2012 Hat Creek Trout Population Estimate

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Introduction

In 1972 a section of Hat Creek, Shasta County (from PG&E's Hat Creek Powerhouse #2 to Lake Britton) became one of California's first designated Wild Trout waters. This section is known as the Hat Creek Wild Trout Area (WTA). California's Heritage and Wild Trout waters are managed to provide aesthetically pleasing and environmentally productive environments for anglers to have the opportunity and experience to enjoy California's wild trout. Designated Heritage and Wild Trout waters have specific management plans that provide the framework to maintain the goals of the Heritage and Wild Trout Program (HWTP). As part of the management of the WTA, understanding the population and population changes over time help fishery managers make decisions on actions to best manage the fishery. In October 2012, HWTP scientists implemented a mark-recapture sampling method to estimate the population of all trout species common to the WTA.

The WTA has been monitored for population trends since the Hat Creek Wild Trout Project (Project) was completed in the late 1960's. Since the Project's completion, several fish sampling/monitoring methods have been implemented to estimate the population or provide an index of relative abundance. Of these methods, the mark-recapture method has remained the preferred method to estimate trout populations in Hat Creek. The 2012 mark-recapture effort was implemented to: 1) generate a current population estimate for rainbow trout (*Oncorhynchus mykiss* sp.) and brown trout (*Salmo trutta*) in the upper WTA, 2) compare the population estimates to past estimates for trends over time, and 3) provide a pre-restoration project baseline using trout population estimates for comparison purposes after the Hat Creek California River Parkway Project has been completed*.

Methods

The population estimate sampling area included the upper 2.7 km of the WTA (PG&E's Hat Creek Power House #2, "powerhouse riffle" area, to the State Highway 299 Bridge crossing)(Figure 1). The sample area was not blocked-off (closed), but fish movement is limited upstream due to the powerhouse effluent, lower flows, and higher gradient above that point. The downstream sampling area endpoint has no barrier to fish movement. However, Regional HWTP staff believes there is negligible movement of fish downstream of the endpoint and out of the sampling area.

