Investigations of Bull Trout (Salvelinus confluentus), Steelhead Trout (Oncorhynchus mykiss), and Spring Chinook Salmon (0. tshawytscha) Interactions in Southeast Washington Streams

Final Report
1992

DOE/BP-17758-2

January 1995

This Document should be cited as follows:

Underwood, Keith, Steven Martin, Mark Schuck, Allan Scholz, ''Investigations of Bull Trout (Salvelinus confluentus), Steelhead Trout (Oncorhynchus mykiss), and Spring Chinook Salmon (0. tshawytscha) Interactions in Southeast Washington Streams'', Project No. 1990-05300, 186 electronic pages, (BPA Report DOE/BP-17758-2)

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P.O. Box 3621
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This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

INVESTIGATIONS OF BULL TROUT (*SALVELINUS CONFLUENTUS*), STEELHEAD TROUT (*ONCORHYNCHUS* MYKISS), AND SPRING CHINOOK SALMON (0. *TSHA WYTSCHA*) INTERACTIONS IN SOUTHEAST WASHINGTON STREAMS

1992 FINAL REPORT

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Project No. 90-053
Contract No. DE-B179-9 IBP17758

JANUARY 1995

ABSTRACT

The goal of this two year study was to determine if supplementation with hatchery reared steelhead trout (*Oncorhynchus mykiss*) and spring chinook salmon (0. *tshawytscha*) negatively impacted wild native bull trout (*Salvelinus confluentus*) through competitive interactions. Four streams with varying levels of supplementation activity were sampled in Southeast Washington: Mill Creek, Tucannon River, Wolf Fork and Asotin Creek. Mill Creek was not supplemented with hatchery reared fish. The Tucannon River was intensely supplemented with hatchery reared steelhead smolts, rainbow trout and spring chinook salmon smolts. Wolf Fork was indirectly supplemented with hatchery reared steelhead smolts by releasing smolts at the mouth of the stream. Asotin Creek was supplemented for three years in the mid- 1980's with hatchery reared steelhead smolts. Sampling in Asotin Creek was discontinued after the first year of study because too few bull trout were collected for analysis (n = 1). Tasks performed during this study were population density, relative abundance, microhabitat utilization, habitat availability, diet analysis, bull trout spawning ground surveys, radio telemetry of adult bull trout, and growth analysis. The data were used to identify the extent of geographic overlap among species and resources utilized by each species. This information was compared among stream populations and among species within a stream to identify changes in behavior that resulted from supplementation activities. We found that bull trout overlapped geographically with the supplemented species in each of the study streams suggesting competition among species was possible. Within a stream, bull trout and the supplemented species utilized dissimilar microhabitats and microhabitat utilization by each species was the same among streams suggesting that there was no shifts in microhabitat utilization among streams. The diet of bull trout and *O. mykiss* significantly overlapped in each of the study streams, however, food was abundant and did not appear to be a limited resource. Age at length and back-calculated lengths identified differences in growth among bull trout and steelhead populations. The stream most intensely supplemented contained bull trout with the slowest growth and the non-supplemented stream contained bull trout with the fastest growth. Conversely, the stream most intensely supplemented contain steelhead with the fastest growth and the non-supplemented stream contained steelhead with the slowest growth. Growth indicated that bull trout may have been negatively impacted from supplementation, although, other factors such as stream temperature may have contributed to the difference in growth. Condition factor among stream populations did not differ suggesting that the ability of each fish species to add weight as length increased was the same among stream populations. At current population levels, and current habitat quantity and quality, we detected no impacts to bull trout as a result of supplementation with hatchery reared steelhead trout and spring chinook salmon. Project limitations and future research recommendations are discussed.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the following students of Eastern Washington University (EWU), Department of Biology for their assistance in field data collection and laboratory analysis: Roy Morrow, Alex Schreiber, and Scott Shattuck. We thank Arthur Viola and Mike Keller of the Washington Department of Wildlife (WDW) for their participation in this project and Dr. Bruce Lang (EWU) for his insightful comments.

This project was funded by the U.S. Department of Energy, Bonneville Power Administration (BPA), Project number 90-53, Agreement number DEB-179-91BP17758, Tom Vogel served as the BPA Project Manager. The WDW and EWU provided technical support and capital equipment. Charles Peven, Chelan County P.U.D., provided technical assistance and expertise in otolith age analysis.

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GLOSSARY

hatchery fish	Fish originating from a hatchery or other artificial propagation facility (egg hatch box artificial rearing pond, net pens, etc.) (Palmisano et al. 1993).
hybrid	For the purposes of this report, one hatchery parent and one native parent regardless of artificial or natural conception.
native	Fish population indigenous to a stream prior to non-Indian settlements (Palmisano et al. 1993).
natural spawners	Fish spawning naturally regardless of their origin (hatchery or native); synonymous with wild spawning (Palmisano et al. 1993).
supplementation	The use of artificial propagation in the attempt to maintain or increase natural production while maintaining the long term fitness of the target population, and keeping the ecological and genetic impacts on non-target populations with in specified biological limits (RASP 1992).
wild fish	Fish spawning naturally in a stream, regardless of origin (Palmisano et al. 1993).

1.0 INTRODUCTION

Wild native populations of bull trout (*Salvelinus confluentus*), steelhead trout (*Oncorhynchus mykiss*) and spring chinook salmon (0. *tshawytscha*) are declining within the Columbia River Basin (Skeesick 1989; NPPC 1991). Extensive research and management plans have been implemented to facilitate steelhead trout and spring chinook salmon survival because of their social and economic importance (Collette and Harrison 1992). Bull trout, on the other hand, have historically been less significant in a social **and** economic context. Few research projects and management plans have been implemented on the behalf of bull trout (Skeesick 1989). As a result, bull trout may be declining due to the one-sided management strategy for anadromous salmonids with little or no regard for the impacts on native bull trout populations.

State and federal agencies, and private interest groups have recently recognized the short comings of the Columbia River Basin fisheries management strategies. They have also identified bull trout as a potential candidate for protection under the Endangered Species Act (ESA). The Washington Department of Wildlife (WDW) and the American Fisheries Society (AFS) have identified bull trout as a species of special concern (Williams et al. 1989). The U.S. Fish and Wildlife Service (USFWS) considered bull trout to be a Category 2 species, meaning more biological research was needed to determine bull trout's status (USDI 1989). In October of 1992, three Montana based conservation groups submitted a petition to the USFWS for listing of bull trout as a threatened or endangered species in selected streams of Washington, Oregon, Idaho, Montana and northern Nevada.

Activities contributing to the decline of Columbia River Basin salmonids include: dam construction, silviculture, agriculture, cattle grazing and other commercial/recreational activities of humans (NPPC 1991). A prominent mitigation strategy for the loss of wild steelhead trout and salmon has been supplementation with hatchery reared salmonids in the Columbia Basin (NPPC 1990a, NPPC 1990b). Palmisano et al. (1993) identified supplementation with hatchery reared salmonids as a potential cause for the decline of wild salmons and trouts in the Columbia River Basin. Wild native bull trout populations may also be declining due to supplementation with hatchery reared salmonids. The goal of this study was to determine if supplementation with hatchery reared steelhead/rainbow trout and spring chinook salmon were negatively effecting wild native bull trout populations through competitive interactions.

Numerous investigators have compared the behavior of hatchery and wild origin salmonids (Barns 1967; Chilcote et al. 1986; Dickson and MacCrimmon 1982; Johnsson and Abrahams 1991; Lachance and Magnan 1990; Reisenbichler and McIntyre 1977). They concluded that the behavior of hatchery origin fish differs from wild origin fish and in many cases the behavior of hatchery-wild hybrids were intermediate between the hatchery and wild fish's behavior. The behavior of hatchery fish differs from wild fish in that they are more aggressive and have reduced reproductive success (Reisenbichler and McIntyre 1977; Johnsson and Abrahams 1991). The difference in behavior between the hatchery and wild fish was believed to be a result of the environment in which they live. The unique selective pressures found in the hatchery compared to the wild caused changes in the behavior and survivability of the hatchery origin fish and over many generations the genetic make up of the hatchery origin fish deviates from the wild population (Waples 1991; Hershberger 1988).

Bugert et al. (1991) reported that wild naturally reproduced spring chinook salmon behave differently than hatchery origin spring chinook salmon in the Tucannon River. The adult wild fish spawn further upstream than the hatchery fish and progeny of wild spring chinook have a higher survival rate when placed in the hatchery than progeny of hatchery origin spring chinook salmon. The unique spawning behavior and reduced survivability of hatchery origin fish suggests that the hatchery origin fish have deviated from the behavioral norm of the wild fish, however, the reasons for the deviation are unknown. As a result, competitive interactions between wild native bull trout and the hatchery origin salmonids may be more intense than interactions between bull trout and the wild portion of the supplemented species. A heightened level of competitive interactions could translate into a decline of the bull trout population. Furthermore, if behavior differences between hatchery origin and wild origin fish is due to a change in the genotype, then hatchery-wild hybrids could potentially be intermediate in their level of competitive interaction with other species such as bull trout. This point is significant because if hybrids are more aggressive and hatchery-wild hybrids are being produced in the wild then the population being supplemented could become more aggressive. Hence, bull trout would experience a higher level of competitive interactions with the hybrid portion of the population which could cause a decline in the bull trout population.

Supplementation with hatchery reared fish can severely disrupt the wild fish community. The fish population density instantaneously increases when hatchery reared fish are released potentially resulting in a decreased growth and condition of wild fish. Fagerlund et al. (1981) found that juvenile coho salmon reared at high density experienced a significant decrease in weight , length and condition factor. The increased density of fish can result in an increased stress level of the wild fish population. The social hierarchy of wild fish is challenged by intruding hatchery fish (Vincent 1987; Ejike and Schreck 1980). The larger more aggressive hatchery fish win the higher ranks of the hierarchy (Ejike and Schreck 1980). As density increases, the preferred habitat is taken from the wild fish by the higher ranking hatchery fish. Food and space becomes scarce, further intensifying competitive interactions. Hatchery and wild fish migrate in search of less crowded space and ample food (Vincent 1987). Such activities create stress on the wild population and stress has been identified as a factor which limits fish growth and predisposes fish to disease (Roberts 1989; Fagerlund et al. 1981; Beacham 1993). Supplementing hatchery reared steelhead/rainbow trout and spring chinook salmon into waters containing wild native bull trout populations may result in an increased level of competition, thereby increasing the stress level of wild bull trout. Increased stress level from competitive interactions with hatchery reared salmonids may increase bull trout mortality, leading to a decline in bull trout populations.

One may argue that supplementation with steelhead and salmon smolts would not substantially increase competitive interactions. Steelhead and salmon in the smolt phase follow the downward currents of a stream and do not stay within the river system for a period long enough to dramatically effect other wild fish populations. However, hatchery reared steelhead smolts have been found to displace wild salmonids from single habitat units when planted in a river system (Pearson et al. 1992). Steelhead are known to residualize, meaning they do not leave the river for the ocean. Instead, the residualized fish remain in the river system for an additional one or more years before migrating to the ocean (Viola and Schuck 199 1; Martin et al. 1993). Residualized fish may have a substantial impact on wild bull trout populations though competitive interactions. Hatchery origin fish grow to a larger size than wild fish because of the controlled environment of the hatchery (i.e. controlled water temperature and ample food supply). Larger fish win and retain preferred habitat (Johnsson and Abrahams 1991). The hatchery fish may compete more intensely with bull trout due to their large size.

This project studied bull trout, steelhead/rainbow trout and spring chinook salmon in four southeast Washington streams: Mill Creek, Tucannon River, Wolf Fork and Asotin Creek (Figure 2.1.). Supplementation levels varied for steelhead/rainbow trout and spring chinook salmon between study streams, resulting in one reference (control) stream and three impact streams. Rainbow trout and steelhead trout were not distinguished in this study and were collectively identified as *O. mykiss*. Data collected from each stream were used to compare the population dynamics and behavior of bull trout, *O. mykiss* and spring chinook salmon to determine if the level of competition changed among study streams.

Figure 1.1 is a flow chart which outlines the protocol used to identify competitive interactions among bull trout, *O. mykiss* and spring chinook salmon. The protocol was developed to test for exploitative competition. Exploitative competition is defined as two or more species that utilize common resources in short supply resulting in negative growth rates or population reductions in at least one of the competing species (Krebs 1985).

1.1 FISHERIES MANAGEMENT HISTORY OF EACH STUDY STREAM

In 1976, Congress authorized the Lower Snake River Compensation Plan. This plan was established to mitigate for the loss of salmon in the Snake River and its tributaries caused by the construction of four federal hydro-power dams: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. The Lyons Ferry Hatchery was constructed as part of this mitigation for the loss of Tucannon River spring chinook salmon and steelhead trout, as well as Snake River fall chinook salmon, and Touchet River steelhead trout. Mitigation levels of returning adults were set at: 1,152 adult spring chinook salmon and 1,000 adult steelhead trout for the Tucannon River; 675 adult steelhead trout for the Touchet River; and, 18,300 adult fall chinook salmon for the Snake River.

In 1980, the U.S. Congress adopted the Northwest Power Act. This legislation created the Northwest Power Planning Council (NPPC) and charged it to balance the need for power with fish and wildlife. The NPPC has set an interim goal of doubling the number of salmon and steelhead returning to the Columbia River annually (Sheets 1984). After eight years of program operation, the steelhead run size in supplemented streams was greater than program goals while only limited success has been achieved with spring chinook salmon (Palmisano et al. 1993).

The following describes the management for spring chinook salmon, 0. *mykiss* and bull trout of each study stream. In 1992, angling for bull trout was prohibited in all four study streams. However before 1992, bull trout followed the same regulations as those regulating rainbow trout in these streams.

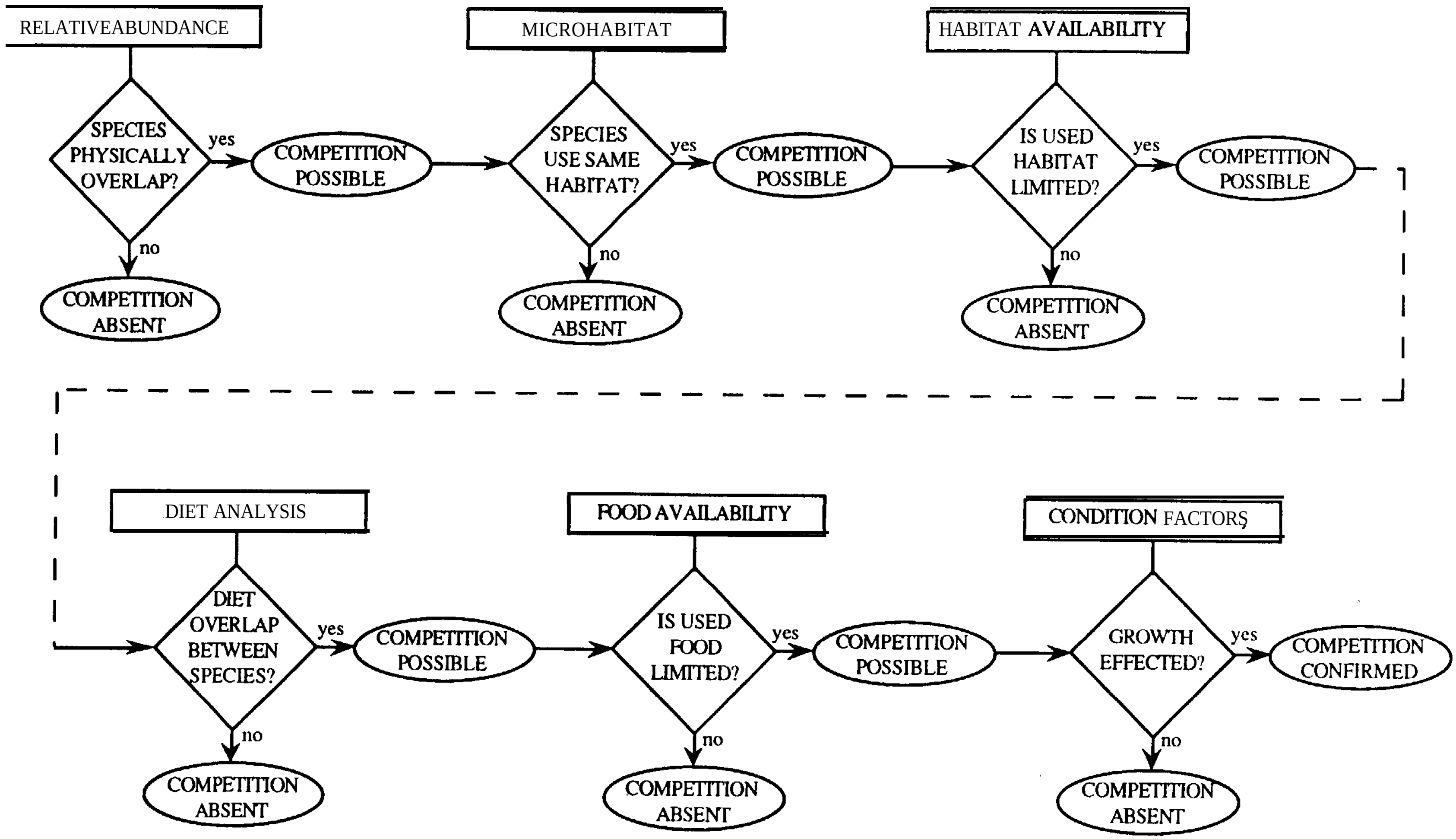

Figure 1.1. The methods used and conclusions needed to determine if wild native bull trout were negatively impacted from competitive interactions with the supplemented steelhead/rainbow trout and spring chinook salmon.

1) Mill Creek (Fig 2.1 and 2.2) is a tributary of the Walla Walla River. This stream is a municipal water source for the city of Walla Walla. The upper third of the Mill Creek watershed has been closed to public access since the early 1900's, leaving this part of the river in pristine condition. A water intake dam located at RK 22.2 blocked anadromous fish from entering the watershed until a fish ladder was installed in 1985. All fish captured in the upper third of the creek were believed to be wild fish and no reports of fish supplementation were found. Species present include bull trout, steelhead/rainbow trout (0. mykiss), whitefish *(Prosopium williamsoni)*, river lamprey (*Lampetra ayres*) and sculpin (*Cottus sp*.).

2) The Tucannon River (Figure 2.1 and 2.3) has been supplemented from 1983 to 1993 annually with 150,000 spring chinook salmon, 160,000 steelhead trout as well as 10,000-20,000 rainbow trout for a put-take fishery. Martin et al. (1993) estimated that 8.6% of the steelhead smolts released into the Tucannon River residualized in 1992. The harvest of adult steelhead trout was restricted to hatchery origin fish over 51 cm (20 inches) in length. Harvest of whitefish and rainbow trout above the confluence of the Tucannon River and the Little Tucannon River was limited to two fish over 30 cm (12 inches) in length and fishing with bait was prohibited. Harvest continued to be prohibited in all tributaries to the Tucannon River. Bull Trout harvest has been closed since 1992 and the harvest of spring chinook salmon has been closed since 1974. Species present included spring chinook salmon, bull trout, steelhead/rainbow trout, whitefish, river lamprey, sculpin, longnose dace *(Rhinichrhus cataractae)*, *speckled* dace (f?. *osculus*), redside shiner (*Richardsonius balteatus*), northern squawfish *(Ptychocheilus oregonensis),* and peamouth (*Mylocheilys caurinus)* (Bugert *et al.* 1989).

3) Wolf Fork (Figure 2.1 and 2.4) is a tributary of the Touchet River which flows into the Walla Walla River. The Touchet River has been supplemented annually from 1983- 1993 with 60,000- 120,000 hatchery steelhead smolts. Smolts were released into the Touchet River below the confluence of Wolf Fork and Touchet River (Schuck, et *al* . 1989). Viola *et* al. (1990) estimated approximately 20% (ranging from 9.9 to 32.8%) of the steelhead smolts planted into the Touchet River residualized. Some of those fish migrated into the Wolf Fork where they remain for one or more years. Also, approximately 13,000 brown trout were planted annually into the Touchet River above Waitsburg, Washington (RK 68.8) for a put-take fishery. A large percentage of the planted brown trout were harvested by sport anglers, however, some migrated into

Wolf Fork where they reared and spawned (Schuck, personal communication WDW). The Touchet River has been recognized as a potential location for reintroduction of spring chinook salmon if water flow problems were corrected (Bugert, personal communication WDF). The harvest of adult steelhead trout from the Touchet River was restricted to hatchery origin fish over 51 cm (20 inches) in length. Harvest of rainbow and brown trout in the Touchet River below the confluence with Wolf Fork was limited to 8 fish daily. Harvest of these fish in the Wolf Fork, South Fork and in the North Fork above its confluence with the Wolf Fork was limited to a daily bag limit of 2 fish over 30 cm (12 inches) in length. Harvest of bull trout has been illegal since 1992. Species present included rainbow trout, bull trout, steelhead trout, brown trout (*Salmo rrutta)*, whitefish, river lamprey, sculpin, longnose dace, bridgelip sucker *(Catostomus columbianus*), northern squawfish , and redside shiner.

4) Asotin Creek (Figure 2.1) supported a remnant population of native spring chinook salmon and a small population of wild steelhead. Asotin Creek was supplemented with 33,000 hatchery steelhead smolts annually from 1983 to 1985 (Schuck, personal communication WDW). Asotin Creek may be supplemented with spring chinook salmon in the future years. (Bugert, personal communication WDF). Harvest of adult steelhead was prohibited during this study. Anglers were able to harvest 2 rainbow trout over 30 cm (12 inches) long in the South Fork and in the North Fork above RK 19.2. Harvest of resident trout below the South Fork and RK 19.2 on the North Fork was limited to 8 trout. Species present included rainbow trout, spring chinook salmon, bull trout, steelhead trout, whitefish, river lamprey, sculpin, longnose dace, bridgelip sucker, and redside shiner

1.2 STUDY GOALS

The flow chart (Figure 1.1.) depicts the protocol used for detecting competitive interactions between bull trout, spring chinook salmon and *O. mykiss* in each of the study streams. Our hypotheses were as follows:

Ho = The supplementation of hatchery reared 0. *mykiss* and/or spring chinook salmon does not increase the occurrence of interspecific competitive interactions between wild bull trout and the supplemented fish, resulting in suppression of bull trout: populations, growth, habitat utilization, diet and condition factor.

H_1 = The supplementation of hatchery reared 0. *mykiss* and/or spring chinook salmon increases the occurrence of interspecific competitive interactions between wild bull trout and the supplemented fish, resulting in suppression of bull trout: populations, growth, habitat utilization, diet and condition factor.

The hypothesis was tested by comparing bull trout, 0. *mykiss* and spring chinook salmon populations from four streams with various levels of supplementation. Mill Creek was not supplemented and was considered the control stream. Tucannon River was supplemented with both steelhead trout and spring chinook salmon. Tucannon River was considered the study stream with the greatest potential for impacts to bull trout. The Wolf Fork was indirectly supplemented with steelhead trout from Touchet River plantings and identified as having a moderate potential for impacts to bull trout. Asotin Creek was previously supplemented with steelhead, but not during this study. Bull trout impacts were believed to be low in this stream. The following information was collected from bull trout, 0. *mykiss* and spring chinook salmon:

1) Temporal-spatial distribution;
2) Growth rates;
3) Feeding habits;
4) Habitat utilization;
5) Adult migration and spawning behavior; and,
6) Statistical comparisons of the data collected between study streams were made to detect competition between bull trout and the supplemented fish.

1.3 STUDY STRATEGY

The four study streams were sampled during the summer and fall of 1991 and 1992. In the first year of sampling, 1991, the following tasks were completed (Martin et al. 1992).

1) Characterized study streams and estimated habitat availability;
2) Estimated population density and size by habitat type;
3) Determined age and growth rates;
4) Estimated relative abundance;

5) Conducted diet analysis to determine the important prey organisms of each fish species;
6) Determined food availability (benthic macroinvertebrates); and
7) Conducted spawning ground surveys.

The above tasks were completed in the hopes of finding indicators of competitive interaction between the supplemented fish and the wild bull trout. Study results were reported by Martin et al. (1992).

The data collected in 1991 did not implicate competitive interaction between wild bull trout and the supplemented fish as a negative factor to wild bull trout populations. In fact we lacked the evidence needed to suggest substantial competitive interactions were occurring at all. As a result, the second year of this study, 1992, was designed to implement new sampling techniques to identify potential competitive interactions not addressed during the first year of study as well as to expand and refine sampling techniques used during the first year of study in order to identify less evident competitive interactions. Only three of the four study streams were sampled during the second year of this study: Mill Creek, Wolf Fork and the Tucannon River. Asotin Creek was not included in the 1992 sampling season because only one bull trout was captured out of five 100 m sample sites during the 1991 sampling season (Martin et al. 1992). The following tasks were completed during the summer and fall of 1992:

1) Characterized study streams and estimated habitat availability;
2) Measured microhabitat;
3) Estimated relative abundance;
4) Determined age and growth rates;
5) Conducted diet analysis;
6) Determined food availability (drift and benthic macroinvertebrates);
7) Conducted spawning ground survey; and
8) Radio tagged and tracked adult bull trout in the Tucannon River.

Study stream characteristics and available habitat data were collected during the 1991 sampling season and again during 1992 to identify whether or not the study streams were similar. If habitat in the study streams was not similar, differences in bull trout population dynamics or growth among streams could have resulted from the differences among streams rather than differing supplementation levels. If the habitat in the study streams was similar, then differences in bull trout populations and growth could potentially be attributed to differing levels of competition caused by different supplementation levels.

In 1991, habitat utilization and preference by bull trout and 0. *mykiss* were determined. Spring chinook salmon, however, were not included in this portion of the study. During the first year of this study spring chinook salmon were petitioned for protection under the Endangered Species Act. To avoid sampling mortality of spring chinook salmon, sites known to contain spring chinook salmon were not electrofished. Since habitat data was based on the fish captured by electrofishing, salmon were not included (Martin et al. 1992). Furthermore, capturing fish by electrofishing did not lend itself to accurately identifying utilization of microhabitat. As a result, snorkeling was used during 1992 to include salmon in habitat utilization and to identify microhabitat use by all fish species studied.

Relative abundance sites were sampled during 1992 to identify the extent of geographic overlap between bull trout and 0. *mykiss* of wild and hatchery origin.

In 199 1, diet analysis was conducted and food availability was determined by collecting benthic macroinvertebrates by Hess sample. Diet overlap between bull trout and 0. *mykiss* appeared to be sufficient for interspecific competition. However, bull trout and 0. *mykiss* appeared to be feeding on drifting macroinvertebrates, but drift samples were not taken during 1991 (Martin et al. 1992). As a result, diet analysis was conducted again during 1992, but with drift samples collected in addition to Hess samples to estimate the available food. Lavage techniques were used during 1992 to minimize the killing of fish and at the same time increase the sample size.

Spawning ground surveys were conducted during 1992 to determine if the number of redds and their temporal-spatial distribution was similar between 1991 and 1992.

In 1992, adult bull trout were radio tagged and tracked in the Tucannon River to better understand the migration behavior, and geographic distribution of adult bull trout. This allowed us to determine if bull trout were adfluvial or fluvial. The Washington Department of Fisheries concurrently tracked returning adult spring chinook salmon. This gave us an opportunity to estimate the physical overlap between adult bull trout and adult spring chinook salmon in the Tucannon River during their spawning season.

2.0 MATERIALS AND METHODS

2.1. STUDY STREAM DESCRIPTION

The study streams of this project originates in the Blue Mountains in Southeast Washington State. Bull trout (*Salvelinus confluentus*) and 0. *mykiss* were sampled in all four streams (Figure 2.1). Spring chinook salmon were present only in the Tucannon River. The following is a description of the study streams and land use. All river kilometers (RK) reported were estimated with a map measurer on 7.5 minute series topography maps.

Mill Creek is approximately 57 RK long and flows from an elevation of 5,640 to 470 ft. This creek is located in the Umatilla National Forest from RK 34 to RK 57 and supplies the city of Walla Walla with its municipal water. The upper third of the Mill Creek watershed from the water intake dam (RK 35.5) to its origin was closed to public access in the early 1900's. The construction of the water intake dam blocked migration of fish above the dam until 1985 when the dam was fitted with a fish ladder. The upper portion of Mill Creek was in pristine condition. From RK 0 to RK 34, agriculture, livestock and recreational uses were prevalent and areas of severe degradation were present.

The Tucannon River is approximately 100 RK long and flows from an elevation of 5,840 to 480 ft. The river is used by livestock, for irrigation and for recreational activities such as camping, hunting and fishing. From RK 0 to 59.5 the river was mainly used for irrigation, livestock management and recreation. From RK 59.5 to 87.4 the river is within the Umatilla National Forest. This section of the river was affected by live stock, forest management and recreation. Seven man-made ponds lie along the borders of the river and were used for recreational fishing. From RK 87.4 to the origin, the river is within the boundaries of the Wenaha-Tucannon Wilderness area where access was limited to persons on horseback or foot and the area was used primarily for recreation.

The Wolf Fork of the Touchet River is approximately 32 RK in length and flows from an elevation of 5,520 to 1900 ft. This stream was used by livestock, for forest management and some limited recreational fishery. From RK 12.7 to its origin access to the river was limited because of privately owned land. This area was grazed by livestock with open access to the river. From RK 0 to 12.7 a road runs near the river giving access to recreational activities. Livestock fed along most of this section of stream.

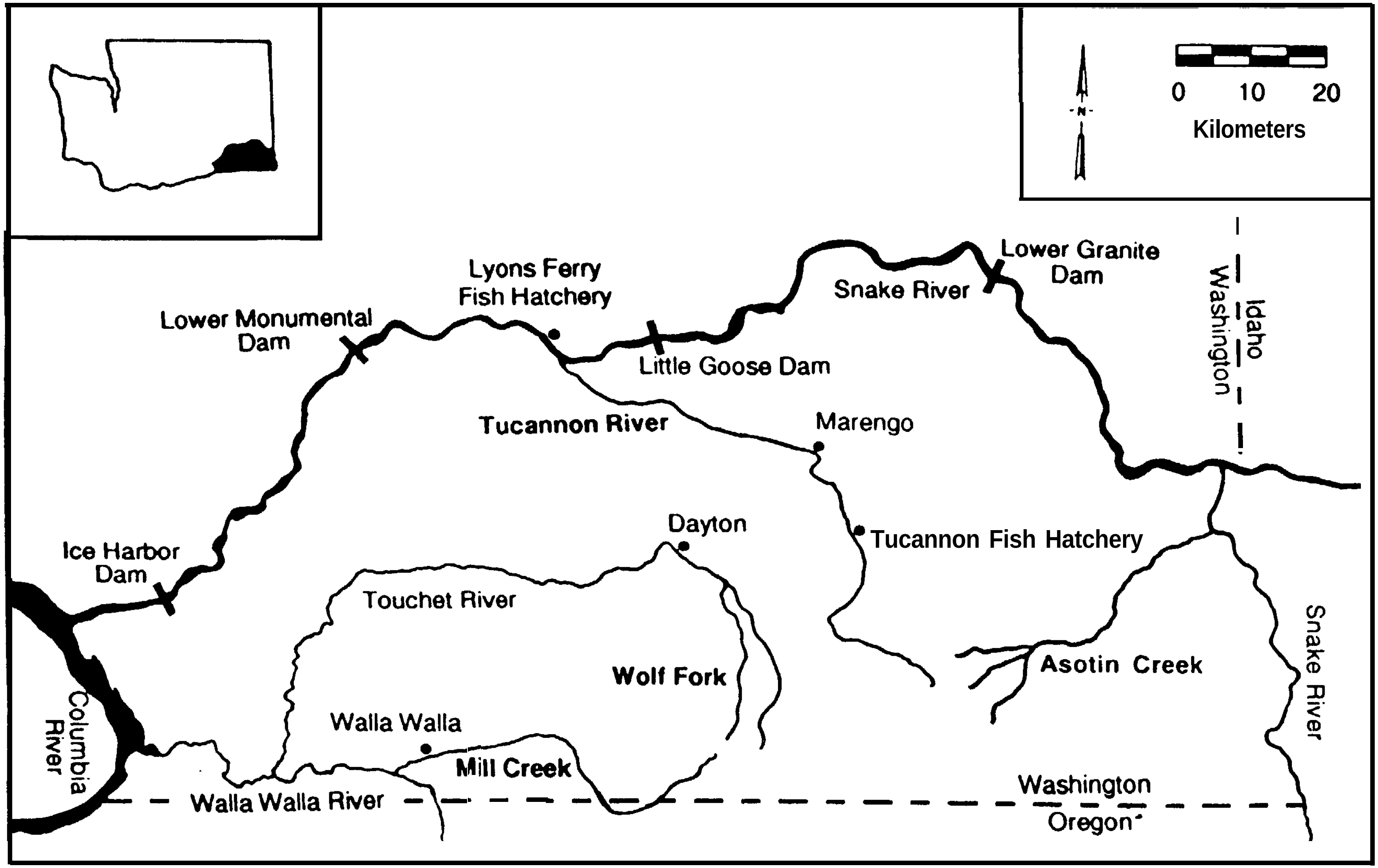

Figure 2.1 Map of Southeast Washington showing location of the study streams.

The North and South Fork of Asotin Creek converge at approximately RK 22 to form the mainstem Asotin Creek. The North Fork is an additional 28 km and the South Fork is an additional 22 km of the total stream length. Asotin Creek flows from an elevation of 5,740 to 750 ft. The South Fork is limited to access by trail from RK 29.1 to the origin and the North Fork is limited to access by trail from RK 28.2. Severe floods occurred in the Asotin Creek watershed during the 1960's. We believe the floods scoured woody debris out of the stream and reduced the number of pools within the stream, thereby, changing the historical character of the stream. The upper reaches of the Asotin Creek watershed lies within the Umatilla National Forest and were currently being logged. This study stream was subjected to other impacts such as cattle grazing, camping, fishing, as well as horseback and motorcycles riding.

2.2 SAMPLE SITE PLACEMENT

Bull trout distribution was limited to the upper portion of each study stream, therefore, all of the sample sites were placed in the upper third of the streams. The type and placement of each sample site for 1992 was noted in Figure 2.2 (Mill Creek); Figure 2.3 (Tucannon River) and Figure 2.4 (Wolf Fork). Sample site placement of 1991 were similar to 1992. Table 2.1. summarizes the temporal-spatial placement of each sample site of 1992. For a description of the sample site placement during 1991 consult the 1991 annual report (Martin et al. 1992). Sampling was conducted from June to December in 1991 and 1992.

The sample sites were established using three criteria:

1. Sample sites were chosen based on a stratified random selection;
2 The sample sites had to be of similar temporal-spatial placement among the study streams; and
3. The site had to be accessible with a reasonable amount of effort.

These criteria were used to insure valid comparisons were made among study streams and between the two sampling years.

Table 2.1 Description of temporal-spatial placement for each sample site of the 1992 sampling season. Site nomenclature is as follows, the prefix "R" refers to relative abundance, evaluation of available habitat and diet analysis sites. The prefix "D" refers to diet analysis only sites. The prefix "H" refers to evaluation of available habitat only sites. The prefix "M" refers to microhabitat sites. Site locations are depicted in Figures 2.2-2.4.

	SITE NUMBER	RIVER (Km)	ELEVATION (ft)	DATE
MILL CREEK	R-l	47.9	2920	4-Aug
	R-2	44.7	2620	17-Aug
	R-3	42.2	2480	17-Aug
	D-l	42.7	2540	1-Jul
	M-l	47.8	2880	1-Sep
	M-2	44.9	2630	3-Sep
	M-3	42.8	2560	3-Sep
	H-l	52.5	3400	2-Oct
TUCANNON R	R-l	91.7	3880	3 1-Jul
	R-2	89.3	3660	18-Aug
	R-3	87.3	3480	24-Aug
	D-l	89.7	3740	29-Jun
	M-l	90.1	3740	31-Aug
	M-2	87.7	3520	29-Aug
	M-3	82.8	3240	29-Aug
	M-4	74.1	2920	27-Aug
	M-5	75.3	2780	25-Aug
	H-l	92.9	4040	3-Oct
WOLF FORK	R-l	21.9	3380	13-Aug
	R-2	15.7	3040	6-Aug
	R-3	12.2	2680	19-Aug
	D-l	16.0	3080	26-Jun
	M-l	17.7	3220	16-Sep
	M-2	13.9	2840	16-Sep
	M-3	18.1	3240	24-Sep
	H-l	12.4	3080	22-Jul
	H-2	14.8	2960	24-Sep

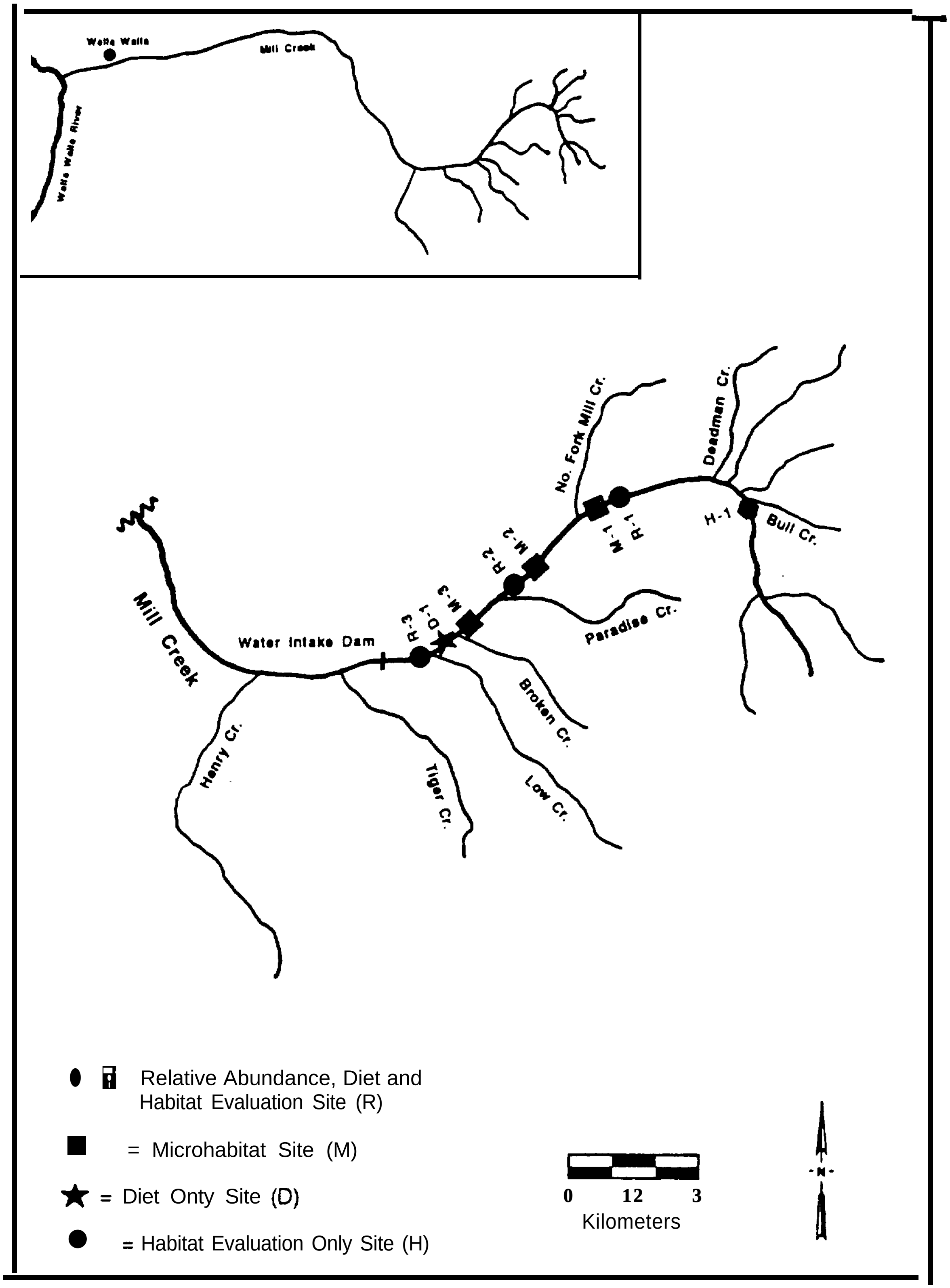

Figure 2.2 **Map of Mill Creek showing sample site locations of 1992.**

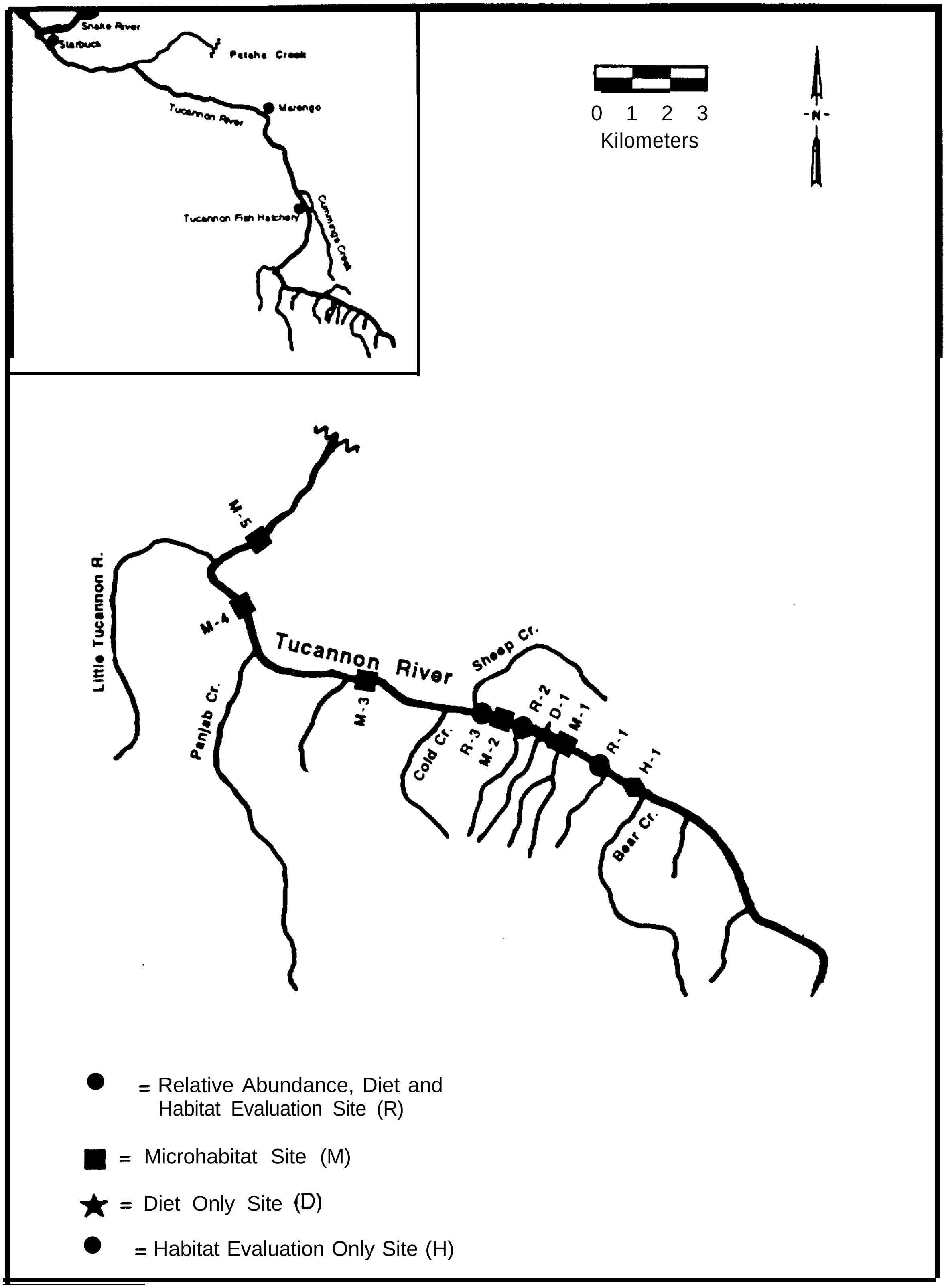

Figure 2.3 Map of Tucannon River and sample site locations of 1992.

