing	pool, no LWD	14.9 – 34.7 m^2	Nov 98 – Apr 99
	By 2	approximately 300 m downstream of By 1	pool with LWD	19 – 22.2 m^2	Nov 98 – Apr 99
Barren	Ba 1	upstream side of Highway 16 crossing	culvert pool	23.3 – 34.7 m^2	Nov 98 – Apr 99
	Ba 2	about 0.5 km upstream of Highway 16 crossing	LWD	11.9 m^2	Nov 98 – Apr 99
	Ba 3	about 0.8 km upstream of Highway 16 crossing	LWD	21 m^2	Nov 98 – Apr 99
Buck	Bu 1	approximately 500 m upstream of mouth	LWD	-	Dec 98 – Mar 99
	Bu 2	upstream of Bu 1, near ball field	pool	-	Dec 98 – Mar 99
	Bu 3	just upstream of lower bridge on Buck Flats Road	LWD	-	Dec 98 – Mar 99
	Bu 4	under lower bridge on Buck Flats Road	pool	-	Dec 98 – Mar 99
	Bu 5	near confluence of Bob Creek	LWD	-	Dec 98 – Mar 99
	Bu 6	about 100 m upstream of Bob Creek	pool above beaver dam	-	Dec 98 – Mar 99
Mission	M 1	along CNR tracks at New Hazelton	beaver pond	-	Dec 98 – Mar 99
	M 2	just downstream of site M1	beaver pond	-	Jan 99 – Apr 99
	M 3	at old Esso bulk plant, ~ 0.5 km downstream M2	culvert pool	-	Jan 99 – Apr 99
	M 4	just downstream of west Highway 16 crossing (at heli pad)	culvert pool	-	Jan 99 – Apr 99
	M 4A	just upstream of site M3	pool	65.0 m^2	April 99
	M 5	along CNR tracks, 0.75 km below mill	channel @ CNR	-	Jan 99 – Feb 99
Tobog-gan	T 1	about 100 m downstream of Brandt Brook	pool with LWD	16-18.7 m^2	Jan 99 – Apr 99
	T 2	about 150 m downstream of Brandt Brook	pool with LWD	12.5 m^2	Jan 99 – Mar 99
	T 3	about 500 m upstream of Brandt Brook	pool with LWD	27.5 m^2	Jan 99 – Apr 99
	T 4	about 1 km upstream of Brandt Brook	pool, no LWD	51.1 m^2	Jan 99 – Apr 99

([1] also see Figure 1 for site locations; Mission and Toboggan Creek sites are not indicated on Figure 1) to these sites, four sites were chosen in Toboggan Creek (near Smithers) and six sites in Mission Creek (near Hazelton). Coho smolt emigration studies have been conducted in Toboggan Creek since the spring of 1995, and it was hoped that Toboggan Creek could be an index for coho smolt production. Within each of these drainages, sites representing a diversity of habitat were selected. All sample sites were located in pools or beaver dam ponds. Some of the sites offered cover from large woody debris while others did not (Table 1). In addition to habitat diversity, site accessibility during the winter was considered during site selection.

2.2 Sampling Methodology

All sampling was coordinated by Brenda Donas and conducted by the technical staff of the Department of Fisheries and Oceans and/or Nadina Community Futures. Sample sites were accessed monthly during the late fall, winter and early spring. Sites initially chosen were sampled at least once a month, but as the sampling season progressed, some sites were deleted, and others added (Table 1).

2.2.1 Physical Characteristics

Physical and chemical parameters were recorded for each sample site. Parameters examined, and equipment utilized are summarized in Table 2. Photographs were taken of each site.

Table 2. Physical parameters recorded in the field for each site sampled in the Morice River overwintering study.

Parameter	**Methods**
Date, Time	chronometer
Air temperature	alcohol thermometer
Water temperature	alcohol thermometer
ice and snow thickness	meter stick
water depth	meter stick
surface area	tape measure
Oxygen (dissolved)	Oxyguard Mark II

2.2.2 Fish Sampling

Fish sampling was conducted by setting three (occasionally four) minnow traps baited with roe at each of the sample sites during each sampling period. The minnow traps were left for 24 hours. Fish were recovered from the traps, identified to species, weighed and released back into the habitat. Fork lengths for individual fish was also recorded in the spring of 1999. Salmonids were marked using a caudal fin clip early in the study, and one other mark later in the study, to allow for two independent mark – recapture estimate of population size.

2.3 Data Analysis

Habitat quality was assessed using density, biomass and species composition present at each site sampled as indicators of quality. In theory, better habitat will support more fish, and different habitat types should support different species assemblages. In addition, density and biomass were compared to factors that may influence habitat quality.

2.3.1 Adjusted Petersen Estimates

The Bulkley River overwintering study included determination of population size using mark-recapture estimates. Two separate marks were applied at most sampled locations, one early in the season and one late in the season. For each of these mark-recapture estimates, marks were applied during initial capture, and marked fish were released. Upon sub-sequent sampling, fish were examined for marks, and returned to the sample site without application of additional marks. Due to the design of the mark-recapture experiment, the adjusted Petersen estimate was used to determine population size. This method is relatively unbiased (Ricker 1975, Bagenal 1978). The equation used to determined the adjusted Petersen estimate is given below (equation 1):

Equation 1: $$N^* = (M+1)\,(C+1) / (R+1)$$

where: N^* = adjusted Petersen estimate
M = number of marked fish
C = catch or sample taken for census
R = number of recaptured marks in the sample.

The validity of the mark-recapture population estimate relies on several assumptions, which must be met. Mark-recapture estimates require that:

- the population is closed (no emigration, immigration, births or deaths
- marked fish are in every way the same as unmarked fish
- marked fish do not loose their marks
- all marked fish are reported upon recapture, and
- either the marking or the re-capture sample is random, or that marked and unmarked fish mix randomly (Ricker 1975, Bagenal 1978).

Confidence intervals were determined by assuming a Poisson distribution of recaptures (r), and by determining the approximate confidence intervals of r from statistical tables (Ricker 1975). The estimated abundance of individual species was determined by multiplying the estimated number of fish at each site with the proportion of the species in the sample taken for census. This requires the additional assumption that the catchability of all species present is the same.

2.3.2 Condition Factor Analysis

Two types of condition factors were calculated for sampling dates where both length and weight of the fish were recorded. Fulton's condition factor (equation 3) is useful where growth is isometric, and/or if the fish to be compared are of approximately the same length. If growth is allometric, and fish to be compared are of different lengths, the allometric condition factor should be used (Ricker 1975, Bagenal 1978). Ricker (1975) gives a detailed explanation for determining the allometric condition factor by regressing length on weight (equation 4).

Equation 3: $K = 10^5 (w / l^3)$

where: K = Fulton's condition factor
w = weight (g)
l = length (mm)

Equation 4: $K' = (10^a)(100{,}000)$

where: K' = allometric condition factor
a is the y-intercept in equation 4a

Equation 4a: $\log_{10} w = b (\log_{10} l) + a$

where: w is the weight (g) of the fish
l is the length (mm) of the fish
b is the slope of the line, and
a is the y-intercept

2.3.3 Species Diversity and Species Richness

Species diversity was determined using the $\log_{10}$ Shannon index of diversity (Zar 1984) (equation 5). The number of potential categories (k) was chosen as the number of species captured among all sites (seven for this study).

Equation 5: $H' = -\Sigma\, p_i \log p_i$

where H' is the Shannon diversity index, and
p_i is the proportion of observations found in category i

Since the Shannon index is dependent on the number of potential categories (k) (Zar 1984), evenness was also calculated, as shown in equation 6.

Equation 6: $J' = H' / H'_{max}$

where J' is evenness
H' is the Shannon diversity index (equation 1)
H'_{max} is the maximum possible diversity calculated as $H'_{max} = \log k$

3.0 RESULTS

The results section of this report has been divided into two major sections. The first section explores the indicators of overwintering habitat quality, which could be derived from the data collected in the winter of 1998/1999. These include measures of fish abundance (catch per unit effort, population size, density), weight distribution and condition factor analysis, and species diversity and richness. The second section explores the different factors which may impact overwintering habitat quality, including habitat size, dissolved oxygen, temperature, cover, ice and snow thickness, among others.

3.1 Indicators of Overwintering Habitat Quality

In order to establish which overwintering sites are of higher quality, it is important to identify methods of comparing between overwintering habitats, and monitoring the overwintering habitat quality over time. Fish abundance and health can be used to indicate the suitability of overwintering habitat. Four potential indicators of overwintering habitat quality were considered:

1. fish density,
2. condition factor,
3. survival
4. species diversity and richness.

3.1.1 FISH ABUNDANCE

Fish abundance can be used as an indicator for overwintering habitat quality. If fish can move between overwintering habitats, and are capable of choosing the most suitable habitat, a higher density of fish would be expected in habitats of better quality. Conversely, if fish are unable to leave a less than optimum habitat, lower densities may result from increased mortality. Comparisons of abundance and density between overwintering habitats should indicate which habitats are more suitable, while comparisons of density over time within a habitat will indicate any deterioration in the habitat quality. Catch per unit effort, adjusted Petersen estimates, and density (by area and volume) were compared between sites and over time to indicate trends in fish abundance.

3.1.1.1 Catch Per Unit Effort

3.1.1.1.1 All Species Combined

Catch per unit effort at each of the sites can be used as an index of relative abundance. Catch per unit effort data is illustrated in Figure 2 for sites in the upper Bulkley watershed (upper Bulkley, Barren, Byman, Richfield and Buck sites), and in Figure 3 for Toboggan and Mission Creeks. Of the sites sampled Mission Creek had the highest catch per unit effort, with 18.33 fish per trap at sites M1 and M4 on January 28, 1999. Of the sites in the upper Bulkley watershed, site Ba 2 in Barren Creek had the highest catch per unit effort with 13.67 fish/trap on Feb. 5, 1999. Within each system, sites with LWD generally have a higher catch per unit effort than sites without LWD, although there are some exceptions. Some systems appear to have a consistently higher overall catch per unit effort than others do. Catch per unit effort in McQuarrie and Barren Creek appears to be higher than for sites sampled in the upper Bulkley River or Buck Creek. Catch per unit effort for Toboggan Creek did not appear to be unusually high, but was comparable to catch per unit effort for systems examined in the upper Bulkley watershed. Overall, variability among and between sites indicates that catch per unit effort may reflect varying overwintering habitat quality at different locations.

Trends in catch per unit effort over time are relatively consistent among sites. Most of the sites show relatively moderate fluctuations in catch per unit effort (e.g. Richfield, Byman, Barren, Buck Creeks, Upper Bulkley River sites UB1-7). Other sites show an increase in catch per unit effort early in the sampling season, followed by a rapid decrease and then stabilization of low catch per unit effort (e.g. Upper Bulkley River site UB8, McQuarrie Creek). Sites M1, M3 and M4 of Mission Creek exhibit a rapid decrease in catch per unit from the start of the sampling period in the system (January 1999), while site T3 of Toboggan Creeks shows a decrease and then an increase in catch per unit effort. Different trends in catch per unit effort among sites may be due to open population, deteriorating overwintering habitat quality, different catchabilities of fish over time or of different catchability of species.

The trends in catch per unit effort data may give some indications as to which sites are open or closed. The initial increase in catch per unit effort for many sites sampled in November and December 1998 indicates that migration between sites is possible early in the winter. This is not surprising since ice has not formed on many of the pools in November, and since the thickness of the ice has not closed off some of the pools at this time. Stabilization and/or decreases in catch per unit effort for most sites sampled following December 1998 is consistent with what would be expected for closed populations, however, these trends may also occur in open populations. Fluctuations in catch per unit effort at some sites (e.g. UB 1 of the Upper Bulkley River sites, R2 in Richfield Creek, Ba 2 in Barren Creek, T3 in Toboggan Creek, M2 in Mission Creek) may indicate that these populations are open. Increases in catch per unit effort at these sites may be random, or may be due to migration patterns of fish. The slight increase in catch per unit effort shown for most sites towards the spring of 1999 (March – April 1999) is due to migration or increased catchability of fish as water temperatures, and hence activity, increases.

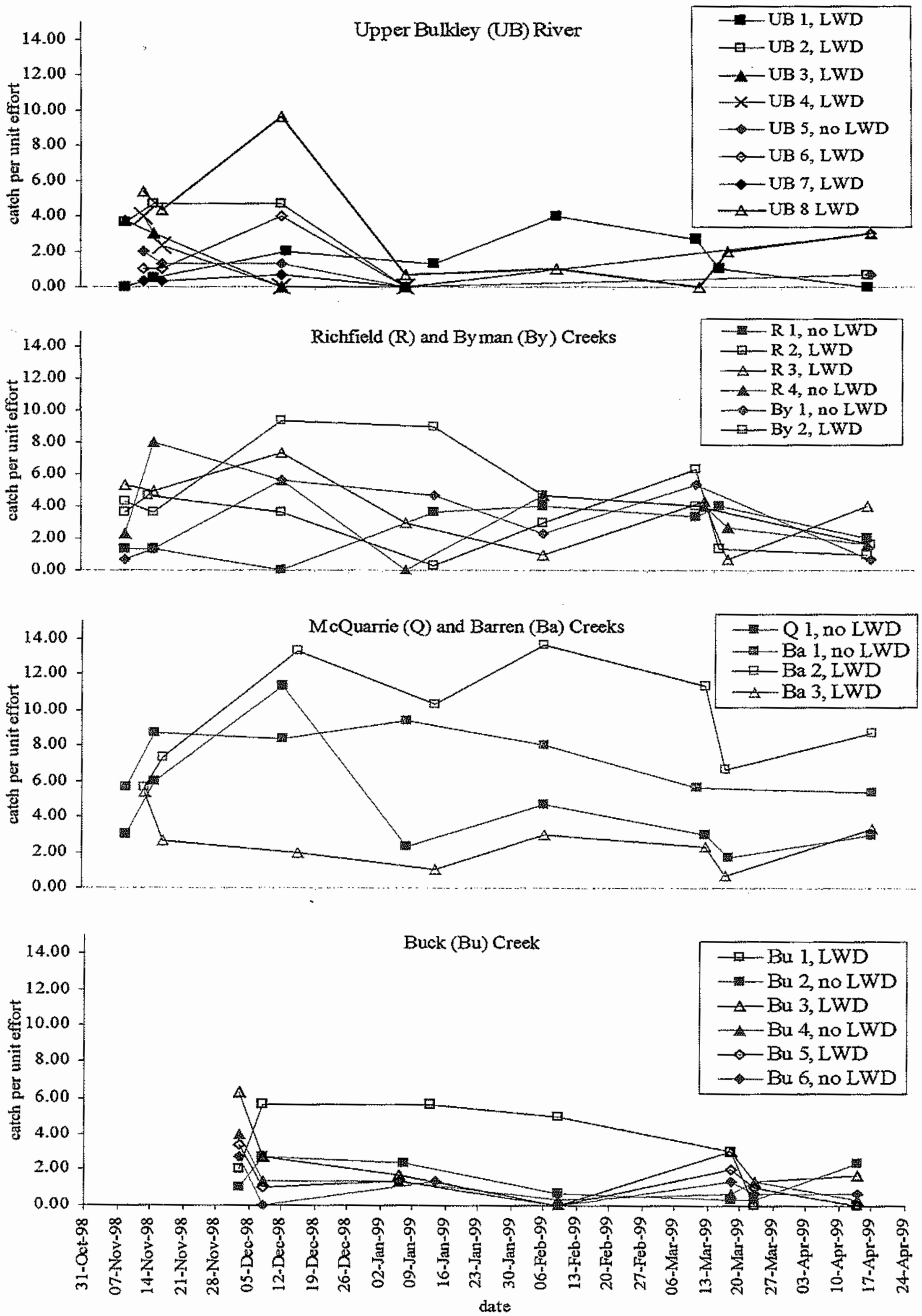


Figure 2. Catch per unit effort of all species for sites sampled in the upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

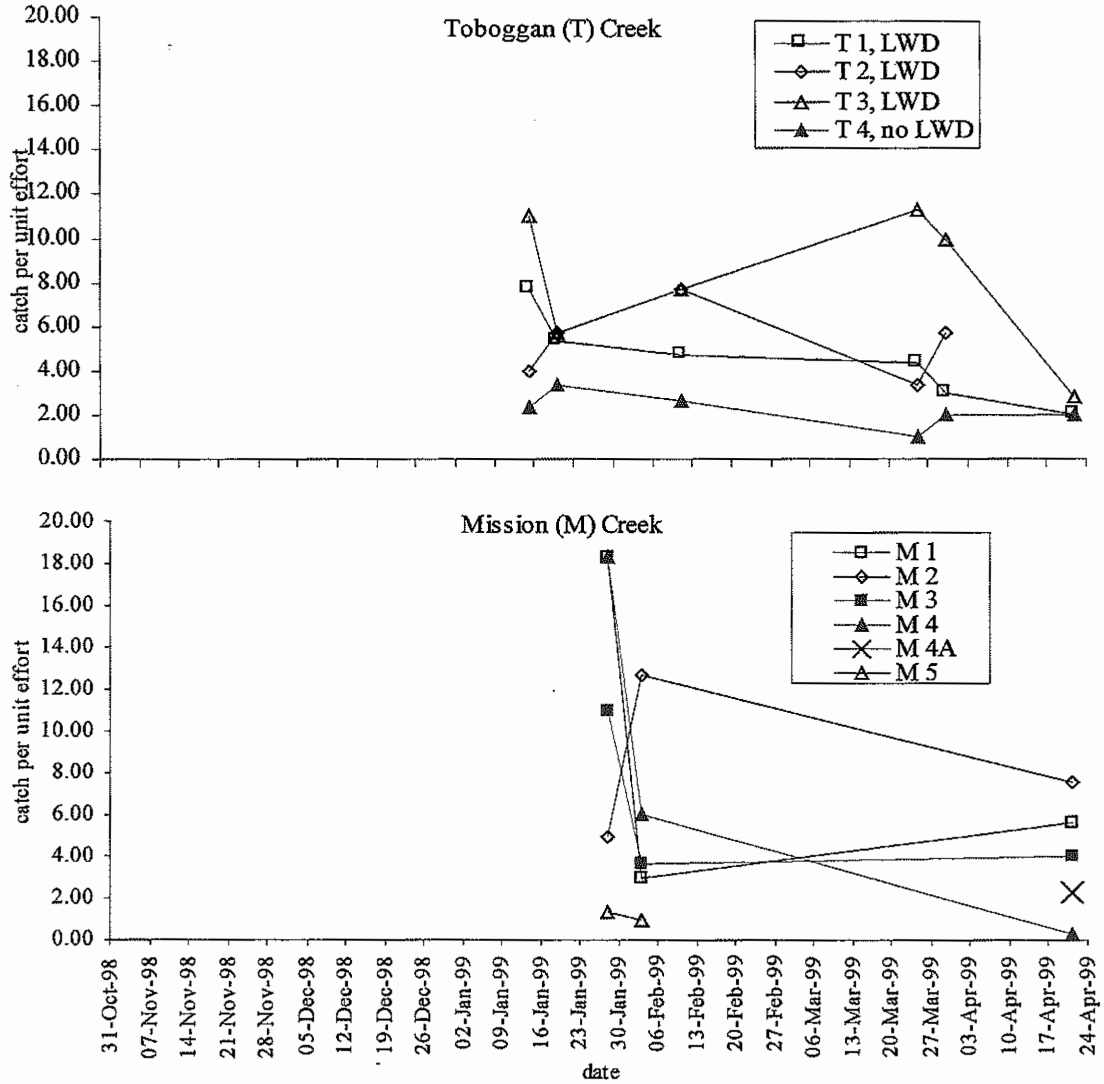


Figure 3. Catch per unit effort of all species for sites sampled in Toboggan and Mission Creeks. Black lines indicate sites with LWD and red lines indicate sites without LWD.

3.1.1.1.2 Coho

Catch per unit effort for the combined sample of fish are not a good reflection of coho abundance at the sites sampled. Other species may contribute a majority of the catch, and although overall catch per unit effort and fish density may be high, coho abundance may be low at some sites. Since the overwintering study focused on coho in particular, catch per unit effort analysis for coho was conducted for each of the sites sampled (Figures 4 and 5). Of the sites sampled in the upper Bulkley watershed, site UB 8 in the upper Bulkley River exhibited the highest catch per unit effort (8.67 coho/trap on Dec. 12, 1998). Capture rates of coho at this site were consistently higher than at other sites in the upper Bulkley River throughout the study, although catch per unit effort declined rapidly from the initial peak observed in December. The rapid decrease in catch per unit effort is primarily due to decreasing water levels in a pool at the site, resulting in high mortalities (Donas pers. comm.). Site Ba 2 in Barren Creek, which exhibited the highest overall catch per unit effort (Figure 2) had a relatively low catch per unit effort for coho (Figure 4). This is due to the large proportion of rainbow trout in the catch at site Ba 2. In addition, Mission Creek which had the highest overall catch per unit effort of all sites examined (Figures 2 and 3) had a very low catch per unit effort for coho (Figure 5). A large proportion of the catch at Mission Creek consisted of Dolly Varden. Also, the apparent dominance of fish in sites with LWD (Figures 2 and 3) is not as clear for coho alone. In Barren and Richfield Creeks, for example, sites without LWD had a higher catch per unit effort for coho than sites with LWD. Other confounding factors (e.g. pool size) may account for this difference in trends. It is interesting to note that Toboggan Creek exhibited a relatively high catch per unit effort for coho, but not for all fish combined. This substantiates the fact the Toboggan Creek is an important coho system. The differences in overall catch per unit effort and catch per unit effort for coho only is likely due to differences in habitat preference and competitive abilities for species present in the samples. Fluctuations in catch per unit effort of coho over time are similar to trends observed for all species combined at most sites. However, fluctuations in catch per unit effort of coho are more severe at some sites than the fluctuations observed for all species combined. At other sites, fluctuations in catch per unit effort for coho are less than those for all species combined. For exampled, catch per unit effort of coho appears to decrease over time in Buck Creek, particularly at sites Bu 1 and Bu 3, both of which offer cover from LWD. Coho catch per unit also generally decreases at sites UB 8, UB 5, R 3, R 4, Q 1 and T 1. In general, however, trends in coho catch per unit effort mirror those for catch per unit effort of all species at sites where coho were captured.

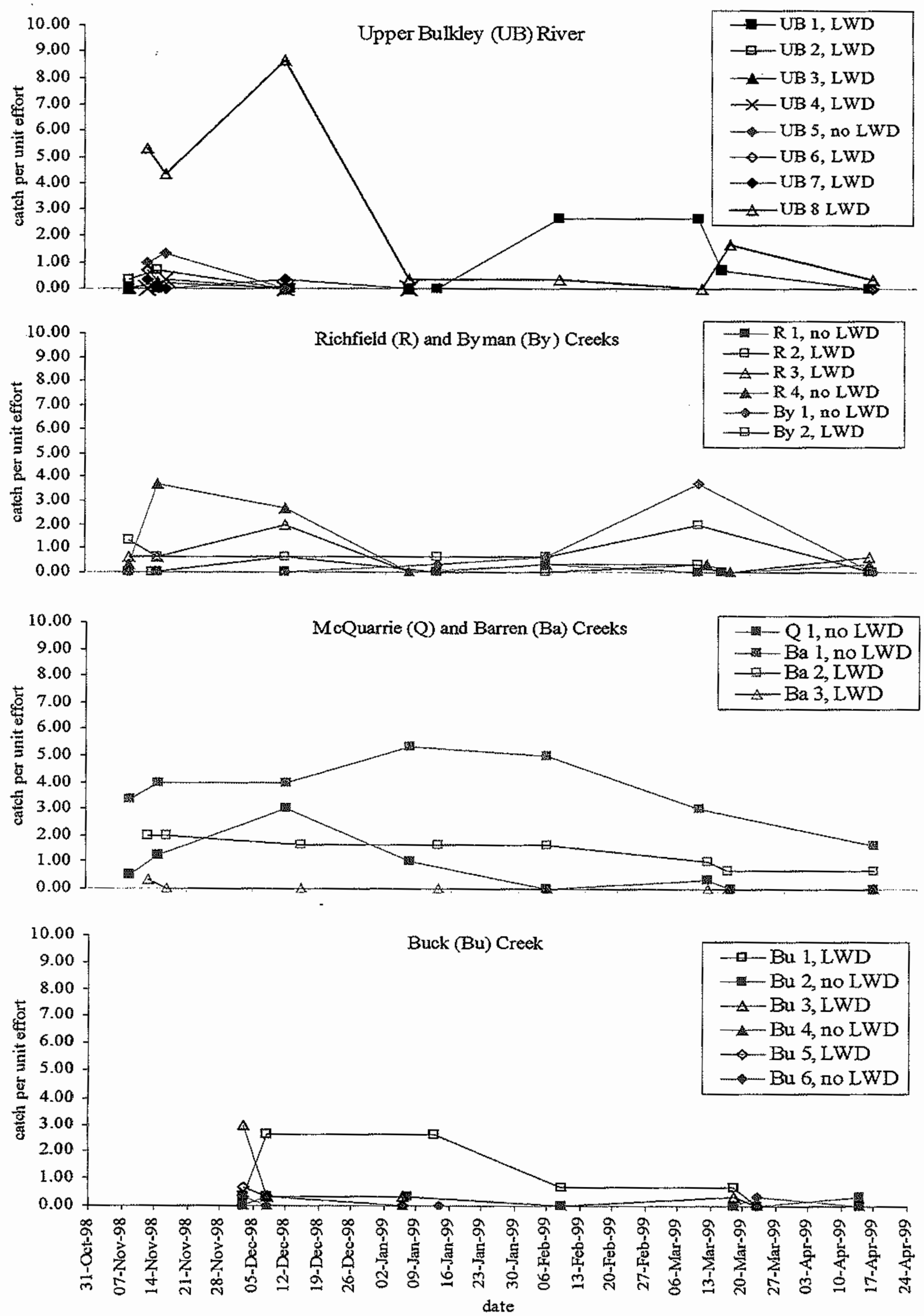


Figure 4. Coho catch per unit effort for sites sampled in the upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

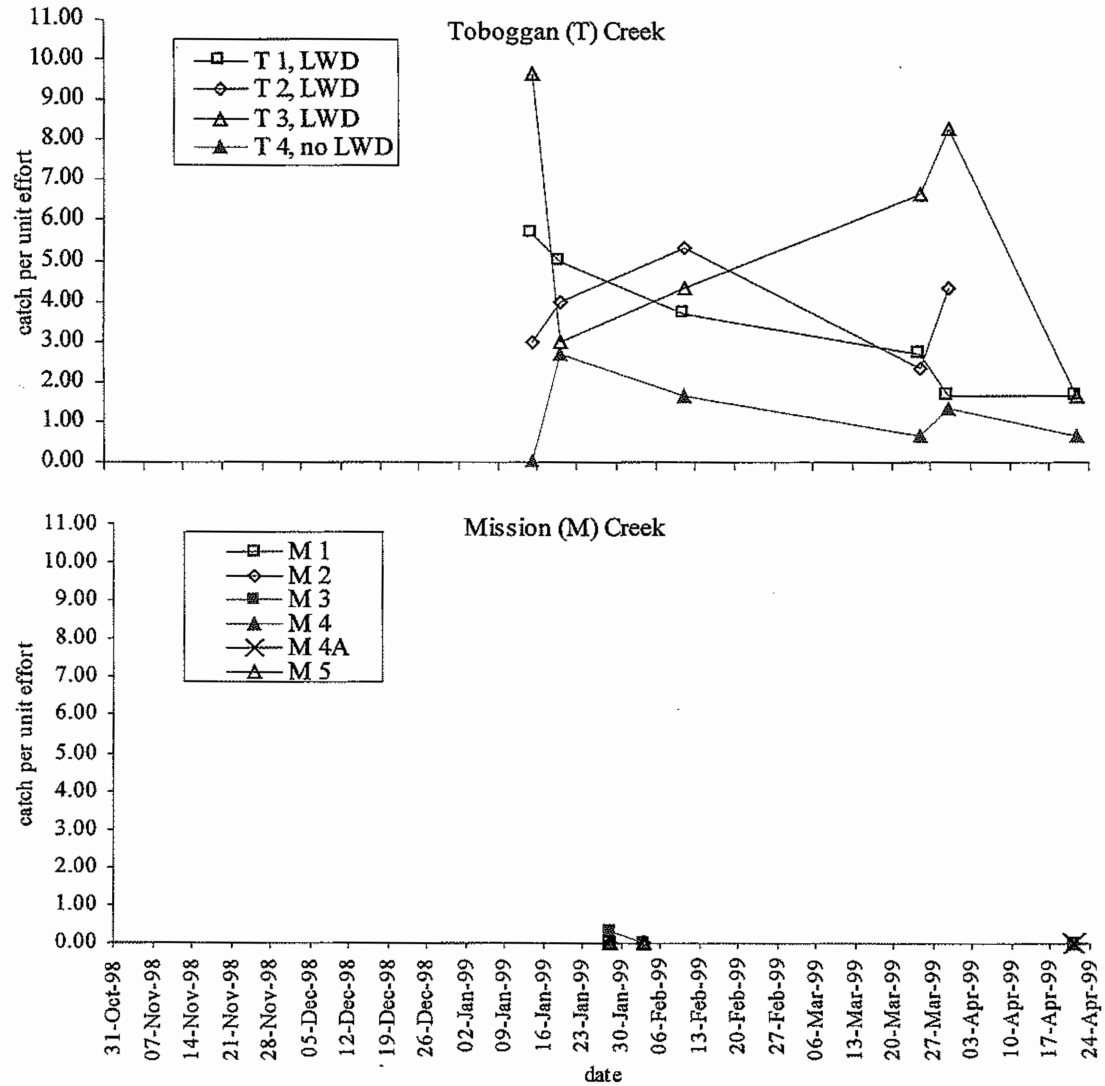


Figure 5. Coho catch per unit effort of coho for sites sampled in Toboggan and Mission Creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

3.1.1.2 Adjusted Petersen Population Estimates

3.1.1.2.1 All Species Combined

Adjusted Petersen estimates of population size using the initial mark and the second mark are illustrated in Figure 6 and 8 for the upper Bulkley watershed sites, and in Figures 7 and 9 for Toboggan and Mission Creeks. Adjusted Petersen estimates and confidence intervals are also summarized in Appendix 3. Of the sites sampled in the upper Bulkley watershed, the highest catch per unit effort was observed for site UB 8 on the Upper Bulkley River on December 12, 1998 ($N^* = 510$ fish). This peak in estimated population size coincides with a high catch per unit effort. The decrease in catch per unit effort and adjusted Petersen estimate from levels in December 1998 at site UB 8 is largely due to decreased water levels at a pool with very high fish densities, resulting in significant mortality (Donas, pers. comm). The adjusted Petersen estimate for site Bu 1 on Buck Creek was also relatively high on December 8, 1998 ($N^* = 432$ fish), and decreased gradually over the winter. Overall, the highest population estimate was obtained for site M1 in Mission Creek, with a Petersen estimate of 735 fish on April 21, 1999. As with catch per unit effort, the adjusted Petersen estimated appears to be higher for sites with LWD.

Temporal variations in population estimates are similar to those for catch per unit effort for some sites, but differ at other sites. Discrepancies between trends in Petersen estimates and catch per unit effort over time are likely due to violations of assumptions in the Petersen estimate, namely that of a closed population. Comparisons of trends in catch per unit effort and adjusted Petersen estimates over time may therefore give some indication to which sites are open to migration (Table 3). Of the sites examined in the upper Bulkley watershed, site BU 1 shows the greatest difference in trends between adjusted Petersen estimates and catch per unit effort. While catch per unit effort decreases somewhat over time at this site, indicating a constant number of fish, the adjusted Petersen estimate decreases rapidly over time. This trend may be due to a selective loss of unmarked fish, a gain in marked fish through migration of marked fish from other sites in the system, or different catchabilities of marked versus unmarked fish. Adjusted Petersen estimates are relatively stable at Toboggan Creek, while catch per unit effort exhibits some fluctuations. For example, catch per unit effort first decreases and then increases for site T3, while the adjusted Petersen estimate shows a slow decline. This is likely due to migration of unmarked fish to the site, and/or emigration of marked fish from the site. Comparisons of catch per unit effort data to adjusted Petersen estimate indicate that sites R 3, R 4, By 1, By 2, Bu 1, M 1, and M 2 were open to migration in the winter of 1998-1999. It is important to take into account that the measures of catch per unit effort and adjusted Petersen estimate are not independent of one another, as the number of fish caught is used in the calculation of the adjusted Petersen estimate. Therefore, sites exhibiting similar trends in catch per unit effort and adjusted Petersen estimates may not necessarily be closed to migration.

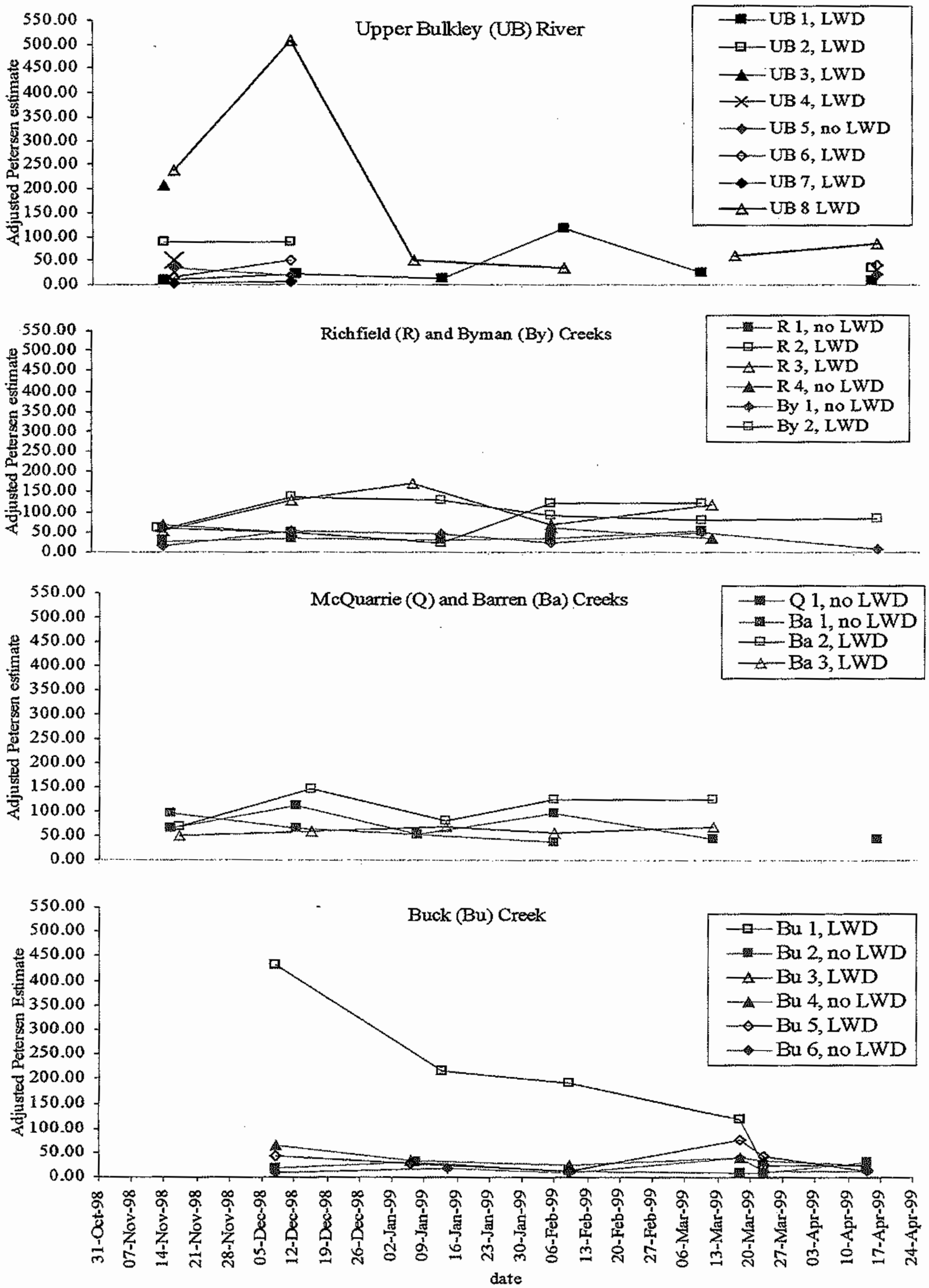


Figure 6. Adjusted Petersen estimates for all species using the initial mark for sites sampled in the upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD. Confidence intervals are given in Appendix 3.

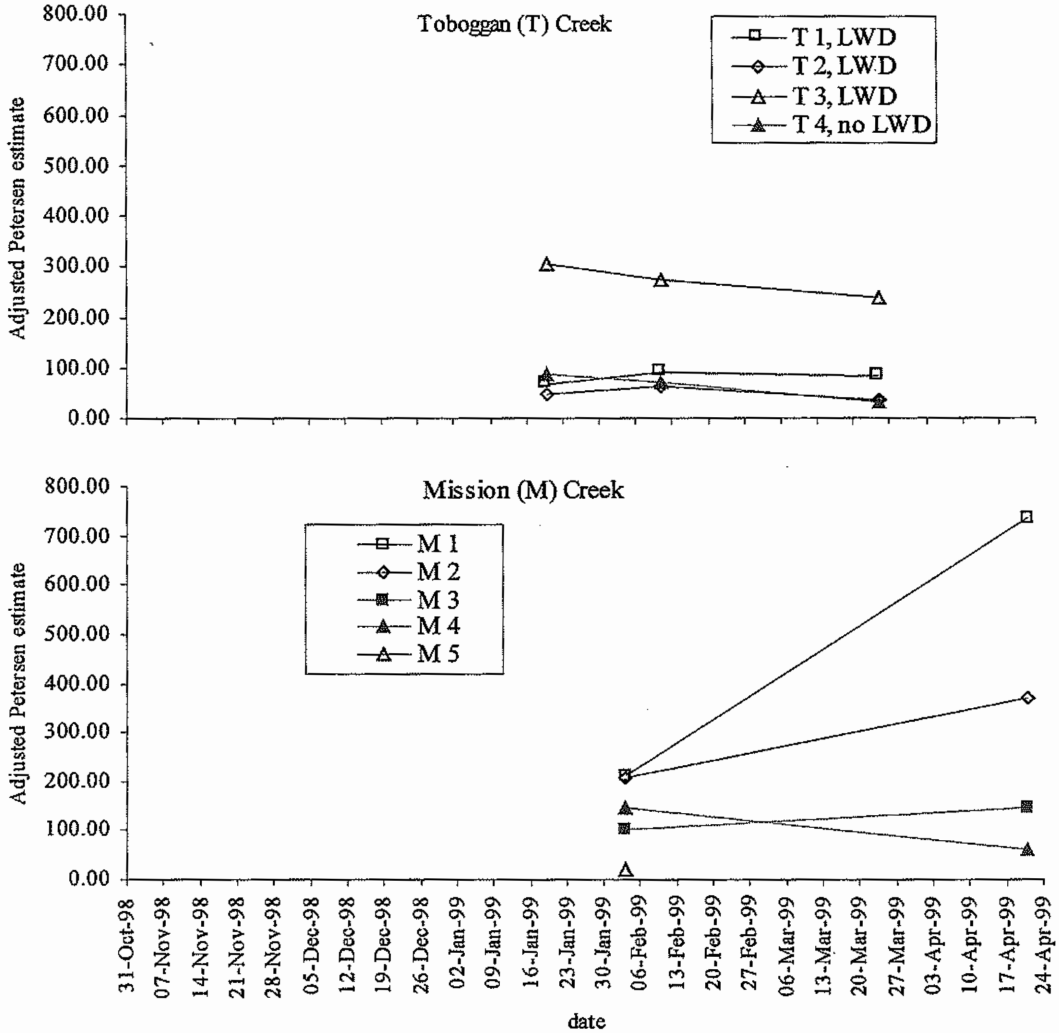


Figure 7. Adjusted Petersen estimates for all species using the initial mark for Toboggan and Mission creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD. Confidence intervals are given in Appendix 3.

Table 3. Comparisons in trends between adjusted Petersen estimates (N^*) and catch per unit effort (CPUE) to indicate which sites are open to migration.

Site	Trends in CPUE	Trends in N^*	Site open to migration?
UB 1	slight increase	slight increase	potentially open
UB 2	decrease	stable	open [1]
UB 3	decrease	only one data point	open [1]
UB 4	decrease	no data point	open [1]
UB 5	slight decrease, stable	stable	open [1]
UB 6	increase, then decrease	slight increase	open [1]
UB 7	stable	stable	open [1]
UB 8	increase, then decrease	increase, then decrease	closed
R 1	increase	slight increase	open [1]
R 2	decrease, then increase	slight increase	open [1]
R 3	decrease, then increase	slight increase, then decrease	open
R 4	decrease, then increase	slight increase	open
By 1	increase, then decrease	stable	open
By 2	increase, then decrease	stable	open
Q 1	increase, then decrease	increase, then decrease	open [1]
Ba 1	slight increase, gradual decrease	gradual decrease	open [1]
Ba 2	increase, then decrease	increase, gradual decrease	unknown
Ba 3	decrease, then stable	stable	unknown
Bu 1	increase, then slight decrease	decrease	open
Bu 2	stable	stable	unknown
Bu 3	stable	stable	probably closed[1]
Bu 4	decrease	slight decrease, then stable	probably closed[1]
Bu 5	stable, some decrease	some decrease, then increase	potentially open
Bu 6	slight decrease, then stable	stable	open [1]
T 1	slight decrease	slight increase, then stable	open [1]
T 2	increase, then decrease	stable	open [1]
T 3	decrease, increase, then decrease	slight decrease	open [1]
T 4	stable	slight decrease	open [1]
M 1	decrease, slight increase	increase	open [2]
M 2	increase, slight decrease	increase	open [2]
M 3	decrease, slight increase	slight increase	probably closed [1]
M 4	rapid decrease, gradual decrease	slight decrease	open [1]
M4A	one data point only	no data point	open [1]
M 5	slight decrease	no data point	open [1]

[1] sites are designated as open based on additional site information provided by Brenda Donas (e.g. flow between pools, fish of one mark recaptured in a different pool)
[2] Migration is possible between sites M1 and M2, but the two sites are closed from migration by beaver dams. These two sites should be combined into one site for the second year of the study.

The second adjusted Petersen estimate was conducted in the spring of 1999 by applying a second mark to fish captured. Comparisons of adjusted Petersen estimates with the initial mark to those with the second mark may be valuable in further identifying sites that are open to migration. However, re-captures of the initial population estimate were not recorded for all sites at which the second population estimate was conducted (e.g. sites in Richfield, Barren, Buck, Toboggan and Mission Creeks). In general, adjusted Petersen estimates for the initial and second marks are similar at the sites at which the second Petersen estimate was conducted (e.g. site UB 1). However, the adjusted Petersen estimate at site M1 on April 21, 1999 was 735 fish using the initial mark, and decreased to 175 fish on April 24, 1999 using the second mark. Although most sites experienced some decrease at this time in the sampling program, the rapid decrease in estimated population size at site M1 indicates that this site is open to migration. Due to the timing of the second Petersen estimate in early spring, as ice is melting and connection between pools is re-established, the second estimate cannot be used to indicate if pools are open or closed to migration during the winter.

3.1.1.2.2 Coho

Petersen estimates are based on a combination of all species captured at the site, and do not necessarily reflect the abundance of coho at the sites. A potential problem with the Petersen estimate is the fact that it assumes equal catchability of all species. Since different species behave differently (e.g. Bagenal 1973), and have different macro and microhabitat preferences, it is unlikely that different species exhibit equal catchability. To confound this problem, the estimated number of coho at each of the sites was determined by multiplying the adjusted Petersen estimate with the proportion of the catch that consisted of coho. The estimated number of coho at each site illustrated in Figures 10 and 11 should therefore by viewed with caution.

Of the sites at which coho were captured, site UB 8 exhibited the highest estimated number of coho (457 coho on Dec. 12, 98). This corresponds to a relatively high maximum density of coho, which exceeds the maximum density recorded for any other system, including Toboggan Creek. The high maximum salmonid and coho adjusted Petersen estimates and densities at site UB 8, which are all short lived, point to this site being a potential trap to overwintering salmonids. Coho abundance at most of the other sites in the upper Bulkley watershed appeared to be low. However, moderate coho abundance (203 coho) were also estimated at site Bu 1 on Dec. 8, 1998). For all months other than December, coho abundances in the upper Bulkley watershed appeared to be low. However, coho abundances were moderate for site T3 of Toboggan Creek, fluctuating around 160 coho for the majority of the sampling season (January – March 1999). Overall, coho densities at sites in Toboggan Creek (sites T1, T2, T3 and T4) appeared to be consistently higher than coho abundances in sites sampled in the upper Bulkley watershed.

The estimated number of coho at sites in Richfield, Byman, Barren and McQuarrie Creek is relatively low. Maximum fish densities at site UB 8 are considerably higher than fish densities at any other site. Since the estimated number of coho present at each site is determined by a combination of coho catch per unit effort and the adjusted Petersen estimate

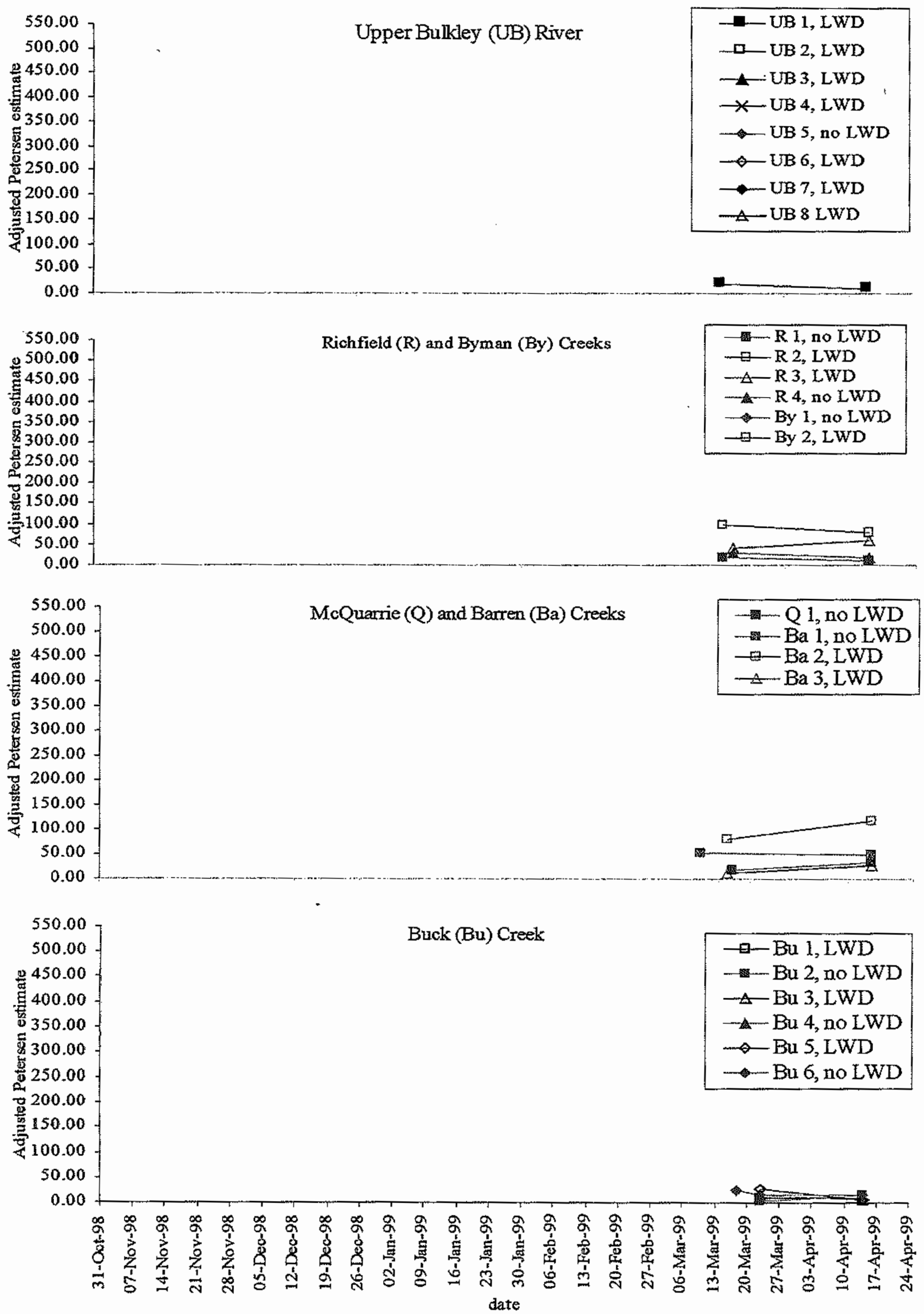


Figure 8. Adjusted Petersen estimates using the second mark for sites sampled in the upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD. Confidence intervals are given in Appendix 3.

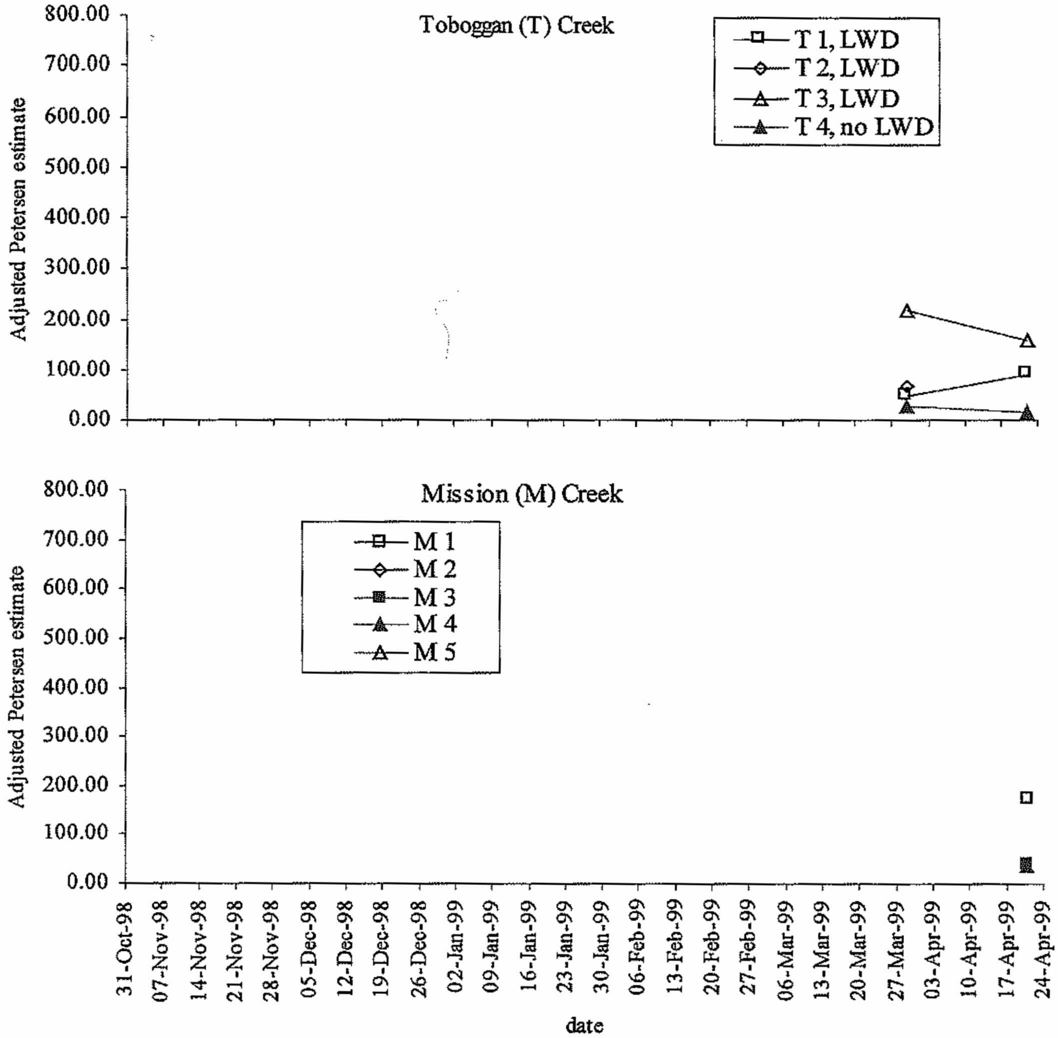


Figure 9. Adjusted Petersen estimate using the second mark for Toboggan and Mission creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD. Confidence intervals are given in Appendix 3.

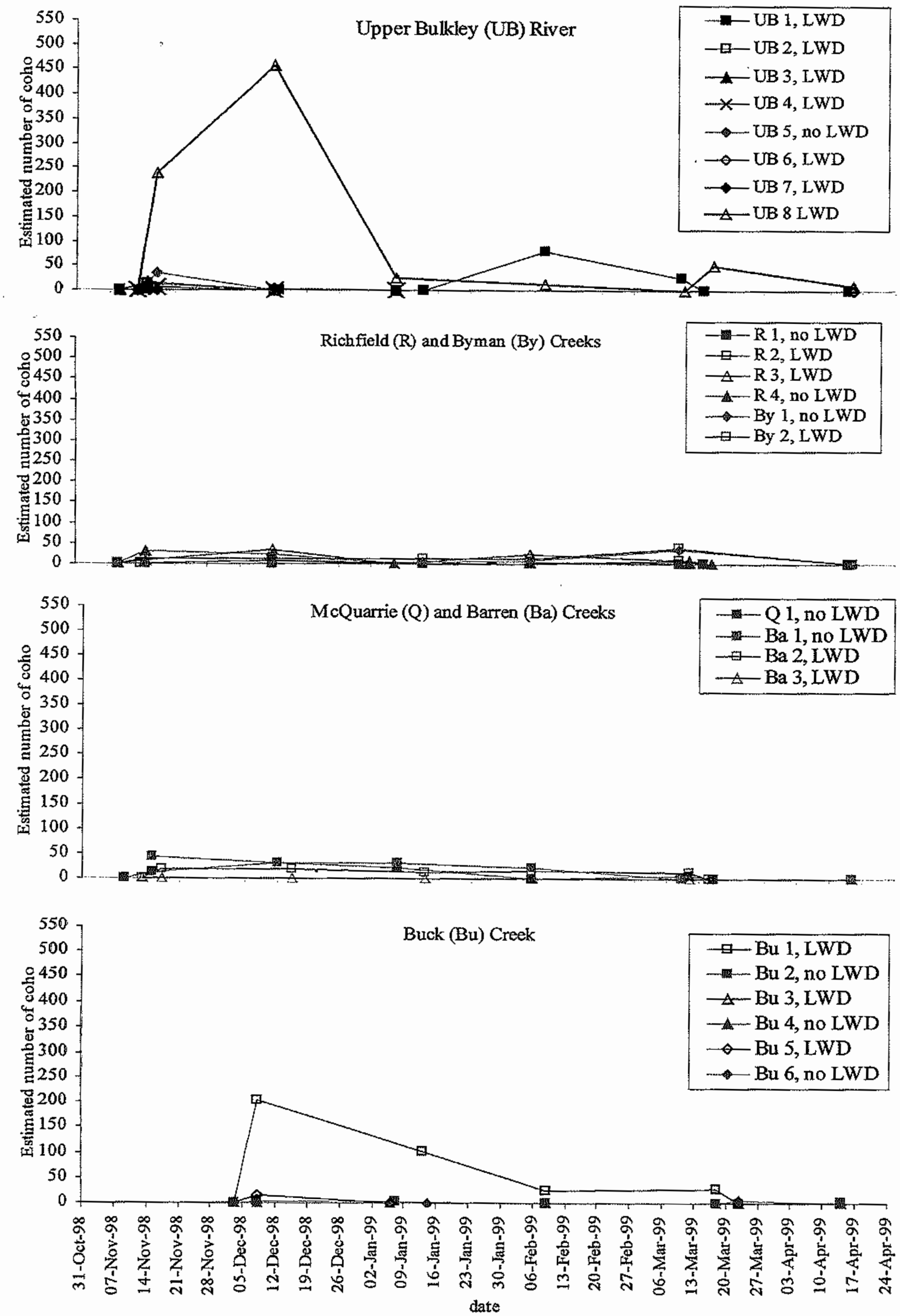


Figure 10. Estimated number of coho for the upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

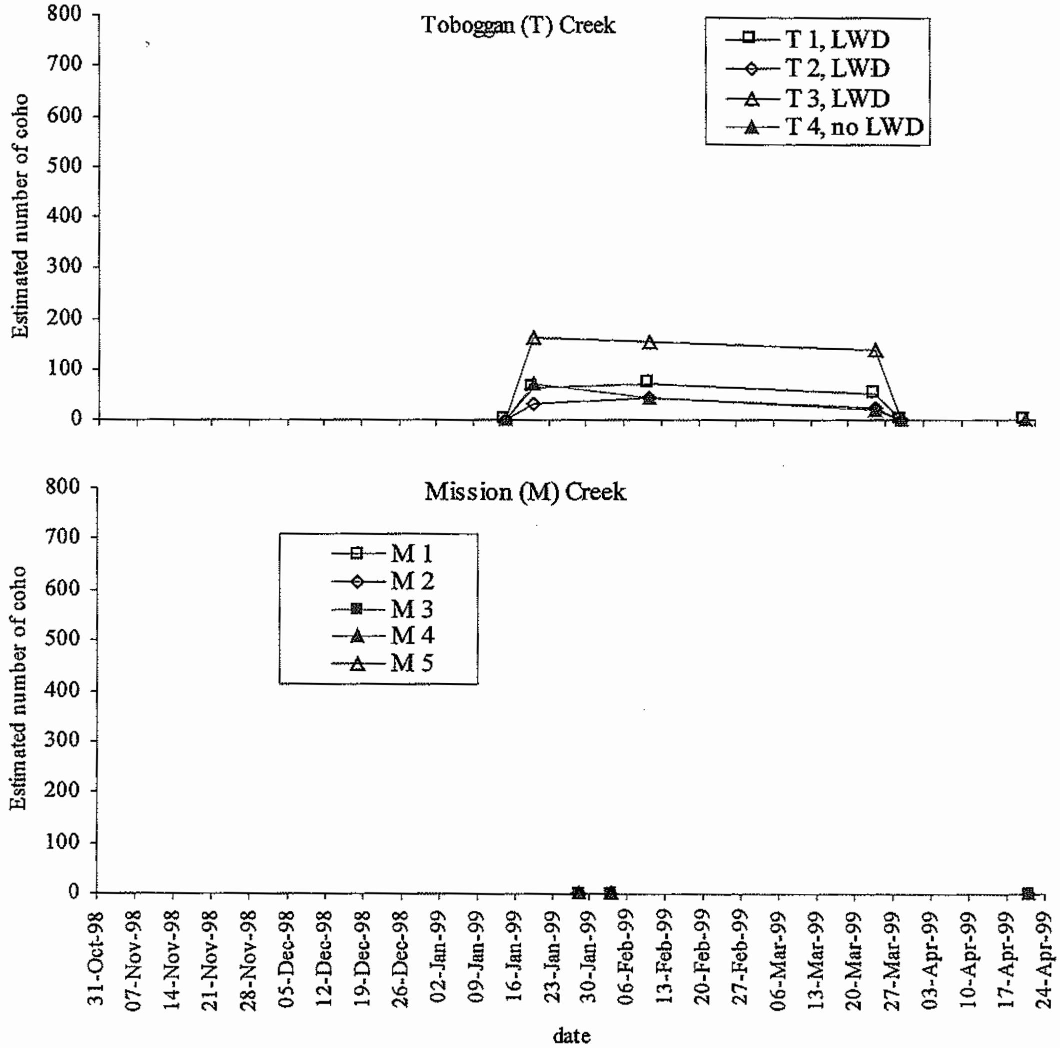


Figure 11. Estimated number of coho for Toboggan and Mission Creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

at each site, it is not surprising to find a close correlation between these three measures. Toboggan Creek is the only system where trends in coho catch per unit effort differs from trends in the estimated number of coho present at the sites. The fluctuations in coho catch per unit effort are substantial, while the estimated number of coho at the site is relatively consistent. Since overall catch per unit effort and the adjusted Petersen estimates in Toboggan Creek are relatively similar, differences for coho alone are likely due to a change in species composition, indicating that the site is open to migration.

3.1.1.3 Density

3.1.1.3.1 Overall Fish Density

The number of fish present at a site is not a direct indicator of fish density, since the sample sites differ in size. Densities in pools are usually expressed as the number of fish per unit area, but can also be expressed as the number of fish per unit volume. Densities were estimated for adjusted Petersen estimates of population size using the initial mark only, since only few sample points were present in the data collected for the second population estimate. The adjusted Petersen estimates illustrated in Figures 6 and 7 are easily converted to the number of fish per unit area (Figures 12 and 13) and per unit volume (Figures 14 and 15).

Density analysis could be conducted for sites in the Upper Bulkley River, Richfield Creek, Byman Creek, McQuarrie Creek, Barren Creek and Toboggan Creek. However, the analysis could not be completed for Buck Creek and Mission Creek since no surface area data was collected due to the timing of the samples. Measurements for the calculation of surface area for these sites will be taken prior to the completion of the study.

Comparisons of density estimates between sites indicates that site UB 8 has the highest overall fish density of all sites examined in the upper Bulkley watershed (Figure 12). The maximum density observed at this site was 51 fish/square meter on December 12, 1998. All other sites exhibit similar estimates in density, generally near 10 fish/square meter. Site UB 8 also has the highest density of fish per cubic meter, with an estimate of 48.1 fish/ cubic meter on December 12, 1998. However, site Ba 2 of Barren Creek also exhibits a relatively high density of fish per square meter and fish per cubic meter, with a maximum of 34.16 fish/m^3 on Feb. 5, 1999. Fish densities at Barren Creek site Ba 2 are consistently higher than at other sites in Barren Creek, and all sites for which density analysis could be completed in the upper Bulkley watershed, except site UB 8. The number of fish per cubic meter is generally higher than the number of fish per square meter, since many of the pool depths averaged less than 1 m in deep. Toboggan Creek also exhibits are relatively large number of fish per cubic meter, with an estimated 25 fish per cubic meter at site T3 on Jan. 20, 1999. Overall, densities are higher at sites with LWD than at sites without LWD. Trends in the estimated density of fish per unit surface area versus unit volume are similar, but the different units of estimating densities may yield different interpretation as to which site offers more productive overwintering habitat.

