Juvenile Salmonid Monitoring in Clear Creek, California, from July 2001 to July 2002

USFWS Report

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Abstract.— The U.S. Fish and Wildlife Service has been conducting a juvenile salmonid monitoring project in Clear Creek, Shasta County, California, using a rotary screw trap (RST) since December 1998. This ongoing monitoring project has three primary objectives: 1) to determine an annual juvenile passage index (JPI) for Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout/steelhead (*O. mykiss*), for inter-year comparisons; 2) obtain juvenile salmonid life history information including size, condition, emergence, and emigration timing, and potential factors limiting survival at various life stages; and 3) collect tissue samples from adult and juvenile salmonids for genetic and otolith analyses. The current report presents an annual progress review for the period from 1 July 2001 through 30 June 2002. We collected a total of 22 fish taxa, including 20 taxa of non-salmonids, and two species of salmonids. The two salmonid species collected were Chinook salmon and rainbow trout/steelhead. The total catch for all runs of Chinook salmon was 811,303, producing a JPI of 6,369,066. Measured fork lengths (FL) of Chinook salmon ranged from 18 - 123 mm, with a median of 46 mm. Data from length-at-date tables implies that populations of fall, late-fall, winter, and spring run size class Chinook salmon were collected. The 12-month JPI were 6,149,672 for fall, 205,086 for late-fall, 71 for winter and 14,237 for spring run. However, due to snorkel survey observations conducted during our sampling period, and the uncertainty of the length-at-date tables we use to designate runs, we suspect that many of the spring-run size class Chinook salmon that were collected may actually have actually been early-emerging fall-run Chinook salmon. We further suspect that our spring-run Chinook salmon catch and JPI are both overestimated. The winter-run size class Chinook salmon JPI of 71 was represented by an actual catch of only 11 individuals. The low catch, low JPI numbers, lack of fry life stage individuals, and lack of observations of adults and redds during our snorkel survey, suggests that winter-run Chinook salmon spawning did not occur in Clear Creek in 2001. We further suggest that the 11 winter-run size class Chinook salmon that were collected were likely slow-growing or late-spawned late-fall-run Chinook salmon, and that winter-run Chinook salmon were not actually collected. A total of 1,078 rainbow trout/steelhead was collected, representing a twelve-month JPI of 13,496. Fork lengths for rainbow trout/steelhead ranged from 23 - 375 mm, with a median of 61 mm.

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Introduction

The U.S. Fish and Wildlife Service (USFWS), Red Bluff Fish and Wildlife Office (RBFWO) has been conducting a juvenile salmonid monitoring project in Clear Creek, Shasta County, California using a rotary screw trap (RST) since December 1998. This ongoing monitoring project has three primary objectives: 1) to determine an annual juvenile passage index (JPI) for Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout/steelhead (*O. mykiss*), for inter-year comparisons; 2) obtain juvenile salmonid life history information including size, condition, emergence, and emigration timing, and potential factors limiting survival at various life stages; and 3) collect tissue samples from adult and juvenile salmonids for genetic and otolith analyses.

Clear Creek is a tributary of the Sacramento River. Four runs of Chinook salmon are known from the Sacramento River watershed, including fall-run, late-fall-run, winter-run, and spring-run. In the Sacramento River Valley, spring-run Chinook salmon are listed as threatened, and winter-run Chinook salmon are listed as endangered under the Federal Endangered Species Act (ESA). Also, the Central Valley steelhead, which inhabit the Sacramento River watershed, are federally listed as threatened under the ESA.

Restoration of anadromous salmonid populations in Clear Creek is an important part of the Central Valley Project Improvement Act (CVPIA). The CVPIA has a specified goal to double populations of anadromous fishes in the Central Valley of California. The Clear Creek Restoration Program authorized by Section 3406 (b)12 of CVPIA, has funded many anadromous fish restoration actions which were outlined in the CVPIA Anadromous Fisheries Restoration Program (AFRP) Working Paper (USFWS 1995), and Draft Restoration Plan (USFWS 1997; finalized in 2000).

The Clear Creek Restoration Program has five major elements (Destaso and Brown 2002): increase stream flow (Brown 1996), improve passage at McCormick-Saeltzer Dam (DWR 1997), supplement the gravel supply which has been blocked by Whiskeytown Dam (WSRCD 2000), restore the degraded stream channel (McBain and Trush 2000), and control erosion (WSRCD 1998) to prevent impacts to salmonid habitat. While all of these elements may have a positive impact on salmonid habitat and populations, the effects of the first three restoration actions will be considered in the current report.

The Dedicated Project Yield Program authorized by Section 3406(b)2 of the CVPIA has also played a major role in the success of the Clear Creek restoration by providing increased water releases from Whiskeytown Dam into Clear Creek. Increased stream flows have been the primary reason for the five-fold increase in fall Chinook spawning escapements in Clear Creek from 1995 to 2002 over the baseline period of 1967 to 1991 (Destaso and Brown 2002). Beginning in 1995, Clear Creek flows were increased to benefit fall and late-fall Chinook spawning and rearing. The flows improved fish passage into Clear Creek, improved water temperatures during spawning and rearing periods, increased the amount of spawning and rearing habitat, and contributed to record numbers of fall Chinook salmon spawning in Clear Creek (Brown 1996). The increased stream flows were based on an Instream Flow Incremental Methodology (IFIM) study performed in the 1980s (USFWS 1985, DWR 1986). The flow schedule was improved for salmonids in the 1990s by incorporating temperature modeling (UC Davis 1998) and improvements in understanding salmonid life history in Clear Creek (Brown 1996). The flow schedule at Clear Creek was further improved for salmonids by providing more naturalistic flow ramping rates, adequate water temperatures for newly emerged late-fall Chinook and steelhead, and a more harmonious balance between higher flows that benefit spawning habitat versus lower flows that benefit rearing habitat.

Beginning in 1999, Clear Creek stream flows were increased in the summer to benefit spring-run Chinook and steelhead. Other significant actions taken specifically for spring-run Chinook and steelhead have included the removal of McCormick-Saeltzer Dam in 2000, and placement of spawning-sized gravel for steelhead below Whiskeytown Dam and the Placer Road Bridge.

Funding for RST sampling from December 1998 through June 2001, came from the Clear Creek Restoration Program. A report summarizing data from this period is planned for completion in the next year. Operations beginning in 1 July 2001, which are included in this report, were funded by CALFED through the 2001 Proposal Solicitation Package, and administered by the National Fish and Wildlife Federation.

Originally we anticipated that RST sampling operations would occur annually from December through June(CAMP 1997). In 1999, a Biological Opinion was issued for Central Valley steelhead and spring Chinook by the National Marine Fisheries Service (NMFS) for the U.S. Bureau of Reclamations' operation of the Central Valley Project. This Biological Opinion required that releases from Whiskeytown Dam to Clear Creek be provided to support steelhead rearing downstream of McCormick-Saeltzer Dam during the summer of 1999. The increased stream flows from 1 June to 1 October could also potentially increase attraction of Federally endangered winter-run Chinook salmon and Federally threatened spring-run Chinook salmon into Clear Creek. Due to this potential, RST sampling was expanded to a year-round schedule to evaluate the impact on winter-run and spring-run Chinook salmon, and to evaluate the benefits to steelhead juveniles using the increased flows.

This report presents an annual progress review of RST sampling in Clear Creek for the period from 1 July 2001 through 30 June 2002. This reporting year is based on the date that the funding contract for the project went into effect. Data from this report will be incorporated into a comprehensive report covering the periods sampled from 1998 through 2002. This comprehensive four-year report is targeted for release in 2003.

Study Area

Clear Creek is a tributary of the Sacramento River in Shasta County, California. The lower portion of Clear Creek flows southeast from Whiskeytown Reservoir approximately 18.1 river miles to the Sacramento River (Figure. 1). The lower Clear Creek watershed, located below Whiskeytown Dam, covers an area of approximately 48.9 $miles^2$, and receives supplemental water from a cross-basin transfer between Lewiston Lake in the Trinity River watershed and Whiskeytown Reservoir in the Sacramento River watershed. Most of the land in the lower Clear Creek watershed is undeveloped, with scattered private residences, gravel mining operations, light industrial, and commercial use being present. Land ownership in this area is a combination of private, commercial, state, and federal entities (including the Bureau of Land Management and National Park Service).

The geological formations of the lower Clear Creek watershed area are primarily composed of assorted granitics, clays, and sands. Some areas of the Clear Creek stream channel have been hydraulically scoured so extensively by high creek flows or past years of gravel and gold mining, that only clay hardpan remains. Whiskeytown Dam acts as a sediment trap, and the lower portion of Clear Creek is sediment starved. This sediment starvation limits recruitment of gravel and cobble below the dam that is needed by spawning salmonids for building their redds.

Ambient air temperatures range from approximately 32 °F in winter to summer highs in excess of 115 °F. Most precipitation falls into this watershed as rainfall. The average rainfall in the Clear Creek watershed ranges from approximately 20 inches in the lowest elevations to more than 60 inches in the highest elevations. Most of the watershed's rainfall occurs between November and April, with little or none occurring during the summer months (McBain and Trush et al. 2000).

The rotary screw trapping site for this project was located 1.7 river miles (RM) above the confluence with the Sacramento River (latitude 40^0 30' 23" north, longitude 122^0 23' 45" west). This location is about 16.4 RM downstream of Whiskeytown Dam. The RST is situated in the thalweg of the channel, about eight feet downstream of a channel constriction. The stream gradient here ranged from approximately 1 - 1.5 degrees. The creek bottom at this location is primarily composed of gravel and cobble. The creek's riparian zone vegetation in this area is dominated by willow (*Salix* spp.), cottonwood (*Populus sp.*), Himalayan blackberry (*Rubus discolor*), and various sedges and grasses. Canopy cover of the riparian vegetation over the channel in the sampling area is generally less than 5%.

Methods

Sampling protocol.—Sampling for juvenile salmonids in Clear Creek was accomplished by using standardized RST sampling techniques that generally were consistent with the CVPIA's Comprehensive Assessment and Monitoring Program (CAMP) standard protocol (CAMP 1997). The RST deployed in Clear Creek, is manufactured by E.G. Solutions®, Corvallis, Oregon. This type of trap consists of a 5-foot diameter cone covered with 3-mm diameter perforated stainless steel screen. This cone acts as a sieve which separates fish from the sampled water. The cone is supported between two pontoons and it's auger-type action passes water, fish, and debris to the rear of the trap, and directly into an aluminum live box. This live box retains fish and debris, and passes water through screens located in its back, sides, and bottom.

We selected two trees with diameter-at-breast height measurements of approximately 12 - 18 inches on opposite banks of the creek to use as attachment points for the traps for securing the RST in the thalweg of Clear Creek. The trees were approximately 240 feet apart, and far enough above the flood plain to avoid most flood waters. Using these trees as anchors, the RST was positioned with a system of cables, ropes, and pulleys. The RST was fished during the current study period from 3 July 2001 through 30 June 2002. An attempt was made to fish the RST 24-hours per day, seven days each week.

Fisheries crews typically accessed the RST by wading from the creek banks. However, for crew access during higher flows, the RST was pulled into shallow water for boarding. After being serviced, the RST was returned back to the thalweg as soon as possible to begin fishing again. The RST was serviced once per day unless high flows, heavy debris loads, or high fish densities required multiple trap checks to avoid mortality of captured fish or damage of equipment.

At each trap servicing, crews would process the collected fish, clear the RST of debris, provide maintenance, and obtain environmental and RST data. Collected data included dates and times of RST operation, creek depth at the RST, RST cone fishing depth, number of rotations of the RST cone, amount and type of debris collected, basic weather conditions, water temperature, current velocity, and water turbidity. Water depths were measured using a graduated staff to the nearest 0.1 feet. The RST cone fishing depth was measured with a gauge that was permanently mounted to the RST frame in front of the cone. The number of rotations of the RST cone was measured with a mechanical stroke counter (Redington Counters, Inc., Windsor, CT) that was mounted to the RST railing adjacent to the cone. The amount of debris in the RST was volumetrically measured using a 10-gallon plastic tub. Water temperatures were continuously obtained with an instream Onset Optic StowAway® temperature data logger. Water velocity was measured as the average velocity from a grab-sample using an Oceanic® Model 2030 flowmeter (General Oceanics, Inc., Miami, Florida). This average velocity was measured in the time period when the live box of the RST was being cleared of debris and the fish sorted from this debris. Water turbidity was measured from a grab-sample with a Hach® Model 2100 turbidity meter (Hach Company, Ames, Iowa).

To remove the contents of the RST live well for examination, we used dip nets to scoop debris and fish onto a sorting table. When the number of all fishes collected in the RST was less than approximately 250 individuals, we counted and measured all fishes while on the aft deck of the RST. When catch exceeded approximately 250 individuals, fishes were transported from the RST and placed in several 25-gallon buckets. When fish numbers collected were greater than approximately 5,000, one or two 60-gallon containers were used as needed to temporarily contain the fish. These containers were constructed with flow-through mesh sides to provide a continuous supply of fresh water when placed in the creek.

We collected juvenile Chinook salmon and rainbow trout /steelhead specimens for the California Department of Fish and Game (CDFG) during the period from May 2002 through June 2002. These otoliths were to be used by CDFG as part of an ongoing Chinook salmon and rainbow trout/steelhead study associated with their Stream Evaluation Program.

Counting and Measurement.—We counted and obtained length measurements (to the nearest 1.0 mm) for all fish taxa that were collected. Counts and measurements were also generated for mortalities for each fish taxa. Fish to be measured were first placed in a 1-gallon plastic tub and anesthetized with tricaine methanesulfonate (MS-222; Argent Chemical Laboratories, Inc. Redmond, Washington) solution at a concentration of 60 - 80 mg/l. After being measured on a wet measuring board with wet hands, the fish were placed in a 10-gallon plastic tub that was filled with fresh creek water to allow for recovery from the anesthetic effects before being released back into the creek. Water in the tubs was replaced as necessary with fresh creek water to maintain adequate temperature and oxygen levels. Due to the large numbers of juvenile salmon that were frequently encountered, and project objectives, we used different criteria to count salmon, trout, and non-salmonid species:

Chinook salmon.—When less than approximately 250 salmon were collected in the RST, all were counted and measured for fork length (FL). The measured juvenile salmon were assigned a life-stage classification of fry, parr, silvery parr, or smolt. For all Chinook salmon that were counted and measured, we also assigned run designations, using length-at-date criteria from Greene (1992). These designations included fall-run, late-fall-run, winter-run, or spring-run.

When more than approximately 250 juvenile salmon were captured, subsampling was conducted. To conduct the subsampling, a cylinder-shaped 1/8" mesh “subsampling net” with a split-bottom construction was used. The bottom of the subsampling net was constructed with a metal frame that created two equal halves. Each half of the subsampling net bottom was built with a mesh bag that was capable of being tied shut, however, just one side was tied shut and the other side was left open. This subsampling net was placed in a 25-gallon bucket that was partially filled with creek water. All collected juvenile salmon were poured into this bucket. The net was then lifted, resulting in a halving of the sample. Approximately one-half of the salmon were retained in the side of the net with the closed mesh bag, and approximately one-half of the salmon in the side with the open mesh bag were left in the bucket. We successively subsampled until approximately 150 - 250 individuals remained. The number of successive splits that we used varied with the number of salmon collected, from one split (= ½ split) and occasionally up to seven splits (= 1/128 split).

After subsampling the salmon to the appropriate split, all fish in the subsample of approximately 150 - 250 individuals were counted and measured for FL. These salmon were also assigned a life-stage classification and run designation, using the methods previously described above. We proceeded to successively count all salmon in each split until at least 5,000 salmon were counted. If more salmon remained after counting approximately 5,000 salmon, we estimated the remainder of the catch by calculating the number of fish counted in each successive split, and multiplying by the appropriate split factor. Using this method, we mathematically estimated the total number of salmon collected in the RST, estimated the number of mortalities, and assigned run designation for uncounted and unmeasured salmon. However, we did not subsample size classes of Chinook salmon that were not abundant, especially those size classes that were known to represent a different run than the bulk of the catch. For these less common size classes, we segregated them from the rest of the catch to conduct an actual count and mesurement. This methodology allowed us to attain a more accurate count than the subsample-and-proportion method.

Rainbow trout/steelhead.—Due to the smaller numbers encountered, we counted and measured the FL of all rainbow trout/steelhead that were collected in the RST. Life stages of juvenile trout were classified similarly as salmon, with the addition of a yolk-sac fry life stage, as requested by the Interagency Ecological Program (IEP) Steelhead Project Work Team. Rainbow trout/steelhead were classified as one of the following yolk-sac fry, fry, parr silvery parr, or smolt. To comply with IEP protocol, we weighed all collected juvenile rainbow trout/steelhead larger than 50 mm FL to the nearest 0.01-gram using a battery-operated Ohaus Scout® digital scale (Ohaus Corporation, Florham Park, New Jersey).

Non-salmonid taxa.—For non-salmonid taxa, we counted all individuals that were collected, but only measured up to 30 randomly selected individuals for each taxa. We measured the total length for lamprey, cottids, and western mosquitofish (*Gambusia affinis*), and measured the FL for all of the other non-salmonid taxa.

Catch data for all fish taxa were typically consolidated to represent weekly sums, medians, and means. Our sampling weeks were identified by year and number. Our first sampling week of the current study was during Week #27 in 2001, and the last sampling week was during Week # 27 in 2002 (Table 1).

Mark-recapture efficiency estimates.—One of the goals of our monitoring project is to develop an estimate of the number of juvenile salmonids passing downstream in a given unit of time, usually in a given week or year. We call this estimate a juvenile passage index (JPI). Since the RST only captures fish from a small portion of the creek cross section, we needed to implement a method to project the RST catch numbers to parts of the creek outside of the RST capture zone. Accordingly, we needed to determine the efficiency of the RST to catch all juvenile salmonid species moving downstream during a given time period. By determining the RST efficiency, we were able to calculate a JPI from the actual catch. To determine efficiencies of the RST, mark-recapture trials were conducted.

During periods when juvenile Chinook salmon capture was sufficient and weather permitted, mark-recapture trials were attempted twice weekly. We generally attempted to mark between 500 to 1,000 juvenile Chinook salmon for each trial, with a goal to recapture at least 30 marked individuals**.** In an effort to meet our goal of recapturing a minimum of 30 individuals, we generally did not conduct mark-recapture studies during periods when numbers of juvenile salmon captured were less than about 200 individuals.

Only naturally-produced (unmarked, unclipped, and untagged) juvenile salmon captured by the RST were used for mark-recapture trials. We used either a single mark or a dual mark to mark salmon over the course of the study period. Single-marking was used when our releases of marked salmon occurred more than five days apart, and when CDFG or other agencies including USFWS, was not actively conducting salmon mark-recapture studies at a nearby location. This CDFG sampling station is located near Ball's Ferry in the Sacramento River, 10.9 river miles downstream of Clear Creek. Dual-marking was used when our releases occurred less than five days apart, or when CDFG was actively conducting similar studies at their Ball's Ferry station. The methods used for single-marking and dual-marking are described below:

Single-marking technique.—Our single-marking technique consisted of immersion staining of salmon with Bismarck brown-Y stain (J.T. Baker Chemical Company, Phillipsburg, New Jersey). The Bismarck brown was applied at a concentration of 8 grams / 380 liters of water (211 mg / liter), and allowed a 50-minute contact time. Due to the frequently high air temperatures in late spring and the summer months, a portable water chiller unit was used during these times to maintain ambient stream temperatures and reduce stress and mortality during the staining process.

