State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

California Wild Trout Program

HAT CREEK WILD TROUT MANAGEMENT PLAN

1998 - 2003

by

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PREFACE

The California Wild Trout Program (WTP) was endorsed by the Fish and Game Commission (Commission) in 1971 to provide quality wild trout angling. Under the program, productive lakes and streams are identified for wild trout management during an ongoing statewide inventory. If suitable for management as quality fisheries, these waters are recommended by the California Department of Fish and Game (Department) to the Commission for wild trout designation. Waters in the WTP must be open to the public and capable of producing, with appropriate fishing regulations, satisfactory trout angling in terms of the number and/or size of fish caught. Stocking of domestic strains of hatchery-reared, catchable-size trout in these waters is prohibited.

Commission policy states: "Wild trout angling is considered a quality experience which provides the angler an opportunity to fish in aesthetically pleasing and environmentally productive waters over trout populations whose numbers or sizes are largely unaffected by the angling process" (Commission Policies, Fish and Game Code, 1995). Three goals for managing designated wild trout streams were established at the outset of the statewide WTP:

1. To maintain wild trout populations at levels necessary to provide satisfactory angling opportunities.

2. To maintain and enhance, where possible, the habitat required for optimum wild trout production.

3. To preserve the natural character of the streamside environment.

The Commission has supported these goals through a directive in its policy that states "All necessary actions, consistent with State law, shall be taken to prevent adverse impact by land or water development projects on designated wild trout waters" (Commission Policies, Fish and Game Code, 1995). Once a stream is designated as a wild trout water by the Commission, the Department is required to develop a plan for managing the fishery.

Hat Creek has filled a unique role in the development of the California WTP. Based largely on the results of an experimental trout restoration project conducted on the stream between 1968 and the early 1970's, the Commission endorsed the initiation of the statewide WTP. The original Hat Creek Management Plan (Gerstung 1975) was the first written for a designated stream in California. Department biologists are continuing to write plans for the over 50 waters now in the WTP. Some of these are also original plans, some are updates, and some are nearly complete revisions. Several aspects of the lower Hat Creek fishery have changed in the past 23 years, but the plan's general objectives and many of the potential environmental problems remain the same: consequently, this plan is both an update and a revision of the original plan.

Lower Hat Creek flows entirely through lands owned by the Pacific Gas and Electric Company (PG&E). The plan identifies the Department's long-standing and proposed cooperative efforts with PG&E to manage the Wild Trout Area (WTA). Problems related to land, instream habitat, and fisheries management are discussed in the plan and programs or policies needed to maintain an attractive and productive wild trout fishery are recommended.

While most current plans are written to cover a five-year period, this plan, due to established monitoring surveys scheduled for 1998 and 2003, is intended to cover the six-year period from 1998 through 2003.

EXECUTIVE SUMMARY AND MAJOR RECOMMENDATIONS

The 3.5-mile Hat Creek WTA has produced some of California's finest rainbow trout fishing. In 1968, a trout restoration project changed Hat Creek from a stream overpopulated with Sacramento suckers and other nongame fish into one of the State's most productive wild trout fisheries. Between 1979 and 1988, the creek's potential as a "trophy-trout" water was realized through the use of an 18-inch minimum size limit. During most of the past 10 years, however, the stream's outstanding fishery has been degraded by heavy sedimentation and an accompanying loss of aquatic vegetation.

Hat Creek was designated as one of the State's first "Wild Trout Streams" by the Commission in 1972. In accordance with Commission policy, a management plan for the WTA was written and published in 1975. Most of the recommended management improvements contained in that plan (i.e., cattle fencing, closure of unnecessary roads, and an instream habitat project) have been implemented. The goals for maintaining an attractive and productive fishery (exclusive of the sediment problem) were likewise achieved.

For the past several years, it was recognized that the new problems facing those responsible for managing the WTA should be addressed in an updated plan. This plan identifies these problems and presents the Department's proposed solutions. The major problems are summarized below along with recommendation (in italics):

Land Management Problems

The PG&E, owner of the WTA, is currently having the land bordering Hat Creek appraised as part of the Federal Energy Regulatory Commission's (FERC) relicensing process. There is a possibility that PG&E's streamside WTA holdings could be listed as surplus property. If this happens, and the WTA is not acquired by a public entity, anglers could lose the privilege of fishing one of California's premiere wild trout streams.

> *If the land along Hat Creek is declared by PG&E to be surplus, seek public acquisition of the WTA. If no other government agency is able to acquire the stream, the Department of Fish and Game should purchase the WTA.*

Sedimentation is currently regarded as the primary environmental problem in the WTA. PG&E has investigated the effects of its hydroelectric operations on sedimentation (Cook and Ellis 1998) and is currently funding additional studies on the sediment budget of Hat Creek. An earlier independent study of the sediment problem conducted by Dr. G. Mathais Kondolf, U.C. Berkeley (1994), was partially completed.

> *If, after reviewing the PG&E sponsored studies, additional investigations are considered necessary, request that PG&E fund the completion of those parts of*

Dr. Kondolf's study that relate to hydroelectric operations. Thereafter, the recommendations contained in that study that are critical to the long-term maintenance of a productive fishery in the WTA should be implemented.

Since aquatic vegetation is critical to the food production and trout cover needed to maintain a productive wild rainbow trout fishery, a study should be undertaken to determine why these plants have not become re-established following a return of more normal sediment levels.

Seek funding for a study of the potential causes of periodic declines of aquatic vegetation in Hat Creek including the impact of excessive sedimentation and the factors that regulate recovery of the aquatic plant community.

Other land management recommendations include consideration of a trail system to encourage use of some lightly fished areas, providing portable rest rooms at major access points, and replacing streamside informational signs.

Instream Habitat Problems

One of the key elements in the maintenance of a productive wild trout fishery on Hat Creek is a fish barrier constructed as part of the 1968 trout restoration project. Without this structure, the stream would again be heavily populated with Sacramento suckers, along with other fish species from Lake Britton.

The barrier should be inspected regularly to identify any indication of pending structural failure. Plans and permits to replace or refurbish the barrier should be on hand in the event the barrier shows signs of failure.

Fisheries Problems

The excessive amounts of sediment and loss of aquatic vegetation over the past decade have contributed to a sharp reduction in the rainbow trout population and caused a major decline in angler use and fishing quality. While the upper reaches of the stream now appear comparatively free of excessive sediment, aquatic vegetation and rainbow trout populations have not fully recovered.

Continue to document the status of the wild trout fishery and endeavor to make both anglers and land managers more aware of the impacts of excessive sedimentation and changes in aquatic vegetation on the fishery. If aquatic vegetation and the trout fishery do not recover, undertake necessary studies and corrective action.

Fisheries Management

Prior to the current prolonged sediment problem, use of the 18-inch minimum size limit brought about substantial increases in the population of rainbow trout ≥12 inches. By 1988, there were appreciable increases in angler use, numbers of trout caught-and-released, and the catch rate.

Retain the present two-trout bag limit, 18-inch minimum size and artificial-lure-barbless-hook gear restrictions.

Continue the intensive every-fifth-year monitoring program with a season-long creel survey to determine angler use and success and a late summer snorkeling survey to assess fish populations.

Limit the use of mark-and-recapture electrofishing surveys, conducted in the past to monitor fish populations, to periods when more detailed data are needed to validate snorkeling surveys or evaluate major declines in the fishery.

Use a volunteer angler survey box program and, as needed, additional snorkeling surveys to monitor the fishery in between the every-fifth-year surveys.

Coordinated Recovery Effort

Solving the problems related to restoring a productive trophy-trout fishery in Hat Creek should involve a coordinated effort by the Department, PG&E, Humboldt State University (HSU), angling groups, and others.

The Department should invite major past participants in the management of the WTA, together with other interested parties, to become part of a team coordinating the funding, design, and completion of projects needed to restore the Hat Creek fishery.

DESCRIPTION OF THE RESOURCE

Description of the Stream

Hat Creek originates as a small mountain stream in northern California's Lassen Volcanic National Park and flows northward for about 45 miles before entering Lake Britton, a hydroelectric impoundment on the Pit River. The WTA is a 3.5-mile reach of stream located just above the lake. A PG&E hydroelectric plant, called the Hat Creek Powerhouse No. 2, and Lake Britton form the upper and lower boundaries of the WTA (Figures 1 through 4).

Above the WTA, inflow from two large spring systems, Rising River and Crystal Lake, change Hat Creek into one of California's largest spring creeks. Flow from these sources enters Baum Lake, a small impoundment located about 0.75 mile above the WTA (Figures 1 and 2). The Hat Creek flume carries outflow from the lake to the powerhouse penstock. The combination of large spring sources, Baum Lake's limited capacity, and historical releases through the powerhouse provide a stable (usually 400 to 650 cfs) flow regime in the WTA.

Outflow from the powerhouse runs down a short, swift flowing riffle into a 2.2-mile long glide or run section. The upper portion of the run has a wide, slower flowing, moderately deep channel that meanders through low rolling grassland with scattered oak and conifers (Figure 5). The streambed has an underlying, sometimes exposed diatomaceous layer. Most of the channel's substrate, however, consists of silt and sand which anchor abundant beds of aquatic plants. In the lower run section, below what is known as the Carbon Bridge site, grasslands give way to thicker stands of oaks and pines (Figure 6). Beds of aquatic vegetation, numerous undercut banks, occasional deep pools, and overhanging or downed alders and other fallen trees provide excellent trout cover.

State Highway 299 crosses over the run section approximately 1.75 miles below the powerhouse. About 0.5 mile below the highway crossing, the run shallows into a wide, 1.2-mile long riffle with a bottom consisting of imbedded rubble and a thin layer of gravel overlaying a diatomaceous substrate. While pine and alders overhang portions of this reach, the fast flowing, open nature of the channel provides limited natural trout cover (Figure 7). Boulders and woody materials have been experimentally placed in parts of the riffle to provide cover. A fish barrier, constructed 0.1 mile above Lake Britton, has created a sediment-filled pool near the lower end of the riffle (Figure 8). Riffle habitat is again present below the barrier and continues on to Lake Britton.

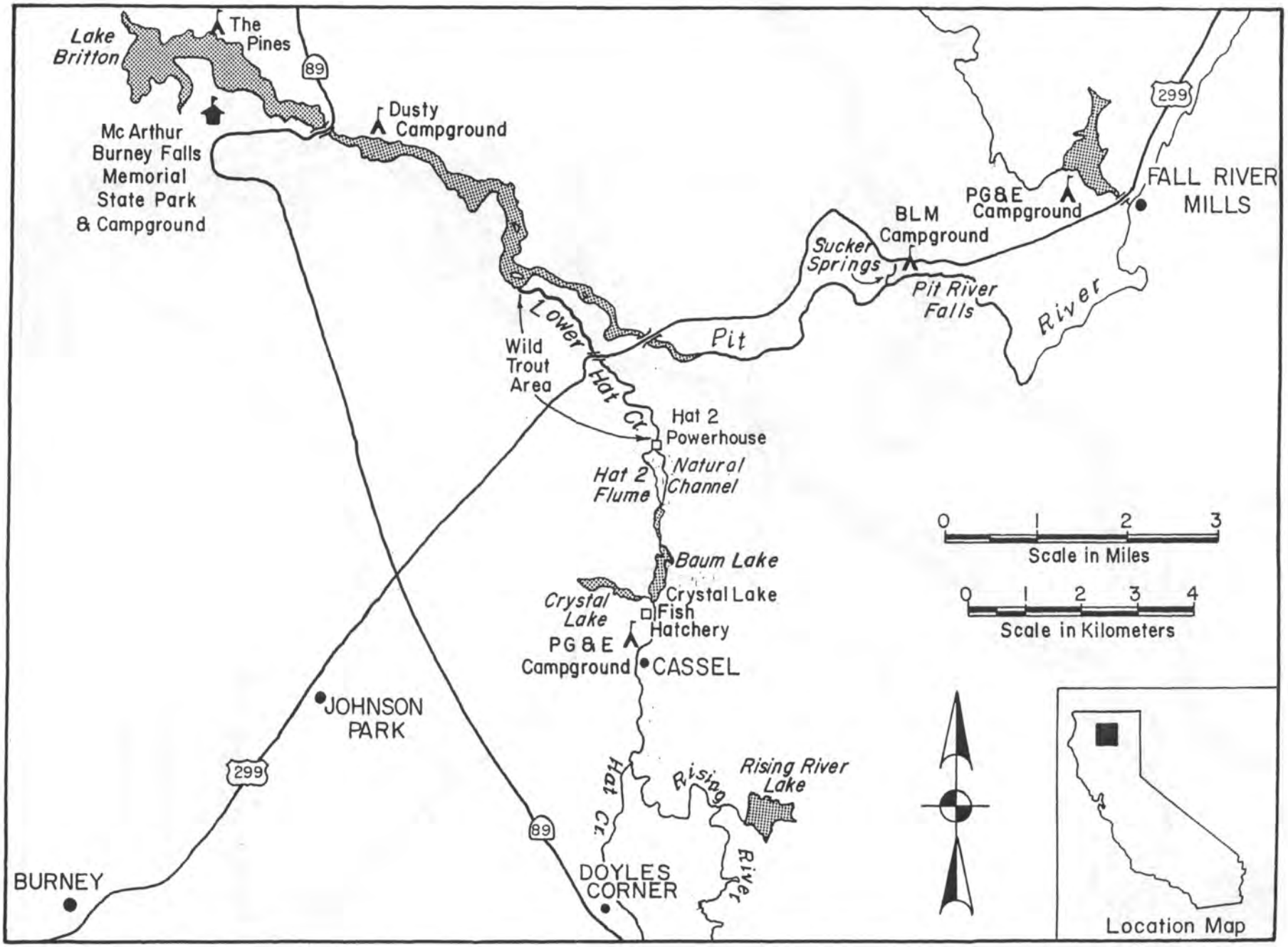

FIGURE 1. Lower Hat Creek Wild Trout Area in relation to Baum Lake, upstream spring sources, State highways, and nearby communities.

