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DEPARTMENT OF FISH AND GAME

ANNUAL REPORT
TRINITY RIVER TRIBUTARY JUVENILE STEELHEAD
INDEX REACH PROJECT, 2002
PROJECT 2c2

By

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Steelhead Research and Monitoring Program
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2001-2002 ANNUAL REPORT
TRINITY RIVER TRIBUTARY JUVENILE STEELHEAD
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ABSTRACT

Three field seasons (2000- 2002) of backpack depletion electrofishing have been completed on 22 index reaches on eight tributaries of the Trinity River in order to quantify juvenile steelhead densities during the low flow period of August through September. Juvenile steelhead were encountered in all (100%) reaches in all years. Sub-yearling densities of juvenile steelhead averaged 0.313, 0.261, and 0.313 fish per square meter for all tributaries, respectively for 2000, 2001, and 2002. Yearling and older (1+) juvenile steelhead densities averaged 0.062 and 0.053, and 0.045 fish per square meter for all tributaries, respectively for 2000, 2001, and 2002.

INTRODUCTION

Estimating juvenile steelhead abundance within small streams is relatively easy to accomplish. The sampling protocol is well established, and it is normally conducted during the period of minimum stream flow (August – September). It can produce a statistically bounded estimate of the current number of steelhead inhabiting a small section of stream. It has the further advantage of examining an earlier life history stage than can be observed using passive out-migration traps. Other agencies, timber companies, consulting firms, and other sections of the Department have long-term index sections located throughout California for comparison.

[1/] Steelhead Research and Monitoring Program report, available from: Department of Fish and Game, 50 Ericson Court, Arcata California 95521 (707) 825-4850

This report should be cited as: Garrison, P.S. 2002. Trinity River Tributaries Juvenile Steelhead Index Reach Project, 2002 Season. Project 2c2. California Department of Fish and Game, P.O. Box 1185, Weaverville, CA 96093. Draft February 2003. 26 pp.

Many of the rivers and streams included in this study have been surveyed and habitat typed by the United States Forest Service (USFS) in the past 12-15 years. These surveys were done to determine fish distribution related to timber harvest and road construction, and to aid in the preparation of watershed analysis reports in accordance with the Northwest Forest Plan (Chris James, USFS unit biologist, personal communication). A current sampling universe of all anadromous tributaries in the Trinity River basin is continuously updated and available through the Weaverville Fish and Game office. Physical barriers to upstream adult steelhead migration were used to delineate the sampling universe whenever possible. In the absence of a physical barrier, an estimated gradient of 20% was used to identify the upper boundary to anadromy.

Study Area

The Trinity River is the largest tributary to the Klamath River, and one of the most important steelhead and salmon sport-fisheries in California. The watershed is mountainous, semi-wilderness region of about 2,900 square miles in Trinity and Humboldt counties. The South Fork Trinity River is the largest tributary to the Trinity and has a drainage area of 898 square miles and originates in the Yolla Bolly wilderness area of southern Trinity County (Healy, 1970). The following map, Figure 1, displays the complete sampling universe of the Trinity basin with selected tributaries designated and highlighted.

METHODS

Sampling Methodology

Index reaches were selected from a sampling universe of all 1^{st}-4^{th} order anadromous tributaries of the Trinity basin accessible to steelhead upstream of the New River, and including the entire South Fork of the Trinity River. The sampling universe was developed by careful evaluation of U.S. Forest Service (USFS) habitat typing files located at Weaverville and Hayfork Ranger Districts and through personal communication with Lee Morgan of the Lower Trinity Ranger District. Creeks not included or documented in USFS or Department habitat typing files were estimated based upon gradient. When no documentation was available, a gradient of 20% was used to estimate the upper bound of anadromy. Upper bounds of anadromy not documented by agency files were added to the priority list of our current barrier documentation survey.

