STREAM INVENTORY REPORT

South Fork Noyo River

INTRODUCTION

A stream inventory was conducted during the summer of 1995 on South Fork Noyo River, starting at the confluence with Kass Creek. In addition, two unnamed tributaries to South Fork Noyo Creek were also inventoried. The 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 South Fork Noyo River. The objective of the biological inventory was to document the presence and distribution of juvenile salmonid species. Adult spawning survey data, as well as records from the California Department of Fish and Game (DFG) egg taking station located on the South Fork Noyo River are available from the DFG, Region 3 Office, in Yountville, California.

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

South Fork Noyo River is tributary to the Noyo River, tributary to the Pacific Ocean, located in Mendocino County, California (Figure 1). South Fork Noyo River's legal description at the confluence with the Noyo River is T18N R17W S14. Its location is 39°25'29" north latitude and 123°43'32" west longitude. South Fork Noyo River is a second order stream and has approximately 21.2 total miles of blue line stream according to the USGS Noyo Hill, Mathison Peak, Comptche, and Northspur 7.5 minute quadrangles. South Fork Noyo River drains a watershed of approximately 27.7 square miles. Summer base runoff is approximately two cubic feet per second (cfs) at the mouth. Elevations range from about 30 feet at the mouth of the creek to 1400 feet in the headwater areas. Redwood and Douglas fir forest dominates the watershed. The watershed is primarily located within Jackson Demonstration State Forest and is managed for timber production. Vehicle access exists via California Department of Forestry and Fire Protection (CDF) Road 300.

METHODS

The habitat inventory conducted in South Fork Noyo River follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi and Reynolds, 1991 rev. 1994). The California Conservation Corps (CCC) Technical Advisors and Watershed Stewards Project/AmeriCorps (WSP/AmeriCorps) members that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG).

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South Fork Noyo River personnel were trained in May, 1995, by Gary Flosi. 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 (Hopelain, 1994). 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. Habitat unit types encountered for the first time are further 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.

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 South Fork Noyo River to record measurements and observations. There are nine components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) at the bottom of the stream survey reach using standard flow measuring equipment, if available. In some cases flows are estimated.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1985 rev. 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.

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. Additionally, in South Fork Noyo River two recording thermographs were deployed from June 15 to October 12 to record temperatures on a 24 hour basis during warm summer months.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1988). 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". South Fork Noyo River 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. Channel dimensions were measured using hip chains, range finders, tape measures, and stadia rods. All units were measured for mean length; additionally, the first occurrence of each unit type and a randomly selected 10% subset of all units were sampled for all features on the sampling form (*Sampling Levels for Fish Habitat Inventory*, Hopelain, 1995). Pool tail crest depth at each pool unit was measured in the thalweg. All measurements were in feet to the nearest tenth.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out reaches is measured by the percent of the cobble that is surrounded or buried by fine sediment. In South Fork Noyo River, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3), 76 - 100% (value 4). Additionally, a rating of "not suitable" (NS) was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate particle size, having a bedrock tail-out, or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide 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. 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 South Fork Noyo River, 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.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual*, 1994. Canopy density relates to the amount of stream shaded from the sun. In South Fork Noyo River, 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 deciduous 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 South Fork Noyo River, the dominant composition type (options 1-4) and the dominant vegetation type (options 5-9) 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 was estimated and recorded.

BIOLOGICAL INVENTORY

Biological sampling during stream inventory is used to determine fish species and their distribution in the stream. In South Fork Noyo River fish presence was observed from the stream banks, and three sites were electrofished using one 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 Habitat, a dBASE 4.2 data entry program developed by Tim Curtis, Inland Fisheries Division, California Department of Fish and Game. This program processes and summarizes the data, and produces the following six tables:

- Riffle, flatwater, and pool habitat types
- Habitat types and measured parameters
- Pool types
- Maximum pool depths by habitat types
- Dominant substrates by habitat types
- Mean percent shelter by habitat types