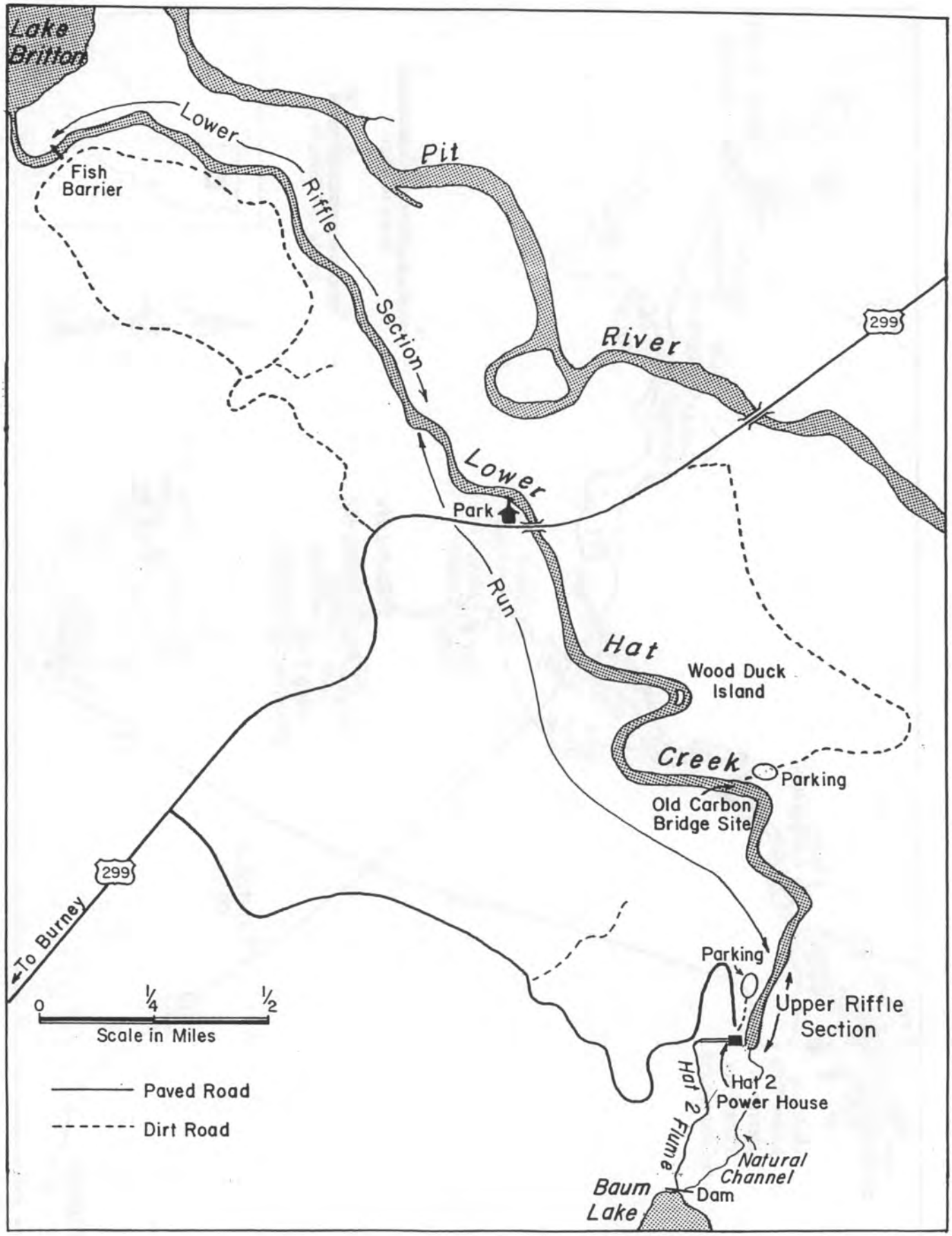

FIGURE 2. General features of the lower Hat Creek Wild Trout Area.

FIGURE 3. Upper boundary of the Wild Trout Area, Hat Creek Powerhouse No. 2.

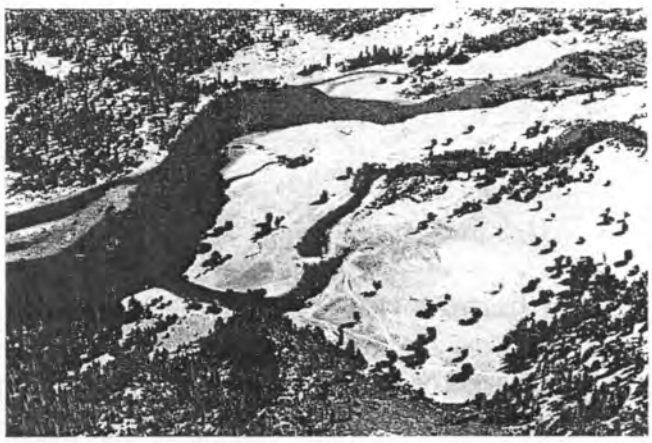

FIGURE 4. Lower boundary of the Wild Trout Area at Lake Britton and the upstream site of the fish barrier.

FIGURE 5. Upper, meandering reach of run section flowing through rolling grasslands.

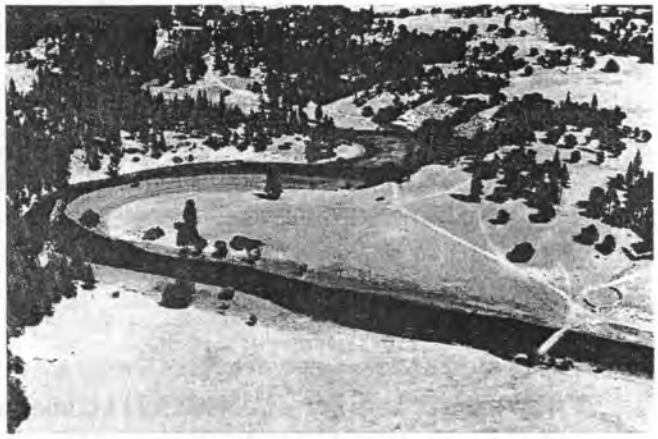

FIGURE 6. Run section from the Carbon Bridge site to Wood Duck Island (Photo taken in 1972).

FIGURE 7. Riparian growth lining part of the lower riffle.

FIGURE 8. Fish barrier, a 110 x 6 ft structure with a concrete apron, located above Lake Britton.

Description of the Fishery

Historical Background

In the early 1900's, Hat Creek reportedly sustained an excellent trout fishery. Shortly after the construction of Lake Britton in 1927, however, the trout fishery began to decline. The lake provided conditions suitable for the production of nongame fish and some species of warmwater gamefish. Soon after, these species, especially Sacramento suckers (*Catostomus occidentalis*), migrated into lower Hat Creek and overpopulated the stream (Gary E. Smith, California Department of Fish and Game, Environmental Services Division, personal communication, 1974).

Attempts by the Department to improve the fishery by stocking catchable-size rainbow trout did not produce satisfactory angling. Anglers caught less than the 50% minimum return rate required by Commission stocking policy for catchable-size trout. The presence of an internal myxosporidian protozoan known as *Ceratomyxa shasta* probably contributed to the poor return rate. While native Pit River drainage rainbow trout are resistant to *Ceratomyxa*, most hatchery stocks are not. When water temperatures exceed 50^0 F, the protozoan infection is usually fatal to these fish in 30-60 days.

Trout Restoration Project

A project to restore lower Hat Creek to a productive wild trout fishery began in the late 1960's. The project initially involved: (1) constructing a fish barrier across the stream just above Lake Britton to block the upstream migration of Sacramento suckers and other potentially competing fish species; (2) chemically treating the stream from Baum Lake to the barrier to reduce or eradicate the existing fish population; (3) restocking the stream with suitable strains of wild trout; (4) decreasing potential overharvest of the post-treatment wild trout population by reducing the limit from 10- to 2-trout per day without any size, gear, or bait restrictions; and, (5) evaluating the project to assess its success and possible application to other California streams.

The trout restoration project became a cooperative effort of PG&E, California members of Trout Unlimited (now known as California Trout), the HSU Cooperative Fisheries Research Unit, and the Department.

The project began with a late April through August 1968 creel census to determine angler use and success prior to restoring the fishery. The barrier and chemical treatment were completed that fall followed by extensive stocking of fingerling to adult-size brown trout from Trinity River and Mt. Whitney hatchery-strain stocks. Small lots of "resident" rainbow, brown, and brook trout captured by electrofishing just prior to the treatment were also restocked. A follow-up plant of a few large *Ceratomyxa* resistant Pit River strain rainbow trout together with a small number

of fingerlings from the same stock was made in 1969. The fingerlings were from the first generation of a newly developed broodstock originating from wild rainbow trout that annually spawned below nearby Sucker Springs on the Pit River (Figure 1).

Based on actual numbers of fish collected during the chemical treatment, Sacramento suckers were the most numerous species present prior to the treatment. Rainbow trout were the second most numerous species, but few brown trout and very few (probably hatchery origin) brook trout were collected. In terms of biomass, over 8,000 of the 9,000 pounds of fish collected during the treatment were Sacramento suckers.

The trout restoration project was an almost immediate success. Continued creel surveys covering the reach from the powerhouse to the barrier documented a substantial increase in angler use and the total number of trout landed (trout kept plus trout released). By 1973, five years after the chemical treatment, estimated angler use (through August) had increased from 5,504 to 18,013 hours. Trout landings had increased from 1,085 to 8,179 and the catch rate increased from 0.20 to 0.45 trout/hour. Season-long (late April through November 15) estimates for angler use and trout landed in 1973 were 21,960 hours and 9,823 fish (Deinstadt and Smith 1976).

Electrofishing surveys indicated very limited recovery of the Sacramento sucker population, the primary target species during the chemical treatment. Five years after the treatment, only 74 of the 8,904 fish captured were Sacramento suckers. During this period, a substantial population of tui chubs that were too small to be included in the electrofishing sample were noted, but their numbers became insignificant in subsequent years. Other potentially competing species were likewise present in relatively small numbers.

Fish Species

Gerstung (1975) reported 17 species of fish were known to be present in lower Hat Creek after the chemical treatment. Seven of these species were limited to the riffle section below the barrier and present in only small numbers. One native salmonid (rainbow trout) and two introduced salmonids (brown and brook trout), one introduced warmwater gamefish (brown bullhead), and six native nongame fish (Sacramento sucker, tui chub, bigeye marbled sculpin, Pit sculpin, rough sculpin, and Pit-Klamath brook lamprey) were present in the WTA above the barrier in 1973. More recent surveys indicate that brown bullheads may no longer be present in the creek. Rough sculpin are currently listed as a threatened species by the State of California, as well as a Federal species of concern. Bigeye marbled sculpin are a California species of special concern.

Angling Regulations

In an effort to increase the population of ≥12-inch trout, the original two-trout limit without a gear restriction was experimentally replaced by an 18-inch minimum size limit and artificial-lures-barbless hook-only gear restriction in 1979. The gear restriction was considered necessary

to reduce mortalities associated with releasing numerous sublegal-size fish. The two-trout daily bag limit remained in place and the new regulations covered the stream from Baum Lake to Lake Britton.

Angler Access and Accommodations

Most anglers reach Hat Creek by driving east from Redding on Highway 299. The most popular access route to the creek from Highway 299 is the road into the Hat Creek Powerhouse No. 2 (Figure 2). Anglers park just below the powerhouse and usually fish the tail end of the upper riffle known as the Powerhouse Riffle (Figure 9). Other lateral roads provide access to: (1) the Carbon Bridge site about 0.75 mile below the powerhouse on the east (Pit River) side of the creek; (2) the Hat Creek county park at the Highway 299 bridge crossing; and (3) the lower riffle and fish barrier. The historic Carbon Bridge was dismantled for safety reasons about 20 years ago. Trails along one or both sides of the stream provide foot access between vehicle access points.

Lodging and other facilities are available in the towns of Burney, Cassel, and Fall River Mills. There is a Bureau of Land Management campground off Highway 299 adjacent to the Pit River, PG&E campgrounds at Cassel, Fall River, and Lake Britton, and a State Park campground at Burney Falls (Figure 1). Other campsites are available to the south off Highway 89 near the towns of Hat Creek and Old Station. No camping is permitted in the WTA.

MANAGEMENT PROGRAM

Management Objectives

Objectives of the lower Hat Creek Wild Trout Management Plan are to:

1. Retain public access to the stream within the WTA.

2. Identify and control major sources of sedimentation derived from the watershed within and above the WTA.

3. Restore and maintain a trout population whose abundance and size structure sustain a trophy trout fishery similar to that present in the 1980's. The run section from the powerhouse riffle to the 299 bridge should contain at least:

    a) 5,000 trout $\geq$8 inches including 2,000 trout $\geq$12 inches.

FIGURE 9. Parking area adjacent to and anglers fishing the lower end of the powerhouse riffle.

4. Restore and maintain an attractive fishery characterized by:

   a) an average landing rate (trout released plus trout kept) of at least 0.75 trout per hour, with

   b) at least 30% of the trout caught $\geq$12 inches.

5. Restore and maintain optimal habitat conditions. For lower Hat Creek management purposes, optimal is characterized by:

   a) stable flow (400-750 cfs) without power production related fluctuations except in flood flow conditions,

   b) temperate water (40-65 F),

   c) high transparency and low suspended sediments,

   d) an absence of harmful pollutants or pesticide levels, and

   e) sufficient clean gravel and cover (rooted aquatic plants) to maintain trout populations at or above levels present in the 1980's.

6. Perpetuate native fishes, specifically indigenous, disease resistant Pit River strain rainbow trout, rough sculpin, and bigeye marble scuplin.

7. Preserve the natural character of the streamside environment.

Land Management Problems

Land Ownership

PG&E ownership of the land along lower Hat Creek has allowed anglers and the public to have access to the stream for decades. The pending deregulation of California's electrical power companies is producing changes in their policies. One of PG&E's policy changes is a decision to sell its surplus land. The lower Hat Creek WTA is not currently on the list of surplus land, but it is currently being appraised as part of the FERC relicensing process, and there is a possibility it will be classified as surplus property. If this happens, public access will no longer be guaranteed and, unless a public entity purchases or otherwise acquires the WTA, anglers could lose the privilege of fishing one of California's foremost wild trout streams.

Recommendation 1. *If the WTA is designated surplus property, the Department should work with PG&E, potential buyers, land trusts, and FERC to assure that there will be public access to, and protection of, the lower Hat Creek fishery. If there is no other alternative, the Department should purchase the 3.5-mile WTA.*

Sedimentation

Sedimentation is currently regarded as the primary environmental problem facing the long-term maintenance of a productive fishery in the WTA. During a September 1988 electrofishing survey, an excessive amount of sediment was observed in the run section immediately below the powerhouse riffle. This "mass" of sediment was tracked for the next five years and, by 1993, its leading edge had moved past the Carbon Bridge site. Over the past decade, this problem (and its accompanying impact on aquatic vegetation) has severely depressed the sport fishery.

In an effort to identify and correct the source of the prolonged 1988 sedimentation episode, Dr. G. Mathais Kondolf of the University of California, Berkeley, Center for Environmental Design, was hired to investigate the problem. The ensuing study identified several potential sediment sources within the basin and local watershed downstream from Baum Lake, but did not identify a single major source of the 1988 episode (Kondolf, Parrish, Booker, and Matthews 1994). However, a spill from the Hat 2 Flume is known to have washed out part of an adjoining hillside and could have been a primary source of sedimentation (W. D. Weidlein, retired California Department of Fish and Game Fisheries Management Supervisor, Region 1, May 12, 1998, personal communication). Dr. Kondolf's initial report recommended further field investigations, but they have not been implemented due to a lack of funding. Recommendations from the study are listed in the Appendix.

A more recent PG&E sponsored sediment study is currently being reviewed and will be carefully considered in any future studies and/or corrective actions sought by the Department.

