Draft Final Report
Scott River Summer Habitat Utilization Study

Report prepared by Erich Yokel, Siskiyou RCD

Funding provided by the United States Fish and Wildlife Service

Jobs-in-the-Woods Project 2004 – JITW – 01

Agreement #113334J023

May, 2006

Table of contents

Abstract

Direct observation surveys were performed throughout the Scott Valley and tributaries in the low flow period of 2005, to observe the distribution and density of the strong cohort of rearing juvenile coho salmon. We wished to use the large population of juvenile coho to indicate areas and types of suitable and preferred habitat and microhabitat. Identification and characterization of over-summer juvenile coho habitat will allow for the directed protection, enhancement, and restoration of essential habitat features utilized by this indicator species.

A sub-sample of representative reaches and habitat types were surveyed for fish presence and density. Divergent juvenile coho densities were observed in the different reaches, habitat types, and microhabitats. It is hypothesized that a "suite" of physical habitat features determines the suitability of the waters in each habitat type. Physical parameters that control the stream's geomorphology (e.g. gradient) or quality (e.g. temperature) differentiated the surveyed reaches, and are hypothesized to largely control the occurrence of suitable habitat. This hypothesis is supported by reaches with similar "channel types" exhibiting, relatively, similar densities of juvenile coho utilization.

Local stream features (microhabitats) were additionally found to affect juvenile coho distributions. The occurrence of elements offering fish cover (e.g. coarse woody debris) often creates local densities of juvenile coho greater than those observed in adjacent areas without cover. Additionally, cold patches of water within a reach of thermally intolerable ambient waters allow for juvenile rearing in reaches that are otherwise inhospitable. Extensive documentation to qualitatively characterize the stream features that created preferred microhabitats was performed. Enhancement and introduction of these desired habitat elements is a feasible short-term restoration approach to potentially create more volume of desired habitat in the stream. Restoration that creates a larger volume of suitable habitat should increase the summer carrying capacity and generate a biological response of an increase in population and/or fish condition.

Introduction

The Scott River Watershed Council (SRWC) has been developing a Limiting Factor Analysis (LFA) for anadromous fisheries in the Scott River basin. Initial efforts centered on the coho salmon (*O. kisutch*) due to its status (state and federal ESA listing) and its unique habitat requirements. Future work will address steelhead and Chinook populations as well. The LFA process identified existing data and essential data gaps to our understanding of the population, distribution, and condition of coho salmon in the Scott River.

It was found that historic on the ground studies of coho distribution and population in the Scott River were scarce. French Creek juvenile data (Maria, 2005) and adult coho surveys (Quigley, 2005) identified that two out of the three brood years of coho salmon in the Scott River are close to extirpation. The third brood year is relatively strong. The primary goal of the SRWC is to protect the existing population while moving to enhance and recover the depleted fishery. A full understanding of the distribution and habitat requirements of the existing fishery will promote protection and restoration that is based on observed fish's requirements and preferences.

A series of studies to identify juvenile fish distribution and habitat utilization were promoted for all life stages of Scott River residence. These studies would compliment the existing data set of adult spawning distribution and potentially identify periods that are limiting coho production. Additionally, these studies would allow for the observation and description of actual habitats being utilized by juvenile coho salmon in the Scott River. The studies were developed for 2005 – 2006 because of the expected (and received) large amount of adult coho spawners in the winter of 2004 – 2005. This large brood year of juveniles insures that usable habitats will be seeded with fish allowing for the identification of occupied and preferred habitats. The direct observation of coho juvenile densities in the Summer of 2005 was identified as an essential and feasible study.

Background

Siskiyou RCD – SRWC

The Scott River Watershed Council, made up of interested community members and agency personnel, who serve in an advisory capacity, has met monthly since 1992 to help manage Scott River natural resources. The Siskiyou Resource Conservation District (SRCD) is the management and implementing partner of the Council. The Council and RCD have planned, funded, and implemented over $3 million worth of restoration projects since 1994.

The Siskiyou RCD and the SRWC's primary interest lie in private land. The RCD gathers access from private landowners and coordinates restoration on the watershed scale.

Scott River Basin – physical and land use.

The Scott River is a major tributary of the Klamath River of Northern California/ Oregon, below Iron Gate Dam. The Scott River watershed covers an area of 819 square miles.

Land ownership is 55% private and 45% public. To be effective, any management efforts or improvements of the watershed must be done with the active help and participation of a large number of individual owners whose needs, desires, and financial conditions vary greatly. Most of these landowners have long-standing cultural practices, many of which depend on the river, including irrigation of pasture and hay fields, stock water, and grazing of riparian areas. The US Forest Service is also an important partner, as the agency manages 42% of the lands in the watershed. Land use is primarily small timber and agriculture, public timber, and small residential.

Adult coho surveys.

Survey reaches for this effort were selected based on data from the winter adult spawning coho surveys of 2004/2005. These survey efforts documented the distribution of spawning throughout the Scott watershed (Quigley, 2005). A large amount of the observed spawning occurred in the streams in the private lands of the Scott Valley. The Siskiyou RCD's ability to gain access to a representative selection of reaches in the Scott Valley allowed for the execution of this study.

All surveys completed by the Siskiyou RCD for this study were conducted on private land. There are several reasons for this: 1) Grant funds utilized for this purpose were limited to use on private lands. 2) The majority of coho spawning (>90%) occurred on private lands. In addition, the United States Forest Service (USFS) performed work within federally managed tributaries in concurrence with this study.

Scott River coho habitat requirements.

Scott River coho exist at the in-land southern edge of the current coho population of the Pacific Northwest. There is the possibility these fish might show some adaptation to this environment. The majority of published literature related to juvenile coho habitat requirements was completed in the coastal systems of Oregon and Washington and the much farther northern regions in British Columbia and Alaska. We would like to verify that the coho of the Scott River have the same habitat requirements as those cited in the scientific literature.

Unlike Chinook, which mostly emigrate from freshwater during the first summer of residence, coho salmon require one year of freshwater residence before smoltification and ocean entry. This necessitates the occurrence of suitable freshwater habitat in all seasons (summer to winter).

The characteristics of the low flow summer fish habitat have been relatively well monitored in the Scott River for several years (temperature (since 1995), flow (since 2002), habitat typing (2003-2005)). The low flow and high temperature period (peak August 1 – approximately September 15) physically limits the volume of habitat available to rear the fishery. Juvenile populations in excess of the habitat's carrying capacity will be lost to predation and other mortality. Several documented environmental conditions: intolerably high temperature in most of main-stem Scott River and East Fork Scott River, and areas of dewatering and fish stranding in alluvial sections of many of the Scott Valley tributaries, limit stream reaches from being suitable summer rearing habitat. Documentation of the actual distribution of successfully rearing coho could both corroborate these earlier observations and document areas where “micro-habitats” offered rearing (refuge) in an otherwise inhospitable environment.

Juvenile coho temperature preferences

Two methods of analyzing temperature data exist in relation to evaluating temperature suitability for coho salmon rearing and growth; 1) Maximum weekly average temperature (MWAT) is calculated to show chronic effect on fish condition, and 2) the periodic maximum temperatures documents areas that are inhospitable to cold water fish during some period of the day.

Laboratory research shows coho salmon growth occurs below an MWAT of 18° and that MWAT’s above 19.0°C will reduce growth 20%. (Sullivan, et al.) Additional research shows that acute temperatures ranging from 21.0°C to 25.5°C are lethal to salmonids.

Ambient mainstem temperatures in all of the Mainstem Scott River (Valley and canyon) have been documented as above the desirable range for juvenile salmon rearing during the low flow warm water period. (Late July to Mid/Late September). (Appendix A). MWAT’s show that the ambient temperature is normally greater than 20°C throughout most of Scott River’s mainstem in the Valley Reach. Mainstem Scott River in the tailings has an approx. MWAT = 20°C and Scott River at Highway 3 fluctuating from MWAT of 20 – 24° C.

Restoration Efforts in the Scott River Basin

Local landowners, through their cooperative efforts with the RCD and SRWC, have shown a desire to do habitat restoration for mitigation and recovery. The SRWC has long identified the need to develop and generate restoration enhancement projects that are effective, that is, projects which create a positive biological response (increase in condition and/or population). By observing the characteristics of habitats that were utilized (and were not) by coho salmon we can find features that successfully rear coho. Effective descriptions of desired habitats can be used as the core principle and desired end result of any in-stream and riparian restoration design. The goal is to introduce more of these features into future restoration projects in the Scott River.

Project Objectives:

1) Determine actual physical habitats being used for summer rearing by coho salmon and other anadromous species in the Scott River.
2) Determine relative density of habitat utilization for habitats in tributaries and mainstem Scott River.
3) Use existing habitat typing data and habitat utilization coefficients to determine summer carrying capacity of Scott River.

4) Identify essential summer rearing habitats for protection, enhancement, and restoration.
5) Use information gathered from surveys to direct management and develop plans for restoration projects that address key summer habitat parameters.

Location:

Reaches were chosen to be representative of the suspected available habitats in the Scott Valley. The different stream characteristics we wanted to survey included: mountainous vs. alluvial channel type, Mainstem and tributaries, thermally tolerable and intolerable, differing densities of adult spawning, different stream types –as characterized by riparian, substrate, grade, etc.

Reaches surveyed:

Middle East Fork (Lower Masterson Road)

Upper South Fork
Middle South Fork

Upper Sugar Cr.
Middle Sugar Cr.
Lower Sugar Cr.

Mainstem Scott River – Tailings
Mainstem Scott River – above French

Middle-French
Upper-French

Middle Etna Cr
Middle Patterson
Middle Kidder

Upper Mill Cr.
Lower Mill Cr.
Shackleford – Mill Cr.

Methods

Initially, the study design was heavily based on Hankin and Reeves' (1988) methodology of determining a basin's juvenile population using calibrated direct observation. Selected stream reaches were surveyed to determine individual habitat units and types. A random sub-sample of each habitat type was selected for a direct observation survey. Replicate "dives" were performed to determine the fish population and distribution in each selected unit. Habitat area and volume were measured and salient habitat features / characteristics were documented. Attempts to calibrate dives with electro-fishing depletion techniques were performed on selected units/reaches of Sugar, French, and Patterson Creek.

Meso - habitat typing

CDFG protocol was utilized to designate individual meso-habitat units in the designated reaches. Reaches are broken into individual habitat units based on characteristics including: grade, water velocity, water depth, channel structure and hydrology. Habitat units can be "typed" at several levels of differentiation (Diagram 1). For this study Level IV habitat typing was completed to capture as much characterization as possible. Along with characterizing the physical channel structure, habitat typing quantifies the availability and amount of fish "cover" elements present and the condition of the riparian corridor. Fish cover elements include: small and large woody debris, root wads, undercut banks, over water terrestrial vegetation and aquatic vegetation, bubble curtain, and substrate cover. An analysis of available habitats and their complexity allows for inferences about stream health and fish rearing conditions.

Selected reaches that had not been habitat typed in prior years (South Fork and Patterson Cr.) were habitat typed previous to the dives. All other reaches were habitat typed in 2003 & 2004. This data was consulted to help designate the dive units chosen.

Microhabitat identification

Meso-habitats can contain a variety of micro-habitats that can not be fully captured with the Level IV habitat typing protocol: for example, a riffle containing a deeper low velocity pocket along a margin. The presence of suitable microhabitats can allow rearing in meso-habitats that generally are not considered habitable for juvenile coho salmon. The utilization of thermal refugia in an otherwise thermally inhospitable reach demonstrates the importance of microhabitats and their identification.

Microhabitats are identified through a detailed analysis of the physical characteristics of the habitat, combined with the observation of fish utilization. Some microhabitats were individually characterized (measured and described) to capture both their physical characteristics and their unique fish densities.

Habitat description of surveyed units

Each dived unit was measured in feet: length, width, average depth, and maximum depth. The physical habitat characteristics were described in a written description for most dived units. Almost all dive units were photographed. Microhabitats and habitats with fish utilization were extensively noted and described.

Dive selection

Random sampling of a sub-sample of similar habitats allows for the characterization of a reach in a feasible amount of time and effort. It was an initial goal of the project to develop "Habitat Utilization Coefficients" for representative habitat types throughout the Scott River in the summer of 2005 (Nickelson, 1992). We hoped that these coefficients could be utilized along with habitat typing data to develop a summer carrying capacity for the Scott River.

Particular attention was paid to insure that all representative habitat types encountered were surveyed and that a random and representative proportion of each habitat type in each reach was surveyed.

All habitat types were surveyed the first time they were encountered. The majority of the surveyed stream's habitat types are alternating riffles and flatwater (runs and glides) with (relatively infrequent) interspersed pools. A percentage of common units – riffle and runs – were randomly chosen for dives, while all pools in reaches were dove. If possible, we dove three individual units representing each habitat type per reach. Often, many habitat types were not represented or only represented by a single unit.

For habitat units that were prohibitively long, a representative proportion (e.g. ½ or 1/3) was selected and surveyed.

Survey for upper extent

Attempts to determine upper extent of juvenile coho salmon utilization were performed on Etna Cr., French Cr, Sugar Cr., Patterson Creek, and South Fork Scott River. During this effort only pools and or deep runs were surveyed for coho presence. Populations were recorded and habitat areas measured. Rigorous protocol was followed on South Fork Scott River, and ten pools were dove after the last coho was observed. This was possibly due to the high pool occurrence in this section of the South Fork. Due to time and access restraints on some of the other tributaries surveyed, we were not able to pinpoint the end of coho utilization as precisely as on the South Fork.

Direct Observation Surveys

Each selected unit was surveyed for anadromous salmonid population and habitat utilization position using direct observation (snorkel dives). Effective snorkel dive surveys allow for a decent and time effective estimate of the resident juvenile population without trapping and handling the fish. Additionally, snorkel surveys allow for the observation of juveniles in natural position, allowing for the documentation of habitats and microhabitats that are being utilized by the fishery.

Direct observation surveys also have their limitations and difficulties:

1) Potential difficulty of species identification of mixed anadromous salmonids in high density.
2) Accurately counting large populations (300+) that are utilizing a small or complex habitat.
3) Accurately counting populations with less habitat fidelity in large habitats (e.g. large pools).
4) Individual surveyors error or bias.
5) Inability to get fish in hand to measure condition factor.

Effective training and survey protocol were utilized to minimize the limitations and reduce the error of direct observation population estimates. All crewmembers had extensive fish identification experience from previous experience operating out-migrant traps. Replicate dives were performed to remove the error of individual dives and divers. Individual divers are ignorant of other diver's counts and units with divergent counts were replicated three or even four times. Areas of high density and micro-habitats with unique densities were often scrutinized and counted individually. These efforts to continuously calibrate and increase diver accuracy throughout the project allow for the best possible results.

Differing diving techniques (one diver vs. two divers) were utilized to determine the best technique for different size and complexity habitats. A single diver performed the survey in smaller habitats. Larger and wider habitats (especially large pools) usually necessitated two divers surveying simultaneously in lanes (river left and river right) to observe all fish. It was quickly found that the two-diver survey technique could decrease accuracy due to a higher probability of double counting fish that were either placed between divers or moved between divers. Communication between divers about the definition of each divers "lane" and groups of fish that each diver is counting reduces this potential for double counting. Single diver surveys were performed on some units that were surveyed with two divers to compare the efficacy of both methods. Single diver surveys were preferred whenever possible, in order to eliminate between diver double counting.

Dive protocol

Habitat units were approached from the downstream boundary and not disturbed (walked through) before the survey to insure fish were occupying their natural position. Surveyors in a neoprene wet suit and mask and snorkel entered the water of each habitat unit from the downstream boundary. Surveyors then slowly crawled or swam through the unit identifying and counting fish by species. Effort was expended to survey all areas of wetted channel for fish presence. Areas that had elements of fish cover were approached cautiously to insure observation of fish in the normal (not hiding) position. Additionally, effort was maintained to not disturb, disrupt or destroy any of the physical features (e.g. small woody debris mass) that were offering fish cover in the surveyed units during the surveys.

Each individual dive's count by species was recorded. Dives that had large numbers of fish or fish utilizing individual microhabitats necessitated recording fish numbers by individual "groups". A short period of time (5 – 10 minutes) was allowed to pass between dives to allow fish to return to position and for turbidity to return to normal. Areas with higher fine sediment required a longer interval between dives for environmental conditions (turbidity) to return to normal. Replicate dives were performed until the most accurate count possible was collected.

Photography

A Nikon Coolpix 4600 with underwater case was used to take digital pictures throughout the survey. Above water pictures of surveyed habitat units, microhabitats, and fish cover were extensively recorded. Underwater photography was utilized to document the actual habitats that the fish is using. Additionally, small amounts of video footage were recorded in attempts to document fish behavior.

Electro-fishing calibration

Hankin and Reeves (1989) utilizes electro-fishing to collect the "true" population of a sub-sample of the reaches that were surveyed using the direct observation technique. This "true" number is then used to calibrate the direct observation survey's estimated population densities. The calibrated dive data can then be expanded to develop a basin population estimate.

Sampling utilizing electro-fishing has the potential of getting a more accurate population estimate through the utilization of multiple pass depletion techniques. Electro-fishing allows for the measurement of fish condition (weight and length). Conversely, electro-fishing is much more time and personnel intensive compared to direct observation and is potentially stressful to the fishery. Inaccurate or ineffectual electro-fishing efforts could generate poor population estimates. These poor estimates would then poorly calibrate direct observation data.

Electro-fishing was performed as a cooperative effort with CDFG biologists owning and operating the electro-fishers. Efforts to calibrate direct observation with electro-fish population estimates were performed on Patterson Cr., Sugar Cr., and French Cr. Several individual units on Patterson Cr. (2-3), and Sugar Cr. (3), were electro-fished. A random sub-sampled of dived units were sampled on French Cr., allowing us to approach Hankin and Reeves methodology.

Data Analysis:

Dive data (population numbers and habitat volume) was entered into Excel spread sheets. Estimated populations were calculated by averaging the counts from replicate dives. Occasionally, a replicate dive count was discarded when there was evidence that the count was inaccurate, usually noted in field, and there existed two other more accurate dives. The density (fish per surface area and fish per volume) was calculated for each individual habitat unit. Average fish densities and standard deviations for habitat types that had multiple occurrences of survey data per reach were calculated. These densities are the habitat utilization coefficients (Nickelson, 1992) that were observed in the low flow period of 2005.

All notes regarding habitat characteristics and fish distribution were entered in the Excel spread sheet with the density data. This allows the habitat data to be connected with density data.

Pictures:

A representative sample of habitat photographs and underwater photographs were labeled and organized to offer a visual record of habitat condition and fish densities during the period of the survey.

Conclusion:

Direct observation surveys were performed in a representative sub-sample of reaches and habitat types throughout the Scott Valley and tributaries. Two main goals were pursued: 1) determination of fish densities in different habitat types and reaches and 2) documentation of preferred physical habitat features utilized by coho salmon. Additionally, these surveys allowed for the documentation of stream and habitat condition and fish behavior within the water column. A large body of quantitative (fish densities) and qualitative (habitat condition and fish behavior) data was collected throughout these surveys.

Reaches surveyed:

The mainstem Scott River and eight tributaries were surveyed in the Scott Valley. Due to differences in stream geomorphology within the surveyed tributaries and mainstem, a total of seventeen reaches were surveyed representing the spectrum of available streams in the Scott Valley. Major stream characteristics that differentiate reaches included: 1) channel type (e.g. alluvial vs. mid gradient), 2) tributary input (e.g. Grouse Cr. in East Fork), and 3) water quality (e.g. ambient temperature regime tolerable or intolerable for juvenile coho salmon). Ambient water temperatures were thermally acceptable for coho salmon in most streams surveyed. The majority of connected alluvial streams in the Scott Valley were surveyed: Shackleford-Mill, Lower Mill Creek, Mid-French Creek, and Lower Sugar Creek. An extensive sample of middle gradient reaches (Upper Mill Creek, Kidder Creek, Patterson Creek, Etna Creek, Middle Sugar Creek, and Middle South Fork) and several higher gradient reaches (Upper French Creek, Upper Sugar Creek, and Upper South Fork) were surveyed. The East Fork of the Scott River and the mainstem of the Scott River were both found to be thermally intolerable to juvenile coho salmon throughout the ambient waters. Four reaches were surveyed in these streams, and juvenile coho were found in areas that offered cold patches of water – "thermal refugia" – that were tolerable for rearing.

Two biological factors appear to play a role in controlling juvenile coho densities and differentiating the reaches surveyed: 1) density of adult coho spawning and 2) ability of juvenile salmon to emigrate or immigrate. It is important to note, that the physical stream characteristics discussed above play a large role in both the density of spawning and fish movement. Information collected in this study begins to address the essential question of juvenile coho's ability to move to suitable habitats above the highest recorded adult spawning. Efforts to document upper extent of juvenile coho rearing in Patterson Creek, Etna Creek, French Creek, Sugar Creek, and the South Fork Scott River illustrated a variety of physical barriers that thwarted the upward migration of juvenile coho in water year 2005. Juvenile coho salmon were found to rear above the last observed location of adult spawning, in diminishing densities as surveys moved above the spawning location towards the upper extent of rearing.

