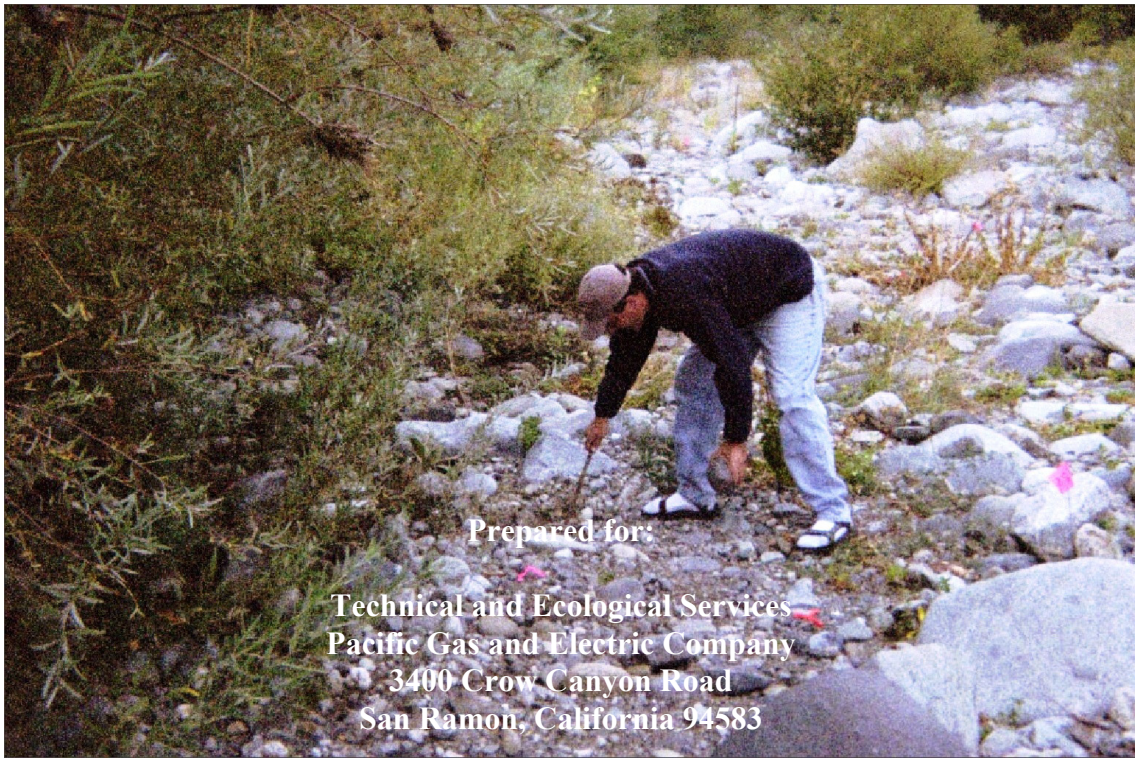
ROCK CREEK-CRESTA (FERC No. 1962)
RECREATION FLOW BIOLOGICAL EVALUATION:
STRANDING AND DISPLACEMENT STUDIES
YEAR 3 - 2004



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Data Report – Notice to Readers

This monitoring data report is part of Pacific Gas and Electric Company's ongoing effort to meet the study requirements of Condition 17 of the Rock Creek – Cresta Project License (FERC No. 1962). This report is part of a three year monitoring effort conducted in consultation with the Ecological Resources Committee (ERC) organized under the Rock Creek – Cresta Settlement Agreement. This report has been submitted to the ERC for review and comment. This report may contain observations made by the authors that may not reflect the opinion of all ERC members. However, as this monitoring report is part of an ongoing study effort, it is not the intent of this report to present final conclusions or recommendations on the overall impacts (positive, negative, or neutral) of recreational streamflow or pulse flow releases. Any use for that purpose would be premature.

Table of Contents

List of Figures and Tables

Figures

List of Figures and Tables (continued)

Tables

List of Appendices

Appendix

Introduction

As part of the Rock Creek-Cresta Relicensing Settlement Agreement (SA), Pacific Gas and Electric Company (PG&E) agreed to provide monthly recreation flows in the Rock Creek and Cresta reaches of the North Fork Feather River (NFFR) during the period of June through October. PG&E agreed to fund a three-year study to determine the effects of the recreation and late-spring pulse flow releases on amphibians, fish, and macroinvertebrates of the NFFR. There is concern that the scheduled flows may potentially displace amphibian egg masses and tadpoles, and fish fry and juveniles from their original locations and/or by stranding amphibian tadpoles, fish fry and juveniles, and macroinvertebrates during down-ramping. High flow releases from dams are known to increase invertebrate drift (Gislason 1985; Irvine 1985; Cobb et al. 1992; Jowett and Richardson 1989; Jowett and Dungey 2000) and potentially cause downstream movement of rearing salmon and trout (McCrimmon 1954; Erman and Leidy 1975; Ottaway and Clarke 1981; Ottaway and Forrest 1983; Heggenes and Traaen 1988; Crisp 1991; Crisp and Hurley 1991; Pearsons et al. 1992) and smallmouth bass. Receding flows following high releases can result in stranding of macroinvertebrates (Kroger 1973; Cushman 1985; Jowett and Dungey 2000) and juvenile salmonids (Maciolek and Needham 1952; Bauersfeld 1977, 1978; Woodin 1984; Hvidsten 1985; Olson 1986, 1990; Olson and Metzgar 1987; Bradford et al. 1995; Higgins and Bradford 1996; Bradford 1997; Saltveit et al. 2001).

Thomas R. Payne and Associates was contracted to conduct the stranding and displacement studies. The hypotheses being tested during the studies are that 1) the release of recreation flows specified in the SA will not displace juvenile fish, and 2) the down-ramping rates for these controlled flows will not result in the stranding of fish, macroinvertebrates, or amphibian tadpoles. Because past studies have suggested that trout populations in the Rock Creek and Cresta reaches may be recruitment limited, displacement and stranding of juvenile trout is of greater concern than similar impacts to juvenile non-game fish, which tend to be very abundant in this area of the NFFR (PG&E 2002).

A secondary objective of the stranding survey was to identify periods during down-ramping that posed the greatest risk for aquatic organisms. The hypotheses are being tested by comparing data on the location and abundance of the species before and after controlled recreation flow events. This report presents the results from the third and final year of evaluations when monthly recreation flows (five in Rock Creek and four in the Cresta reaches) were provided between late June and late October 2004. Results of the biological evaluations conducted during 2002 and 2003 were reported in earlier reports (Salamunovich 2004a, 2004b).

Study Area/Study Sites

The Rock Creek-Cresta Hydroelectric Project (Federal Energy Regulatory Commission [FERC] Project No. 1962) is located on the NFFR in Butte and Plumas Counties. The Project is a vital part of PG&E's NFFR hydropower system, where stored water, mainly from Lake Almanor, produces electricity through a series of nine powerhouses before entering Lake Oroville (Figure 1).

The Rock Creek–Cresta Project consists of the Rock Creek Dam and Powerhouse and the Cresta Dam and Powerhouse. Water (3,300 cfs maximum) is diverted from the Rock Creek Reservoir through the Rock Creek Powerhouse and is discharged into the Cresta Reservoir. The 8.5 mile-long section of the NFFR bypassed by this portion of the project is referred to as the Rock Creek Reach (Figure 2). From Cresta Reservoir, flow (maximum of 3,800 cfs) is diverted through the Cresta Powerhouse and into the Poe Reservoir. The 4.9 mile-long section of the river between Cresta Dam and powerhouse is known as the Cresta Reach of the NFFR (Figure 3).

The Bucks Creek Project (FERC No. 619) Powerhouse discharges water from the Bucks and Grizzly Creek basins into the lower portion of the Rock Creek Reach about one mile upstream of the Rock Creek Powerhouse (Figure 2). Tributaries to the NFFR in the project area include Opapee, Milk Ranch, Chambers, Bucks, Grizzly and Bear Ranch creeks.

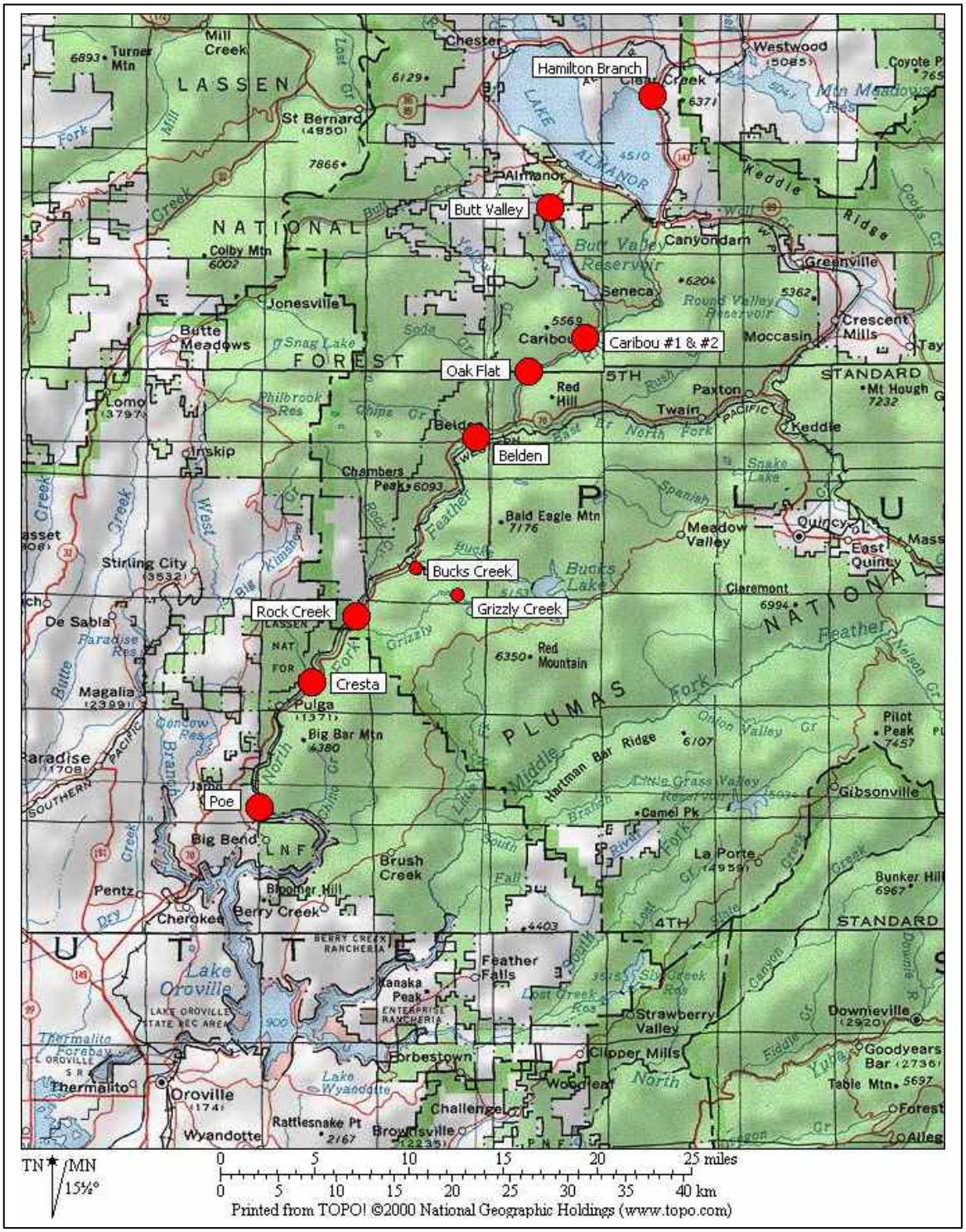

Figure 1. Map showing Pacific Gas and Electric Company's North Fork Feather River hydroelectric facilities including the Rock Creek-Cresta Project (FERC No. 1962).

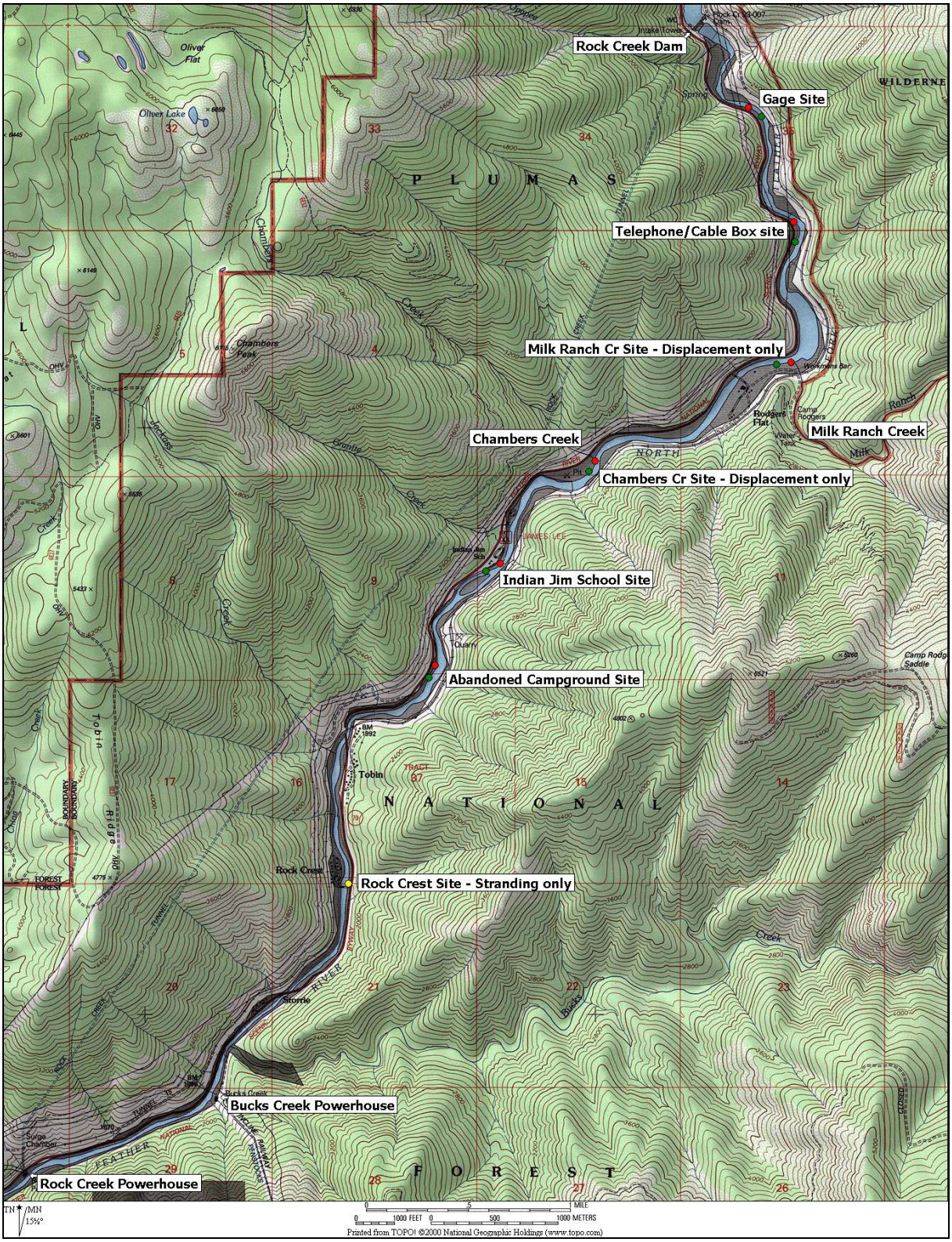

Figure 2. Location of the five stranding and six displacement study sites in the Rock Creek Reach of the NFFR. Green and red dots mark downstream and upstream terminus of study areas, respectively. Yellow dot at Rock Crest site shows location of this 52-foot long site.

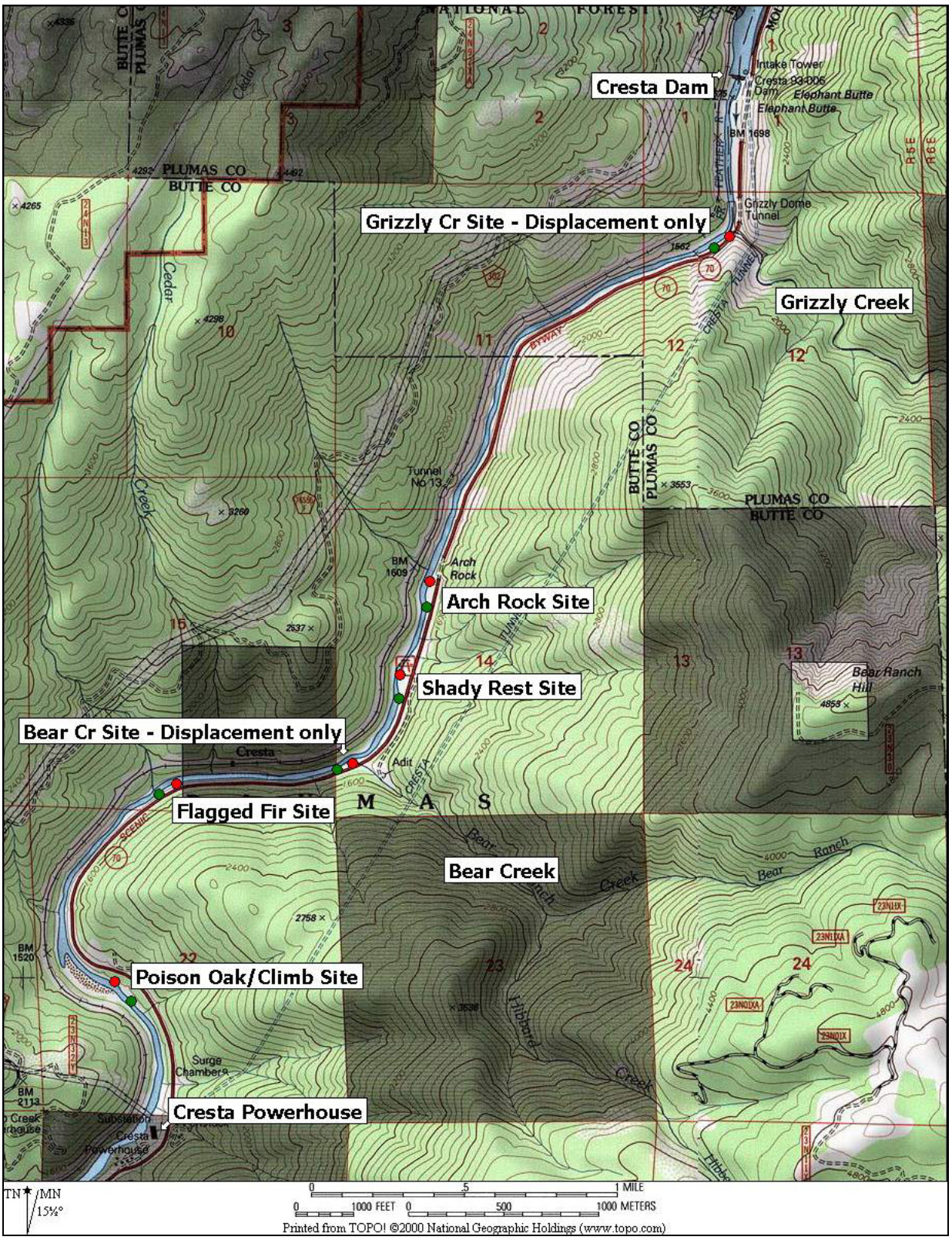

Figure 3. Location of the four stranding and six displacement study sites in the Cresta Reach of the NFFR. Green and red dots mark downstream and upstream terminus of study areas, respectively.

Prior to the first year of biological evaluations in 2002, a survey of the Rock Creek and Cresta study reaches was conducted to identify potential stranding and displacement sites. The lower mile of the Rock Creek Reach was eliminated from consideration due to the confounding influence of the Buck Creeks Project operation on flows in this stretch of the NFFR. The original study plan (PG&E 2002) specified that, if possible, one of the stranding sites be located near known foothill yellow-legged frog (FYLF) habitat, an amphibian species considered as sensitive by Region 5 of the U.S. Forest Service and a species of special concern by the California Department of Fish and Game. The Shady Rest Picnic area along Highway 70 in the Cresta Reach NFFR (Figure 3) was identified as a known FYLF location (Stuart Running, pers. comm.).

Potential stranding sites were identified by the presence of extensive cobble bars (areas had to be at least 150 feet long and 20 feet wide) with low lateral gradients that appeared to pose a high risk of stranding aquatic organisms at elevated flows. Only sites that were on the highway side of the river were evaluated, since attempting to cross the river during high flow and after dark was judged too dangerous for survey crews. Boulder dominated bars were eliminated from consideration since large substrates and their large interstitial spaces, while providing areas of potential stranding could not be adequately surveyed. The identified sites were ranked according to their potential to strand aquatic organisms during receding recreation flows and proximity to known FYLF habitat.

Numerous studies have suggested that young-of-the-year salmon and trout, especially newly emerged fry, are more vulnerable to downstream displacement and stranding than larger juveniles or adults (McCrimmon 1954; Seegrist and Gard 1972; Bauersfeld 1977, 1978; Stober et al. 1981; Woodin 1984; Hvidsten 1985; Irvine 1986; Olson 1986, 1990; Heggenes 1988; Heggenes et al. 1991; Hunter 1992; Harvey et al. 1999; Gido et al 2000). Since the displacement studies were primarily focused on the effects on trout fry (for this study defined as trout less than four inches in length), displacement evaluation sites were

chosen in areas that appeared to have high quality rearing habitat for trout fry. However, all young-of-the-year for all species were identified, when possible, and counted.

We considered high quality fry rearing habitat to be along stream margins (within six feet of wetted edge) with a maximum of shallow, cobble-dominated, low-velocity water habitat (Locke 1987; Moore and Gregory 1988; Bozek and Rahel 1991). In almost all cases these areas were identical to those identified in the stranding site selection and it was decided to conduct the displacement study at the same sites. Several additional displacement evaluation sites were chosen due to their proximity to tributaries where rainbow trout are known to spawn. Wild trout in the Rock Creek and Cresta reaches are thought to be recruited from juvenile fish moving into the NFFR from natal tributary streams (California Department of Fish and Game 1988). These additional "near-tributary" displacement sites were located downstream of Chambers Creek and Milk Ranch Creek in the Rock Creek Reach and downstream of Grizzly Creek and Bear Creek in the Cresta Reach.

Eight stranding and eleven displacement study sites were evaluated during 2002. Another displacement site below Bear Ranch Creek and a small stranding site in the Rock Creek Reach were added during the 2003 field season. These same twelve displacement sites and nine stranding sites were evaluated during 2004 (Figures 2 and 3; Table 1).

The study sites were named for easily recognizable physical or geographic features in the vicinity (Table 1). The Bear Ranch Creek site was commonly referred to as just "Bear Creek" based upon a nearby highway identification sign. The Shady Rest site, judged a high risk stranding area, is also known FYLF habitat. The top and bottom boundary of each survey area was marked with flagging and paint and locations recorded by GPS and transferred to maps.

Desirable site features for the various surveys (i.e. large cobble bars for the stranding surveys, below tributaries for the displacement surveys) and constraints specified in the original study plan (i.e. no sites downstream of the Bucks Creek Powerhouse) limited the

possible site locations to certain portions of the Cresta and Rock Creek study area. For instance, the steep-walled, canyon-confined stream channel of the Cresta Reach upstream of Arch Rock lacked any suitable stranding sites. This fact dictated that all the stranding survey sites were located in the lower half of the Cresta Reach (Figure 3). Conversely, the canyon dominated nature of the NFFR downstream of Tobin with its lack of any suitable stranding sites, combined with the lack of significant spawning tributaries and the elimination of the area downstream of Bucks Creek Powerhouse resulted in the survey sites being confined to the upper half of the Rock Creek Reach (Figure 2).

Table 1. Site names (with abbreviations used for report graphs), reach locations, distance downstream from control dam, site length, and type of surveys conducted for the nine stranding and twelve displacement sites used in the 2004 Rock Creek-Cresta Project recreation flow evaluations.

Study Site Name	(Abbrev.)	Study Reach	Distance Downstream from Dam [1/] (miles)	Reach Length [2/] (feet)	Type of Survey
Gage	(Gage/GA)	Rock	0.62	434	Stranding/Displacement
Telephone/Cable Box	(Tel/TC)	Rock	1.35	660	Stranding/Displacement
Milk Ranch Creek	(Milk/MR)	Rock	2.13	338	Displacement
Chambers Creek	(Chamb/CC)	Rock	3.33	333	Displacement
Indian Jim School	(Ind/IJ)	Rock	4.15	450	Stranding/Displacement
Abandoned Campground	(Ab CG/AC)	Rock	4.82	432	Stranding/Displacement
Rock Crest	(RCr/RC)	Rock	6.20	52	Stranding
Grizzly Creek	(Griz/GR)	Cresta	0.56	346	Displacement
Arch Rock	(Arch/AR)	Cresta	2.22	463	Stranding/Displacement
Shady Rest	(Shady/SR)	Cresta	2.56	470	Stranding/Displacement
Bear Ranch Creek	(Bear/BC)	Cresta	2.86	350	Displacement
Flagged Fir	(Fir/FF)	Cresta	3.50	340	Stranding/Displacement
Poison Oak/Climb	(PO)	Cresta	4.43	433	Stranding/Displacement

1/ Dam refers to Rock Creek Dam in Rock Creek Reach or Cresta Dam in Cresta Reach

2/ Lengths are those measured during original site selection and may differ slightly from lengths measured during each monthly survey

Methods

Displacement Survey

The displacement evaluations involved a comparison of visual fish counts made by two divers moving along each stream bank within 24 hours before and after the scheduled recreation flows. It was assumed that the recently-hatched and juvenile stages of resident fish were most prone to displacement from recreation flows. The larvae and early juveniles of most stream fishes tend to use near shore areas with relatively slow-moving water near cover, vegetation, or sharp vertical relief (Snyder 1990).