The recommendations the Department currently seeks to implement relate primarily to sediment sources within the WTA. These sources involve roads, parking lots, streambanks, and small tributaries. The access road to the Carbon Bridge site and its parking lot are considered potential long-term sources of sediments. The powerhouse parking lot appears more stable, but based on observations during the winter of 1996-97, it could be a bigger source of sediments than the Carbon Bridge road and parking area (Cook and Ellis 1998).

It is clearly recognized that excessive sedimentation can be a recurring problem at lower Hat Creek. A long-term solution to this problem should, therefore, be sought.

Recommendation 2. *If, after reviewing the PG&E sponsored sediment studies, additional investigations are considered necessary, request that PG&E fund completion of the parts of*

Dr. Kondolf's study that relate to hydroelectric problems. Thereafter, the recommendations contained in that study, which are critical to the long-term maintenance of a productive fishery in the WTA, should be implemented..

Compacting Streambanks

Streambanks along most of lower Hat Creek are in good shape. The exclusion of cattle from the banks has helped improve stability, but muskrat burrowing and angler traffic continue to cause bank compaction and/or failure in some areas.

Recommendation 3. *A streambank survey should be conducted to assess and prioritize the need for stability. Once areas are selected, various stabilization projects can be implemented, including natural rock or wood revetments, riparian vegetation plantings, or angler platforms. Methods of effective muskrat control should be researched and discussed to determine possible solution to the burrowing problem.*

Angler Distribution

Prior to the recent sediment episode, there were abundant populations of large rainbow trout in the Carbon Bridge to Wood Duck Island reach and numerous trophy-size brown trout between the Island and Highway 299 bridge. Because of the popularity of the powerhouse riffle, these reaches received comparatively light use. Attempts to make anglers aware of the fishing opportunities in these reaches have been ineffective. Given the value of a trophy rainbow trout stream in California, especially of the caliber of lower Hat Creek, having a major portion of the stream lightly fished is considered an undeveloped opportunity.

Several years ago, California Trout commissioned a study to develop a trail system along most of the upper 2.2-mile run section of the WTA. The plan was not implemented. Recognizing the value of encouraging anglers to fish reaches of the stream other than the powerhouse riffle, the trail plan needs further careful evaluation. That evaluation may include routing anglers away from erosion-prone streambanks.

Recommendation 4. *The Department should review the possibility of encouraging anglers to try additional fishing areas in the upper WTA by reassessing a system of trails proposed several years ago by California Trout.*

Sanitation

Restrooms and garbage facilities are only available to anglers at Hat Creek County Park along Highway 299. Other major access points, especially the powerhouse area, have seen an increase in sanitation problems.

Recommendation 5. *Portable or permanent restrooms should be provided at the powerhouse, Carbon Bridge site, and in the area downstream from Highway 299. Funding for the rental (or construction) and maintenance of these facilities should be sought through PG&E, the Department, fishing organizations, or a combination of these sources.*

Public Education

A public information display describing the 1968 trout restoration project and the statewide Wild Trout Program has been a part of the Hat Creek County Park facilities for over 25 years. A second display is present at the heavily used powerhouse parking lot. Weather and vandalism have damaged both displays.

These displays help anglers understand the present fisheries management program and, in the case of the Park display, increase public awareness of the California Wild Trout Program.

Recommendation 6. *Replace the signs at Hat Creek Park and the powerhouse with new, updated signs. The kiosks associated with these signs should be large enough to display other information (results from recent surveys, proper catch-and-release techniques, habitat management issues, etc.).*

Off-Road Vehicles.

Off-road vehicle use continues to be a problem along lower Hat Creek and is especially evident in the area downstream of Highway 299. The highly erosive soil along the creek is easily disturbed and, combined with the flashy nature of the rainfall, pose a threat to the stream's trout habitat. Downstream areas have been fenced and posted with signs in the past, but vandalism has made the fences ineffective.

Recommendation 7. *New fences and signs need to be erected and the existing vehicle tracks should be removed. Logging slash has been an effective method of closing existing vehicle tracks. The proper authorities need to be contacted and made aware of the problems to help promote interest in patrolling the area.*

Timber Harvest

Timber harvest in the lower Hat Creek corridor is a major concern. A healthy forest adjacent to the stream is essential to maintaining the associated riparian ecosystem, soil stability, shading, insect production, and providing additional trout cover as trees fall into the creek. Much of lower Hat Creek's aesthetic quality is also closely related to its riparian area.

A 1993 logging operation was conducted under timber harvest rules as a salvage operation to remove trees killed by insects. Unfortunately, existing timber harvest rules did not adequately

protect the fragile resources associated with lower Hat Creek. Additionally, the salvage harvest plan review procedures are less stringent than for regular timber harvest. The combination of these two factors resulted in a timber operation that posed a serious threat to the stream's productivity. After extensive post-harvest field review, consultations, and cooperative efforts, the soil was stabilized through a variety of techniques and the risk to the river was minimized.

The cooperative effort in 1993 resulted in a more thorough pre-harvest review of a salvage logging operation conducted in 1994. Through extensive field review and cooperation between those participating in the timber harvest, the Department was able to minimize the risk to lower Hat Creek.

Recommendation 8. *Recognizing that selective harvest may be necessary to maintain the health of the forest, the Department should contact PG&E and/or other land owners and request direct and timely notification prior to any future timber harvest.*

Cattle Grazing

A substantial improvement in cattle grazing practices has occurred along lower Hat Creek. Allotments have been changed, grazing has been eliminated on the west side of the stream and much of the riparian area on the east side is protected by fencing. While cattle are occasionally reported on the stream side of the fence, the detrimental impact of grazing in the riparian corridor has been largely eliminated.

The main concerns at this time are fence maintenance and an assessment of cattle effects on Cinder Flat Creek, a tributary stream entering Hat Creek on the east side about 0.1 mile downstream of the upper powerhouse riffle.

Recommendation 9. *Fences should be inspected at least semiannually and any weak spots repaired. Cinder Flat Creek should be inspected for restoration potential. Cattle exclusion fencing should be considered if necessary.*

Mineral Extraction

Lower Hat Creek lies in a area of extensive diatomaceous earth deposits. Due to their numerous industrial uses, deposits have been actively mined in the Lake Britton area. Though the diatomaceous earth along lower Hat Creek is considered lower quality, mining along the stream scars the area, creates noise and dust, and leads to possible increases in sedimentation.

Recommendation 10. *PG&E, other land owners, and Shasta County should be discouraged from allowing diatomaceous earth mining operations adjacent to lower Hat Creek which may impair the stream's attractiveness or damage its aquatic resources.*

Instream Habitat Problems

Fish Barrier

The fish barrier constructed in 1968 has been the key element in the conversion of lower Hat Creek to a productive trout stream (Figures 4 and 8). There is some concern that, as the barrier gets older, it may weaken structurally and fail. To avoid potentially allowing an influx of undesirable fish into the WTA from Lake Britton, the proper permits needed to replace the barrier should be acquired ahead of that time.

Maintenance of the barrier is currently the Department's responsibility. However, the Department views the barrier as a structure whose necessity was brought about by the construction of the Lake Britton and Pit River hydroelectric project rather than the Hat Creek hydroelectric project.

Recommendation 11. *To help assure timely maintenance or replacement of the barrier, a biannual inspection should be conducted by Department engineers. When the current maintenance agreement expires (October 31, 2003), inspection and possible replacement of the barrier should become PG&E's responsibility as part of the Pit River hydroelectric project costs.*

Recommendation 12. *To allow quick replacement in case of unexpected failure, a new barrier design should be created and the permit process determined. At such time as deemed appropriate, the barrier should be replaced.*

Aquatic Vegetation

Hat Creek is known for its meandering channel and slow current, unique surroundings, large wild trout, and lush rooted aquatic vegetation. This vegetation is essential to maintaining abundant populations of wild trout by providing cover, a source of prolific insect hatches, and home for other invertebrate forage. The factors which influence plant growth in lower Hat Creek have not been studied, but are recognizably limited by excessive amounts of sediment (Figures 10 and 11).

Recommendation 13. *Seek funding for a study of the potential causes of periodic declines of aquatic vegetation in Hat Creek, including the impact of excessive sedimentation and the factors that regulate recovery of the aquatic plant community.*

Recommendation 14. *Photo points and vegetation transects should be established to document changes in aquatic plant abundance and types. Baseline data should be collected at various seasons over 2-3 consecutive years, and then the transects resurveyed at five-year intervals or when there appears to be significant changes in the vegetation.*

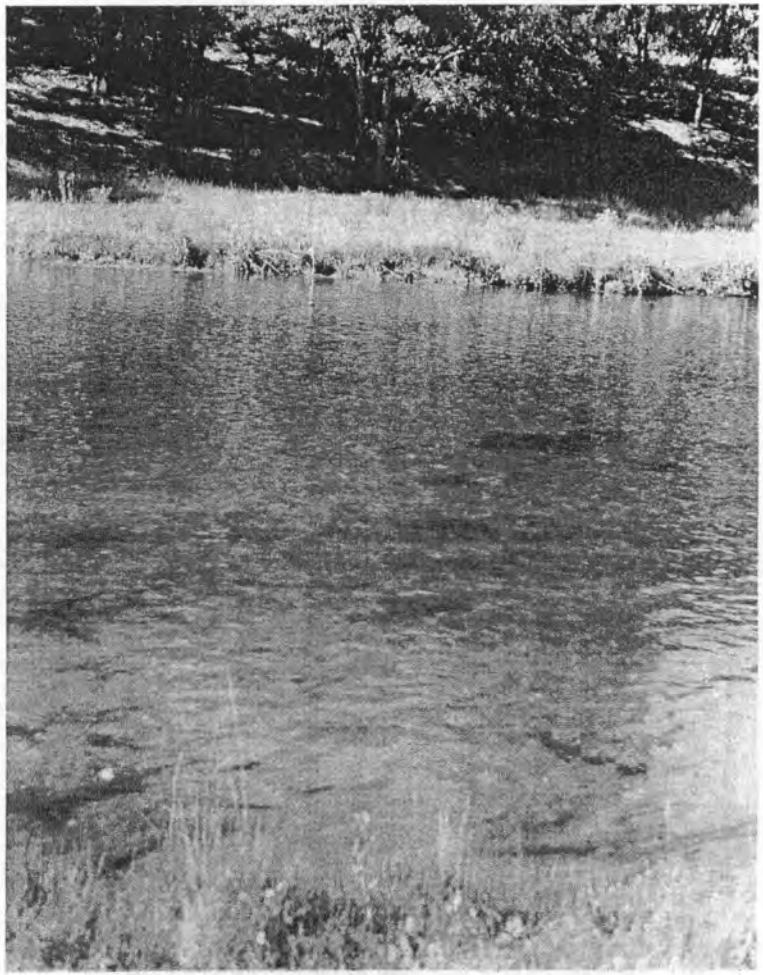

FIGURE 10. Sediment impacted reach of the upper run a little below the powerhouse riffle in 1991.

FIGURE 11. "Typical" stream section showing rooted aquatic plants in a reach above the 299 bridge prior to the prolonged sediment intrusion.

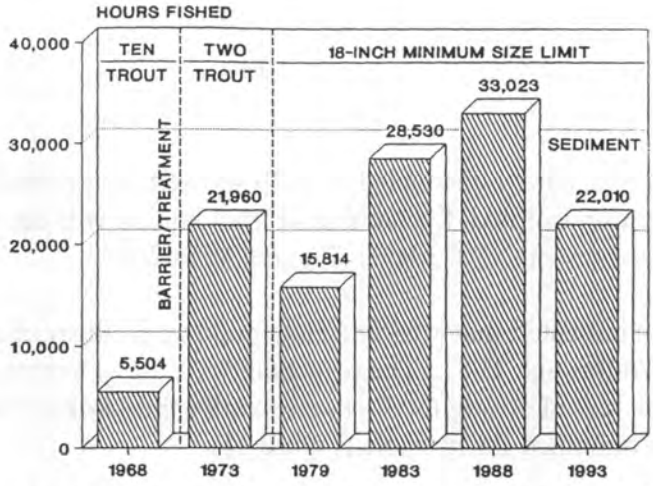

FIGURE 18. Estimated hours fished at Hat Creek before and after the barrier/chemical treatment project.

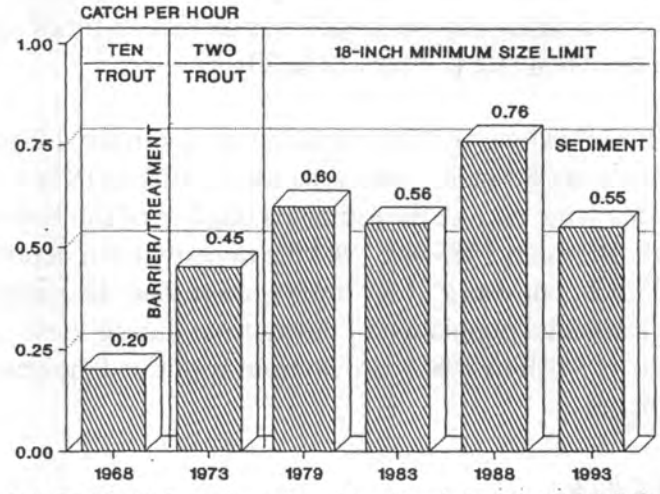

FIGURE 19. Estimated number of trout landed at Hat Creek before and after the barrier/chemical treatment project.

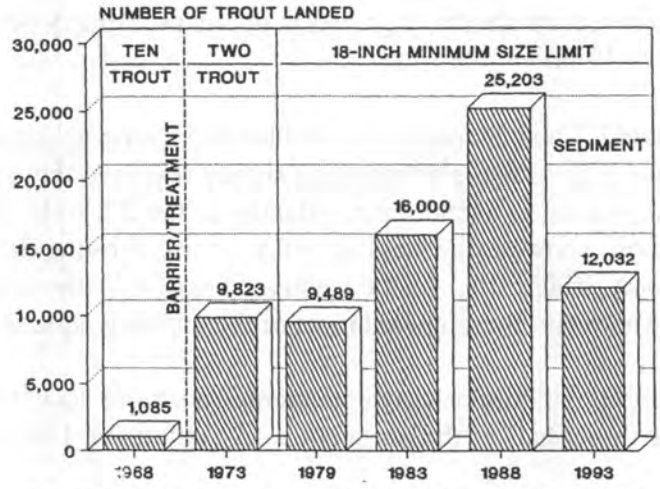

FIGURE 20. Catch per hour at Hat Creek before and after the barrier/chemical treatment project.

Estimates from a creel survey conducted in 1979 showed that, during the first year of the new regulations, angler use declined, the number of trout landed was essentially unchanged, and catch/hour improved over the 1973 level (Figures 18 to 20).

Follow-up surveys indicated that a fairly steady build up in the number of ≥12 inch rainbow trout occurred from 1978 through 1983. The percentage of fish ≥12 inches in the lower density brown trout population increased during the first season after the 18-inch minimum size limit became effective and then remained fairly stable (Figure 21).

