STREAM INVENTORY REPORT
Warden Creek

INTRODUCTION

A stream inventory was conducted during July 2004 on Warden Creek. The survey began at the confluence with Sproul Creek and extended upstream 0.4 miles. The Warden Creek inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the habitat available to anadromous salmonids in Warden Creek. The objective of the biological inventory was to document the presence and distribution of juvenile salmonid species.

The objective of this report is to document the current habitat conditions and recommend options for the potential enhancement of habitat for Chinook salmon, coho salmon, and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Warden Creek is a tributary to Sproul Creek, a tributary to South Fork Eel River, a tributary to the Eel River, located in Humboldt County, California (Map 1). Warden Creek's legal description at the confluence with Sproul Creek is T5S R3E S5. Its location is 40°03'18" north latitude and 123°51'04" west longitude, LLID number 1238510400549. Warden Creek is a first order stream and has approximately 1.82 miles of blue line stream according to the USGS Garberville 7.5 minute quadrangle. Warden Creek drains a watershed of approximately 1.57 square miles. Elevations range from about 475 feet at the mouth of the creek to 1,040 feet in the headwater areas. Redwood/mixed hardwood forest dominates the watershed. The watershed is entirely privately owned and is managed for timber production. Vehicle access exists via a locked gate on Sproul Creek Road.

METHODS

The habitat inventory conducted in Warden Creek follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The California Conservation Corps (CCC) Technical Advisors that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two-person team.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the survey reach. All habitat units included in the survey are classified according to habitat type and their lengths are measured. All pool units are measured for maximum depth, depth of pool tail crest (measured in the thalweg), dominant substrate composing the pool tail crest, and embeddedness. Habitat unit types encountered for the first time are measured for all the

parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement. All pools except step-pools are fully sampled.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the *California Salmonid Stream Habitat Restoration Manual*. This form was used in Warden Creek to record measurements and observations. There are eleven components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) near the bottom of the stream survey reach using a Marsh-McBirney Model 2000 flow meter.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit and within one foot of the water surface.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1990). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Warden Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to the nearest tenth. Habitat characteristics are measured using a clinometer, hip chain, and stadia rod.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out areas is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Warden Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3) and 76 - 100% (value 4). Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like bedrock, log sills, boulders or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide juvenile salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition for prey. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Warden Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs is recorded for each pool.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual*. Canopy density relates to the amount of stream shaded from the sun. In Warden Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of coniferous or hardwood trees.

9. Bank Composition and Vegetation:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Warden Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

10. Large Woody Debris Count:

Large woody debris (LWD) is an important component of fish habitat and an element in channel forming processes. In each habitat unit all pieces of LWD partially or entirely below the elevation of bankfull discharge are counted and recorded. The minimum size to be considered is twelve inches in diameter and six feet in length. The LWD count is presented by reach and is expressed as an average per 100 feet.

11. Average Bankfull Width:

Bankfull width can vary greatly in the course of a channel type stream reach. This is especially true in very long reaches. Bankfull width can be a factor in habitat components like canopy density, water temperature, and pool depths. Frequent measurements taken at riffle crests (velocity crossovers) are needed to accurately describe reach widths. At the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach.

BIOLOGICAL INVENTORY

Biological sampling during the stream inventory is used to determine fish species and their distribution in the stream. Fish presence was observed from the stream banks in Warden Creek. In addition, nine sites were electrofished using a Smith-Root Model 12 electrofisher. These sampling techniques are discussed in the *California Salmonid Stream Habitat Restoration Manual*.

DATA ANALYSIS

Data from the habitat inventory form are entered into Stream Habitat 2.0.3, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Game. This program processes and summarizes the data, and produces the following ten tables:

- Riffle, Flatwater, and Pool Habitat Types
- Habitat Types and Measured Parameters
- Pool Types
- Maximum Residual Pool Depths by Habitat Types
- Mean Percent Cover by Habitat Type
- Dominant Substrates by Habitat Type
- Mean Percent Vegetative Cover for Entire Stream
- Fish Habitat Inventory Data Summary by Stream Reach (Table 8)
- Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
- Mean Percent Shelter Cover Types for Entire Stream

Graphics are produced from the tables using Microsoft Excel. Graphics developed for Warden Creek include:

