# ANALYSIS OF THE CONDITION OF RAINBOW TROUT COLLECTED FROM THE KINGS RIVER DOWNSTREAM OF PINE FLAT DAM 1983-2005


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**Charles H. Hanson, Ph.D., Principal Scientist**
**Farhat Bajjaliya**
**Hanson Environmental, Inc.**
132 Cottage Lane
Walnut Creek, CA 94595
*tel.* (925) 937-4606
www.hansonenvironmentalinc.com


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## ABSTRACT

Results of a 23-year fishery survey were used to examine length-weight relationships and condition factors for rainbow trout (*Oncorhynchus mykiss*) inhabiting the Kings River downstream of Pine Flat Dam. Condition factors averaged 1.13 (n = 2161 rainbow trout) with a length-weight regression slope of 3.00 ($r^2$ = 0.97). Based on these results, we concluded that rainbow trout inhabiting the Kings River are healthy and in good condition. Although statistically significant differences in condition factors were identified among years, no trend was apparent in the data either overtime or in response to hydrologic conditions during the year preceding each fishery survey. No statistically significant differences ($p>0.05$) were detected in condition factors among various sampling sites, with the exception of one site having a small sample size. No statistically significant differences ($p>0.05$) were detected in condition factors for rainbow trout classified as wild when compared to trout identified as having been planted from the San Joaquin River Hatchery (trout designations were based on fin erosion, coloration, fin clips, and tagging). The length-weight relationships and condition factors observed for rainbow trout inhabiting the Kings River downstream of Pine Flat Dam were comparable to indices of condition for rainbow trout within other watersheds that are not affected by operation of Pine Flat Dam.


## INTRODUCTION

The Kings River, extending from Pine Flat Dam downstream to Highway 180 (Figure 1), supports a recreational trout fishery sustained by frequent plants of various life stages from hatcheries and natural reproduction. Rainbow trout (*Oncorhynchus mykiss*) are managed within a harvest (five fish limit) zone between the dam and Alta (Cobbles) Weir along with a catch-and-release zone (zero trout limit). A Kings River Fishery Management Plan (KRFMP) has been developed to improve habitat quality and availability and increase the overall abundance of rainbow trout inhabiting the Kings River downstream of Pine Flat Dam. Pine Flat Reservoir is managed for flood control, agricultural irrigation supply, and hydroelectric power generation. Concerns have been expressed by resource agencies and the public regarding the effects of reservoir operations and streamflow releases on the quality and availability of trout habitat. Fluctuating hydrology and seasonal water temperatures within and among years are also thought to affect trout growth and survival. The existing facilities, operations, and habitat conditions, including competition with non-game fish species inhabiting the river may directly and indirectly affect habitat quality and availability, trout growth, and effects on macroinvertebrate prey. Length-weight and condition factor analyses can be used as a tool to assess the current and previous health and condition of rainbow trout inhabiting the Kings River.

The relationship between length and weight for individual trout can be used to calculate Fulton's Condition Factor Index (CF; Ricker 1958), which is defined as:

$$\text{Conditions Factor (CF)} = [\text{weight}/(\text{length})^3] \times 100$$

where length is measured in centimeters (cm) and weight is measured in grams (g). Condition factors are representative of individual trout condition and the slope of the length-weight relationship can also be used as an indicator of the overall health of a population of trout.

The condition factor provides a general indicator of the overall health of an individual trout that can be used to detect and assess potential changes in the length-weight relationship among years and locations. Condition factor and length-weight regression analyses have been used to assess individual trout health and habitat conditions (e.g., prey availability), as well and the condition of a population of trout inhabiting a stream or river (Cada *et al.* 1987; Murphy 1988; Ensign *et al.* 1990; Cone 1989 and 1990; Springer and Murphy 1990; Gutreuter 1990; Anderson 1990; Miranda and Jackson 1990; Reimers 1963; Filbert and Hawkins 1995; McKinney *et al.* 2001, and others).

As part of the Kings River fishery monitoring program the Kings River Conservation District (KRCD) has conducted an annual electrofishing survey at locations downstream Pine Flat Dam since 1983. Information collected during the electrofishing surveys for rainbow trout includes both length and weight data for individual fish which can be used to evaluate the overall health and condition of trout within the river. Results of a preliminary analysis of length-weight information from the annual fishery surveys indicated that