Creel surveys conducted five years (1983) and ten years (1988) after implementation of the minimum size limit showed angler use approximately doubled that of the baseline 1979 survey. Numbers of trout landed were 1.7 to 2.7 times greater and the catch rates, at first unchanged, also improved in 1988. In comparison to the 1968 pretreatment estimates, angling effort in 1988 was 5-6 times greater, the number of trout landed was almost 25 times higher, and there was nearly a 4-fold increase in the catch rate (Figures 18 to 20).

Estimates derived from extensive electrofishing surveys in the 2.2-mile run section showed the numbers of rainbow trout ≥8 inches increased from 1,989 in 1978 to 6,355 in 1983 (Figures 22 and 23). During this same period, the estimated number of rainbow trout ≥12 inches increased from 375 to 2,590. Between 1983 and 1988 the rainbow trout population in this size class decreased to 1,705 fish, but was still 4.5 times greater than the population present in 1978 (Figure 24). The estimated population of brown trout during these surveys decreased from 599 fish in 1978 to 417 fish in 1988. Brown trout continued, however, to comprise the majority of the trout ≥16 inches.

Sedimentation/Drought

Periodic increases in sedimentation in the WTA have been a concern of anglers and Department biologists for almost two decades. Prior to the current problem, however, these occurrences have been of comparatively short duration. The amount of sediment moving through the WTA currently is considered substantially greater than any previously observed since the restoration of the trout fishery in 1968.

As previously stated (Land Management Problems, Sedimentation), awareness of the current problem began when the 1988 electrofishing survey revealed that substantial amounts of sediment were beginning to accumulate in the top of the 2.2-mile run section. Observations over the next few seasons showed this mass of sediment was moving downstream and, by 1991, had reached the Carbon Bridge site. As the leading edge of this about 12- to 18-inch high sediment mass moved downstream, it smothered most of the existing aquatic plant beds.

A limited 1991 fall population survey documented a severe decrease in the rainbow trout population in the upper half of the run section. An extensive 1993 population survey indicated

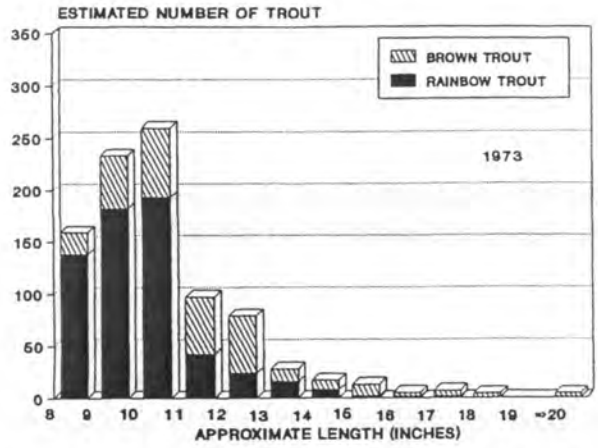

FIGURE 12. Estimated trout population in 0.6 miles of the upper run section of Hat Creek in 1972.

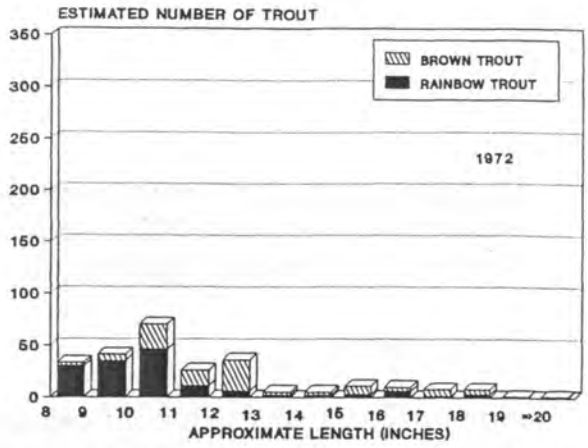

FIGURE 13. Estimated trout population in 0.6 miles of the upper run section of Hat Creek in 1973.

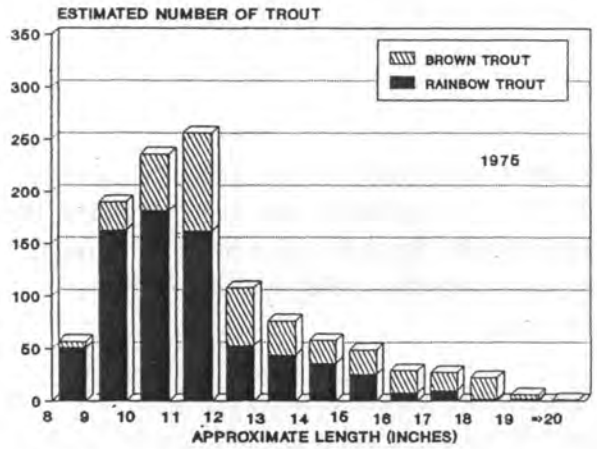

FIGURE 14. Estimated trout population in 0.6 miles of the upper run section of Hat Creek in 1975.

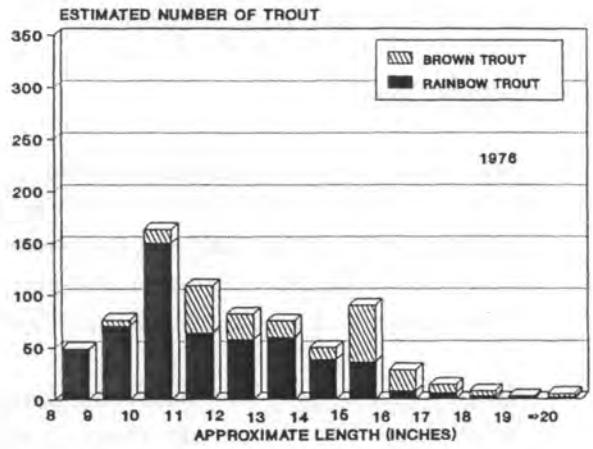

FIGURE 15. Estimated trout population in 0.6 miles of the upper run section of Hat Creek in 1976.

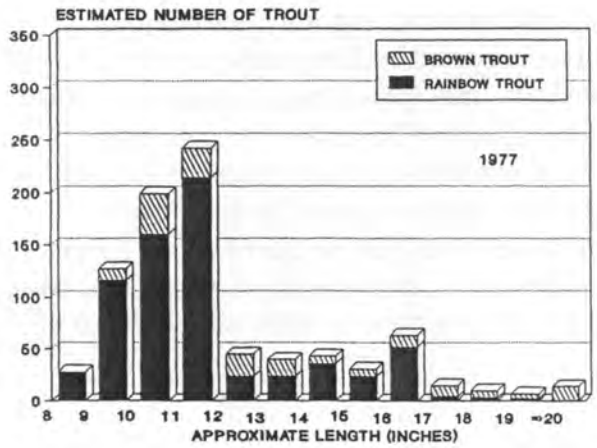

FIGURE 16. Estimated trout population in 0.6 miles of the upper run section of Hat Creek in 1977.

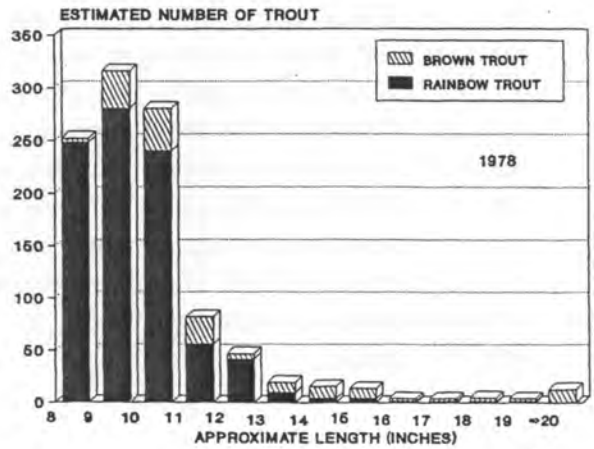

FIGURE 17. Estimated trout population in 0.6 miles of the upper run section of Hat Creek in 1978.

Recommendation 15. *To further document both changes in aquatic plant cover and overall habitat conditions in the WTA, a series of aerial photographs should be periodically shot between Lake Britton and Baum Lake.*

Water Quality

Flows which are free of harmful pollutants or pesticide levels and low in suspended sediment are critical to maintaining a productive wild trout fishery. At the present time, baseline data on water quality are scant and there is no regular monitoring program.

Recommendation 16. *The Department should work with the Regional Water Quality Control Board and the Department of Water Resources to establish baseline water quality data and develop a monitoring program.*

Streamflow

Due to its fairly constant large spring sources and Baum Lake's small storage capacity, there is little concern about flows in the WTA. However, when the powerhouse was first completed, the channel between the lake and the powerhouse was dewatered. Since October of 1979, through the FERC relicensing process, that channel has received a minimum release of 8 cfs from Baum Lake and a wild trout fishery has been reestablished.

Recommendation 17. *If wild trout populations in Hat Creek between Baum Lake and the Powerhouse No. 2 warrant, this stream section should be recommended for addition to the WTA.*

Past Fisheries Management

18-Inch Minimum Size Limit

The first major change in the posttreatment fisheries management program came after an extensive 1978 electrofishing survey confirmed that an expected build-up in the number of trout $\geq$12 inches had not occurred (Figures 12 to 17). Previous creel survey data showed that anglers kept an estimated 3,592 trout averaging 10 inches during the 1973 season. The conclusion reached after the 1978 survey was that angler harvest, particularly because anglers selectively harvested the larger fish, was too great to achieve the desired trophy trout fishery. It was recommended that an experimental 18-inch minimum size restriction be placed on the fishery and, to reduce the level of hooking mortalities for released fish, bait angling be prohibited. These recommendations were approved by the Commission and have been in effect since the start of the 1979 season.

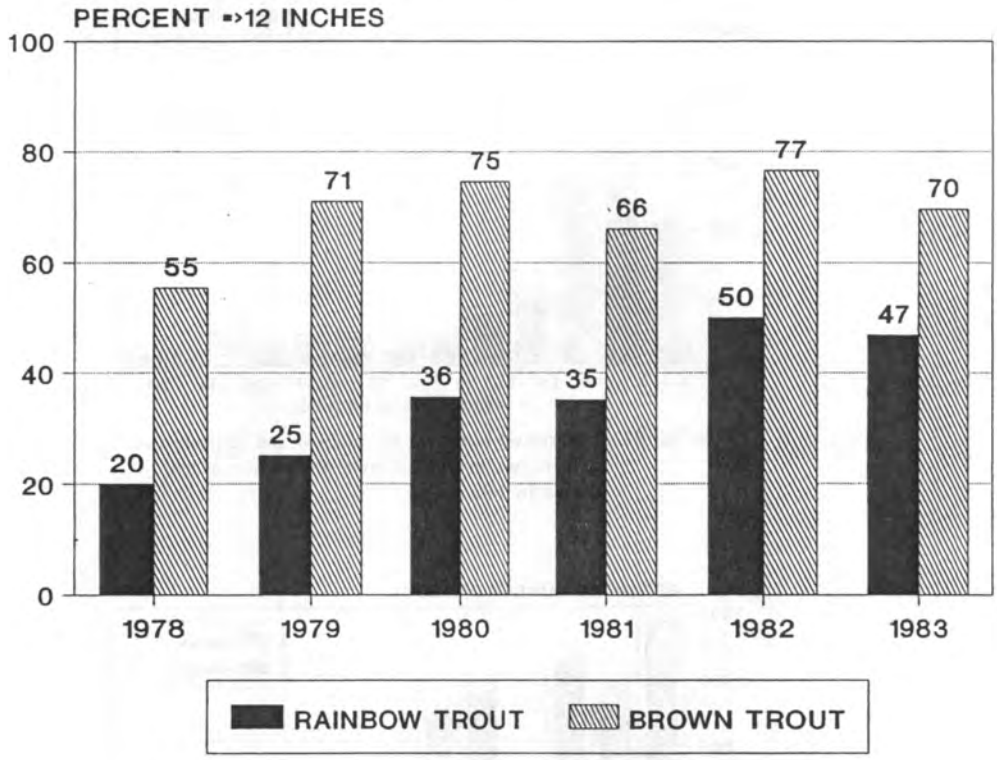

FIGURE 21. Percentages of rainbow and brown trout $\geq$12 inches in the upper 0.6-mile of the run section of Hat Creek before (1978) and after (1979 to 1983) the minimum size limit became effective.

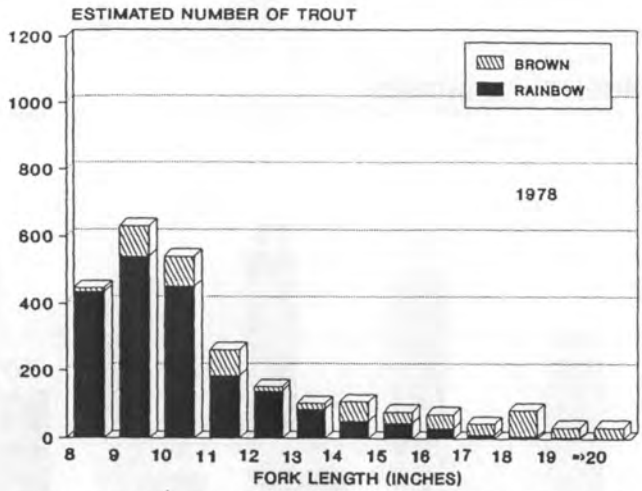

FIGURE 22. Estimated numbers of rainbow and brown trout ≥8 inches in the 2.2-mile run section of Hat Creek in 1978.

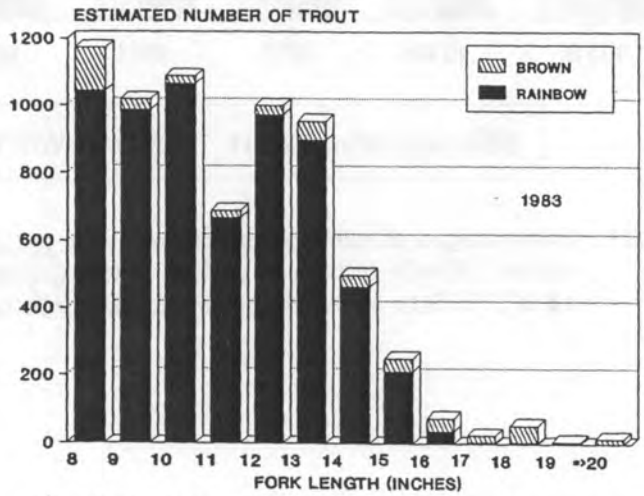

FIGURE 23. Estimated numbers of rainbow and brown trout ≥8 inches in the 2.2-mile run section of Hat Creek in 1983.