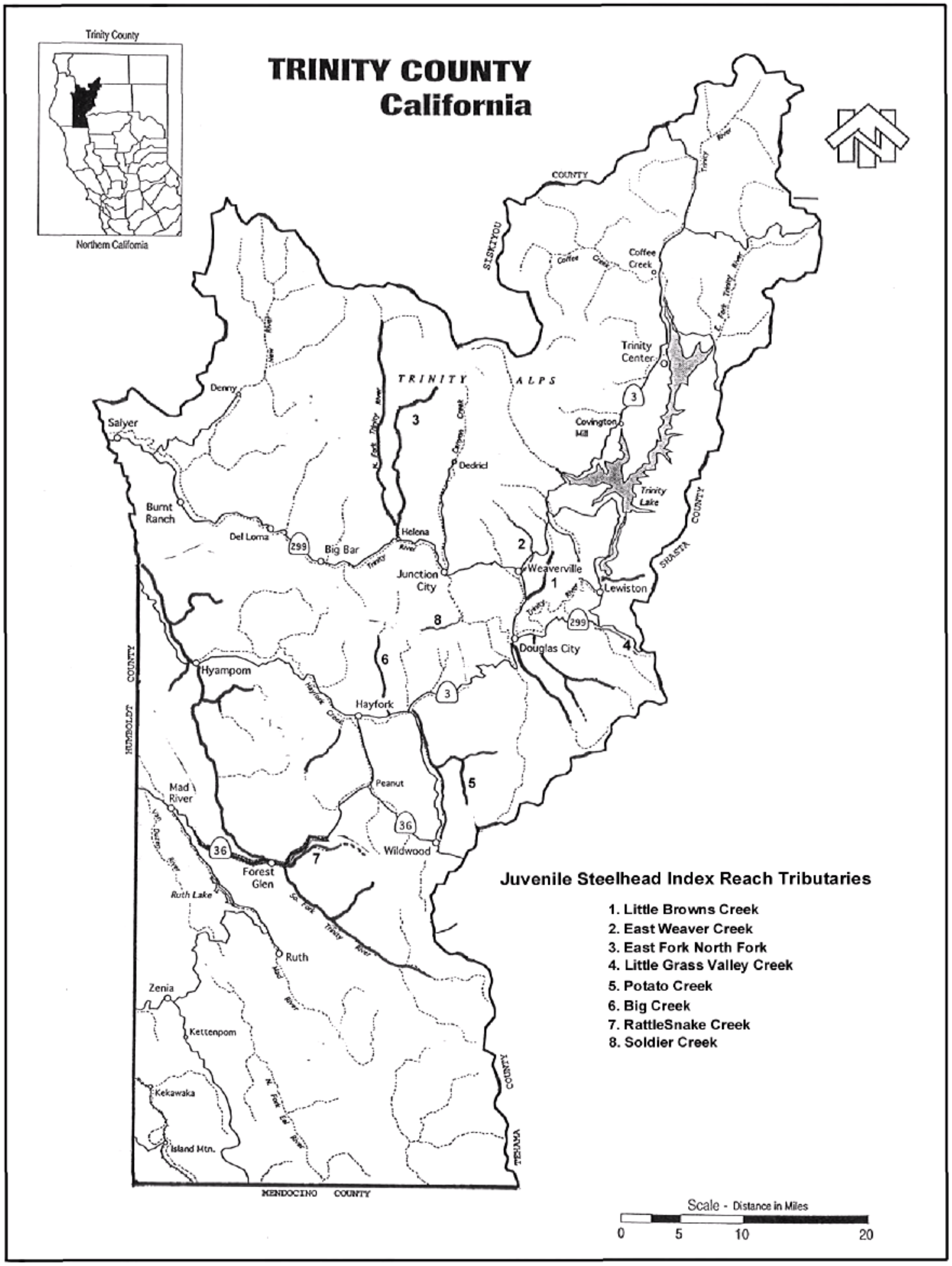

Figure 1. Map of Trinity basin and juvenile Steelhead index reaches

Index reaches were selected using weighted stratified random sampling methodology. Anadromous tributaries were stratified into two basins: South Fork basin and main-stem basin. Within each basin, creeks were assigned ranges of their applicable anadromous river mileage (km). From each basin, seven tributaries were randomly selected, with the probability of selection based upon creek mileage.

Creeks selected from the main-stem basin included East Fork North Fork of the Trinity River (EFNFTR), Rush Creek, Canyon Creek, Soldier Creek, East Weaver Creek, Brock Gulch and Redding Creek. Creeks selected from the South Fork basin included Rattlesnake Creek, Hayfork Creek, Mosquito Creek, Tule Creek, Big Creek, Potato Creek, and Butter Creek. Of these fourteen creeks, seven had index reaches set up on them in 2000. Seven of the fourteen selected tributaries were deemed inappropriate for index reach electrofishing based upon several deviations from essential criteria. Rush Creek, Tule and Reading Creek were dropped due to problems with ascertaining continued permission to sample on private property. Canyon Creek and Brock Gulch were dropped due to size considerations; Canyon Creek has flows that prevent backpack electrofishing even at the lowest water in late September; Brock Gulch did not have substantial surface water flows, especially in critically dry water years. In 2001, three additional creeks were selected at random for sampling. Two of these creeks, North Philpot and Glade, were dry and deemed un-fishable due to the critically-dry water year. Little Grass Valley Creek was successfully selected with all three reaches meeting primary criteria.

The sampling frame for this study consists of all anadromous water of the Trinity River upstream of the New River, including the South Fork Trinity River. Tributaries of the Trinity located within the Hoopa Square were also not included. The sampling frame was developed with the assistance of U.S. Forest Service habitat typing files located in the Hayfork and Weaverville Forest Service Fisheries offices. Tributaries located in the Six Rivers National Forest were confirmed with the local Forest Service zone fisheries biologist (L. Morgan, personal communication). Most habitat typing data from the Forest Service is 15-30 years old; some barriers were classified as semi-permanent, i.e. log-jams, short cascade fields. We are currently verifying and expanding our sampling universe as time allows.

Tributaries were selected with a weighted stratified random sample. Each tributary was assigned a weighted sampling probability dependent upon proportion of available anadromous mileage compared to available mileage in basin strata. Weighted sampling probabilities were used in order to evenly sample the basin by complete anadromous tributary distance instead of standardized length systematically sampled reaches.

Once a tributary was randomly selected for sampling, two to three index reach locations are randomly selected within that creek based upon mileage. Longer creeks have three sites selected, while smaller creeks (less than three km) have two sites selected. Sites were selected by computer, which randomly selects several site mileages from a creek's mileage range. Approximate locations were then plotted on the map before going into the field. Crews then proceeded to the approximate location and selected a site that meets basic site criteria. Some sites had to be "massaged" due to problems with excess pool depth, excessive vegetation, man-made structures within site boundaries, or private property concerns. When "massaging" a site during the selection process, crews were instructed to always look down-stream of the selected site location.

Juvenile index reaches range from 60 to 75 meters in length, and ideally include sections of pool, riffle, and run habitat. Minimum site criteria require the presence of at least one pool, no deeper than three feet, per reach. Also, reaches are not located within areas with evidence of high levels of human activity such as camping or active mining claims, and do not contain man-made structures such as dams, weirs, or culverts.

Index reaches are visited annually by a variety of project crew members over the five year course of this study. Permanent hard copy files are maintained in the SRAMP Weaverville office, as well as electronic files, which identify reach location and length, and the location and type of markers used to locate the reach. Reach coordinates are programmed into portable GPS units. Hard copy files include a map showing the location of the reach, site coordinates, and a physical description of the reach site, especially as it relates to physical markers (such as township range and section markers) and other features. Reach descriptions, including start coordinates and directions are provided in Appendix 1.

Index reaches are sampled once a year during low flow conditions (August/September) by a crew of three to five people. The same panel of selected tributaries and corresponding index sites is revisited every year. No new panel or revisit schedules have been implemented since the project's inception in 1999. A revised revisit schedule with several panels is planned for implementation at the conclusion of the five-year pilot period. Each reach is re-habitat typed every July to insure consistency between years. New physical parameter measurements were used for each year to compute juvenile steelhead densities. Upon completion of mapping, reaches were sampled using a Smith-Root backpack electrofisher (model 12-B, programmable waveform). A detailed electrofishing protocol is provided in Appendix 2.

Selection of appropriate electrofisher settings is critical to the health of the sampled fish. All crew members are required to understand the principles of effective and safe electrofishing operation. Inexperienced crew members only operate the electrofisher under the direction of the crew leader or lead biologist. All members of the electrofishing crew have current CPR certification.