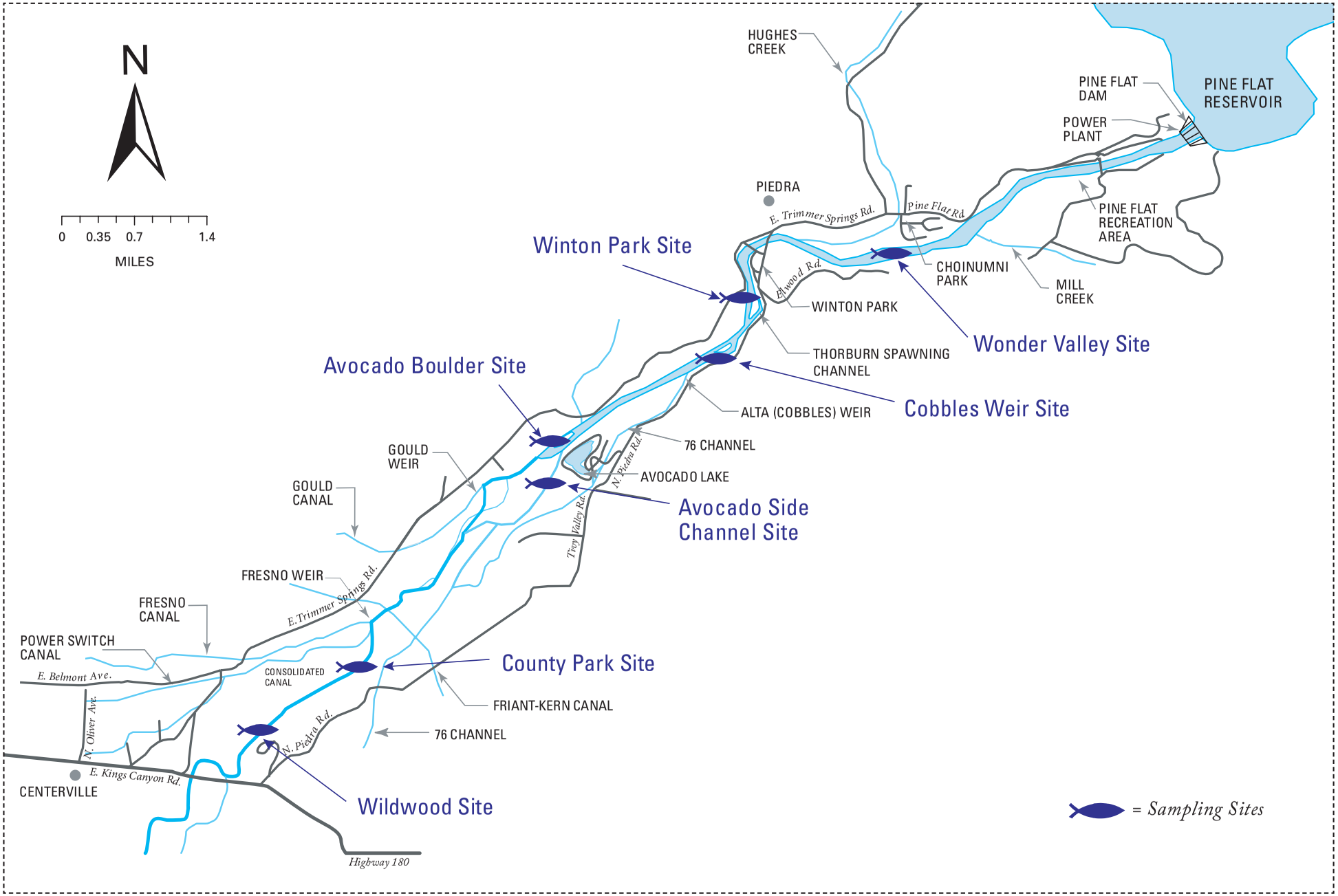


**FIGURE 1**. Sampling locations on the Kings River downstream of Pine Flat Dam.

trout were characterized as being in good condition (KRCD 1993), however no comprehensive analysis of the 23 years of existing data (1983–2005) has been conducted. To provide additional information regarding the health and condition of the Kings River trout population, we analyzed the entire data set available from the annual electrofishing surveys to address the following questions:

- What is the overall length-weight relationship and condition factor for rainbow trout collected between 1983 and 2005 (all years combined) and separately for each year?
- Do condition factors vary significantly among years and/or show a trend in the general health of rainbow trout over the 23-year monitoring period?
- Do condition factors of rainbow trout vary significantly among different sampling locations (Figure 1)?
- Are condition factors significantly different for rainbow trout identified as wild (in-river production and rearing) when compared to trout produced in the San Joaquin River Hatchery and planted into the river?
- Are the condition factors and length-weight relationships for rainbow trout inhabiting the Kings River downstream Pine Flat Dam significantly different from rainbow trout inhabiting other watersheds, including tributaries upstream of Pine Flat Dam?

Two indicators of the health and condition of rainbow trout were selected for use in this analysis, which included, the slope of the log length - log weight linear regression (a slope of 3.0 was selected as an indicator of trout in good condition; allometric growth) for population level comparisons, and Fulton's condition factor of 1.0 for individual trout (Ricker 1958, 1975).

## METHODS

The Kings River Conservation District, in cooperation with the Kings River Water Association (KRWA), California Department of Fish and Game (CDFG), and volunteers have conducted an annual electrofishing survey within the Kings River downstream of Pine Flat Dam since 1983. The annual electrofishing surveys used in these analyses are characterized in Table 1. The electrofishing survey is typically conducted during the late fall, winter, or early spring when river flows are at their seasonal minimums (typically 100–250 cfs). The electrofishing surveys are conducted using a block net and multiple backpack electroshockers (Smith-Root). Electrofishing surveys are conducted within specific reaches of the river including Wonder Valley, Cobbles Weir, Winton Park, County Park, Avocado boulder project area, Wildwood, Avocado side channel, and several locations within the Thorburn side channel (Figure 1). All sites have not been consistently surveyed during the monitoring period.

