Evaluation of the potential for resident bull trout to reestablish the migratory life-form
by M Lee Nelson

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Though once migratory, many remaining bull trout populations now persist as nonmigratory "residents" isolated in headwater streams. Isolation through habitat changes and the loss of a migratory life-form increases the extinction risk of these populations. The goal of this study was to determine if resident bull trout still produce a downstream dispersing component capable of reestablishing a migratory life-form. Downstream dispersal was evaluated with picket-weir and fry traps on three tributaries to the lower Bitterroot River. Study basins had relatively high densities of bull trout (12 — 30 fish/100 m). In 1996 and 1997, a series of traps was operated spring through fall seasons in stream sections with bull trout and 1.0 to 6.5 km below presumed population boundaries. If these populations maintain both resident and migratory life-forms, then downstream movement should be significant. Alternatively, if selection has favored a nonmigratory life-form, then downstream movement below the resident populations should be absent or rare. A total of 215 bull trout were caught in 1045 trapping days; of these, only six were captured at lower traps considered below resident population boundaries. The capture of five large bull trout (343 — 450 mm) and downstream movement of numerous juveniles suggested one stream still maintains a remnant migratory population. Results indicated dispersal rates from tributary populations to the mainstem river were very low from headwater resident populations. This research suggests reestablishment of a migratory life-form from resident populations may be a slow process, even if those conditions that selected against migration are corrected.

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M. Lee Nelson

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M. Lee Nelson

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Though once migratory, many remaining bull trout populations now persist as nonmigratory "residents" isolated in headwater streams. Isolation through habitat changes and the loss of a migratory life-form increases the extinction risk of these populations. The goal of this study was to determine if resident bull trout still produce a downstream dispersing component capable of reestablishing a migratory life-form. Downstream dispersal was evaluated with picket-weir and fry traps on three tributaries to the lower Bitterroot River. Study basins had relatively high densities of bull trout (12 — 30 fish/100 m). In 1996 and 1997, a series of traps was operated spring through fall seasons in stream sections with bull trout and 1.0 to 6.5 km below presumed population boundaries. If these populations maintain both resident and migratory life-forms, then downstream movement should be significant. Alternatively, if selection has favored a nonmigratory life-form, then downstream movement below the resident populations should be absent or rare. A total of 215 bull trout were caught in 1045 trapping days; of these, only six were captured at lower traps considered below resident population boundaries. The capture of five large bull trout (343 — 450 mm) and downstream movement of numerous juveniles suggested one stream still maintains a remnant migratory population. Results indicated dispersal rates from tributary populations to the mainstem river were very low from headwater resident populations. This research suggests reestablishment of a migratory life-form from resident populations may be a slow process, even if those conditions that selected against migration are corrected.

INTRODUCTION

Bull trout (*Salvelinus confluentus*), like many other native inland salmonids (Behnke 1992; Thurow et al. 1997), now exist as increasingly isolated populations within fragmented patches of suitable habitat (Howell and Buchanan 1992; Thomas 1992; Rieman and McIntyre 1993; Rieman et al. 1997). Historically abundant in all major river basins of western Montana, bull trout now occupy only about 42% of their historic distribution (Thomas 1992). Similar declines have been reported for other populations across their native range of northwestern North America (Rieman et al. 1997), and the U.S. Fish and Wildlife Service has listed the bull trout as threatened under the Endangered Species Act (Federal Register, June 10, 1998).

Like other inland salmonids, bull trout express a high degree of life-history variability. Migratory life-history forms reside as adults in large rivers (fluvial) or lakes (adfluvial) and migrate up smaller streams to spawn. Juveniles typically rear one to three years in tributaries before migrating to lakes or larger rivers (Fraley and Shepard 1989; Ratliff 1992; Elle et al. 1994; Elle 1995, Riehle et al. 1997; Stelfox 1997). At age 5 to 7, adults return to natal tributaries to spawn and complete the cycle (Fraley and Shepard 1989; Elle et al. 1994; Elle 1995; Riehle et al. 1997). Migratory movements by fluvial and adfluvial bull trout are among the longest reported for inland salmonids, with movements up to 250 km reported (Fraley and Shepard 1989). In contrast, the "resident" life-history form spawns and rears year-round in headwater, low-order streams, with relatively restricted (< 2 km) spawning and over-wintering movements by adults and juveniles (Jakober et al. 1998).