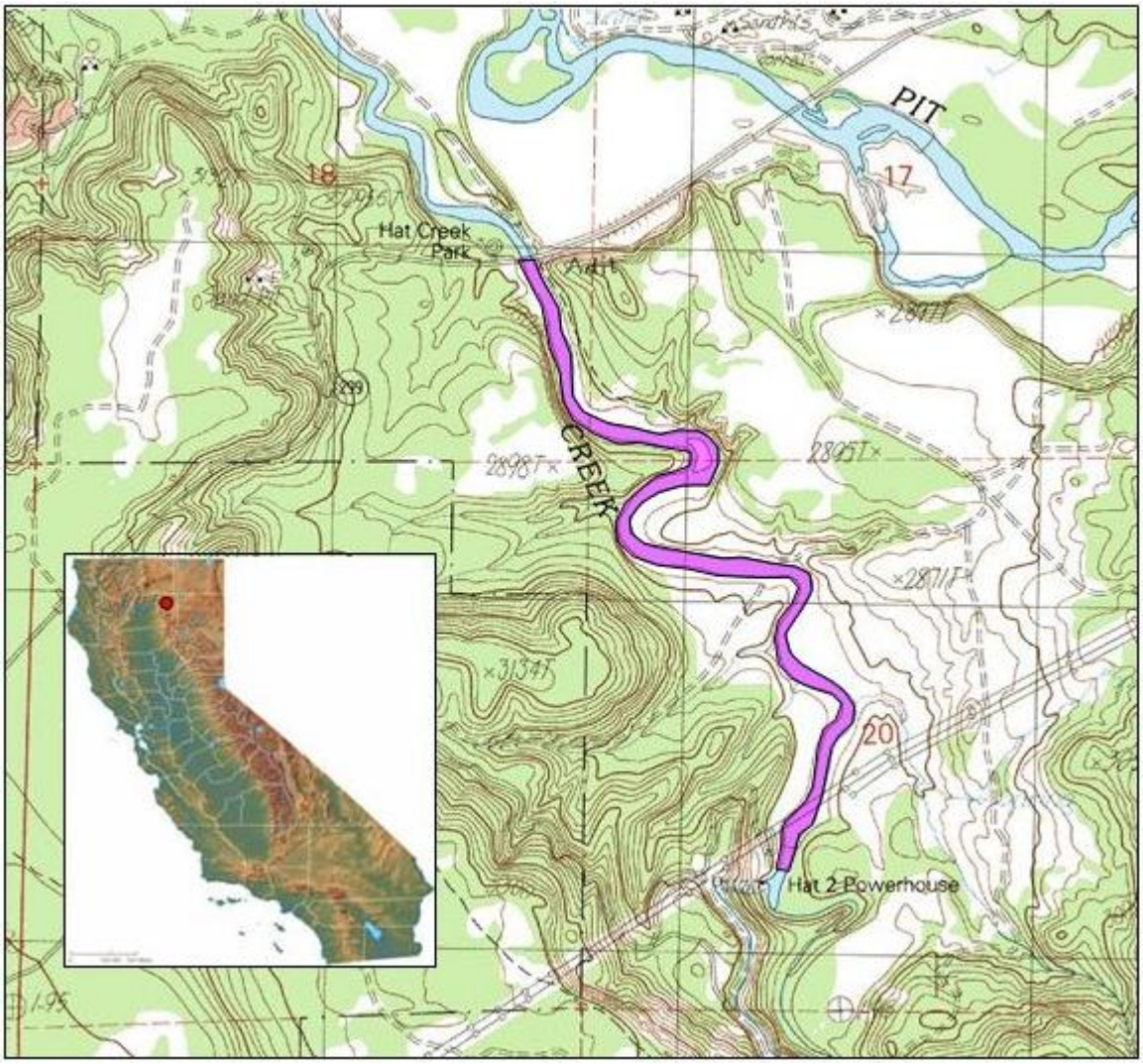
Historically the population estimates protocols for the upper WTA defined three sections within the upper WTA. These sections included Section 1 (Hat Creek Powerhouse riffle to the Carbon Bridge site), Section 2 (Carbon Bridge site to the State Highway 299 Bridge crossing), and Section 3 (State Highway 299 Bridge crossing to the head of the Hat Creek County Park riffle). To sample each section with one boat electrofisher it took three passes (or sampling lanes) completed in the course of a night. As the electrofisher proceeded downstream, each lane would be marked as "right," "center," or "left." Fish processing would

* The Hat Creek California River Parkway Project is anticipated to start in 2013 and be completed by 2016.

occur on the electrofisher as the sampling was occurring. It would take typically take three nights to sample all sections using this method and was repeated for the recapture phase. The 2012 mark-recapture effort implemented the use of a second boat electrofisher and limited the sampling area to Sections 1 and 2. Although the intent of the 2012 effort was to implement historic sampling protocols as much as possible, modification to these sampling protocols were made to increase sampling efficiency, complete marking and recapture phases in two nights, and to compare data between other sampling methods (direct observation, creel surveys, and self-guided angler survey boxes).

The electrofishers shocked in a downstream direction parallel to each other using a zig-zag pattern covering the entire channel width as they moved downstream. The intent was to create a wall of electrical current covering the entire channel width to minimize fish escapement upstream. Each boat electrofisher had a crew of two netters and one boat operator. Prior to sampling, netters were instructed to capture all fish possible, and not to be species or size selective. Each boat crew remained the same throughout the sampling effort (mark or recapture phases) for catch consistency.

Figure 1. The 2012 Hat Creek upper WTA mark-recapture section (PG&E Powerhouse #2 riffle to the State Highway 299 Bridge crossing).