Dual-marking techniques.—To conduct our dual-marking procedures, we first single-marked the salmon with Bismarck brown, as described above. After staining with Bismarck brown was completed, the fish were anesthetized with an MS-222 solution at a concentration of 60 - 80 mg/l. After the salmon were anaesthetized, we used either Photonic® tagging (New West Technologies, Santa Rosa, California) or caudal fin clipping to attain a second mark.

Photonic tagging involves the subcutaneous injection of fluorescent latex microspheres into the fish. This system uses high air pressure, rather than needles, to inject the latex marking solution. This injection system allows for multiple mark types based on tag color and location of application (e.g. dorsal, caudal, or anal fin). For the current project, we used different color tags (blue, pink, orange, or green) placed at the base of the caudal fin to designate specific release groups by date.

We utilized caudal fin clipping as a backup when Photonic tagging equipment was not functioning well. To perform the fin clips, we used small surgical scissors, removing an area of approximately 2 mm^2. To designate different release dates, we marked salmon by clipping a small portion from either the upper or lower caudal fin lobe.

After the single-marking or dual-marking procedures were completed, the marked juvenile salmon were placed in a live car and allowed to recover overnight in the RST live well. This overnight detention allowed us to more reliably detect salmon with latent injuries and mortalities resulting from the marking procedure, so that they could be detected and removed from use in the recapture trials. On the following evening, weak, injured, and dead fish were removed. The remaining fish were counted and transported 0.5 river miles upstream of the RST sampling site to be released. We scheduled such releases in the evening no earlier than 15 minutes before sunset. The nighttime releases of marked fish were designed to 1) reduce the potential for unnaturally high predation on salmon that may be temporarily disorientated by the transportation, and 2) imitate the tendency for natural populations of outmigrating Chinook salmon to move downstream primarily at night (Healey 1998; USFWS, RBFWO, unpublished data). The stained and marked Chinook salmon that were recaptured later by the RST were counted and measured. After being allowed to recover, they were released downstream of the RST to prevent them from being recaptured again.

Trap efficiency estimates were calculated by dividing the number of recaptured juvenile Chinook salmon by the number of released juvenile Chinook salmon (# recaptured / # released).

Trap efficiencies calculated from the mark-recapture trials were used to generate daily JPIs (JPI = total number of each salmonid species captured per day / daily trap efficiency) individually for Chinook salmon and rainbow trout/steelhead using methods described by Thedinga et al. (1994) and Kennen et al. (1994). We combined the daily JPIs to calculate a JPI for each week of our reporting period for each salmonid species. For Chinook salmon, we calculated a separate JPI for each run, and also calculated a total JPI for all runs combined. We numbered our JPI sampling period by year and week (from 1 through 52 for each year) throughout the study (Table 1).

For dates when sampling was not conducted, or when samples were lost or compromised, we used the mean JPI of an equal number of days before, and an equal number of days after, the missing number of sample days. For example, if we were missing three days of sampling data, we would calculate the average of the three sampled days before and three sampled days after the missing period. This calculated average of six sampled days would then be used as the same surrogate value for each of the three days of missing values.

Modifications to reduce mortality and improve efficiency.—During periods of high salmon outmigration, we often implemented a modification in the RST to reduce potential negative affects to juvenile salmon created by overly high fish densities. We implemented this "half-cone modification" to the RST by placing an aluminum plate over one of the two existing cone discharge ports and removing an exterior cone hatch cover. This created a condition where 50% of the collected fish and debris were not collected into the live well, but were discharged from the cone into the creek. This effectively reduced our catch of both fish and debris by 50%, and reduced crowding of fish in the live well. When the RST was fished in this manner, we multiplied the catch numbers for each fish taxa by 2.0 to obtain a corrected value for each taxa.

In addition to the half-cone modification described above, we performed several other modifications to the RST equipment and operations to provide for greater protection to collected fishes and greater efficiency of collection. Other modifications to RST equipment included enlarging the size of live wells, increasing the size of flotation pontoons, and adding live well baffles. Modifications to RST operations have included the use of day and night sampling, water chilling units, and summer work hour changes. To improve JPI computation, we strived to regularly fish high flows when most juvenile salmonids are thought to outmigrate, marked large numbers of salmon, and increased the frequency of mark-recapture trials from previous years.

Results

Sampling Effort

We operated the RST for 296 days of the 365-day report period. This represents 81.1% of the available sampling days. Only 284 of the 296 days sampled (77.8% of the sampling period) were considered successful, because on 12 sampling days heavy debris loads caused the RST cone to cease rotation.

We did not schedule RST sampling on 69 days (18.9% of the sampling period) due to the following reasons: 3 days due to high flows, 3 days due to holidays, and 63 days due to a reduced sampling schedule. Based upon our experience in sampling previous years, we expected to catch consistently low (or zero) daily salmonid numbers in the period from the beginning of July through October. Accordingly, we initiated a reduced sampling schedule of only four or five days per week from 1 July through 21 October 2001, and did not sample for 39 days in this period. During April and May 2002, a reduced sampling schedule was instituted on 24 days due to low staffing levels. The reduced sampling effort in this period was typically reflected in fishing the RST only four days per week.

Due to high juvenile Chinook salmon densities that were either encountered or anticipated, we applied the half-cone modification during the period from 20 December 2001 through 7 May 2002. During this period we fished the RST a total of 117 days. Accordingly, the half-cone modification was utilized 39.5% of the time that the RST was fished.

Physical Criteria

Stream discharge at the study site was approximated by using the U.S. Geological Survey Igo gaging station, located approximately 9.2 river miles above the RST sampling site. Using these data, we determined that mean daily flows ranged from a minimum of 71 cubic feet per second (cfs) in August 2001 to a maximum of 1840 cfs in January 2002. As exemplified by the dates of the minimum and maximum creek discharges, flows typically were the lowest in the summer months, and highest in the winter months (Figure 2). From December 2001 through March 2002, we experienced the highest flows of the study period, which had high mean daily ranges from approximately 600 - 1840 cfs. Except when debris loads were heavy, the RST was physically capable of successfully operating in all of these flows. In fact, we commonly fish our Clear Creek RST in flows as high as 1,900 cfs.

The channel width of Clear Creek at the RST varied from approximately 30 feet at the lowest flows to more than 148 feet at the highest flows. The narrowest channel is typically present during late summer when the flows are lowest. The greatest channel widths are typically present during the winter months, when the highest flows are experienced.

Water depths in Clear Creek at the base of the RST cone varied from 2.5 feet to greater than 5.0 feet, with an average depth of 3.1 ft. The lowest depths were recorded during June 2002, and the deepest depths were recorded from late November 2001 through February 2002.

Turbidity levels ranged from 0.01 nephelometric turbidity units (NTU) in June 2002 to 49.8 NTU in January 2002, with a mean turbidity of 2.0 NTU. Turbidity was typically the lowest during the lower flows of summer, and tended to increase during the higher winter flows (Figure 2).

Mean daily water temperatures ranged from a low of 42.1 °F on 30 January 2001 to 70.7 °F on 26 July 2001. The warmest water temperatures typically were experienced during July and August, while the coolest water temperatures were experienced during January and February. Typically, winter water temperatures were 20 - 30 °F cooler than summer values (Figure 3).

Fish Assemblage

A total of 812,746 individual fish, represented by 22 fish taxa was collected in our RST during the sampling period (Table 2, 3). The most abundant fish taxa collected were Chinook salmon, rainbow trout/steelhead, hardhead, lamprey fry, cottid fry, riffle sculpin, and Sacramento pikeminnow (Table 4).

Non-salmonids.—We collected a total of 1,443 individual non-salmonids from 20 taxa. The most abundant non-salmonids included hardhead (*Mylopharodon conocephalus*), cottid fry (*Cottus* spp.), lamprey fry (*Lampetra* spp.), riffle sculpin (*Cottus gulosus*), Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), Cyprinoidea larvae (Superfamily Cyprinoidea), and Pacific lamprey (*Lampetra tridentata*) (Table 3, 4). These dominant non-salmonid taxa are discussed below:

Hardhead.—With a total of 225 collected, the most common non-salmonid taxa by number was hardhead. Hardhead were collected throughout the year. The greatest numbers were collected during January 2002, with 42 being captured. Fork lengths ranged from 26 - 375 mm, with a median of 74 mm.

Cottid fry.—A total of 211 unidentified cottid fry was collected. This taxon was likely represented by smaller-sized riffle sculpin and prickly sculpin (*C. asper*). Individuals from this taxon were collected from July 2001 until September 2001. The abundance peak occurred during July 2001, when a total of 205 was collected. Fork lengths ranged from 21 - 39 mm, with a median of 30 mm.

Lamprey fry. —A total of 167 unidentified lamprey fry was collected. Individuals from this taxon were likely represented by Pacific lamprey (*Lampetra tridentatus*), and possibly may have also included Pacific brook lamprey (*L. pacifica*) and river lamprey (*L. ayresi*). Lamprey fry were primarily collected during the winter and early spring, with abundance peaks in January 2002 (28 individuals) and March 2002 (86 individuals). Total lengths ranged from 55 - 167 mm, with a median of 127 mm.

Riffle sculpin.—A total of 165 riffle sculpin was collected. Individuals from this species were collected year round, with abundance peaks in July 2001 (54 individuals) and April 2002 (22 individuals). Fork lengths ranged from 24 - 116 mm, with a median of 45 mm.

Sacramento sucker.—A total of 133 Sacramento sucker was collected. Individuals from this species were collected year round, with abundance peaks in July

2001 (40 individuals) and November 2001 (37 individuals). Fork lengths ranged from 24 - 373 mm, with a median of 39 mm.

Sacramento pikeminnow.—A total of 132 Sacramento pikeminnow was collected. Individuals from this species were collected year round, with the peak abundance in July 2001 (20 individuals) January 2001 (44 individuals). Fork lengths ranged from 28 - 500 mm, with a median of 116 mm.

Cyprinoidea fry.—A total of 122 unidentified fry from the Superfamily Cyprinoidea was collected. Individuals from this taxon likely were represented by such species as hardhead, Sacramento sucker, Sacramento pikeminnow, and speckled dace (*Rhinichthys osculus*). We collected 98% of the Cyprinoidea fry (119 individuals) during July and August of 2001. Total lengths ranged from 16 - 33 mm, with a median of 25 mm.

Pacific lamprey.—A total of 94 Pacific lamprey was collected. We collected identifiable Pacific lamprey from October 2001 through January of 2002. However, approximately 93% were collected during November (21 individuals) and December (66 individuals). Total lengths ranged from 107 - 187 mm, with a median of 130 mm.

Chinook salmon.—The only species of salmon collected was Chinook salmon. Length-at-date data of Greene (1992) indicated that we potentially collected individuals from all four Chinook salmon runs known from the Sacramento River basin. A total of 811,303 individuals was collected from all runs, representing 99.82% of the total fish collected by number for all species (Table 5). This value provides adjustments for days when the half-cone modification was implemented. When adjusted for RST efficiency values and days not fished, this total of 811,303 extrapolates to a twelve-month JPI of 6,369,066. The highest JPI values for all combined Chinook runs occurred during weeks 1 through 10 in 2002 (January to March), a period when all weeks produced a JPI greater than 250,000, and a median value of 423,381. The largest JPI values occurred during week 6 (1,133,668), week 5 (669,793), and week 2 (555,640). The maximum catch number for all runs of Chinook collected in one sampling day was on 8 February 2002, when a total of 71,232 individuals were collected, and produced a daily JPI of 611,959. The lowest JPI values were experienced in 2001 during weeks 34 - 45 (August to November), when the median weekly values were 4 (Table 5).

We collected a total of 76 juvenile Chinook salmon for otolith analysis by CDFG for their Stream Evaluation Program. All of these specimens were collected from catch mortalities.

Fork lengths for all runs of Chinook salmon ranged from 18 - 123 mm, with a median of approximately 46 mm (Table 4). The smallest fork lengths were represented by a size class ranging from approximately 18 - 30 mm, which predominantly was constituted by yolk-sac fry. This size class was primarily collected from mid-November through late December (weeks 46 - 52), and according to Greene (1992) were predominantly classified as fall-run size class, however, spring-run size class were also found (Figure 4). The largest fork lengths were represented by smolt size classes ranging from approximately 80 - 123 mm. The majority of these smolt were collected during 2001, from September through December (weeks 37 - 52), and according to Greene (1992) were predominantly classified as late-fall-run Chinook (Figure 4). A secondary abundance peak of larger size class Chinook salmon (approximately 80 - 105 mm) was collected from late May through late June of 2002 (weeks 22 - 27), and according to Greene (1992) were primarily classified as fall-run (Figure 4). In general, we tended to collect a greater number of Chinook salmon from smaller size classes, with the majority of individuals being 39 mm or less in FL (Figure 5). Data trends for each run of Chinook salmon are discussed below:

Fall-run Chinook salmon.—With a total of 798,793 fall-run size class Chinook salmon collected, this race was the most abundant. Fall-run size class Chinook salmon constituted 98.46 % by number of all Chinook salmon collected. As a result of this dominance, the trends in abundance described above for all Chinook salmon runs is largely defined by the trends of the fall run. The 12-month JPI for fall-run size class Chinook salmon was 6,149,672, which is 96.56% of the 12-month JPI for all runs of Chinook salmon (Table 6). The highest JPI values for fall-run size class Chinook salmon occurred during weeks 1 through 10 in 2002 (January to March), a period when all weeks produced a JPI greater than 250,000, and a median value of 423,236. The largest JPI values of the study period fall-run size class Chinook salmon occurred during week 6 (1,133,668), week 5 (669,793), and week 2 (554,874) (Table 6, Figure 6). The maximum number of fall-run size class Chinook collected in one sampling day was on 8 February 2002, when a total of 71,232 individuals was collected, and produced a daily JPI of 611,959. The lowest fall-run size class JPI values of the study period were experienced in 2001 during weeks 34 - 47 (August to November), when the median value was 0 (Table 6, Fig 6). Approximately 69.76% of the 31,593 fall-run size class Chinook salmon that were measured fell into the 30 - 39 mm size range, and 12.51 % were in the 40 - 49 mm size range (Figure 5).

Late-fall-run Chinook salmon.—Late-fall-run size class Chinook salmon were the second most abundant run, with a total of 11,048 collected. Late-fall-run size class accounted for 1.36% by number of all Chinook salmon collected. The 12-month JPI for late-fall-run size class Chinook salmon was 205,086, which was 3.22% of the 12-month JPI for all runs of Chinook salmon (Table 7). The maximum JPIs of late-fall run size class Chinook salmon were encountered in 2002 during weeks 16 - 22 (April through May), a period with all values more than 12,000, and a median value of 19,923. The maximum weekly JPI value of 46,834 occurred in week 20 (May; Figure 7). The maximum number of late-fall-run size class Chinook collected in one sampling day was on 2 May 2002, when a total of 626 individuals was collected, and produced a daily JPI of 5,467. The lowest late-fall-run size class JPI values of the study period were generally experienced from week 34 in 2001 through week 13 in 2002, a period with a median JPI of 0 (Table 7, Figure 7). More than 35.9% of the 5,406 late-fall-run size class Chinook salmon that were measured fell into the 30 - 39 mm size range, and 42.1% were in the 40 - 49 mm size range (Figure 5).

Winter-run Chinook salmon.—We collected a total of 11 juvenile Chinook salmon that were measured to be in the winter-run size class, representing 0.0014% of the total Chinook salmon catch by number. The 12-month JPI for winter-run size class Chinook salmon was 71, which is 0.0011% of the 12-month JPI for all runs of Chinook salmon (Table 8). Winter-run size class Chinook salmon were collected only during weeks 48 - 50 in 2001 and weeks 3 - 12 in 2002, with maximums of only one or two individuals being collected in any sampling day. The highest weekly JPI values occurred during 2002, with a value of 26 individuals for week 8 and 16 individuals for week 12 (Table 8, Figure 8). The winter-run size class Chinook salmon displayed a distinctly different fork length frequency distribution than the other three Chinook salmon run size classes. This difference is that only larger size classes were collected, from 80 - 119 mm. No smaller size classes were collected (Figure 5).

Spring-run Chinook salmon.—We collected a total of 1,450 spring-run size class Chinook salmon. This run accounted for 0.18% of the total Chinook salmon catch. The 12-month JPI for spring-run Chinook salmon was 14,237 which was 0.22% of the 12-month JPI for all runs of Chinook salmon (Table 9). The maximum JPI of spring-run size class Chinook salmon was encountered in 2001during weeks 48 - 51, a period with all values greater than 1,260, and a median value of 1,670. The highest weekly JPI value of 3,267 occurred during week 49. The maximum number of spring-run size class Chinook salmon collected in one sampling day was on 7 December 2001, when a total of 82 individuals was collected, and produced a daily JPI of 415. The lowest spring-run JPI values of the study period were generally experienced in 2001 during weeks 27 - 45 (July to November) and in 2002 during weeks 20 - 27 (May through June) when JPIs were 0 (Table 9, Figure 9). Approximately 72.8% of the 630 spring-run size class Chinook salmon that were measured fell into the 30 - 39 mm size range, and approximately 15.8% fell into the 18 - 29 mm size range (Figure 5).

Rainbow trout/steelhead.—A total of 1,078 rainbow trout/steelhead individuals was collected. When adjusted for RST efficiency values and days not fished, this total extrapolates to a twelve-month JPI of 13,496 (Table 10). The highest JPI values for rainbow trout/steelhead occurred during weeks 10 through 26 in 2002 (March through June), with weekly values ranging from 127 to 2,738, and a median of 619. The highest weekly JPI occurred during week 16 (April; Table 10, Figure 10). The maximum number of rainbow trout/steelhead collected in one sampling day was on 16 April 2002 (week 16), when a total of 52 individuals was collected, and produced a daily JPI of 224. The lowest JPI values were experienced in 2001 during weeks 34 - 44 (August - October), when the median weekly values were 0 (Table 10, Figure 10).

Fork lengths for rainbow trout/steelhead ranged from 23 - 375 mm, with a median of 61 mm (Table 4, Figure 11). The smallest fork length rainbow trout/steelhead (approximately 23 - 30 mm) were primarily collected from February though May 2002 (weeks 5 - 21). The largest rainbow trout/steelhead were approximately 170 - 375 mm in FL. This larger size class was represented by only a few individuals (less than 0.1% of the catch), did not exhibit an abundance peak, and was scattered in distribution from November 2001 until June 2002 (weeks 45 - 25; Figure 11, Figure 12).

We collected a total of 5 rainbow trout/steelhead for otolith analysis by CDFG for their Stream Evaluation Program. All of these specimens were collected from catch mortalities.

Mark-Recapture Efficiency Estimates

We conducted 35 different mark-recapture trials to test for RST efficiency. The release of marked fish started on 4 January 2002 and ended on 28 June 2002. A total of 28,916 Chinook salmon was marked, 844 mortalities occurred from the marking procedures, 28,072 fish were released for recapture, and 4,383 were recaptured (Table 11).

Prior to 14 February 2002, we only single-marked the salmon with Bismarck brown. After 14 February, we began to use dual marking. We single-marked on 14 trials, and dual-marked on 21 trials. For the dual marking, we used a combination of Bismarck brown and caudal fin clipping on 11 trials, and Photonic tagging was used in combination with Bismarck brown on 10 trials. Due to malfunctioning equipment, we were successful with dual-marking all fish from a marking group with Photonic tags on only four trials. As a result of malfunctioning equipment, we resorted to using fin clips to complete dual-marking on five different trials that were initially started with Photonic tags (Table 11).