Data collected during each survey includes the area and duration of electroshocking, river flow, water temperature, and the species composition and abundance of all fish collected. In addition, information collected on rainbow and brown trout includes fork length (mm), weight (grams), and the occurrence of tags, fin clips, or other marks. Individual rainbow trout were classified as being wild or planted from the hatchery based upon coloration, tagging, other marks such as fin clips, and the condition and appearance of fins (hatchery-produced rainbow trout were characterized by eroded and rounded pectoral, anal, and caudal fins, while wild trout — which include trout that may have been planted from the hatchery at a young lifestage or produced in the on-river egg incubators, but have reared within the river — were characterized by little or no fin erosion, fin coloration) and the absence of tags or other markings.

For purposes of this investigation, we limited our analysis to only rainbow trout, which are the dominant species supporting the local recreational fishery and the primary target species of interest for the Kings River Fishery Management Program. Data from each of the electrofishing surveys was compiled into a Microsoft Excel database, critically reviewed as part of a quality assurance program to remove spurious or incomplete observations, and subsequently used in statistical analyses.

## RESULTS

Results of the fishery surveys are summarized in Table 1. A total of 2,161 rainbow trout collected over the 23-year

monitoring period were included in the length-weight and condition factor analyses. Over the 1983–2005 period, Fulton's condition factor averaged 1.13 (SD = 0.16, n=2161). Overall, the mean condition factor was not significantly different from 1.0. The length-weight relationship for trout collected over the 1983–2005 period is shown in Figure 2 and characterized by the linear regression equation:

$$\text{Log weight} = -4.94 + 3.00\ (\log \text{length}) \quad r^2 = 0.97 \quad n = 2161$$

The slope of the linear regression was not significantly different from 3.0.

The length-weight relationship for rainbow trout classified as wild had a regression slope of 3.03 (Figure 3). The length-weight relationship for rainbow trout classified as having been planted in the river from the hatchery had a slope of 2.97 (Figure 4). The regression slopes for trout identified as wild and from the hatchery were not significantly different ($p>0.05$). No statistically significant difference ($p>0.05$) was detected in condition factors for rainbow trout classified as wild (average condition factor 1.14; n = 1126) and trout classified as having been planted from the hatchery (average condition factor 1.12; n = 1035).

No statistically significant relationship ($p>0.05$) was detected between condition factor and trout length (Figure 5). Cone (1989) reported a negative relationship for brook trout with condition factor declining with increasing trout length. Our results showed greater variability in condition factors for smaller fish (Figure 5) but no reduction was detected in condition factors as fish length increased.

Results of an analysis of condition factors comparing each of the individual years included in the survey (Table 1) showed that condition factor varied significantly among years ($p< 0.05$). For example, condition factors observed in 1993, 1995, and 1998 were found to be significantly higher ($p<0.05$) when compared to condition factors from other

TABLE 1. Total number of rainbow trout that were weighed and measured by year and average, minimum, and maximum condition (source: KRCD unpublished data).

| | TOTAL NUMBER OF RAINBOW TROUT WEIGHED AND MEASURED | | | CONDITION FACTOR | | |
|---|---|---|---|---|---|---|
| Year | Wild | Planted | Total Fish | Mean | Minimum | Maximum |
| 1983 | 150 | | 150 | 1.08 | 0.8 | 1.5 |
| 1984 | 95 | | 95 | 1.15 | 0.4 | 1.8 |
| 1985 | 13 | | 13 | 1.09 | 1 | 1.2 |
| 1986 | 155 | | 155 | 1.15 | 0.5 | 1.5 |
| 1987 | 95 | | 95 | 1.16 | 0.7 | 1.4 |
| 1988 | 32 | | 32 | 1.17 | 1 | 1.4 |
| 1989 | 21 | | 21 | 1.07 | 0.9 | 1.3 |
| 1990 | | | 0 | | | |
| 1991 | | | 0 | | | |
| 1992 | | | 0 | | | |
| 1993 | | 13 | 13 | 1.25 | 0.9 | 1.8 |
| 1994 | | 22 | 22 | 1.08 | 0.4 | 1.5 |
| 1995 | 1 | 248 | 249 | 1.23 | 0.7 | 1.7 |
| 1996 | 2 | 180 | 182 | 1.05 | 0.3 | 1.4 |
| 1997 | 26 | 71 | 97 | 1.15 | 0.9 | 1.5 |
| 1998 | 126 | 36 | 162 | 1.27 | 0.9 | 1.9 |
| 1999 | 136 | 77 | 213 | 1.15 | 0.4 | 1.9 |
| 2000 | 126 | 78 | 204 | 1.09 | 0.3 | 1.7 |
| 2001 | 1 | 114 | 115 | 1.09 | 0.4 | 1.5 |
| 2002 | 119 | 148 | 267 | 1.05 | 0.7 | 1.6 |
| 2003 | | | 0 | | | |
| 2004 | 16 | 24 | 40 | 1.06 | 0.9 | 1.3 |
| 2005 | 12 | 24 | 36 | 1.03 | 0.9 | 1.5 |
| Total | 1,126 | 1035 | 2,161 | | | |