As with historic Hat Creek mark-recapture efforts, it was anticipated high catch rates and handling time would limit the number of fish that could be processed. To address this, it was decided to have an onshore fish workup station where additional processing gear and staff (4 dedicated fish processors) could work up fish without the limitations of being on a boat. The workup station was located approximately mid-way through the sampling section (old Carbon Bridge site) to minimize fish transport time. The workup station consisted of portable shop lights, workup tables, live totes (75 to 415 liters), instream live-cars (120 liter), aerators, Alka Seltzer tablets (anesthetization), digital scales, measuring boards, and snips to mark (adipose clip) fish. The workup station (lights and electric aerators) was powered by a 3,000 watt generator. As the electrofisher live-wells were reaching capacity the crew would either 1) use a transfer boat with multiple aerated ice chests to transport the samples to the workup station or 2) transfer the samples directly to the workup station. The method to transport the samples back to the workup station was based on the most efficient way to transport the fish while minimizing the down time of the electrofishers. After processing, fish were held in in-stream live cars to recover and returned to the section where they were sampled from. To minimize sample contamination (fish being recaptured), fish releases only occurred when the electrofishers were approximately 250 m (273 yards) downstream of the release site.

All fish species sampled were recorded for total length (mm), weight (grams) and mortalities noted. In addition, all salmonid species would be inspected for the presents/absence of blackspot disease. Since the focus of the study is on salmonid species and processing time was a concern for fish health, only the first 100 lengths and weights were recorded for all non-salmonid species and plus counts were used after that point. Historic mark and recapture efforts (1969-1993) implemented an 8 inch (203 mm) fork length (FL) cutoff for salmonid fish analyses. The 8 inch cutoff was implemented due to the numbers of fish sampled, handling and boat limitations for fish processing, and a focus on catchable fish. The 2012 effort implemented a ≥150 mm (approximately 6 inch) total length (TL) cutoff to collect information on recruiting year classes, increased fish processing effort, and for cross-comparisons with other current sampling methods. All salmonids ≥150 mm TL captured during the marking phase of the study were marked by clipping the adipose fin off. The Project completed in the late 60's included the removal of all "rough fish" (primarily Sacramento suckers *Catostomus occidentalis*),) from this area of Hat Creek because it was believed they were indirectly competing with salmonid species. To be consistent with goals of the Project and past electrofishing efforts, all Sacramento suckers sampled were removed from the WTA and transported downstream of the Hat Creek fish barrier~~)~~.

The primary objectives for the 2012 mark-recapture effort was to generate population estimates for common trout species (rainbow trout and brown trout) in the upper Hat Creek WTA and compare these results to past efforts for population trends over time. Due to the differences between historic size class population estimates and the current effort, species counts and lengths were required during the 2012 mark and recapture phases. Although the intent was to gather length data on all trout species sampled during the marking and recapture phases, it became unfeasible during the end of the marking phase due to the quantity and large size of fish sampled and a shortage of personnel to accomplish this task without jeopardizing fish health. In addition during the recapture phase, staff shortages prevented measuring all fish sampled and only species counts and whether they were marked or unmarked were recorded.

In order to generate a population estimate where a size class cutoff was implemented, size classes were estimated using the recorded size classes from the marking phase (N=1,068) and applied to the remaining unmeasured catch from the marking phase (n=655) and all of the catch during the recapture phase (n=1,438). The use of estimated size classes was based on the assumption of similar habitats throughout the sampling area and a uniform distribution (size and numbers) of common trout species in these habitats.

All fish in the 2012 mark-recapture effort were measured for TL, but with past mark-recapture efforts all fish were measured for FL. The decision to use TL was based on recent protocol changes to the Heritage and Wild Trout Program and for comparisons with other sampling methods (direct observation, creel surveys, and self-guided angler survey boxes). In this report, when comparison were made with past mark-recapture efforts, TL was converted to FL using the following conversions developed by Sturgess and Moyle (1978): rainbow trout FL=0.9391TL+0.155 and brown trout FL=0.9927TL-10.501.

Catch data was analyzed using a single census Petersen mark-recapture method with a Bailey modification (Bailey 1951) to the equation (N_B=M(C+1)/(R+1)). The sampling design of the 2012 effort included a marking phase in one night, 5-day resting period, and a recapture phase in one night.

Results

During the marking phase 1,726 trout (rainbow trout=1,587, brown trout=137, and brook trout (*Salvelinus fontinalis*)=2) were sampled from the upper WTA. During the recapture phase 1,438 trout (rainbow trout=1,281 and brown trout=157) were sampled from the same area. All analyses were conducted on rainbow and brown trout, brook trout were not considered a common species and were dropped from further analyses. During the end of the marking phase, it was noted by crew members that approximately 15% of the trout released were either mortalities or would become mortalities. The mortalities (15% of the total trout captured during the marking phase) were not used in the Petersen mark-recapture calculations. Other species sampled during the marking phase included Sacramento sucker (sculpin spp. (*Cottus* spp.), tule perch (*Hysterocarpus tarskii*), and tui chub (*Gila bicolor*). Non-salmonid species were not sampled during the recapture phase (Table 1).