The number of individual fish marked for each trial ranged from 92 - 2,010, with an average of 826. The number of individual released fish for each trial ranged from 83 - 2,010, with an average of 802. Recaptured fish numbers per trial ranged from 6 - 560 with an average of 123. Efficiencies for the RST per trial ranged from 3.03% to 28.28 %, with an average of 13.99% (N = 35, S.E. = 1.02; Table 11). The total efficiency (= total fish recaptured for all trials / total fish released for all trials = 4,383/28,072) was 15.61%. The highest RST efficiencies were recorded from 14 January 2002 through 24 February 2002, and this period included all seven dates (20% of the efficiency trials) when efficiency values exceeded 18%. The lowest efficiencies were generally recorded from 28 March 2002 through 22 May 2002, a period when efficiency values were all less than 12%.

Due to low fish collection numbers, we were unable to conduct mark-recapture studies from June 2001 until December 2002. During December 2001, we often had enough salmon available for mark-recapture studies, but due to the generally small size and delicate nature of the fish, we did not initiate marking activities until 4 January 2002. To provide an estimate of RST efficiency for this period when mark-recapture trials were not conducted, we utilized surrogate values from efficiency study trials conducted on what were deemed the most temporally and environmentally comparable dates. For the period from 3 July 2001 through 31 October 2001, we substituted the efficiency average of the four successful mark-recapture trials we conducted in Clear Creek during May 2001, which was 23.24% (USFWS, unpublished data). For the period from 1 November 2001 through 31 December 2001, we substituted the average of the first four mark-recapture trials conducted in January 2002, which was 19.74% (Table 11). The surrogate values calculated for these dates were implemented in the daily and weekly JPI calculations.

Mortality

Marking Mortality.—A total of 844 mortalities occurred among the 28,916 marked Chinook salmon, for a total marking mortality (= total marking mortalities / total number of fish marked = 844/28,916) of 2.92%. Mortalities resulting from our marking procedures for each efficiency trial ranged from 0 - 66.26%, with an average of 5.02%. The highest mortalities generally occurred from 21 May 2002 through 27 June 2002 (Table 11).

Trapping Mortality.—A total of 17,430 mortalities from RST sampling were estimated in the total catch of 811,303 for all runs of Chinook salmon (Table 5). This mortality level corresponds to a 2.15% catch mortality, and 0.27% JPI mortality. The highest mortality numbers for all runs of Chinook salmon occurred during 2002 in weeks 1 - 10. During this period weekly mortality numbers ranged from 546 - 2,648, and a total of 13,848 mortalities occurred, representing 79.45% of the total catch mortality for all runs.

A total of 16,559 mortalities from RST sampling were estimated in the fall-run size class Chinook salmon catch of 6,149,672 (Table 6). This mortality level corresponds to a total catch mortality of 2.07%, and a total JPI mortality of 0.27%. The highest mortality numbers of fall-run size class Chinook salmon occurred during 2002 in weeks 1 - 10 (1 January through 9 March). During this period, weekly mortality numbers ranged from 846 - 2,648, and a total of 13,848 mortalities occurred (Table 6), representing 83.63% of the total catch mortality for this run.

A total of 749 mortalities from RST sampling were estimated in the late-fall-run Chinook salmon size class catch of 11,048 (Table 7). This mortality level corresponds to a 6.78% total catch mortality, and a 0.37% total JPI mortality. The highest mortality numbers of late-fall-run size class Chinook salmon occurred during 2002 in weeks 15 - 23 (7 April through 8 June). During this period, weekly mortality numbers ranged from 41 - 165, and a total of 661 mortalities occurred (Table 7), representing 88.26% of the total catch mortality for this run.

No mortalities from RST sampling were in the winter-run Chinook salmon size class that produced a total catch of 11 and a total JPI of 71 (Table 8).

A total of 121 mortalities from RST sampling were estimated in the spring-run size class Chinook salmon catch of 1,450 (Table 9). For the total spring-run size class catch, this mortality level corresponds to 8.33% of the total catch, and 0.85% of the total JPI. Mortalities for spring-run size class Chinook salmon were only detected during weeks 47 through 51 of 2001 (18 November through 22 December). The highest levels of spring-run size class Chinook salmon mortality by percent of weekly catch were 20.79% (21 fish) during week 48, and 20.67% (51 fish) during week 51. All spring-run size class Chinook salmon mortalities that were measured ranged from 20 - 40 mm FL, with a median of 35 mm.

A total of 20 mortalities was indicated from RST sampling in the total rainbow trout/steelhead catch of 1,078 (Table 10). This mortality level corresponds to a 1.86% total catch mortality, and a 0.15% total JPI mortality. The highest level of rainbow trout/steelhead mortality occurred during week 12 (17 March - 23 March) of 2002, when seven mortalities occurred, representing 35.00% of the total catch mortality. The lowest levels of mortality for rainbow trout/steelhead occurred from week 27 in 2001 through week 10 in 2002, when only one mortality was detected.

Discussion

Chinook salmon emigration timing

All four run size classes of Chinook salmon showed peak outmigration periods that were similar in timing to the periods observed in Clear Creek during 1999 - 2000 (Gaines et al. 2003). We also noticed that the fall-run size class appeared to display abundance peaks that coincided with the highest creek flows. This relationship between salmon abundance peaks and creek peak flows was also noticed in our 1999 -2000 studies (Gaines et al. 2003).

Winter-run Chinook salmon abundance

Winter chinook abundance, or even presence, in Clear Creek is questionable. During the four years of snorkel surveys (1999 through 2002) conducted during the winter-run spawning season, only 6 potential winter Chinook salmon redds were observed (all in 2000) and only one potential winter Chinook salmon carcass was recovered (in 2001). Based on snorkel survey results, very few, if any, winter-run Chinook salmon juveniles would be expected in the RST catch during the current reporting period.

While individuals meeting the winter-run Chinook salmon length criteria were captured, the emigration pattern and size of captured fish was not indicative of natural reproduction. Only 11 juvenile Chinook salmon meeting the winter-run length-at-date criteria (Greene 1992) were captured, and we calculated a 12-month JPI of only 71. All of these winter-run size class Chinook salmon collected were greater than 80 mm FL (Figure 5). These were all smolts, and no fry were collected. Even if these smolt-sized individuals were simply rearing to a greater size before emigration, if winter-run Chinook salmon had spawned in Clear Creek, we would have expected to capture newly emerged fry at some time during our current study period. Given that capture of emergents (generally fish < 40.0 mm FL) was nonexistent, we feel that mis-assignment of run designation was responsible for the few winter-run Chinook salmon we have tentatively identified in our catch. Given the low catch and JPI values, lack of fry life-stage individuals, lack of observations of adults or redds during snorkel surveys, we suggest that winter-run Chinook salmon spawning did not occur in Clear Creek in. We further suggest that the 11 winter-run size class fish that were collected were likely slow-growing or late-spawned late-fall Chinook salmon.

Spring-run Chinook salmon abundance

Spring-run Chinook salmon are a stream type-fish with a somewhat variable juvenile outmigration pattern. In some years, juveniles predominantly outmigrate as fry during winter storms, and in other years juveniles predominantly outmigrate as yearlings during fall freshets (CDFG 1998). The distribution of spring Chinook in the Sacramento River watershed is limited to a few streams with fish passage to upper elevations. Butte, Deer, and Mill creeks are the principal streams in the Sacramento River watershed still supporting spring-run Chinook salmon (Moyle 2002). Snorkel surveys for spring-run Chinook salmon in Clear Creek were initiated in 1999 by the RBFWO. The annual population index of adult spring-run Chinook salmon in Clear Creek is based on August snorkel counts conducted on the majority of the anadromous portion of the stream, similar to efforts on Butte, Deer, and Mill creeks.

The annual snorkel counts for adult spring Chinook in Clear Creek from 1999 through 2002 respectively were 35, 8, 0, and 66 (Matthew R. Brown, unpublished data). Therefore, very few, if any, spring Chinook juveniles would be expected in the RST catch during the current reporting period. However, based on the size-at-date data of Greene, (1992) we initially calculated the presence of a catch total of 1,450 and JPI of 14,237 spring-run size class Chinook salmon.

We believe that the initial calculation overestimated the abundance of spring-run Chinook salmon, based on our snorkel survey data, inherent limitations of the standard length-at-date criteria from Greene (1992) and estimates of emergence timing based on temperature units. The standard length-at-date criteria does not assign run designation to Chinook salmon less than 33 mm FL. Also, Chinook salmon that are less than 45 mm FL on November 30 are classified as spring-run, but all of these fish that are 33 mm FL or less are automatically designated as fall-run on December 1. To classify Chinook less than 33 mm FL, we used the length-at-date equation from Greene (1992) to extrapolate the line shown in Figure 14. The extrapolated criteria were applied to salmon collected from 14 November 2001 through 1 December 2001. This recalculation indicated that 75% of the spring Chinook salmon collected during this two-week period were fall-run Chinook (Figure 14).

On the other hand, applying a temperature-unit-to-emergence analysis to our snorkel survey data, suggests spring-run Chinook salmon fry may be actually emerging and emigrating at dates later than Greene (1992) suggests. Emergence times were calculated from approximate spawning dates obtained from snorkel surveys. The Fahrenheit degree-day calculation subtracts 32 from the temperature to yield degree days. 1,400 cumulative degree days to peak emergence was used in all Chinook calculations. The first redd of the season was September 13. If eggs were deposited on 15 September 2001, 1,400 temperature units would be exceeded on 14 November 2001, the first day of the year for Spring Chinook collection in the RST. During the next snorkel survey in the week of 26 September 2001, 12 redds were seen. If a 26 September 2001, spawn date is used, peak emergence occurred on 29 November 2001. Alternatively assuming that the 26 September 2001 redds were created 1 week before they were detected, peak emergence occurred on 19 November 2001. Temperatures used for the temperature unit analysis were collected at Renshaw Riffle at RM 5. If later emergence and emigration of spring-run Chinook salmon fry is occurring, then we may actually be including a component of the spring-run Chinook salmon population with the fall-run JPI. This overlap of run designation appears to be occurring in Clear Creek, but we currently have no more-accurate criteria for differentiating emergent fall-run and spring-run Chinook salmon fry. We need an accurate method for assigning run designations that is more specific to Clear Creek, especially for spring Chinook. Recent advances in molecular genetics could be used with temperature-unit-to-emergence analysis to develop a Clear Creek spring Chinook run designation criteria. Another alternative would be to trap spring Chinook juveniles in an area isolated from fall Chinook, such as above a weir.

Abundance of "shortie" Chinook salmon fry

The current study detected an abundance peak of Chinook salmon fry with a FL of 18 - 30 mm (hereafter referred to as "shorties") from 14 November through 31 December of 2001 (weeks 46 - 52; Figure 5). During this period 118 (85%) of the twelve-month total of 138 shorties were collected. Of the 118 shorties that were collected in this period, 54 (45%) were classified as fall-run and 64 (54%) were classified as spring-run. Abundance peaks of shorties were also detected during RST sampling in January and November 1999 and March and December 2000 (Gaines et al. 2003), but were noticeably absent during other times of the year when fry were emerging.

We considered several factors for the abundance peak of shorties from mid-November through late December of 2001, including misidentification of salmonid species, presence of scouring flows, presence of unstable channel conditions from dam removal, presence of unstable substrates due to gravel injection, disturbance by redd superimposition, outbreeding depression from hybridization of fall and spring Chinook and thermal effects of incubation temperature on embryo development. Different factors may be responsible for shorties during different seasons or years. As more data from additional years of monitoring is analyzed, we will better understand the reason for the fall shortie abundance peak. These factors are discussed below:

Misidentification of salmonid species.—We considered the possibility that the shorties collected from mid-November through late-December were incorrectly identified as Chinook salmon. Although we only identified Chinook salmon and rainbow trout/steelhead in our catch, the possibility exists that we overlooked the presence of other salmonid species. During the period from mid-November through late December, we frequently collected from 1,000 to 3,000 salmon per day. Considering that we collected more than 811,000 Chinook salmon during the current study, overlooking the presence of up to 138 individuals of other salmonid species that were interspersed with Chinook salmon and rainbow trout/steelhead would be possible.

Besides Chinook salmon and rainbow trout/steelhead, at least six salmonid species are known to exist (some represented by individuals without sustaining populations) in the Sacramento River watershed (Moyle 2002; USFWS, RBFWO, unpublished data). These six species include coho salmon (*Oncorhynchus kisutch*), kokanee/sockeye salmon (*Oncorhynchus nerka*), pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*Oncorhynchus keta*), brown trout (*Salmo trutta*), and brook trout *(Salvelinus frontalis*). However, none of these salmonids appear to undergo fry emergence during mid-November in California.

Kokanee, the landlocked race of sockeye salmon (*Oncorhynchus nerka*) are stocked in Whiskeytown Reservoir. Emergent fry of this species are known to range from 25 - 32 mm FL (Washington Department of Fish and Wildlife 2003). In California, kokanee are known to spawn between early August and February (Moyle 2002). Due to the small size and known spawning periods of kokanee/sockeye fry, we considered the possibility that the shorties we encountered in mid-November of 2001 could have been unrecognized kokanee fry.

Kokanee/sockeye salmon have been seen in Clear Creek in years after Whiskeytown Dam has spilled through the “Glory Hole” overflow spillway (Terry Healey, CDFG District Biologist, personal communication; Matthew R. Brown, unpublished observations). These liberated kokanee/sockeye salmon may return to the Clear Creek area as adults in later years. In 1997, we observed adult kokanee/sockeye salmon in Clear Creek, including spawning activities at the confluence of the Sacramento River. However, during 1997 we did not observe any spawning activity in Clear Creek proper. Prior to November 2001, the last Glory Hole spill was in March 1998, at the end of an El Nino-influenced winter.

California kokanee are known to typically spawn as 3 or 4 year olds. Due to this timing, we considered the possibility that adult kokanee salmon could have returned to spawn in Clear Creek in the early fall of 2001 from the spillover event at Whiskeytown Dam in 1998. However, we began to conduct snorkel surveys in Clear Creek approximately every two weeks since 1997. Despite the relatively high frequency of these snorkel surveys, we have not observed any kokanee/sockeye salmon in Clear Creek since 1997. Spawning kokanee/sockeye salmon are very conspicuous, and probably would not be missed in our snorkel surveys. Since emergence of kokanee fry in California typically occurs from April through June (Moyle 2002), the possibility that our mid-November shorties were kokanee fry seems even less likely.

After ruling out kokanee/sockeye salmon as a likely possibility, we could not identify any salmonid, other than Chinook salmon, which would likely have 18 - 30 mm FL fry emerging in the Sacramento River watershed during mid-November (Moyle 2002, Behnke 2002). Also, a temperature unit analysis determined that these fry were unlikely to be kokanee/sockeye salmon. For the reasons cited above, we suggest that we did not misidentify the shorties, and these fry were probably early-emerging Chinook salmon

Presence of scouring flows.—Scouring flows could prematurely liberate yolk-sac fry from the gravel substrate, and, therefore, cause an increase of shorties in the water column. However, based on mean daily flows (Figure 2) and 15-minute flows (DWR 2003), Clear Creek did not appear to experience scouring flows in the days preceding or during the abundance peaks of shorties in 2001. Significant mobilization of stable spawning gravels probably does not occur below 1,000 cfs, as bankfull discharge on Clear Creek is somewhat above 3,400 cfs (McBain and Trush 2001). Therefore, we can likely rule out the presence of scouring flows as a cause for the shorties' abundance peaks.

Unstable channel conditions resulting from removal of the McCormick-SaeltzerDam.—Removal of the McCormick-Saeltzer Dam in the early winter of 2000 has caused a mass migration of sediments formerly trapped on the upstream side of the dam to locations downstream. These migrated McCormick-Saeltzer sediments would not likely be as stable as pre-existing sediments. Redds that are located in areas of changing channel conditions may have been susceptible to scouring at flows that do not scour non-McCormick-Saeltzer sediments. Perhaps the migrated McCormick-Saeltzer sediments began to scour earlier in the winter season or under lower flows than the pre-existing sediments. Such scouring could have introduced shorties into the water column. However, such unstable channel conditions sediments were not present in the fall of 1999 or March 2000, when shorties were also collected.

Snorkel surveys and spawning area mapping surveys in the fall of 2001 indicated that about 6 redds were in areas that may have been unstable due to dam removal. Regular monthly surveys detected 5 redds in the 0.5 miles upstream of the dam site. Some of the 5 redds may have been may have been within gravel gravels. In September 2001, one redd was detected downstream of the dam site in a reach with areas that may have been unstable due to dam removal. Snorkel surveys or redd surveys were not conducted downstream of the dam site in October or November. Spawning area mapping surveys occur after most of the fall Chinook have spawned in Clear Creek. Rather than mapping individual redds as done in snorkel surveys, entire spawning areas are delineated on aerial photos during spawning area mapping. During December11, 2001 mapping, three spawning locations were in areas that may have been unstable due to dam removal, tow upstream and one downstrem of the dam site.

Unstable substrate conditions resulting from gravel injection.—Gravel has been injected into Clear Creek by the Western Shasta Resource Conservation District (WSRCD) since 1996 to improve salmonid spawning habitat. Gravel placed into Clear Creek by gravel injection may possibly be less stable, and more prone to scouring than non-injected gravel. If redds were placed in less stable, injected gravel, the likelihood of scouring might have been increased. Possibly, the first higher flows of fall may have caused scouring of redds placed in injected gravel. The shorties were more common during and just after the first high flows of late-fall (DWR 2003). Possibly, the injected gravel did not have ample time to stabilize during the lower flows of summer and early fall. The first higher flows experienced in the fall may have been of sufficient velocity to scour injected gravel, but not natural gravel. If such scouring occurred from redd locations, shorties could have been prematurely released into the water column. Since our snorkel surveys did not detect the presence of any redds located in injected gravels during late summer and fall of 2001, we suspect that injected gravel presence was not a factor in causing the presence of shorties.

Disturbance by redd superimpositioning.—Spawning salmon may disturb pre-existing redds as they conduct their own spawning activities (Moyle 2002). If existing redds are disturbed by such superimpositioning, shorties in the pre-existing redds may become prematurely expelled from the sediments, and introduced into the water column. During the fall of 2001, a record escapement of 10,865 adult fall-run Chinook was estimated in Clear Creek

(Colleen Harvey-Arrison, DFG, personal communication). Large numbers of spawners may have resulted in higher levels of superimpositioning.

One measure of superimpositioning, the percentage of unspawned female carcasses, was relatively low in 2001 at 0.3% (Colleen Harvey-Arrison, DFG Red Bluff, personal communication), suggesting that superimposition may not have been high nor responsible for the shorties. The percentage of unspawned females as a percentage of total females encountered in the carcass survey from 1990 to 2000, has averaged 0.6%. In that period, the relationship regression percent unspawned and the total number of returning females yielded an r-sqaure value of 0.618, suggesting that percent unspawned is related to population size or habitat availability. After the removal of McCormick-Saeltzer Dam, percent unspawned decreased at the same time escapement reached record levels, suggesting the increase in habitat upstream of McCormick-Saeltzer Dam had a significant benefit for fall Chinook. In addition, 5 years of aggressive spawning gravel supplementation increased the amount and perhaps the quality of spawning gravel downstream of McCormick-Saeltzer Dam.

Shorties were also present in late-fall Chinook RST catch in March 2000 (Gaines et al 2003). Late fall Chinook counts in 2000 of 67 carcasses Clear Creek were relatively low, suggesting that either it doesn't take many fish to superimpose to produce shorties, or another factor was responsible for shorties in that case.