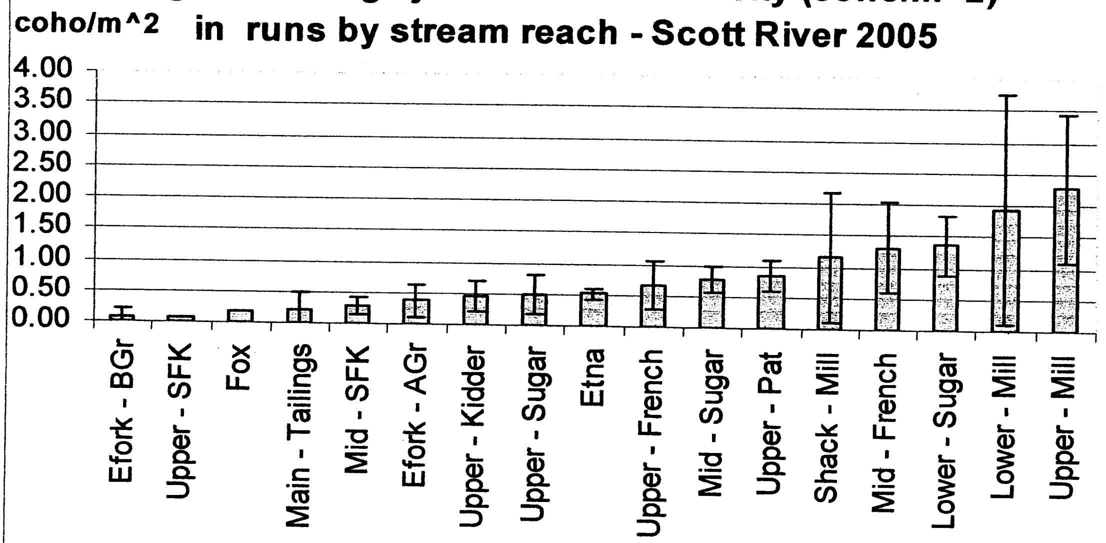
Coho salmon densities:

One of the initial goals of this project was to generate low flow "habitat utilization coefficients" for the Scott River watershed (Nickelson, 1992). These coefficients can be compared to Nickelson's to test the efficacy of utilizing the Habitat Limiting Factor

Model in the Scott Basin and to compare observed densities in the Scott River in 2005 to the literature. Furthermore, it was hoped that the documented "utilization coefficients" for the Scott River could be used with existing habitat typing data to determine the carrying capacity or 2005 standing crop of juvenile coho salmon in the Scott River. This would allow for the quantification of the low flow capacity of the Scott River to rear juvenile coho, an essential step in the determination of the limiting factors that control coho smolt production in the Scott River.

A sub-sample of "like" habitat types were surveyed in each reach to determine average densities of coho utilization by habitat type and reach. Figure 1 shows the average density and standard deviation of juvenile coho observed in runs by reach.

Fig. 1. Average juvenile coho density (coho/m^2) in runs by stream reach - Scott River 2005



Runs were chosen for this illustration because they are the habitat type with the highest sample size in all reaches surveyed.

Table 1. Average coho/m^2 by reach in run habitat types

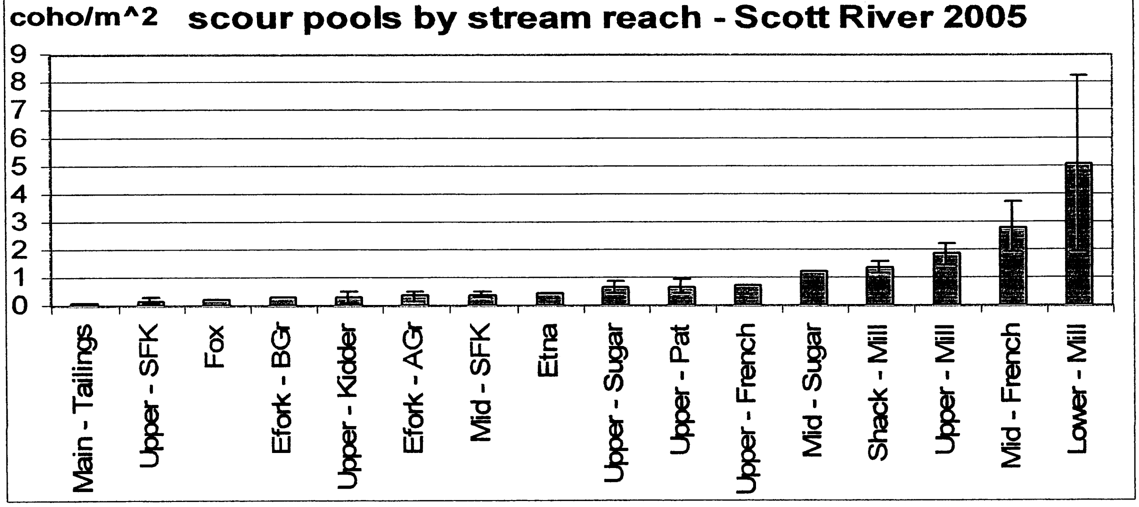
reach	n =		average	s.d.
East Fork - Below Grouse	6		0.08	0.15
Upper - South Fork	1		0.08	0.00
Fox Creek	1		0.19	0.00
Mainstem Scott - Tailings	7		0.19	0.30
Mid - South Fork	5		0.27	0.15
East Fork - Above Grouse	5		0.38	0.26
Upper - Kidder	4		0.44	0.25
Upper - Sugar	7		0.49	0.32
Etna Creek	4		0.51	0.08
Upper - French	9		0.66	0.38
Mid - Sugar	7		0.79	0.21
Upper - Patterson	5		0.85	0.23
Shackleford - Mill	4		1.15	1.04
Mid - French	9		1.31	0.72
Lower - Sugar	8		1.35	0.47
Lower - Mill Creek	7		1.93	1.81
Upper - Mill Creek	7		2.27	1.17

Two observations can be made: 1) standard deviation within each reach is large and 2) there is large divergence in the observed average juvenile coho densities observed in the different reaches.

It is hypothesized that this large variance of observed densities within habitat type and between the reaches is due to the large "suite" of factors that affect juvenile coho rearing densities. Similar habitat types (e.g. runs) within a reach offer different microhabitats, fish cover, depths, and velocities – factors that affect and/or control juvenile coho utilization. The averaging of similar habitats without consideration of these differences generates a large standard deviation due to the variance in densities associated with the variance in "suitable habitat elements". Additionally, a low sample size affects the standard deviation, but reaches with a relatively large sample size of runs, e.g. Lower Mill Creek and Mid-French Creek, still exhibit very high variance in the observed densities. Increased sample size within some reaches showing uniform habitat complexity could reduce the variance, yet rigorous efforts performed in selected reaches to survey a large sample of similar habitat types did not reduce the variance observed during the surveys of 2005.

These trends of large variances in the observed coho densities in similar habitat types between and within reaches are also illustrated in the averages and standard deviation by reach of the surveyed lateral scour pools (Figure 2).

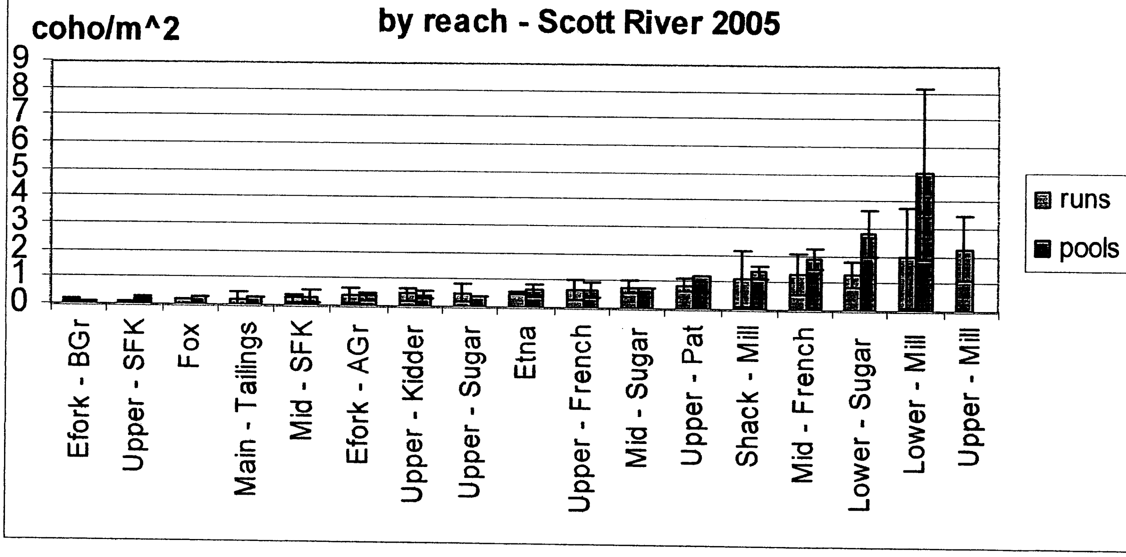
Fig. 2 Average juvenile coho density in lateral scour pools by stream reach - Scott River 2005



This further illustrates the diversity of densities observed in "like" habitat types throughout the Scott Valley. Several of the factors hypothesized to affect coho densities and distribution have been or were quantified through field survey. These include: stream channel type, ambient stream temperature, riparian canopy, and average and maximum depths. These characteristics (especially channel type and temperature) were often used to differentiate the reaches surveyed.

The local characteristics differentiating habitat suitability were extensively noted in qualitative descriptions and often photographed. Yet, a quantitative "grading" system to measure the elements of fish cover and preferred habitat was not employed. For this reason a further statistical analysis of the data within the reaches cannot be approached. It would be relatively difficult to develop a simple and accurate "grading" system for fish cover and preferred habitat in a habitat unit, but measurement of fish cover areas and characteristics could allow for some analysis. A thorough determination of the "Habitat Suitability Criteria" of the juvenile coho salmon in the Scott River will also refine the knowledge and identification of what is suitable habitat within each habitat type.

Figure 3. Average juvenile coho density in pools and runs by reach - Scott River 2005



It is hypothesized that stream channel characteristics (stream geomorphology) and water quality largely affect the volume of suitable habitat and thus the density of juvenile coho rearing. The highest densities of juvenile rearing were mostly observed in alluvial streams that had documented high densities of adult spawning (Lower Mill Creek, Lower Sugar Creek, Mid –French Creek, and Shackleford Mill) (see Figure 3 (above)). The Upper Mill Creek Reach is the exception to this trend, being a small confined mid-gradient stream with limited spawning exhibiting relatively high juvenile rearing densities. The confined mid-gradient reaches (e.g. Mid – Sugar and Upper Kidder) exhibit densities that are relatively similar. The lowest densities were observed in reaches that were either higher gradient (Upper South Fork) or had ambient water temperatures that were unsuitable for rearing coho salmon (East Fork – Below Grouse and Mainstem Tailings). Juvenile coho were observed in high densities in cold patches of suitable water – thermal refugia – within the streams that had high ambient water temperatures.

Many of these observations are corroborated by the preferences of juvenile coho cited in the body of scientific literature, yet the observed densities within the Scott Valley are essential to understanding the behavior and distribution of the fishery on a local level. One large difference observed during this study was a lack of significant preference for pools over runs in many surveyed reaches. Nickleson's research shows utilization coefficients for scour pools two times greater than those for flatwaters (1.4 coho/m^2 vs. .7 coho/m^2). This increased density in pools was observed in Lower Mill Creek and Mid – French Creek, but many other reaches had similar densities between these two essential habitat types. Runs are often viewed as developing and/or filled in pools. Juvenile coho were often observed exhibiting the same behavior (feeding in deepest thalweg position) in both of the habitat units.

Juvenile coho habitat preference:

A major goal of this study was to document instream habitat elements that were associated with increased coho utilization. Through the observance of juvenile coho utilizing their undisturbed niches, we hoped to identify key habitat features that increased the success and survival of fish in the system. This information will be utilized to direct instream protection, enhancement, and restoration projects to create more "desired" habitat for coho rearing. This approach will create effective restoration efforts that generate a biological response of increased growth and survival of the rearing fishery.

The strong brood year of juvenile coho in the Scott Valley filled most available habitats. Many fish were observed actively feeding throughout the day in the deeper and faster waters of the stream. Often the only observable "fish cover" was a mature canopy and deep suitable water. Large amounts of juvenile coho were readily observed from the surface and below utilizing the open waters of relatively shallow runs and glides in the heavily occupied alluvial streams. Little observable direct cover was available outside of the margins of these areas. Though fish were often observed throughout habitat units, fish cover often increased local coho densities.

Elements of fish cover often were associated with coho densities that were much greater than those observed throughout the habitat unit. The fish cover creates microhabitats with velocities and protection that is more desirable than the ambient habitat. Direct observation surveys allow the surveyor to utilize the fish to "point to" structures that are creating preferred microhabitats. Preferred microhabitats were often documented with written descriptions, underwater photographs, and above water photographs to best capture the qualities of these unique instream habitats. In several locations, the fish population and surface area of microhabitats was documented, to try to show the unique densities these habitats support.

Table 2. Habitat types with average densities > 1.50 coho/m^2

Reach	habitat type	average coho/m^2	s.d.	n	coho/m^2 min	coho/m^2 max
Mid - French	Run - side channel	1.54		1	1.54	1.54
Mid - Sugar	LSP - Boulder	1.68		1	1.68	1.68
Upper - Mill Creek	LSP - Root wad	1.79	0.64	2	1.34	2.24
Mid - South Fork	Riffle - microhabitat	1.79		1	1.79	1.79
Mid - South Fork	Run - side channel	1.79		1	1.79	1.79
Mid - French	Plunge pool	1.85		1	1.85	1.85
Lower - Mill Creek	Backwater pool	1.92		1	1.92	1.92
Lower - Mill Creek	Run	1.93	1.81	7	0.00	4.78
Upper - Mill Creek	LSP - Bedrock	1.99		1	1.99	1.99
Lower - Mill Creek	Corner pool	2.10		1	2.10	2.10
Upper - Mill Creek	Run	2.27	1.17	7	0.71	3.78
Mid - French	LSP - Root wad	2.33	0.43	2	2.02	2.64
East Fork - Below Grouse	Alcove - with cold seep	2.59	0.26	2	2.41	2.78
Shackleford - Mill	Corner pool	2.71		1	2.71	2.71
Shackleford - Mill	Run - side channel	3.02		1	3.02	3.02
Lower - Mill Creek	Deep pocket under alder	3.36		1	3.36	3.36
Mid - French	LSP - wood	3.80		1	3.80	3.80
Lower - Mill Creek	Off channel backwater	4.04		1	4.04	4.04
Lower - Mill Creek	LSP - rootwad	5.05	3.14	6	2.16	8.79

Several unique habitats and microhabitats populate the list of habitat types with the highest average coho densities by reach (Table 2). The listed microhabitats have high coho densities, but the surveyed area and density only represents the microhabitat and not the whole habitat unit. The surveyed runs found in side channels and other off channel habitats (e.g. off channel backwater) contained high densities of juvenile coho salmon. An area of thermal refugia (alcove with cold seep in the East Fork below Grouse Creek) had high densities of juvenile coho rearing during the time of survey. Many of the habitat types with the highest observed average coho densities were pools, and some of the highest observed densities occurred in pools formed by woody debris in Lower Mill Creek and Mid French Creek. The average densities of runs in Lower and Upper Mill Creek were also greater than 1.5 coho/m^2.

A large amount of fish cover was offered from three elements that were often associated: coarse woody debris, overhanging and instream terrestrial vegetation, and undercut banks often associated with root mass. These three elements often create the same microhabitat, an area of velocity refuge that additionally offers direct overhead cover for protection from predation. In the wider channels (e.g. Mid – South Fork), coho were often heavily associated with the marginal cover offered by willows growing along and in the wetted edge. Narrow channels (e.g. Lower Sugar) with willow growth along the banks often had fish throughout the habitat unit in high densities, presumably due to ubiquitous cover from the terrestrial vegetation. Larger woody debris plays an essential role in many alluvial streams in developing the deep scour holes of pools. These pools often showed high densities of coho salmon throughout the deep waters of the scour holes.

A different type of micro-habitat is found in streams that have ambient water temperatures that are unsuitable for juvenile coho rearing during some point or all of the day. In these streams cold patches of water create thermal refugia in otherwise inhospitable waters. Juvenile coho were observed utilizing these patches at high densities, regardless of available cover. Yet, cold patches associated with cover (often offered by instream coarse woody debris or terrestrial vegetation) displayed high densities of juvenile utilizing this refuge to survive. The identification of areas offering thermal refugia in the East Fork and Mainstem Scott River and the observance of rearing juvenile coho in these reaches is important to understanding the extent of available habitat in the Scott Valley. Initial attempts were performed to characterize the physical elements that create the cold patch of water. Further investigation into the occurrence and types of thermal refugia in the Scott Valley is desired.

The surveys performed in the Summer of 2005, identified juvenile coho salmon rearing throughout the Scott Valley. This large brood year of coho were often seen as the dominant fish throughout the thalweg of the stream and actively feeding. Though coho were everywhere, a preference for microhabitats created by fish cover elements was often observed. It is hypothesized that direct observation surveys performed in the years of a severely depressed brood will show juvenile coho salmon utilizing the most highly preferred habitats in the Scott Valley. For this reason, the continuation of these direct observation studies in the Scott Valley is recommended to further approach the goals of this study.

French Creek - WAG, 1992. French Creek Watershed Monitoring Plan.

Hankin, D.G. and Reeves, G.H., 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aquat. Sci. 45:834-844.

Maria, Dennis, 2005. *Draft* – French Creek Juvenile Population Surveys. CDFG.

Nickelson, T.E., M.F. Solazzi, S.L. Johnson, and J.D. Rodgers. 1992. An approach to determining stream carrying capacity and limiting habitat for coho salmon. Coho Workshop. May 26-28, 1992. Nanaimo, B.C. Canada. pp. 251-260

Quigley, D., 2003. Stream Inventory Report - Scott River Watershed 2003. Siskiyou RCD.

Quigley, D., 2005. Scott River Watershed Adult Coho Spawning Ground Surveys 2004/2005 Season. Siskiyou RCD.

Sullivan, K., D.J. Martin, R.D. Cardwell, J.E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute. Portland, OR. 192 pp.

East Fork Scott River

Two reaches were surveyed on the East Fork of the Scott River (Map 9). The start of the bottom reach is located approximately five miles above the confluence of the East Fork with the South Fork of the Scott River. The reach break was established at the input of Grouse Creek – a contributor of some cooler water. The surveyed reach below Grouse Creek is .44 miles long and the reach above Grouse Creek is .75 miles long. One survey was performed in Grouse Creek to document presence of coho juveniles. Surveys were performed on 8/24 and 8/25/05.

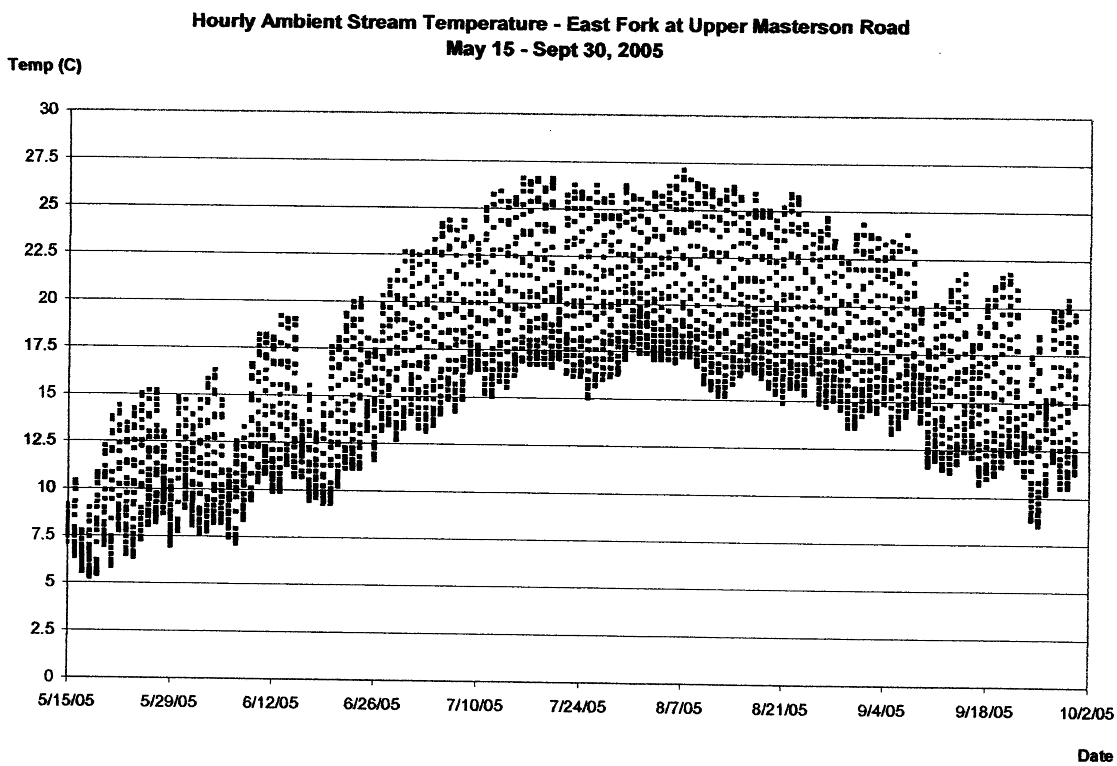
Watershed Description:

The East Fork of the Scott River drains 72,650 acres, 14% of the Scott River watershed. Elevations range from 3,120 feet at Callahan (confluence) and up to 8,540 feet in the headwaters. Land use is mixed Federal and private timberlands in headwaters with rangeland and irrigated agricultural use throughout the large valleys.

Temperature and Discharge:

Water temperatures have been measured in the mainstem of the East Fork since 1996. Stream temperatures documented in the survey reach show a period when temperatures exceed the desirable range for rearing coho salmon.

Figure 1.



The Cal. Dept. of Water Resources has measured discharge from the East Fork at Callahan from 2002 to present. The USFS historically collected data from 1960-1974. This data shows the average August and September flows to be 5 and 3 cfs, respectively.

Discharge was measured in the survey reach above Grouse Creek during the period of survey. 3.7 cfs was observed in the East Fork above Grouse Creek on 08/25/05.

