A basin approach to characterizing spawning and fry rearing habitats for westslope cutthroat trout in a sediment-rich basin, Montana

by James Patrick Magee

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:
This study used a basin-wide scale to identify and characterize critical spawning and fry rearing habitats for westslope cutthroat trout (Oncorhvnchus clarki lewisi) in a sediment-rich basin. Strong spatial and temporal patchiness occurred within the basin. Cache Creek and Wapiti Creek subbasins produced 99% of the redds and fry for the entire basin. The percentage of available spawning substrate was the only habitat variable significantly correlated with redd densities. However, elevation, temperature and gradient were important variables identifying critical spawning and fry rearing areas on a basin level. Availability of suitable spawning gravel, stream size, and gradient were important variables at a reach level. Spawning gravels were highly sedimented (40% of spawning substrate was <6.35 mm). High adult densities in Cache and Wapiti Creek subbasins indicate spawning and fry rearing habitats are not limiting recruitment, but low survival to emergence (mean = 18%, range 9-28%) suggests the amount of sediment may be close to a limiting threshold. Strong spatial patchiness and physical variation over short distances indicate that all scales are important to identify critical habitats, and that none are singularly sufficient.

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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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TABLE OF CONTENTS

	Page
LIST OF TABLES	vii
LIST OF FIGURES	ix
ABSTRACT	xi
INTRODUCTION	1
STUDY AREA	6
METHODS	9
Timing of Spawning and Redd Distribution	9
Substrate Composition of Redds	11
Spawning Habitat Characteristics	14
Fry Distribution and Production	17
RESULTS	20
Spawning Migration and Timing	20
Temperature and Flow During Spawning	27
Redd Distribution	34
Habitat Characteristics of Spawning Areas	38
Substrate Composition of Redds	39
Fry Distribution	46
Fry Emergence and Growth	51
Fry Production	53
DISCUSSION	56
Spawning Migrations	56
Redd Distribution	57
Substrate Composition	61
Habitat Use and Fry Production	65
Effects of Disturbance	69
CONCLUSION	75
REFERENCES CITED	77
APPENDICES	83

TABLE OF CONTENTS--Continued

Page

Appendix A--Regression for Cache Creek and Deadhorse Creek waterlevels 84

Appendix B--Incubation times for cutthroat trout . . . 86

Appendix C--Mean values of substrate characteristics between egg pockets and redds 88

LIST OF TABLES

Table		Page
1.	Wentworth system used to classify substrate size classes (Welch 1948)	14
2.	Streambank stability rating based on the percentage of protected streambank	15
3.	Substrate embeddedness rating based on the percentage of substrate particles covered by fine sediment	16
4.	Characteristics of trap catch for Cache, Deadhorse and Wapiti Creeks for potential spawning fish > 150 mm	23
5.	Mean values for habitat variables ranked by redd density (> or < 3 redds/100 m) for the Taylor Fork drainage	40
6.	Spearman's coefficient of rank correlation and significance of habitat variables with redd densities in the Taylor Fork drainage	41
7.	Mean values and significant differences of substrate characteristics for reaches and between Cache and Wapiti Creek Subbasins	43
8.	Mean values of habitat variables for fry reaches, and significant differences between fry densities >0.15 fry/m² or <0.15 fry/m² . . .	49
9.	Centigrade temperature units for cutthroat trout embryonic development in Cache and Wapiti Creeks .	51
10.	Number of females, percentage of females by size class, and mean fecundity for all females > 150 mm captured in the Cache Creek trap in May-June 1992	53

LIST OF TABLES--Continued

Table Page

11. Number of redds and predicted number of fry produced based on percentage of survival to emergence, from fines <6.35 mm by reach in the Taylor Fork basin 54

12. Percentage of fines <0.85 mm and <6.35 mm and the fredle index in salmonid egg pockets in the Rocky Mountain region 62

13. Centigrade temperature units for embryonic development for cutthroat trout 87

14. Mean values for substrate characteristics between egg pockets and redds, and P-values based on a Mann-Whitney U test 89

LIST OF FIGURES

Figure		Page
1.	Taylor Fork drainage with spawning traps, fry reaches, and thermographs	8
2.	Length-frequency distribution for all fish >150 mm caught in the Cache Creek trap	22
3.	Upstream and downstream trap catch for spawners in Cache Creek, Deadhorse Creek, and Wapiti Creek, with median dates for upstream and downstream migration	25
4.	Weekly mean, maximum and minimum temperatures for lower Cache Creek (A), lower Taylor Fork River (B), Wapiti Creek (C) and Lightning Creek (C) from 10/91-11/92	28
5.	Mean daily temperature and trap catch based on three day averages for Cache Creek	31
6.	Mean, maximum, and minimum daily temperatures during spawning surveys for Wapiti Creek (A) and Cache Creek (B)	32
7.	Mean stream water levels and trap catch based on three day averages for Cache Creek	33
8.	Redd distribution and densities for the Taylor Fork drainage, 1991-1992	35
9.	Redd densities by reach and total redd counts by stream for the Taylor Fork basin	36
10.	Number of redds counted by three day periods for Cache and Wapiti Creeks	37