Prior to each monthly survey, the top and bottom boundary of each study reach were identified by both divers and the distance between the two points was measured to the nearest foot using a hip chain. The margins of both banks at each of the twelve displacement study sites were systematically surveyed by divers moving slowly upstream. Locations with cover were inspected closely for concealed fish. During the 2004 snorkel counts, divers were instructed to group non-larval fish into four size categories: <4 inches, 4–8 inches, 8–14 inches, and >14 inches. Each diver recorded their survey data on a small plastic slate attached to their wrist. The displacement survey data was ultimately recorded on a standardized data sheets (Appendix A). Data collected included the number, species, and size category of fishes observed, station length, estimate of search area, visibility, and survey time. Only the shallow margin areas within six feet of the bank were included in the surveys since this represented the majority of the available fry habitat at each site. Side channels were included in the survey at three of the sites (i.e., the Poison Oak Site in the Cresta Reach and the Abandoned Campground and Milk Ranch sites in the Rock Creek Reach).

To assess dive count accuracy and to promote careful censuses, replicate counts by two different divers were made along each bank. Final counts for each survey site were derived by summing the average of the two replicates made from each bank:

$$\text{Final Dive Count} = \frac{(\text{left bank replicate 1} + \text{replicate 2})}{2} + \frac{(\text{right bank replicate 1} + \text{replicate 2})}{2}$$

To ensure that replicate counts were not biased, each diver recorded their initial counts in separate notebooks without communicating to the other diver what they had seen. After separately recording their data from the first dive, divers then changed sides of the river and repeated the snorkel counts, resulting in two separate independent counts for each bank along the study site. After the second dive count, all the data was transferred to a single data sheet. Divers moved slowly along the banks with a minimum of disturbance to reduce the potential of chasing fish from the census areas and confounding replicate counts.

Visual counts are dependent on water clarity and the ability of divers to see and count fish without disturbing or chasing them out of the census area. To assess the distance divers could identify fish, an estimate of visibility was recorded at each site during the survey. This visibility estimate was based upon the distance (recorded to the nearest 0.5 foot) that a diver could clearly identify the parr marks on a two inch-long artificial trout that floated stationary at a height of six inches above the streambed. Water visibilities were measured perpendicular to flow and in the same lighting (sun or shade) that was predominant at the time of the survey.

The displacement survey was repeated at each site within 24 hours after the completion of the recreation flow. A comparison of the counts made before the recreation flows to those made after the flow event was used to evaluate the potential for the controlled flows to move fish downstream out of the study sites.

During 2003 a series of "control dives" were performed to assess dive count accuracy during a period of stable stream flow conditions (i.e. without any intervening recreation flow releases). This evaluation was reported on in a previous report (Salamunovich 2004b) and was not repeated during the 2004 season.

Stranding Survey

Stranding monitoring stations were visually assessed for fish, tadpoles, and macro-invertebrates during the down-ramping from the peak flows following each of the recreation flows. During 2002 the recreation flows were provided on the first weekend of each month. In order to minimize impacts to FYLF spawning and incubation through late June, the ERC decided to move the recreation flows to the last weekend of each month during the 2003 and 2004 seasons. Due to the numbers of incubating FYLF egg masses found in the Cresta Reach in late June, the recreation flows were cancelled in this reach for this month. With this single exception for June, the recreation flows were scheduled to be maintained for a period of six hours (10 AM to 4 PM) one day each month (staggered by 24 hours) in both NFFR study areas (Table 2).

Table 2. Dates and peak target flow levels for the six-hour recreation flows released in the NFFR during 2004.

Date	Cresta Reach	Rock Creek Reach
June 26	Cancelled to protect FYLF	
June 27		1600 cfs
July 24	1200 cfs	
July 25		1200 cfs
August 28	1000 cfs	
August 29		1000 cfs
September 25	1000 cfs	
September 26		1000 cfs
October 23	1000 cfs	
October 24		1000 cfs

The two-person survey teams began their evaluations at 4 PM (at the start of the down-ramping) by measuring the length of the survey reach (to the nearest foot) with a hip chain, marking the top and bottom of the reach with flagging, and placing markers along the waters edge at 25 foot intervals, except for the 600+ foot-long Telephone Site where 30 foot intervals were used (Figure 4). These initial water edge locations served as "transects" for the remaining hourly surveys. The distance between marks along each transect were measured to the nearest 0.1 foot. These distances along with the known between transect

interval defined discreet areas that could be summed to estimate the area searched during any of the hourly intervals or for the entire reach.

Newly exposed stream banks were systematically searched by two biologists during each hourly interval during down-ramping beginning at 5 PM. If significant portions of the stranding site had not emerged from receding flows at this time, no survey was performed until the next hour interval. This schedule resulted in staggered start times depending on the study site distance from the down-ramp control point (i.e. Cresta Dam or Rock Creek Dam). Surface cobbles and small boulders covering likely stranding locations (i.e. depressions and pockets along the bar) were lifted to inspect underneath for stranded organisms.

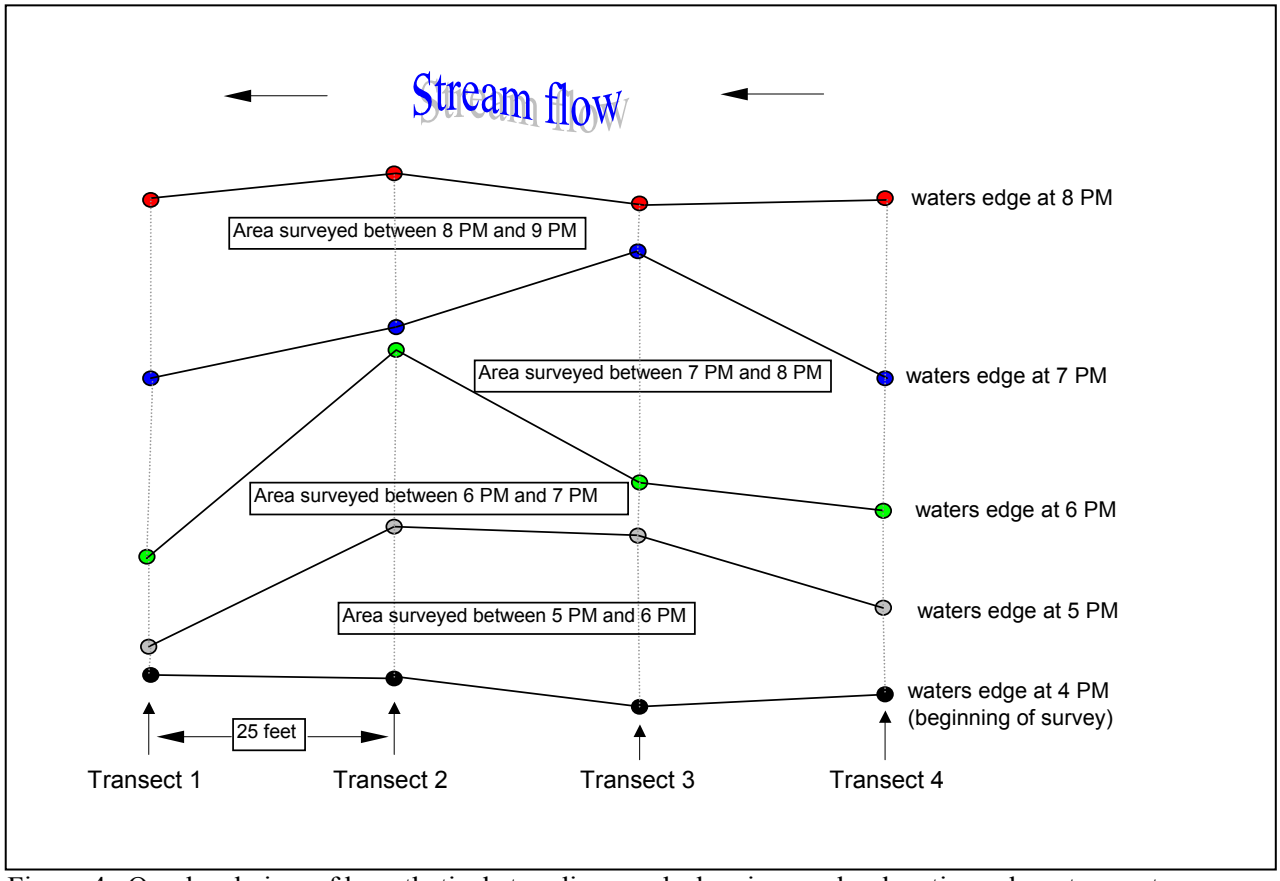

Figure 4. Overhead view of hypothetical stranding reach showing marker locations along transects used to track receding waters edge during hourly surveys and guide crews on areas to search during a particular survey interval. When the distance between markers on a transect were measured, the distances defined dicreet search areas that could be summed to estimate larger search areas for either an hourly interval or for the entire survey.

The original study plan anticipated only moving a small number of randomly-selected cobbles (less than 25 per hourly survey; Stuart Running, pers. comm.). However, during the early 2002 surveys it became apparent that to perform a thorough search of the recently submerged boulder/cobble bar required significantly more effort and would have to be done in a non-random, directed approach. The search teams moved as many rocks as necessary to allow for careful inspection, but limited movements to cobble or boulders that were covering interstitial pockets with a high potential for trapping organisms during receding water levels. Surveyors avoided moving embedded substrate elements that provided little or no risk of trapping organisms.

The survey areas were photo-documented at the time of peak flow and again after the return to the base flow. Hourly efforts were suspended in the last hour of twilight when visibility became reduced and survey conditions became both unsafe and inefficient. The suspension of surveys varied with sunset times during the field season (Table 3). Shoreline searches were completed the following morning.

Table 3. Sunset times for Storrie California (lat.: 39°54'42" N; long.: 121°19'21" W), and times of last hourly stranding survey and waters edge marking before suspending searches for end of daylight for each of the monthly stranding surveys conducted in the Cresta and Rock Creek reaches of the NFFR during 2004. All times indicated are Pacific Daylight Time.

Date	Sunset	Last Stranding Survey Interval completed before dark	Last Waters Edge Marked
June 27	8:38 PM	8:00-9:00	9:00 PM
July 24 & 25	8:25 PM	8:00-9:00	9:00 PM
August 28 & 29	7:41 PM	7:00-8:00	8:00 PM
September 25 & 26	6:55 PM	6:00-7:00	7:00PM
October 23 & 24	6:13 PM	5:00-6:00	6:00 PM

The number, size, and identification of stranded fish, tadpoles, and macroinvertebrates were recorded on standardized field data sheets (Appendix B). Teams identified items to at least the family level whenever possible. If a stranded organism was found under a rock,

this was recorded. Larger, easily identified organisms that were still alive were released back to the water. Less easily identified organisms (e.g. small macroinvertebrates) or dead organisms were preserved in labeled jars of alcohol for later examination and identification. Semi-aquatic organisms (i.e. water-striders) and terrestrial organisms (e.g. millipedes, spiders, or ants) were not recorded during the surveys.

No scavenger-predator evaluations were conducted during the 2004 field season. The results of these assessments included in the 2002 surveys were very consistent each month (Salamunovich 2004a) and they were not repeated for this field season.

During 2003, simulated stranding surveys were conducted along areas of the NFFR in order to estimate the percentage of stranded organisms that are found during the actual stranding surveys (Salamunovich 2004b). These evaluations were not repeated during the 2004 season.

Total Stranding Area Survey and Total Stranding Estimates

Detailed information on the varial zone gradients at the nine stranding evaluation study sites was conducted in June 2003 (Salamunovich 2004b). One of the recommendations following the 2003 field season was to determine an estimate of the total amount of stranding area present in the Rock Creek and Cresta study reaches. This estimate would then provide a perspective on the stranding studies by indicating the percentage of available stranding area represented by the actual stranding study sites, as well as provide a reasonable basis for estimating the total stranding in the entire study area. This estimate of total stranding area when combined with the stranded organisms densities, as adjusted by overnight scavenger/predator losses and search efficiencies, derived from the three years of stranding studies would also provide a reasonable basis for estimating the magnitude of stranding throughout the Project area.

Prior to the June 2004 recreation flow releases, the entire Rock Creek and Cresta reaches were inspected on foot and by kayak to identify all the significant stranding areas. This

initial survey was conducted during the base flow conditions and included the Rock Creek Reach from Rock Creek Dam downstream to Rock Creek Powerhouse and the Cresta Reach from Cresta Dam downstream to Cresta Powerhouse. Both river banks as well as mid-channel islands and bars were inspected. In order to make the site identification more manageable, only sites that appeared to offer areas >300 ft^2 in size with varial zone gradients and substrate characteristics that were judged to be prone to stranding were identified. Steep-banked sites or sites with mostly bedrock substrate were considered unlikely stranding areas and were excluded. During this initial identification survey, information to help relocate the sites was noted and recorded. All sites were marked with high-visibility surveyors flagging, GPS coordinates were noted, as were nearby landmarks or highway mileage markers. Photos of the sites at base flow were also taken.

All sites were revisited during the highest available recreation flow in each study reach using the markers and photos to help relocate sites. The peak recreation flow waters edge was marked at multiple locations along each site using rocks or metal weights denoted with colored surveyors flagging. Several sites in the Rock Creek Reach that were accessible by foot during the high flow were marked by walking crews. Most of the remaining sites were revisited by surveyors using kayaks which allowed access to all portions of the river (including mid-channel and non-road bank) during the high flow conditions. Several sites in the lower Rock Creek Reach downstream of Bucks Creek Powerhouse that had relatively simple gravel/cobble banks were not actually visited at the high flow but were instead carefully photo-documented during the peak flow conditions.

The sites were then revisited again shortly after the peak flows and the distance between the peak flow waters edge marks and the base flow water edge were measured to the nearest 0.1 foot using a surveyors tape. The longitudinal distance between the marks and the length of the entire stranding zone was also measured to the nearest foot using a hip chain. The varial zone gradients were also measured at each of the water edge marker locations using hand-held level and a stadia rod. During this survey, the stranding potential at each site was assessed and recorded based upon the existing substrate and

gradient characteristics at that site in comparison to our actual stranding evaluation sites. Sites were ranked as having high, moderate or low stranding potential. High stranding potential sites had relatively low varial zone gradients and substrate elements that provided significant interstitial spaces or potholes for trapping organisms during down-ramping (e.g., boulder-cobble bars). Low stranding potential sites were those with high gradient varial zones and few interstitial spaces (e.g., gravel/sand banks). Moderate potential sites were those sites that possessed a mixture of high or low stranding potential features.

For the few Rock Creek Reach sites that relied on photo-documentation, the post-flow recreation survey began by first placing high waters edge markers at appropriate locations based upon photographs taken during the peak recreation flow. Once the markers were placed, the surveys continued as described above.

This survey information was then used to compute stranding zone areas and gradients at each site during a particular recreation flow. From the numerous measurements made at the nine stranding evaluation sites over the three years of study we determined the relationship of recreation flow level to survey areas from our detailed monthly stranding site surveys. In the Cresta Reach, the 1200 cfs and 1000 cfs stranding areas were 84.1% and 76.9% of the 1600 cfs stranding area, respectively. In the Rock Creek Reach, the 1200 cfs and 1000 cfs areas were 86.4% and 80.6% of the 1600 cfs area. This information was then used to calculate a total stranding area estimate for each of the three recreation flow levels in both the Cresta and Rock Creek reaches.

In order to generate a total stranding estimate, mean monthly stranding density estimates had to be calculated. These estimates had to be adjusted for both our estimated search efficiencies and for the overnight loss of stranded organisms to scavengers and predators. The overnight loss of stranded organisms to scavengers/predators was derived from the evaluations performed as part of the 2002 surveys (Salamunovich 2004a). This overnight loss was assumed to be 27.8% (or conversely, a 72.2% persistence rate) for all organisms. The search efficiency estimates were derived from simulated stranding evaluations

performed in June 2003 (Salamunovich 2004b) and was assumed to be 58.8% for stranded benthic macroinvertebrates and 80.5% for all fish and tadpole categories.

In order to make these adjustments, the monthly stranding survey results from each site were divided into organisms that were found during the afternoon/evening surveys and those found during the surveys completed the following morning. Both the afternoon/evening and morning results were adjusted by our estimated search efficiencies. Then the adjusted morning results were adjusted again to account for the overnight losses of stranded organisms to scavengers and predators. Once these adjustments had been made, the estimated numbers of organisms stranded during the afternoon/evening surveys were combined with the estimated numbers stranded during the morning surveys to provide an estimate of the total numbers of stranded organisms. Separate estimates were made for benthic macroinvertebrates (BMI), fish, and for tadpoles. The fish category was further separated into the various species categories (i.e., trout fry, non-game post-larvae, etc.). Since there were several cyprinid fry found stranded, but were released alive without adequate identification, there is a separate hardhead/pikeminnow (HH/PKM) category included in the analysis.

The estimated total number of organisms in each category was summed by month over all three years of the surveys and then divided by the search area to generate a mean monthly stranding density estimate for both the Cresta and the Rock Creek reaches. In other words, all the estimated organisms in a category from the June 2002, 2003, and 2004 Rock Creek Reach were summed and then divided by the total area surveyed to generate the mean stranding density for June in the Rock Creek Reach. Since these densities had been adjusted to account for both search efficiencies and overnight losses, they are referred to as the adjusted mean monthly stranding densities, or AMD.

By way of example, the adjusted mean monthly density for stranded BMI during the June 1600 cfs recreation flow down-ramping event in the Rock Creek (RC) Reach of the NFFR ($AMD^{BMI}_{RC(1600)}$) was calculated as follows:

$AMD^{BMI}_{RC(1600)}$ = *((ΣBMI items collected in PM from all Rock Creek sites during all June surveys (2002-2004) ÷ 0.588 [i.e., search efficiency adjustment]) + ((ΣBMI items collected in AM from all Rock Creek sites during all June surveys (2002-2004) ÷0 .588 [i.e., search efficiency adjustment])÷ 0.722 [i.e., overnight loss adjustment])) ÷ Σ area surveyed in Rock Creek Reach sites during all June surveys (2002-2004).*

Similar adjusted mean density estimates were computed for each month and for each stranded item category in both study reaches. These adjusted stranding density estimates were used to calculate a total stranding estimate based upon the estimated total stranding area in each reach.

In order to account for the different stranding potentials at the various stranding sites, the following assumption was made: high potential stranding = 100% of the adjusted mean monthly stranding density computed above; moderate potential stranding = 66.7% of the adjusted mean monthly stranding density; low potential stranding = 33.3% of the adjusted mean monthly stranding density. For example, to derive the total stranding (TS) for benthic macroinvertebrates (BMI) for the Rock Creek Reach at the 1600 cfs June flow (TS $^{BMI}_{RC(1600)}$), the following formula was used:

$$TS^{BMI}_{RC(1600)} = ((\Sigma HQA_{(1600)} \text{ X 100\% of } AMD^{BMI}_{RC(1600)}) + (\Sigma MQA_{(1600)} \text{ X 66.7\% of } AMD^{BMI}_{RC(1600)}) + (\Sigma LQA_{(1600)} \text{ X 33.3\% of } AMD^{BMI}_{RC(1600)}))$$

where, $\Sigma HQA_{(1600)}$ = sum of high potential stranding area in Rock Creek Reach at 1600 cfs;

$\Sigma MQA_{(1600)}$ = sum of potential quality stranding area in Rock Creek Reach at 1600 cfs;

$\Sigma LQA_{(1600)}$ = sum of potential quality stranding area in Rock Creek Reach at 1600 cfs;

$AMD^{BMI}_{RC(1600)}$ = adjusted mean monthly density of stranded BMI from all five Rock Creek stranding sites during all three June 1600 cfs evaluations (2002-2004)

Total stranding estimate values for other items (e.g., trout fry, tadpoles, etc.) at the June 1600 cfs recreation flow down-ramping as well as for the July 1200 cfs recreation flow and the three 1,000 cfs recreation flows (August, September and October) were similarly derived.

Analysis of Larval Fish Data from 2002 Driftnet Sampling

Auxiliary information about displacement of small fish was developed from the drift samples collected from the NFFR at the old Rodgers Flat Bridge (0.25 miles downstream of our Milk Ranch Creek displacement survey site) in the Rock Creek Reach in 2002. During 2002, fifteen-minute duration drift samples were collected every two hours for a five day period each month that included the recreation flows (see Garcia and Associates 2004a for more details). Two 500 μm mesh driftnets, mounted on a 30-cm diameter bongo frame, sampled the stream flow about six inches below the water surface. Samples were preserved in 10 percent formalin. While the focus of the study was to investigate the response of the macroinvertebrate community to the monthly recreation flows, fish were also collected in the samples. I want to acknowledge and thank Mr. Rob Aramayo for making the fish specimens from the June 2002 samples available for examination and use in this analysis.

All the fish examined were stored in vials labeled to indicate sample number, date and time of sample collection, and net of origin (right or left). Garcia and Associates also provided the information on the volume of water sampled so drift densities could be calculated. All fish were identified and measured in the laboratory using a dissecting microscope. Fish abundance (#fish/ sample) and density (#/m3) were examined to determine if these metrics were significantly correlated to either the period of the high recreation flow or some other factor such as time of day.

Results

Detailed plots of the hourly flows for the 72-hour period bracketing the recreation flow releases in the Cresta Reach (gage NF-56) and Rock Creek Reach (gage NF-57) are presented in Appendix C. These plots indicate the times of the displacement and stranding surveys in each of the reaches in relation to the flow data at both stream gages. A broader overview of the flows at the gages for the entire study period is presented in Figure 5. The recreation flows occurred during the fourth full weekend of each month. The June recreation flow in the Cresta Reach was cancelled due to concerns over incubating FYLF egg masses. The June recreation flow in the Rock Creek Reach was somewhat attenuated with fourteen hours of flow greater than 1,000 cfs (8:00 AM to 10:00 PM), including over seven hours of recreation flows greater than 1,600 cfs (9:30 AM to 5:00 PM).

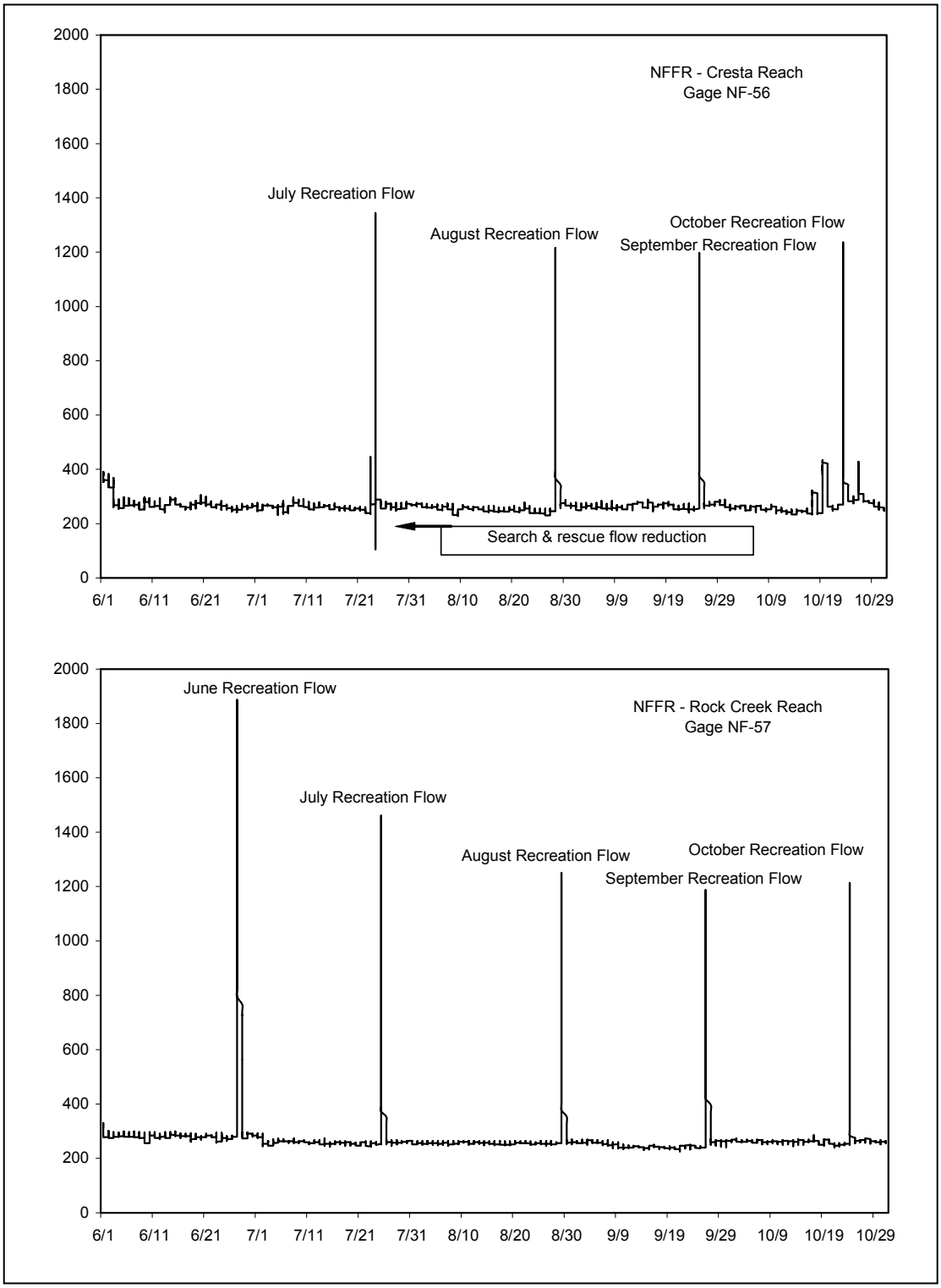

Figure 5. Fifteen-minute flow records for the Cresta and Rock Creek study reaches, June through October 2004.

