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MONITORING OF AQUATIC IMPACTS ASSOCIATED WITH
CONSTRUCTION OF THE U.S. 101 BYPASS

SUMMARY REPORT
(Appendices not included)

REDWOOD NATIONAL PARK
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UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

REDWOOD NATIONAL PARK
ARCATA, CA 95521

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* not included in Summary Report

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SUMMARY

This report identifies monitoring site locations and describes methods used by Redwood National Park to monitor aquatic impacts associated with construction of the U.S. 101 Bypass in northern Humboldt County, California. Timber clearing for the bypass was conducted on the northern alignment during the summer of 1984 and the southern alignment during the summer of 1985. In 1984, limited baseline data were collected at monitoring sites in the northern portion of the project (Klamath River tributaries). In 1985, a more intensive effort provided baseline information for the monitoring sites in the southern portion (Prairie Creek and Prairie Creek tributaries) and first year impact data to assess impacts to Klamath River tributaries in the northern portion of the project.

For 1985, spawning gravel at all monitoring sites except May Creek, were within an acceptable range. Accumulation of fine sediment less than 1.00 mm was not significant in the surface gravels. At some sites percent fine sediment increased with depth. Values for predicted egg-to-emergence survival rates were high at all sites except May and McGarvey Creeks, where values were moderate. Pre-project macroinvertebrate monitoring reflected good water quality conditions at all sites with many sensitive taxa being present (analysis of macroinvertebrate data for 1985 will be presented in the 1987 annual report). Although May Creek had moderate gravel quality, it supported a substantial number of salmonids, with coho salmon as the predominate species.

Ground disturbance from timber clearing operations at the northern portion of the bypass had no apparent impact on gravel quality parameters or predicted egg-to-emergence survival rates at North Fork Ah Pah and McGarvey Creeks. Comparing 1984 to 1985, North Fork Ah Pah Creek showed an increase in percent fines on the surface gravel layers. This was attributed to a non-project related stream crossing which failed during the 1984-85 winter.

INTRODUCTION

To alleviate conflicts between visitor and commercial traffic on U.S. Highway 101, Congress directed in Public Law 95-250 that a bypass highway be constructed east of Prairie Creek Redwoods State Park. The environmental impact statement (California Department of Transportation 1984) for the project states that soil erosion produced by highway construction could significantly reduce aquatic productivity of project area streams. Losses of fishery resources during the five-years of construction were estimated at 75-100 percent in May Creek, the most affected stream, and between 13-90 percent in other affected streams. To reduce aquatic impacts, extensive erosion control measures are being implemented during construction.

On November 26, 1984, Redwood National Park (RNP) and the California Department of Transportation (Caltrans) entered into an agreement to monitor biological conditions of streams affected by construction of the U.S. 101 bypass. The agreement stated that Caltrans would fund RNP to conduct studies to evaluate the effectiveness of erosion control measures by determining impacts to anadromous fish habitat. RNP will monitor change over time in stream substrate composition, aquatic habitat features and aquatic macroinvertebrates. As stipulated in the agreement, RNP now submits the first of five annual reports -results of 1985 data.

SITE DESCRIPTION

The U.S. Highway 101 Bypass project is located in coastal northern California between Eureka and Crescent City (Figure 1). The bypass alignment veers northeasterly through the May Creek watershed, parallels northwesterly the ridge between Prairie Creek and the Klamath River and continues along the state park boundary until it intersects U.S. Highway 101 about 0.5 miles (0.8 km) north of the Humboldt/Del Norte County line. Six streams will be crossed by the alignment: McGarvey and Ah Pah Creeks which are tributaries to the Klamath River and May, Boyes and Brown Creeks which are tributaries to Prairie Creek. Prairie Creek will be affected by the input from its affected tributaries and by a 400 foot (122 m) channel realignment at the southerly end of the project where the new alignment leaves existing Route 101.

The project area is strongly influenced by the Pacific Ocean and has a coastal Mediterranean climate characterized by mild winters and warm, dry summers with frequent fog. The average annual rainfall is 70 inches (178 cm) at Elk Prairie in Prairie Creek Redwoods State Park and occurs between October and June. The average temperature is nearly constant (low of

1. Prairie Creek above Brown Creek
2. Prairie Creek above Boyes Creek.
3. Prairie Creek below Boyes Creek.
4. Prairie Creek above May Creek.
5. Prairie Creek below May Creek.
6. Prairie Creek below Channelization.
7. Lost Man Creek.
8. Brown Creek.
9. Boyes Creek.
10. May Creek.
11. Tarup Creek.
12. N.F. Ah Pah Creek.
13. McGarvey Creek.

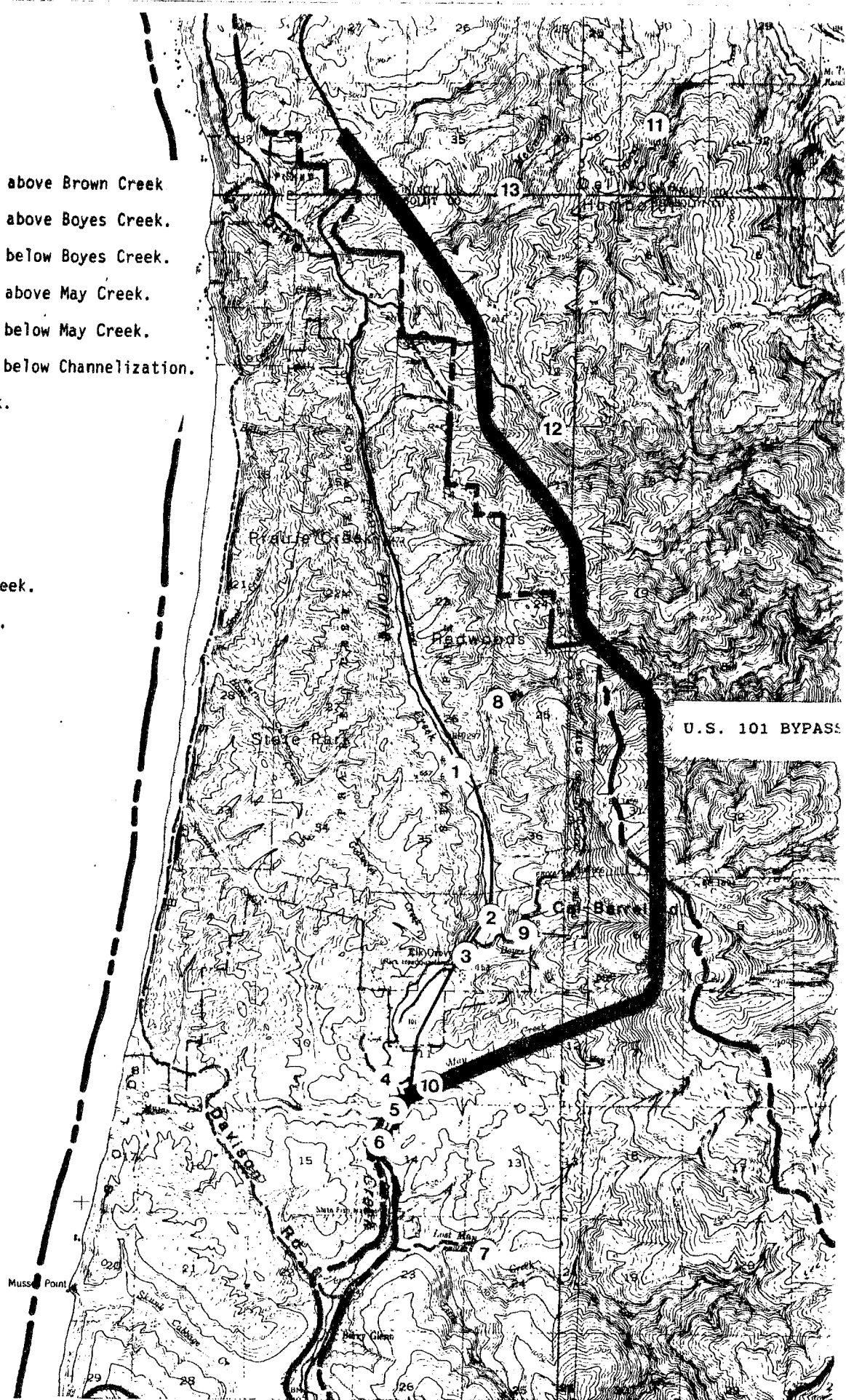


Figure 1. Location of the monitoring sites within three watershed units, Prairie Creek, Prairie Creek Tributary and Klamath River Tributary, Humboldt and Del Norte Counties, California.

45 and high of 60 degrees Fahrenheit), year-round. Higher elevations east of RNP, along the bypass alignment have slightly wider temperature variations and average 5-10 inches (13-25 cm) more annual precipitation.

Watershed size, general logging history and general description of surface-rock types for Prairie Creek, May Creek, Boyes Creek, Brown Creek, Lost Man Creek (control stream), McGarvey Creek, North Fork Ah Pah Creek and Tarup Creek (control stream) are given in Table 1. Detailed vegetation and logging history maps are available at the RNP Arcata Office. Detailed geological descriptions of the region are found in the following references: Bailey and Irwin (1964), Janda and Nolan (1975), and Strand (1963).

SITE SELECTION

Monitoring sites on each of the six streams to be affected by project construction plus two unaffected control streams were selected by a team from RNP, Caltrans and the California Department of Fish and Game. The following criteria were used for site selection:

1. Downstream of highway construction;
2. Proximity to established Caltrans water quality monitoring sites;
3. Within a reach of stream accessible to anadromous fish;
4. Representative of general characteristics for anadromous stream reach;
5. Relatively accessible.

Thirteen permanent monitoring sites were established and divided into the following 3 watershed units, each with a control stream:

Prairie Creek Unit

Prairie Creek above Brown Creek (Control)
Prairie Creek above Boyes Creek
Prairie Creek below Boyes Creek
Prairie Creek above May Creek
Prairie Creek below May Creek
Prairie Creek below Channelization

Prairie Creek Tributary Unit

Lost Man Creek (Control)
May Creek
Boyes Creek
Brown Creek

Table 1. Watershed size in acres (hectares), general logging history and general surface-rock type for Prairie Creek, Brown Creek, Boyes Creek, May Creek, Lost Man Creek, McGarvey Creek, North Fork Ah Pah Creek and Tarup Creek (partially taken from California Department of Transportation (1984) and Iwatsubo et al. (1976)).