Fish Population Estimation

Computer estimation of fish population sizes was accomplished with a maximum likelihood model developed by Dr. Ken Burnham from the U.S. Fish and Wildlife Service's Western Energy Land Use team. This model uses the successive depletion of catch sizes to estimate the actual population size by determining the likelihood of possible population sizes greater than or equal to total catch. The population size with the highest likelihood is considered the best estimate of actual population size. (Platts et al.,1983). From these estimates, juvenile steelhead densities (fish per meter^2) were developed for each index site, per habitat unit. Densities were further pooled to look at sub-yearling and 1+ juvenile steelhead densities in specific creeks and by type of habitat (fast-water or pool).

RESULTS

Juvenile steelhead were encountered in 100% of tributary reaches selected for sampling. Several other species of fish were captured during sampling, and depletion estimates are made for speckled dace and coho salmon when appropriate. Speckled dace, *Rhinichthys osculus*, were captured in East Fork North Fork Trinity River (EFNFTR) and East Weaver Creek. Pacific lamprey ammocetes, *Lampetra tridentata*, were found in EFNFTR, Big and East Weaver Creeks. Klamath small-scaled sucker, *Catastomus rimiculus*, were captured in EFNFTR and East Weaver Creek, but not frequently enough to be included in depletion estimates. Coho salmon, *Oncorhynchus kisutch*, were captured in EFNFTR and Soldier Creeks. East Weaver Creek had the most diverse assemblage of fish with five species present. Brown trout, *salmo trutta*, were not captured during the 2002 season, but were captured during 2001 in EFNFTR, Soldier and East Weaver Creeks.

Juvenile steelhead densities are pooled by tributary and reach for analysis. In 2002, overall juvenile steelhead density was estimated at 0.358 fish per meter^2. Sub-yearling steelhead densities were highest in Potato Creek, while yearling and older densities were highest in Little Grass Valley Creek. Estimated steelhead densities in EFNFTR are consistently below those of other sampled tributaries. EFNFTR is the largest of all sampled tributaries, and therefore displays the highest volume to surface area relationship, thus portraying a lower standing crop of fish because calculated density is a function of area.

Table 1. Juvenile Steelhead Density Summaries per Tributary (August-September, 2002)

Tributary	Units (n=)	Area of Habitat sampled (m^2)	Steelhead 0 Density (per m^2)	Steelhead 1+ Density (per m^2)	Total Juv. Steelhead Density (per m^2)
Little Grass Valley	16	529.6	0.276	0.079	0.355
EFNF Trinity	13	1494.3	0.232	0.017	0.249
Potato	11	402.5	0.596	0.062	0.658
Soldier	19	595.4	0.267	0.077	0.344
Big	15	1078.8	0.315	0.040	0.355
East Weaver	9	555.6	0.407	0.052	0.459
Totals	83	4656.2	0.313	0.045	0.358

Table 2. Trinity Tributary Index Reach Steelhead Catch Results by Reach (2002)

Tributary	Reach	Area (m^2)	SH 0 estimate	SH 0 Density (per m^2)	SH 1+ estimate	SH 1+ Density (per m^2)	Juv SH Density (per m^2)
Little Grass Valley	1	217.3	55	0.253	12	0.055	0.308
Little Grass Valley	2	149.8	36	0.240	16	0.107	0.347
Little Grass Valley	3	162.5	55	0.338	14	0.086	0.425
Big	1	524	137	0.261	22	0.042	0.303
Big	2	310.6	140	0.451	13	0.042	0.493
Big	3	244.2	63	0.258	8	0.033	0.291
Soldier	1	186.4	44	0.236	17	0.091	0.327
Soldier	2	189.2	68	0.359	13	0.069	0.428
Soldier	3	219.8	47	0.214	16	0.073	0.287
Potato	1	212.9	177	0.831	10	0.047	0.878
Potato	2	189.6	63	0.332	15	0.079	0.411
EFNF Trinity	1	576.1	82	0.142	11	0.019	0.161
EFNF Trinity	2	408.1	101	0.247	3	0.007	0.255
EFNF Trinity	3	510.1	164	0.322	11	0.022	0.343
East Weaver	1	376.1	143	0.380	25	0.066	0.447
East Weaver	2	179.5	83	0.462	4	0.022	0.485
Totals		4656.2	1458	0.313	210	0.045	0.358

Length frequency analysis is conducted for each creek and summarized below in Table 3. Sub-yearling (age 0) steelhead are defined as all steelhead under 90 mm (Chicolte, 2001). Length-frequency histograms for all creeks show an obvious nadir around the 90 mm area, confirming the cut-off criteria used by ODFW. Mean length of sub-yearling steelhead ranged from 54.5 to 59.6 mm with a mean of 57.06 mm. Mean length of yearling and older juvenile steelhead ranged from 114.9 to 137 mm, with a mean of 122.96 mm. A one-way ANOVA of length data showed that mean lengths of steelhead per age class were significantly different between creeks ($p<0.009$).

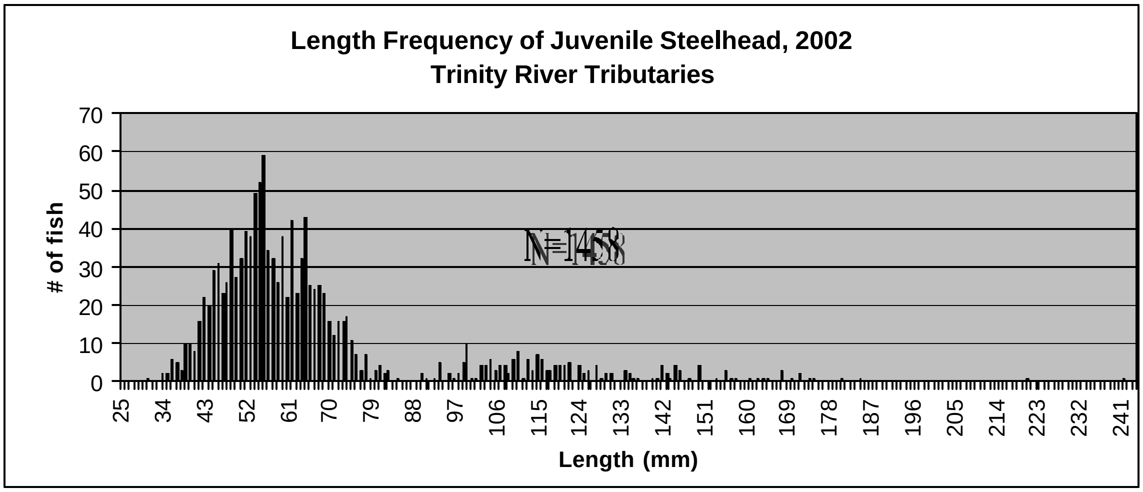

Figure 2. Length-frequency diagram of all juvenile steelhead captured by electrofishing in Trinity River Tributaries, August-September, 2002