Outbreeding depression from hybridization of fall and spring Chinook.— Hybridization can lead to decreased fitness through the breakup of coadapted gene complexes, also known as outbreeding depression (Hallerman 2003). Outbreeding depression has been shown in a wide variety of organisms. We speculate that the breakup of coadapted gene complexes could result in smaller size at emergence, in this case in fall X spring Chinook hybrids. In addition, the progeny of these hybrids may also have reduced size, resulting in a generation of delay between the hybridization event and the shortie.

Thermal effects of incubation temperature on size at emergence.— Laboratory studies have shown that Chinook reared at higher temperatures emerge earlier and are smaller than at lower temperatures. "Chinook held above [50F] experienced reduced survival, hatched and emerged precociously, and were smaller at hatching, at emergence, at maximum tissue weight and at complete yolk absorption than fish at lower temperatures" (Heming 1982). For example, Chinook averaged 39.5 mm FL at emergence when raised at 50°F and 38.3 mm FL when raised at 53.6°F. Murray and McPhail (1988) concluded for five species of Pacific salmon including Chinook that "high incubation temperatures reduced fry size in all species". According to CDWR (1988), this occurs because of increased maintenance costs and lower yolk conversion efficiencies at the higher temperatures. Murray and Beacham (1987) suggested that "temperature regimes that simulate those experienced by a species during natural incubation tend to enhance survival and alevin and fry size". However, CDWR (1988) pointed out that "Fry produced from eggs incubated at warmer temperatures, even though within the preferred temperature range of 53.6°F to 57.3°F selected by juveniles, may hatch sooner but are smaller than those produced at lower temperatures".

Although Chinook raised at higher temperatures were smaller at emergence, they were much larger than our shorties. In addition, the temperatures investigated were typically in the 42.8 to 53.6 F range. We suggest that temperatures higher than used in the aforementioned studies, perhaps around 60 F, may produce shorties.

Steelhead emigration timing

From the total of 1,077 juvenile and 1 adult rainbow trout/steelhead that were caught by RST, we measured and designated life-stage ratings for 807 individuals. Of these 807 specimens, 2 were classified as yolk-sac fry (0.3%), 201 (24.9%) were classified as fry, 492 (60.1%) were classified as parr, 89 (11.0%) were classified as silvery parr, and 23 (2.9%) were classified as smolt.

Fry began their emigration in early February and continued through late May. Emigration continued through June, however, 96.1% of the rainbow trout/steelhead caught during this time period were classified as parr. It is not known what proportion of parr rainbow trout/steelhead we have collected are either resident or the anadromous form. Resident rainbow trout often spend their entire lives in a few hundred meters of stream, although some may migrate considerable distances within a stream system to find suitable spawning grounds (Moyle 2002). Since we collected a combined total of 112 silvery parr and smolt, this indicates that 13.9% of the classified trout were undergoing some degree of smolting (Figure 13). The trout that were classified as silvery parr and smolt, outmigrated during all months of the year, with the exception of October, and only 11 of 112 (9.8%) appeared to actively emigrate from August through October (Figure 11).

Mark-recapture efficiency estimates

The current study produced mean RST efficiency values by trial of of 14.0% (N = 35, S.E. = 1.02; Table 11), a value that was less than efficiency values of 1999, but greater than efficiency values of 2000. During RST efficiency tests in 1999 (Gaines et al. 2003), we produced a mean value of 18.0% (N = 30; S.E. = 1.66). During efficiency tests in 2000 (Gaines et al. 2003), we produced a mean value of 8.2% (N = 16; S.E. = 1.45). The highest RST efficiencies of the current study period were recorded from 14 January through 24 February 2002, and this period included all seven dates (20% of the efficiency trials) when efficiency values exceeded 18%. The lowest efficiencies were generally recorded from 28 March 2002 through 22 May 2002, a period when efficiency values were all less than 12% (Table 11).

A relation may exist between RST efficiency and several factors. Some of the suspected factors include variation in creek flows, fish behavior, channel width, channel depth, marking crew staffing changes, post-release mortality, water temperatures, marking methods, release methods, release locations, and predator populations. Perhaps the variations in RST efficiencies will be better understood after a few more years of efficiency data are gathered and compared.

Rainbow trout/steelhead efficiency estimates

Due to the low numbers of rainbow trout/steelhead collected in the RST, we were not able to acquire enough individuals to conduct mark-recapture tests using this species. Accordingly, we based our trap efficiency values for rainbow trout/steelhead upon the results obtained when conducting mark-recapture tests using juvenile Chinook salmon. Since the RST efficiency likely varies with fish species, our efficiency calculations are likely more accurate for Chinook salmon, and less accurate for rainbow trout/steelhead.

Marking mortality

The total marking mortality (= total number of mortalities / total number of fish marked) of 2.92% for the current study period represents a 29.5% reduction in mortality when compared to the total marking mortality of 4.14% produced in the winter and spring of 2001 (Gaines et al 2003). During April and May of 2002, 53.9% of our total marking mortality occurred during three days of marking (10 April, 21 May, and 28 May). During the spring of 2001, we experienced a similar mortality trend when marking juvenile Chinook salmon in Clear Creek. Of the 623 total mortalities for 2001, 564 (90.5%) occurred during the four trials conducted during the month of May.

We attribute the elevated mortality levels found during the spring of 2001 and 2002 to elevated air temperatures and the presence of larger smolting salmon. In previous years of our studies in Clear Creek, Battle Creek, and the mainstem Sacramento River (USFWS, RBFWO, unpublished data), elevated spring-time temperatures appeared to increase mortality during the handling phase of the marking procedures. We have noticed that smolting salmon tend to be more sensitive to trapping and handling than the smaller-sized fry.

We also attribute the higher level of mortality in late April and May of 2002 to the malfunctioning of our water refrigeration unit. Elevated air temperatures caused the water in marking tanks to rise beyond the thermal capacity of our water chilling system.

The reduced total mortality levels encountered in the current study period likely resulted from improvements in our marking procedures, such as the use of water chilling units, and summer work hour changes. During warm periods, we have switched our hours of fish marking to earlier or later in the day, when air temperatures are cooler. We also supplement our water chilling unit with ice.

Since the time considered in this report, we have implemented the use of shade canopies in our marking area during periods of hot, sunny weather. More frequently monitoring of water temperature in the marking tanks has been implemented. We also conduct more frequent inspections of our water chilling unit. As more data are analyzed from past and future years of mark-recapture studies, we will be able to attain a better understanding of trends in mortality resulting from marking procedures. Such understanding will allow us to further reduce mortality.

Trapping Mortality

We experienced a 3.4-fold reduction in Chinook catch mortality and 2.6-fold reduction in mortality to the JPI from our RST operations in 1999 (January through December; Gaines et al 2003). We suggest that the half-cone modification may be a factor in causing this trapping mortality reduction. During the current study, we used the half-cone modification 39.5% of the RST operation time, primarily during the periods of highest catches, highest flows, and high debris loads. We propose that the use of the half-cone modification halves the RST mortality as it halves the catch. During the study period in 1999, we did not use the half-cone modification at all. In fact, we did not regularly implement the half-cone modification until January 2000. The correlation between use of the half-cone modification and reduced catch mortality is only proposed at this time, and not proven. However, we suggest that the positive effects of the half-cone modification include the following: less fish in the RST live well, less debris in the RST live well, less fish crowding in counting buckets, less time spent in fish counting buckets, and less handling of fish because of reduced subsampling procedures.

We also suggest that our reduced mortality may be a reflection of RBFWO biologists and technicians becoming more familiar with the RST operations over the past few years. We have more staff and management available in our office now than in previous years who are familiar with RST sampling protocol. Such familiarity allows us to operate more efficiently and to more rapidly recognize, avoid, and/or mitigate conditions that increase mortality.

The relatively high level of mortality (8.3%) for spring-run size class Chinook salmon encountered in our current study period was similar during our sampling in1999. In 1999, we incurred a spring-run size class Chinook salmon relative mortality of 10.1% (Gaines et al. 2003). In both years, the relative mortality level among spring-run size class Chinook was the highest for any of the Chinook salmon runs. However, the 8.3 % mortality level during the current study corresponds to an absolute mortality of 121 individuals (Table 9). The 10.1% mortality of 1999 corresponded to 609 mortalities from the catch of 6,050 spring-run size class.

As mentioned previously, all of the spring-run size class Chinook salmon mortalities from the current study period occurred in a five-week period from 18 November through 22 December. The size range of the mortalities for the spring-run size class ranged from 20 - 40 mm FL, with a median of 35 mm. A similar mortality trend occurred during 1999, when 95.7% of our spring-run size class mortalities also occurred during November and December (Gaines et al. 2003).

We attribute many of these mortalities in November and December of both years to the relatively small size of the individuals collected, debris loads, and creek flows. Debris loads tend to be heavier in the RST during November and December than other months. Reasons for these heavier debris loads include leaf fall from deciduous trees, prevalence of high winds, prevalence of wind-fallen tree branches and trunks from early winter storms, and the occurrence of the first winter creek flows of the season. These first winter creek flows tend to transport previously accumulated fall-season debris down the creek channel. Together, the higher debris load and the higher creek flows tend to create stressful conditions for captured fish, especially for the smaller-sized salmon that are typically captured this time of the year. We also suspect that some of the recorded mortalities may have been prematurely emerged yolk-sac fry that entered the RST already dead.

Recommendations

Addition of yolk-sac fry category

Currently, our protocol does not distinguish between fry and yolk-sac fry in our Chinook salmon life stage classification system. We suggest that adding a yolk-sac fry category to this life stage classification system would allow us to more accurately determine when Chinook salmon fry are emerging from the gravel. By adding this yolk-sac fry category, we may also be more able to distinguish fry that emerge from the gravel normally from yolk-sac fry that emerge for the gravel prematurely. Premature gravel emergence occurs naturally, or it may occur due to redd gravel disturbances caused by human factors. Adding the yolk-sac fry category may allow us to determine when redd gravel disturbance events occur. Such knowledge would allow the USFWS and other resource agencies to design and conduct conservation activities that would allow for better yolk-sac fry survival.

*Condition facto*r

In future field sampling we will investigate the collection of length versus weight data for Chinook salmon and rainbow trout/steelhead to help evaluate factors to evaluate the physical condition of individual salmonids.

Alternative run-designation criteria and genetic tissue sampling

Currently, we are using the length-at-date data from Greene (1992) for assigning a run designation to Chinook salmon. Greene's data is based upon juvenile Chinook salmon that were raised in the artificial runs of the now-defunct Tehama-Colusa fish facility. The natural populations of Chinook salmon in Clear Creek and other Sacramento River tributaries would likely grow at different rates than the Tehama-Colusa facility populations.

We suggest that non-lethal fin clip tissue samples should be collected from juvenile salmon in Clear Creek for several years in addtion to samples taken in 1999 and 2000. These samples would be sent to a laboratory for molecular genetic analyses for run determination. These data could then be used to modify Greene's data to more accurately assign run designation using length–at-date criteria in Clear Creek and other tributaries.

Confidence intervals

In the upcoming cumulative report, we should provide 95% confidence intervals for salmonid JPI values.

Reduced sampling during peak spring-run Chinook salmon emigration

Based upon our level of mortalities of spring-run size class Chinook salmon during the period from mid-November through late December of 2001, we should consider initiating the half-cone modification during this period in future years. Theoretically, such a practice may allow us to cut our spring-run size class Chinook mortalities in half. However, before implementing such an action, we should determine if these mortalities are actually occurring before capture in the RST and if mortality can be decreased by other means, such as clearing the trap more often. More frequent monitoring would perhaps be one of the best methods to determine the physical condition of Chinook salmon which have entered the RST.

Reduced marking during warm periods

Consideration should be given to reduce marking activities on Chinook salmon during periods of warmer weather, especially during periods when smolt-sized salmon are being collected.

Half-cone modification and reduced catch mortality

The study of the relationship of the half-cone modification and possible reduced catch mortality between different years of juvenile salmonid monitoring should be pursued. Perhaps a comparison of catch mortality could be made between different RST monitoring projects in the Sacramento River watershed that use the half-cone modification, and those that do not.

Salmonid abundance relationships

In our next Clear Creek RST report, we should include discussions about the relationships of Chinook salmon and rainbow trout/steelhead abundance to creek discharge, temperatures, and turbidity. We should also analyze the relationship of these variables to catch per unit volume.

Steelhead efficiency trials

Since we do not catch sufficient numbers of rainbow trout/steelhead for conducting RST efficiency trials, we suggest that in the future, the use of rainbow trout/steelhead from Coleman National Fish Hatchery should be investigated. Although hatchery fish are known to behave and perhaps outmigrate differently than wild fish, we rationalize that using hatchery rainbow trout/steelhead would possibly be more representative of wild rainbow trout/steelhead behavior than are the currently used wild Chinook salmon.

Placement of an additional RST

The placement of an additional RST above known fall-run Chinook salmon spawning habitat may prove useful for differentiating fall-run Chinook salmon emergence from spring-run Chinook salmon emergence. Use of a weir to exclude adult fall-run Chinook may facilitate such an investigation.

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Tables

Table 1.—Sampling week number and corresponding date for rotary screw trap sampling conducted by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002.

Week	Start Date		Week	Start Date
27	7/1/01		1	12/30/01
28	7/8/01		2	1/6/02
29	7/15/01		3	1/13/02
30	7/22/01		4	1/20/02
31	7/29/01		5	1/27/02
32	8/5/01		6	2/3/02
33	8/12/01		7	2/10/02
34	8/19/01		8	2/17/02
35	8/26/01		9	2/24/02
36	9/2/01		10	3/3/02
37	9/9/01		11	3/10/02
38	9/16/01		12	3/17/02
39	9/23/01		13	3/24/02
40	9/30/01		14	3/31/02
41	10/7/01		15	4/7/02
42	10/14/01		16	4/14/02
43	10/21/01		17	4/21/02
44	10/28/01		18	4/28/02
45	11/4/01		19	5/5/02
46	11/11/01		20	5/12/02
47	11/18/01		21	5/19/02
48	11/25/01		22	5/26/02
49	12/2/01		23	6/2/02
50	12/9/01		24	6/9/02
51	12/16/01		25	6/16/02
52	12/23/01		26	6/23/02
			27	6/30/02

Table 2.—Summary of fish taxa collected by U.S. Fish and Wildlife Service rotary screw trap in Clear Creek, Shasta County, California from July 2001 through June 2002. A total of 22 taxa, including 19 species and 3 species complexes, was collected during this period.

Organism Code	Scientific Name	**Common Name**	Family	Native (N) or Introduced (I)
BGS	*Lepomis macrochirus*	bluegill sunfish	Centrarchidae	I
BRB	*Ameiurus nebulosus*	brown bullhead	Ictaluridae	I
CAR	*Lavinia symmetricus*	California roach	Cyprinidae	N
CENFRY	*Centrarchidae spp.*	sunfish/bass fry, unidentified	Centrarchidae	I
CHN	*Oncorhynchus tshawytscha*	Chinook salmon	Salmonidae	N
COTFRY	*Cottus sp.*	sculpin fry	Cottidae	N
CYPFRY	*Cypriniformes spp.*	minnow/sucker fry, unidentified	Cyprinidae/Catostomidae	N/I
DACE	*Rhinichthys osculus*	speckled dace	Cyprinidae	N
GSF	*Lepomis cyanellus*	green sunfish	Centrarchidae	I
HH	*Mylopharodon conocephalus*	hardhead	Cyprinidae	N
LFRY	*Lampetra spp.*	lamprey fry, unidentified	Petromyzontidae	N
LMB	*Micropterus salmoides*	largemouth bass	Centrarchidae	I
MQF	*Gambusia affinis*	western mosquitofish	Poeciliidae	I
PL	*Lampetra tridentata*	Pacific lamprey	Petromyzontidae	N
PRS	*Cottus asper*	prickly sculpin	Cottidae	N
RBT	*Oncorhynchus mykiss*	rainbow trout/steelhead	Salmonidae	N
RFS	*Cottus gulosus*	riffle sculpin	Cottidae	N
SASQ	*Ptychocheilus grandis*	Sacramento pikeminnow	Cyprinidae	N
SASU	*Catostomus occidentalis*	Sacramento sucker	Catostomidae	N
SPB	*Micropterus punctulatus*	spotted bass	Centrarchidae	I
TSS	*Gasterosteus aculeatus*	three-spine stickleback	Gasterosteidae	N
WHC	*Ameiurus catus*	white catfish	Ictaluridae	I

Table 3.—Summary of individuals for each non-salmonid fish taxa collected by U.S. Fish and Wildlife Service rotary screw trap in Clear Creek, Shasta County, California by week from July 2001 through June 2002. Refer to Table 2 for organism code interpretations.

Organism Code	**Month-Year**												
	Jul-01	**Aug-01**	**Sep-01**	**Oct-01**	**Nov-01**	**Dec-01**	**Jan-02**	**Feb-02**	**Mar-02**	**Apr-02**	**May-02**	**Jun-02**	**Total**
BGS	3	3	5	0	7	2	2	2	0	0	0	1	25
BRB	0	0	0	0	0	0	0	0	0	0	0	2	2
CAR	1	0	0	0	1	0	0	0	0	0	0	0	2
CENFRY	15	6	0	0	2	6	2	0	0	0	0	0	31
COTFRY	205	5	1	0	0	0	0	0	0	0	0	0	211
CYPFRY	102	17	1	0	0	0	0	2	0	0	0	0	122
DACE	8	4	0	3	2	0	0	0	2	0	0	2	21
GSF	3	0	3	2	15	4	10	2	2	6	1	1	49
HH	27	11	2	9	26	10	42	8	24	28	16	22	225
LFRY	1	0	3	2	3	17	28	14	86	8	4	1	167
LMB	0	0	0	3	14	4	0	0	0	0	0	0	21
MQF	0	0	1	3	9	6	6	0	4	0	0	0	29
PL	0	0	0	3	21	66	4	0	0	0	0	0	94
PRS	0	0	0	0	0	0	0	0	0	0	0	1	1
RFS	54	17	2	16	4	6	8	0	14	22	4	18	165
SASQ	20	14	3	3	9	12	44	2	16	4	1	4	132
SASU	40	26	3	2	37	7	5	0	4	2	0	7	133
SPB	0	2	0	0	4	0	0	0	0	0	0	0	6
TSS	0	1	1	0	0	0	2	0	0	0	0	1	5
WHC	1	1	0	0	0	0	0	0	0	0	0	0	2
												Total:	**1,443**

Table 4.—Data summary for the most abundant fish taxa collected by the U.S. Fish and Wildlife Service with a rotary screw trap in Clear Creek, Shasta County, California, from July 2001 through June 2002. Taxa are presented in order of decreasing abundance. Refer to Table 2 for organism code interpretations. Total lengths were measured for lamprey and cottids, all other species were measured for fork length.

Organism Code	Total Number Collected	Month(s) of Greatest Abundance	Fork Lengths (mm)		
			Minimum	Maximum	Median
CHN	811,303	January, February, March	18	123	~ 46
RBT	1,078	March, April, May, June	23	375	61
HH	225	January	26	375	74
COTFRY	211	July	21	39	30
LFRY	167	January, March	55	167	127
RFS	165	July, April	24	116	45
SASU	133	July, November	24	373	39
SASQ	132	July, January	28	500	116
CYPFRY	122	July, August	16	33	25
PL	94	November, December	107	187	130

Table 5.— Summary of abundance and mortality data for all runs of juvenile Chinook salmon captured by rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002. Results include the weekly catch number, weekly juvenile passage index (JPI), weekly number of mortalities, mortality percentage of weekly catch, and mortality percentage of weekly JPI. Asterisk (*) on week 27 of 2002 denotes that data is based only on 1 sampling day, the last day of the reporting period.