Creek	Size acres (hectares)	Logging History	Surface-rock type
Prairie	25,000 (10,125)	old-growth and advanced second- growth Redwood	marine terrace deposits of sands and well rounded gravels
Boyes	950 (385)	predominantly old-growth Red- wood--mid 1970 logging in head- waters	predominantly marine terrace some exposures of Franciscan sandstone
May	1,200 (486)	extensively log- ged Redwood in 1940's and 1950's	same as Boyes
Brown	1,200 (486)	old-growth Red- wood--no logging	same as Boyes
Lost Man	2,500 (1,013)	old-growth and advanced second growth Redwood	predominantly Franciscan sand stone--some marine terrace deposits
McGarvey	5,500 (2,228)	predominantly clear-cut Red- wood and Doug- las Fir	same as Lost Man
North Fork Ah Pah	3,100 (1,256)	same as McGarvey	same as Lost Man
Tarup	4,400 (1,782)	same as McGarvey	same as Lost Man

Klamath River Tributary Unit

Tarup Creek (control)
North Fork Ah Pah Creek
McGarvey Creek

Figure 1 shows the 13 monitoring sites within the 3 watershed units. Stream reach length, percent gradient and percent canopy cover for the 13 monitoring sites is listed in Table 2. Canopy cover was based on five random samples taken at summer/fall invertebrate monitoring sites using a spherical densiometer.

MATERIALS AND METHODS

Gravel Composition

Gravel composition was determined by collecting 6 random samples from riffle crests in each study reach. Samples were collected during summer, low-flow conditions (July, 1985) using a tri-tube freeze-core bulk sampler as described by Lotspeich and Reid (1980). A freeze-core sampler consists of 3 hollow steel tubes which are driven into the stream substrate, 3 smaller manifold tubes which are used to inject compressed carbon dioxide into the tubes and a tripod hoisting device which is used to lift the frozen 16 in (40.4 cm) by 5 in (12.6 cm) diameter column of stream gravel.

The freeze-core sampler was constructed by Caltrans (at the direction of Jeff Gidley, Sacramento Transportation Laboratory) using designs from Everest et al. (1980). After extensive field use, the sampler was modified by replacing structurally weak aluminium elements on the tripod assembly with stronger, more durable steel elements. The original aluminum pieces broke under stress when cores were hoisted from the stream bed.

The frozen cores were taken from the streambed, placed horizontally on a subsampling tray and thawed using a propane torch. Four 4.0 in (10.1 cm) subsamples were stored in porous bags and allowed to air dry for 4 to 5 months.

At Humboldt State University's Geology soils lab, subsamples were weighed and sieved for approximately 20 minutes using a Ro-tap sieving apparatus. The following 6 sieve sizes recommended for fisheries investigations (Platts et al. 1983) were used :

1. less than 0.005 in (0.125 mm)
2. 0.005 in (0.125 mm) to 0.04 in (1.00 mm)
3. 0.04 in (1.00 mm) to 0.16 in (4.00 mm)
4. 0.16 in (4.00 mm) to 1.25 (32.00 mm)

Table 2. Stream Reach length, percent gradient and percent canopy cover for the 13 monitoring sites, U.S. Bypass monitoring project, 1985.

<u>Monitoring Site</u>	<u>Reach Length Feet (m)</u>	<u>Percent Gradient</u>	<u>Percent Canopy Cover</u>
Prairie Creek Unit			
Prairie Creek above Brown Creek (control)	320 (98)	0.52	90
Prairie Creek above Boyes Creek	328 (100)	0.12	69
Prairie Creek below Boyes Creek	270 (82)	0.18	79
Prairie Creek above May Creek	298 (91)	0.24	68
Prairie Creek below May Creek	397 (121)	0.50	72
Prairie Creek below Channelization	370 (113)	0.83	89
Prairie Creek Tributary Unit			
Lost Man Creek (control)		0.90	72
Brown Creek	151 (46)	1.64	96
Boyes Creek	207 (63)	1.38	96
May Creek	244 (74)	1.53	not available
Klamath River Tributary Unit			
Tarup Creek (control)	212 (65)	1.30	98
North Fork Ah Pah Creek	285 (87)	1.30	94
McGarvey Creek	343 (105)	0.69	97

5. 1.25 in (32.00 mm) to 5.00 in (128.00 mm)
6. greater than 5.00 in (128.00 mm)

The sieved fractions were then weighed to compute the percent grain-size composition of each subsample. Stratification of percent fines in the vertical gravel column was tested by conducting a one-way analysis of variance on the 4 subsamples.

Percent fines less than 0.04 in (1.00 mm) and the Fredle index were computed for the total core sample by combining the 4 subsamples. The Fredle index (f) was calculated by the following method (Everest 1982):

$$f = \frac{dg}{So} ;$$

where, dg = geometric mean = $(d_1^{w_1} \times d_2^{w_2} \times \dots \times d_n^{w_n})$

d_n = mid-point diameter of particles retained on the n th sieve

w_n = decimal fraction by weight of particles retained on the n th sieve

$So = \sqrt{\frac{d_{75}}{d_{25}}}$ = sorting coefficient

d_{75} and d_{25} = particle size diameters at which 75 and 25 percent, respectively, of the sample is finer on a weight bases

Particle-size cumulative distribution curves plotted on log probability paper were used to obtained d_{75} and d_{25} .

As part of a limited data collecting effort during summer 1984, 3 freeze-core samples were taken at North Fork Ah Pah and McGarvey Creeks. They were processed and analyzed according to the above procedures.

Stream Mapping

Active channels (that portion of the streambed inundated annually with storm runoff) of each monitoring reach were mapped at low flow conditions (August-September 1985). Steel bars were driven into the streambed at upper and lower ends and at significant bends in the stream reach. A tape was attached to the bars and measurements taken perpendicular to the tape using a 25 foot telescoping fiberglass rod. At prominent morphological features, transects were established and bank lines, water lines, woody debris and substrate were measured to the nearest 0.1 ft (3.0 cm). Along the same transect, depth contours of 1.0 ft (30.5 cm) or more were recorded using a 6.0 ft (1.8 m) rod. Stream maps were refined by sketching in substrate and other larger landmarks which extended between transects. Surface substrate was

visually determined and recorded in the following 5 size classes:

1. Silt less than 0.005 in (0.125 mm)
2. Sand 0.005 in (0.125) to 0.08 in (2.00 mm)
3. Gravel 0.08 in (2.00) to 1.75 in (44.00 mm)
4. Rubble 1.75 in (44.00) to 5.00 in (128.00 mm)
5. Bedrock (including hard consolidated clay)

Above water and submerged large organic debris and leaf packs were also recorded.

Maps were drawn in the field using 18 x 36 in (45 x 91 cm) graph paper with 0.1 in (3.0 cm) grids. A plain table and alidade were used on large stream reaches. Finished maps showing substrate, cross-section locations, longitudinal profiles and prominent stream features were prepared on mylar.

Pools deeper than 1.0 ft (30.5) were classified according to Bisson et al. (1981). The following 7 pool types were used:

1. Backwater pools associated with boulders were along channel margins caused by eddies behind boulders. Pool depths were usually shallow, current velocities low and bottom substrates fine grained.
2. Backwater pools associated with large organic debris were typical backwater pools except formed by large debris.
3. Trench pools associated with bedrock were usually long, deep slots in stable coarse-grained substrate. Current velocities were swift and parallel with the stream bank consisting of bedrock on at least one side (note: hard consolidated clay of Gold Buffs formation was considered bedrock).
4. Lateral scour pools associated with large debris were usually large and deep with highly variable substrate. Stream flow was not parallel with the stream bank as with trench pools but was directed to one side of the stream by large debris. Large debris was part of the pool environment.
5. Lateral scour pools associated with rootwads were typical lateral scour pools but involved rootwads.
6. Lateral scour pools associated with bedrock were typical lateral scour pools but involved bedrock. Undercut banks were usually associated with this pool type.
7. Glides possessed the attribute of both riffle and pools. Depths were shallow, current velocities were even with no turbulence and substrates were typically gravel and cobble. Glides (sometimes called "runs") usually occurred in long, low gradient reaches with stable banks and no major flow obstructions.

Pool volumes were calculated using the formula for the volume of a cone:

$$V = 1/3 Ah$$

where, A = surface area of pool
h = deepest point of pool

Surface areas were obtained from stream maps using a planimeter.

Two pool volumes were calculated: surface water volume using pool bottom to water surface and residual depth volume using pool bottom to elevation of closest downstream riffle crest. Residual depths were determined from longitudinal profiles as described by Lisle (unpublished report).

Cross-sectional Profiles

During August 1985, cross-sectional transects were surveyed at the 13 monitoring sites. At each monitoring site, 4-7 cross-sections were established at prominent habitat types (e.g. pools, riffles, and glides). Transects were oriented approximately perpendicular to stream flow. Streambanks were monumented using 5.0 ft (1.6 m) lengths of 0.5 in (1.3 cm) steel bars. Each bar was driven 3.0-3.5 ft (1.0-1.1 m) into the ground and referenced to 2 triangulation points with a tape and compass. Cross-sections were surveyed using a level, tape and rod. Elevation measurements were recorded at each break in slope.

Profiles were plotted for all cross-sections.

During summer 1984, cross-sections were surveyed at 3 monitoring sites (Prairie Creek above May Creek, Prairie Creek below May Creek and Prairie Creek below channelization). Area of scour or fill were computed for the 3 monitoring sites using a basic scour/fill program.

Longitudinal Profiles

During September 1985, longitudinal transects were surveyed at the 13 monitoring sites. Steel bars were driven into the streambed at upper and lower ends of the monitoring reach. Tape was attached to the bars and a level set-up over one monument. The deepest section of the channel (thalweg) was recorded at measurements along the tape corresponding to breaks in slopes (e.g. pools, edge of pools, and riffle crests). Longitudinal profiles were used to determine stream reach gradient and residual pool depths. Residual pool depth is the depth of a pool minus the depth of its downstream riffle.