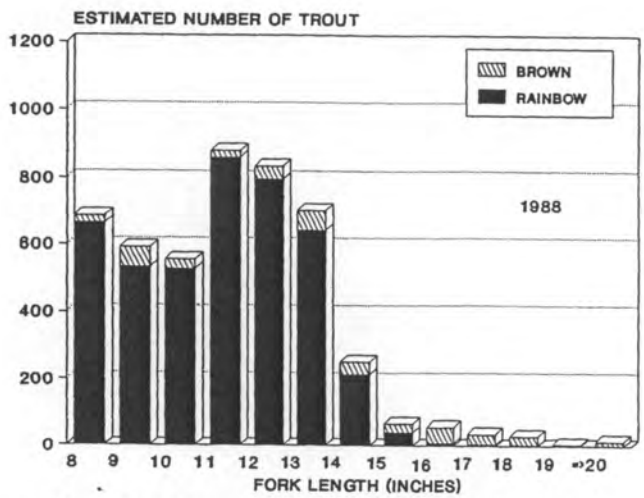

FIGURE 24. Estimated numbers of rainbow and brown trout ≥8 inches in the 2.2-mile run section of Hat Creek in 1988.

that the rainbow trout population was beginning to recover but still remained far below 1983 and 1988 levels (Figures 25 and 26). A season-long creel census in 1993 showed angler use and success were, as anticipated, also below the peak 1988 levels (Figures 18 to 20).

Observations over the past year indicate that the uppermost reach of the run section is again comparatively free of excessive amounts of sediments. Rooted aquatic plant beds appear, at least in some places, to have returned to their former densities. David Longanecker (PG&E aquatic biologist, personal communication) observed that where vegetation had become re-established in the upper end of the run section, the species were different. Beds of *Elodea canadensis* had given way to *Zannichellia palustris* which "is a lower-lying, grass-like plant and doesn't provide as much surface area for bugs and cover through the water column and at the surface compared to species such as *Elodea canadensis*".

Angler Survey Boxes

Survey Method. In 1990, the Department initiated a program of monitoring angling success on about 30 wild trout waters statewide through the use of voluntarily completed angler-survey box forms. The Department realized from the outset that data from these forms are not as accurate as creel survey data. The boxes are considered very useful, however, as long-term indicators of trends in angling quality and angler satisfaction, or as a means of providing data between periodic creel surveys (Deinstadt and Carpenter 1994).

Angler-survey box data are obtained from questionnaires filled out by anglers at the end of a day's fishing. The questionnaires are available in metal boxes placed at major access points. Data requested includes information on angling success and ratings of personal satisfaction with the number of trout caught, size of trout caught, and overall angling experience (Deinstadt, Lentz, Sibbald, and Murphy 1993). Boxes were located on the trail downstream of the powerhouse parking area, at the Carbon Bridge site, and on the main trail leading upstream from Highway 299 (Figure 27).

Catch Rates. In 1993, data from the season-long creel survey and the angler-survey box program were compared. Results showed that catch rates derived from angler-survey box data averaged 40% higher than that from the creel surveys (Figure 28). These results suggest that successful anglers are more likely than unsuccessful anglers to fill out a questionnaire.

It is reasonable to assume that catch rates from angler box surveys may be higher than actual values, but otherwise depict trends. Results from 1990 through 1996 box surveys indicate there has been comparatively little change in angling success. Catch rates over this seven-year period ranged from 0.80 to 1.08 trout/hour and averaged 0.98 trout/hour (Figure 29).

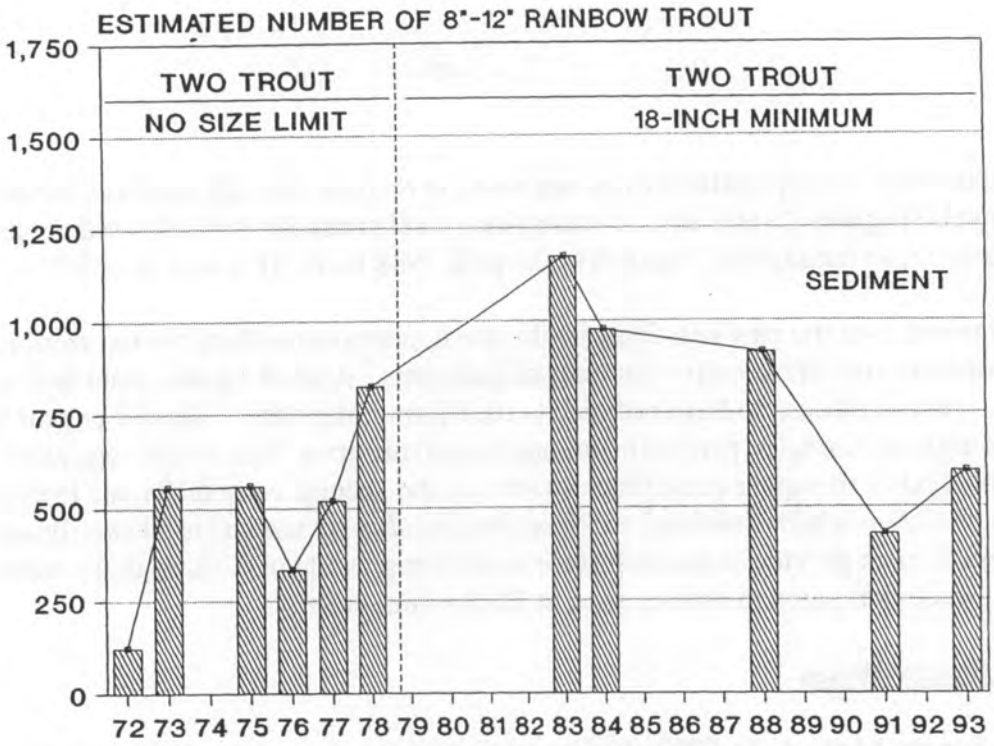

FIGURE 25. Estimated numbers of 8-12 inch rainbow trout in 0.6 miles of the upper run section of Hat Creek from 1972-93.

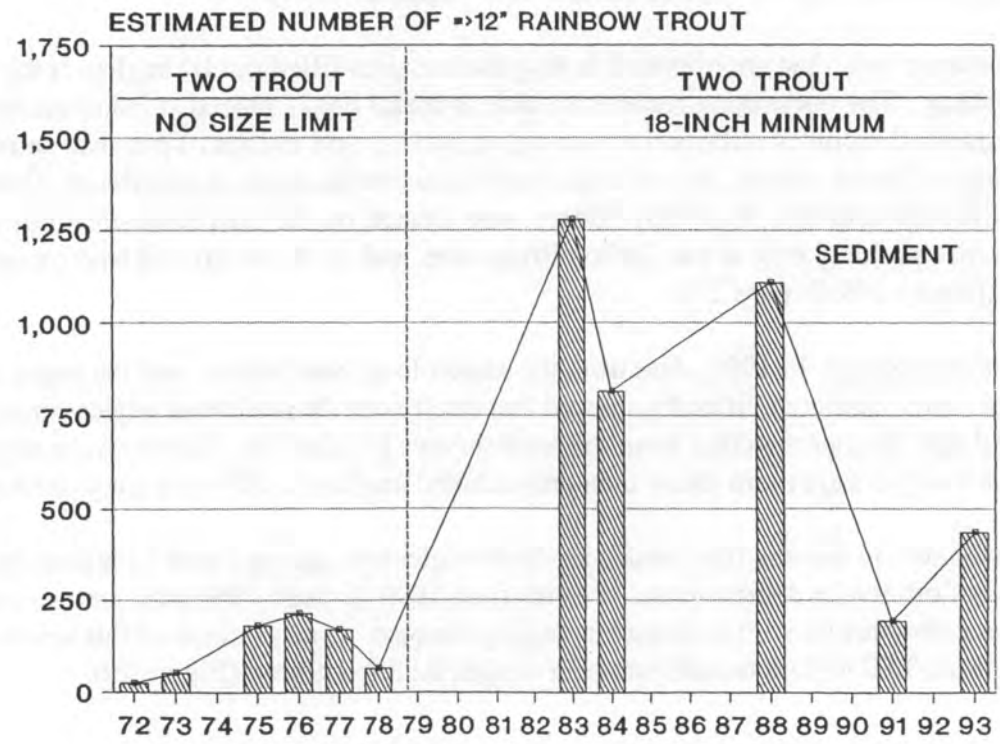

FIGURE 26. Estimated number of ≥12 inch rainbow trout in 0.6 miles of the upper run section of Hat Creek from 1972-93.

FIGURE 27. Angler completing a survey box questionnaire at the Carbon Bridge site.

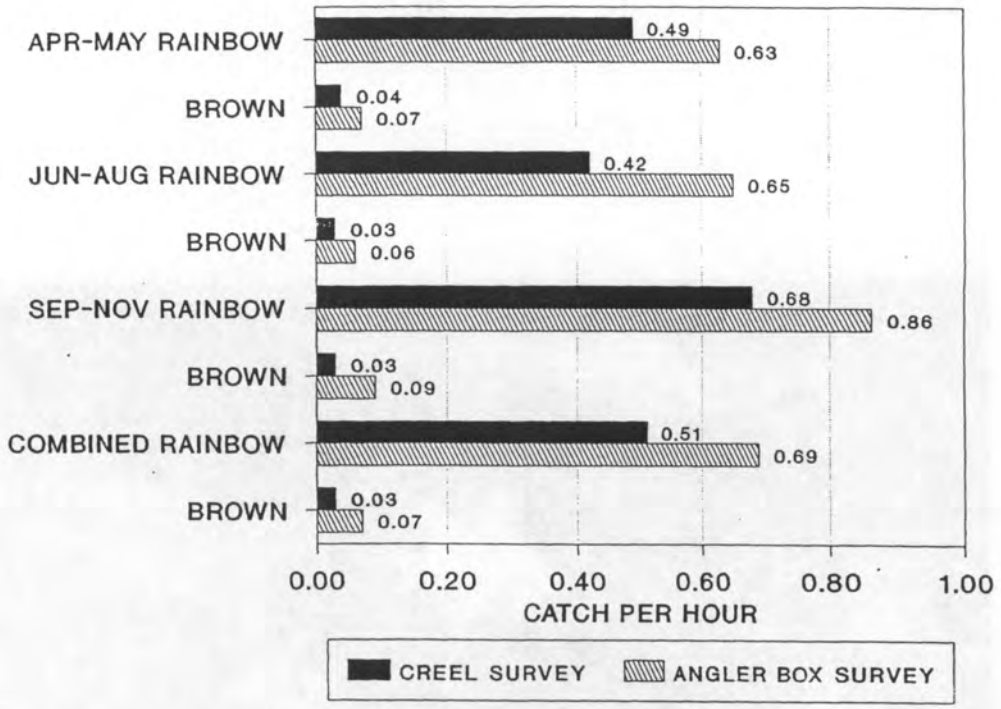

FIGURE 28. Comparisons of catch rates derived from creel and angler box survey data at lower Hat Creek during three periods of the 1993 season.

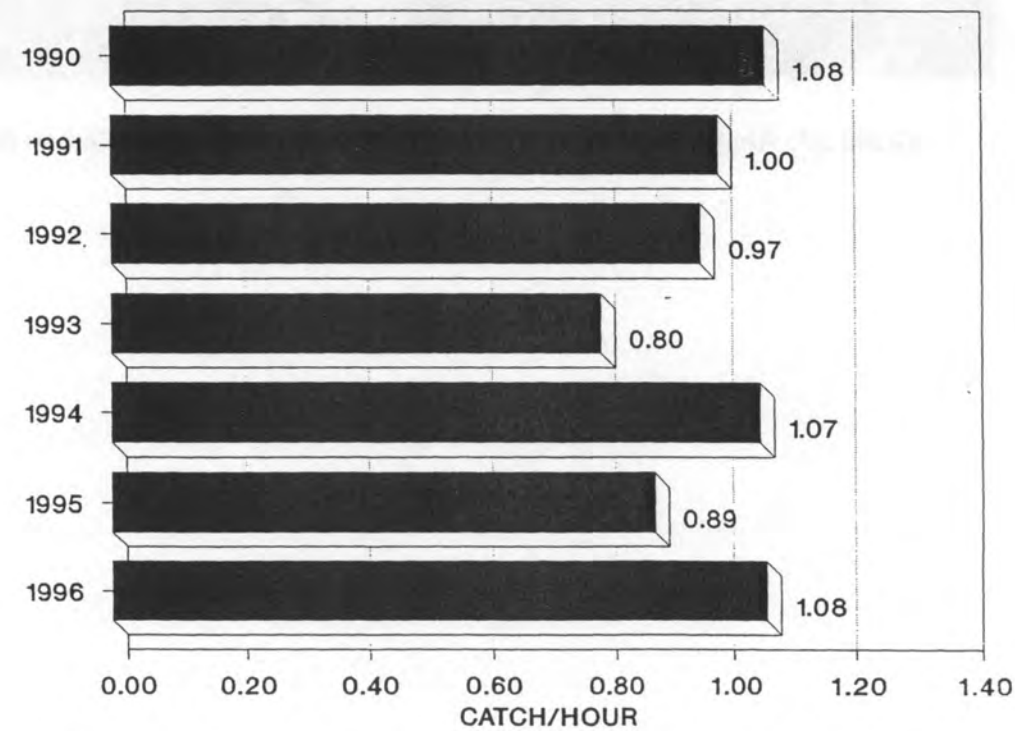

FIGURE 29. Trends in catch rates at Hat Creek based on angler box survey forms returned during the 1990-96 seasons.

Size of Trout. Comparisons indicated the sizes of the rainbow trout that anglers reported catching in the creel and angler box surveys were quite similar (Figure 30). Brown trout sizes, however, showed a greater variation (Figure 31). These differences are attributed mainly to smaller numbers of brown trout reported in both surveys.

Except for 1996, the size of rainbow trout caught over the past seven seasons has been relatively unchanged. Rainbow trout $\leq$7, 8-11.9, 12-15.9, and $\geq$16 inches averaged 42, 32, 21, and 6% of catch, respectively, from 1990-96 (Figure 32). In 1996, for the first time, anglers reported that rainbow trout $\leq$7 inches comprised over 50% of the catch. During the same season, the percentage of trout $\geq$12 inches reached a 7 year low. It should be noted, however, that the decrease in the percentage of trout $\geq$12 inches could be related to an exceptional high level of recruitment from an incoming year class of rainbow trout.

Angler Satisfaction. Satisfaction with the overall angling experience at Hat Creek during the past seven seasons has generally reflected the ups and downs of satisfaction in the number and size of trout caught (Figure 33). During this period, the percentage of anglers satisfied with the number of trout caught, size of trout caught, and overall angling experience averaged 44, 42, and 66%, respectively.

In 1996, 39.3% of the anglers were satisfied with the size of trout caught, which was lower than the seven-year average, while the percentage of anglers satisfied with the number of trout caught (47.4%) and their overall fishing experience (65.6%) was higher than the average. However, in comparison with other major northern California wild trout streams in 1996, Hat Creek had the lowest percentage of satisfied anglers in all three of the categories (Figures 34 through 36).