The order Salmonidae exhibits a large degree of flexibility in expression of multiple life-history forms. The genus *Salmo*, *Oncorhynchus*, and *Salvelinus* all express resident, fluvial, adfluvial, and anadromous forms. The expression of multiple life-history patterns can be viewed as an adaptation to variable environments, with each form conferring advantages under different environmental conditions (Northcote 1992). When movement corridors are intact, migratory forms can utilize multiple habitats which maximize survival or growth for various life stages. For bull trout, this entails the use of clean, cold, headwater tributaries for spawning and rearing (Fraley and Shepard 1989), and lakes and larger rivers where a more abundant prey base allows increased size and fecundity, and hence fitness, for adults. Spawning adfluvial bull trout in the Flathead River basin, for example, average 628 mm in length and 5,482 eggs per female (Fraley and Shepard 1989), whereas resident bull trout seldom exceed 305 mm in length and have only a few hundred eggs per female (Goetz 1989). Additionally, with alternate year spawning and sub-adults residing outside headwater tributaries (Fraley and Shepard 1989; Goetz 1989), several cohorts in migratory populations are removed from extirpating stochastic events, e.g., drought, fire, and debris torrents. This “risk-spreading” may reduce the likelihood of local population extinction and enhance rapid recolonization (Rieman and McIntyre 1993).

Where migration is impossible (i.e., waterfalls), or where migratory corridors have been disrupted, selective pressure will favor the nonmigratory resident life-form (Northcote 1992; 1997). Similarly, residency is advantageous if the energetic cost of movement between multiple habitats outweighs the benefits of such movement, as may occur in some streams where adequate spawning, overwintering, and prey availability are in close proximity (Northcote 1992).

Populations which include migratory and resident life-history strategies potentially have a greater chance to persist under variable habitat conditions (Gross 1991; Northcote 1992). However, when habitat conditions favor large migratory fish with their relatively higher reproductive potential, this life-form usually dominates the population. For example, bull trout populations in the McKenzie (Goetz 1997), Metolius (Riehle et al. 1997), and Flathead river systems (Fraley and Shepard 1989) are composed of mostly large fluvial or adfluvial life-history forms, and resident life-forms are rare (J. Ziller, Oregon Department of Fish and Wildlife; M. Riehle, U.S. Forest Service: personal communication; Thomas 1992).

With increased habitat fragmentation, however, the migratory life-form has become absent or rare in many bull trout populations and the resident life-history form predominates (Dambacher et al. 1992; Thomas 1992; Ziller 1992; Jakober et al. 1998). Reduced connectivity with neighboring populations and exposure to stochastic events places these remaining populations at high risk of extinction (Rieman and McIntyre 1993). Historically, bull trout are thought to have formed metapopulations, or collections of local populations spatially and temporally isolated but connected through periodic dispersal (Hanski and Gilpin 1991; Rieman and McIntyre 1993). Dispersal has been referred to as the "glue" that sustains local populations in a metapopulation, with the rate of dispersal dependent upon the strength and distance between local populations and the availability of migratory corridors (Hansson 1991). For bull trout, connectivity between local populations may include immigration and straying of migratory forms (Rieman and McIntyre 1993). Implicit benefits of dispersal include supporting "sink" populations (Stacey and Taper 1992), maintaining genetic diversity within a metapopulation by increasing exchange between locally adapted populations, and colonizing suitable habitat after local extinctions (Rieman and McIntyre 1993). Consequently, a decrease in dispersal will reduce the stability of a metapopulation by increasing isolation and extinction risks of local populations, thereby moving the entire metapopulation towards extinction.

The bull trout population of the Bitterroot River basin is an example of increased fragmentation and loss of the migratory life-form. Historic accounts of large migratory bull trout in the Bitterroot River (Shields 1889; Evermann 1891) suggest this population once functioned like other fluvial populations: a dominant migratory life-form with adults occupying the main river, and spawning and rearing occurring in tributaries. Historical occurrence of a nonmigratory resident life-form in the drainage is unknown. Currently, however, isolated populations of headwater tributary residents are dominant in the drainage and large migratory bull trout are now rare in the mainstem (Thomas 1992; Montana Bull Trout Scientific Group [MBTSG] 1995).