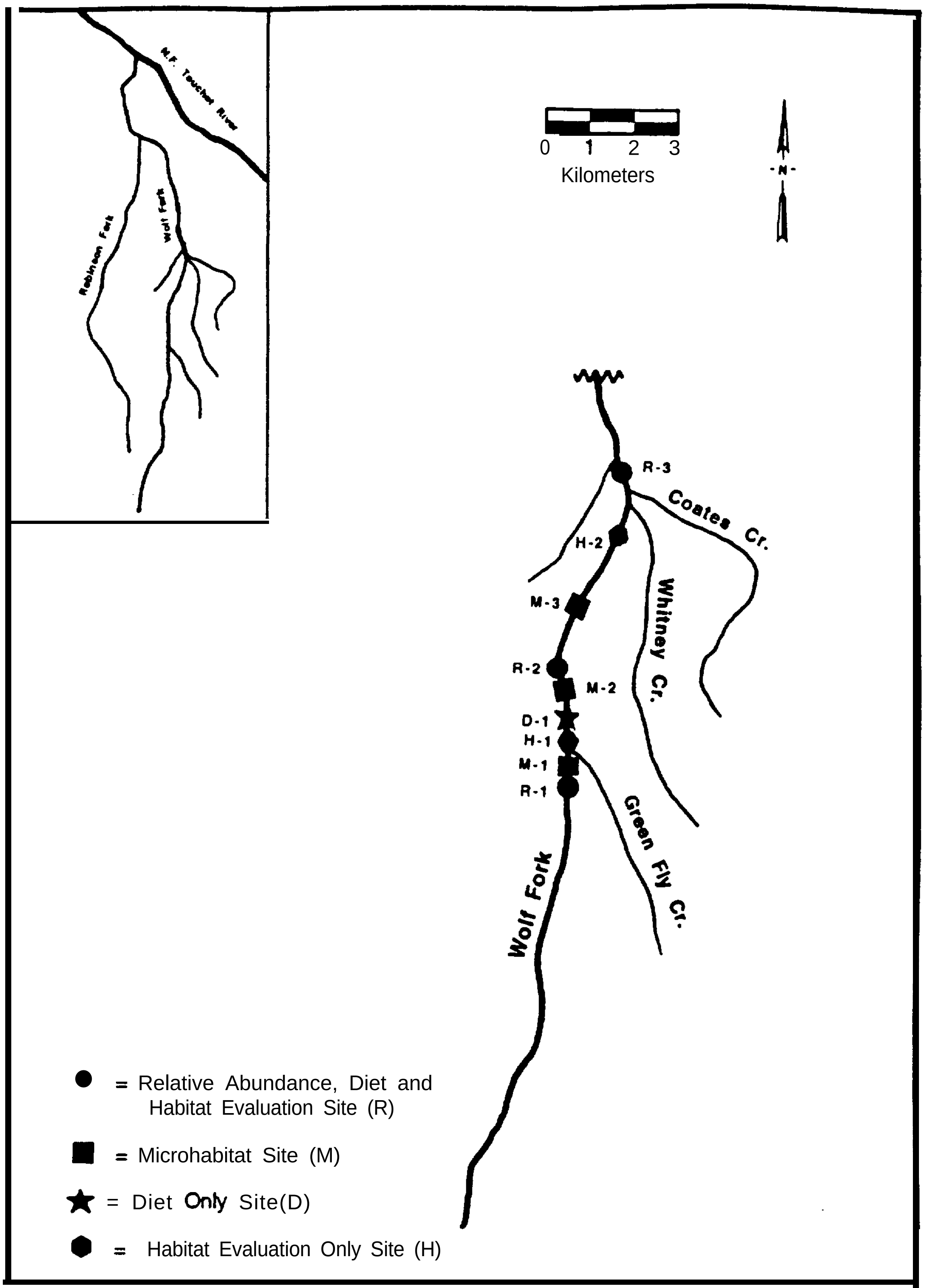

Figure 2.4 Map of Wolf Fork and sample site locations of 1992.

2.3 IDENTIFICATION OF BULL TROUT

The morphological similarities between bull trout and Dolly Varden (Salvelinus malma made differentiating between the two species difficult. To be certain that bull trout were being sampled, Haas and McPhail's (1991) mathematical unweighted linear discriminate function was used which requires several meristic counts be made on the fish in question. Details of the methods and results for bull trout identification are reported in Appendix A.

2.4 POPULATION ESTIMATES AND RELATIVE ABUNDANCE

During the first year of this study, 1991, the population size and density of bull trout and 0. *mykiss* was determined. Four groups of five habitat types (cascade, run, riffle, plunge pool and scour pool) were sampled by electrofishing, making a total of twenty sample sites per stream in Mill Creek, Tucannon River and Wolf Fork (Martin et al. 1992). One group of five habitat types was sampled in Asotin Creek. Zippen's (1958) removal method was used to estimate the fish population. Population estimates were not conducted during the second year of the study so that sampling efforts could be focused on other tasks such as microhabitat utilization and radio tracking adult bull trout.

During the second year of the study, 1992, three relative abundance sites were sampled in Mill Creek, Tucannon River and Wolf Fork in order to collect bull trout and 0. *mykiss* for age, growth, condition, diet estimates and to verify geographic overlap between bull trout and 0. *mykiss*. Asotin Creek was not included during the 1992 sampling season because only one bull trout was captured during 1991. Temporal-spatial placement of each sample site is provided in Table 2.1 and shown in Figures 2.2- 2.4. Each site was measured off to 100 meters in length, taking care not to disturb any fish within the sample site. The site was then sampled by making one pass with a Smith-Root 11-A backpack electrofisher upgraded with a programmable output waveform electronics. Electrofishing began at the down-stream end of the site working in an up-stream direction. Stunned fish were captured by two workers with nets and placed in buckets. All of the bull trout and 0, *mykiss* captured were anesthetized with MS-222 then fork length (mm), and weight (g) was measured. Scales were removed from the captured fish for later age analysis. Approximately 10 percent of the bull trout and 0. *mykiss* captured were killed to obtain stomachs for diet analysis and otoliths for age analysis. No spring chinook salmon where sampled due to their recent protection under the Endangered Species Act (ESA). After recovering from the anesthetic, the remaining fish were released back into the stream.

2.5 AGE AND GROWTH

In 1991, the age of the collected bull trout was determined by otoliths and 0. *mykiss* 's age was determined by scales (Martin et al. 1992). Length frequency histograms were used to verify the estimated age of both bull trout and 0. *mykiss*.

In 1992, otoliths and scales were collected from bull trout and 0. *mykiss* to determine the age of the captured fish and to back-calculate length at annulus formation for each species. Otoliths and scales were taken from the fish killed for diet analysis and scales were taken from the fish captured during relative abundance sampling. Spring chinook salmon were not included in this part of the study due to their protection under the ESA. The ages determined by otoliths and scales were compared to verify the estimated age of the captured fish. Both aging methods were used to maximize precision and reduce biases (Sharp and Bernard 1988, Beamish and McFarlane 1983). We also back-calculated length at age in order to determine if the growth rates of each species differed between study streams.

Otoliths were excised from the fish's head as described by Peven (1990). The otoliths were placed in 99% glycerin for storing. In the laboratory, the otoliths were examined under a stereo microscope. Winter growth of the otolith forms a clear hyaline ring which was considered the annulus. The opaque zone of the otolith was considered to be summer growth (Lux 1971, Jearld 1983). Care was taken not to read the "metamorphic check", a hyaline zone which occurs around the otoiith nucleus at hatching (McKern 1974). Each hyaline zone on the otolith was counted as one year of life. Concurrently, measurements were made from the otolith focus to the ventral outer edge of each hyaline zone with an ocular micrometer to the nearest 0.3 millimeter under constant magnification. These measurements were used to back-calculate the length at age as described below.

Scales were collected from the fish's right side just below the dorsal fin and above the lateral line. The collected scales were magnified and viewed on a microfiche reader. Annuli were determined by "cutting over" of the circuli and by the narrowing of the circuli during winter growth (Jearld 1983). Each annulus was counted as one year of growth. Measurements were made from the scale focus to the posterior outer edge of each annulus to back-calculate the length at age.

The Dahl-Lea Back-Calculation formula was used to back-calculate the length of the fish at annulus formation instead of the more generally accepted Fraser-Lee Back-Calculation formula due to our small sample sizes which caused inaccurate Y intercepts (Francis 1990).

$$L_i = \frac{S_i}{S_c} L_c$$

where:

where:	L_i	=	length of fish (mm) at each annulus;
	L_c	=	length of fish (mm) at time of capture;
	S_c	=	distance (mm) from the focus to the edge of the scale or otolith; and
	S_i	=	distance measured (mm) from the focus to each annulus.

2.5.1 PRECISION OF AGE ESTIMATES

Many researchers have indicated the need for estimating the precision and accuracy of age estimates (Beamish and Foumier 1981, Chang 1982, Dapson 1980). Appendix B details the methods and results of age precision from the 1992 sampling season. The coefficient of variation (V) and the index of precision (D) were used to determine the precision of age estimates (Chang 1982). The precision of aging was also estimated during 1991, for those results refer to the 1991 annual report (Martin et al. 1992)

2.6 CONDITION FACTOR

The condition factor was determined for each bull trout and 0. *mykiss* captured in 1991 and 1992. Condition factor compares the proportion of weight added as the fish grows in length. Busacker et al. (1990) has suggested that condition factor can also be used to determine the relative nutritional state or "well-being" of a fish. For trout species, fork length condition factors ≤0.8 indicates poor nutritional condition and 0.9 to 1.1 suggests an average or good nutritional condition (Carlander 1969). Poor condition factors can be a direct result of competitive interaction for food. Thus, condition factor was considered an indicator of competition. The condition factor formula used was:

$$K_{fl} = \frac{W}{L^3}(10)^5$$

where K_{fl} = condition fac
W = weight of fish in grams; and
L = fork length of fish in millimeters.

Condition factors were grouped by age for each fish species and then compared among study stream populations by an one-way ANOVA to determine if the condition of each fish was significantly different among study streams. For example, the condition factor of one year old bull trout were compared among all three study streams.

2.7. AVAILABLE HABITAT

Available habitat was estimated to determine the amount and type of habitat usable by bull trout, spring chinook salmon and 0. *mykiss* . Measurements were made in Mill Creek, the Tucannon River and the Wolf Fork during both years of the study. Habitat availability was estimated only during 1991 in Asotin Creek. Comparisons were made among the study steams to identify whether each stream provided similar habitat.

During the first year of the study, 1991, six 100 meter sites were measured independent of other sample sites. (Martin et al. 1992). During the second year of the study, 1992, available habitat was estimated at each of the three relative abundance sites and one additional habitat site to make a total of four sample sites. Available habitat was measured physically in 1991 and visually estimated (Hankin and Reeves 1988) in 1992. Habitat estimates made during the second year of study were used to verify the findings of the first study year. In 1992, each 100 meter long site was split into three equal sections. The 100 meter long sites were too large to accurately estimate habitat because of our inability to see the whole site at one time. Thus, each sub-site was estimated independently. The data collected from each sub-site within a sample site was averaged to determine the mean habitat available in that sample site.

The following information was collected at each sample site during both 1991 and 1992:

1. stream name;
2. date;
3. stream temperature;
4. wetted width;
5. discharge;
6. gradient.

Habitat was classified into five categories:

1. low gradient riffles;
2. cascade;
3. plunge pool;
4. scour pool; and
5. run.

Low gradient riffles were shallow (<20 cm) stream sections with moderate water velocity and turbulence. Cascades were a series of small step waterfalls and shallow pools created from water rushing over boulders. Plunge pools were defined as water vertically dropping over a channel obstruction onto the streambed below, scouring out a deep depression. Scour pools were areas where the force of a stream's flow had been diverted toward the stream bank by an obstacle; the current scours out a depression in the side of the stream. Runs were considered to be moderately shallow water with smooth flow that lacked turbulence and major current obstructions (Bisson et al. 1981). Bisson et al. (1981) described twelve habitat types, however, only the five categories noted above were encountered frequently enough to warrant comparisons.

At each habitat site we classified the cover, substrate, embeddedness, depth and current velocity. Cover was categorized into the following categories (Wesche et al. 1987):

1. boulders,
2. undercut banks
3. turbulence
4. overhead cover, and
5. woody debris

Boulders were substrate greater than 250 mm in diameter which were positioned to create spaces for hiding fish. Boulders embedded into the substrate by greater than 40 percent of their diameter were not considered cover. Undercut banks were places where the top of the bank extended over the stream. Turbulence was white water at the surface of the stream which could conceal a fish. Overhead cover was any foliage within 2 meters of the stream's surface that provided shade while the sun was in the 10 to 2 O'clock position. Woody debris was any wood fallen into the stream.

Woody debris was further subdivided into the following categories in 1992 to determine if the same types of woody debris were available in each stream.

1. fallen log;
2. sunken woody debris;
3. log jam; and
4. root wad

Fallen logs were defined as a log fallen into the stream with any orientation to the stream. Sunken woody debris was wood pieces that had become water logged and rest on or near the stream bottom. Log jams were a series of two or more logs fallen within the stream and acting as a debris catcher. Root wads were a clump of roots hanging in the stream from the stream bank (TFW 1990).

Substrate type was broken down into size classes modified from Platts et al. (1984).

1. Organic / silt (<0. lmm);
2. fines (0.1-2.0 mm);
3. small gravel (2.0- 16 mm);
4. large gravel (16-60 mm);
5. small cobble (60-l 30 mm);
6. large cobble (130-250 mm); and
7. boulder (>250 mm)

Streambed embeddedness was estimated by randomly picking up 10 different rocks from the streambed and estimating the percent of the rock that was surrounded by silt. The portion of rock with algae growing on the surface was considered to be exposed to the stream and the portion of rock that appeared "whitish" was considered to be the embedded portion of the rock (TFW 1990). The percent of the rock embedded was used to estimate percent embeddedness. The average was determined and recorded.

Cover types, substrate composition, and stream embeddedness were determined by visual estimates and noted by percentage during each year of the study. To assure consistency and expediency during estimates, percentages were broken into classes and then given a number to represent the class during the second year of the study.

1. <5%
2. 625%;
3. 26-50%
4. 51-75%
5. >76%

Stream gradient was measured at each site during 1991 and each sub-site during 1992. One worker stood at the lower end of the site with a transit and another at the top with a graduated rod. The distance between workers was measured with a measuring tape and the difference in height of the stream between workers was estimated with a transit. The change in height was divided by the length between workers then multiplied by 100 to obtain percent gradient.

Water discharge and depth was taken using an electronic flow meter (Swoffer Model 2100 Series) connected to a graduated depth rod. The stream width was divided into four equal units and one measurement was taken at each unit. If the stream width was greater than four meters then flow and depth measurements were taken every meter of the stream's width. The following equation was used to determine water discharge (TFW 1990).

$$D = \sum_{i=1}^{n} \frac{tw}{n} (v_i)(d_i)$$

Where:
D = Discharge;
n = the number of velocities taken
tw = the total stream width;
v_i = the ith stream velocity; and
d_i = the ith stream depth.

Wetted width, stream depth, gradient, water velocity, water discharge and percent composition of habitat types were statistically compared among streams. A one-way ANOVA was used to determine if there were significant differences among the study streams for each variable measured. If differences were found by ANOVA ($P < 0.05$), Scheffe's F test was used to determine which of the streams differed from one another for that variable (Zar 1984).

2.8. HABITAT UTILIZATION

Habitat utilization and preference was measured for bull trout and 0. *mykiss* during the first year of sampling, 1991. Habitat utilization was expressed as percentage of individuals found in a specific habitat type from population density estimates. Five habitat types were identified: plunge pool, scour pool, run, riffle and cascade. Habitat preference was determined by dividing habitat utilization percentage by the percentage of habitat available in the environment. The resulting product for each habitat type was then normalized by dividing the resulting number by the habitat type product with the greatest magnitude (Martin et al. 1992). Normalizing transformed the data into numbers ranging from 0 to 1, where 1 was the most preferred and 0 indicated no preference.

Microhabitat use was estimated for juvenile bull trout, 0. *mykiss* and spring chinook salmon in Mill Creek, and the Tucannon River during the second year of this study, 1992. Microhabitat was defined as the physical characteristics of the environment occupied by an observed fish. Habitat was defined as the habitat unit type (run, cascade, riffle, plunge pool and scour pool - - Section 2.7) in which the fish were observed (Bisson et al. 1981). One each of the five habitat types were sampled within 10 to 50 meters of one another to make up one microhabitat sample site. Temporal-spatial information on microhabitat sites can be found on Table 2.1 and shown in Figures 2.2- 2.4.

Snorkeling was used to locate fish for microhabitat measurements. Each habitat unit was snorkeled by one or two workers depending on the width of the stream. If the habitat unit was wider than four meters, two workers snorkeled the site in order to assure all fish within the sample site were in view of the workers. This reduced the chance of characterizing the microhabitat more than once for any one individual fish (Hankin and Reeves 1988).

The snorkelers entered the stream approximately 7 meters below the habitat unit. Once settled into the water, they slowly moved upstream. The following was recorded by the snorkeler for each observed fish:

1. species,
2. age based on length
3. vertical distance from the streambed (cm).

Length was used to determine the age of each observed fish. Since water distorts the perceived size of an object, a 30 cm piece of rebar with alternating 1 cm white and red stripes was used as a reference. When a snorkeler located a fish, a comparison was made between the rebar and the fish. The age at length of bull trout and *0. mykiss* from Martin et al. (1992) and the age at length of spring chinook salmon from Bugert et al. (1991) was the criteria used to estimate the observed fish's age. Table 2.2 indicates the size classes used for age estimates.

Table 2.2 Range of fork lengths (mm) for each species used to estimate a fish's age while snorkeling.

	AGE			
	o+	1+	2+	3+
MILL CREEK				
Bull trout	30-70	90-130	135-199	199-270
0. mykiss	30-100	105-145	150-185	190-235
TUCANNON RIVER				
Bull trout	30-65	70-l 10	115-175	168-225
0. mykiss	30-65	70-130	135-175	180-225
Spring chinook salmon	mean=6 1	mean=113		
WOLF FORK				
Bull trout	35-80	85-l 15	120-165	165-175
0. mykiss	30-90	95-120	125-175	1 SO-225

The vertical distance from the streambed to the snout of the fish was estimated to the nearest 1 cm by comparing the reference stick (painted rebar) to the fish's position and then mentally converted to inches. After the species of fish, age and vertical distance for the streambed was recorded, the snorkeler would mark the focal point of each fish with a flag stuck into the streambed, then continue upstream. Once the microhabitat site was snorkeled, the following characteristics were measured at each focal point marked by a flag:

1. most prevalent substrate type;-
2. total depth of stream;
3. nearest cover type;
4. distance to nearest cover type;
5. nearest fish species to fish being measured;
6. distance to nearest fish; and
7. water velocity.

Water velocity was measured with an electronic flow meter (Swoffer Model 2100 Series) connected to a graduated depth rod. The water velocity measurements were made where the fish's snout was observed. Total stream depth was measured with a graduated depth rod to the nearest 0.1 inch. The nearest fish species was determined by measuring longitudinally to within 0.1 meters to the next closest flag marking another fish found while snorkeling. For a detailed breakdown of substrate and cover types see section 2.7.

2.9 FOOD AVAILABILITY

Two methods were used to sample the density of macroinvertebrates; Hess and drift net samples. The samples were taken to identify the taxa of macroinvertebrates present and the density of macroinvertebrates available for fish consumption. Hess samples were the only method used to sample macroinvertebrate density during the first year of this study, 1991. Three Hess samples were collected from each stream in the area of highest overlap between the target species, as determined by electrofishing surveys.

In 1992, the macroinvertebrates on the streambed were sampled by three 0.1 m^2 Hess samples, taken at 0.25, 0.5 and 0.75 of the streams width, which was the same method as in the first year of the study (Martin et al. 1992). The substrate contained within the 0.1m^2 sampler was scrubbed clean of all organic material with a brush to a depth of 8 cm below the streambed surface. Next, the water within the sampler was agitated to insure all of the macroinvertebrates were swept up by the stream current and deposited into the 320 micron mesh catch-bag at the end of the sampler (Klemm et al. 1990).

Drift samples were added to the sampling regime during 1992 to determine the density of macroinvertebrates available within the water column. Four sample sites were established each in Mill Creek, the Tucannon River and the Wolf Fork. Sample sites were numbered D-l, R-l, R-2, and R-3. Table 2.1 indicates the temporal-spatial location of each sample site during 1992. Hess and drift samples were taken in the closest riffle upstream from the relative abundance and diet sample sites. The samples were taken immediately after capturing the fish for diet analysis.

The macroinvertebrates suspended in the water column were sampled with two drift net samplers, which were placed at 0.33 and 0.67 of the streams width simultaneously for one hour. The two drift samplers were positioned so that the bottom of the sampler was in contact with the streambed and the top of the sampler broke the stream’s surface. The funnel shaped sampler terminated with a 320 micron sampling bag where the collected macroinvertebrates were deposited. At the end of the one hour sampling period, water velocity though the sampler was measured with a flow meter placed at the mouth of the net (Klemm et al. 1990).

The following equation was used to determine the volume of water that passed though the net.

$$V = A(v)(t)$$

where:

V = Volume;
A = surface area of the opening of the sampler;
v = water velocity; and
t = time sampler is in water.

Both Hess and drift samples were preserved in 10% formalin immediately after collection and transferred to 70% alcohol two weeks later.

In the laboratory, each Hess and drift sample was poured into a petri dish and examined under a stereo microscope. Each macroinvertebrate within the sample was identified to Family. Macroinvertebrate identification was verified with the following taxonomic keys: Merrit and Cummins (1984); Thorp and Covich (1991); and Borror et al. (1989). Macroinvertebrates which were rarely found in the samples and too difficult to identify to Family were identified to Order. Each macroinvertebrate taxonomic group in a particular sample was separated into its own vial and preserved in 70% alcohol.

The dry weight of each taxonomic group was determined for each Hess and drift sample. The vial containing each taxon was emptied onto a stainless steel screen with a mesh size of 270 microns. The organisms were washed with distilled water then placed in an oven for 20 hours at 105° C (Weber 1973). The specimens were removed from the oven and allowed to cool for 15 minutes in a desiccant chamber filled with calcium sulfate. Each specimen was then placed on an analytical balance which measured to the nearest 0.1 milligram. The stainless steel screens without macroinvertebrates were put through the same procedure. The difference in weight between the stainless steel screen and the screen with a taxon was the dry weight assigned to that taxon for each Hess or drift sample. The weight of each individual within a taxon was determined by dividing the specimen weight by the number of individuals. The individual weight multiplied by the estimated density of the taxa was reported as the dry weight per m^2 for Hess samples and dry weight per m^3 for drift samples.

The benthic macroinvertebrate density and dry weight per sample site were estimated by averaging the results from the three Hess samples taken at each sample site. The density and dry weight of the macroinvertebrates in the water column was estimated by averaging the two drift samples taken at each sample site.

2.10. DIET ANALYSIS

The diet of bull trout and *O. mykiss* was analyzed to determine if competition was occurring for food during both years of this study. Spring chinook salmon were not sampled because of their protection under the ESA. During the first year of study, 1991, ten bull trout and ten *O. mykiss* were collect from each stream twice during the summer months (Martin et al. 1992). The fish were stunned with an electroshocker and then captured by dip net while working upstream. The stomachs were removed from the captured fish, then preserved in 10% formalin for later analysis in the laboratory.

The results from the first year of study indicated that there was a potential for competitive interactions between bull trout and *O. mykiss* for food based on diet overlap (Martin et al. 1992). However, the number of fish and sites sampled during the first year of study was small. Therefore, the diet study was expanded during the second study year by increasing the number of sites and fish sampled, Four sample sites were establish each in Mill Creek, Tucannon River and Wolf Fork, numbered D-l, R-l, R-2, and R-3. The temporal-spatial information of each sample site can be found in Table 2.1. In sample sites D-l, the first ten fish of each species captured while electrofishing were used for diet analysis. In sample sites R-l, R-2 and R-3, all fish captured within the 100 m long relative abundance sites were used for diet analysis. Fish were obtained by stunning them with a backpack electroshocker while working upstream. Stunned fish were captured by two workers using dip nets.

2.10.1 GASTRIC LAVAGE

Gastric lavage was used during the second year of the study to increase the sample size while decreasing the number of fish killed. Light et al. (1983) reviewed the effectiveness of gastric lavage techniques with brook trout and found 100% of the fish survived the procedure, furthermore, 98% by weight of the stomach contents were evacuated from the stomach.

A dulled 18 gauge needle with a 15 cm length of 2mm outside diameter vinyl microtubing was connected by luerlok to a 6Occ syringe filled with 5Occ of river water. The microtubing was inserted into the posterior position of the fish's stomach via the esophagus of an anesthetized fish. Once the tubing was inserted, steady pressure was'applied to the plunger of the syringe forcing the river water into the fish's stomach. The back pressure created from the delivered water, forced the contents of the fish's stomach to be evacuated through the mouth. While the water was being forced into the stomach, the fish was held vertically, head down, over an opened 320 micron mesh bag. The evacuated stomach contents were captured in the bag, then placed in 10% formaiin. The gastric lavage methods used in this study were patterned after Boag (1987). The effectiveness of gastric lavage was analyzed in this study to determine the percent of food items evacuated from bull trout and *O. mykiss* stomachs (Appendix F). The lavage technique removed 82% of the stomach contents of bull trout and 61% of the contents of *O. mykiss*

2.10.2 STATISTICAL ANALYSIS

The prey selectivity index was used to determine the importance of different food items to bull trout and *O. mykiss* for each stream during both years of the study. This index determined the importance of a food item by comparing the relative abundance of a food item in the environment to the relative abundance of the food item in the fish's stomach (Strauss 1979). The relative abundance of food items in the environment was determined by Hess samples during 1991 and drift samples during 1992. During microhabitat surveys in 1992, over 30 bull trout and 30 0. *mykiss* were observed feeding. In each case both bull trout and 0. *mykiss* were observed feeding on drifting macroinvertebrates. Not one fish was viewed feeding off of the streambed. Thus, drift appeared to be a better indication of the relative abundance of food items being fed upon by bull trout and 0. *mykiss. The* following equation was used to compute the prey selectivity index.

$$L = r_i - p_i$$

where:

L = prey-selectivity index;
r_i = relative abundance of prey taxa in the stomach; and
p_i = relative abundance of the prey taxa in the stream.

The values obtained from the prey selectivity index range from +1 to -1. A value of +1 suggested the fish were actively seeking out that food item for consumption. A value of - 1 indicated the fish were not feeding on that food item or were avoiding the food item. A value near zero indicated the fish was not actively seeking or avoiding the food item, but consuming the food item at the same proportion as found in the environment.

The index of relative importance (IRI) indicated the relative contribution of each prey taxa to the fish's diet (George and Hadley 1979). IRI was determined during both years of the study. The formula took into account the frequency of occurrence, the numerical frequency and the weight frequency of a food item in the fish's diet. The IRI attempted to cancel out bias associated with the use of any one measurement mentioned above (George and Hadley 1979).

$$IRI = \frac{100(AI_a)}{\sum_{a=1}^{n} AI_a}$$

where:

IRI = relative importance of food item a;
AI_a = Absolute importance of food item a (*i.e.,* frequency of occurrence + numerical frequency + weight frequency of food item a); and
n = number of different food types.

An IRI was calculated for each food item consumed by each fish species per stream. The products ranged from 0 to 100% for each food item of each fish species and the summation of all resulting IRIs for each fish species equaled 100%. Therefore, the more important the food items, the higher the relative percentages.

The relative abundance of the food items for each fish species was determined by number and by weight. The dry weight of each food item per fish sampled was determined by using the same dry weight methods described in section 2.9.

The results of IRI were used to determine the diet overlap between bull trout and 0. *mykiss* during both years of this study (Keast 1978). The formula for diet overlap used was as follows:

$$C_x = \frac{2\sum_{i=1}^{n}(P_{xi})(P_{yi})}{\sum_{i=1}^{n} P_{xi}^2 + \sum_{i=1}^{n} P_{yi}^2}$$

Where:

C_x = the overlap coefficient;
P_{xi} = the proportion of food category (i) in the diet of species x;
P_{yi} = the proportion of food category (i) in the diet of species y; and
n = the number of food categories.

The values obtained from the above equation ranged from 0 to 1. Numbers ranging from 0.0 to 0.3 suggested that diet overlap was not significant, where as numbers ranging from

0.4 to 0.6 indicated moderate diet overlap and numbers ranging from 0.7 to 1.0 suggested there was significant diet overlap (Keast 1978).

To determine the key prey organisms in the diet of each fish species, food items were ranked by using: frequency of occurrence, percent composition by number, percent composition by weight and electivity index during both years of the study. Each prey item was allotted 3 points for scoring highest in a category, 2 points for second and 1 point for third. Points were totaled and prey items were ranked accordingly (Geist et al. 1988).

2.11. SPAWNING GROUND SURVEY

Mill Creek, Tucannon River and Wolf Fork were surveyed for bull trout redds during September and October of 1991 and 1992. Asotin Creek was not included due to the few bull trout present in the stream (Martin et al. 1992). The number of redds per study stream were estimated by surveying the following reaches: Mill Creek (RK 53.2-47.8), Tucannon River (RK 93.7-87.0) and Wolf Fork (RK 21.9-15.2). The sampling reach of each stream was established in 1990 and 1991 from redd surveys conducted by Martin et al. (1992). Bull trout redds were located by walking the stream from the furthest upstream point of the reach to the lowest down-stream end. Redds were identified by locating areas in the streambed which lacked algae covered substrate. If the "clean" substrate was arranged in a mound, called the tail, which preceded a bowl shaped depression in the streambed, the structure was considered a redd (Grost and Hubert 1991). Each located redd was marked with fluorescent orange biodegradable tape. The marker indicated the survey number and the redd number found during that survey. The following characteristics were measured on every third redd during 1991 and every other redd during 1992:

1. Bowl diameter;
2. Tail length;
3. Percent substrate in bowl and tail for the following size classes;
    - <2mm
    - 2-16mm
    - 16-60mm
    - 60-130mm
    - 130-250mm
    - >250 mm;

4. Water velocity of bowl, tail and adjacent to redd at 60% of stream depth
5. Stream depth at bowl, tail and adjacent to redd;
6. Habitat type
    - Plunge Pool
    - Scour Pool
    - Run
    - Riffle
    - Cascade; and
7. Proximity to stream bank and cover;
8. Cover Type
    - Fallen Log
    - Sunken Woody Debris
    - LogJam
    - RootWad
    - Boulder
    - Undercut bank
    - Turbulence
    - Overhead Cover.

Water velocity was measured with a Swoffer Model 2100 Series open stream current velocity meter. Depths and distances were measured with either a telescoping measuring rod or a tape measure.

2.12. RADIO TELEMETRY

Upstream migrating bull trout captured at the Tucannon Hatchery Trap (RK 61.5) were tagged with unique numbered Floy tags in 1991. However, few tagged fish were located throughout the first year of study and the migration habits of adult bull trout were still in question. Therefore, adult bull trout were radio tagged and tracked in the Tucannon River from July 1992 to December 1992. The goals of the tracking study were to gain a better understanding of bull trout migration behavior and to identify periods in which bull trout and adult spring chinook salmon may geographically overlap. Sixteen adult bull trout were tagged with radio transmitters (Custom Telemetry) designed for implantation into the intraperitoneal cavity. The transmitters weighed 8.5 grams with dimensions of 12mm x 9mm x 35mm. Winter (1983) suggested that transmitters weighing greater that 2% of the fish's body weight induced abnormal behavior. Therefore, the 2% rule was used as the deciding factor in selecting bull trout for radio tagging. Individual fish were identified by individual frequencies spaced 10 kHz apart on the 48 MHz band.

Adult bull trout were captured by hook and line by five different anglers between Camp Wooten (RK 69) and Cold Creek (RK 86). Captured fish were placed in a perforated plastic tote box located in the stream and covered with a lid. The surgical team periodically checked with the anglers to see if any eligible fish had been captured. If the fish weighed greater than 425 grams, it was radio tagged.

The adult bull trout eligible for radio tagging were placed in a 20 gallon tub with benzocaine (ethyl-p-aminobenzoate) at a concentration of 35mg/L to anesthetize the fish. The benzocaine concentration needed for deep narcosis (35-40mg/L for 3 minutes) is much lower than its lethal concentration (65mg/L for >40 minutes) (Gilderhaus 1989). Therefore, the use of benzocaine should have minimized the occurrence of anesthesia induced mortality during the surgical procedure. After the fish had reached a deep narcosis, determined by slowed opercular movement and no reaction to touch, the anesthetized fish was placed on a "V" shaped surgical table with its ventral side up. The surgical table and fish remained in the river. Surgery took place with the fish's head in the stream so that it could still obtain oxygenated water during the surgery.

A 20mm incision was made with a scalpel on the ventral side of the fish approximately 4cm proximal to the pelvic girdle and slightly lateral to the fish's mid-line. The transmitter was inserted into the body cavity of the fish with forceps and situated over the pelvic girdle to reduce the possibility of impingement on vital organs (Hart and Summerfelt 1975; Marty and Summerfelt 1986). Once the transmitter was inserted and positioned, the incision was closed with sutures. The suture material (Dexon II 3-O with a T-5 26mm needle by Davis and Geck, Inc.) was made of polyglycolic acid, a synthetic absorbable suture. Kaseloo et al. (1992) reported that polyglycolic acid suture as the best material for closing incisions with rainbow trout. The sutures were tied at 3-4 millimeters intervals with two double over hand knots. The sutured incision were covered will Basitrasin, an antibiotic, to reduce the possibility of fungal infection at the incision site. Fungal infection has been reported to be a major contributor to fish mortality following surgery (Lucus 1989).

The radio tagged fish were located with the use of two different receivers tuned to 48 MHz. The principle receiver was a scanning receiver (SR-40 manufactured by Smith-Root, Inc.)

with the ability to scan 20 different signals simultaneously. The scanning receiver in conjunction with a yagi antenna mounted on a truck was used to locate the fish from the road adjacent to the river. This set up was used to find the fish's general location. The other receiver was a 16 channel light weight field receiver which could only receive one transmitter signal at a time (Fieldmaster 16 Channel Receiver manufactured by Advanced Telemetry Systems, Inc.). The Fieldmaster outfitted with a dipole loop antenna was used to determine the precise location of the fish at close range (< 25 m).

The location of the radio tagged fish was determined once a week. However, the first week following surgery was considered a recovery period and not counted as normal migration activity.

3.0 RESULTS

3.1. POPULATION ESTIMATES AND RELATIVE ABUNDANCE

The population size and density of bull trout and *O. mykiss* were estimated in 1991. Bull trout population size and density was highest in Mill Creek and lowest in Asotin Creek (Table 3.1 and 3.2). Conversely, 0. *mykiss* population size and density was highest in Asotin Creek and lowest in Mill Creek. The population size and density of bull trout in Asotin Creek was based on one 164 mm fish captured out of the five sample sites (Martin et al. 1992).

Table 3.1 Population size of bull trout and 0. *mykiss* with 95% confidence intervals of each study stream sampled in 1991 (Martin et al. 1992).

	Bull Trout Y-O-Y	Bull Trout Juvenile	0. *mykiss* Y-O-Y	*O. mykiss* Juvenile
Mill Creek	1,754 ± 52	2,171 ± 22	1,154 ± 154	1,036 ± 58
Wolf Fork	1,544 ± 118	1,056 ± 137	1,957 ± 71	1,336 ± 542
Tucannon R.	3,524 ± 335	1,329 ±38	1,953 ± 885	3,822 ± 915
Asotin Cr.	0	284 ± 0	17,756 ± 0	9,645 ± 0

Table 3.2 Population density of bull trout and *O. mykiss* (#/100m^2) for each study stream sampled in 1991 (Martin et al. 1992).

	Bull Trout Y-O-Y	Bull Trout Juvenile	0. *mykiss* Y-O-Y	0. *mykiss* Juvenile
Mill Creek	6.0	7.4	4.0	3.5
Wolf Fork	5.5	3.7	6.9	4.7
Tucannon R.	3.9	1.5	2.1	4.2
Asotin Creek	0.0	0.0	28.5	14.3

In 1992, relative abundance data indicated that bull trout and *O. mykiss* abundance were similar among streams when compared to corresponding sample sites R- 1 through R-3. Asotin Creek was not sampled during 1992 due to the small size of the bull trout population. Sample sites were located along an elevational gradient from highest (R-l) to lowest (R-3). Bull trout were more abundant at the highest elevation sites while, *O. mykiss* were most abundant at the lowest elevation sites in each stream (Figure 3.1). No

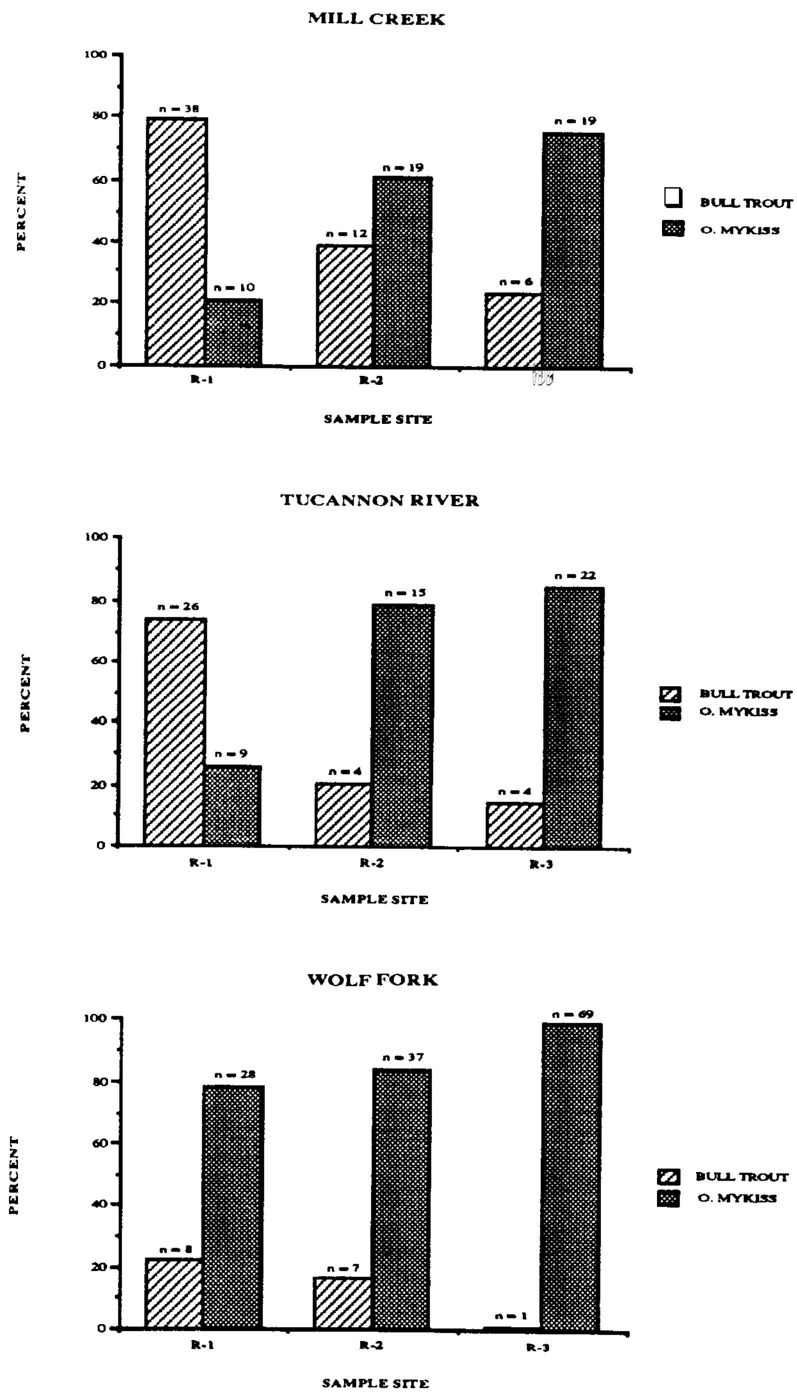

Figure 3.1 Relative abundance of bull trout and *0.* ***mykiss*** by sample site for each stream in 1992.

spring chinook salmon were observed or captured in the sampling sites R-l through R-3 of the Tucannon River.

The population size and density data from 1991 and the relative abundance data from 1992 indicated that bull trout and *O. mykiss* did geographically overlap in all three study streams. However, no *O. mykiss* with marks identifying it as a hatchery origin fish were captured at the population or relative abundance sites in either year. Since the populations of bull trout and *O. mykiss* did overlap, competitive interactions were possible. On the other hand, since no hatchery origin fish were captured among bull trout, it is unlikely that the hatchery origin 0. *mykiss* were directly competing with the wild bull trout.

3.2 AGE AT FORK LENGTH

Based on the data collected in 1990 and 1991, bull trout and *O. mykiss* in Mill Creek were larger than the fish in the Tucannon River or in Wolf Fork (Table 3.3 and 3.4). Mill Creek was the control stream with no supplementation and contained the largest fish. Tucannon River was the most extensively supplemented and contained the smallest bull trout. Wolf Fork was indirectly supplemented and contained medium sized bull trout. The *O. mykiss* in Tucannon River and Wolf Fork were similar in size.

Table 3.3 Bull trout mean fork length (mm) and range for each age class sampled during 1990 and 1991 (Martin et al. 1992).

	BULL TROUT			
	Age: 0+	Age: 1+	Age: 2+	Age: 3t
Mill Creek	55 (30-70) n = 91	110 (90-130) n = 98	160 (135-190) n = 64	235 (199-270) n = 5
Tucannon R.	45 (30-65) n = 21	90 (70- 110) n = 210	145 (115-175) n = 23	195 (168-225) n = 2
Wolf Fork	55 (35-80) n = 26	105 (85-l 15) n = 25	155 (120-185) n = 39	170 (165-175) n = 2
Asotin Cr.			163 n = 1	

Table 3.4 *0. mykiss* mean fork length (mm) and range for each age class sampled during 1990 and 1991. Age determined by length frequency histograms (Martin et al. 1992).

	O. MYKISS			
	Age: 0+	Age: 1+	Age: 2+	Age: 3+
Mill Creek	70 (30-l 10) n = 72	125 (105-145) n = 41	170 (150-185) n = 41	210 (190-235) n= 19
T'ucannon R.	55 (30-65) n = 13	110 (70-130) n = 64	155 (135-175) n = 28	205 (180-225) n= 12
Wolf Fork	65 (30-90) n = 72	110 (95-120) n = 39	150 (125-175) n = 89	205 (180-225) n = 20
Asotin Cr.	50 (30-65) n = 75	120 (70-170) n = 311	200 (175-215) n = 37	240 (220-250) n = 4

Age at fork length was investigated again in 1992 to substantiate the findings of 1991. Table 3.5 and Figure 3.2. gives the mean fork length of bull trout by age captured in each study stream. The fork lengths of 1+ bull trout were significantly different among study streams (F = 11.3, P < 0.01, α=0.05, one-way ANOVA). Scheffe's F test (a = 0.05) indicated that Mill Creek bull trout (n = 5) were longer at age 1+ than Tucannon River bull trout (n = 4) (P < 0.01) and Wolf Fork bull trout (n = 14) were longer than the Tucannon River bull trout (P = 0.01). However, Mill Creek bull trout were not significantly longer than Wolf Fork bull trout. Age 2+ bull trout lengths were, also, significantly different among study streams (F = 30.2, P < 0.01, a = 0.05, one-way ANOVA). Mill Creek bull trout (n = 16) were longer than Tucannon bull trout (n = 10) (P < 0.01, a = 0.05) and Wolf Fork bull trout (n = 4) were longer than Tucannon bull trout (P = 0.01, a = 0.05). At age 3+ the sample size was too small to test for differences among stream populations. Overall, bull trout fork length was the longest in Mill Creek, the shortest in Tucannon River and intermediate in Wolf Fork for ages 1+ and 2+ fish. These 1992 results confirmed those found in 1991.

Table 3.6 and Figure 3.3 gives the mean fork length of 0. *mykiss* by age captured in each study stream. Fork length at age 1+ was significantly different among study streams (F = 4.8, P = 0.01, a = 0.05, one-way ANOVA). Scheffe's F test (a = 0.05) indicated that both Tucannon River (n = 11) and Wolf Fork 0. *mykiss* (n = 33) fork lengths were longer than Mill Creek fish (n = 13) (P = 0.01). Fork lengths of Tucannon River and Wolf Fork

Table 3.5 Bull trout mean fork length (mm) and standard deviation for each age class sampled during 1992. The notation n/s indicates no sampling. Age determined by otoliths

	BULL TROUT Age: 1+	Age: 2+	Age: 3+
Mill Creek	142 ± 18 n = 5	161 ± 14 n= 16	210 n = 1
Tucannon R.	90 ± 21 n = 4	119 ± 12 n = 4	141 ± 17 n = 4
Wolf Fork	124 ± 10 n = 14	147 ± 4 n = 14	222 ± 0 n = 2
Asotin Cr.	n/s	n/s	n/s

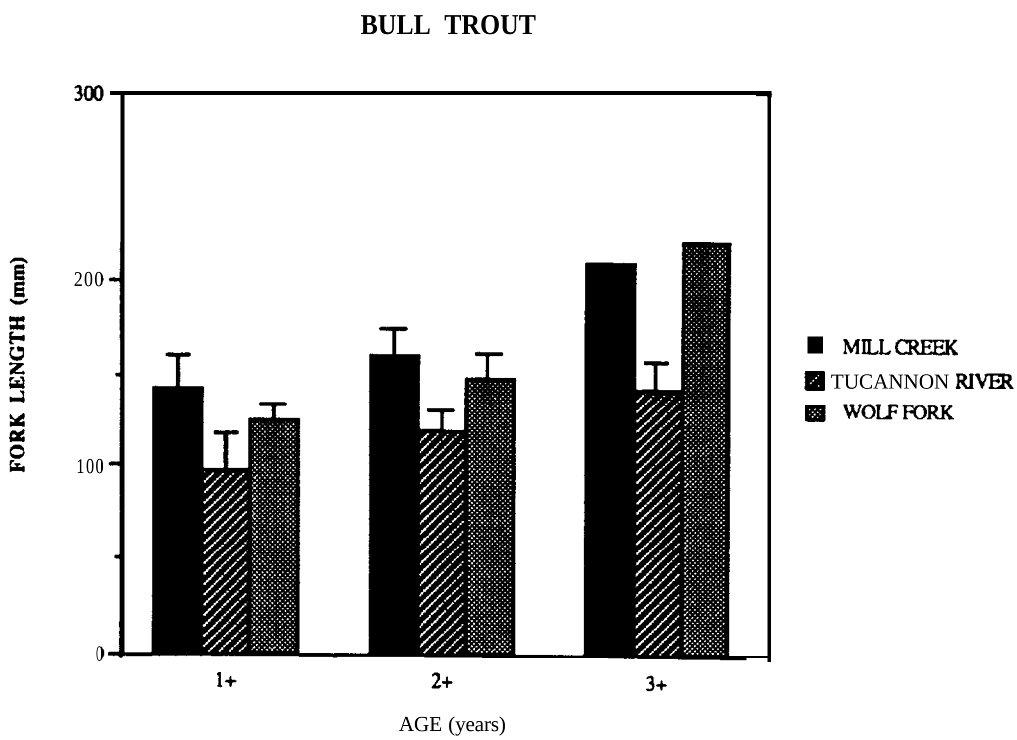

Figure 3.2 Captured bull trout mean fork length at age (error bars indicate standard deviation at 95% confidence interval) based on otoliths collected in 1992.