years. Condition factors observed in other years included in this analysis (Table 1) were not found to be significantly different ($p>0.05$). Hydrologic conditions within the Kings River watershed, as reflected by the percent of normal runoff for each water year preceding a fishery survey reflecting general hydrologic conditions over the period prior to the electrofishing surveys, were characterized as 183% in water year 1997–1998 (preceding the 1998 fishery survey), 151% of normal in water year 1992–1993 (preceding the 1993 fishery survey), and 204% in water year 1994–1995 (preceding the 1995 fishery survey) over the three years found to have the highest condition factors among the surveys. An analysis of the relationship between water year type (percentage of normal), and Pine Flat Dam streamflow releases, as measured by total flow at Piedra (Figure 1) for the water year preceding a fishery survey, showed no consistent trend or statistical relationship ($p>0.05$) with condition factors.

Examination of the relationship between condition factors and sampling sites (Figure 1) for wild and planted trout combined showed no statistically significant differences ($p>0.05$), with the exception of one small sample ($n = 7$) collected at one sampling site within the Thorburn side channel.

## DISCUSSION

Analysis of the length-weight relationship (Figure 2) and condition factors for rainbow trout (Table 1) collected from the Kings River over the 23-year period from 1983 through 2005 consistently were within the range of values reflecting healthy trout, in good condition. Although there was variability in the condition factors observed, there was no evidence of a consistent pattern of fish having poor condition factors. The results of these analyses of the Kings River trout population are consistent with findings of the earlier analysis performed by KRCD (1993). Furthermore, there was no evidence from these analyses that food availability was limiting trout growth or condition, as evidenced by the low variability in the length-weight relationship (slope = 3.00, $r^2 = 0.97$). Field observations and condition factors calculated for individual trout did not detect a large proportion of the population of fish sampled in poor or emaciated condition. Condition factor analyses, although a useful tool for assessing the health and condition of a population of fish, are subject to potential bias in which fish in poor condition may have a higher vulnerability to predation mortality and therefore be removed from the population.

Examination of length-weight analyses and condition factors showed statistically significant differences among years with the three years having the highest condition factors being proceeded by wet hydrologic conditions (runoff and river flows reflecting wet year conditions). We hypothesized that wet year conditions may improve the quality and availability of habitat within the Kings River for trout by increasing reservoir storage and providing lower water temperatures during the summer and early fall months, increasing streamflows and providing improved physical habitat conditions, and potentially providing greater macroinvertebrate drift as a forage base for various lifestages of resident trout. Results of a broader analysis of the relationship between condition factors and hydrologic conditions in the year preceding each fishery survey did not detect a consistent or statistically significant trend between hydrologic conditions and trout condition factors. In addition to physical habitat, a variety of other environmental factors may affect the overall health and condition of trout. Condition factors observed in this investigation were not found to be significantly different between 1983 prior to initiation of operation of the Pine Flat hydroelectric generating plant and those years after the hydroelectric plant began operations. Similarly, no consistent trend was detected in condition factors over the 23-year period of this investigation that would suggest that there has been a long-term trend in decline of habitat or the condition of the trout inhabiting the river, or threshold changes in condition factors within any one year.

Habitat quality and availability for trout varies among locations within the river. The suitability of habitat varies both in response to physical habitat characteristics (water depths, velocity, substrate, etc.) as well as longitudinally in response to a gradient of increasing seasonal water temperatures during the summer and early fall months as a function of distance downstream from Pine Flat Dam. We hypothesized that differences in habitat conditions may be reflected by the condition of trout inhabiting various locations within the river. Results of the statistical analyses did not detect a significant difference in condition factors among the various locations sampled (Figure 1),