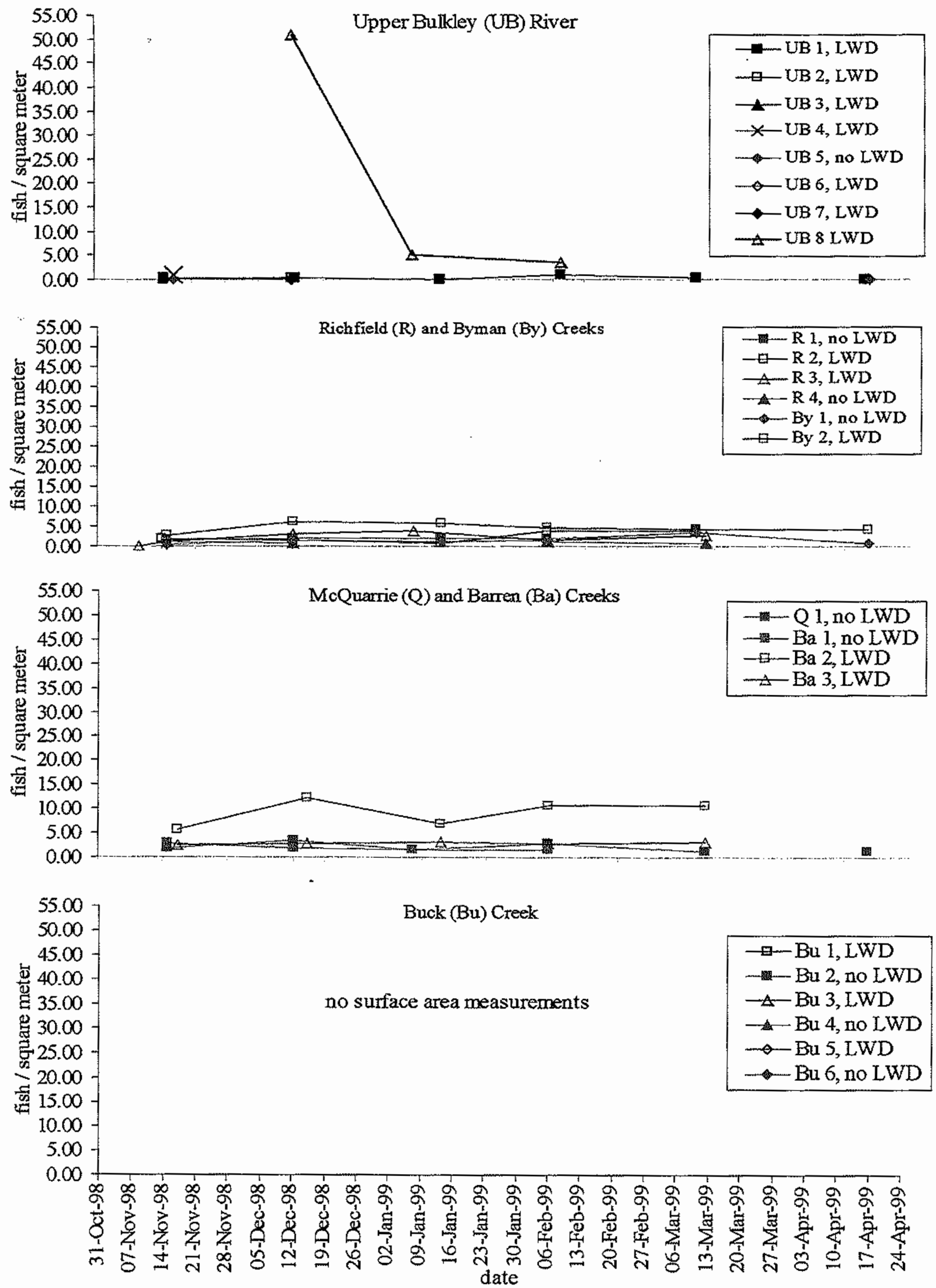


Figure 12. Estimated number of fish per square meter at sites sampled in the upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

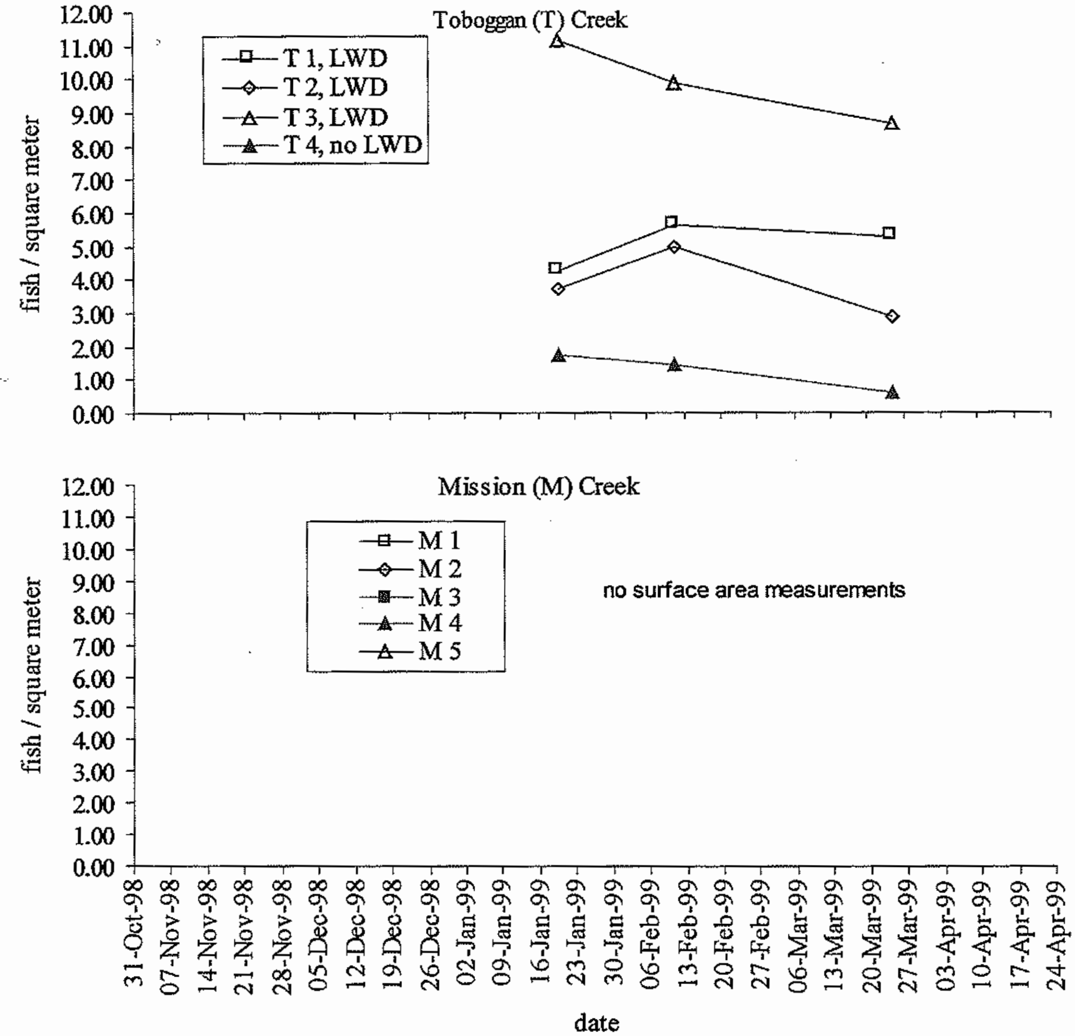


Figure 13. Estimated number of fish per square meter at sites sampled in Toboggan and Mission Creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

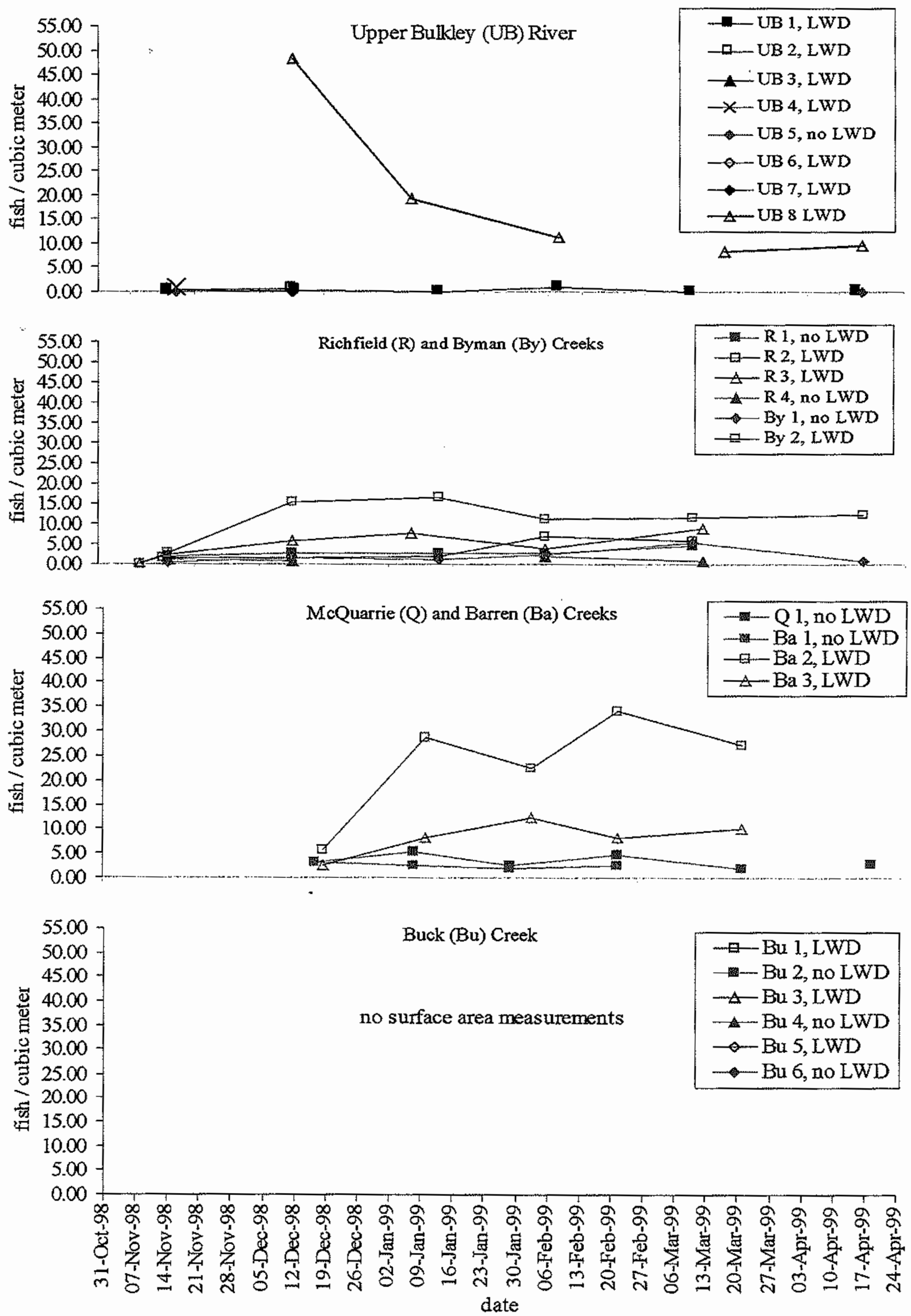


Figure 14. Estimated number of fish per cubic meter at sites sampled in the upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

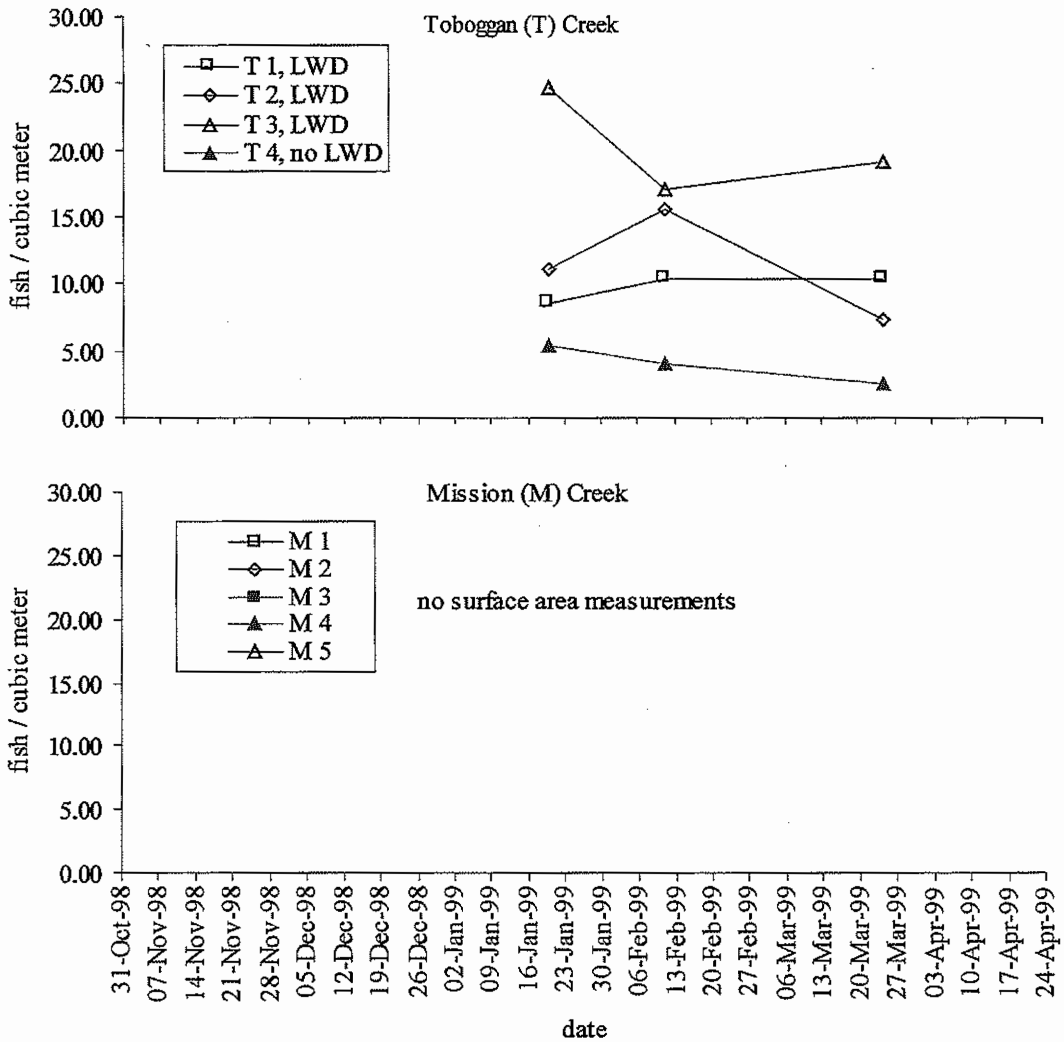


Figure 15. Estimated number of fish per cubic meter at sites sampled in Toboggan and Mission Creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

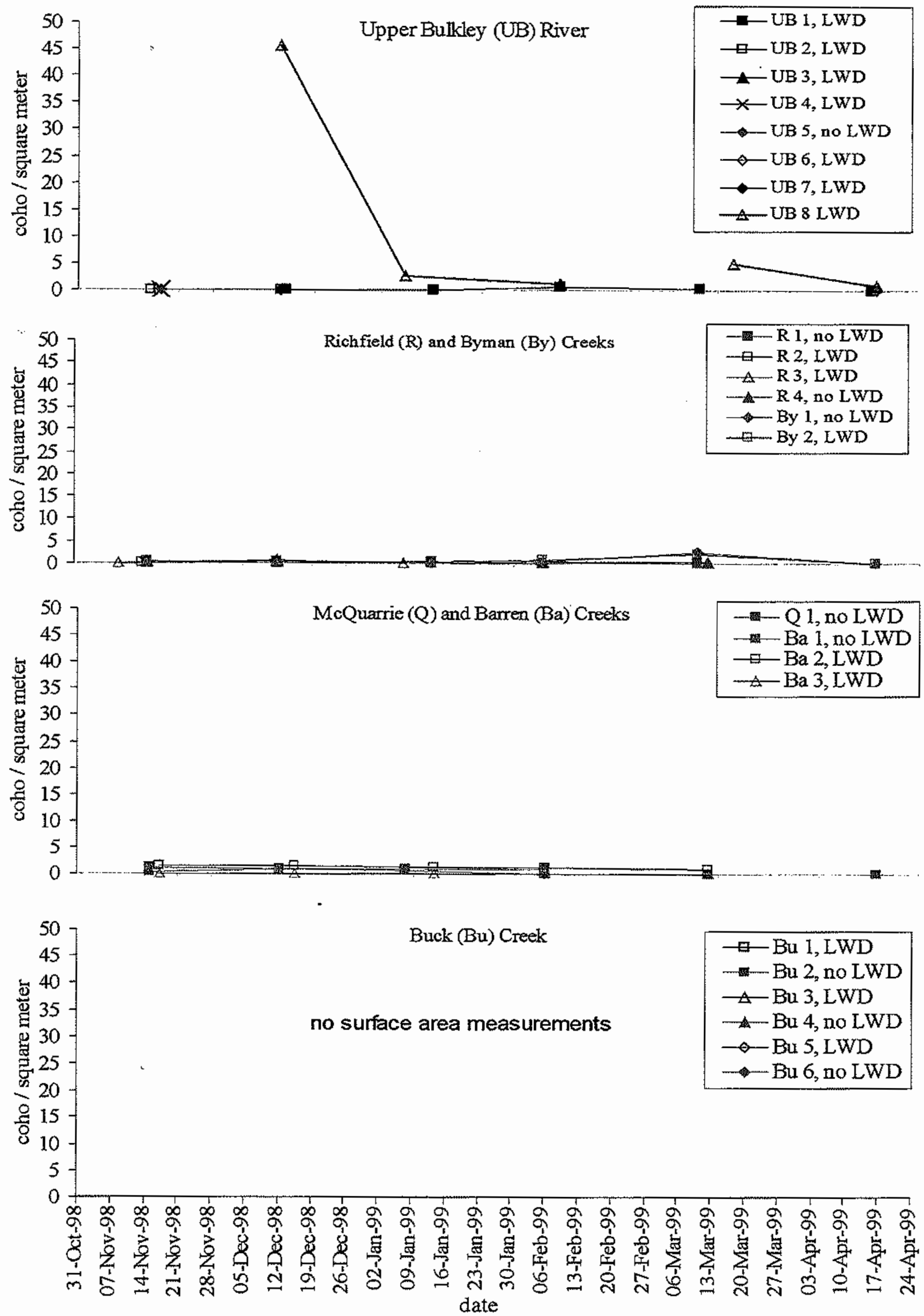


Figure 16. Estimated number of coho per square meter at sites sampled in upper Bulkley River watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

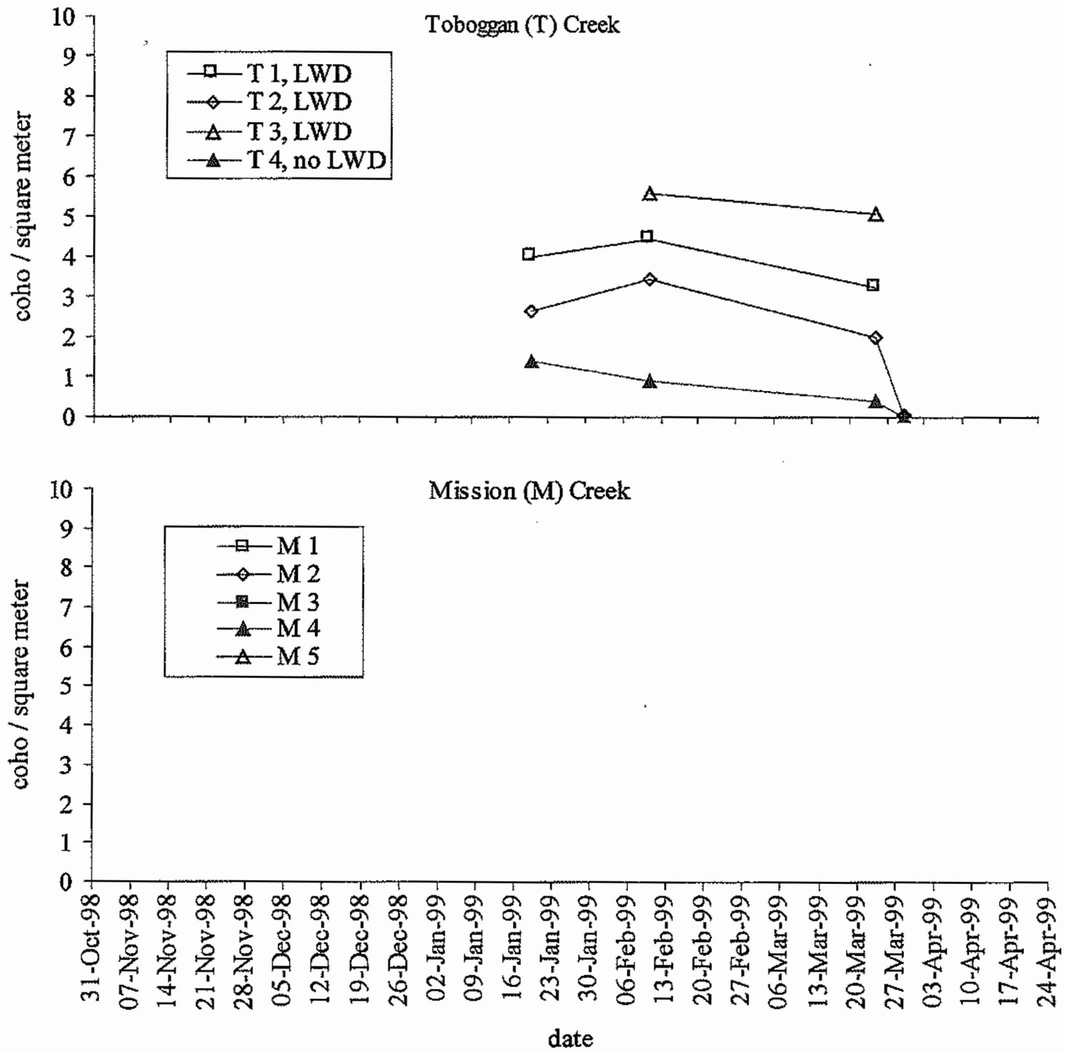


Figure 17. Estimated number of coho per square meter at sites sampled in Toboggan and Mission Creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

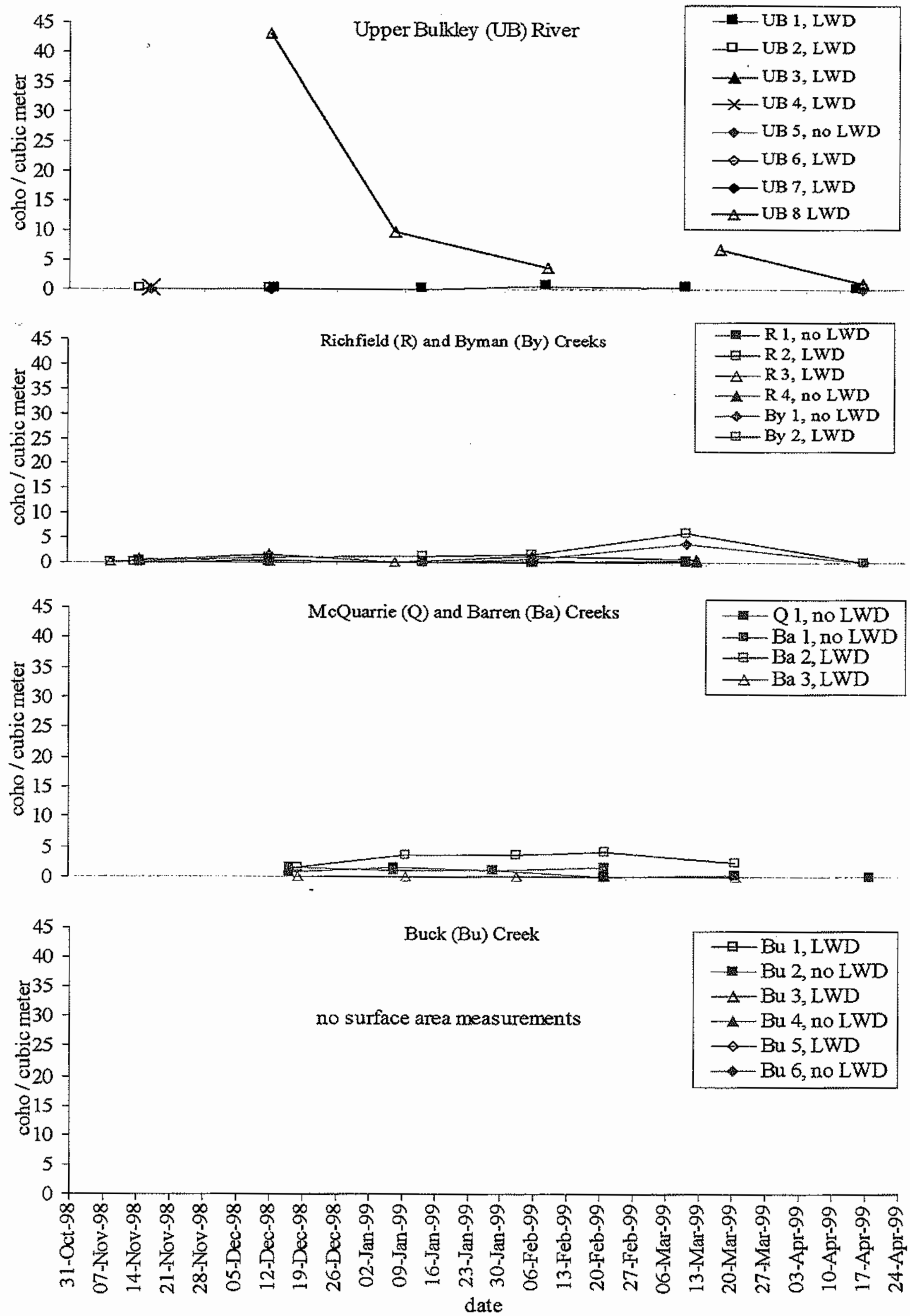


Figure 18. Estimated number of coho per cubic meter at sites sampled in upper Bulkley watershed. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

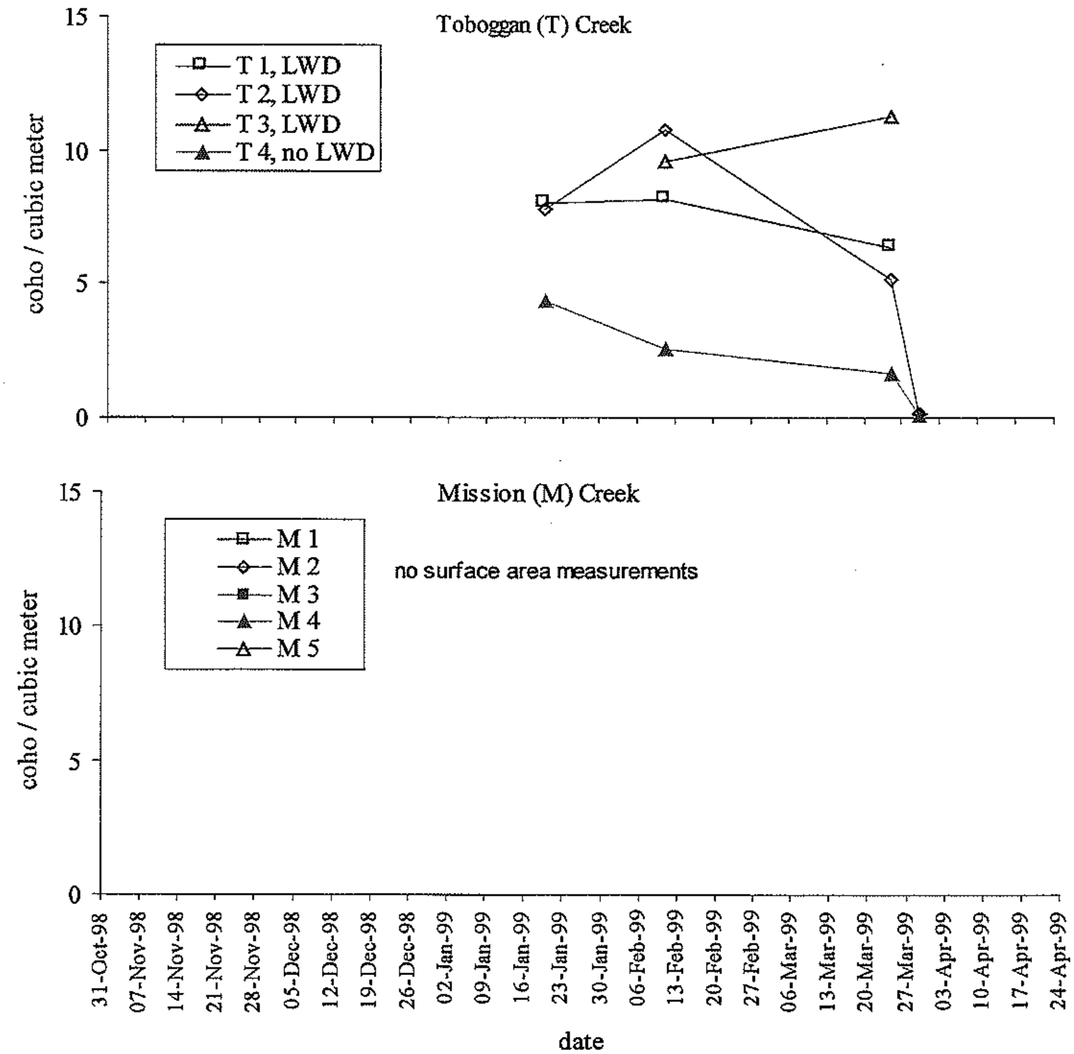


Figure 19. Estimated number of coho per cubic meter at sites sampled in Toboggan and Mission Creeks. Black lines indicate sites with LWD, and red lines indicate sites without LWD.

Trends in changes of density over time are similar to trends observed for adjusted Petersen estimates. Since density is calculated as the adjusted Petersen estimate divided by the surface area or voume, and estimates of surface area and volume change little over time, this is not surprising. Most sites exhibit a decrease or stable density over the majority of the winter, but exhibit a decrease in density in early spring, probably due to migration.

3.1.1.3.2 Coho

Density estimates for coho at each of the sites for which surface area measurements were obtained were also conducted (Figures 15 to 18). Again, temporal variation in the density of coho are similar to those for the estimated coho population size, since densities are determined by dividing the estimated number of coho by the surface area or volume of the site. However, the degree of difference between sites changes when comparing densities versus the adjusted Petersen estimate of population size. As with total density of fish, coho densities were higher at sites with LWD than at sites without LWD. The highest overall coho density was found at site UB 8 in the Upper Bulkley River on Dec 12, 1998 (48 coho / m^2 or 43 coho / m^3). During the remainder of the study, coho densities at site UB 8 were considerably lower than the high in December, but remained higher than coho densities of most sites in the upper Bulkley watershed. In fact, coho densities at site UB 8 resembled coho densities found at Toboggan Creek. Site T3 exhibited the highest coho densities at Toboggan Creek both by surface area and volume. An estimated 5.6 coho / m^2 on Feb. 11, 1999 was the maximum density of coho by area found at Toboggan Creek, while 11.3 coho / m^3 on March 25, 1999 was the maximum number of coho found at Toboggan Creek by unit volume.

3.1.2 Fish Size and Biomass

Weight was recorded for fish captured during the majority of the study, and length was recorded when temperatures were deemed warm enough so that increased handling would not significantly jeopardize the survival of captured fish. Data collected for fish in this study can be used to describe differences in weight over time and among sites, differences in condition factor, and to estimate biomass at different sites over time. Trends in weight, condition factor and biomass may be useful in indicating which site offers the highest quality overwintering habitat.

3.1.2.1 Fish Weight

Mean weight of fish may differ between sites and over time. Since mean weight of fish is contingent on habitat quality, fish condition, age, and species, weight data has been analysed separately for the different species captured in the study. Trends in weight over time may indicate overwintering habitat quality, and/or migration. However, it is important to keep in mind that, unlike length, individual fish can exhibit decreases in weight over time.

3.1.2.1.1 Coho

Coho weight data (mean and standard error) are summarized in Figure 20 for the upper Bulkley watershed, and in Figure 21 for Toboggan and Mission Creeks. Standard error bars were included for all sites where more than one coho was captured. Of the sites sampled in the upper Bulkley watershed, the highest mean weight for coho was observed at site Bu 3 (in Buck Creek) on Dec. 3, 1999 (mean weight = 19.1 g, SE = 3.109). Overall, mean weight of coho in Buck Creek appears to be higher than the mean weight of coho in other systems in the upper Bulkley drainage sampled during the overwintering project. Mean weight of coho also appears to be higher at sites with LWD when compared to sites without LWD. Mean weight of coho at Toboggan Creek is similar to that in the upper Bulkley watershed. Only one coho was captured in Mission Creek, but the weight of this fish is similar to that for coho found in Toboggan Creek and the upper Bulkley watershed. Generally, mean weight of coho appears to be higher for sites with LWD than for sites without LWD. Mean weight of coho exhibits some differences between sites, and may be useful in distinguishing overwintering habitat quality at different sites.

Mean weight of coho appear to fluctuate little over time. Weights for coho appear to be generally stable or decrease slightly through out the winter, with the exception of site Bu 3, where the mean weight of coho decreased early in the winter, and then stabilized by the beginning of January. Relatively stable or slighthly decreasing mean weight of fish is expected due to reduced feeding rates.

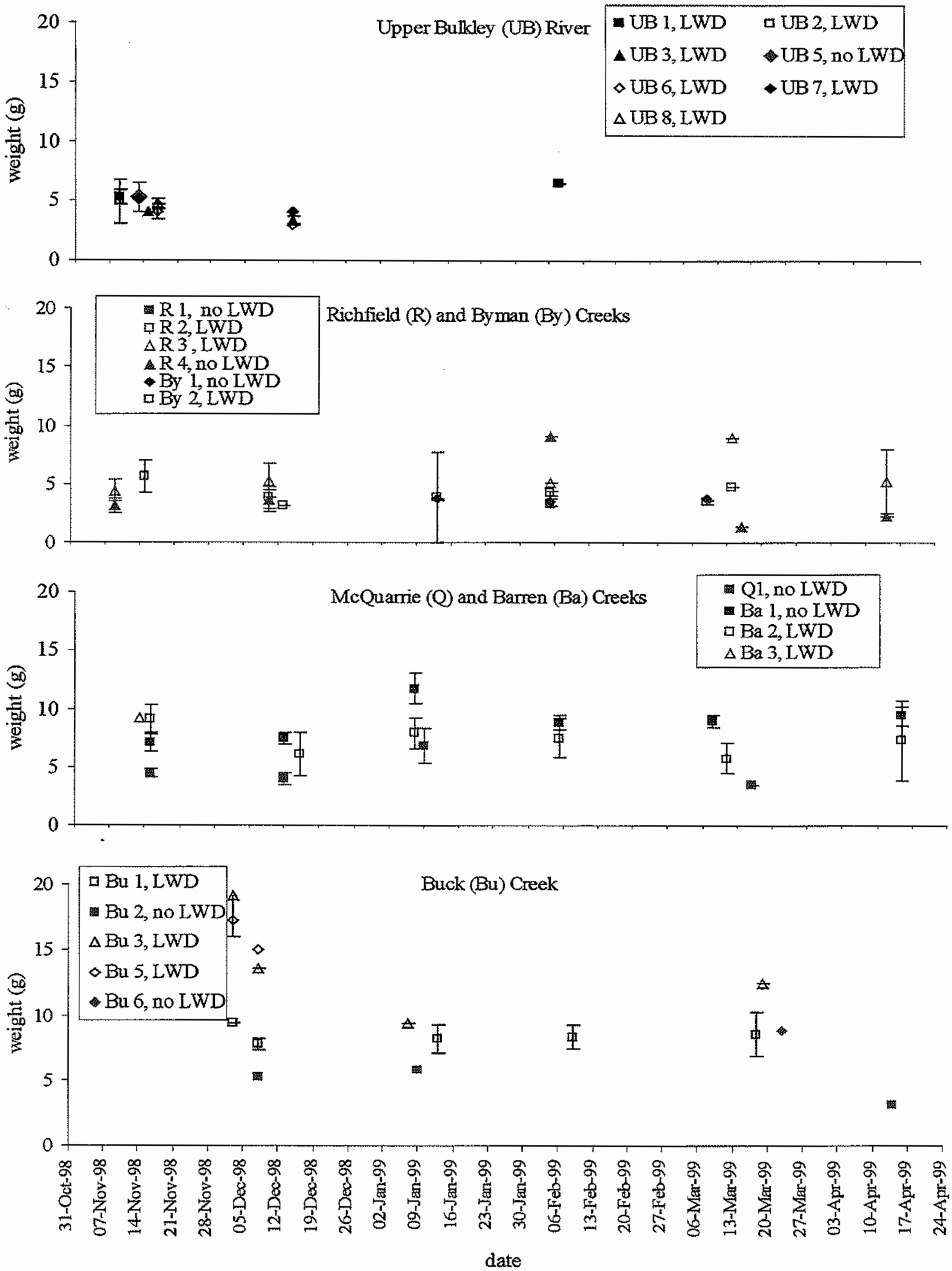


Figure 20. Weight distribution of coho salmon in the upper Bulkley watershed. Error bars indicate standard error for weight.

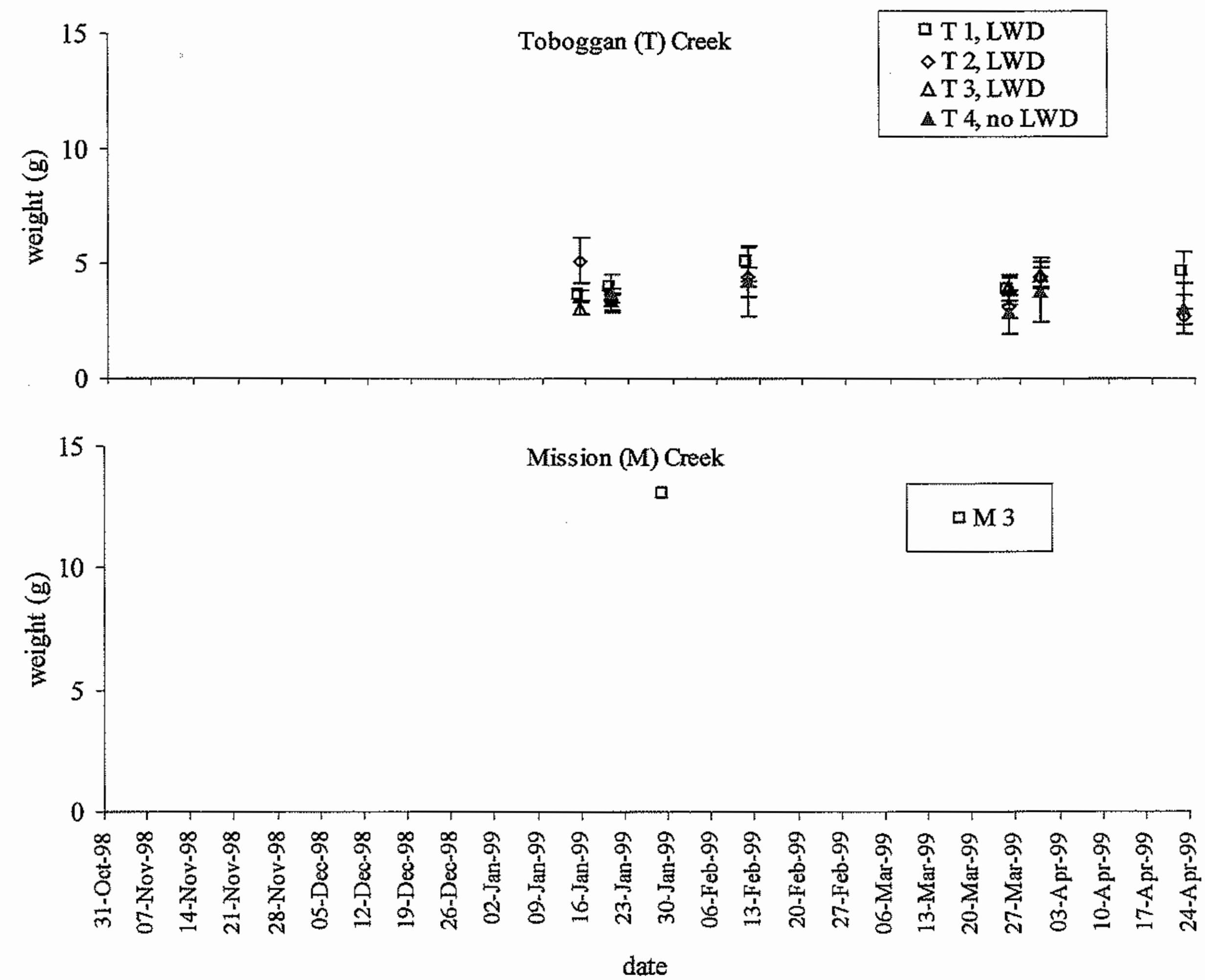


Figure 21. Weight distribution of coho salmon in Toboggan and Mission Creeks. Error bars indicate standard error for weight.

3.1.2.1.2 Chinook

Compared to coho, relatively few chinook salmon were captured throughout the study. The mean weight and standard error for chinook salmon in the upper Bulkley watershed is illustrated in Figure 22. No chinook salmon were captured in Toboggan or Mission Creek. Of the sites sampled, the highest mean weight of chinook salmon was observed in site UB 1 (upper Bulkley River) and Q1 (McQuarrie Creek). Mean weight of chinook salmon was 8.0 g (SE = 2.48) at site Q 1 on Dec 12, 98, and mean weight was 7 g (SE = 0.75) at site UB 1 on Jan 13, 1999. Chinook were only captured at sites with LWD in the upper Bulkley River, but were also present at sites without LWD in Byman, McQuarrie and Buck Creeks. Preliminary data do not appear to show a difference in mean weight of chinook between sites with and without LWD. This may be due to the low sample size of chinook captured in the study, or due to habitat preference. Trends in temporal variation of chinook weight during the winter cannot be analysed effectively due to the low sample size.

3.1.2.1.3 Dolly Varden

Dolly Varden were only captured in Mission and Toboggan creeks, but were not captured in sites sampled in the upper Bulkley watershed. Mean weight of Dolly Varden for Toboggan and Mission creeks are presented in Figure 23. Dolly Varden weight appears to be more variable both among and between sites than coho and chinook mean weight. This may be due to the presence of more age classes, since Dolly Varden in this area are not anadromous, but exhibit either a lacustrine-adfluvial, or fluvial-adfluvial life history. The highest mean weight for Dolly Varden was recorded in Mission Creek at site M 1 (mean weight = 25.6g, SE = 3.50) on March 30, 1999. Mean weights for Dolly Varden were also high at site M 2 in Mission Creek (mean = 24.65 g, SE = 1.50) on February 3, 1999. In fact, mean Dolly Varden weights appeare to be consistently higher at sites M1 and M2 than at other sites surveyed in Mission Creek. The highest mean weight of Dolly Varden in Toboggan Creek was recorded for site T 1 on March 30, 1999, where one Dolly Varden weighing 23.6 grams was captured. The standard error for Dolly Varden weight is greater at Toboggan Creek than at Mission Creek due to lower sample size. Sites with LWD appeared to have a higher mean weight for Dolly Varden than sites without LWD at both Toboggan and Mission Creeks.

3.1.2.1.4 Rainbow Trout / Steelhead

Rainbow trout/steelhead were captured relatively frequently at sites throughout the upper Bulkley watershed and in Toboggan Creek. However, no rainbow trout/steelhead were captured in Mission Creek. Mean weights and standard errors for rainbow trout/steelhead weights are presented in Figures 24 and 25. There is considerable fluctuation in the weight of rainbow trout/steelhead throughout sites in the upper Bulkley watershed, and at Toboggan Creek. The highest mean weight of rainbow trout/steelhead was observed at site Bu 6 (Buck Creek) on March 23, 1999. Two rainbow trout were captured at this site, both weighing 23.5 grams. Rainbow trout/steelhead weight was also high at sites UB 5, UB 4, UB 1, R 4, Ba 1, Bu 3, and Bu 5. Rainbow trout/steelhead weight was high at sites with (UB 4, Bu 3, and Bu

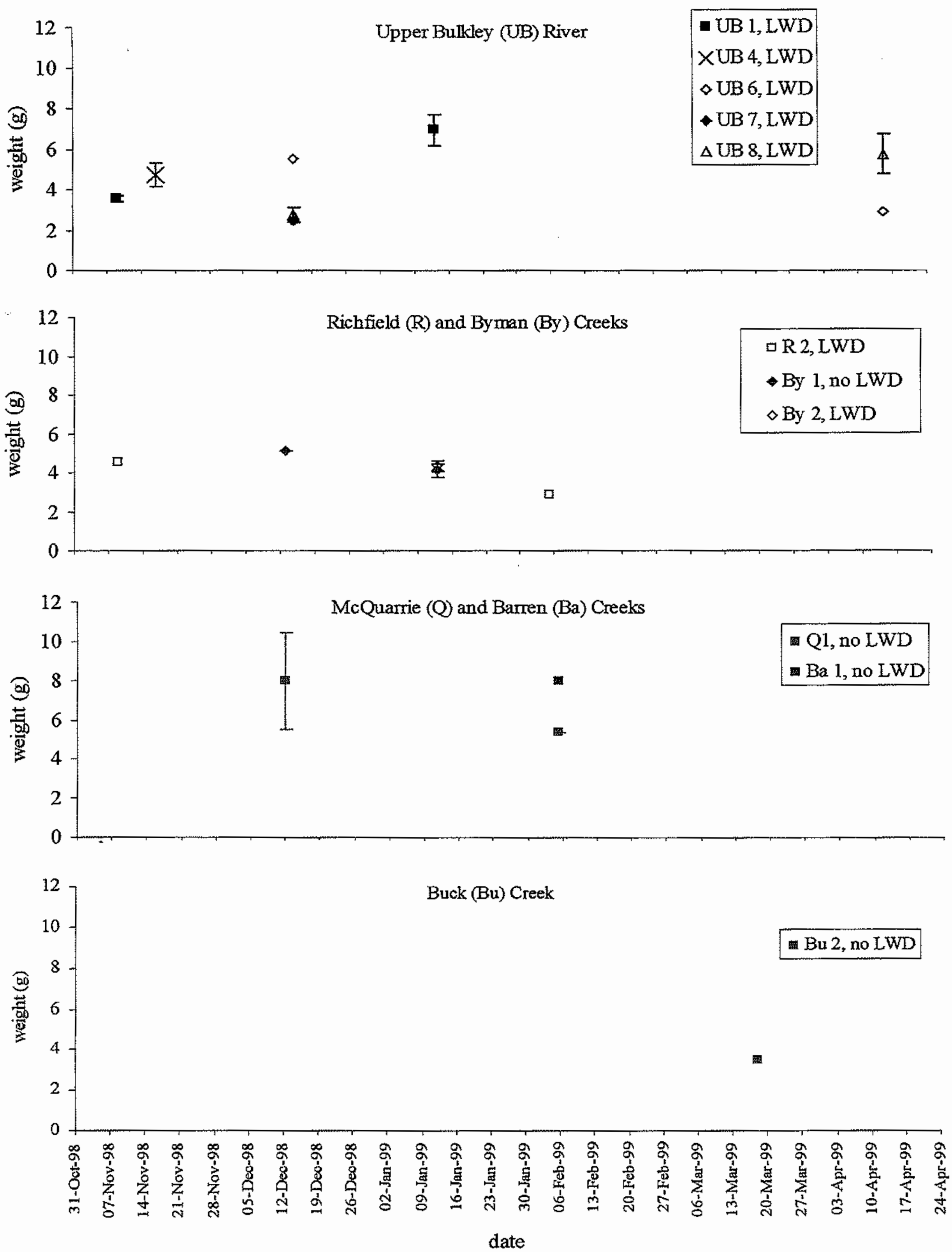


Figure 22. Weight distribution of chinook salmon captured in the upper Bulkley watershed. Error bars indicate the standard error for weight.

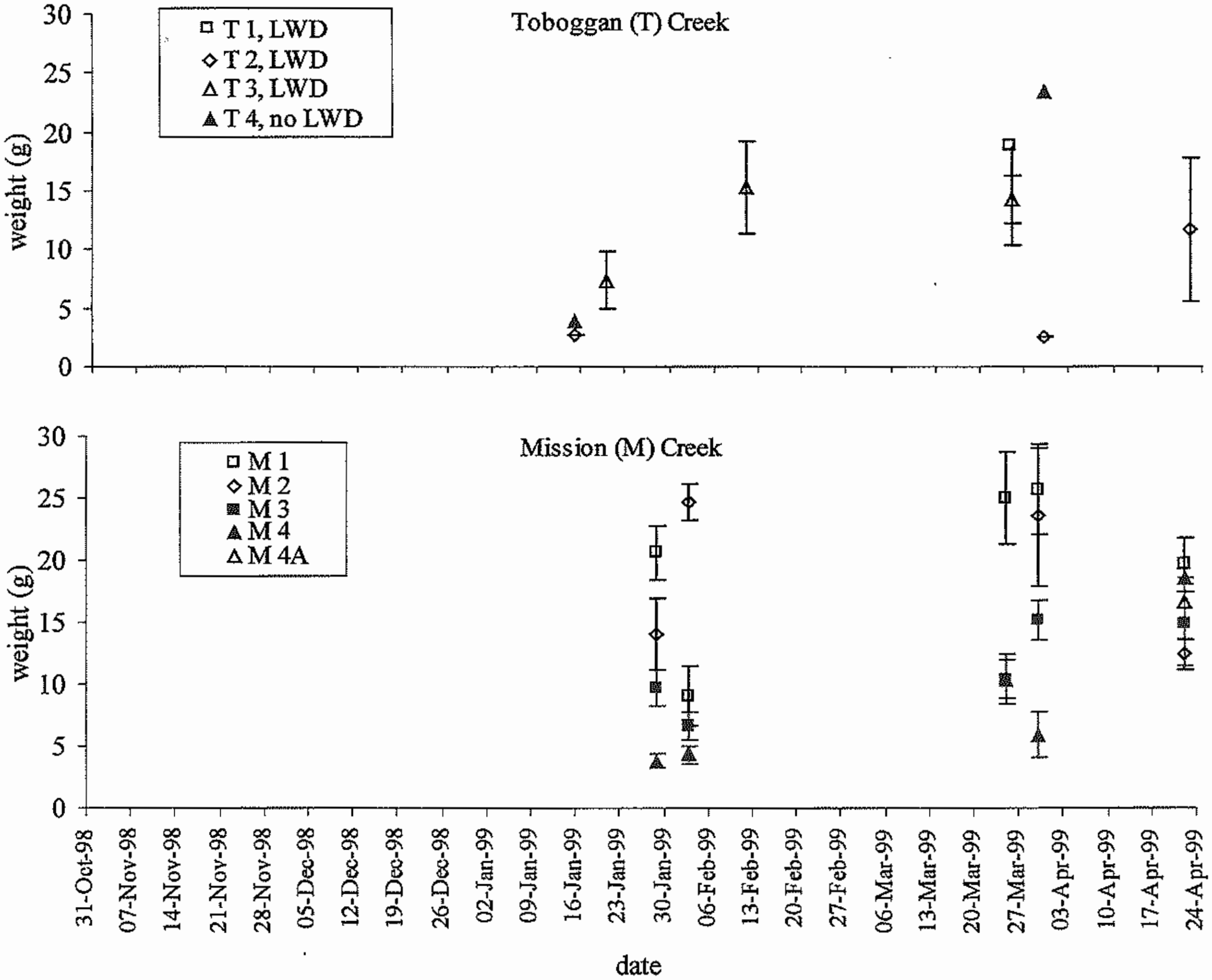


Figure 23. Weight distribution of Dolly Varden captured in Toboggan and Mission Creeks. Error bars indicate the standard error for weight.

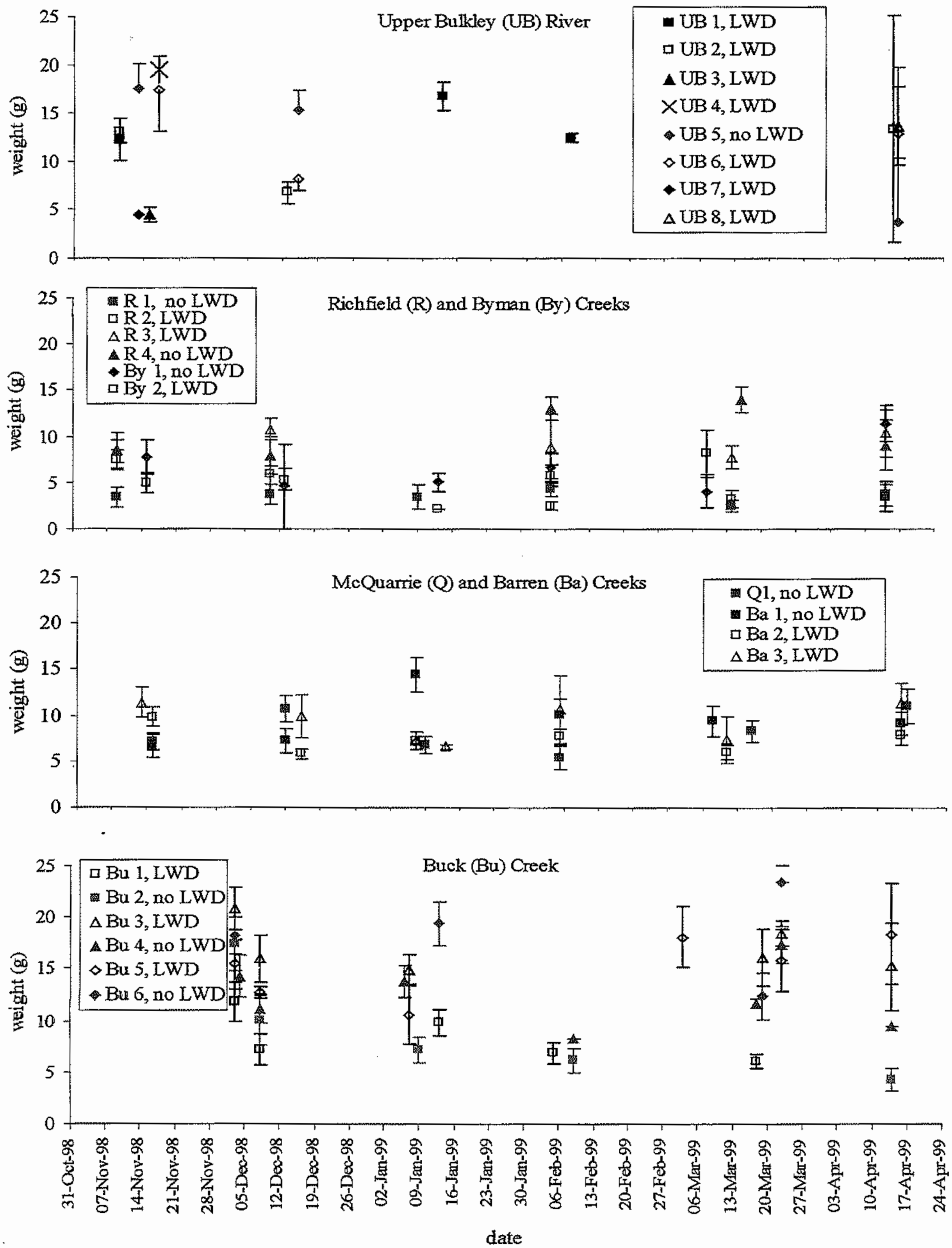


Figure 24. Weight distribution of rainbow trout/steelhead captured in the upper Bulkley watershed. Error bars indicate the standard error for weight.

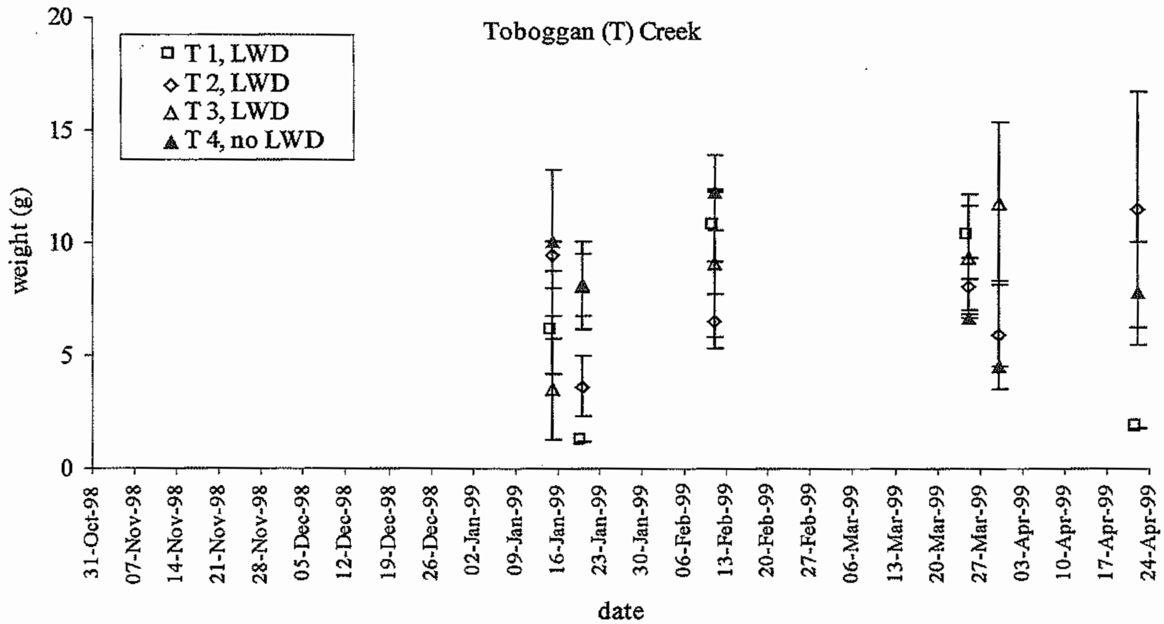


Figure 25. Weight distribution of rainbow trout/steelhead captured in Toboggan Creek. Error bars indicate the standard error for weight.

5) and without LWD (UB 5, R 4, Ba 1, and Bu 6). Mean weight of rainbow/trout steelhead in Toboggan Creek appeared to be similar to sites in the upper Bulkley watershed. The highest mean weight in Toboggan Creek was noted on April 22, 1999 at site T2 (mean weight = 11.6g, SE = 5.218). Fluctuations in rainbow trout/steelhead weight within and between sites may be due to a more complex age structure than that presented by coho and chinook salmon.

Mean weight appears to be relatively stable for rainbow trout/steelhead throughout the winter for sites in the upper Bulkley watershed (Figure 24). However, at Toboggan Creek, mean weight of rainbow trout/steelhead appears to decrease at site T 4 (lacking LWD), and remain stable or increase slightly at the remaining sites. Due to the large variability of rainbow trout/steelhead weight within sites, it is difficult to ascertain if these trends are random, or if they reflect real changes in the weight distribution of rainbow trout/steelhead at the sites.

Weight frequency distribution of all rainbow trout/steelhead in the upper Bulkley watershed appears to change relatively little over time (Figure 26). A larger porportion of the catch of rainbow trout appears to be comprised of age 0+ rainbow trout in November and December, than in January or February. This may be due to mortality of smaller fish, as is also indicated by the most significant reduction in fish under 1.5g in weight in early to mid winter. The large peak of 0+ fish in later winter/early spring (March) may be due to migration patterns. Overall, smaller fish appear to show a decrease in abundance over time.

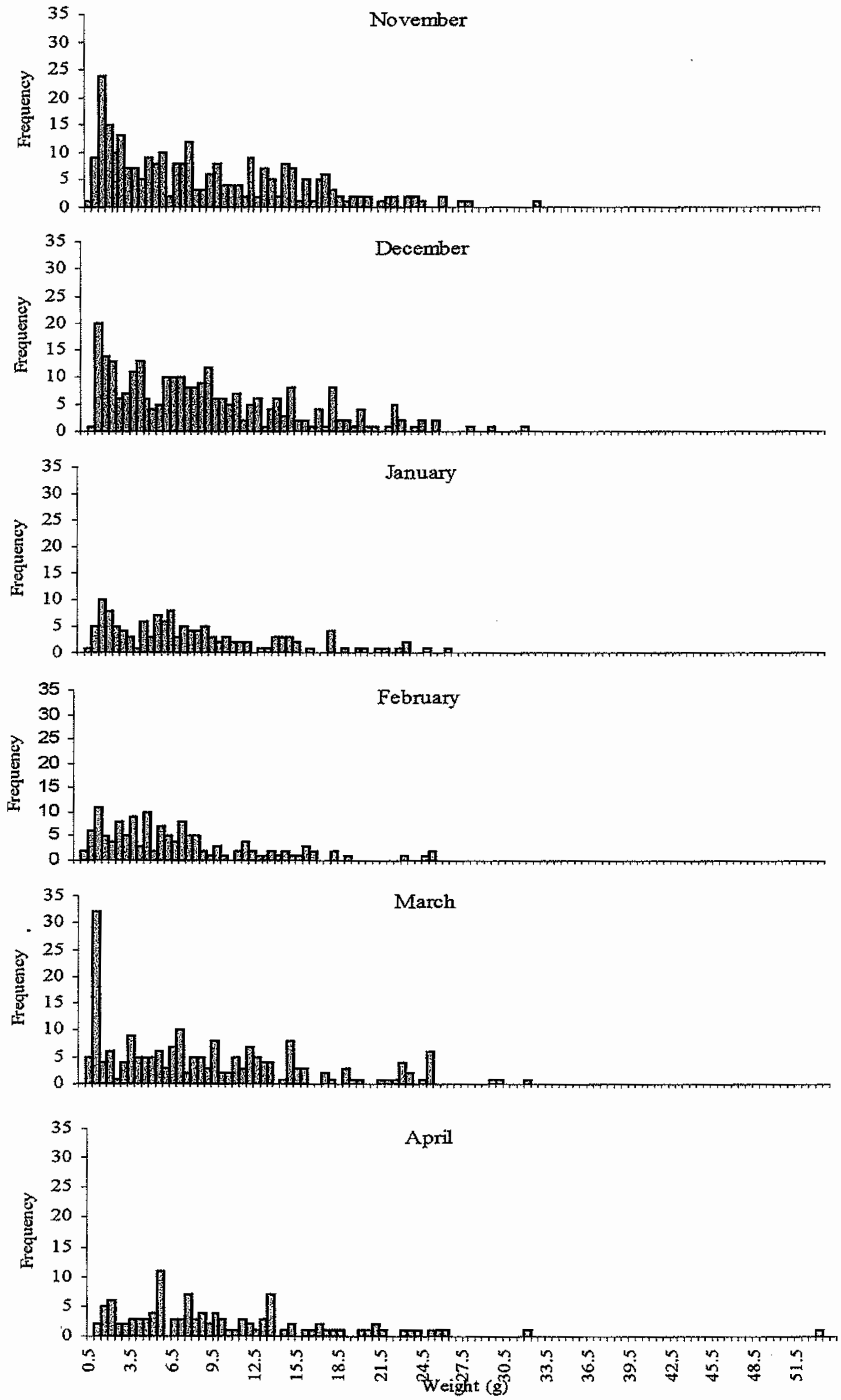


Figure 26. Weight frequency distribution of the pooled sample for rainbow trout for the upper Bulkley Watershed

3.1.2.1.5 Cutthroat Trout

Only one cutthroat trout was captured at the sites sampled during the upper Bulkley River overwintering study. This cutthroat trout was captured at site T 3 on January 15, 1999. The fish weight 21 g. Due to the apparent low abundance of cutthroat trout at the sites sampled, differences in cutthroat trout weight between sites and over time are unlikely to be good indicators of overwintering habitat quality.

3.1.2.1.6 Other Species

The only other species captured through out the study were long nose dace at site Bu 2 on January 9, 1999 and a burbot at site UB 2 on April 14, 1999. The longnose dace weighed 4.1 g, while the burbot weight 1.6 grams. It is somewhat surprising that only so few non-salmonids were captured in the study. The lack of non-salmonids should make the estimation of population size, based on mark – recapture of the fish community at a site (regardless of species) more accurate than if non-salmonids were more frequently captured.

<u>3.1.2.2 Fish Condition Factor</u>

Condition factor is a measure of the "fatness" of the fish (Bagenal 1978). Condition factors are often assumed to be a direct measure of the fish' health. Calculation of condition factors involve a comparison of length to weight. Higher condition is often correlated to abundant food, lower densities, low stress, good growth and forage conditions, and higher survival. Comparisons of condition factors between sites and over time may be useful in identifying sites offering better overwintering habitat.

Weight data was recorded throughout the study, but lengths was only recorded when ambient temperatures were warmer, since lower temperatures can result in significant mortality of fish. Length and weight data were recorded for fish captured at sites sampled in March and April. The data allows for comparisons of condition factor between sites, but is not sufficient to document variations in condition factor over time. Fulton's condition factor (K) has been calculated for each site sampled at which lengths and weights was recorded. Allometric condition factor (K') was determined where the sample size of a species was greater than 2.

3.1.2.2.1 Coho

Fulton's and allometric condition factors for coho are summarized in Table 4. The Fulton's condition factor is relatively similar among sites, ranging from a low of 0.86 (site Ba 2) to a high of 1.25 (site T 1). However, there is considerable fluctuation among the allometric condition factors, ranging from a low of 0.78 (By 2) to a high of 7.91 (Ba 2). The wide variation in allometric condition factor, and in the slope of the regression of log length on log weight indicates that most of the sites do not exhibit isometric growth. In fact, most of the slopes (b) differ substantially from 3, which describes isometric growth. A steeper slope indicates fish that are proportionately heavier with increases in weight, while a lower slope indicates fish that become proportionately skinnier with increases in length. Most of the slopes observed for coho fall below that describing isometric growth (slope = 3), indicating that fish become proportionately skinnier with increases in length.

The relationship between length and weight for coho appears to differ substantially among sites. The differences in the regression equations reflect differences in the slope of the line (b) and the allometric condition factor. For comparisons between populations, Fulton's condition factor is easier to interpret, and use. Fulton's condition factor indicates that fish at site Ba 2 (Barren Creek) are, on the average, skinnier than fish at other sites. This is confirmed by a slope well below the slope of 3 for isometric growth (b = 1.98). The relatively high Fulton's condition factor observed at site T1 indicates that coho at this site are fatter than fish at other sites. The slope of the regression of log weight on log length is only slightly below 3 (b = 2.72), indicating growth that is similar to isometric growth. The allometric condition factor is also relatively high at this site. Trends in allometric condition factors should mirror those in Fulton's condition factor where the b is similar to isometric growth.

Table 4. Summary of Fulton's condition factor (K), allometric condition factor (K'), sample size (n), slope (b) and Pearson correlation coefficient (r^2) of the regression of log_{10} weight on log_{10} fork length (mm) for coho captured in the upper Bulkley River watershed, Toboggan Creek and Mission Creek.

Site	Date	n	K (SD)	K'	b	r^2
UB 8	Apr 15, 99	1	1.16 (n.a.)	n.a.	n.a.	n.a.
R 3	Mar 14, 99	1	1.04 (n.a.)	n.a.	n.a.	n.a.
R 4	Mar 16, 99	1	0.94 (n.a.)	n.a.	n.a.	n.a.
By 1	Mar 9, 99	11	1.09 (0.157)	positive intercept	0.04	0.53
By 2	Mar 9, 99	6	0.97 (0.060)	0.78	3.05	0.88
Q 1	Mar 16, 99	1	1.22 (n.a.)	n.a.	n.a.	n.a.
Ba 1	Mar 8, 99	9	1.03 (0.135)	3.43	2.23	0.93
Ba 2	Mar 11, 99	3	0.86 (0.195)	7.91	1.98	0.94
Bu 1	Mar 18, 99	2	0.93 (0.06)	n.a.	n.a.	n.a.
Bu 2	Apr 14, 99	1	0.99 (n.a.)	n.a.	n.a.	n.a.
Bu 3	Mar 19, 99	3	0.93 (n.a.)	n.a.	n.a.	n.a.
Bu 6	Mar 23, 99	2	1.11 (0)	n.a.	n.a.	n.a.
T 1	Mar 25, 99	8	1.25 (0.263)	3.97	2.72	0.87
T 1	Apr 22, 99	10	1.14 (0.082)	1.52	2.93	0.98
T 2	Mar 25, 99	7	1.09 (0.101)	1.37	3.50	0.94
T 2	Apr 22, 99	10	1.15 (0.079)	1.00	2.93	0.96
T 3	Mar 25, 99	20	1.16 (0.214)	6.77	2.58	0.92
T 4	Mar 25, 99	2	1.17 (0.130)	n.a.	n.a.	n.a.
T 4	Apr 22, 99	2	1.16 (0.024)	n.a.	n.a.	n.a.

3.1.2.2.2 Chinook

Fulton's and allometric condition factors for chinook are summarized in Table 5. Chinook were captured at only two sites in the spring of 1999, both located on the Upper Bulkley

River. Chinook condition appears to be higher for site UB 8 (K = 1.35) than for site UB 1 (K = 0.61). An allometric condition factor could not be determine for site UB 1 due to low sample size, but was calculated at site UB 8, where six chinook were captured. The allometric condition factor is high (K' = 22.6). This can partly be attributed to the poor correlation between log weight and log length (r^2 = 0.33), indicating a relatively poor fit of the regression line. As for coho, Fulton's condition factors appear to be better suited for comparisons between sites.

Table 5. Summary of Fulton's condition factor (K), allometric condition factor (K'), sample size (n), slope (b) and Pearson correlation coefficient (r^2) of the regression of log_{10} weight on log_{10} fork length (mm) for chinook captured in the upper Bulkley River watershed. No chinook were captured in Toboggan Creek and Mission Creek.

Site	Date	n	K (SD)	K'	b	r^2
UB 6	Apr 15, 99	1	0.61 (n.a.)	n.a.	n.a.	n.a.
UB 8	Apr 15, 99	6	1.35 (0.55)	22.6	2.33	0.33

3.1.2.2.3 Dolly Varden

Dolly Varden were only captured in Toboggan Creek and Mission Creek, but were not captured in sites sampled in the upper Bulkley watershed. Fulton's and allometric condition factors for Dolly Varden are summarized in Table 6. Fulton's condition factors appear to vary little between sites, but allometric condition factors show some variability. Of the sites examined, site T 2 exhibited the lower Fulton's condition factor (K = 0.86). This site also had a relatively low allometric condition factor (K' = 1.02), and a slope of 2.96, indicating near isometric growth. Site M4 also exhibited a relatively low Fulton's condition factor (K= 0.90 on March 25). However, the allometric condition factor determined for the same sample was unusually high. The slope of the regression line is low (b = 1.80) indicating allometric growth. Fulton's condition factor was also found to be low at site M2 on March 25, 1999 (K = 0.90). The highest Fulton's condition factor was observed at site T 1 (K = 1.27), where only one Dolly Varden was captured. Variations in allometric condition factor appear to be greater, which can be attributed to different relationships between log weight and log length at the different sites. Most of the sites sampled in Toboggan and Mission creeks do not appear to exhibit isometric growth for Dolly Varden, since most of the slopes are below 3.0.