Down-ramping rates over the past three years were calculated using the available stage data from the two stream gages (NF-56 in the Cresta Reach and NF-57 in the Rock Creek Reach). In both reaches, down-ramping from the recreation flow back to base flow levels is typically in the 2.5 to 5 inch per hour range (Table 4).

Table 4. Down-ramping rates (inches/hour) for the 2002 through 2004 recreation flows as measured at the Cresta (NF-56) and Rock Creek (NF-57) stream flow gages.

Date	Cresta	Rock Creek
2002		
June	4.19	3.20
July	4.03	4.62
August	4.98	4.43
September	4.14	4.49
October	4.80	4.28
2003		
June	No recreation flow	3.67
July	4.32	4.24
August	4.91	4.51
September	11.06*	4.06
October	4.61	4.42
2004		
June	No recreation flow	2.69
July	20.16**	3.08
August	2.59	2.98
September	3.46	2.57
October	2.87	2.78

* Down-ramping rate was 14.35 inches/hr during first 1.5 hours and 6.80 inches/hr over next 3.25 hours and was performed to facilitate county search and recovery efforts

** Down-ramping rate was 28.32 inches/hr during first 1.5 hours and 16.44 inches/hr over next 1.0 hour and was performed to facilitate county search and rescue efforts

Two flow anomalies occurred in the Cresta Reach during the July 2004 surveys. At 10:30 AM on 23 July, immediately prior to our pre-recreation displacement snorkel survey, there was a short duration flow increase from 265 cfs to 445 cfs (Appendix C, Figure C-2). Apparently, PG&E operations personnel raised and lowered the radial gate at Cresta Dam as part of procedure for testing the automatic controller unit (Andrew Cordone, pers.

comm.). The stream flow was back at base flow levels by 1:30 PM. The snorkel surveys were conducted after 2:30 PM on that date.

A near-drowning event during the 24 July recreation flow resulted in flows in the Cresta Reach being abruptly reduced below base flow levels (Appendix C, Figure C-2). The recreation flow was terminated at 2 PM to allow county emergency personnel an opportunity to search the river for an apparent drowning victim. Because of the emergency situation, down-ramping from the recreation flow was accelerated over the normal rates (Table 4). Flows at the Cresta gage (NF-56) were reduced from 1,344 cfs (2 PM) to 107 cfs (4:30 PM). The quick (and successful) rescue effort resulted in flows being held below the SA specified minimum base flow of 220 cfs for only one hour (3:45 PM to 4:45 PM).

The amount of surface area surveyed during the displacement surveys varied by site (Figure 6). Stranding surveys were conducted during the down ramping from each of the recreation flows and the areas surveyed varied by both site, the peak recreation flow released, and for the July Cresta sites the amount of area exposed during the sub-base flow reduction (Figure 6). Results of each of these biological evaluations are presented below by month.

June 2004

Displacement Survey

PG&E provided recreation flows in the Rock Creek Reach on 27 June 2004. The June recreation flow in the Rock Creek Reach was somewhat attenuated, with fourteen hours of flow greater than 1,000 cfs, including over seven hours of recreation flows greater than 1,600 cfs (Figure 5; Appendix C, Figure C-1). The maximum flow recorded at the PG&E stream flow gage NF-57 during the June recreation release was 1,887 cfs. The snorkel surveys were conducted along the margins of the NFFR at the displacement study sites the day before and after the recreation flow release. The stream flow below Rock Creek Dam was about 280 cfs during both the pre-recreation and the post-recreation flow surveys.

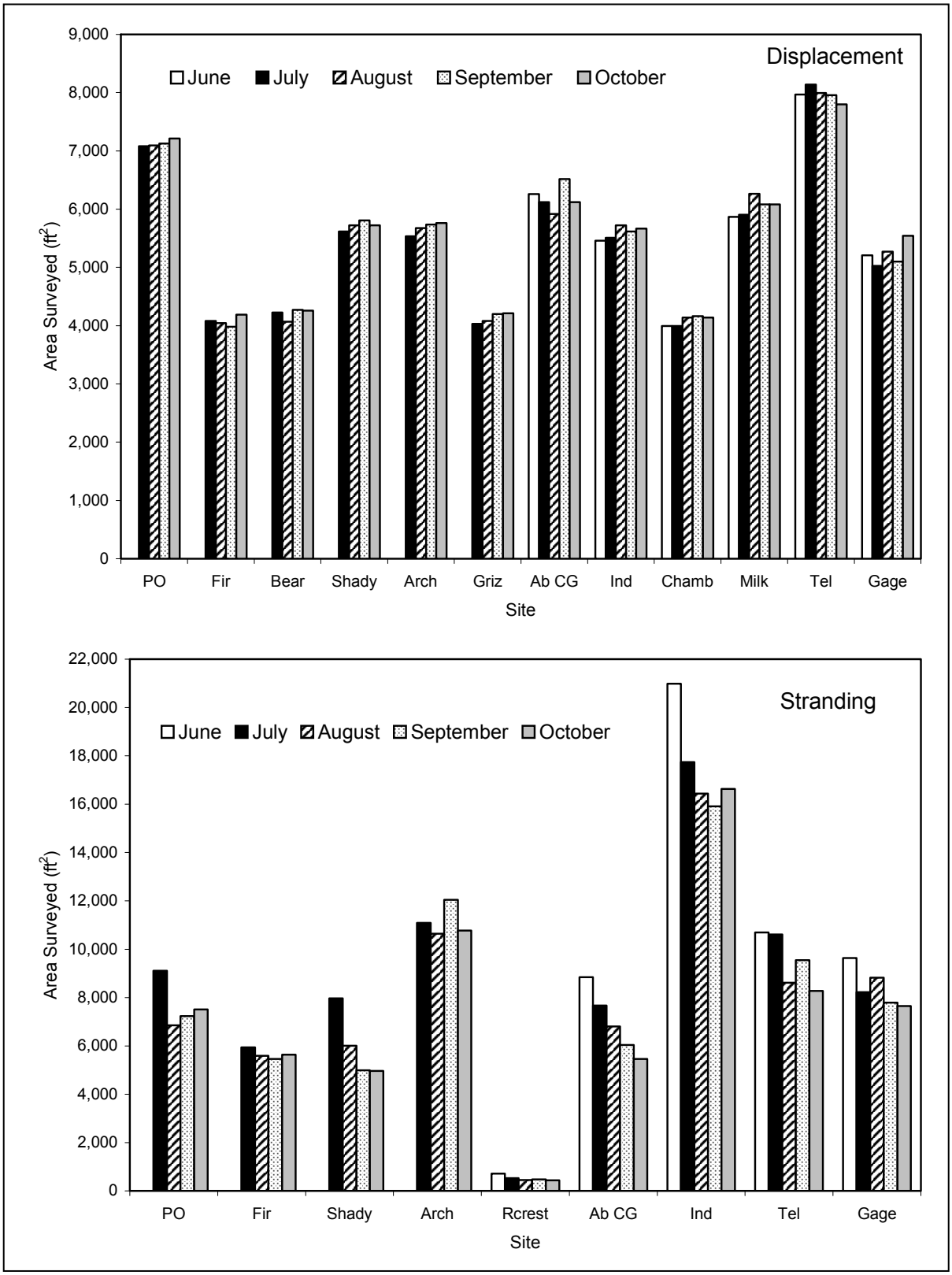

Figure 6. Estimates of areas surveyed by site during the five 2004 monthly displacement (top) and stranding evaluations (bottom).

The June 2004 displacement dive counts for the Rock Creek Reach of the NFFR are presented in Appendix D, Table D-1. Fishes observed during the June displacement surveys included rainbow trout (*Oncorhynchus mykiss*), Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), Sacramento sucker (*Catostomus occidentalis*), smallmouth bass (*Micropterus dolomieu*), and unidentified sculpin (*Cottus sp.*). Minnows less than eight inches in length were generally not identified to species, but rather were considered to be a combination of pikeminnow/hardhead. The recently-hatched sucker or minnow post-larvae were also present during the June surveys. These small (less than 1 inch long) translucent fish were typically present in numerous small to large schools (25 to >250 individuals) that made precise counts challenging, if not impossible. As has been done during the previous years surveys, these post-larval stages of fish were lumped into a separate category referred to as "non-game fry". Other organisms encountered during the control snorkel surveys included signal crayfish (*Pacifastacus leniusculus*) and western aquatic garter snakes (*Thamnophis couchii*).

Recently hatched non-game fry (post-larval sucker or minnows) were the most abundant fish present at all six Rock Creek sites (Figure 7). Rainbow trout fry were observed at all six sites, but appeared to be abundant at only four of the sites. At the Indian Jim School and Telephone/ Cable Box sites the numbers of rainbow trout fry observed were generally low.

A comparison of the pre- and post–recreation flow displacement snorkel counts do not indicate that the June 2004 recreation flow resulted in any consistent or marked changes to the fish inhabiting the shallow margins of the NFFR. The data from three of the six sites indicated that there were generally similar numbers of rainbow trout fry observed after the recreation flow compared to counts made prior to the flow increase (Figure 7). At the Abandoned Campground, Milk Ranch, and Gage sites the counts of trout fry were higher after the recreation flow release. The counts of larger trout (>4" in length) were generally

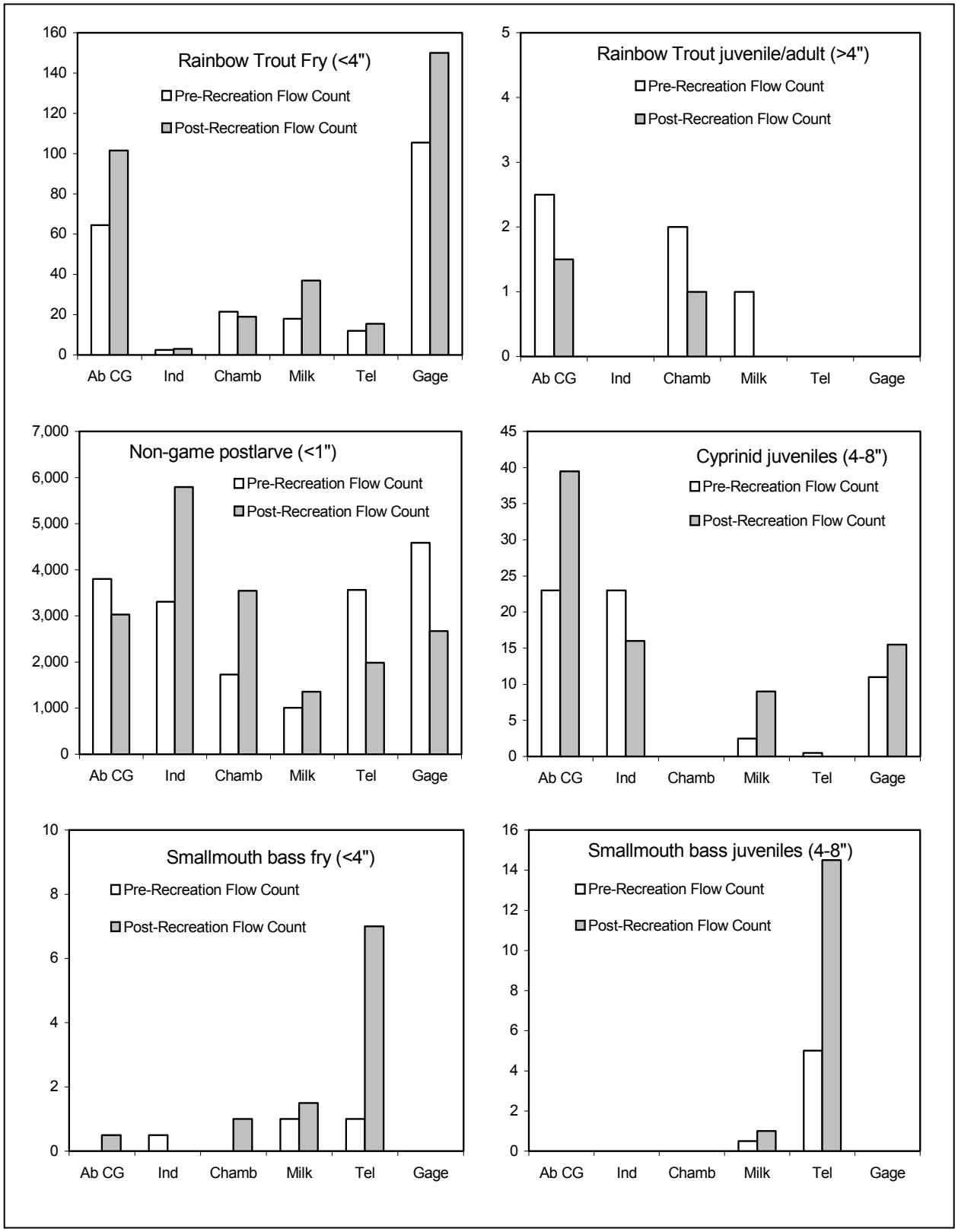

Figure 7. Comparison of pre- and post-recreation flow counts made during late June 2004 for various species/life stage categories of fish at the six displacement survey sites (see Table 1) in the Rock Creek Reach of NFFR.

sporadic, but showed little change before and after the recreation flow (Figure 7). However, the low counts of juvenile and adult trout along the margins, and their tendency to move into and out of the survey area, make margin counts of this particular life stage unreliable for assessing the effects of the recreation flows.

A comparison of the numbers of non-game post-larvae observed prior to the recreation flow to those following the flow did not suggest that there was a significant displacement of this particularly vulnerable species/life stage from the recreation flow (Figure 7). There were near-equal or greater numbers of these small, weak-swimming fish observed at four of the six study sites after the 1,600 cfs flow. In any case, there were large numbers of this small, weak-swimming life stage present at all sites both before and after the June recreation flow release. The numbers of cyprinid juveniles and smallmouth bass fry and juveniles showed variable changes before and after the June recreation flow (Figure 7). Estimates of the pre- and post-flow abundances for these species/life stages showed increases at some sites, decreases at other sites, while abundances at other sites remained unchanged.

Stranding Survey

The stranding surveys were conducted during the down-ramping from the recreation flow in the Rock Creek Reach on 27 June 2004 (Appendix C, Figure C-1). According to the flow schedule, down-ramping was supposed to begin at 4 PM and survey crews were instructed to begin their monitoring protocols at that time. The fifteen-minute flow records at the gage located downstream of Rock Creek Dam indicate that the actual down-ramping began around 3 PM. Despite beginning after down-ramping had begun, the stranding surveys did appear to include the majority of the descending limb of the hydrograph. The flow (at the gage) had returned to the minimum base level by 5 AM. Temporary gages at four of the five Rock Creek stranding study sites confirmed that minimum base flow levels were present at each site by 7 AM. Most of the area surveyed during the hourly stranding evaluations (72-80 percent, depending on site) was exposed during night-time hours (Figure 8). The stranding survey at the small Rock Crest site was performed only

following the return to base flow conditions, so that all of the area surveyed for stranded organisms at this site had been left exposed overnight.

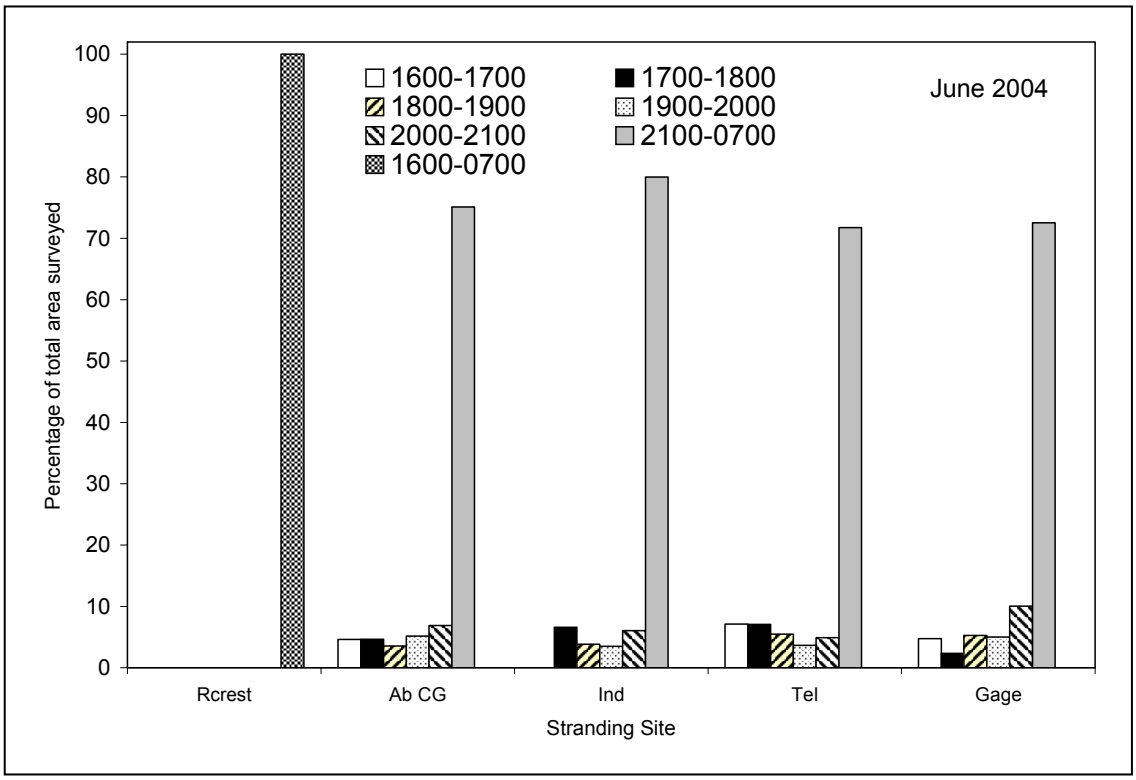

Figure 8. Percentage of total habitat surveyed during the June 2004 stranding surveys by exposure interval at the five evaluation sites in the Rock Creek Reach of NFFR.

The results of the late June stranding survey for the Rock Creek Reach are presented in Appendix E, Table E-1. A total of 136 organisms were recorded during the stranding surveys, which covered an estimated 50,879 square feet (1.17 acres) of cobble bar at five sites. The stranded organisms included 29 benthic macroinvertebrates (mostly crayfish, mayfly larvae, and Asian clams) and 107 fish. Most of the fish (94 individuals, or 88 percent of the salvaged fish) noted during the June 2004 surveys were non-game post-larvae. The remainder of the stranded fish were sucker fry (25 to 32 mm in length). No rainbow trout or tadpoles were found during the June 2004 stranding evaluation.

Results of the June 2004 stranding survey do not suggest that recreation flows pose much risk to the aquatic resources of the NFFR. The densities of stranded organisms recovered at the sites were small. There were fewer than 3 organisms stranded per 1000 square feet

of habitat surveyed at four of the five sites, which represented the areas having the highest potential risk for stranding in the Rock Creek Reach (Table 5). Most of the stranded organisms salvaged during the survey were small benthic macroinvertebrates or newly-hatched post-larval minnow/sucker fry. While most of the stranded organisms were found the morning following down-ramping, examination of the stranding densities by exposure interval suggests that stranding occurs at different times at different sites (Figure 9).

Table 5. Density of stranded organisms (number per 1000 square feet) noted during the June 2004 recreation flow biological evaluations in the Rock Creek Reach of the NFFR. No recreation flows were provided in the Cresta Reach during June, so no stranding surveys were conducted in this reach.

	Benthic Macroinvertebrates	Fish	Tadpoles	Total Organisms
Rock Crest	0.000	0.000	0.000	0.000
Abandoned Campground	0.226	4.750	0.000	4.977
Indian Jim School	0.667	1.620	0.000	2.287
Telephone/Cable Box	0.280	1.215	0.000	1.496
Gage	1.038	1.868	0.000	2.906
All Rock Creek Sites	0.570	2.103	0.000	2.673

The results of the June 2004 displacement and stranding surveys suggest that the 1600-cfs recreation flow generally had a limited effect on the aquatic resources of the NFFR.

July 2004

Displacement Survey

PG&E provided the 1,200 cfs recreation flow during the last weekend in July 2004 (Figure 5). A flow in excess of 1,200 cfs (peak of 1,344 cfs) was provided for 5 hours (9:15 AM to 2:15 PM) in the Cresta Reach on 24 July (Appendix C, Figure C-2). A recreation flow in excess of 1,300 cfs (peak of 1,461 cfs) was maintained for 6.5 hours (9:45 AM to 4:15 PM) in the Rock Creek Reach the following day (Appendix C, Figure C-3). Displacement snorkel surveys were conducted the day prior to (pre-flow survey) and the day following (post-flow survey) the July recreation flow releases. The July displacement surveys were

conducted at stream flows of 258 to 269 cfs, though a short duration flow increase occurred in the Cresta Reach immediately prior to the pre-recreation snorkel surveys.

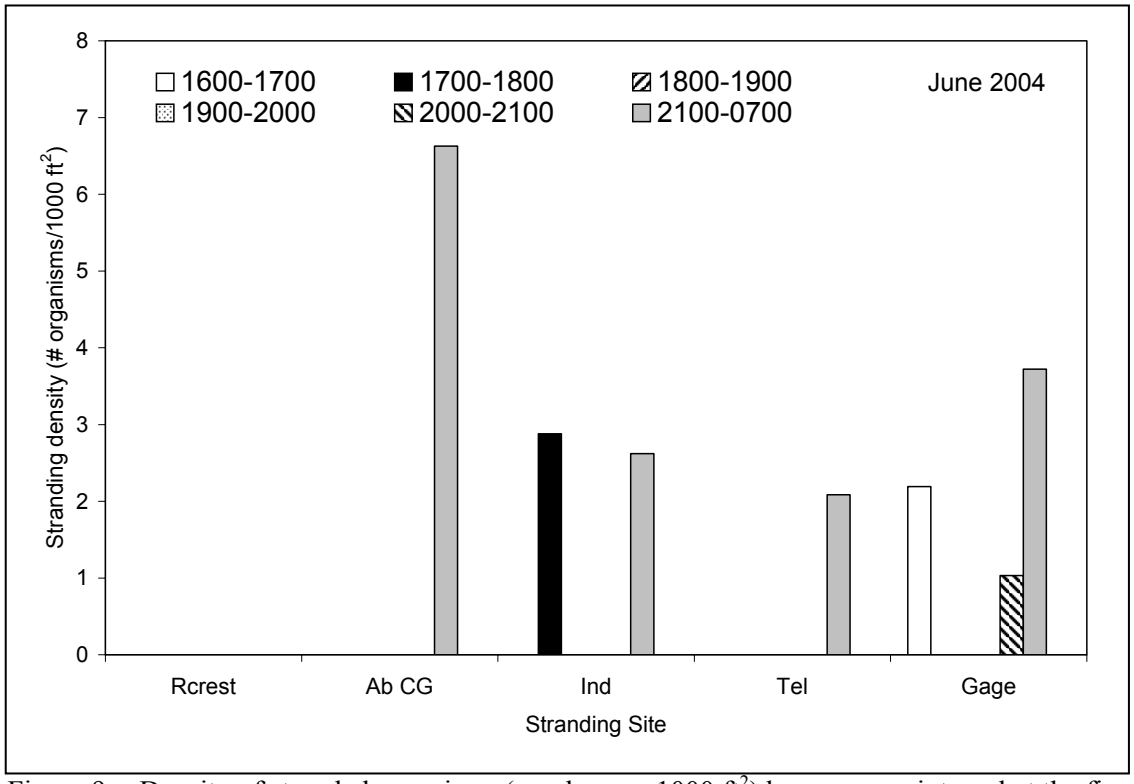

Figure 9. Density of stranded organisms (number per 1000 ft^2) by exposure interval at the five stranding evaluation sites in the Rock Creek Reach of NFFR, June 2004.