Total Chinook Salmon					
	Abundance		Mortality		
Week	Catch	JPI	Number	% of Catch	% of JPI
27	98	611	0	0.00%	0.00%
28	132	783	5	3.79%	0.64%
29	78	525	8	10.26%	1.52%
30	51	323	2	3.92%	0.62%
31	38	241	1	2.63%	0.42%
32	18	138	0	0.00%	0.00%
33	8	86	0	0.00%	0.00%
34	2	9	0	0.00%	0.00%
35	0	0	0	0.00%	0.00%
36	0	0	0	0.00%	0.00%
37	1	4	0	0.00%	0.00%
38	1	4	0	0.00%	0.00%
39	1	4	0	0.00%	0.00%
40	2	9	0	0.00%	0.00%
41	1	4	0	0.00%	0.00%
42	1	4	0	0.00%	0.00%
43	2	9	0	0.00%	0.00%
44	0	0	0	0.00%	0.00%
45	11	10	0	0.00%	0.00%
46	0	66	0	0.00%	0.00%
47	85	481	9	10.59%	1.87%
48	113	2,107	22	19.47%	1.04%
49	1081	9,075	84	7.75%	0.92%
50	1449	9,488	97	6.68%	1.02%
51	3432	17,386	455	13.25%	2.62%
52	2658	27,812	140	5.26%	0.50%
1	21915	250,848	1580	7.21%	0.63%
2	32174	555,640	1286	4.00%	0.23%
3	53532	375,047	1071	2.00%	0.29%
4	82855	382,851	1344	1.62%	0.35%
5	144064	669,793	2648	1.84%	0.40%
6	137870	1,133,668	828	0.60%	0.07%
7	69526	490,569	1187	1.71%	0.24%
8	73934	436,408	2175	2.94%	0.50%
9	63038	317,559	546	0.87%	0.17%
10	43719	410,354	1183	2.71%	0.29%
11	15617	155,039	408	2.61%	0.26%
12	9107	77,173	93	1.02%	0.12%
13	16445	144,313	713	4.34%	0.49%
14	3116	55,447	96	3.08%	0.17%
15	5469	143,870	430	7.86%	0.30%
16	4553	144,824	135	2.96%	0.09%
17	2282	80,298	70	3.09%	0.09%
18	4116	83,253	83	2.01%	0.10%
19	3871	64,671	202	5.22%	0.31%
20	3821	134,974	187	4.90%	0.14%
21	2548	130,042	109	4.29%	0.08%
22	2612	27,073	46	1.78%	0.17%
23	2782	16,491	88	3.15%	0.53%
24	1361	7,941	22	1.62%	0.28%
25	867	5,749	32	3.69%	0.56%
26	690	4,888	28	4.06%	0.57%
27*	156	1,105	17	10.90%	1.54%
Totals	**811,303**	**6,369,066**	**17,430**	**2.15%**	**0.27%**
			Mean	**3.29%**	**0.38%**
			Median	**2.61%**	**0.23%**

Table 6.— Summary of abundance and mortality data for juvenile fall-run Chinook salmon captured by rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002. Results include the weekly catch number, weekly juvenile passage index (JPI), weekly number of mortalities, mortality percentage of weekly catch, and mortality percentage of weekly JPI. Asterisk (*) on week 27 of 2002 denotes that data is based only on 1 sampling day, the last day of the reporting period.

Fall-run Chinook Salmon					
	Abundance		Mortality		
Week	Catch	JPI	Number	% of Catch	% of JPI
27	40	258	0	0.00%	0.00%
28	46	275	0	0.00%	0.00%
29	19	133	0	0.00%	0.00%
30	9	65	0	0.00%	0.00%
31	1	13	0	0.00%	0.00%
32	4	30	0	0.00%	0.00%
33	1	17	0	0.00%	0.00%
34	0	0	0	0.00%	0.00%
35	0	0	0	0.00%	0.00%
36	0	0	0	0.00%	0.00%
37	0	0	0	0.00%	0.00%
38	0	0	0	0.00%	0.00%
39	1	4	0	0.00%	0.00%
40	0	0	0	0.00%	0.00%
41	0	0	0	0.00%	0.00%
42	0	0	0	0.00%	0.00%
43	0	0	0	0.00%	0.00%
44	0	0	0	0.00%	0.00%
45	0	0	0	0.00%	0.00%
46	0	0	0	0.00%	0.00%
47	0	0	0	0.00%	0.00%
48	0	562	0	0.00%	0.00%
49	692	5,770	50	7.26%	0.87%
50	1,180	7,614	91	7.70%	1.19%
51	3,181	16,113	403	12.69%	2.50%
52	2,639	27,087	140	5.30%	0.52%
1	21,915	250,848	1580	7.21%	0.63%
2	32,121	554,874	1286	4.00%	0.23%
3	53,512	374,943	1071	2.00%	0.29%
4	82,855	382,851	1344	1.62%	0.35%
5	144,064	669,793	2648	1.84%	0.40%
6	137,870	1,133,668	828	0.60%	0.07%
7	69,453	489,941	1187	1.71%	0.24%
8	73,930	436,381	2175	2.94%	0.50%
9	62,992	317,332	546	0.87%	0.00%
10	43,692	410,091	1183	2.71%	0.00%
11	15,595	154,828	408	2.62%	0.00%
12	9,103	77,144	93	1.02%	0.00%
13	16,445	144,313	713	4.34%	0.00%
14	3,098	55,119	96	3.10%	0.17%
15	5,278	138,180	358	6.78%	0.00%
16	3,725	123,004	78	2.09%	0.00%
17	1,675	59,746	26	1.57%	0.00%
18	3,084	62,857	42	1.36%	0.00%
19	2,673	45,292	37	1.40%	0.00%
20	2,554	88,140	49	1.92%	0.00%
21	1,881	94,684	65	3.43%	0.00%
22	1,262	14,137	18	1.40%	0.00%
23	1,178	6,980	16	1.38%	0.23%
24	432	2,519	6	1.39%	0.24%
25	295	1,941	9	3.05%	0.46%
26	245	1,734	7	2.86%	0.40%
27*	55	390	6	10.91%	1.54%
Totals	**798,793**	**6,149,672**	**16,559**	**2.07%**	**0.27%**
			Mean	**2.06%**	**0.21%**
			Median	**1.38%**	**0.00%**

Table 7.— Summary of abundance and mortality data for juvenile late fall-run Chinook salmon captured by rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002. Results include the weekly catch number, weekly juvenile passage index (JPI), weekly number of mortalities, mortality percentage of weekly catch, and mortality percentage of weekly JPI. Asterisk (*) on week 27 of 2002 denotes that data is based only on 1 sampling day, the last day of the reporting period.

Late Fall-run Chinook Salmon					
	Abundance		Mortality		
Week	Catch	JPI	Number	% of Catch	% of JPI
27	58	353	0	0.00%	0.00%
28	86	508	5	5.81%	0.98%
29	59	392	8	13.56%	2.04%
30	42	258	2	4.76%	0.77%
31	37	228	1	2.70%	0.44%
32	14	108	0	0.00%	0.00%
33	7	69	0	0.00%	0.00%
34	2	9	0	0.00%	0.00%
35	0	0	0	0.00%	0.00%
36	0	0	0	0.00%	0.00%
37	1	4	0	0.00%	0.00%
38	1	4	0	0.00%	0.00%
39	0	0	0	0.00%	0.00%
40	2	9	0	0.00%	0.00%
41	1	4	0	0.00%	0.00%
42	1	4	0	0.00%	0.00%
43	2	9	0	0.00%	0.00%
44	0	0	0	0.00%	0.00%
45	3	10	0	0.00%	0.00%
46	0	5	0	0.00%	0.00%
47	12	76	0	0.00%	0.00%
48	11	56	1	9.09%	1.79%
49	5	36	0	0.00%	0.00%
50	2	9	0	0.00%	0.00%
51	3	14	0	0.00%	0.00%
52	0	0	0	0.00%	0.00%
1	0	0	0	0.00%	0.00%
2	0	0	0	0.00%	0.00%
3	0	0	0	0.00%	0.00%
4	0	0	0	0.00%	0.00%
5	0	0	0	0.00%	0.00%
6	0	0	0	0.00%	0.00%
7	0	0	0	0.00%	0.00%
8	0	0	0	0.00%	0.00%
9	0	0	0	0.00%	0.00%
10	0	0	0	0.00%	0.00%
11	0	0	0	0.00%	0.00%
12	0	0	0	0.00%	0.00%
13	0	0	0	0.00%	0.00%
14	10	151	0	0.00%	0.00%
15	167	5021	72	42.86%	1.43%
16	798	20880	57	7.15%	0.27%
17	585	19900	44	7.54%	0.22%
18	1006	19923	41	4.03%	0.20%
19	1198	19309	165	13.76%	0.85%
20	1267	46834	138	10.90%	0.30%
21	667	35359	45	6.73%	0.13%
22	1350	12936	29	2.12%	0.22%
23	1604	9511	71	4.45%	0.75%
24	929	5422	16	1.72%	0.30%
25	572	3808	23	4.02%	0.60%
26	445	3154	21	4.72%	0.67%
27*	101	715	11	10.89%	1.54%
Totals	**11,048**	**205,086**	**749**	**6.78%**	**0.37%**
			Mean	**3.03%**	**0.26%**
			Median	**0.00%**	**0.00%**

Table 8.— Summary of abundance and mortality data for juvenile winter-run Chinook salmon captured by rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002. Results include the weekly catch number, weekly juvenile passage index (JPI), weekly number of mortalities, mortality percentage of weekly catch, and mortality percentage of weekly JPI. Asterisk (*) on week 27 of 2002 denotes that data is based only on 1 sampling day, the last day of the reporting period.

Winter-run Chinook Salmon					
	Abundance		Mortality		
Week	Catch	JPI	Number	% of Catch	% of JPI
27	0	0	0	0.00%	0.00%
28	0	0	0	0.00%	0.00%
29	0	0	0	0.00%	0.00%
30	0	0	0	0.00%	0.00%
31	0	0	0	0.00%	0.00%
32	0	0	0	0.00%	0.00%
33	0	0	0	0.00%	0.00%
34	0	0	0	0.00%	0.00%
35	0	0	0	0.00%	0.00%
36	0	0	0	0.00%	0.00%
37	0	0	0	0.00%	0.00%
38	0	0	0	0.00%	0.00%
39	0	0	0	0.00%	0.00%
40	0	0	0	0.00%	0.00%
41	0	0	0	0.00%	0.00%
42	0	0	0	0.00%	0.00%
43	0	0	0	0.00%	0.00%
44	0	0	0	0.00%	0.00%
45	0	0	0	0.00%	0.00%
46	0	0	0	0.00%	0.00%
47	0	0	0	0.00%	0.00%
48	1	5	0	0.00%	0.00%
49	0	3	0	0.00%	0.00%
50	2	10	0	0.00%	0.00%
51	0	0	0	0.00%	0.00%
52	0	0	0	0.00%	0.00%
1	0	0	0	0.00%	0.00%
2	0	0	0	0.00%	0.00%
3	2	10	0	0.00%	0.00%
4	0	0	0	0.00%	0.00%
5	0	0	0	0.00%	0.00%
6	0	0	0	0.00%	0.00%
7	0	0	0	0.00%	0.00%
8	4	26	0	0.00%	0.00%
9	0	0	0	0.00%	0.00%
10	0	0	0	0.00%	0.00%
11	0	0	0	0.00%	0.00%
12	2	16	0	0.00%	0.00%
13	0	0	0	0.00%	0.00%
14	0	0	0	0.00%	0.00%
15	0	0	0	0.00%	0.00%
16	0	0	0	0.00%	0.00%
17	0	0	0	0.00%	0.00%
18	0	0	0	0.00%	0.00%
19	0	0	0	0.00%	0.00%
20	0	0	0	0.00%	0.00%
21	0	0	0	0.00%	0.00%
22	0	0	0	0.00%	0.00%
23	0	0	0	0.00%	0.00%
24	0	0	0	0.00%	0.00%
25	0	0	0	0.00%	0.00%
26	0	0	0	0.00%	0.00%
27*	0	0	0	0.00%	0.00%
Totals	**11**	**71**	**0**	**0.00%**	**0.00%**
			Mean	**0.00%**	**0.00%**
			Median	**0.00%**	**0.00%**

Table 9.— Summary of abundance and mortality data for juvenile spring-run Chinook salmon captured by rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002. Results include the weekly catch number, weekly juvenile passage index (JPI), weekly number of mortalities, mortality percentage of weekly catch, and mortality percentage of weekly JPI. Asterisk (*) on week 27 of 2002 denotes that data is based only on 1 sampling day, the last day of the reporting period.

Spring-run Chinook Salmon					
	Abundance		Mortality		
Week	Catch	JPI	Number	% of Catch	% of JPI
27	0	0	0	0.00%	0.00%
28	0	0	0	0.00%	0.00%
29	0	0	0	0.00%	0.00%
30	0	0	0	0.00%	0.00%
31	0	0	0	0.00%	0.00%
32	0	0	0	0.00%	0.00%
33	0	0	0	0.00%	0.00%
34	0	0	0	0.00%	0.00%
35	0	0	0	0.00%	0.00%
36	0	0	0	0.00%	0.00%
37	0	0	0	0.00%	0.00%
38	0	0	0	0.00%	0.00%
39	0	0	0	0.00%	0.00%
40	0	0	0	0.00%	0.00%
41	0	0	0	0.00%	0.00%
42	0	0	0	0.00%	0.00%
43	0	0	0	0.00%	0.00%
44	0	0	0	0.00%	0.00%
45	8	0	0	0.00%	0.00%
46	0	61	0	0.00%	0.00%
47	73	405	9	12.33%	2.22%
48	101	1484	21	20.79%	1.41%
49	384	3267	33	8.72%	1.02%
50	265	1855	6	2.21%	0.32%
51	249	1260	51	20.67%	4.08%
52	19	725	0	0.00%	0.00%
1	0	0	0	0.00%	0.00%
2	53	765	0	0.00%	0.00%
3	18	94	0	0.00%	0.00%
4	0	0	0	0.00%	0.00%
5	0	0	0	0.00%	0.00%
6	0	0	0	0.00%	0.00%
7	73	627	0	0.00%	0.00%
8	0	0	0	0.00%	0.00%
9	46	227	0	0.00%	0.00%
10	27	263	0	0.00%	0.00%
11	22	210	0	0.00%	0.00%
12	2	13	0	0.00%	0.00%
13	0	0	0	0.00%	0.00%
14	8	177	0	0.00%	0.00%
15	24	668	0	0.00%	0.00%
16	30	940	0	0.00%	0.00%
17	22	651	0	0.00%	0.00%
18	26	474	0	0.00%	0.00%
19	0	70	0	0.00%	0.00%
20	0	0	0	0.00%	0.00%
21	0	0	0	0.00%	0.00%
22	0	0	0	0.00%	0.00%
23	0	0	0	0.00%	0.00%
24	0	0	0	0.00%	0.00%
25	0	0	0	0.00%	0.00%
26	0	0	0	0.00%	0.00%
27*	0	0	0	0.00%	0.00%
Totals	**1,450**	**14,237**	**121**	**8.33%**	**0.85%**
			Mean	**1.35%**	**0.18%**
			Median	**0.00%**	**0.00%**

Table 10.— Summary of abundance and mortality data for juvenile rainbow trout/steelhead captured by rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002. Results include the weekly catch number, weekly juvenile passage index (JPI), weekly number of mortalities, mortality percentage of weekly catch, and mortality percentage of weekly JPI. Asterisk (*) on week 27 of 2002 denotes that data is based only on 1 sampling day, the last day of the reporting period.

Rainbow Trout/Steelhead					
	Abundance		Mortality		
Week	Catch	JPI	Number	% of Catch	% of JPI
27	19	133	0	0.00%	0.00%
28	14	77	0	0.00%	0.00%
29	16	95	0	0.00%	0.00%
30	35	202	1	2.86%	0.49%
31	3	47	0	0.00%	0.00%
32	3	22	0	0.00%	0.00%
33	2	17	0	0.00%	0.00%
34	0	0	0	0.00%	0.00%
35	0	0	0	0.00%	0.00%
36	3	13	0	0.00%	0.00%
37	5	30	0	0.00%	0.00%
38	5	26	0	0.00%	0.00%
39	1	13	0	0.00%	0.00%
40	0	0	0	0.00%	0.00%
41	0	0	0	0.00%	0.00%
42	0	0	0	0.00%	0.00%
43	0	0	0	0.00%	0.00%
44	0	0	0	0.00%	0.00%
45	3	15	0	0.00%	0.00%
46	4	25	0	0.00%	0.00%
47	9	56	0	0.00%	0.00%
48	13	96	0	0.00%	0.00%
49	3	30	0	0.00%	0.00%
50	9	46	0	0.00%	0.00%
51	2	10	0	0.00%	0.00%
52	0	0	0	0.00%	0.00%
1	0	0	0	0.00%	0.00%
2	2	44	0	0.00%	0.00%
3	6	50	0	0.00%	0.00%
4	2	7	0	0.00%	0.00%
5	8	41	0	0.00%	0.00%
6	8	64	0	0.00%	0.00%
7	10	70	0	0.00%	0.00%
8	2	16	0	0.00%	0.00%
9	14	64	0	0.00%	0.00%
10	44	418	0	0.00%	0.00%
11	70	723	2	2.86%	0.28%
12	62	450	7	11.29%	1.56%
13	32	239	0	0.00%	0.00%
14	50	679	1	2.00%	0.15%
15	30	1024	1	3.33%	0.10%
16	104	2738	0	0.00%	0.00%
17	38	1240	1	2.63%	0.08%
18	40	797	1	2.50%	0.13%
19	31	542	2	6.45%	0.37%
20	18	650	1	5.56%	0.15%
21	15	458	0	0.00%	0.00%
22	10	127	0	0.00%	0.00%
23	52	308	2	3.85%	0.65%
24	120	699	1	0.83%	0.14%
25	94	619	0	0.00%	0.00%
26	56	397	0	0.00%	0.00%
27*	11	78	0	0.00%	0.00%
Totals	**1,078**	**13,496**	**20**	**1.86%**	**0.15%**
			Mean	**0.85%**	**0.08%**
			Median	**0.00%**	**0.00%**

Table 11. Summary of rotary screw trap efficiency test data gathered by using mark-recapture trials with juvenile Chinook salmon by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from January 2002 through June 2002. Abbreviations: BB = Bismarck Brown -Y stain; CCL = lower caudal clip, CCU = upper caudal clip, CCX = caudal clip - lobe unspecified, PT = Photonic tag (number tagged - color of tag), PT* = Photonic tagging gear malfunctioned, and dual marking completed with fin clipping.