3.1.2.2.4 Rainbow Trout / Steelhead

Fulton's and allometric condition factors for rainbow trout/steelhead are summarized in Table 7. Fulton's condition factor was relatively high at sites UB 5, UB 6, R 3, Bu 2, Bu 4, and T 4. Low Fulton's condition factors were encountered at sites UB 8, By 1, By 2, Ba 1, and Ba 2. As with other species, the allometric condition factor appears to show more variation between sites than the Fulton's condition factor. This is primarily attributable to different relationships between weight and length of fish. Many of the sites do not exhibit isometric growth (where b = 3). Some sites exhibit slopes greater than 3 (e.g. R 1, R 2, By 1, By 2, Bu 1, Bu 2, Bu 3 Bu 6) while other exhibit slopes lower than three (e.g. R 3, R 4, Q 1, Bu 4, Bu 5, indicating allometric growth. Two sites (Bu 3, T 2) exhibit slopes greater than 3 on March 25, 1999, and a slope lower than 3 on April 22, 1999. This decrease may be due to selective movement of fitter, healthier fish towards the end of the winter. It is interesting to note that of the species captured during the overwintering study, only rainbow trout/steelhead was found to have greater growth than that for isometric populations.

Table 6. Summary of Fulton's condition factor (K), allometric condition factor (K'), sample size (n), slope (b) and Pearson correlation coefficient (r^2) of the regression of $\log_{10}$ weight on $\log_{10}$ fork length (mm) for Dolly Varden captured in Toboggan Creek and Mission Creek. No Dolly Varden were captured in the upper Bulkley watershed.

Site	Date	n	K (SD)	K'	b	r^2
T 1	Mar 25, 99	2	0.99 (0.159)	n.a.	n.a.	n.a.
T 1	Apr 22, 99	1	1.27 (n.a.)	n.a.	n.a.	n.a.
T 2	Apr 22, 99	3	0.86 (0.196)	1.02	2.96	0.95
T 3	Mar 25, 99	3	1.00 (0.134)	11.7	1.99	0.93
M 1	Mar 25, 99	22	1.07 (0.072)	5.31	2.65	0.69
M 1	Apr 22, 99	34	1.06 (0.095)	2.67	3.00	0.98
M 2	Mar 25, 99	18	0.90 (0.121)	3.83	2.71	0.99
M 2	Apr 22, 99	34	1.06 (0.012)	0.79	3.06	0.98
M 3	Mar 25, 99	11	0.96 (0.085)	1.96	2.84	0.99
M 3	Apr 22, 99	13	1.05 (0.115)	3.18	2.76	0.99
M 4	Mar 25, 99	27	0.90 (0.200)	19.7	1.80	0.83
M 4	Apr 22, 99	1	1.10 (n.a.)	n.a.	n.a.	n.a.
M 4A	Apr 22, 99	18	0.99 (0.086)	1.27	2.95	0.98

3.1.2.3 Biomass

Biomass was determined for each species captured at each of the sites. Biomass was calculated as the weight of a species per unit area and per unit volume at each of the sites, to facilitate comparisons with other studies, and the account for differences in water depth. Surface area was not evaluated for sites in Buck and Mission creeks since ice cover at the time of initial survey did not allow for a determination of length and width of the sites. Overall biomass of salmondis was determined for each site by summing the biomass of individual species (Figures 27 and 28).

Overall salmonid biomass was highest at site UB 8 by unit area. This corresponds with a high catch per unit effort, high adjusted Petersen estimate, and high densities of salmonids at this site by unit volume and unit area. Biomass was also high for salmonids at sites Ba 2 and By 2. Site R 3 and T 3 exhibited relatively high biomass as well. Salmonid biomass per unit volume was highest for site Ba 2. Depth at site Ba 2 was relatively low, accounting for the increase in the biomass per unit volume from that per unit area. All of the sites with high

Table 7. Summary of Fulton's condition factor (K), allometric condition factor (K'), sample size (n), slope (b) and Pearson correlation coefficient (r^2) of the regression of log_{10} weight on log_{10} fork length (mm) for rainbow trout/steelhead captured in the upper Bulkley River watershed, Toboggan Creek and Mission Creek.

Site	Date	n	K (SD)	K'	b	r^2
UB 5	Apr 16, 99	2	1.21 (0.019)	n.a.	n.a.	n.a.
UB 6	Apr 15, 99	8	1.39 (0.770)	2.67	1.83	0.93
UB 8	Apr 15, 99	2	0.90 (0.377)	n.a.	n.a.	n.a.
R 1	Mar 14, 99	22	1.03 (0.125)	0.65	3.12	0.97
R 2	Mar 14, 99	22	1.06 (0.131)	0.67	3.12	0.98
R 3	Mar 14, 99	14	1.51 (0.206)	4.90	1.64	0.62
R 4	Mar 16, 99	19	1.10 (0.106)	2.67	2.81	0.95
By 1	Mar 9, 99	2	0.95 (0.426)	0.003	4.33	0.95
By 2	Mar 9, 99	6	0.99 (0.014)	0.158	3.41	0.99
Q 1	Mar 16, 99	13	1.10 (0.115)	1.80	2.88	0.97
Ba 1	Mar 8, 99	8	0.96 (0.118)	1.01	2.99	0.93
Ba 2	Mar 11, 99	31	0.93 (0.066)	1.02	2.98	0.99
Ba 3	Mar 11, 99	7	1.01 (0.089)	0.99	3.00	0.98
Bu 1	Mar 18, 99	7	1.12 (0.065)	0.38	3.24	0.97
Bu 2	Mar 23, 99	2	1.29 (0)	n.a.	n.a.	n.a.
Bu 2	Apr 14, 99	6	1.14 (0.087)	0.62	3.14	0.99
Bu 3	Mar 19, 99	8	1.01 (0.087)	1.79	2.90	0.96
Bu 3	Mar 23, 99	8	1.23 (0.073)	0.03	3.76	0.93
Bu 3	Apr 14, 99	5	1.16 (0.06)	2.24	2.86	0.99
Bu 4	Mar 18, 99	2	1.23 (0.126)	n.a.	n.a.	n.a.
Bu 4	Mar 23, 99	8	1.15 (0.039)			
Bu 5	Mar 23, 99	6	1.10 (0.094)	3.88	2.74	0.99
Bu 6	Mar 19, 99	4	1.06 (0.015)	0.40	3.22	0.97
Bu 6	Mar 23, 99	2	1.12 (0)	n.a.	n.a.	n.a.
Bu 6	Apr 24, 99	2	1.08 (0.001)	n.a.	n.a.	n.a.
T 1	Mar 25, 99	3	1.05 (0.078)	8.35	2.55	0.98
T 1	Apr 22, 99	1	1.14 (n.a.)	n.a.	n.a.	n.a.
T 2	Mar 25, 99	3	1.15 (0.041)	0.29	3.31	
T 2	Apr 22, 99	4	1.27 (0.084)	2.47	2.85	0.99
T 3	Mar 25, 99	11	1.12 (0.129)	3.55	2.74	0.98
T 4	Mar 25, 99	1	1.26 (n.a.)	n.a.	n.a.	n.a.
T 4	Apr 22, 99	4	1.25 (0.052)	4.56	2.17	0.99

biomass per unit area or per unit volume offer cover from LWD. Other sites, lacking LWD, had relatively low salmonid biomass.

3.1.2.3.1 Coho

Coho biomass per unit area is illustrated in Figure 29, while coho biomass per unit volume is illustrated in Figure 30. Coho biomass per unit area and per unit volume was highest at site UB 8. Most of the fish captured at the site were coho, accounting for the similar coho biomass at the site when compared to overall salmonid biomass. Coho biomass was relatively low at all other sites in the Upper Bulkley watershed, but was similar to overall salmonid biomass at Toboggan Creek. As with site UB 8, coho accounted for most of the fish captured at Toboggan Creek. On average, coho biomass appears to be higher at sites with LWD than sites lacking LWD.

3.1.2.3.2 Chinook

Chinook biomass by unit area is illustrated in Figure 31, and chinook biomass by unit volume is illustrated in Figure 32. Biomass for chinook is low for most sites, since chinook were only captured at a few sites (see Table 5). Chinook biomass was highest for site UB 8. Chinook biomass for tributaries to the upper Bulkley River was low, however. Trends in biomass match those of chinook catch per unit effort, and densities.

3.1.2.3.3 Dolly Varden

Dolly Varden biomass by unit area is summarized in Figure 33, and Dolly Varden biomass by unit volume is summarized in Figure 34. No Dolly Varden were captured in the upper Bulkley watershed. Dolly Varden were occasionally captured at Toboggan Creek. The highest Dolly Varden biomass per unit area and per unit volume was observed at site T 4. This site lacked LWD. Mission Creek likely has the highest Dolly Varden biomass of the systems examined, but data to determine surface area has not been collected for the sites sampled in Mission Creek.

3.1.2.3.4 Rainbow trout / steelhead

Rainbow trout/steelhead biomass by area is illustrated in Figure 35, and rainbow trout/steelhead biomass per unit volume is illustrated in Figure 36. Rainbow trout/steelhead biomass was high at sites Ba 2 and By 2, both in terms of weight per unit area and weight per unit volume. Both of these sites had LWD. As with coho, sites with LWD had a higher rainbow trout/steelhead biomass than those without LWD. It is interesting to note that site Ba 2 exhibited both, high rainbow trout/steelhead and coho biomass. Biomass per unit volume was again considerable higher than biomass per unit area at site Ba 2, due to the relatively low depth of the site. Trends in rainbow trout/steelhead biomass appear to match those of both catch per unit effort and densities.

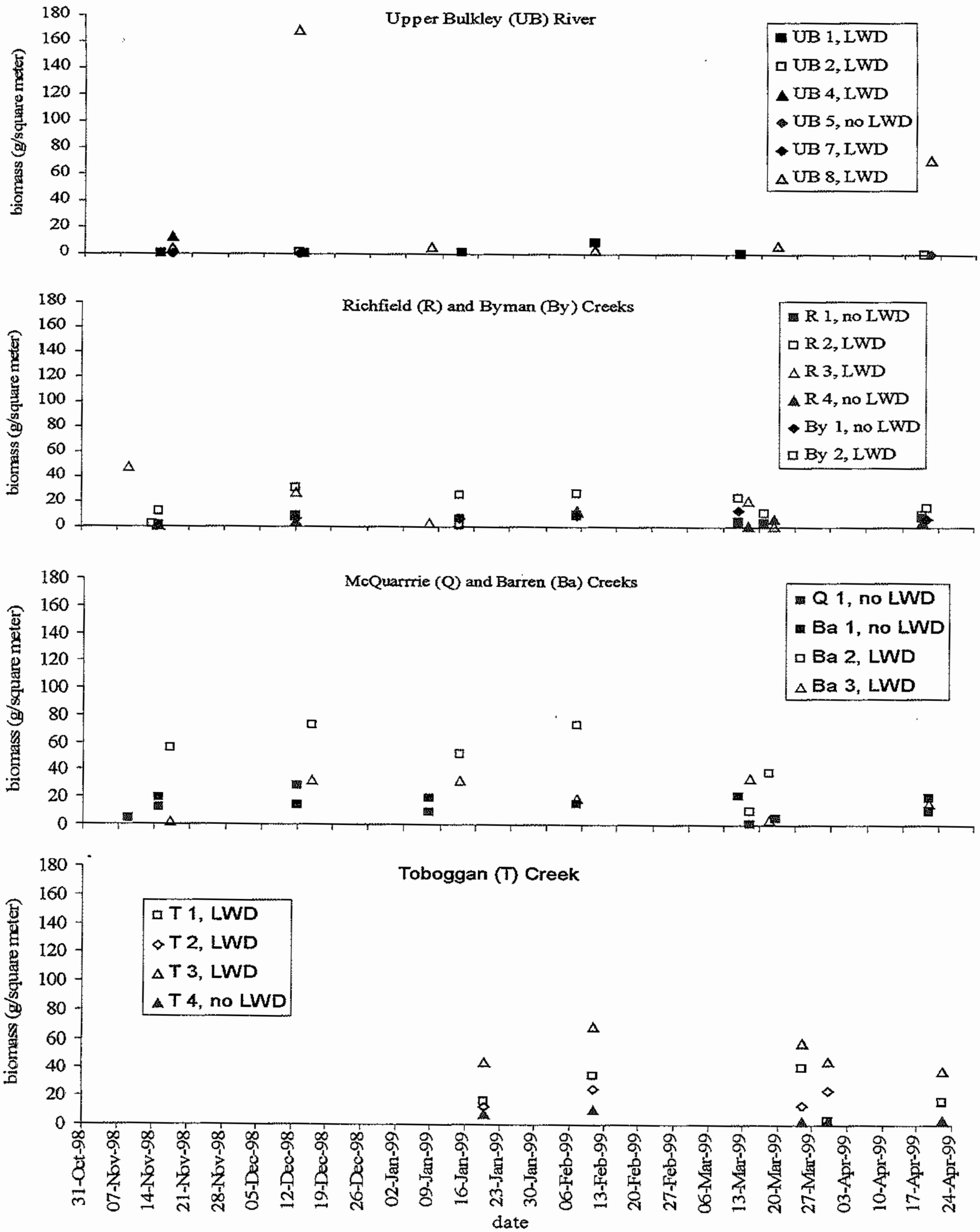


Figure 27. Salmonid biomass by unit area (g/m^2) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

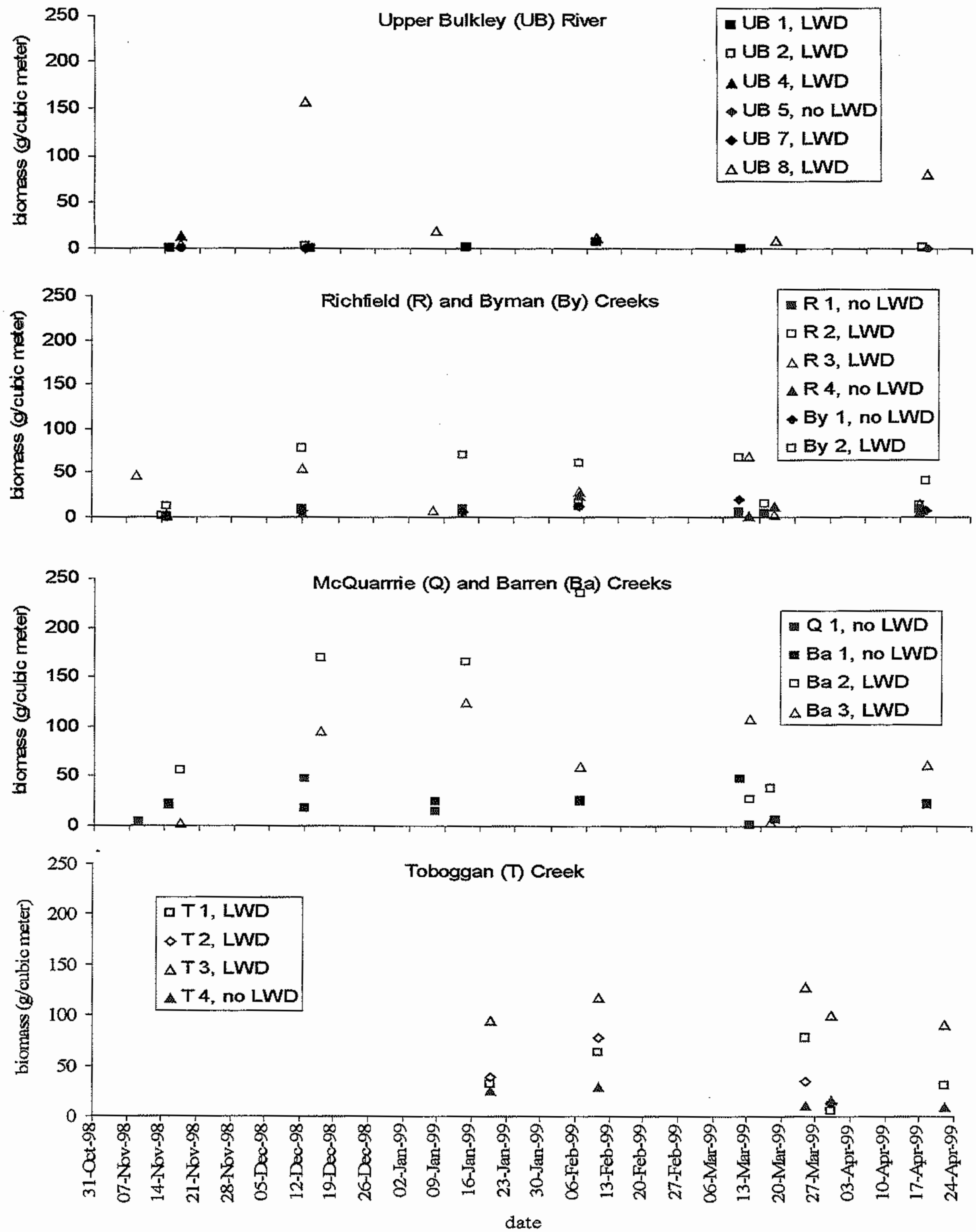


Figure 28. Salmonid biomass by unit volume (g/m^3) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

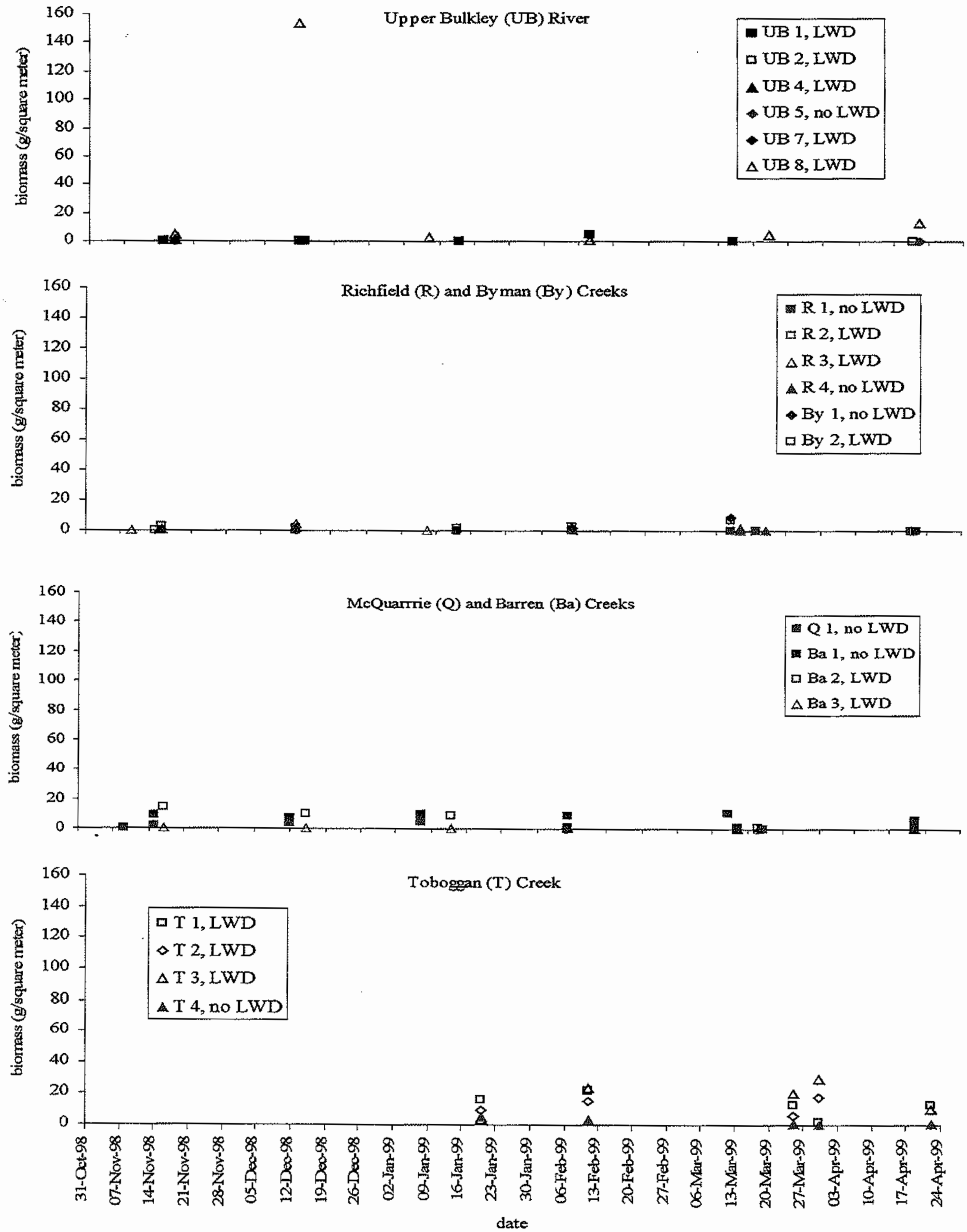


Figure 29. Coho biomass by unit area (g/m^2) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

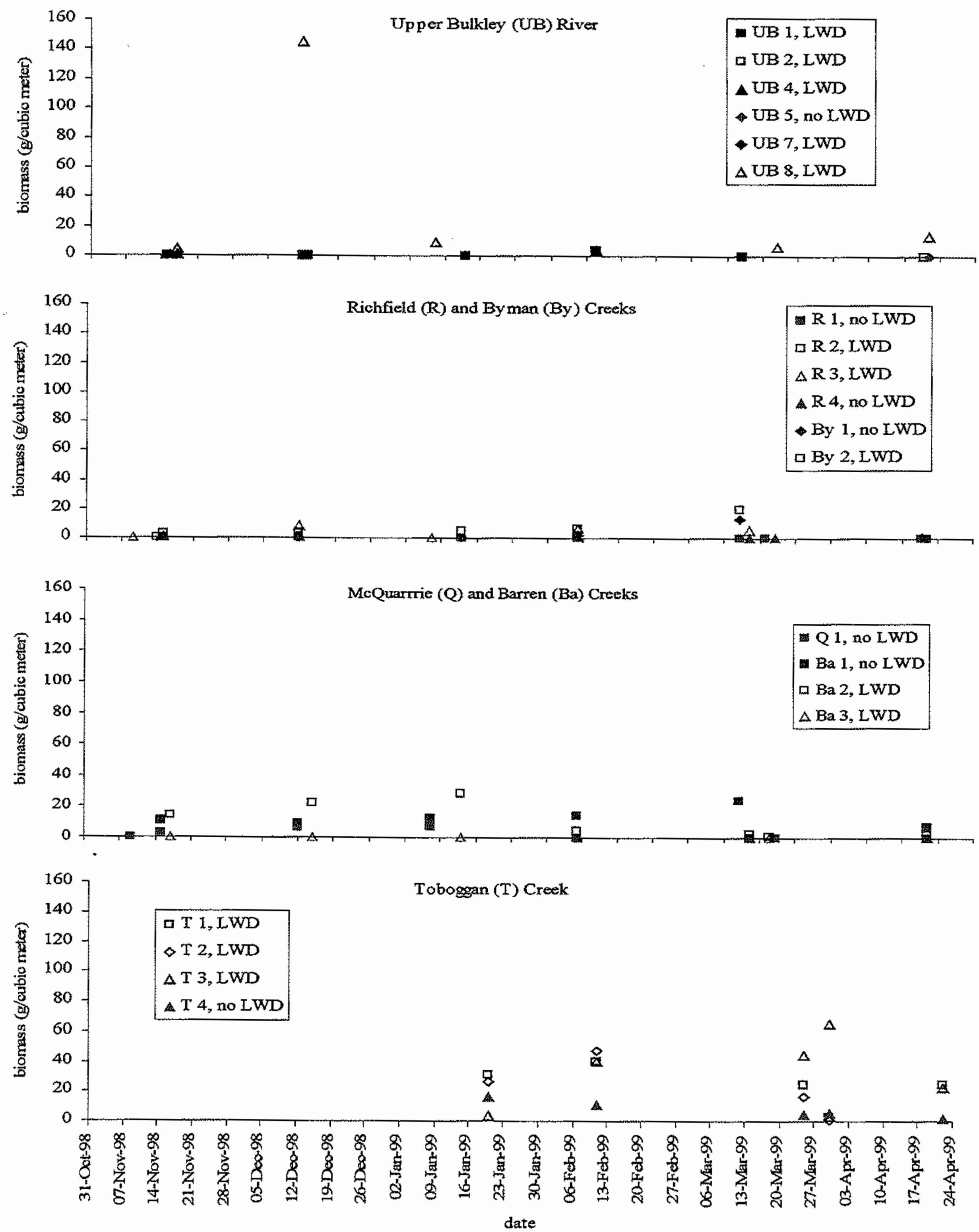


Figure 30. Coho biomass by unit volume (g/m^3) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

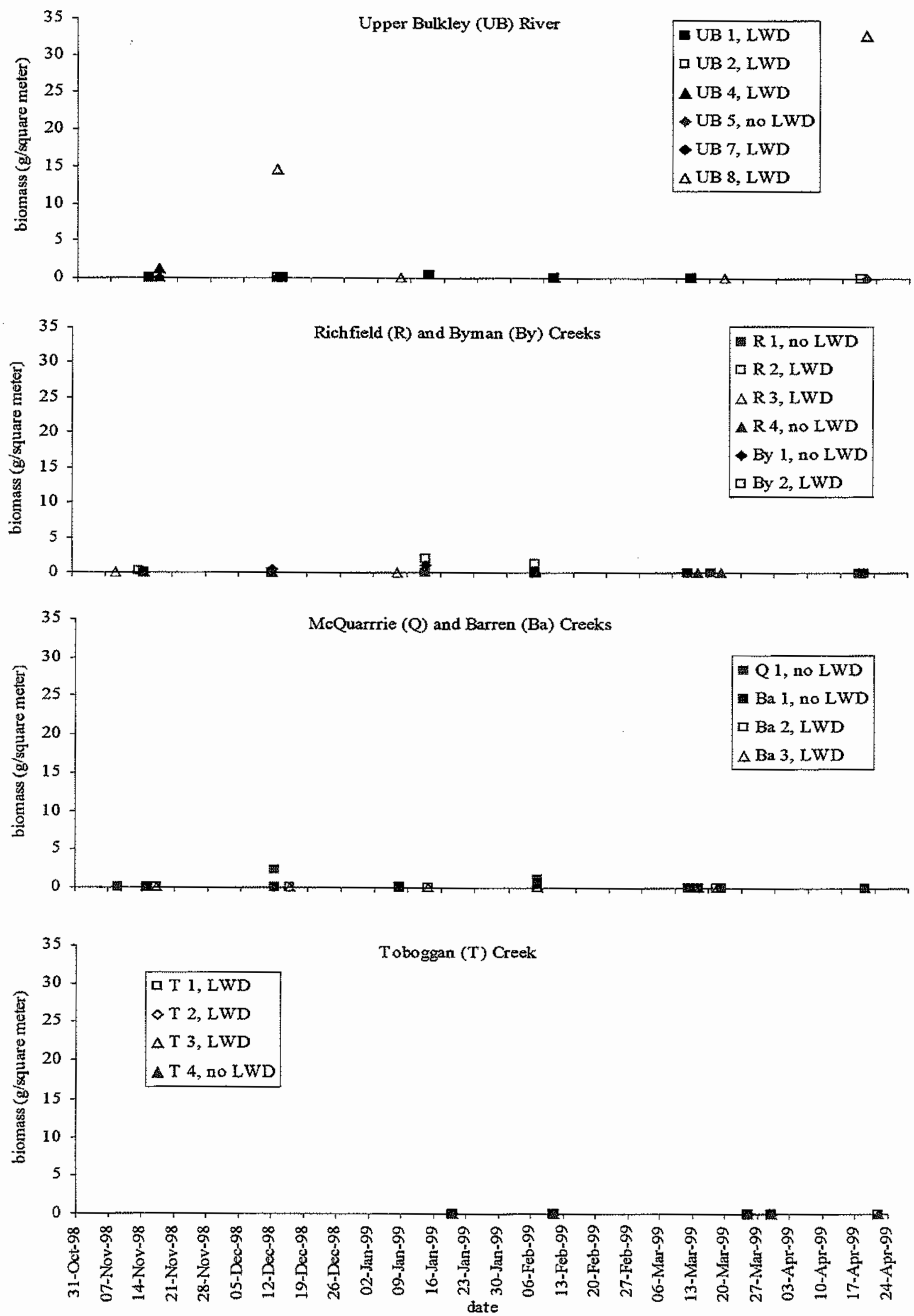


Figure 31. Chinook biomass by unit area (g/m^2) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

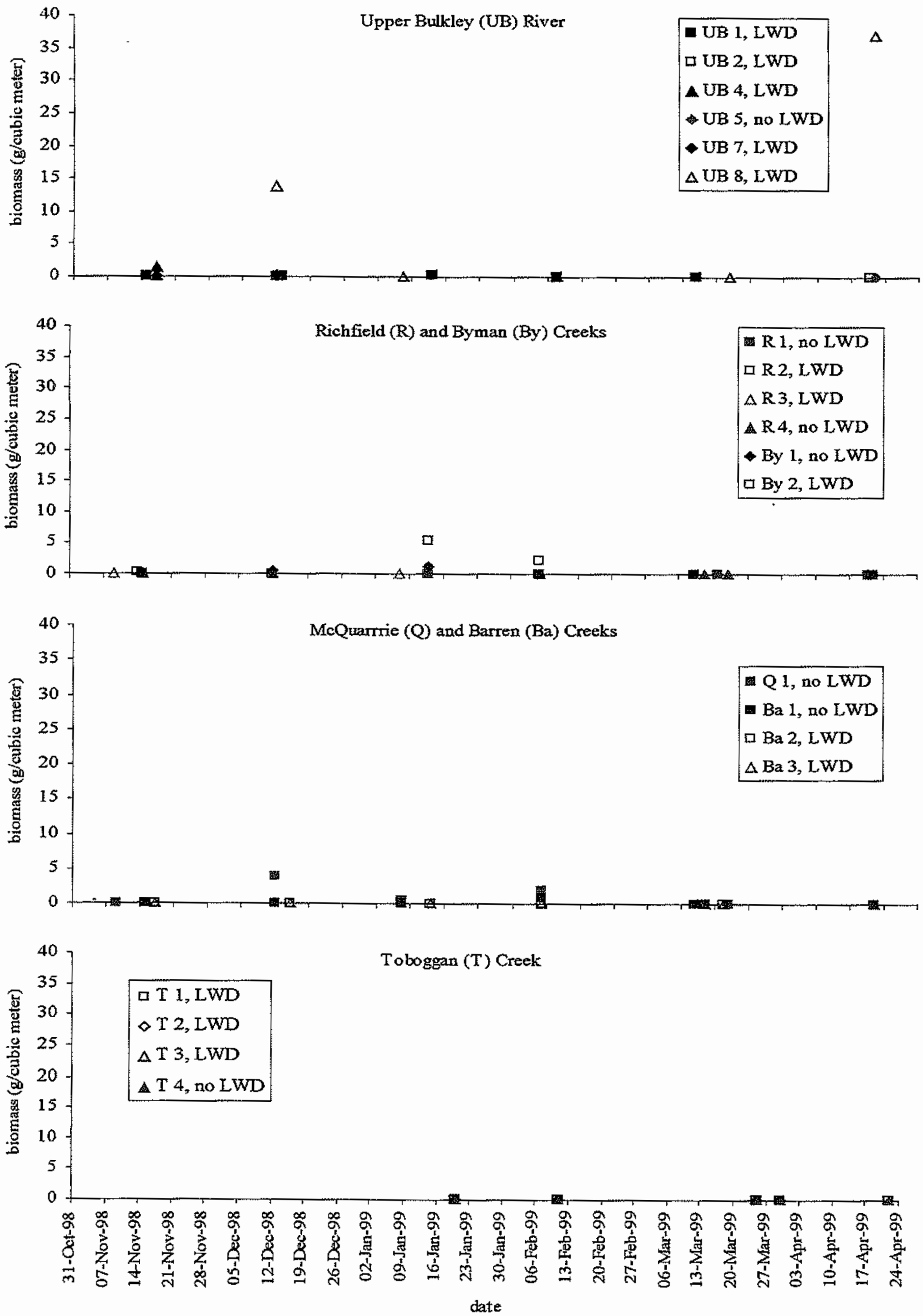


Figure 32. Chinook biomass by unit volume (g/m^3) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

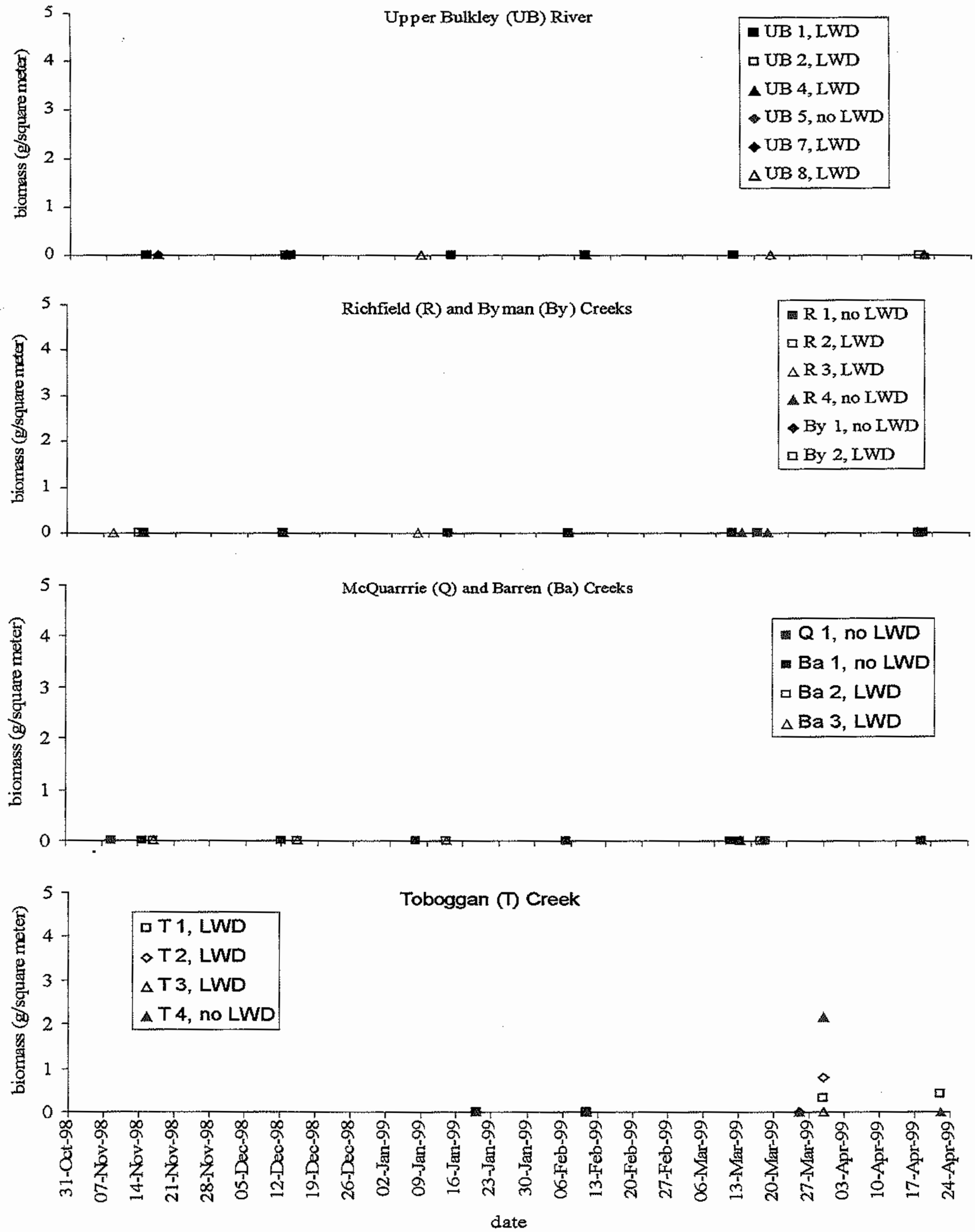


Figure 33. Dolly Varden biomass by unit area (g/m^2) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

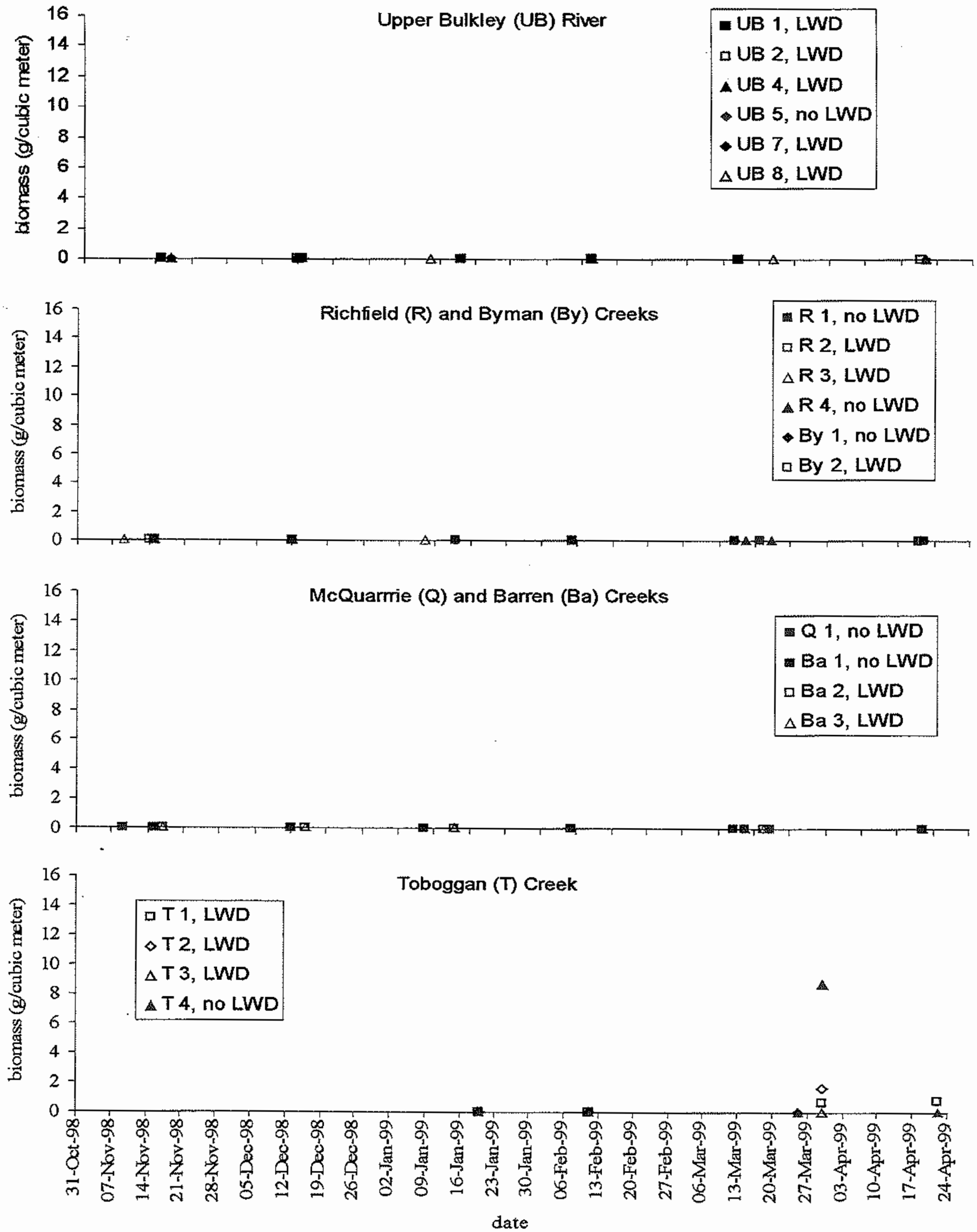


Figure 34. Dolly Varden biomass by unit volume (g/m^3) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

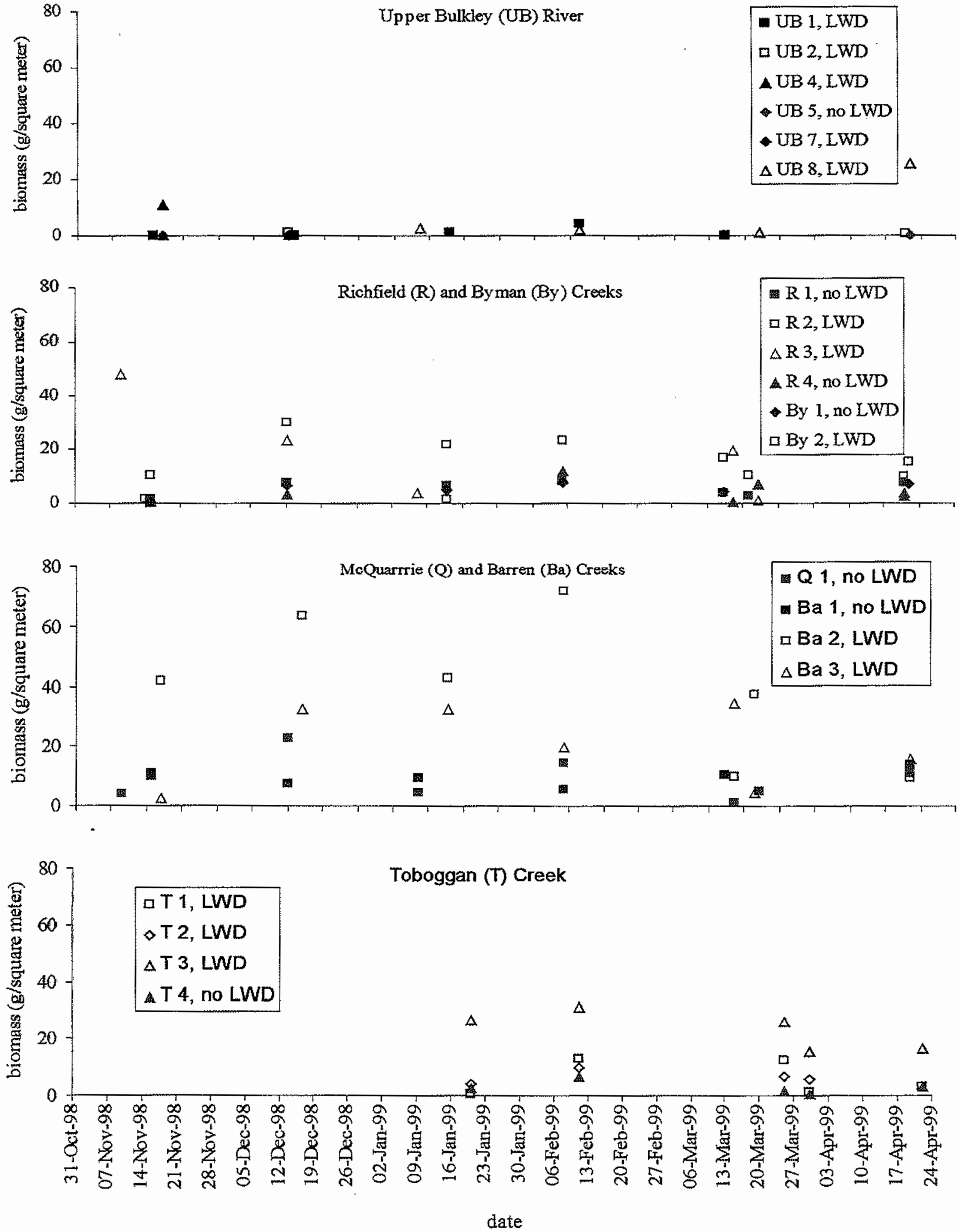


Figure 35. Rainbow trout/steelhead biomass by unit area (g/m^2) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

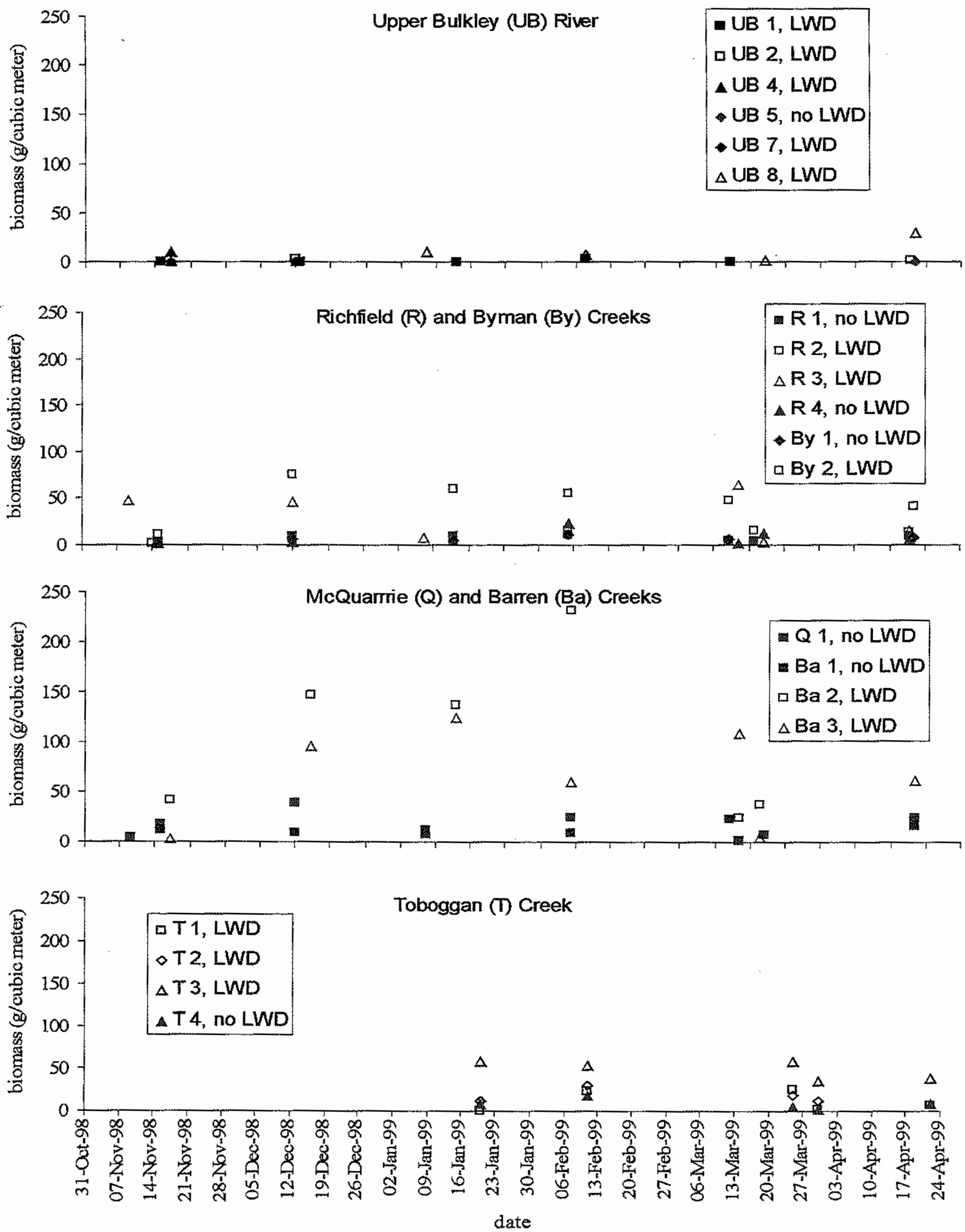


Figure 36. Rainbow trout/steelhead biomass by unit volume (g/m^3) for sites in the Upper Bulkley watershed and at Toboggan Creek. Surface area was not recorded for Buck or Mission creeks.

3.1.3 Fish Survival

Fish survival during the winter is likely contingent on the quality of the habitat. Fish survival is generally difficult to estimate, particularly if a population is open to migration (Ricker 1975, Bagenal 1978). Some of the sites surveyed during the upper Bulkley River overwintering study appear to be open to migration (see Table 3). It is unclear if other sites are closed to migration, or if the effects of migration on adjusted Petersen estimates have been masked in some way.

For closed populations, the number of fish throughout the winter can only decrease, since, by definition, there is no migration, and since there is no recruitment from within the population during the winter (i.e. no births). Habitat that does not deteriorate over the winter, and that is able to sustain fish throughout the winter will show little temporal variation in fish densities. Habitats that deteriorate in quality, and/or are unable to sustain the initial density of fish throughout the winter will exhibit decreases in fish densities, and consequently in catch per unit effort. Site UB 8 exhibited the most drastic decrease in fish abundance from December 1998 to the end of the study. Although this site had the highest adjusted Petersen estimate, the highest overall salmonid biomass, and the highest catch per unit effort at the beginning of the winter, these measures quickly decreased by the middle of January, and remained low for the remainder of the study. This drastic decrease appears to be due to mortality, as a pool exhibiting high fish densities at this site in the beginning of December decreased in water level, and caused high fish mortality (Donas pers. comm). Other sites exhibit some decreases in adjusted Petersen estimates and catch per unit effort. These decreases are relatively low, and may be due to mortality if the sites are closed. Relatively minor fluctuations in catch per unit effort and adjusted Petersen estimates may also be due to chance. Confidence intervals around the Petersen estimates (Appendix 3) show that the estimate is relatively rough. Apparent fluctuations in the data may simply be due to variability at the sites than actual trends which are occurring.

3.1.4 Species Diversity and Species Richness

Species diversity and species richness are likely not good indicators of overall habitat quality, but may be useful measures in determining preferred habitat dependent on the management objectives. If a multi-species management objective is adopted, high species diversity and species richness would be desirable for overwintering habitat. However, if a single species approach is adopted, the habitat supporting only or mainly the target species may be more desirable. Species richness, diversity and evenness are given in Appendix 4, and summarized in Table 8.

Species diversity and species richness appears to be relatively high for sites in the upper Bulkley watershed and at Toboggan Creek compared to values obtained for Mission Creek. Dolly Varden was the most common species at Mission Creek, comprising the majority of the catch. No species other than Dolly Varden were captured at some sites in Mission Creek, accounting for the low species richness, diversity and evenness. Variability in species richness, diversity and evenness was observed between sites and over time. Outside of Mission Creek, the lower species diversity and evenness were observed at site R 1 (Richfield Creek) and Bu 4. High species richness and diversity was observed at some sites where overall fish density was relatively low. For example, the highest species richness was noted at McQuarrie Creek on January 7, 1999, where only 7 fish were captured. The high species richness and diversity indicate a relative homogenous mixture of species, while a low species richness and evenness indicate a community where one species is dominant.

Table 8. Ranges in species richness, diversity and evenness for all sites at which fish were captured during the upper Bulkley River overwintering study.

Site	Species Richness	Species Diversity	Evenness[1]	Species present[2]
UB 1	0 – 2	0 – 0.301	0 – 0.356	CO, RB, CH
UB 2	1 – 2	0 – 0.301	0 – 0.356	CO, RB, CH, BB
UB 3	1 – 2	0 – 0.125	0 – 0.148	CO, RB
UB 4	1 – 3	0 – 0.415	0 – 0.491	CO, RB, CH
UB 5	1 – 2	0 – 0.301	0 – 0.356	CO, RB
UB 6	1 – 2	0 – 0.276	0 – 0.327	CO, RB
UB 7	1 – 2	0 – 0.301	0 – 3.56	CO, RB, CH
UB 8	1 – 3	0 – 0.369	0 – 0.437	CO, RB, CH
R 1	1 – 2	0 – 0.125	0 – 0.148	CO, RB
R 2	1 – 2	0 – 0.206	0 – 0.244	CO, RB, CH
R 3	1 – 2	0 – 0.276	0 – 0.327	CO, RB
R 4	1 – 2	0 – 0.300	0 – 0.355	CO, RB
By 1	1 – 3	0 – 0.330	0 – 0.391	CO, RB, CH
By 2	1 – 3	0 – 2.27	0 – 0.269	CO, RB, CH
Q 1	1 – 3	0 – 0.436	0 – 0.560	CO, RB, CH
Ba 1	2	0.269 - 0.344	0.318 – 0.407	CO, RB
Ba 2	2	0.102 – 0.281	0.121 – 0.332	CO, RB
Ba 3	1 – 2	0 – 0.102	0 – 0.121	CO, RB
Bu 1	0 - 2	0 – 0.300	0 – 0.355	CO, RB
Bu 2	1 – 3	0 – 0.346	0 – 0.409	CO, RB, LNC
Bu 3	1 – 2	0 – 0.300	0 – 0.355	CO, RB
Bu 4	1	0	0	RB
Bu 5	0 - 2	0 – 0.276	0 – 0.327	CO, RB
Bu 6	0 – 2	0 – 0.301	0 – 0.356	CO, RB
T 1	2 – 3	0.102 – 0.400	0.121 – 0.473	CO, RB, DV
T 2	2 – 3	0.263 – 0.284	0.311 – 0.336	CO, RB, DV
T 3	2 – 3	0.152 – 0.426	0.180 – 0.504	CO, RB, DV, CT
T 4	1 – 3	0.130 – 0.403	0.154 - 0.477	CO, RB, DV
M 1	1	0 – 0	0 – 0	DV
M 2	1	0 – 0	0 – 0	DV
M 3	1 – 2	0 – 0.059	0 – 0.698	CO, DV
M 4	1	0 – 0	0 – 0	DV
M 4A	1	0 – 0	0 – 0	DV
M 5	1	0 – 0	0 – 0	DV

[1] Evenness has a maximum value of 1.
[2] Species codes are BB = burbot, LNC = longnose dace, CH = chinook, CO = coho; CT = cutthroat, DV = Dolly Varden, RB = rainbow trout/steelhead

3.2 Factors Determining Overwintering Habitat Quality

Many factors can impact the quality of potential overwintering habitat. Potential factors considered during this overwintering study include:

1. size of overwintering habitat
2. dissolved oxygen,
3. large woody debris and cover,
4. water temperature,
5. ice thickness and snow thickness, and
6. proximity to lakes.

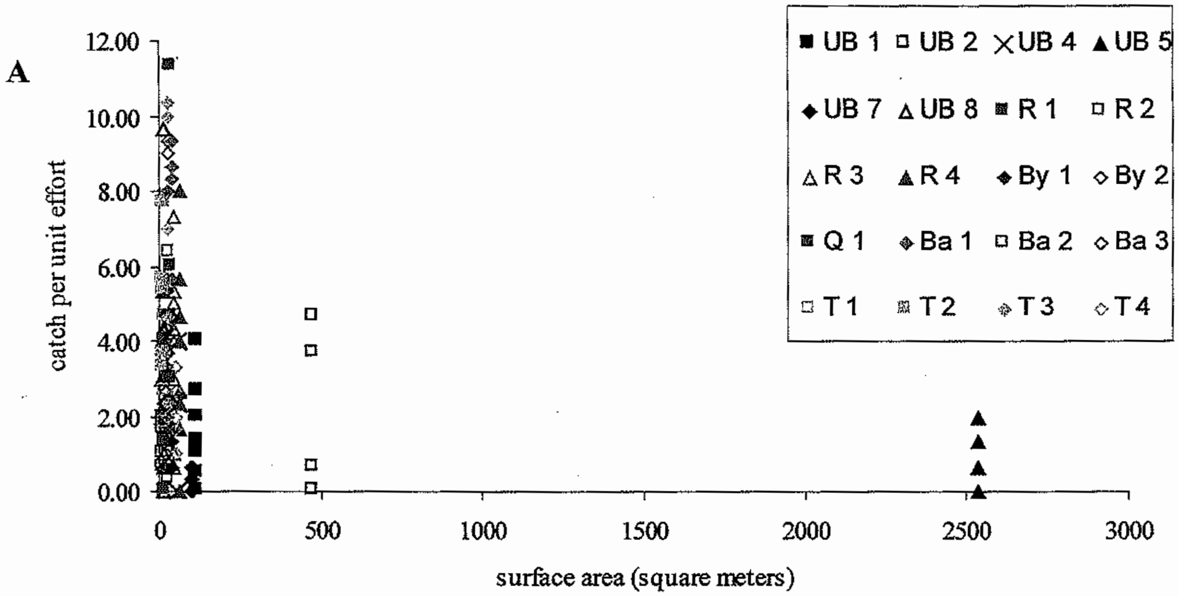
3.2.1 SIZE OF OVERWINTERING HABITAT

The size of the overwintering habitat (surface area, volume) can influence the quality of the habitat, since larger overwintering habitat may be able to support a greater density of fish, with greater species diversity and richness. Small pools may freeze solid, or may suffer severe oxygen depletion. Small pools may also not offer the type of habitat diversity suitable for supporting a higher density and variety of fish.

Catch per unit effort is variable among sites of different surface area, and within sites of the same surface area. Figure 37 illustrates that, overall, catch per unit effort appears to decrease at large surface areas (greater than 500 m^2). Most of the sites had lower surface areas, however. Removal of the two sites with the greatest surface areas (sites UB 2 and UB 5) indicates that, at lower surface areas (below 60 square meters), catch per unit effort appears to vary little with increasing surface areas. Sites with moderate surface areas did, however exhibit a lower catch per unit effort (e.g. sites UB 1 and UB 7). The same trends are observed when coho catch per unit effort is compared among sites with different surface area (Figure 38). Variations of catch per unit effort with volume at the sample site are similar to that of catch per unit effort and surface area (Appendix 4). The decreased catch per unit effort with increased surface areas over 60 square meters may be due to sampling methodology rather than actual changes in fish abundance.

Estimated population size also appeared to decrease at sites with larger surface areas (Figure 39). The estimated number of coho at each site also appears to decrease with increasing surface area of the site. Since the estimation of population size is partly dependent on the catchability of fish at different size, and the size of catches during marking and recapture sampling, the two measures of population size are not independent of one another. As with catch per unit effort, adjusted Petersen estimates, estimated number of coho, and biomass appear to decrease with increase surface area.

Depth appears to have little affect on either catch per unit effort or the estimates populations size at the sites sampled in the upper Bulkley watershed and Toboggan Creek (Figure 40). Both catch per unit effort, and the adjusted Petersen estimate fluctuated at depths less than 1 meter. However, at sites with depths considerably greater than 1 meter, catch per unit effort and the adjusted Petersen estimate decreased.



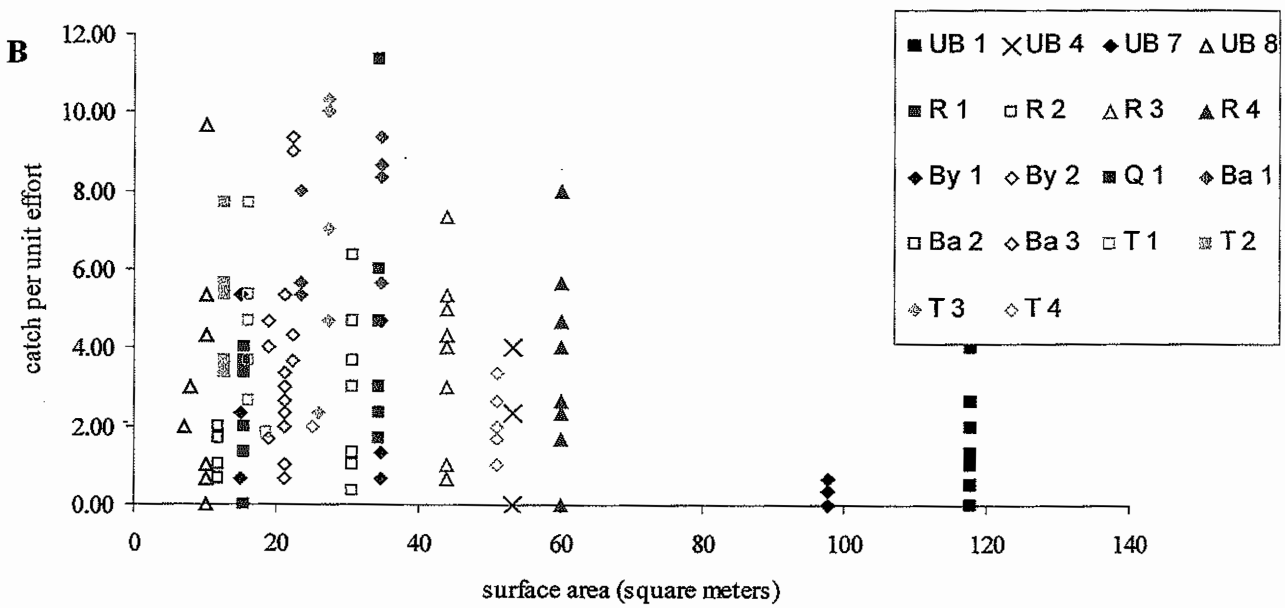
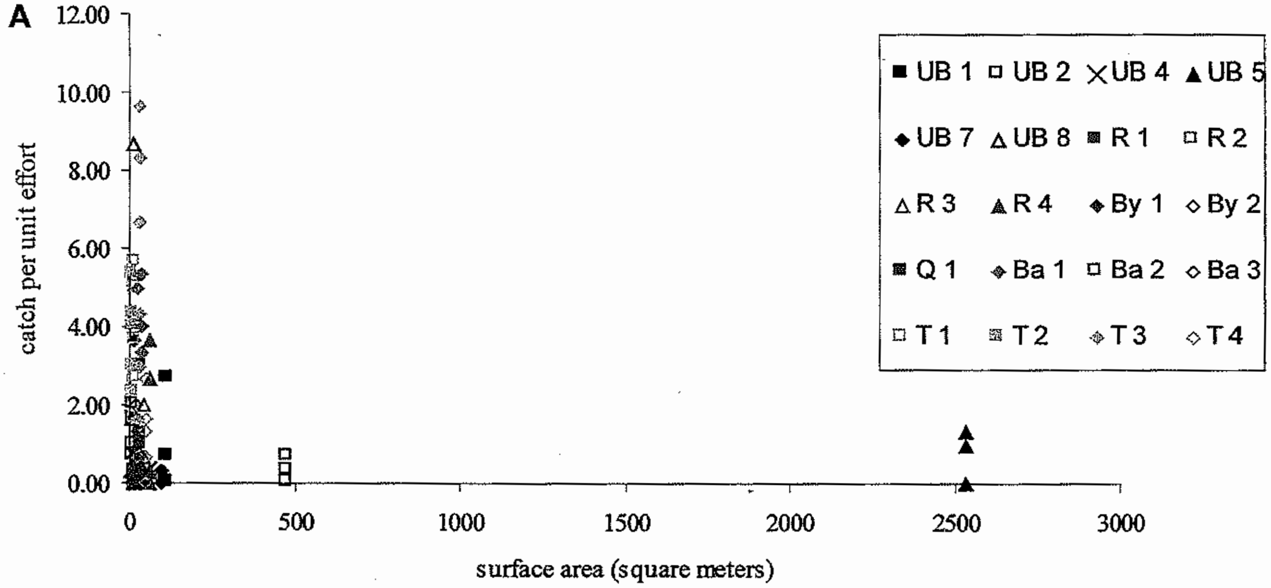


Figure 37. Catch per unit effort versus surface area of site for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Graph A illustrates all sites, while graph B illustrates the sites with surface areas below 500 square meters. Trend line has been fitted by eye.



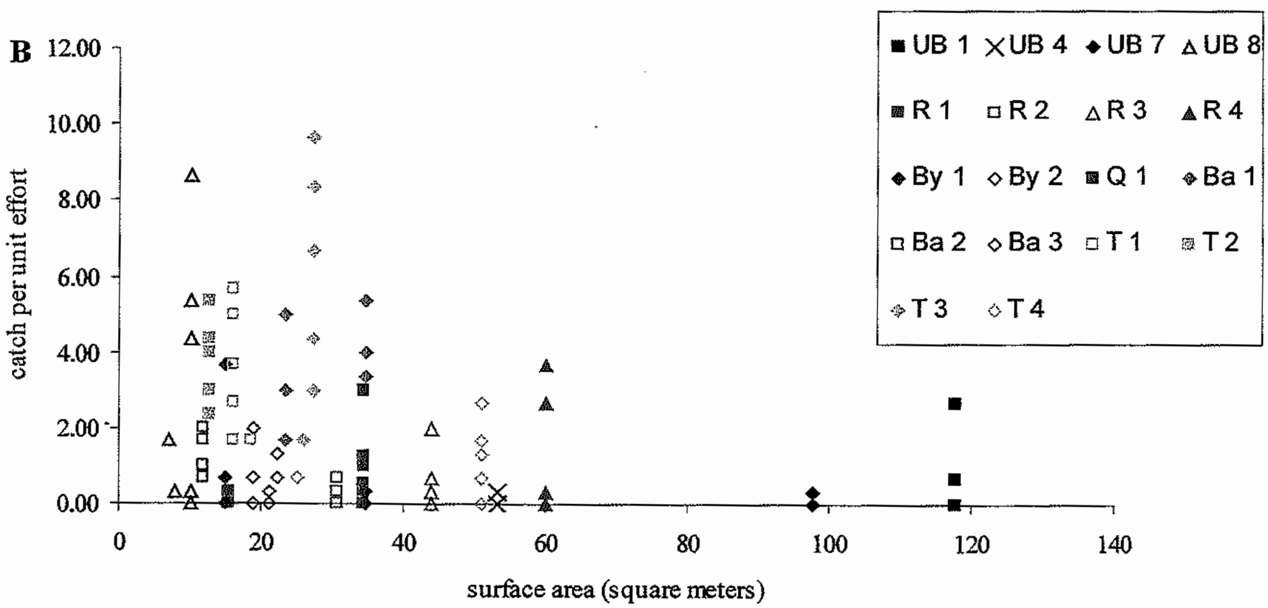
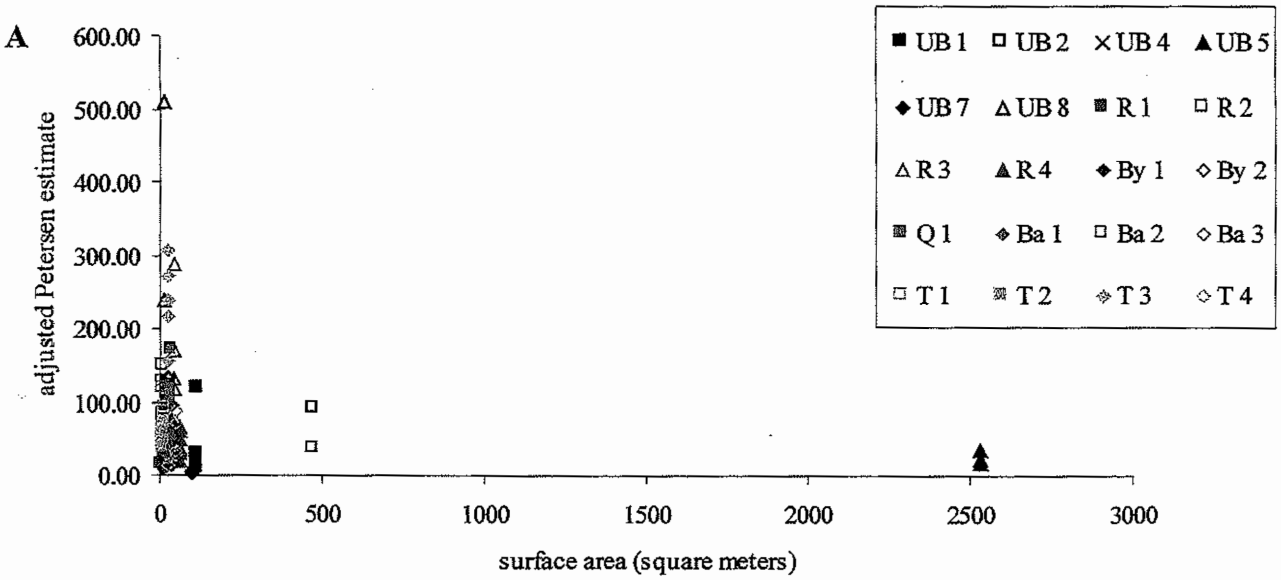


Figure 38. Coho catch per unit effort versus surface area of site for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Graph A illustrates all sites, while graph B illustrates the sites with surface areas below 100 square meters. Trend line has been fitted by eye.