Human alterations of tributaries and the mainstem river suggest bull trout in the Bitterroot River basin may have undergone selection pressure against migratory behavior since the late 1800's. Large migratory fish appear to have become rare or absent in most of the drainage since the 1930's (C. Clancy, Montana Department of Fish, Wildlife, and Parks [MFWP], personal communication). In some cases, such as populations above lowhead dams, downstream migrants have a low probability of returning to spawn in natal tributaries and the migratory trait may be selected against in a local population. In other populations, migratory fish may remain in low numbers and are periodically successful when conditions allow (Jakober et al. 1998).

A combination of factors appear to have strongly selected against the migratory life-form in the Bitterroot River basin. Bull trout are generally associated with maximum water temperatures of 10 to 15°C (Fraley and Shepard 1989; Ratliff 1992), yet temperatures in the lower main river and valley reaches of tributaries commonly exceed 20° C (MBTSG 1995). Elevated temperatures are, in part, due to residential development, grazing, and seasonal dewatering of the mainstem river and tributaries (MBTSG 1995). Such temperatures potentially limit bull trout distribution in the mainstem river and lower reaches of tributaries, and may represent seasonal barriers to movement. Lowhead irrigation dams, common on tributary streams to the mainstem river, restrict or eliminate upstream migratory movement and potentially divert downstream migrants into irrigation canals. Bull trout migrating downstream to the mainstem river also face competition and predation from nonnative salmonids. Resident bull trout and native westslope cutthroat trout (*Oncorhynchus clarki lewisi*) populations typically occupy higher gradient, low-order tributary reaches above the valley floor, whereas nonnative salmonids, including brook trout (*S. fontinalis*), brown trout (*Salmo trutta*) and rainbow trout (*O. mykiss*) populations, now dominate the mainstem river and the lower reaches of tributaries. Interaction, either predation or competition, with nonnative salmonids is likely detrimental to bull trout (Dambacher et al. 1992; Rieman and McIntyre 1993). Additionally, hybridization between bull trout and brook trout is common where the species distributions overlap (Kitano et al. 1994). Currently, brook trout are present in about 75% of the streams occupied by bull trout in the basin, though amount of distribution overlap is generally low (MBTSG 1995; Rich 1996). Due to earlier maturation of brook trout and reduced fertility of hybrids, cross-breeding of brook trout and bull trout can result in brook trout-dominated communities (Leary et al. 1983; Leary et al. 1993). These conditions have led to a fragmented bull trout population with little or no interchange between local populations (MBTSG 1995).

The reestablishment of connectivity between remaining bull trout populations and the migratory life-form is considered essential for bull trout persistence in the Bitterroot River basin and elsewhere (Rieman and McIntyre 1993; MBTSG 1995). However, whether the migratory life-form would be reestablished if selective pressures against migration were fixed is unknown. Some evidence suggests that multiple life-forms can be expressed in one population; for example, Nordeng (1983) found that resident Arctic char (*S. alpinus*) can give rise to anadromous forms and vice versa. Similar examples of a flexible life-history have been described for brown trout (Jonsson 1985), and kokanee and sockeye salmon (Ricker 1938; Rieman et al. 1994). Such flexible life-history response suggests life-history form is not strongly genetically controlled.

In contrast, residency appears to be tightly genetically controlled where long distance movement is deleterious to the fitness of the individual, or when populations reside above impassable barriers (Northcote 1992). When populations exist above impassable barriers, downstream movement over the barrier results in the permanent loss of individuals to the population. Consequently, selection pressure can result in a number morphological and genetic differences between stocks above and below barriers (Northcote and Hartman 1988). Evidence supporting genetic differences between stocks above and below barriers has been described for rheotactic response (Northcote 1981), growth and maturity (Northcote 1981), swimming stamina (Tsuyuki and Williscroft 1977; Northcote and Kelso 1981), and rate of downstream migration (Jonsson 1982; Elliott 1987). Thus, the expression of life-history patterns appears to have two controlling factors. Phenotypic "plasticity" of life-history cued by environmental conditions appears common in salmonid populations where both life-forms can be successful. In other populations where selection strongly favors one life-form, genetic control may predetermine individual life-history.