Trial #	Release Date	Total # Marked	Marking Method(s)	Total # Released	Total # Recaptured	% Efficiency	# Mortalities per Trial	% Mortality per Trial
1	4-Jan-02	1000	BB	930	64	6.88	70	7.00
2	14-Jan-	762	BB	762	148	19.42	0	0.00
3	22-Jan-	1591	BB	1591	450	28.28	0	0
4	25-Jan-	1000	BB	997	244	24.47	3	0.3
5	28-Jan-	1994	BB	1989	560	28.15	5	0.25
6	31-Jan-	1050	BB	1050	118	11.24	0	0
7	4-Feb-02	2010	BB	2010	330	16.42	0	0
8	7-Feb-02	1050	BB	1048	122	11.64	2	0.19
9	10-Feb-	1082	BB	1081	170	15.73	1	0.09
10	14-Feb-	1300	BB,PT(60-orange)	1295	196	15.14	5	0.38
11	18-Feb-	1015	BB,CCU	946	174	18.39	69	6.8
12	21-Feb-	981	BB,CCU	979	226	23.08	2	0.20
13	25-Feb-	1000	BB,CCL	996	204	20.48	4	0.4
14	28-Feb-	1000	BB,CCU	996	134	13.45	4	0.4
15	4-Mar-02	1053	BB,PT*(60-orange),CCU	1045	108	10.33	8	0.76
16	7-Mar-02	996	BB,CCL	985	100	10.15	11	1.1
17	11-Mar-	962	BB,CCU	940	86	9.15	22	2.29
18	14-Mar-	1227	BB,PT*(212), CCL	1196	120	10.03	31	2.53
19	18-Mar-	997	BB,PT*(45-orange;14-blue),	988	152	15.38	9	0.9
20	21-Mar-	580	BB,CCL	576	62	10.76	4	0.69
21	25-Mar-	971	BB,CCU	969	166	17.13	2	0.21
22	28-Mar-	513	BB,PT(513-orange)	490	48	9.80	23	4.48
23	1-Apr-02	282	BB,PT(282-orange)	276	18	6.52	6	2.13
24	10-Apr-	1186	BB, PT*(460-orange), CX	991	56	5.65	195	16.44
25	17-Apr-	450	BB,PT*(270-orange), CCU	430	26	6.05	20	4.44
26	1-May-02	465	BB,CCU	454	52	11.45	11	2.37
27	8-May-02	350	BB,CCL	341	34	9.97	9	2.57
28	15-May-	200	BB,CLU	198	6	3.03	2	1.00
29	22-May-	600	BB	504	55	10.91	96	16
30	29-May-	246	BB	83	14	16.87	163	66.26
31	11-Jun-	235	BB	224	39	17.41	11	4.68
32	18-Jun-	191	BB	166	23	13.86	25	13.09
33	21-Jun-	282	BB	271	40	14.76	11	3.9
34	25-Jun-	203	BB,PT(203-green)	190	26	13.68	13	6.4
35	28-Jun-	92	BB,PT(92-orange)	85	12	14.12	7	7.61
Totals:		**28,916**		**28,072**	**4,383**		**844**	**175.9**
Trial Means:		**826**		**802**	**125**	**13.99%**	**24**	**5.02%**

Figures

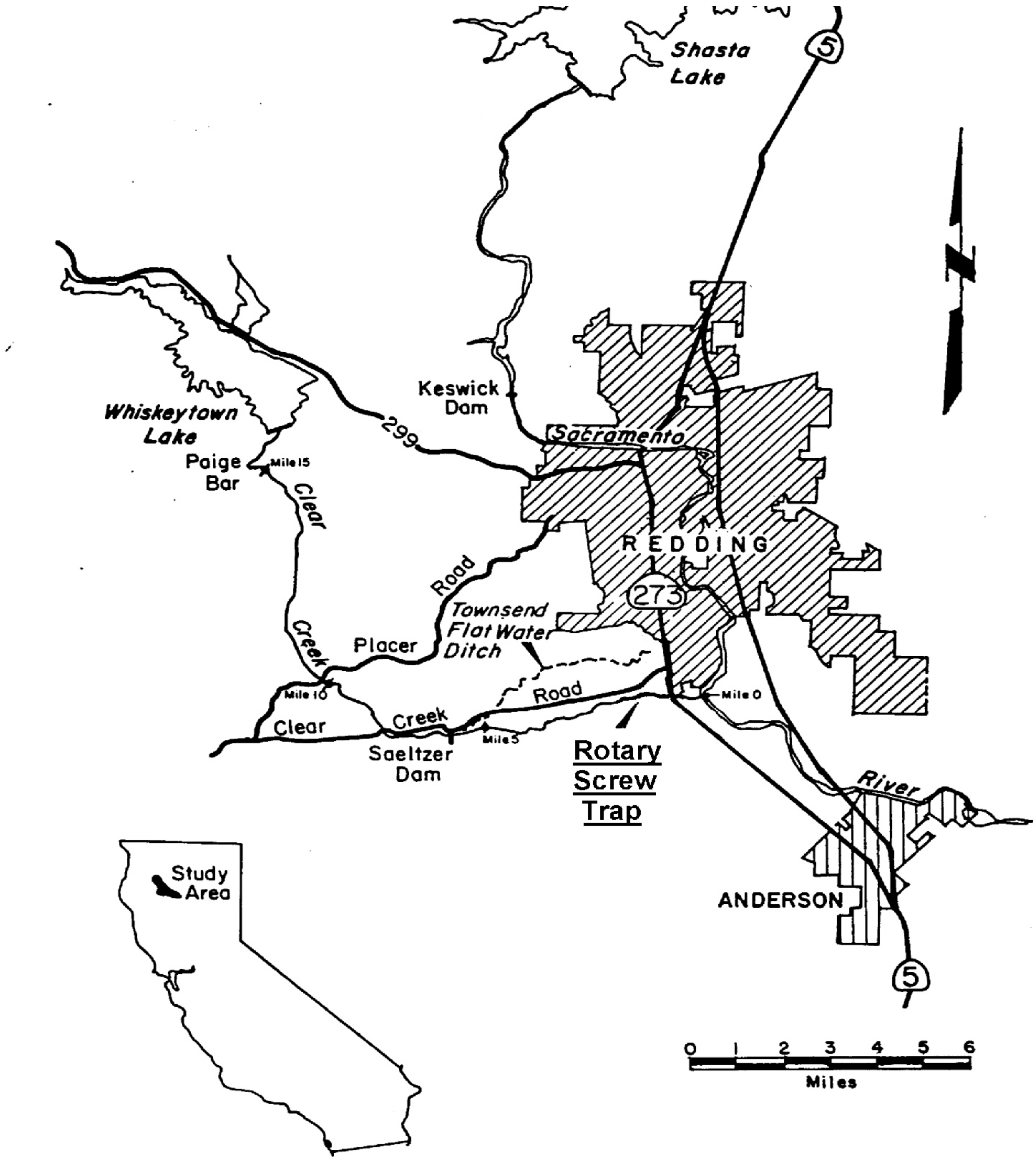

Figure 1.—Location of the rotary screw trap (RST) sampling station used for salmonid monitoring by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002.

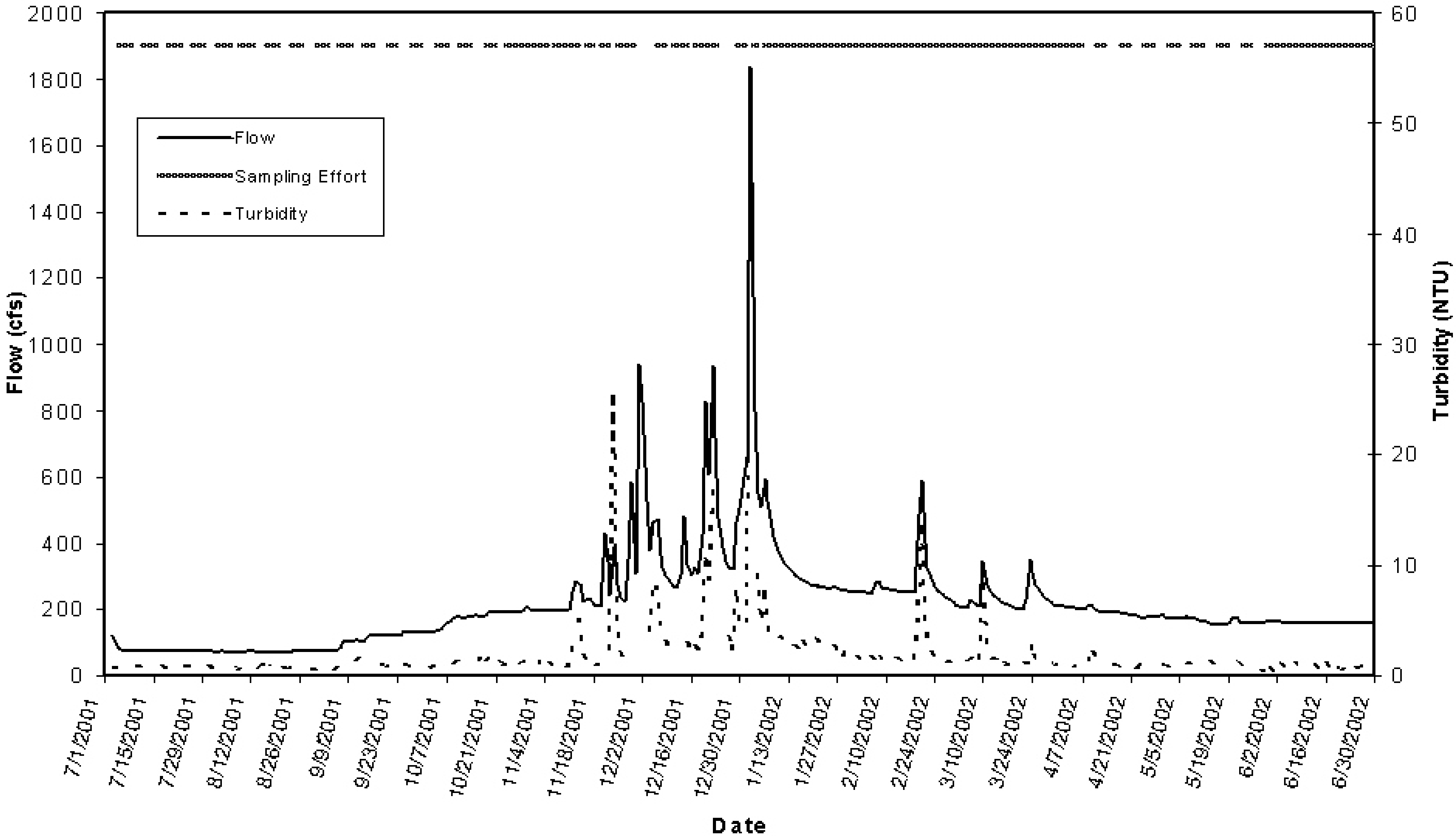

Figure 2.—Mean daily flow in cubic feet per second (cfs), momentary turbidity in nephelometric turbidity units (NTU), and sampling effort (days sampled or not sampled) recorded at U.S. Fish and Wildlife Service rotary screw trap sampling station in Clear Creek, Shasta County, California from July 2001 through June 2002. For sampling effort, a solid portion of line represents a date that was sampled, while a missing portion of line represents a date that was not sampled.

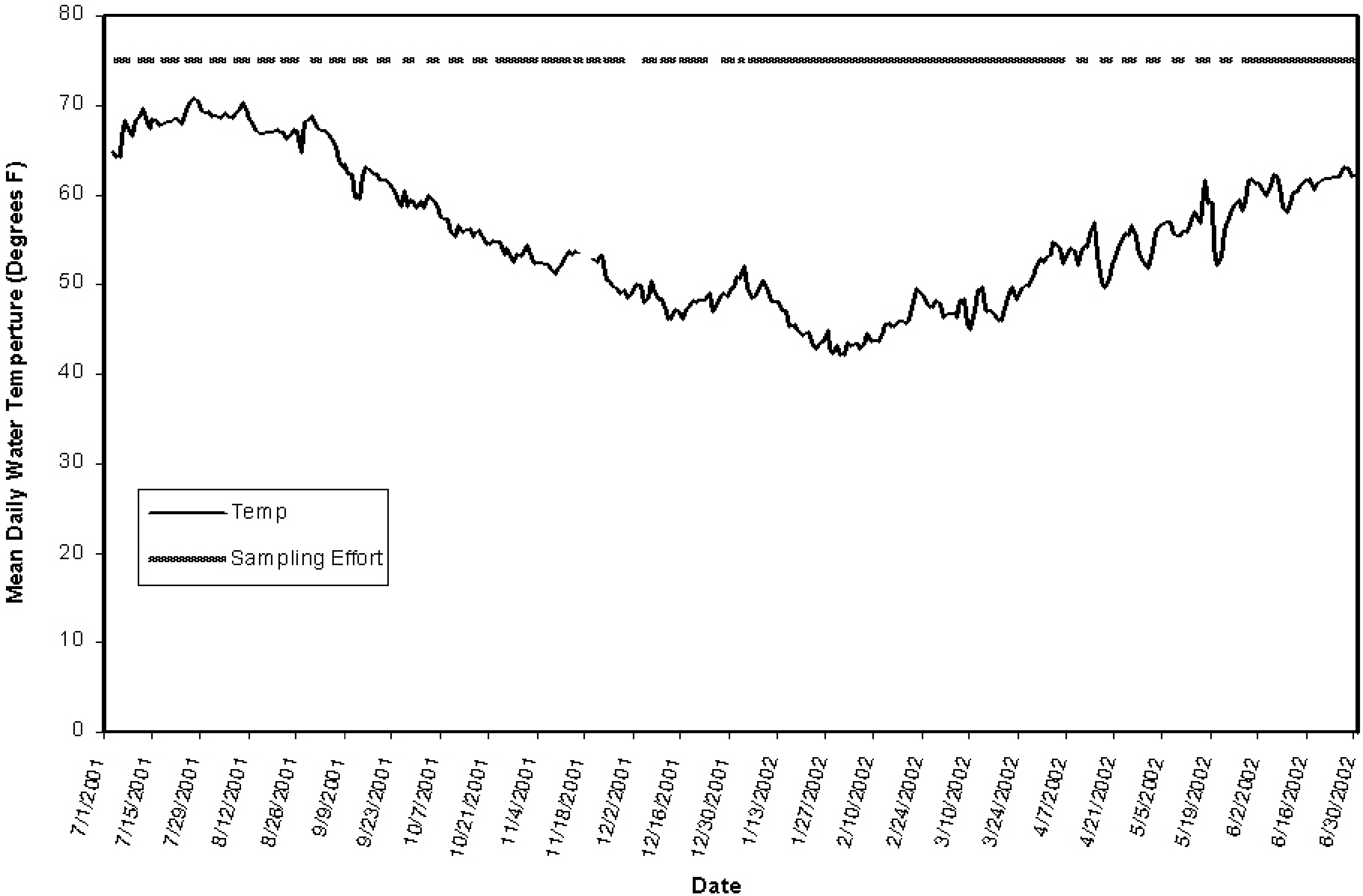

Figure 3.—Mean daily water temperatures (°F) recorded in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from July 2001 through June 2002 at rotary screw trap sampling station. Station location is 1.7 miles upstream of the confluence with the Sacramento River.

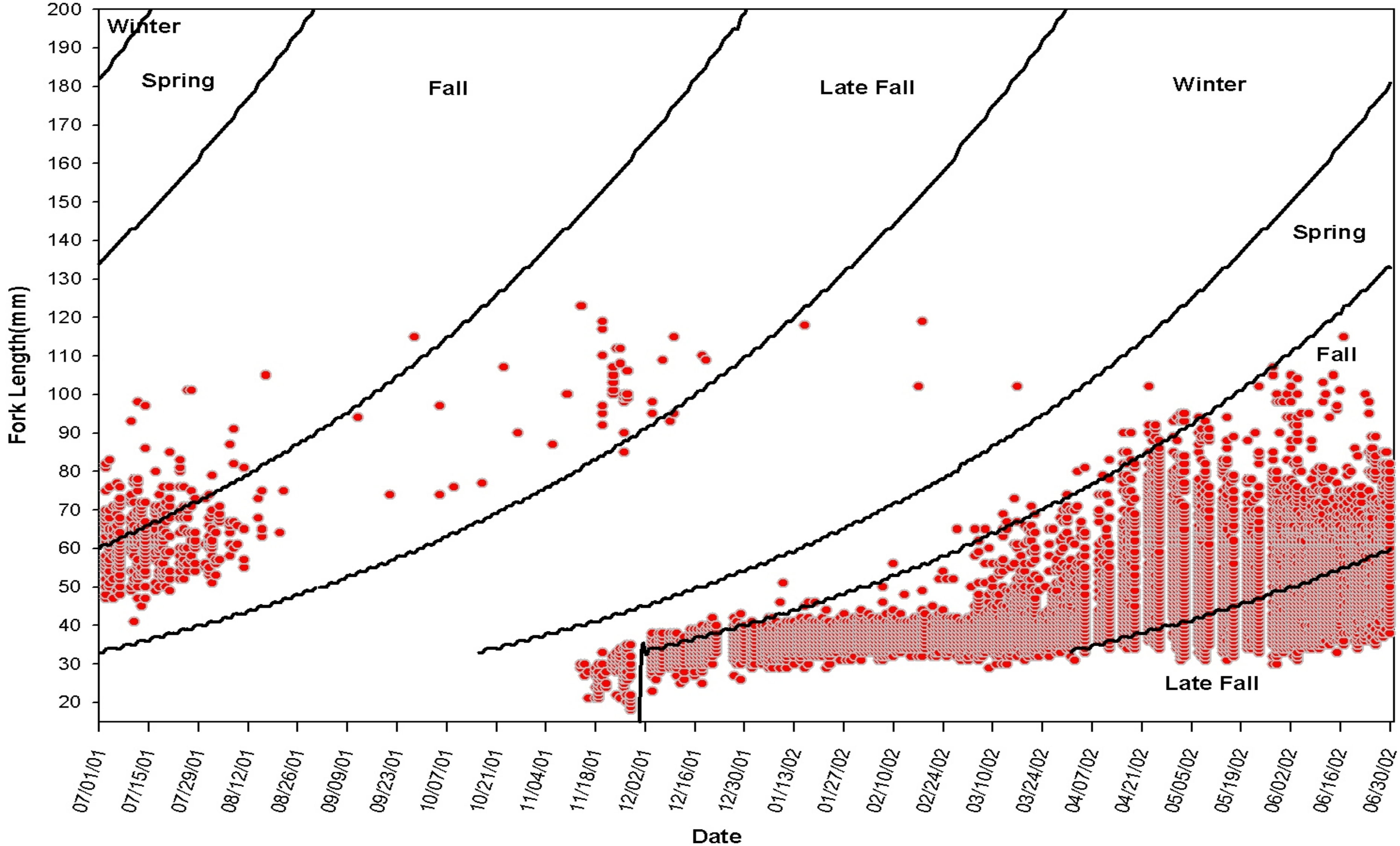

Figure 4.—Fork length (mm) distribution by date and run for Chinook salmon captured by rotary screw trap in Clear Creek, Shasta County, California from July 2001 through June 2002 by the U.S. Fish and Wildlife Service. Spline curves represent the maximum fork lengths expected for each run by date, based upon criteria developed by the California Department of Water Resources (Greene 1992).