Table 3. Mean length of juvenile steelhead per age class in sampled tributaries (2002)

Tributary	Dates Surveyed	Age 0 Steelhead Length		Age 1+ Steelhead Length	
		Mean	S.D.	Mean	S.D.
Big	9/3, 9/4, 9/12	57.1	9.374	117.1	30.29
East Weaver	8/5, 8/6	57	9.877	116.4	20.796
EFNF Trinity	8/7, 8/9, 8/12	57.2	11.016	137	35.951
Little Grass Valley	9/5, 9/10, 9/11	59.6	6.518	124.1	23.109
Potato	9/18, 9/23	54.5	9.757	125.4	23.341
Soldier	8/29, 9/16, 9/17	56.8	10.147	114.9	15.385
Overall	8/5-9/23	57.06	9.82	122.96	24.09

Whenever appropriate, depletion estimates were made for all fish captured in a sampled site. Speckled dace and coho salmon were the only species, in addition to juvenile steelhead, whose numbers warranted expansion using a maximum likelihood model. Klamath small-scaled suckers and Pacific lamprey ammocetes were also captured during the course of electrofishing, but because only one specimen was captured in any one site, depletion estimates were not made. Coho salmon were captured in Soldier and East Weaver Creeks, while speckled dace were captured in EFNFTR and East Weaver Creek.

Table 4. Depletion Estimates Other Fish Species (2002)

Tributary	Reach	Area (m^2)	Dace estimate	Dace Density (per m^2)	Coho salmon estimate	Coho Density (per m^2)	Total Fish Density (per m^2)
East Weaver	1	376.1	56	0.149	4	0.011	0.607
EFNFTR	1	576.1	7	0.012	0	0	0.173
EFNFTR	2	408.1	6	0.015	0	0	.0270
EFNFTR	3	510.1	1	0.002	0	0	0.345
Soldier	1	186.4	0	0	15	0.080	0.407
Soldier	2	189.2	0	0	24	0.127	0.555

Temperature monitoring, in conjunction with electrofishing reaches, was again implemented for the 2002 season. Hydro-thermographs were placed in each reach prior to the beginning of electrofishing (August 1st). The purpose of these installations was to monitor daily mean and maximum water temperatures. The NMFS recommended temperature of 18 °C for backpack electrofishing was exceeded in 17 of the 22 index reaches during the 2002 low flow season. Mean daily temperatures all fall within allowable tolerance levels for juvenile steelhead. Severe maximum temperatures detrimental to juvenile steelhead were observed in Little Brown's and Rattlesnake Creeks, both of which were not electrofished this year. All extreme temperature or flow impaired units were visited several times during the season and no steelhead mortality was ever observed. However, during these periods of low flow, larger juvenile steelhead were observed utilizing deep stagnant pools, again with no observed mortality.

Table 5. Thermograph Summaries, Trinity River tributaries, August 1, 2002- September 30, 2002

Creek	Reach	Mean Daily Temperatures (°C)	Extreme Temperatures (°C)	
			Minimum	Maximum
Big Creek	1	13.33	6.53	18.58
Big Creek	2	13.01	6.53	17.88
Big Creek	3	13.24	5.77	18.42
EFNF	1	17.36	8.69	23.15
EFNF	2	17.33	9.35	22.53
EFNF	3	16.61	9.28	21.47
East Weaver	1	18.33	11.81	25.27
East Weaver	2	14.92	7.91	19.98
Little Browns	1	12.22	9.13	13.31
Little Browns	2	17.07	7.75	25.71
Little Browns	3	15.05	5.91	23.13
Little Grass Valley	1	13.2	6.12	17.83
Little Grass Valley	2	12.83	6.2	19.36
Little Grass Valley	3	12.52	5.74	16.76
Rattlesnake	1	15.59	7.48	22.33
Rattlesnake	2	15.13	7.45	22.12
Rattlesnake	3	14.73	7.46	21.13
Potato	1	14.3	7.19	20.06
Potato	2	14.16	8.09	18.41
Soldier	1	14.64	8.21	18.19
Soldier	2	14.18	8.84	17.13
Soldier	3	13.33	6.53	18.58

DISCUSSION

Densities of sub-yearling and yearling and older juvenile steelhead observed during this study fall within the ranges other agencies have found within the Klamath Mountains Province (KMP) ESU. In 1999 and 2000, Oregon Department of Fish and Wildlife conducted a similar survey of juvenile steelhead in the KMP. Across the entire KMP, the mean density of presumed juvenile steelhead ranged from 0.32 to 0.96 fish/m^2 for sub-yearling and 0.034 to 0.097 fish/m^2 for yearling and older fish (ODFW, 2001). In 2002, densities in Trinity River tributaries (also in the KMP) for juvenile steelhead ranged from 0.086 to 1.65 fish/m^2 for sub-yearlings and 0.012 to 0.257 fish/m^2 for yearling and older fish.

Estimated fish density between tributaries appears to differ greatly within the Trinity basin. Mean sub-yearling densities per tributary ranged from a low of 0.112 fish per meter^2 in EFNF Trinity River in 2000 to a high of 0.596 fish per meter^2 in Potato Creek in 2002. Mean yearling densities per tributary showed a similar dispersion, ranging from 0.017 fish per meter^2 in EFNF Trinity River in 2002 to 0.103 fish per meter^2 in Soldier Creek in 2000. Overall (for all years sampled), sites on the EFNF Trinity River consistently showed the lowest juvenile steelhead rearing densities. Conversely, no specific tributary consistently showed the highest juvenile steelhead rearing densities, although sub-yearling densities in Potato and East Weaver Creeks were consistently above the overall mean density for the season. Preliminary analysis of sub-yearling, yearling+, and total juvenile steelhead density per year using a single factor ANOVA failed to show any significant difference in densities between years ($p>0.05$), although yearling+ densities appear to be declining slightly since 2000.