Coho Spawning:

Adult coho spawning surveys were performed in the East Fork in the winter of 2004-2005. A 1.4 mile reach was surveyed for the presence of coho spawning. A total of 23 coho redds were observed in this reach. The reach surveyed for summer rearing consists of the majority of this spawning survey reach. Additionally, surveys were performed above this reach in the East Fork and in tributaries of the East Fork (Kangaroo, Grouse, and Rail Creek). Few coho redds were observed in these reaches with the exception of the lower 1 mile of Kangaroo Creek where 22 redds were observed (Quigley, 2005)

East Fork below Grouse Creek:

Habitat characterization:

This reach is a medium gradient (2%) stream with a wide and shallow channel offering limited habitat complexity for juvenile salmonid rearing. The stream channel bed is dominated by cobble and boulder. Limited areas of suitable spawning gravel for adult salmon were observed. Pool occurrence is low with long stretches of riffle and flatwater habitats alternating. Canopy is often relatively open with a mature evergreen forest upslope of a narrow riparian corridor composed of willow and alder. Very little in stream direct overhead cover was observed. Most of the available fish cover observed was created by substrate (large cobble, boulder, and bedrock), bubble curtains, and areas of terrestrial vegetation (sedge and willow) growing along stream banks. High flow scour has removed some areas of bank and riparian vegetation away from the low flow wetted edge, precluding these stream features from offering cover. High ambient water temperatures throughout this stream reach appear to exclude coho salmon from rearing in the majority of otherwise suitable habitats. Microhabitats offering thermal refugia due to a coldwater input were observed in multiple locations of this reach.

Survey results:

Sixteen (16) individual habitat types and one cold patch of thermal refugia were surveyed in the reach below Grouse Creek. Densities (Table 1) of coho salmon below Grouse Cr. were extremely low in most habitat types. Two pools and one backwater pool were observed and surveyed in this reach. The majority of units surveyed were runs (n = 8) and riffles. Several areas offering thermal refugia were observed and surveyed. Areas with thermal refugia contained most of the coho salmon observed in this reach.

Table 1. Average density by habitat type of juvenile coho salmon
East Fork Scott River
below Grouse Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
riffle	0.00		2	0.00	0.00
riffle - pocketwater below Grouse	0.07		1	0.07	0.07
step run	0.00		1	0.00	0.00
run	0.002	0.004	5	0.00	0.01
run @ confluence	0.09		1	0.09	0.09
run w thermal refuge	0.37		1	0.37	0.37
plunge pool	0.00		1	0.00	0.00
LSP - bedrock - small	0.26		1	0.26	0.26
off-channel - backwater	0.02		1	0.02	0.02
thermal refuge - spring	1.12		1	1.12	1.12
alcove microhabitat - with seep	2.59	0.26	2	2.41	2.78

Analysis of the data by individual dive unit allows for a clarified view of the importance of thermal refugia in this reach of the East Fork for the rearing of juvenile coho salmon.

Table 2. - juvenile coho densities in individual dive units
East Fork Scott River below Grouse Creek

Areas with no detected thermal refuge

Unit#	Habitat Type	average	length	area	volume	coho/ft2	coho/ft3	**coho/m^2**
1	plunge pool	0	28	644	966	0	0	**0**
3	riffle	0	49	980	686	0	0	**0**
4	run	0	36	648	648	0	0	**0**
5	run	0	30	360		0	0	**0**
7	step run	0	43	731	731	0	0	**0**
12	run	0	100	1700	3060	0	0	**0**
14	riffle - lgr	0	15	360	180	0	0	**0**
15	run	0	47	1128	1128	0	0	**0**
2	run	2	86	2322	2206	0.001	0.001	**0.01**
6	off-channel - backwater	1	40	440	440	0.002	0.002	**0.02**
8	LSP - Bedrock - small	12	23	506	708	0.024	0.017	**0.26**

Areas with detected thermal refuge

Unit#	Habitat Type	average	length	area	volume	coho/ft2	coho/ft3	**coho/m^2**
17	riffle - pocketwater below Grouse Cr	6	46	943	1320.2	0.006	0.005	**0.07**
16	run @ confluence of Grouse Cr	9	53	1060	1590	0.008	0.006	**0.09**
GR-1	run - Grouse Creek	13	42	630	630	0.021	0.021	**0.22**
13	run - with thermal refuge	45	50	1300	2210	0.035	0.020	**0.37**
11	thermal refuge - spring	15	12	144	144	0.104	0.104	**1.12**
9	alcove - seep	34	19	152	152	0.224	0.224	**2.41**
10	alcove - seep	31	15	120	132	0.258	0.235	**2.78**

Few coho salmon were observed in areas exhibiting ambient temperature regimes. Four of the five runs without thermal refugia were absent of coho salmon. Only the LSP – Bedrock pool contained significant juvenile coho salmon without any detected thermal refugia. An ambient water temperature of 24° was recorded below Grouse during survey efforts. This corroborates documented water temperatures upstream (Fig. 1). Habitats with thermal refuge within the reach were often initially identified through the observation of a large fish presence and had distinct densities of coho salmon. Groups of coho were observed in thermal refugia created by seeps or springs entering areas of protected (low velocity) margin –e.g. substrate protected alcove microhabitats along a margin. The velocity protection created by large substrate reduces the "dilution" through mixing of the thermally suitable water coming from seeps and creates a small pocket of habitable refuge. Water temperatures of 19° C and 16° C were recorded at some of these refuge sites.

Thermal refugia often exist as small microhabitats in otherwise unsuitable habitat units. Determination of densities for the entire area of a habitat unit that contains thermal refuge will generate a density value that is much less than the density observed in the suitable refuge. For example, the area actually utilized in the run with thermal refugia (Unit #13) is a pocket 110 square feet across with water temperatures of 22°C (compared to recorded temperatures of 24° C in the rest of the run not utilized by coho salmon). Density calculations for this refuge (coho/m^2 = 4.4) demonstrate the relatively high density of microhabitat occupation.

In addition to microhabitats containing thermal refugia, a stretch of cooler ambient water is created by the input of Grouse Creek into the East Fork. Ambient stream temperatures of 23° C in the East Fork above Grouse Creek and 18.5° in Grouse Creek were recorded at the time of survey. Water temperatures of 19° C were recorded in the run at Grouse Creek's confluence and ambient temperatures of 22° C were recorded in the next habitat unit (riffle – pocket water) below the confluence, demonstrating a short affect after the confluence. Densities of coho are much greater in these thermally acceptable units than in similar units downstream.

Fish Utilization:

Very few fish were observed in the ambient thalweg position feeding, except for in the bedrock scour pool and in the thermally influenced reaches below Grouse Creek. The majority of fish were observed in large dense groups occupying microhabitats of thermally tolerable water. These fish were holding in high density groups, often with little to no direct overhead cover or instream cover available over the majority of the thermally suitable water.

East Fork above Grouse Creek:

Habitat Characterization:

This reach is a lower gradient alluvial reach characterized by a higher occurrence of interspersed pools and gravel bars. The dominant streambed substrate is cobble and gravel with some exposed bedrock. Sorted spawning gravels were observed throughout this reach. The main location that adult coho were observed spawning in the East Fork is at the top of this reach. The riparian corridor is characterized by areas of good riparian growth alternating with areas devoid of riparian vegetation. The occurrence of gravel bars creates banks with little terrestrial vegetation.

This reach has greater habitat complexity compared to the reach below Grouse Cr. Even though large areas of stream surface offer no direct overhead cover, an increase in terrestrial vegetation (especially young willows) directly adjacent and over the wetted stream increases the occurrence of available fish cover. Several cover types were observed offering additional fish cover: areas with small woody debris clusters, some large wood in the active channel, root wads, and cut-banks situated directly over the stream. Several areas of complex habitat (e.g. a root wad associated with a small woody debris aggregate, or small woody debris associated with undercut banks and terrestrial vegetation) were observed. Wetted channel with areas of extensive riparian and in stream willow growth offered excellent habitat for juvenile coho. This willow offers both overhead and instream cover.

During snorkel surveys crews observed and noted many small cold-water seeps entering along the margins of the stream. Waters adjacent to the downstream bank of gravel bars and above some areas of streambed were also noted as having cooler temperature regimes. An increased occurrence of sub-surface inter-gravel (hyporheic) flow and a high occurrence of seeps and springs might make parts of this reach more thermally acceptable than other areas of the East Fork. Additionally, there is a hypothetical possibility of groundwater accretion occurring in this reach

Survey Results:

Nine (9) habitat types were surveyed above Grouse Cr. Densities of coho salmon increased greatly from those observed below Grouse Cr. Juvenile coho were observed in all units surveyed except the riffle habitat. This increase in presence of rearing juvenile coho salmon indicates that the occurrence of suitably cool stream temperatures is more ubiquitous in this reach than in the reach below Grouse Creek. This increased habitat suitability could be generated by an ambient water temperature that is only slightly cooler than temperatures below Grouse Cr. (recorded ambient temperatures of 22° C above and 24° C below Grouse Creek in the East Fork during period of survey) but within the range for rearing juvenile coho salmon.

Table 3. Average density by habitat type of juvenile coho salmon
East Fork Scott River
above Grouse Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
riffle	0.00		1	0.00	0.00
run	0.38	0.26	5	0.05	0.71
LSP-bedrock	0.37	0.06	2	0.33	0.41
LSP-rootwad	0.25		1	0.25	0.25

Average coho densities in the run habitats (Table 3) were .38 coho per square meter. Runs surveyed with good riparian canopy (willows) offering direct overhead cover combined with instream small or large woody debris carried the higher densities of coho salmon (Unit #8 and 9 - coho/m^2 = .62, s.d. = .012, n = 2) than adjacent runs with little over head and instream cover (Unit #7 - coho/m^2 = .19, n = 1). A run (Unit #3) with a complex of small woody debris, undercut bank, and root mass was being utilized (coho/m^2 = .40, n = 1) much greater than an adjacent run (Unit #2 - coho/m^2 = .05, n = 1) with only underwater root mass for cover. This demonstrates the disparate densities that can be observed in stream units that are prescribed the same habitat type. This is due to the potential dependence of density upon available cover and cover complexity. The heterogeneity that cover elements give to similar habitat units limits the efficacy of determining a habitat utilization coefficient for each habitat type; e.g. standard deviation for runs is large and the maximum coho density is greater than ten times the minimum coho density.

Table 4. - juvenile coho densities in individual dive units
East Fork Scott River above Grouse Creek

Unit#	Habitat Type	average coho	length	area	volume	coho/ft2	coho/ft3	coho/m^2
4	riffle	0	42	483	193.2	0.000	0.000	**0.00**
2	run	12	103	2369	3079.7	0.005	0.004	**0.05**
7	run	54	133	2926	4974	0.018	0.011	**0.20**
1	LSP-rootwad	13	24	552	828	0.024	0.016	**0.25**
6	LSP - bedrock - corner pool	77	100	2500	3750	0.031	0.021	**0.33**
3	run	52	74	1406	1546.6	0.037	0.034	**0.40**
5	LSP-bedrock	80	104	2080	4368	0.038	0.018	**0.41**
8	run	52	65	1040	1560	0.050	0.033	**0.54**
9	run	108	102	1632	2285	0.066	0.047	**0.71**

A large group of coho was observed utilizing the thalweg under willow cover in a run (Unit #9) with ambient water temperature of 22° C and no observable temperature microhabitats within the waters. 22° C is the peak stream temperature that juvenile coho salmon were observed utilizing during these surveys.

Three pools were surveyed above Grouse Creek. Bedrock-formed lateral scour pools had greater densities (coho/m^2 = .37, s.d. = .06, n = 2) than those formed by root wads (coho/m^2 = .25, n = 1). This could be a result of greater occurrence and volume of thermal refugia in the surveyed bedrock pools. In both bedrock pools, fish were heavily associated with cold-water inflow and refugia. Two main types of thermal refugia were observed in this reach: 1) protected cold-water seeps and inflows and 2) stream waters adjacent to the bank of a gravel bar. A local water temperature of 18° C (with ambient temperature of 22°C) was observed adjacent to inflow from a gravel bar. The deep scour hole of pools creates locations were the subsurface flow through gravel bars returns to the active channel – contributing cold water to the pool habitat.

Fish Utilization:

Coho were heavily associated with instream and overhead cover and thermal refugia throughout this reach. Most coho were observed in groups utilizing instream cover (small woody debris, root masses, root wads, undercuts, and submerged terrestrial vegetation) or areas that offer thermal refugia. Thalweg positions in pools and runs were usually not occupied due to their lack of cover and/or unsuitable water temperatures. In contrast, large amounts of fish were observed in groups in the thalweg position in habitats towards the top of the reach offering large amounts of willow cover and hypothesized cooler ambient stream conditions.

Grouse Creek

Juvenile coho salmon were observed rearing in Grouse Creek in a single representative habitat unit – a flatwater (Table 2). No spawning has been documented in Grouse Creek. The migration of juveniles from the East Fork up into Grouse Creek seems limited by the abrupt change in elevation (approximately 4 feet) at Grouse Creek's confluence with the East Fork. No additional surveys were performed in Grouse Cr due to time constraint.

South Fork Scott River and Fox Creek

Two reaches were surveyed for juvenile salmonid utilization in the South Fork of the Scott River (Map 3). A .82 mile reach above the confluence of Boulder Creek was surveyed to determine representative densities of salmonids rearing. An upper section of the South Fork was surveyed to determine the upper extent of coho salmon distribution and coho densities in the higher gradient stream. Additionally, Fox Creek was surveyed for presence and upper extent of coho salmon.

Watershed Overview:

The South Fork drains 25,133 acres – 4.8% of the Scott River Watershed. Land ownership in this watershed is primarily mixed ownership (USFS and private) timberlands with federally owned wilderness in much of the headwaters. Limited residential property and small amounts of irrigated pastureland are scattered through the lowest section of the South Fork (Callahan).

Extensive placer mining historically occurred throughout the channel of the South Fork above Callahan, leaving a legacy of stream channel often constricted by tailing piles. These tailing piles affect the channels geomorphology and potential riparian recruitment and condition.

Water Quality:

The Siskiyou RCD has monitored ambient stream temperatures in the lower and middle section of the South Fork since 1996. MWATs for documented years are in Appendix A.

Figure 1. Hourly Ambient Water Temperature - South Fork Scott River 6/15/05 - 9/15/05

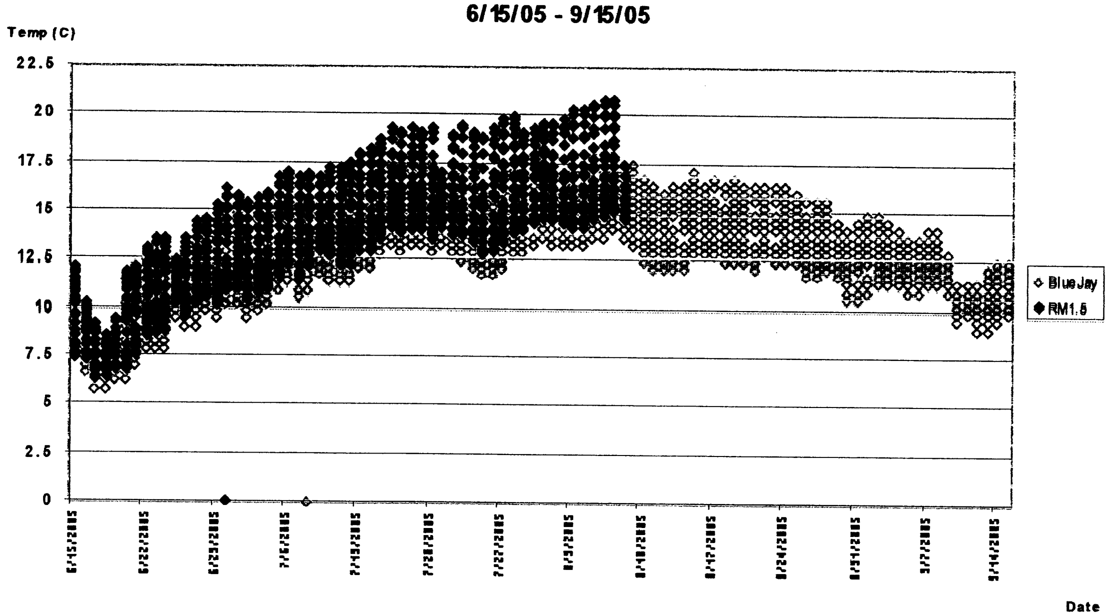
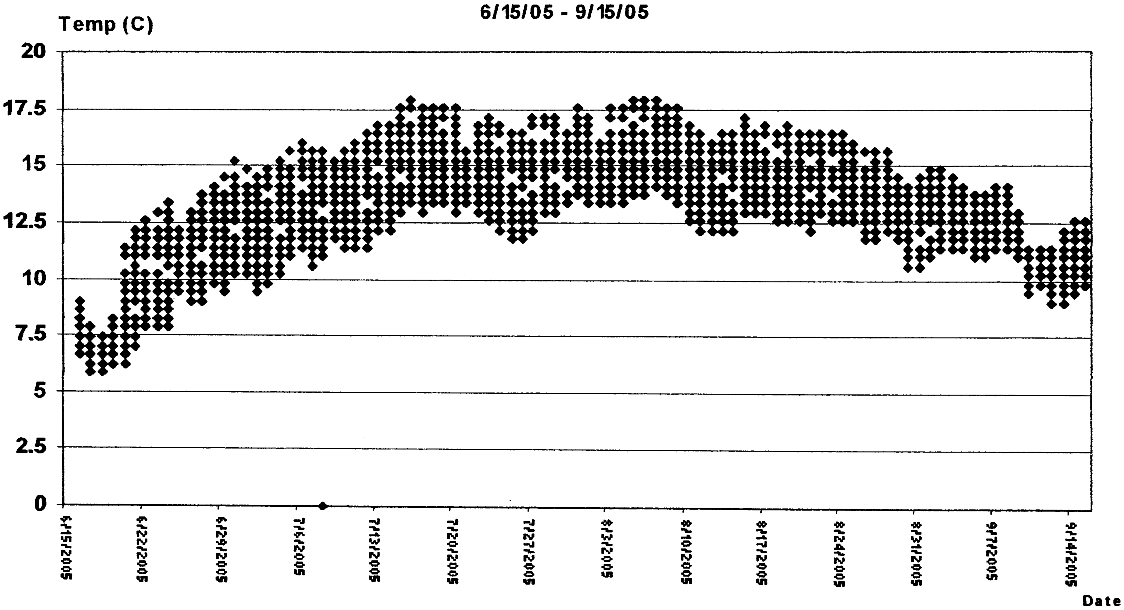


Fig. 2 Hourly Ambient Water Temperature - South Fork Scott River Above Blue Jay Cr
6/15/05 - 9/15/05



The temperature data collected in 2005 show that maximum ambient stream temperature in the South Fork above Blue Jay Creek does not exceed 18° C. Temperature monitoring at RM 1.5 show a 2° C warming from the upper site, but hourly temperatures rarely exceed 20° C.

The California Dept. of Water Resources has monitored stream discharge on the South Fork from 2002 to present, and the USGS historically operated a gauge at the same location from 1958-1960. These measurements show that low flow on the South Fork varies (depending on water year) from 12 cfs (wet) to as low as 2 - 4 cfs (dry). Low flow in 2005 was measured to be 3-4 cfs at the gage (appendix).

In addition, benthic macroinvertebrate samples collected in 2003 at lower South Fork showed a Benthic Invertebrate Index of Biological Integrity (BIBI) score of 44-46, during the summer low flow period, out of a maximum of 50. Other areas which received comparable scores were Upper French Creek and Sugar Creek. (*Stream Inventory Report, Scott River Watershed* 2003)

Spawning:

The Upper South Fork reach (800 m above Fox Creek to Boulder Creek) from the adult coho spawning ground survey (Quigley, 2005), overlaps the Middle and Upper reaches of the juvenile utilization surveys. See Map 3. In 2004, this reach was extensively surveyed for adult coho spawning, and 15 redds were documented in a distance of 2.1 miles. The highest observed adult coho spawning in the South Fork was about 200 meters above the Fox Creek confluence. Spot surveys were performed in the mouths of Fox and Boulder Creek, but no redds were observed.

Spawning appears to be largely limited in this reach by the presence of suitably sorted gravels. Limited spawning gravel was observed, due to the predominance of larger substrate (cobble) in this mid-gradient channel. Areas of suitable gravel (often located in side channels) were often utilized by coho salmon for spawning.

Mid-South Fork Scott River

Habitat characterization:

The South Fork is a relatively large high gradient (high energy) mountainous tributary.

The Middle South Fork is characterized by a high riffle and run occurrence with low pool occurrence (65% riffle, 28% run, and 7% pool by length). Pools that occur are mostly developed by bedrock and feature relatively large and deep scour holes. The mean canopy is approximately 40% - areas of mature riparian canopy are interspersed with areas of no canopy associated with historic mining and tailing piles. Areas lacking mature riparian trees often had abundant younger willow directly adjacent to the river's edge. The dominant stream substrate in this reach is cobble and boulder with bedrock playing a large role in pool formation. Little sorted gravel is available for spawning. The majority of large woody debris observed (which was relatively abundant) was located outside of the wetted low flow channel. The dominant fish cover element throughout the reach was substrate (boulder and large cobble) and bubble curtain. Additionally, small woody debris, undercut banks, root mass, and terrestrial vegetation over and in water offer fish cover in the reach.

The channel's large width limits the amount of stream cover that the abundant terrestrial vegetation along most of the stream's bank can generate. Habitat units were often completely exposed along the middle of the channel (except for ubiquitous substrate cover) with limited amounts of instream cover offered along the banks. These microhabitats of fish cover in an otherwise open stream were often observed to be preferably utilized by coho salmon.

Survey Results:

Twenty Five (25) individual habitat units were surveyed in the Middle South Fork Reach - nine riffle habitats, eight run habitats, and eight pool habitats. Survey crews habitat typed the South Fork immediately before performing the direct observation surveys. During this habitat typing crews flagged 20% (the first and then every fifth) of each riffle and flatwater unit and all pool units. These flagged units were subsequently surveyed using direct observation. This approach generates an equal sample interval of every common habitat type (riffles and runs). It was quickly found that surveying a large amount of riffles was extremely time consuming and relatively difficult. The relatively low occurrence of coho salmon in these riffles could justify a less frequent sample interval (e.g. 10%) in these common habitats, allowing survey crews to cover more distance and sample more preferred habitat types.