- Riffle, Flatwater, Pool Habitat Types by Percent Occurrence
- Riffle, Flatwater, Pool Habitat Types by Total Length
- Total Habitat Types by Percent Occurrence
- Pool Types by Percent Occurrence
- Maximum Residual Depth in Pools
- Percent Embeddedness
- Mean Percent Cover Types in Pools
- Substrate Composition in Pool Tail-outs
- Mean Percent Canopy
- Dominant Bank Composition by Composition Type
- Dominant Bank Vegetation by Vegetation Type

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of 7/13/2004 to 7/15/2004 was conducted by Leslie Merrick and Elizabeth Pope (CCC). The total length of the stream surveyed was 1,991 feet with an additional 45 feet of side channel.

Stream flow was measured 56 feet from the confluence with Sproul Creek with a Marsh-McBirney Model 2000 flowmeter at 0.02 cfs on 8/4/04.

Warden Creek is a B3 channel type for 1,382 feet of the stream surveyed (Reach 1) and a B2 channel type for the remaining 609 feet (Reach 2). B3 channels are moderately entrenched, riffle dominated channels with infrequently spaced pools, very stable plan and profile, stable banks on moderate gradients with low width/depth ratios and cobble dominant substrates. B2 channels have boulder dominant substrates.

Water temperatures taken during the survey period ranged from 60 to 64 degrees Fahrenheit. Air temperatures ranged from 60 to 78 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 46% riffle units, 32% flatwater units, 20% pool units, and 2% culvert units (Graph 1). Based on total length of Level II habitat types there were 57% riffle units, 28% flatwater units, 13% pool units, and 2% culvert units, (Graph 2).

Seven Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 30% run units, 23% high gradient riffle units, and 14% mid-channel pool units, (Graph 3). Based on percent total length, 25% were cascade units, 24% run units, and 19% were high gradient riffle units.

A total of 11 pools were identified (Table 3). Main channel pools were the most frequently encountered, at 73%, and comprised 74% of the total length of all pools (Graph 4).

Table 4 is a summary of maximum residual pool depths by pool habitat types. Pool quality for salmonids increases with depth. Four of the 11 pools (36%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 11 pool tail-outs measured, 2 had a value of 1 (18.2%); 6 had a value of 2 (54.5%); 3 had a value of 3 (27.3%); (Graph 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like bedrock, log sills, boulders, etc.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 27, flatwater habitat types had a mean shelter rating of 12, and pool habitats had a mean shelter rating of 61 (Table 1). Of the pool types, the main channel pools had a mean shelter rating of 59, scour pools had a mean shelter rating of 68 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover types in Warden Creek. Graph 7 describes the pool cover in Warden Creek. Large woody debris is the dominant pool cover type followed by boulders.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel was observed in 45% of pool tail-outs, small cobble observed in 27% of pool tail-outs, and large cobble was observed in 27% of pool tail-outs.

The mean percent canopy density for the surveyed length of Warden Creek was 97%. The mean percentages of hardwood and coniferous trees were 79% and 21%, respectively. Three percent of the canopy was open. Graph 9 describes the mean percent canopy in Warden Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 83%. The mean percent left bank vegetated was also 83%. The dominant elements composing the structure of the stream banks consisted of 63% sand/silt/clay, 30% cobble/gravel, 4% bedrock, and 2% boulder (Graph 10). Deciduous trees were the dominant vegetation type observed in 61% of the units surveyed. Additionally, 30% of the units surveyed had coniferous trees as the dominant vegetation (Graph 11).

BIOLOGICAL INVENTORY RESULTS

Nine sites were electrofished for species composition and distribution in Warden Creek on August 4, 2004. Water temperatures taken during the electrofishing period (10:04-16:00) ranged from 64 to 68 degrees Fahrenheit. Air temperatures ranged from 68 to 75 degrees Fahrenheit. The sites were sampled by Corby Hines and Lindsay Selvaggio (CCC), and Trevor Tollefson and Allan Renger (DFG).

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In reach one, eight sites were sampled between habitat units 004 and 036, a distance of 773 feet, approximately 1,043 from the confluence with Sproul Creek. The reach sites yielded 40 young-of-the-year steelhead; 10 age 1+ and 1 age 2+.