Photographic Documentation

Each of the 13 monitoring sites were photographed in September-October 1985. The middle channel and left and right banks at each cross-section were documented on color slides and black and white film using a 35 mm camera equipped with a 28 mm lens.

Aquatic Macroinvertebrates

For baseline information, aquatic macroinvertebrates were sampled approximately every 6 weeks between summer 1980 and summer 1981 at the following locations established by Terry Hofstra and Jim Harrington of RNP and Gary Winters of Caltrans Facilities Construction Headquarters, Sacramento.

Prairie Creek Unit

Prairie Creek above Boyes Creek
Prairie Creek below Boyes Creek
Prairie Creek above May Creek
Prairie Creek below May Creek

Prairie Creek Tributary Unit

May Creek
Boyes Creek

Klamath River Tributary Unit

North Fork Ah Pah Creek
McGarvey Creek

Macroinvertebrates were collected using an artificial substrate (barbeque-basket) samplers. Samplers were welded wire baskets, 12 in (30 cm) long and 5 in (13 cm) in diameter, and filled with 1-4 in (2.5-10.2 cm) rounded rock.

Three samplers were placed at each site and allowed to colonize for 6 weeks. Three new samplers were placed in the stream at the time of each collection. Samplers were retrieved by swiftly lifting them out of water and placing them into a bucket which was slightly submerged, and as close to the downstream side of the sampler as possible. Samplers were then opened and their contents emptied into the bucket. Each rock was scrubbed with a toothbrush and examined for organisms. Some samplers were vandalized, trampled by elk, lost during high water or dewatered during summer low flow conditions, thus not all samplers were collected.

Once all the rocks were scrubbed and discarded, the contents of each bucket was poured through a No. 35 USA Standard Testing Sieve (mesh opening 0.5 mm). All macroinvertebrates were removed from the sieve and stored in jars containing 70 percent ethyl alcohol.

Macroinvertebrates were separated from the organic debris in the laboratory using a dissecting microscope. All macroinvertebrates were identified to the lowest possible taxon using primarily Edmunds et al. (1976), Merritt and Cummins (1984), Pennak (1978), Usinger (1978), Wiggins (1977) and various monographs obtained from Humboldt State University's Biology Department.

Macroinvertebrate taxons were enumerated and classified according to functional groups described by Merritt and Cummins (1984). Four general functional groups were used:

1. Predators - carnivores which feed by engulfing whole or parts of living animal tissue.
2. Grazers - omnivores which feed by scraping periphyton, attached algae and associated material from mineral and organic surfaces.
3. Shredders - herbivore and detritivores which process coarse particulate organic matter (CPOM) as a food source.
4. Collectors - detritivores which feed by filtering suspended material or by gathering depositional material primarily consisting of decomposing fine particulate organic matter (FPOM).

A diversity index was calculated for each sample using the equation given by Wilhm and Dorris (1968):

$$\text{diversity index} = - \sum_{i=1}^s (n_i/n) \log (n_i/n) ;$$

where, n = the total number of individuals of all taxa
 n_i = the number of individuals in the i th taxon
 s = the total number of taxa in the community

Using a basic macroinvertebrate description program, the following parameters were generated for all sample dates at the 8 locations:

1. Cumulative species lists
2. Mean number of taxa
3. Mean number of individuals
4. Mean diversity index
5. Percent (by individuals) functional group composition

Aquatic macroinvertebrates were sampled June and September 1985 at all 13 monitoring sites. A modified Surber sampler, portable macroinvertebrate box sampler (PIBS) with a 0.0125 in (0.32 mm) mesh net was used to sample riffle habitat. Five samples were collected at random from 1.0 ft (0.3 m) intervals on a transect through the deepest section (thalweg)

of all riffles. Macroinvertebrates and debris were removed from the net and stored in jars containing 70 percent ethyl alcohol. An Ekman dredge was used to sample pool habitat. Three samples were collected at random from 1.0 ft (0.3 m) intervals on a transect through the center of all pools. Dredge spoils were rinsed in a bucket with a 0.0125 in (0.32 mm) mesh bottom, removed and stored in jars containing 70 percent ethyl alcohol. Pools at some monitoring sites could not be sampled because the bottom substrate was too coarse.

Macroinvertebrates from riffle samples were separated from organic debris in the laboratory using a dissecting microscope. Macroinvertebrates from pool samples were separated from fine sediment using a concentrated sugar solution. All macroinvertebrates were identified to lowest possible taxon using previously mentioned references. Body lengths (head to tip of abdomen) of macroinvertebrates greater than 0.04 in (1.0 mm) were measured to the nearest 0.04 in (1.0 mm) for biomass estimates using empirically derived length-mass relationships or published length-mass relationships (Smock 1980).

Using the basic macroinvertebrate description program, the following parameters were generated for sample dates at the 13 monitoring sites:

1. Species list of mean number of observed individuals
2. Mean number of taxa
3. Mean number of individuals
4. Mean biomass
5. Percent (by biomass) functional guild composition

Fisheries

Juvenile fish abundance and composition was determined on September 10, 1985 for the May Creek monitoring site and a control reach in Godwood Creek (a Prairie Creek tributary with similar fisheries habitat, but not within the influence of highway construction). A 79 foot (24 m) section in May Creek and an 81 foot (25 m) section in Godwood Creek were sampled using standard electrofishing techniques (Platts et al. 1983). Fish numbers were estimated using the two-step removal method (Seber and LeCren 1967). The following parameters were generated for both sites:

1. Total number of fish per 100 ft (30.5 m) of linear stream reach;
2. Species composition and proportions of total numbers;
3. Mean and range of fork length for all species.

Numbers of juvenile salmonids supported by available habitat in the 13 monitoring sites were estimated using information gathered by the U.S. Forest Service's Pacific Southwest Experimental Station (Decker unpublished report). In their

study, five stream reaches were monitored: two sites on Prairie Creek above Brown Creek, Prairie Creek above May Creek and two sites on Wolf Creek, a tributary to Prairie Creek. Fish habitat features were mapped using stream mapping techniques, pool types were classified according to (Bisson et al. 1981) and fish abundance was determined using direct observation techniques. Numbers of all fish species present were determined for habitat area and pool volume (measured from pool bottom to water surface).

During the salmonid spawning season, RNP conducted surveys of adult fish and spawning redds. This information was used to indicate utilization of monitored sites by spawning salmonids. Anadromous fish run size for the Prairie Creek drainage was determined using trapping data from the Prairie Creek Hatchery fish weir.

Water Quality

Caltrans personnel have been collecting water quality data since 1980 at the following sites:

- Prairie Creek above Brown Creek
- Prairie Creek below Brown Creek
- Prairie Creek above Boyes Creek
- Prairie Creek below Boyes Creek
- Prairie Creek above May Creek
- Prairie Creek below May Creek
- Boyes Creek at U.S. 101 Bridge
- Boyes Creek at headwaters
- May Creek at U.S. 101 Bridge
- May Creek at headwaters
- North Fork Ah Pah Creek
- Ah Pah Creek
- McGarvey Creek

Water samples are collected monthly and analyzed at Caltrans Environmental Laboratory in Eureka using Standard Methods (American Public Health Association, 1980). The following parameters are determined:

- hardness (mg calcium carbonate/l)
- chloride (mg/l)
- sulfate (mg/l)
- alkalinity (mg calcium carbonate/l)
- pH (laboratory and field readings)
- dissolved oxygen (mg/l)
- temperature (air and water)
- non-filterable residue/sus. sed. conc. (ppm)
- turbidity (NTU)
- specific conductivity (micromhos/cm)

Turbidity determinations are made twice weekly for the

following sites only:

May Creek at U.S. 101 bridge
Boyes Creek at U.S. 101 bridge
Brown Creek at U.S. 101 bridge
Godwood Creek

Gage height and stream flow (cu ft/sec) are recorded monthly at all Caltrans monitoring sites. RNP maintains a continuously recording gaging station for water discharge at Prairie Creek above May Creek

RESULTS AND DISCUSSION

Gravel Composition

Percent fines have been traditionally used to determine spawning gravel quality for salmonid reproduction (Everest et al. 1986). Although an inverse relationship exists between percent fines and survival of salmonid fry, use of this parameter alone ignores the textural composition of the remaining particles (Platts et al. 1983). Percent fines have different effects on survival of salmonid fry depending on the mean diameter of the remaining gravel sample. Platts et al. (1979) proposed using the geometric mean particle diameter to report the entire textural gravel composition. Lotspeich and Everest (1981) noting the use of geometric mean alone can lead to erroneous conclusions about gravel quality, developed the "Fredle index" which provides an indicator of sediment permeability and pore size.

The 1985 weight determinations (4 subsamples for each of the 6 core samples) for the 13 monitoring sites will be maintained at RNP, Arcata office. Table 3 lists the 1985 means for geometric mean particle diameter, sorting coefficient, percent fines less than 0.04 in (1.00 mm) and Fredle index (with 95% confident limits) for the 13 monitoring sites.

Watershed characteristics and land use activity influence the amount and texture of fine sediment in Pacific coastal streams (Everest et al. 1986). The wide variation in fine sediment between coastal streams is illustrated in Table 4. Due to the high variability of fine sediment, even in undisturbed watersheds, a criterion for maximum allowable fine sediment may be unrealistic (Everest et al. 1986). With the exception of May Creek, percent fines in all monitoring sites is within an acceptable range. Despite the high

Table 3. Means for geometric mean particle diameter, sorting coefficient, percent fines less than 0.04 in. (1.00 mm) and Fredle index (with 95% confident limits) for the 13 monitoring sites, U.S. 101 Bypass monitoring project, 1985.

Monitoring Site	Geom Mean	Percent Sorting Coeff	Fredle Index			
			Fines <1.00mm	Mean	95% conf. Limits Upper	Lower
Prairie Creek Unit						
Prairie Creek above Brown (control)	27.00	2.45	8.03	11.26	7.42	15.11
Prairie Creek above Boyes	29.71	2.62	7.45	16.17	9.28	23.06
Prairie Creek below Boyes	37.40	3.75	6.25	18.50	7.18	29.83
Prairie Creek above May	25.46	2.17	7.07	13.04	3.95	22.12
Prairie Creek below May	17.99	2.44	9.21	7.64	3.68	11.60
Prairie Creek below Channel	15.72	2.92	20.30	6.68	1.35	12.01
Prairie Creek Tributary Unit						
Lost Man Creek (control)	28.25	3.06	10.38	13.13	1.63	24.63
Brown Creek	31.09	2.88	8.63	10.75	4.08	17.42
Boyes Creek	23.90	2.40	8.83	10.27	6.84	13.69
May Creek	10.51	3.27	35.77	3.48	2.10	4.87
Klamath River Tributary Unit						
Tarup Creek (control)	25.50	2.21	8.12	13.67	2.31	25.03
North Fork Ah Pah Creek	19.77	2.73	12.75	7.43	5.01	9.85
McGarvey Creek	10.25	3.26	17.98	3.34	1.62	5.06

Table 4. Percent fines for logged and unlogged Pacific coastal streams.