Graphics are produced from the tables using Lotus 1,2,3. Graphics developed for South Fork Noyo River include:

- Riffle, flatwater, pool habitats by percent occurrence
- Riffle, flatwater, pool habitats by total length
- Total habitat types by percent occurrence
- Pool types by percent occurrence
- Total pools by maximum depths
- Embeddedness
- Pool cover by cover type
- Dominant substrate in low gradient riffles
- Percent canopy
- Bank composition by composition type
- Bank vegetation by vegetation type

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HABITAT INVENTORY RESULTS

The following results and discussion are for the South Fork Noyo River above the confluence of Kass Creek. Results and discussion for the two unnamed tributaries follow the main body of this report as subsections.

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

The habitat inventory of September 5-14, 1995, was conducted by Chris Coyle (CCC) and Kyle Young (WSP/AmeriCorps). The total length of the stream surveyed was 49,762 feet with an additional 920 feet of side channel.

Flow was measured at the bottom of the survey reach with a Marsh-McBirney Model 2000 flowmeter at 1.9 cfs on September 20, 1995.

South Fork Noyo River is an F4 channel type for the first 35,467 feet of stream reach surveyed, an F1 for the next 9,458 feet, and an F3 for the remaining 4,837 feet. F-type channels are entrenched, meandering, riffle/pool channels on low gradients with high width/depth ratios. F4 channels have gravel-dominant substrates, F1 channels are bedrock-dominant, and F3 channels are cobble-dominant.

Water temperatures ranged from 56 to 66 degrees Fahrenheit. Air temperatures ranged from 55 to 79 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 43% pool units, 35% flatwater units, and 22% riffle units (Graph 1). Based on total length of Level II habitat types there were 56% pool units, 32% flatwater units, and 12% riffle units (Graph 2).

Twenty-one Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were glides 22%, mid-channel pools 21%, and low-gradient riffles 19% (Graph 3). Based on percent total length, mid-channel pools made up 27%, glides 22%, and low-gradient riffles 11%.

A total of 462 pools were identified (Table 3). Main channel pools were most frequently encountered at 58% and comprised 59% of the total length of all pools (Graph 4).

Table 4 is a summary of maximum pool depths by pool habitat type. Depth is an indicator of pool quality. Two hundred eighty-six of the 462 pools (62%) had a depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 351 pool tail-outs measured, 101 had a value of 1 (28.8%); 131 had a value of 2 (37.3%); 97 had a value of 3 (27.6%); and 22 had a value of 4 (6.3%) (Graph 6). On this scale, a value of 1 indicates the highest quality of spawning substrate.

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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. Pool habitat types had a mean shelter rating of 21, and flatwater habitats had a mean shelter rating of 7 (Table 1). Of the pool types, the backwater pools had the highest mean shelter rating at 29. Main channel pools had a mean shelter rating of 25 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Undercut banks are the dominant cover type in South Fork Noyo River. Large and small woody debris are lacking in nearly all habitat types. Graph 7 describes the pool cover in South Fork Noyo River.

Table 6 summarizes the dominant substrate by habitat type. Gravel was the dominant substrate observed in 17 of the 24 low gradient riffles measured (71%). Small cobble was the next most frequently observed dominant substrate type and occurred in 29% of the low gradient riffles (Graph 8).

The mean percent canopy density for the stream reach surveyed was 89%. The mean percentages of deciduous and coniferous trees were 21% and 79%, respectively. Graph 9 describes the canopy in South Fork Noyo River.

For the stream reach surveyed, the mean percent right bank vegetated was 80%. The mean percent left bank vegetated was 79%. The dominant elements composing the structure of the stream banks consisted of 17.9% bedrock, 0.4% boulder, 34.5% cobble/gravel, and 47.2% sand/silt/clay (Graph 10). Grass was the dominant vegetation type observed in 44% of the units surveyed. Additionally, 18% of the units surveyed had deciduous trees as the dominant vegetation type, and 30% had coniferous trees as the dominant vegetation, including down trees, logs, and root wads (Graph 11).