In reach two, one site was sampled in habitat unit 054, approximately 1,836 feet from the confluence with Sproul Creek. The reach site yielded 6 young-of-the-year steelhead; 2 age 1+ and 1 age 2+.

The following chart displays the information yielded from these sites:

2003 WARDEN CREEK e-fish results.

Date	Site #	Hab. Unit #	Hab. Type	Approx. Dist. from mouth (ft.)	Coho		Steelhead		
					YOY	1+	YOY	1+	2+
Reach 1 B3 Channel Type									
07/26/04	1	004	4.2	56	0	0	2	1	0
07/26/04	2	007	4.2	247	0	0	3	1	0
07/26/04	3	012	5.6	347	0	0	4	1	0
07/26/04	4	014	4.2	380	0	0	2	1	0
07/26/04	5	018	4.2	462	0	0	2	2	0
07/26/04	6	022	4.2	548	0	0	7	2	1
07/26/04	7	026	4.2	635	0	0	2	0	0
07/26/04	8	036	4.2	1,018	0	0	18	3	0
Reach 2 B2 Channel Type									
07/26/04	1	054	5.6	1,817	0	0	6	2	1

DISCUSSION

Warden Creek is a B3 channel type for the first 1,382 feet of stream surveyed and a B2 channel type for the remaining 609 feet. The suitability of B3 and B2 channel types for fish habitat improvement structures is as follows: excellent for plunge weirs, boulder clusters and bank placed boulders, single and opposing wing deflectors, and log cover.

The water temperatures recorded on the survey days 7/13/2004 to 7/15/2004, ranged from 60 to 64 degrees Fahrenheit. Air temperatures ranged from 60 to 78 degrees Fahrenheit. To make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 28% of the total length of this survey, riffles 57%, and pools 13%. The pools are relatively shallow, with only 4 of the 11 (36%) pools having a maximum residual depth greater than 2 feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In first and second order streams, a primary pool is defined to have a maximum residual depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low-flow channel width. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy, or where their installation will not conflict with the modification of the numerous log debris accumulations (LDA's) in the stream.

Eight of the 11 pool tail-outs measured had embeddedness ratings of 1 or 2. Three of the pool tail-outs had embeddedness ratings of 3 or 4. None of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. Sediment sources in Warden Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Eight of the 11 pool tail-outs measured had gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

The mean shelter rating for pools was 61. The shelter rating in the flatwater habitats was 12. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by boulders in Warden Creek. Large woody debris is the dominant cover type in pools followed by boulders. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 97%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was at 83% and 83%, respectively. In areas of stream bank erosion or where bank vegetation is sparse, planting endemic species of coniferous and hardwood trees, in conjunction with bank stabilization, is recommended.

RECOMMENDATIONS

1) Warden Creek should be managed as an anadromous, natural production stream.

2) The limited water temperature data available suggest that maximum temperatures are within the acceptable range for juvenile salmonids. To establish more complete and meaningful temperature regime information, 24-hour monitoring during the July and August temperature extreme period should be performed for 3 to 5 years.

3) Evaluate the culvert at 81’ to determine if it meets DFG and NOAA criteria for adult and juvenile fish passage.

4) Where feasible, design and engineer pool enhancement structures to increase the number of pools. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion.

5) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover is from boulders. Adding high quality complexity with woody cover is desirable.

6) Inventory and map sources of stream bank erosion and prioritize them according to present and potential sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream.

COMMENTS AND LANDMARKS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

Position	Habitat	Comments:
0	0001.00	Start of survey at the confluence with Sproul Creek Channel type is a B3.
18	0002.00	Juvenile salmonids observed
56	0004.00	Electrofishing site #1
81	0005.00	Six foot diameter, corrugated steel culvert, 7' high x 6' wide x 43’long. There is a 1.5’ deep plunge pool below the culvert. The culvert is in good condition, but has some rust on the sides.
247	0007.00	Electrofishing site #2
292	0009.00	Juvenile salmonids observed
347	0012.00	Electrofishing site #3
380	0014.00	Electrofishing site #4