The July displacement dive counts are presented in Appendix D, Table D-2. Fishes observed during the July displacement surveys included rainbow and brown trout, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, and unidentified sculpin. Minnows less than 8 inches were generally not identified to species, but rather were considered to be a combination of pikeminnow/hardhead. Recently-hatched non-game fry (post-larval sucker or minnows) were abundant at most of the survey sites, though apparent good growth conditions prevalent through the early summer contributed to some surveyors discriminating these small fish at some sites into sucker or minnow categories. Signal crayfish were also encountered during the July displacement surveys.

Rainbow trout fry were less abundant at the Rock Creek sites in late July compared to late June. In June the mean post-recreation counts were 37.3 trout fry per site, while the mean post-recreation counts were 54.3 trout fry per site. By late July the pre- and post-recreation mean abundances in the Rock Creek Reach had declined to 6.1 and 8.3 fry, respectively. Similar comparisons in the Cresta Reach were not possible since no June displacement counts had been made in this area. Since no recreation flows occurred between the late June post-recreation survey and the late July pre-recreation survey, managed flows cannot be responsible for the declines. This monthly decline in trout fry abundance throughout the field season has been consistently noted in each of the other two years of studies as well. The apparent seasonal decline is likely a combination of mortality of some individuals, through predation to smallmouth bass, pikeminnows, and aquatic snakes, and growth of other individuals. As the trout fry grow they tend to leave the shallow water nursery areas and disperse into deeper faster water habitats that are not censused as part of this displacement survey.

A comparison of the pre- and post–recreation flow displacement snorkel counts do not provide clear or consistent changes in abundances of the fish inhabiting the shallow margins of the NFFR. It should be kept in mind that in the Cresta Reach there was a severe down-ramping to sub-base flow levels to accommodate search and rescue efforts. Examination of the counts for rainbow trout fry show mixed results (Figure 10). Most of the sites showed little change in the number of rainbow trout fry observed before compared to those made after the July recreation flow. Where changes were noted, fry increased at some locations (Bear Ranch Creek and Gage sites) and declined at others (Shady Rest site).

The counts of larger trout (>4” in length) showed mixed results (Figure 10); however, the low counts of juvenile and adult trout along the margins, and their tendency to move into and out of the survey area, make margin counts of this particular life stage unreliable for assessing the effects of the recreation flows.

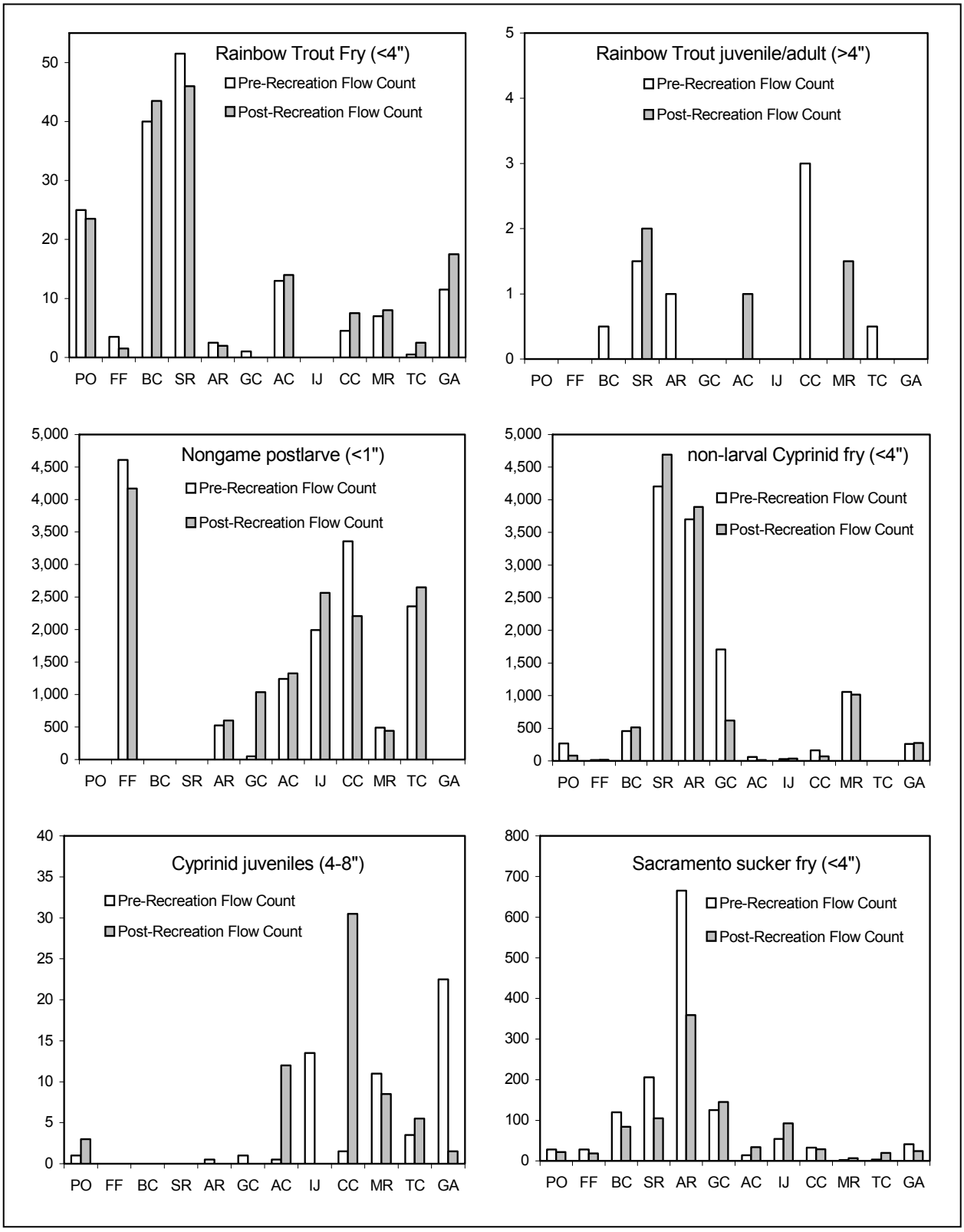

Figure 10. Comparison of pre- and post-recreation flow counts made during late July 2004 for various species/life stage categories of fish at the twelve displacement survey sites (see Table 1) in the Cresta and Rock Creek reaches of NFFR.

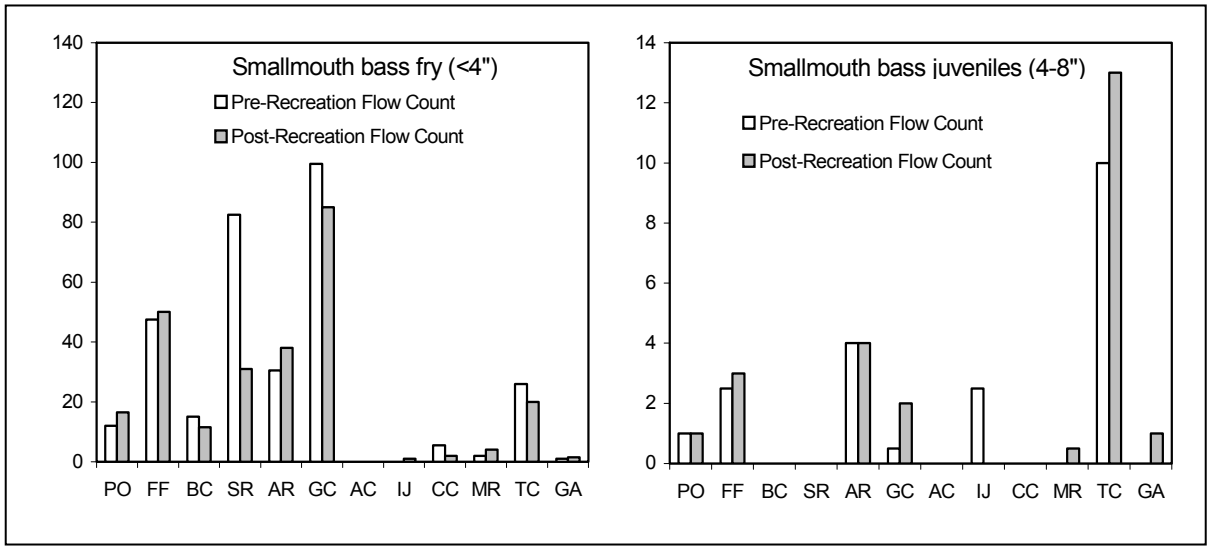

Figure 10. Comparison of pre- and post-recreation flow counts made during late July 2004 for various species/life stage categories of fish at the twelve displacement survey sites (see Table 1) in the Cresta and Rock Creek reaches of NFFR. (continued)

A comparison of the numbers of non-game post-larvae observed prior to the recreation flows to those following the flows did not suggest that there was a substantial change in abundance of this particularly vulnerable species/life stage from the July 2004 recreation flows (Figure 10). There was little change in the counts of these small, weak-swimming fish at nine of the twelve study sites after the 1,200 cfs recreation release flow. For the remaining three sites, one showed a decrease (Chambers Creek), while two (Grizzly Creek and Indian Jim School) showed increased abundance after the flow event.

Counts of minnow fry showed little change at most sites where they were abundant before the recreation flow; however, apparent declines in abundance were noted at the Poison Oak and the Grizzly Creek sites (Figure 10). Very few minnows in the juvenile life stage size category were observed in the Cresta Reach, so the before and after comparisons are not particularly useful as an indicator of displacement. In the Rock Creek Reach mixed results were observed. Large increases in juvenile minnow abundance were noted at two sites (Abandoned Campground and Chambers Creek), decreases at two sites (Indian Jim School and Gage) and little change at two sites (Milk Ranch and Telephone/Cable Box).
The pre- and post-recreation counts for sucker fry showed little change at nine of the twelve survey sites suggesting little movement during the recreation flow (Figure 10).

Declines in the counts were observed at three Cresta Reach sites (Bear Ranch, Shady Rest, and Arch Rock). These observed declines may be indicative of displacement, but their peculiar limitation to the Cresta Reach may indicate an effect of the rapid down-ramping in this reach, rather than displacement by high flows. In past years sucker fry tended to disperse from the margin areas of the NFFR earlier than other species. The down-ramping to sub-base flow levels may have prompted the sucker fry to permanently move from the shallow edge habitat.

The before and after recreation flow counts of smallmouth bass fry were stable at most of the sites (Figure 10). Fewer bass fry were noted after the recreation flow at the Shady Rest and Grizzly Creek sites. A comparison of the pre- and post-recreation flow counts for juvenile bass also show little change at the survey sites.

While the July displacement survey data does provide some limited evidence of upstream loss and downstream gains for some fish, the results are not consistent for all the life stages or even within a study reach. The most compelling evidence that the recreation flows appear to have little effect on the margin-dwelling fish of the NFFR are the counts for the non-game post-larvae (Figure 10). Counts for this seemingly vulnerable life stage showed little change immediately before and after the late July recreation flow releases at nine of the survey sites.

Stranding Survey

The July 2004 stranding surveys were complicated by the premature and rapid reduction in stream flow in the Cresta Reach. Stream flows from Cresta Dam were reduced to help county emergency search and rescue efforts. There was a 92 percent reduction in stream flow (1,344 cfs to 107 cfs) over a 2.5 hour interval (Appendix C, Figure C-2). Ramping rates during the first 1.5 hours of the flow reduction exceeded 28 inches per hour (Table 4). By 4:30 PM rescue efforts were completed and flows were increased back to the Project license minimum levels.

The premature flow changes meant that flows initially changed before survey crews were on site. Made aware of the situation at 2:30 PM, survey crews were on site by 3 PM and instructed to use debris lines and wet sand/rocks to estimate the high flow water's edge. Survey crews were then instructed to mark the actual waters edge at 3 PM and every hour after that and conduct surveys within each of the dewatered intervals according to the standard procedure. It should be noted that down-ramping was in progress at three of the four Cresta Reach stranding survey sites by 3 PM. At the most downstream stranding site (Poison Oak) down-ramping was not observed until after 3 PM. At most sites, markers put out prior to 4 PM included large amounts of surface area that required more than 60 minutes to adequately survey.

It should be noted that despite these time constraints, at each hour the searches in progress were suspended and the new hour marks were put out and then the suspended searches were continued. At most of the survey sites, the stranding area exposed after 4 PM was below the base flow levels and was re-inundated as stream flows returned to base flow levels before that area could be searched for stranded organisms. In those cases the markers were simply retrieved and the area that was searched was recorded. The result was that at three of the four Cresta stranding sites (Poison Oak, Flagged Fir and Arch Rock) the area searched appeared to be the area that was exposed during the rapid down-ramping from 1344 cfs and the return to the base flow levels of around 285 cfs. At these sites, the areas exposed below the base flow levels (i.e., areas exposed between 285 cfs and the lowest stream flow of 107 cfs) were only temporarily exposed and were re-wetted before they could be examined. The hourly stream flow levels at the Arch Rock site (located immediately downstream of the NF-56 Cresta stream flow gage) demonstrated this dynamic water edge phenomenon (Table 6).

Table 6. Hourly stream flow and gage height records for the Cresta Reach stream gage (NF-56) uring the 24 July 2004 survey along with the area exposed, surveyed, and survey times for the Arch Rock stranding survey site. Flow data provided by PG&E.

Time	Discharge (cfs)	Gage Height (ft)	Area exposed (ft^2)	Survey time
2:00 PM	1,344	6.02		
			10,041	3 hours 15 minutes
3:00 PM	420	3.26		
			?	Re-wetted prior to survey
4:00 PM	142	2.02		
			?	Re-wetted prior to survey
5:00 PM	220	2.81		
			1,046	31 minutes
6:00 PM	287	3.00		
7:00 PM	288	3.01		
8:00 PM	289	3.01		

The area exposed during the first hour of down-ramping was almost 0.25 acres and required over three hours to survey. Despite putting markers out at subsequent water edges which were exposing more and more of the cobble bar, by the time the first survey (area exposed to 3 PM was completed) the water had re-wetted all but 1,046 square feet of this zone before it could be surveyed after 6 PM.

At the Shady Rest site sub-base flow areas were included in the survey. This was due to the survey crew examining the sub-base flow area first and then the areas that had been exposed earlier in the down-ramping second. The result of all the complicated and dynamic movement of the waters edge and the ensuing surveys is that our surveys included the area of the stranding sites that had been rapidly dewatered during a severe and abnormal flow reduction from the peak recreation flow of 1,344 cfs to the base flow levels of 280 cfs.

Under normal conditions, the majority of the area surveyed for stranding is exposed during night-time hours. However, due to the premature and rapid reduction in stream flow for the July recreation flow in the Cresta Reach, all the stranding area was exposed and surveyed during the daylight hours (Figure 11).

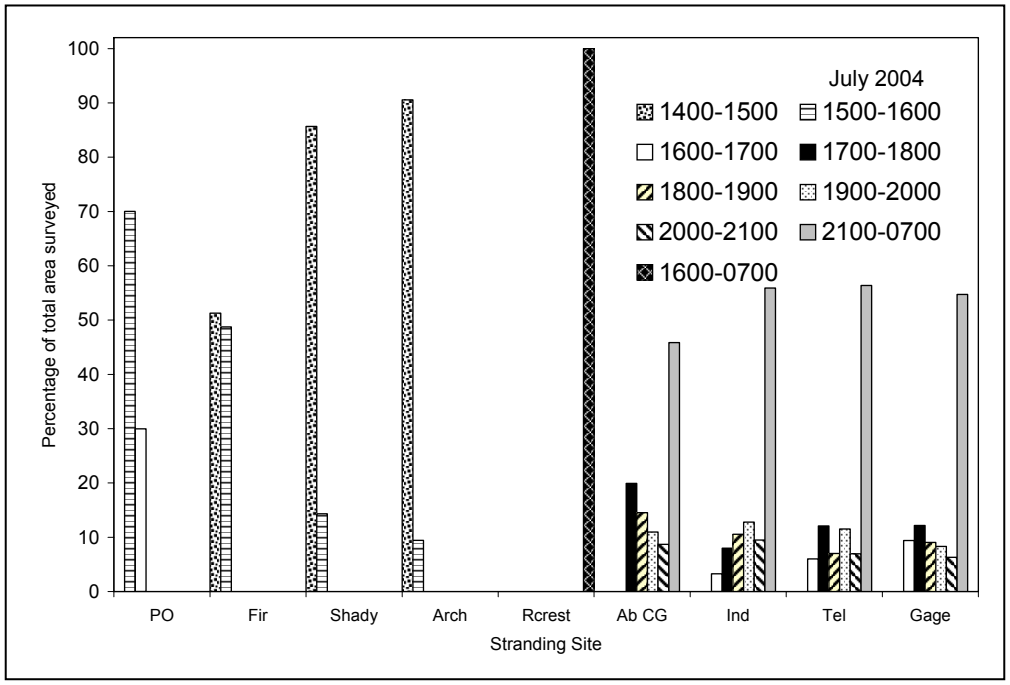

Figure 11. Percentage of total habitat surveyed during the July 2004 stranding surveys by exposure interval at the five evaluation sites in the Rock Creek Reach of NFFR.

Normal down-ramping rates on the order of three inches per hour occurred in the Rock Creek Reach during the July 2004 surveys (Table 4). The largest percentage of the five Rock Creek Reach stranding sites (45-56 percent, depending on site) was exposed during night-time hours (Figure 11).

The results of the late July stranding survey are presented in Appendix E, Table E-2. A total of 96 organisms (67 benthic macroinvertebrates and 29 fish) were recorded during the stranding surveys, which covered an estimated 78,864 square feet (34,100 square feet in the Cresta Reach and 44,764 square feet in the Rock Creek Reach). The stranded macroinvertebrates were mostly crayfish (n=27), water boatmen (n=17), and alderfly larvae (n=18). All of the stranded fish were young-of-the-year fish, 2 inches or less in length. Over 87 percent of the macroinvertebrate items (58 of 67 items) and 90 percent of the stranded fish (26 of 29 fish) were recovered at the Cresta Reach sites, which experienced the rapid down-ramping. All of the stranded fish salvaged from Cresta Reach (24 smallmouth bass fry, 1 pikeminnow fry, and 1hardhead fry) were found at the Arch Rock Site. No trout or tadpoles were found during the July stranding evaluations at any of the sites.

Despite the abnormally rapid recreation flow down-ramping event in the Cresta Reach, the July 2004 stranding survey results only indicated limited stranding of the aquatic resources of the NFFR. The densities of stranded organisms recovered at the sites were small. There were fewer than 4 organisms stranded per 1000 square feet of habitat surveyed at all nine sites, which represented the areas having the highest potential risk for stranding in the Project area (Table 7). Most of the stranded organisms salvaged during the survey were small benthic macroinvertebrates or smallmouth bass fry salvaged from two of the Cresta sites (Poison Oak and Arch Rock) and occurred in the areas exposed during the two hours of down-ramping (Figure 12). Despite the rapid down-ramping, the overall density of stranded macroinvertebrates and fish for the Cresta Reach sites was less than 2 macroinvertebrates and less than one fish per thousand square feet of area surveyed.

Table 7. Density of stranded organisms (number per 1000 square feet) noted during the July 2004 recreation flow biological evaluations in the NFFR. Cresta sites include the density of stranded organisms found during the entire survey of areas exposed by rapid down-ramping to levels and include some portions of the sites below ambient base flow levels.

	Benthic Macroinvertebrates	Fish	Tadpoles	Total Organisms
Cresta Reach				
Poison Oak	3.842	0.000	0.000	3.842
Flagged Fir	0.000	0.000	0.000	0.000
Shady Rest	0.753	0.000	0.000	0.753
Arch Rock	1.533	2.345	0.000	3.879
All Cresta Sites	1.701	0.762	0.000	2.463
Rock Creek Reach				
Rock Crest	0.000	0.000	0.000	0.000
Abandoned Campground	0.261	0.000	0.000	0.261
Indian Jim School	0.113	0.113	0.000	0.225
Telephone/Cable Box	0.377	0.094	0.000	0.471
Gage	0.122	0.000	0.000	0.122
All Rock Creek Sites	0.201	0.067	0.000	0.268
All Sites Combined	0.850	0.368	0.000	1.217

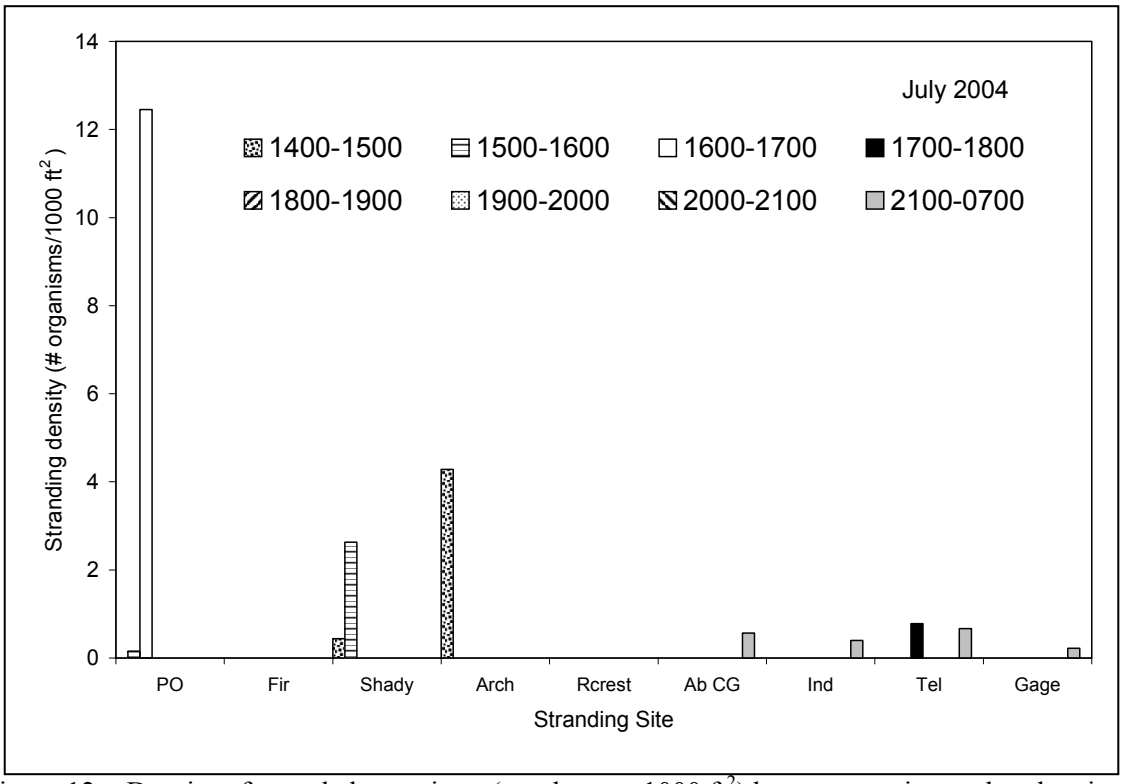

Figure 12. Density of stranded organisms (number per 1000 ft^2) by exposure interval at the nine stranding evaluation sites in the Cresta and Rock Creek reaches of NFFR, July 2004.

The results of the July 2004 displacement and stranding surveys suggest that the 1200-cfs recreation flow generally had a limited effect on the aquatic resources of the NFFR.

August 2004

Displacement Survey

PG&E provided a recreation flow of approximately 1,200 cfs for about five hours during the last weekend in August 2004 (Figure 5; Appendix C, Figures C-4 and C-5). The flow was provided in the Cresta Reach on 28 August 2003 and in the Rock Creek Reach the following day. Displacement snorkel surveys were conducted the day prior to (pre-flow survey) and the day following (post-flow survey) the August recreation flow releases.

The August 2004 displacement dive counts are presented in Appendix D, Table D-3. Fishes observed during the August displacement surveys included rainbow and brown trout, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, and unidentified sculpin. Minnows less than 8 inches were generally not identified to species, but rather were considered to be a combination of pikeminnow/hardhead. Non-game fry (post-larval sucker or minnows) were no longer present at any of the sites. It appears that these fish, which had been so abundant during the June and July surveys, had by late August grown to sizes where they were now identifiable as either pikeminnow/hardhead or sucker fry. Other organisms encountered during the August displacement surveys included aquatic garter snakes and crayfish

A comparison of the pre- and post–recreation flow displacement snorkel counts do not indicate that there was any consistent effect of the recreation flows to the fish inhabiting the shallow margins of the NFFR (Figure 13). In general, fewer rainbow trout fry were counted in late August (average of 4.8 fry pre-flow/6.0 fry post-flow) compared to late July (average of 13.3 fry pre-flow/13.8 fry post-flow). Examination of the late August displacement data for trout fry shows there was a mixture of small increases or decreases at the survey sites where trout were observed, with most of the Cresta sites showing increases and Rock Creek sites decreases (Figure 13). At those sites where no fry were noted before the recreation flow, there was no change in the abundance after the recreation flow.

The counts of larger trout (>4” in length) were quite small and there appeared to be little change in numbers pre-flow compared to post-flow (Figure 13). However, the low counts of juvenile and adult trout along the shallow margins, and their tendency to move into and out of the survey area, make nearshore counts of this particular life stage unreliable for assessing the effects of the recreation flows.