Table 3.6 *0. mykiss* mean fork length (mm) and standard deviation for each age class sampled during 1992. The notation n/s indicates no sampling. Age determined by scales.

0. MYKISS			
	Age: 1+	Age: 2+	Age: 3+
Mill Creek	106 ± 21 n= 13	144 ± 16 n = 10	183 ± 33 n = 14
Tucannon R.	127 ± 17 n= 11	163 ± 18 n= 18	180 ± 12 n= 7
Wolf Fork	122 ± 18 n = 33	158 ± 23 n= 16	183 ± 11 n= 11
Asotin Cr.	n/s	n/s	n/s

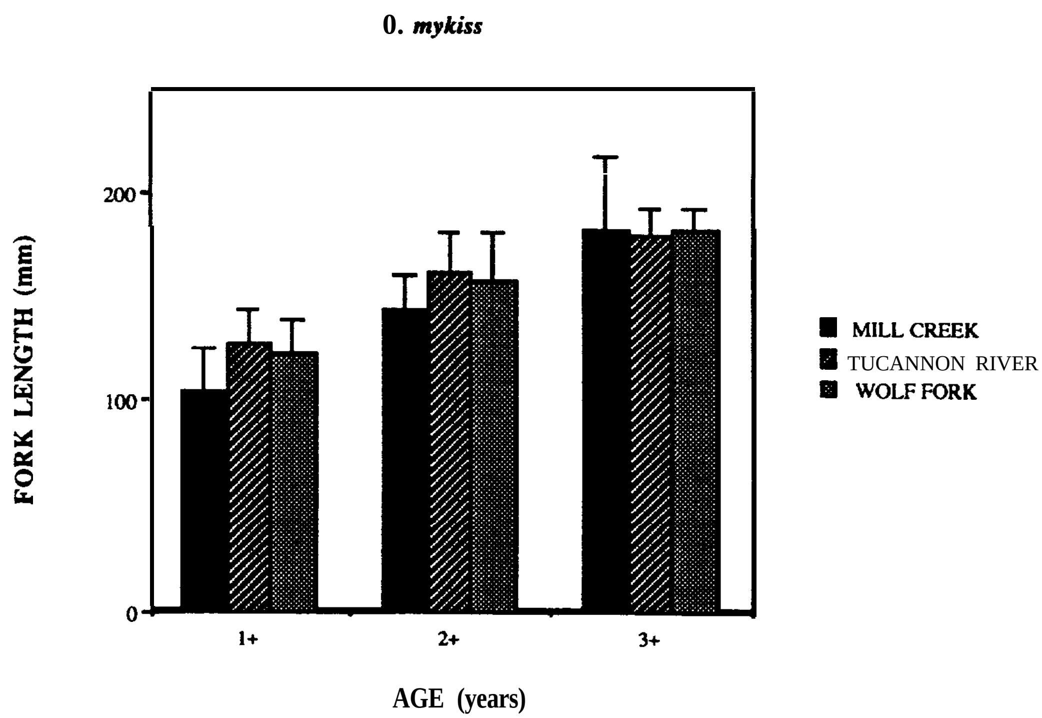

Figure 3.3 Captured 0. ***mykiss*** mean fork length at age (error bars indicate standard deviation) based on scales collected during 1992.

populations were not significantly different (P = 0.30). Also, 0. *mykiss* fork length did not significantly differ among study streams for ages 2+ (n = 44) and 3+ (n = 32) (F = 2.9, P = 0.07 and *F* = 0.03, *P* = 0.96; *a* = 0.05, one-way ANOVA). Appendix C lists the length at age of all fish captured during 1992.

3.3 BACK CALCULATIONS,

Length at age was estimated by back-calculation from the data collected in 1992. Figure 3.4 depicts the mean back-calculated fork length of bull trout by age and study stream. Bull trout back-calculated fork length at age I, II, and III were all significantly different among study streams (*F* = 64.9, *F* = 10.6, *F* = 3.8 respectively, and *P* < 0.01 for all; a = 0.05, one-way ANOVA) (Figure 3.4). Scheffe's F test (a = 0.05) indicated that age I Mill Creek bull trout (n = 26) were longer than age I Tucannon River bull trout (n = 19) (P < 0.01) and age I Wolf Fork bull trout (n=20) (P = 0.03). Age I Tucannon River bull trout were shorter than age I Wolf Fork bull trout (*P* = 0.01). Scheffe's F test (a = 0.05) indicated that age II Mill Creek bull trout (n= 22) were longer than Tucannon bull trout (n = 15) (P < 0.01) and Wolf Fork bull trout (n = 6) were longer than Tucannon River bull trout (P= 0.01). At Age III, Mill Creek bull trout (n = 5) were longer than Tucannon bull trout (n = 5) (*P* = 0.01) and Wolf Fork bull trout were longer than Tucannon bull trout (n = 2) (*P* = 0.02). Overall, Mill Creek bull trout growth was fastest, Tucannon River bull trout growth was slowest and Wolf Fork bull trout growth was intermediate for age groups I, II and III.

Figure 3.5 presents the back-calculated fork length of *O. mykiss* by study stream and age. The fork length of ages I (*F* = 17.1, *P* = O.Ol), II (*F* = 10.4, *P* < O.Ol), and III (*F* = 3.8, *P = 0.03) 0. mykiss* were all significantly different among study streams (a = 0.05, one-way ANOVA). Scheffe's F test (a = 0.05) indicated that age I Tucannon River *O. mykiss* (n = 38) (*P* < 0.01) and age I Wolf Fork *O. mykiss* (n = 61) (*P* < 0.01) were longer than Mill Creek *O. mykiss* (n = 45). The same was true for age II *O. mykiss*. Scheffe's F test (*a* = 0.05) indicated that age II Tucannon River (n = 27) (*P* < 0.1) and Wolf Fork 0. *mykiss* (n = 28) (P = 0.03) were longer than age II Mill Creek *O. mykiss* (n= 31) Age III *0. mykiss* were, also, longer in Tucannon River (n = 9) (*P* = 0.3) and in Wolf Fork (n = 12) (*P* = 0.03) than in Mill Creek (n = 21). No significant differences were found between Tucannon River and Wolf Fork 0. *mykiss* fork length at ages I. II, or III. Overall,

BULL TROUT

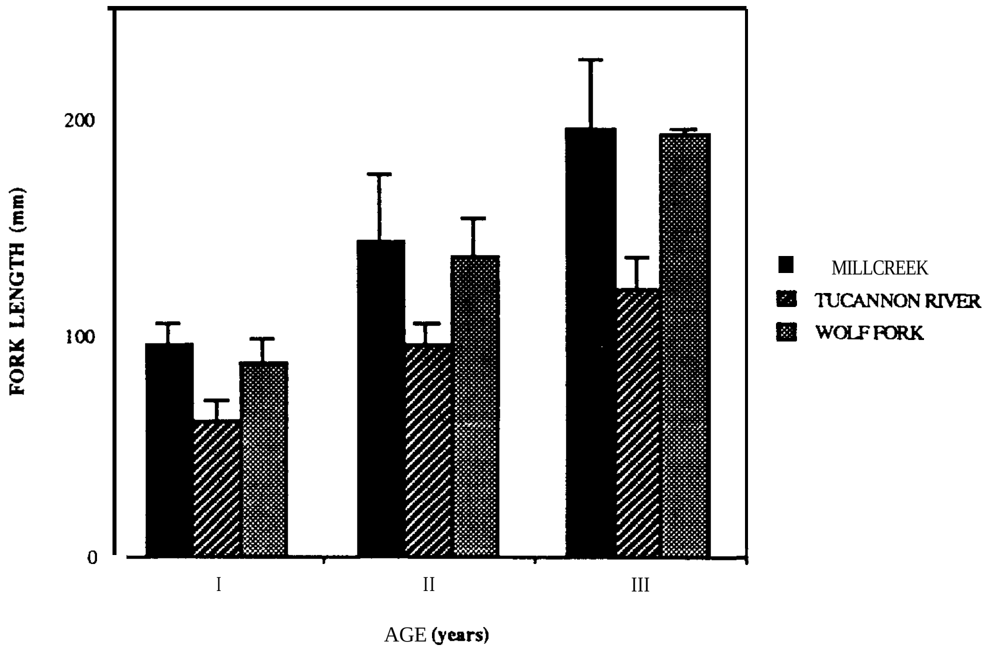

Figure 3.4 Back-calculated fork length at age for bull trout from otoliths collected during 1992.

0. mykiss

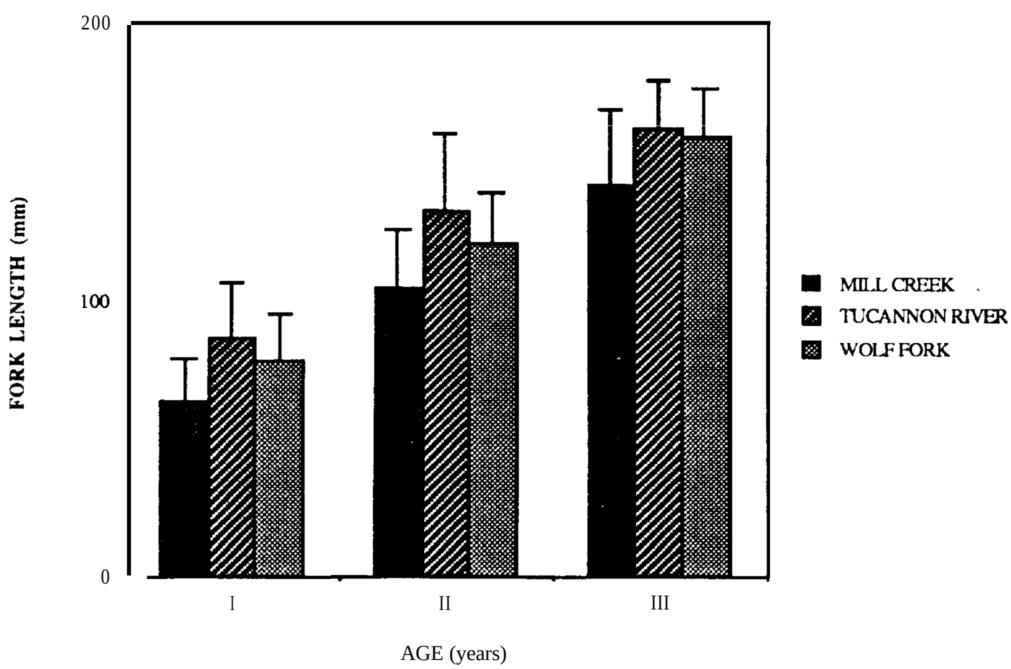

Figure 3.5 Back calculated fork length at age for 0. ***mykiss*** from scales collected during 1992.

Tucannon River and Wolf Fork 0. *mykiss* grew to longer lengths than 0. *mykiss* in Mill Creek. Appendix D reports back-calculated length by cohort.

3.4 CONDITION FACTOR

Based on the data collected in 1991 and 1992, bull trout and *O. mykiss* condition factor did not significantly differ among study streams, sample sites, ages or any combination of the aforementioned variables (a = 0.05, one-way ANOVA). The mean condition factor determined during 1991 and 1992 are listed in Table 3.7 and Appendix C contains the condition factor of each fish captured during 1992.

Table 3.7 Fork length condition factor of fish captured during 1991 and 1992.

	Bull Trout		0. mykiss	
	1991	1992	1991	1992
Mill Creek	1.04 (n = 122)	1.04 (n = 60)	1.19 (n = 141)	1.19 (n = 57)
Tucannon R.	1.10 (n = 54)	1.01 (n = 45)	1.23 (n = 197)	1.13 (n = 53)
Wolf Fork	1.04 (n = 56)	1.00 (n = 29)	1.17 (n = 98)	1.18 (n = 141)
Asotin Creek	N/A	N/A	1.31 (n = 88)	N/A

3.5. AVAILABLE HABITAT

In 1991, stream gradient, percentage of habitat types and elevation of study reaches were found to be similar among study streams (Table 3.8) Water temperatures were also monitored in all four study stream by thermograph during 1991. Summer (June through September) stream temperatures of all the study streams increased steadily until the third week of August and then began to decrease. The mean temperature was highest in Tucannon River (16 “C) and lowest in Mill Creek (11 “C). The average temperature of

Wolf Fork was slightly warmer than Mill Creek by a few tenths of a degree and Asotin Creek's average temperature was approximately 14 °C (Martin et al. 1992).

The water discharge measurements during 1991 indicated that the study streams differed in the amount of discharge (Table 3.9).

Table 3.8 Study stream characteristics measured during 1991 (Martin et al. 1992).

	% Gradient	Study Reach Elevation (m)	HABITAT UNIT TYPE (%) Plunge Pool	Scour Pool	Run	Riffle	Cascade
Mill Cr.	3.1	730-890	0.9%	3.9%	35.8%	30.2%	32.0%
Wolf Fork	3.6	820-960	5.5%	0.3%	19.7%	55.3%	19.2%
Tucannon R.	3.2	900-1150	7.0%	2.9%	42.0%	37.2%	11.0%
Asotin Cr.	2.5	750-960	2.6%	0.7%	33.8%	49.9%	28.1%

Table 3.9 Water discharge of each study stream. The mean, maximum and minimum discharge (c.f.s.) was measured during the last week of June and the first week of July 1991 (Martin et al. 1992).

	Mean	Maximum	Minimum
Mill Creek	29.8	42.3	22.0
Wolf Fork	18.0	34.0	5.0
Tucannon R.	57.9	76.7	39.4
Asotin Creek	47.9	60.3	46.2

Table 3.10 provides a summary of the habitat data collected in 1992. Mean and standard deviation for the physical characteristics, as well as the amount of each habitat type, substrate type and cover type by study stream were tabulated. Few differences were found for the mean width, depth, gradient, water velocity, water discharge and percent of habitat type among study streams. However, the Tucannon River had fewer cascades than Mill Creek (F = 5.23, P = 0.03, n = 12, α = 0.05, one-way ANOVA; $P = 0.04$, $a = 0.05$ Scheffe's F test) and Mill Creek had a greater discharge of water than the Tucannon River (F = 6.66, P = 0.02, n = 11, a = 0.05, one-way ANOVA; P = 0.03, a = 0.05, Scheffe's F test). Care needs to be taken when reviewing this data. The percent of stream surface

Table 3.10 Available habitat and physical characteristics for Mill Creek, Tucannon River and Wolf Fork from data collected in 1992. Embeddedness, substrate type, and cover type are listed as percent classes where, 1 ≤ 5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-75%; and 5 ≥ 76%.

	MILL CREEK	TUCANNON R.	WOLF FORK
'HYSICAL CHARACTER			
WIDTH (M)	7.5±3.0	4.3f0.3	4.9f1.2
DEPTH (FT)	0.77±0.16	0.53±0.19	0.57±0.23
GRADIENT (%)	2.6±1.2	2.9±0.9	3.3k1.7
VELOCITY (FT/S)	1.36±0.52	1.13±0.44	1.54±0.40
DISCHARGE (CFS)	18.99±9.3	3.02±0.42	6.08±5.96
EMBEDDEDNESS	1	2	3
'ABITAT TYPE			
CASCADE (%)	48±28	5±6	37±18
RUN (%)	13±17	18±16	22±14
RIFFLE (%)	28±28	53±23	26±22
PLUNGE POOL (%)	8±12	12±4	10±14
SCOUR POOL (%)	3±3	13±11	5±8
UBSTRATE TYPE			
ORGANIC/SILT	1	1	2
FINES	2	2	2
SMALL GRAVEL	2	2	2
LARGE GRAVEL	2	3	2
SMALL COBBLE	2	2	3
LARGE COBBLE	3	2	2
BOULDER	3	2	3
'OVER TYPE			
FALLEN LOG	1	2	2
SUNKEN WOOD	1	1	1
LOG JAM	1	2	1
ROOT WADE	2	1	1
TOTAL WOOD	2	3	2
BOULDER	2	1	2
UNDERCUT BANK	1	2	2
TURBULENCE	3	2	3
OVERHEAD COVER	4	3	4

area sampled within the study reach of each stream was 1.9% of Mill Creek, 1.6% of the Tucannon River and 2.0% of the Wolf Fork. Due to the small sample size, a great deal of variance was associated with the data. The large variance may have hidden differences among study streams.

Appendix E contains tables of habitat availability and physical characteristics recorded by sample site for each study stream collected during 1992.

3.6. HABITAT UTILIZATION

Based on the findings from the first year of this study, 1991, habitat type utilization and habitat type preference of bull trout and 0. *mykiss* did not appear to differ among study streams (Table 3.11 and 3.12). In all three study streams, bull trout and 0. *mykiss* preferred plunge pool or scour pool habitat. The majority of juvenile bull trout, juvenile 0. *mykiss* and age 0+ 0. *mykiss* observed were using the habitat they preferred most. However, a majority of the age 0+ bull trout in each study stream were not observed using their preferred habitat (Martin et al. 1992). The use of non-preferred habitat may be an indication of interspecific competitive interactions. Age 0+ bull trout subjected to competitive interactions with other fish species could move out of their preferred habitat in order to avoid competitive interactions (Martin et al. 1992). Since age 0+ bull trout exhibited the same behavior in the non-supplemented study stream (Mill Creek) as in the supplemented streams (Tucannon River and Wolf Fork), supplementation could not be implicated as the causative factor.

The utilization and preference of bull trout and 0. *mykiss* for substrate type, overhead cover, woody debris, undercut banks and turbulence were also reported by Martin et al. (1992). No clear trends were observed among study streams or between fish species and, therefore, were not reported here. Martin et al. (1992) describes the habitat utilization and preference observed during 199 1 in greater detail.

During the second year of the study, 1992, microhabitat (i.e., cover type, stream velocity, and substrate type) utilization of bull trout, 0. *mykiss* and spring chinook salmon was measured in each study stream. However, no bull trout in Wolf Fork were observed during the habitat utilization surveys. Therefore, habitat utilization was not determined for

Table 3.11 The top three habitat types utilized and preferred by bull trout in descending order of importance measured during 1991 (Martin et al. 1992).

	AGE 0+		AGE 1+ - 3+	
	Utilization (%)	**Preference (#)**	**Utilization (%)**	**Preference (#)**
Mill Creek	Riffle (35) Cascade (32) Scour Pool (16)	Plunge Pool (1 .O) scow Pool (0.3) Riffle (0.1)	Plunge Pool (23) Run (22) Riffle (20)	Plunge Pool (1.0) Scour Pool (0.3) Riffle (0.1)
Wolf Fork	Riffle (35) Run (34) Cascade (15)	Plunge Pool (1.0) Run (0.6) Cascade (0.0)	Scour Pool (42) Plunge Pool (16) Riffle (16)	Scour Pool (1 .O) Plunge Pool (0.1) Run (0.0)
Tucannon R.	Cascade (34) Plunge Pool (19) Scour Pool (17)	Scour Pool (1 .O) Cascade (0.5) Plume Pool (0.4)	Scour Pool (47) Run (19) Riffle (16)	Scour Pool (1 .O) Plunge Pool (0.1) Run (0.0)

Table 3.12 The top three habitat types utilized and preferred by 0. ***mykiss*** in descending order of importance, measured during 1991 (Martin et al. 1992).

	AGE 0+		AGE 1+ - 3+	
	Utilization (%)	**Preference (#)**	**Utilization (%)**	**Preference (#)**
Mill Creek	Plunge Pool (32) Riffle (21) Cascade (20)	Plunge Pool (1 .O) Scour Pool (0.1) Riffle (0.0)	Run (60) Scour Pool (17) Plunge Pool (11)	Plunge Pool (1 .O) scour Pool (0.2) Run (0.1)
Wolf Fork	scour Pool (30) Riffle (25) Cascade (23)	Scour Pool (1.0) Plunge Pool (0.0) Cascade (0.0)	Scour Pool (50) Run (17) Riffle (15)	Scour Pool (1 .O) Plunge Pool (0.0) Run (0.0)
Tucannon R.	Scour Pool (33) Plunge Pool (28) Cascade (14)	Scour Pool (1 .O) Plunge Pool (0.5) Cascade (0.1)	Plunge Pool (52) Scour Pool (18) Run (11)	Plunge Pool (1.0) Scour Pool (0.5) Cascade (0.1)

bull trout or *O. mykiss* in Wolf Fork. Appendix F list the data collected during the habitat utilization survey.

3.6.1 HABITAT USE BY MILL CREEK FISH

A total of 36 bull trout and 58 0. *mykiss* were observed in Mill Creek. Figure 3.6 indicates the percent utilization of bull trout and 0. *mykiss* by habitat unit type. Figure 3.7 depicts the percent utilization of each species by streambed substrate. The percent utilization of bull trout and 0. *mykiss* in association with cover is indicated in Figure 3.8.

Figure 3.9 depicts the mean and standard deviation of utilization for water velocity, distance to streambed, distance to nearest cover, distance to the nearest fish, and total depth of the stream. No differences were found between bull trout and 0. *mykiss* when water velocity and total depth of steam were compared. Distance from focal point to nearest cover was significantly different between bull trout (mean = 0.06 m) and 0. *mykiss* (mean = 0.43m) (t-value = -2.4, P = 0.02, d.f. 80, α = 0.05, unpaired t test). Distance from focal point to streambed also differed (t-value = -2.94, $P < 0.01$, a = 0.05, unpaired t test). Bull trout were found closer to the streambed (mean = 0.08 ft) than 0. *mykiss* (mean = 0.17 ft).

The fish species in the closest proximity to the fish being measured is reported in Figures 3.10 and 3.11. The closest fish to bull trout were bull trout (65% of the observations) and the closest fish to 0. *mykiss* was 0. *mykiss* (76% of the observations). The mean distance between bull trout and another bull trout was 1.3 m, where as the mean distance between bull trout and 0. *mykiss* was 2.1m. The mean distance between 0. *mykiss* and another 0. *mykiss* was 2.0m (Figure 3.11). Appendix F lists the data collected during the habitat utilization surveys.

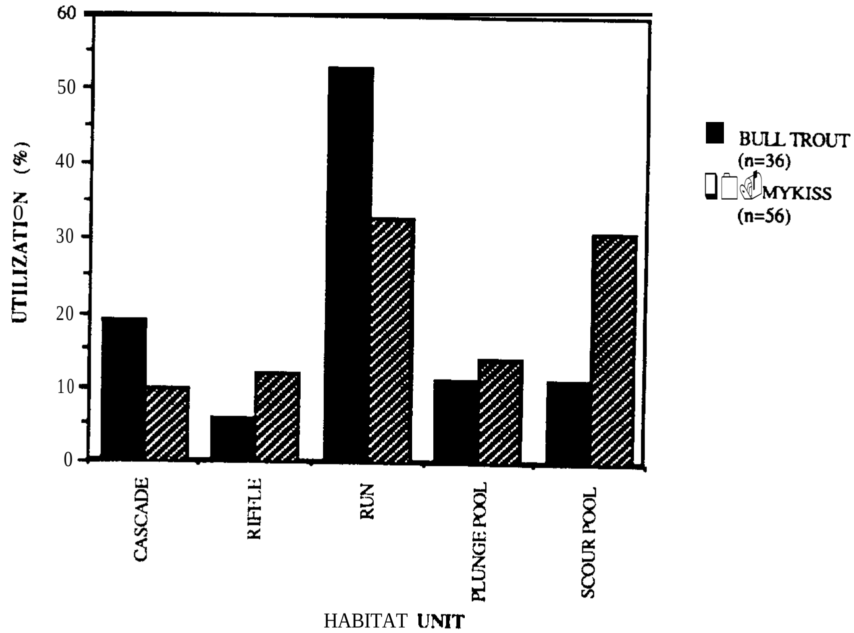

Figure 3.6 Habitat type utilization by all observed bull trout and 0. ***mykiss*** in Mill Creek during 1991.

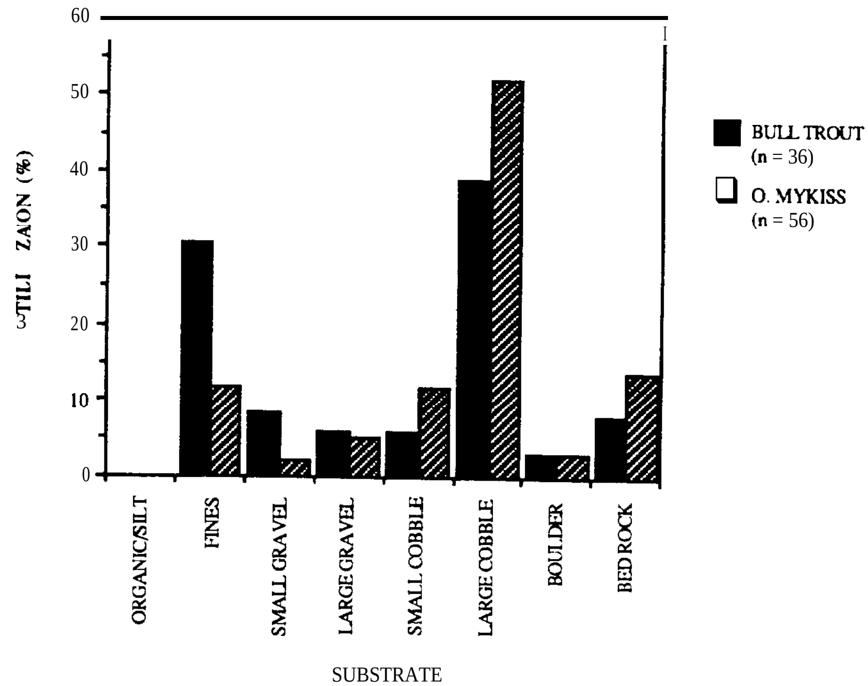

Figure 3.7 Substrate utilization for all bull trout and ***O. mykiss*** observed in Mill Creek during 1992.

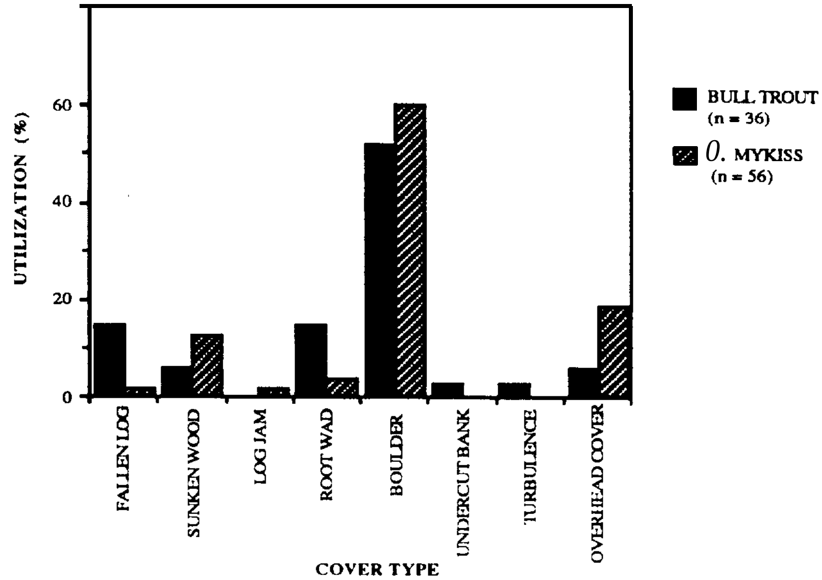

Figure 3.8 Cover utilization of all bull trout and 0. ***mykiss*** observed in Mill Creek during 1992.

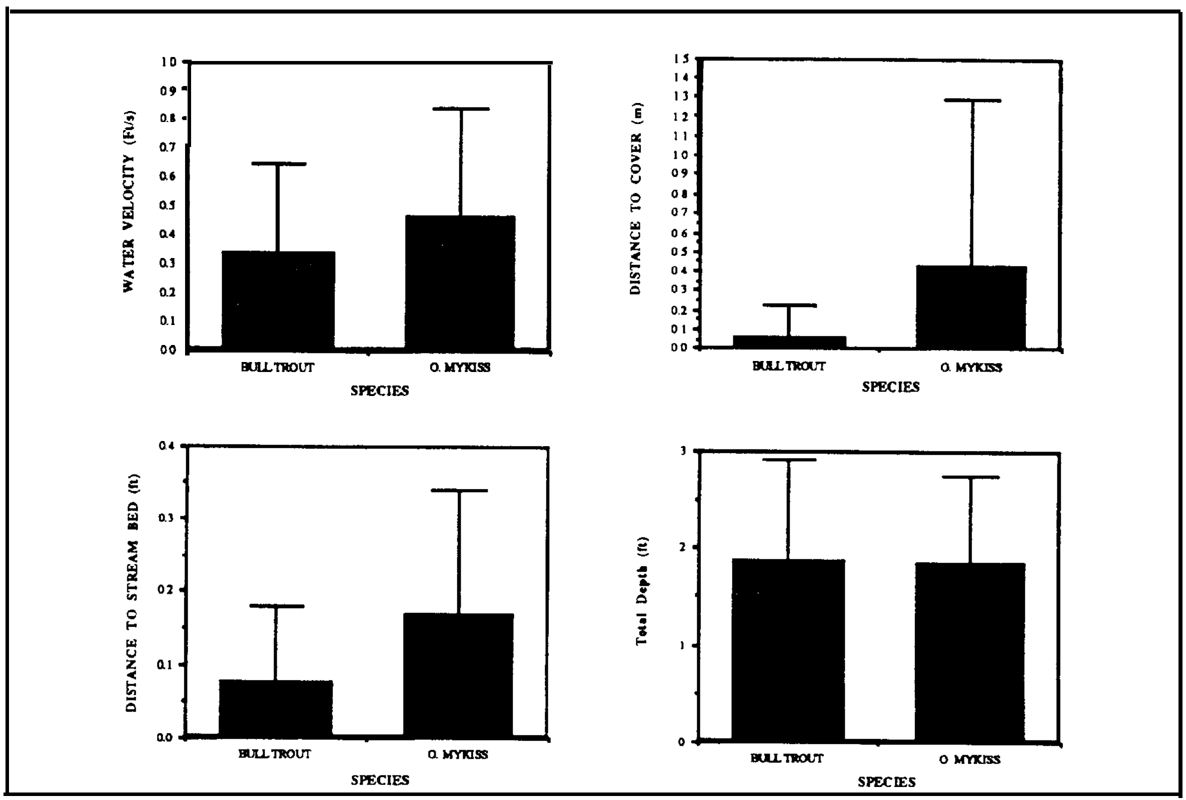

Figure 3.9 Mean water velocity, distance to cover, distance to streambed and total depth of stream for all bull trout and 0. ***mykiss*** in Mill Creek (error bars indicate standard deviation).

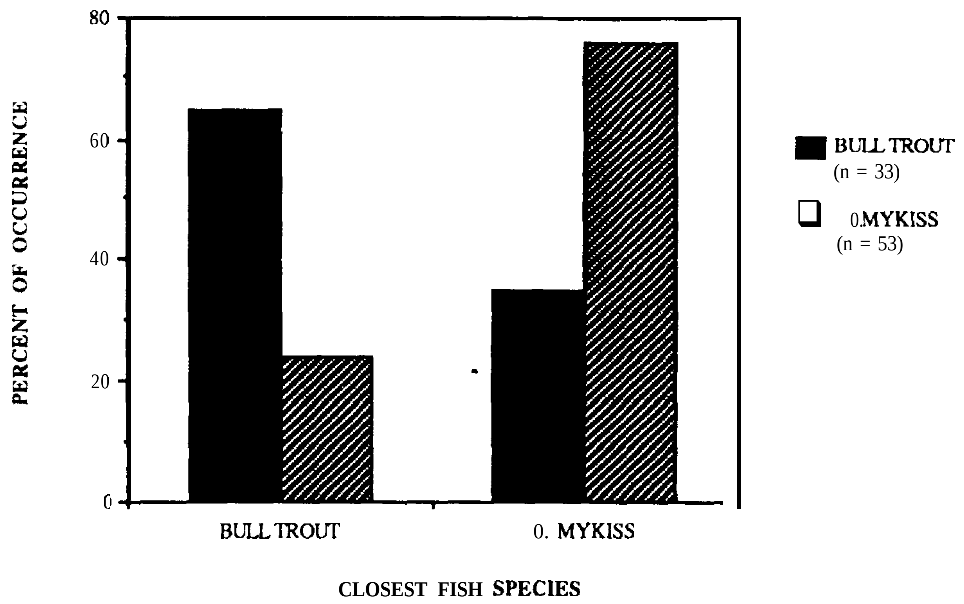

Figure 3.10 Percent occurrence of the closest fish species in proximity to **the bull** trout and 0. ***mykiss*** observed in Mill Creek during **1992.**

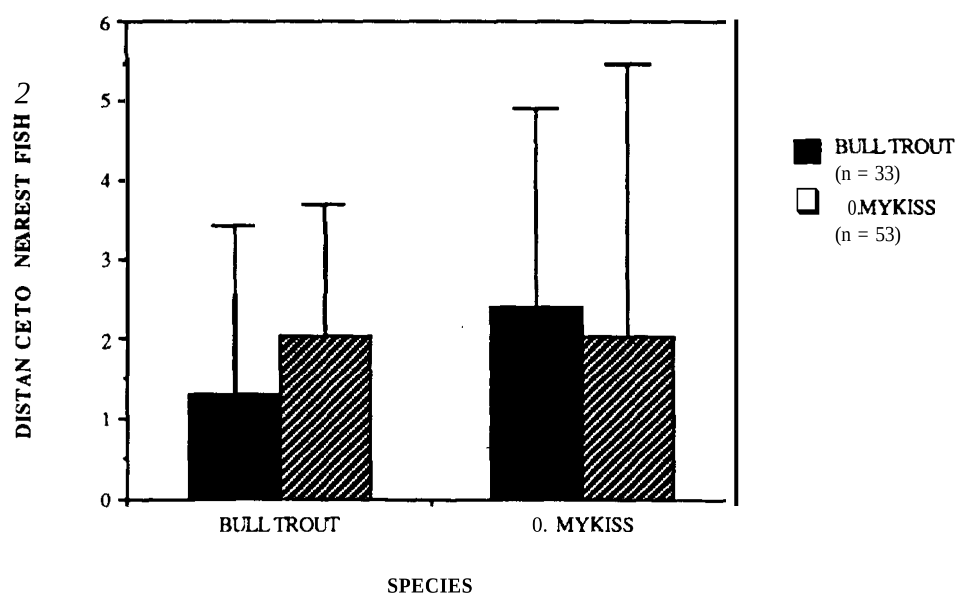

Figure 3.11 Mean distance between species by species for bull trout and *0.* ***mykiss*** with in Mill Creek during 1992 (error bars indicate standard deviation).

3.6.2 HABITAT USE BY TUCANNON RIVER FISH

In the Tucannon River, 21 bull trout, 78 0. *mykiss* and 62 spring chinook salmon were observed. Figure 3.12 indicates the percent utilization of bull trout and 0. *mykiss* by habitat unit type. Figure 3.13 depicts the percent utilization of each species by streambed substrate. Percent utilization for each species by cover type is in Figure 3.14.

Figure 3.15 depicts the mean and standard deviation of utilization for water velocity, distance to streambed, distance to cover and total depth of the stream. No differences were found between the target species when the total stream depth and distance to cover were compared. Distance from focal point to the streambed (F = 8.21, $P < 0.01$, n = 142, a = 0.05; one-way ANOVA) and focal point water velocity (F = 4.27, $P = 0.02$, n = 159, a = 0.05; one-way ANOVA) did significantly differ between fish species. Scheffe's F test (a = 0.05) indicated that the distance from fish to streambed differed significantly between bull trout and *0. mykiss* ($P < 0.01$). Spring chinook salmon also, differed from 0. *mykiss* ($P < 0.01$). Bull trout were closer to the streambed (mean = 0.07 ft, n = 21) than either 0. *mykiss* (mean = 0.15 ft, n = 78) or spring chinook salmon (mean = 0.1 ft, n = 62). Focal point water velocity only differed between spring chinook salmon and *0. mykiss* (P = 0.03). 0. *mykiss* was in faster moving water (mean = 0.73 ft/s, n = 78) than spring chinook salmon (mean = 0.48 ft/s, n = 60). Bull trout were utilizing water velocities (mean = 0.49 ft/s, n = 21) similar to spring chinook salmon.

The fish species in the closest proximity to the fish being measured is reported in Figures 3.16 and 3.17. The closest fish to bull trout were bull trout (39% of the observations), the closest fish to 0. *mykiss* was spring chinook salmon (78% of the observations). The mean distance between bull trout and another bull trout was 0.75m and the mean distance between 0. *mykiss* and spring chinook salmon was 2.3m (Figure 3.17).

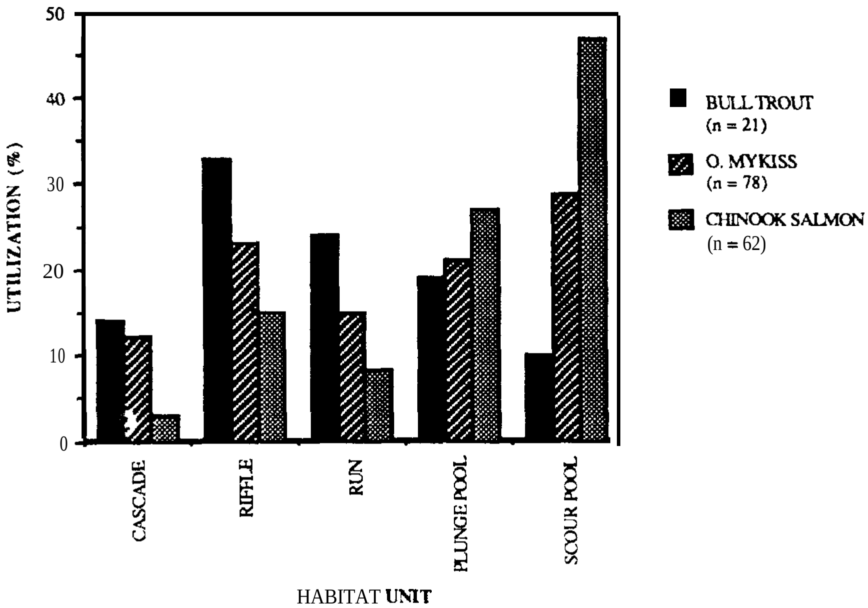

Figure 3.12 Habitat type utilization by all observed bull trout, *0.* ***mykiss*** and spring chinook salmon in Tucannon River during 1992.

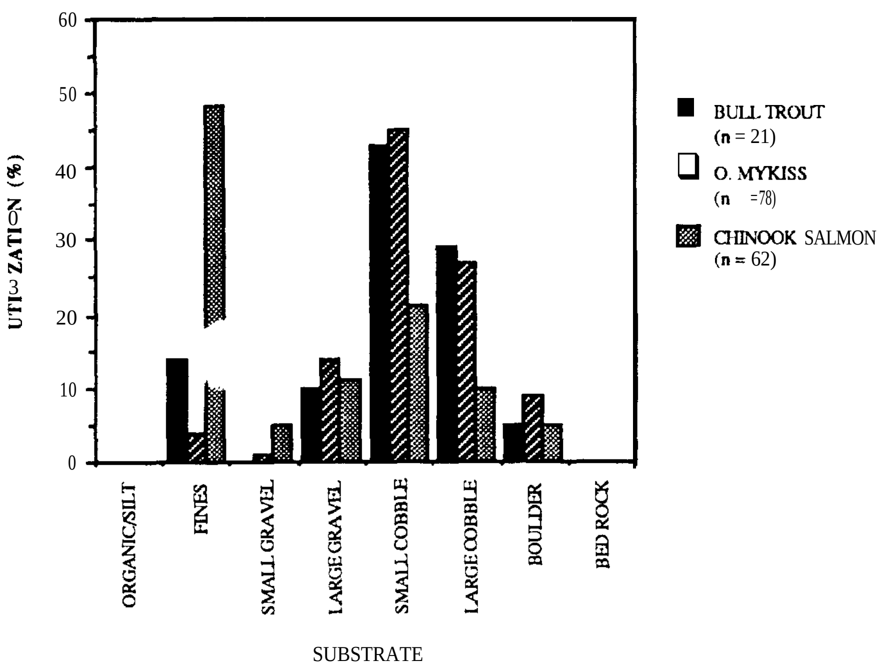

Figure 3.13 Substrate utilization for all bull trout, 0. ***mykiss*****,** and spring chinook salmon observed in the Tucannon River during 1992.

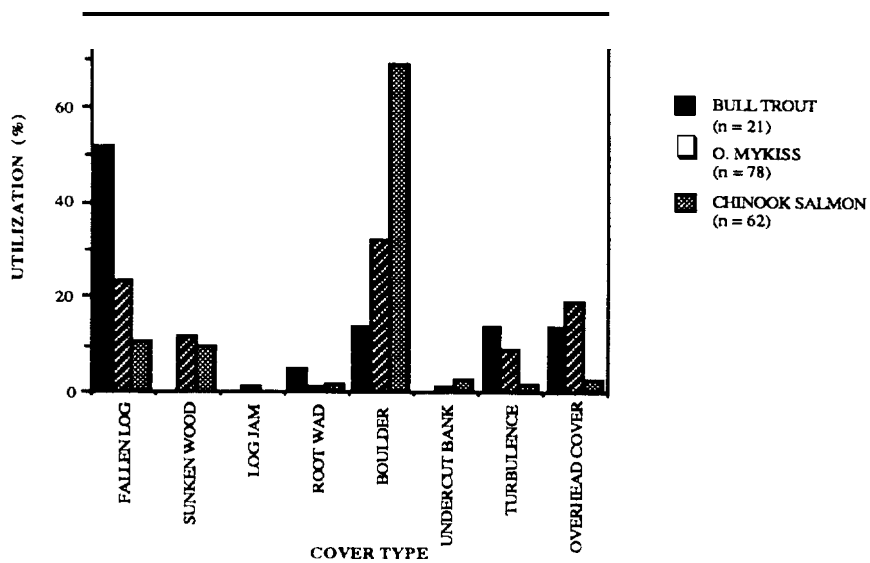

Figure 3.14 Cover utilization of all bull trout, 0. **mykiss** and spring chinook salmon observed in Tucannon River during 1992.

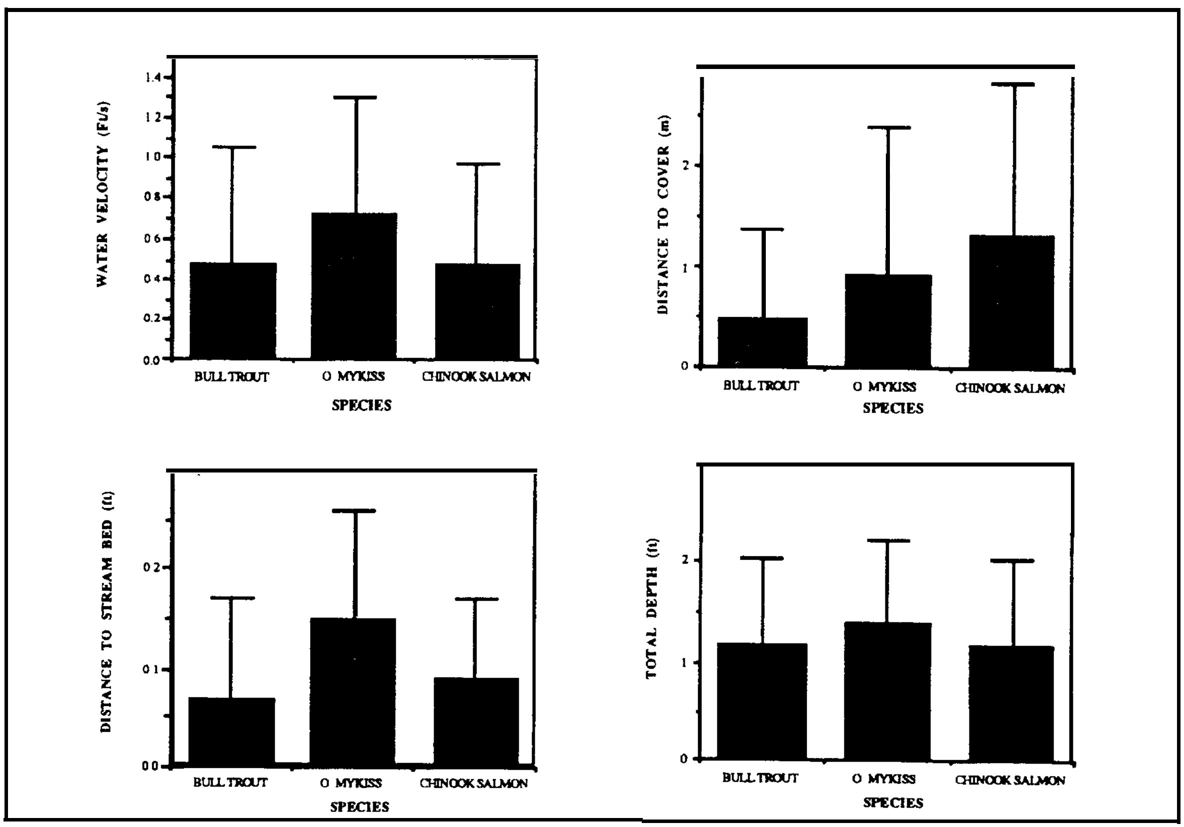

Figure 3.15 Mean water velocity, distance to cover, distance to streambed and total depth of stream for each species sampled in the Tucannon River (error bars = standard deviation).