LIST OF FIGURES--Continued

Figure Page

11. Comparison of percent Wolman fines (A) and percent surface fines from the 49 intersection grid technique (B) with subsurface fines <2.36 mm from McNeil core samples 44

12. Comparison of percent Wolman fines <2.0 mm and percent surface fines from the 49 grid technique <2.0 mm 45

13. Weekly visual fry counts by reach for the Taylor Fork basin 47

14. Comparison of visual fry counts to a population estimate derived from a two-pass electrofishing depletion for 6 meter reach segments 50

15. Fry mean daily growth rates, spawning dates, and mean lengths at the end of the sampling period, by reach, in the Taylor Fork basin . . . 52

16. Regression for Cache and Deadhorse Creek water levels and equation for estimating Cache Creek water levels 85

ABSTRACT

This study used a basin-wide scale to identify and characterize critical spawning and fry rearing habitats for westslope cutthroat trout (Oncorhynchus clarki lewisi) in a sediment-rich basin. Strong spatial and temporal patchiness occurred within the basin. Cache Creek and Wapiti Creek subbasins produced 99% of the redds and fry for the entire basin. The percentage of available spawning substrate was the only habitat variable significantly correlated with redd densities. However, elevation, temperature and gradient were important variables identifying critical spawning and fry rearing areas on a basin level. Availability of suitable spawning gravel, stream size, and gradient were important variables at a reach level. Spawning gravels were highly sedimented (40% of spawning substrate was <6.35 mm). High adult densities in Cache and Wapiti Creek subbasins indicate spawning and fry rearing habitats are not limiting recruitment, but low survival to emergence (mean = 18%, range 9-28%) suggests the amount of sediment may be close to a limiting threshold. Strong spatial patchiness and physical variation over short distances indicate that all scales are important to identify critical habitats, and that none are singularly sufficient.

INTRODUCTION

Westslope cutthroat trout Oncorhynchus clarki lewisi were historically abundant in western Montana, northern and central Idaho, northwestern Wyoming, southern Alberta, southeastern British Columbia and southwest Saskatchewan (Liknes and Graham 1988). Populations have declined dramatically in the past 100 years and shrinking distribution is attributed to habitat loss, hybridization, and overfishing (Liknes 1984; Rieman and Apperson 1989). In Montana, populations now exist in only 27% of their historical range, and genetically pure populations occur in only 2.5% of their original range (Liknes 1984; Liknes and Graham 1988). To protect and enhance this now rare species, the state of Montana has designated westslope cutthroat trout as a species of special concern (Holton 1990). Recent efforts of state and federal agencies are aimed at identifying remaining westslope cutthroat trout populations, increasing the distribution of pure populations, and evaluating habitat requirements and sensitivity to land use.

Variation of physical characteristics and use of critical spawning and rearing habitats for westslope cutthroat trout may depend on life stage, life history form (adfluvial, fluvial, or resident forms), and season (Rieman and Apperson 1989). Identifying where (spatial) and when (temporal) spawning and rearing habitats are used is essential to protect and enhance existing populations. This study focuses on identifying habitats required for spawning and early fry rearing life stages. Although all life history forms of cutthroat trout are known to use small headwater tributaries for spawning (Rieman and Apperson 1989), there is little information regarding the timing of use of these sites and the habitat characteristics that determine their relative suitability. Because spawning and rearing streams are small, they are often overlooked in research or management plans (Rieman and Apperson 1989). However, small headwater tributaries are particularly sensitive to land use disturbances (Platts and Megahan 1975; Everest et al. 1987).

Numerous studies of the effects of fine sediment in spawning substrate have demonstrated that egg-fry survival in salmonids is negatively correlated to the percentage of fine sediment in spawning gravel (Chapman 1988). Fines may decrease permeability and porosity of gravel, thereby reducing the amount of dissolved oxygen and removal of metabolic wastes, and thus increasing mortality during the incubation period (Chapman 1988). Sedimentation may also cause entombment of fry during the emergence stage (Koski 1966; Phillips et al. 1975; Weaver and Fraley 1991) or premature emergence (Everest et al. 1987).

Newly emerged fry utilize lateral habitats along stream margins and backwater areas with suitable velocities, cover, and food sources (Moore and Gregory 1988). Sedimentation of these habitats may reduce available rearing space, thereby limiting production (Everest et al. 1987). Spatial and temporal variability of sediment infiltration into spawning substrate or rearing habitats may cause survival to vary from year to year, depending on sediment transport regime and runoff events (Lisle and Lewis 1992) and from site to site, depending on land type and land use intensity.

Geological characteristics of a drainage basin are likely to have a strong influence on sedimentation and sensitivity to land use disturbance (Snyder et al. 1978). Much of the knowledge of sediment effects on cutthroat trout is based on research of geological formations of the Idaho batholith. These formations are granitic in nature, producing copious amounts of sand-sized fine particles (Bjornn et al. 1977; Rieman and Apperson 1989). Other dominant geological formations in the range of westslope cutthroat trout include the belt series and soft sediment formations. There have been few studies examining sediment effects on westslope cutthroat trout in these geological types.