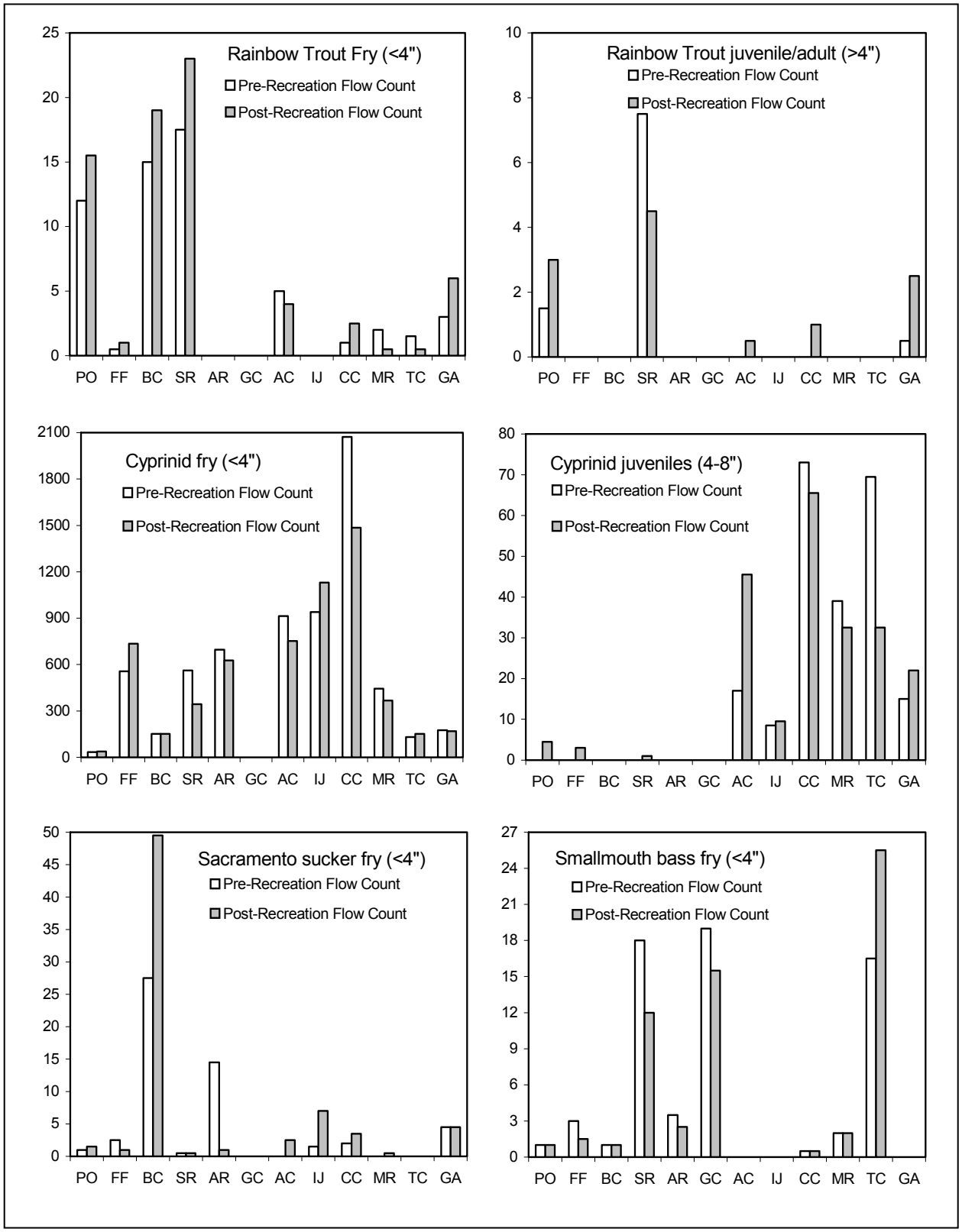

Figure 13. Comparison of pre- and post-recreation flow counts made during late August 2004 for various species/life stage categories of fish at the twelve displacement survey sites (see Table 1) in the Cresta and Rock Creek reaches of NFFR.

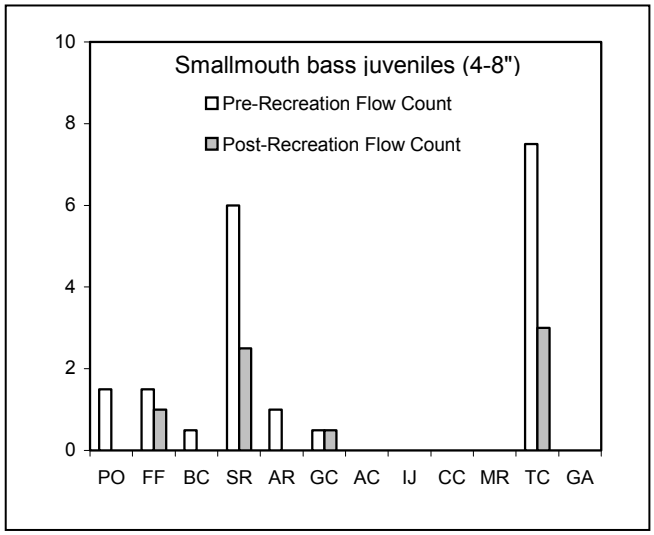

Figure 13. Comparison of pre- and post-recreation flow counts made during late August 2004 for various species/life stage categories of fish at the twelve displacement survey sites (see Table 1) in the Cresta and Rock Creek reaches of NFFR. (continued)

Cyprinid fry (mixture of young-of-the-year pikeminnow/hardhead) were the most abundant fish species observed during the August 2004 displacement snorkel surveys (Figure 13). A comparison of the numbers of cyprinid fry observed prior to the recreation flow to counts made following the flows showed a decline at four sites (Shady Rest, Abandoned Campground, and Chambers Creek), increase at two sites (Flagged Fir and Indian Jim) and little or no change at the remaining seven sites. It should be remembered, that these cyprinid fry generally occurred in a few dense concentrations, and counts should not be considered to be too accurate. In general, the August data suggest that where large numbers of cyprinid fry (>500 fry) were counted prior to the recreation flow, large numbers still remained after the flows.

Almost no cyprinid juveniles (4-8") were observed at the Cresta Reach sites during the August displacement counts (Figure 13). This apparent absence of juvenile cyprinids in the Cresta Reach was also noted during July displacement surveys. The pre- and post counts of cyprinid juveniles from the Rock Creek Reach sites showed mixed results. Examining the before and after recreation flow comparisons for this category revealed increases at some sites (Abandoned Campground and Gage), decreases at others (Chambers Creek, Milk Ranch, and Telephone/Cable Box), and little or no change others (Indian Jim School).

The Sacramento sucker fry and smallmouth bass fry counts were relatively stable, with little or no change observed at nine of the twelve survey sites from the 1,200 cfs recreation flow (Figure 13). For sucker fry in the Cresta Reach there was a large decline in the counts at the Arch Rock site, a large increase at the Bear Ranch Creek site, and relatively little change elsewhere. The pre and post sucker fry counts in the Rock Creek Reach were also mixed, showing an increase in the post-recreation counts at the Indian Jim School site and little change at the other sites.

As was the case for rainbow trout fry, fewer smallmouth bass fry were observed along the margins in late August (average of 5.3 fry pre-flow/5.1 fry post-flow) compared to late July (average of 29.9 fry pre-flow/24.7 fry post-flow). Only at the Telephone/Cable Box site were the August counts comparable to the July counts. The before and after recreation flow counts for August showed post-flow decreases at two sites, increases at one site, and virtually no change at the remaining sites (Figure 13).

The counts of juvenile smallmouth bass were typically low, and in fact, this species life stage was only observed at one site in the Rock Creek surveys (Figure 13). In the Cresta Reach counts for this life stage typically decreased following the recreation flow, while most of the Rock Creek sites showed no change in juvenile smallmouth bass abundance. However, given their low abundance and their tendency to move in and out of the margin habitat, the before and after counts for these yearling fish are probably not a reliable indicator of displacement effects from the recreation flow.

Stranding Survey

The August stranding surveys were conducted during the down-ramping from a peak recreation flow of approximately 1,200 cfs (Appendix C). Normal down-ramping occurred following the recreation flow in both study reaches, with average rates of 2.6 to 3 inches per hour (Table 4). In both the Cresta and Rock Creek reaches flows (at the gages) had returned to the base levels by 2 AM. At seven of the eight sites where hourly surveys were conducted (i.e., all except the Rock Crest site), most of the area surveyed during the

stranding evaluations (49-78 percent, depending on site) was exposed during night-time hours (Figure 14).

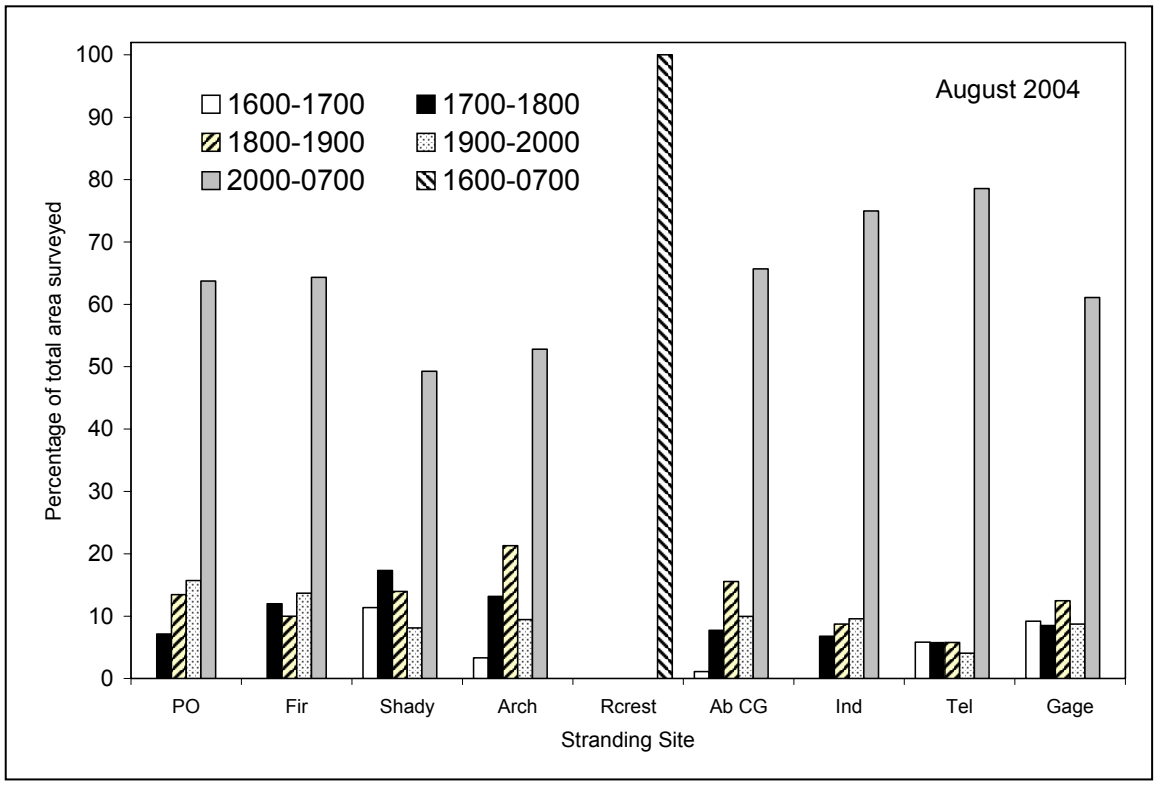

Figure 14. Percentage of total habitat surveyed during the August 2004 stranding surveys by exposure interval at the nine evaluation sites in the Cresta and Rock Creek reaches of NFFR.

The results of the late August stranding survey are presented in Appendix E, Table E-3. A total of 62 organisms were recorded during the stranding surveys, which covered an estimated 70,231 square feet (1.61 acres) of cobble bar at nine sites. The stranded organisms included 61 benthic macroinvertebrates and only one fish, a 31 mm TL Sacramento pikeminnow fry. Eighty percent of the stranded benthic macroinvertebrates (n=49) were pond snails and eighty-two percent of the stranded organisms (n=51) were recovered from a single site (Poison Oak). No rainbow trout or FYLF tadpoles were recovered during the August stranding surveys. Fewer than six organisms were found stranded at eight of the nine sites surveyed, with no documented stranding at four of these

sites. The single fish that was recovered came from the Indian School Jim site in the Rock Creek Reach.

The densities of stranded organisms were low at all sites (Table 8). There was less than one organism stranded per 1000 square feet of habitat surveyed at eight of the nine sites. Most of the organisms stranded were small benthic macroinvertebrates. Overall, there was fewer than one organism stranded per 1000 square feet of habitat surveyed, which represented the areas of the NFFR having the highest potential risk for stranding during receding recreation flows.

Table 8. Density of stranded organisms (number per 1000 square feet) noted during the August 2004 recreation flow biological evaluations in the NFFR.

	Benthic Macroinvertebrates	Fish	Tadpoles	Total Organisms
Cresta Reach				
Poison Oak	7.438	0.000	0.000	0.7.438
Flagged Fir	0.000	0.000	0.000	0.000
Shady Rest	0.166	0.000	0.000	0.166
Arch Rock	0.000	0.000	0.000	0.000
All Cresta Sites	1.787	0.000	0.000	1.787
Rock Creek Reach				
Rock Crest	0.000	0.000	0.000	0.000
Abandoned Campground	0.000	0.000	0.000	0.000
Indian Jim School	0.061	0.061	0.000	0.122
Telephone/Cable Box	0.696	0.000	0.000	0.696
Gage	0.227	0.000	0.000	0.227
All Rock Creek Sites	0.219	0.024	0.000	0.243
All Sites Combined	0.869	0.014	0.000	0.883

Examination of the stranding densities by exposure interval did show that for three of the five sites where stranding was documented, the highest stranding densities occurred in the area exposed overnight (Figure 15). Despite this apparent pattern, no stranding was noted for this interval at five of the nine sites evaluated. Overall, the data for the August surveys does not identify any particularly sensitive time during down-ramping when aquatic organisms are at the greatest risk of stranding.

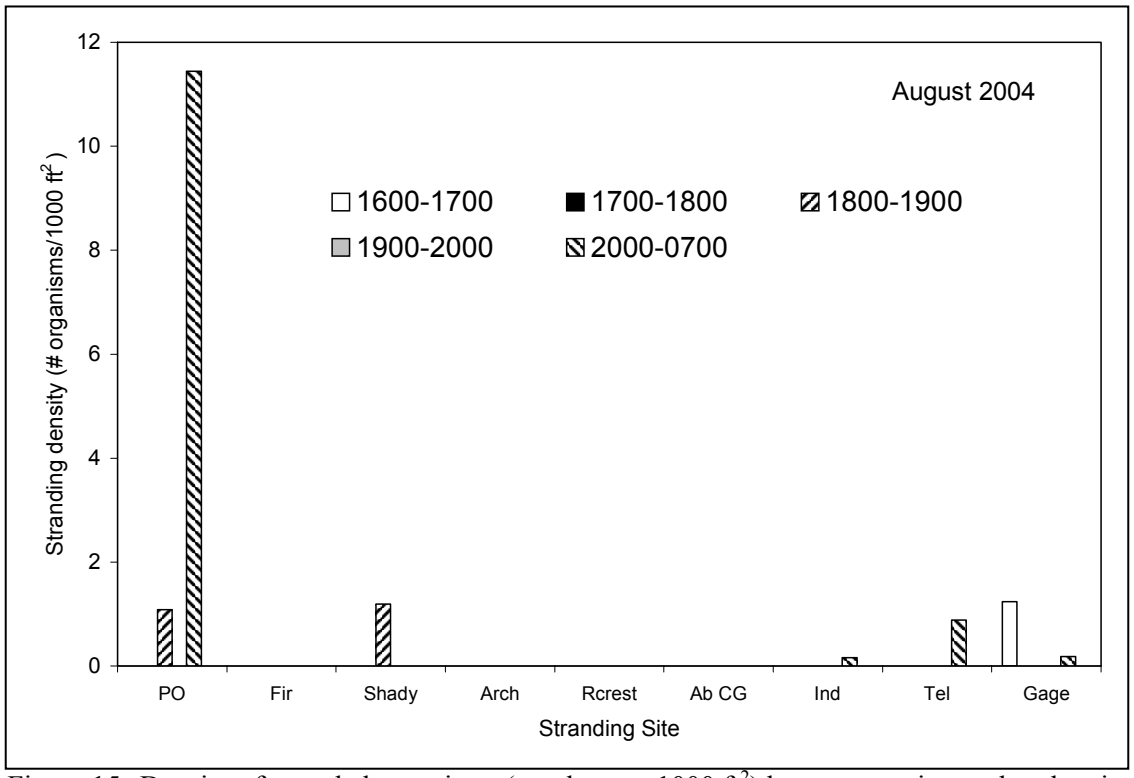

Figure 15. Density of stranded organisms (number per 1000 ft^2) by exposure interval at the nine stranding evaluation sites in the Cresta and Rock Creek reaches of NFFR, August 2004.

The results of the late August 2004 displacement and stranding surveys suggest that the 1,200-cfs recreation flow generally had only limited effects on the aquatic resources of the NFFR.

September 2004

Displacement Survey

PG&E provided recreation flows of about 1,200 cfs for about six hours during the last weekend in September 2004 (Figure 5; Appendix C). The flow was provided in the Cresta Reach on 25 September 2004 and in the Rock Creek Reach the following day. Displacement snorkel surveys were conducted the day prior to (pre-flow survey) and the day following (post-flow survey) the September recreation flow releases (Appendix C).

The September displacement dive counts are presented in Appendix D, Table D-4. Fishes observed during the September displacement surveys included rainbow trout, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, and unidentified sculpin. Other organisms encountered during the September displacement surveys included aquatic garter snakes and signal crayfish.

By late September, rainbow trout fry were not abundant at any of the sites and averaged 2.7 trout fry per site in the pre-recreation counts versus 2.3 trout fry per site in the post-recreation counts. For two of the Cresta Reach sites (Bear Ranch Creek and Shady Rest), slightly fewer rainbow trout fry were counted after the recreation flow (Figure 16). The other four Cresta sites showed little or no change in abundance of trout fry and remained near zero both before and after the recreation flow at three of the sites. In the Rock Creek Reach, four of the sites showed little or no change in trout fry abundance after the recreation flow, while the remaining two sites displayed mixed results (slight increase at Abandoned Campground and slight decrease at Gage).

A comparison of the before and after recreation flow counts of larger trout (>4" in length) showed virtually no change at all of the six Cresta sites and four of the six Rock Creek sites (Figure 16). One of the Rock Creek sites showed a decrease (Abandoned Campground) and one an increase (Gage). We continue to reiterate that the consistently low counts of juvenile and adult trout along the shallow margins, and their tendency to move into and out of the survey area, make nearshore counts of this particular life stage unreliable for assessing the effects of the recreation flows.

Cyprinid fry were the most abundant fish noted at all the displacement survey sites (Figure 16). A comparison of the pre and post-recreation flow counts for this category showed declines at four of the six Cresta sites. In the Rock Creek Reach, five of the sites were relatively stable, with a decline noted at the Milk Ranch site.

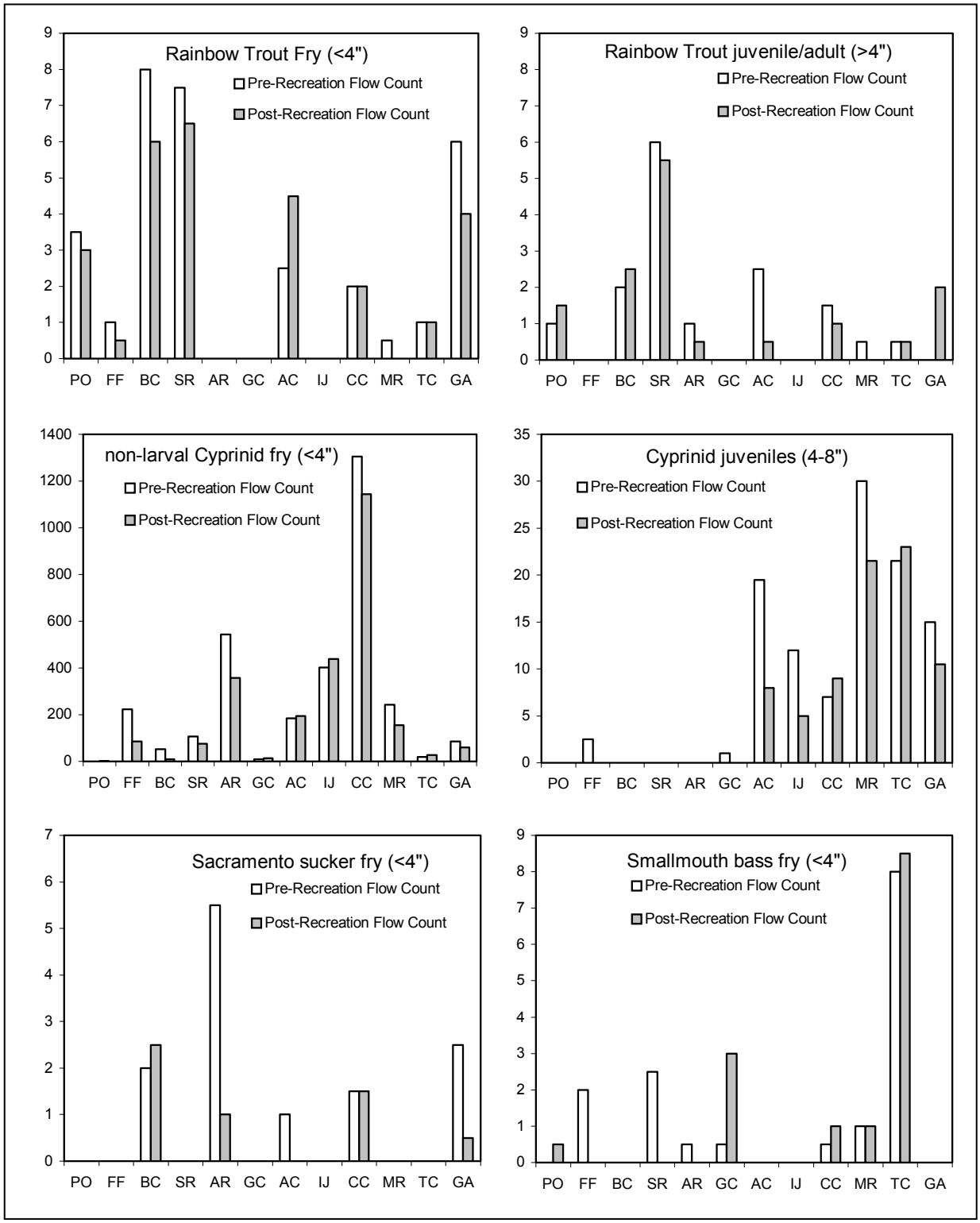

Figure 16. Comparison of pre- and post-recreation flow counts made during late September 2004 for various species/life stage categories of fish at the twelve displacement survey sites (see Table 1) in the Cresta and Rock Creek reaches of NFFR.

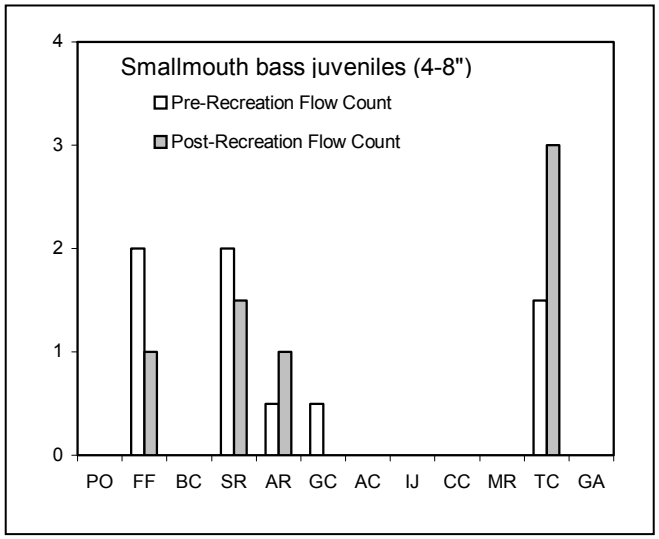

Figure 16. Comparison of pre- and post-recreation flow counts made during late September 2004 for various species/life stage categories of fish at the twelve displacement survey sites (see Table 1) in the Cresta and Rock Creek reaches of NFFR. (continued)

Similar to the previous month's surveys, almost no larger cyprinid juveniles (4-8") were observed at the Cresta Reach sites during the late September displacement counts (Figure 16). The pre- and post counts of cyprinid juveniles from the Rock Creek Reach sites showed declines at four of the sites and a slight increase at two of the sites.

Overall, the counts of young-of-the-year suckers were low at all survey sites. The counts of sucker fry remained relatively stable at ten of the twelve survey sites (Figure16). The post-recreation flow abundance declined at two of the sites (Arch Rock and Gage).