Snorkeling Surveys. There has been a growing concern among both biologists and anglers that electrofishing surveys may result in some injuries or mortalities to trout. This concern has led to growing use of alternative methods of estimating fish populations. Chief among these alternatives has been counting fish by snorkeling.

An experimental effort several years ago to count trout in lower Hat Creek by direct observation with three divers was unsuccessful. The next three efforts to survey the stream's fish populations by snorkeling were made twice in August 1993 and once in 1995. During the first of two 1993 surveys, eight divers counted 5,616 trout (5,499 rainbow trout and 117 brown trout) in the reach from the powerhouse riffle to the Highway 299 bridge. Fourteen divers counted 6,631 trout (6,613 rainbow trout and 18 brown trout) in the same reach during the second 1993 survey. During an August 1995 survey, 11 divers counted 5,083 trout (5,080 rainbow and three brown trout).

Since 1978, electrofishing surveys have been designed to estimate the population of trout $\geq$8 inches. Data collected during an electrofishing survey conducted shortly after the second 1993 snorkeling surveys produced an estimate of 2,497 $\pm$ 446 rainbow and 333 $\pm$ 85 brown trout $\geq$8 inches in the powerhouse riffle to the Highway 299 Bridge reach.

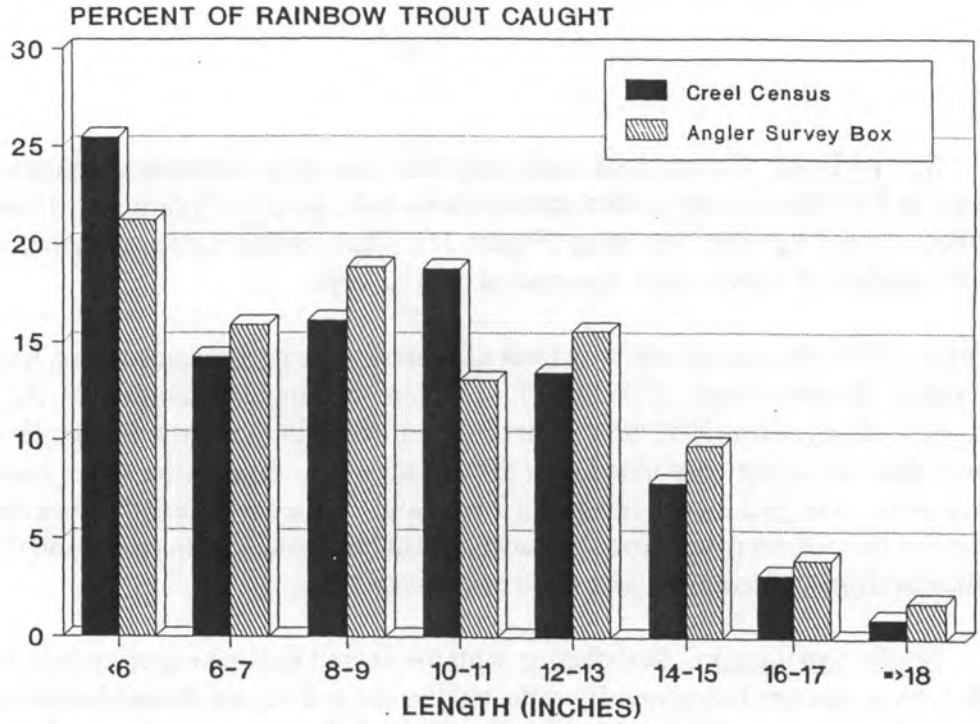

FIGURE 30. Comparison of the sizes of rainbow trout anglers reported catching in the creel and angler box surveys during the 1993 season.

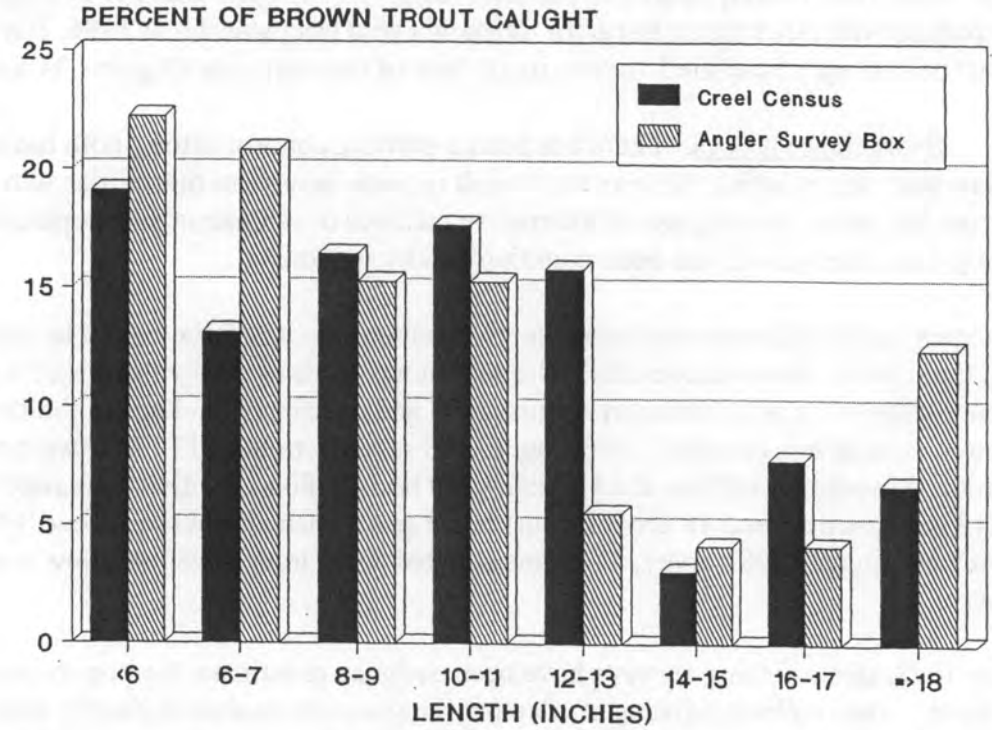

FIGURE 31. Comparison of the sizes of brown trout anglers reported catching in the creel and angler box surveys during the 1993 season.

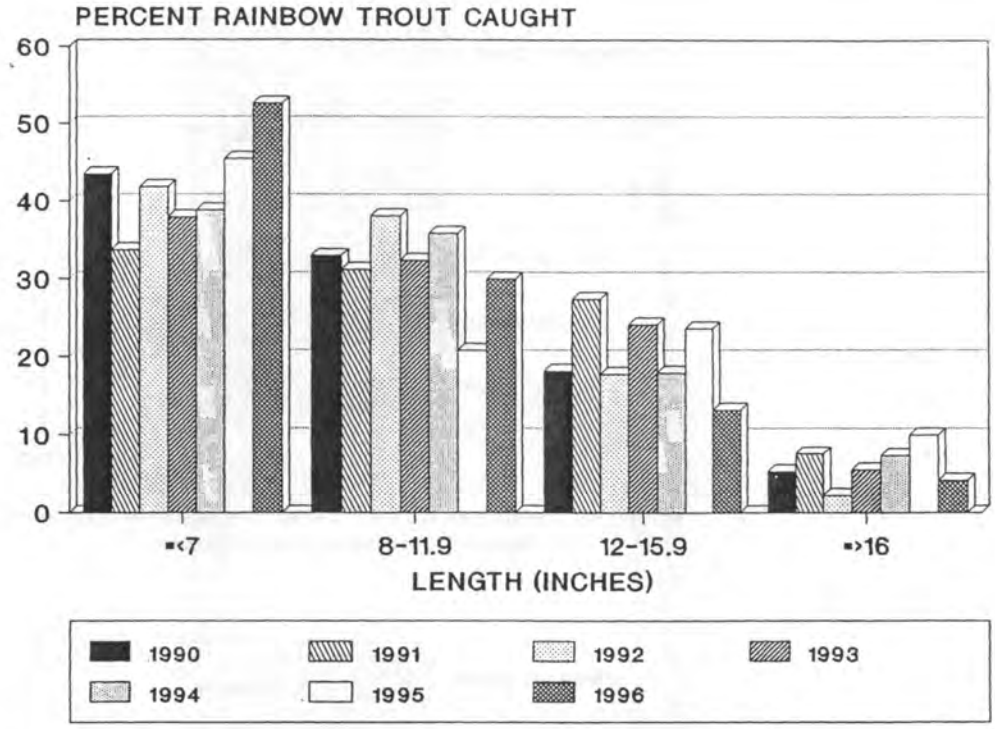

FIGURE 32. Trends in the lengths of rainbow trout landed at Hat Creek based on angler box survey forms returned during the 1990-96 seasons.

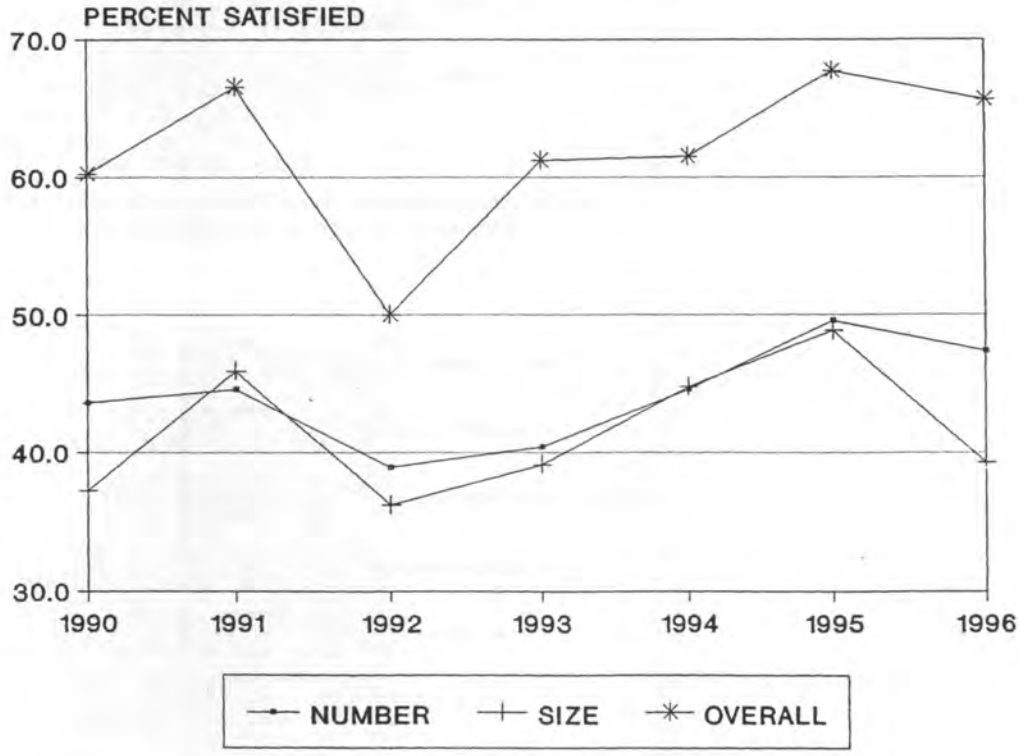

FIGURE 33. Comparisons of the percentages of anglers satisfied with the number of trout caught, size of trout caught, and overall angling experience at lower Hat Creek from 1990 through 1996.

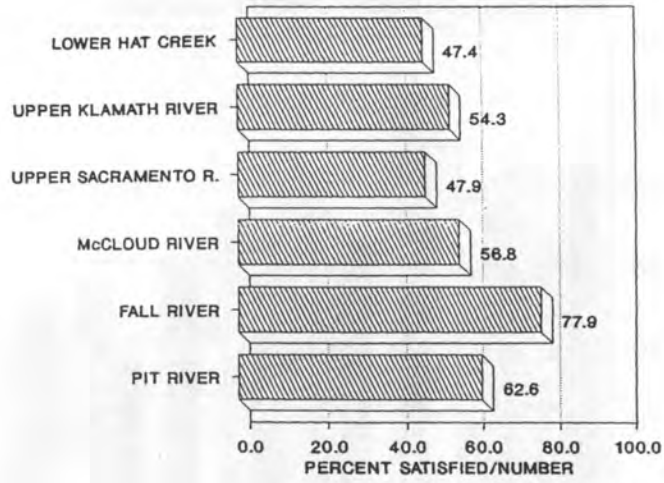

FIGURE 34. Satisfaction with number of trout landed on six northern California streams during the 1996 season.

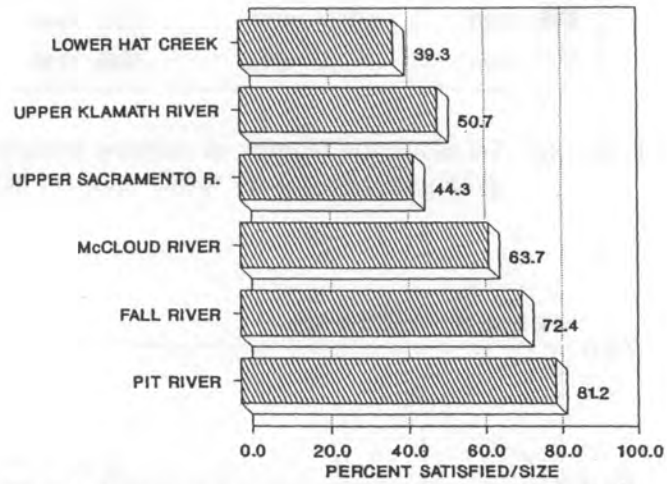

FIGURE 35. Satisfaction with size of trout landed on six northern California streams during the 1996 season.

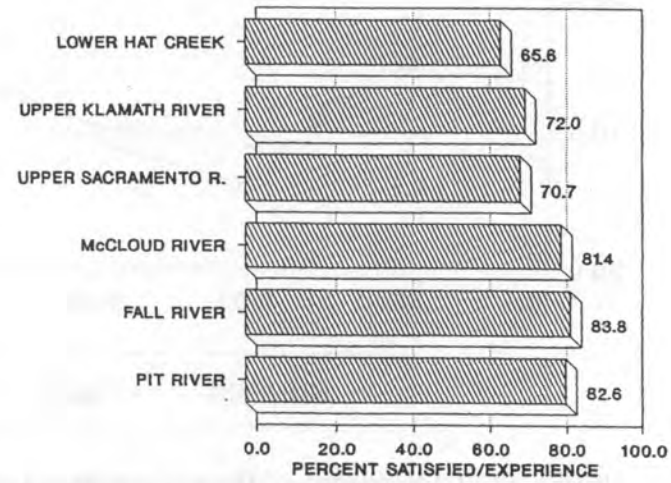

FIGURE 36. Satisfaction with the overall angling experience on six northern California streams during the 1996 season.