Table 6. Sub-yearling steelhead density by tributary for 2000-2002

Tributary	2000	2001	2002
Little Grass Valley	NS$_1$	0.135	0.276
EFNF Trinity	0.112	0.233	0.232
Potato	0.337	0.415	0.596
Soldier	0.207	0.450	0.267
Big	0.290	0.190	0.315
East Weaver	0.560	NS$_2$	0.407
Totals	0.313	0.261	0.313

$_1$ Not surveyed in 2000; was selected as new index site in 2001.
$_2$ Not surveyed in 2001 due to lack of flow.

Table 7. Yearling + steelhead density by tributary for 2000-2002

Tributary	2000	2001	2002
Little Grass Valley	NS$_1$	0.067	0.079
EFNF Trinity	0.035	0.037	0.017
Potato	0.025	0.065	0.062
Soldier	0.103	0.067	0.077
Big	0.062	0.058	0.040
East Weaver	0.066	NS$_2$	0.052
Totals	0.062	0.053	0.045

$_1$ Not surveyed in 2000; was selected as new index site in 2001.
$_2$ Not surveyed in 2001 due to lack of flow.

Juvenile steelhead densities were also pooled to examine the utilization of pool vs. riffle habitat. For the purpose of this comparison, riffle habitat designation was further expanded to include any fast-water habitat. As expected, densities of sub-yearling and yearling and older juvenile steelhead are slightly higher in pool than riffle habitat. Additionally, mean pool densities of yearling and older juvenile steelhead are nearly double that of densities in riffles for all years. ODFW recently examined studies conducted by multiple researchers working in streams of the Pacific Northwest and in tributaries of the Great Lakes containing introduced steelhead populations and found that these studies reported that densities of juvenile steelhead are lower in riffle sections than in other types of stream habitat (ODFW, 2001). One possible explanation to the disparity between densities in pool vs. riffles is that riffles are inherently more difficult to sample. A more probable explanation is that more older (yearling+) juvenile fish inhabit the "preferred" habitat, i.e. the pools, while sub-yearling fish are dispersed throughout all habitat types fairly evenly.

Table 8. Trinity Index Reach Riffle Habitat Steelhead Densities (2002)

Tributary	Units (n=)	Area of riffles Sampled (m^2)	% habitat Riffle	Steelhead 0 Density (per m^2)	Steelhead 1+ Density (per m^2)	Total Juv. Steelhead Density (per m^2)
EFNF Trinity	10	1143.1	76.5	0.240	0.016	0.255
Potato	5	218.1	54.2	0.454	0.018	0.472
Soldier	8	353.4	59.4	0.224	0.045	0.269
Big	8	643.4	59.6	0.365	0.039	0.404
Little Grass Valley	8	345	65.1	0.177	0.049	0.226
East Weaver	7	500.6	90.1	0.384	0.042	0.425
Totals	46	3203.6	68.9	0.293	0.032	0.325

Table 9. Trinity Index Reach Pool Habitat Steelhead Densities (2002)

Tributary	Units (n=)	Area of Pools Sampled (m^2)	% habitat Pool	Steelhead 0 Density (per m^2)	Steelhead 1+ Density (per m^2)	Total Juv. Steelhead Density (per m^2)
EFNF Trinity	3	351.2	23.5	0.208	0.020	0.228
Potato	6	184.4	45.8	0.765	0.114	0.879
Soldier	11	242.0	40.6	0.331	0.124	0.455
Big	7	435.4	40.4	0.241	0.041	0.282
Little Grass Valley	8	184.6	34.9	0.460	0.135	0.596
East Weaver	2	55.0	9.9	0.618	0.145	0.764
Totals	37	1452.6	31.1	0.357	0.075	0.432

In comparing to other juvenile steelhead density studies, it is important to note that this project's sampling frame includes 1st through 4th order streams. Most other agencies currently monitoring juvenile steelhead densities, including ODFW, only include 1st-3rd order streams in their sampling universe. It was determined necessary to include larger streams as there is a pronounced migration of juvenile fish to deeper holding habitat during low flow periods. During the summer, in several larger tributaries within the basin it has been observed what appeared to be significantly high densities of juvenile steelhead occupying every riffle and pool tail-out. The East Fork of the North Fork ranges from 3^{rd} -5^{th} stream order (majority is 4^{th} order) and was included when electrofishing proved plausible. Canyon Creek, another higher order stream was selected but deemed unfeasible due to higher flows.

It is important to recognize possible sources of biases that result from the elimination of certain possible portions of the sampling universe. All inaccessible streams or portions of streams have been removed from the sampling universe, these include all streams that are not within one mile of driving access. Most of the area eliminated by lack of access is wilderness area, specifically a large majority of the North Fork basin, which is generally recognized as the most pristine of the entire basin. Also eliminated from the sampling universe are areas of private property where access has been previously denied to the Department.

Several assumptions must be met when using a depletion removal electrofishing model. No fish must be able to immigrate/emigrate to/from the unit, thus the use of block nets. Sampling effort should be equal between passes, hence the passes are timed and approximately equal effort is used between each pass. Finally, there must be equal sampling probability within each species and age class that is expanded separately. It is important to recognize that some inequity in effort inherently exists when sampling, but is minimized whenever possible. Different people operating the electrofisher have different skill levels, as well as different abilities to communicate. This is why we only change electrofishers between units and not within them. Another possible source of variation in effort is lack of power equalization. Whenever a crew fails to gain positive electrical response from a fish, the generally tendency is to “turn up the juice;” it is important to always keep the same electrofisher setting for the entire habitat unit, for all three passes. Yet another source of variation in equality of effort is density of cover (i.e. large woody debris, boulders, overhanging vegetation), which tends to complicate electrofishing. Whenever possible, excessive cover was held back by a third-party crew - member while electrofishing. Excessive vegetation was never removed, as cover is an important component of fish habitat.