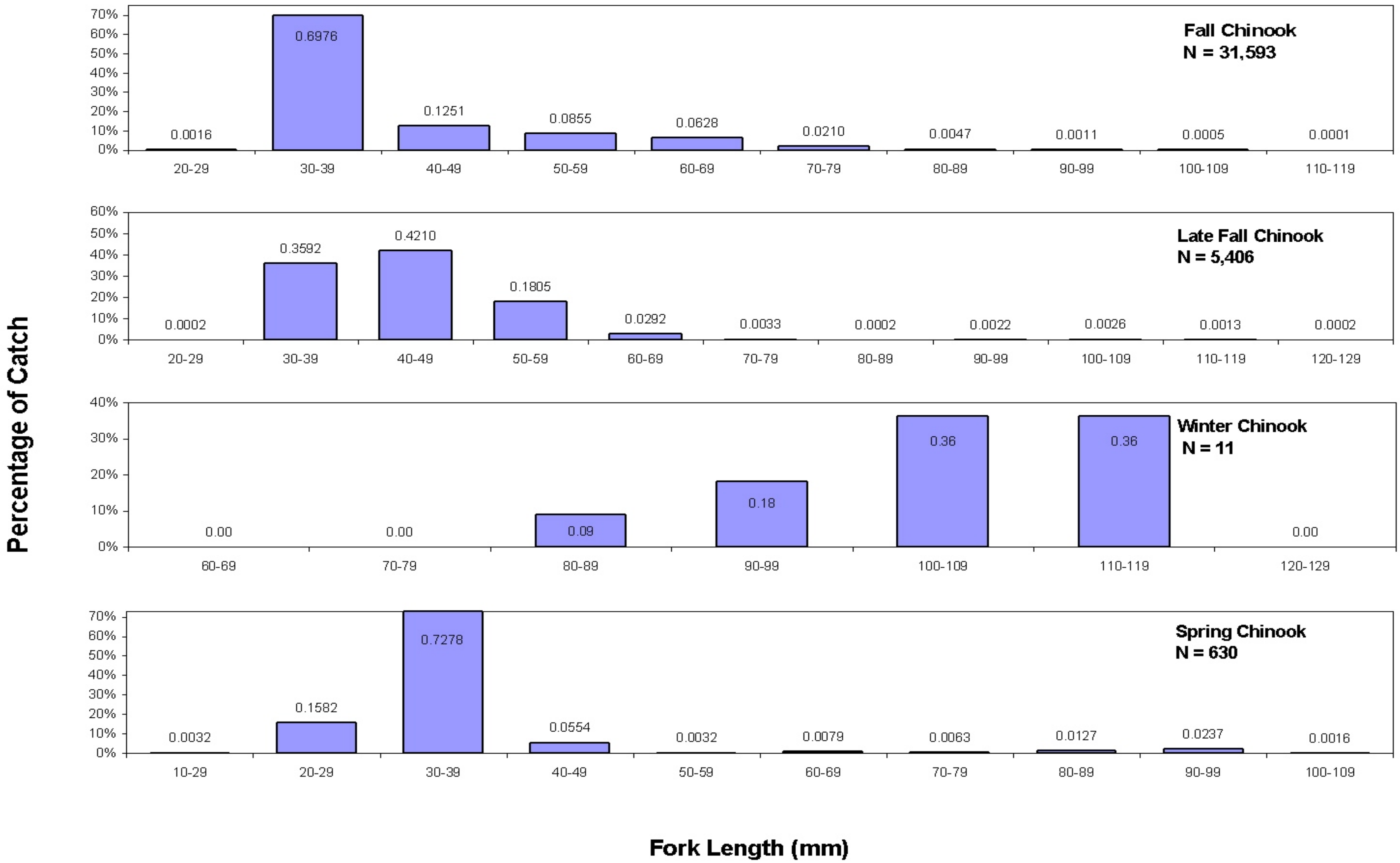

Figure 5.—Fork length (mm) frequency distribution by run for Chinook salmon collected by rotary screw trap in Clear Creek, Shasta County, California from July 2001 through June 2002 by the U.S. Fish and Wildlife Service. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments. The value "N" represents the number of fish measured from the rotary screw trap catch.

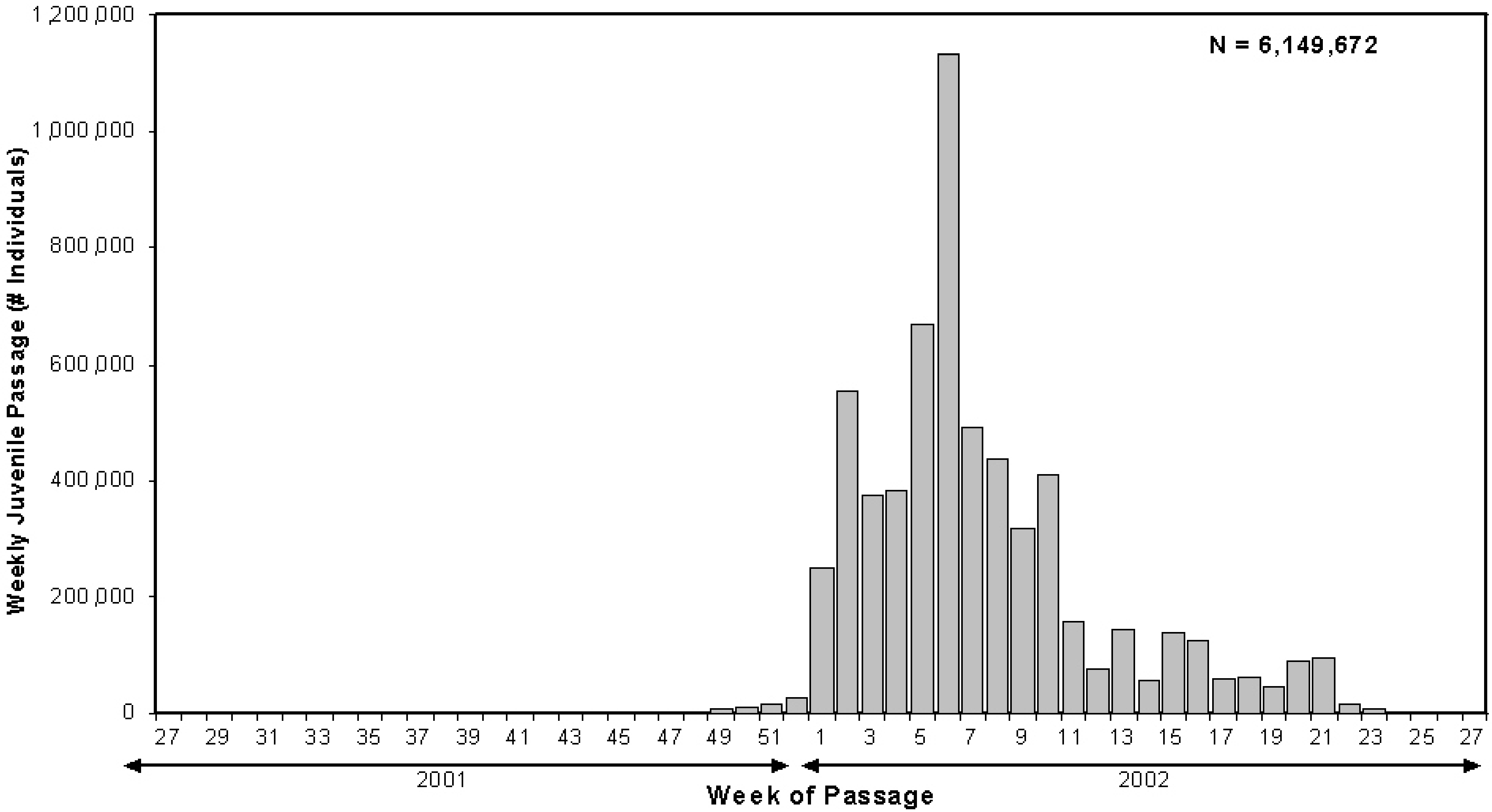

Figure 6.—Juvenile passage index (JPI) by week for fall-run size class Chinook salmon emigrants collected with a rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002.

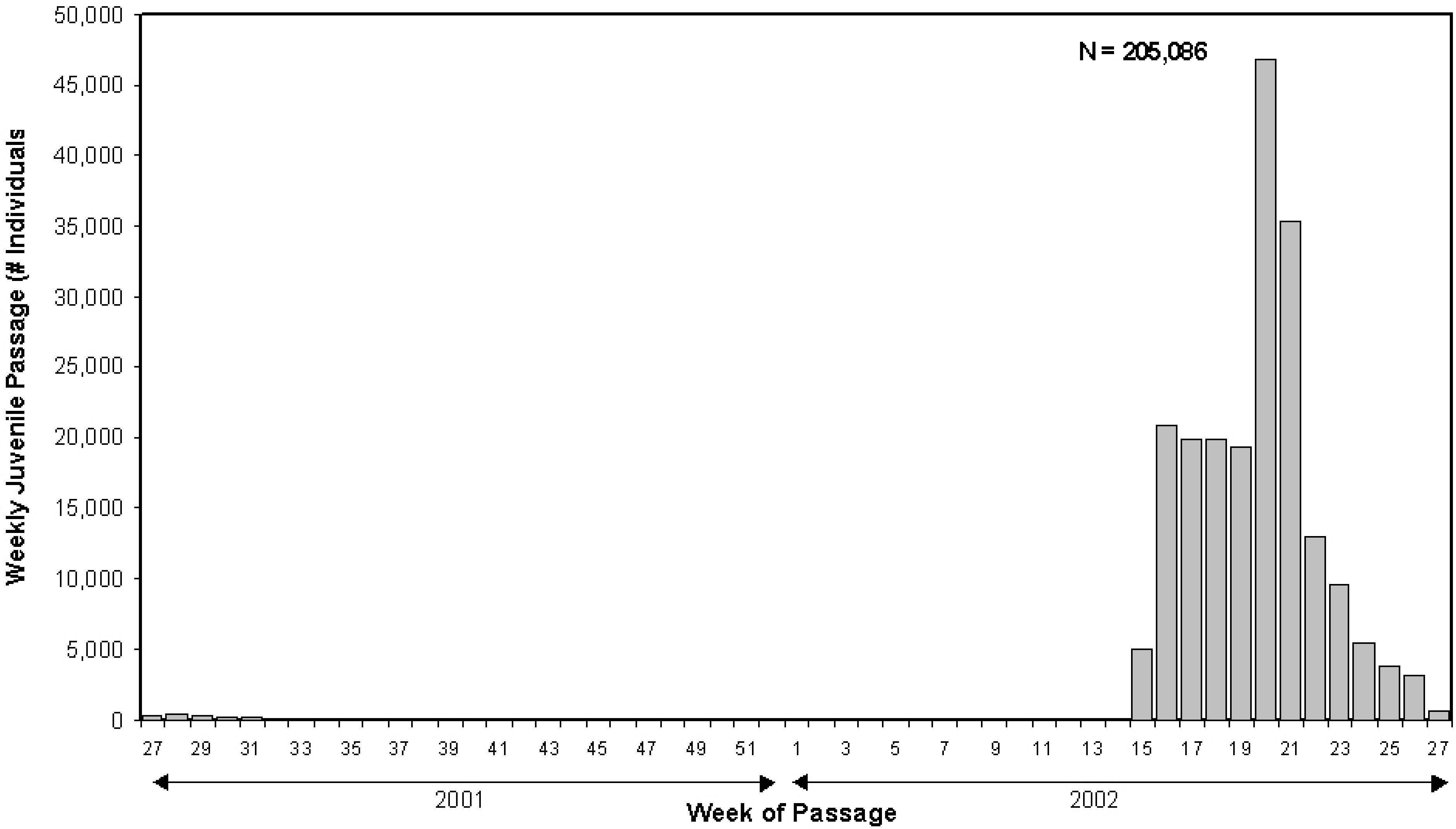

Figure 7.—Juvenile passage index (JPI) by week for late-fall-run size class Chinook salmon emigrants collected with a rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002.

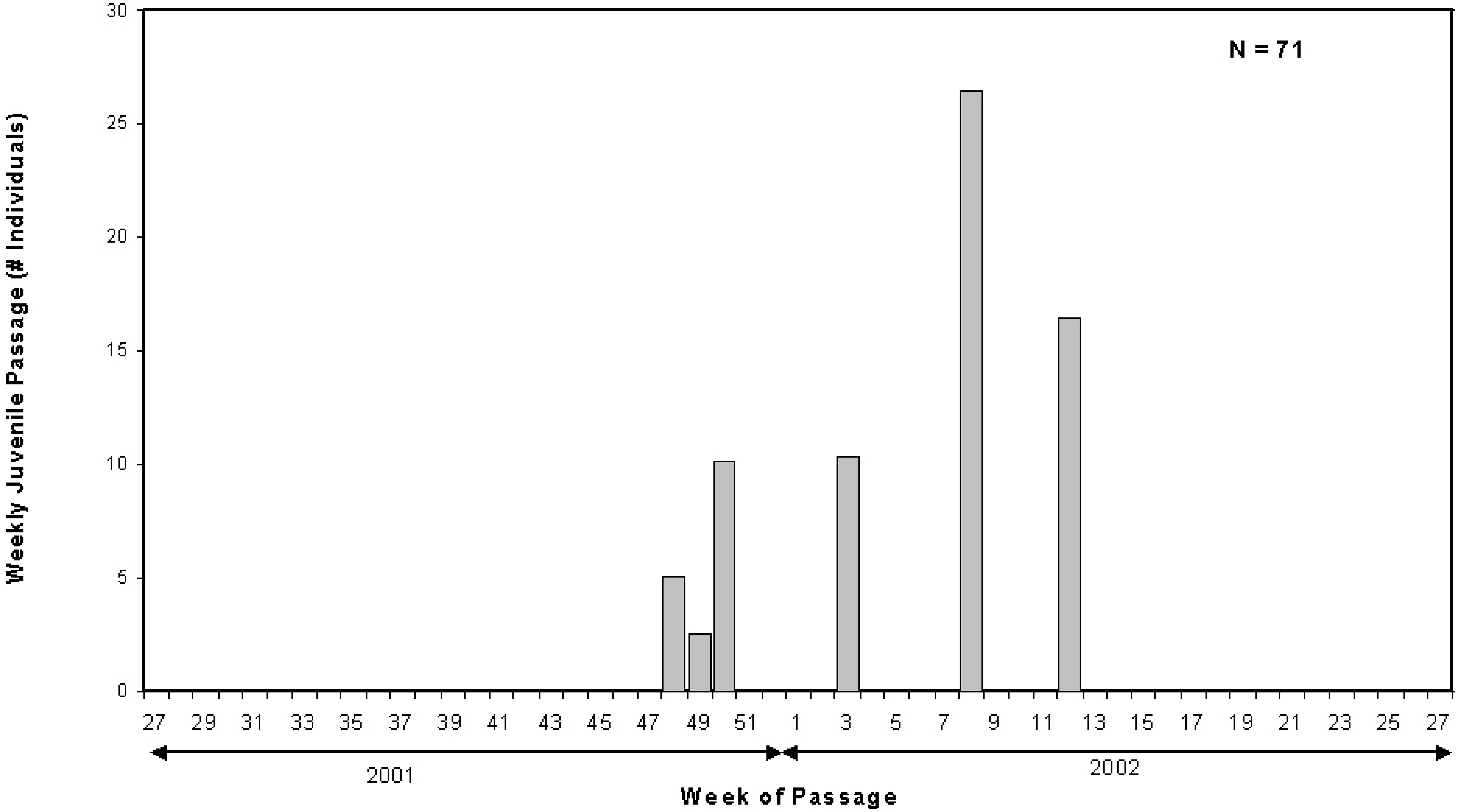

Figure 8.—Juvenile passage index (JPI) by week for winter-run size class Chinook salmon emigrants collected with a rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 200

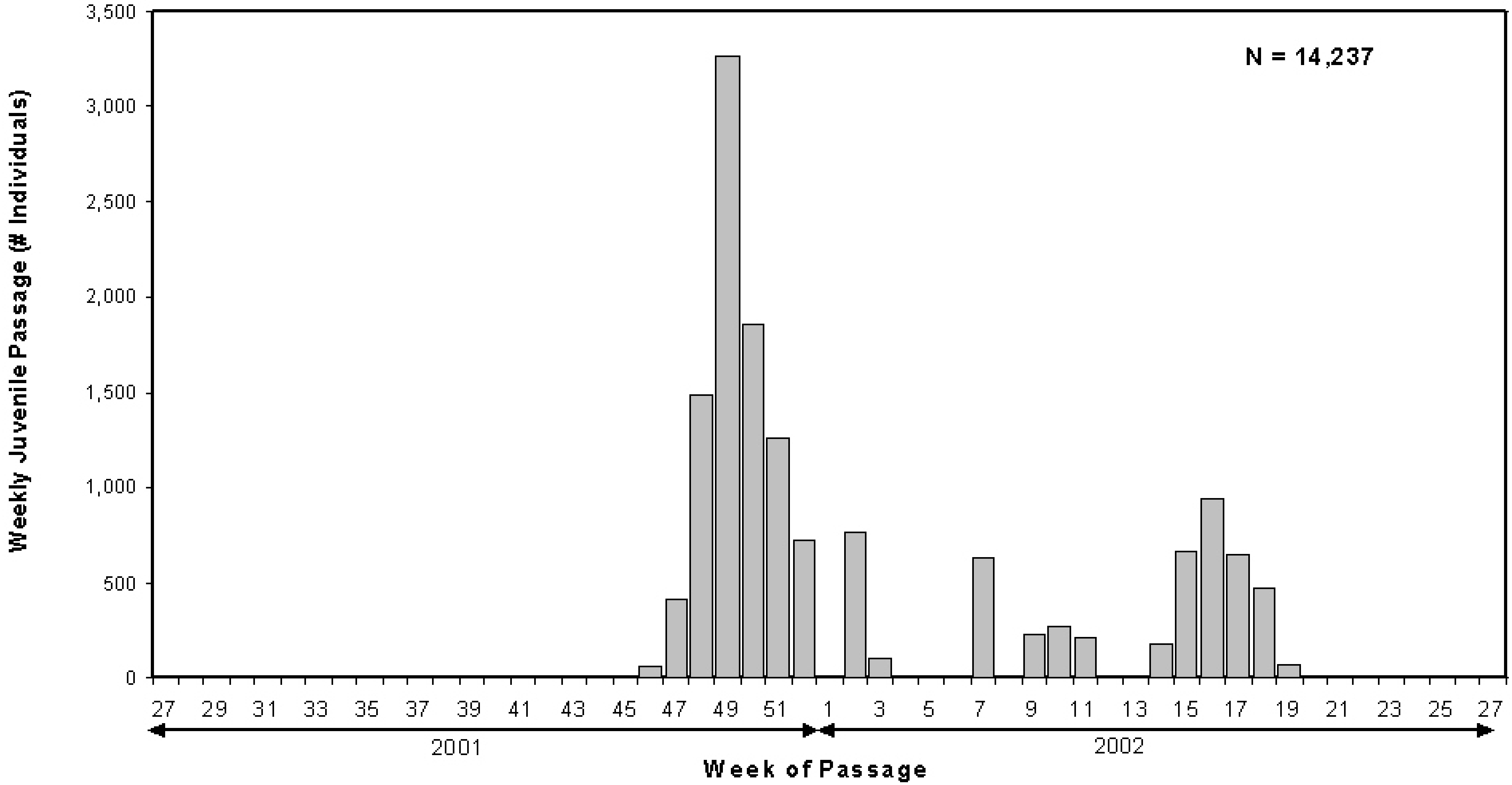

Figure 9.—Juvenile passage index (JPI) by week for spring-run size class Chinook salmon emigrants collected with a rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002.