BIOLOGICAL INVENTORY RESULTS

Three sites were electrofished on September 20, 1995, in South Fork Noyo River. The units were sampled by Chris Coyle (CCC) and Kyle Young (WSP/AmeriCorps).

The first site sampled included habitat units 8 and 9, a log-enhanced lateral scour pool and run approximately 363 feet from the confluence with Kass Creek and within the F4 channel type reach. This site had an area of 448 sq ft and a volume of 400 cu ft. The unit yielded one 0+ coho, two 0+ steelhead, one 1+ steelhead, and one Pacific giant salamander.

The second site included habitat units 754-758, a series of pools and glides located approximately 40,776 feet above Kass Creek and within the F1 channel type reach. This site had an area of 1,420 sq ft. The site yielded eight 0+ coho, one 0+ steelhead, nine sculpin, and one three-spine stickleback.

The third site sampled included habitat units 1037, 1044, and 1046, a mid-channel pool, plunge pool, and trench pool located approximately 49,475 feet above Kass Creek and within the F3 channel type reach. The site had an area of 590 sq ft and a volume of 1080 cu ft. The site yielded ten 0+ coho, six 0+ steelhead, one 1+ steelhead, one 2+ steelhead, and two juvenile

smallmouth bass.

DISCUSSION

South Fork Noyo River is an F4 channel type for the first 35,467 feet of stream surveyed, an F1 for the next 9,458 feet, and an F3 for the remaining 4,837 feet. The suitability of F4 channel types for fish habitat improvement structures is as follows: good for bank-placed boulders; fair for low-stage weirs, single and opposing wing deflectors, channel constrictors, and log cover; and poor for medium-stage weirs and boulder clusters. F1 channels are considered: good for bank-placed boulders; fair for single wing deflectors and log cover; and poor for low- and medium-stage weirs, boulder clusters, and opposing wing deflectors. F3 channels are considered: good for bank-placed boulders and single and opposing wing deflectors; fair for low-stage weirs, boulder clusters, channel constrictors, and log cover; and poor for medium-stage weirs.

The water temperatures recorded on the survey days September 5-14, 1995, ranged from 56 to 66 degrees Fahrenheit. Air temperatures ranged from 55 to 79 degrees Fahrenheit. In addition, temperature data collected by CDF between June 15 and October 12, 1995, indicated a peak temperature of approximately 67 degrees Fahrenheit on July 16, 1995. This was followed by a nighttime low of approximately 61 degrees Fahrenheit. Temperature data for the month of August are unavailable due to the emersion of the temperature monitor due to receding water levels. The data available suggest a water temperature reaching the higher end of the range suitable for salmonids. Sixty-seven degrees Fahrenheit, if sustained, is near the threshold stress level for coho. To make any further conclusions, temperatures would need to be monitored for several years throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 32% of the total length of this survey, riffles 12%, and pools 56%. The pools are relatively deep, with 286 of the 462 (61.9%) pools having a maximum 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 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.

One hundred nineteen of the 351 pool tail-outs measured had embeddedness ratings of 3 or 4. Only 101 had a 1 rating. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. In South Fork Noyo River, sediment sources should be mapped and rated according to their potential sediment yields, and control measures should be taken.

The mean shelter rating for pools was low with a rating of 21. The shelter rating in the flatwater habitats was lower at 7. A pool shelter rating of approximately 100 is desirable. The relatively small amount of cover that now exists is being provided primarily by undercut banks in all habitat types. Additionally, bedrock ledges contribute a small amount. Log and root wad cover structures in the pool and flatwater habitats are needed to improve 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.

All of the 24 low gradient riffles measured had gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

The mean percent canopy density for the stream was 89%. This is a relatively high percentage of canopy. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was high at 80% and 79%, respectively. In areas of stream bank erosion or where bank vegetation is not at acceptable levels, planting endemic species of coniferous and deciduous trees, in conjunction with bank stabilization, is recommended.