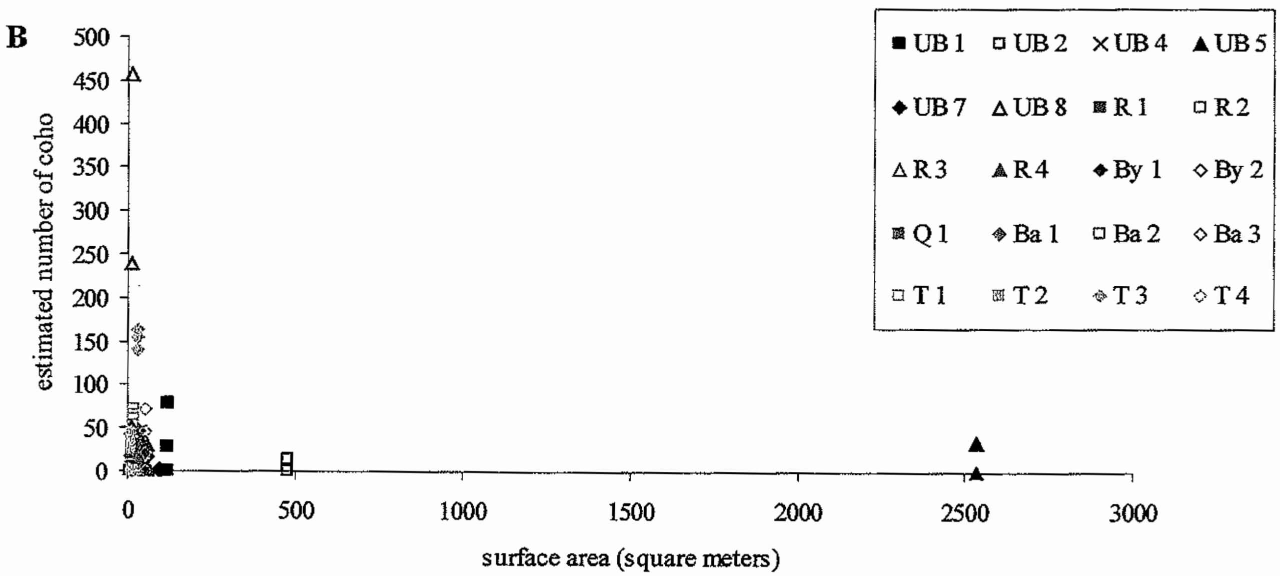
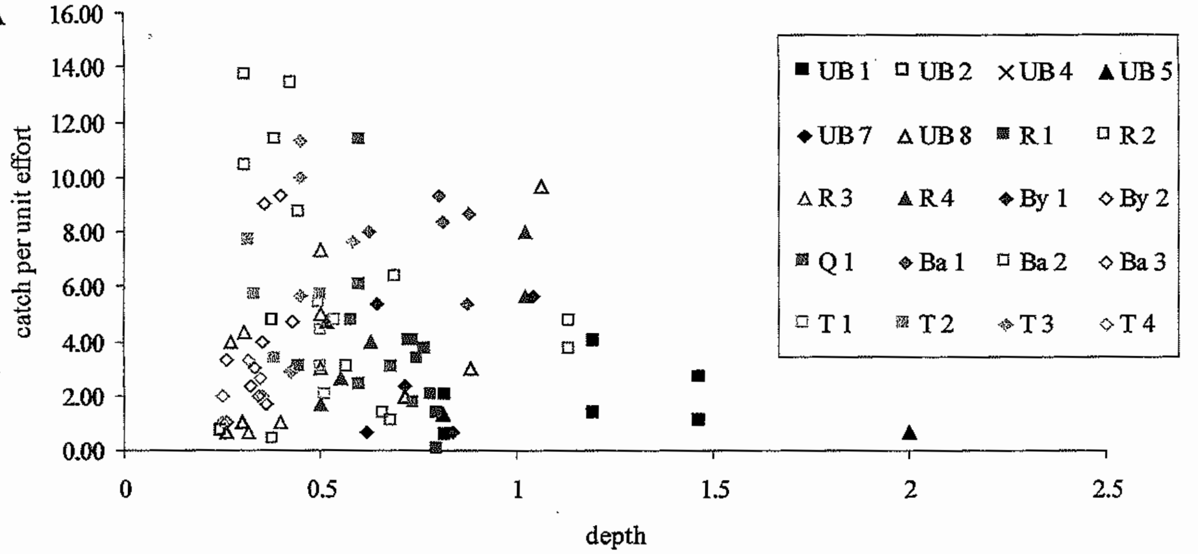


Figure 39. Adjusted Petersen estimate (A) and estimated number of coho (B) versus surface area of site for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Trend line has been fitted by eye.

A



B

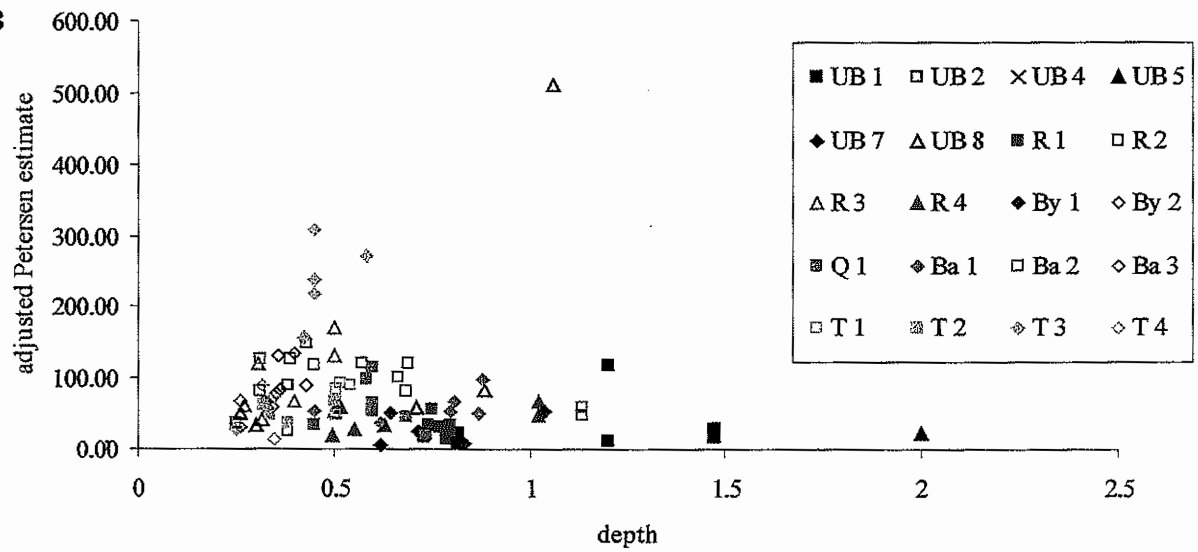
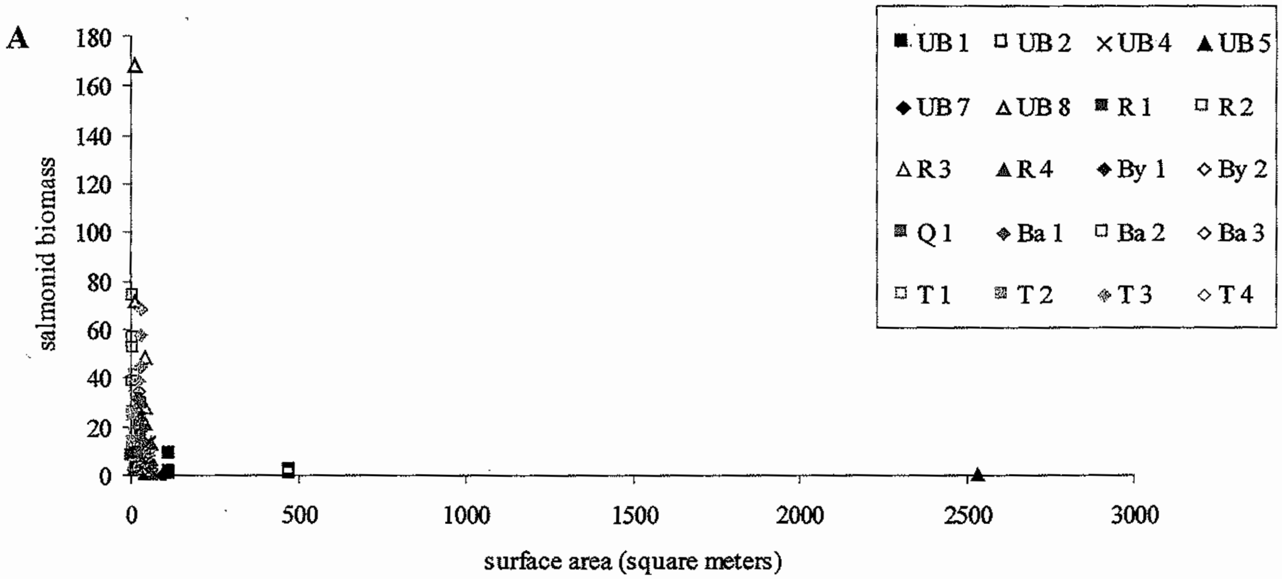


Figure 40. Catch per unit effort (A) and adjusted Petersen estimate (B) versus depth of site for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Trend line has been fitted by eye

Weights of salmonids appeared to vary little over time or between sites (Figures 20 to 25). Therefore, it is not surprising to find that the trends of catch per unit effort and adjusted Petersen estimates are mirrored by biomass (Figure 41). Biomass also appears to be relatively similar among sites with a surface area less than 100 square meters, but decreases at sites with surface areas greater than 100 square meters.

Species diversity appears to be variable between sites, regardless of surface area (Figure 42). Species diversity at sites with lower surface area spans approximately the same range as at sites with higher surface area. However, certain species (e.g. chinook) appear to be captured more frequently at sites with greater surface area (Table 8, Figure 42).



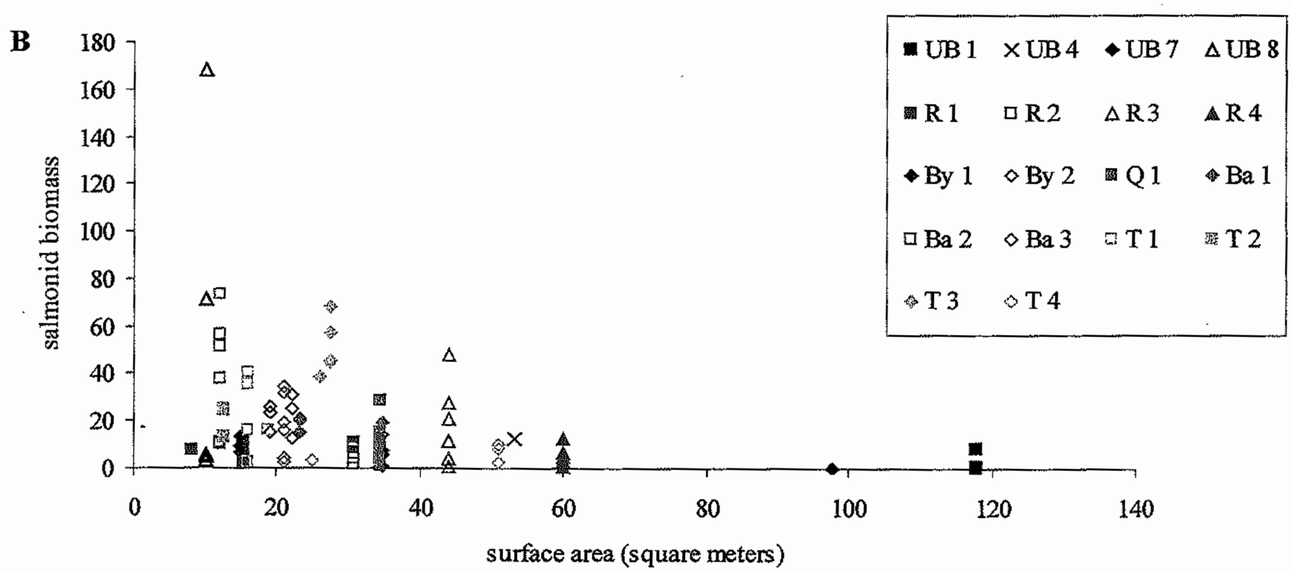


Figure 41. Salmonid biomass versus surface area of site for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Graph A illustrates all sites sampled, while graph B illustrates sites with surface areas of less than 500 square meters. Trend line has been fitted by eye.

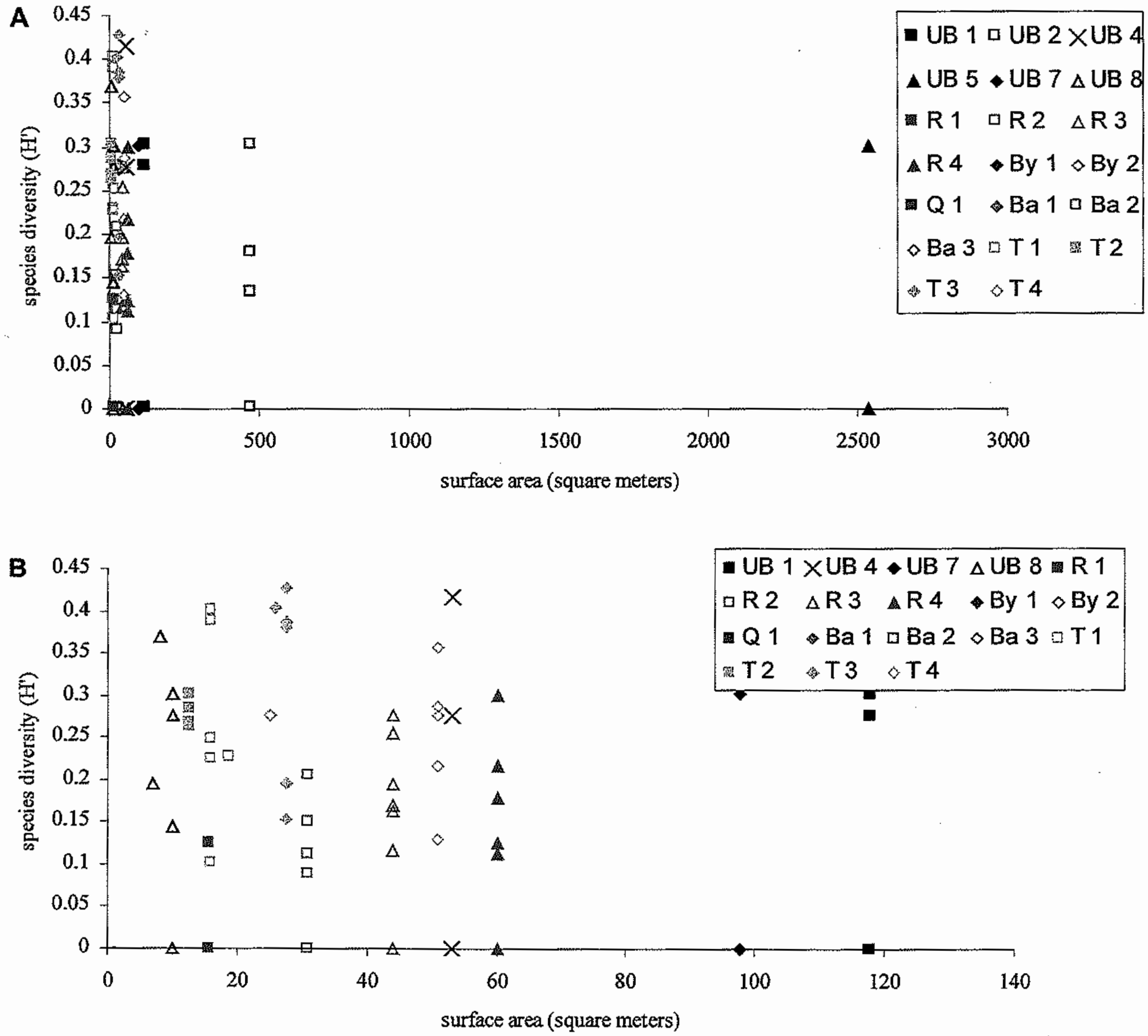


Figure 42. Species diversity (H') versus surface area of site for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Graph A illustrates all sites sampled, while graph B illustrates sites with surface areas of less than 500 square meters.

3.2.2 Dissolved Oxygen

Dissolved oxygen is likely a factor that limits the suitability of several sites for overwintering. Salmonids are sensitive to the concentration of dissolved oxygen in the water. Low oxygen concentrations will result in mortality (e.g. winterkill), and render overwintering habitat unsuitable.

Oxygen concentrations were recorded in March and April 1999 at sites sampled. Oxygen concentrations appeared to have little influence on catch per unit effort of all species, or of coho at the sites sampled (Figure 43). Adjusted Petersen estimate, and the estimated number of coho at sample sites also appears to be relatively independent of oxygen readings obtained at the sites in March and April (Appendix 4). Fish density and biomass (Appendix 4) are variable among sites, but oxygen concentration does not appear to explain this variability. Oxygen concentration in March and April also appears to have little influence on species diversity (Appendix 4). This is not surprising, since ice cover at most of the sites was significantly reduced in March and April, allowing ambient oxygen to replenish oxygen levels in the water. Although there does not appear to be a correlation between dissolved oxygen concentrations in March and April and catch per unit effort, density, biomass or species diversity, dissolved oxygen just prior to ice off may influence species abundance and presence at the sample sites.

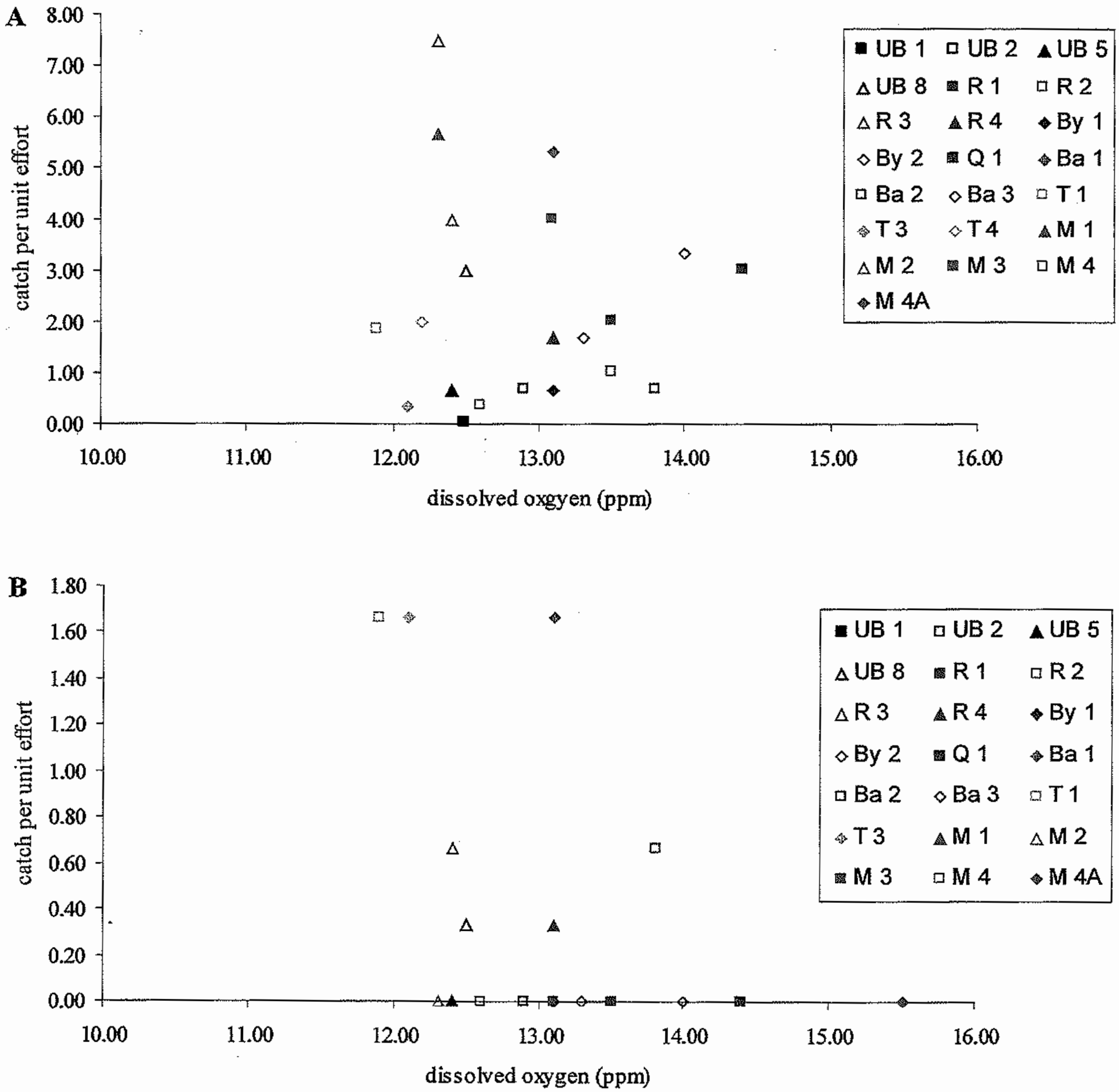


Figure 43. Overall catch per unit effort (A) and coho catch per unit effort (B) versus dissolved oxygen for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks.

3.2.3 Large Woody Debris and Cover

Large woody debris (LWD) and structural diversity of the overwintering habitat increase habitat quality by offering cover and potential food sources/nutrient inputs. Comparisons of sites with and without LWD included comparisons of catch per unit effort, adjusted Petersen estimates, density, biomass, and species diversity. Mission Creek sites were excluded from the analysis since the presence of LWD has not been reported for these sites.

Sites with large woody debris appear to have a slightly higher species richness than sites without large woody debris (Table 9). However, all species found at sites with LWD, except burbot, were also found at sites without LWD. This indicates that no species is entirely dependent on the presence of LWD for overwintering. It is important to consider that LWD is not the only source of cover at pools. Overhanging vegetation, ice, boulders, pool depth, cutbanks, and other factors can add to habitat complexity and provide cover. Species richness may differ substantially at sites with and without cover if other sources of cover are also taken into consideration.

Catch per unit effort for all species, and catch per unit effort for coho appears to be slightly higher at sites with LWD than at sites without LWD (Figure 48). Comparisons of sites with and without LWD in the upper Bulkley watershed and at Toboggan Creek indicates that sites with LWD have a significantly higher overall catch per unit effort for all species ($t = -2.175$, $p = 0.015$) (Table 10). However, catch per unit effort for coho did not appear to differ significantly between sites with and without LWD ($t = -1.449$, $p = 0.074$) (Table 10). Exclusion of Toboggan Creek sites indicate that neither catch per unit effort for all species nor coho catch per unit effort differ significantly (Table 10).

The adjusted Petersen estimate and the estimated number of coho at sites with LWD appears to be slightly higher than for sites without LWD (Figure 49). The same trend is observed for fish and coho densities (Figure 50) and salmonid and coho biomass (Figure 51). Variations in species diversity (Figure 52) do not appear to be explained by the presence or absence of LWD.

Table 9. Species captured for sites sampled with and without large woody debris (LWD) in the Upper Bulkley River overwintering study.

	Site	Description	Species captured at site throughout study
sites with LWD	UB 1	pool with LWD	CO, RB, CH
	UB 2	log jam	CO, RB, CH, BB
	UB 3	pool with LWD	CO, RB
	UB 4	log jam	CO, RB, CH
	UB 6	log jam	CO, RB
	UB 7	pool with LWD	CO, RB, CH
	UB 8	LWD	CO, RB, CH
	R 2	LWD	CO, RB, CH
	R 3	LWD	CO, RB
	By 2	pool with LWD	CO, RB, CH
	Ba 2	LWD	CO, RB
	Ba 3	LWD	CO, RB
	Bu 1	LWD	CO, RB
	Bu 3	LWD	CO, RB
	Bu 5	LWD	CO, RB
	Bu 6	pool above beaver dam	CO, RB
	T 1	pool with LWD	CO, RB, DV
	T 2	pool with LWD	CO, RB, DV
	T 3	pool with LWD	CO, RB, DV, CT
sites without LWD	UB 5	pool, no LWD noted	CO, RB
	R 1	pool, no LWD	CO, RB
	R 4	pool, no LWD	CO, RB
	Q 1	culvert pool, no LWD noted	CO, RB, CH
	By 1	pool, no LWD	CO, RB, CH
	Ba 1	culvert pool, no LWD noted	CO, RB
	Bu 2	pool, no LWD noted	CO, RB, LNC
	Bu 4	pool, no LWD noted	RB
	T 4	pool, no LWD	CO, RB, DV

Table 10. Summary of catch per unit effort for sites with and sites without LWD sampled during the Bulkley overwintering study. Mission Creek sites were excluded from the analysis since LWD presence was not recorded.

	sites with LWD			sites without LWD			F- test			t-test			
	Mean	**SD**	**n**	**Mean**	**SD**	**n**	**F**	**df**	**P**	**t**	**df**	**P**	**comments**
all species	3.79	3.434	121	2.84	2.523	70	0.539	69	0.002	-2.175	181	0.015	includes Toboggan
coho	1.15	1.910	121	0.80	1.353	70	0.501	69	0.001	-1.449	181	0.074	includes Toboggan
all species	3.16	3.021	98	2.91	2.619	64	0.751	63	0.112	0.462	160	0.322	excludes Toboggan
coho	0.67	1.263	98	0.77	1.389	64	1.203	63	0.204	0.462	160	0.322	excludes Toboggan

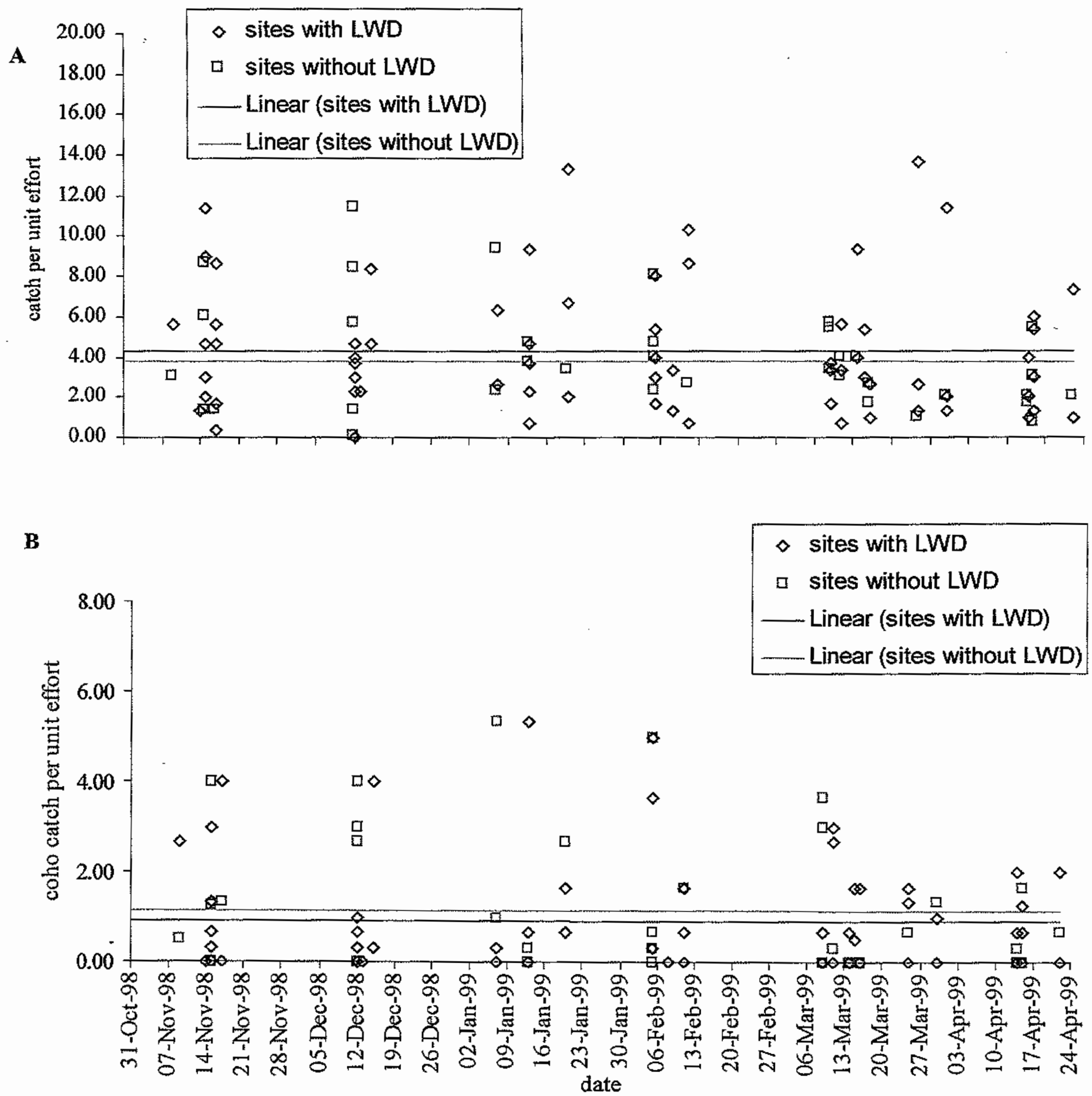


Figure 48. Catch per unit effort for all species (A) and coho catch per unit effort (B) at sites with and without LWD for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Mission Creek was not included in the analysis, since the presence of LWD has not been documented.

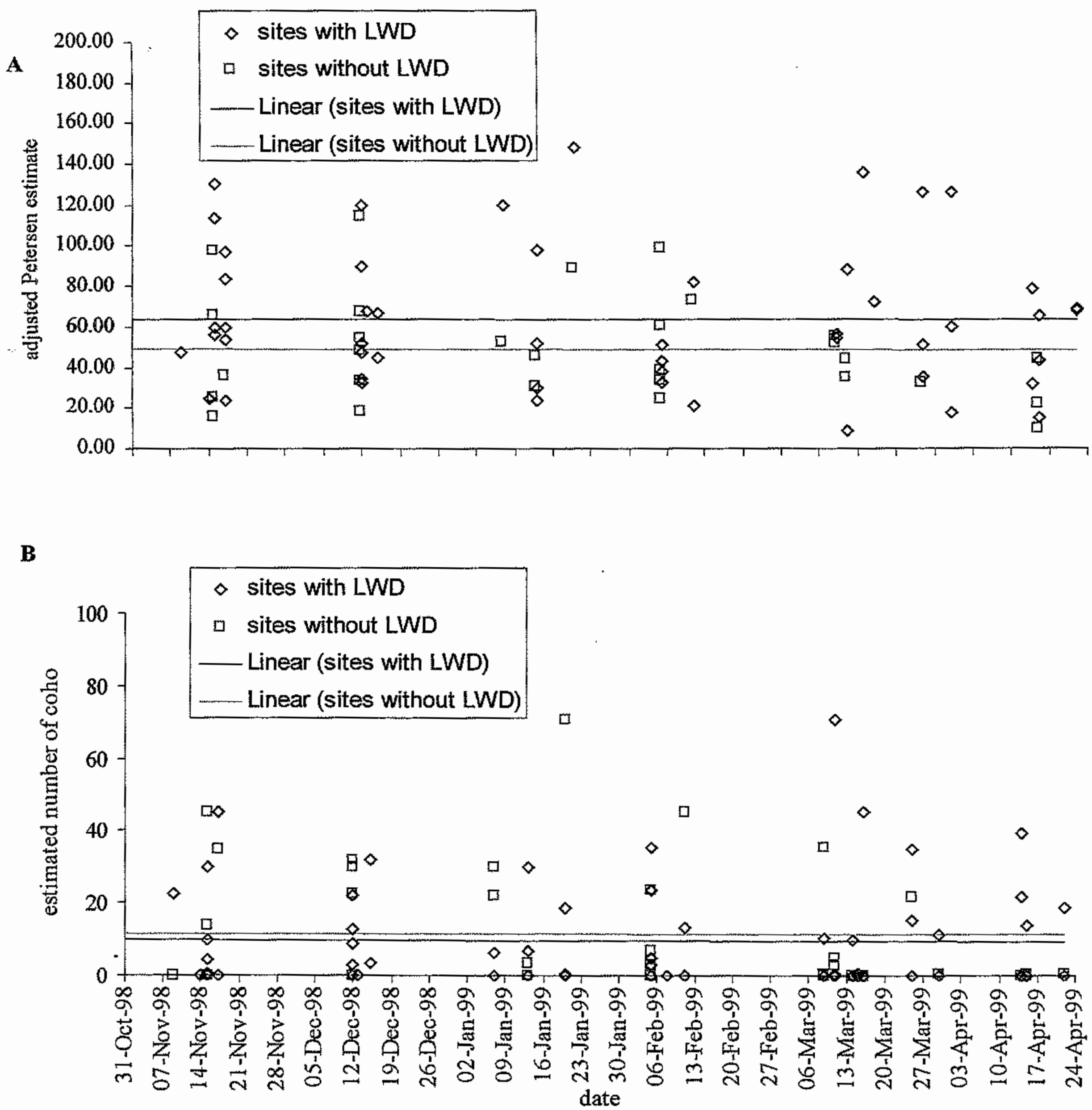


Figure 49. Adjusted Petersen estimate (A) and the estimated number of coho (B) at sites with and without LWD for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Mission Creek was not included in the analysis, since the presence of LWD has not been documented.

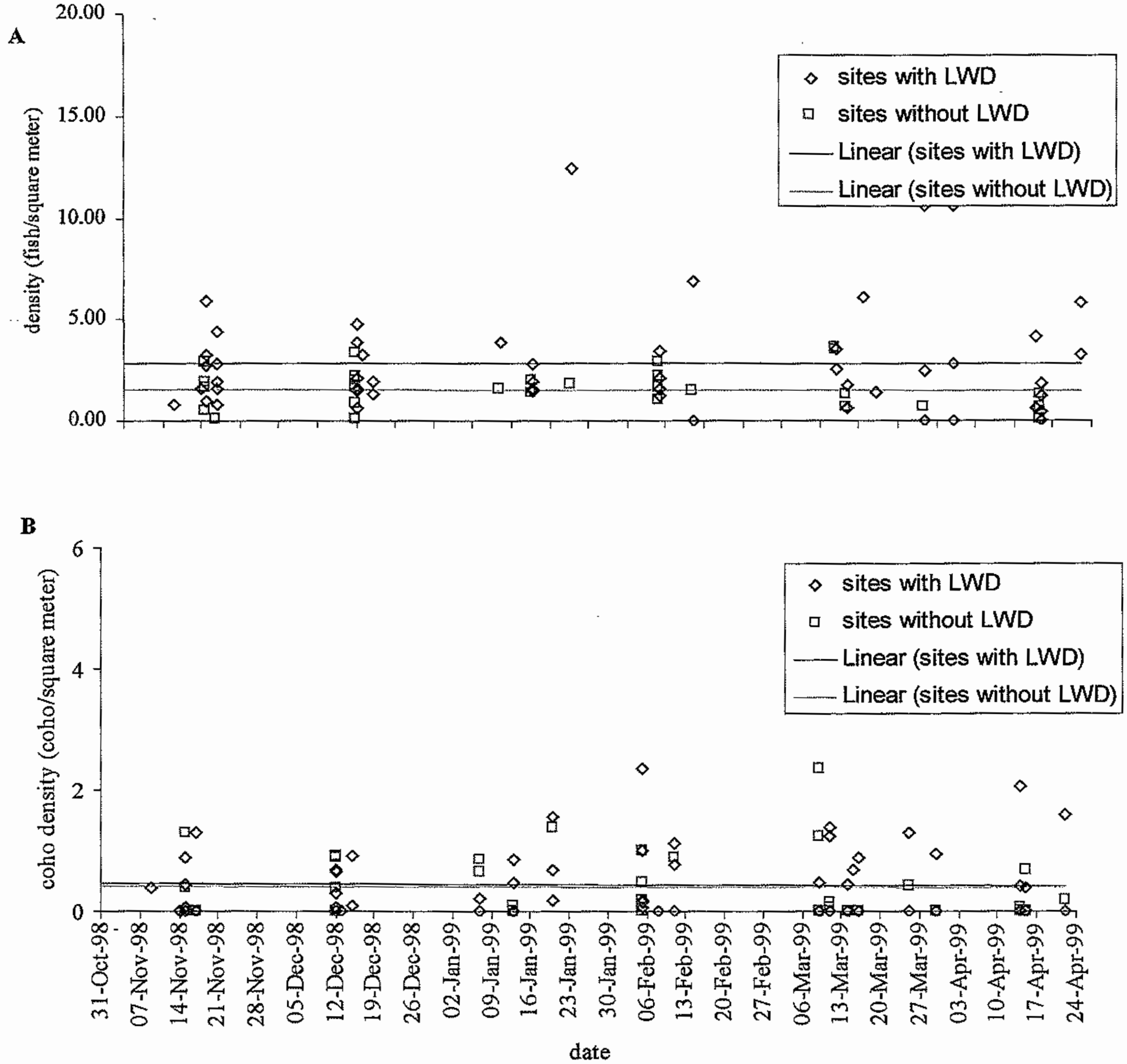


Figure 50. Fish density (A) and coho density (B) at sites with and without LWD for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Mission Creek was not included in the analysis, since the presence of LWD has not been documented.

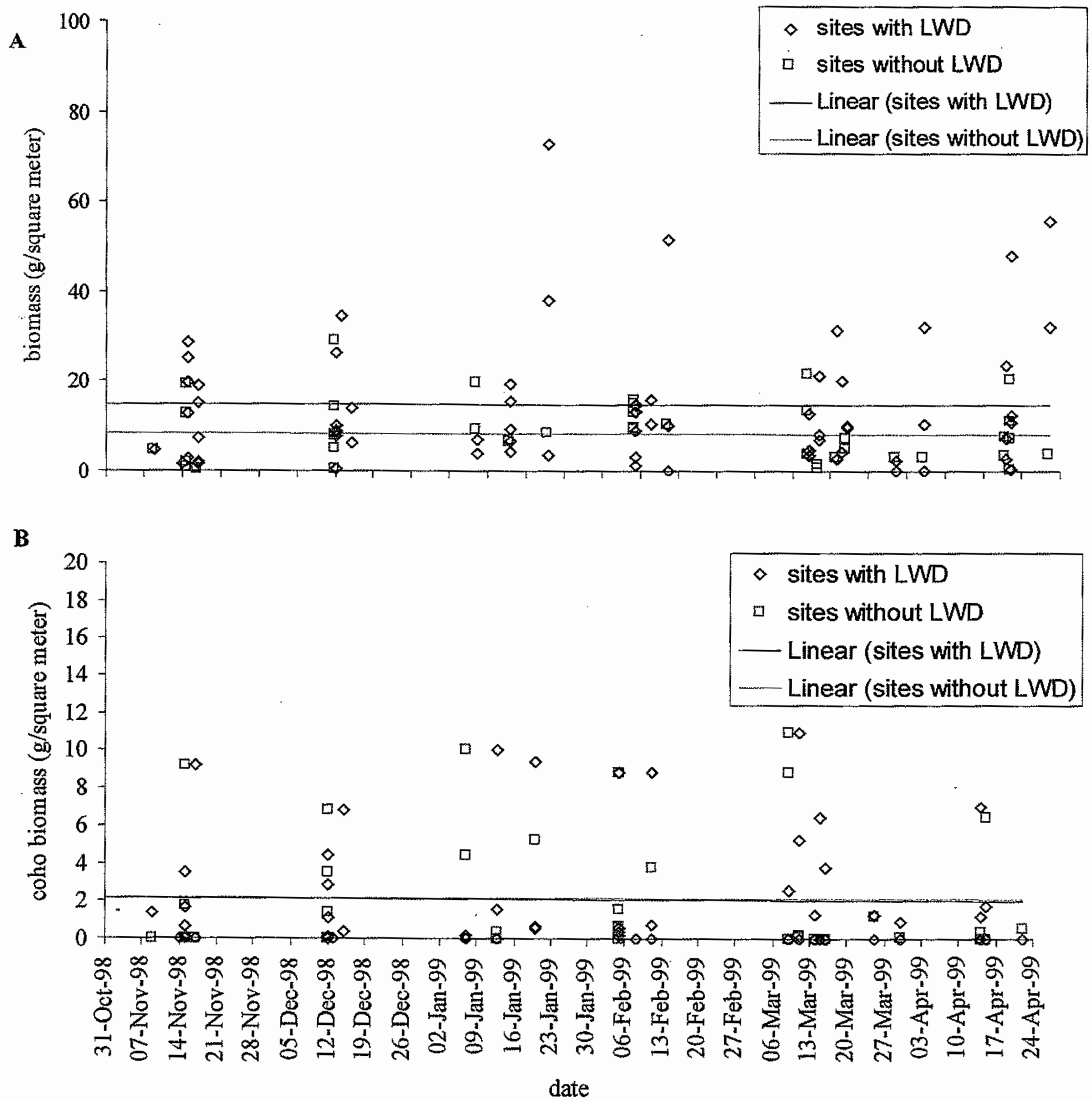


Figure 51. Salmonid biomass (A) and coho biomass (B) at sites with and without LWD for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Mission Creek was not included in the analysis, since the presence of LWD has not been documented.

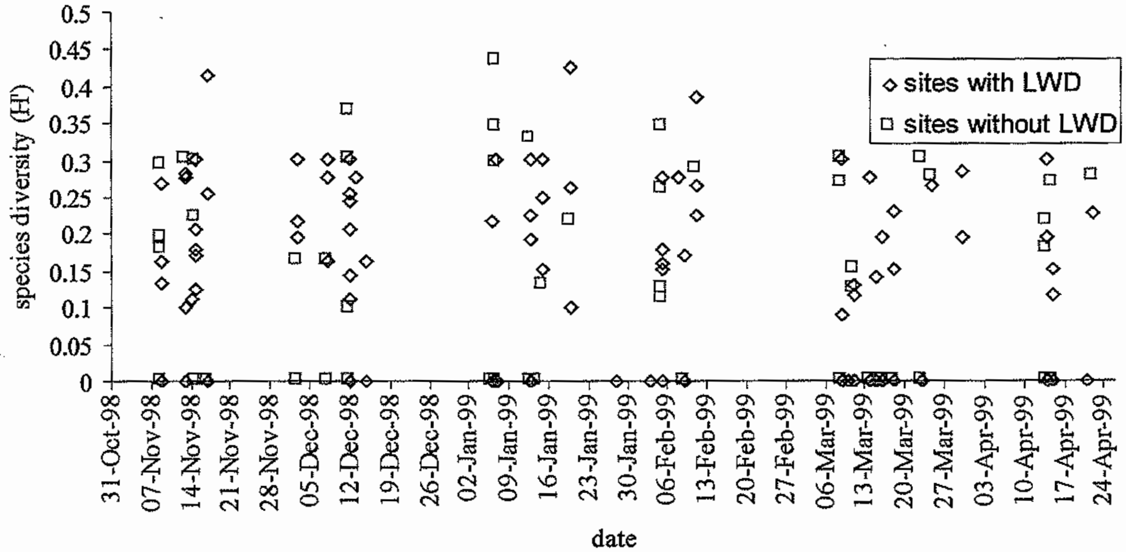
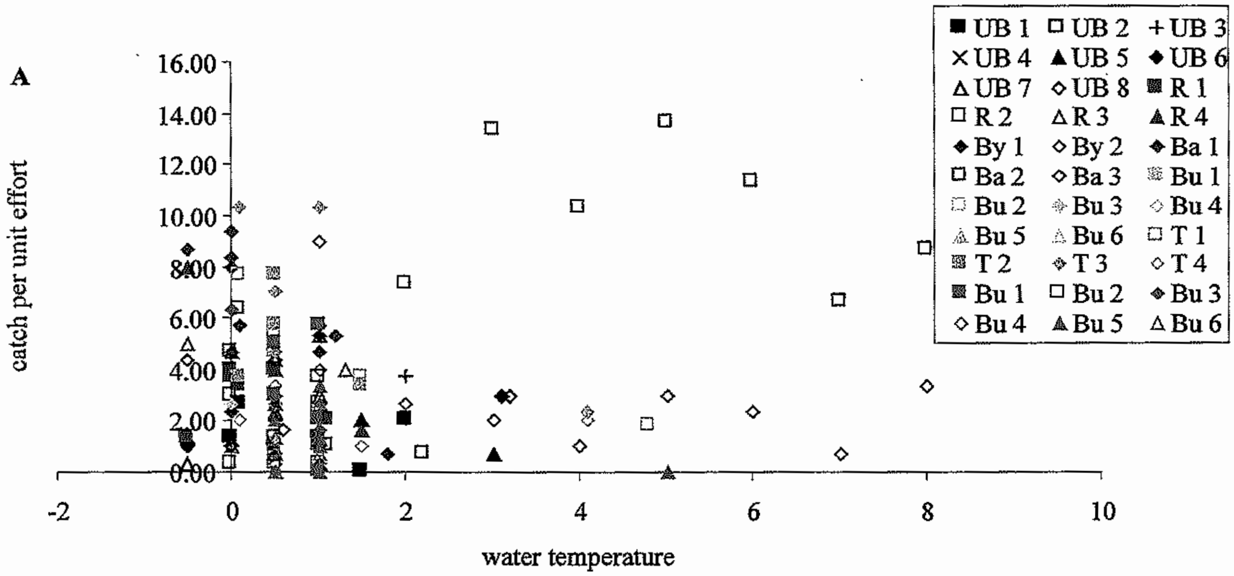


Figure 52. Species diversity (H') at sites with and without LWD for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Mission Creek was not included in the analysis, since the presence of LWD has not been documented.

3.2.4 WATER TEMPERATURE

Salmonids require a minimum temperature to be maintained. Temperatures below the minimum make some habitats unsuitable for overwintering. No fish were captured at water temperatures below -1°C (Figure 53). Catch per unit effort of all fish and for coho in particular appears to be relatively consistent between temperatures of 0 and 3 $^{\circ}$ C (Figure 53). Adjusted Petersen estimates, and estimated number of coho (Figure 54) also appear to be relatively consistent across this range of temperatures. Densities and biomass for salmonids and coho also appear to be independent of temperatures (Figures 55 and 56). However densities, catch per unit effort, population size and biomass appear to decline somewhat with higher temperatures. This coincides with increasing temperatures during the early spring, and may be due to spring migration of juvenile fish rather than the quality of the overwintering habitat. Species diversity also varies little for the majority of the temperatures recorded, but diversity appears to be reduced at higher temperatures (Figure 57). Decreases in species diversity at higher temperatures may also be due to species specific migration of juveniles. Water temperatures below -1°C appear to be unsuitable for overwintering salmonids, while, moderate winter water temperatures appear to have little affect on overwintering habitat quality.



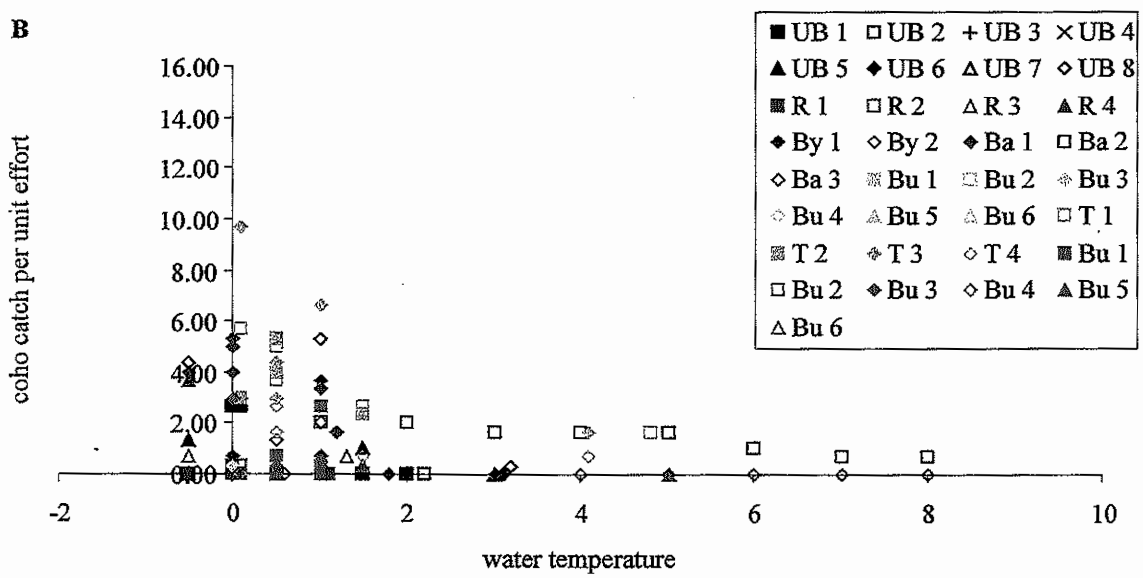


Figure 53. Catch per unit effort for all species (A) and coho catch per unit effort (B) versus water temperature for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks.

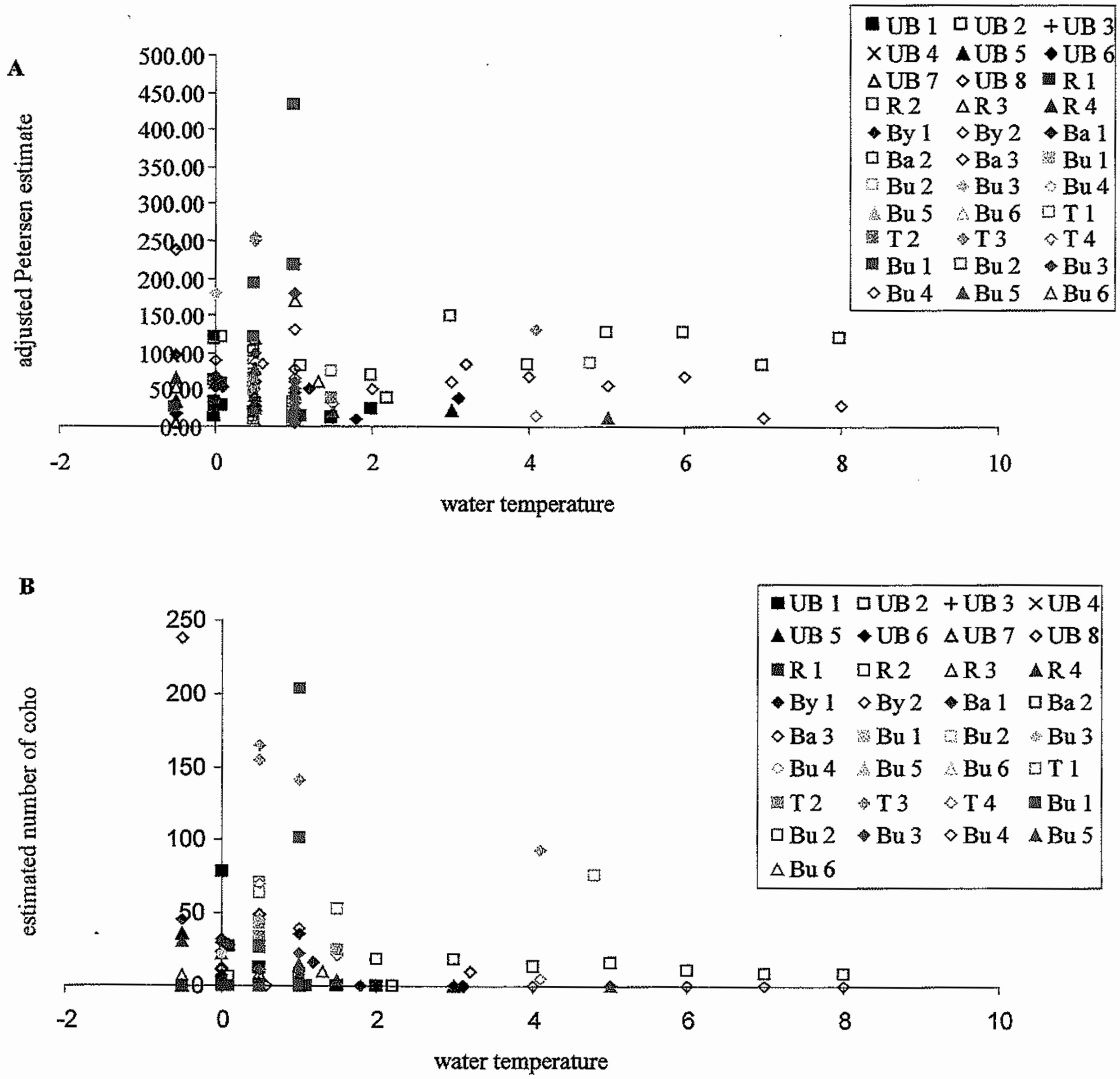


Figure 54. Adjusted Petersen estimate (A) and estimated number of coho (B) versus water temperature for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks.

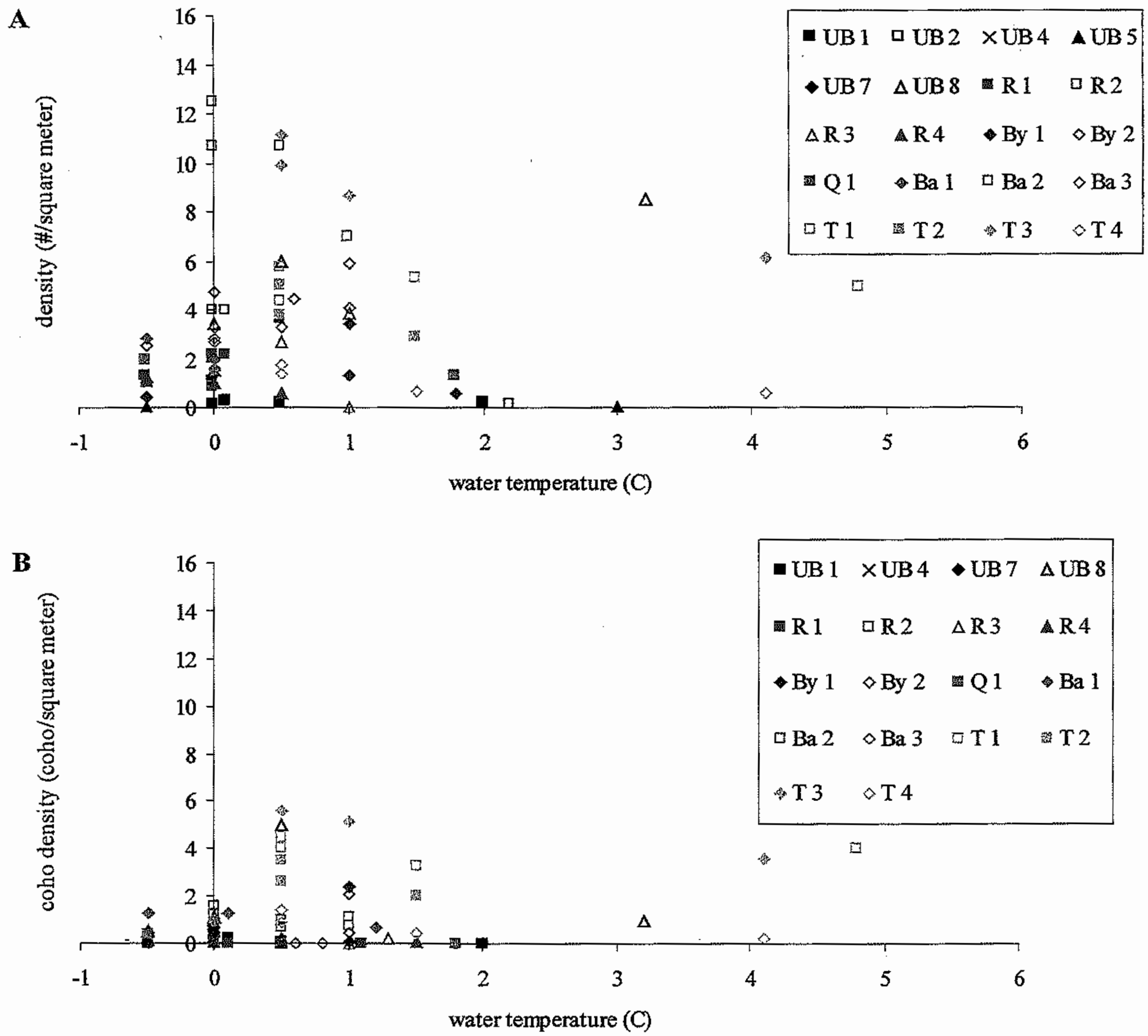


Figure 55. Fish density (A) and coho density (B) versus water temperature for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Trend line was fitted by eye.

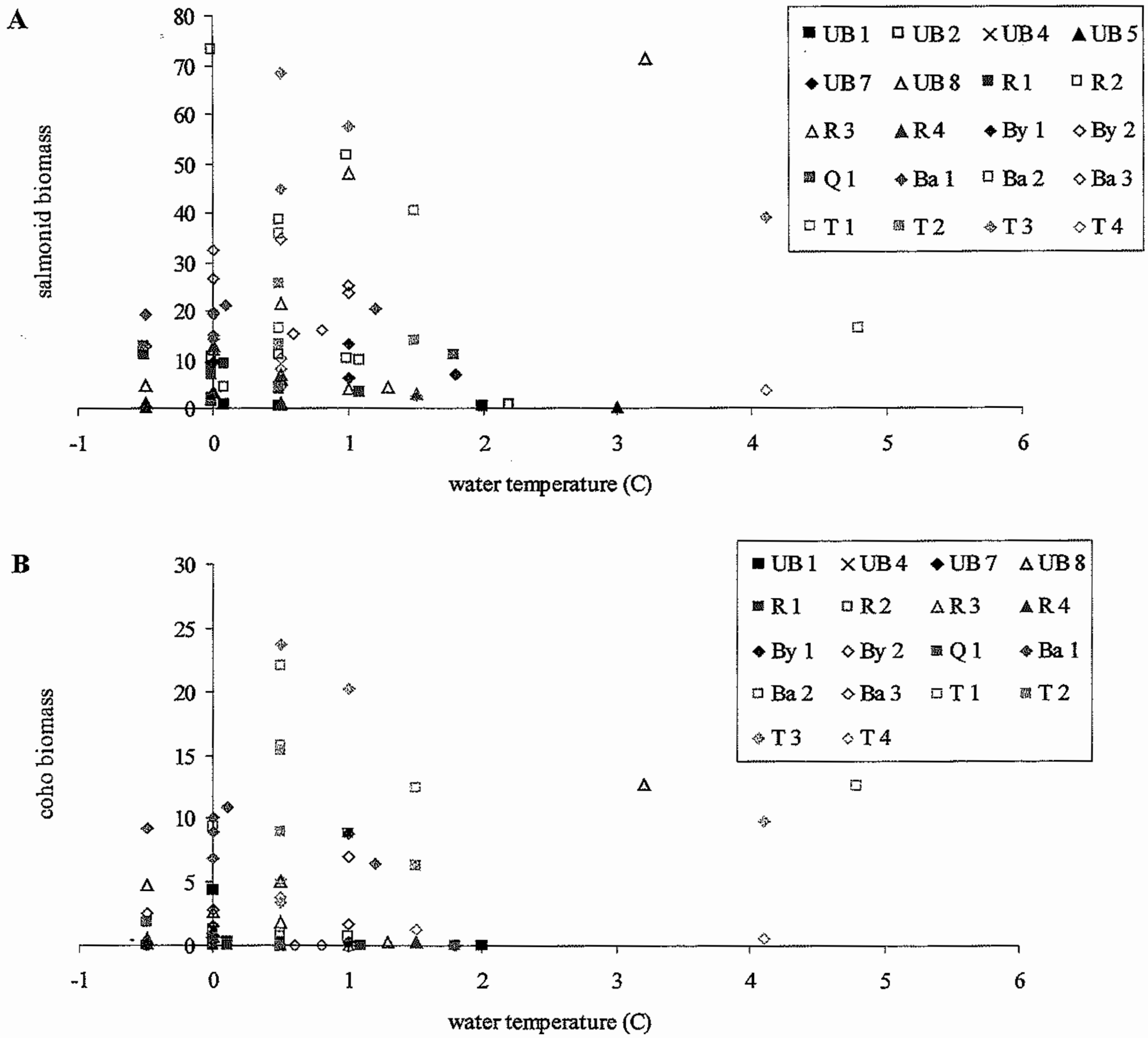


Figure 56. Salmonid biomass (A) and coho biomass (B) (g/m2) versus water temperature for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Trend line has been fitted by eye.

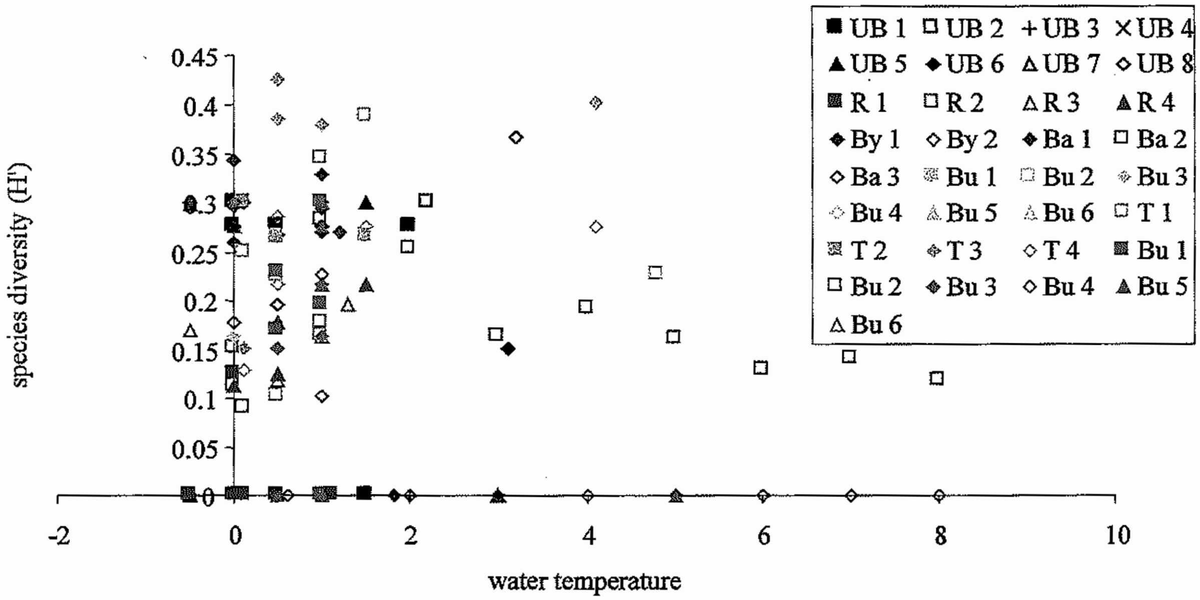


Figure 57. Species diversity (H') versus water temperature for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks.

3.2.5 Ice Thickness

Ice thickness may influence the number of ice free days at a site, the accessibility of the habitat, and the quality of the overwintering habitat. Catch per unit effort (Figure 58) appears to vary little with ice thickness for all species or for coho in particular. Variability for the adjusted Petersen estimate, fish density or biomass (Figures 59, 60 and 61 respectively) also appears to be independent of ice thickness for all species. However, coho biomass (Figure 62) appears to decrease with increasing ice thickness. Variations in species diversity appear to be independent of ice thickness. Ice thickness may indirectly affect overwintering habitat quality, but ice thickness encountered during this study did not appear to be a good indicator of overwintering habitat quality.

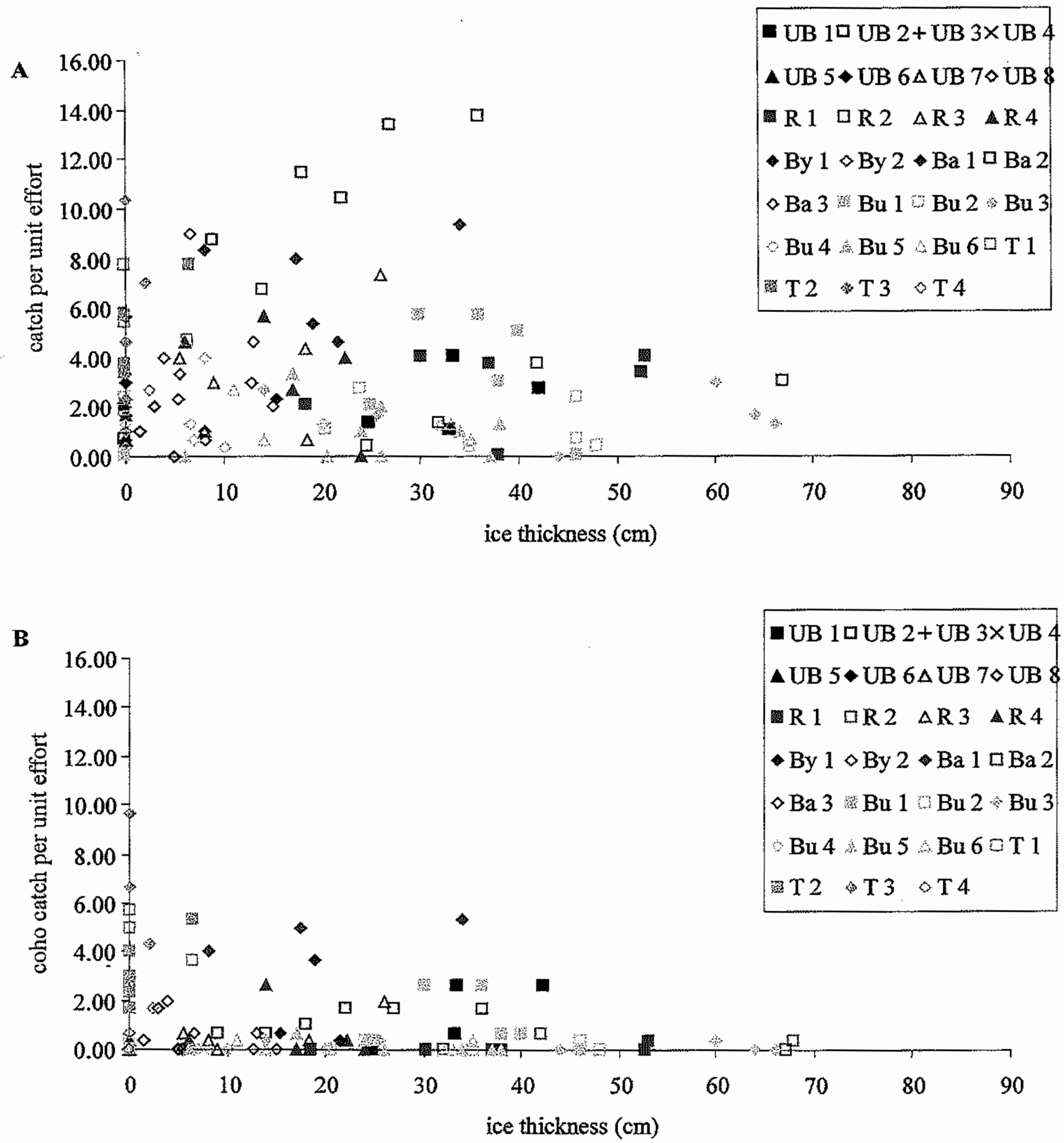


Figure 58. Catch per unit effort (A) and coho catch per unit effort (B) versus ice thickness for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks. Trend line was fitted by eye.