A relatively high diversity of habitat types was surveyed in this reach. Coho salmon were found rearing in all habitat types surveyed, at relatively low densities compared to other surveyed reaches in the Scott Valley (Table 1). The densities show the expected trend of habitat types, characterized by deeper, low velocity water being favored by coho salmon. Microhabitats with direct overhead cover and/or instream cover (usually willow and or small woody debris) associated with velocity refuges were often heavily occupied with groups of coho salmon.

Table 1. Average density by habitat type of juvenile coho salmon
Mid-South Fork Scott River

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Riffle - high gradient	0.02		1	0.02	0.02
Riffle	0.02	0.01	6	0.01	0.04
Riffle - pocketwater	0.13		1	0.13	0.13
Riffle - microhabitat	1.79		1	1.79	1.79
Step run	0.10	0.09	2	0.04	0.17
Run	0.27	0.15	5	0.11	0.47
Run - sidechannel	1.79		1	1.79	1.79
Step-pool	0.11		1	0.11	0.11
LSP - Rootwad	0.24		1	0.24	0.24
LSP - Bedrock	0.41	0.12	5	0.28	0.60
Mid - channel pool	0.90		1	0.90	0.90

Riffles:

Juvenile coho were observed in all the riffles surveyed. Coho were found utilizing small deep pockets occurring in the otherwise shallow and fast riffle habitats. The relatively large stream discharge and substrate of the South Fork, allows for riffles in the South Fork to contain pockets of suitable depth and velocity to offer rearing habitat in the middle of the channel. The South Fork was the only surveyed reach where the riffles commonly had the occurrence of these suitable "pocketwater" habitats. Inspection of individual dive data shows that these riffles often contained very few juvenile coho occupying these rare microhabitats. A riffle with high occurrence of "pocketwater" (Unit #17 – riffle – pocketwater) had a significantly higher density than all other riffle habitats surveyed. This pocketwater habitat type had coho densities equivalent to the lower end of observed densities in run habitats.

Besides these areas of pocketwater, coho were observed in riffles that contained marginal microhabitats offering velocity refuge and cover: e.g. deep water covered by woody debris or terrestrial vegetation. Coho were observed in a micro-habitat (Unit #6) created by willow growing within the riffle. This instream terrestrial vegetation offers both velocity refuge and direct over head cover. The density of utilization of this microhabitat is unique because of its small size (12 ft2), even though only two coho were observed. This demonstrates the importance and unique densities of microhabitats for rearing in otherwise unsuitable mesohabitats.

Flatwater:

Three types of flatwater were surveyed in this reach: step runs, runs, and a sidechannel run. The average densities by habitat type show higher utilization of runs over step runs – probably due to the higher occurrence of uniformly deep slow velocity water in the runs. The relatively high variance of observed coho densities in the run indicates that variables other than "habitat type" are affecting suitability and density of rearing. Available fish cover is likely one of these variables – this hypothesis is supported by the increased density in the sidechannel run that had exceptional cover due to channel's narrow width.

The two step pools surveyed offered different amounts of fish cover, correlating with the different observed densities of coho utilization. One step run had a low velocity pocket associated with terrestrial vegetation cover (willow both directly over and in the water) that contained all the coho observed in the habitat unit (Unit #7 - high density). The other step run had little instream cover (Unit #2 – low density), and the few coho observed occupied a deeper pocket with substrate cover.

Coho salmon were often utilizing the deep thalweg positions of runs with little cover besides streambed substrate. The coho in the run unit with the highest observed density were utilizing the bubble curtain entering from the riffle at the top of the run (Unit #9). These fish appeared to be holding the dominant position and actively feeding on delivered drift. The infrequent occurrence of instream fish cover (besides ubiquitous substrate) appeared to increase densities in some of the surveyed runs – Unit #10 offered terrestrial vegetation cover along a bank and Unit #16 offered Large Woody Debris associated with an eddy, while Units #1 and #21 offered only substrate cover and bubble curtain. It appears that available instream cover increases habitat suitability, but coho were often observed utilizing the dominant feeding position in the open deeper waters. Additional factors (e.g. canopy, food availability) could be affected coho behavior and habitat preference in this stream.

The single side-channel run surveyed had significantly higher density than any other habitat type surveyed in this reach. This small run was almost ½ covered with complex fish cover (terrestrial vegetation over and in water combined with small woody debris). The narrow nature of the sidechannel allows for the terrestrial vegetation to cover all of the wetted width.

Table 2. - juvenile coho densities in individual dive units
Mid South Fork

Unit #	Habitat type	ave. coho	length (feet)	area (feet2)	vol (feet3)	coho/ft2	coho/ft3	coho/m^2
15	Riffle	1	66	1650	990	0.001	0.001	**0.01**
4	Riffle	1	50	650	520	0.002	0.002	**0.02**
11	High gradient riffle	2	43	1247	1122	0.002	0.002	**0.02**
8	Riffle	4	71	1881.5	1129	0.002	0.004	**0.02**
19	Riffle/Run	3	64	1184	1184	0.003	0.003	**0.03**
20	Riffle	8	112	2576	2318	0.003	0.003	**0.03**
2	Step run	3	33	726	581	0.003	0.004	**0.04**
24	Riffle	5	66	1419	922	0.004	0.005	**0.04**
1	Run	16	83	1577	2208	0.010	0.007	**0.11**
14	Step pool	23	94	2256	4061	0.010	0.006	**0.11**
17	Riffle	10	34	833	666.4	0.012	0.015	**0.13**
21	Run	13	42	924	924	0.014	0.014	**0.15**
7	Step run	22	70	1400	1400	0.016	0.016	**0.17**
3	LSP - Rootwad	24	56	1092	2075	0.022	0.012	**0.24**
18	LSP - Bedrock	35	57	1368	2326	0.026	0.015	**0.28**
10	Run	18	41	656	524.8	0.027	0.034	**0.30**
16	Run	38	52	1248	1248	0.030	0.030	**0.33**
12	LSP - Bedrock	62	63	2016	3629	0.031	0.017	**0.33**
5	LSP - Bedrock	60	62	1488	2976	0.040	0.020	**0.43**
23	LSP - Bedrock	46	54	1134	2268	0.041	0.020	**0.44**
9	Run	36	33	825	660	0.044	0.055	**0.47**
13	LSP - Bedrock	84	63	1512	2722	0.056	0.031	**0.60**
25	Mid-channel pool	191	85	2295	5049	0.083	0.038	**0.90**
6	Riffle - microhabitat	2	4	12	7.2	0.167	0.278	**1.79**
22	Run - side-channel	49	42	294	205.8	0.167	0.238	**1.79**

Pools:

Five bedrock formed lateral scour pools were surveyed along with 1 LSP – root wad, 1 mid-channel pool, and 1 step pool. All observed pool densities were significantly less than Nickelson's coefficient for pools (1.74 coho/m2).

Bedrock pools were often large with little to no cover (except substrate and bubble curtain) over all of the scour hole. Coho were observed in two areas in these pools: actively feeding in the thalweg of the scour hole with little to no cover, or utilizing areas affording velocity refuge. The highest occurrence of desirable microhabitats in these pools was areas of velocity shelter created by bedrock and boulders. Occasionally a small amount of additional instream cover (e.g. small woody debris) was observed in pools. The bedrock (sometimes including crevices) and boulders of the pool often offered the only instream cover in the unit (Unit #5 and #13). One pool (Unit #12) had a small wood aggregate associated with a substrate created velocity shelter, creating more complex cover. Yet, this unit did not exhibit exceptional densities of coho rearing. Coho salmon were observed moving from a thalweg feeding position to available areas of velocity shelter (and vice versa) in the same habitat unit at different times of day (e.g. moved to a thalweg position when unit became completely shaded). Coho salmon appear to utilize the uniform deep waters of the pool's scour hole, regardless of direct instream cover. Areas of available cover might increase the suitability of pools by offering an area of escape or rest while feeding opportunity is impeded.

The additional pool types surveyed had divergent coho densities. The surveyed step pool had the lowest utilization densities of all pools in this reach, probably due to the faster velocities associated with the majority of this habitat type. All coho observed in the step pool occupied the velocity refuges offered by eddies. The root-wad-formed scour pool offered fish cover from the root wad and associated undercut, and one might expect higher density rearing in this relatively complex and rare fish cover. However, though most of the coho observed in this unit were associated with this cover, this unit had the lowest densities of all lateral scour pools. The highest density of pool utilization was observed in the mid-channel pool, in which the majority of fish were actively feeding in the scour hole with little cover except some shade from canopy. Additionally, a group of fish was observed utilizing slower velocity waters amongst submerged willows along margin. This occurrence of fish cover within the desired pool habitat might allow an increased density of coho by offering adjacent feeding and hiding habitats.

Upper South Fork – above Fox Creek

Habitat characterization:

This reach has not been habitat typed, so habitat description can only be generated from qualitative field observations. The South Fork is a relatively steep channel after the confluence with Fox Creek, characterized by alternating pools (mostly bedrock formed scour pools) and steep riffle units. The dominant streambed substrate is boulder and large cobble with areas of exposed bedrock. Mature riparian canopy exists throughout the reach. Almost all observed instream cover was substrate cover and bubble curtains.

Survey Results:

Direct observation surveys were performed to determine the upper extent of juvenile coho utilization on the South Fork Scott River and to document densities for comparison to other surveyed reaches. In order to document the upper extent of utilization we surveyed habitats expected to contain coho (runs and pools). Fifteen (15) individual habitat units were surveyed in this reach – 1 run and 14 pools.

Table 3. Average density by habitat type of juvenile coho salmon
Upper South Fork Scott River

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Run	0.08		1	0.08	0.08
Plunge pool	0.07	0.07	3	0.02	0.15
LSP - Bedrock	0.17	0.09	11	0.03	0.31

We observed diminished average densities of coho salmon in the habitat types surveyed in this reach, compared to the Mid-South Fork reach. Bedrock lateral scour pools were the dominant deep water habitat type in this reach, until the stream gradient increased towards the end of the survey reach. This higher gradient section was characterized by interspersed plunge pools and high gradient riffles.

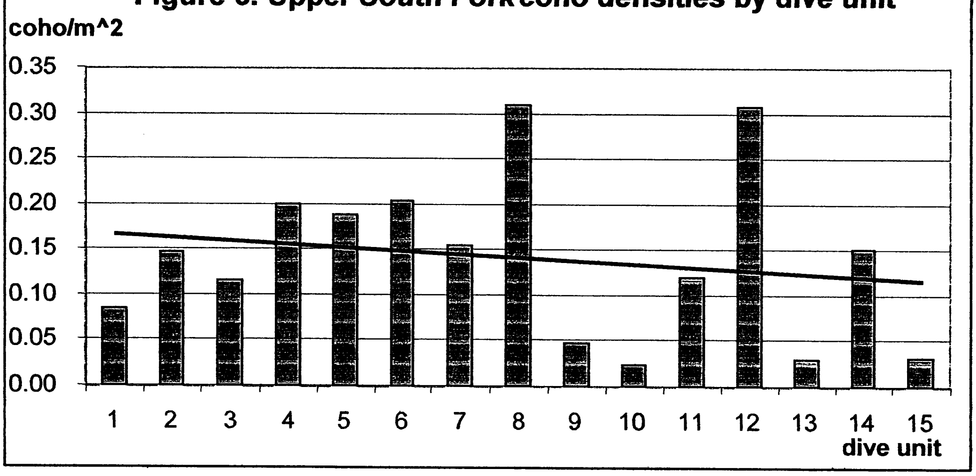
Juvenile coho were observed in all surveyed habitat units below a physical barrier created by an (approximately) 5 foot cascade (falls) over bedrock. The high occurrence of plunge pools in a short distance above this barrier allowed for the surveying of an additional ten pools above the suspected barrier. No coho salmon, only rainbow trout, were observed in these pools, corroborating the belief that the upper extent has been found. This documented upper extent is approximately .7 miles above the highest documented adult coho spawning. Demonstrating upstream movement of juvenile coho to occupy available habitats, until a insurmountable barrier is encountered.

Table 4. - juvenile coho densities in individual dive units
Upper South Fork

Unit #	Habitat type	ave. coho	length (feet)	area (feet2)	vol (feet3)	coho/ft2	coho/ft3	coho/m^2
1	Run	14	60	1800	1440	0.008	0.010	**0.08**
2	LSP - Bedrock	12	35	875	1050	0.014	0.011	**0.15**
3	LSP - Bedrock	8	25	750	1125	0.011	0.007	**0.11**
4	LSP - Bedrock	26	70	1400	1680	0.019	0.015	**0.20**
5	LSP - Bedrock	24	55	1375	2200	0.017	0.011	**0.19**
6	LSP - Bedrock	17	50	900	1440	0.019	0.012	**0.20**
7	LSP - Bedrock	18	50	1250	2500	0.014	0.007	**0.15**
8	LSP - Bedrock	36	50	1250	2500	0.029	0.014	**0.31**
9	LSP - Bedrock	2	25	450	765	0.004	0.003	**0.05**
10	Plunge pool	1	25	450	675	0.002	0.001	**0.02**
11	LSP - Bedrock	9	45	810	1215	0.011	0.007	**0.12**
12	LSP - Bedrock	15	35	525	892.5	0.029	0.017	**0.31**
13	LSP - Bedrock	1	25	375	562.5	0.003	0.002	**0.03**
14	Plunge pool	7	25	500	1000	0.014	0.007	**0.15**
15	Plunge pool	2	45	675	1350	0.003	0.001	**0.03**

Decreasing densities of habitat utilization were not readily apparent in this reach (Figure 1) – unlike other reaches in which rearing density drops as you move upstream to the physical barrier.

Figure 3. Upper South Fork coho densities by dive unit



Fox Creek:

Habitat characterization:

This reach has not been habitat typed, so all habitat descriptions are qualitative from field notes taken during the survey. Fox Creek is a small tributary to the South Fork (Map 3). The moderately steep stream is dominated by boulder and large cobble substrate with good to excellent canopy. Instream fish cover is generated, almost exclusively, by large substrate and bubble curtains. The bottom ½ mile of Fox Creek offers a section of relatively low gradient flatwater and pool habitats. After this short section Fox Creek rapidly becomes steeper.

Survey results:

Direct observation surveys were performed to determine the presence of coho salmon in Fox Creek. Additionally, we attempted to determine the upper extent of coho rearing, but were not able to follow the 10 pool protocol due to time constrains. Direct observation surveys were performed in six (6) units of Fox Creek – 3 runs and 3 pools – in which coho were observed.

Table 5. Average density by habitat type of juvenile coho salmon
Fox Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Step run	0.08	0.03	2	0.06	0.10
Run	0.19		1	0.19	0.19
Plunge pool	0.13	0.08	2	0.07	0.19
LSP - Bedrock	0.25		1	0.25	0.25

Surveys were performed in ideal habitats (pools) for an additional 300 yards above last coho sighting, yielding no further observation of juvenile coho. Fox Creek appeared to increase in stream gradient after the last coho sighting.

The observed densities of coho salmon in Fox Creek are equivalent and higher than those observed in the Upper South Fork Reach of the main-stem. This is largely due to a small occurrence of juvenile coho in habitat units with a small surface area.

Table 6. - juvenile coho densities in individual dive units
Fox Creek

Unit #	Habitat type	ave. coho	length (feet)	area (feet2)	vol (feet3)	coho/ft2	coho/ft3	coho/m^2
1	Step run	10	75	1125	900	0.009	0.011	**0.10**
2	Step run	2	30	360	216	0.006	0.009	**0.06**
3	LSP - Bedrock	8	35	350	525	0.023	0.015	**0.25**
4	Run	12	45	675	675	0.018	0.018	**0.19**
5	Plunge pool	8	30	450	450	0.018	0.018	**0.19**
6	Plunge pool	1	15	150	150	0.007	0.007	**0.07**

Sugar Creek

Three reaches were surveyed for juvenile coho salmon presence and densities on Sugar Creek: lower (alluvial reach), middle, and upper. The lower reach extends from Sugar Creek's mouth to the Highway 3 Bridge (.29 miles), and then continues (after a short break in access) above the Highway 3 Bridge (.25 miles). The middle reach begins at the "cattle guard" on Sugar Creek road and continues upstream for approximately .28 miles. The upper reach begins at the confluence with Tiger Fork and continues upstream to the upper extent of observed juvenile coho rearing (.88 miles). See Map # 4.

In addition to the direct observation surveys, cooperative electro-fishing efforts were performed on the middle reach, with the aid of CDFG. The purpose of this effort was to calibrate the population estimates collected using direct observation.

Watershed Overview:

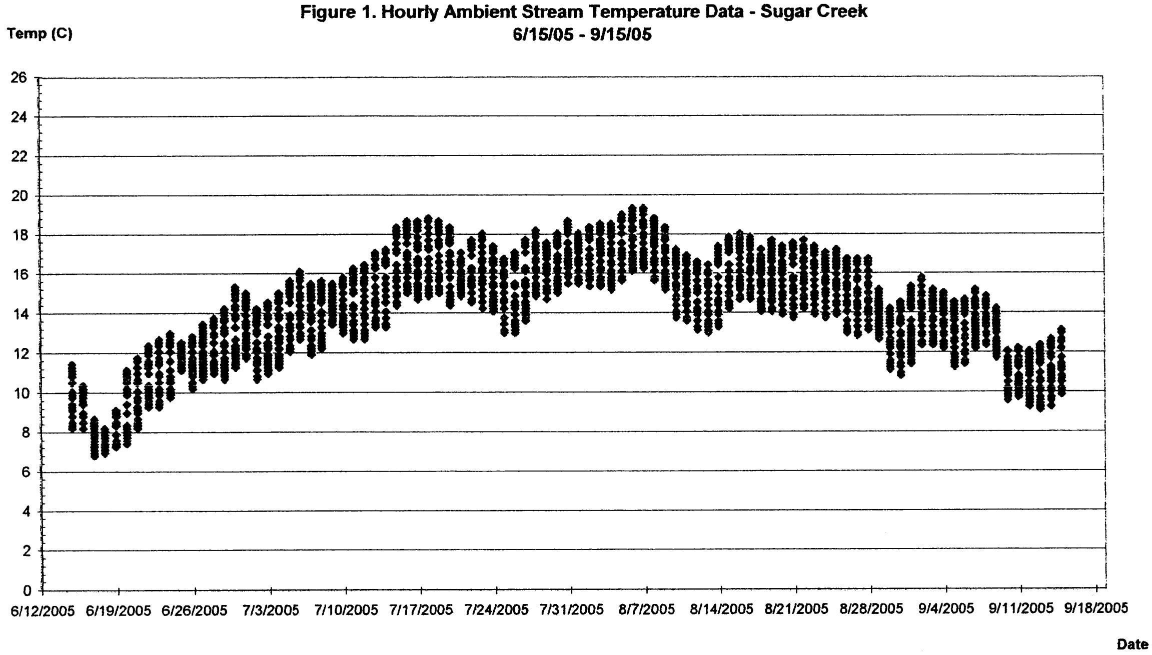
Sugar Creek's watershed is 8,914 acres. The watershed's land use is primarily mixed federal and private timberlands (headwaters in the Russian wilderness area) with small private landowners occupying the bottomlands. The last 1,000 feet of Sugar Creek's channel is constrained by tailing piles (Highway 3 to confluence). The Siskiyou RCD has performed a ditch-piping project in Sugar Creek to increase instream flows, excluded all pastureland from the riparian corridor, and protected all diversion ditches with fish screens.

Water Quality:

The Siskiyou RCD has monitored summer stream discharge in lower Sugar Creek since 2002. Sugar Creek's low flow discharge is approximately 1 cfs, during an average water year, and lasts throughout August and September. A stream discharge of .8 cfs was documented at the time of the survey. Sugar Creek usually remains connected to the Scott River throughout the low flow period.

The Siskiyou RCD has monitored instream water temperatures in lower Sugar Creek from 2002 to the present. Average MWAT for the lower site is 17.2° C. Ambient stream temperatures from 6/15/05 – 9/15/05 are displayed in Figure 1. The seven-day MWAT during this period was 17.4° C. Hourly ambient stream temperatures in Sugar Creek did not exceed 20° C between 6/15 and 9/15. This indicates that there are stream waters suitable for juvenile coho salmon rearing throughout Sugar Creek. In addition, benthic macroinvertebrate samples collected in 2003 at lower Sugar Creek showed a Benthic Invertebrate Index of Biological Integrity (BIBI) score of 46-48 out of a maximum of 50. Other areas which received comparable scores were Upper French Creek and the South Fork Scott. (*Stream Inventory Report, Scott River Watershed,* 2003)

Figure 1. Hourly Ambient Stream Temperature Data - Sugar Creek
6/15/05 - 9/15/05



Lower Sugar

Habitat Characterization:

This reach is a low-gradient, alluvial channel, characterized by the presence of several beaver dams. The bottom portion's (Below Highway 3) floodplain is constrained by historic tailing piles. The streambed substrate is dominated by gravel – with a relatively high occurrence of decomposed granite fines. During summer flows this reach has alternating riffle and run habitat with several long shallow glides associated with beaver dam impoundments. No observed habitat units were designated pools, because all units failed the criteria of having a defined scour hole 2 times the depth of the pool tail crest. Several runs observed in this reach could also be viewed as shallow, partially filled pools. Most of the stream channel is bordered by mature riparian and terrestrial vegetation, except for the areas where tailing piles preclude the establishment of riparian stock. A mature riparian corridor and large amounts of coarse woody debris in and across the stream characterized the upper part of this alluvial reach.