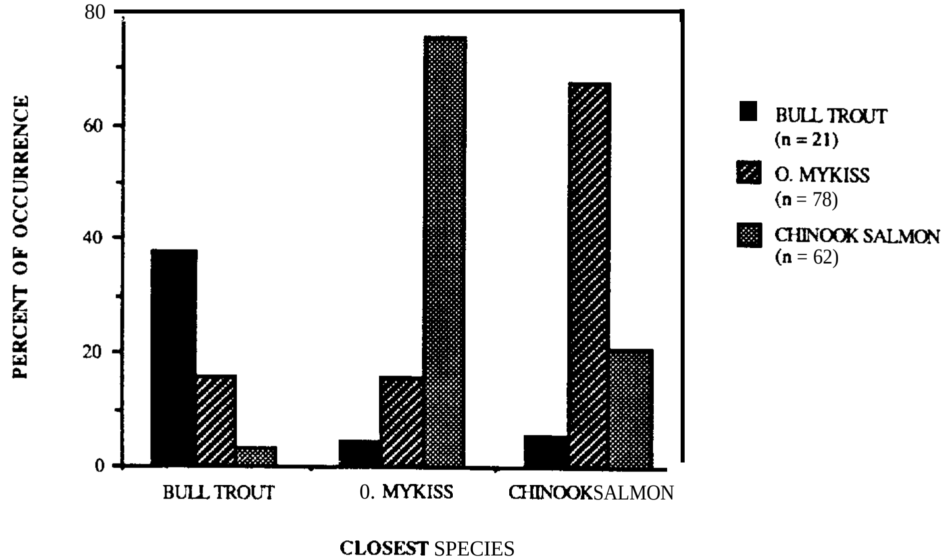

Figure 3.16 Percent occurrence of the closest fish species in proximity to the bull trout, 0. ***mykiss*** and spring chinook salmon observed in the Tucannon River during 1992..

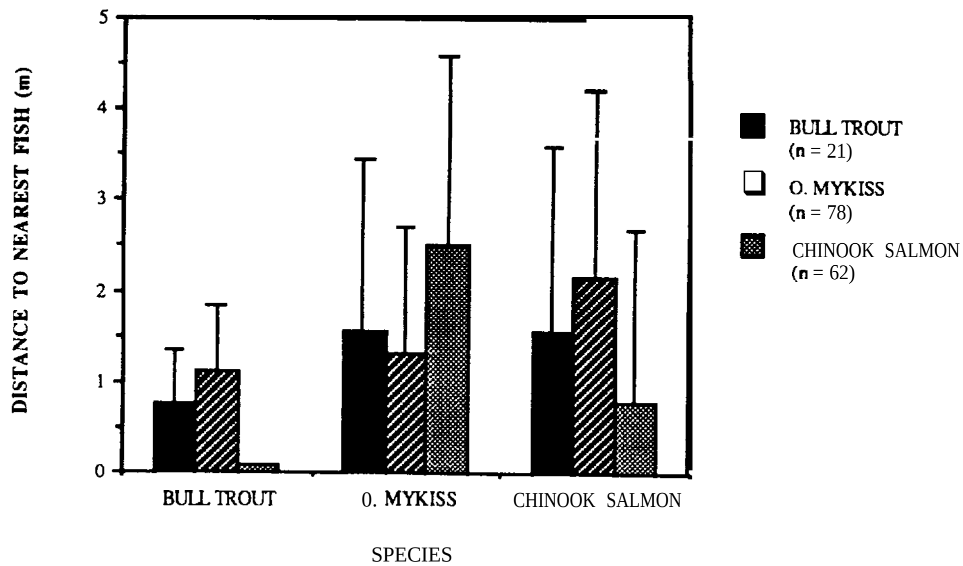

Figure 3.17 Mean distance between species by species for bull trout, 0. ***mykiss*** and spring chinook salmon in the Tucannon River during 1992 (error bars indicate standard deviation).

3.6.3 HABITAT USE BETWEEN STUDY STREAMS

The habitat utilization of all bull trout and *O. mykiss* observed in 1992 were compared between Mill Creek and the Tucannon River by an unpaired one-tailed t test *(a = 0.05).* The same comparisons were made for age 1+ bull trout and 0. *mykiss.* Both age 1+ fish and all fish regardless of age identified the same significant differences for habitat utilization between stream populations.

Habitat use of bull trout in Mill Creek did not differ significantly from bull trout in the Tucannon River for the following variables: focal point water velocity; distance from focal point to nearest cover; distance from focal point to streambed and distance from focal point to nearest fish. However, Mill Creek bull trout did differ from Tucannon River bull trout for utilization of total stream depth at focal point (t value = 2.70, P = 0.01, d.f. = 48). Bull trout in Mill Creek were in deeper water (1.8±0.88 ft) than Tucannon River bull trout (1.1±0.33 ft).

Habitat use of 0. *mykiss* in Mill Creek did not differ significantly from 0. *mykiss* in Tucannon River for the following variables: focal point water velocity; distance from focal point to nearest cover; and distance from focal point to nearest fish. Mill Creek and Tucannon River 0. *mykiss* did differ significantly for utilization of total stream depth at focal point (t value = 3.74, $P < 0.01$, d.f = 90) and for distance from focal point to the streambed (t value = 2.45, P = 0.02, d.f. = 90). Mill Creek 0. *mykiss* were in deeper water (1.89fl.l ft) than Tucannon River 0. *mykiss* (1.4±0.82 ft.) and 0. *mykiss* in Mill Creek were on average farther from the streambed (0.17±0. 17 ft) than 0. *mykiss* in the Tucannon River (0.15±0.1 lft).

The use of deeper water by bull trout and 0. *mykiss* in Mill Creek does not appear to be due to a change in habitat utilization, but a difference in the available habitat. The available habitat data collected during 1992 indicated that Mill Creek was deeper (0.77±0. 16 ft) on average than Tucannon River (0.53±0. 19 ft). Since both bull trout and 0. *mykiss* in Mill Creek were found using deeper water in Mill Creek, it appears that the bull trout and 0. *mykiss* had not changed their utilization behavior but instead were using what was available.

The proximity of bull trout to the fish being measured, substrate type, habitat type and cover type, were also compared between study streams. Bull trout utilized different cover type and habitat unit type when compared between streams, but did not differ for the nearest fish species in proximity of the fish being measured or for substrate type utilized. Mill Creek bull trout were most frequently in association with boulder cover (47%) and Tucannon River bull trout were most frequently in association with fallen logs (79%). Mill Creek bull trout were most often within runs (53%) and Tucannon River bull trout were most often within riffles (33%).

0. *mykiss* also differed between Mill Creek and Tucannon River populations in their frequency of association with cover and habitat type. Boulders (52%) were the most frequently used cover in Mill Creek and turbulence (32%) was the most frequently used in Tucannon River. 0. *mykiss* were most frequently within runs (31%) in Mill Creek and within scour pools (41%) in the Tucannon River.

Habitat utilization differences between the bull trout and 0. *mykiss* stream populations appears to be due to the availability of cover. Boulders (6% to 25%) were more predominant in Mill Creek than fallen logs (<5%). The opposite was true in the Tucannon River. Fallen logs (6% to 25%) were more predominant in the Tucannon River than boulders (<5%).

3.7 AVAILABLE FOOD

3.7.1 BENTHIC SAMPLES

In 1991, the macroinvertebrate density and taxa structure were similar for each study stream. The total abundance (#/m^2) of benthic macroinvertebrates was 26,480; 20,383, and 16,678 for Mill Creek, Tucannon River and Asotin Creek, respectively. Diptera and Ephemeroptera were the two most prevalent macroinvertebrates in all study streams. For a complete listing of the taxa and density of macroinvertebrates sampled, consult the 1991 annual report (Martin et al. 1992).

In 1992, a total of 12 Hess samples were taken from each study stream. Table 3.13 gives the mean density of macroinvertebrates per m^2 by Order. The total abundance (#/m^2) of benthic macroinvertebrates was 13,445; 6,175 and 6,015 for Mill Creek, Tucannon River and Wolf Fork, respectively.

Diptera larvae were the most abundant macroinvertebrates in all three study streams followed by Ephemeroptera nymphs (Table 3.10). Overall, the percent composition of organisms were similar between Mill Creek and Wolf Fork, but the Tucannon River differed slightly (Table 3.14).

3.7.2 DRIFT SAMPLES

A total of eight drift samples were taken from each study stream during 1992. Table 3.15 indicates the mean number of macroinvertebrates per $100m^3$ of water by aquatic and terrestrial taxa. Each stream was similar in the total number of macroinvertebrates suspended in the water column. Mill Creek had an average of 261 macroinvertebrates/$100m^3$, Tucannon River had 304 macroinvertebrates/$100m^3$ and Wolf Fork contained 250 macroinvertebrates/$100m^3$. Appendix G contains the percent by number, percent by weight and mean number of organisms as well as the mean weight per $100m^3$, grouped by Family.

Table 3.16 gives the percent composition of macroinvertebrates suspended in the water column by order. Ephemeroptera nymphs were the most abundant macroinvertebrate followed by Diptera larvae for all three streams. The streams also were similar in the percent of aquatic and terrestrial macroinvertebrates suspended in the water column. Drift from Mill Creek was composed of 9 1% aquatic and 9% terrestrial macroinvertebrates. Drift from the Tucannon River was composed of 93% aquatic and 7% terrestrial macroinvertebrates and drift from Wolf Fork contained 90% aquatic and 10% terrestrial macroinvertebrates.

Table 3.13 Mean number of benthic macroinvertebrates per m^2 for each study stream collected during 1992 (n = 12/stream).

TAXA	Mill Creek Mean	Mill Creek S.D.	Tucannon River Mean	Tucannon River S.D.	Wolf Fork Mean	Wolf Fork S.D.
Diptera	6,628	4,576	1,624	1,167	2,720	1,895
Ephemeroptera	4,862	4,716	1,595	382	2,058	1,544
Plecoptera	788	1,097	548	205	404	414
Trichoptera	288	378	656	267	234	224
Coleoptera	248	344	1,033	551	202	217
Oligocheata	362	642	427	153	98	137
Nematoda	8	13	63	74	24	44
Tricladida	124	210	193	67	186	222
Mollusca	33	58	28	39	28	26
Hydracarina	56	69	9	13	39	47
Ostracoda	10	14	2	3	18	22
Copapoda	39	78	0		3	7
Lepidoptera	1	2	0		1	2
GRAND MEAN	13,445	11,713	6,176	2,711	6,015	3,654

Table 3.14 Percent composition by number of benthic macroinvertebrates for each study stream collected during 1992.

TAXA	Percent Abundance by Number: Mill Creek	Tucannon River	Wolf Fork
Diptera	49.3	26.3	45.2
Ephemeroptera	36.2	25.8	34.2
Plecoptera	5.9	8.9	6.7
Trichoptera	2.1	10.6	3.9
Coleoptera	1.8	16.7	3.4
Oligocheata	2.7	6.9	1.6
Nematoda	0.1	1.0	0.4
Tricladida	0.9	3.1	3.1
Mollusca	0.2	0.5	0.5
Hydracarina	0.4	0.1	0.7
Ostracoda	0.1	0.0	0.3
Copapoda	0.3	0.0	0.1
Lepidoptera	0.0	0.0	0.0

Table 3.15 Mean density ($\#/m^3$) of **drift macroinvertebrates per 100 m3 for** each stream collected during 1992.

	Mill Creek		Tucannon River		Wolf Fork	
AQUATIC	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Diptera Larvae	88.8	94.1	66.1	85.5	82.4	**86.9**
Diptera Pupa	3.3	5.6	0.5	0.9	0.1	0.3
Ephemeroptera Nymph	125.0	105.7	136.0	162.4	**94.1**	109.6
Plecoptera Nymphs	3.1	2.9	16.0	24.2	6.6	10.1
Trichoptera Larvae	4.3	3.2	28.9	42.4	9.0	10.8
Trichoptera Pupa	0.2	0.4			0.4	0.7
Coleoptera Larvae	1.8	1.8	17.7	17.5	6.0	6.8
Coleoptera Adults	0.7	0.6	5.4	4.8	1.0	1.0
Oligocheata	0.5	1.0			1.0	1.8
Nematoda	**0.1**	0.2			0.3	0.7
Tricladida	0.1	0.2	7.2	13.1	8.6	15.9
Bivalvia	0.2	0.3	0.5	0.6	0.6	1.1
Hydracarina	6.8	8.3	4.0	7.0	7.8	12.0
Ostracoda	2.3	3.6	1.0	1.4	6.0	12.0
Lepidoptera Larvae	0.0	0.1				
TERRESTRIAL						
Diptera Adult	15.8	17.9	10.1	16.3	16.3	13.1
Ephemeroptera Adult	1.0	1.3	1.2	2.3	2.0	1.7
Lepidoptera Adult	0.0	0.0	0.7	1.2	0.9	1.6
Hymenoptera Adult	1.8	2.4	4.1	5.3	2.5	2.9
Homoptera Adult	0.7	0.8	1.3	1.9	2.4	4.5
Hemiptera Adult	0.6	0.9	0.1	0.2	0.9	1.8
Orthoptera	0.0	0.1				
Gastropoda			0.3	0.6		
Arachnid	2.1	2.8	2.6	4.1	0.3	0.5
Coleoptera Adult	0.9	1.0	0.1	0.3	0.5	0.9
MEAN						
AQUATIC	237	228	283	359	224	270
TERRESTRIAL	**23**	28	20	32	26	27
GRAND	260	256	304	392	250	297

Table 3.16 Percent composition by number of drift macroinvertebrates in each stream during 1992.

	Percent Abundance by Number		
AQUATIC	**Mill Creek**	**Tucannon River**	**Wolf Fork**
Diptera Larvae	34.1	21.7	33.0
Diptera Pupa	1.3	0.1	0.1
Ephemeroptera Nymph	47.9	44.7	37.7
Plecoptera Nymphs	1.2	5.3	2.7
Trichoptera Larvae	1.6	9.5	3.6
Trichoptera Pupa	0.1		0.2
Coleoptera Larvae	0.7	5.8	2.4
Coleoptera Adults	0.3	1.8	0.4
Oligocheata	0.2	-	0.4
Nematoda	0.0	-	0.1
Tricladida	0.0	2.4	3.4
Bivalvia	0.1	0.2	0.2
Hydracarina	2.6	1.3	3.1
Ostracoda	0.9	0.5	2.4
Lepidoptera Larvae	0.1		
TERRESTRIAL			
Diptera Adult	6.1	3.3	6.5
Ephemeroptera Adult	0.4	0.4	0.8
Lepidoptera Adult	0.1	0.3	0.3
Hymenoptera Adult	0.7	1.3	1.0
Homoptera Adult	0.3	0.4	0.9
Hemiptera Adult	0.2	0.0	0.4
Orthoptera	0.0	-	-
Gastropoda	-	0.1	-
Arachnid	0.8	0.9	0.1
Coleoptera Adult	0.3	0.0	0.2
TOTAL			
AQUATIC	**91**	93	90
TERRESTRIAL	9	7	**10**

3.8 DIET ANALYSIS

3.8.1 DATA COLLECTED DURING 1991

Bull trout and *O. mykiss* from Mill Creek and Tucannon River had a mean diet overlap of 47% and 50%, respectively. Diet overlap between 30% and 70% indicates a potential for competition for food, however, only values greater than 70% are considered to be significant (Strauss 1979) As a result, the bull trout and 0. *mykiss* in Mill Creek and the Tucannon River could potentially be competing for food. Bull trout and 0. *mykiss* in Wolf Fork had a mean diet overlap of 83% (Martin et al. 1992). The diet overlap in Wolf Fork appeared to be significant which suggests that competitive interactions for food were occurring.

The diet of spring chinook salmon was not sampled during 199 1 because of a petition to list the species under the ESA. However, diet overlap was determined between bull trout and spring chinook salmon based upon diet analysis that was conducted with spring chinook salmon during 1989 in the Tucannon River (Bugert et al. 1990). The data collected on bull trout diet during 1991 was compared with data collected from spring chinook salmon during 1989. Diet was found to overlap 8% between bull trout and spring chinook salmon (Martin et al. 1992). Based on these finding, the potential for competitive interactions for food was unlikely. However, these data may not be compatible due to the time separation between sampling spring chinook salmon and bull trout.

The Index of Relative Importance (IRI) indicated that Ephemeroptera was the only taxa of the top three food items, to be important to both bull trout and 0. *mykiss* (Table 3.17). Bull trout fed mostly on food items of aquatic origin and 0. *mykiss* fed on a mix of terrestrial and aquatic food items (Martin et al. 1992).

Table 3.18 gives the top two food items of bull trout and 0. *mykiss* from the Electivity Index using 1991 data. Electivity Index determines the importance of a food item by comparing the percent occurrence of a food item in the stomach of a fish to the percent occurrence of that food item within the environment. Terrestrial macroinvertebrates were found in both bull trout and 0. *mykiss* stomachs, indicating that both fish species were feeding on drifting organisms. However, drift samples were not sampled during 1991. The importance of terrestrial origin food items may have been underestimated by the Electivity Index. Drift samples were taken during 1992 to further investigate this point.

Table 3.17 The three most important food items of bull trout and 0. ***mykiss,*** based on the index of relative importance in 1991 (Martin et al. 1992).

	MILL CREEK		WOLF FORK		TUCANNON RIVER	
	Bull trout	0. mykiss	Bull trout	0. mykiss	Bull	0. mykiss
1	Cottidae	Ephemeroptera	Plecoptera	Oligocheata	Oligocheata	Plecoptera
2	Ephemeroptera	Terrestrial	Ephemeroptera	Ephemeroptera	Diptera	Ephemeroptera
3	Plecoptera	Gastropoda	Tricoptera	Terrestrial	Ephemeroptera	Terrestrial

Table 3.18 The two most important food items of bull trout and 0. ***mykiss*** based on the **electivity** index 1991 (Martin et al. 1992).

	MILL CREEK		WOLF FORK		TUCANNON RIVER	
	Bull	O. mykiss	Bull	O. mykiss	Bull	O. mykiss
1	Ephemeroptera	Ephemeroptera	Tricoptera	Tricoptera	Ephemeroptera	Tricoptera
2	Plecoptera	Tricoptera	Plecoptera	Mollusca	Oligocheata	Ephemeroptera

3.8.2 DATA COLLECTED DURING 1992

The diet of bull trout and *0. mykiss* overlapped 77% in Mill Creek, 61% in Tucannon River and 89% in Wolf Fork. The diet of bull trout and *O. mykiss* in Mill Creek and Wolf Fork significantly overlapped where as the diet of bull trout and *O. mykiss* in Tucannon River did not. This suggests competitive interactions for food may be occurring in Mill Creek and Wolf Fork but competition for food was less likely in the Tucannon River.

Mill Creek

The IRI indicated that Baetidae nymphs, *O. mykiss* and Chironomidae larvae were the three most important food items of bull trout (Table 3.19) The three most important food items of 0. *mykiss* were Baetidae nymphs, Simuliidae larvae and Chironomidae larvae. The IRI for all aquatic taxa was 83% for bull trout and 62% for *O. mykiss*. The IRI for all terrestrial taxa was 17% for bull trout and 38% for *O. mykiss*. The electivity indices for bull trout and *O. mykiss* were less than 0.1 for all food items (Table 3.19). There was no strong avoidance or preference for any food item by either species.

Tucannon River.

Table 3.20 gives the IRI and the Electivity Index for bull trout and *O. mykiss* sampled from the Tucannon River. The three most important food items of bull trout were Baetidae nymph, Ranidae larvae, and Chironomidae larvae. For *O. mykiss*, Brachycentridae larvae, Chironomidae larvae, and Baetidae nymphs were the most important food items. The IRI for aquatic taxa was 86% for bull trout and 70% for *O. mykiss*. The IRI for terrestrial taxa was 14% for bull trout and 30% for *O. mykiss*. The Electivity Index indicated no strong avoidance or preference for any food item by either fish species (Table 3.20).

Wolf Fork

Table 3.21 gives the IRI and Electivity Index for each food item eaten by bull trout and *O. mykiss*. The three most important food items determined from the IRI were Baetidae nymphs, Chironomidae larvae and Ephemerellidae nymphs for bull trout. The three most important food items for *O. mykiss* were Baetidae nymph, Chironomidae larvae and Heptageniidae nymphs. When all aquatic taxa were combined bull trout IRI was 83% and *O. mykiss* IRI was 77%. When all terrestrial taxa were combined bull trout IRI was 17% and *O. mykiss* was 23%. Electivity Index indicated no strong avoidance or preference for any food item by bull trout or *O. mykiss* (Table 3.21)

The three most preferred food items for each fish species of each study stream are reported in Table 3.22. Baetidae nymphs and Chironomidae larvae were within the top three ranked food items for bull trout in each stream. Baetidae and/or Brachycentridae were within the top three ranked food items for 0. *mykiss* in each stream.

Table 3.19 Index of relative importance and **electivity** index for bull trout and 0. ***mykiss*** captured in Mill Creek during the summer of 1992.

AQUATIC	RELATIVE IMPORTANCE Bull Trout	*O. mykiss*	ELECTIVITY INDEX Bull Trout	0. *mykiss*
Diptera Larvae				
Chironomidae	9.68	6.02	-0.02	-0.08
Tipulidae	2.03	0.38	0.01	0.00
Simuliidae	7.17	8.69	-0.09	-0.09
Ceratopogonidae	0.41	0.73	0.00	0.00
Empididae	0.81	0.37	0.00	0.00
Pelecorhynchidae	1.26	0.77	0.00	0.00
Diptera Pupa				
Chironomidae	2.96	3.74	0.01	0.01
Tipulidae	0.00	0.37	0.00	0.00
Simuliidae	0.42	1.68	0.00	0.02
phemeroptera Nymph				
Baetidae	15.90	11.76	-0.01	-0.14
Heptageniidae	8.31	2.91	0.06	0.01
Ephemerellidae	4.91	4.58	0.03	0.05
Leptophlebiidae	0.00	0.37	0.00	0.00
Siphlonuridae	0.00	0.39	0.00	0.00
lecoptera Nymph				
Perlidae	2.97	3.52	0.01	0.01
Chlomperlidae	2.05	0.76	0.01	0.00
Nemouridae	1.22	1.13	0.00	0.00
richoptera Larvae				
Limnephilidae	0.47	0.46	0.00	0.00
Hydropsychidae	1.28	0.74	0.01	0.00
Brachycentridae	0.86	3.66	0.00	0.03
Glossosomatidae	2.11	0.81	0.01	0.00
Rhyacophilidae	2.47	1.89	0.00	0.00
Leptoceridae	1.22	0.77	0.00	0.00
richoptera Pupa				
Rhyacophilidae	0.42	0.92	0.00	0.00
oleoptera Larvae				
Elmidae	0.83	0.37	0.00	-0.01
Hydrophilidae	0.81	0.37	0.00	0.00
oleoptera Adult				
Elmidae	1.22	2.31	0.00	0.01
ligocheata	0.86	0.00	0.00	0.00
Iydracarina	**0.00**	0.37	-0.03	-0.02
stracoda	**0.00**	0.37	-0.01	-0.01
epidoptera Larvae	2.07	3.68	0.01	0.01
steichthyes				
Oncorhynchus mykiss	10.90	0.00	0.00	0.00
Cottidae spp.	1.43	0.00	0.00	0.00
legaloptera				
siadidae	0.82	0.00	0.00	0.00

Table 3.19 Continued.

TERRESTRIAL	RELATIVE IMPORTANCE Bull Trout	*O. mykiss*	ELECTIVITY INDEX Bull Trout	*O. mykiss*
Diptera Adult				
Chironomidae	-0.81	0.41	-0.03	-0.03
Bibionidae	1.23	3.19	0.00	0.02
Simuliidae	1.29	1.13	0.01	0.00
Muscioid	0.48	2.45	0.01	0.01
Cecidomyiidae	0.4 1	1.47	-0.01	-0.01
Asilidae	0.41	1.10	0.00	0.00
Ephemeroptera Adult				
Baetidae	0.4 1	3.72	0.00	0.06
Ephemerellidae	0.00	0.37	0.00	0.00
Lepidoptera Adult	0.4 1	0.87	0.00	0.00
Hymenoptera Adult				
Formicidae	0.41	3.25	0.00	0.02
Vespidae	0.00	3.11	0.00	0.01
Tenthredinidae	0.41	0.00	0.00	0.00
Ichneumonidae	1.25	2.51	0.01	0.01
Homoptera Adult				
Cicadcllidae	0.85	2.12	0.00	0.02
Hemiptera Adult				
Macroveliidae	1.24	0.81	0.00	0.00
Gastropoda	**0.00**	1.48	0.00	0.01
Arachnid	1.74	4.43	0.01	0.03
Coleoptera Adult				
Chrysomelidae	0.00	0.47	0.00	0.01
Cleridae	0.81	2.20	0.00	0.03

Table 3.20 Index of relative importance and the **electivity** index for bull trout and 0. ***mykiss*** captured in Tucannon River during the summer of 1992.

AQUATIC	RELATIVE IMPORTANCE Bull Trout	0. *mykiss*	ELECTIVITY INDEX Bull Trout	*O. mykiss*
Diptera Larvae				
Chironomidae	11.04	7.85	-0.02	-0.07
Tipulidae	0.76	1.27	0.01	0.01
Simuliidae	0.74	1.06	-0.02	-0.19
Pelecorhynchidae	2.35	2.19	0.02	0.01
Unknown Dipteral	0.74	0.00	0.01	0.00
Diptera Pupa				
Chironomidae	0.74	0.71	0.01	-0.01
Simuliidae	0.00	0.36	0.00	0.00
Ephemeroptera Nymph				
Baetidae	14.27	6.49	-0.14	-0.36
Heptageniidae	5.41	6.01	0.02	0.05
Ephemerellidae	3.91	2.76	0.01	0.01
Plecoptera Nymph				
Perlidae	1.78	3.78	0.01	0.02
Chloroperlidae	1.49	**0.36**	0.01	0.00
Nemouridae	3.08	1.80	0.00	0.00
Fricoptera Larvae				
Hydropsychidae	4.93	**2.62**	**0.05**	**0.01**
Brachycentridae	0.00	11.00	**-0.02**	**0.31**
Glossosomatidae	1.59	1.59	0.01	0.01
Rhyacophilidae	**4.67**	1.79	**0.03**	**0.00**
Leptoceridae	**4.88**	**4.28**	**0.02**	**0.04**
Tricoptera Pupa				
Rhyacophilidae	0.00	0.89	0.00	0.01
Coleoptera Larvae				
Elmidae	0.00	1.22	-0.06	0.01
Hydrophi Mae	0.00	1.84	0.00	0.01
Coleoptera Adult				
Elmidae	0.74	2.24	0.00	0.01
Hydrophilidae	0.00	**0.37**	**0.00**	**0.00**
Curculionidae	0.00	0.71	0.00	0.00
Oligocheata	10.19	6.21	0.08	0.03
Ostracoda	0.74	0.00	0.00	-0.01
Lepidoptera Larvae	**0.00**	1.62	0.00	0.01
Amphibian Larvae				
Ranidae	13.97	0.00	0.01	0.00

Table 3.20 Continued.

TERRESTRIAL	RELATIVE IMPORTANCE Bull Trout	RELATIVE IMPORTANCE *O. mykiss*	ELECTIVITY INDEX Bull Trout	ELECTIVITY INDEX *O. mykiss*
Diptera Adult				
Chironomidae	0.00	0.38	-0.03	-0.03
Bibionidae	0.74	1.09	0.01	0.00
Simuliidae	0.00	0.71	0.00	0.00
Muscoid	0.76	1.08	0.01	0.00
Cecidomyiidae	1.49	1.47	0.01	0.00
Asilidae	0.00	0.36	0.00	0.00
Ephemeroptera Adult				
Baetidae	2.23	2.74	0.01	0.03
Ephemerellidae	0.75	0.00	0.01	0.00
Lepidoptera Adult	1.51	0.84	0.01	0.01
Hymenoptera Adult				
Formicidae	1.51	4.27	0.00	0.02
Vespidae	0.00	0.51	0.00	0.00
Tenthredinidae	0.00	0.71	0.00	0.00
Ichneumonidae	0.00	1.90	0.00	0.01
Homoptera Adult				
Cicadellidae	0.74	3.31	0.00	0.02
Hemiptera				
Macroveliidae	0.74	0.36	0.01	0.00
Gastropoda	0.00	2.63	0.00	0.02
Arachnid	1.49	2.59	0.00	0.01
Coleoptera Adult				
Staphylinidae	0.00	0.84	0.00	0.00
Diplopoda	0.00	2.45	0.00	0.02

Table 3.21 Index of reiative importance and **electivity** index for bull trout and 0. ***mykiss*** captured in Wolf Fork **during** the summer of 1992.

AQUATIC	RELATIVE IMPORTANCE Bull Trout	RELATIVE IMPORTANCE *O. mykiss*	ELECTIVITY INDEX Bull Trout	ELECTIVITY INDEX *O. mykiss*
Diptera Larvae				
Chironomidae	11.04	10.22	-0.15	-0.11
Tipulidae	1.44	0.00	0.01	0.00
Simuliidae	6.61	1.71	0.02	-0.04
Pelecorhynchidae	0.00	0.58	-0.01	0.00
Unknown Diptera	0.00	0.97	0.00	0.00
Diptera Pupa				
Chironomidae	1.84	0.57	0.02	0.00
Tipulidac	0.88	0.00	**0.01**	**0.00**
Simuliidae	0.87	0.00	0.01	0.00
Ephemeroptera Nymph				
Baetidac	21.2;	15.60	0.06	-0.05
Heptageniidac	7.04	10.13	0.04	0.06
Ephemerellidae	8.89	7.50	0.02	0.04
Plecoptera Nymph				
Perlidae	3.21	1.73	0.01	0.00
Chloroperlidae	0.00	1.15	0.00	0.01
Nemouridae	0.00	0.57	-0.02	-0.01
Trichoptera Larvae				
Hydropsychidae	4.77	3.62	0.04	0.02
Brachycentridae	1.79	7.45	0.00	0.12
Glossosomatidae	0.00	1.33	0.00	0.00
Rhyacophilidae	1.98	3.21	0.01	0.03
Leptoceridae	6.45	3.72	0.05	0.01
Trichoptera Pupa				
Brachycentridae	0.00	0.58	0.00	0.00
Coleoptera Larvae				
Hydrophilidae	0.94	0.60	0.00	0.00
Coleoptera Adult				
Elmidae	0.00	1.92	0.00	0.02
Oligocheata	4.85	7.73	0.01	0.00
Lepidoptera Adult	1.19	0.00	0.01	0.00

Table 3.21 Continued.

TERRESTRIAL	RELATIVE IMPORTANCE Bull Trout	O. *mykiss*	ELECTIVITY INDEX Bull Trout	O. *mykis*
Diptera Adult				
Simuliidae	0.90	0.00	0.01	0.00
Asilidae	0.00	0.57	0.00	0.00
Ephemeroptera Adult				
Baetidae	0.00	4.60	0.00	0.03
Plecoptera Adult				
Perlidae	0.00	1.73	0.00	0.01
Hymenoptera Adult				
Formicidae	5.98	4.80	0.04	0.05
Ichneumonidae	1.88	0.00	0.02	0.00
Homoptera Adult				
Cicadellidae	1.08	0.00	0.00	-0.01
Hemiptera Adult				
Macroveliidae	1.02	0.00	0.01	0.00
Gastropoda	0.00	3.43	0.00	0.01
Arachnid	2.82	2.32	0.02	0.01
Diplopoda	1.31	1.63	0.01	0.01

Table 3.22 Ranked food items of bull trout and O. *mykiss* in order of preference. "N" indicates the ranked level of preference. Multiple food items listed for one ranking indicates equivalent preference in samples.

	N	BULL TROUT	O. MYKISS
MILL CREEK	**1**	Baetidae Nymph	Baetidae Nymph
	2	Chironomidae Larvae Heptageniidae Nymph Ephemerellidae Nymph	Simuliidae Larvae Ephemerellidae Nymph
TUCANNON RIVER	1	Oligocheata	Brachycentridae Larvae
	2	Baetidae Nymph	Chironomidae Larvae
	3	Chironomidae Larvae	Heptageniidae Nymph Oligocheata
WOLF FORK	**1**	Baetidac Nymph	Baetidae Nymph
	2	Chironomidae Larvae	Brachycentridae Larvae Heptageniidae Nymph
	3	Leptoceridae Larvae	

3.9 SPAWNING GROUND SURVEYS

In 1990 and 1991 surveys were conducted to monitor the number of bull trout redds in each study stream. Table 3.23 indicates the number of redds found in 1990 and 1991 (Martin et al. 1992).

Table 3.23 Number and density (#/Km) of bull trout redds observed during 1990 and 1991 (Martin et al. 1992).

	1990	1991
Mill Creek	66 (10.5)	55 (8.7)
Wolf Fork	49 (9.6)	56 (11.0)
Tucannon R.	60 (8.5)	57 (8.0)

In 1992, four surveys were conducted in Mill Creek and the Tucannon River, and three surveys were conducted in the Wolf Fork. The first survey was conducted during the first week in September for the Tucannon River and the second week of September for Mill Creek and Wolf Fork. Table 3.24 indicates the number of bull trout redds found during each survey per study stream. Spawning in Tucannon River and Wolf Fork appeared to have peaked during the second week of September. Mill Creek bull trout spawning peaked the last week in September.

Table 3.24 Number of bull trout redds observed during each survey per study stream during 1992. Each survey counted only new redds made since the last survey.

	Survey Number				
Stream	# 1	# 2	# 3	# 4	Total number Of Redds
Mill Creek	14 (9/9)	21 (9/17)	20 (10/2)	11 (10/10)	66
Tucannon River	20 (9/4)	28 (9/11)	13 (9/18)	5 (10/3)	66
Wolf Fork	30 (9/10)	15 (9/16)	1 (10/4)	-	46

A majority (77%) of Mill Creek bull trout spawned between Deadman Creek (RK 51.6) and the North Fork (RK 47.8)(Table 3.25). Tucannon River bull trout spawned most abundantly between Bear Creek (RK 93.0) and Tinman Camp (RK 91.2)(62%). In the Wolf Fork, most bull trout spawned between the start of the survey (RK 21.9) and Newby's Residence (RK 17.1)(98%).

Table 3.26 gives the average physical measurements of bull trout redds. Mill Creek bull trout redds had the greatest physical dimensions of the three rivers. Tucannon River redds were second in magnitude for the measured characteristics and Wolf Fork redds were third. The water velocities running over the redds were similar among streams. In all three study streams, redds primarily were built in the tail of a plunge pool or in a run. The most common cover type associated with a redd was overhead cover in Mill Creek and fallen logs in the Tucannon River. Redd placement distance to cover varied between study streams. Bull trout redds were found closest to cover in Mill Creek, Wolf Fork redds were the furthest from cover and Tucannon River redds were intermediate between Mill Creek and Wolf Fork. Lastly, Wolf Fork bull trout redds were found closest to the stream bank; Mill Creek was second and Tucannon River bull trout redds were located furthest from the stream bank.

In Mill Creek 18% of the redds observed during 1992 were placed in the same location as redds in 1991; 41% of the redds in Wolf Fork were in the same location as 1991 and 23% of the redds in Tucannon River were in the same area as 199 1.

Redds were frequently located next to or within ground water seeps or springs. Nine percent of the redds in Mill Creek and 17% of the redds in Wolf Fork were located near visable springs in 1992. In the Tucannon River no redds were found next to a spring, however, unidentified subsurface springs may have been present.

Table 3.25 Temporal and spatial distribution of bull trout redds in each study stream during 1992.

Mill Creek

	9-Sep	17-Sep	2-Oct	10-Oct
Survey start (RK 53.2)				
	0	5	1	0
Bull Creek (RK 52.9)				
	1	6	2	0
Deadman Creek (RK 51.6)				
	13	10	17	11
North Fork (RK 47.8)				
Total	14	21	20	11

Tucannon River

	4-Sep	11-Sep	18-Sep	3-Oct
Survey Start (RK 93.7)				
	4	2	3	0
Bear Creek (RK 93.0)				
	16	15	5	5
Tinman Camp (RK 91.2)				
	0	8	4	0
Ruchert's Camp (RK 89.4)				
	0	3	1	0
Sheep Creek (RK 87.0)				
Total	20	28	13	5

Wolf Fork

	10-Sep	16-Sep	4-Oct
Survey Start (RK 21.9)			
	30	14	1
Newby's Residence (RK 17.1)			
	0	1	0
Road Crosses Stream (RK 15.2)			
Total	30	15	1

Table 3.26 The mean, standard deviation and number of bull trout redds characterized in each study stream during 1992.

	Mill Creek		Tucannon River		Wolf Fork	
	n	Mean (S.D.)	n	Mean (S.D.)	n	Mean (S.D.)
Redd Surface Area (m^2)						
Bowl	28	0.35 (0.29)	30	0.25 (0.20)	21	0.16 (0.14)
Tail	28	0.41 (0.30)	30	0.25 (0.20)	21	0.24 (0.27)
Total	28	0.76 (0.53)	30	0.5 1 (0.39)	21	0.40 (0.39)
Redd Dimensions (cm)						
Bowl Diameter	28	63 (22)	30	52 (22)	21	42 (18)
Bowl Depth	15	12 (8)	21	10 (4)	17	7 (4)
Tail Length	28	116 (55)	30	85 (36)	21	91 (72)
Water Velocity (ft/s)						
Bowl	17	0.50 (0.47)	21	0.5 1 (0.3 1)	17	0.89 (1.48)
Tail	17	1.20 (1.04)	21	1.10 (0.47)	17	1.33 (0.61)
Side	16	1.00 (0.76)	21	0.77 (0.47)	16	1.06 (0.74)
ubstrate Size (mm)						
Bowl	27	60-130	25	60-130	22	16-60
Tail	14	16-60	7	16-60	14	2.-16
Stream Depth (cm) at						
Bowl	17	24 (12)	21	24 (8)	17	21 (6)
Tail	17	18 (20)	21	13 (7)	17	12 (11)
Side	15	13 (11)	21	14 (8)	17	14 (8)
roximity to Stream Bank (cm)						
Bowl	16	45 (66)	20	120 (102)	14	18 (24)
Proximity to Cover (cm)						
Bowl	26	44 (82)	29	68 (91)	20	97 (138)
Habitat Type (% utilized)						
Plunge Pool	3	8.8	1	3.3	0	0.0
Tail of Plunge Pool	14	41.1	6	20.0	8	34.8
Scour Pool	2	5.9	1	3.3	3	13.0
Tail of Scour Pool	2	5.9	0	0.0	1	4.3
Run	3	8.8	21	70.0	8	34.8
Riffle	6	17.6	1	3.3	3	13.0
cascade	4	11.8	0	0.0	0	0.0
'over Type (% utilized)						
Fallen Log	3	10.7	12	42.9	5	26.3
Sunken Woody Debris	1	3.6	5	17.9	1	5.3
Log Jam	0	0.0	3	10.7	0	0.0
Root Wad	3	10.7	4	14.3	2	10.5
Boulder	5	18.0	0	0.0	1	5.3
Undercut Bank	7	25.0	2	7.1	4	21.1
Turbulence	0	0.0	0	0.0	1	5.3
Overhead Cover	9	32.0	2	7.1	5	26.3

3.10 RADIO TELEMETRY

Table 3.27 gives the length, weight, site and date of capture for each adult bull trout radio tagged in the Tucannon River during 1992. There was no mortality during any of the surgeries, however, two radio tagged fish were found dead during the tracking study. Adult bull trout were captured for radio tagging by hook and line. One of these fish were hooked in the eye while being captured. This fish was found dead four weeks after release. Washington Department of Fisheries personnel (personnal communication, WDF) saw the injured fish while snorkeling three weeks after the fish was tagged and released. The fish was blind in one eye and fungus was growing on its adipose fin, but the incision site appeared to have healed properly. The second fish was found dead on August 21 approximately 6 weeks after radio tagging. This fish was found tangled in woody debris within a low water side channel. We estimated the fish had been dead for one to two days, based on a crude assessment of body decay. The estimated time of death coincided with a rain event. We hypothesized that the fish was trapped in the side channel due to dewatering after the rain. The incision site of the fish had healed completely and was not believed to be the cause of death.

We had limited success locating the radio tagged fish on a weekly basis. The transmitters were outfitted with internal antenna instead of an external antenna in order to reduce the possibility of fish mortality from infection caused by agitation to the tissue at the site the antenna exited the body. Unfortunately, internal antennas also limited the range of the transmitter. The effective range of our transmitters were 300 feet on level ground. Due to the limitations of the equipment no single fish was located weekly for the duration of the study.

The following analysis of adult bull trout migration behavior was based on the combined activities of all fish sampled. Table 3.28 gives the river kilometer at which each fish was found during the radio tracking study. During the first three weeks of July, the tagged bull trout were concentrated between RK 76.5 through RK 86.0. This reach of stream was believed to be the holding area before adults made their final ascent to the spawning grounds. There was a slow upstream migration occurring during this time with fish moving upstream between 10 and 400 meters a week. Spring chinook salmon were also

Table 3.27 Length, weight, site and date of capture for the bull trout radio tagged in Tucannon River. The weight of fish numbered 4 and 7 was estimated due to a scale malfunction.

‘ish No.	Date Captured	Capture Site (RK)	Fork Length (mm)	Weight (g)
1	30-Jun	78.8	356	468
2	30-Jun	78.8	381	504
3	30-Jun	79.7	381	554
4	30-Jun	81.1	464	>800
5	30-Jun	81.1	330	394
6	30-Jun	82.8	342	434
7	30-Jun	83.4	501	>I,000
8	7-Jul	76.5	368	509
9	7-Jul	78.1	318	392
10	7-Jul	81.1	493	1,141
11	7-Jul	85.4	481	1,163
12	14-Jul	85.7	377	548
13	14-Jul	85.7	444	859
14	17-Jul	79.8	373	535
15	17-Jul	79.9	394	650
16	17-Jul	85.1	461	1,001

found holding prior to spawning in the same area as bull trout (Mendel, personnal communication, WDF). Thus, bull trout and adult spring chinook salmon appear to geographically overlap during the holding period. While holding, bull trout and adult spring chinook salmon may compete for space.

Beginning in the last week of July the fish began migrating towards their spawning grounds. Individual fish moved between 0.1 km to 2.5 km per week from the last week in July until the last week in August. Spawning was believed to begin during the last week of August in the Tucannon River, although the first redds were found September 4 during the first spawning ground survey. Locating tagged fish was difficult once the fish began accelerating their ascent towards the spawning grounds.

By the last week of September, spawning was over and no tagged fish were located above Sheep Creek (RK 87). Immediately after spawning the tagged fish descended the stream at rates of up to 9 km a week. Two of the 16 tagged fish appeared to have migrated out of the Tucannon River and into the Snake River by the last week of October, however, no tagged

Table 3.28 River kilometer of each tagged adult bull trout found during the radio tracking study in Tucannon River. Asterisk indicates probable spawning location and date, based on the migration direction.

Date	Radio Tagged Fish Number															
Located	1	2	3	4	5	6	7	8	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
9-Jul	78.9	78.8	79.9	81.5	81.4	82.8	-	-	-	-	-	-	-	-	-	-
16-Jul	79.1	78.9	79.9	82.0	81.4	82.9	86.6	76.5	-	81.2	87.3	-	-	-	-	-
23-Jul	79.3	79.5	81.6	84.5	81.4	84.5	86.6	76.6	80.7	81.4	-	-	86.0	79.8	79.9	85.3
28-Jul	79.3	81.4	83.5	86.3	8 1.4	84.9	86.6	76.6	81.4	81.3	-	-	86.6	79.8	81.3	-
6-Aug	-	83.4	-	87.0	-	86.6	86.6	76.6	81.3	-	91.0	88.1	86.5	79.8	83.4	85.2
12-Aug	-	-	-	-	-	-	86.6	76.7	82.8	87.0	-	-	86.5	79.8	83.4	85.2
21-Aug	-	-	89.5	-	-	87.3	-	76.8	-	90.3	-	-	86.5	79.9	86.4	86.0
28-Aug	-	-	90.6	92.3	-	-	90.7	-	-	90.8	-	-	-	79.9	-	-
4-Sep	-	-	91.2	92.3*	-	-	91.3	87.5	-	-	-	-	-	79.9	92.0*	-
12-Sep	-	-	91.7*	73.8	89.5*	-	92.1*	90.0*	-	91.2*	-	-	90.4*	79.9	88.0	-
18-Sep	-	-	91.2	73.8	-	-	91.5	88.5	-	-	-	-	89.7	-	86.5	86.6*
25-Sep	-	-	64.0	73.8	-	-	-	79.5	-	81.1	-	-	-	80.1	-	84.7
10-Oct	-	-	-	73.8	-	-	-	76.5	-	81.1	-	-	-	79.8	-	84.9
17-ocl	-	87.9	-	73.8	-	-	-	76.5	-	81.1	-	-	-	79.8	-	84.9
23-Oct	-	87.8	-	73.8	-	-	-	76.5	-	81.1	-	-	-	-	-	84.9
28-Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.4	-
22-Nov	-	-	-	73.8	-	-	-	-	-	-	-	-	28.3	-	-	-

fish were located in the Snake River.