<u>Geographical Area</u>	<u>Watershed disturbance</u>	<u>No. of Streams</u>	<u>Ave. fine Sediment dia.</u>	<u>Range of percent fines</u>	<u>Source</u>
Coastal Alaska	unlogged	18	<0.83mm	5.0 - 11.7	Sheridan et. al. (1984)
Coastal Oregon	unlogged	21	<1.00mm	10.6 - 29.4	Adams and Beschta (1980)
Southwest Oregon	logged	4	<1.00mm	8.3 - 25.5	Everest et. al. (1982)
Southwest Washington	logged	12	<2.00mm	7.6 - 65.5	Duncan and Ward (1985)
Northwest California (Godwood Creek)	unlogged	1	<0.83mm	17.3 - 17.4	Burns (1970)

percent sediment in its gravels, May Creek supports a substantial number of juvenile coho salmon (see fishery portion of this report). The amount of fine sediment is probably reduced by the hydraulic excavation of salmon during spawning. Everest et al. (1986) cites a case in Oregon where chinook salmon reduced fines less than 1.00 mm in diameter from 30.0% before spawning to 7.2% after spawning.

Table 5 shows predicted survival-to-emergence rates for chinook salmon, coho salmon and steelhead trout at the 13 monitoring sites. Predictions for coho salmon and steelhead trout were developed through relationships between Fredle index values and survival-to-emergence (Figure 2), developed by Lotspeich and Everest (1981). Since survival rates based on the Fredle index are not available for chinook salmon, Huntington (1985) suggested using an index developed by Shirazi and Seim (1981). Their index was based on the relationship between survival and the ratio of the geometric mean particle diameter and the average egg diameter of the species of interest (Figure 3). For purposes of monitoring effects of highway construction, survival rates will be used as relative indices for yearly comparisons and not as absolute predictors of embryo survival.

Predicted survival rates at most monitoring sites appeared exceptionally high. May and McGarvey Creeks had the lowest, but still acceptable predicted survival rates for coho salmon and steelhead trout. Predicted survival rates for chinook salmon eggs was 35% at both May and McGarvey Creeks. This would be of no concern, however, since chinook salmon do not spawn in the monitored reaches of these streams.

Vertical stratification of fine sediment is highly variable in streams, especially those with high average fine sediment content (Everest et al 1986). Based on the assumption that increased suspended sediment during highway construction will result in increased fine sediment in the upper layer of gravel, stratification of fines less than 0.04 in (1.00 mm) was tested at all monitoring sites. Since 1985 was baseline data for the Prairie Creek and Prairie Creek Tributary units, we did not expect increased fines in the upper gravel layers. Stratification was not evident (Table 6) except for Prairie Creek below Boyes and Tarup Creek where fines increased with depth (Figure 4 and Figure 5, respectively).

Since ground disturbance occurred at the northern end of the bypass project in 1984, gravels were sampled at the North Fork Ah Pah and McGarvey Creek monitoring sites. Table 7 compares 1984 and 1985 gravel quality parameters and predicted survival rates for North Fork Ah Pah and McGarvey Creeks. Although not statistically tested, there was no substantial difference in gravel quality parameters and predicted survival rates between 1984 and 1985. Comparison

Table 5. Ratio of geometric mean particle diameter (from gravel samples) and chinook egg diameter (dg/de) and predicted survival-to-emergence rates for chinook salmon, coho salmon and steelhead trout for the 13 monitoring sites, U.S. 101 Bypass monitoring project, 1985.

Monitoring Site	Chinook Salmon ^b dg/de ^a	Coho Salmon ^c % Survival	Steelhead trout % Survival
Prairie Creek Unit			
Prairie Creek above Brown (control)	4.2	90	100
Prairie Creek Above Boyes	4.6	90	100
Prairie Creek below Boyes	5.8	90	100
Prairie Creek Above May	3.9	90	100
Prairie Creek below May	2.8	70	90
Prairie Creek below Channel	2.4	60	80
Prairie Creek Tributary Unit			
Lost Man Creek (control)			
Brown Creek	4.3	90	100
Boyes Creek	4.8	90	100
May Creek	3.7	90	100
	1.6	35	65
Klamath River Tributary Unit			
Tarup Creek (control)			
North Fork Ah Pah Creek	3.9	90	100
McGarvey Creek	3.0	80	90
	1.6	35	65

a de = 6.5 mm (Scott and Crossman 1973)

b Source: Shirazi and Seim 1981

c Source: Lotspeich and Everest 1981

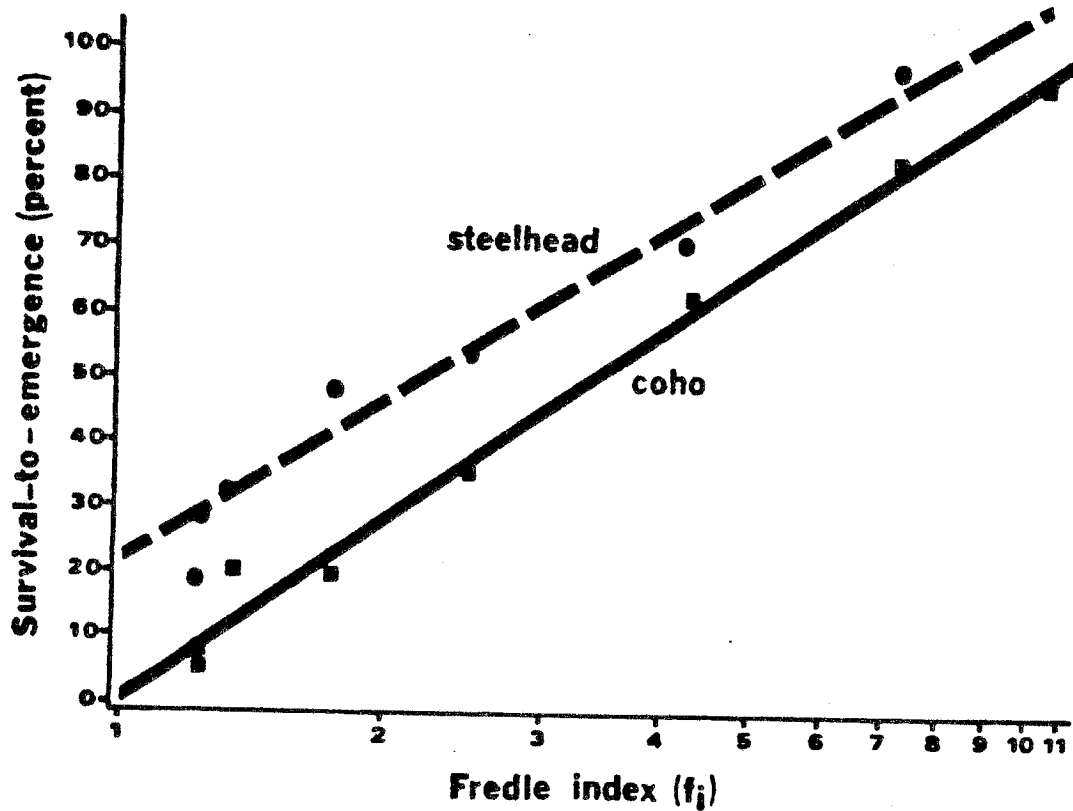


Figure 2. Relationship between Fredle index values and survival-to-emergence for coho salmon and steelhead trout (from Lotspeich and Everest, 1981).