Adult coho spawning:

Sugar Creek was extensively surveyed for adult coho spawning during the winter of 2004-2005 (Quigley, 2005). A total of 26 redds were observed in the lowest .7 miles of Sugar Creek (below Hwy 3). Multiple fish on redds and superimposition of redds was documented in this alluvial reach.

Survey Results:

A total of ten habitat units were surveyed in the lower reach: 2 riffles and 8 runs. No pools were observed in the parts of this reach surveyed.

Table 1. Average density by habitat type of juvenile coho salmon
Lower Sugar Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Riffle	0.13	0.12	2	0.04	0.22
Run	1.23	0.42	8	0.69	1.99

The majority of the habitat units encountered in this reach were long shallow runs (greater than 100 feet) in which large amounts of fish were observed from the surface. The fish were observed throughout the habitat (sometimes in relatively dense groups) and showed little fidelity to a location. The large area of habitat combined with a high density of fish that are actively moving increased the difficulty of the surveying of these large runs using direct observation techniques. A sub-sample of the smaller runs and a representative portion of the bigger runs were surveyed to capture representative densities of utilization in this reach.

All habitat units surveyed in the Lower Sugar reach were observed to contain coho salmon. The relatively high variance in observed densities in "similar" habitat types generates a high standard deviation when attempting to average densities to determine "utilization coefficients" for individual habitat types. This high variance indicates that other variables than meso-habitat type affect observed rearing densities of juvenile coho salmon in this reach.

Table 2. - juvenile coho densities in individual dive units
Lower Sugar

Unit#	Habitat Type	average coho	length	area	volume	coho/ft2	coho/ft3	**coho/m^2**
1	Riffle	13	37	629	252	0.021	0.052	**0.22**
2a	Run - bottom of unit	186	67	1005	804	0.185	0.231	**1.99**
2b	Run - top of unit	214	115	1955	1955	0.109	0.109	**1.18**
3	Run	72	80	1120	1120	0.064	0.064	**0.69**
4	Run	43	32	416	333	0.103	0.129	**1.11**
5	Run - below bridge	150	76	950	475	0.158	0.316	**1.70**
6	Run	72	54	675	743	0.106	0.096	**1.14**
7	Run	113	80	1160	696	0.097	0.162	**1.05**
8	Riffle	1	28	246	99	0.004	0.010	**0.04**
9	Run	106	40	580	290	0.183	0.366	**1.97**

Riffles:

One riffle (photo 38) that contained marginal microhabitat (deeper velocity refuge) was observed. This riffle's microhabitat was occupied by a group of juvenile coho (approximately 13). The portion of this habitat unit that exhibited the physical characteristics of a riffle (fast and shallow water) was not occupied by coho. The other surveyed riffle was characteristically shallow and uniform without pocket microhabitats. A single juvenile coho was observed in this riffle.

Runs:

Eight runs were surveyed showing densities with a large range (from .7 to 2.0 coho/m$^{2)}$. Many of these coho were observed in the middle of the channel actively feeding (fish observed feeding on terrestrial insects in one site in the early morning) (photo 37). These fish were not utilizing any observable overhead or instream cover.

Groups of coho were also observed utilizing marginal cover elements, mainly overhanging terrestrial vegetation (willows) and undercut banks (sometimes formed by beaver holes). Habitat units with less wetted width had greater amounts of the channel covered with terrestrial vegetation (photo 40) and had relatively high densities of coho salmon (Unit #5 - 1.7 coho/m^2).

Surveyed run habitats showed densities expected (Nickelson, 1992) for runs at the lower densities observed and for pools at the higher densities observed, indicating that runs can support densities of juvenile coho normally associated with pools.

Several habitat units were very long runs with fish readily observed throughout the stream. These fish were actively moving and easily displaced from natural habitats. Some of these units were not surveyed due to the infeasibility of accurately estimating the population.

Middle Sugar Creek

Habitat Characterization:

The channel in this reach is a B channel dominated by bedrock, cobble and boulders with a relatively high pool occurrence (15% by length) interspersed with riffles (58% by length) and runs (27% by length). This reach maintains good mature canopy throughout with some terrestrial brush offering overhead and in-water cover along the margins. The majority of fish cover is substrate (boulder and bedrock) and bubble curtain. However, there is an occurrence of a variety of fish cover elements: small woody debris, terrestrial vegetation in and over water, and undercut banks associated with root mass.

Survey Results:

A total of 16 habitat units were surveyed. Habitat types included a variety of riffle (4 units), flatwater (5 units), and pool types (7 units surveyed).

Juvenile coho were observed in all units except the mid-gradient riffle. Average coho densities are similar to what is reported in the literature: pools holding a higher density than run habitats. The variance between dives in similar habitat units is smaller than that observed in the lower reach. This could indicate more uniform habitat features throughout this short reach. The majority of coho observed in this reach were utilizing the deeper waters of the thalweg or scour hole. The mature canopy along with an abundance of small woody debris offered the majority of fish cover.

The observed densities in Middle Sugar are some of the highest for non-alluvial stream reaches surveyed in the Scott River, demonstrating that a small discharge of high quality water in excellent habitat can rear a significant amount of juvenile coho salmon. Inspection of the single dive data shows that these habitat units usually held forty to a hundred coho salmon each.

Table 3. Average density by habitat type of juvenile coho salmon
Middle Sugar Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Mid-Gradient Riffle	0.00		1	0.00	0.00
Riffle	0.17	0.06	3	0.12	0.23
Step Run	0.35		1	0.35	0.35
Run	0.69	0.14	4	0.54	0.88
Small Bdrock pools	0.51		1	0.51	0.51
Trench Pool	1.07	0.02	2	1.05	1.08
Bedrock plunge pool	0.86	0.11	2	0.79	0.94
LSP - Bedrock	1.02		1	1.02	1.02
LSP-Boulder	1.67		1	1.67	1.67

Table 4. - juvenile coho densities in individual dive units
Middle Sugar Creek

Unit#	Habitat Type	average coho	length	area	volume	coho/ft2	coho/ft3	coho/m^2
10	Run	89	94	1429	1429	0.062	0.062	**0.67**
11a	Riffle	8	74	722	361	0.011	0.022	**0.12**
11b	Small bedrock pools	18	30	383	383	0.047	0.047	**0.51**
12	Plunge Pool - Bedrock	57	30	780	1560	0.073	0.037	**0.79**
13	Plunge Pool - Bedrock	39	28	448	896	0.087	0.044	**0.94**
14	LSP - Bedrock	54	48	570	741	0.095	0.073	**1.02**
15	Run	20	24	317	238	0.062	0.083	**0.67**
16	Run	81	87	1610	1610	0.050	0.054	**0.54**
17	Step Run	15	44	449	314	0.032	0.140	**0.35**
18	Trench Pool - Bedrock	33	33	330	396	0.101	0.084	**1.08**
19	Mid-Gradient Riffle	0	25	275	83	0.000	0.000	**0.00**
20	Riffle	8	50	375	150	0.021	0.053	**0.23**
21	Trench Pool	40	45	405	405	0.098	0.098	**1.05**
22	Run	40	35	490	392	0.082	0.089	**0.88**
23	Riffle	3	24	194	97	0.015	0.031	**0.17**
24	LSP - Boulder	124	53	795	1272	0.156	0.097	**1.67**

Upper Sugar Creek – Above Tiger Fork

Habitat Characterization:

This reach begins above the input of the Tiger Fork. Stream channel gradient in this reach is higher than Middle Sugar. Substrate is dominated by boulder. Deep low energy habitat units – pools (12% occurrence by length) and runs (27% occurrence by length) - are interspersed with high energy cascades and long reaches of mid - gradient riffle (60% occurrence by length). Several habitat units surveyed contained good cover offered by woody debris and overhanging terrestrial vegetation. The relatively narrow channel allows for an increased occurrence of terrestrial vegetation offering direct fish cover. The majority of fish cover was still created by substrate and bubble curtain. Several stretches of relatively high gradient channel were documented along with one logjam. These obstacles could potentially impede upward migration of adults and/or juveniles.

Spawning data:

Adult coho surveys completed in 2004-2005 documented 14 redds in the 2.1 mile reach of Upper Sugar Creek (from Upper FGS bridge to the cattle guard). This spawning survey reach includes both the middle and upper Sugar reaches surveyed for juvenile rearing (Map 4). The highest observed coho redd was .6 miles above Tiger Fork. This mountainous stream is highly limited in available spawning gravel, due to the preponderance of large cobble and boulder. Adult coho were observed utilizing introduced substrate (gravel road bed of a stream crossing) for redd formation in areas of this high grade (large streambed substrate) reach.

Survey results:

A total of 16 habitat units were surveyed – nine runs and seven pools – in the Upper Sugar Creek reach to determine the upper extent of coho utilization in Sugar Creek and to document some representative rearing densities in this small steep stream.

Table 5. Average density by habitat type of juvenile coho salmon
Upper Sugar Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Run	0.62	0.37	9	0.05	1.12
Plunge pool	0.34	0.00	1	0.34	0.34
Pool - Deep Run	0.35	0.00	1	0.35	0.35
LSP - Boulder	0.37	0.00	1	0.37	0.37
LSP - Bedrock	0.74	0.17	3	0.54	0.86
Pool - dammed	0.55	0.00	1	0.55	0.55

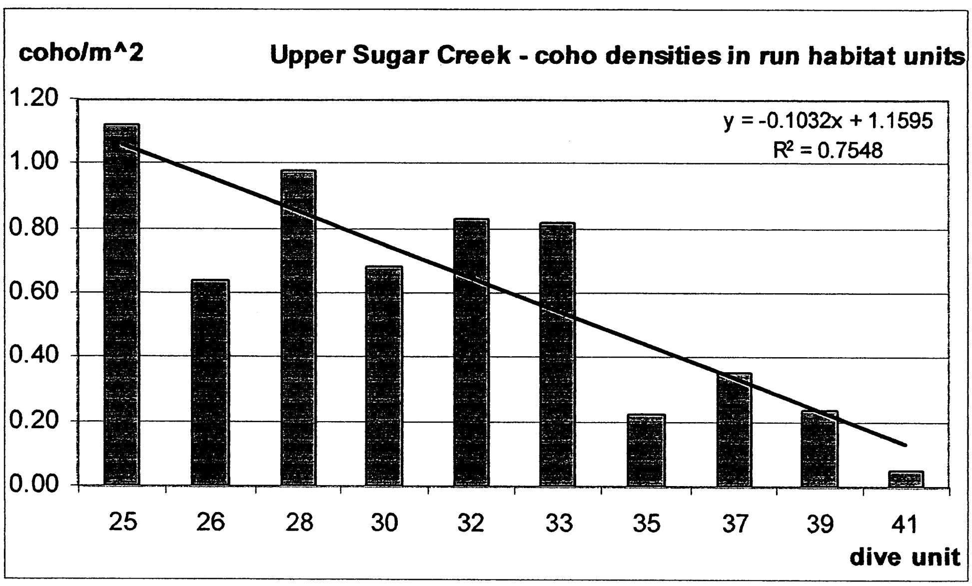
The calculated average densities of coho utilization in runs are relatively similar between the middle and upper reach. Yet it is important to note that the range of observed values for runs is extremely divergent. Inspection of the adult spawning distribution (Map 4) demonstrates that a relatively high occurrence of spawning occurred in the lower half of the surveyed reach with little spawning occurring in the top half. The available stream cover and canopy throughout this reach is relatively consistent. The main limitation to rearing in the upper reach is the ability of the juvenile coho to migrate upstream to occupy suitable habitat. An increase in gradient and occurrence of long stretches of steep shallow water as you move upstream in this reach, could increase the difficulty of occupying the highest habitats.

All units surveyed had presence of juvenile coho salmon, until the surveyor reached the suspected upper extent of rearing. Several hundred yards of stream were further surveyed in search of juvenile coho above this point, and none were observed. It was infeasible to survey ten pools above the suspected upper extent due to time constraints. This survey allowed us to document juvenile coho rearing .4 miles past the last observed coho redd. Some of these juvenile coho were observed to have moved above long steep reaches and a logjam. No obvious barrier to upward migration of juvenile coho was observed at the location of suspected upper extent.

Table 6. - juvenile coho densities in individual dive units
Upper Sugar Creek above Tiger Fork

Unit#	Habitat Type	average coho	length	area	volume	coho/ft2	coho/ft3	coho/m^2
25	Run	23	22	218	174	0.104	0.130	**1.12**
26	Run	13	24	224	224	0.059	0.059	**0.64**
27	LSP - Bedrock	17	30	180	162	0.092	0.185	**0.99**
28	Run	36	36	396	356	0.091	0.101	**0.98**
29	Mid-Channel Pool/ Glide	91	82	1353	2030	0.067	0.045	**0.72**
30	Run	8	18	126	113	0.063	0.071	**0.68**
31	Pool	93	91	1820	2912	0.051	0.032	**0.55**
32	Run	17	17	221	179	0.077	0.095	**0.83**
33	Run	17	16	224	179	0.076	0.095	**0.82**
34	LSP - Boulder	6	16	176	134	0.034	0.045	**0.37**
35	Run	10	32	480	319	0.021	0.031	**0.22**
36	LSP - Bedrock	26	40	520	520	0.050	0.050	**0.54**
37	Deep Run - Shallow Pool	11	26	338	450	0.033	0.024	**0.35**
38	LSP - Bedrock	53	44	660	1089	0.080	0.048	**0.86**
39	Run	8	23	368	368	0.022	0.022	**0.23**
40	Plunge Pool	3	12	96	106	0.031	0.028	**0.34**
41	Run	1	21	231	219	0.004	0.005	**0.05**

The density of coho salmon rearing in similar run habitats decreased as we moved upstream towards the documented upper extent of coho rearing. This demonstrated an upstream movement of juvenile coho, but showed densities in upstream suitable habitats were less than densities in similar units close to adult spawning.



French Creek

Two reaches were surveyed in French Creek – a middle alluvial reach (Mid-French) and an upper higher gradient reach above the North Fork (Upper French) (See Map 5). The Middle French reach is below the confluence of Miner's Creek and encompasses .94 miles of creek, including a site that was historically surveyed for FCWAG biological monitoring (FC1a). The Upper French reach is .41 miles long and centered around the confluence of Payne's Creek with French Creek.

A cooperative pilot project was performed in the Middle and Upper French reaches as part of the French Creek Watershed Advisory Group's (FCWAG) biological monitoring, utilizing the direct observation data collected for this project, to determine the feasibility of performing a basin-wide population estimate using calibrated direct observation data (Hankin and Reeves, 1998).

Additional direct observation surveys were performed in three locations above the Upper French reach in cooperation with electro-fishing efforts (FCWAG sites FC3 + FC4) and in order to determine the upper extent of juvenile coho utilization. No direct observation surveys were performed in Miner's Creek due to time limitations.

Watershed Overview:

The French Creek watershed is 20,584 acre. Land ownership in French Creek is: 54% USFS (including headwaters in Russian Wilderness Area), 35% private timber industry, and 11% rural residential and ranches. A high incidence of granite in French Creek's watershed causes a relative high occurrence of small sediment (decomposed granite) in channel. The FCWAG was established in 1990 to cooperatively address sediment source issues (upland roads and drainage systems) in a mixed ownership watershed. Ongoing biological and physical monitoring has been performed in sites in middle and upper French Creek (FCWAG 1992, Mariah 2005).

All agricultural diversions in areas of French Creek utilized by coho salmon are fish screened. Most of the agricultural riparian areas are fenced to exclude livestock. Fish friendly vortex weirs have been installed at head gates to reduce the need to annually alter the stream for irrigation.

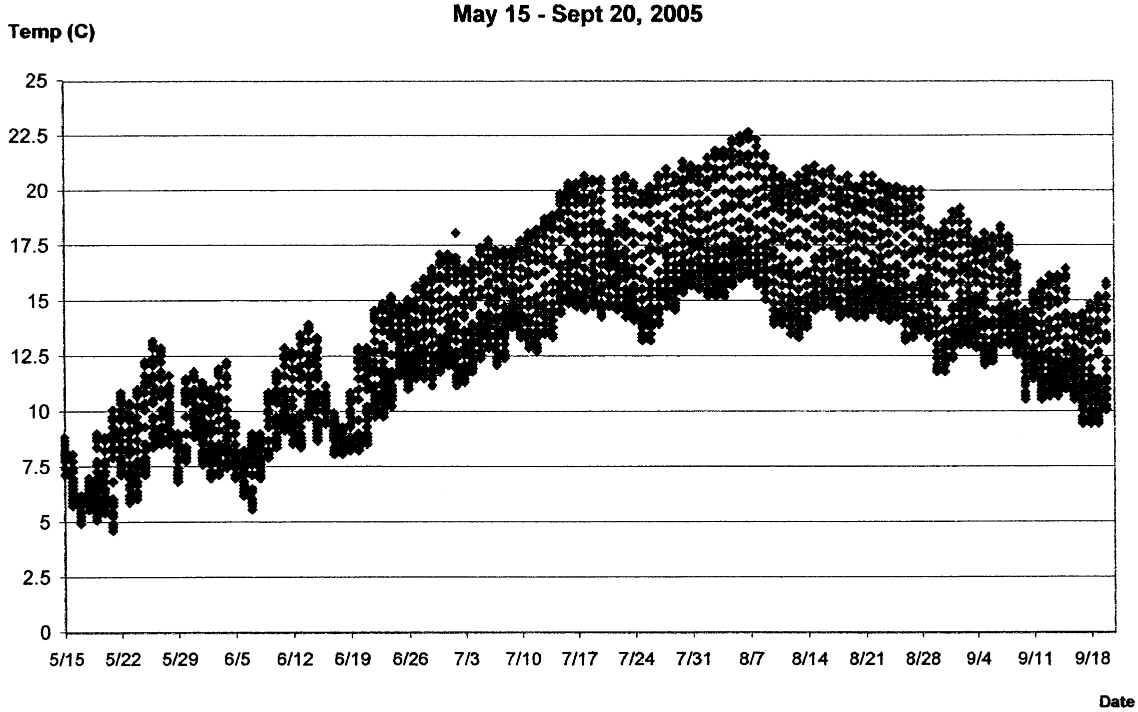
Temperature and Flow:

A flow gage on French Creek above the North Fork has been operated during water master season (April – October) off and on since the 1960's. The California Dept. of Water Resources has a permanent flow station at Highway 3, which was established in 2003. This station is in operation year round, but is only rated for low flow. Data from water year 2005 shows French Creek at low flow stage from late July through Mid-September.

The mouth of French Creek was observed to be disconnected in late September, 2005. The full period of disconnection in 2005 is unknown.

The Siskiyou RCD has monitored the instream temperature in the lower and middle alluvial reaches since 1996 and 2002, respectively. Temperatures documented in the middle alluvial reach (Appendix A) are within suitable range for salmonid rearing. Temperatures in the lowest alluvial section above the mouth are higher than those documented above, but most years documented show an MWAT less than 20' C. Hourly ambient stream temperatures documented in a riffle in the Mid French survey reach during the summer of 2005 are shown in Fig. 1.

Figure 1. Hourly Ambient Stream Temperature Data - Mid French Cr.
May 15 - Sept 20, 2005



Spawning Data:

A large portion of French and Miner's Creek was surveyed in 2004-2005 for adult coho spawning (Quigley, 2005). Adult coho redds were found throughout the surveyed lower gradient reaches of French and Miner's Creek – additionally a few redds were observed in the higher gradient upper reach (Map 5):

Reach	Description	Distance	# redds
French Creek			
Lower	Hwy 3 to mouth	0.7	20
Middle	Miner's confluence to above Hwy 3	1.63	27
Upper	Payne's Creek and Duck Lake	1	2
Miner's Creek	From access to confluence	0.9	43

Habitat Characterization:

Middle French

The middle reach is a low gradient channel (0% - 1% grade in survey reach) with a large connected flood plain and extensive side channels that contain water at an unknown stream discharge. Few side-channels were connected during the period of survey in 2005. The dominant substrate of the streambed is gravel and cobble with a high occurrence of decomposed granite throughout the reach. The riparian condition in the middle reach surveyed is good to excellent – characterized by mature stands of alders and areas of large willows along the banks. Pool occurrence in the reach is relatively low (approx. 5 – 10% by length) and the reach is dominated by flatwater (approximately 60% by length) interspersed with riffles (approximately 30% by length). Few pools (4 in a .94 mile reach) were observed in the Middle French reach during the time of survey. Survey crews used the criteria that a pool had to be at least twice as deep as its pool tail crest and that the pool's scour hole had to span at least one half the width of active channel. Often flatwater units with deep sections were observed with a scour hole not sufficiently developed to warrant pool designation. Long runs and glides were relatively prevalent in this reach, including a very large glide above a vortex weir that contained a large volume of suitable habitat for rearing salmonids.

A variety of fish cover was offered in many of the units surveyed. Fish cover was offered by terrestrial vegetation over and in the water, aquatic vegetation, small and large woody debris, undercut banks and root mass. Several units surveyed offered complex fish cover generated by multiple cover elements existing together; e.g. woody debris, undercut, and terrestrial vegetation in the same unit. Several large and complex log jams with water going under and through were documented in this reach. It was not feasible to survey these wood aggregates.

Survey Results:

Middle French

Twenty three (23) individual habitat units were surveyed in a .94 mile reach in Middle French Creek (Table 1) – five riffles, fourteen flatwaters, and four pools.

Table 1. Average density by habitat type of juvenile coho salmon Mid French Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
riffle	0.01	0.01	5	0.00	0.03
glide	0.93	0.14	4	0.72	1.04
run	1.31	0.72	9	0.61	2.62
side channel - run	1.54		1	1.54	1.54
plunge pool	1.85		1	1.85	1.85
LSP - rootwad	2.33	0.43	2	2.02	2.64
LSP - wood	3.79		1	3.79	3.79

Almost all habitat units surveyed (except for riffles) had densities equal to or greater than the summer habitat utilization coefficients in Nickelson's Habitat Limiting Factor Model (Nickelson, 1992).