Possible safety concerns exist, both to person and wildlife, when electricity is used in connection with water. All personnel have been CPR and First Aid certified, and made aware of the dangers of electricity, prior to the field season. Excessive mortality to fish can result from either the excessive use of power or time when electrofishing. Aside from mortality, “over-shocking” is apparent by the appearance of bruising, back deformities, and increased recovery times (Reynolds, 1996). Mortality was minimal throughout all seasons of this study (2.4% in 2000, 3.02% in 2001 and 3.34% in 2002). During the 2000 season, electrofishing frequencies of 50-60 Hz were used. In 2001, protocol was changed to use only frequencies from 30-40 Hz, in an attempt to reduce mortality. However, mortality between years of sampling increased by 0.52%. One possible explanation to increased mortality could be the critically dry water years; fish get shocked harder when there is a lesser volume of water to power relationship. Another possible explanation could be the change in shape and size of the electrical field (with less power) and how it relates to severity of fish response and the amount of time it takes to net a fish. High frequencies elicit a greater response from the fish, therefore making the fish easier to net, eliminating additional mortality due to over-shocking and smashing. Mortality in 2002 again patterned that of 2001, actually increasing 0.31%. This seems to confirm the relationship between dry water years and increased electrofishing mortality.

Temperature plays an important role in fish abundance, migration and our ability to electrofish. NMFS backpack electrofishing guidelines state that no one should electrofish in water that is expected to exceed 18 °C during that sampling day (NMFS, 1998). This upper limit for backpack electrofishing was exceeded in 17 of the 22 index reaches during the 2002 low flow season, during the 2001 season 16 of 22 reaches had the temperature exceeded. During the 2000 season, we used an upper limit to electrofish of 20°C, and only one day of electrofishing had to be postponed, on Little Brown's Creek. In 2001, we changed our upper limit to 18 °C, and again were lucky to have to cancel only one day of electrofishing, again on Little Brown's Creek. Later in the season additional thermal/low flow problems became apparent on Little Brown's, East Weaver, and Rattlesnake Creeks, all of which were not electrofished in 2001 to minimize the risk to juvenile steelhead stocks. In 2002, electrofishing was again not conducted on Little Brown's and Rattlesnake Creeks due to lack of flow and temperature concerns.

Regression analysis of fish density versus temperature was examined by comparing reach and point densities to their corresponding thermograph daily mean, maximum and temperature at time of sampling. This season, no relationships were discovered between juvenile steelhead densities and temperature. Last season (2001), there was a weak to moderate correlation (R^2=0.35) between daily mean temperature and yearling and older steelhead density. There was also a moderate correlation (R^2=0.39) between seasonal maximum temperature and yearling+ steelhead density.

De-watering of index reaches in critically dry years appears to be a major problem in the Trinity basin, especially in more highly populated areas such as Weaverville. It is nearly impossible to tell if a creek should have surface flow or if it is being over-diverted by local citizens. Diversion law is enforced by the Department; further complicating any private landowner relationships if we were to "turn in" the offending over-diverters. We have recently forwarded a list of over-diverted creeks in Trinity basin to the Department's water quality specialist, Jane Vorpagel, for further investigation.

RECOMMENDATIONS

I have several recommendations to improve and focus our efforts to monitor over-summering juvenile steelhead.

Sample size should be increased to increase the power of any statistical inferences. At present only 22 index reaches are sampled on an annual basis. A properly trained and staffed field crew should be able to sample approximately 40 reaches per season, weather and water-year permitting. New sites should and will be selected whenever budgetary and staffing requirements permit.

A multi-panel design should be developed with multiple year revisit schedule. Tributaries were originally selected prior to the 2000 season using a weighted random sample. These sites were initially selected to be sampled annually. Upon completion of this project's five-year pilot time-frame, I propose initiating a rotating panel design, similar to that developed by Trent McDonald for the Forest Science Projects to detect trends in juvenile coho populations (McDonald and Nielsen, 2001). This would entail three rotating panels. The first panel would sample every selected site on an annual basis, the second panel would sample each selected site every three years, and the third panel would sample randomly selected sites only to be sampled once. A combination of these panels should prove to provide a more representative sample of steelhead densities throughout the Trinity basin.

The sampling universe of all anadromous habitat available to steelhead in the Trinity basin needs to be expanded and refined. Many tributaries in the Trinity basin are in federal ownership (USFS or BLM), but a substantial portion still lies within private ownership. Most tributaries on federal lands have semi-current surveys, but most private land has never been surveyed. Currently, when survey information is unavailable, anadromous river mileage is estimated based upon gradient. Agreements need to be made with private landowners to survey possible steelhead tributaries. Additionally, past surveys need to be re-examined for validity of migrational barriers. Many structures previously classified as barriers are no longer considered barriers to fish passage. Debris jams have most likely moved, and small cascades we now know fish can navigate.

Sample site response burden needs to be examined. Sites sampled every year for multiple years may show decreasing densities of juvenile steelhead over time. Currently, there is no mechanism available to measure if this represents the overall trend or if sites are "wearing out" due to over-sampling. Next season, additional sites within selected tributaries will be selected for sampling to examine response burden of other sites within that tributary. This expanded sampling protocol, in combination with a rotating panel revisit schedule, should provide a less biased sample of juvenile steelhead over-summer standing crops throughout the Trinity River basin.

More emphasis needs to be focused on decreasing electrofishing mortality. It is an ongoing concentration of this project to minimize electrofishing and handling mortality of captured fish. Mortality is recorded on a daily basis in compliance with the Department's Section 10 permit. I believe that mortality can be further minimized by implementing the following recommendations. The lead biologist should participate in all electrofish sampling whenever possible. Immediate mortality due to electrofishing decreased to 1.4% when the lead biologist was present. Biological samples should only be taken off of captured fish when selected through the systematic sample as defined in the sampling protocol, i.e. do not over-sample fish. De-watered or thermally impaired reaches of selected tributaries should be electrofished later in the season, possibly in late September or even early October.