The site of this study, the Taylor Fork drainage in the upper Gallatin River basin in southwest Montana, is comprised predominantly of soft sedimentary rock. This material is highly erosive and produces large amounts of fine sediment during runoff events and is very sensitive to land use disturbances (Snyder et al. 1978). Variation in land use intensities in the Taylor Fork basin have resulted in conditions ranging from pristine to highly disturbed. The Taylor Fork also contains one of the last strongholds of westslope cutthroat trout in the Gallatin River basin (Liknes 1984), and thus provides an ideal setting to study sedimentation and land use effects on cutthroat trout spawning and early rearing stages.

Recently, fisheries biologists have shown the importance of defining critical habitat requirements and of evaluating effects of land management over entire drainage basins (Bisson 1985). Previously, most studies have derived habitat use information from representative reaches or sections of streams, and extrapolated these findings to the entire watershed. However, Bisson (1985) illustrated that such an approach can lead to large sources of error when attempting to identify areas of critical habitat or limiting habitat factors for a population. In this study, I characterized critical habitats for spawning and fry-rearing of westslope cutthroat trout at the basin, subbasin and reach scale. The overall working hypothesis was that all three scales are important in defining habitat requirements and sensitivity to land use disturbance.

Specific objectives of the study were to determine:

1) location of spawning redds throughout a drainage.
2) the physical factors accounting for variation in redd densities on a basin, subbasin, and reach scale.

3) the effects of land use on sedimentation of redds.

4) the timing of spawning movements and characteristics of spawners.

5) the distribution and relative production of early fry stages throughout the basin.

STUDY AREA

The Taylor Fork River originates on the east slope of the Madison-Hilgard Range in southwest Gallatin County, Montana, and flows east approximately 27 km before entering the upper Gallatin River (Figure 1). Elevations range from 2804 m at the headwaters to 2012 m at the mouth. The basin encompasses approximately 161 km^2 of sagebrush/grasslands, forested slopes, and steep alpine ridges. Cache, Wapiti, and Lightning creeks are the major third-order tributaries in the basin; the mainstem Taylor Fork is a fourth-order stream. Major fish species include westslope cutthroat trout, rainbow trout <u>Oncorhynchus mykiss</u>, brown trout <u>Salmo trutta</u>, mountain whitefish <u>Prosopium williamsoni</u>, and mottled sculpin <u>Cottus bairdi</u>. Over 300,000 rainbow trout were stocked in the Taylor Fork River from 1928 through the late 1980's (N. Hetrick, Fisheries Biologist, Montana Department of Fish Wildlife and Parks, personal communication) resulting in hybridization with native cutthroat trout. Hybridization has also occurred between westslope cutthroat trout and Yellowstone cutthroat trout <u>Oncorhynchus clarki bouvieri</u> in upper Wapiti Creek (B. May, Gallatin National Forest Fishery Biologist, personal communication). Previous electrophoretic analysis indicate that westslope cutthroat trout in Cache Creek are approximately 87% genetically pure, one of the highest purities remaining in the Gallatin River drainage (Liknes 1984).

The geology of the basin is primarily soft, sedimentary rock (88%) with a small amount of bedrock (12%) (Snyder et al. 1978). The drainage is naturally highly erosive with a high potential for landslides and yields a large amount of fine sediments (Snyder et al. 1978). The combination of unstable geological conditions and high land use disturbance in the Taylor Fork basin have resulted in highly unstable channels and banks (Snyder et al. 1978). Land use disturbance ranges from very low in the upper Wapiti Creek subbasin to moderate to high in the Cache Creek and mainstem Taylor Fork River subbasins. Predominant past and present land uses include logging, livestock grazing, channelization, and splash damming (Snyder et al. 1978). Two grazing allotments (220 cow-calf pairs each) are present along Cache Creek, middle Taylor Fork and middle Wapiti Creeks. Recent clearcuts are present along Cache Creek and the upper Taylor Fork River. The Taylor Fork basin is also a popular recreational area for dude ranching, hunting, and fishing.