It is unknown if bull trout populations that have undergone apparent selection pressure for residency and against migration can give rise to a migratory form through phenotypic plasticity. If genetic control of migratory tendencies is strong, it is possible that selection against migration may remove the trait from the population. In this situation, the reestablishment of the migratory life-form may require evolutionary adaptation, or the introduction of migratory stocks.

In this study, I addressed the question whether remaining bull trout populations in three tributaries to the Bitterroot River basin maintain both resident and migratory tendencies, or if selective pressure has eliminated the migratory component of the population. My main objective was to determine the potential for reestablishing a migratory life-form from resident bull trout populations by assessing the magnitude and timing of dispersal or outmigration from isolated headwater populations. If remaining resident populations maintain both resident and migratory life-forms, then downstream movement from headwater populations should still be significant. Alternatively, if downstream migration has a strong genetic component, then dispersal and outmigration should now be rare and the potential for reestablishing a migratory life-form would be low.

STUDY AREA

The Bitterroot River is formed by the confluence of the East and West Forks of the Bitterroot River near Conner, MT (Figure 1). The river flows 137 km north to its junction with the Clark Fork of the Columbia River near Missoula, MT. The basin encompasses 7,288 km^2 of national forest, wilderness and private lands. Mean annual flow at the mouth is 74 m^3/s (U.S. Geological Survey 1999). No natural fish barriers exist on the mainstem river.

Lack of natural barriers and historical evidence suggest migratory bull trout were once common throughout the Bitterroot River drainage. Evermann (1891) captured "salmon trout" by hook and line weighing up to 6.35 kg near the river mouth. Shields (1889) describes "trout" (presumably bull trout) between 4.1 and 5.2 kg captured in 1883 near Corvallis, MT. It is unknown if these bull trout represented a population of migratory fish from the Bitterroot River, the Clark Fork of the Columbia, or adfluvial fish from Flathead Lake, MT, or Lake Pend Oreille, ID.

Migratory bull trout are now rare in the Bitterroot River basin (MBTSG 1995; Jakober et al. 1998). Small bull trout (< 300 mm) are occasionally captured during MFWP fall electrofishing population estimates in the mainstem river above Victor, MT, but none have been collected downstream since electrofishing estimates began in 1989 (MFWP, data files, Hamilton). Larger bull trout (> 500 mm) are occasionally collected

Figure 1. Distribution and status of bull trout in the Bitterroot River drainage.

during electrofishing estimates in the upper East Fork and West Fork of the Bitterroot rivers, suggesting small, remnant populations of fluvial fish persist in some drainages (MBTSG 1995; Jakober et al. 1998).

Based on evidence from other migratory bull trout populations (e.g., Swanberg 1997), the tributaries to the Bitterroot River historically supported migratory juvenile fish, and seasonally, large adult spawners from the mainstem. However, most remaining populations are now located in upper reaches of larger tributaries (3^{rd} – 5^{th} order) in the Bitterroot National Forest below natural barriers (Figure 1), and appear to spend their entire lives in these streams. Compared to fluvial life-history forms, these resident populations have relatively restricted movement (< 2 km) between spawning and overwintering habitats (Jakober et al. 1998). Additionally, remaining populations are separated by long distances (Figure 1), and by conditions which restrict or prevent movement between the populations (e.g. high temperatures, dewatering, and lowhead dams) (MBTSG 1995).

In addition to bull trout, native species in the drainage include westslope cutthroat trout, mountain whitefish (*Prosopium williamsoni*), longnose sucker (*Catostomus catostomus*), largescale sucker (*C. macrocheilus*), redside shiner (*Richardsonius balteatus*), longnose dace (*Rhinichthys cataractae*), northern squawfish (*Ptychocheilus oregonensis*), peamouth (*Mylocheilus caurinus*), and slimy sculpin (*Cottus cognatus*). Common nonnative species include brook trout, brown trout, and rainbow trout.