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APPENDIX 1 – REACH DESCRIPTIONS

Soldier Creek

Reach	1	2	3	Total
Location	N 40 41.418 W 123 02.276	N 40 41.423 W 123 02.935	N 40 41.469 W 123 03.165	
Directions to:	3.5 Miles up Dutch Creek to Soldier Pass then proceed up 1/4 mile.	Go up Soldier Pass Rd about 2 miles. Pull out at grass turn out on left, start at entry to creek.	Go up Soldier Pass Rd. to 1st culvert, go down stream 100 meters to flag below culvert.	
Length (m)	57.0	64.8	78.5	200.3
Area (m^2)	186.4	189.0	219.8	595.2
Volume (m^3)	41.4	42.5	48.7	132.6
Mean Width	3.1	3.1	2.9	3.0
Mean Depth	0.22	0.23	0.22	0.22
Max Pool Depth	0.61	0.61	0.64	0.62
Mean Residual Pool Depth	0.14	0.17	0.17	0.16
Dominant substrate	Boulder	Boulder	Boulder	Boulder
Sub-dominant substrate	Gravel	Cobble	Cobble	Cobble
% in-stream cover	41.0%	27.5%	40.0%	36.2%
Dominant cover	Boulder/Veg.	Boulder/Veg.	Boulder/Veg.	Boulder/Veg.
% Canopy cover	85%	79.4%	85.0%	83.1%
Major Changes in 2002	None	None	None	

Big Creek

Reach	1	2	3	Total
Location	N 40 36.909 W 123 09.679	N 40 37.975 W 123 09.764	N 40 39.212 W 123 09.425	
Directions to:	200 ft before 32N23 turn off Big Creek Rd.	150 ft below Donaldson Creek confluence	100 ft upstream of Packer's Creek confluence	
Length (m)	91.0	63.4	80.2	234.6
Area (m^2)	524.0	310.6	244.2	1078.8
Volume (m^3)	98.25	80.1	64.3	242.65
Mean Width	6.0	5.3	3.1	4.8
Mean Depth	0.19	0.26	0.26	0.24
Max Pool Depth	0.61	0.58	0.51	.57
Mean Residual Pool Depth	0.24	0.18	0.13	0.18
Dominant substrate	Boulder	Boulder/Cobble	Bedrock	Boulder
Sub-dominant substrate	Cobble	Boulder	Cobble	Cobble
% in-stream cover	31.25%	38.0%	35.0%	34.75%
Dominant cover	Boulder/Veg.	Boulder	Boulder	Boulder
% Canopy cover	77.5%	58.0%	83.3%	72.9%
Major changes 2001 to 2002	Went from 5 units to 4 – combined units 3 & 4	None	Dropped upper unit; now only 6 units	

East Fork North Fork Trinity River(EFNFTR)

Reach	1	2	3	Total
Location	N 40 48.780 W 123 07.227	N 40 49.620 W 123 07.528	N 40 50.870 W 123 07.969	
Directions to:	Funky Nugget mine 3.5 miles from Hwy 299	Turn left @ mile marker 5, 7/10 of a mile above 2nd bridge	N.Fork Rd to the end, access rd. to gate	
Length (m)	97.6	66.5	88.1	252.2
Area (m^2)	576.1	408.1	510.1	1494.3
Volume (m^3)	193.0	80.8	135.2	409.0
Mean Width	5.4	6.2	5.75	5.78
Mean Depth	0.34	0.20	0.27	0.27
Max Pool Depth	0.94	n/a	0.79	0.87
Mean Residual Pool Depth	0.31	n/a	0.21	0.26
Dominant substrate	Cobble	Boulder	Boulder/Cobble	Boulder/Cobble
Sub-dominant substrate	Boulder	Cobble	Cobble	Cobble
% in-stream cover	31.25%	34.0%	35.0%	33.4%
Dominant cover	Boulder	Boulder	Boulder	Boulder
% Canopy cover	76.25%	66.0%	60.0%	67.4%
Major changes 2001 to 2002	1st pool unit lengthened downstream	Deposition flattened pool habitat to run habitat, No pools in 2002	None	

Potato Creek

Reach	1	2	Total
Location	N 40 30.091 W 123 02.350	N 40 29.468 W 123 01.719	
Directions to:	East Fork rd. to Potato Creek Bridge, then upstream 120 meters up Potato Crk. Rd.	Potato Creek. Rd. to first creek crossing, 50 ft. upstream	
Length (m)	74.75	63.8	138.6
Area (m^2)	212.9	189.6	402.5
Volume (m^3)	58.9	62.2	121.1
Mean Width (m)	2.9	3.2	3.1
Mean Depth (m)	0.28	0.33	0.31
Max Pool Depth	0.73	0.82	0.78
Mean Residual Pool Depth	0.1	0.12	0.11
Dominant substrate	Boulder/Bedrock	Boulder	Boulder
Sub-dominant substrate	Cobble	Gravel	Cobble/Gravel
% in-stream cover	29.2%	35.0%	32.1%
Dominant cover	Boulder/cobble	Boulder/Veg.	Boulder
% Canopy cover	75.0%	61.0%	68.0%
Major changes 2001 to 2002	None	Dropped unit 1; combined units 3 & 4 into an LGR; went from 7 units to 5.	

East Weaver Creek

Reach	1	2	Total
Location	N 40 44.091 W 122 55.703	N 40 46.427 W 122 55.448	
Directions to:	Browns Ranch Rd. to swimming hole, upstream 100 meters	East Weaver campground bridge, upstream 100 meters	
Length (m)	113.6	64.3	177.9
Area (m^2)	383.6	179.5	563.1
Volume (m^3)	76.0	30.5	106.1
Mean Width (m)	3.1	2.7	2.9
Mean Depth (m)	0.20	0.17	0.19
Max Pool Depth	0.52	0.44	0.48
Mean Residual Pool Depth	0.18	0.06	0.12
Dominant substrate	Boulder	Boulder	Boulder
Sub-dominant substrate	Cobble	Cobble/Sand	Cobble
% in-stream cover	37.0%	31.25%	34.1%
Dominant cover	Boulder	Boulder/Wood	Boulder
% Canopy cover	36.0%	61.25%	38.6%
Major changes 2001 to 2002	Electro-fished in 2002	Electro-fished in 2002	Electro-fished in 2002