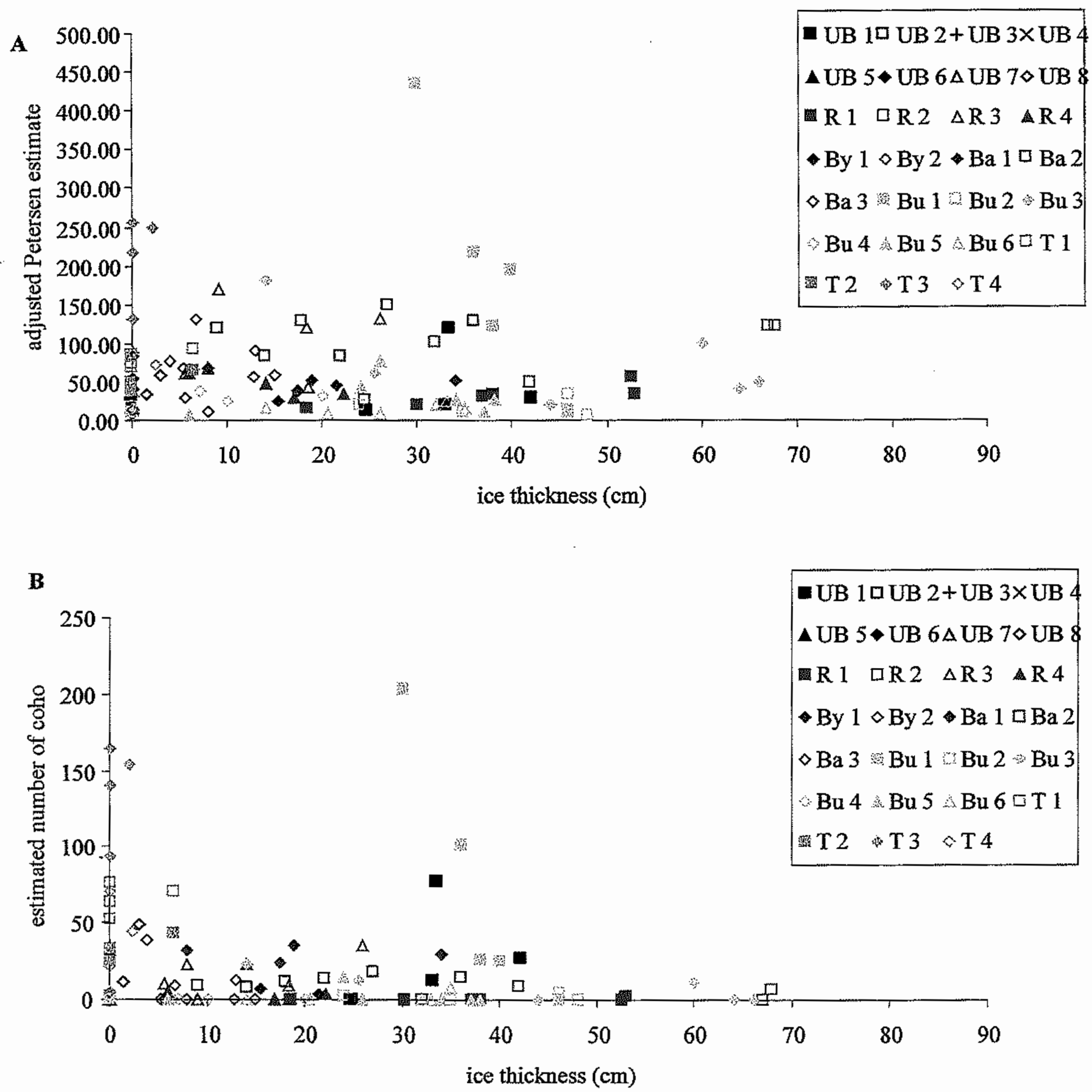


Figure 59. Adjusted Petersen estimate (A) and estimated number of coho (B) versus ice thickness for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks. Trend line was fitted by eye.

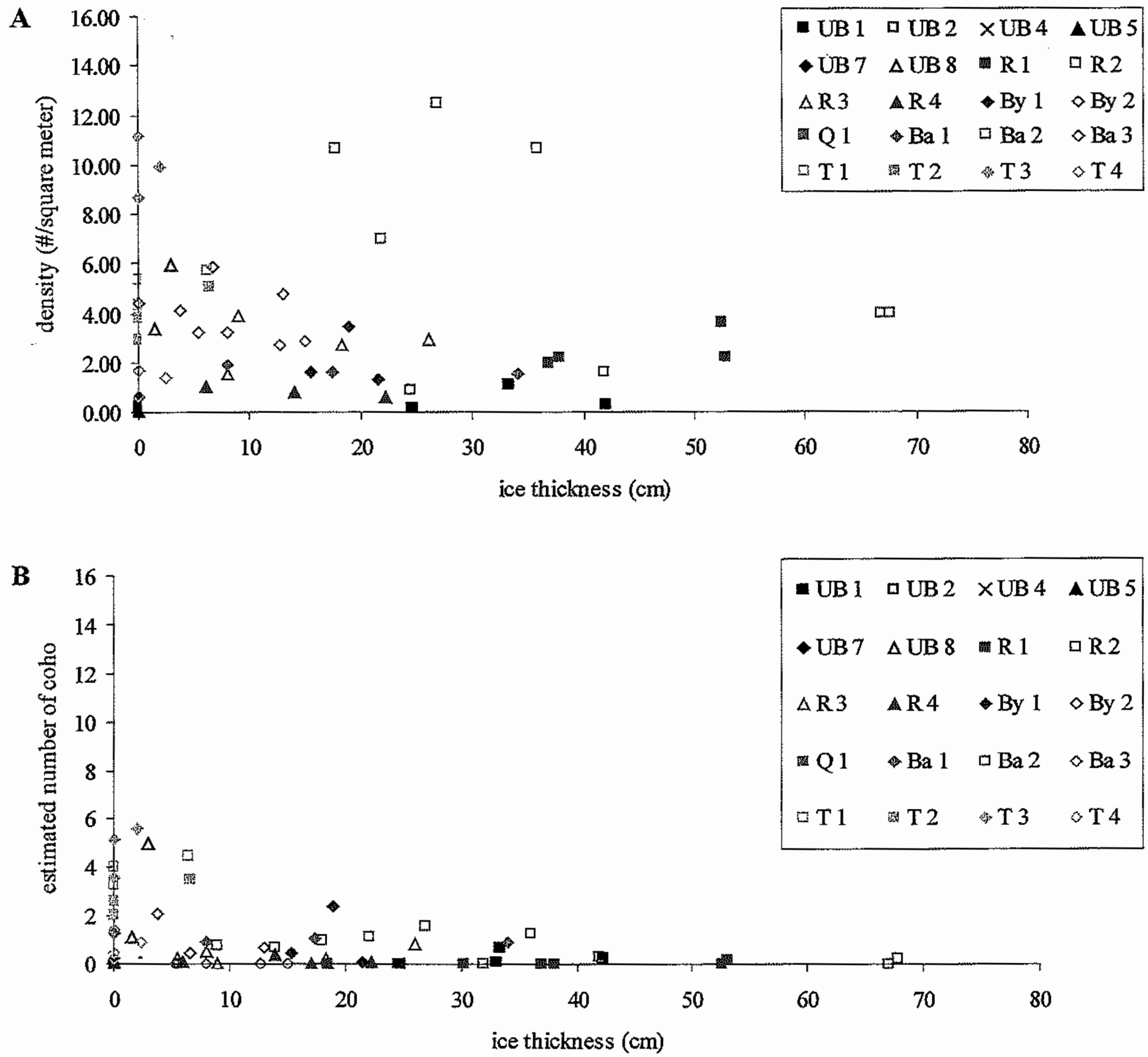


Figure 60. Overall density (A) and coho density (B) versus ice thickness for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Trend line was fitted by eye.

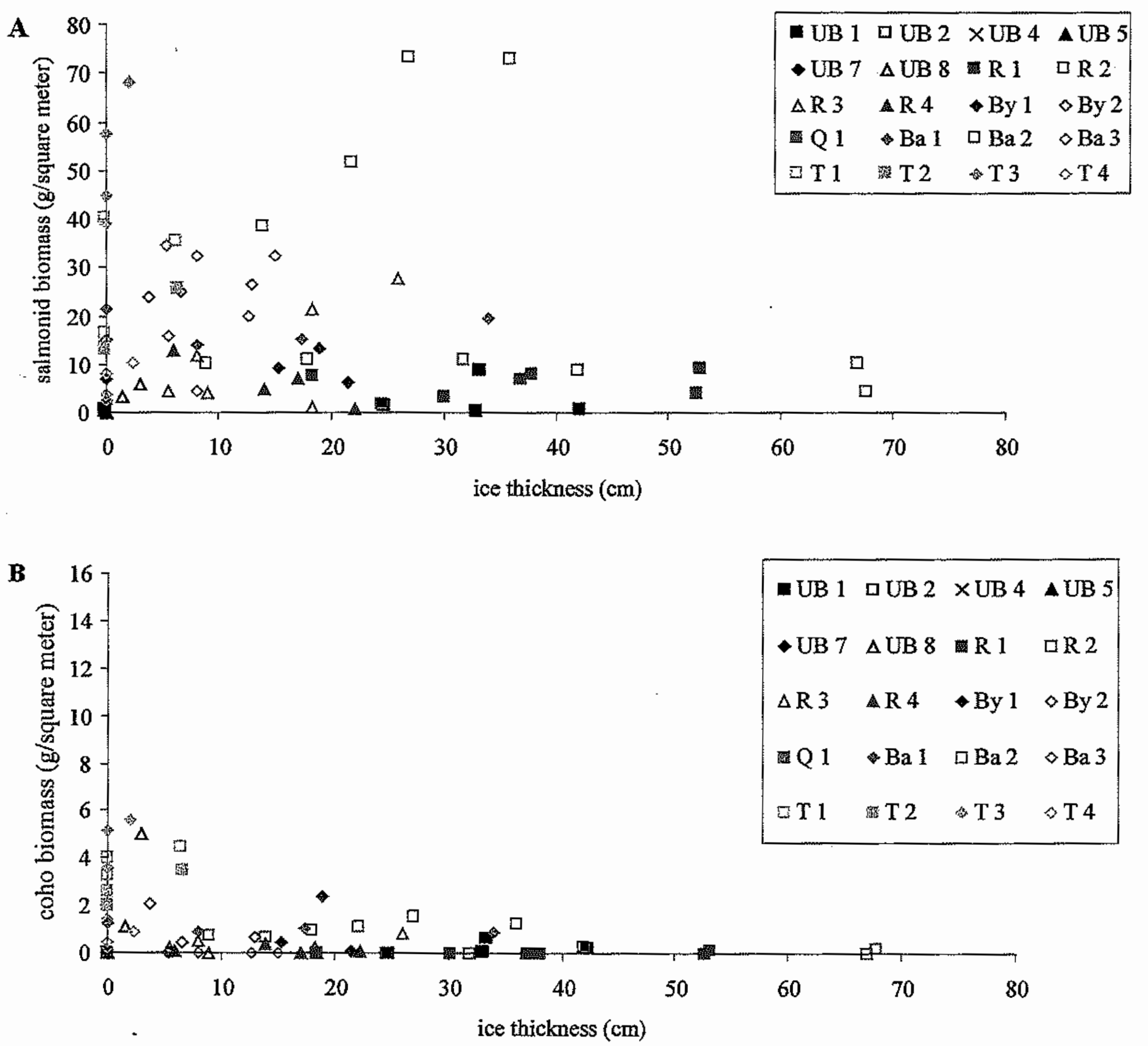


Figure 61. Salmonid biomass (A) and coho biomass (B) versus ice thickness for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Trend line was fitted by eye.

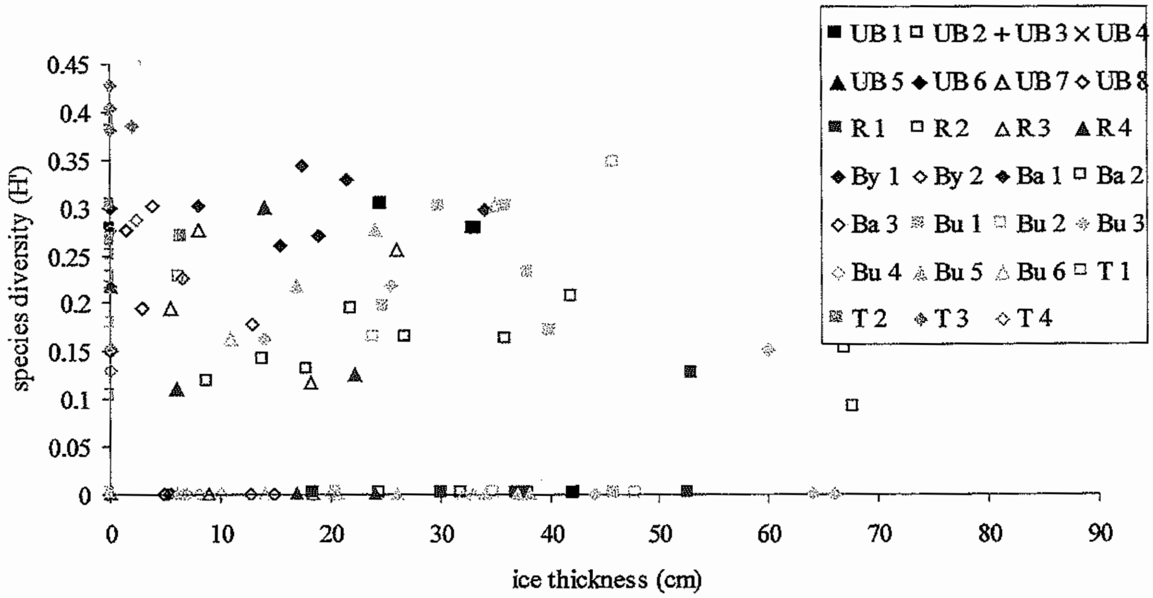


Figure 62. Species diversity (H') versus ice thickness for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks.

4.0 DISCUSSION

This interim report summarizes the results from the initial phase of a study on overwintering habitat for fish in the upper Bulkley River watershed. This report includes a detailed assessment of all preliminary data in search of habitat characteristics that influence overwintering habitat quality. The majority of the data collected were not suitable for statistical analyses, and thus were only used to identify potentially critical factors and to design feasible sampling methodologies for evaluating the quality and limitations of overwintering habitats. From the data collected for this preliminary study, fish abundance, fish size and biomass, survival, species diversity and species richness were assessed for comparative measures of overwintering habitat quality among sites. The variability of these indicators of overwintering habitat quality was then correlated with differences in physical parameters of the sites. It was hoped that these comparisons may indicate which physical parameter(s) are important in determining overwintering habitat quality. However, the ability to use the data collected to firmly identify factors that determine overwintering habitat quality was limited. The following sections describe limitations of the data collected to date, and suggest modifications to the study methodology in order to increase the validity of the data.

4.1 Indicators of Overwintering Habitat Quality

For this overwintering study, the abundance and health of the fish themselves were considered to be the indicators of habitat quality. Theoretically, poor habitat is expected to result in low abundances and conditions of fish due to mortality, starvation, stress, and migration. In addition, larger and fitter fish are assumed to have a competitive advantage, and are expected to displace smaller, lower condition fish from better habitat in areas that are open to migration. Therefore, accurate estimates of fish abundance, biomass, and condition are assumed to be good indicators of habitat quality and these estimates will be critical toward completing more detailed evaluations of the limiting factors in the overwintering habitats that were identified in this study. Assessment of the preliminary data has allowed recognition of the many difficulties in collecting this type of data during winter conditions in north central British Columbia. Some modifications to data collection methodologies are suggested for continuation of this study.

4.1.1 FISH ABUNDANCE

Measures of fish abundance used in this study include catch per unit effort, adjusted Petersen estimates, and estimates of fish density (by unit area and by unit volume). Measures of fish abundance during the study appeared to be relatively similar between sites and over time. Some sites appeared to exhibit slightly higher fish abundance (catch per unit effort, adjusted Petersen estimated, density) than other sites. Most of these sites offered cover from LWD. Fish abundance at most of the sites varied sporadically over the winter, and then decreased in March with the onset of spring, increasing water temperatures, and movement of juveniles from overwintering habitat. The adjusted Petersen estimate also showed a gradual decline of species abundance over time at the sites examined. The relatively small differences, coupled with substantial variability in measures of abundance between sites and over time may not accurately reflect actual differences in abundance over time since some of the data gathered is limited by the validity of assumption, sampling intensity, and study design. Measures of fish abundance over time and between sites are a main indicator of overwintering habitat quality. Some suggestions to increase the quality of fish abundance estimates are given in this section. In order to identify good overwintering habitat, the accuracy and precision of indicators of abundance used in the study must be increased. Preliminary sampling methodologies to estimate fish abundance rely on several assumptions and which are violated, in addition to relatively low sample size due to difficulties in sampling under winter conditions.

Open Populations

During the initial year of the overwintering study, sites were assumed to be closed to migration for mark-recapture estimates of population size. However, this assumption was clearly violated at some sites, and remains untested for other sites (Table 3). The level if migration from and to open sites in the study is also not monitored. Compensation for known migration rates can be made, but unknown migration rates seriously affects the validity of mark-recapture population estimates (Bagenal 1978). For sites that are open to migration, the adjusted Petersen estimate is increasingly inaccurate as time progresses from initial marking. The second mark-recapture estimate, conducted in the spring of 1999, should therefore give a more accurate estimate of the population size at sites in the spring. However, all sites are open to migration in the spring, and fish movement from overwintering habitat to other habitat that is suitable for rearing appears to be relatively significant, as indicated in decreases in catch per unit effort and mark-recapture data. For sites with unknown migration, catch per unit effort appears to be a better indicator of population size than mark-recapture estimates.

Unless the rate of migration is known, mark-recapture estimates should only be used at sites with closed populations. This can be achieved by monitoring migration rates throughout the winter (e.g. Envirocon 1984). Alternatively, sites that will likely be closed to migration can be identified prior to freeze up. The depth of the riffle crest will likely influence which pools will be unaffected by migration. Whether a site is open to migration can be ascertained in the winter by determining the pool depth and extrapolating how surface flow connects the site to others in the system and/or by checking regularly for surface flow at the pool inlet and outlet. Sites with limited migration may exhibit a higher mortality rate, as fish become stranded in unsuitable or deteriorating habitat. Focusing on pools that may isolate fish from other suitable habitat in the system may lead to an underestimate of overwinter survival in the system. Batch marking fish at different sites with unique marks may allow documenting migration during the winter. A sample of both closed and open sites (with monitoring of migration rates at open sites) would be beneficial in identifying important characteristics of overwintering habitat.

Low Proportion of Marked Fish

For the preliminary population estimates, a low proportion of fish were recaptured, resulting in large confidence intervals around the estimate. The accuracy of the adjusted Petersen estimate is dependent on the proportion of the population marked, and the validity of assumptions made for the estimate. The number of fish marked initially is relatively low (mean = 13.38, SD = 8.32 for initial mark, mean = 13.95, SD = 10.94 for second mark). Consequently, the numbers of recaptures is also relatively low (mean = 1.30, SD = 1.81 for initial mark, mean = 1.95, SD = 2.23 for second mark). Confidence intervals around the Petersen estimates (Appendix 3) are relatively large. Marking a greater proportion of the populations present at sites sampled in the upcoming year would increase the accuracy of the adjusted Petersen estimates. Proportions of marked fish can be achieved by applying marks during sampling for recaptures, and estimating population size using the Jolly-Seber method (which assumes unknown mortality). However, continuous marking of unmarked fish may obscure the determination of open populations. Alternatively, an intense tagging effort could be conducted at the beginning of the study, to increase the number of marked fish to allow using the adjusted Petersen estimate. The accuracy of the adjusted Petersen estimate (and the Jolly-Seber estimate) could further be increased by trapping until a pre-determined number of recaptures has been obtained (Ricker 1975). Catch per unit effort can still be evaluated by using only the catch in an initial capture effort, or adjusting the catch by the effort expended to obtain the sample. Intensive marking to increase the proportion of marked fish in the population, and intensive sampling to increase subsequent capture rates will increase handling, stress, and mortality, particularly at low temperatures. The number of fish to be marked can be estimated by conducting a population estimate in late fall, using multiple pass electroshocking (e.g. Leslie Depletion method). The population sizes at sites in the winter will likely be greater than that in late fall, but the depletion estimate will give some indication as to the size of the population that can be expected at each site. Areas adjacent to the overwintering pools chosen for study should also be sampled using triple pass electroshocking, as these fish are likely to move into the pool for overwintering. In order to justify marking fish, it is critical to commit to marking a minimum number of fish at the site, and to expend significant effort to assure an adequate sample for re-captures. Fish mortality increases with time exposed to cold temperatures, and every effort should be made to minimize exposure of fish to the air. If concerns of overhandling of fish will limit the proportion of marked fish and future capture efforts significantly, other measures of fish abundance (e.g. catch per unit effort) should be used.

Un-equal Catchability for All Species

The adjusted Petersen estimate conducted in this study treated all species identically, and generated an overall estimate of fish abundance. Catch per unit effort can be regarded as an index of population size, and fish density. However, different species and different size groups of fish are known to exhibit different catchabilities (Bagenal 1978). A population estimate for each species, or for species of special concern (e.g. coho) may be more accurate than an estimate that combines all species together, since this would not require the assumption of equal catchability. However, decreased numbers of marked and re-captured fish would increase the confidence intervals around the estimate. In any case, it is important to consider the implications of equal catchability of species, when the catchability of each species is unknown. It is suggested that studies in the upper Bulkley watershed between Houston and Bulkley Lake focus on coho and rainbow trout for analysis of abundance as indicators of habitat quality, since these species comprised the majority of the catch.

Estimating Density

Density was evaluated as the number of fish per unit area and the number of fish per unit volume. Volume of water in a pool is expected to decrease over the winter, as water levels decrease. Therefore, the number of fish per unit volume may be more accurate reflection of the density of fish at a site. However, either measure assumes that the surface area of accessible habitat remains unchanged over the course of the winter, and that the entire surface area of the pool is useable by fish. With the formation of frazile ice, and decreases in water depth, the surface area and of suitable habitat will decrease during the winter. It may be more useful to determine a measure of useable area (e.g. surface area at 10 cm depth contour of pool). In addition, the surface area of the sites was determined by multiplying the length with the width of the pool. The shape of the pool will influence the accuracy of this estimate of surface area. Using a digital planimeter, or more accurately measuring surface area at sites will increase the accuracy of estimated densities of fish, both by unit area, and by unit volume. In addition, depth was measured at three sites at the pool and do not reflect maximum or mean depth. This makes comparisons of depth and habitat type between pools difficult. More accurate measurements of depth will allow for more accurate estimates of volume, more accurate estimates of mean and maximum pool depth, and better comparisons between sites and temporal variation within sites. This can be achieved by conducting detailed measurements of depth throughout the pool prior to freeze up, and marking the sampling locations.

Given the interim data, density per unit volume did not appear to differ significantly from densities per unit area in this study. However, with more accurate measures of surface area, volume and depth, trends in density estimates per unit area and per unit volume may differ in the magnitude. However, since densities are generally recorded by unit area in the literature, comparisons to historic data will be facilitated if densities are calculated per unit area.

4.1.2 Fish Size and Biomass

Weight was collected for all species captured throughout the study, and length data was collected in the spring of 1999. Weight appeared to change little over time, although a slight decrease in mean weight appeared to be present at some sites. Trends in biomass mirrored those of trends in fish abundance. Condition factors showed some variations between sites. However, changes in condition factors over time could not be evaluated since length data was only collected at the end of the study. The lack of clear differences over time and between sites in weight, biomass, and fish condition is partly due to variation in the data collected, coupled with relatively low sample sizes. Despite the lack of clear trends for fish size and biomass data collected in 1998-1999, measures of fish size and biomass should be considered as important indicators of overwintering habitat quality. The following sections describe limitations of the fish size and biomass data collected to date, and suggest changes to the methodology to compensate for some of these limitations.

Low Sample Size

Fish size is not expected to change drastically over the winter due to low growth rate as a result of low water temperature and low metabolic rate. Energy expenditures are reduced in the winter, due to reduced metabolic rate and less time spent defending a territory (Cunjak 1996, Heggenes *et al.* in prep). However, feeding rates are also reduced (Cunjak 1996, Heggenes *et al.* in prep), and feeding does not compensate for the energy expenditure during the winter. This results in an energy deficit, the extent of which determines the rate of decrease in weight over time. Slight changes in mean weight may only be documented with relatively intense sampling and large sample sizes, due to the variability weight of individual fish in a population. The greatest number of fish of a species captured was 34, and the greatest sample size for coho weight was 20 fish. However, most of the sample sizes were below 10 fish of a species. These sample sizes may be insufficient to document decreases in fish weight over time. In addition, samples may be biased, since different size fish may behave differently. For example, smaller fish may be less likely to enter a trap that has already captured a larger fish. It is likely that different size groups are affected differently by weight loss in the winter. Fish of marginal condition are likely to be pushed to marginal habitat in the pool, and will exhibit the most drastic decrease in weight, while fish of moderate and high condition may not exhibit measurable changes in weight. Setting minnow traps that select for smaller sized fish (e.g. smaller opening to trap), along with standard minnow traps may indicate if sampling in 1998/99 was size selective. Changes in weight will only be apparent when a larger proportion of the population is sampled through increased capture effort (more traps set, or traps over a longer time period).

Lack of Length Data for Most Sample Dates

Condition factor data collected in the study allow for comparisons of condition factors between sites in the spring. However, at this time, some sites are open to migration, and condition factors of fish present at the sites may not reflect the condition factors of fish that overwintered at the site. In addition, seasonal variation of condition factor at the site cannot be evaluated unless length and weight data are collected throughout the winter. Measuring fish length can increase mortality at cold ambient temperatures. Since coho stocks in the upper Bulkley River are depressed, it is understandable that mortality incurred in the study should be minimal. However, other measures of fish condition can be used. Rather than length, the volume of water displaced by a fish can serve as a measure of the fish's size. This data can be collected in conjunction with determining weight. Alternatively, a fish placed in a narrow, graduated cylinder may allow for a relatively accurate estimate of length. Decreasing exposure to adverse ambient conditions will decrease the impact on the fish. Handling should be minimized, and exposure of fish to air should be reduced as much as possible. This can be achieved by emptying traps in a container of water, measuring fish in the water or placing fish in water in a graduated cylinder, and marking under water (for fin clips). Other researchers conducting water quality sampling, which are sensitive to freezing, have processed samples in warm shelters (e.g. trucks, heated tents) (Schreier *et al.* 1980).

Other measurements, and increased marking could also be conducted without increasing mortality due to low water temperatures, if a shelter is used. Processing fish in a shelter with higher temperatures can reduce mortality and stress, while allowing for length and weight data to be recorded when air temperatures are below 0°C.

Allometric Growth at Some Sites

Insufficient data was collected in the initial year of the study to allow for comparisons of condition factors over time. Regressions of log weight on log length are useful in indicating which populations exhibit isometric growth, and which populations do not. Several of the species captured at different sites did not exhibit isometric growth. Therefore, Fulton's condition factor and the allometric condition factor differed substantially for some of these sites. Comparisons of Fulton's condition factors are easier, and are more commonly used in the literature. Fulton's condition factor is suitable for comparisons of fish condition for fish of similar size (Ricker 1975), as is the case in this study. Comparisons of Fulton's condition factor should be valuable as a measure of overwintering habitat quality for all sites, despite the lack of isometric growth, since fish are of similar size.

Inaccuracies in Biomass Estimates

Changes in biomass showed no obvious differences to changes in fish density over time and between sites, possibly due to relatively low sample size. Comparisons of biomass are, however, associated with greater error than comparisons of densities, or adjusted Petersen estimates. This is due to the fact that each measure is associated with a degree of uncertainty. Measures of biomass in this study are associated with a relatively large margin of error due to the large confidence intervals associated with the adjusted Petersen estimates (Appendix 3), and the variability in weight measurements. Multiplying mean weight with density, for example, results in an increase of error, as the errors associated with each parameter increase the error of the product considerably. Biomass estimated in this study are considerably higher than biomass reported in other studies (e.g. Bustard 1992, see Table 11). Fish biomass may be higher during the upper Bulkley overwintering study since the study was conducted later in the season, allowing for growth of individual fish. In addition, fish may congregate in pools for overwintering, as has been suggested for coho (Sandercock 1991), causing a higher density and hence biomass at pools during the overwintering study. Alternatively the inaccuracy of biomass measurements in this study, particularly in light of violations against assumptions of mark-recapture population estimates may give misleading results. Previous studies frequently report fish abundance as a measure of biomass, and this measure remains important for comparisons between studies. The accuracy of biomass estimates will improve in conjunction with more accurate determinations of population size, surface area, and mean weight of selected species at different sites.

Table 11. Maximum total biomass reported for the Kitwanga, Morice, and Sustut rivers (Bustard 1992).

	Total Biomass (g/m^2)	
Drainage	**Mean**	**Maximum**
Kitwanga	2.7	5
Morice	1.8	8
Sustut	0.4	1.13
this study	33.05	168

4.1.3 Survival

Overwinter mortality was not evaluated during the initial year of the upper Bulkley overwinter study. However, survival can only be estimated at sites with known migration rates, or at sites that are closed to migration. By comparing trends in catch per unit effort t adjusted Petersen estimates, some sites can be classified as open. Other sites may be open or closed to migration (e.g. upper Bulkley River sites, McQuarrie Creek, Barren Creek, some Buck, Toboggan and Mission creek sites, Table 3). Of the sites sampled, site UB 8 had the greatest decrease in catch per unit effort, adjusted Petersen estimate, density and biomass. This drastic decrease appears to be primarily due to mortality, since a pool associated with the site exhibited severely reduced water depth resulting in winterkill (Donas pers. comm.). Other sites appear to show some gradual decrease or stability in catch per unit effort and adjusted Petersen estimates over the winter. A detailed winter assessment of site UB 8 may be considered to better evaluate limiting factors and indicators of poor overwintering habitat.

Overwinter survival in the watershed has been associated with the ability of fish to move between sites (Cunjak 1996, Heggensen *et al.* in prep.). A fish's ability to move between sites during the winter can increase survival since fish may not be stranded in unsuitable habitat. Closed sites do not allow for movement between areas of suitable overwintering habitat, and may, by definition, result in lowered overwinter survival for the watershed. Limiting studies of overwinter survival to closed sites can underestimate the ability of the system to support fish during the winter. Although movement during the winter is likely minimal (Envirocon 1984, Cunjak 1996), it can be important in allowing fish to avoid deteriorating habitat. Marking fish at different sites using unique batch marks may allow for indirect monitoring of migration between sites. Some consideration should be given toward assessing habitat preference and changes in habitat preference of different species during winter.

4.1.4 Species Diversity and Species Richness

Assessment of species diversity and species richness provided interesting trends in species distribution, and has potential to indicate the importance of intra and interspecific interactions during the winter. Species richness at all sites examined appears to be relatively low, with the number of species captured at any sampling time ranging between none and three (Table 8). Species diversity and evenness is also generally low, indicating a low homogeneity among the species captured. Usually, a species dominates the catch at a site, and only few fish are comprised of other species. Coho was found to dominate at the catches at only a few sites in the upper Bulkily River and at Toboggan Creek and formed the minority of the catch or was absent at other sites. This is not surprising, since the competitive abilities of the fish, coupled with their habitat preference, will influence species presence/absence at the sites sampled.

Of the species captured, the most striking trend in presence/absence was observed for Dolly Varden and chinook. A culvert on Mission Creek has been identified as a potential barrier to the upstream migration of anadromous fish, explaining the lack of chinook salmon in the system. In fact, rainbow trout/steelhead were also not recorded in Mission Creek, and coho were only recorded at site M 3, located at the culvert. Dolly Varden were the most abundant species captured at Mission Creek. Dolly Varden were also captured in Toboggan Creek, but were not reported for the upper Bulkley watershed sites sampled in 1998/1999. The lack of Dolly Varden from sites in the upper Bulkley watershed may be due to habitat preference. Chinook are present in the upper Bulkley watershed, but were not captured at Toboggan or Mission creeks. Chinook are relatively rare in Toboggan Creek, and have only recently strayed into the system. Only a few chinook have been recorded at the adult migration fence on Toboggan Creek every year (O'Neill per. com.). A few chinook smolts have been recorded during the enumeration of smolt migrating from Toboggan Creek (Saimoto 1995, SKR Consultants Ltd 1996, 1997, 1998, in prep.). Chinook salmon was also lacking from catches recorded in Mission Creek. Species specific overwintering habitat types can play an important role in determining species assemblages, and should be considered carefully in identifying sample site for the continuation of this study.

4.2 Factors Determining Overwintering Habitat Quality

4.2.1 Size of Overwintering Habitat

The size of the overwintering habitat appear to play a role in the ability of the habitat to support overwintering fish. Small, shallow pools freeze solid, thus causing high mortality of fish at these sites. Larger pools may not close off completely, and may be open to migration. Pool size and depth likely are factors in determining overwintering habitat quality, since salmonids have been reported to selected deep pools at low temperatures (Sandercock 1991, Cunjak 1996). All pools studied during the upper Bulkley overwintering project offered suitable overwintering habitat to salmonids, but one of the smaller pools (site UB 8) exhibited high mortality. This indicates that small pools may be unable to sustain overwintering juveniles throughout the winter. Data collected to date indicates that fish abundance (as indicated by catch per unit effort and adjusted Petersen estimate) decreases at large pool size and depth. Variations in fish abundance at moderate pool size appears to be independent of the surface area or depth of the pool. This is contrary to trends reported by Sandercock (1991) and Cunjak (1996). However, most of the inaccuracies in population estimates and catch per unit effort are increased with increasing pool size and depth (see section 4.1.1). In addition to problems with fish abundance data previously discussed, pool size and depth recorded for the interim study may also be misleading. Factors limiting the accuracy of data for evaluation of pool size on overwintering habitat quality are summarized below, and some modifications to sampling design are given.

Surface Area

Generally, pools will exhibit a decreased amount of habitat available to fish during the winter, since ice forming on the margins of the pool will decrease the effective surface area of the pool. Water depth decreased during the winter, and further causes a decrease in the available habitat to fish. This phenomenon has been found to reduce wetted areas in selected side channels of the Morice River by up to 87% (Envirocon 1984). Very large pools will not offer uniform habitat throughout, and some microhabitats in these pools may be less suitable to overwintering than others (e.g. microhabitat with and without LWD). Pools likely have to be a minimum size to offer overwintering habitat that will persist throughout the winter, and pools of very large size may have a lower proportion of useable habitat for fish. Measuring surface area at the beginning of the winter may overestimate the amount of useable habitat to fish. Detailed site measurements of pool surface area at different depths will allow for accurate adjustments of useable surface area at the site throughout the winter.

Uniform Sampling Intensity

During the upper Bulkley overwintering study, generally three minnow traps were set at each site, regardless of the size of the site. For smaller sites, the majority of fish may have encountered the traps while they were set at the site, but for larger sites, the trap encounter rate, and therefore the catch efficiency may be lowered. This hypothesis would explain instances where the adjusted Petersen estimate was relatively large, and the catch per unit effort relatively low. Although catch per unit effort does decrease with increasing surface area of the site, the adjusted Petersen estimate also decreases for these sites. The relatively good match between trends in catch per unit effort and adjusted Petersen estimates at sites of varying size indicates that sampling intensity was probably adequate for all pools included in the study. However, this could be better evaluated by increasing trapping intensity at some sites, since the confidence interval around the adjusted Petersen estimate would decrease (see section 4.1.1). It may be necessary to set a larger number of traps at larger sites in order to obtain a better indication of fish abundance.

Water Depth

Water depth measurements recorded in the upper Bulkley overwintering study may be biased, since water depth measurements do not reflect the mean depth of the pool, but are averages of three depths taken in the pool. Water depths may therefore not be comparable among pools, since they neither reflect the mean nor the maximum depth at the pool. Similarly, estimates of pool volume are biased, since depth measurements are not reflective of the mean depth at the pool. Depth and pool volume can be more clearly described by generating detailed maps of the sample sites, that will allow extrapolation of volume and mean depth from one depth measurement taken throughout the winter at a predetermined site (i.e. staff gauge).

4.2.2 Dissolved Oxygen

Dissolved oxygen is a known limiting factor of the suitability of habitat for overwintering. If dissolved oxygen concentrations drop to below critical levels, increased stress, and ultimately mortality of fish can result (e.g. winterkill, Davis 1975). At sites where ice cover is complete, oxygen can only enter the system from upstream. However, oxygen is depleted through respiration and decomposition, resulting in a net loss of dissolved oxygen during the winter (Davis 1975). This net loss of oxygen during the winter can reduce oxygen concentrations to below critical levels (6 ppm for salmonids; Davis 1975, Canadian Council of Ministers of the Environment 1991). Dissolved oxygen data collected in the winter of 1998 – 1999 was limited to April due to the lack of suitable sampling equipment (Donas pers. comm.). Oxygen concentrations recorded after ice off were well above the critical limit of 6 ppm. However, oxygen readings were taken after oxygen concentrations had been replenished through contact with the atmosphere. Oxygen readings recorded in the interim study are not indicative of oxygen concentrations just prior to ice off, and are unable to predict which sites suffer significant oxygen depletion. Monitoring of oxygen levels on a regular basis (e.g. monthly), or deployment of oxygen data loggers will be helpful in identifying sites that are unable to support populations of overwintering salmonids due to low oxygen.

4.2.3 Large Woody Debris and Cover

Sites with and without large woody debris were included in the upper Bulkley overwintering study to evaluate if LWD presence affected the quality of overwintering habitat. Fish appeared to be more abundant at sites with than sites without LWD. However, the difference in abundance between sites with and without LWD was only statistically significant for comparisons of catch per unit effort of the upper Bulkley watershed and Toboggan Creek. LWD has been identified as an important factor in determining overwintering habitat quality in other studies (Bustard and Narver 1975 as in Sandercock 1991, Envirocon 1984, Cunjak 1988, Riehle and Griffith 1993, Cunjak 1996, Wet'suwet'en Fisheries 1999, Heggenes *et al.* in prep). Other sources of cover (e.g. cutbanks, deep pools) were not taken into account during the current study and may compensate for a lack of cover by LWD at some sites. In addition to LWD, substrate and cutbanks may be important source of cover during the winter in streams that exhibit ice cover (Cunjak 1988, Riehle and Griffith 1993, Cunjak 1996, Heggenes *et al.* in prep). Improved estimates of habitat quality (e.g. fish abundance, biomass, weight) should allow for a better evaluations of the importance LWD. The affect of LWD and other sources of cover on overwintering habitat quality may be more apparent if percentage of cover provided by different sources is compared between sites.

4.2.4 Water Temperature

As with oxygen, a minimum water temperature must be maintained to allow for the existence of aquatic life. Prolonged exposure to low temperatures can cause stress, decreased metabolic rate, and death (Canadian Council of Ministers of the Environment 1991). Lower lethal temperatures for coho, chinook, rainbow trout, steelhead and cutthroat trout are summarized in Table 12. For all salmonids examined, lower lethal temperatures recorded in the literature do not drop below 0°C (Levy and Slaney 1993). This coincides with the lack of fish captured at temperatures below -0.5°C, allowing for some variability in readings of temperature, and a low duration of exposure to temperatures below 0°C. Lower water temperatures causes a reduction in metabolic rate of ectothermic animals, such as fish, and results in decreased swimming velocities (Sandercock 1991). Water temperatures above the lower lethal limit appears to have little influence on the quality of overwintering habitat (Figure 53-56). Higher water temperatures are generally found towards the end of the sampling period (March and April 1999), as ambient temperature increases. Lowered catch per unit effort and adjusted Petersen estimate at these higher water temperatures are likely are result of migration from the overwintering habitat. Such a movement of juveniles from overwintering habitat in the spring has been reported in the literature (e.g. Tschaplinski and Hartman 1983 as in Sandercock 1991). Sites with consistently elevated water temperatures (e.g. due to groundwater inflow) may form temperature refuges for juvenile salmonids (Cunjak 1996), and may exhibit higher fish densities provided the groundwater inflow does not depress oxygen concentrations to below critical levels (Schreier *et al* 1983). None of the sites appeared to have consistently warmer water temperatures than others, indicating that none of the sites chosen had significant groundwater influence. At the sites examined, lower limits of water temperatures appears to affect the ability of juvenile salmonids to overwinter at some sites, but differences in water temperatures between sites were insufficient to identify any trends in overwinter habitat quality based on water temperature.

Table 12. Lower lethal, upper lethal and preferred temperatures for coho, chinook, rainbow trout, steelhead and cutthroat trout (adapted from Levy and Slaney 1993).

Species	Lower Lethal Temperature[a]	Upper Lethal Temperature[b]	Preferred Temperature	Technique[d]
chinook	0.8	26.2	12-14	ILT
coho	1.7	26.0, 28.8[c]	12-14	ILT, CTM
steelhead	0.0	23.9	10-13	
rainbow		29.4, 25.0		CTM, ILT
cutthroat trout	0.6	22.8		

[a] Acclimation temperature was 10°C; no mortality occurred in 5,500 min.
[b] Acclimation temperature was 20°C unless noted otherwise, 50% mortality occurred in 1,000 min.
[c] Acclimation temperature was 15°C
[d] ILT – incipient lethal temperature, CTM = critical lethal temperature

4.2.5 ICE THICKNESS

Ice and snow thickness were assessed during the initial year of the upper Bulkley overwintering study to determine if they influence overwintering habitat quality. Ice is a source of cover from non-aquatic predators, but is also a barrier to input of organic nutrients during the winter, input of ambient oxygen into the system, and can be a barrier to migration. Ice thickness itself did not appear to affect fish abundance, weight, or diversity in the upper Bulkley overwintering study. However, ice thickness may influence overwintering habitat quality indirectly. Measuring ice thickness alone may therefore not indicate how ice cover limits overwintering habitat quality. Combinations of other criteria may indicate dynamics of overwintering habitat quality in areas where ice cover is a factor. Potential impacts of ice formation on streams, and suggested methods for estimating these impacts are given below.

Proportion and Duration of Ice Cover

The proportion and duration of ice cover can affect oxygen concentrations of overwintering habitat. A major source of oxygen to streams is through contact of the water surface with the air. Oxygen dynamics of sites with incomplete ice cover will differ from those with complete ice cover, as oxygen can enter the water throughout the winter. In addition, the duration of ice cover can influence the level of oxygen depletion at overwintering sites. Sites that have greater ice thickness may have a shorter ice free period. Ice free periods are the only periods when ambient oxygen can enter the stream. A longer duration of ice cover may decrease oxygen concentrations towards the conclusion of the winter, and may cause oxygen levels to drop to critical levels (Schreier *et al.* 1980). Maximum ice thickness can be determined at all sample pools during winter, when ambient conditions indicate that ice thickness is at its greatest. Percent ice cover at sites can be estimated throughout the winter, and can be combined with measurements of dissolved oxygen to allow for an evaluation of the importance of ice cover at overwintering habitats.

Available and Accessible Fish Habitat

Ice thickness can affect the amount of free water, size of available habitat to fish, and movement between overwintering habitat. Ice along the shore can render marginal habitat unsuitable, thus decreasing the size of the habitat that is actually available to fish (Cunjak 1996). In addition, the formation of river ice, and the level of ice formation may influence overwinter survival by restricting movement of fish, and potentially trapping fish in unsuitable or less than optimal habitat (Cunjak 1996, Heggenes *et al.* in prep). Formation of anchor ice, drifting ice and frazile ice may trap fish, and cause mortality (Heggenes *et al.* in prep). Severe freezing has been estimated to account for over 60 % of overwinter mortality (Cunjak 1996). Changes in availability of useable habitat, and abilities to move between habitats can be determined through detailed measurements of pool dimensions, riffle crest, and consistent measures of pool depth during the winter.

Fish Behaviour

Ice formation can impact fish behaviour, since fish have been reported to become more active at night with the onset of winter. Salmonids generally appear to exhibit photonegative responses during the fall and winter, and are likely more active at night (Cunjak 1988). Spatial heterogeneity due to ice formation is increased at night, due to increased heat radiation during the night (Heggenes *et al.* in prep). Heggenes *et al.* (in prep) argue that this is one potential explanation for increased nocturnal activity for brown trout, since the probability of being trapped in newly forming ice is greater at night than during the day. Fish behaviour studies in winter have been conducted using snorkel surveys, even at sites with ice cover (Cunjak 1988, 1996, Heggenes *et al.* in prep.). Changes in fish behaviour over the winter are interesting, but are likely not good indicators of overwintering habitat quality, and may be of limited importance in comparing overwintering habitats. However, fish behaviour studies may identify preferred microhabitats and competitive interactions in pools during winter.

Stream Hydraulics and Flow Pattern

Ice cover likely also influences stream hydraulics and flow regime under the ice (Cunjak 1996) Energy expenditures may differ substantially with different flow regimes under the ice, influencing fish condition and survival. Flow measurements under the ice can be conducted using a flow meter to determine if flow regime has a significant influence on overwintering habitat quality.

4.2.7 Other Factors

In addition to the factors addressed in this study, other physical and biological constraints may impact the quality of overwintering habitat. Some of these factors may interact, and thus, they are not independent of one another. Many of these factors help identify differences in microhabitat characteristics which likely effect species presence, richness, diversity, abundance and condition. Factors such as stream gradient, water velocity, substrate composition, water quality, proximity to lakes, proximity to beaver dams, and food abundance are discussed to illustrate the complexity of natural conditions.

4.2.7.1 Gradient

Stream gradient can determine fish access, stream hydrology, stream morphology and substrate type. Steeper gradient streams may exhibit a step-pool morphology, have larger particle size in the bed material, exhibit restricted access, and have higher water velocities. Some species prefer steeper gradient streams than others. Gradient can also determine the proportion of different microhabitats found in streams (e.g. pool:riffle ratio). Gradient measurements at the site and for the reach is easily conducted, and can give useful information on habitat characteristics of sample sites.

4.2.7.2 Water velocity

Water velocity may be an important indicator of overwintering habitat quality. Fish need to expend energy to maintain their position in the water column (Moyle and Cech 1988) and energy expenditure is directly related to water velocity. Reduced energy expenditures in the winter may be critical to fish survival (Cunjak 1996), and coho are found to select deep pools with low water velocities for overwintering (Sandercock 1991). Water velocity increases with increasing gradient, and the proportion of pools are reduces with increasing gradient (Hunter 1991). Water velocity and flow regimes may be altered by ice cover (Cunjak 1996), and the presence of LWD can provide microhabitat with different water velocities (Hunter 1991). If possible, monitoring flow regimes around root wads and other LWD structures may indicate if these structures provide refuge from higher velocity microhabitats in pools.

4.2.7.3 Substrate

Gradient can influence substrate composition since higher gradient streams exhibit higher water velocity, and consequently larger particle size in the streambed (Hunter 1991). Different species exhibit different preferences for substrate, and substrate composition influence species composition at sites. Coho prefer sites with clean substrate for overwintering over sites with silted substrate (Bustard and Narver 1975 as in Sandercock 1991). Larger substrate size has greater interstitial space, and provides cover for salmonids. For example, smaller size groups of brown trout (*Salmo trutta*) have been found to shelter passively in the substrate during the day (Heggenes *et al.* in prep). Cunjak (1988) and Riehle and Griffith (1993) have reported that juvenile salmonids seek refuge in substrate, near LWD, and under cutbanks. Substrate size has been identified as the main criteria determining habitat suitability for overwintering, along with water depth (Cunjak 1988). Recording substrate size (e.g. D and/or D_{90}), substrate compositions (percentages), as well as siltation of the substrate can be used to correlate substrate type with indicators of overwintering habitat quality.

4.2.7.4 Water quality

Water quality can increase stress on fish, and result in increased mortality (Canadian Council of Ministers of the Environment 1991). Dissolved oxygen concentrations and temperature can influence the effect of other water quality parameters on fish (Davis 1975). For example, ammonia solutions, salts of zinc, lead, and copper and monohydric phenols can increase in toxicity to fish at lower oxygen concentrations (Davis 1975). Some water quality parameters change naturally as the winter progresses. At streams exhibiting ice cover, dissolved oxygen usually decreases over the winter, along with iron, nitrogen components, phosphorus, and some trace metals, until spring thaw (Schreier *et al.* 1980). Other parameters, including alkalinity, calcium, magnesium, sodium, silica and sulfate increase in concentration as the winter progresses (Schreier *et al.* 1980). Water quality has been recorded in the upper Bulkley watershed and at Toboggan Creek (Donas pers. comm.). However, if past water quality measurements do not include sampling during the winter, additional water quality samples should be collected just prior to ice off.

4.2.7.5 Proximity to Lakes

Lakes may offer important overwintering habitat, although their importance relative to streams has not been evaluated. The importance of lakes as coho overwintering habitat in some systems is suspected to be relatively significant (Finnegan pers com.). The presence of lakes in the watershed can influence water quality downstream (Wetzel 1983) by moderating turbidity, temperature, and chemical disturbance, all of which may influence overwintering habitat quality (see above). If lakes provide good quality overwintering habitat, this habitat may be preferred to overwintering habitat in streams associated with the lake, resulting in reduced densities in stream overwintering habitat. Juvenile coho have been reported to move from lakes to inlet streams for overwintering in some systems, while movement into lakes in the fall has been reported in other systems (Sandercock 1991). None of the sites examined during the upper Bulkley overwintering study were located near lakes. The importance of lakes for overwintering in the upper Bulkley watershed, and in Toboggan Creek needs to be evaluated.

4.2.7.6 Proximity to Beaver Dams

Beaver dams are usually associated with deep pools of slow moving water. Water depth and water velocity can influence overwintering habitat quality (see sections 4.2.1, 4.2.7.1.1). Beaver ponds may form critical habitat in the winter, particularly in systems lacking deep pools (Cunjak 1996). Beaver ponds have been documented to be important overwintering habitat for Dolly Varden, coho, bull trout, and other salmonids in coastal and Alaskan streams (Cunjak 1996). Beaver ponds are particularly important in stream exhibiting low depth of pools, and where ice may form to the bottom of pools. Three of the sites studied during the upper Bulkley overwintering study were associated with beaver dams. Site Bu 6 is located in a pool upstream of a beaver dam, and sites M1 and M2 are both located at a beaver pond. No surface area was measured for these sites, but catch per unit effort, and adjusted Petersen estimates were determined. Sites M1 and M2 have a relatively high catch per unit effort (M1 = 18.33 fish/trap on January 28, 1999, M2 = 12.67 fish/trap on February 3, 1999) and Petersen estimate (M1= 735 fish on Apr. 21, 1999, M2, 368 fish on April 21, 1999), while site catch per unit effort and adjusted Petersen estimates at site Bu 6 are similar to other sites in Buck Creek. Beaver ponds may offer important overwintering habitat in the upper Bulkley watershed. The importance of beaver dams may become apparent as methodologies for overwintering habitat assessment become refined. Beaver pools should be included in sites sampled during the second year of the upper Bulkley overwintering study.

4.2.7.7 Groundwater Sources

Groundwater inflow to overwintering habitat can affect the quality of the habitat. Input of groundwater will increase water temperature, and may form temperature refuges during very cold conditions (Schreier *et al.* 1980). Elevated water temperatures due to groundwater sources can allow open water to persist throughout the winter, allowing increased oxygen concentrations due to the water's contact with the air (Schreier 1980). However, if ice cover remains complete, low oxygen concentrations of some groundwater sources can drop oxygen levels at the overwintering habitat to below critical levels (Davis 1975, Schreier 1980). The importance of groundwater sources can be addressed by documenting oxygen and temperature dynamics at sites with known groundwater inflow, as well as estimating indicators of overwintering habitat quality (e.g. fish abundance, weight, species diversity).

4.2.7.8 Food abundance

Although feeding is generally reduced during the winter some feeding likely occurs for most salmonids (Cunjak 1988, Riehle 1993, Cunjak 1996, Heggenes *et al* in prep). Sites with higher availability of food may be better able to compensate for energy expenditures during the winter, and reduce the energy deficit generally experienced by fish at this time of year (Heggenes *et al.* in prep). Sites with a higher availability of food should produce fish in better condition at the end of the winter. Food abundance can thus influence the condition of fish at the site, and their ability to survive the winter and/or spring. Food availability can be determined by sampling for invertebrates in the streams during the winter.

5.0 RECOMMENDATIONS

Although many studies on juvenile salmonid biology and ecology have been published, overwintering habitat and overwinter survival have frequently been overlooked. In order to understand and manage juvenile salmonids effectively, a solid understanding of habitat requirements and constraints is required. Overwinter survival may be a bottleneck to smolt production in many systems, and it is critical to understand the biological and ecological processes affecting juveniles salmonid survival during the winter. Overwintering studies can be valuable in determining if overwinter survival is limiting, and how overwinter survival may be improved. However, studies on overwintering habitat quality and quantity, overwinter movement of fish, and survival during the winter are faced with several logistical problems. Studies need to be innovative, and methodologies need to evolve as the study progresses.

5.1 Studying overwinter survival in a watershed can be a daunting task, especially considering seasonal and spatial variability, interaction of different factors, logistical difficulties of studying fish under the ice and in adverse environmental conditions, and the relatively poor knowledge of overwintering dynamics of juvenile salmonids. It is important to generate clear and concise objectives for further studies of overwintering habitat, and to pose questions that can be answered given the current knowledge and resources for the study. Listing objectives in order or priority will allow as many questions to be answered as possible. A planning meeting, involving several representatives of different agencies can be invaluable in identifying potential parameters that can be addressed in future overwintering studies. A suggested agenda, and suggested changes to methodologies currently used in the study are presented in Appendix 5 to foster discussions during the meeting. Methodologies should be tailored to the objectives and hypothesis of the study as it is formulated at such a meeting. Representatives of the following agencies, among others, should be included in a planning meeting to aid in the refinement of study objectives:

- Department of Fisheries and Oceans
- B.C. Environment (fisheries and environmental protection branch)
- knowledgeable consultants, guides, long time residents of the area
- local stakeholders
- groups conducting similar studies in other areas, particularly nearby.

5.2 Overwintering habitat quality may be influenced by several factors, which may or may not operate independently. It is important to understand what factors may affect overwinter habitat quality, and how these potential factors may interact. The generation of a conceptual model (e.g. a habitat suitability model) may be useful in developing hypothesis as to how potential factors interact in determining overwinter habitat quality. Models have previously been developed to estimate carrying capacity of different habitats (e.g. Levy and Slaney 1993, Korman *et al* 1994). Existing models can be built on to generate a model of overwintering habitat carrying capacity.

5.3 Field data collection can be the most expensive and time-consuming aspect of a study of this type. Especially for temporal comparisons, consistency in data collection is essential. Compiling a complete data collection form at the start of the project, and entering data as it is collected will ensure data sets are completed. Interim analysis of the data can allow for fine tuning of the methodologies and objectives as the study progresses, and can foster an adaptive study approach.

5.4 Coho stocks in the upper Bulkley watershed are depressed, and may be vulnerable to further reductions in numbers. Attempts to assess characteristics that determine overwintering habitat quality in a system that exhibits low coho abundance may result in further declines in the stock (due to mortality incurred as a result of sampling). In addition, coho numbers may be so low that sample sizes will be insufficient to indicate which areas offer better quality overwintering habitat. Coho escapements in 1997 were low, indicating that a low proportion of 2+ fish will overwinter in the system in the winter of 1999/2000. However, improved escapement of coho in 1998 should result in a relatively greater proportion of 1+ juveniles at overwintering sites (O'Neill pers. comm.). Studies of overwintering habitat in a smaller system with more stable coho abundance (e.g. Toboggan Creek) may be better able to identify habitat characteristics that influence overwintering habitat quality. Models can be used to provide useful criteria for determining potential productivity of the system for different species. A detailed comparison of suitability of a few different, carefully selected habitat types among sites in Toboggan Creek could provide valuable information that can be extrapolated to the upper Bulkley watershed.

5.5 Overwinter survival has been identified by several researchers as a critical time for salmonids (Schreier 1980, Cunjak 1988, Cunjak 1996, Heggersen *et al.* in prep). However, other critical times in juvenile salmonid survival may also effect the productivity of the system. More than one bottleneck may be present in a watershed. It is important to consider and evaluate the importance of other times in the juvenile coho life history that may affect their survival (e.g. summer survival) and will ensure data requirements for valuable analysis are maintained.

5.6 Lakes have been hypothesized as important coho overwintering habitat. However, to date, no studies have been done to test this hypothesis. If lakes are important for rearing coho in the winter, the lack of accessible lakes in the watershed can account for some decrease in coho production. A study on the importance of lakes (e.g. Toboggan Lake) to overwintering coho in north-central B.C. may be valuable to determining the relative importance of lack of accessible lake habitat in the upper Bulkley watershed.

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Appendix 1. Habitat Data For Sample Sites Examined During The Upper Bulkley River Overwintering Habitat Study (Nov. 1998 – April 1999).

Site	Date	Description	Width Metres	Length Metres	Depth Metres	Volume Metres^3	Pack cms	Thick cms	Temp. C	Temp. C	Oxygen PPM
Barren 1	09-Nov-98	culvert pool	5.1	6.8					1	2	
Barren 1	15-Nov-98	culvert pool	5.1	6.8	0.88	30.52			-0.5	-2	
Barren 1	12-Dec-98	culvert pool	5.1	6.8	0.81	28.09	11	8	0	0	
Barren 1	07-Jan-99	culvert pool	5.1	6.8	0.8	27.74	42	34	0	-2	
Barren 1	05-Feb-99	culvert pool	3.1	7.5	0.62	14.45	33.5	17.4	0	-6	
Barren 1	09-Mar-99	culvert pool	3.1	7.5	0.45	10.56	51.5	0	0.1		
Barren 1	15-Apr-99	culvert pool	3.1	7.5	0.87				1.2	7	13.1
Barren 2	13-Nov-98	woody debris	2	5.95	0.3	3.57			1'C	4'C	
Barren 2	17-Nov-98	woody debris	2	5.95							
Barren 2	15-Dec-98	woody debris	2	5.95	0.43	5.08	13	27	0	0	
Barren 2	13-Jan-99	woody debris	2	5.95	0.31	3.67	48	22	1	-10	
Barren 2	05-Feb-99	woody debris	2	5.95	0.31	3.67	55.5	36	0	-7	
Barren 2	11-Mar-99	woody debris	2	5.95	0.39	4.59	38	18	0.5	4	
Barren 2	15-Mar-99	woody debris					54.9	14	0.5	-3	
Barren 2	15-Apr-99	woody debris	2	5.95	0.45	5.3	9	9	1	7	13.8
Barren 3	13-Nov-98	woody debris	3	7	0.53	11.13			1'C	4'C	
Barren 3	17-Nov-98	woody debris	3	7							
Barren 3	15-Dec-98	woody debris	3	7	0.34	7.07	13	15	0	0	
Barren 3	13-Jan-99	woody debris	3	7	0.26	5.56	43	8	0	-2	
Barren 3	05-Feb-99	woody debris	3	7	0.33	6.98	55.5	12.7	0	-7	
Barren 3	11-Mar-99	woody debris	3	7	0.32	6.72	27	5.3	0.5	4	
Barren 3	15-Mar-99	woody debris					54.9	8	0.5	-3	
Barren 3	15-Apr-99	woody debris	3	7	0.26	5.5	24.5	5.5	0.8	7	14
Buck 1	03-Dec-98	LWD						25	1	-1	
Buck 1	08-Dec-98	LWD					4	30	1	-6	
Buck 1	13-Jan-99	LWD					28	36	1	-2	
Buck 1	09-Feb-99	LWD			1.1		50	40	0.5	-15	
Buck 1	18-Mar-99	LWD			1.1			38	0.5	1	
Buck 1	23-Mar-99	LWD			1.12		35	46	1	1	
Buck 1	14-Apr-99	LWD			0.963		0	0	1	-2	
Buck 2	03-Dec-98	pool						20.5	1	0	
Buck 2	08-Dec-98	pool						24	1	-6	
Buck 2	07-Jan-99	pool					30.5	46	1	-7	
Buck 2	09-Feb-99	pool			0.9		50	46	0.5	-15	
Buck 2	18-Mar-99	pool			0.95		48	35	0.5	1	

Site	Date	Description	Width Metres	Length Metres	Depth Metres	Volume Metres^3	Pack cms	Thick cms	Temp. C	Temp. C	Oxygen PPM
Buck 2	23-Mar-99	pool			0.96		34	48	1	1	
Buck 2	14-Apr-99	pool			0.95		0	0	1	-2	
Buck 3	03-Dec-98	D area u/s bridge						14	0	-2.5	
Buck 3	08-Dec-98	D area u/s bridge						25.5	1	-10	
Buck 3	06-Jan-99	D area u/s bridge						44	1	-7	
Buck 3	09-Feb-99	D area u/s bridge			1.25		81	60	0.5	-6	
Buck 3	18-Mar-99	D area u/s bridge			1.47		76	66	0.5	0	
Buck 3	23-Mar-99	D area u/s bridge			1.44		65	64	1	3	
Buck 3	14-Apr-99	D area u/s bridge			0.853		46	9	1	-2	
Buck 4	03-Dec-98	under Buck bridge						8	1		
Buck 4	08-Dec-98	under Buck bridge						6.5	1	-10	
Buck 4	06-Jan-99	under Buck bridge						20	1	-7	
Buck 4	09-Feb-99	under Buck bridge			0.35		81	10	0.5	-6	
Buck 4	18-Mar-99	under Buck bridge			0.32		76	7	0.5	0	
Buck 4	23-Mar-99	under Buck bridge			0.367		65	0	1	4	
Buck 4	14-Apr-99	under Buck bridge			0.433		46	0	1	-2	
Buck 5	03-Dec-98	LWD area						17	1	2.5	
Buck 5	08-Dec-98	LWD area						24	1	-10	
Buck 5	06-Jan-99	LWD area					46	38	1	-7	
Buck 5	09-Feb-99	LWD area			0.63		81	37	5	-6	
Buck 5	18-Mar-99	LWD area			0.83		76	26	0.5	0	
Buck 5	23-Mar-99	LWD area			1.06		65	34	1	5	
Buck 5	14-Apr-99	LWD area			0.773		46	6	1	-2	
Buck 6	03-Dec-98	u/s of beaver dam					16.5	11	1	3	
Buck 6	08-Dec-98	u/s of beaver dam					10	20.5	1	-10	
Buck 6	14-Jan-99	u/s of beaver dam					39	32	1	-2	
Buck 6	09-Feb-99	u/s of beaver dam			1.097		81	26	0.5	-6	
Buck 6	18-Mar-99	u/s of beaver dam			1.017		76	33	0.5	1	
Buck 6	23-Mar-99	u/s of beaver dam			1.05		65	35	1	6	
Buck 6	14-Apr-99	u/s of beaver dam			1.09		46	14	1	-2	
Byman 1	09-Nov-98	pool no wd	5.1	6.8	0.88	30.52			0.5	-0.5	
Byman 1	15-Nov-98	pool no wd	5.1	6.8					-2.2	-0.5	
Byman 1	12-Dec-98	pool no wd	5.1	6.8	1.04	36.07					
Byman 1	13-Jan-99	pool no wd	5.1	6.8			45.2	21.5	1	-1	
Byman 1	05-Feb-99	pool no wd	3.1	4.8	0.716	10.65	63	15.4	0	-4	

Site	Date	Description	Width Metres	Length Metres	Depth Metres	Volume Metres^3	Pack cms	Thick cms	Temp. C	Temp. C	Oxygen PPM
Byman 1	09-Mar-99	pool no wd	3.1	4.8	0.645	9.60	28.2	18.9	1	3	
Byman 1	15-Apr-99	pool no wd	3.1	4.8	0.836	12.43	0	0	1.8	7	13.1
Byman 2	09-Nov-98	woody debris	3	7.4	1	22.2			0.5	-4	
Byman 2	15-Nov-98	woody debris	3	7.4					-2.2	-0.5	
Byman 2	12-Dec-98	woody debris	3	7.4	0.40	8.81					
Byman 2	13-Jan-99	woody debris	3	7.4	0.36	7.89	43	6.6	1	-1	
Byman 2	05-Feb-99	woody debris	3.8	5	0.43	8.15	63	13	0	-4	
Byman 2	09-Mar-99	woody debris	3.8	5	0.35	6.68	46.7	3.8	1	3	
Byman 2	15-Apr-99	woody debris	3.8	5	0.36	6.86	0	0	0.6	7	13.3
MC 1	28-Jan-99	beaver pond/									
MC 1	03-Feb-99	beaver pond/									
MC 1	21-Apr-99	beaver pond/			0.34				5.6	9.8	12.3
MC 2	28-Jan-99	beaver pond/									
MC 2	03-Feb-99	beaver pond/									
MC 2	21-Apr-99	beaver pond/							5.6	9.8	12.3
MC 3	28-Jan-99	culvert pool									
MC 3	03-Feb-99	culvert pool									
MC 3	21-Apr-99	pool			0.832				5.3	9.8	13.1
MC 4	28-Jan-99	culvert pool									
MC 4	03-Feb-99	culvert pool									
MC 4	21-Apr-99	culvert pool			0.554				4.6	9.8	12.6
MC 4A	21-Apr-99	pool	7.3	8.9	0.608				5	9.8	15.5
MC 5	28-Jan-99	hannel @CNR									
MC 5	03-Feb-99	Chann. @CNR									
McQuarrie	09-Nov-98	culvert pool	5.3	6.5					0.5	-2	
McQuarrie	15-Nov-98	culvert pool	5.3	6.5	0.6	20.67			-0.5	-0.5	
McQuarrie	12-Dec-98	culvert pool	5.3	6.5	0.6	20.67					
McQuarrie	07-Jan-99	culvert pool	5.3	6.5	0.6	20.67					
McQuarrie	05-Feb-99	culvert pool	5.3	6.5	0.58	20.07					
McQuarrie	11-Mar-99	culvert pool	5.3	6.5	0.68	23.55					
McQuarrie	16-Mar-99	culvert pool	5.3	6.5	0.74	25.44					
McQuarrie	15-Apr-99	culvert pool	5.3	6.5	0.45				1.8	7	14.4
Rich 1	09-Nov-98	pool no wd	5	3.1					1	1	
Rich 1	15-Nov-98	pool no wd	5	3.1	0.8	12.4			-0.5	-1.7	
Rich 1	12-Dec-98	pool no wd	5	3.1	0.8	12.4	0	38			