I evaluated dispersal from bull trout populations occupying three tributaries to the Bitterroot River: Sweathouse, Skalkaho, and Sleeping Child creeks. Streams were chosen based on having an abundant resident bull trout population (high potential to produce and detect outmigration), adequate access, and a stream size that allowed for effective trapping. Sweathouse Creek is a third order, 17-km long stream (watershed area 73 km^2) which joins the mainstem Bitterroot River near Victor, MT (Figure 2). The lower 8 km is characterized by a wide valley floor, stream widths of 5 to 13 m, and large pools and low-gradient riffles and runs. Above river km 8, the stream flows through a narrow canyon where wetted widths vary from 3 to 7 m and plunge-pools and high-gradient riffles are the dominant habitat types. Two natural waterfall barriers occur at river km 11 and 11.5. A high-gradient section at river km 8.0, built in the 1960's during mining operations, appears to inhibit upstream movement as indicated by nonnative brook trout common below the site, but rare above. Flow regime in Sweathouse Creek, and other study streams, is typical of Rocky Mountain streams. Peak runoff normally occurs during spring snowmelt (May - June), decreases to base flow by late fall or winter, then increases due to late winter and early spring freshets. Peak discharge exceeded 15 m^3/s at the stream mouth in June 1997. Base flow is about 0.2 m^3/s above irrigation withdrawals. Irrigation withdrawals occur throughout the lower 8 km of stream; however, flow is generally present through the year to the mouth. Peak summer temperature ranges from 14° C at river km 7.3, to 21° C at the stream mouth.

Sweathouse Creek has a relatively abundant, but restricted, bull trout population numbering about 1000 - 2000 fish (Figure 3). The population is mostly confined to the 3 km section between the manmade high-gradient section and the first falls (Figure 2). Cutthroat trout are abundant above river km 7, but are uncommon below (Figure 3).