Rattlesnake Creek

Reach	1	2	3	Total
Location	N 40 22.235 W 123 18.763	N 40 23.166 W 123 17.499	N 40 23.465 W 123 16.713	
Directions to:	100 meters up stream of the confluence with South Fork at Hell Gate campground	Hwy 36 & USFS road 14, turn east @ road 14, u-turn and drive on old dirt/pavement rd 0.2 miles to end. Site is 75 meters upstream	Hwy 36 and Rattlesnake Rd., drive up Rattlesnake Rd. .2 miles, site is on right, also about .2 miles below confluence of Post Crk.	
Length (ft)	79.2	61.7	66.5	207.4
Area (m^2)	374.9	203.4	249.5	827.8
Volume (m^3)	129.0	63.2	53.2	245.4
Mean Width	4.8	3.5	3.6	3.9
Mean Depth	0.34	0.31	0.21	0.28
Max Pool Depth	0.76	0.91	0.85	0.91
Mean Residual Pool Depth	0.55	0.73	0.48	0.54
Dominant substrate	Boulder	Boulder	Boulder	Boulder
Sub-dominant substrate	Bedrock	Bedrock	Cobble	Bedrock
% in-stream cover	37.0%	30.0%	37.1%	35.0%
Dominant cover	Boulder/cobble	Boulder/cobble	Boulder/cobble	Boulder/cobble
% Canopy cover	53.0%	44.0%	70.7%	57.6%
Major changes 2001 to 2002	Considerably lower flow	Stagnant pools, with algal sheen	Reach is dry	Not Electrofished in 2002 due to critically-dry water year

Little Brown's Creek

Reach	1	2	3	Total
Location	N 40 41.303 W 122 56.144	N 40 41.816 W 122 55.400	N 40 42.027 W 122 55.238	
Directions to:	Little Browns Creek bridge on hwy 299, 100 ft. upstream	Little Browns Mt. Rd. to Browns Mt. Rd. to 1st bridge, 100 meters. Upstream from bridge	.5 miles up Little Browns Mtn. Rd. to 1st dirt rd. on right after Browns Mtn. Rd.	
Length (ft)	86.0	80.4	107.8	274.2
Area (m^2)	290.4	197.4	268.2	756.1
Volume (m^3)	56.6	57.3	46.6	160.4
Mean Width	3.5	3.1	4.1	3.5
Mean Depth	0.20	0.29	0.17	0.22
Max Pool Depth	0.61	0.82	0.55	0.82
Mean Residual Pool Depth	0.47	0.60	0.42	0.50
Dominant substrate	Cobble	Bedrock	Cobble	Cobble
Sub-dominant substrate	Sand	Boulder	Gravel	Gravel
% in-stream cover	26.0%	38.0%	18.0%	27.0%
Dominant cover	Boulder/cobble	Boulder/cobble	Boulder/cobble	Boulder/cobble
% Canopy cover	76%	38%	69%	60.3%
Major changes 2001 to 2002	Dry due to over-diversion	Dry due to over-diversion	Water isolated to pools	Not electrofished in 2002 due to critically-dry water year

Little Grass Valley Creek

Reach	1	2	3	Total
Location	N 40 39.660 W 122 46.835	N 40 39.191 W 122 45.460	N 40 38.751 W 122 44.822	
Directions to:	Mile Post 68.63 on Hwy 299, turn out on right side of Hwy near 40 mph sign	Mile Post marker 70, Hwy 299 downstream of drive way to Ludden Tree Farm	Mile Post 70.73, Hwy 299 Large pull-out left side of hwy	
Length (m)	72.0	63.8	62.6	198.4
Area (m^2)	217.3	149.8	162.5	529.6
Volume (m^3)	43.0	31.5	34.7	109.2
Mean Width	3.0	2.4	2.5	2.6
Mean Depth	0.20	0.21	0.21	0.21
Max Pool Depth	0.55	0.58	0.49	0.58
Mean Residual Pool Depth	0.12	0.14	0.09	0.12
Dominant substrate	Sand	Bedrock	Sand	Sand
Sub-dominant substrate	Bedrock/Sand	Sand	Boulder	Sand
% in-stream cover	26.0%	33.0%	35.8%	31.6%
Dominant cover	Cobble/Veg.	Cobble/Veg.	Cobble/Veg.	Cobble/Veg.
% Canopy cover	78.0%	77.0%	80.0%	78.3%
Major Changes from 2001 to 2002.	None	None	Unit 4 changed from MCP to Step Pool	

APPENDIX 2 - DEPLETION ELECTROFISHING PROTOCOL

1) Place block nets to separate habitat types within each index site.
2) Measure water conductivity and temperature.
3) For each habitat type within the index site, perform a single upstream electrofishing pass. Record time taken in first pass, so that equal effort can be made on each subsequent passes.
4) Collect fish in buckets, anesthetize with MS-222, and record species, length and weight. Take required biological samples.
5) Move fish to fresh water tank and observe recovery.
6) Hold fish in perforated in-stream bucket, in sheltered location outside of reach.
7) Conduct second and third passes in the same manner as the first and repeat data collection procedures. Repeat if necessary.
8) Remove block nets and record physical reach data and additional environmental parameters.

All necessary precautions are taken to avoid disturbing the sampling reach, especially prior to placement of block-nets. Water temperature and specific conductance are taken prior to electrofishing to determine the appropriateness of electrofisher settings. Electrofishing protocol will follow accepted DFG depletion methods.

The following electrofishing settings are to be used with their corresponding conductivities. Do not electrofish at conductivities below 50µS/cm^3.

50-100µS/cm^3- Start with 300V G4, if no fish response, increase to G5; then to 400 G4….400G5 etc. Do not exceed 500 V or 50 Hz.

100-300µS/cm^3- Start with 300V G4, if no fish response, increase to G5. Do not exceed 400 V or 40 Hz.

300+µS/cm^3- Start with 200V G4, if no fish response, increase to G5, then to 300V G4. Do not exceed 300V or 40Hz .

Upon completion of each electrofishing pass, fish are anesthetized and the following data is collected: fork length (mm); weight (g); and total number. The fish will then be returned to a container of fresh water, and observed for injury or mortality. All fish mortalities are collected for future analysis. Additionally, genetic samples (upper caudal clip) are taken from every 10th sub-yearling steelhead and every 3rd yearling and older steelhead. After the fish have recovered sufficiently they are returned to the stream in a sheltered location downstream of current electrofishing efforts. Other species are counted and returned to the stream. All salamanders are immediately removed from any actively fished unit to reduce the chance of predation.