In general, fewer smallmouth bass fry were counted in late September (average of 1.2 fry pre-flow/1.2 fry post-flow) compared to late August (average of 7.8 fry pre-flow/6.5 fry post-flow). In the Cresta Reach, the abundance of bass fry declined at two sites (Flagged Fir and Shady Rest) and increased at one site (Grizzly Creek). The counts at the remaining Cresta sites and all six of the Rock Creek survey sites showed little or no change following the September recreation flow (Figure 16). The counts for the larger juvenile smallmouth bass (4-8") were extremely low, but the limited data does not suggest that the September recreation flows in the Cresta or Rock Creek reaches had any impacts on their overall abundance (Figure 16).

Examined as a whole, the late September displacement survey snorkel counts do not provide any overwhelming evidence that either of the 1,200 cfs recreation flows in the Cresta and Rock Creek reaches resulted in any large changes in the number of fish in the NFFR. The abundance of the small margin-dwelling fishes remained relatively stable following the recreation flow at most of the sites in both study reaches. No consistent pattern of decline or increase in young-of-the-year fishes (including rainbow trout) was evident from the data. Except for the counts of young-of-the-year cyprinids, the late September counts for most other species life stages were so low as to make their usefulness for assessing local population changes questionable.

Stranding Survey

The September 2004 stranding surveys were conducted during the down-ramping from a peak recreation flow of approximately 1,200 cfs (Appendix C). Normal down-ramping occurred following the recreation flow in both study reaches, with average rates of 2.6 to 3.5 inches per hour (Table 4). In both the Cresta and Rock Creek reaches flows (at the gages) had returned to the base levels by 2 AM. At seven of the eight sites where hourly surveys were conducted (i.e., all except the Rock Crest site), most of the area surveyed during the stranding evaluations (66-86 percent, depending on site) was exposed during night-time hours (Figure 17).

The results of the late September stranding survey are presented in Appendix E, Table E-4. A total of 45 benthic macroinvertebrates were recovered from the nine survey sites, which covered an estimated 69,469 square feet (1.59 acres) of cobble bar. No fish or FYLF tadpoles were found during the September stranding surveys. Most of the recovered macroinvertebrates were water boatmen (n=20), crayfish (n=11) and water mites (n=8).

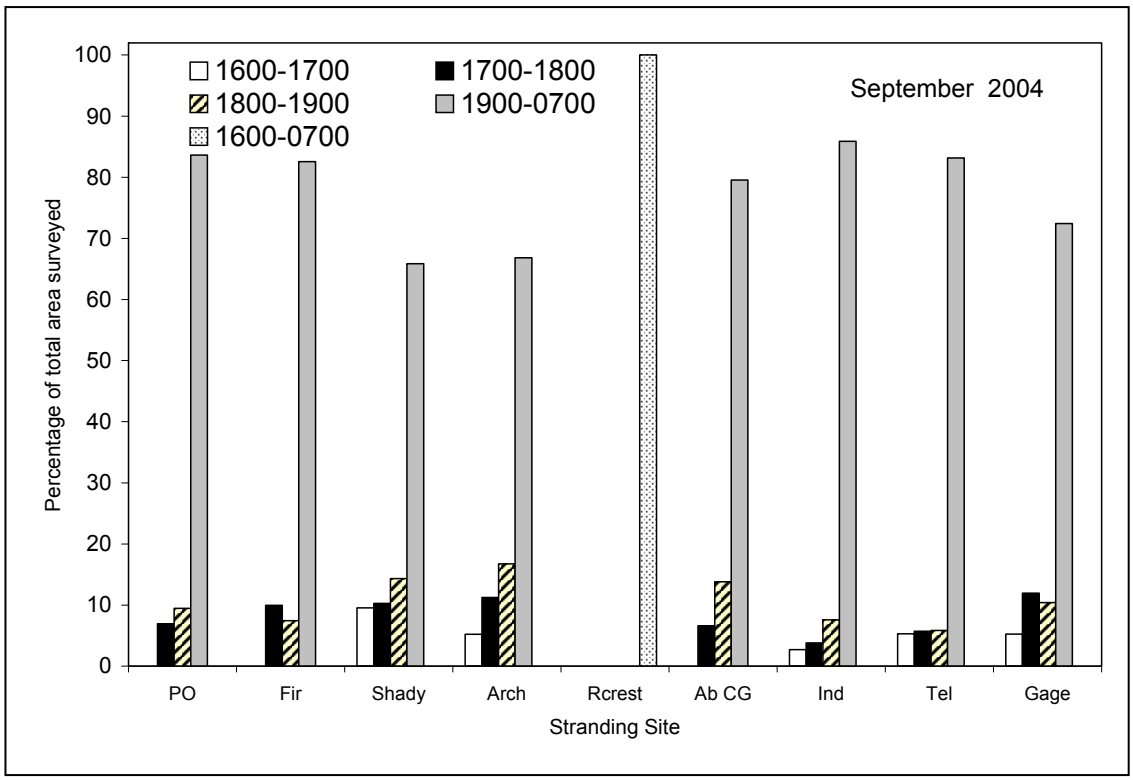

Figure 17. Percentage of total habitat surveyed during the September 2004 stranding surveys by exposure interval at the nine evaluation sites in the Cresta and Rock Creek reaches of NFFR.

Results of the late September 2004 stranding survey suggest that the recreation flows and existing down-ramping schedules pose a limited risk to the aquatic resources of the NFFR. Fewer than four organisms were found stranded at seven of the nine sites surveyed, with no documented stranding at two of these sites.

The densities of stranded organisms were low at all sites (Table 9). Less than one organism per 1000 square feet of habitat surveyed was stranded at seven of the nine sites. All of the organisms stranded were small benthic macroinvertebrates. Overall, there was fewer than one organism stranded per 1000 square feet of habitat surveyed, which represented the areas of the NFFR having the highest potential risk for stranding during receding recreation flows.

Table 9. Density of stranded organisms (number per 1000 square feet) noted during the September 2004 recreation flow biological evaluations in the NFFR.

	Benthic Macroinvertebrates	Fish	Tadpoles	Total Organisms
Cresta Reach				
Poison Oak	0.000	0.000	0.000	0.000
Flagged Fir	2.015	0.000	0.000	2.015
Shady Rest	0.401	0.000	0.000	0.401
Arch Rock	1.993	0.000	0.000	1.993
All Cresta Sites	1.245	0.000	0.000	1.245
Rock Creek Reach				
Rock Crest	0.000	0.000	0.000	0.000
Abandoned Campground	0.331	0.000	0.000	0.331
Indian Jim School	0.126	0.000	0.000	0.126
Telephone/Cable Box	0.105	0.000	0.000	0.105
Gage	0.385	0.000	0.000	0.385
All Rock Creek Sites	0.201	0.000	0.000	0.201
All Sites Combined	0.648	0.000	0.000	0.648

Examination of the stranding densities by exposure interval did show that for six of the seven sites where stranding was documented, the highest stranding densities occurred in the area exposed overnight (Figure 18). Since this overnight period was not surveyed until the next morning and this morning survey area encompassed several hourly down-ramping intervals combined, it is impossible to determine which hourly exposure interval contributed to the stranding and posed the greatest risk of stranding.

The results of the late September 2004 displacement and stranding surveys suggest that the 1,200-cfs recreation flow generally had a limited effect on the aquatic resources of the NFFR.

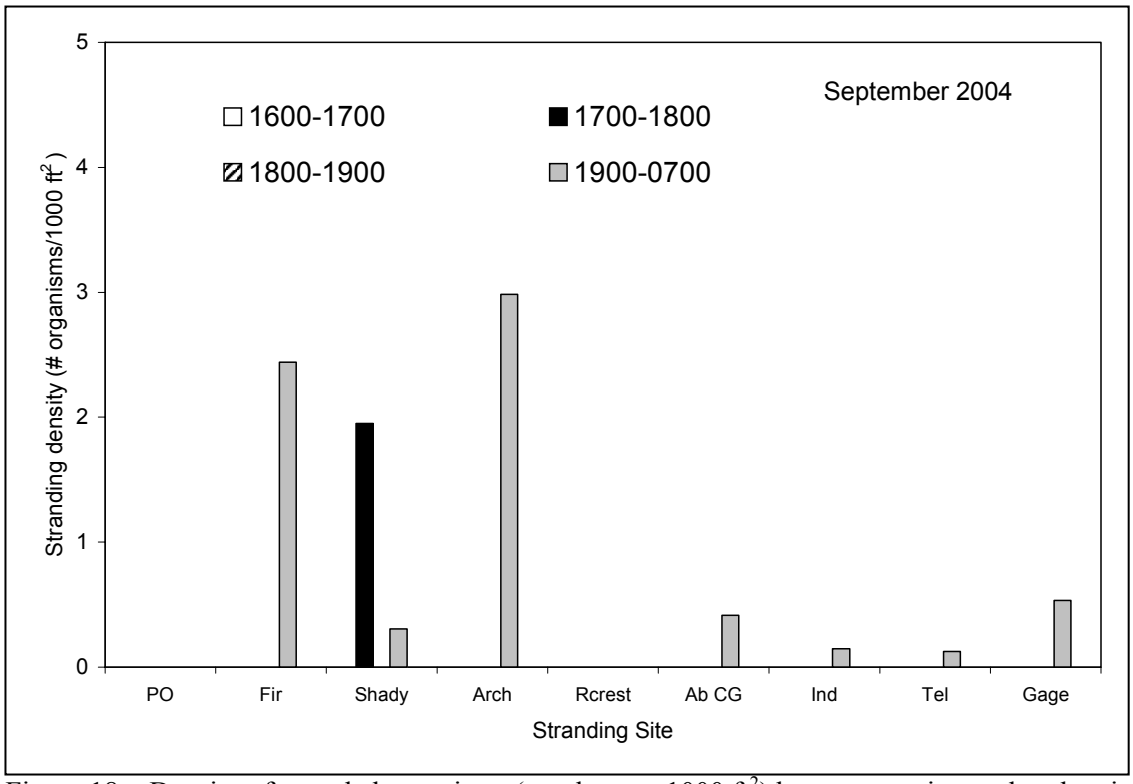

Figure 18. Density of stranded organisms (number per 1000 ft^2) by exposure interval at the nine stranding evaluation sites in the Cresta and Rock Creek reaches of NFFR, September 2004.

October 2004

Displacement Survey

PG&E provided recreation flows of about 1,200 cfs for almost seven hours during late October 2004 (Figure 5; Appendix C). The flow was provided in the Cresta Reach on 23 October 2004 and in the Rock Creek Reach the following day. Displacement snorkel surveys were conducted the day prior to (pre-flow survey) and the day following (post-flow survey) the October recreation flow releases (Appendix C).

The October displacement dive counts are presented in Appendix D, Table D-5. Fishes observed during the October displacement surveys included rainbow trout, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, and unidentified sculpin. Signal crayfish were the only other organisms encountered during the late October displacement surveys.

By late October, rainbow trout fry were not abundant at any of the sites and averaged 0.8 trout fry per site in the pre-recreation flow counts versus 1.1 trout fry per site in the post-recreation counts. In fact, no rainbow trout fry were observed on either pre- or post-recreation dives at seven of the twelve sites during the October 2004 displacement surveys (Figure 19). It is presumed that by this date the young-of-the-year trout had grown to sizes that utilize deeper, faster-water habitats away from the bank and outside our margin-focused search area. In streams, rainbow trout juveniles (50 - 120 mm in length) begin to emigrate from shallow, low velocity margin habitats and seek out deeper and faster water near rocks or other cover where more invertebrate drift is available (Moyle 2002). In the Cresta Reach there were no changes in the pre- and post-recreation flow counts at four of the six sites. The post-recreation flow abundances increased at the Poison Oak site and decreased slightly at the Bear Ranch Creek site. In the Rock Creek Reach no changes in trout fry abundance were documented at five of the six survey sites. A very small decrease was reported for the Gage site.

A comparison of the before and after recreation flow counts of larger trout (>4" in length) showed virtually no change at five of the six Cresta sites and five of six Rock Creek sites (Figure 19). The two sites where small changes were noted both exhibited an increase in abundance in juvenile and adult trout after the recreation flow. The consistently low counts of juvenile and adult trout along the shallow margins, and their tendency to move into and out of the survey area, make nearshore counts of this particular life stage unreliable for assessing the effects of the recreation flows.

Cyprinid fry were the most abundant fish noted during the late October displacement surveys (Figure 19). A comparison of the pre- and post-recreation flow counts in the Cresta Reach for this category showed increases following the recreation flow at three of the six sites and a decrease at one site. In the Rock Creek Reach, little or no change in abundance was noted at four of the six displacement survey sites. The remaining two sites (Abandoned Campground and Gage) showed increases in the post-flow counts.

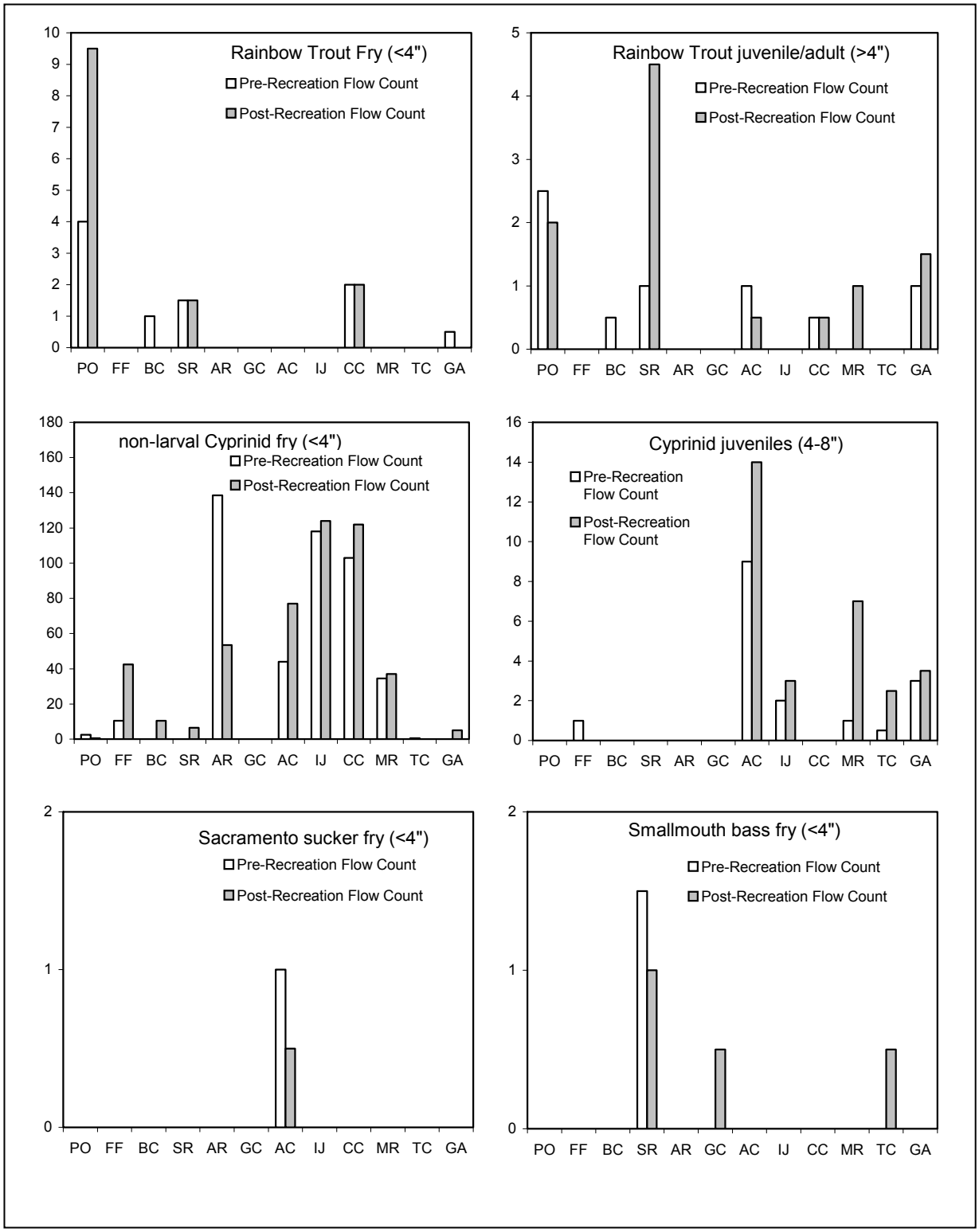

Figure 19. Comparison of pre- and post-recreation flow counts made during late October 2004 for various species/life stage categories of fish at the twelve displacement survey sites (see Table 1) in the Cresta and Rock Creek reaches of NFFR.

Similar to the previous three monthly survey results, the larger-sized cyprinid juveniles (4-8") were virtually absent from our Cresta Reach sites and so showed no change in abundance between the pre-and post-recreation flow counts (Figure 19). In the Rock Creek Reach, the post-recreation flow counts of cyprinid juveniles increased at three sites and remained virtually unchanged at three sites.

Sucker and smallmouth bass fry had almost completely disappeared from the stream margins of our survey sites by late October (Figure 19). Young-of-the-year suckers were observed at only one site, and even then at extremely low numbers. Smallmouth bass fry were observed at only three displacement survey sites, again in very low abundance levels. The extremely low abundances for these two species of fry make their use for assessing displacement unsound.

The late October displacement survey snorkel counts do not provide any overwhelming evidence that the 1,200 cfs recreation flows in the Cresta and Rock Creek reaches had any substantial effects on fish in the NFFR. The abundance of the small margin-dwelling fishes remained relatively stable following the recreation flow at most of the sites in both study reaches. No consistent pattern of decline or increase in young-of-the-year fishes (including rainbow trout) was evident from the data. Except for the counts of young-of-the-year cyprinids, which showed mixed results, the late October counts for most other species life stages were so low as to make their usefulness for assessing local population changes questionable.

Stranding Survey

The October 2004 stranding surveys were conducted during the down-ramping from peak recreation flows of approximately 1,236 cfs in the Cresta Reach and 1,212 cfs in the Rock Creek Reach (Appendix C). Normal down-ramping occurred following the recreation flow in both study reaches, with average rates of 2.8 inches per hour (Table 4). In both the Cresta and Rock Creek reaches, flows (at the gages) had returned to the base levels by midnight. At seven of the eight sites where hourly surveys were conducted (i.e., all except

the Rock Crest site), most of the area surveyed during the stranding evaluations (75-90 percent, depending on site) was exposed during night-time hours (Figure 20).

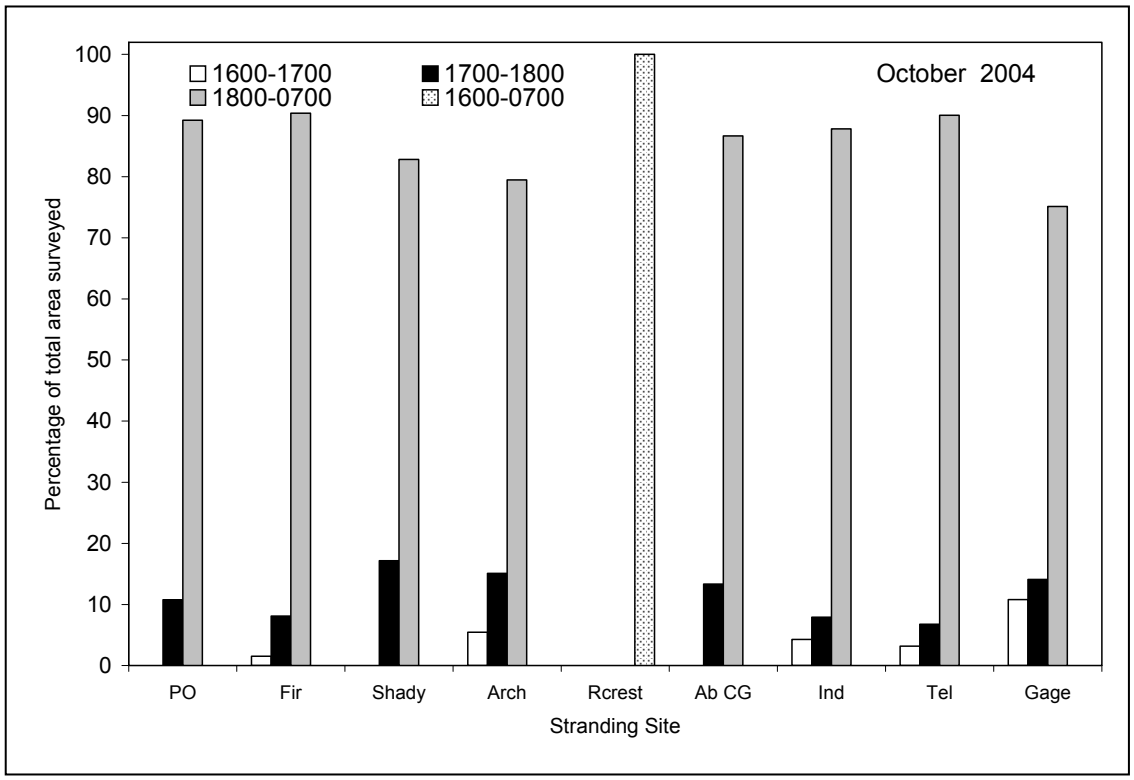

Figure 20. Percentage of total habitat surveyed during the October 2004 stranding surveys by exposure interval at the nine evaluation sites in the Cresta and Rock Creek reaches of NFFR.

The results of the late October stranding survey are presented in Appendix E, Table E-5. A total of two crayfish were recovered from the nine survey sites, which covered an estimated 67,337 square feet (1.55 acres) of cobble bar. No fish or FYLF tadpoles were found during the October surveys. One crayfish was recovered in the Cresta Reach (Shady Rest site) and one from the Rock Creek Reach (Telephone/Cable Box site). As might be expected from these results, the late October 2004 stranding survey suggests that the recreation flows and existing down-ramping schedules pose a very limited risk to the aquatic resources of the NFFR. No stranded organisms were observed at seven of our nine survey sites and only one organism was recovered at either of the other two sites.

The densities of stranded organisms were low at all sites (Table 10). There was less than one stranded organism per 1000 square feet of habitat surveyed at all nine sites. Overall, our density estimates indicate there were about three crayfish stranded per 100,000 square feet of habitat surveyed, which represented the areas of the NFFR having the highest potential risk for stranding during receding recreation flows.

Table 10. Density of stranded organisms (number per 1000 square feet) noted during the October 2004 recreation flow biological evaluations in the NFFR.

	Benthic Macroinvertebrates	Fish	Tadpoles	Total Organisms
Cresta Reach				
Poison Oak	0.000	0.000	0.000	0.000
Flagged Fir	0.000	0.000	0.000	0.000
Shady Rest	0.201	0.000	0.000	0.201
Arch Rock	0.000	0.000	0.000	0.000
All Cresta Sites	0.035	0.000	0.000	0.035
Rock Creek Reach				
Rock Crest	0.000	0.000	0.000	0.000
Abandoned Campground	0.000	0.000	0.000	0.000
Indian Jim School	0.000	0.000	0.000	0.000
Telephone/Cable Box	0.121	0.000	0.000	0.121
Gage	0.000	0.000	0.000	0.000
All Rock Creek Sites	0.026	0.000	0.000	0.026
All Sites Combined	0.030	0.000	0.000	0.030

Because of the extremely low incidence recorded during the late October surveys, no particular period of down-ramping could be identified that put aquatic organisms at great risk. Both stranded crayfish were recovered form the large areas of the two sites that were exposed after dark (Figure 21).

The results of the late October 2004 displacement and stranding surveys suggest that the 1,200-cfs recreation flow had a very limited effect on the aquatic resources of the NFFR.

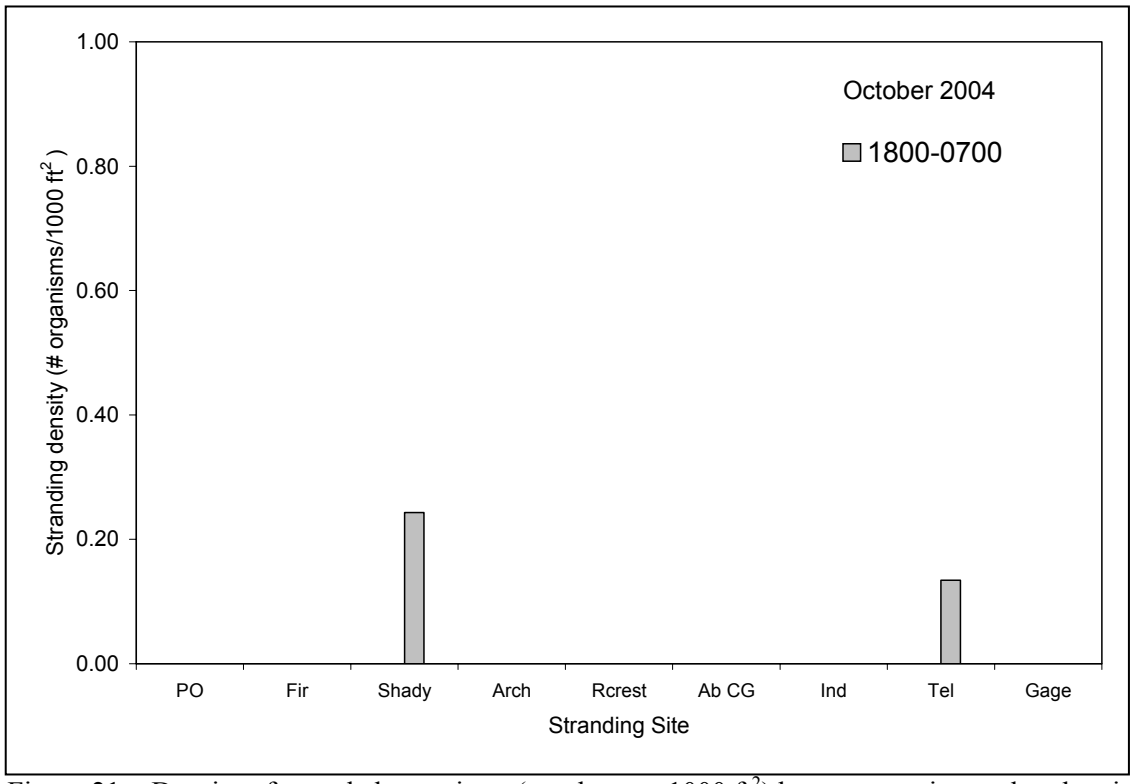

Figure 21. Density of stranded organisms (number per 1000 ft^2) by exposure interval at the nine stranding evaluation sites in the Cresta and Rock Creek reaches of NFFR, October 2004.