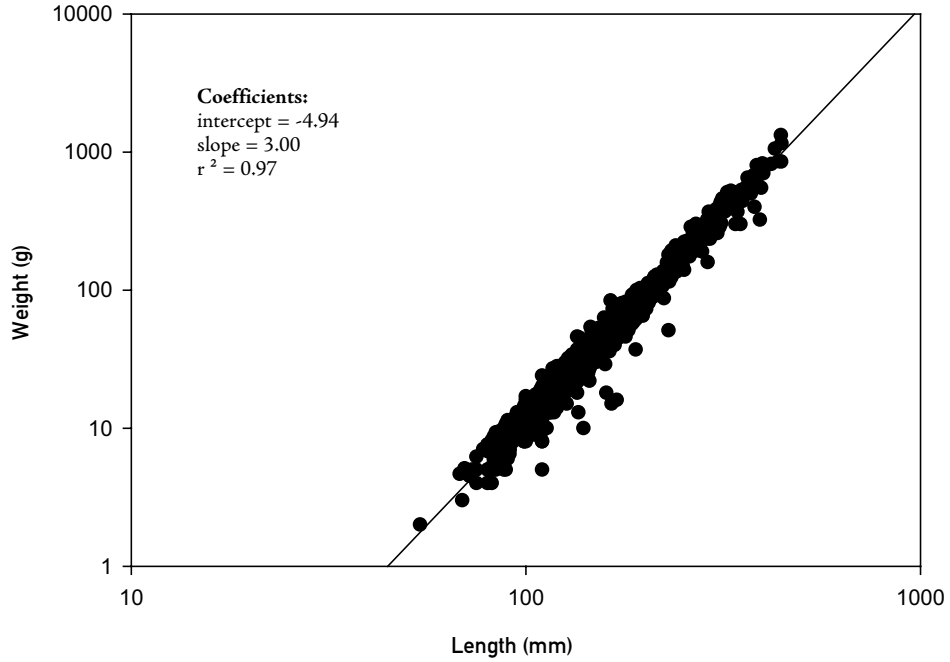


**FIGURE 2**. Length-weight relationship for rainbow trout collected from the Kings River downstream of Pine Flat dam, 1983-2005 (source: KRCD unpublished data).

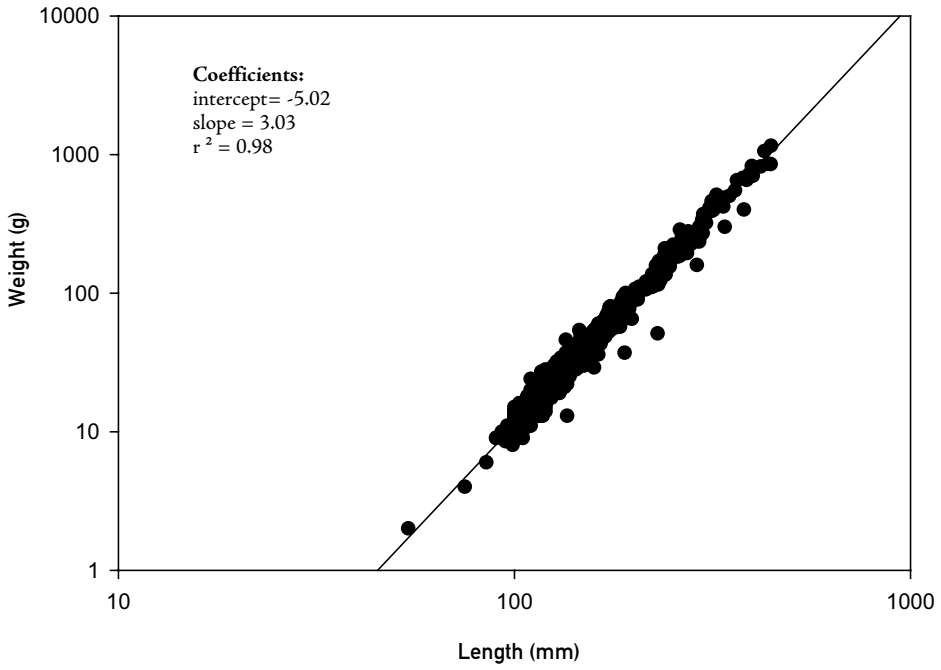


**FIGURE 3**. Length-weight relationship for rainbow trout classified as wild from the Kings River (source: KRCD unpublished data).

with the exception of one small sample collected from a location within the Thorburn channel. Results of these analyses suggest that the habitat units sampled as part of this investigation were suitable to support resident trout in good condition and/or there is extensive trout movement among habitat units that would influence the ability to detect a relationship between condition factor and the various habitat units surveyed. Very little information is available regarding habitat usage and movement patterns for trout on the Kings River. As part of the Kings River Fishery Management Program a radio tagging investigation will be initiated during the fall 2005 that will provide useful information on habitat selectivity, residence times, and movement patterns by adult trout.

Analysis of condition factors for rainbow trout classified as wild (in-river production and/or rearing) and trout thought to have been planted in the river by CDFG in support of recreational fishery, did not detect significant differences between planted and wild trout. The lack of a significant difference in condition factors between wild and planted trout was somewhat surprising. We had hypothesized that trout reared in the hatchery under controlled conditions, and fed a commercial diet, would have higher condition factors when compared to trout rearing in the river which are exposed to variable water velocities, variable water temperatures, potential fluctuations in the availability and species composition of macroinvertebrates as a forage base, responding to inter- and intraspecific competition, and having to avoid predators. One of the difficulties, however, in evaluating differences between wild and planted trout is the inherent uncertainty in the accuracy and reliability of the ability to distinguish the origin of trout based on fin erosion patterns and other subjective criteria.