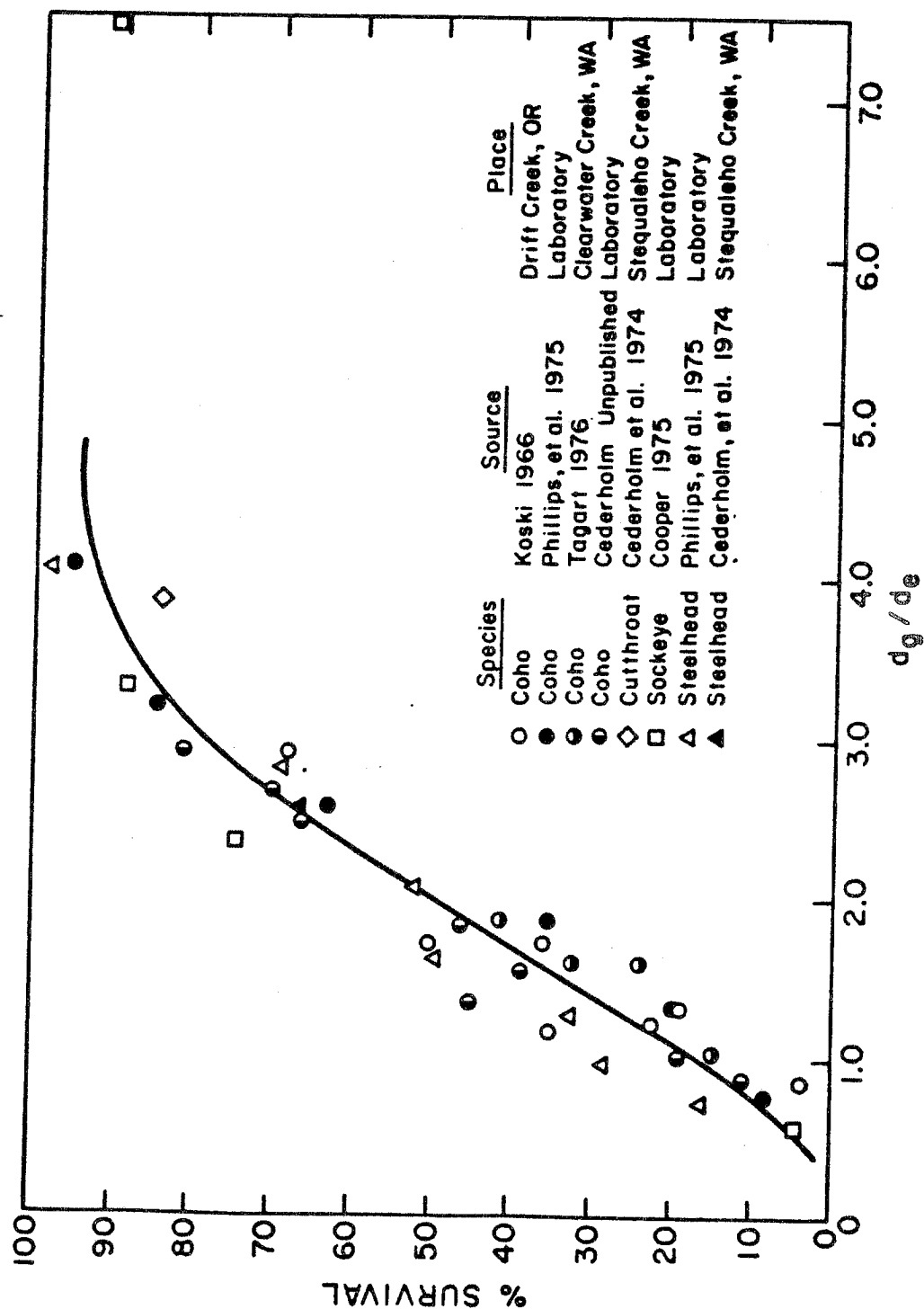


Figure 3. Relationship between the embryo survival index (dg/de) and survival-to-emergence for salmon and trout, where dg = geometric mean diameter of gravel sample and de = egg diameter of fish (from Shirazi and Seim 1981).

Table 6. F-statistic and significance for percent fines less than 0.04 in. (1.00 mm) in verticle gravel columns at the 13 monitoring sites, U.S. 101 Bypass monitoring project, 1985. Four subsamples of 4 in. (10 cm) columns were tested with n=6.

<u>Monitoring Sites</u>	<u>F</u>	<u>Signifiance</u>
Prairie Creek Unit		
Prairie Creek above Brown (control)	1.08	ns
Prairie Creek above Boyes	1.87	ns
Prairie Creek below Boyes	3.55	<.05
Prairie Creek above May	0.83	ns
Prairie Creek Below May	1.77	ns
Prairie Creek below Channel	0.78	ns
Prairie Creek Tributary Unit		
Lost Man Creek (control)	0.93	ns
Brown Creek	0.62	ns
Boyes Creek	1.05	ns
May Creek	0.42	ns
Klamath River Tributary Unit		
Tarup Creek (control)	6.10	<.01
North Fork Ah Pay Creek	0.28	ns
McGarvey Creek	1.09	ns

PRAIRIE CREEK BELOW BOYES

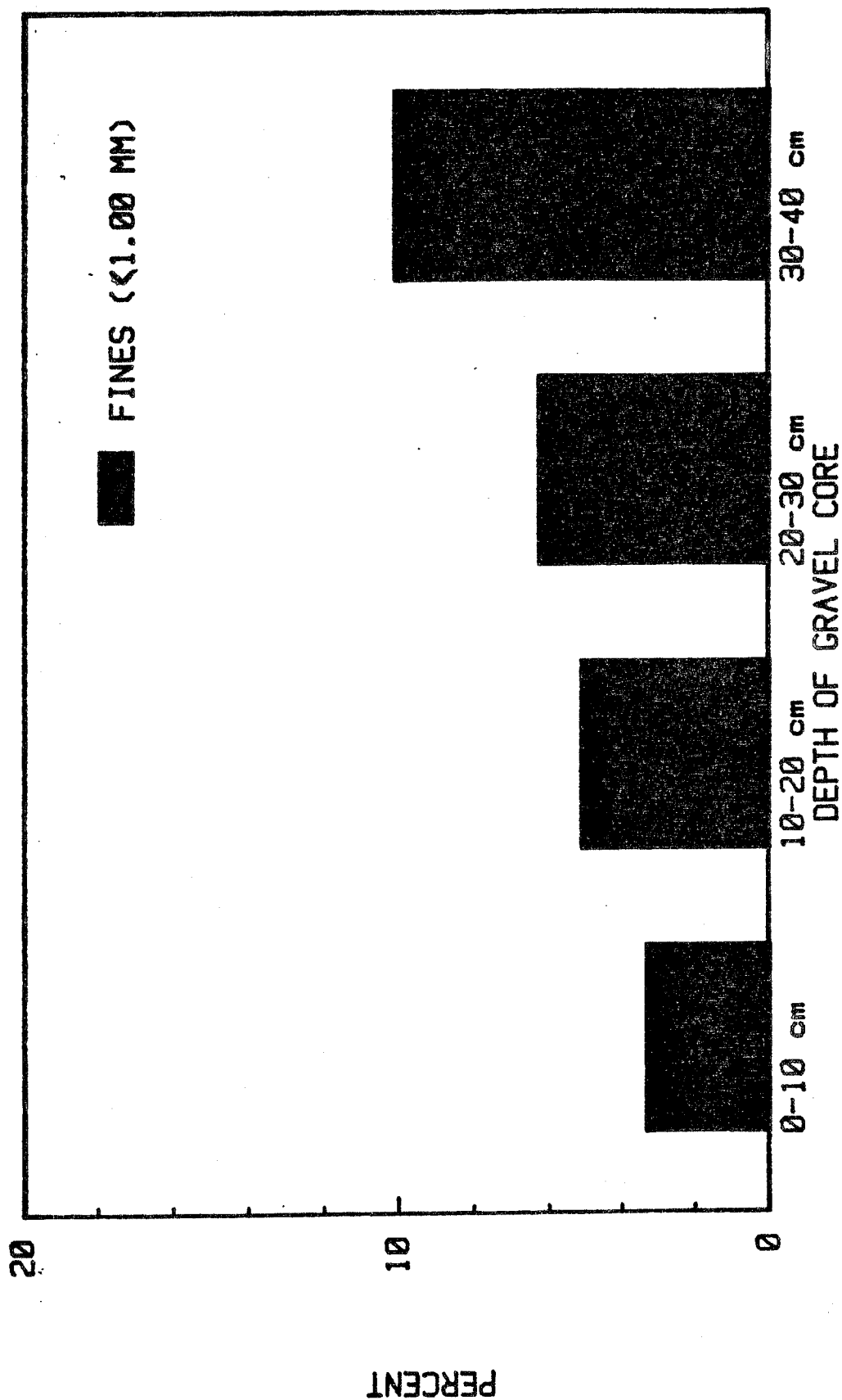


Figure 4. Percent fines less than 1.00 mm at 10 cm intervals down a verticle gravel column at Prairie Creek below Boyes Creek, U.S. 101 Bypass monitoring project, 1985.

TARUP CREEK

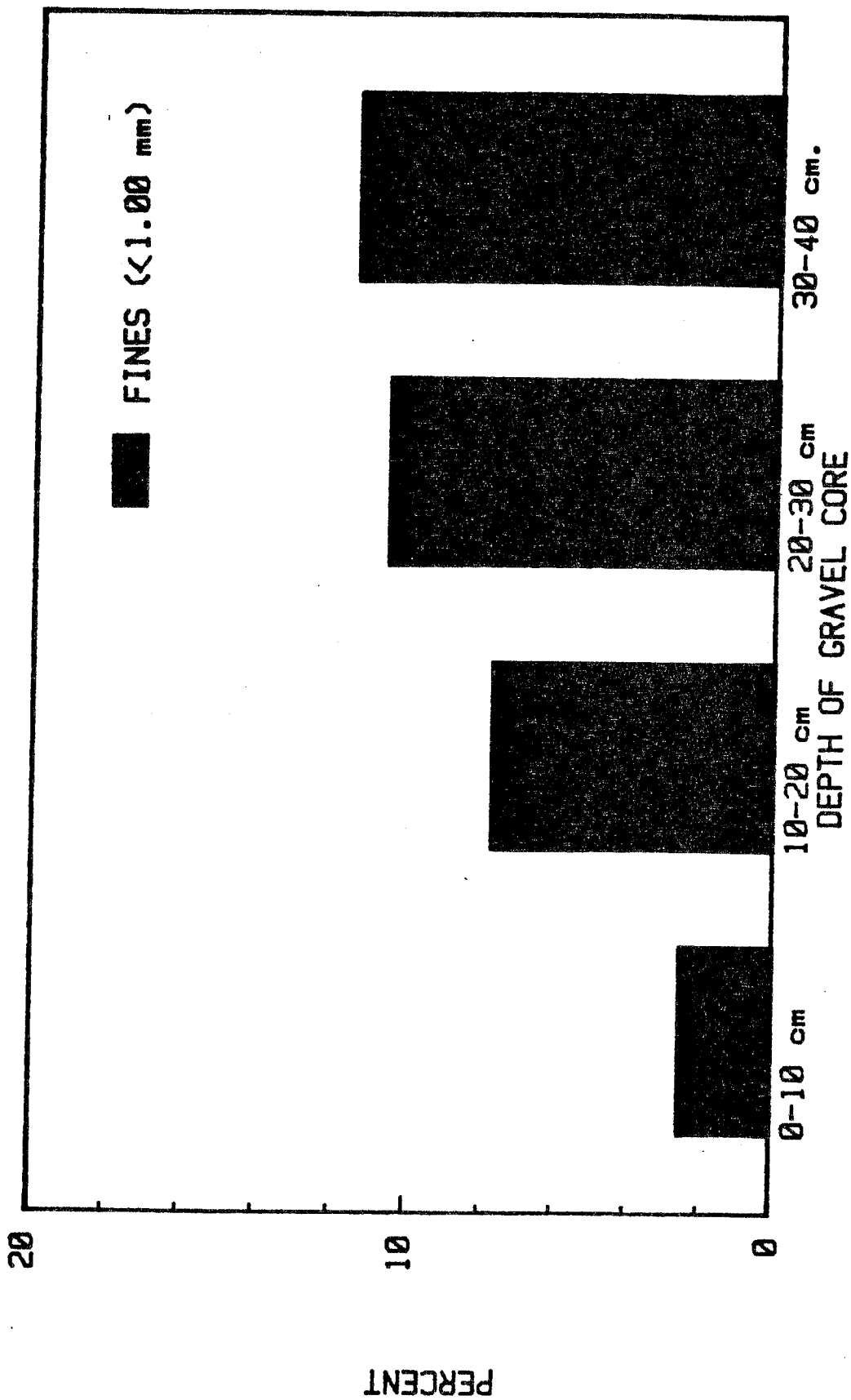


Figure 5. Percent fines less than 1.00 mm at 10 cm intervals down a verticle gravel column at Tarup Creek, U.S. 101 Bypass monitoring project, 1985.