Divers during the first snorkeling survey divided their counts into trout <14 or ≥14 inches. During the second snorkeling survey, counts were divided into fish <6, 6-14, and ≥14 inches. The only direct comparisons between the electrofishing and snorkeling surveys, therefore, were for trout ≥14 inches. During the first snorkeling survey, divers counted 330 rainbow and two brown trout ≥14 inches. During the second dive, the counts were 404 rainbow trout and three brown trout.

Estimates of rainbow and brown trout ≥14 inches derived from electrofishing were 394 and 115 fish, respectively. The highest of the two snorkeling counts (404) and the electrofishing estimate (394) for rainbow trout ≥14 inches were surprising close. Surveys on another California stream have indicated that brown trout, due to their behavior, are more difficult for snorkelers to observe than rainbow trout and may be underestimated (Pert and Deinstadt 1997).

It should also be mentioned that snorkelers in Hat Creek may have difficulty distinguishing brown trout from rainbow trout. In Hat Creek, larger brown trout are "silvery" and lack the distinctive red spots with surrounding light halos and other coloration generally characteristic of this species in most California streams. Considering this, the counts of rainbow and brown trout could be combined, in which case, snorkelers "underestimated" the count of brown trout ≥14 inches.

Current or Potential Fisheries Management Problems

Impacts of Sediment/Drought

Based on population estimates, the sizes and numbers of rainbow trout available to anglers were substantially reduced by the impacts of the sediment mass on wild trout habitat, first observed in the upper run in 1988, and possibly combined, to an unknown extent, with the 1987-1992 drought (Figures 25 and 26). Though the upper reach of the WTA is recovering, anglers may have to wait several more years for the rainbow trout population to reach levels comparable to those present in 1983 or 1988. The fishery, therefore, will have been severely depressed for over a decade by primarily this one sediment episode and the accompanying loss of aquatic vegetation.

Recommendation 18. *Continue to document the recovery of the fishery and endeavor to make both anglers and land managers more aware of the impacts of excessive sedimentation. If the aquatic vegetation and the fishery do not recover, undertake necessary studies and corrective actions.*

Nongame Fish Populations/Fish Barrier

When Gerstung wrote the 1975 management plan, one of his major concerns in maintaining trout populations and angling quality was nongame fish competition. He listed seven danger signals

which could be identified when monitoring the catch and trout populations. Five of these seven danger signals related to nongame fish competition. If these signals (i.e., nongame fish constituting >50% of the biomass) pointed strongly to nongame fish competition as the cause of a decline in the trout population, the proposed solution was a second chemical treatment.

Since the 1968 chemical treatment, only three species of nongame fish, other than sculpins and lamprey, have become moderately abundant in the WTA: tui chub, brown bullhead, and Sacramento suckers. Tui chubs were abundant in the 1970's, but have since declined and are now present in relatively small numbers. Brown bullheads were also abundant in the 1970's, but have not been observed in the WTA during more recent surveys. Early electrofishing surveys failed to detect the presence of more than a few Sacramento suckers. By the late 1970's, however, their presence was evident and by the late 1980's, large, five- to 20-year old Sacramento suckers were being captured.

Three factors are viewed as having contributed to limiting the abundance of Sacramento suckers in lower Hat Creek since the chemical treatment. The first factor may be the continued presence of an abundant trout population. Heavy stocking of several size classes of brown trout shortly after the chemical treatment filled a void in the stream's fish population. Since the fall of 1968, the densities of brown trout, and later rainbow trout, have remained high. Though competition (and predation) between suckers and these trout populations has not been studied, it seems probable that it has contributed to limiting Sacramento sucker abundance.

Second, suckers captured during electrofishing surveys have been removed to reduce the threat of a build-up in their population. Suckers captured through 1978 were measured, weighed, fin clipped, and released back into the stream. After the 1978 survey, biologists realized that the presence of rough sculpin, a State-listed threatened species, may prevent any future chemical treatments proposed to improve the sport fishery. Recognizing that Sacramento suckers were the only nongame fish which may present a long-term threat to the trout fishery, a decision was made to remove any suckers captured in forthcoming electrofishing surveys. This decision has resulted in the removal of over 500, primarily large suckers, from the WTA.

A third factor, the fish barrier, has been the key to maintaining an abundant trout population. There is little doubt that without the barrier, the WTA would have again been overpopulated with Sacramento suckers migrating upstream from Lake Britton. Recommendations 12 and 13, regarding the maintenance and possible replacement of the barrier, are key elements in maintaining a productive sport fishery in Hat Creek.

The following additional recommendations are made in association with controlling the Sacramento sucker population:

Recommendation 19. *Sacramento suckers should continue to be captured and removed whenever electrofishing surveys are conducted.*

Recommendation 20. *If the Sacramento sucker population ever expands beyond desired levels, capture and removal of this species by electrofishing should be considered as an alternative to chemical treatment, which may kill nontarget native fish species and invertebrates.*

Angling Regulations

The 18-inch minimum size limit and artificial-lures-only gear restrictions produced a dramatic change in the lower Hat Creek fishery. In 1972 and 1973, under the two-trout limit without gear restrictions, anglers were keeping about 50 to 60% of the ≥8 to <12 inch rainbow trout and about 45% of the ≥12 to <15 inch fish. Though anglers reported catching a few hundred legal size trout in the 1983 and 1988 creel surveys, very few were kept and the stream became primarily a catch-and-release fishery. The estimated population of rainbow trout ≥12 inches in the 2.2-mile run section increased from 172 fish/mile in 1973 to 1,186 fish/mile in 1983. This increase in larger trout was attributed directly to the reduction in harvest accompanying the 18-inch minimum size limit (Deinstadt 1997).

By 1988, angling effort had increased 1.5 times, the number of trout landed increased 2.6 times, and the catch rate almost doubled the levels present in 1973 (Figures 18 through 20). Though the numbers of larger trout caught-and-released was not accurately determined, there is little doubt that it amounted to a several fold increase.

Increased rainbow trout densities combined with the low harvest rates over a 10-year period (1979-1988) produced what may be called a climax population (a population in which an unimpaired shift to large, older fish is achieved). There were two unexpected results in association with this population. First, it was expected that there would be an increase in the number of ≥12-inch rainbow trout, but that the standing crop would remain relatively unchanged. In 1983, the rainbow trout standing crop was four times higher than during preregulation surveys.

Second, while there was a major increase in the density of 12- to 15-inch rainbow trout, there was essentially no increase in the number of ≥16-inch rainbow trout. Based on age and growth data collected during the pre- and post-regulation surveys, the failure to produce more large rainbow trout may be related to a slowing of the growth rate as trout population densities increased. The absence of more trout ≥16 inches detracts little from the overall gains in the abundance of rainbow trout ≥12 inches (Deinstadt 1997).

Recommendation 21. *Retain the present two-trout bag limit and 18-inch minimum size and artificial-lure-only gear restrictions in the WTA.*

Law Enforcement

Enforcement of regulations in the WTA is vital to the success of the management program. Department wardens have large areas to cover, but are cognizant of the special nature of the wild trout fishery and patrol the stream frequently. Despite their efforts, illegal activities undoubtedly take place.

A special effort should be made to adequately post the Hat Creek County Park area. Travelers who use the park as a rest stop are often unaware of the stream's special management program and fish in violation of the angling regulations.

Recommendation 22. *Regular patrols of lower Hat Creek should be continued. Use the streamside displays and other methods to educate the public on the benefits of the regulations, especially in the Hat Creek County Park and powerhouse riffle areas. Make anglers aware of the CalTip program and encourage their participation in that program.*

Angler Impacts

Trout Mortalities from Repeated Catch-and-Release Angling. The majority of anglers currently attracted to the Hat Creek WTA fish the lower end of the powerhouse riffle. This means that 10,000 to 15,000 hours of fishing per season occurs in about 200 feet of stream (Figure 9). Given a catch rate of at least 0.5 trout/hour, anglers fishing this short reach land 5,000 to 7,500 trout/season.

If trout from downstream continually move in and out of the area at the bottom of the riffle to feed, hooking mortalities associated with catch-and-release angling (about 5% for artificial lures) (Wydoski 1977) may not appreciably impact angling quality. If, however, anglers are fishing over a more stable, "resident" population, the effects of being caught and released numerous times during a season could shorten a trout's life. If the accumulated effects of being released season after season are considered, the number of trout reaching "trophy" size could be decreased. Since so many lower Hat Creek anglers fish the powerhouse riffle exclusively, the potential impact on angling quality could be significant.

Recommendation 23. *Assess, possibly as a graduate student study, the effects of repeated catch-and-release angling on trout populations in the short, heavily-fished area at the bottom of the powerhouse riffle.*

Walking on Spawning Substrate and Redds. Angling at lower Hat Creek is heaviest in the spring and is concentrated on the lower end of the powerhouse riffle. This area has a potential for rainbow trout spawning. There has been some concern that the thousands of hours

of wading in the lower riffle may kill developing trout eggs and fry. An assessment of recently documented rainbow trout spawning periods and probable water temperatures in lower Hat Creek indicates that most fry should have emerged from the gravel by the end of April (J.D. Cook and M.J. Ellis, pers. comm., 1998). Observations during the most recent electrofishing surveys and the number of small fish reported through angler-survey box questionnaires indicated rainbow trout recruitment is currently not a problem at Hat Creek.

Recommendation 24. *If future surveys indicate rainbow trout recruitment limits the fishery, the present assumption that egg and egg/fry losses are minimal should be confirmed by an examination of redds just prior to the start of the fishing season.*

Disturbance of Aquatic Insect Habitat. As mentioned in the previous section, wading in the powerhouse riffle is heavy at times. Not only does this activity have the potential to reduce trout recruitment, but it may also impact insect populations. Riffles are prime habitat for aquatic insect production because of the large amount of surface area and cover provided by interstitial spaces between gravel and cobble substrates. As the powerhouse riffle is the only riffle section present in the upper two-thirds of the WTA, the aquatic insects it produces may be especially important to the fishery.

Extensive wading in riffles can dislodge insects and compact substrates reducing interstitial spaces. Disturbance of cobble and gravel substrates may also reduce aquatic periphyton growth, which is the preferred food of many aquatic insects. Beyond these problems, some anglers purportedly shuffle their feet along the bottom to dislodge insects.

Recommendation 25. *A literature search should be performed on the impacts of wading on aquatic insects. If the literature indicates a negative impact, an assessment should be made of the potential damage to the insect populations from wading in the powerhouse riffle. If warranted, corrective measures should then be considered.*

Brown Trout Populations

When the trout restoration project was designed in the late 1960's, some biologists and others involved thought lower Hat Creek would become a "classic brown trout fishery". About 5,000 pounds of brown trout, 200 pounds of rainbow trout, and 65 pounds of brook trout were stocked in the stream following the 1968 chemical treatment. While brown trout initially sustained the fishery, by 1973, over 75% of the catch consisted of rainbow trout. Estimates from the season-long creel surveys in 1983, 1988, and 1993, showed brown trout comprised 10.0, 6.0, and 6.3% of the catch, respectively. Out of the over 50,000 trout that anglers reported catching during those seasons, an estimated 350 were brown trout $\geq$18 inches.

During the past seven seasons, based on angler survey box reports, the percentage of brown trout in the catch has ranged from 7 to 13% and averaged 10%. While brown trout may continue to

comprise the majority of the larger size trout in the population, their contribution to the trophy fishery is currently less than that of rainbow trout. Based on the angler survey box data, brown trout comprised 6, 14, and 24% of the total 14- to15-, 16- to 17-, and ≥18-inch trout landed, respectively, from 1990-96.

Over the years, some lower Hat Creek anglers have been interested in enhancing the brown trout fishery. These anglers would like to have a greater opportunity to catch brown trout, especially the more challenging large, older fish. Since brown trout recruitment has been low for many years (including the pretreatment years), proposed enhancement has generally centered around adding gravel in areas known to be utilized by brown trout spawners. For the most part, Department biologists have resisted these proposals.

From the Department's perspective, lower Hat Creek (when habitat conditions do not appreciably reduce trout production) is one of the State's premiere wild rainbow trout fisheries. The presence of a native, "Pit River"-strain rainbow trout adds to the value of the fishery. While rainbow trout are native to the Sacramento and San Joaquin river systems, and are still the most common salmonid in most west slope streams, California has relative few "trophy" rainbow trout fisheries. The Department considers trophy rainbow trout streams, therefore, to be a limited, but exceptionally valuable resource.

The brown trout population in lower Hat Creek creates diversity and an occasional "true trophy" trout. However, the contribution of these trophy-size trout is relatively small. Given the potential life span and piscivorous nature of these larger brown trout, building up their population could negatively impact the desired rainbow trout fishery.

Recommendation 26. *While the Department recognizes the diversity in angling opportunities created by the brown trout population in lower Hat Creek, no efforts should be made to favor that species over rainbow trout.*

Recommendation 27. *The value and special qualities of the lower Hat Creek rainbow trout fishery should have a prominent place in the new informational signs proposed in Recommendation 7.*

Proposed Fisheries Management

Proposed fisheries management programs are designed to continue monitoring the recovery of the fishery, provide insights into the long-term management of a California wild trout stream, and determine whether the objectives of the management program are being achieved.

Monitoring Angling Success

Creel Surveys. Established every-fifth-year creel surveys have been the primary method of evaluating whether the angling quality objectives of the management plan are being achieved. In recent years, data from the creel surveys allowed the Department to document decreases in angler use, catch rates, and sizes of trout caught and released associated with the prolonged sediment episode. Earlier surveys helped evaluate the need for and subsequent effectiveness of the 18-inch minimum size limit and, in doing so, provided some notable side benefits to the statewide WTP. When the minimum size limit was being evaluated (1979-1988), special angling regulations were not as widely accepted as they are today. Data produced by the creel surveys were frequently used to illustrate the successful use of special angling regulations. The results also complemented the trout population survey data in helping the Department gain a knowledge of rainbow trout population dynamics in a productive spring creek.

Recommendation 28. *The every-fifth-year creel survey should continue as scheduled in 1998 and 2003. Methods established in 1972 and followed in each of the five season-long surveys conducted since that time should continue to be used.*

Recommendation 29. *Angler use and success in the powerhouse riffle should be recorded separately to help Department personnel and, possibly, a graduate student assess the impacts of concentrated fishing on the trout population and angling quality.*

Volunteer Angler-Survey-Box Program. Data obtained from the angler-survey-box program, despite some recognizable biases, are a valuable part of the current management program. Trends developed from voluntarily completed questionnaires help biologists interpret results from the every-fifth-year creel survey and population monitoring programs. These data also provide an "early warning system" for problems which might otherwise go undetected, and a method for anglers to comment on fishing conditions, habitat problems, poaching, etc.

Beyond these benefits to the lower Hat Creek fishery, the box data provide a means of annually comparing fishing quality on a regional and, periodically, a statewide basis. They also provide a method of assessing angler satisfaction on the same basis. None of these evaluations are currently available or affordable by other means.