The length-weight relationships and condition factors for rainbow trout examined as part of this investigation for the Kings River downstream of Pine Flat Dam were compared to data from several other trout populations (S. Stephens, unpublished data). Information on the length-weight relationships for rainbow trout collected in fishery surveys conducted by CDFG and others was compiled and analyzed. A comparison of length-weight relationships and condition factors for these trout populations, which are independent of potential effects of Pine Flat Dam and habitat conditions within the Kings River downstream of the reservoir, are summarized in Table 2. Condition factors and length-weight relationships for trout collected on the Kings River are similar to trout presented in the scientific literature for other river systems (Table 2). Length-weight regressions for rainbow trout collected from Dinkey Creek, located within the Kings River watershed upstream of Pine Flat Dam, the Tule River, and Kaweah River (Figures 6, 7, and 8) showed relationships comparable to those observed for trout collected on the Kings River downstream of Pine Flat Dam.

Cada *et al.* (1987) reported condition factors for rainbow trout collected from southern Appalachian streams that

TABLE 2. Comparison of length-weight regression relationships for rainbow trout populations inhabiting the Kings River downstream of Pine Flat Dam and other watersheds.

| LOCATION | SEASON | REGRESSION SLOPE | $R^2$ | SAMPLE SIZE | SOURCE |
|---|---|---|---|---|---|
| Kings River, CA | Winter-Spring | 3.00 | 0.97 | 2,161 | This study |
| Dinkey Creek, CA | Summer | 2.98 | 0.79 | 213 | KRCD unpublished |
| North Fork Tule River, CA | Summer | 3.13 | 0.92 | 91 | CDFG unpublished |
| Marble Fork Kaweah River, CA | | 3.06 | 0.94 | 66 | CDFG unpublished |
| Green River (site 1), UT | Fall | 3.00 | 0.95 | 58 | Filbert and Hawkins (1995) |
| Green River (site 1), UT | Winter | 3.11 | 0.99 | 53 | Filbert and Hawkins (1995) |
| Green River (site 1), UT | Spring | 3.15 | 0.97 | 61 | Filbert and Hawkins (1995) |
| Green River (site 1), UT | Summer | 2.92 | 0.98 | 70 | Filbert and Hawkins (1995) |
| Green River (site 2), UT | Fall | 3.11 | 0.99 | 58 | Filbert and Hawkins (1995) |
| Green River (site 2), UT | Winter | 3.10 | 0.98 | 43 | Filbert and Hawkins (1995) |
| Green River (site 2), UT | Spring | 3.01 | 0.96 | 56 | Filbert and Hawkins (1995) |
| Green River (site 2), UT | Summer | 2.70 | 0.99 | 61 | Filbert and Hawkins (1995) |

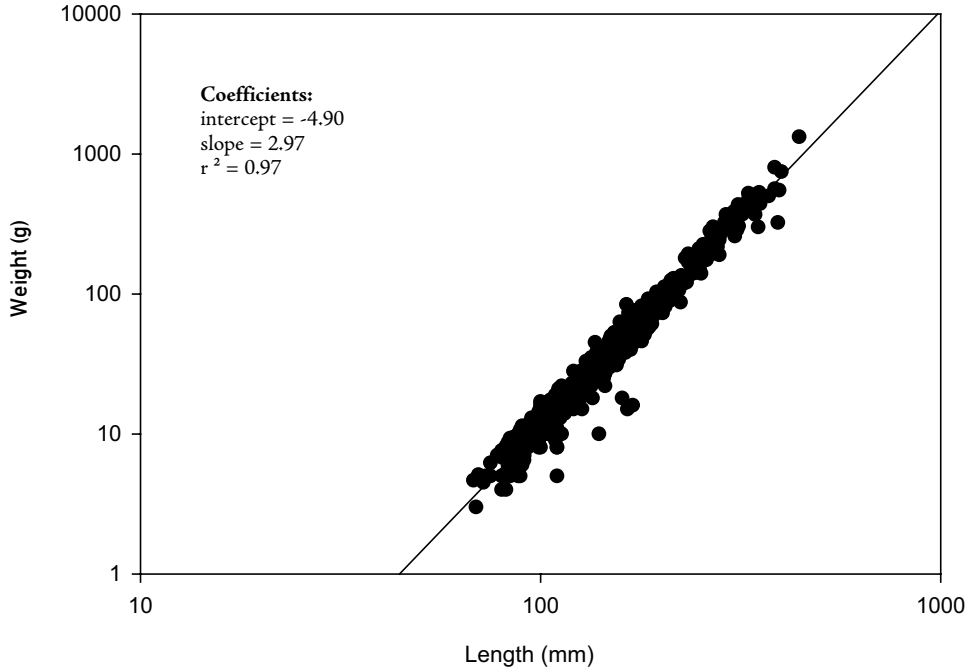


**FIGURE 4**. Length-weight relationship for rainbow trout classified as hatchery plants from the Kings River (source: KRCD unpublished data).