Site	Date	Description	Width Metres	Length Metres	Depth Metres	Volume Metres^3	Pack cms	Thick cms	Temp. C	Temp. C	Oxygen PPM
Rich 1	13-Jan-99	pool no wd	5	3.1	0.77	11.935	43.2	37	0	-1	
Rich 1	05-Feb-99	pool no wd	5	3.1	0.742	11.50	61.4	53	0	-8	
Rich 1	09-Mar-99	pool no wd	5	3.1	0.752	11.66	60	52.6	0.1	5	
Rich 1	14-Mar-99	pool no wd	5	3.1	0.731	11.33	61	30.2	0.5	1	
Rich 1	14-Apr-99	pool no wd	5	3.1	0.788		29	18.5	1.1	4	13.5
Rich 2	09-Nov-98	woody debris	3.5	8.8					1	1	
Rich 2	14-Nov-98	woody debris	3.5	8.8	1.14	34.99			0	-1.7	
Rich 2	12-Dec-98	woody debris	3.5	8.8	1.14	34.99		42			
Rich 2	13-Jan-99	woody debris	3.5	8.8	0.381	11.74507	43.2	24.6	0	-1	
Rich 2	05-Feb-99	woody debris	3.5	8.8	0.572	17.60	57.3	67	0	-8	
Rich 2	09-Mar-99	woody debris	3.5	8.8	0.692	21.31	57.5	67.8	0.1	5	
Rich 2	14-Mar-99	woody debris	3.5	8.8	0.664	20.45	61	32	0.5	1	
Rich 2	14-Apr-99	woody debris	3.5	8.8	0.686				1.1	4	13.5
Rich 3	09-Nov-98	woody debris	6.1	7.2					1	1	
Rich 3	15-Nov-98	woody debris	6.1	7.2	0.5	22.0			-0.5	-1.7	
Rich 3	12-Dec-98	woody debris	6.1	7.2	0.5	22.0	17	26			
Rich 3	07-Jan-99	woody debris	6.1	7.2	0.5	22.0	36	9	1	-8	
Rich 3	05-Feb-99	woody debris	6.1	7.2	0.4	17.6	71	8	0	-5	
Rich 3	11-Mar-99	woody debris	6.1	7.2	0.305	13.4	48.4	18.3	0.5	2	
Rich 3	16-Mar-99	woody debris	6.1	7.2	0.318	14.0	53.5	18.4	0.5	-3	
Rich 3	14-Apr-99	woody debris	6.1	7.2	0.271		24	5.5	1.3	4	12.4
Rich 4	09-Nov-98	pool no wd.	6	10					0.5	-6	
Rich 4	15-Nov-98	pool no wd.	6	10	1.02	61.2			-0.5	-1.7	
Rich 4	12-Dec-98	pool no wd.	6	10	1.02	61.2		14			
Rich 4	07-Jan-99	pool no wd.	6	10	0.52	30.92	36	24	1	-8	
Rich 4	05-Feb-99	pool no wd.	6	10	0.52	30.92	71	6	0	-5	
Rich 4	11-Mar-99	pool no wd.	6	10	0.63	37.62	48.4	22.2	0.5	2	
Rich 4	16-Mar-99	pool no wd.	6	10	0.55	33.16	63.5	17	0.5	-3	
Rich 4	14-Apr-99	pool no wd.	6	10	0.498		26	0	1.5	4	13.10
Toboggan 1	15-Jan-99	pool w.d.	2.8	5.7			44.2	0	0.1	-6	
Toboggan 1	20-Jan-99	pool w.d.	2.8	5.7	0.50	7.96	45.8	0	0.5	-10	
Toboggan 1	11-Feb-99	pool w.d.	2.8	5.7	0.54	8.67	61.8	6.4	0.5	-12	
Toboggan 1	25-Mar-99	pool w.d.	2.8	5.7	0.51	8.07	51.5	0	1.5	5	
Toboggan 1	30-Mar-99	pool w.d.	2.8	5.7	0.51	8.07					
Toboggan 1	22-Apr-99	pool w.d.	2.6	7.2	0.52	9.64	0	0	4.8	10.4	11.9

Site	Date	Description	Width Metres	Length Metres	Depth Metres	Volume Metres^3	Pack cms	Thick cms	Temp. C	Temp. C	Oxygen PPM
Toboggan 2	15-Jan-99	pool w.d.	2.2	5.7			44.2	0	0.1	-6	
Toboggan 2	20-Jan-99	pool w.d.	2.2	5.7	0.34	4.23	45.8	0	0.5	-10	
Toboggan 2	11-Feb-99	pool w.d.	2.2	5.7	0.32	4.02	61.8	6.5	0.5	-12	
Toboggan 2	25-Mar-99	pool w.d.	2.2	5.7	0.39	4.84	51.5	0	1.5	5	
Toboggan 2	30-Mar-99	pool w.d.	2.2	5.7	0.51	6.34					
Toboggan 3	15-Jan-99	pool w.d.	4.5	6.1			44.2	0	0.1	-6	
Toboggan 3	20-Jan-99	pool w.d.	4.5	6.1	0.45	12.38	45.8	0	0.5	-10	
Toboggan 3	11-Feb-99	pool w.d.	4.5	6.1	0.58	15.97	61.8	2	0.5	-12	
Toboggan 3	25-Mar-99	pool w.d.	4.5	6.1	0.45	12.37	51.5	0	1	5	
Toboggan 3	30-Mar-99	pool w.d.	4.5	6.1	0.45	12.37					
Toboggan 3	22-Apr-99	pool w.d.	3.2	8.1	0.43	11.04	0	0	4.1	10.4	12.1
Toboggan 4	15-Jan-99	pool no wd	6.9	7.4			44.2	0	0.1	-6	
Toboggan 4	20-Jan-99	pool no wd	6.9	7.4	0.32	16.09	45.8	0	0.5	-10	
Toboggan 4	11-Feb-99	pool no wd	6.9	7.4	0.35	17.63	61.8	2.4	0.5	-12	
Toboggan 4	25-Mar-99	pool no wd	6.9	7.4	0.25	12.70	51.5	0	1.5	8.5	
Toboggan 4	30-Mar-99	pool no wd	6.9	7.4	0.25	12.70					
Toboggan 4	22-Apr-99	pool no wd	3.2	7.8	0.35	8.74	0	0	4.1	10.4	12.2
UBR #1	09-Nov-98	pool with wd	6.2	19							
UBR #1	15-Nov-98	pool with wd	6.2	19	0.82	96.596					
UBR #1	13-Dec-98	pool with wd	6.2	19	0.82	96.596		14.5	0	2	
UBR #1	13-Jan-99	pool with wd	6.2	19	1.2	141.36		43.2	24.8	0	-1
UBR #1	08-Feb-99	pool with wd	6.2	19	1.2	141.36		76.2	33.4	0	-8
UBR #1	09-Mar-99	pool with wd	6.2	19	1.47	173.166		66.8	42.2	0.1	2
UBR #1	14-Mar-99	pool with wd	6.2	19	1.47	173.166		61	33.1	0.5	1
UBR #1	14-Apr-99	pool with wd	6.2	19	1.44		0	0	1.5	4	12.50
UBR #2	09-Nov-98	log jam	20.3	23.5	0.53	252.8365					
UBR #2	15-Nov-98	log jam	20.3	23.5							
UBR #2	12-Dec-98	log jam	20.3	23.5	0.385	183.6643					
UBR #2	07-Jan-99	log jam	20.3	23.5		183.6643					
UBR #2	14-Apr-99	log jam	20.3	23.5	0.25		31	0	2.2	7	12.9
UBR #3	09-Nov-98	pool with wd			0.88				2	1	
UBR #3	15-Nov-98	pool with wd									
UBR #3	12-Dec-98	pool with wd			0.81						
UBR #3	07-Jan-99	pool with wd			0.468333						
UBR #4	13-Nov-98	log jam	2	26.6							

Site	Date	Description	Width Metres	Length Metres	Depth Metres	Volume Metres^3	Pack cms	Thick cms	Temp. C	Temp. C	Oxygen PPM
UBR #4	17-Nov-98	log jam	2	26.6							
UBR #4	12-Dec-98	log jam	2	26.6							
UBR #4	07-Jan-99	log jam	2	26.6							
UBR #5	13-Nov-98	pool	61.8	41	0.88				1.5	5	
UBR #5	17-Nov-98	pool	61.8	41					-0.5	-2.7	
UBR #5	12-Dec-98	pool	61.8	41	0.81	2052.378					
UBR #5	07-Jan-99	pool	61.8	41							
UBR # 5	15-Apr-99	Henry's pool	61.8	41	2		22.5	0	3	7	12.4
UBR #6	13-Nov-98	log jam							1	7	
UBR #6	17-Nov-98	log jam							-0.5	-0.5	
UBR #6	12-Dec-98	log jam			0.523333						
UBR #6	07-Jan-99	log jam									
UBR #6	15-Apr-99	log jam			0.599		0	0	3.1	11.7	12.9
UBR #7	13-Nov-98	pool with wd	12.7	7.7	0.616667	60.30383			1	1	
UBR #7	17-Nov-98	pool with wd							-0.5	-1.7	
UBR #7	12-Dec-98	pool with wd	12.7	7.7	0.616667	60.30383					
UBR #7	07-Jan-99	pool with wd	12.7	7.7	0	0					
UBR #8	13-Nov-98	woody debris	2	5	1.06	10.6			1	1	
UBR #8	17-Nov-98	woody debris							-0.5	-1.7	
UBR #8	12-Dec-98	woody debris	2	5	1.06	0					
UBR #8	07-Jan-99	woody debris	2	5	0.26	2.63					
UBR #8	08-Feb-99	woody debris	2	5	0.30	3.03	66.2	1.5	0	-4	
UBR #8	10-Mar-99	woody debris	2	5			53	5	1	5	
UBR #8	16-Mar-99	woody debris	2	5	0.712	7.12	51.7	3	0.5	-3	
UBR #8	15-Apr-99	woody debris	2	5	0.8825				3.2	11.8	12.5

Date	Location	# Traps	CO	RB	CH	DV	BB	LNC	Ttl capt.	Mark #1 # marked	Mark #1 # recaptured	Mark #2 # marked	Mark #2 # recaptured
09-Nov-98	Barren 1	3.00	10	7	0				17.00	17			
15-Nov-98	Barren 1	3.00	12	14	0				26.00	17	4.00		
12-Dec-98	Barren 1	3.00	12	13	0				25.00	17	6.00		
07-Jan-99	Barren 1	3.00	16	12	0				28.00	17	9.00		
05-Feb-99	Barren 1	3.00	15	8	1				24.00	17	11.00	17.00	
09-Mar-99	Barren 1	3.00	9	8	0				17.00	17		17.00	5.00
15-Apr-99	Barren 1	3.00	5	11	0				16.00	17		17.00	5.00
13-Nov-98	Barren 2	3.00	6	11	0				17.00	17			
17-Nov-98	Barren 2	3.00	6	16	0				22.00	17	5.00		
15-Dec-98	Barren 2	3.00	5	35	0				40.00	17	4.00		
13-Jan-99	Barren 2	3.00	5	26	0				31.00	17	6.00		
05-Feb-99	Barren 2	3.00	5	36	0				41.00	17	5.00		
11-Mar-99	Barren 2(lv)	3.00	3	31	0				34.00	17	4.00	34.00	
15-Mar-99	Barren 2 (lv)	3.00	2	18	0				20.00	17		34.00	8.00
15-Apr-99	Barren 2 (lv)	3.00	2	24	0				26.00	17		34.00	7.00
13-Nov-98	Barren 3	3.00	1	15	0				16.00	16			
17-Nov-98	Barren 3	3.00	0	8	0				8.00	16	2.00		
15-Dec-98	Barren 3	3.00	0	6	0				6.00	16	1.00		
13-Jan-99	Barren 3	3.00	0	3	0				3.00	16	0.00		
05-Feb-99	Barren 3	3.00	0	9	0				9.00	16	2.00		
11-Mar-99	Barren 3	3.00	0	7	0				7.00	16	1.00	7.00	
15-Mar-99	Barren 3 (lv)	3.00	0	2	0				2.00	16		7.00	1.00
15-Apr-99	Barren 3 (lv)	3.00	0	10	0				10.00	16		7.00	2.00
03-Dec-98	Buck 1	3.00	1	5	0			0	6.00	6.00			
08-Dec-98	Buck 1	3.00	8	9	0			0	17.00	23.00			
13-Jan-99	Buck 1	3.00	8	9	0			0	17.00	23.00	1.00		
09-Feb-99	Buck 1	3.00	2	13	0			0	15.00	23.00	1.00		
18-Mar-99	Buck 1	3.00	2	7	0			0	9.00	23.00	1.00	9.00	
23-Mar-99	Buck 1	3.00	0	0	0			0	0.00	23.00	0.00	9.00	0.00
14-Apr-99	Buck 1	3.00	0	0	0			0	0.00	23.00	0.00	9.00	0.00
03-Dec-98	Buck 2	3.00	0	3	0			0	3.00	3.00			
08-Dec-98	Buck 2	3.00	1	7	0			0	8.00	3.00	1.00		
07-Jan-99	Buck 2	3.00	1	5	0			1	7.00	3.00	0.00		
09-Feb-99	Buck 2	3.00	0	2	0			0	2.00	3.00	0.00		
18-Mar-99	Buck 2	3.00	0	0	1			0	1.00	3.00	0.00	1.00	

Date	Location	# Traps	CO	RB	CH	DV	BB	LNC	Ttl capt.	Mark #1 # marked	Mark #1 # recaptured	Mark #2 # marked	Mark #2 # recaptured
23-Mar-99	Buck 2	3.00	0	1	0			0	1.00	3.00	0.00	1.00	0.00
14-Apr-99	Buck 2	3.00	1	6	0			0	7.00	3.00	0.00	1.00	0.00
03-Dec-98	Buck 3	3.00	9	10	0			0	19.00	19.00			
08-Dec-98	Buck 3	3.00	1	7	0			0	8.00	19.00	0.00		
06-Jan-99	Buck 3	3.00	1	4	0			0	5.00	19.00	1.00		
09-Feb-99	Buck 3	3.00	0	0	0			0	0.00	19.00	0.00		
18-Mar-99	Buck 3	3.00	1	8	0			0	9.00	19.00	1.00		
23-Mar-99	Buck 3	3.00	0	4	0			0	4.00	19.00	1.00		
14-Apr-99	Buck 3	3.00	0	5	0			0	5.00	19.00	2.00		
03-Dec-98	Buck 4	3.00	0	12	0			0	12.00	12.00			
08-Dec-98	Buck 4	3.00	0	4	0			0	4.00	12.00	0.00		
06-Jan-99	Buck 4	3.00	0	4	0			0	4.00	12.00	1.00		
09-Feb-99	Buck 4	3.00	0	1	0			0	1.00	12.00	0.00		
18-Mar-99	Buck 4	3.00	0	2	0			0	2.00	12.00	0.00	2.00	
23-Mar-99	Buck 4	3.00	0	4	0			0	4.00	12.00	1.00	2.00	0.00
14-Apr-99	Buck 4	3.00	0	1	0			0	1.00	12.00	0.00	2.00	0.00
03-Dec-98	Buck 5	3.00	2	8	0			0	10.00	10.00			
08-Dec-98	Buck 5	3.00	1	2	0			0	3.00	10.00	0.00		
06-Jan-99	Buck 5	3.00	0	4	0			0	4.00	10.00	1.00		
09-Feb-99	Buck 5	3.00	0	0	0			0	0.00	10.00	0.00		
18-Mar-99	Buck 5	3.00	0	6	0			0	6.00	10.00	0.00	6.00	
23-Mar-99	Buck 5	3.00	0	3	0			0	3.00	10.00	0.00	6.00	0.00
14-Apr-99	Buck 5	3.00	0	0	0			0	0.00	10.00	0.00	6.00	0.00
03-Dec-98	Buck 6	3.00	1	7	0			0	8.00	7.00			
08-Dec-98	Buck 6	3.00	0	0	0			0	0.00	7.00	0.00		
14-Jan-99	Buck 6	3.00	0	4	0			0	4.00	7.00	1.00		
09-Feb-99	Buck 6	3.00	0	0	0			0	0.00	7.00	0.00		
18-Mar-99	Buck 6	3.00	0	4	0			0	4.00	7.00	0.00	4.00	
23-Mar-99	Buck 6	3.00	1	1	0			0	2.00	7.00	1.00	4.00	
14-Apr-99	Buck 6	3.00	0	2	0			0	2.00	7.00	1.00	4.00	
09-Nov-98	Byman 1	3.00	0	2	0				2.00	2.00			
15-Nov-98	Byman 1	3.00	0	4	0				4.00	2.00	0.00		
12-Dec-98	Byman 1	3.00	0	16	1				17.00	2.00	0.00		
13-Jan-99	Byman 1	3.00	1	10	3				14.00	2.00	0.00		
05-Feb-99	Byman 1	3.00	2	5	0				7.00	2.00	0.00		

Date	Location	# Traps	CO	RB	CH	DV	BB	LNC	Ttl capt.	Mark #1 # marked	Mark #1 # recaptured	Mark #2 # marked	Mark #2 # recaptured
09-Mar-99	Byman 1	3.00	11	5	0				16.00	2.00	0.00		
15-Apr-99	Byman 1	3.00	0	2	0				2.00	2.00	0.00		
09-Nov-98	Byman 2	3.00	4	9	0				13.00	13			
15-Nov-98	Byman 2	3.00	2	9	0				11.00	13	2.00		
12-Dec-98	Byman 2	3.00	2	26	0				28.00	13	2.00		
13-Jan-99	Byman 2	3.00	2	23	2				27.00	13	2.00		
05-Feb-99	Byman 2	3.00	2	12	0				14.00	11	1.00		
09-Mar-99	Byman 2	3.00	6	6	0				12.00	11	1.00		
15-Apr-99	Byman 2	3.00	0	5	0				5.00	13	0.00		
28-Jan-99	MC 1	3.00	0	0		55			55.00	20			
03-Feb-99	MC 1	3.00	0	0		9			9.00	20	0.00	9.00	
21-Apr-99	MC 1	6.00	0	0		34			34.00	20.00	0.00	9.00	1.00
28-Jan-99	MC 2	3.00	0	0		15			15.00	15			
03-Feb-99	MC 2	3.00	0	0		38			38.00	15	2	38.00	
21-Apr-99	MC 2	6.00	0	0		45			45.00	15.00	1.00	38.00	1.00
28-Jan-99	MC 3	3.00	1	0		32			33.00	33.00			
03-Feb-99	MC 3	3.00	0	0		11			11.00	33.00	3.00	11.00	
21-Apr-99	MC 3	3.00	0	0		12			12.00	33.00	2.00	11.00	3.00
28-Jan-99	MC 4	3.00	0	0		55			55.00	30.00			
03-Feb-99	MC 4	3.00	0	0		18			18.00	30.00	3.00	18.00	
21-Apr-99	MC 4	3.00	0	0		1			1.00	30.00	0.00	18.00	0.00
21-Apr-99	MC 4A	3.00	0	0		17			7.00				3.00
28-Jan-99	MC 5	3.00	0	0		4			4.00	4.00			
03-Feb-99	MC 5	3.00	0	0		3			3.00	4.00	0.00		
09-Nov-98	McQuarrie 1	4.00	2	10	0				12.00	12.00			
15-Nov-98	McQuarrie 1	4.00	5	19	0				24.00	12.00	4.00		
12-Dec-98	McQuarrie 1	3.00	9	22	3				34.00	12.00	3.00		
07-Jan-99	McQuarrie 1	3.00	3	3	1				7.00	12.00	1.00		
05-Feb-99	McQuarrie 1	3.00	0	13	1				14.00	12.00	1.00		
11-Mar-99	McQuarrie 1	3.00	1	8	0				9.00	12.00	2.00	9.00	
16-Mar-99	McQuarrie 1	3.00	0	5	0				5.00	12.00		9.00	2.00
15-Apr-99	McQuarrie 1	3.00	0	9	0				9.00	12.00	2.00	9.00	2.00
09-Nov-98	Rich 1	3.00	0	4	0				4.00	4.00			
15-Nov-98	Rich 1	3.00	0	4	0				4.00	4.00	0.00		
12-Dec-98	Rich 1		0	12	0				12.00	4.00	1.00		

Date	Location	# Traps	CO	RB	CH	DV	BB	LNC	Ttl capt.	Mark #1 # marked	Mark #1 # recaptured	Mark #2 # marked	Mark #2 # recaptured
13-Jan-99	Rich 1	3.00	0	11	0				11.00	4.00	1.00		
05-Feb-99	Rich 1	3.00	1	11	0				12.00	4.00	1.00		
09-Mar-99	Rich 1	3.00	0	10	0				10.00	4.00	0.00	10.00	
14-Mar-99	Rich 1	3.00	0	12	0				12.00	4.00		10.00	7.00
14-Apr-99	Rich 1	3.00	0	6	0				6.00	4.00		10.00	5.00
09-Nov-98	Rich 2	3.00	0	11	0				11.00	11.00			
14-Nov-98	Rich 2	3.00	0	13	1				14.00	11.00	2.00		
12-Dec-98	Rich 2	3.00	2	9	0				11.00	11.00	2.00		
13-Jan-99	Rich 2	3.00	0	1	0				1.00	11.00	0.00		
05-Feb-99	Rich 2	3.00	0	8	1				9.00	11.00	0.00		
09-Mar-99	Rich 2	3.00	1	18	0				19.00	11.00	1.00	19.00	
14-Mar-99	Rich 2	3.00	0	4	0				4.00	11.00		19.00	0.00
14-Apr-99	Rich 2	3.00	0	3	0				3.00	11.00		19.00	0.00
09-Nov-98	Rich 3	3.00	2	14	0				16.00	16.00			
15-Nov-98	Rich 3	3.00	2	13	0				15.00	16.00	4.00		
12-Dec-98	Rich 3	3.00	6	16	0				22.00	16.00	2.00		
07-Jan-99	Rich 3	3.00	0	9	0				9.00	16.00	0.00		
05-Feb-99	Rich 3	3.00	1	2	0				3.00	16.00	0.00		
11-Mar-99	Rich 3	3.00	1	12	0				13.00	16.00	1.00	13.00	
16-Mar-99	Rich 3	3.00	0	2	0				2.00	16.00		13.00	0.00
14-Apr-99	Rich 3	3.00	2	10	0				12.00	16.00		13.00	2.00
09-Nov-98	Rich 4	3.00	1	6	0				7.00	7.00			
15-Nov-98	Rich 4	3.00	11	13	0				24.00	7.00	2.00		
12-Dec-98	Rich 4	3.00	8	9	0				17.00	7.00	2.00		
07-Jan-99	Rich 4												
05-Feb-99	Rich 4	3.00	1	13	0				14.00	7.00	1.00		
11-Mar-99	Rich 4	3.00	1	11	0				12.00	7.00	2.00	12.00	
16-Mar-99	Rich 4	3.00	0	8	0				8.00			12.00	3.00
14-Apr-99	Rich 4	3.00	1	4	0				5.00			12.00	3.00
15-Jan-99	Toboggan 1	3.00	17	6	0				23.00	23.00			
20-Jan-99	Toboggan 1	3.00	15	1	0				16.00	23.00	5.00		
11-Feb-99	Toboggan 1	3.00	11	3	0				14.00	23.00	3.00		
25-Mar-99	Toboggan 1	3.00	8	3	2				13.00	23.00	3.00	13.00	
30-Mar-99	Toboggan 1	3.00	5	3	1				9.00	23.00		13.00	2.00
22-Apr-99	Toboggan 1	6.00	10	1	1				12.00	23.00		13.00	1.00

Date	Location	# Traps	CO	RB	CH	DV	BB	LNC	Ttl capt.	Mark #1 # marked	Mark #1 # recaptured	Mark #2 # marked	Mark #2 # recaptured
15-Jan-99	Toboggan 2	3.00	9	2	1				12.00	12.00			
20-Jan-99	Toboggan 2	3.00	12	5	0				17.00	12.00	4.00		
11-Feb-99	Toboggan 2	3.00	16	7	0				23.00	12.00	4.00		
25-Mar-99	Toboggan 2	3.00	7	3	0				10.00	12.00	3.00	10.00	
30-Mar-99	Toboggan 2	3.00	13	3	1				17.00	12.00		10.00	2.00
15-Jan-99	Toboggan 3	3.00	29	2	2				33.00	33.00			
20-Jan-99	Toboggan 3	3.00	9	5	3				17.00	33.00	1.00		
11-Feb-99	Toboggan 3	3.00	13	8	2				23.00	33.00	2.00		
25-Mar-99	Toboggan 3	3.00	20	11	3				34.00	33.00	4.00	34.00	
30-Mar-99	Toboggan 3	3.00	25	5	0				30.00	33.00		34.00	4.00
22-Apr-99	Toboggan 3	6.00	10	4	3				17.00	33.00		34.00	3.00
15-Jan-99	Toboggan 4	3.00	0	6	1				7.00	7.00			
20-Jan-99	Toboggan 4	3.00	8	2	0				10.00	7.00	0.00		
11-Feb-99	Toboggan 4	3.00	5	3	0				8.00	7.00	0.00		
25-Mar-99	Toboggan 4	3.00	2	1	0				3.00	7.00	0.00	3.00	
30-Mar-99	Toboggan 4	3.00	4	1	1				6.00	7.00		3.00	0.00
22-Apr-99	Toboggan 4	3.00	2	4	0				6.00	7.00		3.00	1.00
09-Nov-98	UBR#1	4.00	0	0	0				0.00	0.00			
15-Nov-98	UBR#1	4.00	0	1	1				2.00	2.00			
13-Dec-98	UBR#1	3.00	0	4	2				6.00	2.00	0.00		
13-Jan-99	UBR#1	3.00	0	2	2				4.00	8.00	3.00		
08-Feb-99	UBR#1	3.00	8	4	0				12.00	8.00	0.00		
09-Mar-99	UBR#1	3.00	8	0	0				8.00	8.00	2.00	8.00	
14-Mar-99	UBR#1	3.00	2	0	1				3.00	8.00		8.00	1.00
14-Apr-99	UBR#1	3.00	0	0	0		0		0.00	8.00	0.00	8.00	0.00
09-Nov-98	UBR#2	3.00	1	10	0				11.00	11.00			
15-Nov-98	UBR#2	3.00	2	12	0		0		14.00	11.00	1.00		
12-Dec-98	UBR#2	3.00	0	14	0		0		14.00	11.00	1.00		
07-Jan-99	UBR#2												
14-Apr-99	UBR #2	3.00	0	1	0		1		2.00	11.00	0.00		
09-Nov-98	UBR#3	4.00	0	15	0		0		15.00	15.00			
15-Nov-98	UBR#3	4.00	1	11	0		0		12.00	15.00	0.00		
12-Dec-98	UBR#3												
07-Jan-99	UBR#3												
13-Nov-98	UBR#4	3.00	0	8	4		0		12.00	12.00			

Date	Location	# Traps	CO	RB	CH	DV	BB	LNC	Ttl capt.	Mark #1 # marked	Mark #1 # recaptured	Mark #2 # marked	Mark #2 # recaptured
17-Nov-98	UBR#4	3.00	1	4	2		0		7.00	12.00	1.00		
12-Dec-98	UBR#4												
07-Jan-99	UBR#4												
13-Nov-98	UBR #5	3.00	3	3	0		0		6.00	6.00			
17-Nov-98	UBR #5	3.00	4	0	0		0		4.00	6.00	0.00		
12-Dec-98	UBR#5	3.00	0	4	0		0		4.00	6.00	1.00		
07-Jan-99	UBR#5												
15-Apr-99	UBR #5	3.00	0	2	0		0		2.00	6.00	0.00		
13-Nov-98	UBR #6	3.00	2	1	0		0		3.00	3.00			
17-Nov-98	UBR #6	3.00	0	3	0		0		3.00	3.00	0.00		
12-Dec-98	UBR #6	3.00	1	10	1		0		12.00	3.00	0.00		
07-Jan-99	UBR #6												
15-Apr-99	UBR #6	3.00	0	8	1		0		9.00	3.00	0.00		
13-Nov-98	UBR #7	3.00	1	0	0		0		1.00	1.00			
17-Nov-98	UBR #7	3.00	0	1	0		0		1.00	1.00	0.00		
12-Dec-98	UBR #7	3.00	1	0	1		0		2.00	1.00	0.00		
07-Jan-99	UBR #7												
13-Nov-98	UBR #8	3.00	16	0	0		0		16.00	16.00			
17-Nov-98	UBR #8	3.00	13	0	0		0		13.00	16.00	0.00		
12-Dec-98	UBR #8	3.00	26	0	3		0		29.00	16.00	0.00		
07-Jan-99	UBR #8	3.00	1	1	0		0		2.00	16.00	0.00		
08-Feb-99	UBR #8	3.00	1	2	0		0		3.00	16.00	1.00		
10-Mar-99	UBR #8												
16-Mar-99	UBR #8	3.00	5	1	0		0		6.00	16.00	1.00		
15-Apr-99	UBR #8	3.00	1	2	6		0		9.00	16.00	1.00		

Appendix 2. Individual Fish Data For Fish Captured Locations In The Upper Bulkley River Overwintering Habitat Study (Nov. 98 – April 1999).

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Barren	1	15-Nov-98	CO	2.6			
Barren	1	15-Nov-98	CO	2.6			
Barren	1	15-Nov-98	CO	3			
Barren	1	15-Nov-98	CO	3.8			
Barren	1	15-Nov-98	CO	3.9			
Barren	1	15-Nov-98	CO	4.9			
Barren	1	15-Nov-98	CO	4.9			
Barren	1	15-Nov-98	CO	5			
Barren	1	15-Nov-98	CO	6.1			
Barren	1	15-Nov-98	CO	7.1			
Barren	1	15-Nov-98	CO	8.2			
Barren	1	15-Nov-98	CO	8.6			
Barren	1	15-Nov-98	CO	8.8			
Barren	1	15-Nov-98	CO	9.2			
Barren	1	15-Nov-98	CO	9.8			
Barren	1	15-Nov-98	CO	10			
Barren	1	15-Nov-98	CO	10.2			
Barren	1	15-Nov-98	CO	12.8			
Barren	1	15-Nov-98	CO	13.3			
Barren	1	15-Nov-98	RB	0.5			
Barren	1	15-Nov-98	RB	1.4			
Barren	1	15-Nov-98	RB	1.4			
Barren	1	15-Nov-98	RB	1.5			
Barren	1	15-Nov-98	RB	2			
Barren	1	15-Nov-98	RB	2.8			
Barren	1	15-Nov-98	RB	3			
Barren	1	15-Nov-98	RB	3.4			
Barren	1	15-Nov-98	RB	3.6			
Barren	1	15-Nov-98	RB	4.8			
Barren	1	15-Nov-98	RB	4.8			
Barren	1	15-Nov-98	RB	4.9			
Barren	1	15-Nov-98	RB	5.5			
Barren	1	15-Nov-98	RB	7.6			
Barren	1	15-Nov-98	RB	9.7			
Barren	1	15-Nov-98	RB	12.1			
Barren	1	15-Nov-98	RB	12.2			
Barren	1	15-Nov-98	RB	14.7			
Barren	1	15-Nov-98	RB	18			
Barren	1	15-Nov-98	RB	18.7			
Barren	1	12-Dec-98	CO	4.4			
Barren	1	12-Dec-98	CO	6			
Barren	1	12-Dec-98	CO	6.2			
Barren	1	12-Dec-98	CO	6.2			
Barren	1	12-Dec-98	CO	7			
Barren	1	12-Dec-98	CO	7.1			
Barren	1	12-Dec-98	CO	7.5			
Barren	1	12-Dec-98	CO	8			
Barren	1	12-Dec-98	CO	8.2			
Barren	1	12-Dec-98	CO	8.5			
Barren	1	12-Dec-98	CO	8.6			
Barren	1	12-Dec-98	CO	11.2			
Barren	1	12-Dec-98	RB	2.6			
Barren	1	12-Dec-98	RB	3			
Barren	1	12-Dec-98	RB	3.7			
Barren	1	12-Dec-98	RB	3.9			
Barren	1	12-Dec-98	RB	4			
Barren	1	12-Dec-98	RB	4.5			
Barren	1	12-Dec-98	RB	5.6			
Barren	1	12-Dec-98	RB	7.1			
Barren	1	12-Dec-98	RB	7.8			
Barren	1	12-Dec-98	RB	8.6			
Barren	1	12-Dec-98	RB	10.5			
Barren	1	12-Dec-98	RB	14.5			
Barren	1	12-Dec-98	RB	18.3			
Barren	1	07-Jan-99	CO	2.9			
Barren	1	07-Jan-99	CO	6.9			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Barren	1	07-Jan-99	CO	7			
Barren	1	07-Jan-99	CO	8.2			
Barren	1	07-Jan-99	CO	8.3			
Barren	1	07-Jan-99	CO	8.6			
Barren	1	07-Jan-99	CO	11			
Barren	1	07-Jan-99	CO	11			
Barren	1	07-Jan-99	CO	11.2			
Barren	1	07-Jan-99	CO	13.4			
Barren	1	07-Jan-99	CO	13.5			
Barren	1	07-Jan-99	CO	15.3			
Barren	1	07-Jan-99	CO	19			
Barren	1	07-Jan-99	CO	19.3			
Barren	1	07-Jan-99	CO	22			
Barren	1	07-Jan-99	CO	10			
Barren	1	07-Jan-99	RB	6.3			
Barren	1	07-Jan-99	RB	6.9			
Barren	1	07-Jan-99	RB	9.3			
Barren	1	07-Jan-99	RB	10			
Barren	1	07-Jan-99	RB	11.3			
Barren	1	07-Jan-99	RB	11.3			
Barren	1	07-Jan-99	RB	14.3			
Barren	1	07-Jan-99	RB	14.8			
Barren	1	07-Jan-99	RB	18.5			
Barren	1	07-Jan-99	RB	20.6			
Barren	1	07-Jan-99	RB	23.1			
Barren	1	07-Jan-99	RB	26.6			
Barren	1	05-Feb-99	CH	8			
Barren	1	05-Feb-99	CO	4.4			
Barren	1	05-Feb-99	CO	6			
Barren	1	05-Feb-99	CO	6.6			
Barren	1	05-Feb-99	CO	7.3			
Barren	1	05-Feb-99	CO	7.7			
Barren	1	05-Feb-99	CO	8.6			
Barren	1	05-Feb-99	CO	8.7			
Barren	1	05-Feb-99	CO	8.8			
Barren	1	05-Feb-99	CO	9.2			
Barren	1	05-Feb-99	CO	9.6			
Barren	1	05-Feb-99	CO	10.6			
Barren	1	05-Feb-99	CO	10.7			
Barren	1	05-Feb-99	CO	12.9			
Barren	1	05-Feb-99	CO	14.1			
Barren	1	05-Feb-99	CO	7.1			
Barren	1	05-Feb-99	RB	5.3			
Barren	1	05-Feb-99	RB	5.3			
Barren	1	05-Feb-99	RB	5.5			
Barren	1	05-Feb-99	RB	9			
Barren	1	05-Feb-99	RB	12.5			
Barren	1	05-Feb-99	RB	13			
Barren	1	05-Feb-99	RB	14			
Barren	1	05-Feb-99	RB	16.6			
Barren	1	08-Mar-99	CO	10.1	91	0.134029	
Barren	1	08-Mar-99	CO	9.7	103	0.088769	
Barren	1	08-Mar-99	CO	6.8	89	0.096458	
Barren	1	08-Mar-99	CO	7.6	93	0.094485	
Barren	1	08-Mar-99	CO	11.4	101	0.110647	
Barren	1	08-Mar-99	CO	8.5	93	0.105674	
Barren	1	08-Mar-99	CO	8.3	96	0.093813	
Barren	1	08-Mar-99	CO	7.6	90	0.104252	
Barren	1	08-Mar-99	CO	10	101	0.097059	
Barren	1	08-Mar-99	RB	5	80	0.097656	
Barren	1	08-Mar-99	RB	13.2	110	0.099174	
Barren	1	08-Mar-99	RB	15.9	113	0.110195	
Barren	1	08-Mar-99	RB	12.6	116	0.080723	
Barren	1	08-Mar-99	RB	5.6	88	0.082175	
Barren	1	08-Mar-99	RB	11.9	103	0.108902	
Barren	1	08-Mar-99	RB	6.7	92	0.086042	

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Barren	1	08-Mar-99	RB	4.4	75	0.104296	
Barren	1	08-Mar-99	RB				
Barren	1	15-Apr-99	CO	7.4			
Barren	1	15-Apr-99	CO	7.9			
Barren	1	15-Apr-99	CO	9.8			
Barren	1	15-Apr-99	CO	10.2			
Barren	1	15-Apr-99	CO	11.6			
Barren	1	15-Apr-99	RB	4.3			
Barren	1	15-Apr-99	RB	4.9			
Barren	1	15-Apr-99	RB	5.5			
Barren	1	15-Apr-99	RB	5.5			
Barren	1	15-Apr-99	RB	7.7			
Barren	1	15-Apr-99	RB	7.8			
Barren	1	15-Apr-99	RB	10.3			
Barren	1	15-Apr-99	RB	11.6			
Barren	1	15-Apr-99	RB	13.2			
Barren	1	15-Apr-99	RB	13.5			
Barren	1	15-Apr-99	RB	16.1			
Barren	2	15-Nov-98	CO	2.4			
Barren	2	15-Nov-98	CO	3.8			
Barren	2	15-Nov-98	CO	6.9			
Barren	2	15-Nov-98	CO	7.2			
Barren	2	15-Nov-98	CO	7.7			
Barren	2	15-Nov-98	CO	8.7			
Barren	2	15-Nov-98	CO	8.9			
Barren	2	15-Nov-98	CO	11.2			
Barren	2	15-Nov-98	CO	11.6			
Barren	2	15-Nov-98	CO	12.2			
Barren	2	15-Nov-98	CO	12.6			
Barren	2	15-Nov-98	CO	16.3			
Barren	2	15-Nov-98	RB	1.5			
Barren	2	15-Nov-98	RB	1.5			
Barren	2	15-Nov-98	RB	3			
Barren	2	15-Nov-98	RB	3.2			
Barren	2	15-Nov-98	RB	3.8			
Barren	2	15-Nov-98	RB	4.6			
Barren	2	15-Nov-98	RB	4.8			
Barren	2	15-Nov-98	RB	5.6			
Barren	2	15-Nov-98	RB	6.6			
Barren	2	15-Nov-98	RB	6.7			
Barren	2	15-Nov-98	RB	7.3			
Barren	2	15-Nov-98	RB	7.6			
Barren	2	15-Nov-98	RB	8.1			
Barren	2	15-Nov-98	RB	8.7			
Barren	2	15-Nov-98	RB	9.1			
Barren	2	15-Nov-98	RB	9.9			
Barren	2	15-Nov-98	RB	9.9			
Barren	2	15-Nov-98	RB	10.3			
Barren	2	15-Nov-98	RB	11			
Barren	2	15-Nov-98	RB	12.3			
Barren	2	15-Nov-98	RB	13.8			
Barren	2	15-Nov-98	RB	14.8			
Barren	2	15-Nov-98	RB	14.8			
Barren	2	15-Nov-98	RB	16.1			
Barren	2	15-Nov-98	RB	16.2			
Barren	2	15-Nov-98	RB	18.8			
Barren	2	15-Nov-98	RB	20.7			
Barren	2	15-Nov-98	RB	22.8			
Barren	2	15-Nov-98	RB	12			
Barren	2	15-Dec-98	CO	2.2			
Barren	2	15-Dec-98	CO	3			
Barren	2	15-Dec-98	CO	6.1			
Barren	2	15-Dec-98	CO	6.4			
Barren	2	15-Dec-98	CO	12.6			
Barren	2	15-Dec-98	RB	0.9			
Barren	2	15-Dec-98	RB	1.4			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Barren	2	15-Dec-98	RB	2.1			
Barren	2	15-Dec-98	RB	2.1			
Barren	2	15-Dec-98	RB	3.2			
Barren	2	15-Dec-98	RB	3.4			
Barren	2	15-Dec-98	RB	3.6			
Barren	2	15-Dec-98	RB	4.1			
Barren	2	15-Dec-98	RB	7			
Barren	2	15-Dec-98	RB	7.2			
Barren	2	15-Dec-98	RB	7.5			
Barren	2	15-Dec-98	RB	9.2			
Barren	2	15-Dec-98	RB	9.2			
Barren	2	15-Dec-98	RB	9.4			
Barren	2	15-Dec-98	RB	10.2			
Barren	2	15-Dec-98	RB	10.3			
Barren	2	15-Dec-98	RB	12.6			
Barren	2	15-Dec-98	RB	16.2			
Barren	2	15-Dec-98	RB	1.3			
Barren	2	15-Dec-98	RB	3.2			
Barren	2	15-Dec-98	RB	3.3			
Barren	2	15-Dec-98	RB	3.7			
Barren	2	15-Dec-98	RB	4			
Barren	2	15-Dec-98	RB	4			
Barren	2	15-Dec-98	RB	4.3			
Barren	2	15-Dec-98	RB	4.4			
Barren	2	15-Dec-98	RB	4.4			
Barren	2	15-Dec-98	RB	4.5			
Barren	2	15-Dec-98	RB	4.6			
Barren	2	15-Dec-98	RB	4.7			
Barren	2	15-Dec-98	RB	6.4			
Barren	2	15-Dec-98	RB	6.5			
Barren	2	15-Dec-98	RB	7.2			
Barren	2	15-Dec-98	RB	7.5			
Barren	2	15-Dec-98	RB	11.2			
Barren	2	07-Jan-99	CO	10.8			
Barren	2	07-Jan-99	CO	3.5			
Barren	2	07-Jan-99	CO	6.6			
Barren	2	07-Jan-99	CO	9.2			
Barren	2	07-Jan-99	CO	9.5			
Barren	2	07-Jan-99	RB	1.5			
Barren	2	07-Jan-99	RB	2			
Barren	2	07-Jan-99	RB	2.4			
Barren	2	07-Jan-99	RB	3.4			
Barren	2	07-Jan-99	RB	3.8			
Barren	2	07-Jan-99	RB	4.3			
Barren	2	07-Jan-99	RB	4.6			
Barren	2	07-Jan-99	RB	4.8			
Barren	2	07-Jan-99	RB	4.9			
Barren	2	07-Jan-99	RB	5.8			
Barren	2	07-Jan-99	RB	5.9			
Barren	2	07-Jan-99	RB	5.9			
Barren	2	07-Jan-99	RB	6.7			
Barren	2	07-Jan-99	RB	6.8			
Barren	2	07-Jan-99	RB	6.8			
Barren	2	07-Jan-99	RB	6.8			
Barren	2	07-Jan-99	RB	7.6			
Barren	2	07-Jan-99	RB	7.9			
Barren	2	07-Jan-99	RB	8			
Barren	2	07-Jan-99	RB	8.3			
Barren	2	07-Jan-99	RB	9.2			
Barren	2	07-Jan-99	RB	9.2			
Barren	2	07-Jan-99	RB	10.8			
Barren	2	07-Jan-99	RB	11.7			
Barren	2	07-Jan-99	RB	19.4			
Barren	2	07-Jan-99	RB	22.4			
Barren	2	05-Feb-99	CO	4			
Barren	2	05-Feb-99	CO	4.2			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Barren	2	05-Feb-99	CO	6.5			
Barren	2	05-Feb-99	CO	11.4			
Barren	2	05-Feb-99	CO	11.4			
Barren	2	05-Feb-99	RB	1			
Barren	2	05-Feb-99	RB	2			
Barren	2	05-Feb-99	RB	2.6			
Barren	2	05-Feb-99	RB	3.5			
Barren	2	05-Feb-99	RB	3.5			
Barren	2	05-Feb-99	RB	3.8			
Barren	2	05-Feb-99	RB	3.9			
Barren	2	05-Feb-99	RB	4.1			
Barren	2	05-Feb-99	RB	4.2			
Barren	2	05-Feb-99	RB	4.3			
Barren	2	05-Feb-99	RB	4.3			
Barren	2	05-Feb-99	RB	4.8			
Barren	2	05-Feb-99	RB	5.2			
Barren	2	05-Feb-99	RB	5.2			
Barren	2	05-Feb-99	RB	5.2			
Barren	2	05-Feb-99	RB	5.5			
Barren	2	05-Feb-99	RB	5.8			
Barren	2	05-Feb-99	RB	6.1			
Barren	2	05-Feb-99	RB	6.2			
Barren	2	05-Feb-99	RB	6.7			
Barren	2	05-Feb-99	RB	6.9			
Barren	2	05-Feb-99	RB	7.1			
Barren	2	05-Feb-99	RB	7.6			
Barren	2	05-Feb-99	RB	8			
Barren	2	05-Feb-99	RB	8.2			
Barren	2	05-Feb-99	RB	8.8			
Barren	2	05-Feb-99	RB	9.3			
Barren	2	05-Feb-99	RB	9.5			
Barren	2	05-Feb-99	RB	12.2			
Barren	2	05-Feb-99	RB	14.6			
Barren	2	05-Feb-99	RB	17			
Barren	2	05-Feb-99	RB	19			
Barren	2	05-Feb-99	RB	20			
Barren	2	05-Feb-99	RB	25.2			
Barren	2	05-Feb-99	RB	10.5			
Barren	2	05-Feb-99	RB	5.2			
Barren	2	11-Mar-99	CO	6.4	88	0.093914	
Barren	2	11-Mar-99	CO	7.6	106	0.063811	
Barren	2	11-Mar-99	CO	3.3	69	0.100454	
Barren	2	11-Mar-99	RB	22.9	132	0.099567	
Barren	2	11-Mar-99	RB	14	116	0.089692	
Barren	2	11-Mar-99	RB	4	79	0.081129	
Barren	2	11-Mar-99	RB	1.4	50	0.112	
Barren	2	11-Mar-99	RB	8.8	99	0.090694	
Barren	2	11-Mar-99	RB	6.9	94	0.083074	
Barren	2	11-Mar-99	RB	5.6	86	0.088043	
Barren	2	11-Mar-99	RB	3.7	75	0.087704	
Barren	2	11-Mar-99	RB	7.1	90	0.097394	
Barren	2	11-Mar-99	RB	3.2	71	0.089408	
Barren	2	11-Mar-99	RB	1.2	50	0.096	
Barren	2	11-Mar-99	RB	3.2	72	0.085734	
Barren	2	11-Mar-99	RB	5.5	85	0.089558	
Barren	2	11-Mar-99	RB	9.5	102	0.089521	
Barren	2	11-Mar-99	RB	8.1	94	0.097522	
Barren	2	11-Mar-99	RB	12.2	110	0.09166	
Barren	2	11-Mar-99	RB	9.9	102	0.09329	
Barren	2	11-Mar-99	RB	9.9	100	0.099	
Barren	2	11-Mar-99	RB	3.4	69	0.103498	
Barren	2	11-Mar-99	RB	7.3	90	0.100137	
Barren	2	11-Mar-99	RB	3.7	74	0.091308	
Barren	2	11-Mar-99	RB	3.7	75	0.087704	
Barren	2	11-Mar-99	RB	5.1	80	0.099609	
Barren	2	11-Mar-99	RB	4	75	0.094815	

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Barren	2	11-Mar-99	RB	4.2	79	0.085186	
Barren	2	11-Mar-99	RB	3.8	73	0.097682	
Barren	2	11-Mar-99	RB	1.1	50	0.088	
Barren	2	11-Mar-99	RB	4.3	77	0.094188	
Barren	2	11-Mar-99	RB	2.8	69	0.085234	
Barren	2	11-Mar-99	RB	5.6	85	0.091187	
Barren	2	11-Mar-99	RB	1.6	56	0.091108	
Barren	2	15-Apr-99	CO	3.9			
Barren	2	15-Apr-99	CO	10.7			
Barren	2	15-Apr-99	RB	1			
Barren	2	15-Apr-99	RB	3			
Barren	2	15-Apr-99	RB	3.2			
Barren	2	15-Apr-99	RB	3.4			
Barren	2	15-Apr-99	RB	3.9			
Barren	2	15-Apr-99	RB	4.7			
Barren	2	15-Apr-99	RB	4.9			
Barren	2	15-Apr-99	RB	5			
Barren	2	15-Apr-99	RB	5.3			
Barren	2	15-Apr-99	RB	5.3			
Barren	2	15-Apr-99	RB	5.3			
Barren	2	15-Apr-99	RB	5.3			
Barren	2	15-Apr-99	RB	6.4			
Barren	2	15-Apr-99	RB	6.4			
Barren	2	15-Apr-99	RB	8.1			
Barren	2	15-Apr-99	RB	8.2			
Barren	2	15-Apr-99	RB	8.4			
Barren	2	15-Apr-99	RB	8.9			
Barren	2	15-Apr-99	RB	10.9			
Barren	2	15-Apr-99	RB	11.1			
Barren	2	15-Apr-99	RB	12.4			
Barren	2	15-Apr-99	RB	17.3			
Barren	2	15-Apr-99	RB	20.9			
Barren	2	15-Apr-99	RB	21.3			
Barren	3	13-Nov-98	CO	9.2			
Barren	3	13-Nov-98	RB	1.2			
Barren	3	13-Nov-98	RB	1.4			
Barren	3	13-Nov-98	RB	1.4			
Barren	3	13-Nov-98	RB	2.3			
Barren	3	13-Nov-98	RB	2.9			
Barren	3	13-Nov-98	RB	3.2			
Barren	3	13-Nov-98	RB	4.4			
Barren	3	13-Nov-98	RB	5.2			
Barren	3	13-Nov-98	RB	8			
Barren	3	13-Nov-98	RB	9			
Barren	3	13-Nov-98	RB	9.1			
Barren	3	13-Nov-98	RB	11			
Barren	3	13-Nov-98	RB	12.3			
Barren	3	13-Nov-98	RB	13.2			
Barren	3	13-Nov-98	RB	13.7			
Barren	3	13-Nov-98	RB	14.8			
Barren	3	13-Nov-98	RB	15.3			
Barren	3	13-Nov-98	RB	17			
Barren	3	13-Nov-98	RB	17.7			
Barren	3	13-Nov-98	RB	23.9			
Barren	3	13-Nov-98	RB	24.4			
Barren	3	13-Nov-98	RB	24.6			
Barren	3	13-Nov-98	RB	26.5			
Barren	3	13-Nov-98	RB				
Barren	3	15-Dec-98	RB	4.3			
Barren	3	15-Dec-98	RB	5			
Barren	3	15-Dec-98	RB	5.8			
Barren	3	15-Dec-98	RB	11.5			
Barren	3	15-Dec-98	RB	14.8			
Barren	3	15-Dec-98	RB	18.3			
Barren	3	07-Jan-99	RB	7.3			
Barren	3	13-Jan-99	RB	6.3			
Barren	3	13-Jan-99	RB	6.9			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Barren	3	05-Feb-99	RB	1			
Barren	3	05-Feb-99	RB	1.4			
Barren	3	05-Feb-99	RB	2.3			
Barren	3	05-Feb-99	RB	3.1			
Barren	3	05-Feb-99	RB	6.1			
Barren	3	05-Feb-99	RB	6.8			
Barren	3	05-Feb-99	RB	23.6			
Barren	3	05-Feb-99	RB	25.9			
Barren	3	05-Feb-99	RB	25.9			
Barren	3	11-Mar-99	RB	6.2	90	0.085048	
Barren	3	11-Mar-99	RB	5.4	78	0.113792	
Barren	3	11-Mar-99	RB	2.1	59	0.10225	
Barren	3	11-Mar-99	RB	6.3	85	0.102585	
Barren	3	11-Mar-99	RB	5.6	83	0.097939	
Barren	3	11-Mar-99	RB	3.6	71	0.100584	
Barren	3	11-Mar-99	RB	22.5	128	0.107288	
Barren	3	15-Apr-99	RB	1.3			
Barren	3	15-Apr-99	RB	6.1			
Barren	3	15-Apr-99	RB	6.9			
Barren	3	15-Apr-99	RB	7			
Barren	3	15-Apr-99	RB	7.4			
Barren	3	15-Apr-99	RB	12.8			
Barren	3	15-Apr-99	RB	13.2			
Barren	3	15-Apr-99	RB	15			
Barren	3	15-Apr-99	RB	19.9			
Barren	3	15-Apr-99	RB	24			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	comments
Buck	1	03-Dec-98	CO	9.5			marked with TC
Buck	1	03-Dec-98	RB	8.3			marked with TC
Buck	1	03-Dec-98	RB	13.6			marked with TC
Buck	1	03-Dec-98	RB	7.2			marked with TC
Buck	1	03-Dec-98	RB	12.8			marked with TC
Buck	1	03-Dec-98	RB	17.3			marked with TC
Buck	1	08-Dec-98	CO	6.8			marked with TC
Buck	1	08-Dec-98	CO	8.4			marked with TC
Buck	1	08-Dec-98	CO	8.3			marked with TC
Buck	1	08-Dec-98	CO	5.4			marked with TC
Buck	1	08-Dec-98	CO	7.8			marked with TC
Buck	1	08-Dec-98	CO	9.4			marked with TC
Buck	1	08-Dec-98	CO	8.4			marked with TC
Buck	1	08-Dec-98	CO	8			marked with TC
Buck	1	08-Dec-98	RB	8.2			marked with TC
Buck	1	08-Dec-98	RB	18.4			marked with TC
Buck	1	08-Dec-98	RB	9.3			marked with TC
Buck	1	08-Dec-98	RB	3.6			marked with TC
Buck	1	08-Dec-98	RB	4.5			marked with TC
Buck	1	08-Dec-98	RB	4.7			marked with TC
Buck	1	08-Dec-98	RB	5.8			marked with TC
Buck	1	08-Dec-98	RB	3.6			marked with TC
Buck	1	08-Dec-98	RB	6.3			marked with TC
Buck	1	13-Jan-99	CO	12			TC recapture
Buck	1	13-Jan-99	CO	7.4			
Buck	1	13-Jan-99	CO	7.1			
Buck	1	13-Jan-99	CO	12.4			
Buck	1	13-Jan-99	CO	9.6			
Buck	1	13-Jan-99	CO	9.1			
Buck	1	13-Jan-99	CO	5.2			
Buck	1	13-Jan-99	CO	3			
Buck	1	13-Jan-99	RB	8.1			
Buck	1	13-Jan-99	RB	20.1			
Buck	1	13-Jan-99	RB	9.2			
Buck	1	13-Jan-99	RB	6.4			
Buck	1	13-Jan-99	RB	8.6			
Buck	1	13-Jan-99	RB	8.6			
Buck	1	13-Jan-99	RB	10.2			
Buck	1	13-Jan-99	RB	7.8			
Buck	1	13-Jan-99	RB	10			
Buck	1	09-Feb-99	CO	7.4			
Buck	1	09-Feb-99	CO	9.3			TC recapture
Buck	1	09-Feb-99	RB	15.6			
Buck	1	09-Feb-99	RB	11.8			
Buck	1	09-Feb-99	RB	8.9			
Buck	1	09-Feb-99	RB	3.9			
Buck	1	09-Feb-99	RB	3.7			
Buck	1	09-Feb-99	RB	3.1			
Buck	1	09-Feb-99	RB	4.5			
Buck	1	09-Feb-99	RB	6.2			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	comments
Buck	1	09-Feb-99	RB	6.2			
Buck	1	09-Feb-99	RB	7.7			
Buck	1	09-Feb-99	RB	6.4			
Buck	1	09-Feb-99	RB	2.4			
Buck	1	09-Feb-99	RB	8.5			
Buck	1	18-Mar-99	CO	10.3	102	0.097059	marked with LV
Buck	1	18-Mar-99	CO	6.9	92	0.088611	marked with LV
Buck	1	18-Mar-99	RB	7.4	86	0.116342	marked with LV
Buck	1	18-Mar-99	RB	4.7	76	0.107067	TC recaptured, marked
Buck	1	18-Mar-99	RB	5.5	78	0.115899	marked with LV
Buck	1	18-Mar-99	RB	6.3	85	0.102585	marked with LV
Buck	1	18-Mar-99	RB	5.9	81	0.111019	marked with LV
Buck	1	18-Mar-99	RB	3.8	70	0.110787	marked with LV
Buck	1	18-Mar-99	RB	9.2	91	0.122085	marked with LV
Buck	2	03-Dec-98	RB	22.7			marked with BC
Buck	2	03-Dec-98	RB	14.6			marked with BC
Buck	2	03-Dec-98	RB	15.1			marked with BC
Buck	2	08-Dec-98	CO	5.2			
Buck	2	08-Dec-98	RB	23.1			
Buck	2	08-Dec-98	RB	12.3			
Buck	2	08-Dec-98	RB	9.6			recaptured TC
Buck	2	08-Dec-98	RB	3.5			
Buck	2	08-Dec-98	RB	7.2			
Buck	2	08-Dec-98	RB	7.8			
Buck	2	08-Dec-98	RB	6.9			
Buck	2	06-Jan-99	CO	5.8			
Buck	2	06-Jan-99	LNC	4.1			
Buck	2	06-Jan-99	RB	5.5			
Buck	2	06-Jan-99	RB	11.7			
Buck	2	06-Jan-99	RB	8.1			
Buck	2	06-Jan-99	RB	6.1			
Buck	2	06-Jan-99	RB	4.7			
Buck	2	09-Feb-99	RB	7.3			
Buck	2	09-Feb-99	RB	5			
Buck	2	18-Mar-99	CH	3.5	67	0.116371	marked with LV
Buck	2	23-Mar-99	RB	25.1	125	0.128512	
Buck	2	23-Mar-99	RB	25.1	125	0.128512	
Buck	2	14-Apr-99	CO	3.1	68	0.09859	
Buck	2	14-Apr-99	RB	9	91	0.119431	
Buck	2	14-Apr-99	RB	1.1	47	0.10595	
Buck	2	14-Apr-99	RB	2.7	64	0.102997	
Buck	2	14-Apr-99	RB	5.5	78	0.115899	
Buck	2	14-Apr-99	RB	4.5	76	0.102511	
Buck	2	14-Apr-99	RB	3.2	64	0.12207	
Buck	3	03-Dec-98	CO	14.9			marked TC
Buck	3	03-Dec-98	CO	18.4			marked TC

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	comments
Buck	3	03-Dec-98	CO	17.3			marked TC
Buck	3	03-Dec-98	CO	21.2			marked TC
Buck	3	03-Dec-98	CO	18.7			marked TC
Buck	3	03-Dec-98	CO	21.1			marked TC
Buck	3	03-Dec-98	CO	16.6			marked TC
Buck	3	03-Dec-98	CO	25.4			marked TC
Buck	3	03-Dec-98	CO	17.9			marked TC
Buck	3	03-Dec-98	RB	32.2			marked TC
Buck	3	03-Dec-98	RB	25			marked TC
Buck	3	03-Dec-98	RB	20			marked TC
Buck	3	03-Dec-98	RB	21.1			marked TC
Buck	3	03-Dec-98	RB	17.6			marked TC
Buck	3	03-Dec-98	RB	19			marked TC
Buck	3	03-Dec-98	RB	29.7			marked TC
Buck	3	03-Dec-98	RB	18.2			marked TC
Buck	3	03-Dec-98	RB	15.3			marked TC
Buck	3	03-Dec-98	RB	10.1			marked TC
Buck	3	08-Dec-98	CO	13.6			
Buck	3	08-Dec-98	RB	12.4			
Buck	3	08-Dec-98	RB	20.1			
Buck	3	08-Dec-98	RB	22.7			
Buck	3	08-Dec-98	RB	9.6			
Buck	3	08-Dec-98	RB	15.4			
Buck	3	08-Dec-98	RB	8.6			
Buck	3	08-Dec-98	RB	22.9			
Buck	3	07-Jan-99	CO	9.4			TC recapture
Buck	3	07-Jan-99	RB	18.1			
Buck	3	07-Jan-99	RB	16			
Buck	3	07-Jan-99	RB	14.9			
Buck	3	07-Jan-99	RB	10.7			
Buck	3	19-Mar-99	CO	12.4	110	0.093163	
Buck	3	19-Mar-99	RB	14.7	115	0.096655	
Buck	3	19-Mar-99	RB	23.5	126	0.117478	

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	comments
Buck	3	19-Mar-99	RB	32.4	145	0.106277	
Buck	3	19-Mar-99	RB	12.6	101	0.122294	
Buck	3	19-Mar-99	RB	11.7	101	0.113559	
Buck	3	19-Mar-99	RB	10.6	100	0.106	TC recapture
Buck	3	19-Mar-99	RB	13.4	104	0.119126	
Buck	3	19-Mar-99	RB	9.9	98	0.105186	
Buck	3	23-Mar-99	RB	23.6	122	0.129967	TC recapture
Buck	3	23-Mar-99	RB	19.2	115	0.126243	
Buck	3	23-Mar-99	RB	15.7	112	0.111749	
Buck	3	23-Mar-99	RB	15.4	108	0.12225	
Buck	3	23-Mar-99	RB	23.6	122	0.129967	TC recapture
Buck	3	23-Mar-99	RB	19.2	115	0.126243	
Buck	3	23-Mar-99	RB	15.7	112	0.111749	
Buck	3	23-Mar-99	RB	15.4	108	0.12225	
Buck	3	14-Apr-99	RB	14.8	109	0.114283	TC recapture
Buck	3	14-Apr-99	RB	31.7	142	0.110712	TC recapture

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	comments
Buck	3	14-Apr-99	RB	11.5	98	0.122185	
Buck	3	14-Apr-99	RB	9.4	95	0.109637	
Buck	3	14-Apr-99	RB	9.1	91	0.120758	
Buck	4	04-Dec-98	RB	9.7			marked BC
Buck	4	04-Dec-98	RB	28.1			marked BC
Buck	4	04-Dec-98	RB	22.3			marked BC
Buck	4	04-Dec-98	RB	14			marked BC
Buck	4	04-Dec-98	RB	12.8			marked BC
Buck	4	04-Dec-98	RB	8.9			marked BC
Buck	4	04-Dec-98	RB	11			marked BC
Buck	4	04-Dec-98	RB	15.3			marked BC
Buck	4	04-Dec-98	RB	11.4			marked BC
Buck	4	04-Dec-98	RB	9			marked BC
Buck	4	08-Dec-98	RB	9.1			
Buck	4	08-Dec-98	RB	9.6			
Buck	4	08-Dec-98	RB	15.1			
Buck	4	08-Dec-98	RB	11			
Buck	4	06-Jan-99	RB	13.8			BC recapture
Buck	4	06-Jan-99	RB	15.3			
Buck	4	06-Jan-99	RB	16.7			
Buck	4	06-Jan-99	RB	9.5			
Buck	4	09-Feb-99	RB	8.3			
Buck	4	18-Mar-99	RB	12.1	102	0.114021	marked LV
Buck	4	18-Mar-99	RB	11.3	95	0.131798	marked LV
Buck	4	23-Mar-99	RB	12.3	101	0.119383	BC recapture
Buck	4	23-Mar-99	RB	25.5	132	0.110871	
Buck	4	23-Mar-99	RB	16.5	112	0.117444	
Buck	4	23-Mar-99	RB	15.3	111	0.111872	
Buck	4	23-Mar-99	RB	12.3	101	0.119383	BC recapture
Buck	4	23-Mar-99	RB	25.5	132	0.110871	
Buck	4	23-Mar-99	RB	16.5	112	0.117444	
Buck	4	23-Mar-99	RB	15.3	111	0.111872	
Buck	4	14-Apr-99	RB	9.5	98	0.100936	
Buck	5	03-Dec-98	CO	16.6			marked TC
Buck	5	03-Dec-98	CO	17.9			marked TC
Buck	5	03-Dec-98	RB	24.5			marked TC
Buck	5	03-Dec-98	RB	22.6			marked TC
Buck	5	03-Dec-98	RB	6.6			marked TC
Buck	5	03-Dec-98	RB	12.9			marked TC
Buck	5	03-Dec-98	RB	19.1			marked TC
Buck	5	03-Dec-98	RB	12.4			marked TC
Buck	5	03-Dec-98	RB	19.2			marked TC
Buck	5	03-Dec-98	RB	6.4			marked TC
Buck	5	08-Dec-98	CO	15			
Buck	5	08-Dec-98	RB	13.2			
Buck	5	08-Dec-98	RB	12.1			
Buck	5	07-Jan-99	RB	12.2			
Buck	5	07-Jan-99	RB	13.1			
Buck	5	07-Jan-99	RB	15			TC recapture
Buck	5	07-Jan-99	RB	2.1			marked LV

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	comments
Buck	5	03-Mar-99	RB	30.4			marked LV
Buck	5	03-Mar-99	RB	23.3			marked LV
Buck	5	03-Mar-99	RB	13.6			marked LV
Buck	5	03-Mar-99	RB	16.5			marked LV
Buck	5	03-Mar-99	RB	12.5			marked LV
Buck	5	03-Mar-99	RB	12.6			marked LV
Buck	5	23-Mar-99	RB	9.7	95	0.113136	
Buck	5	23-Mar-99	RB	12.4	108	0.098435	
Buck	5	23-Mar-99	RB	25.5	129	0.118788	
Buck	5	23-Mar-99	RB	9.7	95	0.113136	TC recapture or marked
Buck	5	23-Mar-99	RB	12.4	108	0.098435	TC recapture or marked
Buck	5	23-Mar-99	RB	25.5	129	0.118788	TC recapture or marked
Buck	6	03-Dec-98	CO	22.1			marked TC
Buck	6	03-Dec-98	RB	20.2			marked TC
Buck	6	03-Dec-98	RB	20.4			
Buck	6	03-Dec-98	RB	23			marked TC
Buck	6	03-Dec-98	RB	23.1			marked TC
Buck	6	03-Dec-98	RB	9.9			marked TC
Buck	6	03-Dec-98	RB	15.8			marked TC
Buck	6	03-Dec-98	RB	15.1			marked TC
Buck	6	13-Jan-99	RB	21.7			TC recapture
Buck	6	13-Jan-99	RB	23.7			
Buck	6	13-Jan-99	RB	14.1			
Buck	6	13-Jan-99	RB	18.2			
Buck	6	19-Mar-99	RB	18.4	120	0.106481	marked LV
Buck	6	19-Mar-99	RB	9.1	95	0.106138	marked LV
Buck	6	19-Mar-99	RB	13.2	108	0.104786	marked LV
Buck	6	19-Mar-99	RB	9	94	0.108357	marked LV
Buck	6	23-Mar-99	CO	8.9	93	0.110647	
Buck	6	23-Mar-99	CO	8.9	93	0.110647	
Buck	6	23-Mar-99	RB	23.5	128	0.112057	TC recapture
Buck	6	23-Mar-99	RB	23.5	128	0.112057	TC recapture
Buck	6	14-Apr-99	RB	23.3	129	0.108539	TC recapture
Buck	6	14-Apr-99	RB	13.5	108	0.107167	