The data collected were inconclusive as to whether the out-migrating fish continued downstream until they reached the Snake River or whether they remained within the lower reaches of the Tucannon River. Viola (personnel communication, WDW) indicated that two bull trout were captured by anglers in November 1992 at approximately RK 21 in 1992. A tagged fish was found while radio tracking on November 22, 1992 at RK 28.3. That was the last time a radio tagged-bull trout was found during this study, although attempts were made to find the tagged bull trout in December. The Tucannon River was walked with a hand held receiver from the Tucannon Hatchery (RK 64.5) to the river’s mouth. No tagged fish were found in mid-December, which suggests that the bull trout had moved into the Snake River. On the other hand, the life of the transmitter battery was believed to end in January, but could have ended earlier.

This tracking study did not conclusively show that bull trout were entering the Snake River after spawning, however, we hypothesis that they were entering the Snake River after spawning. Adult bull trout have been seen migrating past the fish counting stations at Lower Monumental Dam and Little Goose Dam (Kleist, personnel communication, WDF). Lower Monumental Dam and Little Goose Dam bracket the Tucannon River and therefore bull trout passing the counting stations could be migration to the Tucannon River (Figure 2.1). The observations of bull trout at the counting stations substantiates the fact that bull trout were in the Snake River during this study. Furthermore, the sightings of bull trout were made prior to spawning events at a logical time when bull trout would be passing the dams in order to arrive at the Tucannon River in time to spawn. Table 3.29 list the adult bull trout sighted at each station. As a result, there was a strong possibility that the tagged bull trout did leave the Tucannon River and reside in the Snake River during the winter months.

Each time a transmitter bearing fish was visually located within the stream, the habitat type, and cover type was noted. The habitat type observations were noted for thirteen of the sixteen tagged fish. Sixty two percent of the fish were found in runs, 30% were in plunge pools and 8% were in riffles. The thirteen tagged fish were found utilizing wood as cover 100% of the time.

Table 3.29 Number of adult bull trout seen at fish counting stations on the Snake River (Kleist, personnel communication, WDF).

Year	Lower Monumental Dam	Little Goose Dam
1991	2 (July)	1 (July)
1992	2 (May)	-
1993	1 (June) 2 (April)	1 (April)

4.0 DISCUSSION

The protocol used to identify whether bull trout were negatively impacted from competitive interactions with the supplemented species, 0. *mykiss* and spring chinook salmon is presented by flow chart in Figure 4.1 and 4.2. The following discussion is an elaboration of the flow chart which identifies the rational behind the conclusions made.

4.1 GEOGRAPHIC OVERLAP

4.1.1 JUVENILES

Two observations were consistent among all of the study streams during both years of this project. First, juvenile *O. mykiss* populations geographically overlapped with juvenile and adult bull trout throughout all of the bull trout's range. Secondly, the relative abundance of bull trout and 0. *mykiss* changed as one sampled further upstream. Juvenile bull trout were more abundant in the upstream sample sites and juvenile 0. *mykiss* were more abundant in the downstream sample sites (Figure 3.1). Ziller (1992) conducted a study in tributaries of the Sprague River and reported similar findings. Bull trout were more abundant in the upstream sample sites than 0. *mykiss* and 0. *mykiss* was more abundant in the downstream sample sites than bull trout. The geographic overlap of bull trout and 0. *mykiss* indicated that there was a potential for competitive interactions between both species. However, the population centers of juvenile bull trout and juvenile 0. *mykiss* were spatially distinct, resulting in a reduction of possible competitive interactions between the juvenile age classes of each species.

During both years of this study, neither adult nor juvenile spring chinook salmon were collected in the relative abundance or the population estimate sites above Sheep Creek (RK 87) in the Tucannon River. Therefore, competitive interactions between bull trout and spring chinook salmon were unlikely in the Tucannon River above Sheep Creek due to their spatial separation. On the other hand, juvenile spring chinook salmon and juvenile bull trout were collected during population estimates at RK 82.2 during 1991 (Martin et al. 1992). Juvenile bull trout as well as juvenile spring chinook salmon were also observed during snorkel surveys in the microhabitat sites below Sheep Creek during 1992. Others have reported the observation of juvenile bull trout and spring chinook salmon between

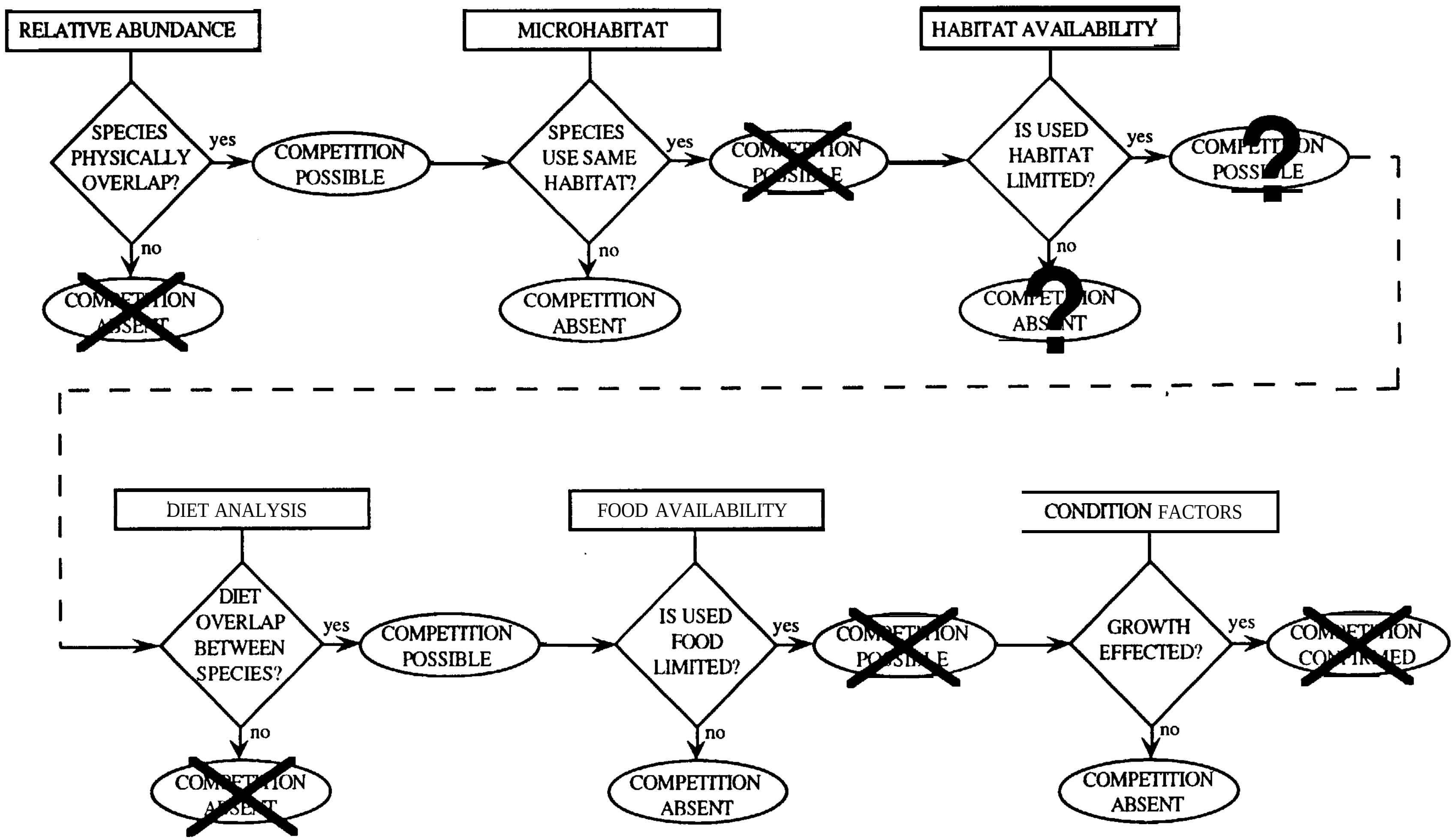

Figure 4.1 The methods used and the conclusions may to determine if wild bull trout were negatively impacted from competitive interaction with the supplemented species in the Tuccanon River and in Mill Creek. The "X" indicates either the alternative was not taken or a block in the path to implicating supplementation as a factor negatively affecting wild bull trout. The "?" indicates that we were unable to answer the question.

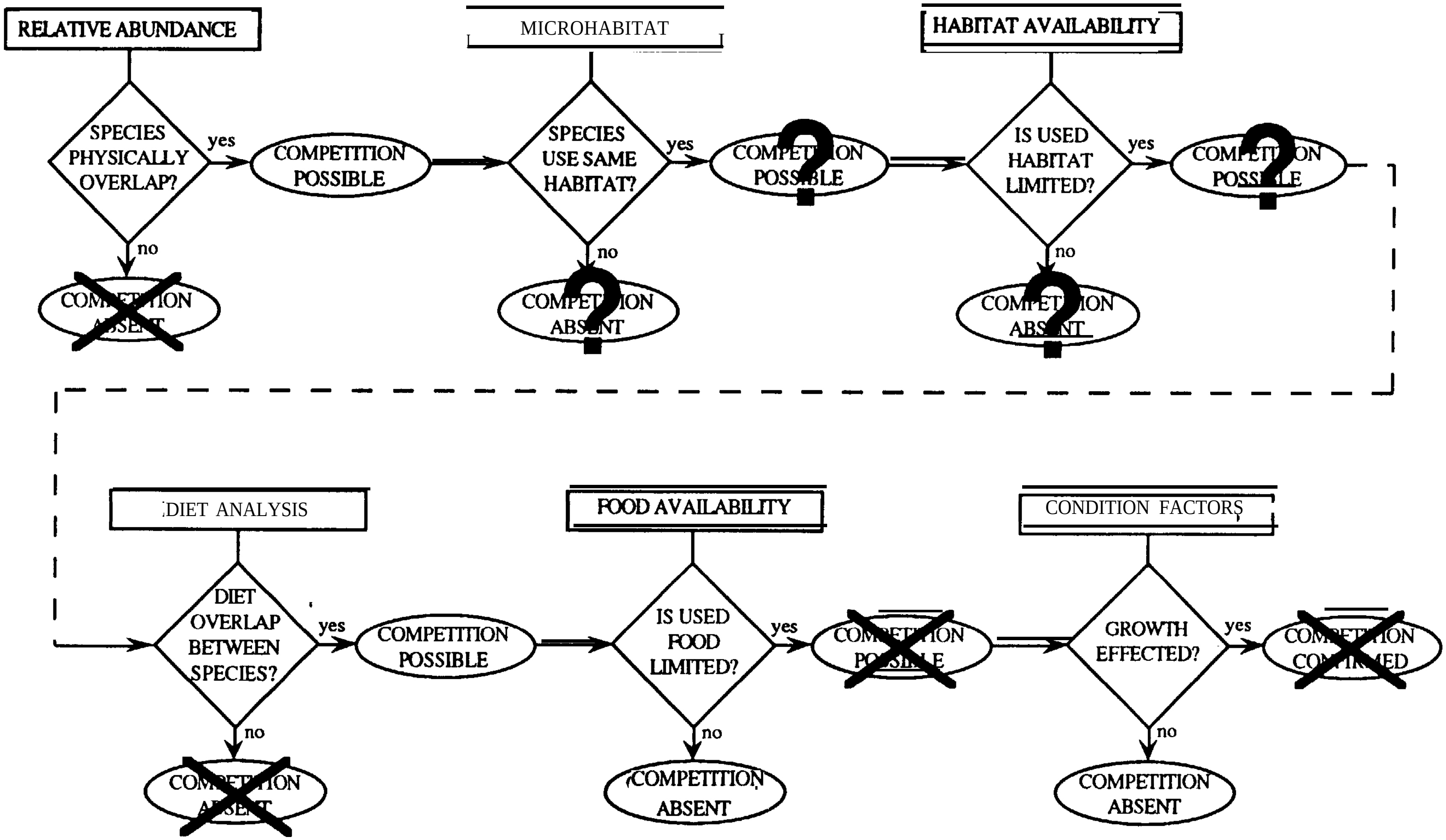

Figure 4.2 **The** methods used and the conclusions may to determine if wild bull trout were negatively impacted from competitive interaction with the supplemented species in the Wolf Fork. The **"X"** indicates either the alternative was not taken or a block in the path to implicating supplementation as a factor negatively affecting wild bull trout. The **"?"** indicates that we were unable to answer the question.

Sheep Creek and Big Four Lake (RK 70) (Groat, personnel communication USFS; Bugert 1991).

These reports suggest that spring chinook salmon and bull trout do geographically overlap below Sheep Creek. As a result, competitive interactions were possible between these two species below Sheep Creek in the Tucannon River.

The population centers of juvenile *O. mykiss* and spring chinook salmon appeared to be segregated from the population centers of juvenile bull trout in each study stream. Bull trout populations appeared to be primarily upstream from the other species. The segregation may be a mechanism to minimize competitive interactions between bull trout and the other species. However at an individual level, bull trout were in sympatry with 0. *mykiss* and spring chinook salmon. Competitive interaction between bull trout and the other species where possible for food and space at an individual level. Based on the extent of geographic overlap, competitive interactions could not be ruled out among species.

4.1.2 ADULTS

The adult bull trout population in the Tucannon River appeared to migrate into the upper reaches (RK 75 through 82) of the river by June and held for two months prior to spawning. Adult spring chinook salmon migrated into the Tucannon River at the same time as bull trout and held prior to spawning within the same area as adult bull trout (Mendel, personnel communication, WDF). Adult bull trout and adult spring chinook salmon geographically overlapped during the holding phase of their spawning migration. During the holding phase, adult bull trout and adult spring chinook salmon may compete for habitat. No aggressive behavior was observed between the adults of these species during microhabitat surveys; however, these surveys were of short duration and it is possible that snorkelers could have influenced typical behavioral interactions between the species, so it was not possible to rule out aggressive interactions.

Bull trout did not appear to compete with either spring chinook salmon or 0. *mykiss* for spawning gravel in the Tucannon River owing to geographic and temporal partitioning. The WDF conducted spring chinook salmon spawning ground surveys while we conducted bull trout spawning ground surveys in the Tucannon River. The furthest upstream spring chinook salmon redd in the Tucannon River was at approximately RK 83.5 (Mendel, personnel communication WDF). No spring chinook redds were located above Sheep Creek (RK 87), while no bull trout redds were located below Sheep Creek. Thus, there was no geographic overlap. Also, *0. mykiss* spawn during spring where as bull trout spawn in the autumn and therefore would not compete for spawning gravels.

Adult bull trout also geographically overlapped with juvenile spring chinook salmon and 0. *mykiss*. Diet analysis of adult bull trout indicated that they did feed on juvenile 0. *mykiss* and therefore, the geographic overlap of adult bull trout with the juvenile salmonids was believed to benefit adult bull trout, not harm them.

The geographic overlap of adult bull trout and adult 0. *mykiss* was not identified in this study. Some of the adult bull trout radio tagged during 1992 appeared to be emigrating from the Tucannon River and entering the Snake River during the fall and winter months. The Tucannon River summer steelhead run begins in fall and continues through winter. While the adult bull trout were emigrating out of the Tucannon River, the steelhead were migrating into the river. There was some degree of geographic overlap but, whether the fish competed for food or space was unknown.

4.1.3 BULL TROUT AND HATCHERY ORIGIN FISH

During 1991, one hatchery reared juvenile *0. mykiss* was collected in Wolf Fork at a diet analysis sample site (Martin, personnel communication WDW). During 1992, no hatchery origin fish were observed in the relative abundance sites in any of the study streams. This information indicated that few hatchery reared *0. mykiss* and/or spring chinook salmon overlapped geographically with bull trout and therefore, the chance of direct competitive interaction between bull trout and the hatchery reared fish was remote in each study stream.

However, competitive interactions between bull trout and hatchery reared fish may have been more frequent below Sheep Creek in the Tucannon River. Hatchery reared 0. *mykiss* were released into the Tucannon River just above the confluence with the Little Tucannon River (RK 76) during 1992. Since bull trout have been observed in this area, interactions between the supplemented fish and bull trout were likely (Groat, personnel communication USFS; Martin et al. 1992). However, since sampling was limited below Sheep Creek we can not estimate the extent of the geographic overlap between bull trout and the hatchery reared fish in this reach of stream.

Naturally reproducing bull trout, *0. mykiss* and spring chinook salmon did geographically overlap in the streams studied and, therefore, competitive interactions between bull trout and the other species was possible. However, the origin of spring chinook salmon and 0. *mykiss* observed during this study was unknown. In the Tucannon River, approximately half of the adult spring chinook salmon and adult *0. mykiss* allowed to pass upstream of the Tucannon fish trap (RK 61.5) were of hatchery origin (Bugert et al. 1991, 1992; Schuck et al. 1993). The hatchery origin adults appeared to have spawned naturally in the Tucannon River among wild origin fish. Therefore, hatchery-wild hybrid crosses were most likely occurring in the naturally spawning population.

Bugert et al. (199 1) reported that wild naturally reproducing spring chinook salmon behave differently than hatchery origin spring chinook salmon in the Tucannon River. A majority of the adult wild fish spawned further upstream than the hatchery origin fish and progeny of wild spring chinook have a higher survival rate when placed in the hatchery than the progeny of hatchery origin spring chinook salmon. The unique spawning behavior and reduced survivability of hatchery origin fish suggests that the hatchery origin fish have deviated from the behavioral norm of the wild fish, however, the reasons for the deviation is unknown at this time. The unusual behavior of the hatchery origin fish may be a result of learned behavior while rearing in the hatchery or may be a result of the unique selective pressures within the hatchery environment which have caused a shift in the genotype of the hatchery origin fish moving them away from the genotype of the wild fish over subsequent generations.

Numerous investigators have compared the behavior of hatchery and wild origin salmonids (Dickson and MacCrimmon 1982; Johnsson and Abrahams 1991; Chilcote et al. 1986; Reisenbichler and McIntyre 1977). They concluded that the behavior of hatchery origin fish did differ from that of wild origin fish and in many cases the behavior of hatchery-wild hybrids were intermediate to the different behaviors exhibited by the hatchery and wild fish. Hatchery origin fish differed from wild origin fish in that they are more aggressive and had reduced reproduced success (Reisenbichler and McIntyre 1977; Johnsson and Abrahams 1991). These unique behaviors were believed to occur because the selective pressures of a hatchery were different from the wild and these selective pressures were changing the genotype of the hatchery origin fish though subsequent generations. Over many generations the genotype of the hatchery origin fish deviates from the wild population (Waples 1991).

The interactions between wild bull trout and wild-hatchery hybrid spring chinook salmon and 0. *mykiss* may have been more intense thereby, negatively impacting bull trout populations greater than interactions with wild salmonids. We were unable to identify hybrids from wild fish, and therefore we were unable to report differences in behavior between the wild and wild-hatchery hybrid fish.

4.1.4 A COMPARISON AMONG STUDY STREAMS

The abundance of bull trout in relation to the abundance of 0. *mykiss* on an elevation gradient were similar in the non-supplemented stream, Mill Creek, and the most intensely supplemented stream, the Tucannon River. Bull trout were the most abundant fish of the three target species in the upstream sample sites and 0. *mykiss* was most abundant fish in the downstream sample sites. At a population level, the release of hatchery reared 0. *mykiss* and spring chinook salmon into the Tucannon River did not appear to displace the bull trout population. If supplementation with hatchery reared fish was displacing the bull trout population one would expect to find a higher relative abundance of the supplemented species in the upper sample sites than bull trout. Wolf Fork, however, did differ from the other study streams. In the Wolf Fork, bull trout were not the most abundant fish in the upper sample sites, 0. *mykiss* were the most abundant. Since the Wolf Fork was considered to be intermediate in terms of supplementation pressure and further since habitat and food availability did not appear to significantly differ among study streams, we are unable to argue that supplementation was the only factor which could have caused the high abundance of 0. *mykiss* in the upper sample sites of Wolf Fork. Instead, other forces not identified by this study may have negatively impacted the bull trout population giving 0. *mykiss* a competitive advantage over bull trout.

4.2 HABITAT UTILIZATION

4.2.1 HABITAT TYPE

The results from the first year of data collection, 1991, suggested that age 0+ bull trout utilized riffle and cascade habitat but, preferred plunge and scour pools habitat in each of the study streams (Martin et al. 1992). Furthermore, juvenile bull trout as well as age 0+ and juvenile *O. mykiss* primarily utilized and preferred plunge pools and scour pools in all of the study streams (Tables 3.9 and 3.10). In support of the 1991 data, Ratliff and Fies (1989) reported that bull trout utilized slow water areas which would be consistent with the water velocities found in plunge and scour pools.

The results from the second year of study, 1992, differed slightly from the first study year. The data collect during 1992 suggested that juvenile bull trout utilized mostly runs in Mill Creek and mostly riffles in the Tucannon River. Pratt (1984) reported that juvenile bull trout were most often in large run-riffle habitat, and Armstrong and Elliot (1972) stated that riffles and glides were utilized by juvenile bull trout in British Columbia streams. The second year of data also indicated that *O. mykiss* and spring chinook salmon were utilizing mostly pool habitat in the Tucannon River and 0. *mykiss* were utilizing mostly run habitat in Mill Creek (Figs. 3.6 and 3.12.).

The different habitat utilization results between study years may have been due to differing sampling methods. The results from the first year of data was determined from electrofishing habitat sites enclosed by block nets. The density of each target species was used to identify habitat type utilization and density was determined from population estimates. Sampling methods were changed to snorkeling during the second year of the study because we questioned whether the target species were exiting from the sample site during block net placement. Snorkeling may have minimized the problem of fish exiting the sample site, however, the total number of bull trout in a habitat site may not have been observed due to their cryptic coloration and their ability to conceal themselves from sight (Skeesick 1989). Furthermore, snorkel surveys estimated the total number of target species within each habitat type to determine utilization. The snorkeling method did not take into account the surface area sampled or the efficiency of snorkeling versus electrofishing estimates. In this respect, the first year of data collection was more accurate because the density of each target species for each habitat type was estimated which accounted for the size or, in other words, the effort of sampling in each habitat type. In addition, during the second year, bull trout were not observed in Wolf Fork which resulted in a smaller sample size for the second year. Thus, the first year of data appears to be a more accurate representation of habitat utilization than the second year of data.

Both years of data indicated that bull trout, *O. mykiss*, and spring chinook salmon utilized all of the habitat types identified by this study. All three species seemed to prefer habitat types which contained slower water velocities such as runs, plunge and scour pools. This information is in agreement with other studies (Chapman 1989, Dambacher et al 1992, Pearson et al. 1993, Shepard et al. 1984, Pratt 1992). Competitive interactions for space may have occurred between bull trout and the other species because they utilize similar habitat types. However, habitat type utilization of bull trout and the other species did not appeared to significantly differ when compared between the supplemented and non-supplemented streams. Therefore, habitat type utilization did not indicate an increase of competitive interactions as a result of supplementation activity.

4.2.2 MICROHABITAT

Microhabitat utilization was estimated in Mill Creek and Tucannon River, unfortunately, it was not possible in Wolf Fork. Snorkeling of Wolf Fork sites were scheduled for the first week in September. The day before the first scheduled sampling date, a heavy rain event occurred resulting in high stream discharge and turbidity. These factors precluded sampling. A second attempt was made to snorkel Wolf Fork during the third week of September, however, no bull trout were observed. On the same day, personnel of the Washington Department of Wildlife elecuofished a sample site about 100 m above one of the snorkeled sites. They captured approximately 10 bull trout of ages 0+ and 1+. This suggested that the bull trout of Wolf Fork were still in the stream, but were effectively hidden from the snorkeler. The most plausible explanation for this phenomena was the bull trout had sought refuge under the streambed substrate. Shepard and Graham (1982) indicated that bull trout were more difficult to observe at cooler water temperatures. Salmonids have been documented to dig into the rocky substrate as an adaptation for winter survival (Bjornn 1971; Bustard and Narver 1975). Temperature has been suggested to be the cue for the “digging in” behavior. The water temperature of Wolf Fork during the microhabitat survey was 3°C. Mill Creek bull trout were observed in the water column when the temperature was 2°C. Thus, temperature may not be the only cue for “digging in”. Other factors such as light period may influence the bull trout’s microhabitat choice. Mill Creek was snorkeled two weeks prior to Wolf Fork, the two week separation between sampling periods may have been long enough for the Wolf Fork populations to change their microhabitat selection.

4.2.2.1 MICROHABITAT UTILIZATION BY SPECIES

Juvenile bull trout microhabitat utilization differed between juvenile *O. mykiss* and juvenile spring chinook salmon. Juvenile bull trout utilized slow water velocities created by boulders and woody debris. Bull trout were in closer proximity to in-stream cover and to the streambed than the other species. Juvenile *O. mykiss* and spring chinook utilized water velocities of the main stream without in-stream obstructions. They were further from in-stream cover and the streambed than-bull trout (Figure 3.9 and 3.15). Pratt (1994) reported similar microhabitat utilization by bull trout in the Flathead River Basin. This information leads us to believe that bull trout and the other target species were partitioning their resources by utilizing different microhabitats. The utilization of distinct microhabitats by different species is a mechanism used to partition the resources (Holbrook and Schmitt 1989). Furthermore, resource partitioning is a mechanism used to reduce competitive interactions between fish species (Baltz et al. 1982; Hodgson et al. 1991; Reeves et al. 1987; Norton 1991).

If supplementation with hatchery reared *O. mykiss* and spring chinook salmon was increasing competitive interactions between bull trout and the supplemented species, than we would expect to find an increase in the use of similar microhabitat among species. The target species in the Tucannon River should have utilized similar microhabitats and the target species in Mill Creek should have utilized dissimilar microhabitats. However, this was not the case. The microhabitat utilization of bull trout and *O. mykiss* did not appear to significantly differ between study streams, although slight differences in microhabitat utilization were identified.

Mill Creek bull trout primarily utilized boulders as an in-stream cover. In Mill Creek, the most abundant in-stream cover type was boulders. Tucannon River bull trout primarily utilized fallen logs as in-stream cover. In the Tucannon River, the most abundant in-stream cover was fallen logs. Bull trout microhabitat utilization did differ between Mill Creek and Tucannon River. However, we believe that boulders and fallen logs were functionally identical. Each diverted the water velocity of the stream creating a slow water pocket which the fish could utilize. Utilization appears to be directly related to instream cover availability. Juvenile bull trout utilized the same cobble size substrate, similar water velocities, similar distances to cover and similar distances to the streambed in the Tucannon River and Mill Creek. The microhabitat utilized by bull trout did not appear to functionally change between the supplemented and non-supplemented stream. Based on the microhabitat utilization data supplementation activities did not appear to increase the level of competitive interactions between bull trout and the supplemented species.

O. mykiss microhabitat utilization also did not functionally change between study streams. *O. mykiss* of Mill Creek were found more often in deeper water and further from the streambed than *O. mykiss* of the Tucannon River. These differences were related to available habitat. Mill Creek was estimated to be deeper than Tucannon River and 0. *mykiss* were found further from the streambed in Mill Creek than in the Tucannon River. *O. mykiss* may be cueing on the stream surface to determine positioning in the water column. If this is the case, one would expect to find *O. mykiss* further from the streambed when in deeper streams.

Bull trout and the other fish species utilized dissimilar microhabitats and the use of dissimilar microhabitats appeared to be a mechanism to minimize competitive interactions. In addition, bull trout, 0. *mykiss* and spring chinook salmon seemed to segregate themselves within a habitat unit. Bull trout were observed more frequently next bull trout rather than to 0. *mykiss* or spring chinook salmon. However, all three species were commonly observed in the same habitat unit. This suggested that bull trout and the other fish species were spatially segregating themselves. Armstrong and Elliot (1972) indicated that Dolly Varden were not visibly territorial unless in the presence of another fish species. The bull trout observed in this study tended to form territories adjacent to one another as a method to reduce competitive interactions with other species.

Limited time and funding precluded the quantification of available microhabitat for each species. As a result, we were unable to determine if microhabitat was a limited resource to the target species. Therefore, we can not speculate on whether microhabitat resource partitioning was a result of current competitive interaction between bull trout and the supplemented species or a result of unique physiological and behavior characteristics which have evolved over the centuries.

4.3 AVAILABLE HABITAT

The physical characteristics of each study stream differed slightly (refer to Table 3.1). The Tucannon River had fewer cascades and a greater number of riffle habitats than Mill Creek or Wolf Fork. The Tucannon River also had fewer boulders and a greater amount of woody debris than Mill Creek or Wolf Fork. The water temperature of the Tucannon River was approximately 16°C during the summer. The water temperature in Mill Creek and the Wolf Fork was approximately 11°C during the summer (Martin et al. 1992). Despite differences among study streams, the target species appeared to use similar habitat among the study streams, suggesting that the behavior of each fish species had not changed due to unique features of the streams.

4.4 FOOD AVAILABILITY AND DIET

Drift and Hess samples indicated that the taxa composition of macroinvertebrates were similar among study streams, but the density of macroinvertebrates differed. Mill Creek contained twice as many individuals as the Tucannon River and the Wolf Fork even though the total population density of the target species was similar among the study streams (Martin et al. 1992). The availability of invertebrates for consumption was greater in Mill Creek than in the other streams. Based on this information, one may deduce that the fish in the Tucannon River and Wolf Fork would be more apt to compete for food than the fish in Mill Creek since Mill Creek has twice as much food available. However, in 1989 Bugert et al. (1990) estimated that it would take 128 days to eliminate the most limiting macroinvertebrate population in the Tucannon River and suggested that food was not limiting. The estimated density of macroinvertebrates in this study was 3 to 4 times greater than the estimates reported by Bugert et al. (1990). Thus, the time needed to deplete the most limiting macroinvertebrate may be longer than that estimated in 1988. As a result, food did not appear to be a limiting factor to the fish in the streams studied.

Diet did significantly overlap between bull trout and 0. *mykiss* in Mill Creek, the Tucannon River and the Wolf Fork. A significant diet overlap does not necessarily suggest competition for food was occurring. Keast (1978) reported that when food availability is high there is a corresponding high degree of diet overlap between the species of concern. Furthermore, as food availability decreases, diet overlap decreases as each species begins to specialize by selectively preying on specific food items. When food resources are scarce one species will shift its diet so that the competing species partitions the limited resources which reduces competition. The data collected during this study seems to verify Keast's statement for the following reasons. First, food availability appeared to be high in each stream. Second, bull trout and 0. *mykiss* fed on over 50 different macroinvertebrate taxa and life history stages. Based on the electivity indices, neither fish species were actively seeking out or selectively preying on specific food items, suggesting that prey selection was random and relative to availability.

On the other hand, the diet overlap of spring chinook salmon and bull trout was not significant in the Tucannon River (Martin et al. 1992). This finding does not follow Keast's interpretation of the mechanism for partitioning a food source. Since food is abundant in the Tucannon River the diet of bull trout and spring chinook salmon should significantly overlap. Martin et al. (1992) compared the diet of spring chinook to the diet of bull trout from data collected by two separate studies. The diet of spring chinook salmon was determined during the summer of 1988 and reported by Bugert et al (1989). The diet of the bull trout was determined during the summer of 1991 and reported by Martin et al. (1992). The time separation between the two studies may not have accounted for a change in the macroinvertebrate composition in the Tucannon River between the study years. Furthermore, the sample site of each study differed. The spring chinook salmon were sampled further downstream than the bull trout. Whether bull trout and spring chinook salmon diets significantly overlap is still in question, but we doubt significant competitive interaction would occur for food due to the different microhabitat requirements and large geographic separation of population centers of bull trout and spring chinook salmon as well as the abundant food base.

4.5 GROWTH AND CONDITION

Both the mean fork length and back-calculated fork length indicated that bull trout and 0. *mykiss* growth differed among streams. Bull trout growth was fastest in Mill Creek and slowest in Tucannon River. Conversely, growth of 0. *mykiss* was slowest in Mill Creek and fastest in the Tucannon River. Wolf Fork bull trout and 0. *mykiss* were intermediate in growth among the study streams. Supplementation negatively related to the growth of bull trout and positively related to the growth of 0. *mykiss*. Researchers have previously linked competitive interaction to slowed growth of fish species (Beacham 1993; Fagerlund et al 1981). In this study, the difference of growth among stream populations seemed to indicate that supplementation was causing negative impacts to bull trout through competitive interactions with the supplemented species. However, competition is not the only factor which could have caused this phenomena. There are a host of factors, such as food abundance and water temperature that could have influenced growth (Fry 197 1). Mill Creek was identified as having the greatest amount of food available (13,445 macroinvertebrates/m²) and the coolest mean summer water temperature (1 1° C). Conversely, the Tucannon River had half the available food (6,175 macroinvertebrates/m²) and had warmer mean summer water temperatures (16" C) than the other streams. The availability of food may have been a significant factor in the growth of bull trout however, food availability did not explain the difference in growth of 0. *mykiss* stream populations. *0. mykiss* were growing fastest in the Tucannon River, the stream with less food.

Water temperature may better explain differences of growth among stream populations than food abundance. Hokanson et al. (1977) reported the physiological maximum of 0. *mykiss* to be 17.2°C. The physiological maximum of bull trout was not found in the literature, however, we believe that the thermal maximum of bull trout is less than 17.2°C. In the hatchery, the best water temperature for rearing Dolly Varden is 7 - 8 ° C and disease problems become acute at 12" C and above (Brown 1985). Water temperatures above 14" C act as thermal barriers to Arctic char, a close relative of bull trout (Jensen 1981). Ratliff (1992) indicated that bull trout were found only in streams that averaged 10° C in the tributaries of the Metolius River and *0. mykiss* were abundant in streams greater than 10 C. The scope of growth is mediated in part by water temperature due to physiological limitations of the fish species (Fry 1971). Therefore, the growth differences between stream population may be a result of the differences in stream temperatures. However, without further study to identify shifts in metabolic performance of bull trout we were unable to accept temperature as the only factor that could have limited bull trout growth in the streams studied.

The most likely explanation for the growth differences is a combination of factors. Food availability, water temperature and other factors not addressed here could be effecting the growth based on the metabolic performance of each species. Furthermore, supplementation activities, food availability, water temperature may all effect the level of competitive interactions between bull trout and the other fish species thereby changing the rate of growth. Keast (1978) stated the smaller the food base the greater the potential for competitive interactions because interactions would occur more frequently for the same resource. Therefore, we would expect to find competition for food more intense in the Tucannon River than in Mill Creek. From the diet data collected during this study we were unable to find a significant difference in food habits between stream populations. Competitive interactions have also been related to water temperatures. Steelhead trout were found to use the same type of habitat at water temperatures between 12 - 15" C in the presence or absence of redside shiners. In warmer water temperatures (19 - 22" C) the type of habitat used by steelhead trout changed when in the presence of redside shiners. Steelhead trout appeared to have the competitive advantage at water temperatures between 12 - 15” C but, redside shiners had the competitive advantage at water temperatures of (19 - 22” C (Reeves et al. 1987). The unique physical characteristics of each study stream may give the competitive advantage to one of the fish species regardless of supplementation activities. Bull trout may have the competitive advantage in the non-supplemented, cool waters of Mill Creek where *as 0. mykiss* may have the competitive advantage in the supplemented, warm waters of the Tucannon River.

Although growth differed among study stream populations, condition factor did not. Beacham (1993) suggested that stress experienced by competing fish can result in slowed weight gain. Slowed weight gain would result in a reduced condition factor. Therefore, if the level of competitive interactions were increased as a result of supplementation, we expected to find the condition factor of bull trout to be lower in the supplemented streams than the non-supplemented stream. Condition factor of bull trout stream populations did not differ significantly. This finding suggested that supplementation did not cause an increase in the level of competition to the point where bull trout were unable to sustain the same weight to length ratio as that of the bull trout in the non-supplemented streams.

4.6 PROJECT SUMMARY AND LIMITATIONS

Negative impacts to wild native bull trout populations as a result of supplementation with hatchery reared spring chinook salmon, steelhead trout and rainbow trout were not detected in three streams of Southeast Washington. Bull trout and the supplemented species did geographically overlap, which identified the potential for competitive interactions. Bull trout, 0. *mykiss* and spring chinook salmon utilized similar habitat unit types, but microhabitat analysis identified that bull trout and the supplemented species were utilizing dissimilar microhabitat. These species appeared to have been partitioning the habitat which suggests a mechanism was in place to minimize competitive interaction. However, since microhabitat use for each species did not change among streams, supplementation could not be identified as a cause for habitat partitioning. Partitioning of resources has been identified as an adaptive mechanism to reduce competitive interaction when a resource is limited (Keast 1978). Thus, the potential for competitive interactions were still possible because microhabitat partitioning was found. However, we were unable to identify whether microhabitat was limiting and therefore were unable to identify potential reasons

for resource partitioning. Diet and food availability analysis identified a food base which was not limited and therefore competitive interaction for food was unlikely. The growth of bull trout and 0. ***mykiss*** did relate to supplementation intensity. The greater the supplementation intensity, the slower the growth of bull trout and the faster the growth of *0. mykiss*. Although, unique characteristics of the study streams such as food availability and water temperature may have had an effect on growth independent from supplementation. As a result, the cause for the growth differences among streams is still in question. The condition factor of bull trout and 0. ***mykiss*** did not differ among study streams suggesting that supplementation had not increase the level of competitive interaction to the point where bull trout and 0. ***mykiss*** were unable to maintain the normal weight to length ratio. However, supplementation may have increased the level of competition to a point where the energy exerted during the competitive activities resulted in a reduced growth rate of bull trout but not a reduced condition factor.

5.0 FUTURE RESEARCH RECOMMENDATIONS

Supplementation of hatchery reared salmonids in areas of high bull trout density could have a negative impact on the bull trout population. We suggest hatchery reared fish be released outside of the juvenile bull trout's range. This study did not address the instantaneous effects on juvenile bull trout at a hatchery reared salmonid release site. Vincent (1987) found that hatchery fish did displace-wild fish when released and therefore, we believe that until the affects of supplementation of salmonids on bull trout are better understood, supplementation activities should take every measure possible to minimize potential impacts to bull trout. Further study should be conducted in this area.

This study was designed to identify whether competitive interactions caused from supplementation with hatchery reared spring chinook salmon and 0. *mykiss* resulted in a negative impact on bull trout at a population level. The precision of this study was, therefore, limited due to the variability inherent with a population. The variability of the populations studied may have been large enough to mask subtle negative impacts from competitive interactions. This study did not address competitive interactions at an individual level and the impact on the individual due to competitive interactions. In order to identify the effects of competitive interaction on the individual, laboratory studies need to be conducted which identifies changes in behavior when bull trout were sympatric with different densities of the supplemented species of wild and hatchery origin.

The effect of water temperature on the behavior and life history of bull trout is not thoroughly understood. Many researchers implicate water temperature as the cause for limiting the geographic range of bull trout, spawning sites selection and growth rate (Pratt 1984; Ratliff 1992; Skeesick 1989; Shepard and Graham 1982). However, to the best of our knowledge no work has been completed which identifies the thermal maximums of bull trout or the change in metabolic efficiency at different temperatures. We suggest a laboratory study be completed which determines the scope of growth in relation to temperatures and determine if bull trout have a competitive advantage over other 0. *mykiss* and spring chinook salmon at specific water temperatures.

This study addressed bull trout interactions with 0. *mykiss* and spring chinook salmon during day light hours of the summer months over a two year period. A five to seven year study focusing on one or two streams would answer questions that this study was not able to answer. The goal of the study would be to determine the annual availability of microhabitat and the types of habitat used by bull trout, *0. mykiss* and spring chinook salmon annually. The study would identify the effect of temperature on microhabitat selection of the target species and quantify the intensity as well as the frequency of competitive interactions between bull trout and other species day and night throughout the year. To address Vincent's (1987) findings, the remaining objective of the proposed study would be to determine if microhabitat utilization shifts occur when 0. *mykiss* and spring chinook salmon are experimentally released into areas of high bull trout density.

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APPENDIX A

MATHEMATICAL IDENTIFICATION OF BULL TROUT

Introduction

Bull trout (*Salvelinus confluentus*) is one of two native char species indigenous to the pacific northwest, the other is Dolly Varden *(Salvelinus malma).* Bull trout were first described by George Suckley in 1860 (Cavender 1978) but Suckley's classification of the bull trout was not accepted by the scientific community. Due to morphological similarities between bull trout and Dolly Varden, bull trout were classified as *Salvelinus malma* until Cavender (1978) re-described the Dolly Varden - bull trout complex. He found that bull trout and Dolly Varden museum specimens did have distinct meristic characters. However, bull trout and Dolly Varden were still difficult to distinguish even after Cavender's work. Haas and McPhail (1991) collected field specimens of Bull trout and Dolly Varden living in sympatry and allopatry. They made meristic measures and developed a linear discriminate function (LDF) that when, used differentiated between bull trout and Dolly Varden. The LDF was used in this study to verify bull trout were the species being studied.

Materials and Methods

Bull trout captured during the sampling season of 1992 were randomly selected for the linear discriminate function measurements. Fish were captured by electrofishing as well as hook and line. Four different measurements were collected from each fish chosen for the LDF: total anal fin ray number, branchiostegal ray number, standard length and maxillary length. The total number of anal fin rays were determined by running a metal probe along the base of the fin and counting each click caused by the probe moving from bone to soft tissue. Total branchiostegal ray number was counted by extending the operculum forward which spread the branchiostegal rays apart. The count was made with the aid of a probe. Maxillary length was made with a veneer caliper that measured to the nearest 0.1 mm. The measurement was made from the tip of the nose strait back to the tip of the maxillary while the mouth was closed.

The following equation was used to differentiate bull trout from Dolly Varden (Haas and McPhail, 1991).

$$LDF = 0.629N_b + 0.178N_a + 37.310\frac{L_j}{L_s} - 21.8$$

Where:

LDF = Linear discriminate function;
N_b = Number of branchiostegal rays;
N_a = Number of anal fin rays;
L_j = Total length of the upper jaw; and
L_s = Standard length of the fish.

If the LDF is greater than 0 then the fish was a bull trout; if the LDF was less than 0 then the fish was a Dolly Varden.

Results

Tables A.l, A.2, and A.3 gives the LDF and meristic data measured on bull trout by study stream. The LDF of fish captured in Mill Creek suggests 92% of the fish were bull trout (n=1 1) and 8% were Dolly Varden (n=1). The LDF of fish sampled in Wolf Fork suggests 65% were bull trout (n=1 1) and 35% were Dolly Varden (n=6). The LDF of fish sampled in Tucannon River indicated 77% were bull trout (n=30) and 23% were Dolly Varden (n=9).

According to Haas and McPhail (1991), the single best character to distinguish between bull trout and Dolly Varden is the branchiostegal ray number with a median of 27 for bull trout and 22 for Dolly Varden (Haas and McPhail 1991). However, branchiostegal ray counts did overlap between species, bull trout ranged between 22 to 3 1 and Dolly Varden ranged 17 to 23. The anal fin ray counts were too close to use independently as a distinguishing character. Median anal fin ray counts were reported to be 12 for bull trout and 11 for Dolly Varden. However, they reported that the bull trout anal fin ray count of 12 was statistically strong and any number deviating from 12 was considered a statistical outlier. Bull trout were also found to have a larger upper jaw to their body length than Dolly Varden.

The results of this study differed from Haas and McPhail (1991). When the fish from all three study streams were combined, the median branchiostegal count of bull trout was 26 (range 23-30) and the median anal fin ray count was 10 (range 8-1 1). The Dolly Varden median branchiostegal count was 24 (21-25) and the median anal fin ray count was 10 (range 9- 10).

Discussion

Out of 68 measured fish, the LDF indicated 52 of the sampled fish were bull trout and 16 were Dolly Varden. Bull trout inhabit waters of both the western and eastern portions of Washington State. Dolly Varden, on the other hand, are believed to inhabit streams west of the Cascade Mountains in Washington State (Skeesick 1989). Therefore, all of the char sampled during this study should have been identified as bull trout, but this was not the case. Either Dolly Varden were sampled in the study streams, errors were made during the meristic counts or the LDF formula does not apply to bull trout this far east of the Cascade Mountains. We believe the latter is true. The LDF was developed from Canadian coastal stream fish, a bull trout population geographically removed from bull trout east of the Cascade Mountains. Since bull trout appear to live a fluvial or adfluvial life style, we believe the bull trout populations of the east are reproductively isolated from the west . Leary (1985) suggested that bull trout genomes vary up to 26% between populations. The genotypes of bull trout located west of the Cascade Mountains may differ great enough to produce phenotypes of bull trout unique from bull trout populations located east of the Cascade Mountains. The Haas and McPhail LDF may not be a valid method of differentiating bull trout from Dolly Varden in Southeast Washington or other inland areas.