Table 1. Hat Creek upper WTA (sections 1 and 2) fish species catch.

	Mark Phase	Recapture Phase
Rainbow Trout	1,587	1,281
Brown Trout	137	157
Brook Trout	2	0
Sacramento Sucker	216[1]	
Sculpin spp.	27	
Tule Perch	3	
Tui Chub	11	

[1] Sacramento suckers only sampled during part of the marking phase.

<u>2012 Trout Populations Estimates ≥150 mm and ≥203 mm</u>

The upper WTA (sections 1 and 2) population estimates for common trout species using the ≥150 mm (approximately 6 inch) TL cutoff included: rainbow trout 2,754 and brown trout 329. Population estimates for common trout species ≥203 mm (8 inch) FL cutoff included: rainbow trout 1,737 and brown trout 287 (Table 2).

Table 2. Hat Creek upper WTA population estimates for common trout species ≥150 mm (approximately 6 inches) TL and ≥203 mm (8 inch) FL (October 2012).

	Estimated Population	Lower Confidence Interval (95%)	Upper Confidence Interval (95%)	Confidence Interval Percent
Rainbow Trout ≥150 mm	2,754	2,313	3,194	±16
Brown Trout ≥150 mm	329	226	431	±31
Rainbow Trout ≥203 mm	1,737	1,647	2,447	±21
Brown Trout ≥203 mm	287	186	388	±35

The second objective of the study compared population trends over time. Although population surveys have been conducted in the Hat Creek WTA since 1969, comparable data was limited to 1983-2012 due to differences between pooled data and limited historical data still existing. The years between 1983 and 2012 represent the “before” and “after” sediment influx event that is believed to have degraded the instream habitat for trout in the upper WTA. The 2012 rainbow trout population estimate (≥203 mm FL) of 1,737 showed little change from the early 1990's population estimates (1,347 (1991) and 2,452 (1993)), but still remains considerably lower than the 1980’s estimates (5,932 (1983) and 3,951 (1988))(Figure 1a). The 2012 brown trout population estimate of 287 is the lowest recorded during the time period, but shows little change from the 1983-1993 population estimates (Figure 1b).

Fish abundance, as well as, size class data is limited to the catch efficiency of the electrofishing equipment (among other variables) and most likely under represents smaller size classes (Peterson et. al. 2004). Field crews sampled all trout species regardless of size (mark and recapture phases). No estimates on electrofishing catch efficiency were made with this analysis, but all recorded lengths from the marking phase were plotted for rainbow trout (N=979)(Figure 2a) and brown trout (N=86)(Figure 2b). In addition to lengths, weights were also recorded and used to generate a length-weight condition factor (K-factor)(Fulton 1902) for specific size classes (based on length frequency groupings) (Figures 2a and 2b).

Figure 1a. Comparison of mark and recapture population estimates for rainbow trout ≥ 203 mm (8 inches) FL sampled in the upper WTA (sections 1 and 2) of Hat Creek (1983-2012).