422	0016.00	Log debris accumulation (LDA), 7' high x 25' wide x 18' long, consisting of fourteen pieces of large woody debris which water can flow through. Not a barrier, but the LDA is creating erosion upstream on right bank.
462	0018.00	Electrofishing site #5
477	0019.00	Three foot plunge
490	0020.00	A 2’ diameter x 30’long log anchored to the bank, retaining cobbles and large wood. Right bank erosion, 46’ long x 8’ high, related to road failure.
548	0022.00	Log debris accumulation 4' high x 20' wide x 15' long, composed of 8 pieces of large woody debris, which water can flow through. Right bank erosion, 50’ long x 4’ high, related to the wood accumulation on left bank. Electrofishing site #6
568	0023.00	Right bank erosion, 50 feet long by 4 feet tall.
600	0025.00	Left bank erosion, 25’ long x 3’ high, related to an upstream LDA.
635	0026.00	Channel becomes very tight and choked with a root mass from each bank. The large conifer roots are causing a small woody debris accumulation throughout the unit. Electrofishing site #7
685	0027.00	Channel becomes very tight and choked with a root mass from each bank. Root debris throughout unit acting as a LDA with some sediment retention.
718	0028.00	Left bank erosion, 20’ long x 2’ high, related to the downstream LDA or root mass.
1,018	0036.00	Electrofishing site #8
1,123	0040.00	Right bank tributary. The water temperature downstream of tributary is 60° F, the tributary is 59° F and upstream is 60° F degrees. It is accessible to fish, although no fish were observed.
1,191	0041.00	Dry tributary. Property line fence.
1,217	0042.00	Left bank erosion, 35’ long x 12’ high.
1,339	0043.01	Warden Creek goes dry 25 feet into unit.
1,339	0044.00	Three foot plunge with no pool.

1,382	0046.00	Channel type change to a B2. Right bank erosion, 20'long x 6" high.
1,463	0047.00	Left bank erosion, 35' long x 8' high.
1,488	0048.00	Left bank erosion.
1,644	0051.00	Small dry drainage on left bank.
1,817	0054.00	Electrofishing site #9.
1,836	0055.00	Survey ends at a 20 foot high boulder plunge. There is a 155 foot cascade directly downstream at this plunge thus no possible way for fish to attempt a jump. At the top of the cascade the creek splits with both channels ending in massive plunges.

REFERENCES

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and Collins, B. 1998. *California Salmonid Stream Habitat Restoration Manual*, 3rd edition. California Department of Fish and Game, Sacramento, California.

LEVEL III and LEVEL IV HABITAT TYPES

RIFFLE			
Low Gradient Riffle	(LGR)	[1.1]	{ 1}
High Gradient Riffle	(HGR)	[1.2]	{ 2}
CASCADE			
Cascade	(CAS)	[2.1]	{ 3}
Bedrock Sheet	(BRS)	[2.2]	{24}
FLATWATER			
Pocket Water	(POW)	[3.1]	{21}
Glide	(GLD)	[3.2]	{14}
Run	(RUN)	[3.3]	{15}
Step Run	(SRN)	[3.4]	{16}
Edgewater	(EDW)	[3.5]	{18}
MAIN CHANNEL POOLS			
Trench Pool	(TRP)	[4.1]	{ 8 }
Mid-Channel Pool	(MCP)	[4.2]	{17}
Channel Confluence Pool	(CCP)	[4.3]	{19}
Step Pool	(STP)	[4.4]	{23}
SCOUR POOLS			
Corner Pool	(CRP)	[5.1]	{22}
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]	{10}
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]	{11}
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]	{12}
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]	{20}
Plunge Pool	(PLP)	[5.6]	{ 9 }
BACKWATER POOLS			
Secondary Channel Pool	(SCP)	[6.1]	{ 4 }
Backwater Pool - Boulder Formed	(BPB)	[6.2]	{ 5 }
Backwater Pool - Root Wad Formed	(BPR)	[6.3]	{ 6 }
Backwater Pool - Log Formed	(BPL)	[6.4]	{ 7 }
Dammed Pool	(DPL)	[6.5]	{13}
ADDITIONAL UNIT DESIGNATIONS			
Dry	(DRY)	[7.0]	
Culvert	(CUL)	[8.0]	
Not Surveyed	(NS)	[9.0]	
Not Surveyed due to a marsh	(MAR)	[9.1]	