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Byman	1	15-Nov-98	RB	5.7		
Byman	1	15-Nov-98	RB	1.2		
Byman	1	15-Nov-98	RB	8.2		
Byman	1	15-Nov-98	RB	14.7		
Byman	1	15-Nov-98	RB	7.1		
Byman	1	15-Nov-98	RB	9.5		
Byman	1	13-Dec-98	CH	5.1		
Byman	1	13-Dec-98	RB	2.4		
Byman	1	13-Dec-98	RB	2.2		
Byman	1	13-Dec-98	RB	9.3		
Byman	1	13-Dec-98	RB	1.4		
Byman	1	13-Dec-98	RB	2.2		
Byman	1	13-Dec-98	RB	1.9		
Byman	1	13-Dec-98	RB	1.7		
Byman	1	13-Dec-98	RB	1.7		
Byman	1	13-Dec-98	RB	2.3		
Byman	1	13-Dec-98	RB	1.3		
Byman	1	13-Dec-98	RB	4.3		
Byman	1	13-Dec-98	RB	1.5		
Byman	1	13-Dec-98	RB	6		
Byman	1	13-Dec-98	RB	1.2		
Byman	1	13-Dec-98	RB	9.3		
Byman	1	13-Dec-98	RB	24.8		
Byman	1	13-Jan-99	CH	4.6		
Byman	1	13-Jan-99	CH	3.5		
Byman	1	13-Jan-99	CH	4.3		
Byman	1	13-Jan-99	CO	3.7		
Byman	1	13-Jan-99	RB	1.9		
Byman	1	13-Jan-99	RB	3.3		
Byman	1	13-Jan-99	RB	6.4		
Byman	1	13-Jan-99	RB	10.7		
Byman	1	13-Jan-99	RB	5.2		
Byman	1	13-Jan-99	RB	1.5		
Byman	1	13-Jan-99	RB	2.5		
Byman	1	13-Jan-99	RB	9.8		
Byman	1	13-Jan-99	RB	7.4		
Byman	1	13-Jan-99	RB	1.8		
Byman	1	05-Feb-99	CO	3.5		
Byman	1	05-Feb-99	CO	3.4		
Byman	1	05-Feb-99	RB	10.4		
Byman	1	05-Feb-99	RB	4.5		
Byman	1	05-Feb-99	RB	1.7		
Byman	1	05-Feb-99	RB	8.6		
Byman	1	05-Feb-99	RB	8.2		
Byman	1	09-Mar-99	CO	3.8	65	0.138371
Byman	1	09-Mar-99	CO	5.2	77	0.113902
Byman	1	09-Mar-99	CO	3.7	68	0.117673
Byman	1	09-Mar-99	CO	3.3	66	0.114784
Byman	1	09-Mar-99	CO	5.4	77	0.118283
Byman	1	09-Mar-99	CO	2.9	68	0.09223
Byman	1	09-Mar-99	CO	2.7	68	0.085869
Byman	1	09-Mar-99	CO	4.8	78	0.101148
Byman	1	09-Mar-99	CO	2.8	66	0.097393
Byman	1	09-Mar-99	CO	3.8	68	0.120853
Byman	1	09-Mar-99	CO	2.7	66	0.093914
Byman	1	09-Mar-99	RB	8.9	82	0.161417
Byman	1	09-Mar-99	RB	8.3	91	0.110142
Byman	1	09-Mar-99	RB	1.1	58	0.056378
Byman	1	09-Mar-99	RB	1.3	54	0.082559
Byman	1	09-Mar-99	RB	0.9	52	0.064008
Byman	1	14-Apr-99	RB	13.4		
Byman	1	14-Apr-99	RB	9.4		
Byman	2	15-Nov-98	CO	2.7		
Byman	2	15-Nov-98	CO	4.4		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Byman	2	15-Nov-98	CO	3.3		
Byman	2	15-Nov-98	CO	11.6		
Byman	2	15-Nov-98	CO	6.9		
Byman	2	15-Nov-98	CO	4.5		
Byman	2	15-Nov-98	RB	16.2		
Byman	2	15-Nov-98	RB	4.7		
Byman	2	15-Nov-98	RB	5.8		
Byman	2	15-Nov-98	RB	11.9		
Byman	2	15-Nov-98	RB	7		
Byman	2	15-Nov-98	RB	1.2		
Byman	2	15-Nov-98	RB	1.8		
Byman	2	15-Nov-98	RB	1.4		
Byman	2	15-Nov-98	RB	1.3		
Byman	2	15-Nov-98	RB	1.6		
Byman	2	15-Nov-98	RB	9.5		
Byman	2	15-Nov-98	RB	1.7		
Byman	2	15-Nov-98	RB	2.6		
Byman	2	15-Nov-98	RB	2.4		
Byman	2	15-Nov-98	RB	1.1		
Byman	2	15-Nov-98	RB	4.7		
Byman	2	15-Nov-98	RB	12.2		
Byman	2	15-Nov-98	RB	1.5		
Byman	2	13-Dec-98	CO	3.1		
Byman	2	13-Dec-98	CO	3		
Byman	2	13-Dec-98	RB	1.3		
Byman	2	13-Dec-98	RB	2.3		
Byman	2	13-Dec-98	RB	1.2		
Byman	2	13-Dec-98	RB	1.9		
Byman	2	13-Dec-98	RB	1.4		
Byman	2	13-Dec-98	RB	1.6		
Byman	2	13-Dec-98	RB	1.3		
Byman	2	13-Dec-98	RB	1.1		
Byman	2	13-Dec-98	RB	1.4		
Byman	2	13-Dec-98	RB	1.6		
Byman	2	13-Dec-98	RB	1.6		
Byman	2	13-Dec-98	RB	2.2		
Byman	2	13-Dec-98	RB	2.6		
Byman	2	13-Dec-98	RB	18.5		
Byman	2	13-Dec-98	RB	8.8		
Byman	2	13-Dec-98	RB	1.5		
Byman	2	13-Dec-98	RB	2.7		
Byman	2	13-Dec-98	RB	5		
Byman	2	13-Dec-98	RB	1.2		
Byman	2	13-Dec-98	RB	2.3		
Byman	2	13-Dec-98	RB	14.1		
Byman	2	13-Dec-98	RB	12.6		
Byman	2	13-Dec-98	RB	6.1		
Byman	2	13-Dec-98	RB	18.4		
Byman	2	13-Dec-98	RB	18.1		
Byman	2	13-Dec-98	RB	6.7		
Byman	2	13-Jan-99	CH	4.1		
Byman	2	13-Jan-99	CH	4.6		
Byman	2	13-Jan-99	CO	4.8		
Byman	2	13-Jan-99	CO	2.9		
Byman	2	13-Jan-99	RB	2.1		
Byman	2	13-Jan-99	RB	2.3		
Byman	2	13-Jan-99	RB	1.9		
Byman	2	13-Jan-99	RB	1.1		
Byman	2	13-Jan-99	RB	1.8		
Byman	2	13-Jan-99	RB	7.7		
Byman	2	13-Jan-99	RB	6.9		
Byman	2	13-Jan-99	RB	2.8		
Byman	2	13-Jan-99	RB	3.4		
Byman	2	13-Jan-99	RB	1.8		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Byman	2	13-Jan-99	RB	4.7		
Byman	2	13-Jan-99	RB	15.9		
Byman	2	13-Jan-99	RB	4		
Byman	2	13-Jan-99	RB	2.8		
Byman	2	13-Jan-99	RB	5.7		
Byman	2	13-Jan-99	RB	8.1		
Byman	2	13-Jan-99	RB	5.9		
Byman	2	13-Jan-99	RB	5.6		
Byman	2	13-Jan-99	RB	2.6		
Byman	2	13-Jan-99	RB	3.6		
Byman	2	13-Jan-99	RB	3.5		
Byman	2	13-Jan-99	RB	2.3		
Byman	2	13-Jan-99	RB	2.2		
Byman	2	05-Feb-99	CO	4.4		
Byman	2	05-Feb-99	CO	4		
Byman	2	05-Feb-99	RB	6		
Byman	2	05-Feb-99	RB	2		
Byman	2	05-Feb-99	RB	7.7		
Byman	2	05-Feb-99	RB	2.9		
Byman	2	05-Feb-99	RB	17.2		
Byman	2	05-Feb-99	RB	6.8		
Byman	2	05-Feb-99	RB	7.8		
Byman	2	05-Feb-99	RB	2.7		
Byman	2	05-Feb-99	RB	3.1		
Byman	2	05-Feb-99	RB	3.9		
Byman	2	05-Feb-99	RB	3.4		
Byman	2	05-Feb-99	RB	6.3		
Byman	2	09-Mar-99	CO	2.5	65	0.091033
Byman	2	09-Mar-99	CO	3.8	74	0.093775
Byman	2	09-Mar-99	CO	4	74	0.098711
Byman	2	09-Mar-99	CO	3	66	0.104349
Byman	2	09-Mar-99	CO	3.9	72	0.104488
Byman	2	09-Mar-99	CO	3.3	71	0.092202
Byman	2	09-Mar-99	RB	13	108	0.103198
Byman	2	09-Mar-99	RB	4.6	76	0.104789
Byman	2	09-Mar-99	RB	8.6	95	0.100306
Byman	2	09-Mar-99	RB	1.4	55	0.084147
Byman	2	09-Mar-99	RB	18	115	0.118353
Byman	2	09-Mar-99	RB	3.4	75	0.080593
Byman	2	14-Apr-99	RB	9.9		
Byman	2	14-Apr-99	RB	1.6		
Byman	2	14-Apr-99	RB	2.3		
Byman	2	14-Apr-99	RB	1.3		
Byman	2	14-Apr-99	RB	2		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
McQuarrie	1	15-Nov-98	CO	3.6		
McQuarrie	1	15-Nov-98	CO	3.7		
McQuarrie	1	15-Nov-98	CO	4.1		
McQuarrie	1	15-Nov-98	CO	4.2		
McQuarrie	1	15-Nov-98	CO	4.4		
McQuarrie	1	15-Nov-98	CO	5.7		
McQuarrie	1	15-Nov-98	CO	5.7		
McQuarrie	1	15-Nov-98	RB	0.7		
McQuarrie	1	15-Nov-98	RB	0.7		
McQuarrie	1	15-Nov-98	RB	1		
McQuarrie	1	15-Nov-98	RB	1		
McQuarrie	1	15-Nov-98	RB	1		
McQuarrie	1	15-Nov-98	RB	1.1		
McQuarrie	1	15-Nov-98	RB	3		
McQuarrie	1	15-Nov-98	RB	3.8		
McQuarrie	1	15-Nov-98	RB	4.3		
McQuarrie	1	15-Nov-98	RB	4.5		
McQuarrie	1	15-Nov-98	RB	5		
McQuarrie	1	15-Nov-98	RB	5.5		
McQuarrie	1	15-Nov-98	RB	5.8		
McQuarrie	1	15-Nov-98	RB	6.2		
McQuarrie	1	15-Nov-98	RB	6.6		
McQuarrie	1	15-Nov-98	RB	7.3		
McQuarrie	1	15-Nov-98	RB	7.7		
McQuarrie	1	15-Nov-98	RB	7.8		
McQuarrie	1	15-Nov-98	RB	7.8		
McQuarrie	1	15-Nov-98	RB	8		
McQuarrie	1	15-Nov-98	RB	9.8		
McQuarrie	1	15-Nov-98	RB	9.8		
McQuarrie	1	15-Nov-98	RB	10.9		
McQuarrie	1	15-Nov-98	RB	11.4		
McQuarrie	1	15-Nov-98	RB	12.1		
McQuarrie	1	15-Nov-98	RB	13.1		
McQuarrie	1	15-Nov-98	RB	15.1		
McQuarrie	1	15-Nov-98	RB	17.1		
McQuarrie	1	15-Nov-98	RB	18		
McQuarrie	1	12-Dec-98	CH	4.6		
McQuarrie	1	12-Dec-98	CH	6.5		
McQuarrie	1	12-Dec-98	CH	12.8		
McQuarrie	1	12-Dec-98	CO	0.9		
McQuarrie	1	12-Dec-98	CO	2.8		
McQuarrie	1	12-Dec-98	CO	3.6		
McQuarrie	1	12-Dec-98	CO	4.2		
McQuarrie	1	12-Dec-98	CO	4.5		
McQuarrie	1	12-Dec-98	CO	4.5		
McQuarrie	1	12-Dec-98	CO	4.6		
McQuarrie	1	12-Dec-98	CO	5		
McQuarrie	1	12-Dec-98	CO	5.9		
McQuarrie	1	12-Dec-98	RB	1.5		
McQuarrie	1	12-Dec-98	RB	3.9		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
McQuarrie	1	12-Dec-98	RB	4.4		
McQuarrie	1	12-Dec-98	RB	4.9		
McQuarrie	1	12-Dec-98	RB	5.4		
McQuarrie	1	12-Dec-98	RB	6.8		
McQuarrie	1	12-Dec-98	RB	8		
McQuarrie	1	12-Dec-98	RB	8.5		
McQuarrie	1	12-Dec-98	RB	8.6		
McQuarrie	1	12-Dec-98	RB	8.7		
McQuarrie	1	12-Dec-98	RB	8.8		
McQuarrie	1	12-Dec-98	RB	9.2		
McQuarrie	1	12-Dec-98	RB	9.3		
McQuarrie	1	12-Dec-98	RB	10.5		
McQuarrie	1	12-Dec-98	RB	10.7		
McQuarrie	1	12-Dec-98	RB	11.8		
McQuarrie	1	12-Dec-98	RB	12.6		
McQuarrie	1	12-Dec-98	RB	13.6		
McQuarrie	1	12-Dec-98	RB	16		
McQuarrie	1	12-Dec-98	RB	20.3		
McQuarrie	1	12-Dec-98	RB	25.6		
McQuarrie	1	12-Dec-98	RB	25.7		
McQuarrie	1	09-Jan-99	CH	3.6		
McQuarrie	1	09-Jan-99	CO	5.4		
McQuarrie	1	09-Jan-99	CO	8.3		
McQuarrie	1	09-Jan-99	RB	5.50		
McQuarrie	1	09-Jan-99	RB	6.40		
McQuarrie	1	09-Jan-99	RB	8.70		
McQuarrie	1	05-Feb-99	CH	5.4		
McQuarrie	1	05-Feb-99	CO			
McQuarrie	1	05-Feb-99	CO			
McQuarrie	1	05-Feb-99	RB	1.30		
McQuarrie	1	05-Feb-99	RB	1.40		
McQuarrie	1	05-Feb-99	RB	1.5		
McQuarrie	1	05-Feb-99	RB	1.7		
McQuarrie	1	05-Feb-99	RB	1.7		
McQuarrie	1	05-Feb-99	RB	2		
McQuarrie	1	05-Feb-99	RB	2.40		
McQuarrie	1	05-Feb-99	RB	7.30		
McQuarrie	1	05-Feb-99	RB	7.60		
McQuarrie	1	05-Feb-99	RB	8.90		
McQuarrie	1	05-Feb-99	RB	9.60		
McQuarrie	1	05-Feb-99	RB	10.70		
McQuarrie	1	05-Feb-99	RB	14.50		
McQuarrie	1	16-Mar-99	CO	3.5	66	0.121741
McQuarrie	1	16-Mar-99	RB	6.70	86	0.105337
McQuarrie	1	16-Mar-99	RB	7.8	88	0.114458
McQuarrie	1	16-Mar-99	RB	10.1	95	0.117801
McQuarrie	1	16-Mar-99	RB	7.5	96	0.084771
McQuarrie	1	16-Mar-99	RB	11.7	107	0.095507
McQuarrie	1	16-Mar-99	RB	7.2	86	0.113198
McQuarrie	1	16-Mar-99	RB	8.4	92	0.107874

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
McQuarrie	1	16-Mar-99	RB	5.5	75	0.13037
McQuarrie	1	16-Mar-99	RB	5.6	79	0.113581
McQuarrie	1	16-Mar-99	RB	19.8	124	0.103848
McQuarrie	1	16-Mar-99	RB	6.9	85	0.112355
McQuarrie	1	16-Mar-99	RB	10.1	94	0.121601
McQuarrie	1	16-Mar-99	RB	1.1	47	0.10595
McQuarrie	1	16-Apr-99	RB	15.6		
McQuarrie	1	16-Apr-99	RB	9.8		LV
McQuarrie	1	16-Apr-99	RB	14.2		
McQuarrie	1	16-Apr-99	RB	7.2		TC
McQuarrie	1	16-Apr-99	RB	17		
McQuarrie	1	16-Apr-99	RB	1.7		
McQuarrie	1	16-Apr-99	RB	11.7		
McQuarrie	1	16-Apr-99	RB	5.3		TC, LV
McQuarrie	1	16-Apr-99	RB	17		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	1	29-Jan-99	DV	9.7		
Mission	1	29-Jan-99	DV	10.9		
Mission	1	29-Jan-99	DV	11.6		
Mission	1	29-Jan-99	DV	12.7		
Mission	1	29-Jan-99	DV	14.4		
Mission	1	29-Jan-99	DV	14.8		
Mission	1	29-Jan-99	DV	16		
Mission	1	29-Jan-99	DV	16.6		
Mission	1	29-Jan-99	DV	17.3		
Mission	1	29-Jan-99	DV	18.3		
Mission	1	29-Jan-99	DV	18.7		
Mission	1	29-Jan-99	DV	18.8		
Mission	1	29-Jan-99	DV	20.3		
Mission	1	29-Jan-99	DV	20.8		
Mission	1	29-Jan-99	DV	21.3		
Mission	1	29-Jan-99	DV	22.6		
Mission	1	29-Jan-99	DV	24.7		
Mission	1	29-Jan-99	DV	32.2		
Mission	1	29-Jan-99	DV	40.5		
Mission	1	29-Jan-99	DV	49.2		
Mission	1	03-Feb-99	DV	1.5		
Mission	1	03-Feb-99	DV	3.7		
Mission	1	03-Feb-99	DV	4.2		
Mission	1	03-Feb-99	DV	4.5		
Mission	1	03-Feb-99	DV	10.4		
Mission	1	03-Feb-99	DV	10.8		
Mission	1	03-Feb-99	DV	10.8		
Mission	1	03-Feb-99	DV	13.7		
Mission	1	03-Feb-99	DV	22.1		
Mission	1	25-Mar-99	DV	36.2	165	0.080585
Mission	1	25-Mar-99	DV	25.1	137	0.097614
Mission	1	25-Mar-99	DV	16	116	0.102505
Mission	1	25-Mar-99	DV	17	126	0.084984
Mission	1	25-Mar-99	DV	15.2	118	0.092512
Mission	1	25-Mar-99	DV	20.4	130	0.092854
Mission	1	25-Mar-99	DV	36.9	159	0.091798
Mission	1	25-Mar-99	DV	29.3	147	0.092239
Mission	1	25-Mar-99	DV	7.8	95	0.090975
Mission	1	25-Mar-99	DV	60.8	195	0.081997
Mission	1	25-Mar-99	DV	77.6	122	0.427349
Mission	1	25-Mar-99	DV	26.3	145	0.086268
Mission	1	25-Mar-99	DV	23.5	137	0.091392
Mission	1	25-Mar-99	DV	42.8	172	0.084112
Mission	1	25-Mar-99	DV	26.9	145	0.088237
Mission	1	25-Mar-99	DV	12	110	0.090158
Mission	1	25-Mar-99	DV	12.9	110	0.09692
Mission	1	25-Mar-99	DV	10.6	101	0.102883
Mission	1	25-Mar-99	DV	14.1	112	0.100361
Mission	1	25-Mar-99	DV	14.4	117	0.089909
Mission	1	25-Mar-99	DV	12.6	110	0.094666

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	1	25-Mar-99	DV	11	105	0.095022
Mission	1	30-Mar-99	DV	10.1		
Mission	1	30-Mar-99	DV	11.3		
Mission	1	30-Mar-99	DV	11.3		
Mission	1	30-Mar-99	DV	11.4		
Mission	1	30-Mar-99	DV	12.2		
Mission	1	30-Mar-99	DV	14.6		
Mission	1	30-Mar-99	DV	15.2		
Mission	1	30-Mar-99	DV	15.7		
Mission	1	30-Mar-99	DV	15.8		
Mission	1	30-Mar-99	DV	16.1		
Mission	1	30-Mar-99	DV	17.1		
Mission	1	30-Mar-99	DV	17.3		
Mission	1	30-Mar-99	DV	17.6		
Mission	1	30-Mar-99	DV	19.1		
Mission	1	30-Mar-99	DV	24.5		
Mission	1	30-Mar-99	DV	24.7		
Mission	1	30-Mar-99	DV	25.4		
Mission	1	30-Mar-99	DV	25.5		
Mission	1	30-Mar-99	DV	26.9		
Mission	1	30-Mar-99	DV	32.3		
Mission	1	30-Mar-99	DV	35.4		
Mission	1	30-Mar-99	DV	46.8		
Mission	1	30-Mar-99	DV	51.6		
Mission	1	30-Mar-99	DV	60.6		
Mission	1	30-Mar-99	DV	80.8		
Mission	1	22-Apr-99	DV	10.9	100	0.109
Mission	1	22-Apr-99	DV	60.1	180	0.103052
Mission	1	22-Apr-99	DV	13.5	113	0.093562
Mission	1	22-Apr-99	DV	23.6	130	0.107419
Mission	1	22-Apr-99	DV	40.5	165	0.090158
Mission	1	22-Apr-99	DV	39.2	151	0.113856
Mission	1	22-Apr-99	DV	12.6	102	0.118733
Mission	1	22-Apr-99	DV	1.6	56	0.091108
Mission	1	22-Apr-99	DV	17.8	119	0.105628
Mission	1	22-Apr-99	DV	19.7	118	0.1199
Mission	1	22-Apr-99	DV	21.6	123	0.116075
Mission	1	22-Apr-99	DV	14.6	109	0.112739
Mission	1	22-Apr-99	DV	20	120	0.115741
Mission	1	22-Apr-99	DV	16.4	113	0.11366
Mission	1	22-Apr-99	DV	16.3	117	0.101772
Mission	1	22-Apr-99	DV	10.7	104	0.095123
Mission	1	22-Apr-99	DV	11.5	103	0.105241
Mission	1	22-Apr-99	DV	59.6	175	0.111207
Mission	1	22-Apr-99	DV	18	117	0.112387
Mission	1	22-Apr-99	DV	10.9	105	0.094158
Mission	1	22-Apr-99	DV	16.8	113	0.116432
Mission	1	22-Apr-99	DV	18.4	123	0.098879
Mission	1	22-Apr-99	DV	21.6	124	0.113289
Mission	1	22-Apr-99	DV	21.4	130	0.097406

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	1	22-Apr-99	DV	11	100	0.11
Mission	1	22-Apr-99	DV	17.4	121	0.098218
Mission	1	22-Apr-99	DV	27.4	149	0.082831
Mission	1	22-Apr-99	DV	14.4	114	0.097196
Mission	1	22-Apr-99	DV	17.6	115	0.115723
Mission	1	22-Apr-99	DV	12.8	103	0.117138
Mission	1	22-Apr-99	DV	15.5	115	0.101915
Mission	1	22-Apr-99	DV	13.5	110	0.101427
Mission	1	22-Apr-99	DV	9.9	96	0.111898
Mission	1	22-Apr-99	DV	10.4	100	0.104
Mission	2	29-Jan-99	DV	1.5		
Mission	2	29-Jan-99	DV	4.1		
Mission	2	29-Jan-99	DV	4.5		
Mission	2	29-Jan-99	DV	7.8		
Mission	2	29-Jan-99	DV	8.7		
Mission	2	29-Jan-99	DV	9.3		
Mission	2	29-Jan-99	DV	10.4		
Mission	2	29-Jan-99	DV	11.1		
Mission	2	29-Jan-99	DV	11.3		
Mission	2	29-Jan-99	DV	11.3		
Mission	2	29-Jan-99	DV	13		
Mission	2	29-Jan-99	DV	20.3		
Mission	2	29-Jan-99	DV	22.1		
Mission	2	29-Jan-99	DV	32.7		
Mission	2	29-Jan-99	DV	42.8		
Mission	2	03-Feb-99	DV	12.1		
Mission	2	03-Feb-99	DV	12.8		
Mission	2	03-Feb-99	DV	13.4		
Mission	2	03-Feb-99	DV	13.5		
Mission	2	03-Feb-99	DV	15.4		
Mission	2	03-Feb-99	DV	15.7		
Mission	2	03-Feb-99	DV	16.4		
Mission	2	03-Feb-99	DV	17.6		
Mission	2	03-Feb-99	DV	18.2		
Mission	2	03-Feb-99	DV	18.9		
Mission	2	03-Feb-99	DV	20.5		
Mission	2	03-Feb-99	DV	20.8		
Mission	2	03-Feb-99	DV	21.1		
Mission	2	03-Feb-99	DV	21.3		
Mission	2	03-Feb-99	DV	21.6		
Mission	2	03-Feb-99	DV	24.6		
Mission	2	03-Feb-99	DV	25		
Mission	2	03-Feb-99	DV	26.2		
Mission	2	03-Feb-99	DV	29.1		
Mission	2	03-Feb-99	DV	29.7		
Mission	2	03-Feb-99	DV	30.9		
Mission	2	03-Feb-99	DV	31.4		
Mission	2	03-Feb-99	DV	32		
Mission	2	03-Feb-99	DV	32.4		
Mission	2	03-Feb-99	DV	33		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	2	03-Feb-99	DV	35.2		
Mission	2	03-Feb-99	DV	36.8		
Mission	2	03-Feb-99	DV	40.2		
Mission	2	03-Feb-99	DV	40.7		
Mission	2	03-Feb-99	DV	42		
Mission	2	03-Feb-99	DV	47.6		
Mission	2	03-Feb-99	DV	13		
Mission	2	03-Feb-99	DV	17		
Mission	2	03-Feb-99	DV	19		
Mission	2	03-Feb-99	DV	19.7		
Mission	2	03-Feb-99	DV	20.7		
Mission	2	03-Feb-99	DV	22.5		
Mission	2	03-Feb-99	DV	28.7		
Mission	2	25-Mar-99	DV	85.7	215	0.086231
Mission	2	25-Mar-99	DV	80.8	216	0.080177
Mission	2	25-Mar-99	DV	69.5	196	0.092303
Mission	2	25-Mar-99	DV	73	200	0.09125
Mission	2	25-Mar-99	DV	36	163	0.083127
Mission	2	25-Mar-99	DV	77.2	221	0.071522
Mission	2	25-Mar-99	DV	50.3	172	0.098851
Mission	2	25-Mar-99	DV	23.2	138	0.088278
Mission	2	25-Mar-99	DV	25.4	143	0.086861
Mission	2	25-Mar-99	DV	36.6	162	0.086087
Mission	2	25-Mar-99	DV	31.1	163	0.071812
Mission	2	25-Mar-99	DV	23.3	142	0.081375
Mission	2	25-Mar-99	DV	15.5	115	0.101915
Mission	2	25-Mar-99	DV	15.7	121	0.088622
Mission	2	25-Mar-99	DV	15	114	0.101246
Mission	2	25-Mar-99	DV	18.2	125	0.093184
Mission	2	25-Mar-99	DV	22	136	0.087459
Mission	2	25-Mar-99	DV	2.3	57	0.124195
Mission	2	30-Mar-99	DV	11.7		
Mission	2	30-Mar-99	DV	12.3		
Mission	2	30-Mar-99	DV	13.1		
Mission	2	30-Mar-99	DV	13.8		
Mission	2	30-Mar-99	DV	15.2		
Mission	2	30-Mar-99	DV	16.8		
Mission	2	30-Mar-99	DV	22		
Mission	2	30-Mar-99	DV	54.8		
Mission	2	30-Mar-99	DV	66.9		
Mission	2	30-Mar-99	DV	11.2		
Mission	2	30-Mar-99	DV	21.9		
Mission	2	22-Apr-99	DV	23.4	130	0.106509
Mission	2	22-Apr-99	DV	22.1	125	0.113152
Mission	2	22-Apr-99	DV	15.6	113	0.108116
Mission	2	22-Apr-99	DV	10.6	100	0.106
Mission	2	22-Apr-99	DV	15.4	113	0.10673
Mission	2	22-Apr-99	DV	8.9	95	0.103805
Mission	2	22-Apr-99	DV	11.4	104	0.101346
Mission	2	22-Apr-99	DV	9.9	98	0.105186

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	2	22-Apr-99	DV	13.3	106	0.111669
Mission	2	22-Apr-99	DV	15.6	112	0.111038
Mission	2	22-Apr-99	DV	10.7	103	0.09792
Mission	2	22-Apr-99	DV	12.7	108	0.100817
Mission	2	22-Apr-99	DV	27.4	131	0.121881
Mission	2	22-Apr-99	DV	24.6	120	0.142361
Mission	2	22-Apr-99	DV	14	106	0.117547
Mission	2	22-Apr-99	DV	9.2	96	0.103986
Mission	2	22-Apr-99	DV	8.2	94	0.098726
Mission	2	22-Apr-99	DV	2.5	59	0.121726
Mission	2	22-Apr-99	DV	12.7	105	0.109707
Mission	2	22-Apr-99	DV	10.7	103	0.09792
Mission	2	22-Apr-99	DV	29.1	143	0.099514
Mission	2	22-Apr-99	DV	13.1	108	0.103992
Mission	2	22-Apr-99	DV	11.2	103	0.102496
Mission	2	22-Apr-99	DV	11.5	104	0.102235
Mission	2	22-Apr-99	DV	9.8	99	0.101
Mission	2	22-Apr-99	DV	9.4	96	0.106246
Mission	2	22-Apr-99	DV	9.9	102	0.09329
Mission	2	22-Apr-99	DV	8	91	0.106161
Mission	2	22-Apr-99	DV	2	60	0.092593
Mission	2	22-Apr-99	DV	1.8	55	0.108189
Mission	2	22-Apr-99	DV	18.4	123	0.098879
Mission	2	22-Apr-99	DV	13.5	111	0.098711
Mission	2	22-Apr-99	DV	2.5	60	0.115741
Mission	2	22-Apr-99	DV	2	62	0.083918
Mission	3	29-Jan-99	CO	13.1		
Mission	3	29-Jan-99	DV	3.9		
Mission	3	29-Jan-99	DV	4		
Mission	3	29-Jan-99	DV	4.1		
Mission	3	29-Jan-99	DV	5.4		
Mission	3	29-Jan-99	DV	5.7		
Mission	3	29-Jan-99	DV	6.1		
Mission	3	29-Jan-99	DV	7.7		
Mission	3	29-Jan-99	DV	8.1		
Mission	3	29-Jan-99	DV	8.2		
Mission	3	29-Jan-99	DV	9.4		
Mission	3	29-Jan-99	DV	9.5		
Mission	3	29-Jan-99	DV	11.3		
Mission	3	29-Jan-99	DV	19.2		
Mission	3	29-Jan-99	DV	30		
Mission	3	29-Jan-99	DV	30.2		
Mission	3	29-Jan-99	DV	33.6		
Mission	3	29-Jan-99	DV	1.7		
Mission	3	29-Jan-99	DV	2.7		
Mission	3	29-Jan-99	DV	2.8		
Mission	3	29-Jan-99	DV	2.9		
Mission	3	29-Jan-99	DV	4		
Mission	3	29-Jan-99	DV	6.1		
Mission	3	29-Jan-99	DV	6.4		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	3	29-Jan-99	DV	6.6		
Mission	3	29-Jan-99	DV	6.9		
Mission	3	29-Jan-99	DV	7.4		
Mission	3	29-Jan-99	DV	7.4		
Mission	3	29-Jan-99	DV	8		
Mission	3	29-Jan-99	DV	8.1		
Mission	3	29-Jan-99	DV	10.2		
Mission	3	29-Jan-99	DV	13.8		
Mission	3	29-Jan-99	DV	17.1		
Mission	3	03-Feb-99	DV	2.1		
Mission	3	03-Feb-99	DV	3.3		
Mission	3	03-Feb-99	DV	3.3		
Mission	3	03-Feb-99	DV	3.7		
Mission	3	03-Feb-99	DV	4		
Mission	3	03-Feb-99	DV	4.4		
Mission	3	03-Feb-99	DV	8.2		
Mission	3	03-Feb-99	DV	9.1		
Mission	3	03-Feb-99	DV	10.7		
Mission	3	03-Feb-99	DV	11.7		
Mission	3	03-Feb-99	DV	11.8		
Mission	3	25-Mar-99	DV	2.2	60	0.101852
Mission	3	25-Mar-99	DV	8	92	0.102737
Mission	3	25-Mar-99	DV	11.2	105	0.09675
Mission	3	25-Mar-99	DV	2.3	61	0.10133
Mission	3	25-Mar-99	DV	7	94	0.084278
Mission	3	25-Mar-99	DV	15	117	0.093656
Mission	3	25-Mar-99	DV	15.3	122	0.084258
Mission	3	25-Mar-99	DV	12.9	113	0.089403
Mission	3	25-Mar-99	DV	9.7	95	0.113136
Mission	3	25-Mar-99	DV	16.7	120	0.096644
Mission	3	25-Mar-99	DV	13.6	112	0.096802
Mission	3	30-Mar-99	DV	4.6		
Mission	3	30-Mar-99	DV	8.2		
Mission	3	30-Mar-99	DV	10.4		
Mission	3	30-Mar-99	DV	10.6		
Mission	3	30-Mar-99	DV	11.8		
Mission	3	30-Mar-99	DV	12.5		
Mission	3	30-Mar-99	DV	13		
Mission	3	30-Mar-99	DV	13.5		
Mission	3	30-Mar-99	DV	14.7		
Mission	3	30-Mar-99	DV	17.1		
Mission	3	30-Mar-99	DV	17.4		
Mission	3	30-Mar-99	DV	17.8		
Mission	3	30-Mar-99	DV	23.5		
Mission	3	30-Mar-99	DV	23.9		
Mission	3	30-Mar-99	DV	25.6		
Mission	3	30-Mar-99	DV	37.4		
Mission	3	30-Mar-99	DV	39.7		
Mission	3	30-Mar-99	DV	2.4		
Mission	3	30-Mar-99	DV	6.8		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	3	30-Mar-99	DV	7.4		
Mission	3	30-Mar-99	DV	7.7		
Mission	3	30-Mar-99	DV	8.1		
Mission	3	30-Mar-99	DV	8.2		
Mission	3	30-Mar-99	DV	9.5		
Mission	3	30-Mar-99	DV	9.9		
Mission	3	30-Mar-99	DV	10.4		
Mission	3	30-Mar-99	DV	11.5		
Mission	3	30-Mar-99	DV	11.9		
Mission	3	30-Mar-99	DV	11.9		
Mission	3	30-Mar-99	DV	12.9		
Mission	3	30-Mar-99	DV	14.9		
Mission	3	30-Mar-99	DV	26.7		
Mission	3	30-Mar-99	DV	37.9		
Mission	3	22-Apr-99	DV	19.4	129	0.090372
Mission	3	22-Apr-99	DV	47.5	171	0.094996
Mission	3	22-Apr-99	DV	17.5	111	0.127958
Mission	3	22-Apr-99	DV	15.8	115	0.103888
Mission	3	22-Apr-99	DV	12.3	105	0.106252
Mission	3	22-Apr-99	DV	14.3	116	0.091614
Mission	3	22-Apr-99	DV	11.5	105	0.099341
Mission	3	22-Apr-99	DV	13.3	110	0.099925
Mission	3	22-Apr-99	DV	9.4	95	0.109637
Mission	3	22-Apr-99	DV	2.1	55	0.126221
Mission	3	22-Apr-99	DV	9.6	96	0.108507
Mission	3	22-Apr-99	DV	4.6	77	0.100759
Mission	4	29-Jan-99	DV	1.9		
Mission	4	29-Jan-99	DV	2		
Mission	4	29-Jan-99	DV	2		
Mission	4	29-Jan-99	DV	2.3		
Mission	4	29-Jan-99	DV	2.4		
Mission	4	29-Jan-99	DV	2.7		
Mission	4	29-Jan-99	DV	2.9		
Mission	4	29-Jan-99	DV	3		
Mission	4	29-Jan-99	DV	3.1		
Mission	4	29-Jan-99	DV	3.2		
Mission	4	29-Jan-99	DV	3.6		
Mission	4	29-Jan-99	DV	3.7		
Mission	4	29-Jan-99	DV	3.7		
Mission	4	29-Jan-99	DV	3.9		
Mission	4	29-Jan-99	DV	4		
Mission	4	29-Jan-99	DV	4.4		
Mission	4	29-Jan-99	DV	8.8		
Mission	4	29-Jan-99	DV	10.1		
Mission	4	03-Feb-99	DV	1.8		
Mission	4	03-Feb-99	DV	2.3		
Mission	4	03-Feb-99	DV	2.3		
Mission	4	03-Feb-99	DV	2.4		
Mission	4	03-Feb-99	DV	2.8		
Mission	4	03-Feb-99	DV	2.9		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	4	03-Feb-99	DV	2.9		
Mission	4	03-Feb-99	DV	3.1		
Mission	4	03-Feb-99	DV	3.2		
Mission	4	03-Feb-99	DV	3.3		
Mission	4	03-Feb-99	DV	3.7		
Mission	4	03-Feb-99	DV	3.7		
Mission	4	03-Feb-99	DV	3.7		
Mission	4	03-Feb-99	DV	4.3		
Mission	4	03-Feb-99	DV	4.8		
Mission	4	03-Feb-99	DV	7.3		
Mission	4	03-Feb-99	DV	11		
Mission	4	03-Feb-99	DV	11.5		
Mission	4	25-Mar-99	DV	4.9	80	0.095703
Mission	4	25-Mar-99	DV	2.4	64	0.091553
Mission	4	25-Mar-99	DV	12	110	0.090158
Mission	4	25-Mar-99	DV	7	92	0.089895
Mission	4	25-Mar-99	DV	10.4	104	0.092456
Mission	4	25-Mar-99	DV	3.4	69	0.103498
Mission	4	25-Mar-99	DV	3.3	71	0.092202
Mission	4	25-Mar-99	DV	7.5	97	0.082176
Mission	4	25-Mar-99	DV	4.6	78	0.096934
Mission	4	25-Mar-99	DV	2.6	63	0.10398
Mission	4	25-Mar-99	DV	13.3	112	0.094667
Mission	4	25-Mar-99	DV	10	104	0.0889
Mission	4	25-Mar-99	DV	9	96	0.101725
Mission	4	25-Mar-99	DV	3.5	73	0.08997
Mission	4	25-Mar-99	DV	3.1	73	0.079688
Mission	4	25-Mar-99	DV	3.8	73	0.097682
Mission	4	25-Mar-99	DV	45.8	465	0.004555
Mission	4	25-Mar-99	DV	41.1	176	0.075388
Mission	4	25-Mar-99	DV	21.3	129	0.099223
Mission	4	25-Mar-99	DV	3	63	0.119977
Mission	4	25-Mar-99	DV	4.5	78	0.094826
Mission	4	25-Mar-99	DV	5.4	78	0.113792
Mission	4	25-Mar-99	DV	15.7	120	0.090856
Mission	4	25-Mar-99	DV	16	124	0.083918
Mission	4	25-Mar-99	DV	13.3	123	0.071472
Mission	4	25-Mar-99	DV	5	83	0.087445
Mission	4	25-Mar-99	DV	8.5	98	0.090311
Mission	4	30-Mar-99	DV	1.8		
Mission	4	30-Mar-99	DV	2.9		
Mission	4	30-Mar-99	DV	3.4		
Mission	4	30-Mar-99	DV	3.8		
Mission	4	30-Mar-99	DV	10.6		
Mission	4	30-Mar-99	DV	12.7		
Mission	4	22-Apr-99	DV	18.5	118	0.112597
Mission	5	22-Apr-99	no sampled due to previous poor capture rates			
Mission	4A	22-Apr-99	DV	41.2	160	0.100586
Mission	4A	22-Apr-99	DV	19.7	120	0.114005
Mission	4A	22-Apr-99	DV	18	121	0.101605
Mission	4A	22-Apr-99	DV	22.1	132	0.096088

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Mission	4A	22-Apr-99	DV	25.8	146	0.082901
Mission	4A	22-Apr-99	DV	6.2	85	0.100957
Mission	4A	22-Apr-99	DV	15.4	118	0.093729
Mission	4A	22-Apr-99	DV	30.7	141	0.109517
Mission	4A	22-Apr-99	DV	14.5	113	0.100492
Mission	4A	22-Apr-99	DV	9.3	98	0.098811
Mission	4A	22-Apr-99	DV	9.2	100	0.092
Mission	4A	22-Apr-99	DV	12.4	105	0.107116
Mission	4A	22-Apr-99	DV	16	117	0.099899
Mission	4A	22-Apr-99	DV	4.1	75	0.097185
Mission	4A	22-Apr-99	DV	15	118	0.091295
Mission	4A	22-Apr-99	DV	14.9	121	0.084107
Mission	4A	22-Apr-99	DV	9	95	0.104972

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Richfield	1	09-Nov-98	RB	1.4			
Richfield	1	09-Nov-98	RB	1.4			
Richfield	1	09-Nov-98	RB	1.6			
Richfield	1	09-Nov-98	RB	2.6			
Richfield	1	09-Nov-98	RB	6			
Richfield	1	09-Nov-98	RB	7.6			
Richfield	1	10-Dec-98	RB	1.3			
Richfield	1	10-Dec-98	RB	1.3			
Richfield	1	10-Dec-98	RB	1.4			
Richfield	1	10-Dec-98	RB	1.5			
Richfield	1	10-Dec-98	RB	1.8			
Richfield	1	10-Dec-98	RB	2.1			
Richfield	1	10-Dec-98	RB	2.3			
Richfield	1	10-Dec-98	RB	2.6			
Richfield	1	10-Dec-98	RB	4.1			
Richfield	1	10-Dec-98	RB	5.5			
Richfield	1	10-Dec-98	RB	6.1			
Richfield	1	10-Dec-98	RB	14.2			
Richfield	1	09-Jan-99	RB	0.9			
Richfield	1	09-Jan-99	RB	1.2			
Richfield	1	09-Jan-99	RB	1.3			
Richfield	1	09-Jan-99	RB	1.6			
Richfield	1	09-Jan-99	RB	1.7			
Richfield	1	09-Jan-99	RB	1.7			
Richfield	1	09-Jan-99	RB	1.8			
Richfield	1	09-Jan-99	RB	2.6			
Richfield	1	09-Jan-99	RB	2.9			
Richfield	1	09-Jan-99	RB	7			
Richfield	1	09-Jan-99	RB	15.4			
Richfield	1	05-Feb-99	CO	3.2			
Richfield	1	05-Feb-99	RB	1.7			
Richfield	1	05-Feb-99	RB	1.8			
Richfield	1	05-Feb-99	RB	2			
Richfield	1	05-Feb-99	RB	2.6			
Richfield	1	05-Feb-99	RB	3.3			
Richfield	1	05-Feb-99	RB	3.4			
Richfield	1	05-Feb-99	RB	4.3			
Richfield	1	05-Feb-99	RB	4.5			
Richfield	1	05-Feb-99	RB	7.3			
Richfield	1	05-Feb-99	RB	8			
Richfield	1	05-Feb-99	RB	8.3			
Richfield	1	14-Mar-99	RB	1.5	50	0.12	
Richfield	1	14-Mar-99	RB	2.2	60	0.101852	
Richfield	1	14-Mar-99	RB	7.5	85	0.122125	
Richfield	1	14-Mar-99	RB	1.4	49	0.118998	
Richfield	1	14-Mar-99	RB	2.5	60	0.115741	
Richfield	1	14-Mar-99	RB	1.3	50	0.104	
Richfield	1	14-Mar-99	RB	1	47	0.096318	
Richfield	1	14-Mar-99	RB	2	58	0.102505	
Richfield	1	14-Mar-99	RB	1.4	51	0.10554	

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Richfield	1	14-Mar-99	RB	1.3	48	0.117549
Richfield	1	14-Mar-99	RB	1.1	51	0.082924
Richfield	1	14-Mar-99	RB	1.5	54	0.09526
Richfield	1	14-Mar-99	RB	1.2	46	0.123284
Richfield	1	14-Mar-99	RB	2.1	61	0.092519
Richfield	1	14-Mar-99	RB	0.9	47	0.086686
Richfield	1	14-Mar-99	RB	1.3	51	0.098002
Richfield	1	14-Mar-99	RB	1.3	51	0.098002
Richfield	1	14-Mar-99	RB	4.5	78	0.094826
Richfield	1	14-Mar-99	RB	1.4	54	0.088909
Richfield	1	14-Mar-99	RB	15.3	111	0.111872
Richfield	1	14-Mar-99	RB	1.1	49	0.093498
Richfield	1	14-Mar-99	RB	1.1	50	0.088
Richfield	1	14-Apr-99	RB	1.4		
Richfield	1	14-Apr-99	RB	1.4		
Richfield	1	14-Apr-99	RB	2		
Richfield	1	14-Apr-99	RB	2.5		
Richfield	1	14-Apr-99	RB	7.2		
Richfield	1	14-Apr-99	RB	7.5		
Richfield	2	09-Nov-98	CH	4.5		
Richfield	2	09-Nov-98	RB	1.1		
Richfield	2	09-Nov-98	RB	1.1		
Richfield	2	09-Nov-98	RB	2		
Richfield	2	09-Nov-98	RB	2.2		
Richfield	2	09-Nov-98	RB	2.2		
Richfield	2	09-Nov-98	RB	2.3		
Richfield	2	09-Nov-98	RB	2.5		
Richfield	2	09-Nov-98	RB	2.8		
Richfield	2	09-Nov-98	RB	3.5		
Richfield	2	09-Nov-98	RB	3.8		
Richfield	2	09-Nov-98	RB	4.3		
Richfield	2	09-Nov-98	RB	5.3		
Richfield	2	09-Nov-98	RB	5.7		
Richfield	2	09-Nov-98	RB	7.1		
Richfield	2	09-Nov-98	RB	9.1		
Richfield	2	09-Nov-98	RB	9.7		
Richfield	2	09-Nov-98	RB	10.3		
Richfield	2	09-Nov-98	RB	11.4		
Richfield	2	09-Nov-98	RB	13		
Richfield	2	09-Nov-98	RB	13.2		
Richfield	2	09-Nov-98	RB	15		
Richfield	2	09-Nov-98	RB	16.3		
Richfield	2	09-Nov-98	RB	17.3		
Richfield	2	09-Nov-98	RB	17.8		
Richfield	2	10-Dec-98	CO	2.9		
Richfield	2	10-Dec-98	CO	4.7		
Richfield	2	10-Dec-98	RB	1.6		
Richfield	2	10-Dec-98	RB	2		
Richfield	2	10-Dec-98	RB	4.5		
Richfield	2	10-Dec-98	RB	6.3		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Richfield	2	10-Dec-98	RB	7		
Richfield	2	10-Dec-98	RB	8.3		
Richfield	2	10-Dec-98	RB	8.4		
Richfield	2	10-Dec-98	RB	8.5		
Richfield	2	10-Dec-98	RB	9.8		
Richfield	2	13-Jan-99	RB	2.1		
Richfield	2	13-Jan-99	RB			
Richfield	2	13-Jan-99	RB			
Richfield	2	13-Jan-99	RB			
Richfield	2	13-Jan-99	RB			
Richfield	2	13-Jan-99	RB			
Richfield	2	13-Jan-99	RB			
Richfield	2	13-Jan-99	RB			
Richfield	2	13-Jan-99	RB			
Richfield	2	05-Feb-99	CH	2.9		
Richfield	2	05-Feb-99	RB	1.2		
Richfield	2	05-Feb-99	RB	1.5		
Richfield	2	05-Feb-99	RB	1.8		
Richfield	2	05-Feb-99	RB	1.9		
Richfield	2	05-Feb-99	RB	2.1		
Richfield	2	05-Feb-99	RB	2.4		
Richfield	2	05-Feb-99	RB	4.5		
Richfield	2	05-Feb-99	RB	4.9		
Richfield	2	14-Mar-99	CO	4.7	76	0.107067
Richfield	2	14-Mar-99	RB	2.3	59	0.111988
Richfield	2	14-Mar-99	RB	1.2	49	0.101998
Richfield	2	14-Mar-99	RB	7.3	83	0.12767
Richfield	2	14-Mar-99	RB	14	112	0.099649
Richfield	2	14-Mar-99	RB	1.3	49	0.110498
Richfield	2	14-Mar-99	RB	1.2	52	0.085344
Richfield	2	14-Mar-99	RB	1.1	48	0.099465
Richfield	2	14-Mar-99	RB	1.1	48	0.099465
Richfield	2	14-Mar-99	RB	1.7	56	0.096802
Richfield	2	14-Mar-99	RB	1.6	54	0.101611
Richfield	2	14-Mar-99	RB	1	45	0.109739
Richfield	2	14-Mar-99	RB	1.2	51	0.090463
Richfield	2	14-Mar-99	RB	1.2	50	0.096
Richfield	2	14-Mar-99	RB	1.1	48	0.099465
Richfield	2	14-Mar-99	RB	1	48	0.090422
Richfield	2	14-Mar-99	RB	1.2	50	0.096
Richfield	2	14-Mar-99	RB	1.4	50	0.112
Richfield	2	14-Mar-99	RB	1.2	48	0.108507
Richfield	2	14-Mar-99	RB	15.1	109	0.1166
Richfield	2	14-Mar-99	RB	9.9	94	0.119193
Richfield	2	14-Mar-99	RB	1.3	45	0.142661
Richfield	2	14-Apr-99	RB	1		
Richfield	2	14-Apr-99	RB	1.6		
Richfield	2	14-Apr-99	RB	7.9		
Richfield	3	09-Nov-98	CO	2.5		
Richfield	3	09-Nov-98	CO	4.1		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Richfield	3	09-Nov-98	CO	4.1			
Richfield	3	09-Nov-98	CO	6.9			
Richfield	3	09-Nov-98	RB	0.7			
Richfield	3	09-Nov-98	RB	1.8			
Richfield	3	09-Nov-98	RB	1.8			
Richfield	3	09-Nov-98	RB	1.9			
Richfield	3	09-Nov-98	RB	2.7			
Richfield	3	09-Nov-98	RB	3.1			
Richfield	3	09-Nov-98	RB	3.6			
Richfield	3	09-Nov-98	RB	5.5			
Richfield	3	09-Nov-98	RB	5.6			
Richfield	3	09-Nov-98	RB	5.7			
Richfield	3	09-Nov-98	RB	5.8			
Richfield	3	09-Nov-98	RB	5.9			
Richfield	3	09-Nov-98	RB	6.5			
Richfield	3	09-Nov-98	RB	7.2			
Richfield	3	09-Nov-98	RB	7.7			
Richfield	3	09-Nov-98	RB	9.9			
Richfield	3	09-Nov-98	RB	10.3			
Richfield	3	09-Nov-98	RB	13.6			
Richfield	3	09-Nov-98	RB	14.3			
Richfield	3	09-Nov-98	RB	14.6			
Richfield	3	09-Nov-98	RB	15.1			
Richfield	3	09-Nov-98	RB	15.2			
Richfield	3	09-Nov-98	RB	20.3			
Richfield	3	09-Nov-98	RB	21.6			
Richfield	3	10-Dec-98	CO	2.2			
Richfield	3	10-Dec-98	CO	2.6			
Richfield	3	10-Dec-98	CO	4			
Richfield	3	10-Dec-98	CO	4.2			
Richfield	3	10-Dec-98	CO	7.2			
Richfield	3	10-Dec-98	CO	11.4			
Richfield	3	10-Dec-98	RB	2.5			
Richfield	3	10-Dec-98	RB	3.6			
Richfield	3	10-Dec-98	RB	4.2			
Richfield	3	10-Dec-98	RB	6.6			
Richfield	3	10-Dec-98	RB	7.3			
Richfield	3	10-Dec-98	RB	7.6			
Richfield	3	10-Dec-98	RB	7.7			
Richfield	3	10-Dec-98	RB	7.9			
Richfield	3	10-Dec-98	RB	8.9			
Richfield	3	10-Dec-98	RB	10.8			
Richfield	3	10-Dec-98	RB	11.4			
Richfield	3	10-Dec-98	RB	12.1			
Richfield	3	10-Dec-98	RB	14.3			
Richfield	3	10-Dec-98	RB	15			
Richfield	3	10-Dec-98	RB	17.4			
Richfield	3	10-Dec-98	RB	19			
Richfield	3	07-Jan-99	RB	4.6			
Richfield	3	07-Jan-99	RB	6			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Richfield	3	07-Jan-99	RB	7.5		
Richfield	3	07-Jan-99	RB	9		
Richfield	3	07-Jan-99	RB	10.4		
Richfield	3	07-Jan-99	RB	12.5		
Richfield	3	07-Jan-99	RB	14.1		
Richfield	3	07-Jan-99	RB	23.9		
Richfield	3	07-Jan-99	RB	25.4		
Richfield	3	05-Feb-99	CO	5.1		
Richfield	3	05-Feb-99	RB	5.4		
Richfield	3	05-Feb-99	RB	12.4		
Richfield	3	14-Mar-99	CO	8.9	95	0.103805
Richfield	3	14-Mar-99	RB	13.7	110	0.10293
Richfield	3	14-Mar-99	RB	19.1	119	0.113342
Richfield	3	14-Mar-99	RB	7.2	82	0.130584
Richfield	3	14-Mar-99	RB	11.1	101	0.107736
Richfield	3	14-Mar-99	RB	7.8	92	0.100168
Richfield	3	14-Mar-99	RB	5	74	0.123389
Richfield	3	14-Mar-99	RB	3.6	72	0.096451
Richfield	3	14-Mar-99	RB	2.4	61	0.105736
Richfield	3	14-Mar-99	RB	4.8	42	0.647878
Richfield	3	14-Mar-99	RB	7.5	87	0.113895
Richfield	3	14-Mar-99	RB	7	88	0.102719
Richfield	3	14-Mar-99	RB	4.4	75	0.104296
Richfield	3	14-Mar-99	RB	6.9	82	0.125143
Richfield	3	14-Mar-99	RB	8.2	84	0.138349
Richfield	3	14-Apr-99	CO	2.5		
Richfield	3	14-Apr-99	CO	7.9		
Richfield	3	14-Apr-99	RB	3.9		
Richfield	3	14-Apr-99	RB	4		
Richfield	3	14-Apr-99	RB	5.4		
Richfield	3	14-Apr-99	RB	5.5		
Richfield	3	14-Apr-99	RB	6.8		
Richfield	3	14-Apr-99	RB	7.2		
Richfield	3	14-Apr-99	RB	7.4		
Richfield	3	14-Apr-99	RB	12.7		
Richfield	3	14-Apr-99	RB	24.7		
Richfield	3	14-Apr-99	RB	25.8		
Richfield	4	09-Nov-98	CO	1.8		
Richfield	4	09-Nov-98	CO	1.8		
Richfield	4	09-Nov-98	CO	2		
Richfield	4	09-Nov-98	CO	2.3		
Richfield	4	09-Nov-98	CO	2.4		
Richfield	4	09-Nov-98	CO	2.5		
Richfield	4	09-Nov-98	CO	2.5		
Richfield	4	09-Nov-98	CO	2.6		
Richfield	4	09-Nov-98	CO	2.9		
Richfield	4	09-Nov-98	CO	3		
Richfield	4	09-Nov-98	CO	3.5		
Richfield	4	09-Nov-98	CO	10.1		
Richfield	4	09-Nov-98	RB	0.9		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Richfield	4	09-Nov-98	RB	1.2		
Richfield	4	09-Nov-98	RB	1.2		
Richfield	4	09-Nov-98	RB	1.5		
Richfield	4	09-Nov-98	RB	2		
Richfield	4	09-Nov-98	RB	2.1		
Richfield	4	09-Nov-98	RB	2.2		
Richfield	4	09-Nov-98	RB	2.7		
Richfield	4	09-Nov-98	RB	4.6		
Richfield	4	09-Nov-98	RB	5.1		
Richfield	4	09-Nov-98	RB	7.2		
Richfield	4	09-Nov-98	RB	8.7		
Richfield	4	09-Nov-98	RB	12.2		
Richfield	4	09-Nov-98	RB	13.2		
Richfield	4	09-Nov-98	RB	13.9		
Richfield	4	09-Nov-98	RB	15.3		
Richfield	4	09-Nov-98	RB	16.4		
Richfield	4	09-Nov-98	RB	17.6		
Richfield	4	09-Nov-98	RB	33.1		
Richfield	4	10-Dec-98	CO	1.7		
Richfield	4	10-Dec-98	CO	2.4		
Richfield	4	10-Dec-98	CO	2.5		
Richfield	4	10-Dec-98	CO	2.7		
Richfield	4	10-Dec-98	CO	2.8		
Richfield	4	10-Dec-98	CO	3.1		
Richfield	4	10-Dec-98	CO	3.6		
Richfield	4	10-Dec-98	CO	9.7		
Richfield	4	10-Dec-98	RB	1.6		
Richfield	4	10-Dec-98	RB	1.8		
Richfield	4	10-Dec-98	RB	1.8		
Richfield	4	10-Dec-98	RB	5.1		
Richfield	4	10-Dec-98	RB	7.7		
Richfield	4	10-Dec-98	RB	9.5		
Richfield	4	10-Dec-98	RB	10.6		
Richfield	4	10-Dec-98	RB	16.2		
Richfield	4	10-Dec-98	RB	16.8		
Richfield	4	05-Feb-99	CO	9.1		
Richfield	4	05-Feb-99	RB	5.3		
Richfield	4	05-Feb-99	RB	6.9		
Richfield	4	05-Feb-99	RB	7.9		
Richfield	4	05-Feb-99	RB	10.1		
Richfield	4	05-Feb-99	RB	11.8		
Richfield	4	05-Feb-99	RB	13.2		
Richfield	4	05-Feb-99	RB	14.5		
Richfield	4	05-Feb-99	RB	15.2		
Richfield	4	05-Feb-99	RB	15.3		
Richfield	4	05-Feb-99	RB	16.3		
Richfield	4	05-Feb-99	RB	16.9		
Richfield	4	05-Feb-99	RB	17.5		
Richfield	4	05-Feb-99	RB	19		
Richfield	4	16-Mar-99	CO	1.4	53	0.094037

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K	
Richfield	4	16-Mar-99	RB	15.3	110	0.114951	
Richfield	4	16-Mar-99	RB	29.6	141	0.105593	
Richfield	4	16-Mar-99	RB	13.1	112	0.093243	
Richfield	4	16-Mar-99	RB	8.7	94	0.104746	
Richfield	4	16-Mar-99	RB	11.4	102	0.107425	
Richfield	4	16-Mar-99	RB	12.7	106	0.106632	
Richfield	4	16-Mar-99	RB	11.3	107	0.092242	
Richfield	4	16-Mar-99	RB	9.9	100	0.099	
Richfield	4	16-Mar-99	RB	21.6	126	0.10798	
Richfield	4	16-Mar-99	RB	7.1	86	0.111625	
Richfield	4	16-Mar-99	RB	17.6	119	0.104441	
Richfield	4	16-Mar-99	RB	20.3	125	0.103936	
Richfield	4	16-Mar-99	RB	10.8	94	0.130029	
Richfield	4	16-Mar-99	RB	24.6	126	0.122977	
Richfield	4	16-Mar-99	RB	6.7	82	0.121516	
Richfield	4	16-Mar-99	RB	9.7	92	0.124569	
Richfield	4	16-Mar-99	RB	11.1	97	0.121621	
Richfield	4	16-Mar-99	RB	15.4	111	0.112603	
Richfield	4	16-Mar-99	RB	8.4	94	0.101134	
Richfield	4	14-Apr-99	CO	2.2			
Richfield	4	14-Apr-99	RB	2			
Richfield	4	14-Apr-99	RB	7.5			
Richfield	4	14-Apr-99	RB	13.2			
Richfield	4	14-Apr-99	RB	13.5			

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Toboggan	1	15-Jan-99	CO	2		
Toboggan	1	15-Jan-99	CO	4.7		
Toboggan	1	15-Jan-99	CO	3.3		
Toboggan	1	15-Jan-99	CO	2.4		
Toboggan	1	15-Jan-99	CO	3		
Toboggan	1	15-Jan-99	CO	4		
Toboggan	1	15-Jan-99	CO	4.6		
Toboggan	1	15-Jan-99	CO	4.2		
Toboggan	1	15-Jan-99	CO	2		
Toboggan	1	15-Jan-99	CO	5.1		
Toboggan	1	15-Jan-99	CO	4.1		
Toboggan	1	15-Jan-99	CO	3.7		
Toboggan	1	15-Jan-99	CO	4.4		
Toboggan	1	15-Jan-99	CO	1.8		
Toboggan	1	15-Jan-99	CO	3.8		
Toboggan	1	15-Jan-99	CO	3.6		
Toboggan	1	15-Jan-99	CO	3.9		
Toboggan	1	15-Jan-99	RB	12.9		
Toboggan	1	15-Jan-99	RB	5.9		
Toboggan	1	15-Jan-99	RB	1		
Toboggan	1	15-Jan-99	RB	7.5		
Toboggan	1	15-Jan-99	RB	8.5		
Toboggan	1	15-Jan-99	RB	0.9		
Toboggan	1	20-Jan-99	CO	10.6		
Toboggan	1	20-Jan-99	CO	3.6		
Toboggan	1	20-Jan-99	CO	2.5		
Toboggan	1	20-Jan-99	CO	1.9		
Toboggan	1	20-Jan-99	CO	5.5		
Toboggan	1	20-Jan-99	CO	2.6		
Toboggan	1	20-Jan-99	CO	3.6		
Toboggan	1	20-Jan-99	CO	2.8		
Toboggan	1	20-Jan-99	CO	4.3		
Toboggan	1	20-Jan-99	CO	2.2		
Toboggan	1	20-Jan-99	CO	5.2		
Toboggan	1	20-Jan-99	CO	1.7		
Toboggan	1	20-Jan-99	CO	4.6		
Toboggan	1	20-Jan-99	CO	3.2		
Toboggan	1	20-Jan-99	CO	4.7		
Toboggan	1	20-Jan-99	RB	1.2		
Toboggan	1	11-Feb-99	CO	4.9		
Toboggan	1	11-Feb-99	CO	4.1		
Toboggan	1	11-Feb-99	CO	1.8		
Toboggan	1	11-Feb-99	CO	2.6		
Toboggan	1	11-Feb-99	CO	4.5		
Toboggan	1	11-Feb-99	CO	5.8		
Toboggan	1	11-Feb-99	CO	10		
Toboggan	1	11-Feb-99	CO	5.1		
Toboggan	1	11-Feb-99	CO	8		
Toboggan	1	11-Feb-99	CO	5.3		
Toboggan	1	11-Feb-99	CO	2.8		
Toboggan	1	11-Feb-99	RB	8.7		
Toboggan	1	11-Feb-99	RB	9.8		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Toboggan	1	11-Feb-99	RB	13.8		
Toboggan	1	25-Mar-99	CO	4.8	80	0.09375
Toboggan	1	25-Mar-99	CO	5.8	80	0.113281
Toboggan	1	25-Mar-99	CO	2.3	58	0.117881
Toboggan	1	25-Mar-99	CO	4.3	63	0.171968
Toboggan	1	25-Mar-99	CO	5	69	0.152203
Toboggan	1	25-Mar-99	CO	5.3	77	0.116092
Toboggan	1	25-Mar-99	CO	1.6	49	0.135998
Toboggan	1	25-Mar-99	CO	1.6	54	0.101611
Toboggan	1	25-Mar-99	DV	27	135	0.109739
Toboggan	1	25-Mar-99	DV	10.4	106	0.08732
Toboggan	1	25-Mar-99	RB	9.6	99	0.098939
Toboggan	1	25-Mar-99	RB	14	111	0.102367
Toboggan	1	25-Mar-99	RB	7.5	87	0.113895
Toboggan	1	22-Apr-99	CO	10.8	98	0.114748
Toboggan	1	22-Apr-99	CO	7.3	85	0.118868
Toboggan	1	22-Apr-99	CO	6.2	83	0.108432
Toboggan	1	22-Apr-99	CO	3.5	69	0.106542
Toboggan	1	22-Apr-99	CO	2.1	54	0.133364
Toboggan	1	22-Apr-99	CO	5.3	78	0.111684
Toboggan	1	22-Apr-99	CO	4.7	76	0.107067
Toboggan	1	22-Apr-99	CO	2.1	57	0.113395
Toboggan	1	22-Apr-99	CO	2.4	59	0.116857
Toboggan	1	22-Apr-99	CO	1.5	52	0.10668
Toboggan	1	22-Apr-99	DV	33.4	138	0.127089
Toboggan	1	22-Apr-99	RB	1.8	54	0.114312
Toboggan	2	15-Jan-99	CO	3.6		
Toboggan	2	15-Jan-99	CO	5.9		
Toboggan	2	15-Jan-99	CO	12.6		
Toboggan	2	15-Jan-99	CO	3.7		
Toboggan	2	15-Jan-99	CO	4.4		
Toboggan	2	15-Jan-99	CO	3.7		
Toboggan	2	15-Jan-99	CO	4.5		
Toboggan	2	15-Jan-99	CO	3.8		
Toboggan	2	15-Jan-99	CO	4.1		
Toboggan	2	15-Jan-99	DV	2.7		
Toboggan	2	15-Jan-99	RB	8.8		
Toboggan	2	15-Jan-99	RB	10.1		
Toboggan	2	20-Jan-99	CO	5.9		
Toboggan	2	20-Jan-99	CO	3.8		
Toboggan	2	20-Jan-99	CO	1.9		
Toboggan	2	20-Jan-99	CO	4.5		
Toboggan	2	20-Jan-99	CO	2.5		
Toboggan	2	20-Jan-99	CO	4.9		
Toboggan	2	20-Jan-99	CO	2.8		
Toboggan	2	20-Jan-99	CO	1.4		
Toboggan	2	20-Jan-99	CO	2.9		
Toboggan	2	20-Jan-99	CO	4.1		
Toboggan	2	20-Jan-99	CO	3.7		
Toboggan	2	20-Jan-99	CO	2.2		
Toboggan	2	20-Jan-99	RB	3.1		
Toboggan	2	20-Jan-99	RB	7.7		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Toboggan	2	20-Jan-99	RB	5.5		
Toboggan	2	20-Jan-99	RB	1.5		
Toboggan	2	20-Jan-99	RB	0.4		
Toboggan	2	11-Feb-99	CO	2.9		
Toboggan	2	11-Feb-99	CO	4.4		
Toboggan	2	11-Feb-99	CO	4.6		
Toboggan	2	11-Feb-99	CO	2.2		
Toboggan	2	11-Feb-99	CO	6.5		
Toboggan	2	11-Feb-99	CO	5		
Toboggan	2	11-Feb-99	CO	6.4		
Toboggan	2	11-Feb-99	CO	6.7		
Toboggan	2	11-Feb-99	CO	1.3		
Toboggan	2	11-Feb-99	CO	5.1		
Toboggan	2	11-Feb-99	CO	4.4		
Toboggan	2	11-Feb-99	CO	6.7		
Toboggan	2	11-Feb-99	CO	2.6		
Toboggan	2	11-Feb-99	CO	5.7		
Toboggan	2	11-Feb-99	CO	4.1		
Toboggan	2	11-Feb-99	CO	2.1		
Toboggan	2	11-Feb-99	RB	5		
Toboggan	2	11-Feb-99	RB	4.2		
Toboggan	2	11-Feb-99	RB	9.4		
Toboggan	2	11-Feb-99	RB	10.8		
Toboggan	2	11-Feb-99	RB	6.2		
Toboggan	2	11-Feb-99	RB	1.8		
Toboggan	2	11-Feb-99	RB	8.5		
Toboggan	2	25-Mar-99	CO	4.6	73	0.118247
Toboggan	2	25-Mar-99	CO	2.6	62	0.109093
Toboggan	2	25-Mar-99	CO	4.9	76	0.111623
Toboggan	2	25-Mar-99	CO	4	69	0.121762
Toboggan	2	25-Mar-99	CO	2.4	61	0.105736
Toboggan	2	25-Mar-99	CO	2.2	62	0.09231
Toboggan	2	25-Mar-99	CO	1.5	53	0.100754
Toboggan	2	25-Mar-99	RB	9.9	94	0.119193
Toboggan	2	25-Mar-99	RB	5.7	80	0.111328
Toboggan	2	25-Mar-99	RB	8.8	92	0.113011
Toboggan	2	30-Mar-99	CO	6.9		
Toboggan	2	30-Mar-99	CO	4.8		
Toboggan	2	30-Mar-99	CO	4.9		
Toboggan	2	30-Mar-99	CO	5.4		
Toboggan	2	30-Mar-99	CO	5.5		
Toboggan	2	30-Mar-99	CO	1.7		
Toboggan	2	30-Mar-99	CO	5.4		
Toboggan	2	30-Mar-99	CO	4.4		
Toboggan	2	30-Mar-99	CO	3.7		
Toboggan	2	30-Mar-99	CO	5.8		
Toboggan	2	30-Mar-99	CO	2.5		
Toboggan	2	30-Mar-99	CO	4.2		
Toboggan	2	30-Mar-99	CO	2.3		
Toboggan	2	30-Mar-99	DV	2.6		
Toboggan	2	30-Mar-99	RB	10.3		
Toboggan	2	30-Mar-99	RB	5.6		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Toboggan	2	30-Mar-99	RB	2		
Toboggan	2	22-Apr-99	CO	2.2	58	0.112756
Toboggan	2	22-Apr-99	CO	2.3	57	0.124195
Toboggan	2	22-Apr-99	CO	2	57	0.107995
Toboggan	2	22-Apr-99	CO	2.3	59	0.111988
Toboggan	2	22-Apr-99	CO	4.4	74	0.108582
Toboggan	2	22-Apr-99	CO	2.2	56	0.125273
Toboggan	2	22-Apr-99	CO	5.3	77	0.116092
Toboggan	2	22-Apr-99	CO	2.5	59	0.121726
Toboggan	2	22-Apr-99	CO	1.7	55	0.102179
Toboggan	2	22-Apr-99	CO	2.4	58	0.123006
Toboggan	2	22-Apr-99	DV	8.8	111	0.064345
Toboggan	2	22-Apr-99	DV	23.5	132	0.102175
Toboggan	2	22-Apr-99	DV	2.9	68	0.09223
Toboggan	2	22-Apr-99	RB	26	131	0.115654
Toboggan	2	22-Apr-99	RB	11.4	96	0.128852
Toboggan	2	22-Apr-99	RB	7.2	83	0.125921
Toboggan	2	22-Apr-99	RB	1.6	49	0.135998
Toboggan	3	15-Jan-99	CO	1.8		
Toboggan	3	15-Jan-99	CO	3.6		
Toboggan	3	15-Jan-99	CO	2.2		
Toboggan	3	15-Jan-99	CO	4.6		
Toboggan	3	15-Jan-99	CO	2.3		
Toboggan	3	15-Jan-99	CO	5.9		
Toboggan	3	15-Jan-99	CO	1.7		
Toboggan	3	15-Jan-99	CO	1.6		
Toboggan	3	15-Jan-99	CO	3.3		
Toboggan	3	15-Jan-99	CO	1.9		
Toboggan	3	15-Jan-99	CO	1.8		
Toboggan	3	15-Jan-99	CO	3.8		
Toboggan	3	15-Jan-99	CO	1.4		
Toboggan	3	15-Jan-99	CO	2.6		
Toboggan	3	15-Jan-99	CO	2.1		
Toboggan	3	15-Jan-99	CO	3.4		
Toboggan	3	15-Jan-99	CO	5.5		
Toboggan	3	15-Jan-99	CO	1.7		
Toboggan	3	15-Jan-99	CO	2.7		
Toboggan	3	15-Jan-99	CO	1.9		
Toboggan	3	15-Jan-99	CO	7		
Toboggan	3	15-Jan-99	CO	3		
Toboggan	3	15-Jan-99	CO	2		
Toboggan	3	15-Jan-99	CO	4		
Toboggan	3	15-Jan-99	CO	2.8		
Toboggan	3	15-Jan-99	CO	3.5		
Toboggan	3	15-Jan-99	CO	6.9		
Toboggan	3	15-Jan-99	CO	3.3		
Toboggan	3	15-Jan-99	CO	1.6		
Toboggan	3	15-Jan-99	CT	21		
Toboggan	3	15-Jan-99	RB	5.8		
Toboggan	3	15-Jan-99	RB	1.3		
Toboggan	3	20-Jan-99	CO	4.1		
Toboggan	3	20-Jan-99	CO	3.9		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Toboggan	3	20-Jan-99	CO	2.4		
Toboggan	3	20-Jan-99	CO	1.6		
Toboggan	3	20-Jan-99	CO	2.4		
Toboggan	3	20-Jan-99	CO	4.7		
Toboggan	3	20-Jan-99	CO	2.2		
Toboggan	3	20-Jan-99	CO	6.5		
Toboggan	3	20-Jan-99	CO	2.9		
Toboggan	3	20-Jan-99	DV	2.8		
Toboggan	3	20-Jan-99	DV	11.2		
Toboggan	3	20-Jan-99	DV	8.1		
Toboggan	3	20-Jan-99	RB	10.8		
Toboggan	3	20-Jan-99	RB	5.4		
Toboggan	3	20-Jan-99	RB	5.9		
Toboggan	3	20-Jan-99	RB	14.5		
Toboggan	3	20-Jan-99	RB	4.1		
Toboggan	3	11-Feb-99	CO	1.9		
Toboggan	3	11-Feb-99	CO	2.6		
Toboggan	3	11-Feb-99	CO	3.1		
Toboggan	3	11-Feb-99	CO	9.2		
Toboggan	3	11-Feb-99	CO	1.5		
Toboggan	3	11-Feb-99	CO	2.4		
Toboggan	3	11-Feb-99	CO	3.5		
Toboggan	3	11-Feb-99	CO	4.9		
Toboggan	3	11-Feb-99	CO	5.1		
Toboggan	3	11-Feb-99	CO	5.9		
Toboggan	3	11-Feb-99	CO	3.9		
Toboggan	3	11-Feb-99	CO	6.8		
Toboggan	3	11-Feb-99	DV	11.4		
Toboggan	3	11-Feb-99	DV	19.2		
Toboggan	3	11-Feb-99	RB	30.3		
Toboggan	3	11-Feb-99	RB	5.9		
Toboggan	3	11-Feb-99	RB	5.6		
Toboggan	3	11-Feb-99	RB	12.6		
Toboggan	3	11-Feb-99	RB	0.9		
Toboggan	3	11-Feb-99	RB	8.4		
Toboggan	3	11-Feb-99	RB	1.4		
Toboggan	3	11-Feb-99	RB	8		
Toboggan	3	25-Mar-99	CO	5.3	78	0.111684
Toboggan	3	25-Mar-99	CO	3.4	76	0.077453
Toboggan	3	25-Mar-99	CO	5.1	75	0.120889
Toboggan	3	25-Mar-99	CO	3.6	73	0.092541
Toboggan	3	25-Mar-99	CO	5.2	74	0.128324
Toboggan	3	25-Mar-99	CO	8.5	98	0.090311
Toboggan	3	25-Mar-99	CO	3.8	69	0.115674
Toboggan	3	25-Mar-99	CO	1.6	49	0.135998
Toboggan	3	25-Mar-99	CO	1.2	43	0.15093
Toboggan	3	25-Mar-99	CO	5.9	71	0.164845
Toboggan	3	25-Mar-99	CO	3.6	71	0.100584
Toboggan	3	25-Mar-99	CO	2.7	63	0.10798
Toboggan	3	25-Mar-99	CO	2.2	59	0.107119
Toboggan	3	25-Mar-99	CO	4	68	0.127214
Toboggan	3	25-Mar-99	CO	3.7	69	0.11263