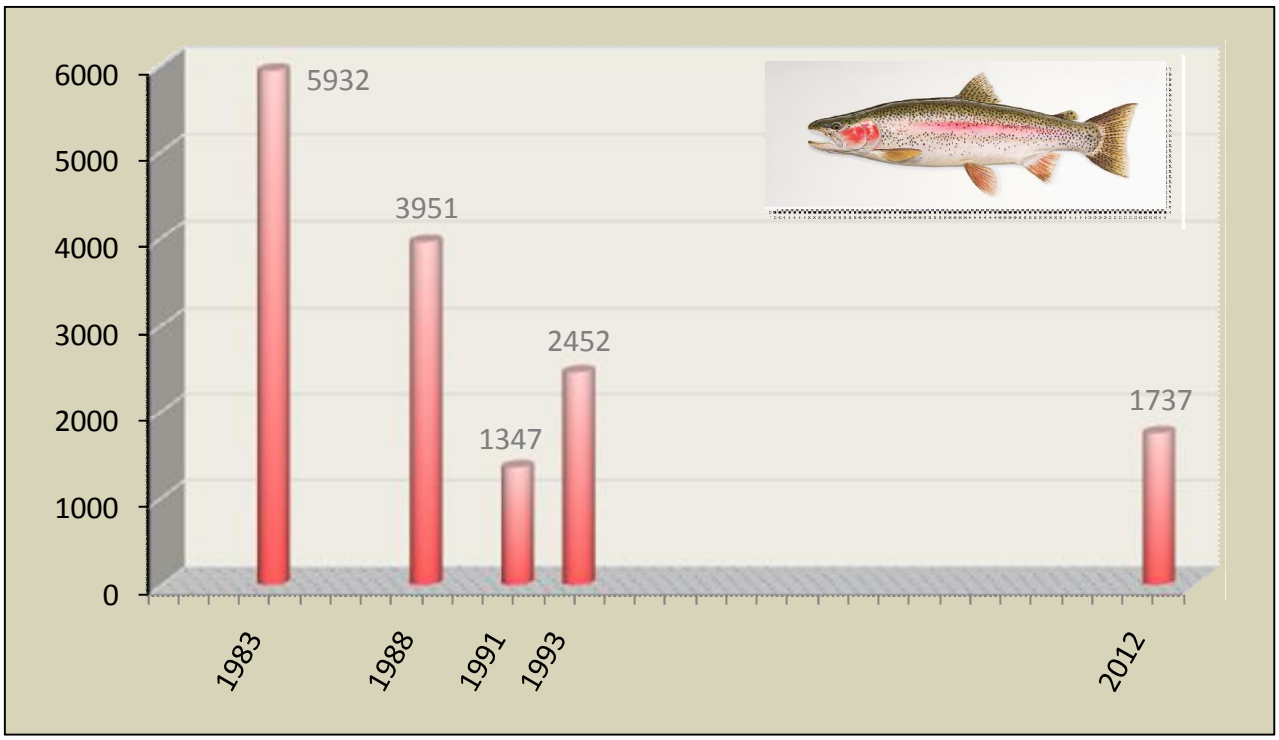


Figure 1b. Comparison of mark and recapture population estimates for brown trout ≥ 203 mm (8 inches) FL sampled in the upper WTA (sections 1 and 2) of Hat Creek (1983-2012).