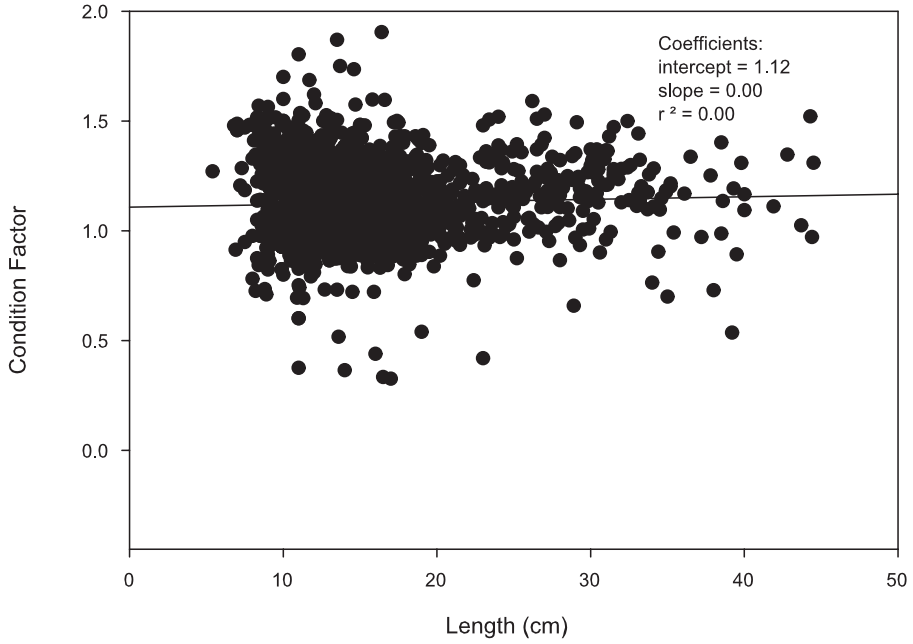


**FIGURE 5**. Relationship between condition factor and trout length from the Kings River downstream of Pine Flat Dam.

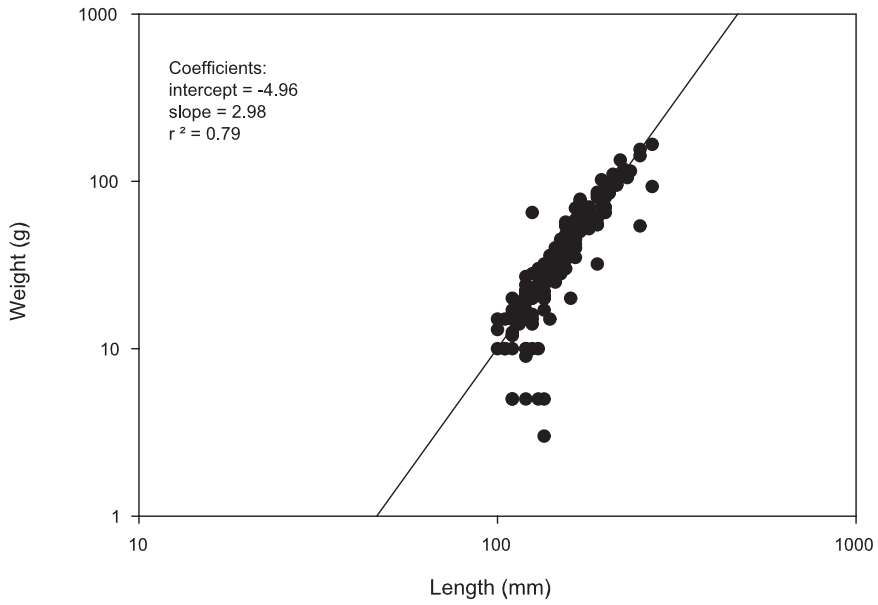


**FIGURE 6**. Length-weight relationship for rainbow trout collected from Dinkey Creek, located in the Kings River watershed upstream of Pine Flat Dam (source: CDFG unpublished).

ranged from 0.82 to 1.17, which are similar to the condition factors calculated for rainbow trout from the Kings River. Ensign *et al.* (1990) reported condition factors for rainbow trout from a southern Appalachian stream generally within the range from 0.95 to 1.10, similar to the estimates from the Kings River population. Murphy (1988) sampled wild rainbow trout from the Kings River downstream of Pine Flat Dam between July and December 1986 that had an average condition factor of 1.13 (n = 119) that was not significantly different ($p>0.05$) from the overall condition factor estimated for the 23 years of this survey. Reimers (1963), Cada *et al.* (1987), and Ensign *et al.* (1990) reported a seasonal trend in condition factor, with generally reduced condition during the summer and fall when compared to the winter and spring.

Results of these comparisons show that condition factors and length-weight relationships for trout collected on the Kings River downstream of Pine Flat Dam are consistent and within the range of values observed for other rainbow trout populations. The similarity in length-weight relationships and condition factors for the Kings River trout population and other populations provides further support for the general finding that rainbow trout inhabiting the Kings River are in good condition.