Coho and steelhead were observed throughout the entire 49,762 feet of stream surveyed.

RECOMMENDATIONS

1) South Fork Noyo River should be managed as an anadromous, natural production stream.

2) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover is from undercut banks. Adding high quality complexity with woody cover is desirable and in some areas the material is locally available. In particular, large wood should be placed in a manner to increase backwater areas to produce winter holdover habitat.

3) Active and potential sediment sources related to the road system need to be identified, mapped, and treated according to their potential for sediment yield to the stream and its tributaries.

4) Non-native fish, in this case sunfish (*Lepomis* spp.) and smallmouth bass (*Micropterus dolomieui*), were either observed or sampled in the stream. Both of these are predatory species and may prey upon juvenile salmonids as well as compete with them for food and shelter. Both of these species probably escaped from the impoundment in the headwaters of South Fork Noyo River. The dam at this impoundment should be inspected and, if necessary, measures taken to prevent further escapement. Downstream reaches should be monitored to determine if non-native species are becoming established and/or expanding their range.

5) The water temperature data available suggest that maximum temperatures are reaching the higher end of the range suitable 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.

6) Inventory and map sources of stream bank erosion and prioritize them according to present and potential sediment yield. Identified sites, like the site at 3,695', 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 (ft):	Comments:
0'	Begin survey at confluence with Kass Creek. Channel type is F4.
56'	Log stringer bridge 12' long x 50' wide x 11' clearance.
166'	Dry left bank tributary.
277'	Debris raft 40' long x 50' wide. Not a barrier and no gravel retained (NBNG).
3524'	Left bank tributary. Estimated flow 0.05 cfs. Mouth dry at time of survey, otherwise accessible to fish.
3695'	Left bank erosion 50' high contributing fines and debris.
3915'	Sunfish observed.
5375'	Right bank tributary. Estimated flow 0.01 cfs. Mouth dry at time of survey, otherwise accessible to fish.
6232'	Left bank tributary. Estimated flow 0.01 cfs. Not accessible to fish (NAF).
7069'	Dry left bank tributary.
7623'	Left bank tributary. Estimated flow <0.01 cfs. NAF.
10636'	Right bank tributary. Estimated flow 0.01 cfs. Accessible to fish, but none observed.
12516'	Right bank 3' diameter corrugated metal pipe (CMP) culvert. No outfall.
12528'	Right bank spring.
12942'	Left bank tributary. Estimated flow 0.01 cfs. NAF.
14246'	Dry right bank tributary.
14940'	Left bank tributary. Estimated flow <0.01 cfs. NAF.

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17058'	Right bank 1.5' diameter CMP culvert. No outfall.
17611'	Right bank 1.5' diameter CMP culvert. No outfall.
19347'	Left bank 2' diameter CMP culvert. Estimated one gallon per minute (gpm) outfall.
20122'	Concrete dam at Noyo egg-taking station. A bypass exists through the egg-taking station.
20358'	North Fork of South Fork Noyo River enters right bank. The flow in NFSF Noyo River was measured at 0.5 cfs on October 11, 1995.
20584'	CDF Road 350 plate arch bridge 24' wide x 36' long x 7' clearance.
21720'	Log stringer footbridge 8' long x 35' wide x 7' clearance.
21981'	Right bank 1.5' diameter CMP culvert. No outfall.
22243'	Peterson Gulch enters left bank. See separate report.
23113'	Right bank 1.5' diameter CMP culvert. No outfall.
24035'	Left bank tributary. Estimated flow one gpm. NAF.
24553'	Right bank 1.5' diameter CMP culvert. No outfall.
25788'	Bear Gulch enters right bank. See separate report.
26880'	Left bank tributary. Estimated flow <0.01 cfs. NAF.
28708'	Right bank 2' diameter CMP culvert. No outfall.
31606'	Right bank ravine.
31840'	Water drafting site.
33494'	Left bank relic railroad trestle.
34022'	Concrete dam. Approximately 2% gradient on spillway with 1' high slot weir at top. There is no fishway over this dam, but it was not a barrier to anadromous fish passage in the winter of 1994/95.
34504'	Parlin Creek enters right bank. See separate report.
34735'	Unnamed Tributary A (23 Gulch) enters left bank. See subsection in this report.