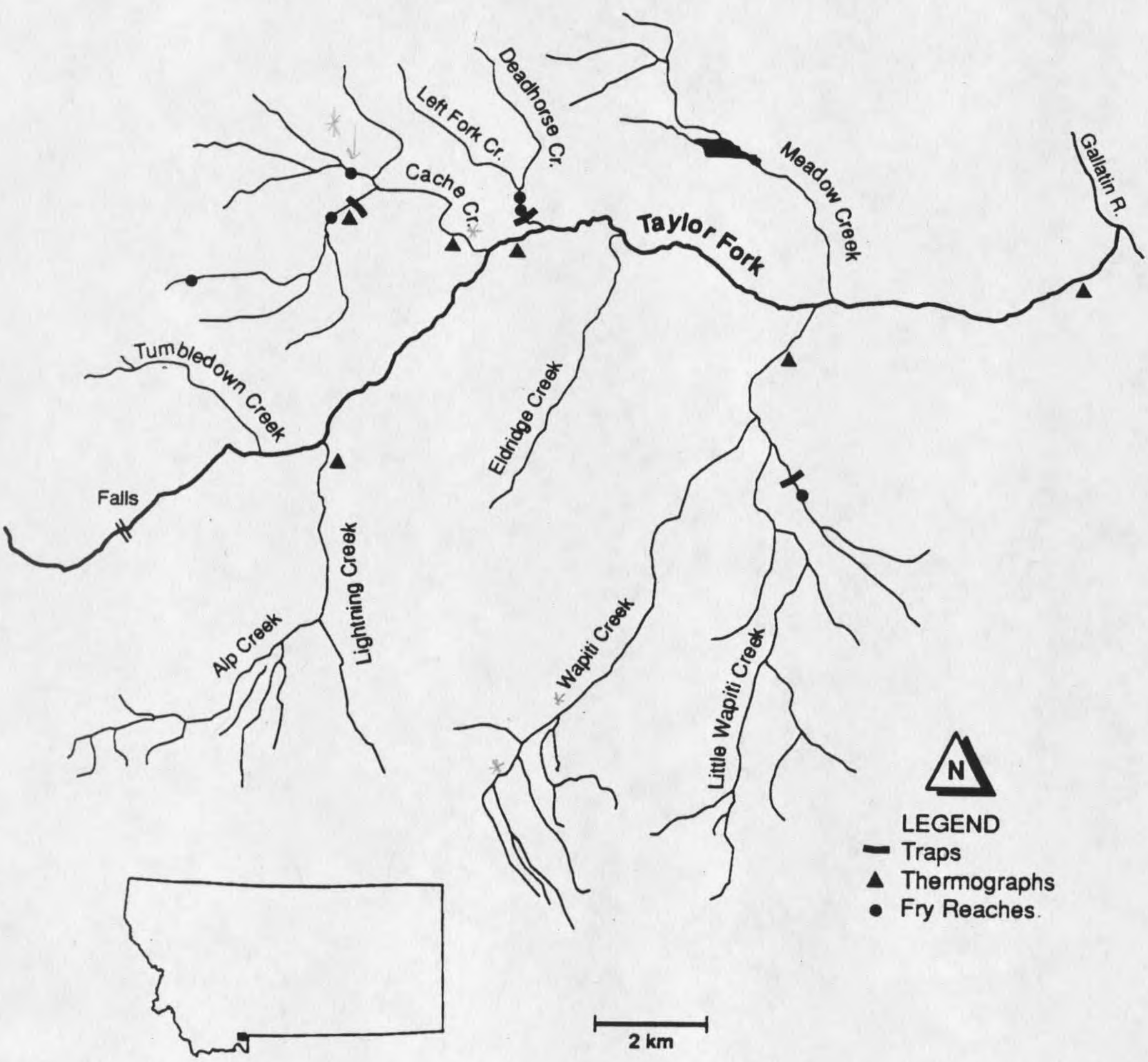

Figure 1. Taylor Fork drainage showing spawning traps, fry reaches, and thermographs locations.

METHODS

Timing of Spawning and Redd Distribution

To determine the timing and magnitude of spawning, and characteristics of spawning westslope cutthroat trout, traps were installed in three headwater tributaries located in the upper, middle and lower parts of the basin (Figure 1). Traps consisted of 1.1 cm plastic mesh fence supported by metal stakes driven into the substrate and anchored with sandbags. Upstream and downstream traps were attached to fences to capture migrants. Fences were installed on 19 May when weather, road, and runoff conditions permitted. Fences were dissembled on 19 June, 1992, as daily catch rate declined and it appeared most migration had occurred. Traps were checked twice daily, weather permitting. All fish captured were anesthetized with MS222, weighed, measured (fork length (FL)), and marked with an adipose fin clip. Fish were tagged with individually numbered visible implant tags in the adipose tissue behind the left eye. Sex and spawning condition were determined by the presence of milt or eggs. Duration of spawning and weight loss were calculated from spawners tagged in the upstream trap and recaptured in the downstream trap. An adipose fin clip was used to identify tag loss on recaptured fish. Species were classified as westslope cutthroat trout, rainbow trout, or hybrids. Hybrids were identified as fish with a spotting pattern similar to rainbow trout but also had characteristic orange slashes on the lower jaw (Holton 1990).

To determine potential spawning sites, I surveyed most of the watershed in 1991 for the presence of spawning substrate (0.2-3.5 cm) or newly emerged fry. Suitable areas were included in more detailed redd counts in 1992. I divided potential spawning areas into 18 reaches according to gradient, topography, stream order, tributary junctions, or road crossings (Cache Creek reaches are referred to as CC and Wapiti Creek as WC) (Figure 8). In 1992, redd counts were made in each reach every 3-4 days from 25 May to 19 June. Salmonid redds consist of a depression or pit in the upstream portion of the redd and mound of substrate or tailspill downstream, which contain the centrums or egg pockets (Chapman 1988; Young et al. 1989; Grost et al. 1991). In previous studies, salmonid redds have been counted by identifying clean gravel sites with the pit-tailspill configuration (Grost et al. 1991). In the Taylor Fork, redds were counted only by the presence of spawning fish as substrate disturbance was relatively minimal and could not be used as a reliable indicator of redd building. Probable redd locations were marked with numbered wooden stakes and maps were drawn for each redd. Spawning activity at a particular redd was noted during subsequent surveys to determine if multiple redds were constructed at each site.