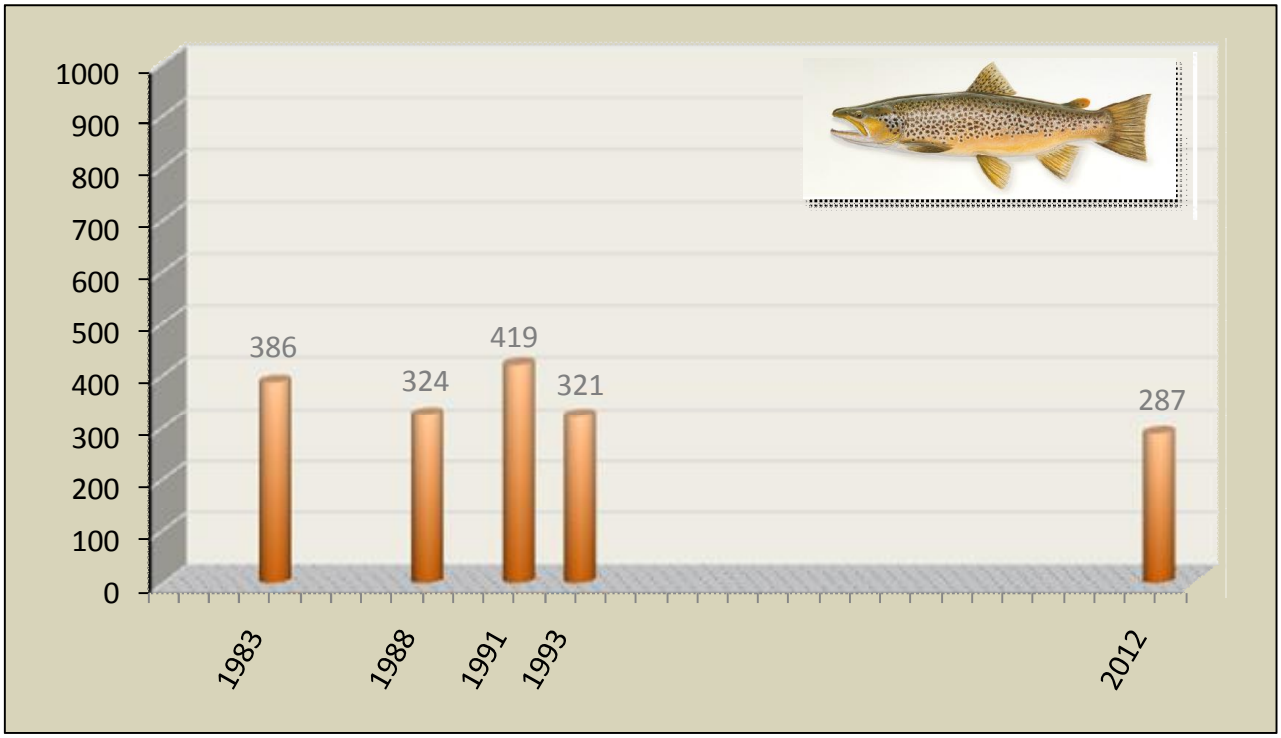


Figure 2a. Hat Creek upper WTA length frequency (TL) and mean size class condition factor (K-Factor) of rainbow trout (October 2012).