Table 7. Comparison of 1984 and 1985 gravel quality parameters and predicted survival rates for North Fork Ah Pah and McGarvey Creek, U.S. 101 Bypass monitoring project.

	<u>N.F. Ah Pah Creek</u> <u>1984</u>	<u>1985</u>	<u>McGarvey Creek</u> <u>1984</u>	<u>1985</u>
n=	3	6	3	6
<u>Gravel Quality Parameters</u>				
Geometric Mean	22.10	19.77	7.98	10.25
Sorting Coefficient	2.45	2.73	4.16	3.26
Percent Fines < 1.00mm	7.10	12.75	26.50	17.98
Fredle Index				
mean	9.10	7.43	2.04	3.34
upper limit (95% conf.)	5.48	5.01	0	1.62
lower limit (95% conf.)	12.72	9.85	5.33	5.06
<u>Survival Rates</u>				
Chinook Salmon				
dg/de (de = 6.5mm)	3.4	3.0	1.2	1.6
% survival	85	80	20	35
Coho Salmon				
% survival	90	80	30	50
Steelhead Trout				
% survival	100	90	45	65

of percent fines less than 0.04 in (1.00 mm) with core depth is illustrated in Figure 6 for the North Fork Ah Pah and Figure 7 for the McGarvey Creek monitoring sites. North Fork Ah Pah Creek had an increase in percent fines in the surface gravel layers between 1984 to 1985. The increase was likely the result of a crossing failure on a non-project logging road located immediately upstream.

Stream Mapping

To assess environmental change, important components of stream habitat must be identified (Bisson et al. 1981). Pool habitats are essential for rearing fish, and are vulnerable to increased suspended sediment.

The 1985 stream reach maps are illustrated in Appendix I for the 13 monitoring sites. Each map shows the dominant surface substrate size, banklines, undercut banks and large organic debris. The 1985 depth contours at 1.0 ft (30.5 cm) intervals for pools at each of the 13 monitoring reaches will be maintained at RNP, Arcata office. Pool types and volumes were obtained from stream maps and depth profiles (Table 8). The following pool type codes were originally used by Bisson (1981) and retained in this study for convenience:

- Pool Type #5 - Backwater pools associated with boulders
- Pool Type #7 - Backwater pools associated with large organic debris
- Pool Type #8 - Trench pools associated with bedrock
- Pool Type #10 - Lateral scour pools associated with large debris
- Pool Type #11 - Lateral scour pools associated with rootwads
- Pool Type #12 - Lateral scour pools associated with bedrock
- Pool Type #14 - Glides

Surface water elevations fluctuate with discharge. For precise measurements, residual depth volumes which are independent of discharge (Lisle unpublished report), will be used to monitor possible change in pool volume during highway construction. Pool volume to water surface will be used to predict the number of fish that pools can support based on research conducted in Prairie Creek by Decker (unpublished report) (see Fisheries section).

Cross-sectional Profiles

Cross-sectional areas usually change with increased sediment load (Iwatsubo et al. 1976). Aggradation often occurs causing filling of pools, insilting of spawning riffles and movement of gravels even during small winter storms (California Department of Water Resources 1982). The 1985 cross-sectional profiles for the 13 monitoring sites will be

NORTH FORK AH PAH CREEK

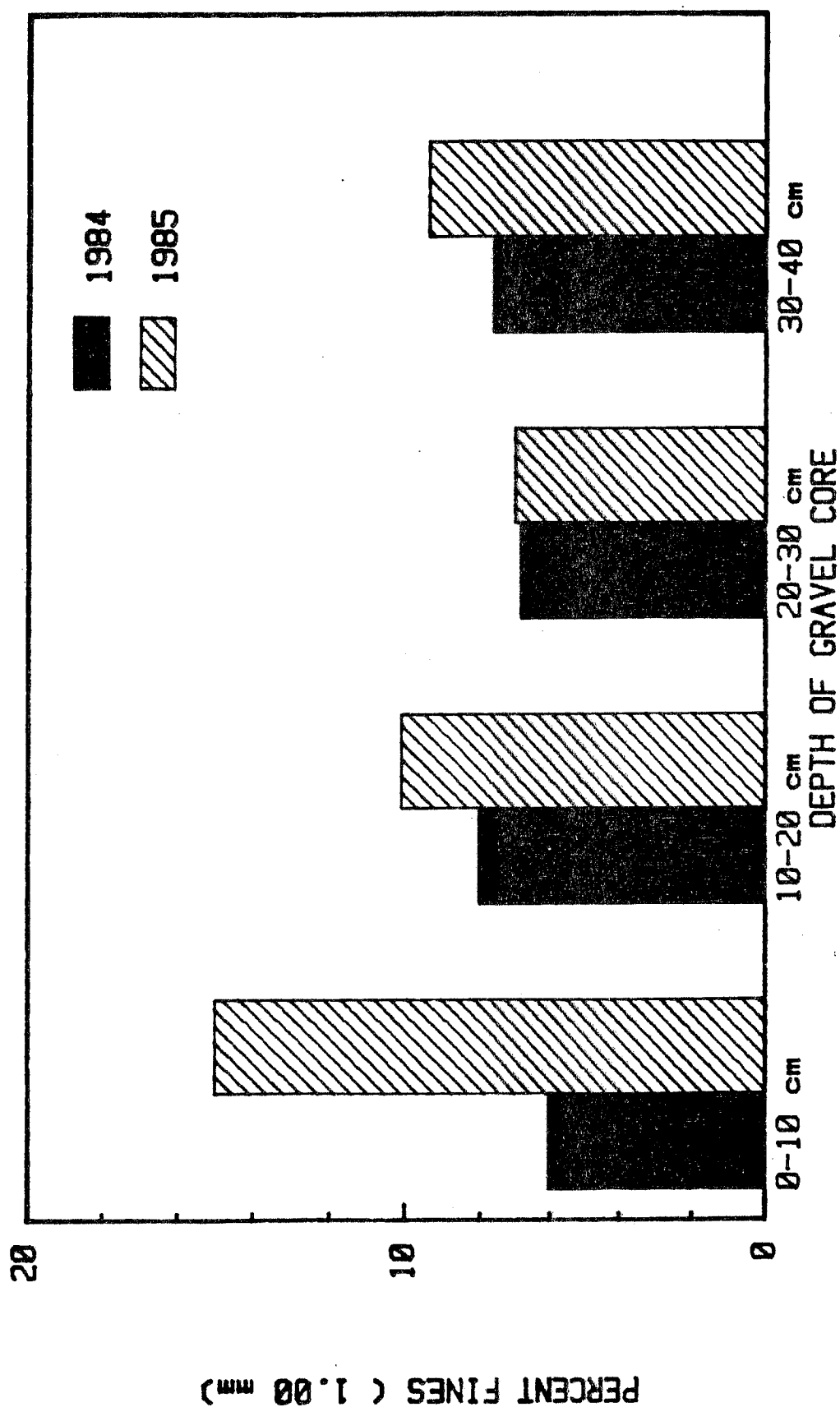


Figure 6. Comparison of 1984 and 1985 percent fines less than 1.00 mm at 10 cm intervals down a verticle gravel column at N.F. Ah Pah Creek, U.S. 101 Bypass monitoring project.