Temperature and water levels were measured to determine potential effects of these factors on the timing of spawning. Hourly temperatures were recorded from thermographs placed in the upper and lower Taylor Fork, Wapiti Creek, Lightning Creek, and upper and lower Cache Creek (Figure 1). Stream water level was measured on the mainstem Taylor Fork, Deadhorse Creek, Wapiti Creek, and Cache Creek. Missing measurements in Cache Creek were supplemented through use of a regression between Deadhorse Creek and Cache Creek water levels (Appendix 1).

Substrate Composition of Redds

To determine substrate composition of redds, McNeil core samples were taken from 21 redds in Cache Creek and 15 redds in Wapiti Creek following the techniques of Shepard and Graham (1983). Core samples were taken from 23 July - 6 August 1992 to represent conditions in the redd at the time of emergence (emerging fry were first observed on 22 July). Cores were taken in the front third of the tailspill to a depth of 10 cm based on the depth of egg pockets from previous sampling of westslope cutthroat trout redds (B. May, Fisheries Biologist, Gallatin National Forest, personal communication). Redd maps were used to position core samples near egg pockets. Egg pockets were verified by the presence of eggs in the core sampler or by digging in the substrate to expose eggs in areas adjacent to core samples.

Core samples were dried and passed through a series of sieves of sizes: 50.8, 25.4, 12.4, 9.5, 6.3, 2.36, 0.85, and 0.074 mm. Volume of fines <0.074 mm which remained in suspension in the corer were sampled via an Imhoff Cone (Shepard and Graham 1983). Conversion of volume to dry weight was calculated using a gravel density of 2.2 g/cm^3, the estimated density of the sediment type present in the Taylor Fork drainage (S.Custer, Hydrologist, Montana State University, personal communication). The fredle index (Lotspeich and Everest 1981) and percentage of fine sediment <6.35, 2.36, and 0.85 mm in diameter were calculated for each core sample. The fredle index is a quality index used as an indicator of sediment permeability and pore size to characterize the suitability of substrate for incubation and emergence (Platts et al. 1983). The percentage of fine sediment <6.35, 2.36, and 0.85 mm in diameter were used because of their inverse relationship with the survival of salmonid fry (Everest et al. 1987; Chapman 1988) and to compare with other salmonid studies in the Rocky Mountain region.

To determine how well the more labor-intensive core sampling techniques compared to less labor-intensive measurements of fine sediments, I related the percentage of fine sediment <2.36 mm from McNeil core samples to percent surface fines <2.0 mm as determined via Wolman pebble counts (Wolman 1954) and via percent surface fine grid (Kramer and Swanson 1990). Wolman pebble counts consisted of categorizing substrate particles by size via the Wentworth scale (Table 1) for 50 points taken across the redd. Points were measured at 5 cm intervals along transects across the redd. The surface fines measurements were calculated by counting the number of intersections with substrate < 2.0 mm on a 7x7 grid drawn on a clear plexiglass sheet. The percent surface fines for each redd was calculated as the average of the ratio of intersections with fines (< 2.0 mm) to the total number intersections (49) for five random grid tosses on each redd.

A Mann-Whitney, two-sample analysis was used to test for the differences in substrate composition of core samples containing egg pockets with those without egg pockets. Substrate composition of redds in subbasins of high (Cache Creek) and low (Wapiti Creek) land use disturbance were also tested with a Mann-Whitney, two-sample analysis.

A one-way analysis (ANOVA) and a Fisher's Least Significant Difference (LSD) multiple range test was used to compare substrate composition between reaches. A significance level of $P \leq 0.05$ was used for all tests. Regression analysis was used to compare percentage of fines obtained from McNeil Core samples with that obtained from Wolman pebble counts and from the surface fines grid.

Table 1. Wentworth system used to classify substrate size classes (Welch 1948).

Substrate Class	Particle Diameter (mm)
Sand/Silt	<2.0
Peagravel	2-6
Gravel	6-7.5
Rubble	7.5-15
Cobble	15-30
Boulder	>30
Bedrock	

Spawning Habitat Characteristics

To describe factors that may account for variation in redd densities, habitat surveys were conducted in Deadhorse Creek and the Cache and Wapiti Creek subbasins. Surveys were completed in 11 of the 18 spawning reaches before freeze-over in mid-October. Characteristics of spawning habitat were determined using the INT/R1/R4 Standard Watershed Inventory System developed by USDA Forest Service Intermountain Research Station, Boise, Idaho. Length, wetted width, maximum depth, habitat type (Bisson et al. 1982) and potential spawning substrate were determined for each consecutive channel unit (pool, riffle, glide) moving upstream. Potential spawning substrate was estimated as the percent surface area having substrate sizes similar to those seen in redds (0.2 - 3.5 cm).