Results of the condition factor and length-weight analysis of rainbow trout collected from the Kings River over the 23-year period from 1983 through 2005 provide useful and valuable insight regarding fish inhabiting the river. Results of these analyses do not, however, take into account factors affecting the overall abundance of adult trout, spawning and reproductive success, survival of juvenile rearing trout, or the influence of various sources of mortality on the population dynamics of trout inhabiting the river. As part of the Kings River Fishery Management Program, additional investigations are being conducted to provide information on factors such as habitat selectivity and use, the performance of habitat restoration and enhancement measures, dispersal and movement patterns, and the contribution of hatchery planting to the population abundance and recreational angler harvest within the river. Results of the length-weight and condition factor analyses represent one component of the more comprehensive and integrated fishery investigations being performed on the river.

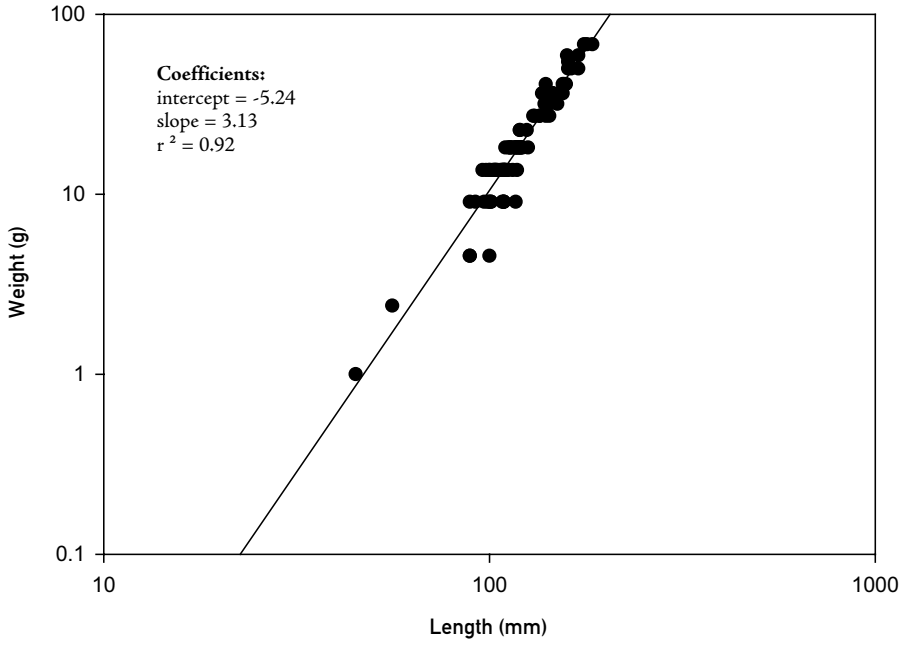


**FIGURE 7**. Length-weight relationship for rainbow trout collected on the North Fork Tule River (source: CDFG unpublished).

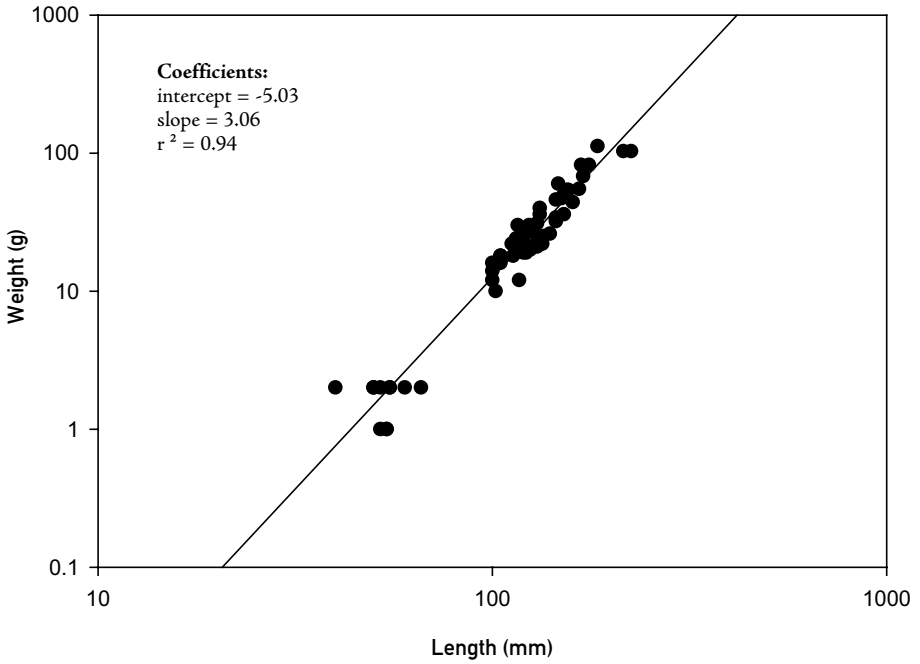


**FIGURE 8**. Length-weight relationship for rainbow trout collected on the Marble Fork Kaweah River (source: CDFG unpublished).

## ACKNOWLEDGMENTS

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