McGARVEY CREEK

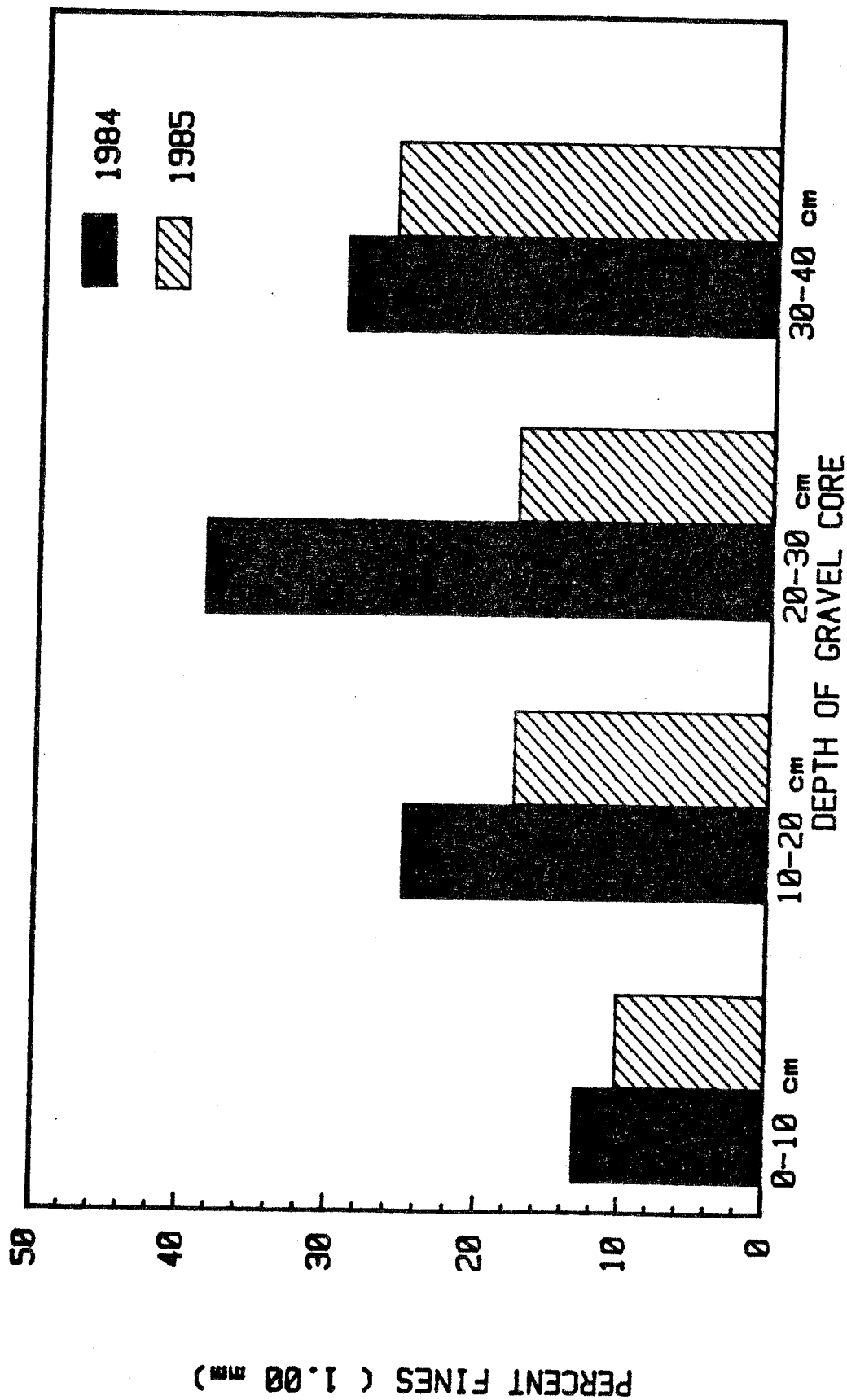


Figure 7. Comparison of 1984 and 1985 percent fines less than 1.00 mm at 10 cm intervals down a verticle gravel column at McGarvey Creek, U.S. 101 Bypass monitoring project.

Table 8. Pool types (from Bisson 1981) surface area, surface water volume and residual depth volume for all pools with depth 1.0 ft. (30.5 mm) or greater at the 13 monitoring sites, U.S. 101 Bypass monitoring project, 1985.

PRAIRIE CREEK UNIT			
Pool type ^a	Surface water ^b		Residual depth ^c
	Surface Area ft ² (m ²)	Volume ft ³ (m ³)	Volume ft ³ (m ²)
<u>Prairie Creek Above Brown</u>			
7	103 (9.6)	82 (2.3)	55 (1.5)
12	453 (42.1)	317 (9.0)	211 (6.0)
12	64 (5.9)	30 (0.8)	21 (0.6)
Total	620 (57.6)	429 (12.1)	287 (8.1)
<u>Prairie Creek Above Boyes</u>			
10/11	760 (70.6)	962 (27.2)	861 (24.4)
14/10	385 (35.8)	260 (7.4)	90 (2.5)
Total	1145 (106.4)	1222 (34.6)	951 (26.9)
<u>Prairie Creek below Boyes</u>			
10/12	213 (19.8)	170 (4.8)	99 (2.8)
12	608 (56.5)	810 (22.9)	608 (17.2)
10	112 (10.4)	86 (2.4)	48 (1.4)
10/12	73 (6.8)	48 (1.4)	22 (0.6)
Total	1006 (93.5)	1114 (31.5)	777 (22.0)
<u>Prairie Creek Above May</u>			
14	538 (50.0)	358 (10.1)	224 (6.3)
10	20 (1.9)	8 (0.2)	2 (0.1)
12	26 (2.4)	11 (0.3)	5 (0.1)
10	1.5 (0.1)	2 (0.1)	1 (0.1)
8	24 (2.2)	10 (0.3)	8 (0.2)
10	89 (8.3)	42 (1.2)	37 (1.0)
10	33 (3.1)	11 (0.3)	9 (0.2)
Total	731.5 (68.0)	442 (12.5)	286 (8.0)
<u>Prairie Creek Below May</u>			
10	447 (41.5)	343 (9.7)	298 (8.4)
10	684 (63.5)	547 (15.5)	479 (13.6)
5	35 (3.2)	14 (0.4)	10 (0.3)
10/11	602 (55.9)	622 (17.6)	381 (10.8)
10/11	924 (85.8)	986 (27.9)	616 (17.4)
Total	2692 (249.9)	2512 (71.1)	1784 (50.5)

PRAIRIE CREEK UNIT (cont.)

<u>Pool type</u>	<u>Surface water</u>		<u>Residual depth</u>
	<u>Surface Area ft²(m²)</u>	<u>Volume ft³(m³)</u>	<u>Volume ft³(m³)</u>
<u>Prairie Creek Below Channelization</u>			
7	711 (66.0)	806 (22.8)	545 (15.4)
14	228 (21.2)	99 (2.8)	53 (1.5)
12	91 (8.5)	39 (1.1)	21 (0.6)
11	8 (0.7)	3 (0.1)	2 (0.1)
12	96 (8.9)	45 (1.3)	22 (0.6)
12	35 (3.2)	14 (0.4)	8 (0.2)
10	108 (10.0)	83 (2.4)	58 (1.6)
Total	1277 (118.5)	1089 (30.9)	709 (20.0)

PRAIRIE CREEK TRIBUTARY UNIT

Brown Creek

10	35 (3.2)	15 (0.4)	14 (0.4)
11/10	58 (5.4)	23 (0.6)	19 (0.5)
Total	93 (8.6)	38 (1.0)	33 (0.9)

Boyes Creek

12	114 (10.6)	103 (2.9)	72 (2.0)
10/12	44 (4.1)	34 (1.0)	28 (0.8)
Total	158 (14.7)	137 (3.9)	100 (2.8)

May Creek

10	91 (8.4)	57 (1.6)	36 (1.0)
14	6 (0.5)	2 (0.1)	1 (0.1)
14	4 (0.4)	2 (0.1)	1 (0.1)
10	40 (3.7)	28 (0.8)	23 (0.6)
Total	141 (13.0)	89 (2.6)	61 (1.8)

Lost Man Creek

11	270 (25.1)	261 (7.4)	171 (4.8)
12	375 (34.8)	312 (8.8)	150 (4.2)
12	22 (2.0)	9 (0.2)	8 (0.2)
12	1799 (167.1)	2835 (80.3)	2417 (68.4)
12	2 (0.2)	2 (0.1)	1 (0.1)
10	10 (0.9)	3 (0.1)	1 (0.1)
Total	2478 (230.1)	3422 (96.9)	2748 (77.8)

KLAMATH RIVER TRIBUTARY UNIT

		Surface water	Residual depth
<u>Pool type</u>	<u>Surface Area ft²(m²)</u>	<u>Volume ft³(m³)</u>	<u>Volume ft³(m³)</u>
<u>Tarup Creek</u>			
14	6 (0.6)	2 (0.1)	1 (0.1)
14	4 (0.4)	2 (0.1)	1 (0.1)
14	6 (0.6)	2 (0.1)	1 (0.1)
10	97 (9.0)	58 (1.6)	39 (1.1)
10	57 (5.3)	38 (1.1)	29 (0.8)
Total	170 (15.9)	102 (3.0)	70 (2.2)

<u>Ah Pah Creek</u>			
12	16 (1.5)	7 (0.2)	4 (0.1)
10	41 (3.8)	26 (0.7)	20 (0.6)
Total	57 (5.3)	33 (0.9)	24 (0.7)

<u>McGarvey Creek</u>			
10	146 (13.6)	102 (2.9)	68 (1.9)
10	157 (14.6)	149 (4.2)	97 (2.7)
Total	303 (28.2)	251 (7.1)	165 (4.6)

- a. Pool Type #5 - Backwater pools associated with boulders
- Pool Type #7 - Backwater pools associated with large organic debris
- Pool Type #8 - Trench pools associated with bedrock
- Pool Type #10 - Lateral scour pools associated with large debris
- Pool Type #11 - Lateral scour pools associated with rootwads
- Pool Type #12 - Lateral scour pools associated with bedrock
- Pool Type #14 - Glides
- b. Surface water volume was measured using pool bottom to water surface.
- c. Residual depth volume was measured using pool bottom to elevation of closest downstream rifflecrest.

maintained at RNP, Arcata office. The stream maps in Appendix I show the orientation of 1985 cross-sectional transects in relation to channel features and the longitudinal profile at the 13 monitoring sites.

Scour/fill could not be calculated for the Prairie Creek and Prairie Creek Tributary units since the 1985 cross-sections represent baseline data. Personnel constraints prohibited surveying 1984 cross-sections of the Klamath River Tributary unit. Cross-sections were surveyed during 1984 at Prairie Creek above May Creek, Prairie Creek below May Creek and Prairie Creek below Channelization, allowing comparisons with 1985 transects (Appendix II). Table 9 gives cross-section number, habitat type transected and net area of scour or fill which occurred between 1984 and 1985 at these three monitoring sites.

There was no noticeable change in the cross-sectional profiles between 1984 and 1985. In a separate study, Lisle (unpublished data) reported no noticeable change based on 15 cross-sectional transects surveyed on Prairie Creek (the vicinity of the Prairie Creek above and below May creek monitoring sites) between 1980 and 1984.

Longitudinal Profiles

Longitudinal profiles for the 13 monitoring sites are included with stream maps in Appendix I. Table 2 contains stream reach gradients for each of the 13 monitoring sites. Longitudinal profiles were surveyed primarily to obtain stream reach gradient and determine residual pool depths (discussed in Stream Mapping section). Significant changes in stream gradient due to effects of highway construction are not expected

Photographic Documentation

Black/white prints and color slides of mid-channel and left and right banks at each cross-section for the 13 monitoring sites during 1985 will be maintained at RNP, Arcata office.

Aquatic Macroinvertebrates

Diversity and numbers of aquatic macroinvertebrates determine the health of fish populations (Platts et al. 1983). They are the major food source for salmonid fish in northcoast streams and possess characteristics which make them useful in detecting environmental perturbations. Most notably, they have limited mobility and a life-span of several months to a few years. This makes them excellent indicators of relatively recent conditions at the immediate vicinity of collection.

Table 9. Cross-sectional number, habitat type transected and area of scour or fill which occurred between 1984 and 1985 at Prairie Creek above May, Prairie Creek below May and Prairie Creek below channelization, U.S. 101 Bypass monitoring project.