Additional measurements of dominant and subdominant substrate, bankfull width, average depth, bank stability, embeddedness, and riparian composition were determined at every tenth channel unit. Bank stability (Table 2) and embeddedness (Table 3) were estimated using the visual rating systems developed by Platts et al. (1983). Riparian composition was determined as the percentage of each bank consisting of bare soil, grass, shrubs or trees.

Table 2. Streambank stability rating based on percentage of protected streambank from Platts et al. (1983).

Rating	Percent	Description
4 (Excellent)	75-100	>75% of the streambank surfaces are covered by vigorous vegetation or by boulders and rubble. If not covered by vegetation the streambank is protected by materials that do not allow bank erosion.
3 (Good)	50-75	50-75% of the streambank surfaces are covered by vegetation or by gravel or larger materials. Those areas not covered by vegetation are protected by materials that allow only minor erosion.
2 (Fair)	24-49	25-49% of streambank surfaces are covered by vegetation or by gravel or larger materials. Those areas not covered by vegetation are covered by materials that give limited protection.
1 (Poor)	0-24	<25% of the streambank surfaces are covered by vegetation or larger materials. That area not covered by vegetation provides little or no control over erosion and banks are usually eroded each year by high water flows.

Table 3. Substrate embeddedness rating based on the percentage of substrate particles covered by fine sediment from Platts et al. (1983).

Rating	Description
5	Gravel, rubble, and boulder particles have <5% of their surfaces covered by fine sediment.
4	Gravel, rubble, and boulder particles have 5-25% of their surfaces covered by fine sediment.
3	Gravel, rubble, and boulder particles have 25-50% of their surfaces covered by fine sediment.
2	Gravel, rubble, and boulder particles have 50-75% of their surfaces covered by fine sediment.
1	Gravel, rubble, and boulder particles have >75% of their surfaces covered by fine sediment.

Substrate composition was measured via Wolman pebble counts and the surface fines grid technique on pool tailouts and riffles. Wolman pebble counts were based on 100 points (50 points in streams <1 m width). Wolman points were taken at equal distances (5 cm intervals in streams < 1 m width, and 10 cm intervals in streams > 1 m width) along a transect from bank to bank across the stream . Percent surface fines were based on 5 random grid tosses in small streams (<1.0 m width) and 10 grid tosses in larger streams (>1.0 m width).

A non-parametric Spearman rank correlation analysis was used to test for associations between redd density and specific habitat features. A Mann-Whitney two sample analysis was used to test for differences in habitat variables between high (>3 redds/100 m) and low (<3 redds/100 m) redd densities.

Fry Distribution and Production

Visual counts of fry in various sections of the basin were used to identify important fry rearing areas. Preliminary surveys of fry locations were conducted throughout the basin in 1991. In 1992, weekly fry counts began 1 week after the first observed fry, and were conducted from 1 August - 1 October in six reaches located in various parts of the basin (Figure 1). An observer crawled along the one bank and counted fry for each 6 m segment of a reach following the methods of Bozek and Rahel (1991). After each segment was surveyed, the observer waited 90 seconds to allow fry to recover from disturbance before beginning the next segment count. Visual counts were compared with two-pass electrofishing depletion population estimates (Everhart and Youngs 1981) on 10 occasions at four different reach sites to estimate accuracy of visual counts. Regression analysis was used to compare visual counts with two-pass electrofishing depletion estimates.

Habitat features measured during detailed spawning habitat surveys (see previous section) were used to identify variables that could account for differences in fry densities.

Fry counts were standardized as densities per m^2 based on the highest number of fry counted. Regression analysis was used to compare fry densities with redd densities. A Mann-Whitney two sample analysis was used to test for differences in habitat variables between high (>0.15 fry/100 m) and low fry density reaches (<0.15fry/100m).

I compared changes in mean lengths of fry over time to determine relative growth rates of fry in different reaches. Fry were captured in a small hand net during visual surveys and electrofishing removals, and lengths were measured to the nearest millimeter.

I estimated dates of peak hatching and peak emergence to describe temporal differences in fry incubation rates between sites and to compare incubation times in the Taylor Fork with other cutthroat trout studies. Incubation time in centigrade temperature units (CTU's) was determined for peak emergence as the time of peak spawning (from redd surveys) to the time of emergence (visual observation of newly emerged free swimming fry) in reach CCB. Time of peak hatching (from egg to alevin stage) was calculated using 310 CTU's from peak spawning (Rieman and Apperson 1989). A CTU is defined as the sum of the mean daily temperatures over 0°C (Rieman and Apperson 1989).