Table 2. - juvenile coho densities in individual dive units
Mid - French

unit #	habitat type	ave coho	length (ft)	area (ft^2)	vol (ft^3)	coho/ft^2	coho/ft^3	coho/m^2
3	riffle	0	37	389	117	0.00	0.00	0.00
15	riffle	0	22	154	46.2	0.00	0.00	0.00
22	riffle	0	43	753	339	0.00	0.00	0.00
7	riffle	2	77	1309	392.7	0.00	0.01	0.02
9	riffle	1	36	396	150	0.00	0.01	0.03
21	run	69	64	1216	608	0.06	0.11	0.61
5	glide	95	59	1416	1982	0.07	0.05	0.72
8	run	100	85	1445	1012	0.07	0.10	0.74
10	run	41	39	517	258	0.08	0.16	0.85
2	run	56	57	656	328	0.09	0.17	0.92
18	glide	149	111	1721	1721	0.09	0.09	0.93
6	glide	148	83	1577	2366	0.09	0.06	1.01
12	run	70	49	735	368	0.10	0.19	1.02
23	run	78	45	810	567	0.10	0.14	1.04
1	glide - (FC-1a)	380	157	3925	5691	0.10	0.07	1.04
19	side channel - run	39	26	273	191	0.14	0.20	1.54
14	run	94	52	572	572	0.16	0.16	1.77
16	plunge pool	33	24	192	240	0.17	0.14	1.85
17	LSP - rootwad	94	40	500	450	0.19	0.21	2.02
20	run	133	46	644	451	0.21	0.29	2.22
13	run	125	61	512.4	640.5	0.24	0.20	2.62
4	LSP - rootwad	322	71	1314	1576	0.25	0.20	2.64
11	LSP - wood	67	20	190	190	0.35	0.35	3.79

Three out of five riffles were the only habitat units in which juvenile coho salmon were not observed. The shallow depths found in the riffles did not often offer deeper microhabitats suitable for juvenile coho rearing. Juvenile trout were prevalent throughout the riffle habitats.

The majority of habitat units surveyed were runs (n = 10) and glides (n = 4). Glides are differentiated from runs by their greater depth and slower uniform surface velocity. Densities of coho utilization observed in glides were relatively similar (.72 – 1.04 coho/m^2). Surveyed glides contained areas of open water without any observable direct overhead cover and areas with cover – mostly offered by substrate cover, conglomerates of small woody debris, and undercut banks associated with root mass and overhanging terrestrial vegetation. Coho were observed in glides both actively feeding in the middle of the channel without any observable cover and in areas that offered elements of fish cover. Glides were the largest habitat units encountered in the Mid-French reach with large amounts of fish observed freely moving around in the large volume of suitable habitat. The large volume of water occupied by moving fish increases the difficulty of utilizing direct observation to generate accurate population estimates in these habitat units.

One glide surveyed was French Creek WAG site – FC1a. This site has been electro-fished from 1992 – 2004 as a biological monitoring site for effectiveness of restoration in the French Creek watershed. In 2005, access for electro-fishing was denied. The population estimate from direct observation surveys is the only existing population data for this site in 2005.

Runs were the most frequent and most surveyed habitat type in the Middle French reach. Runs had the highest variance of coho densities within a habitat type. This variance is likely due to difference in habitat characteristics (e.g. fish cover and/or depth) offered by each habitat unit. Coho densities in several runs were similar to densities observed in pools with fully formed scour holes. The run with highest documented coho density (Unit #13) featured complex habitat cover offered by undercut banks and a large conglomerate of small woody debris associated with root mass. The additional highly utilized runs (Unit #14 and Unit #20) did not offer complex cover but were characterized by having areas of greater depth than many of the other runs. Fish were often observed utilizing areas of no over head cover in the middle of the channel in the deeper parts of these runs.

The runs with low to middle density often offered shallower water and little fish cover. Small amounts of small woody debris or overhead cover from terrestrial vegetation were observed in these units. Fish were often observed utilizing the middle of the channel with no direct overhead cover. Coho were, additionally, utilizing the little available fish cover in these units.

The single surveyed side-channel run had densities at the low end of the highest density runs. This is contrary to relatively high densities observed in side channel habitats in other tributaries, e.g. South Fork Scott River. This unit did not have any significant cover, yet fish were found throughout the suitably deep water column. The availability of fish cover and/ or increased depth in runs appears to increase potential carrying capacity of this common habitat unit in the Mid – French reach. Relatively uniform riparian corridor and canopy and adult spawning throughout this survey reach, could allow for the observation of the dependence of coho densities on instream cover and depth.

The four pool habitats surveyed showed some of the highest coho densities observed in this reach of French Creek. A small lateral scour pool (LSP) formed by coarse wood associated with terrestrial vegetation (Unit 11) had the highest density of fish observed in this reach. The wood conglomerate covered almost 2/3 of the scour hole in this unit and all coho observed were holding under this cover. The other pools contained some elements of fish cover, including: small woody debris, undercut banks, and aquatic vegetation. Direct cover over the pool's scour hole was often limited. The coho observed in these pools were mostly utilizing the deep water of the scour hole with some utilizing small woody debris along the pool's margin, if available. Fish were often observed in relatively high density in the pool's scour hole, (e.g., approximately 300 juvenile coho in a large swarm in one pool).

Upper French Creek

Habitat Characterization

The Upper French Creek reach is higher gradient (approximately 2% grade in the survey reach) and is characterized by a high occurrence of boulders and large cobble in the streambed. Decomposed granite was prevalent in much of the interstitial spaces between the large substrate and along the banks. The riparian corridor is predominantly mature alder throughout the reach with almost total canopy and shade. Pool occurrence is low (approximately 3% by length) with the majority of habitat consisting of alternating flatwater and riffle (approx. 49% and 48% by length, respectively).

Large substrate and bubble curtains create the majority of fish cover. Small and large woody debris is found frequently and offers fish cover, but it is often just outside of the low flow active channel. Undercut banks, root mass, and terrestrial vegetation were also observed offering fish cover in this reach.

Survey Results:

Fifteen individual habitat units were surveyed in the Upper French Creek reach – 2 riffles, 10 runs, and 3 pools. Juvenile coho were observed in all habitat unit surveyed, except one riffle. Densities of juvenile coho utilization were considerably lower than those observed in the lower Mid-French reach. The average densities of runs in this higher gradient, higher energy reach are still relatively high compared to other similar reaches in Scott River watershed (Mid-South Fork) and comparable to reaches in Sugar Creek.

Table 3. Average density by habitat type of juvenile coho salmon

Upper French Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
riffle	0.03	0.04	2	0.00	0.05
step run	0.14	0.00	1	0.14	0.14
run	0.66	0.38	9	0.15	1.26
plunge pool	0.63	0.07	2	0.58	0.68
LSP - bedrock	0.74	0.00	1	0.74	0.74

In-stream fish cover is relatively rare in this reach with some small woody debris and overhanging terrestrial vegetation observed. Bubble curtains and large substrate (boulder and large cobble) create the vast majority of available fish cover in this upper reach. Large substrate plays an important role by generating suitable microhabitats of lower velocity then surrounding waters. These areas of velocity refuge were often seen utilized by juvenile coho in habitats that otherwise had no suitable cover or water velocity. Marginal microhabitats, created by a large substrate velocity refuge associated with small woody debris, were also observed as offering rearing habitat for juvenile coho. In channel small woody debris was observed being utilized by coho salmon, when available. The unit with highest coho density (Unit 11) featured small woody debris associated with a small scour hole.

Table 4. - juvenile coho densities in individual dive units
Upper - French

unit #	habitat type	ave coho	length (ft)	area (ft^2)	vol (ft^3)	coho/ft^2	coho/ft^3	coho/m^2
14	riffle	0	18	211	126	0.00	0.00	0.00
4	riffle	2	33	429	300	0.00	0.01	0.05
7	step run	6	30	450	405	0.01	0.01	0.14
15	run	9	38	608	304	0.01	0.03	0.15
13	run - shallow	11	32	426	298	0.02	0.04	0.27
6	run	14	29	493	444	0.03	0.03	0.29
3	run - bedrock trench	7	16	160	160	0.04	0.04	0.47
1	plunge pool bedrock	49	50	900	1080	0.05	0.04	0.58
8	riffle/run	24	24	384	307	0.06	0.08	0.67
5	plunge pool	62	49	980	1078	0.06	0.06	0.68
12	LSP bedrock/run	54	60	780	858	0.07	0.06	0.74
9	run	30	37	389	389	0.08	0.08	0.82
2	run/trench pool	80	87	1001	921	0.08	0.09	0.85
10	run	87	46	920	1104	0.09	0.08	1.02
11	deep run/small pool	49	30	420	504	0.12	0.10	1.26

Habitat units offering deeper, lower velocity water were often utilized by juvenile coho at higher densities than shallower and faster units. A velocity micro-habitat (behind boulder) allowed juvenile coho to occupy a riffle habitat, but coho were not found in any high velocity waters characteristic of riffles. In a representative riffle/run habitat (Unit #8) all coho were observed in deeper marginal velocity refuges with and without additional cover from small woody debris. No coho were found in the shallower higher velocity portion of this unit. Several of the units with higher densities of juvenile coho utilization offered no overhead cover, but they offered areas of deeper, low velocity water (scour holes and deep pockets behind large substrate). Shallower units (Unit #15 & #13) without deep microhabitats and units characterized by higher velocity flow (step run) often had lower densities of juvenile coho. The existence of a low velocity habitat or microhabitat in this relatively high gradient stream (for juvenile coho rearing), often determines the presence of rearing juvenile coho.

Payne's Creek

Five juvenile coho were observed in a small pool (64 ft^2) in Payne's Creek about 20 feet above the confluence.

Surveys above Upper French Creek reach:

Three spot surveys were performed above the Upper French Creek reach- FC3, FC4, and a short reach above FC3. Juvenile coho were observed only in FC3. An area of stream between FC3 and the surveyed reach above was not surveyed due to lack of access. It is indicated that the upper extent of summer rearing is some where above FC3 and below the surveyed reach. Additionally, the low density of observed juvenile coho in FC3 - .01 coho/m^2 – could indicate that this location is relatively close to the upper extent of juvenile coho rearing.

Etna Creek

A short reach was surveyed on Etna Creek to determine juvenile coho presence and the upper extent of rearing (Map 6).

Watershed Overview:

Etna Creek drains a 27,500-acre watershed. Etna Creek's headwaters are in the wilderness with timberlands throughout the top and middle of the watershed. The lower gradient and alluvial portion of the watershed contains residential, municipal (city of Etna), and agricultural land. Etna Creek has Etna's city water diversion and agricultural diversions. All agricultural diversions have been screened. The alluvial fan (below Highway 3) normally goes dry during low flow due to subsurface flow.

Flow and Temperature:

Few surveys to determine available physical habitat types in Etna Creek have been performed to date. No flow data has been collected, but base flows are estimated to vary from 3 – 6 cfs at the City of Etna Diversion. Temperature data has been collected above the surveyed reach by Timber Products Co. This data indicates that this portion is within the desirable range. A water temperature of 14° C at 15:00 was recorded during surveys on September 6, 2005, demonstrating the available cold water in this mid gradient reach.

Habitat data:

The reach of Etna Creek surveyed was characterized by a wide and shallow low to mid gradient channel (approximately 1%). The streambed composition was dominated by large substrate - cobble and boulder. Excellent mature canopy was present throughout the reach surveyed. This canopy offered a microclimate of shaded cooler air. The relatively wide channel precluded much of this terrestrial vegetation from offering direct fish cover – riparian vegetation was often several feet from the stream's wetted edge. The majority of fish cover observed in this reach was offered by the large stream substrate. Additionally, woody debris (including a large log jam) offered fish cover in some areas of the surveyed reach.

Spawning data:

Adult coho spawning surveys have been performed in Etna Creek from 2002 – 2004 (Quigley, 2005). Adult coho were observed spawning in Etna Creek for the first time in the winter of 2004 - 2005. During these surveys, crews observed 7 redds in 1 mile of reach. The juvenile habitat reach surveyed was the upper portion of the adult spawning reach, with two redds observed in 2004-2005. The highest redd observed in 2004 was 150 to 200 yards below the Etna City Water Diversion Dam.

In the winter of 2004 - 2005 the lowest 2.25 miles of Etna Creek (Highway 3 to Mouth) was surveyed, and 50 coho redds were observed. This reach normally goes dry during low flows and was dewatered in 2005.

Survey Results:

Thirteen (13) individual habitat units were surveyed in Etna Creek below the dam and two units were surveyed above the dam (Table 1).

Table 1. Average density by habitat type of juvenile coho salmon
Etna Cr.
below Etna city diversion

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
riffle	0.06	0.04	2	0.04	0.07
step run	0.38	0.02	2	0.37	0.39
run	0.51	0.08	4	0.43	0.61
plunge pool	0.17		1	0.17	0.17
LSP-bedrock	0.41		1	0.41	0.41
riffle - side channel	0.00		1	0.00	0.00
run - side channel	0.36		1	0.36	0.36
backwater - side channel	0.72		1	0.72	0.72

All surveyed habitat units located below the dam contained juvenile coho salmon, except the side channel riffle. Surveyed runs and pools demonstrated densities lower than other mountainous streams of the Scott River. The two main-channel riffles contained a few coho juveniles in deeper pocket water microhabitats. A backwater side channel with complex cover from woody debris had the highest density of rearing juvenile coho; this is due to its small size. A large flatwater habitat (Unit #5) and a very large scour pool each contained a relatively high number of juvenile coho salmon. Coho were found throughout the margins and thalweg of the pool with little available direct cover. The large run was the unit with the second highest observed density in this reach. This run offered a large aggregate of small and large woody debris along its bottom margin. Almost half of the coho observed in this run were directly associated with (next to or under) this large conglomerate of wood cover.

Table 2. - juvenile coho densities in individual dive units
Etna Creek

Unit#	Hab. Type	average coho	length (ft)	area (ft2)	volume (ft3)	coho/ft2	coho/ft3	coho/m^2
1	LSP-bedrock	151	116	3944	9466	0.038	0.016	**0.41**
2a	step run	14	29	397	317	0.034	0.043	**0.37**
2b	step run	11	20	312	436	0.036	0.026	**0.39**
3a	riffle - side channel	0	20	216	108	0.000	0.000	**0.00**
3b	run - side channel	8	22	242	242	0.033	0.033	**0.36**
3c	backwater - side channel	8	12	120	120	0.067	0.067	**0.72**
4	run	15	24	376	414	0.040	0.036	**0.43**
5	run w/wood aggregate	104	69	1829	1189	0.057	0.088	**0.61**
6	run	39	42	819	901	0.048	0.043	**0.51**
7	mid-gradient riffle	3	40	432	302	0.007	0.010	**0.07**
8	low gradient riffle	2	40	504	353	0.004	0.006	**0.04**
9	run	23	29	493	394	0.046	0.057	**0.49**
10	plunge pool	18	27	1080	4320	0.016	0.004	**0.17**

The averaging of coho densities by habitat type in this reach shows less variance in the densities observed in the individual run units, compared to many other reaches surveyed for this study. This could be due to a more uniform holding capacity due to a uniform availability of fish cover throughout the surveyed stream.

Fish Utilization:

Juvenile coho salmon were often found in the suitable deep low velocity habitats surveyed. The pool and flatwater habitats had coho throughout the deeper waters of the thalweg. These fish are presumed to be actively feeding in the suitable waters under the protection of a mature canopy. Additionally, a preference for available in stream cover was shown by the high density of fish utilizing an area with dense coarse woody debris cover. The only other instream cover fish were observed utilizing was the large substrate of the streambed.

Upper extent of juvenile coho rearing:

Juvenile coho were observed utilizing suitable habitats up to the plunge pool below the dam for the Etna City Diversion. This is documentation that juvenile coho are able to move some distance above their highest spawning location. A fish ladder was in place at the dam, but it is steep with a large amount of high velocity water coming down it (Photo 104). Two ideal habitats surveyed (lateral scour pools with extensive terrestrial vegetation offering cover (Photo 105)) were surveyed above the dam to document presence or absence of juvenile coho salmon. No coho juveniles were found in these ideal habitats above the Etna City Diversion. These observations lead to the conclusion that the fish ladder is ineffective in allowing the upward migration of both adult and juvenile coho salmon past the diversion's dam.

Patterson Creek

A single reach in Patterson Creek was surveyed for representative juvenile coho densities. This reach is .27 miles long, and extends from above the disconnected stream reach to the previously known barrier to adult coho passage.

Watershed overview:

Patterson Creek is a small watershed with an estimated area of 4,000 acres. The land use in the watershed is primarily mixed ownership timberlands and agricultural with a small amount of private residences. All agricultural diversion ditches are screened.

Adult coho spawning:

Three reaches in Patterson Creek were surveyed in the previous winter to determine locations of adult coho spawning (Quigley, 2005). These reaches are: lower (below Hwy 3), middle (above Hwy 3), and upper (from falls down). In the winter of 2004 – 05, survey crews observed 6 coho redds in the upper reach (.3 miles), 19 coho redds in the middle reach (1.6 miles), and 232 redds in the lowest reach (1.3 miles).

The highest redd observed was approximately ¼ of a mile below a known barrier to coho salmon migration – a significant bedrock cascade/ falls.

Flow and Temperature data:

Patterson Creek is a small watershed with loss of connectivity due to subsurface flow in a large portion of its alluvial fan. In the stream reaches of Patterson Creek that are still connected in the low flow period of later summer, there is high quality water within the desirable temperature range for salmonids.

Base low flow above the alluvial fan and agricultural diversions is estimated at 1-3 cfs. No permanent or long term effort to measure discharge on Patterson Creek has been performed. Discharge measurements of 1.3 cfs and 2.1 cfs were documented at two different locations in the surveyed reach on 8/2/05 and 8/4/05, respectively.

The Fruit Growers Supply Co. documents temperatures in the surveyed reach of Patterson Creek. These temperatures - MWAT is 17.4°. – indicate ambient stream temperatures suitable for rearing juvenile coho salmon.

Habitat:

A reach from Highway 3 to the anadromous barrier (7,141 feet) was habitat typed on 8/1/05 and 8/2/05. A large portion of the alluvial stream above and below Highway 3 was going dry, with many fish observed in isolated pools. The stream channel above the alluvial fan was channel typed as B3 – characterized by a moderately entrenched channel with a moderate width to depth ratio and a grade of 2 – 3%. The level 2 habitat units by length in the surveyed reach were: pool – 9%, riffle – 40%, flatwater – 21% and dry 30%. Some of the wetted stream habitat typed existed as stranded islands and likely became dewatered after the survey.

The dominant stream substrate in Patterson Creek is large cobble and gravel. Observed pools had well defined scour holes developed from wood or bedrock hard points. Areas of mature riparian canopy interspersed with areas of open gravel bars and large eroded banks characterize the surveyed reach. Coarse woody debris, undercut bank, and terrestrial vegetation offered direct fish cover in and directly over the water of some habitats. But, some stream sections contain open habitats offering only substrate cover.

Survey Results:

Sixteen different habitat units were surveyed in the Upper Patterson Creek stream reach with connectivity during low flow– 4 riffles, 4 runs, and 8 pools (Table 1). A riffle unit, run unit, and pool unit were surveyed twice in a two-day period to train crews and verify diver accuracy.

All habitat units surveyed contained juvenile coho salmon. Juvenile coho were observed occupying deeper microhabitats (pocketwater) in the riffles surveyed. Patterson Creek had some of the highest observed coho densities in riffle habitats observed throughout this survey. Runs and lateral scour pools exhibited similar, relatively high densities of juvenile coho utilization.

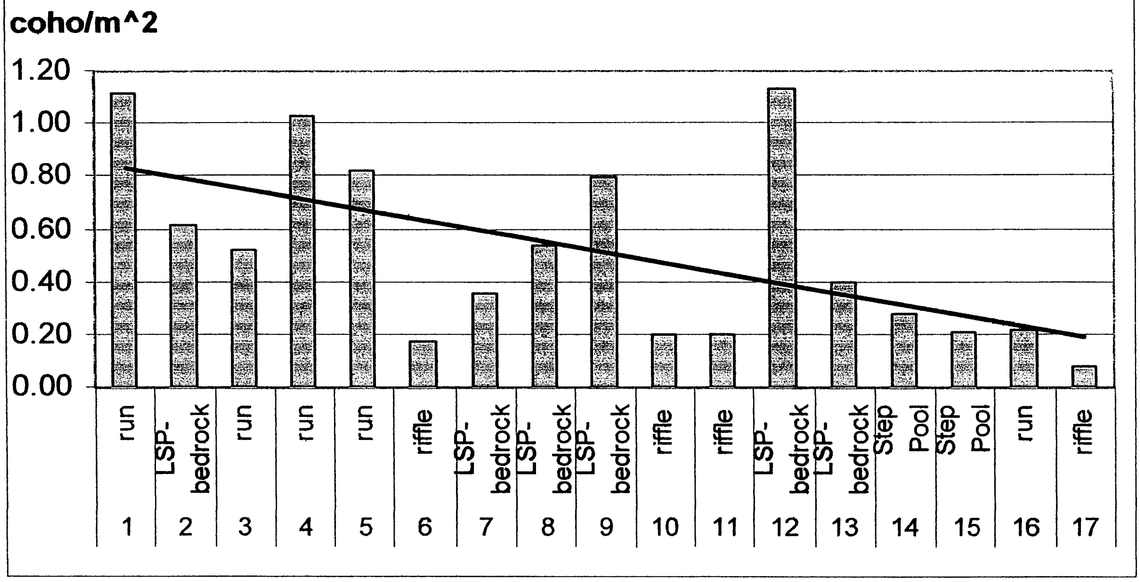
Table 1. Average density by habitat type of juvenile coho salmon
Upper Patterson Creek

habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
riffle	0.16	0.06	4	0.07	0.20
run	0.87	0.26	4	0.52	1.11
Step Pool	0.24	0.05	2	0.21	0.28
LSP - bedrock	0.68	0.28	7	0.36	1.13

Similar habitat types (e.g. runs) had documented densities that varied over a large range. This large range of observed densities (and limitations on sample size) created a large standard deviation when averaging individual dives to determine an average "utilization coefficient" for each habitat type surveyed in the reach. This large standard deviation indicates that variables besides habitat type play a large role in the density of observed juvenile coho rearing. These variables could be: differences in relative seeding due to locations of adult spawning, differences in the occurrence and type of cover elements available to rearing coho, and the occurrence of preferred microhabitat characteristics (areas with deeper water and slower velocity) not resolved with the habitat typing methods utilized.