Table A.1 Linear discriminate function and meristic data measured on bull trout from Mill Creek, 1992.

Date Collected	LDF	Standard Length (mm)	Maxillary Length (mm)	Branchio-stegal No.	Anal Fin Ray No.
I-Jul	2.37	140	20.3	27	10
I-Jul	3.35	148	18.6	30	9
1-Jul	2.28	179	32.4	25	9
1-Jul	0.76	254	34.4	25	10
4-Aug	1.56	107	15.0	26	10
4-Aug	2.82	164	23.0	28	*lo
4-Aug	-0.15	172	22.0	24	10
4-Aug	1.29	173	23.0	26	10
4-Aug	1.78	325	42.0	27	10
4-Aug	3.40	540	84.0	28	10
17-Aug	4.18	132	30.0	25	10
17-Aue	1.52	152	16.0	28	10

Table A.2 Linear discriminate function and meristic data measured on bull trout from Wolf Fork, 1992

Date Collected	LDF	Standard Length (mm)	Maxillary Length (mm)	Branchio-stegal No.	Anal Fin Ray No.
26-Jun	0.01	97	13.8	24	8
26-Jun	2.25	101	13.1	28	9
26-Jun	-1.02	103	13.0	23	9
26-Jun	0.89	108	13.7	26	9
26-Jun	-0.07	111	13.1	25	9
26-Jun	1.83	115	13.6	28	9
26-Jun	2.22	116	14.4	28	10.
26-Jun	-0.02	127	16.7	24	10
26-Jun	1.25	139	18.3	26	10
7-Aug	3.59	100	12.7	30	10
7-Aug	-3.05	110	11.6	21	9
7-Aug	3.43	114	14.0	30	10
7-Aug	0.51	125	14.0	26	10
7-Aug	-0.78	138	13.0	25	10
13-Aug	2.64	152	18.0	29	10
13-Aug	-0.88	166	18.0	24	10
13-Aug	0.83	166	20.0	26	10

Table A.3 Linear discriminate function and meristic data measured on **bull** trout from Tucannon River, 1992.

Date (Collected	LDF	Standard Length (mm)	Maxillary Length (mm)	Branchio-stegal No.	Anal Fin Ray No.
30-May	3.88	428	64.9	29	10
30-May	2.49	525	80.3	27	9
30-May	**1.65**	580	88.1	26	8
30-May	3.54	590	77.0	30	9
29-Jun	0.54	73	10.7	24	10
29-Jun	**-0.31**	76	9.4	24	10
29-Jun	**1.87**	87	10.4	28	9
29-Jun	0.38	109	15.5	24	10
29-Jun	**1.54**	113	14.4	27	9
29-Jun	**0.19**	116	15.9	24	10
29-Jun	**1.04**	117	15.3	26	9
29-Jun	3.70	121	19.8	28	10
29-Jun	-0.44	132	18.1	23	10
29-Jun	0.94	348	48.8	25	10
30-Jun	-0.02	241	32.8	24	9
30-Jun	**0.21**	276	38.0	24	10
30-Jun	-0.08	305	44.7	23	10
30-Jun	-0.38	311	39.4	24	9
30-Jun	-0.35	324	41.3	24	9
30-Jun	0.54	343	46.1	25	9
30-Jun	0.27	439	61.1	24	10
30-Jun	**2.16**	457	73.6	26	9
7-Jul	2.66	169	38.0	23	9
7-Jul	1.86	209	38.0	24	10
7-Jul	**1.63**	244	47.0	23	10
7-Jul	0.07	269	36.0	24	10
7-Jul	**2.01**	293	41.0	27	9
7-Jul	1.48	318	40.0	27	9
7-Jul-	0.22	342	43.0	25	9
7-Jul	2.76	448	62.0	28	10
7-Jul	1.84	448	64.0	26	11
14-Jul	-0.48	250	31.0	24	9
14-Jul	-0.63	285	39.0	23	9
14-Jul	**-1.03**	305	37.0	23	10
14-Jul	0.40	350	44.0	25	10
14-Jul	**1.28**	385	51.0	26	10
17-Jul	2.28	345	45.0	28	9
17-Jul	2.82	364	51.0	28	10
17-Jul	2.85	419	61.0	28	9

APPENDIX B

PRECISION OF AGE DETERMINATION

Introduction

Bony structures from bull trout and 0. *mykiss* captured during 1992 were used to estimate the age of each fish sampled and the fish's growth rate from back-calculations. In the early 1980's a series of papers were published calling for a need to identify the precision and accuracy of ages estimated by bony structures (Beamish and Fournier 1981, Chang 1982, Dapson 1980). As a result, the use of bony structures as a media for aging and back-calculated growth rate has become a topic of heated debate (Francis 1990; Carlander 198 1; Campana 1990). The debate has revolved around which bony structures best estimates the age and growth rate of a given species and to what extent is somantic growth coupled with bony structure growth (Hubert et al. 1987; Sharp and Bernard 1988; Wright et al. 1990). An attempt was made in this study to identify the bony structure which best estimates the age and growth rate of bull trout and *O. mykiss.*

The two bony structures used in this study were otoliths and scales. These structures were chosen as the media for aging due to the following reasons: (1) Otoliths have been identified as the preferred bony structure for aging bull trout (Schill 1991) and *O. mykiss* (McKe et al. 1974); (2) To obtain otoliths the fish must be killed (Schneidervin and Hubert 1986). Thus, scales were taken from a majority of the fish to reduce sampling mortality; and (3) Comparisons between otolith and scale derived age of a given fish acted as a method to verify the precision of age estimates (Dapson 1980).

This study only addressed the precision of estimating age, (in other words, the ability to arrive at the same age for a given fish repeatedly). This study did not address the accuracy of the estimated ages. In order to determine accuracy one must follow a fish population through time with mark and recapture methods to determine if annuli appear on a yearly basis. This study was not conducted over a sufficient length of time to allow for an examination of aging accuracy.

Materials and Methods

An estimate of the precision of aging bull trout and *O. mykiss* by bony structures was accomplished through three different methods. The first method was to determine the precision of age estimates made by a single reader. The otoliths from each fish were viewed three times. During each viewing the age and distance between annuli was determined without knowledge of the fish's length or results from previous viewings. The second method was the precision of age estimates between Keith Underwood the Lead biologist for this study during 1992, and the age determined by Steve Martin, lead biologist during 199 1. The otoliths of ten randomly selected bull trout and ten randomly selected 0. mykiss were independently aged by the two biologists, then compared to determine the differences between readers. Lastly, the fish in which both otoliths and scales were collected were compared to determine if the estimated ages differed between bony structures of the same fish.

The coefficient of variation (V) was used to estimate the precision of aging (Chang 1982).

$$V = \frac{\left(\frac{\left(\sum X_{ij} - X_j \right)^2}{R(R-1)} \right)^{1/2}}{X_j}$$

where: v = coefficient of variation.
R = the number of times the fish was aged;
X_{ij} = the ith age determined for thejth fish; and
Xj = the average age calculated for the jth fish.

The product of the above formula gives the percent error. The coefficient of variation tested the reproducibility between readers, or for an individual reader that has viewed a structure repeatedly. Two comparative statistical tests, an one-way ANOVA and a paired one-tailed "t" test (a = 0.05), were used to identify differences in precision between ages determined by the two different bony structùres and between stream populations of the same species. Statistical tests were completed on a Macintosh computer with the software package, StatView 4.01 (Abacus Concepts 1992).

Results

Table B. 1 and B.2 gives the mean coefficient of variance for each fish species by age and study stream. An one-way ANOVA (a = 0.05) was used to compare the coefficient of variation among the three stream populations for each species studied. The comparison was made to identify whether the precision of aging was similar between the study streams. The test indicated no significant difference for bull trout (F = 0.89, *P = 0.35,* n = 67) or for 0. *mykiss* (F = 1.02, *P* = 0.36, n = 51) between streams. This indicated that the level of

Table B.l. Bull trout age estimated from otoliths. Coefficient of variation (V) and the number of fish measured (n) for otolith age estimated from three trials.

AGE		MILL	TUC	WOLF	MEAN
		RIVER			
1+	n	5	4	14	
	V	0.08	0.00	0.03	**0.04**
2+	n	15	9	4	
	V	0.00	0.04	0.00	**0.01**
3+	n	1	4	2	
	V	0.00	0.00	0.10	**0.03**
4+	n	2	1	0	
	V	0.00	0.20	-	**0.07**
5+	n	1	0	-	
	V	0.12	0.00	-	**0.12**
6+	n	1	2	-	
	V	0.00	0.15	-	**0.10**
7+	n	1	1	-	
	v	0.00	0.15	-	0.08
GRAND MEAN	V				**0.06**

Table B.2. *O. mykiss* age estimated from otoliths. Coefficient of variation (V) and the number of fish sampled (n) for otolith age estimated from three trials.

AGE		MILL	TUC	WOLF	MEAN
			RIVER		
1 +	n	5		1	
	V	0.16	-	0.00	0.13
2 +	n	5	3	9	
	V	0.05	0.00	0.06	0.05
3 +	n	9	5	5	
	V	0.04	0.03	0.03	0.03
4 +	n	1	2	2	
	V	0.15	0.00	0.00	0.03
5 +	n	2	1		
	V	0.00	0.10	-	0.03
6 +	n	-	1		
	v	-	0.00	-	0.00
GRAND MEAN	V				0.05

precision was similar between stream populations and that it was valid to combine the fish aged in all three study streams for additional analyses. The mean coefficient of variation for ages estimated with otoliths viewed three times by one reader was 0.06 for bull trout and 0.05 for *0. mykiss*.

When the aging was conducted by two different readers, the coefficient of variation was 0.08 for bull trout and 0.39 for *0. mykiss* (Table B.3 and B.4). A one-tailed paired "t" test indicated no significant difference between the ages estimated by the two readers for bull trout (t value = -2.00, $P = 0.09$, d.f. = 8). However, there was a significant difference between the ages estimated for 0. *mykiss* (t value = -3.35, $P < 0.01$, d.f. = 9). When ages differed between readers Mr. Underwood consistently aged *0. mykiss* a year older than Mr. Martin.

When the age of a given fish was estimated by both otoliths and scales, the mean coefficient of variance was 0.12 for bull trout and 0.28 for 0. *mykiss* (Table B.5 and B.6). Furthermore, a one-tailed paired "t" test indicated that both bull trout and 0. *mykiss the* ages determined by otoliths significantly differed from ages determined by scales (bull trout: t value = -4.81, $P < 0.01$, n = 36 and 0. *mykiss*: t value = -2.70, $P = 0.01$, d.f. = 45).

Figure B. 1 depicts the ages estimated from otoliths against ages estimated from scales for bull trout and in Figure B.2 for *0. mykiss. The* points that fall on the line within the graph indicate agreement between ages determined by both bony structures. The points that fall above the line suggest aging from otoliths results in older ages than scales. Conversely, the points that fall below the line suggests aging from scales result in older ages than otoliths.

Of the 39 bull trout aged by both otoliths and scales, 64% of the fish aged by both bony structures agreed, 33% of the fish were aged older by otoliths and 3% of the fish were aged older by scales. The fish estimated to be older by otoliths ranged from ages 1 to 6 with a one year spread.

Table B.3 Age of bull trout based on otoliths from two separate readers sampled during 1992 (SM = Steve Marten, KU = Keith Underwood).

RIVER	DATE CAPTURED	FORK LN (mm)	READER SM	READER KU	MEAN AGE	V
Tucannon R.	29-Jun	95	1	1	1	0.00
Tucannon R.	29-Jun	106	1	2	2	0.47
Wolf Fork	26-Jun	108	1	1	1	0.00
Mill Creek	4-Aug	115	1		1	0.00
Tucannon R.	29-Jun	120	2	:	2	0.00
Mill Creek	25-Jul	150	2	2	2	0.00
Wolf Fork	23-Jul	222	3	3	3	0.00
Tucannon R.	1-Jun	278	5	6	6	0.13
Mill Creek	4-Aug	592	6	7	7	0.11
					MEAN	**0.08**

Table B.4 Age of bull trout based on otoliths from two separate readers sampled during 1992 (SM = Steve Marten, KU = Keith Underwood).

RIVER	DATE CAPTURED	FORK LN (mm)	READER SM	READER KU	MEAN AGE	V
Mill Creek	4-Aug	82	0	0	0	0.00
Mill Creek	4-Aug	92	0	1	1	1.41
Wolf Fork	7-Aug	103	1	2	2	0.47
Tucannon R.	29-Jun	118	2	2	2	0.00
Wolf Fork	26-Jun	138	2	2	2	0.00
Mill Creek	4-Aug	140	1	2	2	0.47
Wolf Fork	26-Jun	146	1	2	2	0.47
Tucannon R.	31-Jul	174	2	3	3	0.28
Tucannon R.	29-Jun	190	3	6	5	0.47
Tucannon R.	31-Jul	250	3	5	4	0.35
					MEAN	**0.39**

Table **B.5** Comparison of aging precision between scales and otolith for bull trout. The coefficient of variation (V) and the number of fish sampled **(n)** was listed.

AGE		RIVER MILL	TUC	WOLF	MEAN
1 +	N	3	4	6	
	v	0.00	0.00	0.00	0.00
2 +	N	10’	4	3	
	V	0.17	0.26	0.16	0.19
3 +	N	0	2	1	
	V	0.00	0.28	0.00	0.19
4 +	N	2	-	-	
	v	0.10	-	-	0.10
5 +	N	2	-	-	
	V	0.20	-	-	0.20
6 +	N	-	1	-	
	V	-	0.13	-	0.13
GRAND MEAN	V				0.13

Table B.6 Comparison of aging precision between scales and otolith for *0. mykiss.* The coefficient of variation (V) and the number of fish sampled (n) was listed

AGE		MILL	TUC	WOLF	MEAN
			RIVER		
1 +	n	6	1	1	
	V	0.23	1.41	0.00	**0.35**
2 +	n	3	4	5	
	V	0.00	0.59	0.24	**0.30**
3 +	n	7	4	5	
	V	0.21	0.34	0.22	**0.25**
4 +	n	4	3	2	
	V	0.10	0.53	0.10	**0.24**
GRAND MEAN	V				**0.23**

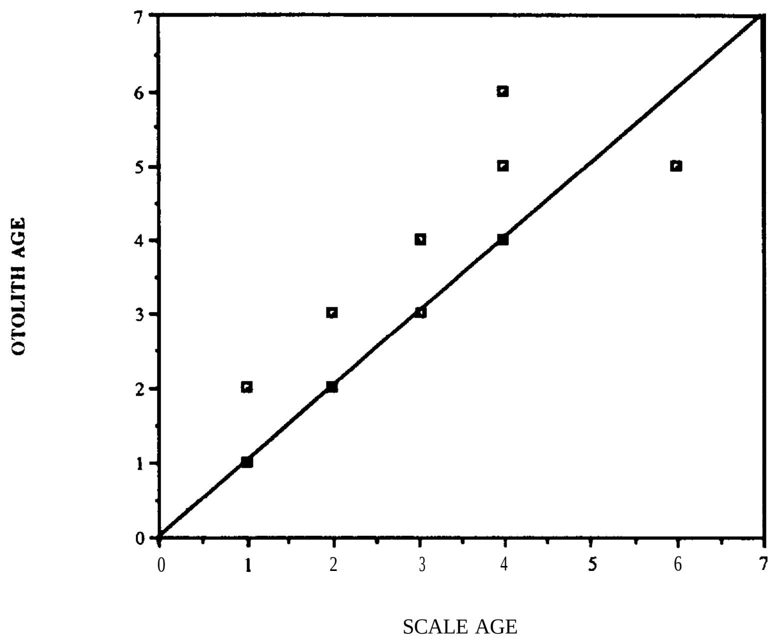

Figure B.l Comparison between fish age determined **by scales and otoliths for** bull trout captured from of Mill Creek, Tucannon River and Wolf Fork. Points on the diagonal line indicate that age estimated from both otoliths and scales were identical for a given fish.

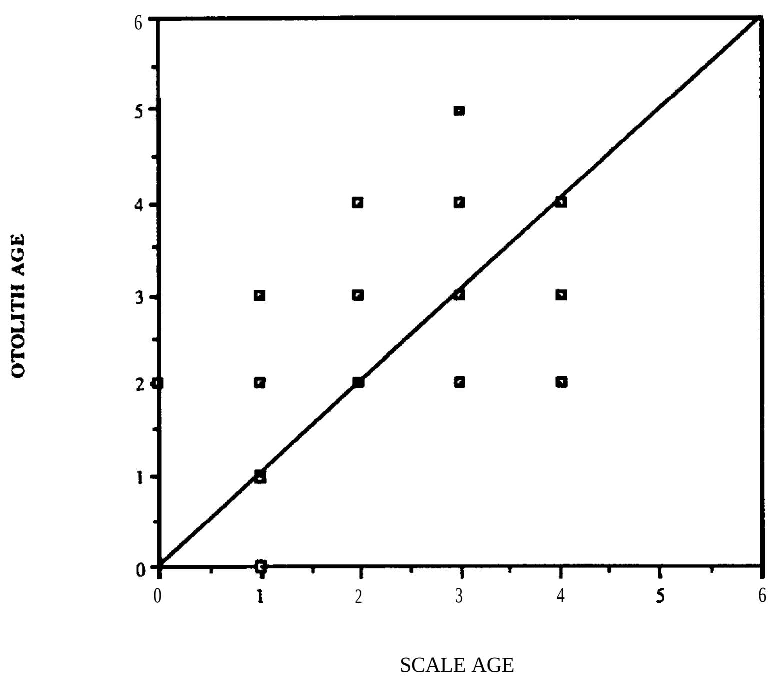

Figure B.2 Comparison between fish age determined by scales and otoliths for 0. ***mykiss*** captured from of Mill Creek, Tucannon River and Wolf Fork. Points on the diagonal line indicates the assigned ages by both bony structures were identical for a given fish.

Of the 46 0. mykiss aged by both otoliths and scales, 40% of the fish aged by both methods agreed, 45% of the fish were aged older by otoliths and 15% of the fish were aged older by scales. The 0. *mykiss* aged older by otoliths ranged from age 1 to 5 and were estimated to be one year older than the scales except for one fish where a 2 year spread was observed.

Discussion

A single reader aging bull trout from otoliths was able to determine the same age of a given fish 94% of the time. Age estimates with otoliths between readers were reproducible 92% of the time. Time did not allow for multiple readings of scales by a single reader or between more than one reader. However, the ages determined by otoliths were compared against the ages determined by scales of a given bull trout. Thirty three percent of the time otolith ages were greater by one year than the ages determined by scales. Schill(l991) reported similar results. Otolith aged fish were estimated to be older than those estimated by scales. Lake trout *(Salvelinus namaycush)* otoliths have been reported to be the best out of five different bony structures for aging (Sharp and Bernard 1988). Bull trout are taxonomic cousins of lake trout and are morphologically similar. Based on the data collected from this study and from other studies, otoliths were determined to be the best bony structure for age estimates. The scales of bull trout are small and the annuli of bull trout scales are difficult to differentiate for non-annular circuli. During this study, scales were viewed under magnification using a microfiche reader. In order to use scales as an aging method, alternative techniques will have to be developed to accurately find annuli. Two possible methods may be the use of a projector to enlarge the scales many times larger than a microfiche reader, use of scanning electron microscope or scan images of bull trout scales into a computer which could use filters to enhance annuli.

0. mykiss otoliths were more difficult to interpret than bull trout otoliths. When one reader estimated the age of an *0. mykiss* repeatedly, 95% of the time the same age was determined. However, when two readers estimated the age of an 0. *mykiss,* 61% of the time the same age was given. Since accuracy of the assigned ages was not studied, there was no way of determining which readers assigned the more accurate ages. As a result otoliths were not used as the method to determine 0. *mykiss* year class at capture and growth rates. Hubert et al.(1987) found no difference in precision when aging cutthroat trout by scales or otoliths. Thus, scales were used for aging because three times as many scales were collected as otoliths. The greater the sample size the more representative a sample is to the population (Zar 1984). For this reason scales were believed to be a better representative of 0. *mykiss* age.

APPENDIX C

LENGTH, WEIGHT, CONDITION FACTOR AND ESTIMATED AGE OF ALL TARGET SPECIES CAPTURED DURING 1992

Table C.l Length, weight, condition factor, age and method aged for all target species captured during 1992 (0 = otolith and S = scale).

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C.F.	Haas No.
Mill Creek	D-l	I-Jul	Bull Trout	2+ / 2+	O / S	158	43	1.090	2.37
Mill Creek	D-l	1-Jul	Bull Trout	2+ / 2+	O / S	159	43	1.070	3.35
Mill Creek	D-l	1-Jul	Bull Trout	4+ / 3+	O / S	194	85	1.164	2.28
Mill Creek	D-l	1-Jul	Bull Trout	4+ / 4+	O / S	273	256	1.258	0.76
Mill Creek	D-l	1-Jul	0. *mykiss*	1+ / 1+	S / 0	89	8	1.135	-
Mill Creek	D-l	I-Jul	0. *mykiss*	1+ / 1+	S / O	111	17	1.243	-
Mill Creek	D-l	1-Jul	0. mykiss	2+ / 2+	s / o	135	30	1.219	-
Mill Creek	D-l	1-Jul	*0. mykiss*	3+ / 3+	S / O	144	40	1.340	-
Mill Creek	D-l	1-Jul	0. *mykiss*	2+	S	146	36	1.157	-
Mill *Creek*	D-l	1-Jul	0. *mykiss*	3+ / 3+	S / O	150	41	1.215	-
Mill Creek	D-l	1-Jul	*0. mykiss*	3+ / 3+	S / O	170	61	1.242	-
Mill Creek	D-l	1-Jul	0. mykiss	4+ / 5+	S / O	201	104	1.281	-
Mill Creek	D-l	1-Jul	*O*. mykiss	4+ / 4+	S / O	222	146	1.334	
Mill Creek	D-l	1-Jul	*0. mykiss*	4+ / 3+	S / O	229	166	1.382	-
Mill Creek	R-l	4-Aug	Bull Trout			55	2	1.202	
Mill Creek	R-l	4-Aug	Bull Trout			56	2	1.139	
Mill Creek	R-l	4-Aug	Bull Trout			57	2	1.080	
Mill Creek	R-l	4-Aug	Bull Trout			58	2	1.025	
Mill Creek	R-l	4-Aug	Bull Trout			58	2	1.025	
Mill Creek	R-l	4-Aug	Bull Trout			59	3	1.461	
Mill Creek	R-l	4-Aug	Bull Trout			60	2	0.926	
Mill Creek	R-l	4-Aug	Bull Trout			62	3	1.259	
Mill Creek	R-l	4-Aug	Bull Trout			64	2	0.763	
Mill Creek	R-l	4-Aug	Bull Trout			66	3	1.043	
Mill Creek	R-l	4-Aug	Bull Trout			66	3	1.043	
Mill Creek	R-l	4-Aug	Bull Trout			67	3	0.997	
Mill Creek	R-l	4-Aug	Bull Trout			68	3	0.954	
Mill Creek	R-l	4-Aug	Bull Trout	*o+*	*S*	79	6	1.217	
Mill Creek	R-l	4-Aug	Bull Trout	1+	*S*	108	12	0.953	
Mill Creek	R-l	4-Aug	Bull Trout			109	13	1.004	
Mill Creek	R-l	4-Aug	Bull Trout			110	14	1.052	
Mill Creek	R-l	4-Aug	Bull Trout			113	14	0.970	
Mill Creek	R-l	4-Aug	Bull Trout	1+	*S*	115	15	0.986	
Mill Creek	R-l	4-Aug	Bull Trout	1+ / 1+	O / S	115	15	0.986	1.56
Mill Creek	R-l	4-Aug	Bull Trout			116	17	1.089	
Mill Creek	R-l	4-Aug	Bull Trout			118	16	0.974	
Mill Creek	R-l	4-Aug	Bull Trout	1+	*S*	119	17	1.009	
Mill Creek	R-l	4-Aug	Bull Trout			123	19	1.021	
Mill Creek	R-l	4-Aug	Bull Trout	1+	*S*	129	20	0.932	
Mill Creek	R-l	4-Aug	Bull Trout	2+ / 1+	*o / s*	137	27	1.050	
Mill Creek	R-l	4-Aug	Bull Trout			143	29	0.992	
Mill Creek	R-l	4-Aug	Bull Trout	2+ / 1+	O / S	149	33	0.998	
Mill Creek	R-l	4-Aug	Bull Trout	2+ / 1+	O / S	150	33	0.978	
Mill Creek	R-l	4-Aug	Bull Trout	2+	*0*	159	37	0.920	
Mill Creek	R-l	4-Aug	Bull Trout	2+ / 2+	O / S	175	54	1.008	2.82
Mill Creek	R-l	4-Aug	Bull Trout	2+	*0*	183	60	0.979	
Mill Creek	R-l	4-Aug	Bull Trout	2+ / 2+	*o / s*	184	61	0.979	0.15
Mill Creek	R-l	4-Aug	Bull Trout	2+	*0*	186	63	0.979	1.29
Mill Creek	R-l	4-Aug	Bull Trout	2+	*S*	190	66	0.962	
Mill Creek	R-l	4-Aug	Bull Trout	3+ / 3+	*o / s*	210	94	1.015	

Table C.l Continued.

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C. F.	Haas No.
Mill Creek	R-l	4-Aug	Bull Trout	6+ / 4+	O / S	349	538	1.266	1.78
Mill Creek	R-l	4-Aug	Bull Trout	7+ / 7+	o / s	592	2225	1.072	3.40
Mill Creek	R-l	4-Aug	0. *mykiss*	1+ / 0+	S / O	82	9	1.632	-
Mill Creek	R-l	4-Aug	0. *mykiss*	1+ /1+	S / O	90	8	1.097	-
Mill Creek	R-l	4-Aug	0. *mykiss*	1+ / 1+	s / o	92	9	1.156	-
Mill Creek	R-l	4-Aug	0. *mykiss*	1+ / 0+	S / O	113	18	1.247	-
Mill Creek	R-l	4-Aug	0. *mykiss*	1+ / 1+	s / o	116	17	1.089	-
Mill Creek	R-l	4-Aug	0. *mykiss*	1+ / 2+	S / O	118	19	1.156	-
Mill Creek	R-l	4-Aug	0. *mykiss*	2+ / 2+	S / 0	140	32	1.166	-
Mill Creek	R-l	4-Aug	0. *mykiss*	3+ / 2+	s / o	163	56	1.293	-
Mill Creek	R-l	4-Aug	0. *mykiss*	2+ / 3+	S / O	168	50	1.054	-
Mill Creek	R-l	4-Aug	0. *mykiss*	3+ / 5+	s / o	264	200	1.087	-
Mill Creek	R-2	17-Aug	Bull Trout	1+	S	126	19	0.950	
Mill Creek	R-2	17-Aug	Bull Trout	1+	S	130	23	1.047	
Mill Creek	R-2	17-Aug	Bull Trout	1+	S	133	24	1.020	
Mill Creek	R-2	17-Aug	Bull Trout	1+	S	140	30	1.093	
Mill Creek	R-2	17-Aug	Bull Trout	1+	S	142	31	1.083	
Mill Creek	R-2	17-Aug	Bull Trout	1+ / 1+	o / s	142	26	0.908	
Mill Creek	R-2	17-Aug	Bull Trout	1+	S	143	31	1.060	
Mill Creek	R-2	17-Aug	Bull Trout	1+	S	145	33	1.082	
Mill Creek	R-2	17-Aug	Bull Trout	1+	0	147	32	1.007	
Mill Creek	R-2	17-Aug	Bull Trout	2+ / 2+	O / S	152	36	1.025	
Mill Creek	R-2	17-Aug	Bull Trout	2+ / 1+	o / s	154	36	0.986	
Mill Creek	R-2	17-Aug	Bull Trout	2+	S	165	47	1.046	1.52
Mill Creek	R-2	17-Aug	0. *mykiss*			91	12	1.592	
Mill Creek	R-2	17-Aug	0. *mykiss*			98	12	1.275	
Mill Creek	R-2	17-Aug	0. *mykiss*			103	14	1.281	
Mill Creek	R-2	17-Aug	0. *mykiss*			105	13	1.123	
Mill Creek	R-2	17-Aug	0. *mykiss*			108	15	1.191	
Mill Creek	R-2	17-Aug	0. *mykiss*			108	14	1.111	
Mill Creek	R-2	17-Aug	0. *mykiss*	1+	S	109	16	1.235	
Mill Creek	R-2	17-Aug	0. *mykiss*	1+	S	112	16	1.139	
Mill Creek	R-2	17-Aug	0. *mykiss*			121	23	1.298	
Mill Creek	R-2	17-Aug	0. *mykiss*	1+	S	127	24	1.172	
Mill Creek	R-2	17-Aug	0. *mykiss*	1+	S	144	34	1.139	
Mill Creek	R-2	17-Aug	0. *mykiss*	2+	S	152	48	1.367	
Mill Creek	R-2	17-Aug	0. *mykiss*	2+	S	154	41	1.123	
Mill Creek	R-2	17-Aug	0. *mykiss*	2+	S	154	40	1.095	
Mill Creek	R-2	17-Aug	0. *mykiss*	3+	S	173	57	1.101	
Mill Creek	R-2	17-Aug	0. *mykiss*	3+	S	182	68	1.128	
Mill Creek	R-2	17-Aug	0. *mykiss*	3+	S	184	67	1.076	
Mill Creek	R-2	17-Aug	0. *mykiss*	3+	S	188	83	1.249	
Mill Creek	R-2	17-Aug	0. *mykiss*	3+	S	208	105	1.167	
Mill Creek	R-3	17-Aug	Bull Trout	1+	S	145	28	0.918	-
Mill Creek	R-3	17-Aug	Bull Trout	1+	S	148	34	1.049	-
Mill Creek	R-3	17-Aug	Bull Trout	2+	0	160	42	1.025	-
Mill Creek	R-3	17-Aug	Bull Trout	2+	S	180	42	0.720	-
Mill Creek	R-3	17-Aug	Bull Trout	3+	S	249	205	1.328	4.18
Mill Creek	R-3	17-Aug	Bull Trout	5+ / 4+	o / s	328	371	1.051	-
Mill Creek	R-3	17-Aug	0. *mykiss*	-		36	>1		

Table C.l Continued.

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C. F.	Haas No.
Mill Creek	R-3	17-Aug	*O. mykiss*	-		55	2	1.202	-
Mill Creek	R-3	17-Aug	0. *mykiss*			55	2	1.202	
Mill Creek	R-3	17-Aug	0. *mykiss*			57	2	1.080	
Mill Creek	R-3	17-Aug	0. *mykiss*			87	9	1.367	
Mill Creek	R-3	17-Aug	0. *mykiss*			93	14	1.741	
Mill Creek	R-3	17-Aug	0. *mykiss*	1+	S	104	13	1.156	
Mill Creek	R-3	17-Aug	0. *mykiss*			118	18	1.096	
Mill Creek	R-3	17-Aug	0. *mykiss*	2+ / 2+	S / O	132	25	1.087	
Mill Creek	R-3	17-Aug	0. *mykiss*			147	37	1.165	
Mill Creek	R-3	17-Aug	0. *mykiss*	2+	S	152	36	1.025	
Mill Creek	R-3	17-Aug	0. *mykiss*	3+	S	165	52	1.158	
Mill Creek	R-3	17-Aug	0. *mykiss*	4+ / 2+	S / O	181	71	1.197	
Mill Creek	R-3	17-Aug	0. *mykiss*	4+ / 3+	S / 0	190	74	1.079	
Mill Creek	R-3	17-Aug	0. *mykiss*	4+	S	191	77	1.105	
Mill Creek	R-3	17-Aug	0. *mykiss*	3+ / 3+	S / O	208	109	1.211	
Mill Creek	R-3	17-Aug	0. *mykiss*	3+	S	220	125	1.174	
Mill Creek	R-3	17-Aug	0. *mykiss*	4+	S	231	132	1.071	
Mill Creek	R-3	17-Aug	0 . *mykiss*	4+	S	250	173	1.107	-
Tucannon R.	D-l	29-Jun	Bull Trout	0+	S	70	4	1.166	
Tucannon R.	D-l	29-Jun	Bull Trout	1+ I 1+	o / s	83	6	1.049	-0.31
Tucannon R.	D-l	29-Jun	Bull Trout	1+	0	84	7	1.181	0.54
Tucannon R.	D-l	29-Jun	Bull Trout	1+	0	95	8	0.933	1.87
Tucannon R.	D-l	29-Jun	Bull Trout	2+ / 1+	O / S	120	20	1.157	0.38
Tucannon R.	D-l	29-Jun	Bull Trout	2+ / 2+	O / S	125	21	1.075	1.54
Tucannon R.	D-l	29-Jun	Bull Trout	2+ / 1+	O / S	126	19	0.950	0.19
Tucannon R.	D- 1	29-Jun	Bull Trout	1+ / 2+	O / S	128	22	1.049	1.04
Tucannon R.	D-l	29-Jun	Bull Trout	2+ / 1+	O / S	130	21	0.956	3.70
Tucannon R.	D-l	29-Jun	Bull Trout	3+ / 2+	O / S	145	41	1.345	-0.44
Tucannon R.	D-l	29-Jun	Bull Trout	4+	S	385	654	1.146	0.94
Tucannon R.	D-l	29-Jun	*O. mykiss*	0+ / 2+	S / O	96	13	1.469	
Tucannon R.	D-l	29-Jun	0. *mykiss*	1+ / 2+	S / O	113	17	1.178	
Tucannon R.	D-l	29-Jun	0. *mykiss*	1+ / 2+	S / O	118	23	1.400	
Tucannon R.	D-l	29-Jun	0. *mykiss*	1+ / 3+	S / O	137	29	1.128	
Tucannon R.	D-l	29-Jun	0. *mykiss*	1+ / 3+	S / O	142	38	1.327	
Tucannon R.	D-l	29-Jun	0. *mykiss*	2+	S	152	47	1.338	
Tucannon R.	D-l	29-Jun	0. *mykiss*	2+ / 3+	s / o	154	47	1.287	
Tucannon R.	D-l	29-Jun	0. *mykiss*	2+ / 4+	S / O	163	58	1.339	
Tucannon R.	D-l	29-Jun	0. *mykiss*	3+ / 6+	S / O	190	90	1.312	
Tucannon R.	D-l	29-Jun	0. *mykiss*	3+ / 4+	S / O	192	80	1.130	
Tucannon R.	R-l	31-Jul	Bull Trout			44	1	1.174	
Tucannon R.	R-l	31-Jul	Bull Trout			44		1.174	
Tucannon R.	R-l	31-Jul	Bull Trout			47		0.963	
Tucannon R.	R-l	31-Jul	Bull Trout			47	1	0.963	
Tucannon R.	R-l	31-Jul	Bull Trout			48	1	0.904	
Tucannon R.	R-l	31-Jul	Bull Trout			49	1	0.850	
Tucannon R.	R-l	31-Jul	Bull Trout			49	1	0.850	
Tucannon R.	R-l	31-Jul	Bull Trout			51		0.754	
Tucannon R.	R-l	31-Jul	Bull Trout			53	1	0.672	
Tucannon R.	R-l	31-Jul	Bull Trout			54	2	1.270	
Tucannon R.	R-l	31-Jul	Bull Trout	0+	S	83	7	1.224	

Table C.1 Continued.

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C. F.	Haas No.
Tucannon R.	R-1	31-Jul	Bull Trout	-		91	8	1.062	
Tucannon R.	R-1	31-Jul	Bull Trout	1+	O	98	8	0.850	
Tucannon R.	R-1	31-Jul	Bull Trout			103	9	0.824	
Tucannon R.	R-1	31-Jul	Bull Trout	1+	S	107	13	1.061	
Tucannon R.	R-1	31-Jul	Bull Trout			109	12	0.927	
Tucannon R.	R-1	31-Jul	Bull Trout			117	17	1.061	
Tucannon R.	R-1	31-Jul	Bull Trout			127	18	0.879	
Tucannon R.	R-1	31-Jul	Bull Trout			128	18	0.858	
Tucannon R.	R-1	31-Jul	Bull Trout	1+	S	132	20	0.870	
Tucannon R.	R-1	31-Jul	Bull Trout			138	27	1.027	
Tucannon R.	R-1	31-Jul	Bull Trout			148	30	0.925	
Tucannon R.	R-1	31-Jul	Bull Trout	3+/2+	O / S	158	36	0.913	
Tucannon R.	R-1	31-Jul	Bull Trout			165	45	1.002	
Tucannon R.	R-1	31-Jul	Bull Trout	2+	S	167	43	0.923	
Tucannon R.	R-1	31-Jul	Bull Trout			178	74	1.312	
Tucannon R.	R-1	31-Jul	O. mykiss			37		1.974	
Tucannon R.	R-1	31-Jul	O. mykiss			37	1	1.974	
Tucannon R.	R-1	31-Jul	O. mykiss			38		1.822	
Tucannon R.	R-1	31-Jul	O. mykiss	oi	S	75	5	1.185	
Tucannon R.	R-1	31-Jul	O. mykiss	2+	S	153	43	1.201	
Tucannon R.	R-1	31-Jul	O. mykiss	2+	S	158	46	1.166	
Tucannon R.	R-1	31-Jul	O. mykiss	2+/3+	S / O	174	64	1.215	
Tucannon R.	R-1	31-Jul	O. mykiss			201	112	1.379	
Tucannon R.	R-1	31-Jul	O. mykiss	3+/5+	S/O	250	202	1.293	
Tucannon R.	R-2	18-Aug	Bull Trout	1+ / 1+	S/O	110	13	0.977	-
Tucannon R.	R-2	18-Aug	Bull Trout	1+	S	110	14	1.052	
Tucannon R.	R-2	18-Aug	Bull Trout	1+	S	125	20	1.024	
Tucannon R.	R-2	18-Aug	Bull Trout	2+ / 1+	O / S	134	23	0.956	
Tucannon R.	R-2	18-Aug	O. mykiss			49		0.850	
Tucannon R.	R-2	18-Aug	O. mykiss	1+	S	124	21	1.101	
Tucannon R.	R-2	18-Aug	O. mykiss	1+	S	129	23	1.071	
Tucannon R.	R-2	18-Aug	O. mykiss	2+	S	135	25	1.016	
Tucannon R.	R-2	18-Aug	O. mykiss	1+	S	144	33	1.105	
Tucannon R.	R-2	18-Aug	O. *mykiss*	1+	S	148	35	1.080	
Tucannon R.	R-2	18-Aug	O. mykiss	2+	S	152	36	1.025	
Tucannon R.	R-2	18-Aug	O. *mykiss*	2+	S	164	46	1.043	
Tucannon R.	R-2	18-Aug	O. *mykiss*	2+	S	166	54	1.181	
Tucannon R.	R-2	18-Aug	O. *mykiss*	2+	S	171	57	1.140	
Tucannon R.	R-2	18-Aug	O. *mykiss*			172	60	1.179	
Tucannon R.	R-2	18-Aug	O. *mykiss*	2+	S	177	64	1.154	
Tucannon R.	R-2	18-Aug	O. *mykiss*	2+	S	188	78	1.174	
Tucannon R.	R-2	18-Aug	O. *mykiss*			188	72	1.084	
Tucannon R.	R-2	18-Aug	O. *mykiss*	2+	S	201	92	1.133	
Tucannon R.	R-3	24-Aug	Bull Trout	1+	S	105	12	1.037	
Tucannon R.	R-3	24-Aug	Bull Trout	2+	S	128	22	1.049	
Tucannon R.	R-3	24-Aug	Bull Trout	1+	S	128	21	1.001	
Tucannon R.	R-3	24-Aug	Bull Trout	2+	S	140	28	1.020	
Tucannon R.	R-3	24-Aug	O. *mykiss*			44		1.174	
Tucannon R.	R-3	24-Aug	O. *mykiss*			45		1.097	
Tucannon R.	R-3	24-Aug	O. *mykiss*			50		0.800	

Table C.l **Continued.**

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C. F.	Haas No.
Tucannon R.	R-3	24-Aug	*O. mykiss*	-		52	1	0.711	-
Tucannon R.	R-3	24-Aug	0. *mykiss*			85	6	0.977	
Tucannon R.	R-3	24-Aug	0. *mykiss*	1+	S	87	8	1.215	
Tucannon R.	R-3	24-Aug	0. *mykiss*			103	17	1.556	
Tucannon R.	R-3	24-Aug	*O. mykiss*			121	20	1.129	
Tucannon R.	R-3	24-Aug	0. *mykiss*			130	25	1.138	
Tucannon R.	R-3	24-Aug	0. *mykiss*	2+	S	131	22	0.979	
Tucannon R.	R-3	24-Aug	0. *mykiss*	1+	S	135	24	0.975	
Tucannon R.	R-3	24-Aug	0. *mykiss*			140	34	1.239	
Tucannon R.	R-3	24-Aug	0. *mykiss*	2+	S	149	37	1.119	
Tucannon R.	R-3	24-Aug	0. *mykiss*	2+	S	150	38	1.126	
Tucannon R.	R-3	24-Aug	0. *mykiss*	3+	S	165	53	1.180	
Tucannon R.	R-3	24-Aug	0. *mykiss*	3+	S	168	47	0.991	
Tucannon R.	R-3	24-Aug	0. *mykiss*	2+	S	173	60	1.159	
Tucannon R.	R-3	24-Aug	0. *mykiss*		-	175	61	1.138	
Tucannon R.	R-3	24-Aug	0. *mykiss*	3+	S	180	65	1.115	
Tucannon R.	R-3	24-Aug	0. *mykiss*			188	79	1.189	
Tucannon R.	R-3	24-Aug	0. *mykiss*	3+	S	195	88	1.187	
Tucannon R.	R-3	24-Aug	0. *mykiss*	4+	S	216	119	1.181	-
Wolf Fork	D-l	26-Jun	Bull Trout	-		49	1	0.850	
Wolf Fork	D-l	26-Jun	Bull Trout			58	1	0.513	
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	O / S	108	14	1.111	0.01
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	O / S	108	13	1.032	3.59
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	O / S	110	11	0.826	2.25
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	O / S	112	11	0.783	-1.02
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	O / S	118	17	1.035	-3.05
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	O / S	119	16	0.949	0.89
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	o / s	120	17	0.984	-0.07
Wolf Fork	D-l	26-Jun	Bull Trout	1+ / 1+	O / S	126	17	0.850	1.83
Wolf Fork	D-l	26-Jun	Bull Trout	1+	0	126	19	0.950	2.22
Wolf Fork	D-l	26-Jun	Bull Trout	2+ / 1+	O / S	138	29	1.103	-0.02
Wolf Fork	D-l	26-Jun	Bull Trout	2+ / 2+	O / S	150	35	1.037	1.25
Wolf Fork	D-l	26-Jun	0. my kiss	1+ / 1+	S / O	95	12	1.400	
Wolf Fork	D-l	26-Jun	*O.* my kiss	2+ / 2+	S / O	138	34	1.294	
Wolf Fork	D-l	26-Jun	0. my kiss	2+ / 2+	S / O	140	33	1.203	
Wolf Fork	D-l	26-Jun	0. *mykiss*	2+ / 2+	S / O	146	46	1.478	
Wolf Fork	D-l	26-Jun	*O. mykiss*	2+ / 3+	S / O	162	59	1.388	
Wolf Fork	D-l	26-Jun	*O. mykiss*	2+	S	167	57	1.224	
Wolf Fork	D-l	26-Jun	*0. mykiss*	3+	S	168	57	1.202	
Wolf Fork	D-l	26-Jun	*0. my kiss*	2+ / 3+	S / O	175	63	1.176	
Wolf Fork	D-l	26-Jun	*0. mykiss*	3+ / 3+	S / O	183	85	1.379	
Wolf Fork	D-l	26-Jun	*0. mykiss*	3+	S	190	77	1.123	
Wolf Fork	R-l	13-Aug	Bull Trout	1+	S	125	19	0.973	-
Wolf Fork	R-l	13-Aug	Bull Trout	1+	S	125	20	1.024	-
Wolf Fork	R-l	13-Aug	Bull Trout	2+	S	160	43	1.050	-
Wolf Fork	R-l	13-Aug	Bull Trout	2+ / 2+	O / S	166	49	1.071	2.64
Wolf Fork	R-l	13-Aug	Bull Trout	2+	S	178	59	1.046	-0.88
Wolf Fork	R-l	13-Aug	Bull Trout	2+	S	180	60	1.029	0.83
Wolf Fork	R-l	13-Aug	Bull Trout	2+	S	180	60	1.029	-
Wolf Fork	R-l	13-Aug	Bull Trout	3+	S	190	77	1.123	-

Table C.l Continued.