Fry production for 10 reaches was estimated by the following equation:

$$F = R \times E \times STE$$

where F = fry production per reach, R = number of redds per reach, E = egg deposition per female, STE = survival to emergence. Egg deposition was calculated from a westslope cutthroat trout fecundity-length relationship equation ($E = 3 \times 10^{-4} \times L^{2.57}$), ($R^2 = 0.88$), (Rieman and Apperson 1989). The following equation was used to estimate egg deposition per reach: E_r= redds/reach x percent size class of the total catch x mean fecundity of the size class. A length-frequency distribution for females captured in the Cache Creek trap was used to estimate the percentage of total spawners within 25 mm size classes. Fecundity was estimated for each size class from the average fecundity of all fish within the class.

Survival to emergence was estimated based on the average substrate composition of redds in a given reach (average percent fines <6.35 mm from core samples) and the relationship between substrate composition and STE for westslope cutthroat trout as determined by Weaver and Fraley (1991) (STE = -0.654812 (% fines <6.35 mm) + 35.6749).

RESULTS

Spawning Migration and Timing

There were large differences in the numbers of spawning fish caught in the three traps. A total of 579 fish were captured in Cache Creek, compared to only 18 in Deadhorse Creek, and 10 in Little Wapiti Creek (Table 4). Because spawning movements appear to have initiated prior to trap installation and some migrants may have avoided capture, trap catch represents a subsample of the total number of spawners.

Fish size, sex ratio, and species composition also differed between sites (Table 4). Migrating females as small as 159 mm were sexually mature. Historical length-frequency data from the Taylor Fork basin indicate that a 150-mm fish is approximately 3 years old (N. Hetrick, Fisheries Biologist, Montana Department of Fish, Wildlife, and Parks, personal communication). Thus, I considered 3-year-old fish as the earliest age of spawners. Of the potential spawners in Cache Creek, females averaged 191 mm, slightly larger than the average size for males (189 mm) (Figure 2). We found an abundance (34 % of the total trap catch) of small males <200 mm, and few (5% of the total trap catch) large fish >250 mm, of either sex.

Sex could be identified for 438 fish, with 282 males and 156 females (1.8:1 ratio). Sex could not be identified in 141 of the potential spawners caught in the trap, which may account for a higher sex ratio in Cache Creek than either Deadhorse (1.2:1) or Wapiti Creeks (1:1). I did not test for differences of sex ratios between tributaries due to small sample sizes in Deadhorse and Wapiti Creeks and the large number of unidentified fish in Cache Creek. There were also 259 fish <150 mm captured in the Cache Creek trap in which sex could not be identified.

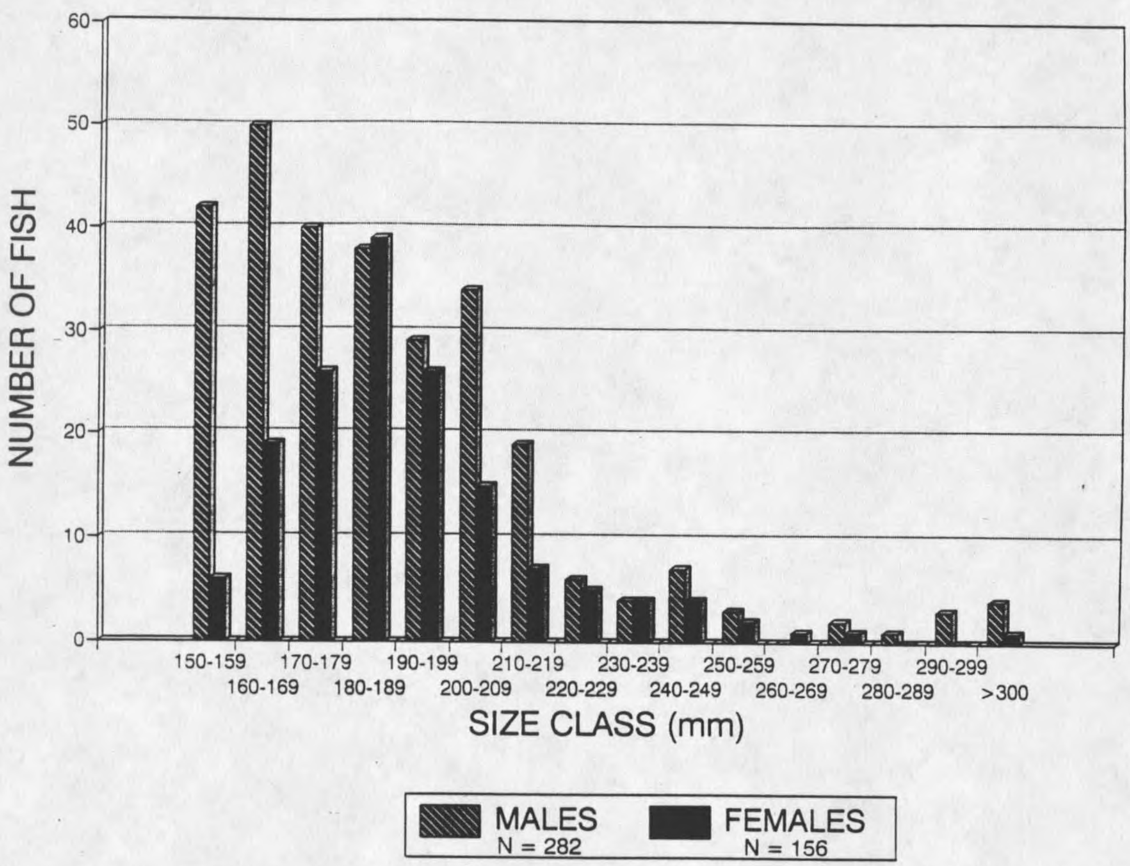

Figure 2. Length-frequency distribution for all fish >150 mm caught in the Cache Creek trap.