Inspection of the estimated densities of juvenile coho observed in individual dive units (Figure 2) allows for greater resolution of the patterns of utilization observed in this reach. Inspection of the adult spawning (Map 7) shows that the juvenile surveys started around the upper extent of spawning and continued to the physical barrier. A decrease in relative density can be observed as survey crews moved further upstream towards the physical barrier.

Fig. 1. Patterson Cr. - coho densities by dive unit



For example, the runs surveyed in the lowest section of the reach had densities of 1.1 to .5 coho per m^2 and the last run surveyed (Unit #16) had only .2 coho per m^2. These observations demonstrate upstream movement by juvenile coho to occupy available habitats. It appears that habitats upstream are utilized at densities less than habitats in the close vicinity of adult spawning.

Table 2. - juvenile coho densities in individual dive units
Upper Patterson Creek

unit #	habitat type	average coho	length (ft)	area (ft2)	volume (ft3)	coho/ft2	coho/ft3	coho/m^2
1	run	39	28	372	186	0.103	0.207	**1.11**
2	LSP-bedrock	33	41	574	975.8	0.057	0.033	**0.61**
3	run	39	57	798	399	0.048	0.096	**0.52**
4	run	88	54	918	642.6	0.095	0.136	**1.03**
5	run	38	50	500	200	0.076	0.190	**0.82**
6	riffle	3	22	187		0.016		**0.17**
7	LSP-bedrock	5	20	160	128	0.033	0.041	**0.36**
8	LSP-bedrock	19	30	375	375	0.050	0.050	**0.54**
9	LSP-bedrock	37	37	499.5	849.2	0.073	0.043	**0.79**
10	riffle	4	20	220	132	0.018	0.030	**0.20**
11	riffle	4	20	220	132	0.018	0.030	**0.20**
12	LSP-bedrock	34	36	324	486	0.105	0.070	**1.13**
13	LSP-bedrock	29	47	775.5	1163.3	0.037	0.024	**0.40**
14	Step Pool	9	32	352	352	0.026	0.026	**0.28**
15	Step Pool	6	32	288	288	0.019	0.019	**0.21**
16	run	8	34	374	336.6	0.020	0.022	**0.22**
17	riffle	2	24	216	129.6	0.007	0.012	**0.07**

Additionally, differences in rearing densities are likely due to differences in available instream fish cover. In this reach, we planned to characterize the individual cover available in the dive habitats through the "shelter value" and riparian canopy measurements collected while performing the CDFG "Habitat Typing" Protocol. For this reason, less individual habitat data was collected for each individual dive unit on this stream –e.g. no written description and photograph were taken of each habitat unit. The habitat typing data shows the majority of habitat units surveyed offering some fish cover. Small woody debris, overhanging terrestrial vegetation, and undercut banks often created cover in addition to the ubiquitous cover offered by large instream substrate.

This data shows no significant difference in cover between two bedrock pools (#12 & #13) with different coho densities and areas. Stream canopy was often dense, with some habitat units having little direct instream fish cover but excellent canopy (Unit #4). The surveyed dive units at the bottom of this reach had some of the sparsest fish cover and canopy, yet their densities were above .5 coho per m^2. Insufficient sample size prohibits analyzing the efficacy of utilizing data from CDFG Habitat Typing to observe effects of fish cover and canopy on coho rearing densities. It is also possible that fish cover and canopy are not the controlling variable to habitat suitability in this reach.

Upper Extent of Rearing

Juvenile coho were observed up to the massive plunge pool below a large bedrock cascade. No juvenile coho were observed in the series of step pools above the significant barrier of the falls.

Fish Utilization:

Coho salmon were often observed in the deeper thalweg positions of pools and flatwaters. Though a decent occurrence of instream fish cover was observed, juvenile coho were often found in the open waters with little observable over head or instream cover. This fish appeared to be actively feeding.

Trout were observed through the surveyed reach. Large trout were often observed in microhabitats offering direct cover – undercut banks with root wads in water, small woody debris, or bedrock (substrate) crevices.

Upper Kidder Creek

A single reach (.61 miles) was surveyed in upper Kidder Creek (Map 7). We wished to document presence of juvenile coho salmon and collect some representative densities of juvenile coho utilization in this large mountainous stream.

Watershed Overview:

The Kidder Creek Watershed is 50,144 acres from the headwaters to the confluence with Big Slough. Land use in this watershed is wilderness in the headwaters, private timber upslope, and residential (including town of Greenview) and agricultural in the valley section.

Water Quality-Flow and Temperature:

The Siskiyou RCD has operated a flow gage on upper Kidder from 2002-2005. This gage has documented September base flow fluctuating between 2 and 8 cfs. During the period of the survey, flow was documented at 4 cfs.

Fruit Grower's Supply Co. has monitored stream temperature in Upper Kidder from 2000 – 2005. This location has a MWAT of 16-19°C during summer – demonstrating temperatures within the tolerable range for coho salmon rearing.

A reach of Lower Kidder Creek (above Highway 3 down), characterized by a large alluvial fan, goes dry during summer low flow.

Spawning data:

Three reaches of Kidder Creek were surveyed for spawning adult coho salmon in 2004 – 2005 (Quigley, 2005). 63 redds were observed in the two reaches (1.9 miles) above and below Highway 3. No redds were observed in the upper reach, but live adult coho were observed holding in pools.

Survey crews documented local areas of suitable sorted gravels, adequate for coho spawning, in the Upper Kidder survey reach. Besides these pockets of sorted gravel, the majority of the streambed substrate is boulder and cobble dominated and not suitable for salmon spawning.

Habitat:

Kidder Creek is a large mid gradient (approximately 1%+) mountainous stream. The streambed substrate is dominated by bedrock, boulder, and cobble. This reach is characterized by large pool and flatwater habitats interspersed with low to medium gradient riffle habitats. Exposed bedrock creates most of the pool's deep slow velocity scour holes. This reach had the most exceptional water clarity observed during surveys.

A mature riparian corridor offering canopy and stream shading was present through much of the reach surveyed. However, this terrestrial vegetation offers little direct overhead fish cover in the low flow stream channel. This is due to the large width of the channel and the distance from the riparian vegetation to stream's wetted edge. Very little fish cover other than ubiquitous substrate cover was observed throughout the surveyed stream. This reach offers a high occurrence of large deep habitat units with high quality water but little overhead cover. Coho salmon readily utilized these habitats, regardless of the lack in cover.

Survey results:

Fourteen habitat units were surveyed for presence and relative density of anadromous fish – four runs, nine pools, and one side channel pool (Table 1). Coho salmon were observed in all habitat units surveyed. The densities of coho juveniles in runs and pools are overlapping and relatively similar. However, attempts to average individual surveys of similar habitat types, in order to develop an average density coefficient by habitat type, generate a large standard deviation. This indicates that factors other than habitat type are playing a role in determining the density of juvenile coho utilization in this reach.

Table 1. Average density by habitat type of juvenile coho salmon
Upper Kidder

Habitat type	average coho/m^2	s.d	n	min	max
Run	0.44	0.25	4	0.25	0.66
Trench pool	0.41		1	0.41	0.41
LSP - Bedrock	0.31	0.23	8	0.15	0.77
Plunge pool -sidechannel	0.98		1	0.98	0.98

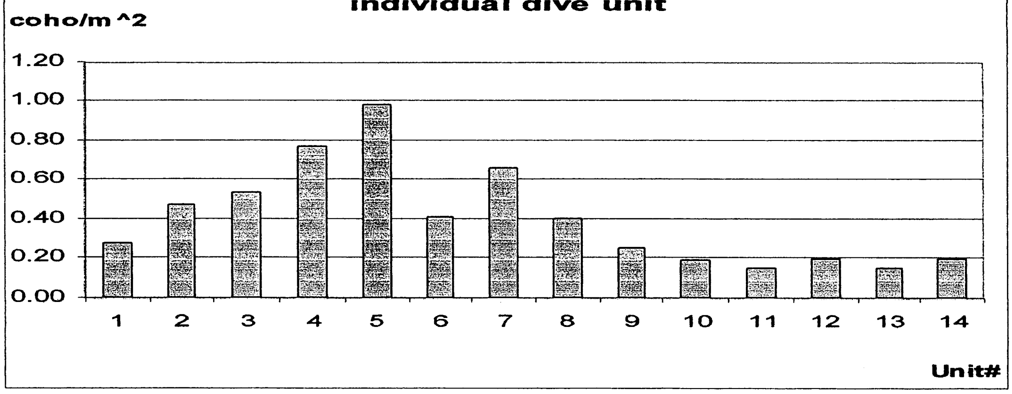
The habitat type with the highest density of juvenile coho rearing was a side channel plunge pool, due to high coho utilization of a small habitat. It did not have any exceptional cover elements – only minor bubble curtain and substrate cover in the scour hole. Pool and run densities are comparable to other mid gradient mountainous streams with limited observed adult coho spawning. Slight preference for association with direct overhead cover was observed in one surveyed pool. This preference could not be validated in this reach due to the uniform lack of over head cover throughout most of the stream surveyed.

Table 2. - juvenile coho densities in individual dive units
Upper Kidder - coho density by individual dive unit

Unit #	Habitat type	ave. coho	length (feet)	area (feet2)	vol (feet3)	coho/ft2	coho/ft3	coho/m^2
1	LSP-bedrock	70	86	2752	6330	0.025	0.011	0.27
2	Run	43	45	990	891	0.043	0.048	0.47
3	LSP-bedrock	97	93	1953	8984	0.050	0.011	0.53
4	LSP-bedrock	83	58	1160	3306	0.072	0.025	0.77
5	Plunge pool -sidechannel	30	22	330	561	0.091	0.053	0.98
6	Trench pool	10	25	250	350	0.038	0.027	0.41
7	Run-bedrock	25	51	408	571	0.061	0.044	0.66
8	Run/Plunge pool	48	53	1272	2162	0.037	0.022	0.40
9	Run	50	71	2130	3941	0.023	0.013	0.25
10	LSP-bedrock	19	60	1080	2160	0.018	0.009	0.19
11	LSP-bedrock	29	80	2080	6240	0.014	0.005	0.15
12	LSP-bedrock	8	55	440	440	0.018	0.018	0.20
13	LSP-bedrock	29	80	2080	6240	0.014	0.005	0.15
14	LSP-bedrock	8	55	440	440	0.018	0.018	0.20

Inspection of the individual dive data indicates a decrease in coho rearing densities from the bottom of the reach to the top. Lack of information pertaining to the location of adult coho spawning in this reach and its vicinity hinders a spatial analysis of the density data. Adult coho sightings in this reach could indicate that at least one redd occurred in this reach.

Figure 1. Upper Kidder Creek - coho density by individual dive unit



It is interesting to note that the density of coho rearing is relatively similar between Upper Kidder Creek and Middle Etna Creek – two stream reaches with relatively similar available habitat and cover.

Fish utilization:

Juvenile coho were often observed in the thalweg position utilizing no cover elements except for the deeper waters and velocity shelter of substrate cover. Juvenile coho were observed both in the scour hole and shallower margins of the large pools. Large amounts of yearling and older trout were observed throughout the deeps of the large pools. Survey crews observed (and documented with photo and video) coho utilizing the top part of pools to catch feed entering from riffle habitat.

Shackleford – Mill Creek

Three reaches were surveyed for the presence and density of anadromous salmonids in the Shackleford – Mill Watershed - Shackleford-Mill Cr. (.54 miles), Lower Mill Cr. (.82 miles), and Upper Mill Creek (.40 miles). See Map 8.

Watershed Overview:

The Shackleford-Mill watershed drains a total of 31,869 acres. The watershed's headwaters are in the Marble Mountain Wilderness, feeding the alluvial Quartz Valley. Land use is a combination of federal and private timber, small residential, and agriculture.

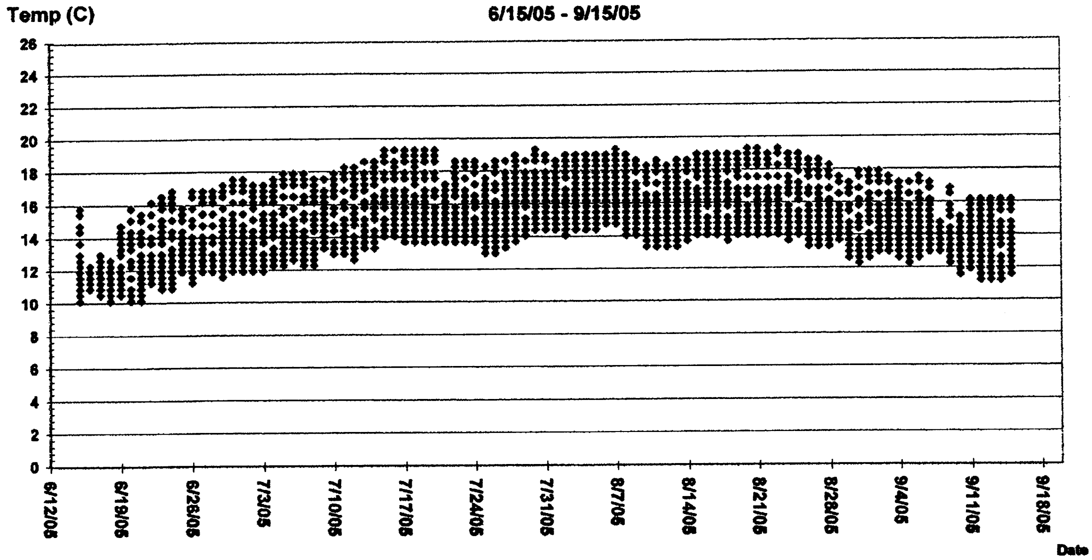
Many restoration projects have been performed in the Shackleford-Mill watershed due to the historic identification of the importance of its fishery in the Scott Valley. In-stream and riparian restoration projects include: cattle exclusion fencing, fish screening water diversions, fish friendly diversion structures, removal of tail-water return, and riparian protection and enhancement. Additionally, Fruit Growers Supply Co. has decommissioned and improved roads to reduce legacy upslope effects.

The Shackleford-Mill watershed has stream channels characterized by large alluvial fans in several locations of the low gradient valley floor. The occurrence of a widely spread alluvial fan is typically associated with stream reaches that are disconnected during low summer flows, due to subsurface flow through the loose alluvial deposits in these sections. In the Shackleford-Mill watershed, these disconnected reaches occur in two locations: 1) at the base of the canyon reaches of Shackleford Creek and Mill Creek and 2) at the confluence of Shackleford-Mill Creek with the Scott River. These disconnected reaches create an isolated (no ingress or egress) reach of suitable rearing habitat that is heavily utilized by anadromous salmonids. The California Department of Fish and Game has historically "rescued" and relocated salmonids isolated in this reach of Shackleford-Mill Creek. In 2005, CDFG relocated 3,768 juvenile coho salmon from lower Shackleford-Mill Creek.

Flow and Temperature:

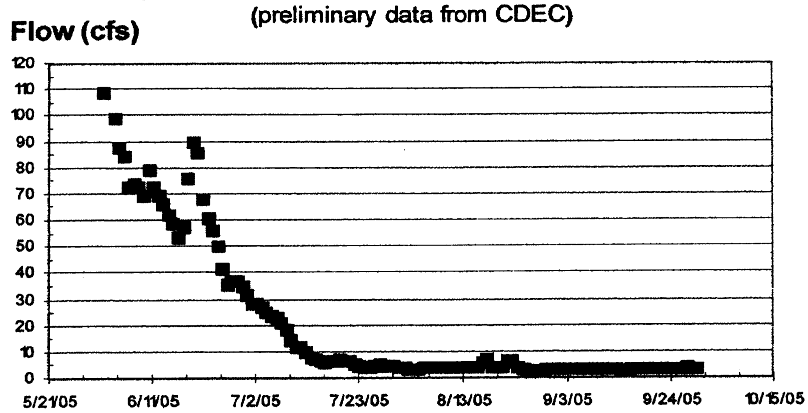
Flow and temperature have not been documented until recently in the alluvial reaches of Shackleford-Mill Creek. The Siskiyou RCD has documented temperatures in Mill Creek and Shackleford-Mill Creek since 2004. Figure 1 shows hourly water temperatures recorded in Mill Creek above the confluence with Shackleford Creek from 6/14/05 to 9/14/05. Stream temperatures from 2004 in Shackleford-Mill Creek below the confluence demonstrate a cooling influence from the sub-surface contribution of Shackleford Creek. The downstream extent of this effect is enforced by several springs entering below this confluence (FLIR data, 2004).

Figure 1. Hourly Ambient Stream Temperature Data - Mill Creek (Shackleford-Mill) above confluence 6/15/05 - 9/15/05



A series of flow stations have been established in Shackleford-Mill Creek, Upper and Lower Mill Creek, and Shackleford Creek since 2003. The Cal. Dept. of Water Resources operates a flow gage year round in lower Shackleford – Mill Creek. Flow is shown in Figure 2 – stream discharge is approximately 3 cfs during the low flow period of August to November.

Figure 2. Shackleford-Mill Creek at Lower Bridge (preliminary data from CDEC)



The Siskiyou RCD operates gage stations in Mill Creek and Shackleford Creek above all agricultural diversions. Stream discharge measurements taken in the Upper Mill Creek reach during the low flow period (end of August) documented discharge at less than 1 cfs (approximately .6 cfs). The low flow stream discharge in Shackleford Creek was documented at 5 – 6 cfs in 2005.

Adult coho spawning - 2004-2005:

Adult coho spawning surveys performed in 2004-2005, documented some of the highest densities of spawning in the Scott River in the Shackleford - Mill watershed. Four reaches were surveyed for adult coho salmon in the Shackleford-Mill watershed (Table 1): Shackleford-Mill Creek, Shackleford Creek, and Lower and Upper Mill Creek (Quigley, 2005).

Table 1 – documented coho redds in surveyed reach – Shackleford –Mill - 2004-2005

Reach	Description	Length (miles)	# of coho redds observe
Shackleford-Mill Cr.	mile 2 to mouth	2.2	76
Shackleford Cr.	below falls	0.5	1
Lower Mill Cr.	bridge to confluence	1.6	127
Upper Mill Cr.	above upper bridge	0.5	5

Adult spawning was found throughout the alluvial reaches of Lower Mill Creek and Shackleford-Mill Creek, largely due to an abundance of sorted spawning gravels in close proximity to terrestrial vegetation offering direct overhead cover. Occurrence of spawning significantly decreased in the mid-gradient reaches of Upper Mill Creek and Shackleford Creek.

Shackleford-Mill Creek
Habitat Characterization:

Shackleford-Mill Creek is a low gradient alluvial reach characterized by pools interspersed with stretches of alternating riffle and flatwater units. Pool occurrence is decent (11% by habitat unit) in this reach, but a little lower if viewed by length (8%) due to pool's shorter length comparable to riffles and flatwaters (37% and 55% by length, respectively). This reach is characterized by relatively high occurrence of side channels during the winter flow regime. Few of these side channels were still connected during the low flow period of survey. The streambed's dominant substrate in this reach is largely gravel with small amounts of cobble. Little fine sediment was observed in the substrate of the streambed.

A large riparian corridor is protected throughout this reach. Large mature alders and cottonwoods on the terrace with younger alders and willow along the stream bank characterize the riparian flora. This high occurrence of terrestrial vegetation directly adjacent to the stream channel creates a large portion of the direct overhead and instream fish cover associated with this reach. Additionally, coarse woody debris, root wads, and undercut banks offer elements of habitat cover to rearing salmonids throughout the reach. Several habitats with complex cover (e.g. coarse woody debris associated with overhanging terrestrial vegetation, undercuts, and/or root mass) were observed through this reach.

Survey Results:

Fourteen individual habitat units were surveyed in Shackleford-Mill Creek in a .54 mile reach – 2 riffles, 5 runs (1 in a side channel), and 7 pools. Large amounts of juvenile coho and trout in small habitats increased the difficulty of accurate population estimates. Several habitat types were surveyed using three and four replicates in order to develop the best possible density estimates.

Table 2. Average density by habitat type of juvenile coho salmon
Shackleford-Mill Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Riffle	0.00		2	0.00	0.00
Run	1.15	1.04	4	0.12	2.36
Run - side channel	3.02		1	3.02	3.02
Corner pool	2.71		1	2.71	2.71
LSP - boulder	1.46		1	1.46	1.46
LSP - rootwad	1.36	0.22	5	1.10	1.64

Juvenile coho were observed in all habitat types surveyed, except the riffles. The surveyed riffles offered only very shallow waters without any deep pockets of suitable waters. The surveyed runs and pools consistently supported greater than 1 coho/m^2, with some unique habitat types rearing high amounts of juvenile coho. Juvenile coho and trout were observed throughout the pool's scour holes and the deeper portions of the runs. Most pools offered in-water fish cover (coarse woody debris and root wads) and direct overhead cover over a portion of the scour hole from the terrestrial vegetation along the banks (willow and alder). This relatively uniform and excellent fish cover appears to generate observed fish densities in lateral scour pools (1.1 – 1.6 coho/m^2) that are relatively homogenous; e.g. small standard deviation of average.