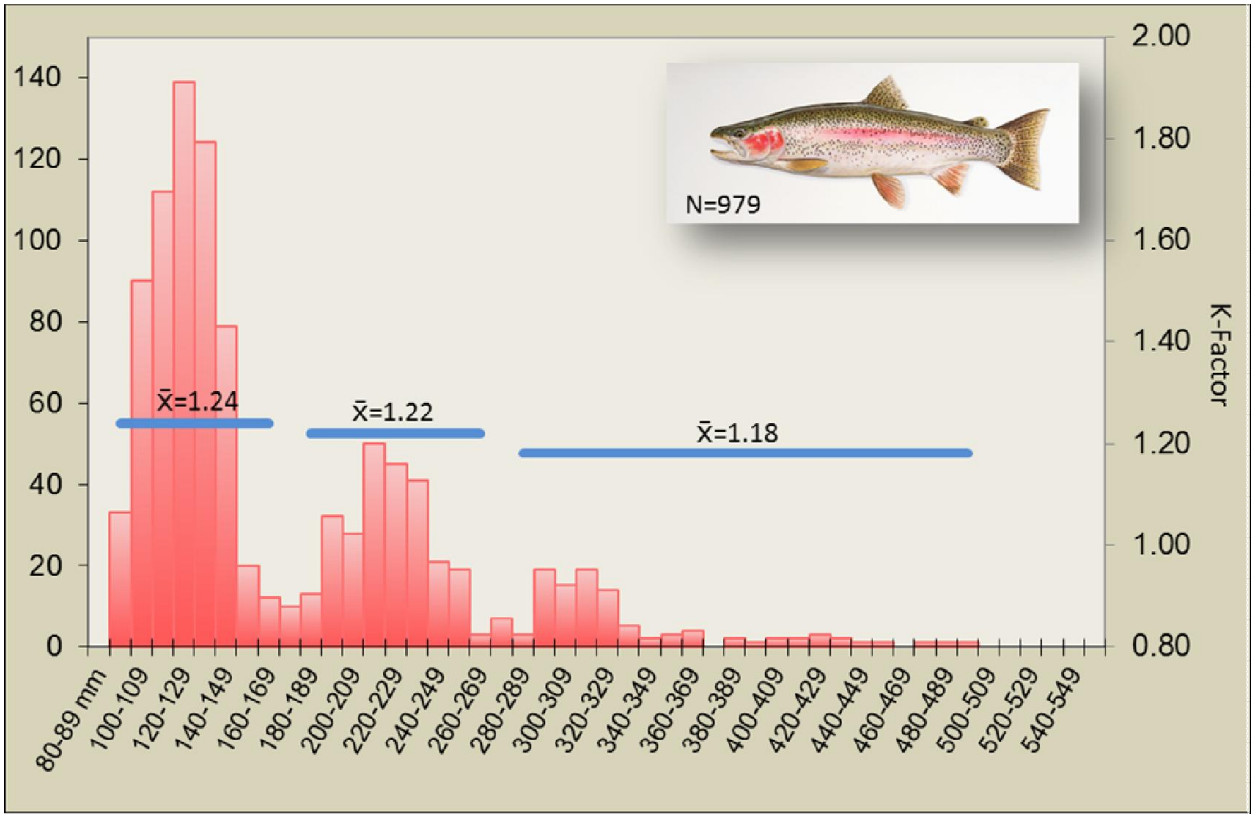
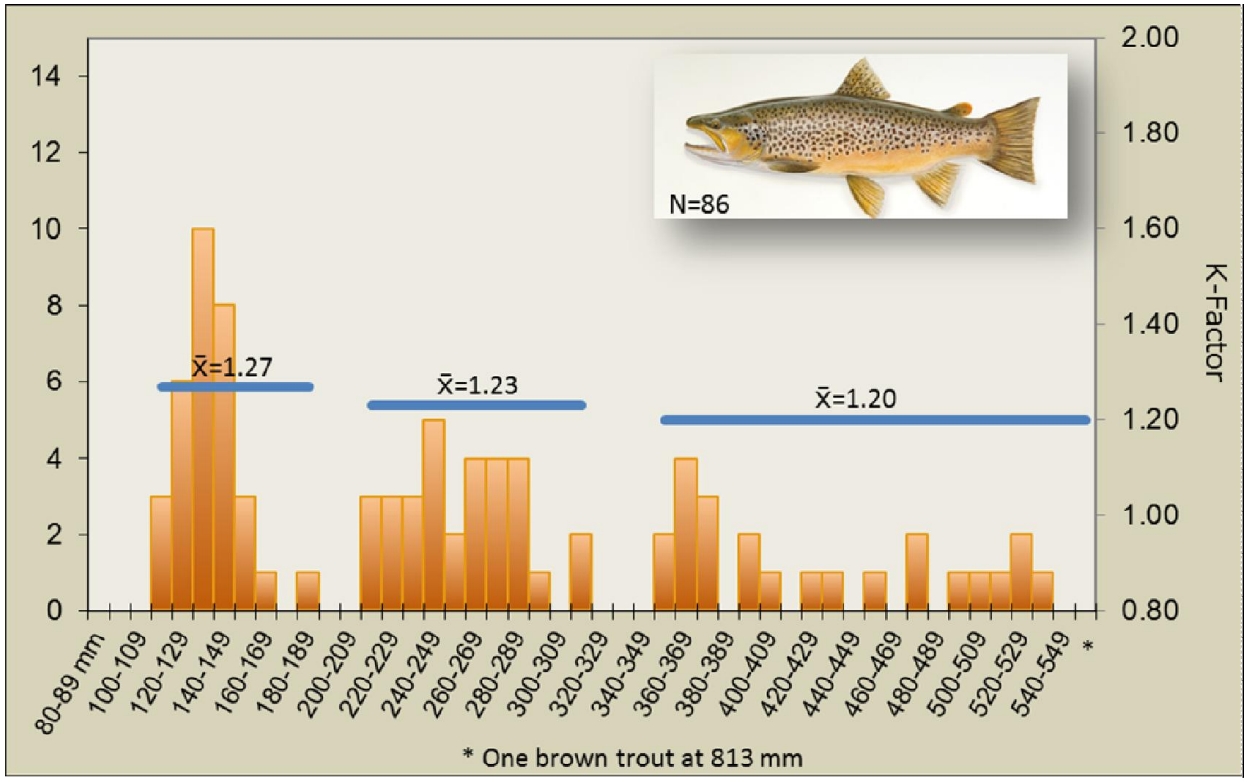


Figure 2b. Hat Creek upper WTA length frequency (TL) and mean size class condition factor (K-Factor) of brown trout (October 2012).