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C.F.	Haas No.
Wolf Fork	R-l	13-Aug	0. *mykiss*			34	>1		
Wolf Fork	R-l	13-Aug	0. *mykiss*			38	1	1.822	
Wolf Fork	R-l	13-Aug	0. *mykiss*			42	1	1.350	
Wolf Fork	R-l	13-Aug	0. *mykiss*	0+	S	88	8	1.174	
Wolf Fork	R-l	13-Aug	0. *mykiss*	1+	S	94	10	1.204	
Wolf Fork	R-l	13-Aug	0. *mykiss*		-	95	10	1.166	
Wolf Fork	R-l	13-Aug	0. *mykiss*			95	12	1.400	
Wolf Fork	R-l	13-Aug	0. *mykiss*			97	12	1.315	
Wolf Fork	R-l	13-Aug	0. *mykiss*			98	9	0.956	
Wolf Fork	R-l	13-Aug	0. *mykiss*			104	14	1.245	
Wolf Fork	R-l	13-Aug	0. *mykiss*			108	16	1.270	
Wolf Fork	R-l	13-Aug	0. *mykiss*	1+	S	109	15	1.158	
Wolf Fork	R-l	13-Aug	0. *mykiss*			111	20	1.462	
Wolf Fork	R-l	13-Aug	0. *mykiss*			112	16	1.139	
Wolf Fork	R-l	13-Aug	0. *mykiss*			112	18	1.281	
Wolf Fork	R-l	13-Aug	0. *mykiss*	1+	S	114	20	1.350	
Wolf Fork	R-l	13-Aug	0. *mykiss*			115	18	1.184	
Wolf Fork	R-l	13-Aug	0. *mykiss*			115	20	1.315	
Wolf Fork	R-l	13-Aug	0. *mykiss*	1+	S	118	19	1.156	
Wolf Fork	R-l	13-Aug	0. *mykiss*	1+	S	119	19	1.127	
Wolf Fork	R-l	13-Aug	0. *mykiss*	1+	S	126	23	1.150	
Wolf Fork	R-l	13-Aug	0. *mykiss*			130	25	1.138	
Wolf Fork	R-l	13-Aug	0. *mykiss*	1+	S	145	33	1.082	
Wolf Fork	R-l	13-Aug	0. *mykiss*			170	60	1.221	
Wolf Fork	R-l	13-Aug	0. *mykiss*	3+	S	178	60	1.064	
Wolf Fork	R-l	13-Aug	0. *mykiss*	3+ / 4+	S / O	179	67	1.168	
Wolf Fork	R-l	13-Aug	0. *mykiss*	3+	S	190	84	1.225	
Wolf Fork	R-l	13-Aug	0. *mykiss*	3+	S	198	98	1.262	
Wolf Fork	R-2	7-Aug	Bull Trout	0+	S	75	4	0.948	
Wolf Fork	R-2	7-Aug	Bull Trout	o+	S	78	8	1.686	
Wolf Fork	R-2	7-Aug	Bull Trout	l+ / 1+	O / S	112	13	0.925	
Wolf Fork	R-2	7-Aug	Bull Trout	1+	S	116	14	0.897	
Wolf Fork	R-2	7-Aug	Bull Trout	1+	S	129	20	0.932	3.43
Wolf Fork	R-2	7-Aug	Bull Trout			137	20	0.778	0.51
Wolf Fork	R-2	7-Aug	Bull Trout	1+	S	151	38	1.104	0.78
Wolf Fork	R-2	7-Aug	0. *mykiss*			42	1	1.350	
Wolf Fork	R-2	7-Aug	O. *mykiss*	-	-	43	1	1.258	
Wolf Fork	R-2	7-Aug	0. *mykiss*	-	-	61	2	0.881	
Wolf Fork	R-2	7-Aug	0. *mykiss*	-	-	73	4	1.028	
Wolf Fork	R-2	7-Aug	0. *mykiss*			85	7	1.140	
Wolf Fork	R-2	7-Aug	0. *mykiss*			87	9	1.367	
Wolf Fork	R-2	7-Aug	0. *mykiss*	1+	S	94	11	1.324	
Wolf Fork	R-2	7-Aug	O. *mykiss*			95	8	0.933	
Wolf Fork	R-2	7-Aug	0. *mykiss*	1+	S	97	9	0.986	
Wolf Fork	R-2	7-Aug	0. *mykiss*	1+	S	98	10	1.062	
Wolf Fork	R-2	7-Aug	O. *mykiss*			98	10	1.062	
Wolf Fork	R-2	7-Aug	O. *mykiss*			101	14	1.359	
Wolf Fork	R-2	7-Aug	O. *mykiss*	1+	S	102	12	1.131	
Wolf Fork	R-2	7-Aug	0. *mykiss*	2+	0	103	12	1.098	
Wolf Fork	R-2	7-Aug	0. *mykiss*	1+	S	107	15	1.224	

Table C.l Continued.

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C.F.	Haas No.
Wolf Fork	R-2	7-Aug	0. mykiss			107	15	1.224	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	110	14	1.052	-
Wolf Fork	R-2	7-Aug	0. mykiss			111	17	1.243	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	118	20	1.217	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+ / 2+	S / O	123	23	1.236	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	124	22	1.154	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	125	21	1.075	-
Wolf Fork	R-2	7-Aug	O. mykiss	1+	S	126	23	1.150	-
Wolf Fork	R-2	7-Aug	0. mykiss			129	24	1.118	-
Wolf Fork	R-2	7-Aug	0. mykiss			131	24	1.068	-
Wolf Fork	R-2	7-Aug	0. mykiss	2+	S	132	25	1.087	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	133	27	1.148	-
Wolf Fork	R-2	I-Aug	0. mykiss	2+	0	135	27	1.097	-
Wolf Fork	R-2	7-Aug	0. mykiss			139	31	1.154	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	141	34	1.213	-
Wolf Fork	R-2	7-Aug	0. mykiss		-	143	32	1.094	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	144	31	1.038	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	148	37	1.141	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+	S	151	42	1.220	-
Wolf Fork	R-2	7-Aug	0. mykiss	1+ / 2+	S	168	60	1.265	-
Wolf Fork	R-2	7-Aug	0. mykiss	2+	S	176	56	1.027	-
Wolf Fork	R-2	7-Aug	0. mykiss	2+	S	204	92	1.084	-
Wolf Fork	R-3	19-Aug	Bull Trout	3+ / 3+	O / S	222	142	1.298	
Wolf Fork	R-3	19-Aug	0. mykiss			35	>1		
Wolf Fork	R-3	19-Aug	0. mykiss			42	1	1.350	
Wolf Fork	R-3	19-Aug	0. mykiss			47	1	0.963	
Wolf Fork	R-3	19-Aug	0. mykiss			48	2	1.808	
Wolf Fork	R-3	19-Aug	0. mykiss			49		0.850	
Wolf Fork	R-3	19-Aug	0. mykiss			49		0.850	
Wolf Fork	R-3	19-Aug	0. mykiss			50	2	1.600	
Wolf Fork	R-3	19-Aug	0. mykiss			50	2	1.600	
Wolf Fork	R-3	19-Aug	0. mykiss			53	2	1.343	
Wolf Fork	R-3	19-Aug	0. mykiss			55	2	1.202	
Wolf Fork	R-3	19-Aug	0. mykiss			55	3	1.803	
Wolf Fork	R-3	19-Aug	0. mykiss			59	2	0.974	
Wolf Fork	R-3	19-Aug	0. mykiss	1+	S	62	2	0.839	
Wolf Fork	R-3	19-Aug	0. mykiss			64	3	1.144	
Wolf Fork	R-3	19-Aug	0. mykiss			64	3	1.144	
Wolf Fork	R-3	19-Aug	0. mykiss			65	3	1.092	
Wolf Fork	R-3	19-Aug	0. mykiss			70	4	1.166	
Wolf Fork	R-3	19-Aug	0. mykiss			75	4	0.948	
Wolf Fork	R-3	19-Aug	0. mykiss			76	5	1.139	
Wolf Fork	R-3	19-Aug	0. mykiss			82	7	1.270	
Wolf Fork	R-3	19-Aug	0. mykiss			83	6	1.049	
Wolf Fork	R-3	19-Aug	0. mykiss			84	7	1.181	
Wolf Fork	R-3	19-Aug	0. mykiss			88	9	1.321	
Wolf Fork	R-3	19-Aug	0. mykiss			91	9	1.194	
Wolf Fork	R-3	19-Aug	0. mykiss			92	9	1.156	
Wolf Fork	R-3	19-Aug	0. mykiss			93	11	1.368	
Wolf Fork	R-3	19-Aug	0. mykiss			95	10	1.166	

Table C.1 Continued.

STREAM	SITE	DATE	SPECIES	AGE	METHOD AGED (1)	FORK LN. (mm)	WEIGHT (g)	C. F.	Haas No.
Wolf Fork	R-3	19-Aug	0. *mykiss*			98	12	1.275	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			100	12	1.200	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			100	10	1.000	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			102	12	1.131	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			102	11	1.037	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			103	12	1.098	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	1+	S	105	13	1.123	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			106	13	1.092	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			110	14	1.052	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			111	14	1.024	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			114	18	1.215	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			114	17	1.147	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			116	18	1.153	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			117	17	1.061	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	1+	S	117	18	1.124	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			119	17	1.009	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	1+	S	120	21	1.215	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			129	26	1.211	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			130	33	1.502	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	1+	S	132	25	1.087	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	2+	0	134	24	0.997	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			135	24	0.975	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			135	28	1.138	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	1+	S	137	29	1.128	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	2+	S	143	34	1.163	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			150	38	1.126	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			150	46	1.363	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	2+	S	151	39	1.133	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			153	34	0.949	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			156	40	1.054	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	2+	S	160	46	1.123	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	2+	S	161	46	1.102	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	3+ / 3+	S / O	167	47	1.009	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	3+	S	175	60	1.120	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			177	76	1.371	-
Wolf Fork	R-3	19-Aug	*O. mykiss*			178	66	1.170	-
Wolf Fork	R-3	19-Aug	*O. mykiss*			178	59	1.046	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	3+	S	184	82	1.316	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	2+	S	190	76	1.108	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	3+	S	198	92	1.185	-
Wolf Fork	R-3	19-Aug	0. *mykiss*			200	92	1.150	-
Wolf Fork	R-3	19-Aug	0. *mykiss*	4+ / 4+	S / O	206	94	1.075	-

NOTE: (1)
S = SCALES
0 = OTOLITHS

APPENDIX D

BACK-CALCULATED LENGTH AT ANNULUS BY COHORT

Table D.l. Mean back-calculated fork length for bull trout from Mill Creek, 1992.

COHORT	N	MEAN±S.D. BACK CALCULATED FORK LENGTH AT ANNULUS (OTOLITH AGE) 1	2	3	4	5	6
1992	5	95±15					
1991	16	96±10	137±14				
1990	1	99	135	174			
1989	2	92±5	137±20	177±30	214±46		
1988	1	103	182	239	262	297	
1987	1	107	145	212	273	309	347
GRAND MEAN		**96±10** **N=26**	**139±16** **N=21**	**196±32** **N=5**	**241±41** **N=4**	**303±9** **N=2**	**347** N=1
MEAN ANNUAL GROWTH INCREMENTAL		96	43	57	45	63	44

Table D.2. Mean back-calculated fork length for bull trout from Tucannon River, 1992.

COHORT	N	MEAN±S.D. BACK CALCULATED FORK LENGTH AT ANNULUS (OTOLITH AGE) 1	2	3	4
1992	4	67±14			
1991	10	61±6	99±8		
1990	4	62±11	97±13	126±13	
1989	2	98±50	152±22	198±23	247±29
GRAND MEAN		**66±15** **N=20**	**105±21** **N=16**	**150±40** **N=6**	**247±29** **N=2**
MEAN ANNUAL GROWTH INCREMENTAL		66	39	45	97

Table D.3. Mean back-calculated fork length for bull trout from Wolf Fork, 1992.

COHORT	N	MEAN±S.D. BACK CALCULATED FORK LENGTH AT ANNULUS (OTOLITH AGE) 1	2	3	4	5
1992	14	92±6				
1991	4	72±10	125±10			
1990	1	105	164	192		
GRAND MEAN		**88±11 N=20**	**136±20 N=5**	**192 N=1**		
MEAN ANNUAL GROWTH INCREMENTAL		**88**	**48**	**56**		

Table D.4. Mean back-calculated fork length for 0. ***mykiss*** from Mill Creek, 1992.

COHORT	N	MEAN±S.D. BACK CALCULATED FORK LENGTH AT ANNULUS (SCALE AGE) 1	2	3	4
1992	13	71±15			
1991	10	70±14	112±19		
1990	14	63±11	109±22	148±28	
1989	7	50±8	83±7	129±17	171±21
GRAND MEAN		**64±14 N=44**	**103±22 N=31**	**140±26 N=21**	**171±21 N=7**
MEAN ANNUAL GROWTH INCREMENTAL		**64**	**39**	**37**	**31**

Table **D.5.** Mean back-calculated fork length for 0. ***mykiss*** from Tucannon River, 1992.

COHORT	N	**MEAN±S.D.** BACK CALCULATED FORK LENGTH AT **ANNULUS** (SCALE AGE) 1	2	3	4	5
1992	11	96±20				
1991	18	89±15	144±26			
1990	7	63±8	107fll	158±17		
1989	2	84±32	112±33	174±14	209±24	
GRAND MEAN		**86±20 N=38**	**132±28 N=27**	**162±17 N=9**	**209±24 N=2**	
MEAN ANNUAL GROWTH **INCREMENTAL**		86	46	30	47	

Table D.6. Mean back-calculated fork length for 0. ***mykiss*** from Wolf Fork, 1992.

COHORT	N	**MEAN±S.D.** BACK CALCULATED FORK LENGTH AT **ANNULUS** (SCALE AGE) 1	2	3	4
1992	33	83±20			
1991	16	68±15	121±18		
1990	11	74fll	121±19	159±18	
1989	1	64	110	156	191
GRAND MEAN		**93±15 N=61**	**130±17 N=28**	**164f 15 N=12**	**191 N=1**
MEAN ANNUAL GROWTH INCREMENTAL		93	37	44	27

APPENDIX E

AVAILABLE HABITAT BY SAMPLE SITE FOR EACH STUDY STREAM

Table E.l. Mill Creek available habitat and physical characteristics by site. Embeddedness, substrate type, and cover type are listed as percent classes where, 1 ≤ 5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-75%; and 5 ≥ 76%.

	SITE NUMBER R-l	R-2	R-3	H-l
'HYSICAL CHARACTER				
DATE	4-Aug-92	17-Aug-92	17-Aug-92	2-Oct-92
ELEVATION (ft)	2,920	2,620	2,480	3,400
TEMPERATURE (F)	50	56	50	34
SURFACE AREA (m^2)	641	851	1,108	403
WIDTH (m)	6.7	8.0	11.2	4.1
DEPTH (Ft)	0.95	0.69	0.66	
GRADIENT (%)	2.0	2.2	1.9	4.4
VELOCITY (Ft/S)	1.95	1.05	1.07	
DISCHARGE (CFS)	10.5	17.5	29.0	
EMBEDDEDNESS	2	1	1	1
***IABITAT** TYPE*				
CASCADE (%)	25.0	40.0	36.7	88.3
RUN (%)	38.3	10.0	0.0	5.0
RIFFLE (%)	8.3	50.0	53.3	0.0
PLUNGE POOL (%)	25.0	0.0	3.3	3.3
SCOUR POOL (%)	3.3	0.0	6.7	3.3
***;UBSTRATE** TYPE*				
ORGANIC/SILT	1	1	1	2
FINES	1	2	2	2
SMALL GRAVEL	2	2	2	1
LARGE GRAVEL	2	2	3	2
SMALL COBBLE	3	2	3	2
LARGE COBBLE	3	3	3	2
BOULDER	2	3	2	4
***:OVER** TYPE*				
FALLEN LOG	1	2	1	1
SUNKEN WOOD	1	1	1	1
LOG JAM	1	1	1	1
ROOT WAD	3	1	2	1
TOTAL WOOD	3	2	2	1
BOULDER	2	2	2	3
UNDERCUT BANK	2	1	1	1
TURBULENCE	2	3	4	4
OVERHEAD COVER	3	5	4	3

Table E.2. Tucannon River available habitat and physical characteristics by site. Embeddedness, substrate type, and cover type are listed as percent classes where, 1 ≤ 5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-75%; and 5 ≥ 76%.

	SITE NUMBER			
	R-1	R-2	R-3	H-1
HYSICAL CHARACTER				
DATE	31-Jul-92	18-Aug-92	24-Aug-92	3-w-92
ELEVATION (ft)	3,880	3,660	3,480	4,040
TEMPERATURE (F)	-	58	54	46
SURFACE AREA (m^2)	473	402	387	407
WIDTH (m)	4.8	4.1	4.2	4.1
DEPTH (Ft)	0.74	0.60	0.48	0.30
GRADIENT (%)	3.9	2.5	1.9	3.5
VELOCITY (Ft/S)	0.84	0.66	1.51	1.50
DISCHARGE (CFS)	3.23	3.23	3.21	2.39
EMBEDDEDNESS	1	3	2	3
HABITAT TYPE				
CASCADE (%)	0.0	6.7	0.0	13.3
RUN (%)	0.0	23.3	36.7	13.3
RIFFLE (%)	83.3	40.0	30.0	56.7
PLUNGE POOL (%)	16.7	6.7	13.3	10.0
SCOUR POOL (%)	0.0	23.3	20.0	6.7
SUBSTRATE TYPE				
ORGANIC/SILT	1	2	1	1
FINES	2	2	2	2
SMALL GRAVEL	2	3	3	2
LARGE GRAVEL	3	3	3	2
SMALL COBBLE	3	2	3	2
LARGE COBBLE	3	1	1	2
BOULDER	2	1	1	3
OVER TYPE				
FALLEN LOG	1	1	2	2
SUNKEN WOOD	1	2	2	1
LOG JAM	1	2	2	2
ROOT WAD	1	1	1	1
TOTAL WOOD	2	3	3	3
BOULDER	2	1	1	1
UNDERCUT BANK	1	2	2	3
TURBULENCE	3	1	1	2
OVERHEAD COVER	3	4	3	3

Table E.3. Wolf Fork available habitat and physical characteristics by site. Embeddedness, substrate type, and cover type are listed as percent classes where, 1 ≤ 5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-75%; and 5 ≥ 76%.

	SITE NUMBER			
	R-1	R-2	R-3	H-1
HYSICAL CHA RACTER				
DATE	13-Aug-92	6-Aug-92	19-Aug-92	16-Sep-92
ELEVATION (ft)	3,380	3,040	2,680	3,080
TEMPERATURE (F)	56	51	54	47
SURFACE AREA (m^2)	368	466	639	476
WIDTH (m)	3.7	4.7	6.5	4.8
DEPTH (Ft)	0.31	0.76	0.63	
GRADIENT (%)	3.9	2.7	1.3	5.2
VELOCITY (Ft/S)	0.94	1.38	2.31	
DISCHARGE (CFS)	0.91	4.72	12.61	
EMBEDDEDNESS	2	4	5	3
***HABITAT** TYPE*				
CASCADE (%)	13.3	41.7	38.3	55.0
RUN (%)	13.3	8.3	38.3	28.3
RIFFLE (%)	43.3	45.0	15.0	0.0
PLUNGE POOL (%)	30.0	0.0	8.3	0.0
SCOUR POOL (%)	0.0	5.0	0.0	16.7
UBSTRATE TYPE				
ORGANIC/SILT	2	1	2	1
FINES	2	2	2	2
SMALL GRAVEL	2	2	1	2
LARGE GRAVEL	2	2	2	2
SMALL COBBLE	3	3	3	3
LARGE COBBLE	3	2	3	3
BOULDER	2	3	2	3
'OVER TYPE				
FALLEN LOG	2	2	1	1
SUNKEN WOOD	1	1	1	1
LOG JAM	2	1	1	1
ROOT WAD	1	1	2	1
TOTAL WOOD	3	2	2	2
BOULDER	2	2	1	3
UNDERCUT BANK	1	2	2	1
TURBULENCE	2	3	3	4
OVERHEAD COVER	5	3	3	3

APPENDIX F

DATA COLLECTED FROM EACH FISH OBSERVED DURING HABITAT UTILIZATION SURVEY

Table F.l. Data collected from each fish observed during habitat utilization survey during 1992.

Stream	Habitat Type	Site #	Dale	Time	Species {A}	Age	Waler Temp.(°C)	FOCUS Water Velocity (Ft/s)	FOCUS Substrate Size {B}	FOCUS TO Streambed (In)	Stream Depth (ft.)	Cover Type {C}	Focus to Cover	Focus to Closest Fish Species	Focus to Closest Fish Distance (m)
Mill Creek	SCOUR	M-l	1-Sep	13:00	BULL	2+	4	0.34	6	0.08	1.20	5	0.70	RBT	1.30
Mill Creek	SCOUR	M-l	1-Sep	13:00	RBT	ot	4	0.16	6	1.oo	2.80	4	0.00	RBT	0.60
Mill Creek	SCOUR	M-l	1-Sep	13:00	RBT	1+	4	0.75	6	0.08	2.00	5	0.70	RBT	0.90
Mill Creek	SCOUR	M-l	1-Sep	13:00	RBT	1+	4	0.02	6	0.08	1.90	5	0.40	RBT	1.70
Mill Creek	SCOUR	M-1	1-Sep	13:00	RBT	I+	4	0.02	6	1.00	3.00	4	0.00	RBT	0.60
Mill Creek	SCOUR	M-l	1-Sep	13:00	RBT	1+	4	0.07	7	0.10	2.50	5	0.00	RBT	0.50
Mill Creek	SCOUR	M-l	1-Sep	13:00	RBT	2t	4	0.26	6	0.17	2.10	8	1.00	RBT	0.90
Mill Creek	SCOUR	M-l	1-Sep	13:00	RBT	2t	4	0.81	6	0.08	1.70	0	0.40	RBT	1.70
Mill Creek	SCOUR	M-l	1-Sep	13:00	RBT	2+	4	0.48	7	0.30	2.45	5	0.00	RBT	0.50
Mill Creek	RIFFLE	M-l	1-Sep	12:30	BULL	1+	4	1.04	5	0.08	1.22	8	0.00	RBT	0.50
Mill Creek	RIFFLE	M-l	1-Sep	12:30	RBT	1+	4	1.28	5	0.08	0.55	8	0.00	RBT	0.50
Mill Creek	RIFFLE	M-l	1-Sep	12:30	RBT	1+	4	1.47	5	0.08	0.77	8	0.00	BULL	0.40
Mill Creek	CASCADE	M-l	1-Sep	11:15	BULL	1+	4	0.20	4	0.00	1.02	7	0.00	RBT	3.00
Mill Creek	CASCADE	M-l	1-Sep	11:15	RBT	It	4	0.55	6	0.17	0.91	8	0.00	RBT	0.60
Mill Creek	CASCADE	M-l	1-Sep	11:15	RBT	1+	4	0.60	6	0.25	1.15	8	0.00	RBT	0.60
Mill Creek	CASCADE	M-l	1-Sep	11:15	RBT	2t	4	0.25	6	0.25	0.95	5	0.01	RBT	9.50
Mill Creek	CASCADE	M-l	1-Sep	11:15	RBT	2+	4	0.21	6	0.08	0.85	5	0.00	BULL	3.00
Mill Creek	PLUNG	M-l	1-Sep	12:00	BULL	Ot	4	0.06	2	0.08	0.35	1	0.00	RBT	2.40
Mill Creek	PLUNG	M-l	1-Sep	12:00	RBT	1+	4	0.01	2	0.17	1.10	1	0.00	BULL	2.40
Mill Creek	PLUNG	M-l	1-Sep	12:00	RBT	2t	4	0.43	6	0.04	1.25	8	0.00	BULL	2.40
Mill Creek	PLUNG	M-l	1-Sep	12:00	RBT	2t	4	0.24	3	0.17	0.85	3	0.00	BULL	3.00
Mill Creek	RUN	M-l	1-Sep	lo.30	BULL	Ot	4	0.08	2	0.00	0.56	2	0.10	RBT	6.00
Mill Creek	RUN	M-l	1-Sep	10:30	BULL	1+	4	0.17	6	0.00	1.15	5	0.50	RBT	1.00
Mill Creek	RUN	M-l	1-Sep	10:30	RBT	1+	4	0.06	6	0.08	1.25	5	0.50	BULL	1.00
Mill Creek	RUN	M-l	1-Sep	10:30	RBT	1+	4	0.55	4	0.04	0.25	5	3.00	RBT	3.00
Mill Creek	RUN	M-l	1-Sep	10:30	RBT	1+	4	0.85	4	0.04	1.20	8	2.00	RBT	3.00
Mill Creek	RUN	M-l	1-Sep	10:30	RBT	2t	4	0.41	5	0.08	1.75	5	0.10	RBT	0.70
Mill Creek	RUN	M-l	1-Sep	10:30	RBT	2+	4	0.02	5	0.08	1.80	5	1.00	RBT	0.70
Mill Creek	SCOUR	M-2	3-Sep	10:30	BULL	1+	4	0.05	7	0.00	1.85	8	0.00	RBT	050
Mill Creek	SCOUR	M-2	3-Sep	10:30	RBT	It	4	0.28	5	0.00	2.15	8	0.00	BULL	0.50
Mill Creek	PLUNG	M-2	3-Sep	10:20	BULL	1+	4	0.42	6	0.00	1.85	2	0.00	RBT	1.00
Mill Creek	PLUNG	M-2	3-Sep	10:20	RBT	1+	4	0.20	6	0.08	2.30	2	0.80	BULL	1.00
Mill Creek	CASCADE	M-2	3-Sep	10:10	BULL	1+	4	0.69	4	0.08	0.80	5	0.50	BULL	3.30
Mill Creek	CASCADE	M-2	3-Sep	10:10	BULL	1+	4	0.02	2	0.00	0.93	5	0.03	BULL	3.30
Mill Creek	CASCADE	M-2	3-Sep	lo.10	BULL	3+	4	0.38	5	0.17	0.90	5	0.01	BULL	6.00
Mill Creek	RIFFLE	M-2	3-Sep	10:00	BULL	1+	4	0.41	6	0.08	1.50	5	0.03	-	

Table F.l. Continued.

Stream	Habitat Type	Site #	Date	Time	Specks (A)	Age	Waler Temp.(°C)	FOCUS Water Velocity (Ft/s)	FOCUS Substrate Size (B)	FOCUS To Streambed (In)	Stream Depth (ft.)	Cover Type (C)	Focus to Cover	Focus to Closest Fish Species	Focus to Closest Fish Distance (m)
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	1+	4	0.19	6	0.08	2.22	5	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	I+	4	0.19	6	0.08	2.22	5	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	1+	4	0.19	6	0.08	2.22	5	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	1+	4	0.01	6	0.17	1.80	5	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	1+	4	0.97	6	0.08	1.65	5	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	1+	4	0.97	6	0.17	1.65	5	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	1+	4	0.97	6	0.12	1.65	5	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	2+	4	0.21	2	0.17	3.00	4	0.02	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	2+	4	0.2 I	2	0.17	3.00	4	0.01	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	2+	4	0.21	2	0.17	3.00	4	0.00	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	2+	4	0.21	2	0.17	3.00	4	0.00	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	2+	4	0.21	2	0.17	3.00	4	0.00	BULL	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	BULL	3+	4	0.67	6	0.00	1.95		0.00	RBT	3.00
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	o+	4	0.01	6	0.12	1.80		0.03	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	o+	4	0.01	6	0.12	1.80	5	0.03	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	o+	4	0.01	6	0.12	1.80	5	0.03	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	1+	4	0.45	6	0.21	1.80	5	0.06	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	I+	4	0.45	6	0.2 I	1.80	5	0.06	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	1+	4	0.45	6	0.21	1.80	5	0.06	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	1+	4	0.45	6	0.2 I	I.80	5	0.06	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	1+	4	0.45	6	0.21	1.80	5	0.06	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	I t	4	0.45	6	0.21	I.80	5	0.06	RBT	0.03
Mill Creek	RUN	M-2	3-Sep	9:50	RBT	I t	4	0.45	6	0.2 I	I.80	5	0.06	RBT	0.03
Mill Creek	SCOUR	M-3	3-Sep	16:30	BULL	2+	4	0.29	a	0.29	4.00	0		RBT	3.00
Mill Creek	SCOUR	M-3	3-Sep	16:30	BULL	3+	4	0.5 I	8	0.42	4.15	0		BULL	0.50
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	1+	4	0.59	6	0.17	4.20	0		BULL	0.50
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	1+	4	0.59	8	0.2 1	4.00	0		RBT	0.30
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	1+	4	0.59	8	0.21	4.00	0		RBT	0.30
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	1+	4	0.59	8	0.21	4.00	0		RBT	0.30
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	1+	4	0.59	8	0.21	4.00	0		RBT	0.30
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	1+	4	0.59	8	0.21	4.00	0		RBT	0.30
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	2+	4	0.59	8	0.21	4.00	0		RBT	0.40
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	2 t	4	0.59	8	0.21	4.00	0		RBT	0.40
Mill Creek	SCOUR	M-3	3-Sep	16:30	RBT	2 t	4	0.59	8	0.21	4.00	0		RBT	0.40
Mill Creek	CASCADE	M-3	3-Sep	16:00	BULL	1+	4	0.91	6	0.00	88.00	6	0.00	BULL	5.00
Mill Creek	CASCADE	M-3	3-Sep	16:00	BULL	It	4	0.66	3	0.00	1.05	5	0.00	RBT	1.00

Table F.1. Continued.

Stream	Habitat Type	Site #	Date	Time	Species {A}	Age	Water Temp.(°C)	FOCUS Water Velocity (Ft/s)	FOCUS Substrate Size {B}	FOCUS To Streambed (in)	Stream Depth (ft.)	Cover Type {C}	Focus to Cover	Focus to Closest Fish Species	Focus to Closest Fish Distance (m)
Mill Creek	CASCADE	M-3	3-Sep	16:00	BULL	1+	4	0.25	6	0.00	1.20	5	0.04	BULL	6.00
Mill Creek	CASCADE	M-3	3-Sep	16:00	RBT	1+	4	0.05	2	0.17	0.90	5	0.00	BULL	10.00
Mill Creek	CASCADE	M-3	3-Sep	16:00	RBT	1+	4	1.20	5	0.04	1.50	5	0.50	BULL	1.00
Mill Creek	RUN	M-3	3-Sep	15:40	BULL	1+	4	0.03	3	0.00	1.62	1	0.00	-	-
Mill Creek	RUN	M-3	3-Sep	15:40	BULL	1+	4	0.03	3	0.00	1.90	1	0.00	-	-
Mill Creek	RUN	M-3	3-Sep	15:40	BULL	2+	4	0.01	2	0.00	2.30	5	0.00	-	-
Mill Creek	RUN	M-3	3-Sep	15:40	BULL	3+	4	0.16	8	0.00	2.95	0	-	-	-
Mill Creek	RUN	M-3	3-Sep	15:40	RBT	0+	4	0.90	4	0.05	0.53	8	0.00	RBT	10.00
Mill Creek	RUN	M-3	3-Sep	15:40	RBT	1+	4	0.61	6	0.17	2.15	2	3.00	-	-
Mill Creek	RUN	M-3	3-Sep	15:40	RBT	1+	4	1.34	6	0.17	2.45	2	3.00	-	-
Mill Creek	RUN	M-3	3-Sep	15:40	RBT	1+	4	0.12	6	0.17	2.33	2	3.00	-	-
Mill Creek	PLUNG	M-3	3-Sep	15:20	BULL	1+	4	0.18	2	0.00	1.15	1	0.00	BULL	1.00
Mill Creek	PLUNG	M-3	3-Sep	15:20	BULL	1+	4	0.08	2	0.00	1.00	1	0.00	BULL	1.00
Mill Creek	PLUNG	M-3	3-Sep	15:20	RBT	0+	4	0.50	2	0.08	0.85	2	0.02	RBT	4.00
Mill Creek	PLUNG	M-3	3-Sep	15:20	RBT	0+	4	0.00	2	0.17	0.48	5	0.01	BULL	3.00
Mill Creek	PLUNG	M-3	3-Sep	15:20	RBT	1+	4	0.25	6	0.25	2.10	5	0.00	RBT	0.10
Mill Creek	PLUNG	M-3	3-Sep	15:20	RBT	2+	4	0.25	6	0.25	2.10	5	0.00	BULL	3.00
Mill Creek	RIFFLE	M-3	3-Sep	15:00	RBT	0+	4	0.95	5	0.08	0.60	5	0.10	RBT	5.00
Mill Creek	RIFFLE	M-3	3-Sep	15:00	RBT	0+	4	0.90	2	0.08	0.50	5	0.60	RBT	11.00
Mill Creek	RIFFLE	M-3	3-Sep	15:00	RBT	0+	4	0.45	2	0.04	0.30	2	0.10	RBT	12.00
Mill Creek	RIFFLE	M-3	3-Sep	15:00	RBT	1+	4	0.17	2	0.08	0.50	5	0.10	RBT	11.00
Mill Creek	RIFFLE	M-3	3-Sep	15:00	RBT	2+	4	1.43	6	0.08	1.00	5	0.10	RBT	3.00
Tucannon R.	PLUNG	M-1	31-Aug	14:00	BULL	0+	6	0.00	2	0.00	0.90	1	0.00	RBT	0.4
Tucannon R.	PLUNG	M-1	31-Aug	14:00	RBT	0+	6	0.81	2	0.00	0.90	1	0.00	BULL	0.4
Tucannon R.	PLUNG	M-1	31-Aug	14:00	RBT	1+	6	1.35	5	0.08	0.50	1	0.50	RBT	1.3
Tucannon R.	PLUNG	M-1	31-Aug	14:00	RBT	1+	6	0.39	6	0.08	1.00	1	0.10	RBT	1.0
Tucannon R.	PLUNG	M-1	31-Aug	14:00	RBT	2+	6	0.52	6	0.08	1.25	7	0.00	RBT	1.0
Tucannon R.	PLUNG	M-1	31-Aug	14:00	RBT	3+	6	0.08	6	0.00	1.10	1	0.00	RBT	1.6
Tucannon R.	RIFFLE	M-1	31-Aug	13:00	BULL	0+	6	0.03	4	0.00	0.27	1	0.10	RBT	1.8
Tucannon R.	RIFFLE	M-1	31-Aug	13:00	RBT	1+	6	1.72	6	0.08	0.45	7	0.20	BULL	1.8
Tucannon R.	RIFFLE	M-1	29-Aug	16:40	RBT	1+	5	0.01	6	0.00	1.00	1	0.00	RBT	0.8
Tucannon R.	RIFFLE	M-1	29-Aug	16:40	RBT	1+	5	0.47	6	0.00	0.85	1	0.00	BULL	0.1
Tucannon R.	RUN	M-1	31-Aug	12:30	BULL	0+	5	0.00	6	0.00	1.50	1	0.00	BULL	0.5
Tucannon R.	RUN	M-1	31-Aug	12:30	BULL	0+	5	0.00	6	0.00	1.50	1	0.00	BULL	0.5
Tucannon R.	RUN	M-1	31-Aug	12:30	BULL	0+	5	0.00	5	0.00	1.42	1	0.00	RBT	0.2
Tucannon R.	RUN	M-1	31-Aug	12:30	RBT	0+	5	0.06	5	0.08	1.45	1	0.01	BULL	0.2

Table F.1. Continued.

Stream	Habitat Type	Site #	Date	Time	Species {A}	Age	Water Temp.(°C)	FOCUS: Water Velocity (Ft/s)	FOCUS: Substrate Size {B}	FOCUS: To Streambed (in)	Stream Depth (ft.)	Cover Type {C}	Focus to Cover	Focus to Closest Fish: Species	Focus to Closest Fish: Distance (m)
Tucannon R.	RUN	M-1	31-Aug	12:30	RBT	0+	5	0.34	2	0.17	0.95	4	0.00	BULL	7.0
Tucannon R.	SCOUR	M-1	31-Aug	13:30	RBT	0+	6	0.03	6	0.08	0.43	2	0.10	RBT	5.8
Tucannon R.	SCOUR	M-1	31-Aug	13:30	RBT	0+	6	0.28	5	0.21	1.45	2	0.40	RBT	0.1
Tucannon R.	SCOUR	M-1	31-Aug	13:30	RBT	1+	6	0.28	5	0.21	1.45	2	0.40	RBT	0.1
Tucannon R.	SCOUR	M-1	31-Aug	13:30	RBT	1+	6	0.28	5	0.21	1.45	2	0.40	RBT	0.1
Tucannon R.	SCOUR	M-1	31-Aug	13:30	RBT	1+	6	0.28	5	0.21	1.45	2	0.40	RBT	0.1
Tucannon R.	SCOUR	M-1	31-Aug	13:30	RBT	2+	6	0.28	5	0.21	1.45	2	0.40	RBT	0.1
Tucannon R.	CASCADE	M-2	29-Aug	14:15	RBT	0+	5	0.73	6	0.04	0.40	5	0.00	-	-
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	BULL	0+	5	0.35	5	0.04	0.53	1	1.00	BULL	1.0
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	BULL	1+	5	0.47	6	0.00	0.85	1	0.00	BULL	0.8
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	BULL	1+	5	0.29	6	0.08	0.70	1	1.00	BULL	2.0
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	BULL	1+	5	0.24	6	0.00	0.80	1	0.00	RBT	1.0
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	BULL	1+	5	1.70	5	0.00	0.55	1	0.00	BULL	1.0
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	RBT	0+	5	0.11	6	0.08	0.83	8	0.00	RBT	0.2
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	RBT	0+	5	0.11	6	0.08	0.83	8	0.00	RBT	0.2
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	RBT	0+	5	0.74	6	0.04	0.32	5	0.00	RBT	4.0
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	RBT	0+	5	1.44	6	0.04	0.50	8	1.00	RBT	1.0
Tucannon R.	RIFFLE	M-2	29-Aug	16:40	RBT	0+	5	0.62	6	0.04	0.57	8	1.00	RBT	1.0
Tucannon R.	RUN	M-2	29-Aug	14:45	RBT	1+	5	0.65	5	0.08	0.70	8	0.00	RBT	5.0
Tucannon R.	SCOUR	M-2	29-Aug	16:00	CHN	0+	5	0.18	4	0.25	2.02	8	0.00	RBT	1.0
Tucannon R.	SCOUR	M-2	29-Aug	16:00	CHN	1+	5	0.31	4	0.17	2.49	6	0.00	RBT	0.5
Tucannon R.	SCOUR	M-2	29-Aug	16:00	RBT	0+	5	0.48	5	0.25	0.62	8	0.00	RBT	2.0
Tucannon R.	SCOUR	M-2	29-Aug	16:00	RBT	0+	5	0.01	4	0.04	2.25	8	0.00	RBT	2.0
Tucannon R.	SCOUR	M-2	29-Aug	16:00	RBT	0+	5	1.46	6	0.04	1.32	7	0.00	RBT	2.0
Tucannon R.	SCOUR	M-2	29-Aug	16:00	RBT	1+	5	1.90	4	0.25	2.50	8	0.00	RBT	0.5
Tucannon R.	SCOUR	M-2	29-Aug	16:00	RBT	1+	5	0.81	4	0.17	2.70	6	0.00	CHN	1.0
Tucannon R.	CASCADE	M-3	29-Aug	11:15	RBT	0+	4	0.79	5	0.04	0.59	1	0.00	-	-
Tucannon R.	PLUNG	M-3	29-Aug	11:00	BULL	3+	4	0.30	2	0.25	2.15	7	0.00	BULL	0.1
Tucannon R.	PLUNG	M-3	29-Aug	11:00	BULL	3+	4	0.03	2	0.25	2.15	7	0.00	BULL	0.1
Tucannon R.	RUN	M-3	29-Aug	10:15	BULL	1+	4	0.68	5	0.00	1.26	1	0.00	RBT	2.0
Tucannon R.	RUN	M-3	29-Aug	10:15	RBT	0+	4	1.01	5	0.08	1.30	1	0.00	BULL	2.0
Tucannon R.	RUN	M-3	29-Aug	10:15	RBT	1+	4	0.58	4	0.08	2.10	1	1.00	RBT	0.1
Tucannon R.	SCOUR	M-3	29-Aug	10:45	BULL	1+	4	0.82	5	0.08	1.02	8	0.00	RBT	0.5
Tucannon R.	SCOUR	M-3	29-Aug	10:45	RBT	0+	4	0.73	5	0.08	1.18	8	0.00	RBT	0.5
Tucannon R.	SCOUR	M-3	29-Aug	10:45	RBT	0+	4	0.41	5	0.08	1.18	8	0.00	RBT	0.5
Tucannon R.	SCOUR	M-3	29-Aug	10:45	RBT	1+	4	1.73	5	0.08	1.00	8	0.00	BULL	0.5

Table F.1. Continued.

Stream	Habitat Type	Site #	Date	Time	Species {A}	Age	Water Temp.(°C)	FOCUS Water Velocity (Ft/s)	FOCUS Substrate Size {B}	FOCUS To Streambed (in)	Stream Depth (ft.)	Cover Type {C}	Focus to Cover	Focus to Closest Fish Species	Focus to Closest Fish Distance (m)
Tucannon R.	CASCADE	M-4	28-Aug	11:30	BULL	0+	8	1.47	5	0.00	0.60	5	0.80	RBT	0.4
Tucannon R.	CASCADE	M-4	28-Aug	11:30	CHN	3+	8	2.30	7	0.25	1.45	7	0.30	RBT	7.0
Tucannon R.	CASCADE	M-4	28-Aug	11:30	RBT	0+	8	0.50	5	0.41	0.70	1	0.80	BULL	0.4
Tucannon R.	CASCADE	M-4	28-Aug	11:30	RBT	1+	8	1.42	6	0.12	1.10	1	4.00	CHN	7.0
Tucannon R.	PLUNG	M-4	27-Aug	15:00	CHN	0+	7	0.02	6	0.08	1.50	5	4.00	CHN	5.0
Tucannon R.	PLUNG	M-4	27-Aug	15:00	CHN	1+	7	0.23	5	0.25	3.15	2	0.00	RBT	0.5
Tucannon R.	PLUNG	M-4	27-Aug	15:00	CHN	3+	7	0.46	5	0.00	4.30	2	0.00	CHN	0.5
Tucannon R.	PLUNG	M-4	27-Aug	15:00	RBT	0+	7	0.23	7	0.25	2.73	5	0.10	CHN	5.0
Tucannon R.	PLUNG	M-4	27-Aug	15:00	RBT	1+	7	0.34	7	0.12	3.60	5	0.50	RBT	1.0
Tucannon R.	PLUNG	M-4	27-Aug	15:00	RBT	1+	7	0.77	7	0.29	4.60	5	3.00	RBT	1.0
Tucannon R.	PLUNG	M-4	27-Aug	15:00	RBT	1+	7	0.05	5	0.17	2.20	2	0.00	CHN	0.5
Tucannon R.	PLUNG	M-4	27-Aug	15:00	RBT	1+	7	0.11	7	0.25	2.63	7	0.00	RBT	1.0
Tucannon R.	PLUNG	M-4	27-Aug	15:00	RBT	1+	9	0.64	7	0.25	3.45	7	0.00	RBT	6.0
Tucannon R.	PLUNG	M-4	27-Aug	15:00	RBT	3+	7	0.00	2	0.00	1.50	5	0.00	RBT	1.0
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	BULL	2+	8	0.61	5	0.00	0.40	8	0.00	RBT	1.0
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	CHN	0+	8	1.29	5	0.04	1.10	2	0.10	RBT	0.5
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	CHN	0+	8	0.47	6	0.25	0.47	5	0.00	RBT	0.3
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	CHN	0+	8	0.97	5	0.17	0.44	2	0.00	CHN	2.0
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	CHN	0+	8	1.89	5	0.25	0.82	1	0.50	CHN	0.5
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	CHN	0+	8	1.11	5	0.04	0.90	1	0.80	CHN	0.5
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	CHN	0+	8	1.45	6	0.08	1.10	5	1.00	RBT	3.5
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	CHN	3+	8	0.08	2	0.00	0.85	8	0.00	RBT	0.5
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	0+	8	0.02	6	0.08	0.72	5	0.00	CHN	0.3
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	0+	8	0.18	5	0.08	1.10	5	0.10	RBT	0.2
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	0+	8	0.95	5	0.08	0.95	1	2.00	RBT	0.1
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	0+	8	1.24	5	0.08	0.80	1	2.20	RBT	0.1
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	0+	8	0.88	6	0.17	1.15	1	0.30	RBT	1.0
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	1+	8	2.21	5	0.08	0.76	3	0.00	CHN	0.5
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	1+	8	0.67	6	0.08	0.73	8	0.00	CHN	3.5
Tucannon R.	RIFFLE	M-4	28-Aug	11:00	RBT	2+	8	0.13	5	0.17	1.20	5	0.20	RBT	0.2
Tucannon R.	RUN	M-4	27-Aug	17:00	BULL	2+	10	0.76	5	0.08	1.82	5	2.00	RBT	0.6
Tucannon R.	RUN	M-4	27-Aug	17:00	CHN	0+	10	1.39	7	0.04	1.40	2	0.20	CHN	3.8
Tucannon R.	RUN	M-4	27-Aug	17:00	CHN	0+	10	0.02	5	0.08	1.60	2	2.00	RBT	3.8
Tucannon R.	RUN	M-4	27-Aug	17:00	CHN	1+	10	1.57	7	0.29	1.25	5	0.20	RBT	2.6
Tucannon R.	RUN	M-4	27-Aug	17:00	RBT	0+	10	1.05	5	0.29	2.40	5	1.50	BULL	0.6
Tucannon R.	RUN	M-4	27-Aug	17:00	RBT	0+	10	0.90	5	0.08	1.50	5	0.02	RBT	1.7

Table F.1. Continued.