Table 3. - juvenile coho densities in individual dive units
Shackleford - Mill Creek

Unit #	Habitat type	ave. coho	length (feet)	area (feet2)	vol (feet3)	coho/ft2	coho/ft3	coho/m^2
4	Riffle	0	33	611	275	0.000	0.000	0.00
12	Riffle	0	32	416	146	0.000	0.000	0.00
5	Run - shallow	11	51	969	630	0.011	0.017	0.12
13	Run	31	54	702	421	0.043	0.072	0.47
7	LSP - rootwad	58	33	561	561	0.102	0.102	1.10
2	LSP - rootwad - shallow	188	82	1722	2927	0.109	0.064	1.17
10	LSP - rootwad	192	67	1508	3618	0.127	0.053	1.37
8	LSP - boulder	150	58	1102	1322	0.136	0.113	1.46
1	LSP - rootwad	123	49	882	1588	0.139	0.077	1.50
9	LSP - rootwad - coldwater inflow	158	65	1040	1664	0.152	0.095	1.64
3	Run - complex habitat	184	52	1196	1196	0.154	0.154	1.65
6	Run - willow & SWD	150	36	684	684	0.219	0.219	2.36
11	Corner pool - with wood aggregate	250	62	992	2182	0.252	0.115	2.71
14	Run - side channel - willow cover	88	24	312	218	0.281	0.401	3.02

Exceptional fish cover elements in the pools increased observed coho densities. Several pools (e.g. unit #11 – Corner pool) had large aggregates of large and small woody debris. These aggregates create complex habitats with many partitioned niches for rearing fish and were often heavily occupied. An additional observed microhabitat that was occupied by coho salmon at higher densities was a patch of colder water in a LSP-root wad (Unit #9). This unit had a backwater with an inflow of 12° C water and coarse woody debris cover. Many coho that appeared to be larger than others observed were utilizing this backwater. Additionally, this habitat unit had water temperatures throughout the scour hole of 16° C, compared to ambient temperatures of 17.5° C in the riffle directly upstream. These colder patches of water in streams that are already suitable could increase the condition and survival of rearing fish.

The surveyed run habitats had largely divergent densities of observed juvenile coho salmon. The large range of densities (.12 – 2.36 coho/m^2) indicates that variables other than habitat type are playing a large role in differentiating the suitability of the surveyed run habitats. The two runs with the highest densities (Unit #3 and Unit #6) both contained complex habitats created by in-water small and large woody debris associated with extensive overhanging terrestrial vegetation. These habitats with complex fish cover reared significant amounts of juvenile coho salmon (>150 fish in each unit) and had coho densities similar to those observed in pools throughout this reach. Surveyed runs that offered largely shallow waters (Unit #5) and/or little instream or overhead cover (Unit #13), had significantly lower coho densities. These units were often heavily occupied by 0+ trout with small amounts of coho rearing. The significant differences in densities between "like" habitat units with differing fish cover elements and depths, demonstrates the importance of these variables in determining the volume of suitable and preferred habitat for coho rearing in each habitat unit.

The single side-channel habitat unit that was surveyed demonstrates the importance of overhead cover offered by terrestrial vegetation in creating preferred fish habitat. Willows growing along the banks and in the water surrounded this relatively narrow run. These willows offer both direct overhead cover and instream cover when branches and trunks are in the water. The smaller wetted channel of this side channel allows for greater surface area coverage and greater coho density.

Lower Mill Creek

Habitat Characterization

Lower Mill Creek is a low gradient alluvial reach with an active floodplain, which is enhanced by the occurrence of several beaver generated impoundments associated with extensively braided channels. Pools are mainly formed by the root wads of living trees. Pool occurrence by habitat unit is relatively high (17%) but is much lower if determined by percent length (6%). A large portion of stream reach is characterized by long riffles and flatwater (62% and 32% by length, respectively) interspersed between relatively short pool units. The streambed in this reach is composed almost exclusively of gravel with very small amounts of cobble and fine sediment observed. The only habitat unit observed that had a high occurrence of sand and silt was the beaver impoundment.

Fish cover was often offered by overhanging terrestrial vegetation (mostly willow and alder) growing directly on the stream bank. Additionally, a variety of fish cover elements were prevalent throughout this reach: small and large woody debris, root mass, undercuts, aquatic vegetation, and submerged terrestrial vegetation. Several habitat units with complex fish cover and/or a high percentage of covered active channel were observed in this reach. These complex and highly covered habitats had some of the highest density of rearing coho salmon observed in this study.

A very large beaver impoundment in the middle of the surveyed reach created a unique and essential habitat for salmonid rearing. The impoundment created a huge volume of deep water. Large amounts of submerged terrestrial vegetation offer cover and complexity throughout much of the impoundment. A high occurrence of side channel above the deep portion of the impoundment offered habitat with high occurrence of terrestrial vegetation cover.

Survey Results:

Twenty (20) individual habitat types were surveyed in Lower Mill Creek. We surveyed three riffles, eight pools, seven runs, and two microhabitats. The beaver impoundment was surveyed for fish presence and position, but the enormity of available habitat and the large amount of observed fish precluded any attempt to estimate population or fish densities.

The Lower Mill Creek reach had some of the highest densities observed in pools and runs in the Scott Valley during this survey. A large amount of juvenile coho salmon (many large pools had approximately 300 juvenile coho) occupied this smaller alluvial stream with excellent available habitat.

Table 4. Average density by habitat type of juvenile coho salmon
Lower Mill Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Riffle	0.17	0.15	3	0.00	0.30
Run	1.93	1.81	7	0.00	4.78
Backwater pool	1.92		1	1.92	1.92
Corner pool	2.10		1	2.10	2.10
LSP - rootwad	5.05	3.13	6	2.16	8.78
Deep pocket under alder	3.36		1	3.36	3.36
Off channel backwater	4.04		1	4.04	4.04

Juvenile coho occupied two out of the three riffles surveyed in this reach. The riffle with uniformly shallow water (Unit #10) did not support any coho rearing. Riffles that offered microhabitats of deeper and slower waters (Units #4 & #19) supported rearing coho. These marginal microhabitats were created by instream woody debris that protected pockets of deep slow water that were often additionally covered by overhanging terrestrial vegetation. The identification of these microhabitats that allow juvenile coho rearing in otherwise inhospitable riffles is important to the full understanding and inventory of types of suitable rearing habitat.

Densities of juvenile coho rearing in pools are uniformly high (greater than 2 coho/m^2) with some pools showing exceptional densities. The majority of pools surveyed were LSP – root wad pools and six of these habitat types were surveyed. Though this habitat type had a relatively high sample size the variance between habitat units is very large. Inspection of the individual dive data shows that the surveyed LSP-root wad units fall into two groups of density: 1) pools with moderately high density (2.2 – 2.4 coho/m^2) and 2) pools with exceptional densities (6.4 – 8.8. coho/m^2). The pools with moderate density often had elements of fish cover within the habitat unit, but those with exceptional densities had significant fish cover over more than half of the habitat unit. The majority of fish cover observed in this reach was created by overhanging riparian vegetation growing directly along the wetted edge on many of the stream banks. This terrestrial vegetation was often associated with instream coarse woody debris and undercut banks with in-water root mass. Some of the most significant cover was created by the introduction of partially fallen whole living trees (alder and willow) into and over the channel. These trees play a dual role of providing the hard-point for pool formation, and providing a large amount of direct overhead and instream cover to the deep waters of the scour hole.

Table 5. - juvenile coho densities in individual dive units
Lower Mill Creek

Unit #	Habitat type	ave. coho	length (feet)	area (feet2)	vol (feet3)	coho/ft2	coho/ft3	coho/m^2
10	Riffle	0	25	150	80	0.00	0.00	0.00
13	Run - shallow	0	25	96	88	0.00	0.00	0.00
4	Riffle	8	82	410	164	0.02	0.05	0.21
19	Riffle w/ deep margin microhabitat	26	42	220.5	647	0.03	0.04	0.30
14	Run	8	28	480	126	0.03	0.06	0.34
1	Run	30	24	200	204	0.07	0.14	0.78
7	Run	61	42	406	369	0.11	0.17	1.16
15	Backwater pool	57	22	252	319	0.18	0.18	1.92
3	Corner pool	29	10	924	120	0.20	0.24	2.10
16	LSP - rootwad	281	52	435	2106	0.20	0.13	2.16
2	LSP - rootwad	57	24	250	185	0.22	0.31	2.34
8	LSP - rootwad	30	16	567	68	0.22	0.44	2.35
5	Run	200	47	252	705	0.28	0.28	3.05
12b	deep pocket under alder	30	12	120	96	0.31	0.31	3.36
17	Run	79	24	136	202	0.31	0.39	3.39
6	Off channel backwater	45	20	1404	NA	0.38	NA	4.04
11	Run	100	25	705	18	0.44	0.49	4.78
18	LSP - rootwad	288	30	225	816	0.60	0.35	6.44
12	LSP - rootwad	333	30	264	0	0.77	0.40	8.25
9	LSP - rootwad	180	21	319	132	0.82	1.36	8.78

The run habitat types display a huge divergence of observed densities (.0 to 4.8 coho/m^2). Habitat factors previously discussed (depth and quantity and quality of available fish cover) appear to affect the observed densities. The runs with the lower densities were all relatively shallow (max depth .8 to 1.0 foot), with the shallowest run (max depth = .7 foot) having no observed juvenile coho. The runs with the higher densities of coho rearing (Units #5, #17, and #11) offered increased water depths (max depth 1.2 to 1.6 feet), with depths approaching those of some of the observed scour holes. The densities of these deeper runs fall into the middle of the observed densities of the lateral scour pools. These runs did not have significantly greater cover than the runs with shallower depths, indicating that increased depth could be the controlling factor to the increased density of utilization. Coho salmon were often readily observed from the surface occupying the deeper positions and thalweg of these units.

Several unique habitats were surveyed in this reach. Most of these habitats were directly associated with a large beaver dam and impoundment occurring in the bottom third of the reach. Above and below this beaver dam, the stream is divided into extensive side-channels by willow growth. Fish were readily observed from the surface in these side-channels and one microhabitat (Unit #6) was surveyed to generate a representative density. Juvenile coho in numbers too numerous to count were observed in large sections of the beaver impoundment. Fish were heavily utilizing areas of submerged terrestrial vegetation and adjacent areas with slowly moving water. No juvenile coho salmon were observed in a large off-channel beaver "pond", characterized by deep and completely still waters. Observed juvenile coho were readily moving throughout the desired slow velocity habitats of the impoundment, exasperating any possibility of accurately counting their numbers. The large and heavily occupied habitat associated with this beaver dam contains a significant amount of juvenile coho salmon that we could not enumerate due to time constraints and the difficulty of accurate estimates using the direct observation technique. In order to capture representative densities in this unique and essential habitat, a large commitment of time and utilization of alternative survey methods would be necessary.

Upper Mill Creek

Habitat Characterization

This reach is above the disconnected alluvial fan and represents the bottom portion of the higher gradient "canyon" reach of Mill Creek that is utilized by coho salmon. The channel bed is dominated by small and large cobble with occurrence of bedrock and small amounts of gravel. Root wads of trees largely drive pool formation with some pools formed by bedrock. Riparian condition throughout this reach is mature to excellent with mature hardwood and softwood throughout the riparian terrace. This mature canopy does not offer direct overhead cover along much of the stream; little young riparian vegetation was present directly along the stream's margin.

The majority of in-stream cover observed was offered by small and large woody debris. Many occurrences of small woody debris aggregates and log piles composed of large and small woody debris were observed. Significant softwood (Douglas fir) large woody debris was observed in the wetted channel. Other elements of fish cover in this reach include root mass and undercut banks. Undercut banks were often observed significantly above the wetted edge and not playing a role in fish cover. Large portions of this reach did not have any complex cover elements, except for substrate cover in the suitably deep water and total shade from the functioning canopy. The majority of coho were found in these "open" habitats.

Survey Results:

18 habitat types were surveyed in Upper Mill Creek- three riffles, ten runs, and 5 pools. Juvenile coho salmon were observed in all habitat units surveyed. This reach had the highest densities observed for pools and runs in a mid-gradient reach. The observed densities were often equivalent or greater than the densities for like habitat types in the alluvial reaches. Five adult coho redds were observed in this reach in the winter of 2004/2005. The high density of juvenile coho in this reach could be due to high survival of the brood from these redds and/or upward movement of non-natal juveniles from downstream habitats. Regardless of the source, a significant amount of juvenile coho (greater than 50 coho in many habitat types) was found occupying this confined mid-gradient stream with a small discharge (.6 cfs) of high quality water.

Table 6. Average density by habitat type of juvenile coho salmon

Upper Mill Creek

Habitat type	average coho/m^2	s.d	n	coho/m^2 min	coho/m^2 max
Riffle	0.35	0.28	3	0.14	0.65
Step run	0.63	0.26	3	0.47	0.94
Run	2.10	1.21	7	0.71	3.78
LSP - bedrock	1.99	0.00	1	1.99	1.99
LSP - rootwad	1.71	0.80	4	0.77	2.50

The juvenile coho observed in the riffles were occupying deeper protected waters. These pockets were usually associated with large substrate that offered velocity refuge and probably scoured out the deeper microhabitat. Likewise, juvenile coho utilized the deeper slower velocity "runs" of the step run habitats. It is interesting to note that on average, the step runs demonstrated average densities of utilization in between those observed for riffles and runs. Step runs offer a combination of riffle habitats – the steps – and run habitats.

Average densities for the pool and run habitat types were relatively similar. The expected higher density in pools is actually lower than that observed in pools, on average. This indicates that in this reach pools and runs are serving similar functions for rearing fish. The majority of juvenile coho salmon observed in the pools and runs were occupying the deepest thalweg position of the channel. These coho appeared to be the dominant fish, occupying the feeding lane and upstream position in deeper habitats. Besides the ubiquitous substrate cover and excellent mature canopy, many habitat units had little observable direct overhead or instream fish cover. Several habitat units with instream fish cover offered by coarse woody debris had coho salmon mostly utilizing the deeper waters with no direct overhead cover. It appears that the middle of the channel offered the juvenile coho suitable and preferred habitat in this reach. It is hypothesized that the preferred water quality (e.g. ambient stream temperatures of 14° - 18° C) defining this reach, allows successful fish growth if adequate feed is available. Observation of "feeding" behavior by the coho salmon supports this hypothesis, along with the observation of some fish that were significantly larger than those observed in densely occupied alluvial habitats. All evidence is anecdotal, until a sufficient amount of condition factor (length vs. weight) data is collected in the various survey reaches.

A large aggregate (logjam) of large and small woody debris created a pool at the top of the surveyed reach. A large Douglas fir trunk created a significantly complex pool that was occupied by juvenile coho salmon and many large rainbow trout.

Table 7. - juvenile coho densities in individual dive units

Upper Mill Creek - coho densities by dive unit

Unit #	Habitat type	ave. coho	length (feet)	area (feet2)	vol (feet3)	coho/ft2	coho/ft3	coho/m^2
13	Riffle	5	55	385	154	0.013	0.032	0.14
7	Riffle	12	33	479	191	0.025	0.063	0.27
15	Step run	18	41	410	287	0.044	0.063	0.47
5	Step run	18	46	391	196	0.046	0.092	0.50
2	Riffle - pocketwater	32	39	526.5	0	0.061	0.122	0.65
3	Run - shallow	20	21	294	176	0.066	0.111	0.71
18	LSP - rootwad	41	38	570	1140	0.072	0.036	0.77
10	Step run	21	23	242	169	0.087	0.124	0.94
14	Run	68	41	656	525	0.103	0.129	1.11
8	LSP - rootwad	49	27	392	392	0.124	0.124	1.34
17	Run	62	45	495	495	0.125	0.125	1.35
12	Run	35	23	230	230	0.152	0.152	1.64
6	LSP - bedrock	80	33	429	472	0.185	0.168	1.99
16	LSP - rootwad	53	28	252	328	0.208	0.160	2.24
11	LSP - rootwad	76	31	326	326	0.232	0.232	2.50
4	Run	58	27	243	170	0.237	0.339	2.56
1	Run	99	23	299	150	0.331	0.662	3.56
9	Run	150	37	426	404	0.351	0.370	3.78

This pool (Unit #18) had the lowest observed densities of coho observed in pools in this reach. This indicates factors other than habitat complexity are controlling coho densities in this reach. One factor is likely the phenomena of decreased densities as we move upstream from the location of the highest adult spawning. This hypothesis cannot be tested, because time constraints did not allow for surveys above this unit that still had significant juvenile coho utilization. This could also be the source of the large standard deviation that is observed in the averaging of the run and pool habitat types.

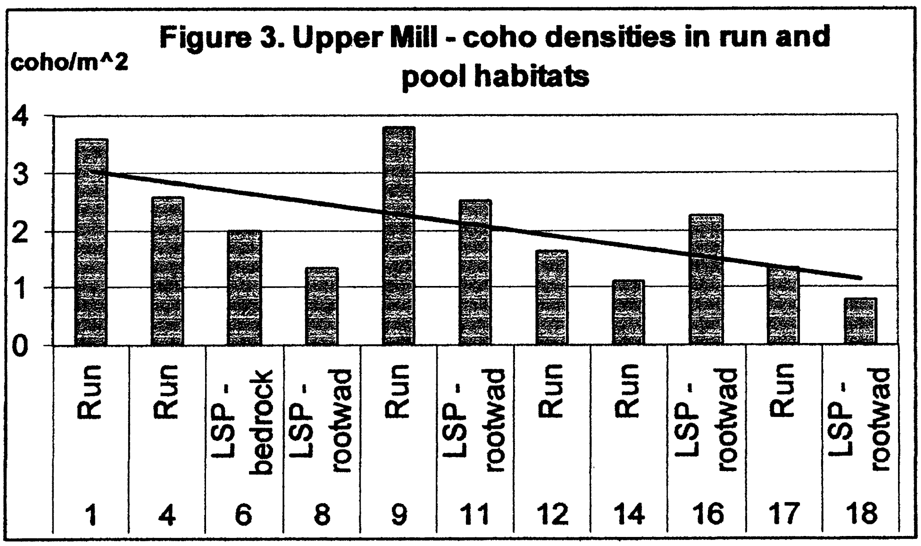


Figure 3. Upper Mill - coho densities in run and pool habitats

Attachment A

Siskiyou RCD Temperature Monitoring Data - Moving Weekly Average Temperatures (MWAT)

Station Number	Location Name	1997 Deg C	1998 Deg C	1999 Deg C	2000 Deg C	2001 Deg C	2002 Deg C	2003 Deg C	2004 Deg C	2005 Deg C	Max MWAT Deg C	Avg MWAT Deg C
		Scott	River	Tributaries								
Rrl01	Rail Creek	0	16	15.1	17.3	16.7	17.9	18.3	17.3	16.6	18.3	15.0
Ref02	East Fork - Upper Masterson	NDC	21	ND	21.4	20.9	21.3	22.7	21.5	21.1	22.7	21.4
REF01	East Fork - Callahan	NDC	14.4	19.4	21.6	21.9	21.8	22.5	21.8	21.4	22.5	20.6
Rbj01	South Fork @ Blue Jay	ND	14.8	13.5	15.4	15.8	15.3	15.9	15.6	15.2	15.9	15.2
RSF01	South Fork above Scott River	ND	16.3	13.8	17.3	17.8	17.3	17.4	17.2	missing data	17.8	16.7
RSU01	Sugar Creek above Hwy 3	NDC	NDC	NDC	NDC	NDC	16.2	16.9	18.1	17.4	18.1	17.2
Rfr02	French below Miners Cr	NDC	NDC	NDC	NDC	NDC	18.2	18.2	stolen	18.4	18.4	18.3
Rfr01	Mouth of French	20.7	19.7	18.1	21.1	ND	17.1	18.9	Unit Lost	19.8	21.1	19.3
RET01	Mouth of Etna Cr.	NDC	16.3	ND	ND	ND	22	NDC	NDC	NDC	22	19.2
SH02	Mill above confluence with Shackleford	NDC	NDC	NDC	NDC	NDC	NDC	NDC	20.8	16.4	20.8	18.6
RSH01	Shackleford below Mill	NDC	NDC	NDC	NDC	NDC	NDC	NDC	16.6	NDC	16.6	16.6
RSC33	Rattlesnake Creek	21	ND	19.8	ND	ND	24.2	23.3	23.3	NDC	24.2	22.3
		Scott	River	Mainstem								
Rsc57	Lower tailings(Middle Tailings)	ND	ND	ND	20.3	Air	Air	20	19.8	19.2	20.3	19.8
Rsc52_5	Fay Lane	19.6	19.2	ND	20	19.3	ND	20.1	19.7	unit out of water	20.1	19.7
Rsc50_9	Above mouth of French	20.8	19.7	18.5	19.8	18	20	20.3	19.9	20.3	20.8	19.7
Rsc50_7	Below mouth of French	20.9	18.2	18.7	19.1	Dry	19	20.2	19.7	19.8	20.9	19.5
Rsc45_2	Above mouth of Etna	20.7	19.7	ND	17.2	Dry	17.6	NDC	NDC	NDC	20.7	18.8
Rsc45_0	Below mouth of Etna	20.6	20	ND	20.6	Dry	ND	NDC	NDC	NDC	20.6	20.4
RSC39	Shell Gulch(Below Black Bridge)	22.1	20.5	19.9	22.5	Dry	22	21.9	Lost Data	22.5	22.5	21.6
Rsc36	Serpa Lane	23.1	ND	21	23.6	Dry	ND	23.2	23.3	NDC	23.6	22.8
Rsc29	Scott @ Hwy 3	21.7	21.1	19.9	22.5	Dry	24.2	?	NDC	NDC	24.2	21.9
Rsc29	Scott @ Meamber Br.	22.8	ND	21.2	ND	ND	21.4	23.3	21.6	21.4	23.3	22.0
Rsc27	Scott @ Meamber Cr.	ND	ND	19.8	21.8	21.4	20.7	22.4	21.3	21.2	22.4	21.2