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Toboggan	3	25-Mar-99	CO	10.5	101	0.101912
Toboggan	3	25-Mar-99	CO	2.7	60	0.125
Toboggan	3	25-Mar-99	CO	2.6	57	0.140394
Toboggan	3	25-Mar-99	CO	2.3	61	0.10133
Toboggan	3	25-Mar-99	CO	1.5	53	0.100754
Toboggan	3	25-Mar-99	DV	12.5	103	0.114393
Toboggan	3	25-Mar-99	DV	18.5	128	0.088215
Toboggan	3	25-Mar-99	DV	12.1	108	0.096054
Toboggan	3	25-Mar-99	RB	4.1	75	0.097185
Toboggan	3	25-Mar-99	RB	27	140	0.098397
Toboggan	3	25-Mar-99	RB	5.9	83	0.103185
Toboggan	3	25-Mar-99	RB	8.9	95	0.103805
Toboggan	3	25-Mar-99	RB	3.8	67	0.126345
Toboggan	3	25-Mar-99	RB	4.7	70	0.137026
Toboggan	3	25-Mar-99	RB	8.9	90	0.122085
Toboggan	3	25-Mar-99	RB	5.8	82	0.105193
Toboggan	3	25-Mar-99	RB	7.9	87	0.119969
Toboggan	3	25-Mar-99	RB	4.6	73	0.118247
Toboggan	3	25-Mar-99	RB	21.7	127	0.105937
Toboggan	3	30-Mar-99	CO	3.2		
Toboggan	3	30-Mar-99	CO	3.4		
Toboggan	3	30-Mar-99	CO	2.6		
Toboggan	3	30-Mar-99	CO	4.3		
Toboggan	3	30-Mar-99	CO	3.4		
Toboggan	3	30-Mar-99	CO	1.8		
Toboggan	3	30-Mar-99	CO	3.1		
Toboggan	3	30-Mar-99	CO	9.2		
Toboggan	3	30-Mar-99	CO	5.6		
Toboggan	3	30-Mar-99	CO	3.1		
Toboggan	3	30-Mar-99	CO	6.4		
Toboggan	3	30-Mar-99	CO	12.7		
Toboggan	3	30-Mar-99	CO	2.3		
Toboggan	3	30-Mar-99	CO	7.9		
Toboggan	3	30-Mar-99	CO	11.1		
Toboggan	3	30-Mar-99	CO	4.2		
Toboggan	3	30-Mar-99	CO	3.2		
Toboggan	3	30-Mar-99	CO	1.7		
Toboggan	3	30-Mar-99	CO	1.2		
Toboggan	3	30-Mar-99	CO	5.3		
Toboggan	3	30-Mar-99	CO	6.1		
Toboggan	3	30-Mar-99	CO	2.6		
Toboggan	3	30-Mar-99	CO	2		
Toboggan	3	30-Mar-99	CO	2.7		
Toboggan	3	30-Mar-99	CO	2.8		
Toboggan	3	30-Mar-99	RB	25.3		
Toboggan	3	30-Mar-99	RB	9.1		
Toboggan	3	30-Mar-99	RB	13		
Toboggan	3	30-Mar-99	RB	4.7		
Toboggan	3	30-Mar-99	RB	7.1		
Toboggan	4	15-Jan-99	DV	4		
Toboggan	4	15-Jan-99	RB	19.6		
Toboggan	4	15-Jan-99	RB	9.1		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Toboggan	4	15-Jan-99	RB	19.7		
Toboggan	4	15-Jan-99	RB	5.5		
Toboggan	4	15-Jan-99	RB	5.5		
Toboggan	4	15-Jan-99	RB	0.9		
Toboggan	4	20-Jan-99	CO	3.8		
Toboggan	4	20-Jan-99	CO	5.3		
Toboggan	4	20-Jan-99	CO	5.4		
Toboggan	4	20-Jan-99	CO	4		
Toboggan	4	20-Jan-99	CO	3.3		
Toboggan	4	20-Jan-99	CO	3		
Toboggan	4	20-Jan-99	CO	3.7		
Toboggan	4	20-Jan-99	CO	1.8		
Toboggan	4	20-Jan-99	RB	6.8		
Toboggan	4	20-Jan-99	RB	9.6		
Toboggan	4	11-Feb-99	CO	6		
Toboggan	4	11-Feb-99	CO	3.3		
Toboggan	4	11-Feb-99	CO	4.6		
Toboggan	4	11-Feb-99	CO	4.2		
Toboggan	4	11-Feb-99	CO	3.1		
Toboggan	4	11-Feb-99	RB	9.5		
Toboggan	4	11-Feb-99	RB	15.3		
Toboggan	4	11-Feb-99	RB	12.1		
Toboggan	4	25-Mar-99	CO	3.8	67	0.126345
Toboggan	4	25-Mar-99	CO	2	57	0.107995
Toboggan	4	25-Mar-99	RB	6.7	81	0.126072
Toboggan	4	30-Mar-99	CO	4		
Toboggan	4	30-Mar-99	CO	2.4		
Toboggan	4	30-Mar-99	CO	7.7		
Toboggan	4	30-Mar-99	CO	1.3		
Toboggan	4	30-Mar-99	DV	23.6		
Toboggan	4	30-Mar-99	RB	4.6		
Toboggan	4	22-Apr-99	CO	2	56	0.113885
Toboggan	4	22-Apr-99	CO	4.2	71	0.117348
Toboggan	4	22-Apr-99	RB	1.5	42	0.202462
Toboggan	4	22-Apr-99	RB	9.3	94	0.111969
Toboggan	4	22-Apr-99	RB	12.3	111	0.089937
Toboggan	4	22-Apr-99	RB	8.2	95	0.095641

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Upper Bulkley	1	09-Nov-98	CH	8.4		
Upper Bulkley	1	09-Nov-98	RB	15.8		
Upper Bulkley	1	14-Dec-98	CH	3.4		
Upper Bulkley	1	14-Dec-98	CH	3.7		
Upper Bulkley	1	14-Dec-98	CO	4		
Upper Bulkley	1	14-Dec-98	CO	6		
Upper Bulkley	1	14-Dec-98	CO	3.9		
Upper Bulkley	1	14-Dec-98	CO	5.6		
Upper Bulkley	1	14-Dec-98	CO	7		
Upper Bulkley	1	14-Dec-98	RB	11.3		
Upper Bulkley	1	14-Dec-98	RB	15.5		
Upper Bulkley	1	14-Dec-98	RB	11.8		
Upper Bulkley	1	14-Dec-98	RB	11.2		
Upper Bulkley	1	14-Dec-98	RB	17.1		
Upper Bulkley	1	14-Dec-98	RB	18.3		
Upper Bulkley	1	14-Dec-98	RB	1.1		
Upper Bulkley	1	13-Jan-99	CH	6.2		
Upper Bulkley	1	13-Jan-99	CH	7.7		
Upper Bulkley	1	13-Jan-99	RB	18.3		
Upper Bulkley	1	13-Jan-99	RB	15.3		
Upper Bulkley	1	08-Feb-99	CO	6.5		
Upper Bulkley	1	08-Feb-99	RB	13		
Upper Bulkley	1	08-Feb-99	RB	12.1		
Upper Bulkley	2	09-Nov-98	CO	3.1		
Upper Bulkley	2	09-Nov-98	CO	3		
Upper Bulkley	2	09-Nov-98	CO	8.6		
Upper Bulkley	2	09-Nov-98	RB	17.6		
Upper Bulkley	2	09-Nov-98	RB	15		
Upper Bulkley	2	09-Nov-98	RB	7.5		
Upper Bulkley	2	09-Nov-98	RB	14.3		
Upper Bulkley	2	09-Nov-98	RB	12.5		
Upper Bulkley	2	09-Nov-98	RB	18.2		
Upper Bulkley	2	09-Nov-98	RB	15.2		
Upper Bulkley	2	09-Nov-98	RB	17.5		
Upper Bulkley	2	09-Nov-98	RB	11.2		
Upper Bulkley	2	09-Nov-98	RB	9.2		
Upper Bulkley	2	09-Nov-98	RB	11.3		
Upper Bulkley	2	09-Nov-98	RB	20.7		
Upper Bulkley	2	09-Nov-98	RB	6.7		
Upper Bulkley	2	09-Nov-98	RB	23.7		
Upper Bulkley	2	09-Nov-98	RB	22.4		
Upper Bulkley	2	09-Nov-98	RB	23		
Upper Bulkley	2	09-Nov-98	RB	2		
Upper Bulkley	2	09-Nov-98	RB	5.5		
Upper Bulkley	2	09-Nov-98	RB	7		
Upper Bulkley	2	09-Nov-98	RB	8.2		
Upper Bulkley	2	09-Nov-98	RB	9.6		
Upper Bulkley	2	09-Nov-98	RB	10.7		
Upper Bulkley	2	13-Dec-98	RB	6		
Upper Bulkley	2	13-Dec-98	RB	7.7		
Upper Bulkley	2	13-Dec-98	RB	6.7		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Upper Bulkley	2	13-Dec-98	RB	7		
Upper Bulkley	2	13-Dec-98	RB	17.4		
Upper Bulkley	2	13-Dec-98	RB	6.6		
Upper Bulkley	2	13-Dec-98	RB	8.1		
Upper Bulkley	2	13-Dec-98	RB	10.2		
Upper Bulkley	2	13-Dec-98	RB	1.8		
Upper Bulkley	2	13-Dec-98	RB	6.5		
Upper Bulkley	2	13-Dec-98	RB	2.6		
Upper Bulkley	2	13-Dec-98	RB	2.1		
Upper Bulkley	2	13-Dec-98	RB	3.1		
Upper Bulkley	2	13-Dec-98	RB	9.2		
Upper Bulkley	2	14-Apr-99	BB	1.6		
Upper Bulkley	2	14-Apr-99	RB	25.1		
Upper Bulkley	3	15-Nov-98	CO	4		
Upper Bulkley	3	15-Nov-98	RB	6.9		
Upper Bulkley	3	15-Nov-98	RB	7.2		
Upper Bulkley	3	15-Nov-98	RB	3.6		
Upper Bulkley	3	15-Nov-98	RB	3		
Upper Bulkley	3	15-Nov-98	RB	3		
Upper Bulkley	3	15-Nov-98	RB	7.7		
Upper Bulkley	3	15-Nov-98	RB	13.3		
Upper Bulkley	3	15-Nov-98	RB	2.7		
Upper Bulkley	3	15-Nov-98	RB	1.6		
Upper Bulkley	3	15-Nov-98	RB	1.6		
Upper Bulkley	3	15-Nov-98	RB	5.3		
Upper Bulkley	3	15-Nov-98	RB	1.5		
Upper Bulkley	3	15-Nov-98	RB	7.8		
Upper Bulkley	3	15-Nov-98	RB	2.4		
Upper Bulkley	3	15-Nov-98	RB	2.4		
Upper Bulkley	3	15-Nov-98	RB	12.1		
Upper Bulkley	3	15-Nov-98	RB	1.7		
Upper Bulkley	3	15-Nov-98	RB	10.4		
Upper Bulkley	3	15-Nov-98	RB	7		
Upper Bulkley	3	15-Nov-98	RB	4		
Upper Bulkley	3	15-Nov-98	RB	1.6		
Upper Bulkley	3	15-Nov-98	RB	3.4		
Upper Bulkley	3	15-Nov-98	RB	0.8		
Upper Bulkley	3	15-Nov-98	RB	1		
Upper Bulkley	3	15-Nov-98	RB	3.2		
Upper Bulkley	3	15-Nov-98	RB	1.1		
Upper Bulkley	4	17-Nov-98	CH	4.3		
Upper Bulkley	4	17-Nov-98	CH	4.5		
Upper Bulkley	4	17-Nov-98	CH	7.2		
Upper Bulkley	4	17-Nov-98	CH	5.3		
Upper Bulkley	4	17-Nov-98	CH	3.9		
Upper Bulkley	4	17-Nov-98	CH	3		
Upper Bulkley	4	17-Nov-98	CO	4.6		
Upper Bulkley	4	17-Nov-98	RB	12.6		
Upper Bulkley	4	17-Nov-98	RB	19.4		
Upper Bulkley	4	17-Nov-98	RB	13.2		
Upper Bulkley	4	17-Nov-98	RB	20.5		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Upper Bulkley	4	17-Nov-98	RB	20		
Upper Bulkley	4	17-Nov-98	RB	24.5		
Upper Bulkley	4	17-Nov-98	RB	28		
Upper Bulkley	4	17-Nov-98	RB	17.3		
Upper Bulkley	4	17-Nov-98	RB	26.2		
Upper Bulkley	4	17-Nov-98	RB	15.4		
Upper Bulkley	4	17-Nov-98	RB	18.2		
Upper Bulkley	4	17-Nov-98	RB	18.4		
Upper Bulkley	5	13-Nov-98	CO	12.7		
Upper Bulkley	5	13-Nov-98	CO	4.5		
Upper Bulkley	5	13-Nov-98	CO	4.9		
Upper Bulkley	5	13-Nov-98	CO	3.2		
Upper Bulkley	5	13-Nov-98	CO	4		
Upper Bulkley	5	13-Nov-98	CO	3.6		
Upper Bulkley	5	13-Nov-98	CO	3.8		
Upper Bulkley	5	13-Nov-98	RB	17.1		
Upper Bulkley	5	13-Nov-98	RB	22.3		
Upper Bulkley	5	13-Nov-98	RB	13.1		
Upper Bulkley	5	15-Dec-98	RB	20.8		
Upper Bulkley	5	15-Dec-98	RB	14.2		
Upper Bulkley	5	15-Dec-98	RB	15.3		
Upper Bulkley	5	15-Dec-98	RB	11.1		
Upper Bulkley	5	16-Apr-99	RB	20.6	120	0.119213
Upper Bulkley	5	16-Apr-99	RB	52.8	163	0.121919
Upper Bulkley	6	17-Nov-98	CO	3.4		
Upper Bulkley	6	17-Nov-98	CO	4.7		
Upper Bulkley	6	17-Nov-98	RB	20		
Upper Bulkley	6	17-Nov-98	RB	28.4		
Upper Bulkley	6	17-Nov-98	RB	7.7		
Upper Bulkley	6	17-Nov-98	RB	13.8		
Upper Bulkley	6	15-Dec-98	CH	5.5		
Upper Bulkley	6	15-Dec-98	CO	3		
Upper Bulkley	6	15-Dec-98	RB	6.1		
Upper Bulkley	6	15-Dec-98	RB	3.1		
Upper Bulkley	6	15-Dec-98	RB	7.4		
Upper Bulkley	6	15-Dec-98	RB	5.4		
Upper Bulkley	6	15-Dec-98	RB	8.2		
Upper Bulkley	6	15-Dec-98	RB	13.6		
Upper Bulkley	6	15-Dec-98	RB	7.2		
Upper Bulkley	6	15-Dec-98	RB	14.5		
Upper Bulkley	6	15-Dec-98	RB	9.3		
Upper Bulkley	6	15-Dec-98	RB	6.5		
Upper Bulkley	6	15-Apr-99	CH	2.9	168	0.006116
Upper Bulkley	6	15-Apr-99	RB	8.1	90	0.111111
Upper Bulkley	6	15-Apr-99	RB	22.9	131	0.101864
Upper Bulkley	6	15-Apr-99	RB	20.1	125	0.102912
Upper Bulkley	6	15-Apr-99	RB	18.3	118	0.111379
Upper Bulkley	6	15-Apr-99	RB	13	111	0.095055
Upper Bulkley	6	15-Apr-99	RB	11.1	104	0.098679
Upper Bulkley	6	15-Apr-99	RB	5.1	67	0.169569
Upper Bulkley	6	15-Apr-99	RB	4.5	52	0.320039

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Upper Bulkley	7	13-Nov-98	CO	5.2		
Upper Bulkley	7	13-Nov-98	RB	4.5		
Upper Bulkley	7	15-Dec-98	CH	2.5		
Upper Bulkley	7	15-Dec-98	CO	4		
Upper Bulkley	8	17-Nov-98	CO	8.5		
Upper Bulkley	8	17-Nov-98	CO	8.8		
Upper Bulkley	8	17-Nov-98	CO	3.8		
Upper Bulkley	8	17-Nov-98	CO	5		
Upper Bulkley	8	17-Nov-98	CO	4.1		
Upper Bulkley	8	17-Nov-98	CO	3.9		
Upper Bulkley	8	17-Nov-98	CO	4.1		
Upper Bulkley	8	17-Nov-98	CO	5.5		
Upper Bulkley	8	17-Nov-98	CO	6.2		
Upper Bulkley	8	17-Nov-98	CO	6.1		
Upper Bulkley	8	17-Nov-98	CO	3.7		
Upper Bulkley	8	17-Nov-98	CO	12.7		
Upper Bulkley	8	17-Nov-98	CO	6		
Upper Bulkley	8	17-Nov-98	CO	4.3		
Upper Bulkley	8	17-Nov-98	CO	6.6		
Upper Bulkley	8	17-Nov-98	CO	6		
Upper Bulkley	8	17-Nov-98	CO	3.5		
Upper Bulkley	8	17-Nov-98	CO	2.5		
Upper Bulkley	8	17-Nov-98	CO	2.9		
Upper Bulkley	8	17-Nov-98	CO	4.5		
Upper Bulkley	8	17-Nov-98	CO	2.6		
Upper Bulkley	8	17-Nov-98	CO	2.2		
Upper Bulkley	8	17-Nov-98	CO	2.2		
Upper Bulkley	8	17-Nov-98	CO	4.5		
Upper Bulkley	8	17-Nov-98	CO	2.2		
Upper Bulkley	8	17-Nov-98	CO	4.5		
Upper Bulkley	8	17-Nov-98	CO	2.2		
Upper Bulkley	8	17-Nov-98	CO	3.7		
Upper Bulkley	8	15-Dec-98	CH	2.9		
Upper Bulkley	8	15-Dec-98	CH	2.1		
Upper Bulkley	8	15-Dec-98	CH	3.3		
Upper Bulkley	8	15-Dec-98	CO	2.9		
Upper Bulkley	8	15-Dec-98	CO	3.8		
Upper Bulkley	8	15-Dec-98	CO	2.3		
Upper Bulkley	8	15-Dec-98	CO	3.4		
Upper Bulkley	8	15-Dec-98	CO	2.8		
Upper Bulkley	8	15-Dec-98	CO	3		
Upper Bulkley	8	15-Dec-98	CO	2.4		
Upper Bulkley	8	15-Dec-98	CO	2		
Upper Bulkley	8	15-Dec-98	CO	2.8		
Upper Bulkley	8	15-Dec-98	CO	7.9		
Upper Bulkley	8	15-Dec-98	CO	3		
Upper Bulkley	8	15-Dec-98	CO	3		
Upper Bulkley	8	15-Dec-98	CO	2.1		
Upper Bulkley	8	15-Dec-98	CO	8		
Upper Bulkley	8	15-Dec-98	CO	3.6		
Upper Bulkley	8	15-Dec-98	CO	2.1		

Creek	Site	Date	SPECIES	Weight (g)	Length (mm)	K
Upper Bulkley	8	15-Dec-98	CO	5		
Upper Bulkley	8	15-Dec-98	CO	2.5		
Upper Bulkley	8	15-Dec-98	CO	2.6		
Upper Bulkley	8	15-Dec-98	CO	4.1		
Upper Bulkley	8	15-Dec-98	CO	4		
Upper Bulkley	8	15-Dec-98	CO	3.1		
Upper Bulkley	8	15-Dec-98	CO	2.2		
Upper Bulkley	8	15-Dec-98	CO	3.4		
Upper Bulkley	8	15-Dec-98	CO	2		
Upper Bulkley	8	15-Dec-98	CO	3.3		
Upper Bulkley	8	15-Apr-99	CH	7.3	75	0.173037
Upper Bulkley	8	15-Apr-99	CH	7.5	69	0.228304
Upper Bulkley	8	15-Apr-99	CH	4.3	74	0.106114
Upper Bulkley	8	15-Apr-99	CH	3.9	78	0.082183
Upper Bulkley	8	15-Apr-99	CH	8.8	90	0.120713
Upper Bulkley	8	15-Apr-99	CH	2.8	65	0.101957
Upper Bulkley	8	15-Apr-99	CO	13.4	105	0.115754
Upper Bulkley	8	15-Apr-99	RB	17.8	141	0.063498
Upper Bulkley	8	15-Apr-99	RB	9.7	94	0.116785

Appendix 3. Adjusted Petersen estimate and confidence intervals for sites sampled during the Bulkley River Overwintering Habitat Study (Nov. 98 – April 1999).

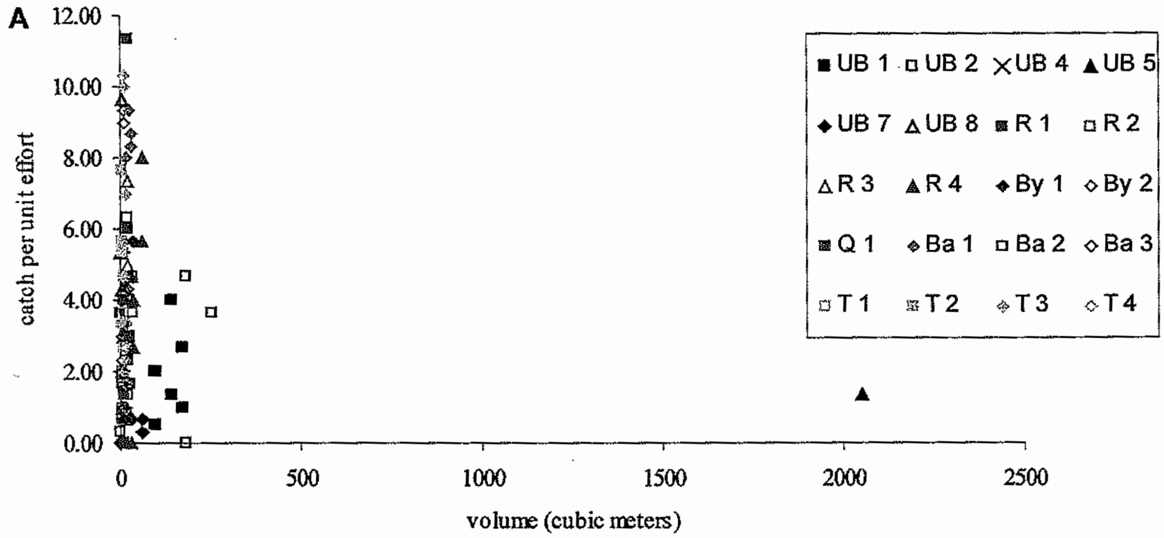
Date	Location	Mark #1 N	Mark #2 N	Mark #1 lower CI for N	Mark #1 upper CI for N	Mark #2 lower CI for N	Mark #2 upper CI for N
15-Nov-98	Barren 1	97.20		43.39	243.00		
12-Dec-98	Barren 1	66.86		33.19	146.25		
07-Jan-99	Barren 1	52.20		28.84	104.40		
05-Feb-99	Barren 1	37.50		21.74	70.31		
09-Mar-99	Barren 1		54.00			25.51	41.54
15-Apr-99	Barren 1		51.00			24.09	41.54
17-Nov-98	Barren 2	69.00		32.60	159.23		
15-Dec-98	Barren 2	147.60		65.89	369.00		
13-Jan-99	Barren 2	82.29		40.85	180.00		
05-Feb-99	Barren 2	126.00		59.53	290.77		
11-Mar-99	Barren 2(lv)	126.00		56.25	315.00		
15-Mar-99	Barren 2 (lv)		81.67			43.75	71.59
15-Apr-99	Barren 2 (lv)		118.13			61.36	73.68
17-Nov-98	Barren 3	51.00		18.66	127.50		
15-Dec-98	Barren 3	59.50		18.03	108.18		
13-Jan-99	Barren 3	68.00		14.47	68.00		
05-Feb-99	Barren 3	56.67		20.73	141.67		
11-Mar-99	Barren 3	68.00		20.61	123.64		
15-Mar-99	Barren 3 (lv)		12.00			3.64	14.55
15-Apr-99	Barren 3 (lv)		29.33			10.73	20.00
15-Nov-98	Byman 1	15.00		3.19	15.00		
12-Dec-98	Byman 1	54.00		11.49	54.00		
13-Jan-99	Byman 1	45.00		9.57	45.00		
05-Feb-99	Byman 1	24.00		5.11	24.00		
09-Mar-99	Byman 1	51.00		10.85	51.00		
15-Apr-99	Byman 1	9.00		1.91	9.00		
15-Nov-98	Byman 2	56.00		20.49	140.00		
12-Dec-98	Byman 2	135.33		49.51	338.33		
13-Jan-99	Byman 2	130.67		47.80	326.67		
05-Feb-99	Byman 2	90.00		27.27	163.64		
09-Mar-99	Byman 2	78.00		23.64	141.82		
15-Apr-99	Byman 2	84.00		17.87	84.00		
09-Nov-98	McQuarrie 1						
15-Nov-98	McQuarrie 1	65.00		29.02	162.50		

Date	Location	Mark #1 N	Mark #2 N	Mark #1 lower CI for N	Mark #1 upper CI for N	Mark #2 lower CI for N	Mark #2 upper CI for N
12-Dec-98	McQuarrie 1	113.75		46.43	284.38		
07-Jan-99	McQuarrie 1	52.00		15.76	94.55		
05-Feb-99	McQuarrie 1	97.50		29.55	177.27		
11-Mar-99	McQuarrie 1	43.33		15.85	108.33		
16-Mar-99	McQuarrie 1		20.00			7.32	25.00
15-Apr-99	McQuarrie 1	43.33	33.33	15.85	108.33	12.20	25.00
15-Nov-98	Rich 1	25.00		5.32	25.00		
12-Dec-98	Rich 1	32.50		9.85	59.09		
13-Jan-99	Rich 1	30.00		9.09	54.55		
05-Feb-99	Rich 1	32.50		9.85	59.09		
09-Mar-99	Rich 1	55.00		11.70	55.00		
14-Mar-99	Rich 1		17.88			9.29	23.16
14-Apr-99	Rich 1		12.83			6.06	25.38
14-Nov-98	Rich 2	60.00		21.95	150.00		
12-Dec-98	Rich 2	48.00		17.56	120.00		
13-Jan-99	Rich 2	24.00		5.11	24.00		
05-Feb-99	Rich 2	120.00		25.53	120.00		
09-Mar-99	Rich 2	120.00		36.36	218.18		
14-Mar-99	Rich 2		100.00			21.28	20.00
14-Apr-99	Rich 2		80.00			17.02	20.00
09-Nov-98	Rich 3						
15-Nov-98	Rich 3	54.40		24.29	136.00		
12-Dec-98	Rich 3	130.33		47.68	325.83		
07-Jan-99	Rich 3	170.00		36.17	170.00		
05-Feb-99	Rich 3	68.00		14.47	68.00		
11-Mar-99	Rich 3	119.00		36.06	216.36		
16-Mar-99	Rich 3		42.00			8.94	14.00
14-Apr-99	Rich 3		60.67			22.20	35.00
15-Nov-98	Rich 4	66.67		24.39	166.67		
12-Dec-98	Rich 4	48.00		17.56	120.00		
05-Feb-99	Rich 4	60.00		18.18	109.09		
11-Mar-99	Rich 4	34.67		12.68	86.67		
16-Mar-99	Rich 4		29.25			11.94	32.50
14-Apr-99	Rich 4		19.50			7.96	32.50
20-Jan-99	Toboggan 1	68.00		32.13	156.92		

		Mark #1	Mark #2	Mark #1	Mark #1	Mark #2	Mark #2
Date	Location	N	N	lower CI for N	upper CI for N	lower CI for N	upper CI for N
11-Feb-99	Toboggan 1	90.00		36.73	225.00		
25-Mar-99	Toboggan 1	84.00		34.29	210.00		
30-Mar-99	Toboggan 1		46.67			17.07	35.00
22-Apr-99	Toboggan 1		91.00			27.58	25.45
20-Jan-99	Toboggan 2	46.80		20.89	117.00		
11-Feb-99	Toboggan 2	62.40		27.86	156.00		
25-Mar-99	Toboggan 2	35.75		14.59	89.38		
30-Mar-99	Toboggan 2		66.00			24.15	27.50
20-Jan-99	Toboggan 3	306.00		92.73	556.36		
11-Feb-99	Toboggan 3	272.00		99.51	680.00		
25-Mar-99	Toboggan 3	238.00		106.25	595.00		
30-Mar-99	Toboggan 3		217.00			96.88	87.50
22-Apr-99	Toboggan 3		157.50			64.29	87.50
20-Jan-99	Toboggan 4	88.00		18.72	88.00		
11-Feb-99	Toboggan 4	72.00		15.32	72.00		
25-Mar-99	Toboggan 4	32.00		6.81	32.00		
30-Mar-99	Toboggan 4		28.00			5.96	4.00
22-Apr-99	Toboggan 4		14.00			4.24	7.27
15-Nov-98	UBR#1	9.00		9.00	9.00		
13-Dec-98	UBR#1	21.00		4.47	21.00		
13-Jan-99	UBR#1	11.25		45.00	45.00		
08-Feb-99	UBR#1	117.00		24.89	117.00		
09-Mar-99	UBR#1	27.00		9.88	67.50		
14-Mar-99	UBR#1		18.00			5.45	16.36
15-Nov-98	UBR#2	90.00		27.27	163.64		
12-Dec-98	UBR#2	90.00		27.27	163.64		
14-Apr-99	UBR #2	36.00		7.66	36.00		
17-Nov-98	UBR#4	52.00		15.76	94.55		
17-Nov-98	UBR #5	35.00		7.45	35.00		
12-Dec-98	UBR#5	17.50		5.30	31.82		
15-Apr-99	UBR #5	21.00		4.47	21.00		
17-Nov-98	UBR #7	4.00		0.85	4.00		
12-Dec-98	UBR #7	6.00		1.28	6.00		
17-Nov-98	UBR #8	238.00		50.64	238.00		
12-Dec-98	UBR #8	510.00		108.51	510.00		

Date	Location	Mark #1 N	Mark #2 N	Mark #1 lower CI for N	Mark #1 upper CI for N	Mark #2 lower CI for N	Mark #2 upper CI for N
07-Jan-99	UBR #8	51.00		10.85	51.00		
08-Feb-99	UBR #8	34.00		10.30	61.82		
16-Mar-99	UBR #8	59.50		18.03	108.18		
15-Apr-99	UBR #8	85.00		25.76	154.55		

Appendix 4. Additional Figures



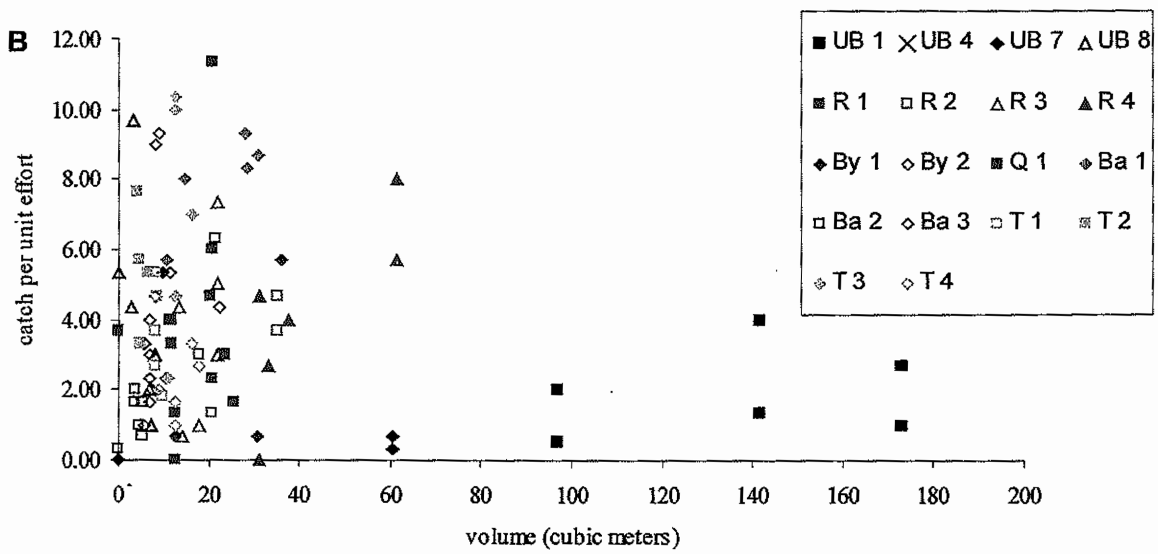


Figure 1. Catch per unit effort versus volume of site for sites sampled in the upper Bulkley watershed, and at Toboggan Creek. Graph A illustrates all sites, while graph B illustrates the sites with surface areas below 500 square meters.

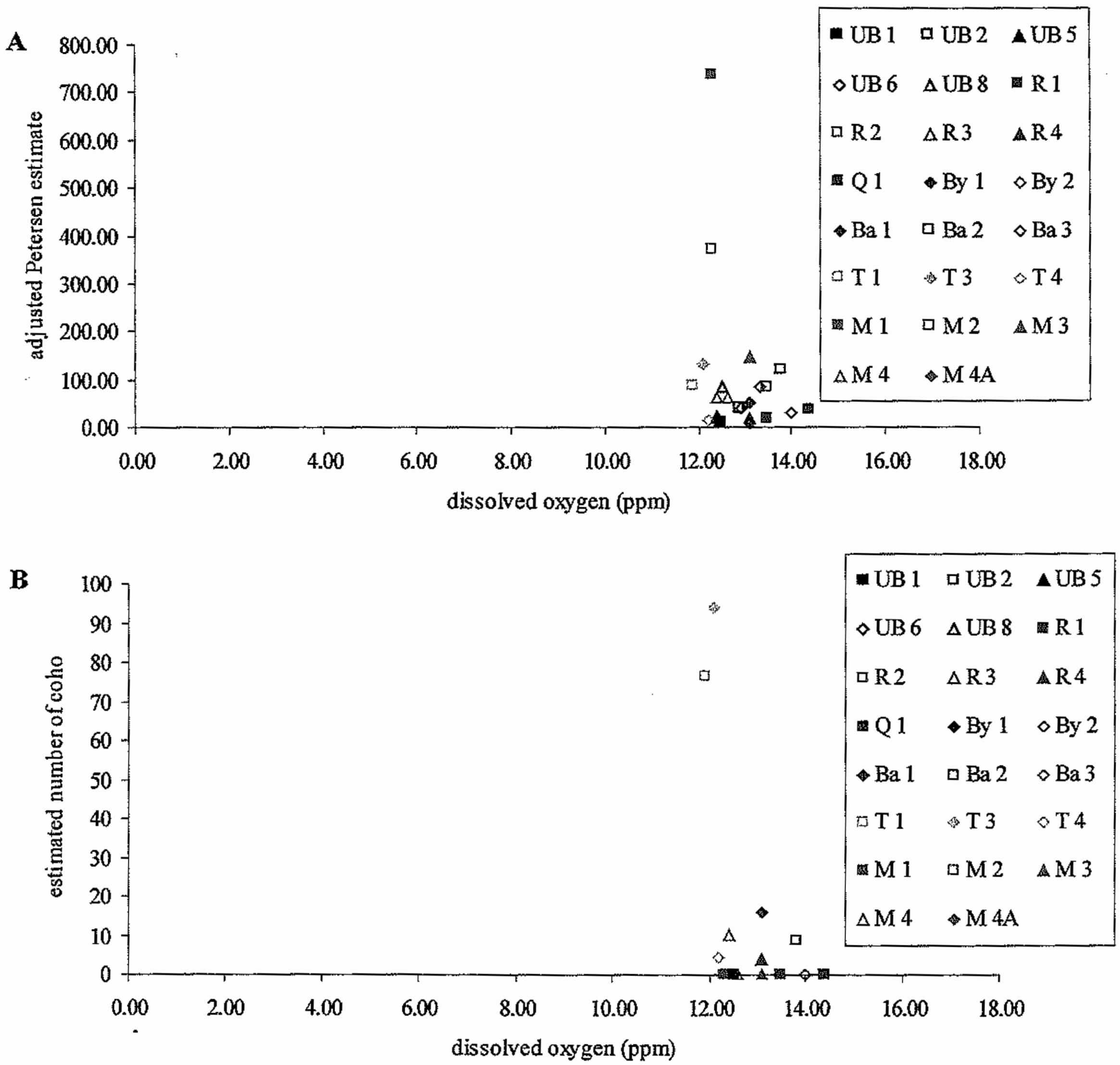


Figure 2. **Adjusted Petersen estimate (A) and estimated number of coho (B) versus dissolved oxygen for sites sampled in the upper Bulkley watershed, and at Mission and Toboggan creeks.**

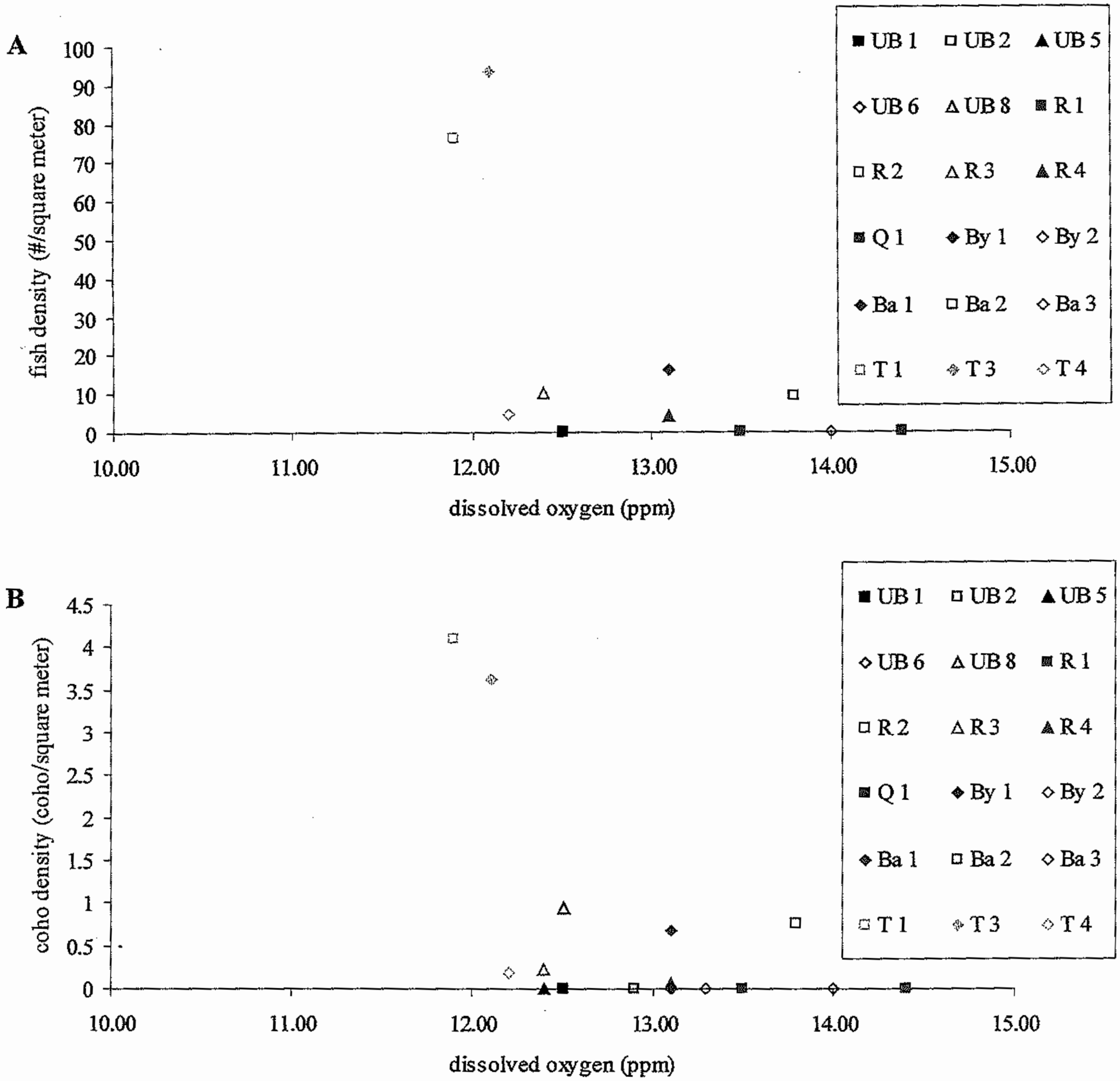
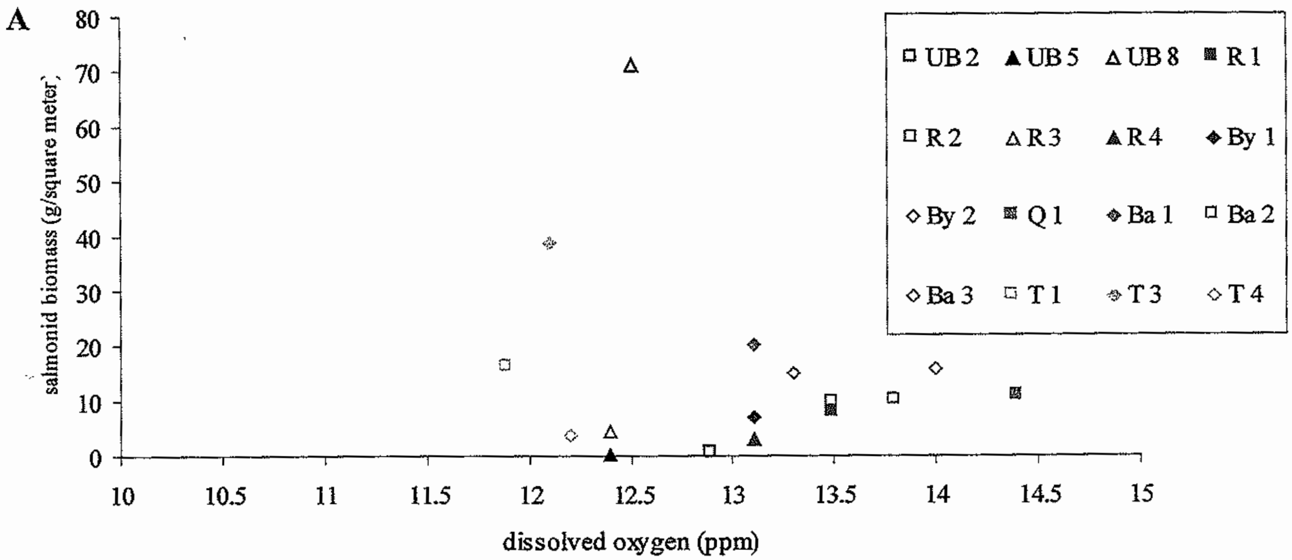


Figure 3. Fish density (A) and coho density (B) versus dissolved oxygen for sites sampled in the upper Bulkley watershed, and at Toboggan Creek.



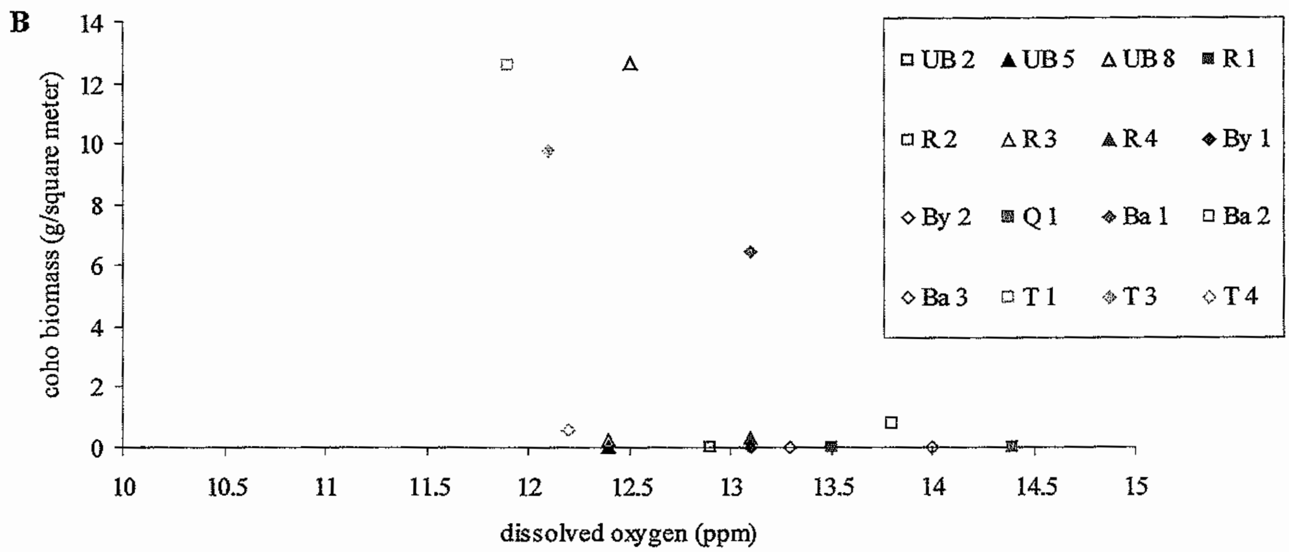


Figure 4. Salmonid biomass (A) and coho biomass (B) versus dissolved oxygen for sites sampled in the upper Bulkley watershed, and at Toboggan Creek.

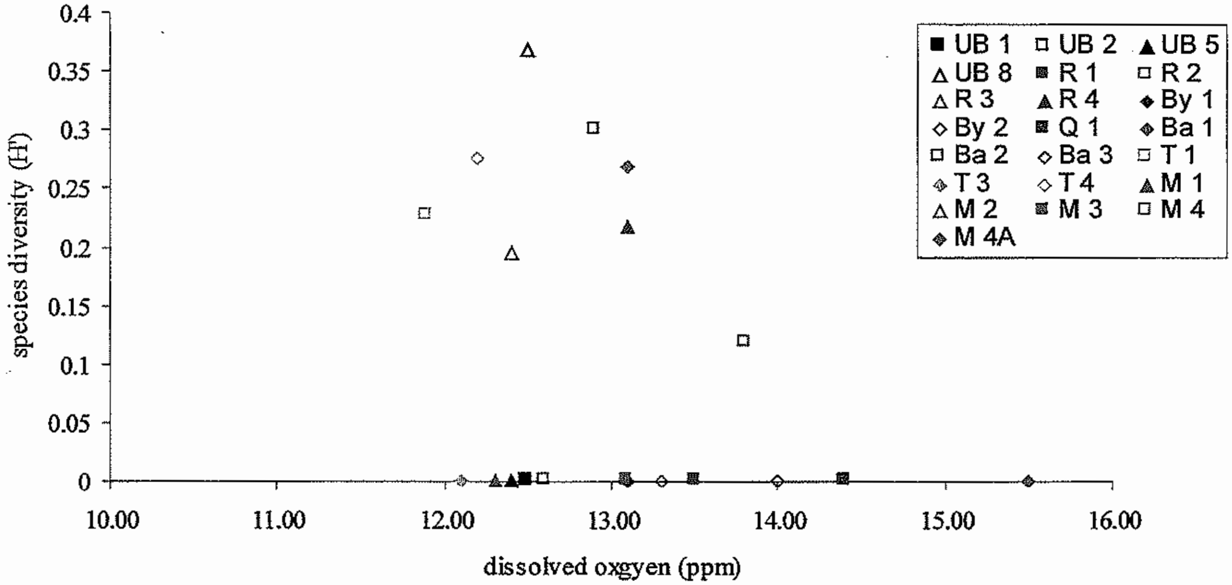


Figure 5. Species diversity (H') versus dissolved oxygen for sites sampled in the upper Bulkley watershed, and at Toboggan Creek.

Appendix 5. Notes for Upper Bulkley Overwintering Study Planning Meeting, July 12, 1999

Upper Bulkley Overwintering Study
Planning Meeting for the 1999/2000 field season
Notes

Date:	July 12, 1999
Location:	Department of Fisheries and Oceans, Smithers, B.C.
Present:	Brenda Donas (Community Advisor, Department of Fisheries & Oceans)
	Scott McKay (Fisheries Coordinator, Nadina Community Futures)
	Regina Saimoto (Fisheries Biologist, SKR Consultants Ltd., Smithers)
	Ron Saimoto (Fisheries Biologist, SKR Consultants Ltd., Smithers)

Potential Major Goals of the Upper Bulkley Overwintering Study:

1. Is overwintering habitat limiting in the upper Bulkley?
   - What are the species of main concern? Coho?

     Main species of concern is coho, but there is interest in other species as well.
   - Do we want to take a multispecies approach to management, or manage for a single species?

     A multispecies approach to management is preferred. Data will be collected for all species, but budget constraints may require that data for coho be analysed only, with the goal of analysing data for other species, as funds become available. The final report to be produced at the completion of the study in the spring of 2000 will focus on coho.
   - What information do we need to know before we can answer this questions?

     We need to know what makes good overwintering habitat, how much overwintering habitat is present in the watershed that is accessible to coho. Using data collected in the study, it may be feasible to construct a habitat suitability model (HSI model)

2. What is the fish movement pattern over the winter?
   - Why do fish move?
   - How far do they move?
   - When do they move?
   - How do movement patterns differ by species?

3. How does habitat quality change during the winter?
   - What parameters are important to monitor?
   - How frequently should we be monitoring them?
   - How should parameters be measured?

4. Can we estimate survival?
   - Estimating survival for closed sites
   - Estimating survival for open sites

How can the methods used in 1998/1999 be improved to try and address these questions?

CONSTRAINTS:
Budget constraints will impact sampling intensity
Vulnerability of coho stock will require cautious sampling, and careful planning of sampling to yield maximum data in order to justify jeopardizing survival of some fish.

SUGGESTIONS:
It is unlikely that we can answer all the major questions listed above during next years study. Can we prioritize these questions?

Suggested Methods for Discussion

Indicators of Overwintering Habitat Quality

1. Fish Capture Techniques
   - Minnow trapping is good fish capture technique that should be used in winter.
   - Trapping intensity should be adjusted to the size of the habitat. E.g. set three minnow traps per hole / 10 m^2 habitat. Avoid setting traps in water more than 2 meters deep. Set traps on substrate (do not suspend). Ensure that entire trap, or at least both entrances to trap are submerged.
   - Trap at least once per month, at regular intervals (e.g. middle of each month). If staff is unable to trap at one month, try coordinating with other projects to have them trap your sites.
   - Minnow traps may be size selective. Set two different types of trap, one that will trap only smaller fish (e.g. smaller entrances), one that will select larger fish (e.g. larger entrance) and one standards GEE trap. Record fish captured in the different trap types separately to allow for an evaluation of size selectivity.
   - Set traps for a consistent time, or carefully record soak time for each trap.
   - Conduct triple pass minnow trapping (use stop nets to close the site, and place captured fish in a live box) in late fall to estimate population present at the site in the fall. Also include marginal areas around the study site, since fish from marginal areas are likely to migrate to the pool for winter. Alternatively, conduct triple pass electroshocking for the pool and/or marginal area. This may allow for comparisons of population size using two different methods, and can give an indication of how many fish to mark for mark-recapture estimates (see below).

2. Fish Handling Techniques
   - Avoid exposing fish to air as much as possible. Traps should be emptied in the water, fish should be kept in water as much as possible. Fin clipping can be conducted in water. Fish can be weighed and measured while submerged. Especially for tagged fish, handling and exposure to air should be minimized.
   - Try to sample on the warmest day within 1 week of your sampling time (e.g. middle of month ± 3 days).

- If handling is prolonged, try sampling fish in sheltered area, when near a road (e.g. process fish in truck).

3. Fish Sampling
   - Record length (to nearest mm) and weight (to nearest 0.1 g) and notes on fish condition for all fish, or at least 30 fish of every species, selected randomly.
   - Record tags applied by species, and recaptures by species.
   - Carefully confirm species identification. Count branchiostegal rays, if possible.

4. Marking / Recaptures
   - Mark fish using unique batch marks for each site. Do not mark during triple pass estimates in fall since populations are still open, and fish are likely to move considerable distances. Initial marking should be in December when water temperatures are low, and ice is forming on pools.
   - Predetermine which marks to use where.
   - Decide on using the Jolly-Seber or the adjusted Petersen method prior to initiating sampling.
   - Upon recapture, record the recaptures by species.
   - If a second population estimate is to be conducted, do so prior to break up. Also, keep recording recaptures from the initial method separately
   - Mark a greater proportion of the population (e.g. 20% of each species (Bagenal 1978)). Triple pass depletion estimates of selected study sites and surrounding areas in late fall may give a vague indication as to the population size at the pool. It is important to keep in mind that overwintering fish may form dense aggregations, and that population estimates in late fall will likely underestimate the number of fish overwintering at a site. Marking until a predetermined percent of the capture sample is marked can also be used to indicate when a sufficient proportion of fish has been tagged.
   - Optimally, recapture until a predetermined number of recaptures have been obtained (e.g. Ricker 1975), or until a predetermined number of fish of each species have been examined for marks (e.g. Bagenal 1978). However, given budget, time, and environmental constraints (e.g. weather), do the best possible.
   - Attempt to document which assumptions of the mark-recapture experiment are violated (e.g. migration, selective mortality or behaviour). Applying unique marks for each site may help in determining migration, and migration patterns (e.g. distance of movement, time of movement, movement selective to species).

5. Catch per unit effort
   - Record catch per unit effort by species. Record number of traps and soak time. If more intense trapping is required to obtain a predetermined number of recaptures, only use initial captures for catch per unit effort.

Factors determining overwintering habitat quality

Prior to freeze up, identify sites to be sampled, and sample throughout winter, even if no fish are captured. Lack of fish is useful data.
Mark each sample station carefully and consistently to ensure that the same sites will be sampled.

A. Measurements that can be taken prior to freeze up (coincide with Leslie Depletion estimate in fall):

1. Size of overwintering habitat
   - Compile a detailed sketch of each pool, and indicate depth contours, if possible
   - Record depth at a predetermined location throughout the winter. From this one depth measurement, maximum and mean depth for each site can be extrapolated.
   - Volume and surface area can be estimated more accurately with more accurate measurements of the dimensions of the pool.
   - Consider using weighted useable area (e.g. area of pool with depth > 10 cm).

2. Other physical measurements
   - Gradient of site and reach should be taken prior to freeze up.
   - Record pool:riffle ratio for reach
   - Collect data on substrate composition (by percent) and D, D_{90}
   - Document siltation on substrate, and, if necessary or possible, quantify this.
   - Collect data on percent cover available to fish, and describe the proportion of cover contributed by LWD, cutbanks, instream veg etc. The cover can be marked on the detailed sketches produced for each site. It may be beneficial to have the same person estimate cover at all sites.
   - Document fish access to the site
   - Carefully map the site locations, and describe why these sites where chosen (e.g. what is unique/noteworthy at each site).
   - Measure the riffle crest, and residual pool depth (see above). Recording riffle crest may aid in determining if sites are likely to be open or closed.
   - Consider conducting flow measurements prior to freeze up, and determine the affect of cover (e.g. root wads, LWD, cutbanks) on flow dynamics.
   - Record proximity to beaver dams and/or lakes

B. Measures to be taken during the winter

3. Physical measurements
   - Water depth must be recorded at a predetermine site during every sampling date.
   - Consider recording flow under the ice to document if flow regimes change with ice cover (consult Scott McKay in this regard)
   - Record which traps are set around LWD, and record their capture separately.
   - Record percent ice cover. Record ice thickness when ice formation is at its maximum.
   - Record duration of ice cover.
   - Record factors that may influence ice cover at each site (e.g. shade)

- Check the pool outlet and inlet for flow under the ice. This will aid in documenting fish movement. Also record flow over the ice during winter thaw periods.
- Document food presence, if possible. This may be difficult to do under the ice, but insect traps could be set in place while minnow trapping. Potential methods need to be researched. Depending on the sampling methodology, this could allow for an estimate of food abundance. Alternatively, consider stomach content analysis of some fish (this is secondary in importance). Stomach content analysis can be costly, by may be done through PBS (Brenda will check on this).

4. Water quality measurements
    - Ensure all field meters are carefully calibrated prior to every field day.
    - Consider taking back up water quality kits, and standards to verify measurements that appear unusual.
    - Record water temperature and dissolved oxygen on a monthly basis. At the very least, oxygen should be recorded just prior to break up. Ensure oxygen is recorded first, since disturbance of the water surface will affect dissolved oxygen. Consider purchasing one or two dissolved oxygen data loggers for comparisons with monthly readings of oxygen. Consider deploying temperature data loggers, if some are available.
    - Identify groundwater sources, if possible

Sample site selection

- Identify which physical paramater(s) is likely most important in determining overwintering habitat quality. Consider using paired sample sites in the same system to allow for evaluation of the importance of these parameters (e.g. sites with and without LWD. Could do pair wise analysis).
- Select some sites at beaver dams.
- Select some sites near lakes.
- Consider doing lake sampling to document their importance for overwintering habitat quality.
- For the upper Bulkley, the following was agreed on during the July 12, 1999 meeting:
    - ♦ Mission Creek sites will be sampled, but the data will be kept separate and a separate report will be prepared when funds are available
    - ♦ Sites on Toboggan Creek will be used to establish what parameters determine overwintering habitat quality. Some sites in the upper Bulkley will also be sampled.
    - ♦ The upper Bulkley study will try to document if LWD / cover, substrate, and site isolation (i.e. closed vs. open sites) influence overwintering habitat quality. The Morice study should document if groundwater plays a role, among other criteria.
    - ♦ The upper Bulkley study will include sites as follows:

Toboggan:	Toboggan Lake sites (at best location, e.g. outlet)
	closed site with LWD (i.e. no migration)
	closed site without LWD (i.e. no migration)
	open site with LWD

open site without LWD

Upper Bulkley: mainstem site (e.g. UB 5)
mainstem site UB 8
closed site with LWD (2 sites preferred)
closed site without LWD (2 sites preferred)
open site with LWD (2 sites preferred)
open site without LWD (2 sites preferred)

Toboggan Creek sites will have complete ice cover. Mike O'Neill and/or Randy may be consulted in site selection to determine which Toboggan Creek sites are likely to remain open, and which sites are likely to be closed. All Toboggan Creek sites are to have clean substrate with a low proportion of fines.

Upper Bulkley Sites other than the mainstem sites will be selected in sections of tributaries known to be accessible to coho. Open sites may be R3 (no LWD), R4 (LWD), By1 (no LWD), By2 (LWD). Closed sites may be Ba 2 (LWD), Ba 3 (LWD), McQuarrie sites upstream of feed lot (sites with and without LWD, closed sites likely present).

Site selection will be confirmed in the fall. Closed sites may be closed off during the winter to ensure that there is no migration. Physical paramaters described above will be selected for all sites. Fish at all sites will be marked to document population size (closed sites) and migration patterns (open sites).

Site selection should allow for pair wise comparisons between closed and open sites, sites with and without LWD, sites with clean substrate (Toboggan) and silted substrate (upper Bulkley). Lake and mainstem sampling may give an indication of the importance of these habitats for coho overwintering.

Data collection and compilation

- Design detailed field forms, one for fall sampling and collection of background information, one for use during the winter.
- Train field staff in the use of field equipment, calibration of equipment, fish handling, fish id. and completion of field data forms. Train staff from the upper Bulkley and Morice overwintering studies together.
- Encourage field staff to check each others form. Work on completing the data forms as much as possible.
- Enter the data soon after field work. This will allow in identification of data gaps, which may be filled from memory. Also, cursory analysis of the data can be invaluable in identifying potential trends, and methods that work vs. methods that require modification.
- If several different people are involved in data entry, consider building a database that will ensure data are entered consistently. For example, data entered into an MsAccess database can easily be transferred to excel. The MsAccess database can be built to ensure data are complete, and entered consistently.

- Spot check data and data entry collected by field staff. Consider having a de-briefing after each months field work to discuss problem. Consider presenting interim data from the previous month to increase interest in the study by field staff. It would be useful to have members of both the upper Bulkley and the Morice overwintering studies present to discuss results, problems, and find solutions/improvements to methodologies.