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35352'	Unnamed Tributary B enters from the left bank. CDF Road 320 parallels this tributary. See subsection in this report.
35467'	Channel type changes to F1.
35575'	CDF Road 320 trestle bridge 15' long x 50' wide x 11' clearance.
38040'	Right bank tributary. Estimated flow <0.01 cfs. Accessible to fish.
39133'	Right bank erosion 10' high x 30' long contributing fines and cobble.
41510'	Left bank tributary. Estimated flow <0.01 cfs. NAF.
41704'	Left bank tributary. Estimated flow <0.01 cfs. NAF.
41909'	Right bank tributary. Only residual pools remain. Accessible to fish, but none observed.
42261'	Fallen log creating possible low-flow barrier.
42997'	Left bank tributary. Estimated flow 0.01 cfs. Accessible to fish, but none observed.
43960'	Left bank ravine.
44925'	Channel type changes to F3.
46303'	Left bank seep.
47013'	Right bank tributary. Estimated flow <0.1 cfs. Possibly fish-bearing.
47054'	Old vehicle crossing.
47723'	Right bank tributary. Only residual pools remain. Difficult access for fish and none observed.
49475'	The third biological inventory site sampled included a mid-channel pool, plunge pool, and trench pool. The site yielded ten 0+ coho, six 0+ steelhead, one 1+ steelhead, one 2+ steelhead, and two juvenile smallmouth bass.
49576'	Left bank erosion 10' high x 58' long contributing fines and gravel.
49762'	End of survey at dam spillway.