In addition to the mark-recapture sampling, other sampling methods (angler survey box, creel, and direct observation) were conducted in 2012 to assess other fishery variables (such as angler use). All of the sampling methods in 2012 record catch or counts of trout species within the upper WTA (sections 1 and 2) of Hat Creek. Comparing the catch results between the different sampling methods will have biases due to the selectivity and/or efficiency of the method, but general catch trends and percent sampled or counted are summarized in Table 3. With additional years of comparable sampling data, calibration factors may be developed to estimate relative populations for common trout species using less intensive non-mark and recapture sampling methods.

Table 3. Comparison of the mark-recapture effort using the ≥150 mm (approximately 6 inches) TL cutoff to other sampling methods conducted in 2012 (self-guided angler survey box, creel, and direct observation.

	Angler Survey Box	Creel	Direct Observation	Mark-Recapture
Rainbow Trout approximately ≥6 inches	278	907	315	2,754
Brown Trout approximately ≥6 inches	15	20	8	329
Percent of Total Rainbow Trout/Brown Trout	**95/5**	**98/2**	**98/2**	**89/9**

Discussion/Recommendations

The 2012 Hat Creek WTA population estimate using a mark-recapture method was the first time since 1993 that such a population analysis was completed. Since the mid-1990's the use of electrofishing equipment in Hat Creek has been limited due to the perceived higher mortality rates and negative opinions associated with this type of sampling gear. In its place, other sampling methods, such as direct observation, angler creel surveys, and self-guided angler survey boxes have been implemented to generate relative abundance, angler use data, and describe trends over time. While the other "lower impact" surveys have provided valuable information on the wild trout fishery, the mark-recapture method (when assumptions are met) provides a more precise population estimate due to reduced biases when compared with the other sampling methods.

When designing the 2012 mark-recapture sampling effort, we incorporated both historical sampling methods and new modifications to account for a single census mark-recapture design utilizing two boat electrofishers. Ideally to compare mark-recapture population estimates over time, the sampling design/methods should remain constant over the years. The 2012 effort incorporated the design/methods used over the past 40 years where applicable, but also included elements from other sampling methods (direct observation, angler creel surveys, and angler survey box) for correlation comparisons.

During the 2012 marking phase we realized the numbers and size of trout, as well as the supplemental catch of Sacramento suckers, were hampering our processing operations. The onshore fish workup station did not have the capacity or personnel to process what two boat electofishers could sample. Approximately halfway through the marking phase an attempt was made to "slow down" the boat electofishers, but the onshore fish workup station was not able catch-up without jeopardizing fish health. With approximately 65% of the upper WTA sampled, a decision was made to stop measuring and weighing trout due to concerns with fish health, but fish processors continued to mark trout ≥150 mm TL until the conclusion of the marking phase. The trout sampled for lengths and weights (approximately 65% of the sample area) were used as estimators for the remaining fish sampled. By the end of the marking phase it was estimated that approximately 15% of all trout sampled had become mortalities. As noted before, these mortalities were removed from the marking phase catch totals and not use in the population estimates.

Although some aspects of themarking and recapture processing operations did not go as planned, we feel the 2012 mark-recapture effort produced representative population estimates using the marking phase estimates for fish lengths. When the Hat Creek mark-recapture sampling effort is implemented in the future, the 2012 design should be implemented with an increase capacity to process fish. The fish processing station should be designed to handle 400-500+ trout an hour (of all size classes). If other species are to be processed (including Sacramento sucker removal) the processing time and holding capacity will need to be increased. In addition, the boat electrofishers were sampling trout species below 150 mm TL with good consistency (although not analyzed in this report for catch efficiency). Therefore, all trout sampled should be processed for lengths and weights and used to generate a catch efficiency curve. Using this data, a lower cutoff size could be generated and used in future population estimates, which better represents the population as a whole (multiple year-classes). A final recommendation would be to include historic section stop points (Section 1 - "powerhouse riffle" to Carbon Bridge site and Section 2 - Carbon Bridge site to State Highway 299 Bridge crossing), this will allow for better comparisons with historical data.

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