<u>Monitoring Site</u>	<u>Cross-Section Number</u>	<u>Habitat Type</u>	<u>Scour-/fill+ Ft³(m³)</u>
Prairie Creek above May Creek	1	glide(id#14)	-5.83 (-0.54)
	2	pool(id#12)	-8.17 (-0.76)
	3	pool(id#10)	6.27 (0.58)
	4	pool(id#10)	5.55 (0.52)
Prairie Creek below May Creek	1	riffle	-74.26 (6.89)
	2	pool(id#10)	-0.9 (0.08)
	3	pool(id#10)	0.16 (0.02)
	4	pool(id#10)	18.37 (1.71)
	5	pool(id#5)	5.22 (0.48)
	6	riffle	1.98 (0.18)
	7	new for 1985	
Prairie Creek below Channel	1	new for 1985	
	2	pool(id#12)	-5.98 (0.55)
	3	riffle	-3.22 (0.30)
	4	pool(id#12)	0.29 (0.03)
	5	glide(id#14)	4.15 (0.38)

Laboratory and field studies (Williams and Mudie 1978) have shown increased fine sediment can affect benthic organism abundance and community composition. Typically, certain groups of organisms are replaced by others more tolerant to habitat changes. Biomass will usually decrease, but if tolerant species flourish and become overabundant, biomass can increase. Even with increased macroinvertebrate biomass, fish can be adversely affected if they can not utilize the abundant species as food.

Diversity index is widely used to detect change in community composition. Diversity is calculated mathematical from information on the number of taxa present in a community. High values result from few individuals in many taxa and low values from an overabundance of individuals in only a few taxa. In general, diversity index values greater than 3 indicate clean water, values from 1 to 3 moderate pollution and values less than 1 heavy pollution (Platts et al. 1983).

Cummins (1974) recommends classifying macroinvertebrates into functional categories (defined on page 12) based on feeding behavior. Vannote et al. (1980) hypothesizes that functional group composition is based on the position of macroinvertebrate communities along a stream continuum from headwaters to mouth. They also hypothesizes that as with the physical system, the biological system is in dynamic equilibrium and any stream perturbation will elicit a rapid adjustment and consequential redistribution of functional groups.

In 1980, a macroinvertebrate sampling program was initiated to obtain baseline information in streams which could be impacted by highway construction. The program was abandon after a year when the future of the highway project became in doubt. By 1984, construction of the bypass was reconfirmed and funding became available for aquatic monitoring. The original macroinvertebrate sampling program was redesigned eliminating problems and providing more quantitative information for statistically detecting change due to highway construction. Artificial substrate samples which were vandalized and trampled by elk were replaced with a standard, unit area sampling device acceptable for estimating biomass.

The 1980-81 macroinvertebrate sampling program will serve as a qualitative survey providing a taxonomic list of organisms and trends in diversity and abundance for an entire year. The survey will aid in interpreting changes detected in the quantitative program starting with the 1985 data year.

Appendix III contains a cumulative list of taxa for the 1980-81 macroinvertebrate samples taken at Prairie Creek above and below Boyes Creek, Prairie Creek above and below May Creek, Boyes Creek, May Creek, North Fork Ah Pah Creek and McGarvey

Creek. Mean diversity indices, mean number of taxa, mean number of individuals and percent (by individuals) functional group composition for the eight 1980-81 monitoring sites are presented in Appendix IV.

The four Prairie Creek unit sites exhibited consistently moderate diversity index values (2.2-2.5) throughout the sampling period. The community composition was dominated by collectors such as midges (Chironomidae), black fly larva (Simulium) and a variety of mayflies (Epeorus, Serratella, Baetis, Ironodes and Rhithrogena). Grazers such as the aquatic snail, Juga, and the caddis fly, Glossosoma, were abundant in the late summer and fall when periphyton was dense. Shredders such as the stonefly Zapada and the caddisfly Lepidostoma were low in abundance typical of fifth and sixth order streams (Vannote et al. 1980). Predators such as the stoneflies Hesperoperla and Isoperla and the caddisflies Polycentropus and Rhyacophila were low in abundance, but at expected levels (Vannote et al. 1980). Abundance of taxa and individuals increased during spring and fall since these are the seasons of peak activity and emergence on most coastal streams.

The Prairie Creek Tributary unit was represented by Boyes and May Creeks (Brown and Lost Man Creeks were not sampled in 1980-81). Diversity index values fluctuated between 1.8 and 3.1 (average of 2.4) in Boyes Creek and only averaged 2.0 in May Creek. Community composition was similar in both streams. Collectors such as midges (Chironomidae), riffle beetles (Narpos concolor) and mayflies (Epeorus (Boyes Creek only), Baetis, and Paraleptophlebia) dominated. Grazers such as the aquatic snail, Juga and the mayfly, Cinygmula, were also important components of the community throughout the year. Shredders such as the scud, Anisogammarus (Boyes Creek only), the stonefly, Zapada, and the caddisfly, Lepidostoma, were consistently present in low numbers. Predator abundance was low. In winter months, the number of taxa and individuals were unusually high in Boyes Creek while low in May Creek. The number of taxa and individuals in May Creek peaked only in the spring.

The two streams in the Klamath River Tributary unit, North Fork Ah Pah Creek and McGarvey Creek, had similar mean diversity index values (2.2 and 2.1, respectively). Collector organism such as midges (Chironomidae) and mayflies (Ironodes (McGarvey Creek only), Baetis, and Epeorus) were abundant in both streams. The grazer mayfly, Cinygmula, was an important component of McGarvey Creek and to a lesser extent in North Fork Ah Pah Creek. Predator abundance was low in McGarvey Creek but unusually high during the winter in North Fork Ah Pah Creek. Shredder numbers were lower than expected since these sites are located high in the watershed where shredder composition tends to be higher due to ecosystem reliance on allocthonous inputs (Vannote 1980).

In general, the assemblage of benthic macroinvertebrates in all the 1980-81 monitoring sites reflected good water quality. Although some of the abundant taxa (Chironomidae, Simulium and Juga) are considered tolerant to stream perturbation, the majority of the species are considered moderate to very sensitive (based upon tolerance to alkalinity, sulfate, sedimentation and stream gradient (Winget and Mangum 1979)).

Due to the intensity of a quantitative study, the macroinvertebrate community will not be sampled again until 1987 and 1989. The 1985 results will be available in the 1986 annual report.

Fisheries

"Fish populations are a result of the physical, biological and chemical factors surrounding them and especially those biotic factors in the trophic levels below them " (Everest et al. 1983). To accurately estimate fish numbers each year in the subject streams would be expensive (estimated by CDFG in excess of \$100,000/year) and since many uncontrollable factors (e.g. sport fishing, commercial fishing, ocean environmental conditions and hatchery management) influence fish numbers, it would be difficult to attribute change to highway construction impacts. Consequently, efforts have been concentrated on monitoring the physical, biological and chemical factors which control fish numbers.

Juvenile fish abundance and composition was determined only for May Creek and a control stream, Godwood Creek. May Creek was chosen because it has a substantial number of coho salmon (Briggs 1953, California Department of Transportation 1984 and observation by RNP personnel) which is estimated to be temporarily reduced by 75-100 percent during highway construction. The 1985 pre-construction estimate for May and Godwood Creeks is shown in Table 10. Although May and Godwood Creeks had similar size composition of salmonids, May Creek had a higher abundance (per unit area) composed primarily of coho salmon (86% of all salmonids).

Number of salmonids which could be supported by available habitat in the 13 monitoring sites could not be estimated for this report. Data have been collected, but as yet not processed (Decker unpublished report).

The Prairie Creek Hatchery estimated the 1985-86 chinook salmon run for the Prairie Creek drainage (including Prairie, May, Boyes, Lost Man, Brown and Godwood) at 320 to 400 with a 1 to 2 sex ratio of females to males. The coho salmon run was estimated at 280 to 360 with a 2 to 1 sex ratio. The steelhead trout run was estimated at 500 to 600 with a 1 to 1 sex ratio. Estimates were based on fish trapped in the

Table 10. Abundance and composition of juvenile fish estimated using the Two-step Method (Seber and LeCren 1967) for 100 ft. (30 m) section of May Creek and Godwood Creek, U.S. 101 Bypass monitoring project, September 10, 1985.

	<u>May Creek</u>	<u>Godwood Creek</u>
Total population estimate	51	40
95% confidence interval ($\pm$)	2	3
<u>Coho Salmon</u>		
Total Number	44	26
Average Length (cm)	5.8	5.5
Length Range (cm)	5.0.7.0	4.5.85
<u>Steelhead Trout</u>		
Total Number	4	12
Average Length (cm)	7.8	6.4
Length Range (cm)	7.0.8.5	5.5.9.0
<u>Cutthroat Trout</u>		
Total Number	3	2
Average Length (cm)	7.8	7.8
Length Range (cm)	6.0.95	5.5.10.0

Prairie Creek weir being 20 to 25 percent of the total run (Steve Sanders, hatchery manager, personal communication). A total of eight spawner surveys were conducted by RNP personnel between November 1985 and February 1986. Based on those surveys, the salmon run began the first week of November, peaked the last week of November and ended the first week of January. Steelhead trout and some late run salmon continued to spawn through March.

The majority of the spawning in Prairie Creek occurred from just below the confluence with May Creek to just above the confluence with Brown Creek. Salmon primarily choose riffle crests as spawning sites. Spawning occurred within four of the Prairie Creek unit monitoring sites. At the Prairie Creek above Boyes Creek site, multiple redds were found on the riffle crest at cross-section 2 and a single redd in a riffle section 30 feet (10 m) downstream of cross-section 4. At the Prairie Creek below Boyes Creek site, multiple redds were found on the riffle crest at cross-section 1. At the Prairie Creek above May Creek site, two redds were found in a riffle section between cross-section 2 and 3. At the Prairie Creek below May Creek site, multiple redds were found in the riffle crest at and below cross-section 7. Two redds were found in the section of Prairie Creek which will be channelized and relocated for the southern interchange of the bypass project. Based on size and timing, all redds found in monitoring sites were believed to be from chinook salmon. Whether redds contained eggs is unknown since Briggs (1953) reported salmon construct many false redds in Prairie Creek.

Water Quality

Water quality and stream flow data from 1980 to 1985 is available through the Caltrans District 01 Eureka Office and will be used to interpret monitoring results when necessary.

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