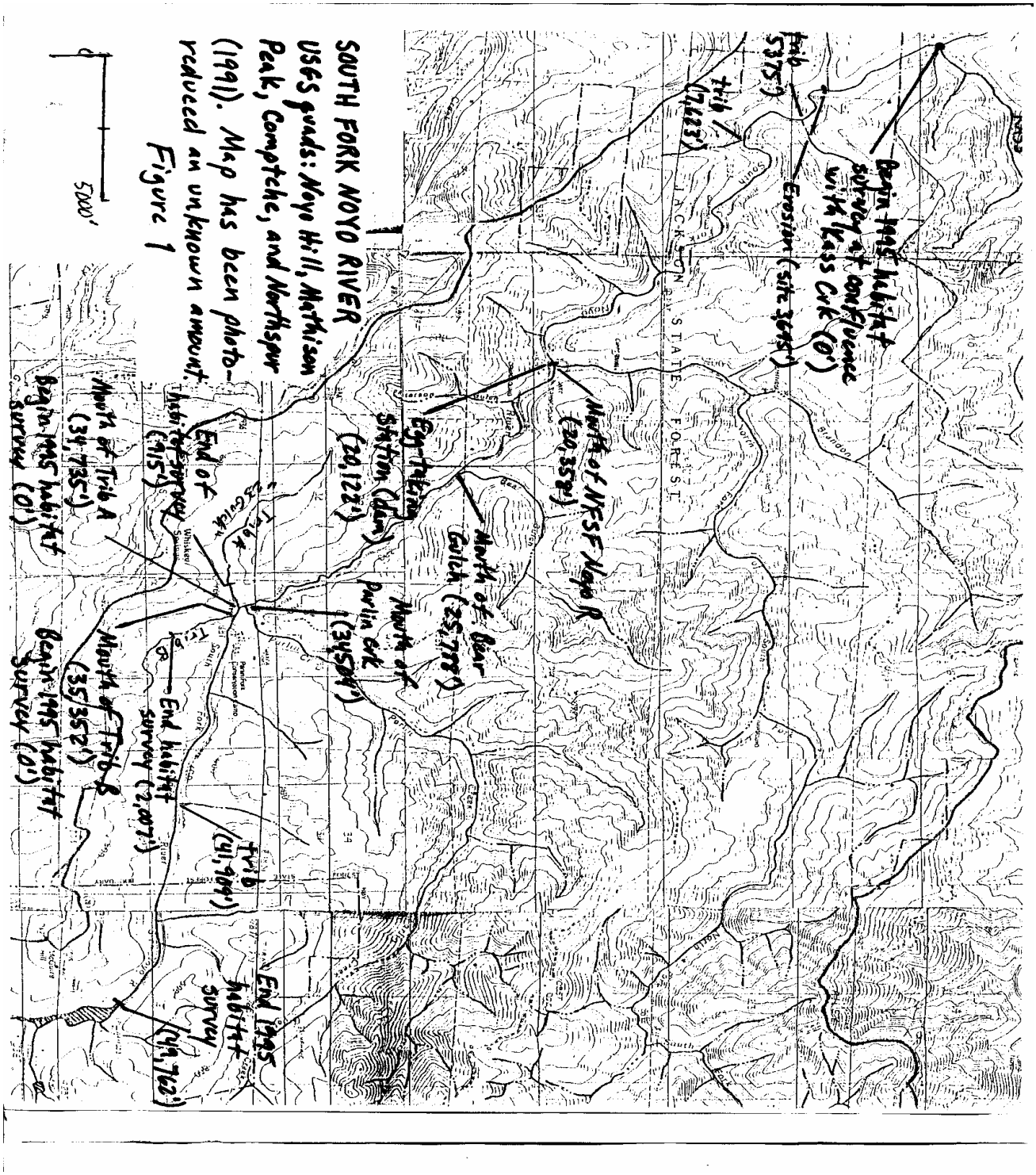
REFERENCES

Flosi, G., and F. Reynolds. 1994. California salmonid stream habitat restoration manual, 2nd edition. California Department of Fish and Game, Sacramento, California.

Hopelain, J. 1995. Sampling levels for fish habitat inventory, unpublished manuscript. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California.

LEVEL III and LEVEL IV HABITAT TYPE KEY

HABITAT TYPE	LETTER	NUMBER
RIFFLE		
Low Gradient Riffle	[LGR]	1.1
High Gradient Riffle	[HGR]	1.2
CASCADE		
Cascade	[CAS]	2.1
Bedrock Sheet	[BRS]	2.2
FLATWATER		
Pocket Water	[POW]	3.1
Glide	[GLD]	3.2
Run	[RUN]	3.3
Step Run	[SRN]	3.4
Edgewater	[EDW]	3.5
MAIN CHANNEL POOLS		
Trench Pool	[TRP]	4.1
Mid-Channel Pool	[MCP]	4.2
Channel Confluence Pool	[CCP]	4.3
Step Pool	[STP]	4.4
SCOUR POOLS		
Corner Pool	[CRP]	5.1
Lateral Scour Pool - Log Enhanced	[LSL]	5.2
Lateral Scour Pool - Root Wad Enhanced	[LSR]	5.3
Lateral Scour Pool - Bedrock Formed	[LSBk]	5.4
Lateral Scour Pool - Boulder Formed	[LSBo]	5.5
Plunge Pool	[PLP]	5.6
BACKWATER POOLS		
Secondary Channel Pool	[SCP]	6.1
Backwater Pool - Boulder Formed	[BPB]	6.2
Backwater Pool - Root Wad Formed	[BPR]	6.3
Backwater Pool - Log Formed	[BPL]	6.4
Dammed Pool	[DPL]	6.5



SOUTH FORK NOYO RIVER

USGS quads: Noyo Hill, Mathison Peak, Comptche, and Northspur (1991). Map has been photo-reduced an unknown amount.

Figure 1