Stream	Habitat Type	Site #	Date	Time	Species {A}	Age	Water Temp.(°C)	FOCUS Water Velocity (Ft/s)	FOCUS Substrate Size {B}	FOCUS To Streambed (in)	Stream Depth (ft.)	Cover Type {C}	Focus to Cover	Focus to Closest Fish Species	Focus to Closest Fish Distance (m)
Tucannon R.	RUN	M-4	27-Aug	17:00	RBT	0+	10	1.78	7	0.08	0.98	5	0.10	RBT	1.7
Tucannon R.	RUN	M-4	27-Aug	17:00	RBT	1+	10	1.04	5	0.08	1.55	2	1.30	RBT	1.8
Tucannon R.	RUN	M-4	27-Aug	17:00	RBT	2+	10	0.99	4	0.29	1.60	2	0.50	RBT	0.8
Tucannon R.	SCOUR	M-4	28-Aug	13:00	BULL	1+	8	0.39	6	0.00	1.23	4	0.09	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.18	3	0.04	1.50	5	0.40	CHN	2.0
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.34	2	0.04	0.09	5	0.05	CHN	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.05	6	0.08	1.38	4	0.05	BULL	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.65	5	0.04	1.21	6	0.80	RBT	4.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.19	3	0.08	1.32	5	0.20	CHN	0.5
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.26	4	0.17	1.80	1	1.20	CHN	0.3
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	0.23	4	0.29	1.76	1	1.00	CHN	0.3
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	0+	8	1.15	6	0.04	1.28	1	2.00	RBT	1.8
Tucannon R.	SCOUR	M-4	28-Aug	13:00	CHN	1+	8	0.08	3	0.08	1.93	5	0.40	CHN	0.4
Tucannon R.	SCOUR	M-4	28-Aug	13:00	RBT	0+	8	0.37	6	0.04	1.86	1	2.00	CHN	1.8
Tucannon R.	SCOUR	M-4	28-Aug	13:00	RBT	1+	8	0.57	5	0.08	0.85	5	4.00	CHN	3.6
Tucannon R.	SCOUR	M-4	28-Aug	13:00	RBT	1+	8	1.48	5	0.08	1.51	5	1.20	RBT	1.0
Tucannon R.	SCOUR	M-4	28-Aug	13:00	RBT	1+	8	0.50	4	0.50	2.74	5	0.60	CHN	1.0
Tucannon R.	SCOUR	M-4	28-Aug	13:00	RBT	2+	8	0.32	5	0.33	2.53	5	0.40	RBT	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	RBT	2+	8	0.32	5	0.33	2.53	5	0.40	RBT	0.1
Tucannon R.	SCOUR	M-4	28-Aug	13:00	RBT	2+	8	0.32	5	0.33	2.53	5	0.40	RBT	0.1
Tucannon R.	CASCADE	M-5	27-Aug	12:20	BULL	3+	7	1.86	4	0.25	1.20	7	3.50	RBT	2.0
Tucannon R.	CASCADE	M-5	27-Aug	12:20	BULL	3+	7	0.03	7	0.12	1.35	5	0.00	RBT	1.0

Table F.1. Continued.

Stream	Habitat Type	Site #	Date	Time	Species {A}	Age	Water Temp.(°C)	FOCUS: Water Velocity (Ft/s)	FOCUS: Substrate Size {B}	FOCUS: To Streambed (in)	Stream Depth (ft.)	Cover Type {C}	Focus to Cover	Focus to Closest Fish: Species	Focus to Closest Fish: Distance (m)
Tucannon R.	CASCADE	M-5	27-Aug	12:20	CHN	0+	7	0.35	4	0.12	0.70	5	3.00	BULL	3.0
Tucannon R.	CASCADE	M-5	27-Aug	12:20	RBT	0+	7	0.90	4	0.08	0.40	5	1.00	RBT	4.0
Tucannon R.	CASCADE	M-5	27-Aug	12:20	RBT	1+	7	1.82	5	0.17	0.90	7	1.00	BULL	2.0
Tucannon R.	CASCADE	M-5	27-Aug	12:20	RBT	1+	7	0.70	7	0.12	0.68	5	3.00	BULL	1.0
Tucannon R.	CASCADE	M-5	27-Aug	12:20	RBT	1+	7	0.26	4	0.12	0.67	5	0.50	RBT	2.0
Tucannon R.	CASCADE	M-5	27-Aug	12:20	RBT	1+	7	1.63	5	0.33	1.06	7	3.50	RBT	2.0
Tucannon R.	PLUNG	M-5	25-Aug	14:00	BULL	3+	8	0.02	5	0.25	3.82	8	1.30	RBT	2.4
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	CHN	0+	8	0.19	2	0.08	1.72	5	3.20	CHN	0.1
Tucannon R.	PLUNG	M-5	25-Aug	14:00	RBT	1+	8	0.70	4	0.12	2.16	5	3.30	RBT	3.3
Tucannon R.	PLUNG	M-5	25-Aug	14:00	RBT	2+	8	1.52	4	0.12	1.95	5	3.60	RBT	0.3
Tucannon R.	PLUNG	M-5	25-Aug	14:00	RBT	3+	8	0.05	5	0.50	2.20	1	0.00	CHN	3.9
Tucannon R.	PLUNG	M-5	25-Aug	14:00	RBT	3+	8	0.48	3	0.20	1.70	8	3.70	BULL	2.4
Tucannon R.	RIFFLE	M-5	27-Aug	12:50	CHN	0+	9	1.18	4	0.04	0.70	1	0.50	RBT	2.0
Tucannon R.	RIFFLE	M-5	27-Aug	12:50	CHN	0+	9	1.44	4	0.04	1.15	1	1.00	CHN	11.0
Tucannon R.	RIFFLE	M-5	27-Aug	12:50	RBT	1+	9	1.75	6	0.17	0.92	1	2.00	RBT	2.0
Tucannon R.	RIFFLE	M-5	27-Aug	12:50	RBT	1+	9	2.09	6	0.25	1.00	1	4.00	CHN	2.0
Tucannon R.	RUN	M-5	25-Aug	16:00	CHN	1+	9	-	5	0.17	0.95	5	2.70	CHN	0.1
Tucannon R.	RUN	M-5	25-Aug	16:00	CHN	1+	9	-	5	0.17	0.95	5	2.70	CHN	0.1
Tucannon R.	RUN	M-5	25-Aug	16:00	RBT	1+	9	1.40	5	0.21	1.40	8	7.00	RBT	1.0
Tucannon R.	RUN	M-5	25-Aug	16:00	RBT	1+	9	1.01	4	0.12	1.48	8	6.00	RBT	1.0
Tucannon R.	SCOUR	M-5	27-Aug	14:00	CHN	0+	9	0.57	5	0.04	1.20	5	1.00	CHN	0.7
Tucannon R.	SCOUR	M-5	27-Aug	14:00	CHN	0+	9	0.39	5	0.29	1.23	5	1.50	CHN	0.7
Tucannon R.	SCOUR	M-5	27-Aug	14:00	CHN	0+	9	0.37	5	0.04	0.87	5	2.00	CHN	0.2

Table F.l. Continued.

								FOCUS						Focus lo Closest Fish	
Stream	Habitat Type	Site #	Date	Tlme	Species {A}	Age	Waler Temp.(°C)	Waler Velocity (Ft/s)	Substrate Size {B}	To Streambed (In)	Stream Depth (ft.)	Cover Type {C}	Focus to Cover	Species	Distance (m)
Tucannon R.	SCOUR	M-5	27-Aug	14:00	CHN	0+	9	0.08	6	0.08	135	5	7.00	CHN	5.0
Tucannon R.	SCOUR	M-5	27-Aug	14:00	RBT	o+	9	0.70	5	0.17	1.60	5	1.00	RBT	1.0
Tucannon R.	SCOUR	M-5	27-Aug	14:00	RBT	1+	9	0.48	5	0.25	1.98	5	0.50	RBT	1.0

NOTE:

{A} **Species**
BULL = bull trout
RBT = 0. mykiss
CHN = spring chinook salmon

{B} Substrate Size Class
1 = organic/silt (<0.1mm)
2 = fines (0.1-2.0mm)
3 = small gravel (2.0-16mm)
4 = large gravel (16-60mm)
5 = small cobble (60-130mm)
6 = large cobble (130-250mm)
7 = boulder (>250mm)

{C} **Cover Type**
0 = none
1 = log
2 = sunken Wood
3 = log Jam
4 = root wad
5 = boulder
6 = undercut bank
7 = turbulence
8 = overhead cover
9 = water depth

APPENDIX G

DENSITY AND WEIGHT OF DRIFT ORGANISMS

Table G.l Percent by number, percent by weight, mean number per **100m³** and mean weight per **100m³** for drift organisms collected in Mill Creek, 1992

AOUATIC	Density NO. per loo m3 Mean	S.D.	% by Number	Weight(mg) per 100 m3	% by Weigh
)iptera Larvae					
Chironomidae	36.8	22.5	14.1	2.5	5.7
Tipulidae	0.1	0.1	0.0	0.1	0.1
Simuliidae	5 1.4	70.6	19.7	5.0	11.3
Ceratopogonidae	0.1	0.2	0.0	0.0	0.0
Empididae	0.0	0.1	0.0	0.0	0.0
Pelecorhynchidae	0.4	0.7	0 . 2	1.0	2.3
)iptera Pupa					
Chironomidaa	2.7	4.9	1.0	0.1	0.3
Simuliidae	0.6	0.8	0 . 2	0.2	0 . 4
:phemeroptera Nymph					
Baetidae	118.0	101.0	45.3	13.6	31.1
Heptageniidae	5.2	3.3	2.0	1.3	3.0
Ephemerellidae	1.8	1.4	0 . 7	1.9	4 . 4
'lecoptera Nymphs					
Perlidae	0.6	0.5	0.2	0.3	0.6
Chloroperlidae	0.9	1.2	0.3	0.1	0.3
Nemouridae	1.7	1.3	0 . 6	0.2	0 . 6
'richoptera Larvae					
Limnephilidae	0.1	0.2	0.0	0.9	2.1
Hydropsychidae	0.4	0.5	0.1	0.1	0.1
Brachycentridae	1.8	0.8	0.7	0.6	1.3
Glossosomatidae	0.0	0.0	0.0	0.0	0.0
Rhyacophilidae	1.5	1.2	0.6	1.2	2.7
Leptoceridae	0.4	0.5	0 . 2	0.1	0 . 2
'richoptera Pupa					
Limnephilidae	0.0	0.1	0.0	0.1	0.1
Brachycentridae	0.1	0.2	0.0	0.1	0.2
Rhyacophilidae Pupa	0.0	0.1	0 . 0	0.1	0 . 1
:oleoptera Larvae					
Elmidae Larvae	1.8	1.7	0.7	0.3	0.7
Hydrophilidae Larvae	0.0	0.1	0.0	0.0	0.0
:oleoptera Adults					
Elmidae	0 . 5	0.5	0.2	0.2	0.5
Curculionidae	0.1	0.1	0 . 0	0.2	0.4
)ligocheata	0.5	1.0	0.2	0.1	0.1
Jematoda	0.1	0.2	0 . 0	0.0	0.0
'ricladida					
Planariidae	0.1	0.2	0 . 0	0.1	0 . 1
ivalvia					
Sphaeriidae	0.2	0.3	0.1	0.0	0 . 1
Iydracarina	6.8	8.3	2 . 6	0.7	1 . 7
)stracoda	2.3	3.6	0.9	0.2	0 . 6
Ierpacticodia	0.0	0.0	0 . 0	0.0	0 . 0
.epidotera Larvae	0.0	0.1	0 . 1	0.4	1 . 0
AOUATIC TOTAL	**237.4**	**228.5**	**Y1.l**	**31.4**	**72.1**

Table G.1 Continued.

TERRESTRIAL	Density No. per 100 M3 Mean	S.D.	% by Number	Weight(mg) per 100m3	% by Weight
Diptera Adult					
Chironomidae	9.7	9.6	3.7	0.5	1.2
Bibionidae	0.5	0.7	0.2	0.5	1.2
Simulidae	0.4	0.5	0.2	0.1	0.3
Ceratopogonidae	0.9	1.8	0.3	0.0	0.1
Tabanidae	0.0	0.1	0.0	0.1	0.1
Muscidae	0.5	0.6	0.2	0.1	0.3
Cecidomyiidae	3.2	3.9	1.2	0.2	0.4
Pipunculidae	0.0	0.1	0.0	0.0	0.0
Scathophagidae	0.1	0.3	0.1	0.1	0.2
Asilidae	0.3	0.3	0.1	0.1	0.3
Ephemeroptera Adult					
Baetidae	1.0	1.3	0.4	0.5	1.1
Lepidoptera Adult	0.0	0.0	0	0.8	2.0
Hymenoptera Adult					
Formicidae	0.4	0.3	0.2	0.2	0.4
Vespidae	0.0	0.1	0.0	1.2	2.8
Tenthredinidae Adult	0.1	0.2	0.0	0.0	0.1
Syrphidae	0.0	0.1	0.0	0.0	0.0
Eulophidae	0.4	0.7	0.2	0.0	0.1
Diapriidae	0.1	0.3	0.1	0.0	0.0
Pompilidae	0.0	0.1	0.0	0.0	0.0
Agaonidae	0.1	0.2	0.0	0.0	0.1
Ichneumonidae	0.5	0.6	0.2	0.2	0.5
Homoptera Adult					
Cicadellidae	0.5	0.6	0.2	0.2	0.4
Aphididae	0.1	0.2	0.0	0.0	0.0
Hemioptera Adult					
Tingidae	0.1	0.3	0.1	0.0	0.0
Macroveliidae	0.5	0.6	0.2	0.6	1.3
Orthoptera					
Tridactylidae	0.0	0.1	0.0	4.8	10.9
Arachnid	2.1	2.8	0.8	0.4	0.9
Coleoptera Adult					
Chrysomelidae	0.1	0.3	0.1	0.3	0.7
Coccinellidae	0.3	0.2	0.1	0.8	1.8
Staphylinidae	0.0	0.1	0.0	0.1	0.2
Cleridae	0.4	0.4	0.1	0.2	0.5
TERRESTRIAL TOTAL	**23.3**	**27.9**	**8.9**	**12.2**	**27.9**

Table G.2 Continued.

TERRESTRIAL	Density No. per 100 m^3 Mean	S.D.	% by Number	Weight(mg) per 100 m^3	% by Weight
Diptera Adult					
Chironomidae	8.2	13.0	2.7	0.5	0.6
Ceratopogonidae	0.2	0.3	0.1	0.0	0.0
Musciod	0.1	0.1	0.0	0.0	0.1
Mycetophilidae	0.1	0.2	0.0	0.0	0.0
Pteromalidae	0.2	0.4	0.1	0.0	0.0
Asilidae	1.4	2.4	0.5	0.6	0.8
Ephemeroptera Adult					
Baetidae	1.2	2.3	0.4	0.3	0.3
Lepidoptera Adult	0.7	1.2	0.2	0.1	0.1
Hymenoptera					
Formicidae	3.6	4.3	1.2	1.0	1.2
Tenthredinidae	0.4	0.8	0.1	0.0	0.0
Ichneumonidae	0.1	0.2	0.0	0.3	0.4
Homoptera					
Cicadellidae	0.9	1.3	0.3	0.5	0.6
Aphididae	0.4	0.6	0.1	0.1	0.1
Hemioptera					
Berytidae	0.1	0.2	0.0	0.2	0.2
Gastropoda	0.3	0.6	0.1	20.0	24.6
Arachnid	2.6	4.1	0.9	0.2	0.3
Coleoptera Adult					
Coccinellidae	0.1	0.3	0.0	1.0	1.2
TERRESTRIAL TOTAL	**20.5**	**32.2**	**6.8**	**24.8**	**30.5**

Table G.2 Continued.

TERRESTRIAL	Density No. per 100 m^3 Mean	S.D.	% by Number	Weight(mg) per 100 m^3	% by Weight
Diptera Adult					
Chironomidae	8.2	13.0	2.7	0.5	0.6
Ceratopogonidae	0.2	0.3	0.1	0.0	0.0
Muscioc	0.1	0.1	0.0	0.0	0.1
Mycetophilidae	0.1	0.2	0.0	0.0	0.0
Pteromalidae	0.2	0.4	0.1	0.0	0.0
Asilidae	1.4	2.4	0.5	0.6	0.8
Ephemeroptera Adult					
Baetidae	1.2	2.3	0.4	0.3	0.3
Lepidoptera Adult	0.7	1.2	0.2	0.1	0.1
Hymenoptera					
Formicidae	3.6	4.3	1.2	1.0	1.2
Tenthredinidae	0.4	0.8	0.1	0.0	0.0
Ichneumonidae	0.1	0.2	0.0	0.3	0.4
Homoptera					
Cicadellidae	0.9	1.3	0.3	0.5	0.6
Aphididae	0.4	0.6	0.1	0.1	0.1
Hemioptera					
Berytidae	0.1	0.2	0.0	0.2	0.2
Gastropoda	0.3	0.6	0.1	20.0	24.6
Arachnid	2.6	4.1	0.9	0.2	0.3
Coleoptera Adult					
Coccinellidae	0.1	0.3	0.0	1.0	1.2
TERRESTRIAL TOTAL	**20.5**	32.2	6.8	24.8	30.5

Table G.3 Percent by number, percent by weight, mean number per $100m^3$ and mean weight per $100m^3$ for drift organisms collected in Wolf Fork, 1992.

AQUATIC	Density No. per 100 m^3 Mean	S.D.	% by Number	Weight (mg) per 100m3	% by Weight
Diptera Larvae					
Chironomidae	66.2	65.6	26.5	4.6	6.1
Simuliidae	13.8	17.9	5.5	1.6	2.1
Empididae	0.3	0.7	0.1	0.1	0.1
Pelecorhynchidae	1.7	1.8	0.7	1.0	1.4
Canaceidae	0.5	0.9	0.2	1.0	1.4
Diptera Pupa					
Simuliidae	0.1	0.3	0.1	0.0	0.0
Ephemeroptera Nymph					
Baetidae	77.1	92.5	30.8	12.7	16.9
Heptageniidae	11.2	10.3	4.5	2.2	2.9
Ephemerellidae	5.4	5.9	2.1	5.0	6.6
Leptophlebiidae	0.5	0.9	0.2	0.1	0.1
Plecoptera Nymph					
Perlidae	2.1	3.5	0.8	8.1	10.7
Chloroperlidae	0.2	0.3	0.1	0.0	0.1
Nemouridae	4.3	6.4	1.7	0.3	0.3
Trichoptera Larvae					
Hydropsychidae	0.3	0.4	0.1	1.2	1.6
Brachycentridae	2.1	2.1	0.8	0.4	0.5
Glossosomatidae	0.6	0.9	0.2	0.1	0.1
Rhyacophilidae	0.8	0.9	0.3	1.6	2.2
Leptoceridae	5.3	6.6	2.1	0.8	1.1
Trichoptera Pupa					
Rhyacophilidae	0.4	0.7	0.2	0.5	0.7
Coleoptera Larvae					
Elmidae	5.1	5.0	2.1	1.2	1.6
Hydrophilidae	0.9	1.8	0.4	1.3	1.8
Coleoptera Adult					
Elmidae	1.0	1.0	0.4	0.4	0.6
Oligocheata	1.0	1.8	0.4	4.1	5.4
Nematoda	0.3	0.7	0.1	0.0	0.0
Panariidae	8.6	15.9	3.4	3.0	4.0
Bivalvia					
Sphaeridae	0.6	1.1	0.2	0.0	0.0
Hydracarina	7.8	12.0	3.1	0.2	0.2
Ostracoda	6.0	12.0	2.4	0.1	0.1
AQUATIC TOTAL	224.1	269.8	89.7	51.4	68.5

Table G.3 Continued.

TERRESTRIAL	Density No. per 100 m3 Mean	S.D.	% by Number	Weight (mg) per 100 m3	% by Weight
Diptera Adult					
Chironomidae	13.0	8.6	5.2	5.5	7.3
Bibionidae	0.8	1.0	0.3	0.4	0.5
Simulidae	0.3	0.4	0.1	0.2	0.2
Ceratopogonidae	0.8	0.9	0.3	0.2	0.3
Stratiomyidae	0.3	0.7	0.1	0.0	0.0
Muscidae	0.4	0.6	0.2	0.4	0.5
Cecidomyiidae	0.1	0.1	0.0	0.0	0.0
Asilidae	0.6	0.7	0.2	0.2	0.3
Ephemeroptera Adult					
Baetidae	1.1	0.9	0.4	0.4	0.6
Heptageniidae	0.0	0.0	0.0	0.0	0.0
Ephemerellidae	0.9	0.8	0.4	0.6	0.8
Lepidoptera Adult	0.9	1.6	0.3	1.0	1.4
Hymenoptera Adult					
Formicidae	2.0	1.9	0.8	2.7	3.6
Vespidae	0.1	0.1	0.0	4.7	6.2
Cimbicidae	0.1	0.3	0.1	0.1	0.2
Tenthredinidae	0.1	0.1	0.0	0.0	0.0
Eulophidae	0.1	0.1	0.0	0.0	0.0
Agaonidae	0.1	0.3	0.1	0.0	0.0
Homoptera Adult					
Cicadellidae	1.4	2.7	0.6	0.5	0.7
Aphididae	0.9	1.8	0.4	0.0	0.0
lemiptera Adult					
Aradidae	0.5	0.9	0.2	4.0	5.3
Pentatomidae	0.5	0.9	0.2	2.2	2.9
racnids	0.3	0.5	0.1	0.1	0.1
oleoptera Adult					
Tenebrionidae	0.5	0.9	0.2	0.4	0.5
TERRESTRIAL TOTAL	25.8	26.9	10.3	23.6	31.5

APPENDIX H

EVALUATION OF GASTRIC LAVAGE

Introduction

Gastric lavage was used as an alternative method to killing fish to obtain stomach contents for diet analysis. Gastric lavage has been reported to be a non-lethal method of obtain stomach contents (Light et al. 1983). Light et al. (1983) also reported a 98% evacuation of food items by weight from brown trout (*Salmo truttu)* and 100% evacuation of food items from slimy sculpin (*Cottus cognatus*) stomachs. Meehan and Miller (1978) used gastric lavage on coho salmon (*Oncorhynchus kisutch*), cutthroat trout *(Salmo clarki*) and rainbow trout. Their study reported evacuation by number to be 99% for coho salmon, 92% for cutthroat and 90% for rainbow trout. Boag (1987) reported used gastric lavage methods with bull trout and rainbow trout, and reported obtaining food items from 66% of the bull trout sampled (n=50) and 98% from the rainbow trout sampled (n=63). However, Meehan and Miller (1978) suggested that the size of the fish being lavaged, the size of the food items in the stomach and the morphology of the food items may all be factors in the effectiveness of gastric lavage. They found the larger the fish the less efficient the evacuation. Larger food items were suggested to be less effectively removed by lavage than smaller food items. Invertebrates with long, strong appendages equipped with sharp claws may not be effectively removed from the stomach because such an organism would have a higher probability of becoming lodged in the stomach and/or esophagus. Thus to assure the diet analysis within this study was not biased from selective removal of organisms by lavage, the efficiency of gastric lavage was examined.

Methods

For a description of the gastric lavage apperatus see section 2.10.1.

Thirteen bull trout and nineteen 0. *mykiss* were randomly selected and killed. After gastric lavage their stomachs was removed and placed in 10% formalin for two weeks then transferred to 70% alcohol. In the laboratory the stomachs were cut open and the food items within the stomach were enumerated by the taxon Family. The efficiency of gastric lavage was determined by estimating the percent by number lavaged from the stomach and the percent by dry weight lavaged from the stomach. Consult section 2.9 for a description of the dry weight methods.

Results

The mean fork length of the bull trout killed was 164mm (range 137-210mm). The efficiency of gastric lavage per organism family is reported in Table H. 1. Eighty two percent of the total food items by number and 75% of the food items by weight were removed by the lavage technique.

The mean fork length of the 0. *mykiss* killed was 147mm (range 75-231mm). The efficiency of gastric lavage per organism family is reported in Table H.2. Sixty one percent of the total food items by number and 51% of the food items by weight were removed.

Discussion

The lavage technique used in this study was more efficient on bull trout than 0. *mykiss*. However, because of the small sample size, it is difficult to determine if the efficiency of gastric lavage differs between the two fish species due to morphology of the fish's stomach or to the morphology of the food items. Further, each fish species had a large variety of organisms in their diet. We believe that the larger food items such as tricopteran larvae and food items with long appendages such as Ephemerellidae were not evacuated as readily as smaller food items with short appendages. The diet analysis within this study may be biased due to the selective nature of gastric lavage.

Table H.1 Efficiency of gastric lavage evacuation of food items for bull trout.

	No. in Lavage	No. in Stomach	% Removed by Number	% Removed by Weight
Diptera Larvae				
Chironomidae	61	15	80	55
Tipulidae	4	0	100	100
Simuliidae	22	5	81	64
Ceratopogonidae	1	0	100	100
Pelecorhynchidae	3	1	75	92
Diptera Pupa				
Chironomidae	13	0	100	100
Ephemeroptera Nymph				
Baetidae	170	30	85	79
Heptageniidae	16	2	89	58
Ephemerellidae	19	11	63	59
Plecoptera Nymph				
Perlidae	5	0	100	100
Chloroperlidae	1	0	100	
Nemouridae	1	0	100	100
Trichoptera Larvae				
Limnephilidae	2	0	100	100
Hydropsychidae	1	1	50	28
Glossosomatidae	2	1	67	44
Rhyacophilidae	6	3	67	67
Trichoptera Pupa				
Rhyacophilidae	1	1	50	76
Coleoptera Larvae				
Hydrophilidae	1	0	100	100
Oligocheata	2	0	100	100
Lepidoptera Larvae	1	0	100	100
Diptera Adult				
Simuliidae	1	0	100	100
Muscoids	1	1	50	100
Lepidotera Adult	1	0	100	100
Hymenoptera Adult				
Ichneumonidae	1	2	33	2
Hemiptera Adult				
Macroveliidae	1	1	50	100
Arachnid			100	100
Megaloptera				
Sialidae	1	0	100	100
Osteichthyes				
Cottidae	1	0	100	100
Total	**341**	**74**	**82**	**75**

Table H.2 Efficiency of gastric lavage evacuation of food items for ***O. mykiss.***

	No. in Lavage	No. in Stomach	% Removed by Number	% Removed by Weight
)iptera Larvae				
Chironomidae	35	40	47	47
Simuliidae	18	9	67	84
Ceratopogonidae	1	0	100	100
Pelecorhynchidae	2	0	100	100
)iptera Pupa				
Chironomidae Pupa	11	0	100	100
:phemeroptera Nymph				
Baetidae	126	65	66	66
Heptageniidae	24	5	83	81
Ephemerellidae	23	20	53	43
Leptophlebiidae	1	0	100	100
'lecoptera Nymph				
Perlidae	5	7	42	28
Chloroperlidae	2	0	100	100
Nemouridae	3	1	75	100
[richoptera Larvae				
Hydropsychidae	2	4	33	7
Brachycentridae	4	10	29	20
Glossosomatidae	0	4	0	0
Rhyacophilidae	5	5	50	78
Leptoceridae	7	4	64	38
:oleoptera Larvae				
Elmidae	1	0	100	100
:oleoptera Adult				
Elmidae	1	0	100	
)stracod	1	0	100	
)iptera Adults				
Bibionidae	2	0	100	100
Simuliidae	1	0	100	100
Muscoids	1	0	100	100
Cecidomyiidae	1	1	50	0
Asilidae	3	0	100	100
:phemeroptera Adult				
Baetidae	5	1	83	88
.epidoptera Adult	1	0	100	100
Iymenoptera Adult				
Formicidae	7	4	64	74
Vespidae	1	0	100	100
Ichneumonidae	3	0	100	100
Iomoptera Adult				
Cicadellidae	2	1	67	94
Iemiptera Adult				
Macroveliidae	0	4	0	0
;astropoda	3	0	100	100
.rachnid	6	1	86	92
TOTAL	**308**	**186**	**62**	**51**

APPENDIX I

PERCENT BY NUMBER, FREQUENCY OF OCCURRENCE, PERCENT BY WEIGHT AND INDEX OF RELATIVE IMPORTANCE FOR FOOD ITEMS

Table I.1 Percent by number, frequency of occurrence, percent by weight and index of relative importance (IRI) of food items for bull trout and 0. ***mykiss*** captured from Mill Creek during 1992.

AQUATIC	BULL TROUT % by No.	BULL TROUT Freq. Occur.	BULL TROUT % by Weight	BULL TROUT IRI	0. *MYKISS* % by No.	0. *MYKISS* Freq. Occur.	0. *MYKISS* % by Weight	0. *MYKISS* IRI
Diptera Larva								
Chironomidae	12.56	67.74	0.21	**9.68**	6.58	55.56	1.15	**6.02**
Tipulidae	0.74	16.13	0.02	**2.03**	0.14	3.70	0.13	**0.38**
Simuliidae	10.93	48.39	0.36	**7.17**	10.78	77.78	2.85	**8.69**
Ceratopogonidae	0.15	3.23	0.00	**0.41**	0.28	7.41	0.03	**0.73**
Empididae	0.30	6.45	0.00	**0.81**	0.14	3.70	0.07	**0.37**
Pelecorhynchidae	0.59	9.68	0.21	**1.26**	0.28	7.41	0.46	**0.77**
Diptera Pupa								
Chironomidae	2.07	22.58	0.02	**2.96**	2.10	37.04	0.18	**3.74**
Tipulidae	0.00	0.00	0.00	**0.00**	0.14	3.70	0.08	**0.37**
Simuliidae	0.30	3.23	0.01	**0.42**	2.10	14.81	0.79	**1.68**
Ephemeroptera Nymph								
Baetidae	43.87	87.10	1.34	**15.90**	30.81	85.19	7.69	**11.76**
Heptageniidae	7.53	61.29	0.31	**8.31**	2.66	25.93	2.01	**2.91**
Ephemerellidae	3.40	35.48	1.96	**4.91**	5.60	29.63	12.98	**4.58**
Leptophlebiidae	0.00	0.00	0.00	**0.00**	0.14	3.70	0.03	**0.37**
Siphlonuridae	0.00	0.00	0.00	**0.00**	0.14	3.70	0.22	**0.39**
Plecoptera Nymph								
Perlidae	1.62	22.58	0.53	**2.97**	1.54	33.33	2.12	**3.52**
Chloroperlidae	0.89	16.13	0.03	**2.05**	0.28	7.41	0.28	**0.76**
Nemouridae	0.44	9.68	0.01	**1.22**	0.56	11.11	0.17	**1.13**
Trichoptera Larvae								
Limnephilidae	0.30	3.23	0.41	**0.47**	0.14	3.70	0.97	**0.46**
Hydropsychidae	0.89	9.68	0.12	**1.28**	0.28	7.41	0.11	**0.74**
Brachycentridae	0.44	6.45	0.23	**0.86**	3.22	33.33	1.95	**3.66**
Glossosomatidae	1.18	16.13	0.26	**2.11**	0.28	7.41	0.87	**0.81**
Rhyacophilidae	1.03	19.35	0.12	**2.47**	0.84	18.52	0.58	**1.89**
Leptoceridae	0.44	9.68	0.01	**1.22**	0.42	7.41	0.28	**0.77**
Trichoptera Pupa								
Rhyacophilidae	0.15	3.23	0.08	**0.42**	0.28	7.41	2.01	**0.92**
Coleoptera Larvae								
Elmidae	0.44	6.45	0.01	**0.83**	0.14	3.70	0.06	**0.37**
Hydrophilidae	0.30	6.45	0.02	**0.81**	0.14	3.70	0.06	**0.37**
Coleoptera Adult								
Elmidae	0.44	9.68	0.02	**1.22**	0.98	22.22	1.07	**2.31**
Oligocheata	0.30	6.45	0.43	**0.86**	0.00	0.00	0.00	**0.00**
Hydracarina	0.00	0.00	0.00	**0.00**	0.14	3.70	0.01	**0.37**
Ostracoda	0.00	0.00	0.00	**0.00**	0.14	3.70	0.00	**0.37**
Lepidoptera Larvae	0.74	16.13	0.37	**2.07**	1.40	18.52	18.78	**3.68**
Megaloptera								
Sialidae	0.30	6.45	0.05	**0.82**	0.00	0.00	0.00	**0.00**
Osteichthyes								
Salmonidae	0.30	3.23	87.17	**10.90**	0.00	0.00	0.00	**0.00**
Cottidae	0.30	6.45	5.12	**1.43**	0.00	0.00	0.00	**0.00**

Table 1.1. Continued.

TERRESTRIAL	BULL TROUT % by No.	BULL TROUT Freq. Occur.	BULL TROUT % by Weight	BULL TROUT IRI	O. MYKISS % by No.	O. MYKISS Freq. Occur.	O. MYKISS % by Weight	O. MYKISS IRI
Diptera Adult								
Chironomidae	0.30	6.45	0.00	**0.81**	0.56	3.70	0.07	**0.41**
Bibionidae	0.44	9.68	0.08	**1.23**	2.38	29.63	1.56	**3.19**
Simuliidae	1.03	9.68	0.05	**1.29**	0.56	11.11	0.18	**1.13**
Muscoid	0.74	3.23	0.04	**0.48**	0.98	22.22	2.61	**2.45**
Cecidomyiidae	0.15	3.23	0.00	**0.41**	0.56	14.81	0.13	**1.47**
Asilidae	0.15	3.23	0.02	**0.41**	0.42	11.11	0.03	**1.10**
Ephemeroptera Adult								
Baetidae	0.15	3.23	0.01	**0.41**	6.86	29.63	2.67	**3.72**
Ephemerellidae	0.00	0.00	0.00	**0.00**	0.14	3.70	0.10	**0.37**
Lepidoptera Adult	0.15	3.23	0.05	**0.41**	0.42	7.41	1.37	**0.87**
Hymenoptera Adult								
Formicidae	0.15	3.23	0.06	**0.41**	2.38	25.93	5.84	**3.25**
Vespidae	0.00	0.00	0.00	**0.00**	0.98	25.93	5.81	**3.11**
Tenthredinidae	0.15	3.23	0.04	**0.41**	0.00	0.00	0.00	**0.00**
Ichneumonidae	0.74	9.68	0.02	**1.25**	1.40	22.22	2.83	**2.51**
Homoptera Adult								
Cicadellidae	0.59	6.45	0.04	**0.85**	2.10	18.52	1.73	**2.12**
Hemiptera Adult								
Macroveliidae	0.59	9.68	0.04	**1.24**	0.42	7.41	0.67	**0.81**
Gastropoda	0.00	0.00	0.00	**0.00**	0.56	7.41	7.63	**1.48**
Arachnid	1.48	12.90	0.10	**1.74**	3.36	37.04	6.20	**4.43**
Coleoptera Adult								
Chrysomelidae	0.00	0.00	0.00	**0.00**	0.56	3.70	0.66	**0.47**
Cleridae	0.30	6.45	0.02	**0.81**	2.66	18.52	1.96	**2.20**

Table I.2 Percent by number, frequency of occurrence, percent by weight and index of relative importance **(IRI)** of food items for bull trout and ***O. mykiss*** captured from Tucannon River during 1992.

AQUATIC	BULL TROUT % by #	Freq. Occur.	% by Weight	IRI	0. MYKISS % by #	Freq. Occur.	% by Weight	IRI
Diptera Larvae								
Chironomidae	16.36	52.00	0.09	**11.04**	6.68	59.0	0.43	**7.45**
Tipulidae	0.61	4.00	0.13	**0.76**	0.67	7.7	1.20	**1.08**
Simuliidae	0.61	4.00	0.00	**0.74**	0.67	10.3	0.01	**1.23**
Pelecorhynchidae	2.42	12.00	0.15	**2.35**	1.17	17.9	0.46	**2.21**
Unknown Diptera	0.61	4.00	0.01	**0.74**	0.17	2.6	0.16	**0.33**
Diptera Pupa								
Chironomidae	0.61	4.00	0.00	**0.74**	0.33	5.1	0.01	**0.62**
Simuliidae	0.00	0.00	0.00	**0.00**	0.50	7.7	0.10	**0.94**
Ephemeroptera Nymph								
Baetidae	24.24	64.00	0.23	**14.27**	8.35	41.0	0.50	**5.62**
Heptageniidae	5.45	28.00	0.06	**5.41**	6.84	43.6	1.25	**5.83**
Ephemerellidae	3.64	20.00	0.59	**3.91**	2.67	23.1	2.66	**3.20**
Leptophlebiidae	0.00	0.00	0.00	**0.00**	0.50	5.1	0.01	**0.64**
Plecoptera Nymph								
Perlidae	2.42	8.00	0.63	**1.78**	2.67	28.2	7.23	**4.30**
Chloroperlidae	1.21	8.00	0.02	**1.49**	0.33	5.1	0.05	**0.62**
Nemouridae	3.03	16.00	0.04	**3.08**	1.00	12.8	0.04	**1.56**
Trichoptera Larvae								
Hydropsychidae	4.85	24.00	1.72	**4.93**	2.67	25.6	6.63	**3.94**
Brachycentridae	0.00	0.00	0.00	**0.00**	27.88	48.7	6.70	**9.39**
Glossosomatidae	1.82	8.00	0.02	**1.59**	1.50	20.5	1.23	**2.62**
Rhyacophilidae	4.85	24.00	0.12	**4.67**	1.00	15.4	0.14	**1.86**
Leptoceridae	6.06	24.00	0.18	**4.88**	3.84	28.2	0.82	**3.71**
Trichoptera Pupa								
Rhyacophilidae	0.00	0.00	0.00	**0.00**	0.50	5.1	1.07	**0.76**
Coleoptera Larvae								
Elmidae	0.00	0.00	0.00	**0.00**	1.17	7.7	0.43	**1.05**
Caradidae	0.00	0.00	0.00	**0.00**	0.17	2.6	0.02	**0.31**
Hydrophilidae	0.00	0.00	0.00	**0.00**	1.00	12.8	0.29	**1.59**
Coleoptera Adult								
Elmidae	0.61	4.00	0.01	**0.74**	1.67	17.9	0.65	**2.28**
Hydrophilidae	0.00	0.00	0.00	**0.00**	0.17	2.6	0.14	**0.32**
Curculionidae	0.00	0.00	0.00	**0.00**	0.33	5.1	0.03	**0.62**
Oligocheata	9.09	36.00	18.11	**10.19**	2.84	20.5	28.51	**5.85**
Ostracoda	0.61	4.00	0.01	**0.74**	0.00	0.0	0.00	**0.00**
Lepidoptera Larvae	0.00	0.00	0.00	**0.00**	1.50	12.8	2.03	**1.84**
Amphibian								
Ranidae	1.21	8.00	77.40	**13.97**	0.00	0.0	0.00	**0.00**

Table I.2 Continued.

TERRESTRIAL	BULL TROUT % by #	BULL TROUT Freq. Occur.	BULL TROUT % by Weight	BULL TROUT IRI	O. MYKISS % by #	O. MYKISS Freq. Occur.	O. MYKISS % by Weight	O. MYKISS IRI
Diptera Adult								
Chironomidae	0.00	0.00	0.00	**0.00**	0.33	2.6	0.01	**0.33**
Bibionidae	0.61	4.00	0.01	**0.74**	0.50	7.7	0.15	**0.94**
Simuliidae	0.00	0.00	0.00	**0.00**	0.33	5.1	0.03	**0.62**
Musciods	0.61	4.00	0.09	**0.76**	0.50	7.7	0.10	**0.93**
Cecidomyiidae	1.21	8.00	0.00	**1.49**	1.00	10.3	0.05	**1.28**
Asilidae	0.00	0.00	0.00	**0.00**	0.17	2.6	0.05	**0.31**
Ephemeroptera Adult								
Baetidae	1.82	12.00	0.04	**2.23**	3.01	20.5	0.67	**2.73**
Ephemerellidae	0.61	4.00	0.05	**0.75**	0.00	0.0	0.00	**0.00**
Lepidoptera Adult	1.21	8.00	0.15	**1.51**	2.50	7.7	8.31	**2.09**
Hymenoptera Adult								
Formicidae	1.21	8.00	0.13	**1.51**	3.17	35.9	3.85	**4.84**
Vespidae	0.00	0.00	0.00	**0.00**	0.17	2.6	1.05	**0.43**
Tenthredinidae Adult	0.00	0.00	0.00	**0.00**	0.33	5.1	0.01	**0.62**
Ichneumonidae	0.00	0.00	0.00	**0.00**	1.34	15.4	0.94	**1.99**
Homoptera Adult								
Cicadellidae	0.61	4.00	0.00	**0.74**	2.34	25.6	0.27	**3.18**
Aphididae	0.00	0.00	0.00	**0.00**	0.00	0.0	0.00	**0.00**
Hemiptera Adult								
Macroveliidae	0.61	4.00	0.01	**0.74**	0.17	2.6	0.05	**0.31**
Gastropoda	0.00	0.00	0.00	**0.00**	1.67	5.1	11.45	**2.06**
Arachnid	1.21	8.00	0.01	**1.49**	1.50	17.9	0.43	**2.24**
Coleoptera Adult								
Staphylinidae	0.00	0.00	0.00	**0.00**	0.17	2.6	3.19	**0.67**
Diplopoda	0.00	0.00	0.00	**0.00**	1.67	10.3	5.89	**2.01**

Table I.3 Percent by number, frequency of occurrence, percent by weight and index of relative importance **(IRI)** of food items for bull trout and 0. ***mykiss*** captured in Wolf Fork during 1992.

	BULL TROUT				*0. MYKISS*			
AQUATIC	% by #	Freq. Occur.	% by Weight	IRI	% by #	Freq. Occur.	% by Weight	IRI
Diptera Larvae								
Chironomidae	13.07	52.38	2.35	11.04	17.55	46.67	1.92	10.22
Tipulidae	0.57	4.76	3.52	1.44	0.00	0.00	0.00	0.00
Simuliidae	6.25	33.33	0.98	6.61	0.99	10.00	0.09	1.71
Pelecorhynchidae	0.00	0.00	0.00	0.00	0.33	3.33	0.09	0.58
Anthomylidae	0.00	0.00	0.00	0.00	0.33	3.33	2.59	0.97
Diptera Pupa								
Chironomidae	1.70	9.52	0.07	1.84	0.33	3.33	0.02	0.57
Tipulidae	0.57	4.76	0.07	0.88	0.00	0.00	0.00	0.00
Simuliidae	0.57	4.76	0.00	0.87	0.00	0.00	0.00	0.00
Ephemeroptera Nymph								
Baetidae	36.36	76.19	18.02	21.27	24.83	73.33	2.75	15.60
Heptageniidae	7.95	28.57	6.72	7.04	9.93	53.33	2.29	10.13
Ephemerellidae	4.55	33.33	16.71	8.89	5.96	36.67	5.90	7.50
Plecoptera Nymph								
Perlidae	1.70	9.52	8.49	3.21	0.99	10.00	0.17	1.73
Chloroperlidae	0.00	0.00	0.00	0.00	0.66	6.67	0.09	1.15
Nemouridae	0.00	0.00	0.00	0.00	0.33	3.33	0.00	0.57
Trichoptera Larvae								
Hydropsychidae	3.98	23.81	1.50	4.77	2.32	20.00	1.08	3.62
Brachycentridae	1.14	9.52	0.33	1.79	12.58	30.00	5.64	7.45
Glossosomatidae	0.00	0.00	0.00	0.00	0.66	6.67	1.27	1.33
Rhyacophilidae	1.14	9.52	1.50	1.98	2.98	16.67	1.12	3.21
Leptoceridae	6.82	28.57	4.24	6.45	2.98	20.00	1.12	3.72
Trichoptera Pupa								
Brachycentridae	0.00	0.00	0.00	0.00	0.33	3.33	0.07	0.58
Coleoptera Larvae								
Hydrophilidae	0.57	4.76	0.46	0.94	0.33	3.33	0.19	0.60
Coleoptera Adults								
Elmidae	0.00	0.00	0.00	0.00	1.99	10.00	0.43	1.92
Oligocheata	1.70	14.29	13.77	4.85	0.33	3.33	46.36	7.73
Lepidoptera Larvae	0.57	4.76	1.96	1.19	0.00	0.00	0.00	0.00

Table I.3 Continued.

TERRESTRIAL	BULL TROUT % by #	Freq. Occur.	% by Weight	IRI	O. MYKISS % by #	Freq. Occur.	% by Weight	IRI
Diptera Adult								
Simuliidae	0.57	4.76	0.20	**0.90**	0.00	0.00	0.00	**0.00**
Asilidae	0.00	0.00	0.00	**0.00**	0.33	3.33	0.04	**0.57**
Ephemeroptera Adult								
Baetidae	0.00	0.00	0.00	**0.00**	3.64	20.00	6.10	**4.60**
Plecoptera Adult								
Perlidae	0.00	0.00	0.00	**0.00**	0.66	6.67	3.83	**1.73**
Hymenoptera Adult								
Formicidae	5.11	19.05	12.53	**5.98**	5.30	20.00	5.77	**4.80**
Ichneumonidae	1.70	9.52	0.33	**1.88**	0.00	0.00	0.00	**0.00**
Homoptera Adult								
Cicadellidae	0.57	4.76	1.31	**1.08**	0.00	0.00	0.00	**0.00**
Hemiptera Adult								
Macroveliidae	0.57	4.76	0.91	**1.02**	0.00	0.00	0.00	**0.00**
Gastropoda	0.00	0.00	0.00	**0.00**	1.32	13.33	7.52	**3.43**
Arachnid	1.70	14.29	1.31	**2.82**	1.32	13.33	0.37	**2.32**
Diplopoda	0.57	4.76	2.74	**1.31**	0.66	6.67	3.20	**1.63**