One problem in the use of these boxes is maintaining angler interest in filling out survey forms year-after-year. To overcome this problem, the Department has prepared press releases and published newsletter articles covering the results obtained from box data. Consideration is currently being given to posting the annual results from the boxes at major streamside access points. The Department has emphasized that with over 50 waters in the WTP, anglers must now become partners in providing the data needed to manage these fisheries successfully. It is anticipated that the angler-box-survey program at lower Hat Creek and statewide will continue well into the next century.

Recommendation 30. *Continue to use the angler-survey-box program as a method of following trends in the lower Hat Creek fishery through the 2003 season.*

Recommendation 31. *To make more effective use of angler-box-survey data, continue to make comparisons between them and creel-survey data compiled in 1998 and 2003.*

Monitoring Fish Populations

Electrofishing Surveys. Electrofishing surveys, generally using mark-and-recapture techniques, were initially designed to determine if management plan objectives for trout populations were being met. They have, however, accomplished much more. The 1978 survey provided the data used to recommend the adoption of the 18-inch minimum size limit. Surveys from 1979 through 1982 documented changes in the percentages of larger rainbow and brown trout in the population, and the 1983 and 1988 surveys, in conjunction with creel surveys, showed the long-term response of the fishery to the 18-inch minimum size limit. The 1991 and 1993 electrofishing surveys showed the major changes in the rainbow trout population associated with excessive amounts of sediment.

The status of the tui chub, brown bullhead, and Sacramento sucker populations have all been monitored by electrofishing.

Stream lengths, number of nights sampled, and sizes of trout sampled during electrofishing surveys have varied with the objectives for conducting the surveys. Extensive, generally six night surveys, were conducted throughout the 2.2-mile run section at five-year intervals (1978, 1983, 1988, and 1993). Shorter duration surveys, often limited to the upper 0.6 mile on the run section, were conducted in 1975-77, 1979-1982, 1984 and 1991. Obtaining reliable estimates of young-of-the-year trout populations required several additional nights of sampling. Because of the added possibility of injuring fish and the expense involved, such surveys were abandoned in the mid-1970's. After a variety of experiences and results, electrofishing surveys have generally evolved into the present every-fifth-year monitoring program conducted in conjunction with a season-long creel survey.

The problem of injuries to rainbow trout continues to be a concern in future use of electrofishing surveys at lower Hat Creek. Based on past observations, the low percentage of such injuries is considered to be an acceptable trade-off for the more detailed and reliable data obtained by electrofishing. There is, however, a recognized need for evaluating this problem.

Recommendations regarding future electrofishing are made in conjunction with those on snorkeling.

Snorkeling Surveys. The Department's experience with snorkeling surveys is growing, but at lower Hat Creek this experience has been limited to the three surveys conducted in 1993

and 1995. The primary advantage of these surveys is that they avoid the problem of injuries to trout associated with electrofishing. Secondary advantages are that counts include trout <8 inches and are less expensive to conduct.

The data obtained by snorkeling have the following disadvantages: (1) they lack detail, (2) they are, in part, subjective, (3) they do not include confidence intervals, and (4) they may be subject to the differences in species appearance and behavior. Divers cannot generally be expected to divide their observations into more than two or three different size groups (i.e., <8, 8-14, ≥14 inches). Size distinctions are based on the divers' judgment and may vary between individuals or teams. The present snorkeling methods do not produce confidence intervals used to judge the reliability of the results. Brown trout, due possibly to their lack of distinctive coloration in Hat Creek and their secretive behavior, may not be as accurately assessed by divers as rainbow trout.

At the present time, snorkeling surveys at lower Hat Creek are being conducted in conjunction with surveys at Fall River. Assembling one team to accomplish both surveys on successive days will save travel time and expenses and, with experience, increase the team's effectiveness on at least one of the two waters.

Recommendation 32. *Continue to monitor fish populations in lower Hat Creek by conducting snorkeling surveys at least every other year. If management problems are identified which require more detailed or statistically valid population estimates, electrofishing surveys may be conducted.*

Recommendation 33. *If electrofishing surveys are necessary, try to limit these surveys to a maximum of four nights--two nights of marking and two nights of recapture. If population estimates with wider confidence intervals and, possibly, a less accurate representation of the size structure are adequate, limit the survey to one night of marking and one night of recapture.*

Recommendation 34. *When conducting electrofishing surveys, endeavor to use the techniques outlined by Deinstadt and Healey (1993). Specifically, these techniques include: (1) using the Highway 299 bridge as the downstream boundary of the sampling area, (2) taking a 5 to 7 day break between mark-and-recapture runs to reduce possible trout avoidance of the electrical field, (3) using two netters in the bow, and (4) releasing marked fish as close to the capture site as possible.*

Habitat Improvement Projects

Trout Cover. In 1986, boulder clusters were placed in lower Hat Creek below Highway 299 to create trout habitat. Researchers have since assessed their effectiveness and

found that boulder clusters by themselves do not tend to hold fish. Clusters placed close to large woody debris or near streambanks do tend to hold trout. To enhance the boulders appeal to trout, tree tops were set aside during the 1995 timber harvest which can be used as supplemental cover.

Recommendation 35. *Boulder clusters need to be surveyed and prioritized to determine where tree tops can be added most effectively. Tree tops should then be cabled to the boulders in a way that will create additional trout habitat without becoming a hazard to occasional rafters. Boulder clusters that have no value as trout cover should be moved to better locations or removed from the stream..*

Spawning Gravel. Surveys conducted in 1994, 1996, and 1997 indicate that trout are using areas of lower Hat Creek above and below the powerhouse for spawning. Trout were also observed spawning at two artificially created beds: (1) in gravel placed near the Carbon Bridge site in 1982 as mitigation for the failure of the Hat 2 flume and (2) in gravel added to the east side of the powerhouse riffle in 1993 as part of a HSU masters thesis project.

Recommendations 36. *If rainbow trout recruitment consistently limits achieving the desired fishery, consideration should be given to adding more spawning gravel.*

Fishery Research (Summary provided by Dr. Roger Barnhart, HSU Cooperative Fisheries Research Unit)

Recent Graduate Student Projects. During the period 1993-95, three projects were conducted by graduate students under supervision of the California Cooperative Fishery Research Unit at HSU. The projects were related and the overall objectives were to determine relationships between trout and various habitat characteristics in lower Hat Creek and to identify habitat problems which might be affecting trout reproduction, growth, or survival. An investigation of the effectiveness of boulder clusters and their use by trout in the riffle area below Highway 299 revealed that fish used those clusters most which had associated overhead cover in the form of attached tree tops. Some clusters need to be relocated.

An investigation of microhabitat use by trout in the glide (run) section of lower Hat Creek showed that trout distribution was strongly related to distribution and abundance of aquatic plants. Young-of-year trout used vegetation for concealment. Large trout used more open areas with large substrate elements such as chunks of diatomaceous earth as focal point locations. Dense vegetation was avoided by larger trout, possibly due to interference with sight feeding. Vegetation growth and distribution were greatly affected by sediment influx.

An investigation of spawning times and locations of lower Hat Creek trout found that rainbow trout spawned during January and February primarily in the glide section above Highway 299 and brown trout spawned in November mostly below Highway 299 in the margins of riffles. Late-season angler use of the glide section might affect spawning distribution of brown trout.

Sediment influx during the rainbow trout incubation period brought considerable sediment onto a gravel bed constructed for spawning in the riffle area below the Hat 2 powerhouse. Source of the sediment need to be identified and eliminated, if possible.

Future Graduate or Special Honors Student Projects. Two potential graduate or honor student projects related to managing the lower Hat Creek fishery have been identified. One, a study of trout mortalities from repeated catch-and-release angling, was previously discussed. The second is a need to better define the extent of possible injuries to rainbow trout caused by electrofishing. While numerous studies on this subject have been published recently, Department biologists think a study of the specific problems related to electrofishing at lower Hat Creek would be helpful in determining management options. The latter study appears to be the type suited for a special honors student project.

Recommendation 37. *Continue to work with the HSU Cooperative Fisheries Unit to select and help finance graduate student projects needed to solve fisheries management problems at Hat Creek.*

Coordinated Recovery Effort

During the 1980's, lower Hat Creek was recognized as one of California's finest wild trout fisheries and one of its comparatively rare trophy rainbow trout streams. Since the 1988 sediment episode, the stream's trophy trout status has declined and, in 1996, angler satisfaction with the Hat Creek fishery was lower than that of other major northern California's wild trout streams. Department biologists have struggled to understand why the trophy trout fishery is not recovering. They recognize the need to solve several problems, among these are muskrat damage to streambanks, sanitation facilities, and potential relocation of major access points. Identifying more fully the probable cause of the 1988 sediment episode and preventing a reoccurrence of this problem is an over-riding need. Accompanying this problem is the need to understand why the previously prolific beds of aquatic plants have failed to become re-established in some segments of the WTA.

The Department recognizes that its efforts alone will not solve the problems the fishery is now facing. It recognizes that a team effort involving the coordinated support of several parties is now needed. Hopefully, those who have had a long-term interest in lower Hat Creek will once again be willing to help solve the fisheries' current problems.

Recommendation 38. *The Department should invite major past participants in the management of the WTA, together with other interested parties, to become part of a team coordinating the funding, design, and completion of projects needed to restore the Hat Creek fishery.*

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IMPLEMENTATION SCHEDULE

Task	Responsible party	Years
Maintaining Public Access		
Monitoring WTA ownership status	Region 1	Ongoing
Seeking public ownership or implementing purchase of WTA	Region 1/FPB	If needed
Land Management		
Establishing coordination team	Region 1	1999
Evaluating need for additional sediment studies	Region 1/FPB	1998-2000
Relocating Carbon and Hat 2 parking lots		
Engineering assessment	Region 1/WIFD engineers/PG&E	1999-2000
Implementing relocation	As above	2000
Streambank conditions		
Survey of conditions	Region 1	1998
Correcting problems	Region 1	1999-2003
Angler access and use		
Evaluating need for improved trail access	Region 1/PG&E	1999
Obtaining portable restrooms	Region 1/PG&E/others	1999-2000
Replacing informational signs	Region 1	2000
Off-road vehicle control	Region 1/PG&E	As needed
Coordination timber harvest	Region 1/PG&E	As needed
Cattle grazing		
Maintaining fences	Region 1/PG&E	Ongoing
Potential tributary restoration	Region 1/PG&E	2000
Monitoring mineral extraction	Region 1	Ongoing
Instream Habitat Management		
Fish barrier		
Semi-annual inspections	WIFD engineers	1998-2000-2002
Obtaining permits	Region 1	1998
Aquatic vegetation recovery		
Funding study	Region 1/FPB	1999-2000
Establishing and maintaining photo transects	Region 1	1998-2000-2002
Aerial photo reconnaissance	Region 1	1998-2000-2002

IMPLEMENTATION SCHEDULE (continued)

Task	Responsible party	Years
Water quality		
Establish baseline data	Region 1/Others	1998-1999
Ongoing monitoring	Region 1/Others	As needed
Evaluating old channel "wild trout" designation	Region 1/FPB	2000
Fisheries Management Problems		
Documenting and publicizing sediment recovery	Region 1/FPB	1998-2003
Controlling nongame fish populations		
Sucker removal by electrofishing	Region 1/FPB	As possible
Additional removal by electrofishing	Region 1	If needed
Monitoring changes in aqueduct-penstock-PH	Region 1	Ongoing
Law enforcement within WTA	Region 1	Ongoing
Angler Impacts		
Effects of repeated catch and release angling	Region 1/HSU	Unknown
Trout egg losses due to walking on redds	Region 1	If needed
Disturbance of aquatic insect habitat		
Literature search	Region 1	Ongoing
Corrective action	Region 1	If needed
Publicizing value of native rainbow trout fishery	Region 1/FPB	Ongoing
Fisheries Management		
Monitoring angling success		
Creel censuses	Region 1/FPB	1998-2003
Angler survey boxes	Region 1/FPB	Ongoing
Monitoring trout populations		
Electrofishing surveys	Region 1/FPB	As needed
Snorkeling surveys	Region 1/FPB	1998-2000-2002
Habitat improvement projects		
Boulder cluster survey	Region 1	1998
Adding tree tops	Region 1	1999
Coordinating future graduate student projects	Region 1/HSU	As students are available

APPENDIX 1. Recommendations from "Geologic and Hydrologic Studies of Sedimentation in the Hat Creek Wild Trout Reach Shasta County, California" (Kondolf, et al. 1994).

1. Establish a reliable streamflow gage in the study reach. This could be contracted with the US Geological Survey on a cost-share basis, as is frequently done in connection with hydroelectric projects. The existing spill data are of exceedingly poor quality; even after enormous effort manipulating the existing data, we have only estimates based on poor data. Without reliable estimates of high flow (the flows at which sediment transport occurs), we are severely hampered in our ability to understand processes of fundamental importance in Lower Hat Creek.

2. Resurvey the established cross-section network biannually or after each wet year to determine changes in sediment storage in the channel.

3. Establish an oversight committee to provide guidance in management of watershed lands tributary to Lower Hat Creek. Some sort of multi-agency environmental review of land management actions in this watershed is needed to avoid potentially serious erosion impacts from well-meaning activities that might be considered routine elsewhere but would have serious consequences in this ecological sensitive setting.

4. Undertake measures to control erosion from the canal road, Carbon Bridge Road, and other roads and their road cuts. Removal of cattle from the channel margin and attempts to control sediment delivery from First and Corral creeks were steps in the right direction, but road erosion remains a major source of sediment to Lower Hat Creek.

5. Conduct a sedimentation survey in Baum Lake Reservoir to determine volume of sediment accumulation and distribution of various grain sizes as a basis for evaluating potential sediment transport through the spill gate and sink holes. This survey should be repeated to document changes in sediment storage in the future.

6. Sample sediment transport through the spill gate and issuing from the springs. Previous observations suggest that most flow (and presumably most transport) occurs at high reservoir stages, which have not occurred during this study period. Prior to high spring runoff, sediment traps could be excavated, and samples of sediment in transit during high flow could be collected and analyzed.

7. If sink holes are confirmed to be an important sediment transport path, structural changes to the Baum Lake Reservoir infrastructure should be seriously considered. These could involve moving the dam upstream to its former location (upstream of the sink holes) or draining the

APPENDIX 1. Recommendations from "Geologic and Hydrologic Studies of Sedimentation in the Hat Creek Wild Trout Reach Shasta County, California" (Kondolf, et al. 1994) (continued).

reservoir and sealing the bottom to prevent leakage. Sealing the reservoir bed would probably dry up the springs, eliminating the existing aquatic habitat in the spring-fed channel and reducing flow in the reach above the Hat-2 Powerhouse return.

8. If the spill gate is confirmed to be an important sediment transport path, construction of a sediment trap immediately upstream of Baum Lake Reservoir should be considered. This trap could be cleaned out annually, preventing bedload sediment from passing through the reservoir to the spill gate.

9. We do not recommend any instream habitat improvement structures at this time. A big part of the problem in the Pool Section is lack of transport energy, so artificial structures are likely to become buried in sediment.