Total Stranding Area Survey & Total Stranding Estimates

Prior to the June 2004 recreation flow releases, 48 additional potential stranding locations were identified in the Rock Creek Reach, which included 23 west bank bars, 20 east bank bars and 5 mid-channel island bar areas (Appendix F). All but one of the Rock Creek sites was measured or photographed at the 1,600 cfs recreation flow. There was difficulty in re-locating one of the sites during both the June and July recreation flows; and consequently, it was not measured until the September 1000 cfs recreation flow. The total stranding area encompassed by these 48 sites along with the 5 sites stranding evaluation sites at the highest recreation flow was estimated to be 484,817 square feet (Table 11). About 82 percent of the total area was judged to be high stranding potential, 11 percent was considered moderate stranding potential, with the remainder was considered low stranding potential. Seven of the 53 total Rock Creek sites were inundated at all the recreation flows. The remaining 46 sites provided less stranding area at the two lesser recreation flows.

Table 11. Total stranding area estimates (ft^2) by stranding potential for the three recreation flow levels in the Cresta and Rock Creek Reaches of the NFFR, 2004.

Stranding Potential	1600 cfs Recreation flow	1200 cfs Recreation flow	1000 cfs Recreation flow
		Cresta Reach	
High	131,958	113,639	103,398
Moderate	50,981	43,746	40,470
Low	34,278	28,828	26,360
Reach Total	217,217	186,213	170,227
		Rock Creek Reach	
High	399,208	347,221	322,671
Moderate	54,066	46,788	43,684
Low	31,543	27,642	25,978
Reach Total	484,817	421,651	392,333

Beside the four sites surveyed during the regular monthly stranding evaluations in the Cresta Reach, 37 additional potential stranding areas were identified in the reach. These sites included 21 east bank bars, 11 west bank bars and 5 mid-channel island bar areas (Appendix F). One of the sites, a large mid-channel boulder bar located about 0.7 miles upstream of the Cresta Powerhouse, was split into two sites by virtue of the two sides of this extensive island area (>0.2 miles long) being judged to have different stranding-risk potentials, making a total of 38 sites.

Since no 1,600 cfs recreation flow was provided in the Cresta Reach during 2004, the highest available flow to measure the varial zone was during the 1,200 cfs July recreation flow. The high flow waters edge was marked at only 15 of the Cresta Reach sites prior to the emergency-related, premature down-ramping. The high flow areas at the remaining Cresta sites were marked and measured during the late September recreation flow.

The total stranding area encompassed by the 38 sites including the 4 regular monthly stranding evaluation sites in the Cresta Reach at the highest 1,600 cfs recreation flow was estimated to be 217,217 square feet (Table 11). About 61 percent of this total area was judged to be high stranding potential, 24 percent was considered moderate stranding potential, with the remainder considered as low stranding potential. Six of the 42 sites

were inundated at all three recreation flows, the remaining 36 sites provided less stranding area at the two lesser recreation flows.

Comparing areas covered by our monthly stranding surveys with the total stranding area estimates indicated that in the Cresta Reach we are conducting monthly stranding surveys on about 16 percent of the available stranding habitat, while in the Rock Creek Reach our monthly surveys cover about 11 percent of the total available stranding habitat.

Mean monthly stranding densities for various organism categories were calculated for both the Cresta and Rock Creek reaches using the results of the three years of stranding studies from the respective reaches. In September 2003 an emergency down-ramping event to aid search and recovery efforts resulted in many stranded organisms being recovered in areas of our survey sites that were below the normal base flow level. This event was discussed in some detail in Salamunovich (2004b). When computing the mean monthly stranding densities for September in the Cresta Reach, only those items that were found stranded during the 2003 surveys in the areas between the peak recreation flow and the normal base flow were used. Because of the rapid fluctuations in flow during the July 2004 emergency down-ramping, it was not possible to confidently identify and eliminate those organisms stranded below base flow levels at all the sites. The data did appear to suggest that most of the stranding did occur in the areas that were exposed between the peak recreation flow and the normal base flow. When computing the mean monthly stranding densities for July in the Cresta Reach, all the July 2004 data was included. The stranding data was also adjusted to account for both search efficiencies and for overnight losses to scavengers and predators (see Methods section for more detail). The final adjusted mean monthly stranding densities for the Cresta and Rock Creek reaches are presented in Table 12.

Table 12. Adjusted mean monthly densities of stranded organisms (number per 1000 square feet) in the Cresta and Rock Creek reaches of the NFFR during the monthly recreation flows. Data derived from three-years of stranding surveys (2002-2004) and adjusted for search efficiency estimates (2003 evaluations) and overnight scavenger/predator loss estimates (2002 evaluations). BMI = benthic macro-invertebrates; FYLF = foothill yellow-legged frog; HH = hardhead; PKM = Sacramento pikeminnow; HH/PKM = combination of unidentified hardhead/pikeminnow fry; SKR = Sacramento sucker; SMB = smallmouth bass. All fish salvaged during stranding evaluations (except for sculpin were <4" in length)

				Fish categories							
	BMI	Fish	FYLF Tadpoles	Trout fry	Non-game post-larvae	HH fry	PKM fry	HH/PKM fry	SKR fry	SMB fry	Sculpin
Cresta Reach											
June*	6.705	1.250	0.000	0.000	1.222	0.000	0.000	0.000	0.000	0.000	0.028
July	2.590	3.570	0.045	0.011	2.883	0.011	0.011	0.000	0.169	0.484	0.000
August	5.354	0.178	0.013	0.000	0.000	0.038	0.038	0.051	0.013	0.038	0.000
September	2.385	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000
October	1.996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rock Creek Reach											
June	2.040	3.063	0.000	0.081	2.819	0.000	0.007	0.000	0.149	0.000	0.007
July	1.306	0.096	0.000	0.000	0.048	0.008	0.008	0.000	0.032	0.000	0.000
August	0.897	0.009	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000
September	0.386	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000
October	0.295	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

* densities based upon 2002 data only since, no recreation flows or stranding surveys were conducted in this reach during 2003 or 2004.

It should be remembered that June stranding surveys were conducted at the four Cresta Reach sites only in 2002. No June recreation flows were released in the Cresta Reach during either the 2003 or 2004 field seasons. With a couple of exceptions, the general trend in the data suggests that stranding for all the various categories tends to decrease over the course of the recreation flow period (Table 12). There was an increase in the mean BMI stranding densities for August in the Cresta Reach compared to July levels. There was also an increase in the mean fish stranding densities for July in the Cresta Reach compared to June. This increase in the July fish stranding estimates was due to increased stranding of non-game post-larvae during July compared to June.

In order to get an idea of the order of magnitude of the estimated stranding, the adjusted mean monthly stranding density data (Table 12) was multiplied by the total stranding areas (Table 11) after accounting for the various site-specific stranding potential (see Methods section for more detail). The resulting values represent the total number of stranded organism by month for a single recreation flow in either the Cresta or Rock Creek Reach of the NFFR (Table 13).

The three years of data suggest that down-ramping from the five monthly recreation flows result in stranding of 2,939 benthic macroinvertebrates, 793 fish, and 9 YLF tadpoles in the Cresta Reach. Crayfish, water boatmen, and pond snails accounted for 82.8 percent of the total benthic macroinvertebrates recovered in the areas dewatered between peak flow and base flow levels during the three years of stranding studies stranding and so it stands to reason that these categories would dominate the total stranding estimates. About 82.7 percent of the estimated stranded fish in the Cresta Reach over the five month period of recreation flows are made up of non-game post-larvae. Another 10.2 percent of the Cresta Reach total is composed of smallmouth bass fry. Over 96 percent of the total estimated stranded fish and almost 54 percent of the total stranded macroinvertebrates occurred during the first two monthly recreation flows. Only two rainbow trout fry are estimated to have been stranded from down-ramping during the five months of recreation flows in the

Table 13. Estimates of the total number of stranded organisms during the monthly recreation flows in the Cresta and Rock Creek reaches of the NFFR. Estimates based upon by the total stranding area estimates and the adjusted mean monthly stranding density estimates. BMI = benthic macroinvertebrates; FYLF = foothill yellow-legged frog; HH = hardhead; PKM = Sacramento pikeminnow; HH/PKM = combination of unidentified hardhead/pikeminnow fry; SKR = Sacramento sucker; SMB = smallmouth bass. All fish salvaged during stranding evaluations (except for sculpin were <4" in length)

				Fish categories							
	BMI	Fish	FYLF Tadpoles	Trout fry	Non-game post-larvae	HH fry	PKM fry	HH/PKM fry	SKR fry	SMB fry	Sculpin
Cresta Reach											
June	1,189	222	0	0	217	0	0	0	0	0	5
July	395	545	7	2	439	2	2	0	26	74	0
August	745	24	2	0	0	5	5	7	2	5	0
September	332	2	0	0	0	0	0	0	0	2	0
October	278	0	0	0	0	0	0	0	0	0	0
Total	2,939	793	9	2	656	7	7	7	28	81	5
Rock Creek Reach											
June	909	1,365	0	36	1,257	0	3	0	66	0	3
July	506	37	0	0	19	3	3	0	12	0	0
August	323	3	0	0	0	0	3	0	0	0	0
September	139	3	0	0	0	0	0	0	0	3	0
October	106	0	0	0	0	0	0	0	0	0	0
Total	1,983	1,408	0	36	1,276	3	9	0	78	3	3

Cresta Reach. This trout total figure may be an underestimate, since only one June survey period is included in the data, and was collected in early June 2002 whereas all other June flow releases were conducted late in the month, when it is probable that more trout fry are present. If the June Cresta flows continue to be cancelled in future years then the total loss of macro-invertebrates and fish (especially non-game-post larvae) would be commensurately less.

In the Rock Creek Reach, down-ramping from the five monthly recreation flows is estimated to result in the loss of 1,983 benthic macroinvertebrates, and 1,408 fish. No FYLF populations are known to exist in the Rock Creek Reach at this time, so this species does not appear to be at risk from stranding in this area of the NFFR during recreation flows. As in the Cresta Reach, the total estimate for stranded fish is dominated by the non-game post-larvae category (90.6 percent of the total). Over 99 percent of the total estimated stranded fish and 71 percent of the total stranded macroinvertebrates occurred during the first two monthly recreation flows. Only thirty-six rainbow trout fry were estimated to have been stranded from down-ramping during the five months of recreation flows in the Rock Creek Reach, and all during the first recreation flow in June.

Analysis of Larval Fish Data from 2002 Driftnet Sampling

Only fish captured in the June 2002 driftnet samples were available for analysis. A total of 122 driftnet samples were collected (two pseudo-replicate samples every two hours for 120 hours). Sixty-four of the samples were collected prior to the recreation flow, twenty-four during the recreation flow, and thirty-four following the recreation flow. The flows were elevated above base flow levels for about 23 hours during the June 2002 recreation flow in the Rock Creek Reach. The average stream flow during this period was 1,177 cfs, with flows in excess of 1,600 cfs for 7.25 hours of this period, a peak discharge of 1,850 cfs. The mean discharge during the pre-recreation and post-recreation driftnet sample periods was 258 cfs and 241 cfs, respectively. There was about a 40-minute lag time from the stream flow gage (NF-57) and the Rodgers Flat sample site (Garcia and Associates 2004a),

and this temporal offset was used to determine if samples were classified as recreation flow samples or not.

A total of 82 fish were collected from the 122 samples collected over the five days of driftnet sampling. This total was composed of 51 larval sculpin (size range: 4.0-8.5 mm TL, mean: 5.2 mm TL) and 31 larval suckers (size range: 14.0-17.0 mm TL, mean: 15.3 mm TL). No trout or FYLF tadpoles were collected. A comparison of the sizes of fish collected during recreation flow period to those collected during base flow period (combined pre- and post-recreation samples) did not indicate that there was any significant difference in the size of either species collected during either the base flow or recreation flow periods (Table 14).

Table 14. Comparison of the mean length of the two larval fish species collected during the pre- and post-recreation base flow period with those collected during the recreation flow period. Data from June 2002 driftnet survey at Rodgers Flat, Rock Creek Reach of the NFFR. Probability is the probability that the Student's t-test value will be exceeded. Probabilities less than 5% (0.05) are typically considered statistically significant.

	Base flow samples		Recreation flow samples		
Species	n	Mean length (mm)	n	Mean length (mm)	Probability
Sucker larvae	27	15.33	4	15.25	0.8438
Sculpin larvae	27	5.06	24	5.35	0.2164

The abundance and densities of the larval fish collected over the course of the five day period were plotted against the stream flow (Figures 22 and 23). These plots show that larval fishes were present in the drift during both the base flow and recreation flow periods. The abundance and densities of larval fish in driftnet samples collected during the base flow periods are not significantly different from the data collected during the recreation flow period (Table 15). This analysis suggests that larval fishes occur in the drift in similar abundances and densities during both base flow and recreation flow periods and that there was no large increases in larval fish drift or displacement during the 24 hours of elevated recreation flow.

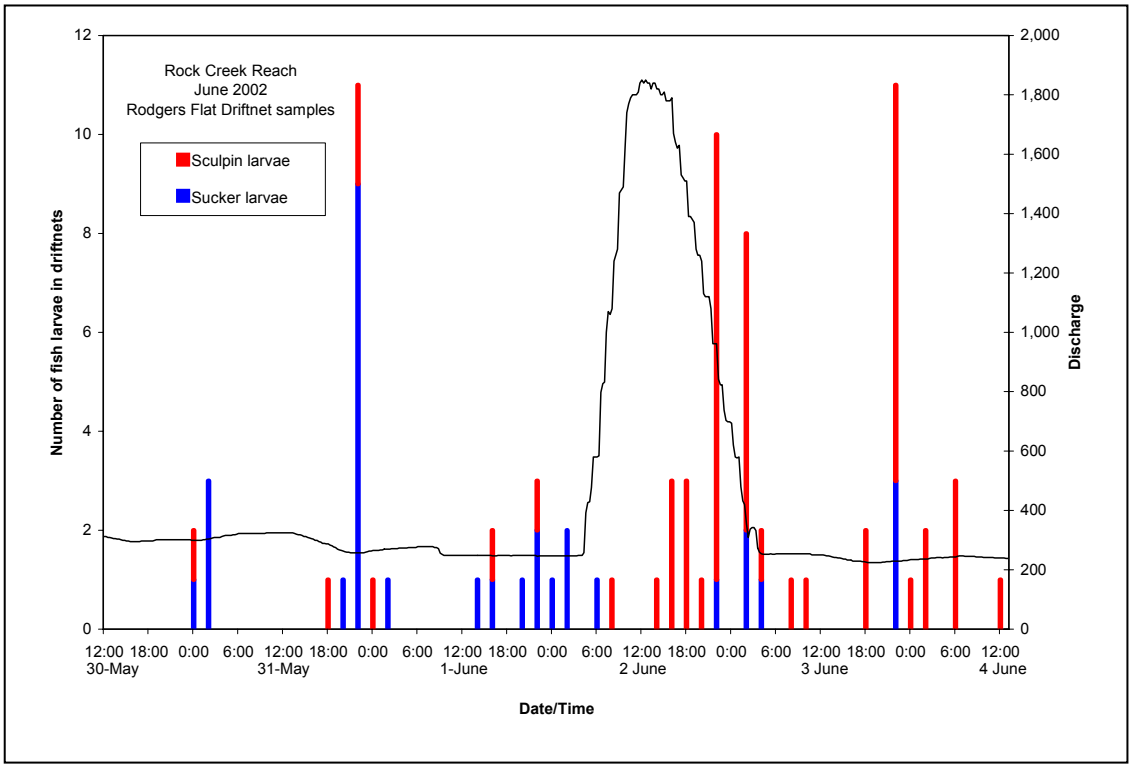

Figure 22. Fish abundance by species in 15-minute duration driftnet samples collected every two hours for five days during the June 2002 recreation flow. Data from the right and left nets have been combined.

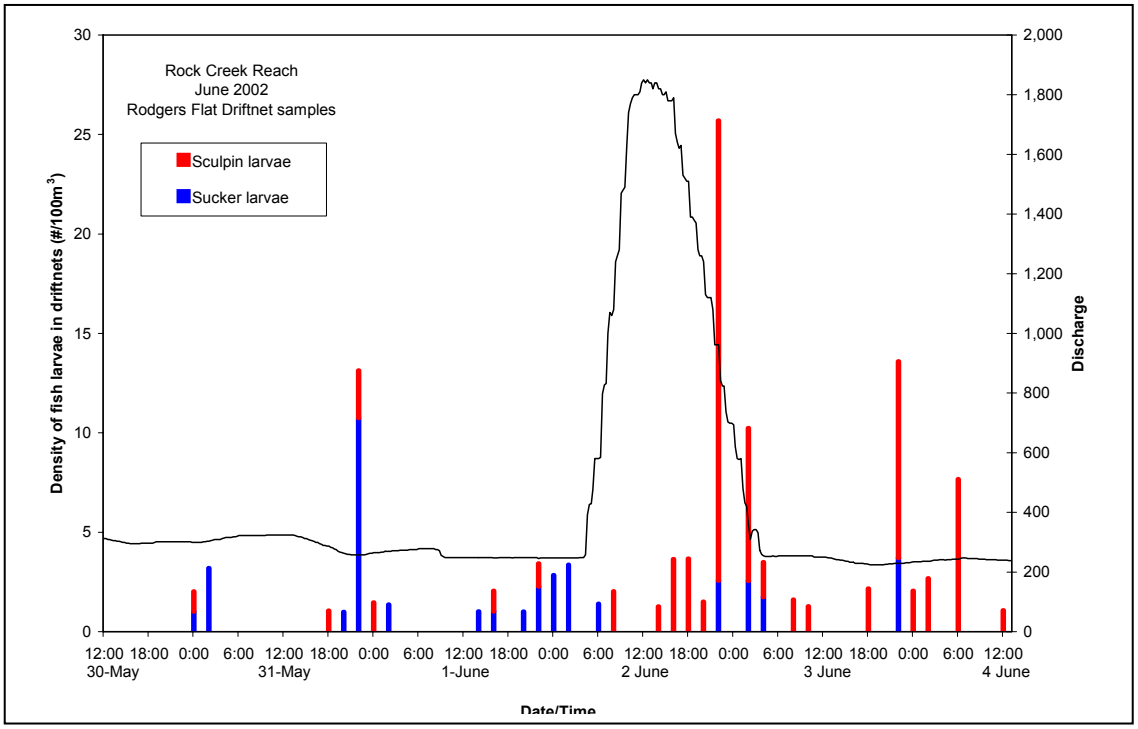

Figure 23. Fish density by species in 15-minute duration driftnet samples collected every two hours for five days during the June 2002 recreation flow. Data from the right and left nets have been combined.

Table 15. Comparison of the mean abundance and mean density of fish larvae categories for base flow versus recreation flow periods. Data from June 2002 driftnet survey at Rodgers Flat, Rock Creek Reach of the NFFR. Probability is the probability that the Student's t-test value will be exceeded. Probability levels less than 5% (0.05) are typically considered statistically significant and are noted with an asterisk *.

	Sucker		Sculpin		All larvae		
Metric	Base flow	Recreation flow	Base flow	Recreation flow	Base flow	Recreation flow	Probability
No./sample	0.55	0.33					0.4401
No./sample			0.55	2.00			0.1125
No./sample					1.10	2.33	0.2425
No./m^3	0.0070	0.0054					0.6891
No./m^3			0.0078	0.0358			0.1444
No./m^3					.0148	0.0412	0.2468

Table 16. Comparison of the mean abundance and mean density of fish larvae categories for day (5AM to 9PM) versus night (9PM to 5AM). Data from June 2002 driftnet survey at Rodgers Flat, Rock Creek Reach of the NFFR. Probability is the probability that the Student's t-test value will be exceeded. Probability levels less than 5% (0.05) are typically considered statistically significant and are noted with an asterisk *.

	Sucker		Sculpin		All larvae		
Metric	Day	Night	Day	Night	Day	Night	Probability
No./sample	0.12	1.30					0.0210*
No./sample			0.46	1.60			0.0846
No./sample					0.59	2.90	0.0144*
No./m^3	0.0013	0.0177					0.0094*
No./m^3			0.0068	0.0266			0.1300
No./m^3					.0081	0.0443	0.0234*

The driftnet data provide additional evidence that there does not appear to be displacement of large numbers of fish during the recreation flows. The data suggest that larval fish in the NFFR move in the drift at low levels at all times regardless of flow conditions and that the recreation flow levels of 1,850 cfs do not result in increased movement or displacement of larval fish. While the data may suggest that young-of-the-year fish larger than about 17 mm in length do not appear to be moving in the drift during base flows or recreation flow levels, an alternative explanation may be that larger young-of-the-year fish can successfully avoid the driftnets. If one assumes these fish have enough swimming ability to avoid the nets, then it would logically follow that these fish would also have enough swimming ability to seek refuge areas and avoid downstream displacement during periods of elevated stream flow.

When the June 2002 driftnet data is examined by time of day, an interesting pattern can be seen (Figures 24 and 25). It appears that most of the larval drift occurs during the night. The abundance and densities of larval suckers and all larval fish combined in driftnet samples collected during the night (9PM to 5AM) are significantly higher than those numbers or densities recorded from the day samples (Table 16). The nighttime larval sculpin abundances and densities are higher than those from the day drift samples, but the difference is not significant at the 5 percent evaluation level. The June 2002 driftnet data would appear to suggest that the movement of larval fish in the NFFR is largely behavioral and occurs during the night regardless of flow. These temporal patterns in the drift of larval fish in the Cresta and Rock Creek reaches of the NFFR are consistent with other research that has indicated larval suckers and larval sculpin exhibit diurnal drift patterns, with higher drift rates occurring after dark (Muth and Schmulbach 1984; Marchetti and Moyle 2000).

The fish specimens collected during the remaining four months of driftnet sampling were not available for examination at the time this report was being prepared. However, additional information that may be useful for this analysis is contained in the driftnet survey report (Garcia and Associates 2004a). During the early July 2002 driftnet survey it

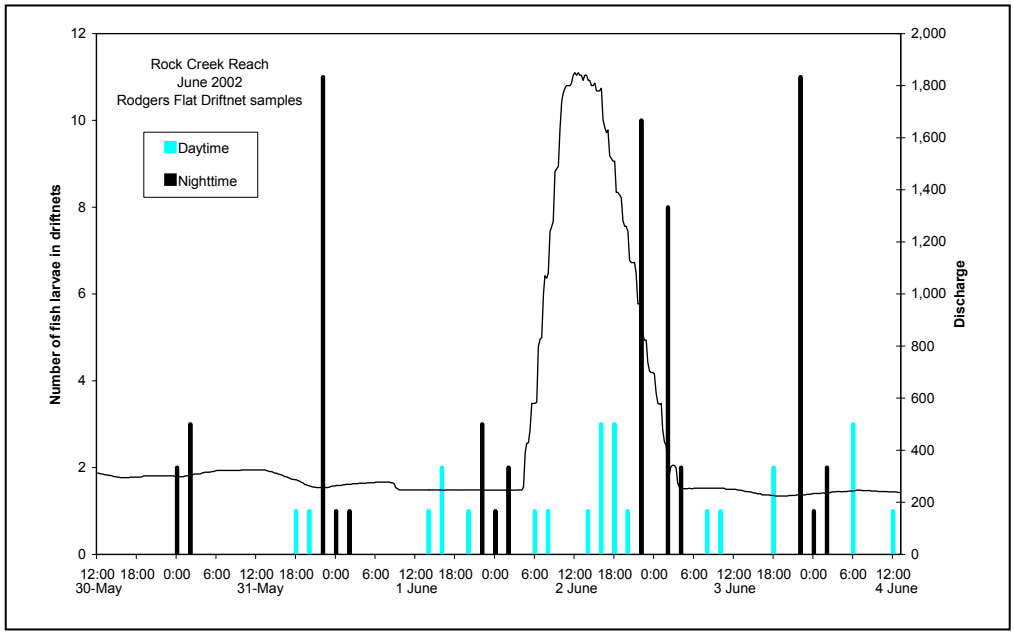

Figure 24. Day (0600-2000hr) versus night (2200-0400hr) fish abundance (suckers and sculpin combined) in 15-minute duration driftnet samples collected every two hours for five days during the June 2002 recreation flow.