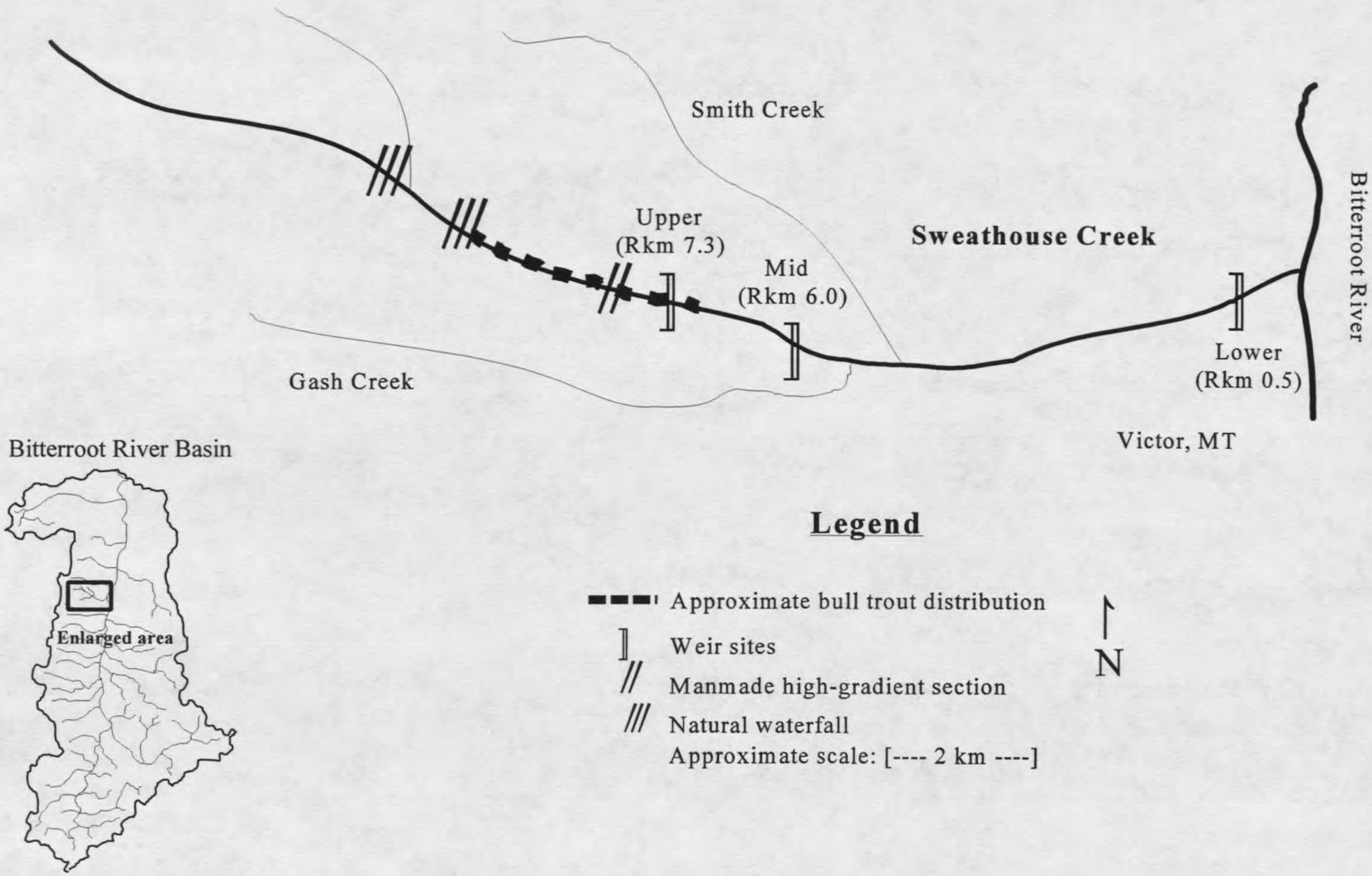

Figure 2. Bull trout distribution and trapping sites on Sweathouse Creek, Ravalli County, MT.

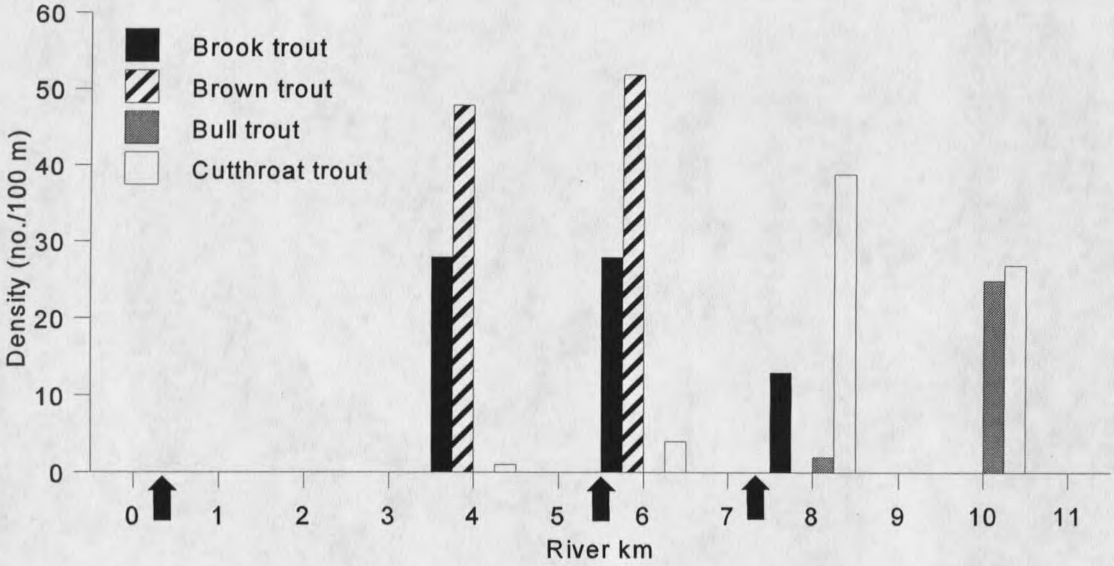

Figure 3. Salmonid densities by river section along Sweathouse Creek. Data obtained from electrofishing estimates, 1991— 1996 (MFWP, data files, Hamilton). Arrows denote locations of weirs.

Unlike bull trout, cutthroat are found above the falls. Brook trout, brown trout, and rainbow trout are common in the first 7 km, but are rare where bull trout are found. Detailed population estimates for all salmonids for study streams are listed in Appendix A, Table 4.

Skalkaho Creek is a fifth-order, 43-km long stream (watershed area 228 km^2) which joins the Bitterroot River near Hamilton, MT (Figure 4). The lower 19 km flows through a wide valley floor and the stream is characterized by low gradient riffles and runs, and stream widths of 10 to 15 m. Above river km 19, the stream flows through a constrained valley, and is characterized by fast water habitats. Several low-head dams