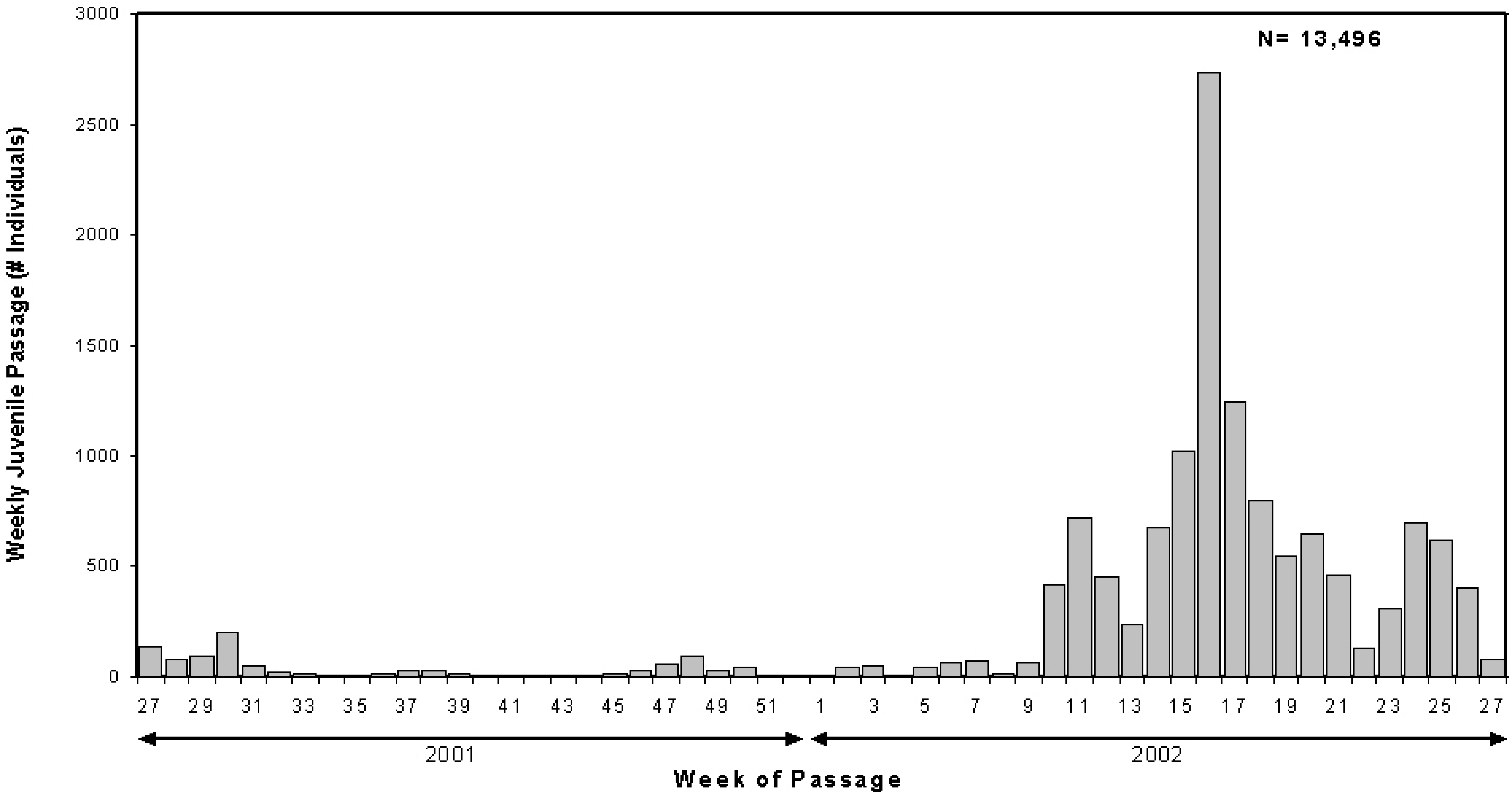

Figure 10.—Juvenile passage index (JPI) by week for juvenile rainbow trout/steelhead collected with a rotary screw trap by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2001 through June 2002.

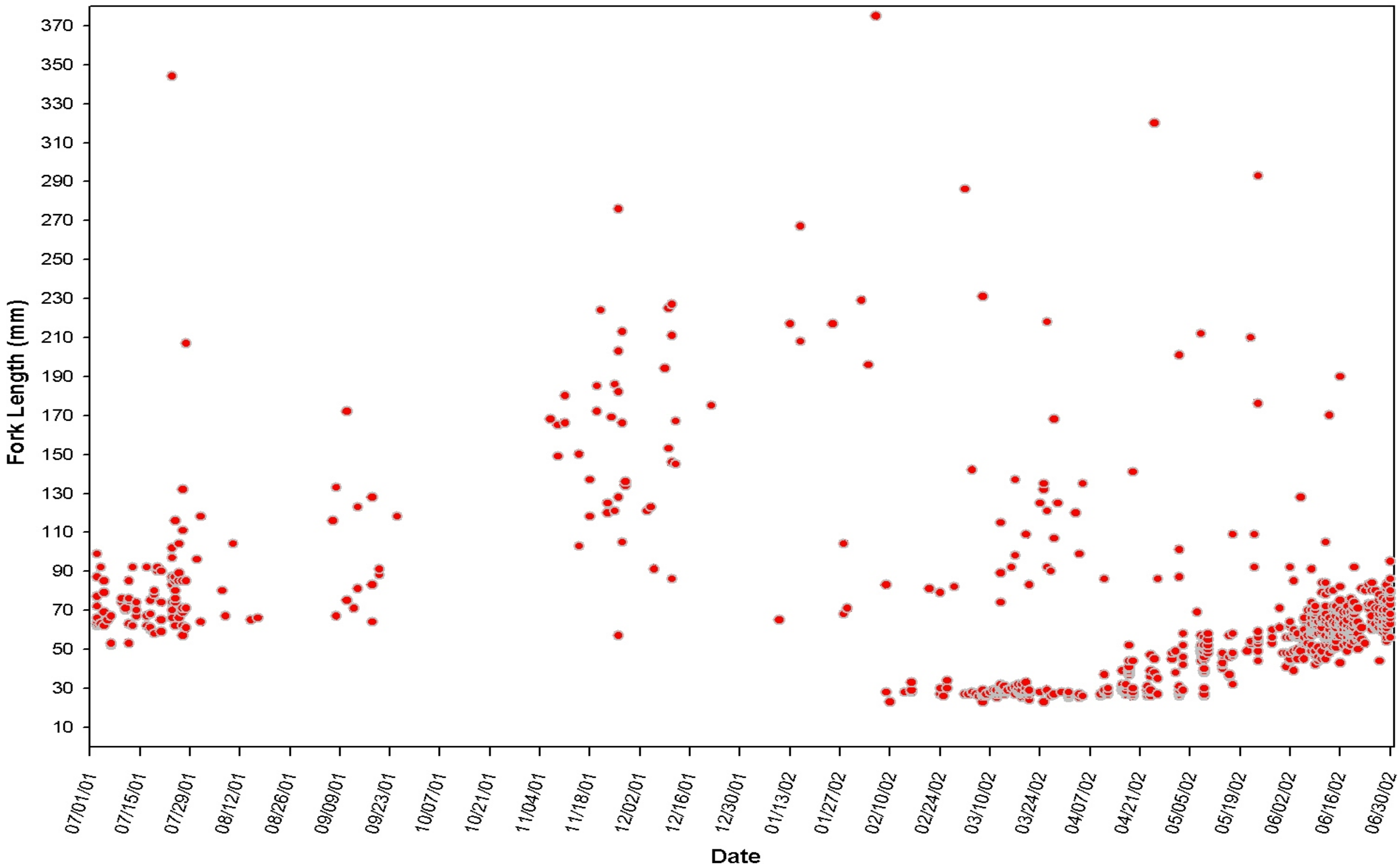

Figure 11.—Fork length (mm) distribution by date for rainbow trout/steelhead captured by rotary screw trap in Clear Creek, Shasta County, California from July 2001 through June 2002 by the U.S. Fish and Wildlife Service.

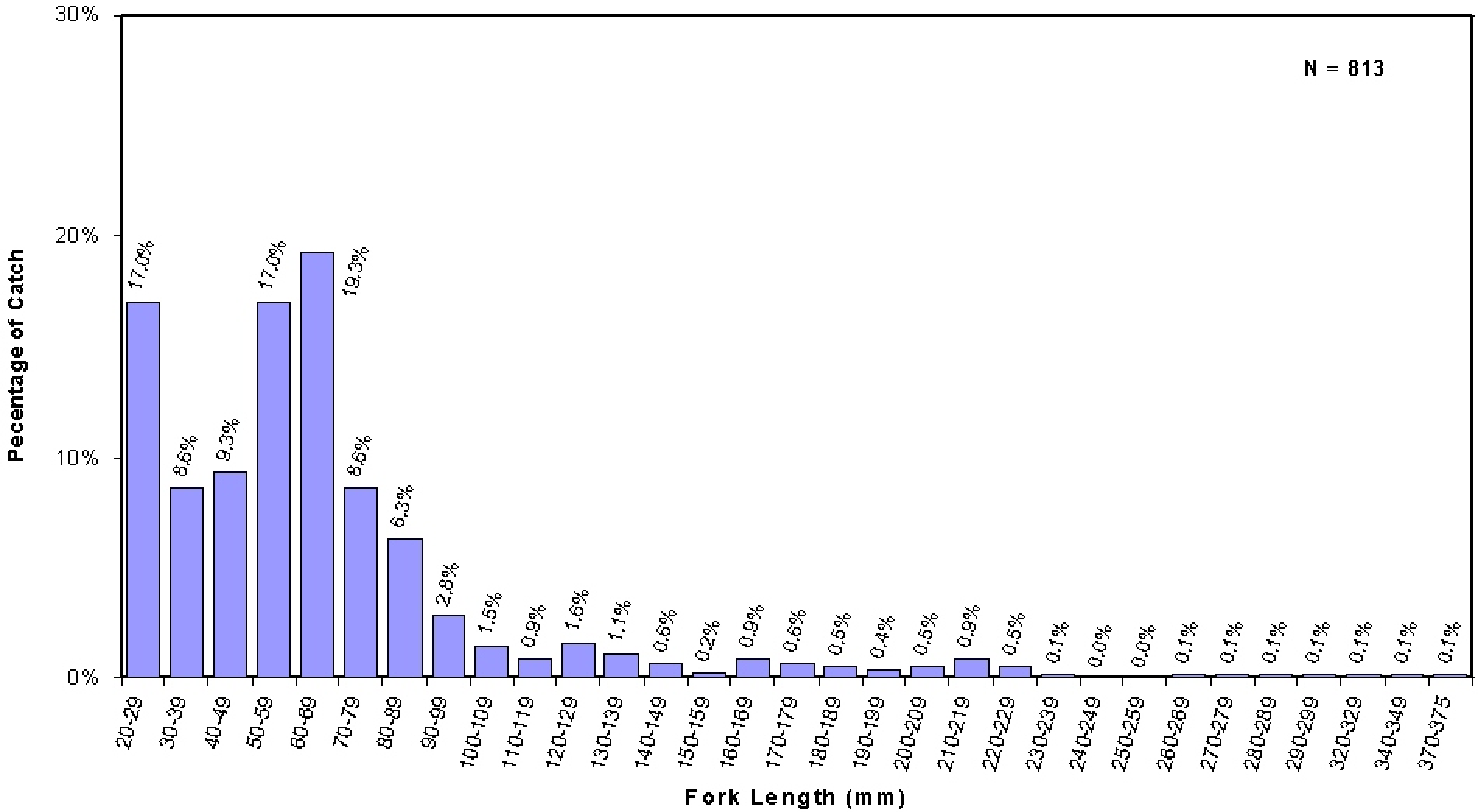

Figure 12.—Fork length frequency distribution and percentage of catch for rainbow trout/steelhead captured by rotary screw trap in Clear Creek, Shasta County, California from July 2001 through June 2002 by the U.S. Fish and Wildlife Service. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments. The value "N" represents the number of fish measured from the total rainbow trout/steelhead catch.

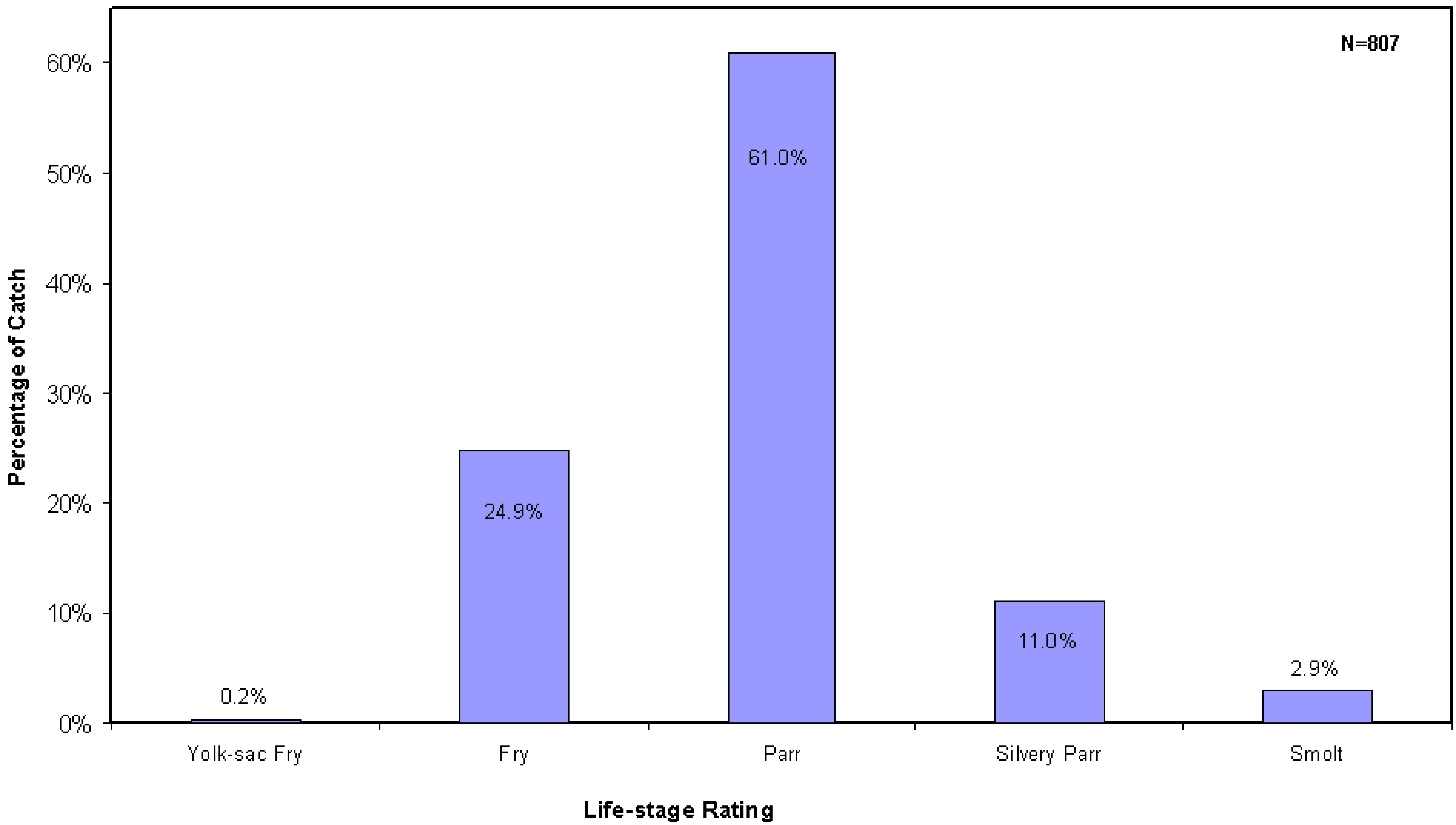

Figure 13.—Life-stage rating distribution for rainbow trout/steelhead captured with a rotary screw trap in Clear Creek, Shasta County, California from July 2001 through June 2002 by the U.S. Fish and Wildlife Service. Life stages were classified as follows: yolk-sac fry, fry, parr, silvery parr, and smolt. The value "N" represents the number of fish assigned a life-stage rating from the total rainbow trout/steelhead catch.

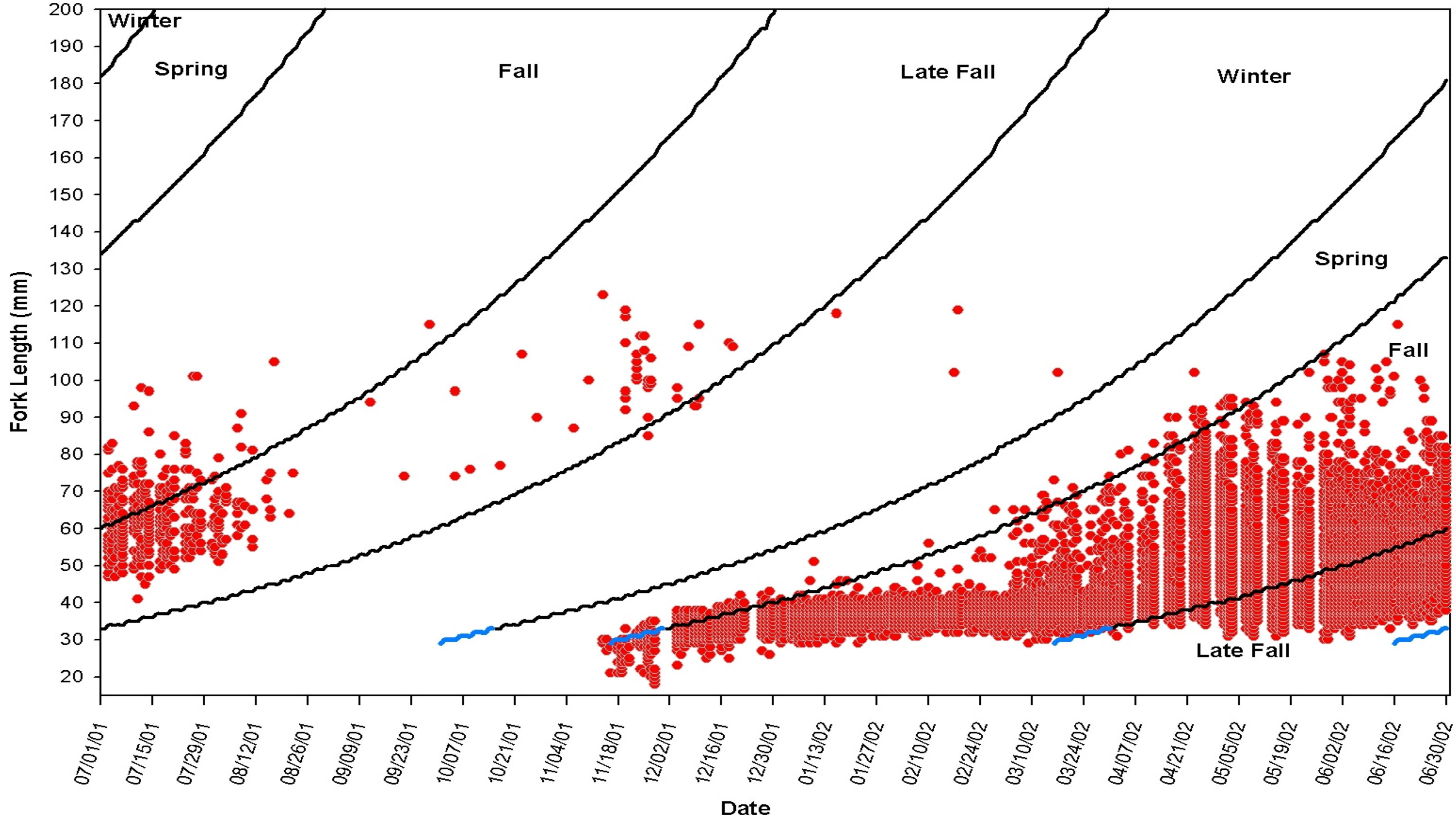

Figure 14.— Fork length (mm) distribution for Chinook salmon captured by rotary screw trap in Clear Creek, Shasta County, California from July 2001 through June 2002 by the U.S. Fish and Wildlife Service. The standard length-at-date tables do not assign run designations to Chinook salmon with fork lengths less than 33 mm. However, the extended spline curves of this graph assign run designations to these shorter fish.