Table 4. Characteristics of trap catch for Cache, Deadhorse and Little Wapiti Creeks for potential spawning fish >150 mm. (STD = standard deviation.)

TRAP	CACHE	DEADHORSE	WAPITI
TOTAL CATCH:	579	18	10
MEAN LENGTH: (mm)			
MALES (STD)	189 (39)	185 (15)	262 (71)
FEMALES (STD)	191 (30)	252 (32)	297 (29)
MALES	282	6	5
FEMALES	156	5	5
UNKNOWN	141	7	0
SEX RATIO	1.8:1	1.2:1	1:1
SPECIES COMPOSITION (%)			
WSCTT (%)[a]	99.6	72.0	0.0
RBT (%)[b]	0.4	6.0	70.0
HYBRIDS (%)	0.0	22.0	30.0
RECAPTURES			
MALES	96	1	0
FEMALES	74	0	1
SPAWNING DURATION (DAYS)			
MALES (RANGE)	9.21 (0-26)	14	-
FEMALES (RANGE)	11.36 (0-30)	-	18
WEIGHT LOSS (g)			
MALES (STD)	4.88 (9.74)	4.0	-
FEMALES (STD)	10.29 (8.14)	-	46.0

[a] WSCTT (westslope cutthroat trout)
[b] RBT (rainbow trout)

Species composition differed between tributaries and was affected by elevation. Cache Creek had the highest elevation and also was comprised mostly of westslope cutthroat trout (99.6%). Species composition in Deadhorse Creek was also dominated by cutthroat trout (72%), but westslope cutthroat x rainbow trout hybrids comprised most of the remaining spawners. By contrast, in the lowest elevation tributary of Little Wapiti Creek, spawning fish were comprised primarily of rainbow trout (70%), with the remainder (30%) cutthroat x rainbow trout hybrids. The predominance of rainbow trout in Little Wapiti Creek may account for the greater size of spawners than in either the Cache or Deadhorse traps (Table 4).

The timing of upstream migration was similar for all three streams; however, downstream migration showed more variation (Figure 3). In Cache Creek, 79% of the upstream migration occurred between 19 May and 4 June. Most downstream movement occurred between 1 June and 17 June. The pattern of upstream spawning movement suggests that some upstream migration had occurred prior to trap installation.

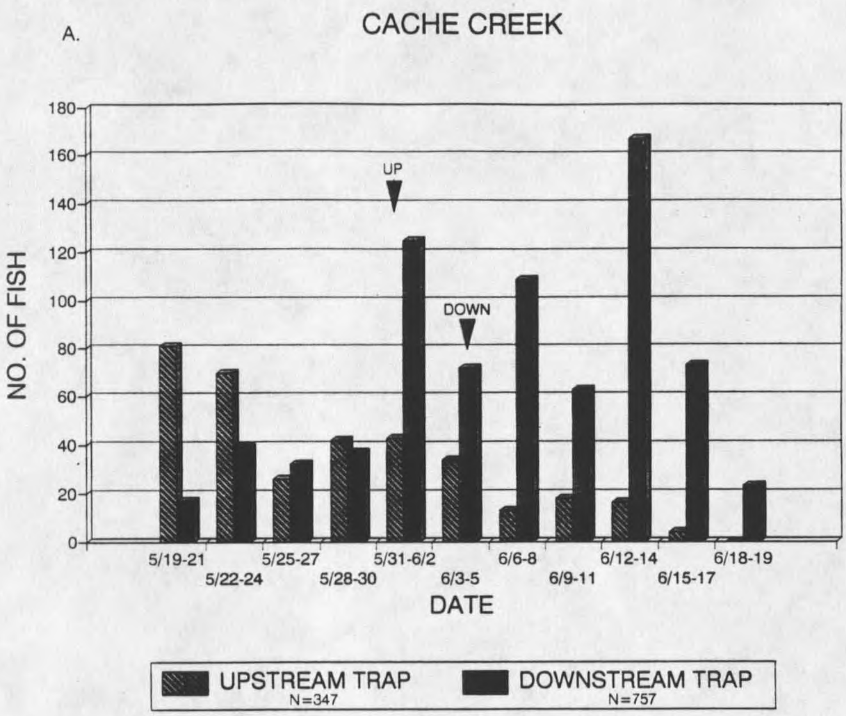

Figure 3. Upstream and downstream trap catch for spawners in Cache Creek (A), Deadhorse Creek (B) and Little Wapiti Creek (C). Arrow indicates median dates for upstream and downstream migration.