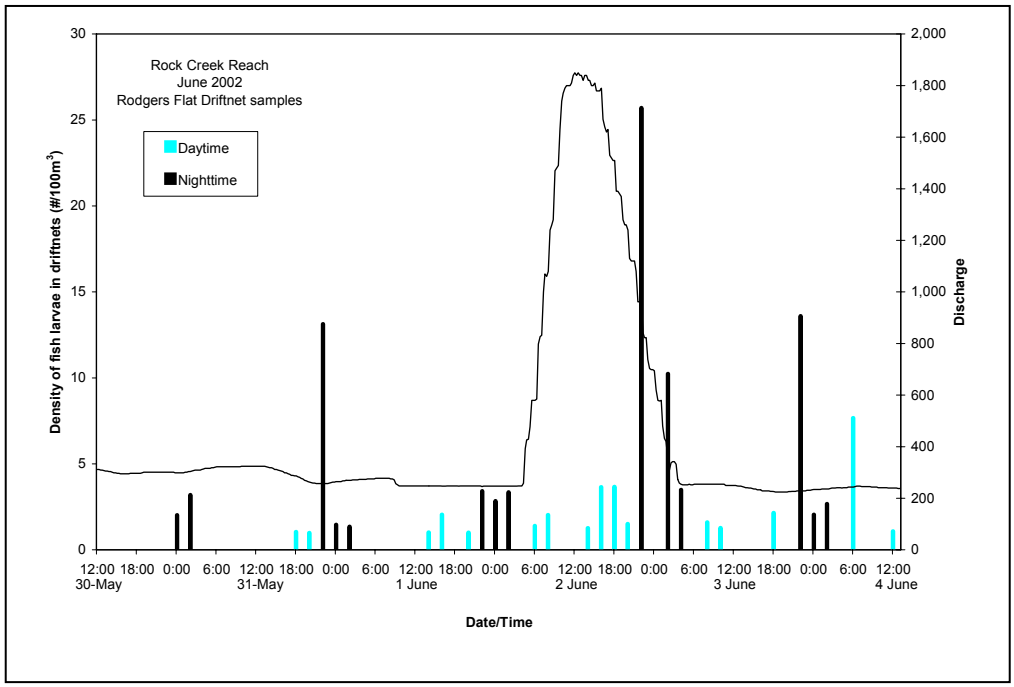

Figure 25. Day (0600-2000hr) versus night (2200-0400hr) fish density (suckers and sculpin combined) in 15-minute duration driftnet samples collected every two hours for five days during the June 2002 recreation flow.

was reported that ten fish larvae (no identification) were collected from the five days of sampling and that all were captured during the pre- or post-recreation base flow periods. The lack of any fish larvae being collected during the early July recreation flow, when flows in excess of 1,300 cfs occurred for 7.5 hours, indicate that the young-of-the-year fish rearing along the margins of the NFFR are resistant to downstream displacement from high flows. Of the ten fish larvae reportedly collected from the samples, nine came from night samples, again suggesting a diurnal drift pattern, as was noted from the June driftnet samples.

The early August 2002 driftnet sample data also suggest that the local populations of young-of-the-year fish in the NFFR are not prone to displacement since only six fish larvae were collected during the five day sample period and all during the pre-and post-recreation base flow periods. No fish were reported in the samples collected during the 14 hours of elevated stream flows, which included 6.75 hours of flows in excess of 1,000 cfs. All fish were caught in night samples.

No fish were reported from any of the early September 2002 or early October 2002 driftnet samples, despite recreation flows in excess of 1,100 cfs in both months.

Discussion

Displacement

Results of the five fish displacement surveys during the 2004 field season failed to show any consistent or appreciable changes in the number of resident fishes from the monthly recreation flows. The results of the third year of the evaluations were typically mixed, with various combinations species/life stages exhibiting increases, decreases, or little change at the twelve evaluation sites. The 2004 survey data was very similar to that noted during both 2002 and 2003, and did not provide evidence of a general downstream movement of fishes inhabiting the near-bank, margin areas as an immediate response to the recreation flows.

Hunter (1992) reported that he observed a very rapid increase in stream flow from 200 to 1,800 cfs over a 30 minute period on NF Skokomish River in Washington. This flow increase was about the same magnitude as the June pulse/recreation flow provided on the NFFR, but occurred at a much higher rate of change compared to the NFFR recreation flows. The NF Skokomish has drainage area of about 117 square miles compared to 1,914 square miles for the NFFR at Grizzly Creek. In general, it might be expected that the flood effects for comparable flow levels would be more pronounced in the smaller basin. Yet Hunter (1992) reported that the rapid flow increase had little or no impact on salmonid populations based upon before and after index counts.

The trout fry observed in the NFFR during the displacement were typically in the 40-50 millimeter size range by the time of the first recreation flow release in late June 2003. Many investigators have suggested there may be some size threshold for downstream movement of salmonids during high flow events. McCrimmon (1954) stated that vulnerability of salmonids to displacement is a function of size and that their susceptibility lasts only for a short time. Ottaway and Clarke (1981) confirmed this opinion when they reported the relationship between displacement and water velocity is always changing throughout the early life history stages of salmonids and at certain ages, fish appear more vulnerable to downstream displacement. Their results indicated that young salmonids pass through a short period when they are vulnerable to downstream displacement. Harvey (1987) examined the downstream displacement of young-of-the-year, non-trout fishes (primarily centrarchids and cyprinids) and found a rapid decline in displacement as fish exceeded a certain size. Fish less than 10 millimeters were extremely vulnerable to displacement, while those in the 10-25 mm size class were much less so. Larimore (1975) suggested that smallmouth bass fry rely on visual and tactile cues to maintain their position during high flow conditions. Heggenes and Traaen (1988), using artificial stream channel tests, found that it was newly emerged salmonid fry entering the free-feeding stage that were most susceptible to displacement. Trout fry greater than 30 mm in length were much more likely to seek out areas of low velocity during periods of increasing flow, thus becoming less vulnerable to downstream displacement at higher velocities. Heggenes

(1988) found that high flows did not significantly influence the distribution or movement of juvenile or adult brown trout greater than 67 millimeters in length. Irvine (1986) reported that water velocities in an artificial stream channel had to exceed 0.8 feet per second to displace chinook fry less than 40mm in length. Shirvell (1994) found that salmon fry will move both laterally and longitudinally up or downstream seeking suitable microhabitats during increasing stream flows. Jowett and Richardson (1994) found that there was a significant lateral movement of fish in response to changing hydraulic conditions during flood flows and that edge-dwelling fishes responded quickly to flow changes by moving with the river margin to minimize changes in depth. Saltveit et al. (2001) reported that during rapidly fluctuating flow conditions associated with hydro peaking operations, juvenile salmon and trout will follow the water's edge both up and down as stream flow changes.

Irvine (1987) investigated the effects of varying stream flows on rainbow trout fry held in artificial stream channels. He found that five-fold fluctuations in discharge that occurred twice daily, five days per week, for approximately thirteen weeks had no discernible effect on trout fry growth rates, downstream movement, distribution, or habitat use. Arndt et al. (2002) found that while summer floods can temporarily disturb growth rates of juvenile salmonids, young-of-the year fish recover quickly. They concluded that juvenile salmonids appear to be resilient to floods of a magnitude that would occur as part of the normal life history of most cohorts.

Our studies focused on the shallow margin areas of the NFFR where the smaller and presumably more vulnerable fish reside. The literature suggests that larger juveniles and adult fish are relatively safe from flood effects. Seegrist and Gard (1972) reported that juvenile and adult trout were relatively secure from flood damage in Sagehen Creek. Gido et al. (2000) found adult rainbow trout were not displaced downstream during extended periods of high flow releases below a reservoir. Pearsons et al. (1992) and Harvey et al. (1999) suggested that the ability of trout and salmon populations to withstand bankfull flooding depended on the availability of refuge cover, especially large woody debris.

Travnichek and Maceina (1994) found flow changes had little effect on deeper water pool-dwelling fishes compared to shallow water residents. Research has confirmed that fish that are able to move into suitable refuge areas during periods of high flow are able to resist the negative effects of those floods, namely displacement downstream (Dolloff et al. 1994; Swanson et al. 1998; Murchie and Smokorowski 2004). Our survey displacement results and observations made during the high flow and subsequent down-ramping suggest that the shallow-water, margin-dwelling fish find refuge from high velocities during the recreation flow releases by moving laterally with the waters edge as it rises and falls, with the recreation flow hydrograph.

Jowett and Richardson (1989) did find significant losses of juvenile and adult trout (100 mm to >400 mm in length) from index sites in seven New Zealand Rivers during severe flood flows. However, these fish displacements occurred as a result of extreme flows associated with floods of the magnitude of 20 to 500 year frequencies that also resulted in significant physical changes to the stream channel. Carline and McCullough (2003) studied the effects of flood flows on brook trout populations in West Virginia mountain streams. They reported that flood flows had severe impacts on resident trout; however, the floods they evaluated had recurrence intervals of 5 to 25 years and resulted in large scale bedload movements, that scoured redds and resulted in significant changes to stream macrohabitats. Smith and Atkinson (1999) and Swanson et al. (1998) noted that it was the debris flow associated with large flood events (50 to >500 year recurrence events) that resulted in adverse impacts to resident trout populations. The recreation flows on the NFFR have exceedance values of 8-15 percent (based upon 20+ years of recent stream flow data). Flows of this magnitude do not constitute unusual or severe flood conditions and probably do not include wholesale movement of debris or bottom substrates. Casual observations made during our snorkel surveys suggest to us that the levels of flow present during the monthly recreation releases have little if any apparent effect on stream substrates at our survey sites. Based on the literature review and our observations, it would appear that the flows of 1,100 to 1,900 cfs magnitudes for short periods of time during the summer will have only very limited effects on the fish populations of the NFFR.

Most of displacement and dispersal studies were conducted on anadromous salmon and trout which exhibit a natural downstream migratory behavior during their early life history stages as they migrate from spawning to rearing to ocean habitats. There may be some natural downstream movement by the resident fishes of the NFFR. This would be true under the premise that the resident trout populations of the NFFR are derived from recruits that drift downstream from local tributary streams (California Department of Fish and Game 1988). Slow downstream dispersal of the abundant sucker and minnow post-larvae observed along the stream margins in June and July should also be expected and is confirmed in the results of the 2002 driftnet surveys. The driftnet survey results suggest there is a slow and near constant downstream drift of larval fish especially at night, regardless of the flow conditions. The driftnet sample data supports the findings of our displacement snorkel surveys that the small, margin-dwelling fishes present in the Cresta and Rock Creek reaches of the NFFR are resistant to displacement during high flows.

The 2002-2004 snorkel surveys of the stream margins do not provide any clear indication that the monthly recreation flows resulted in any substantial or consistent changes to the fish populations of the NFFR. While we could not confidently be sure that individual fish noted before and after the flow events were in fact the same fish, their presence in the same general locations and in the same general densities suggest that the local populations are tolerant of short term recreation flow events of the magnitude and duration seen during the three years of study. Most of the trout and bass fry noted after the late-June survey were larger than fish typically considered susceptible to displacement from the literature. The literature suggest that for more territorial species, such as bass and trout, once these fish grow to a size with more territorial tendencies, they are less apt to emigrate in response to flow changes (McCrimmon 1954; Seegrist and Gard 1972; Ottaway and Clark 1981; Irvine 1986). Our informal observations made along the stream margins during the period as flows were receding to base flow conditions revealed that the post-larval stages of minnow and suckers moved laterally with the waters edge across the varial zone as it flooded or dewatered, thereby effectively avoiding areas of excessive water velocity. All our data and

observations during the three years of studies suggest that there was no consistent changes in the resident fish populations in the study reaches of the NFFR due to the summer and fall recreation flows.

Stranding

While stranding of macroinvertebrates, fish, and amphibians was documented during down-ramping following the 2004 recreation flows, it generally occurred at low levels and with the highest levels occurring in June and July, and then decreasing during each subsequent monthly survey. During our five monthly evaluations, we surveyed an estimated area of about 337,000 square feet (7.7 acres) of cobble/boulder bar (Table 17). As part of our search effort, we moved 27,404 rocks in order to inspect interstitial pockets for stranded organisms. During our 2004 stranding surveys we salvaged a total of 204 stranded benthic macroinvertebrates, 137 fish, and no FYLF tadpoles.

Table 17. Estimated total area surveyed, number of rocks turned, and total density of stranded organisms (number per 1000 square feet) noted during the June through October 2004 recreation flow biological evaluations in the NFFR. No recreation flow and hence no stranding surveys were conducted in the Cresta Reach during June 2004. The Cresta Reach data includes all of the July survey data which included areas dewatered below ambient base flow levels.

Site	Total Area (ft^2)	Rocks Turned	Benthic Macroinvertebrates	Fish	Tadpoles	Total Organisms
Cresta Reach						
Poison Oak	30,701	4,329	2.801	0.000	0.000	2.801
Flagged Fir	22,626	3,497	0.486	0.000	0.000	0.486
Shady Rest	23,932	1,372	0.418	0.000	0.000	0.418
Arch Rock	44,547	2,750	0.920	0.584	0.000	1.504
All Cresta Sites	121,806	11,948	1.215	0.213	0.000	1.429
Rock Creek Reach						
Rock Crest	2,599	358	0.000	0.000	0.000	0.000
Abandoned CG	34,802	2,375	0.172	1.207	0.000	1.379
Indian Jim School	87,718	5,365	0.217	0.422	0.000	0.638
Telephone/Cable Box	47,742	3,706	0.314	0.293	0.000	0.607
Gage	42,114	3,652	0.380	0.427	0.000	0.807
All Rock Creek Sites	214,975	15,456	0.260	0.516	0.000	0.777
All Sites Combined	336,781	27,404	0.606	0.407	0.000	1.013

Over 71 percent of the macroinvertebrates salvaged during the 2004 stranding surveys were made up of crayfish (n=54), pond snails (n=49), and corixids (n=43; Table 18). Over 68 percent of the stranded fish were post-larval cyprinid and catostomid fry that were less than 1 inch (25 mm) in length. The peak of the fish stranding occurred during the late-June survey when the non-game post-larvae were quite abundant along the stream margins (Figure 7). During the late-July survey another 29 fish were found stranded, including 24 smallmouth bass fry and 2 minnow fry from the Arch Rock site (Table 18; Appendix E, Table E-2). It is likely the initial rapid down-ramping rates in the Cresta Reach during the July survey (28.3 inches/hour) contributed to the fish stranding. Even with this rapid down-ramping, no trout or FYLF tadpoles were recovered during the surveys, and in fact at the three remaining Cresta Reach sites, no fish at all were documented. Only one fish was recovered during the final three months of stranding surveys. Similar to the 2002 field season,

Table 18. Number of various taxonomic categories recovered during the five monthly stranding surveys conducted during 2004 recreation flow biological evaluations in the NFFR. No recreation flow and hence no stranding surveys were conducted in the Cresta Reach during June 2004. The Cresta Reach data included all of the July survey data, which included areas dewatered below normal base flow levels.

Category	June	July	August	September	October	Total
Crayfish	10	27	4	11	2	54
Water mites	0	0	0	8	0	8
Dragonflies	0	0	0	1	0	1
Mayflies	9	1	0	1	0	11
Corixids	0	17	6	20	0	43
Helgrammites	0	19	0	0	0	19
Beetles	3	0	2	0	0	5
True flies	3	2	0	1	0	6
Clams	4	1	0	3	0	8
Snails	0	0	49	0	0	49
Macroinvertebrate Total	29	67	61	45	2	204
Non-game post-larvae	94	0	0	0	0	94
Trout fry	0	0	0	0	0	0
Sucker fry	13	2	0	0	0	15
Bass fry	0	24	0	0	0	24
Minnow fry	0	3	1	0	0	4
Sculpin	0	0	0	0	0	0
Fish Total	107	29	1	0	0	137
FYLF tadpoles	0	0	0	0	0	0

no trout were recovered at any of the survey sites during 2004. The three years of studies at eight stranding sites suggest that the overall risk of stranding organisms during the down-ramping from the monthly recreation flows is small, particularly for trout and tadpoles.

Kroger (1973) estimated huge losses of benthic macroinvertebrates due to stranding associated with rapidly fluctuating water levels below a dam. In his study area the main channel was being periodically dewatered from 100 cfs to less than 10 cfs over a five minute period of time. The NFFR recreation flows were provided for a very short duration (6-8 hours) followed by a gradual period of down-ramping (9 to 14 hours) before returning to a minimum base flow of about 275 cfs. The exception was during the emergency down-ramping episode in the Cresta Reach during July. This scenario of gradual down-ramping limited macroinvertebrate stranding to the varial zones outside of the base flow channel that would have been subjected to settlement by drifting macroinvertebrates for a very brief period. Under this type of down-ramping schedule the stranding densities for benthic macroinvertebrates are usually quite small.

On the whole, the densities of stranded organisms were quite low (Table 17). Bradford et al. (1995) reported salmonids stranded in densities of 4.6 fish per 1000 square feet on cobble bars following a flow reduction on the Seton River, British Columbia. Saltveit et al. (2001) in experiments using wild young-of-the-year Atlantic salmon on the Nidelva River in Norway, estimated stranding densities of 24.8 to 70.6 fish per 1000 square feet. These figures exceed by orders of magnitude the estimated densities of stranded trout fry during our three years of studies on the NFFR, even after adjusting them for search efficiencies and overnight losses to scavengers/predators (Table 12).

In 2002 and 2004 no trout fry were recovered during any of the NFFR stranding surveys. During 2003, eight trout fry were recovered during the surveys, all during the first two months of the surveys (June and July). The small numbers of stranded trout fry noted in the NFFR surveys and their limited occurrence to the early summer surveys, suggests that

by the time of the first recreation flows most of the trout fry are capable of avoiding being stranded during down-ramping from the elevated flows. Several studies suggest that resident trout fry are less susceptible to stranding than anadromous fry (Hvidsten 1985; Irvine 1987; Bradford1995). Results from a two year study on the incidence of fish stranding in a hydro peaking reach of the upper Klamath River focused on areas of highest risk (large exposure area and lateral bar gradients less than two percent). Five sites (comprising 75,500 square feet of varial zone habitat) were surveyed following six separate down-ramping episodes during the peak of rainbow trout fry abundance. No trout fry were found stranded during the surveys and only six juvenile non-game fish (four marbled sculpin; one speckled dace, and one unidentified sucker) were recovered (PacifiCorp, 2004).

By late-June the trout fry in the Cresta and Rock Creek reaches of the NFFR (as observed during the displacement surveys) were typically in the 35-45 mm size range. This size range is right on the cusp of what the literature reports as the upper limit of susceptibility of salmonid fry to stranding. Many investigators have reported that it is the newly-emerged salmonid fry that are most vulnerable to stranding (Hamilton and Buell 1976; Woodin 1984; Hvidsten 1985; Hunter 1992). Stober et al. (1981), Beck and Associates (1989), and Olson (1986; 1990) studying the effects of hydro peaking projects in Washington, found that steelhead larger than 40 mm are less susceptible to stranding. Bauersfeld (1978) found that stranding was size selective and differentially impacted salmonid fry in the 35-45 mm size range. Bauersfeld (1977) found that 86 percent of the salmonids found stranded in lower Columbia were fish in the 35-50 mm size range. Cushman (1985) in his review of the effects of rapid changes in stream flows stated that mature fish are less susceptible to stranding mortality because their habitat preference shifts from shallow littoral areas to deeper areas in the main channel away from the influence of receding waters. This was confirmed by Irvine (1987) and Olson (1990) who noted a behavioral shift in habitat use from shallow margins to deeper areas with slower water velocities as trout fry increase in size during their first year.

The ambient water temperatures and physical character of the river may have contributed to the low rate of stranding observed along the NFFR during our three years of studies. The literature suggests that there is less fish stranding during down-ramping events in rivers with single channel and relatively steep banks (Hunter 1992). Both Bradford et al. (1995) and Adams et al. (1999) reported reduced fish stranding on steeper gravel bars compared to more gently sloping stream banks. Beck and Associates (1989) found the majority of salmon and steelhead stranding in a hydro peaking reach of the Skagit River, Washington, occurred on gravel bars with lateral slopes less than five percent. Investigations on the Sultan River in Washington, found that salmon and steelhead fry stranding occurred on river bars with lateral slopes of less than four percent (Olson and Metzgar 1987; Olson 1990). The average lateral gradient at the nine stranding study sites in the NFFR exceeded eight percent, and at eight of the sites the mean slope in the varial zone was greater than ten percent (Salamunovich 2004b). While there were some portions of the study sites that had gradients less than five percent, these areas were limited. Considering the additional sites identified and measured as part of the total stranding estimates (Appendix F) along with our monthly stranding sites, the average varial zone gradient in the Cresta and Rock Creek Reaches is 19.2 percent and 16.3 percent, respectively. Therefore, the steep, confined, canyon nature of the NFFR in Cresta and Rock Creek reaches of the NFFR, with its steep banks and limited floodplain probably contributes to minimize stranding of fish, invertebrates and amphibians during receding flow conditions.

Bradford (1997) found that the overall incidence of stranding over lateral gravel bars was low due to the ability of salmonid fry to move to deeper water as flows recede. Beck and Associates (1989) reported that coarse substrates (>3 inches) was less likely to strand salmonid fry than small substrates (<3 inches). While no measurements on substrate sizes were collected as part of this study, the stranding areas in the NFFR are composed primarily of cobble and small boulder substrates and would definitely qualify as coarse substrate as defined above.

Stranding incidence has been related to water temperature, with greater stranding occurring at lower water temperatures when salmon and trout are inactive and in the substrate during the day (Bradford et al, 1995). Bradford (1997) studying juvenile salmonid stranding in artificial stream channels found that gravel bar stranding averaged about 4.5 percent at 6ºC (42.8ºF) compared to about 0.5 percent during his 12ºC (53.6ºF) trials. During the three years of our studies, the summer and fall water temperatures during our studies ranged from 11º to 25ºC (51.8º to 77ºF) (Table 19), temperatures at which fish would be expected to be actively swimming and feeding and thus, less prone to stranding.

Table 19. Mean, minimum and maximum water temperatures in the Rock Creek-Cresta Reach of the NFFR during monthly snorkel surveys, 2002-2004. Sample sizes are indicated.

Month	n	Mean (°C)	Minimum (°C)	Maximum (°C)
June	74	19.2	16.7	22.0
July	66	21.1	17.8	25.0
August	64	20.3	17.5	23.3
September	69	17.6	15.0	20.0
October	70	13.7	11.0	17.8

The apparently moderate down-ramping schedule (maximum rate of about 150 cfs per hour or changes in water surface of less than five inches per hour) may also have contributed to generally low incidence of stranding. Gradual down-ramping rates have been shown to reduce fish stranding compared to rapid flow decreases (Hamilton and Buell 1976; Olson 1986, 1990; Hunter 1992; Bradford 1997). Very little stranding was noted for resident fishes (including rainbow trout) of the upper Klamath River during down-ramping events of 8.4 inches/hour (PacifiCorp 2004). The normal down-ramping rates for the Cresta and Rock Creek reaches during our three years of studies are typically less than 5 inches/hr (Table 4). It should be noted that the rapid reduction in stream flow that occurred in the Cresta Reach during September 2003 and July 2004 did not result in catastrophic levels of stranding. After the September 2003 event, only one sculpin was found after surveying the four stranding sites in this portion of the NFFR. Even the rather high macroinvertebrate stranding documented in the Cresta Reach during the September survey was limited to one site (Arch Rock), and appeared to be a function of the below normal base flow levels

achieved rather than the rate of the flow decline. Very few macroinvertebrates were actually stranded in the varial zone bounded by the recreation flow and the normal base flow level that was dewatered over the course of about two hours. The July 2004 down-ramping found only 26 young-of-the-year fish (24 bass fry and 2 minnow fry) at one Cresta site, with an estimated density of about 2.3 fish per 1000 square feet (Table 7).

As was noted during the previous two years, most of the fish recovered during the 2004 stranding surveys were small, non-game post-larvae and occurred primarily in late-June (Table 18). The small number of stranded fish found overall, compared to the large numbers of post-larvae present along the stream margins (see Figure 7), suggests there is a low overall incidence of stranding even for these small fish. Jowett and Richardson (1994) have suggested that fish residing along the stream margins respond quickly to flow changes and move laterally to avoid changes in depth. Harvey (1987) examining the susceptibility of small post-larval fish (mainly centrarchids and cyprinids) to downstream displacement, found fish larger than 10 mm much less vulnerable. The capacity for lateral movement probably serves to both reduce both displacement during periods of increasing flows and stranding during periods of declining stream flow conditions.

Despite the low incidence of stranding by minnows and suckers, the general decline in stranding throughout the summer and fall, suggest that there is a size vulnerability to stranding for these species. Large numbers of minnow fry (<4") were still present along the margins of the stream later in the summer and fall, but very few are found during stranding. Our results indicate that once the minnow and sucker fry exceed about 1 inch in length they are much less vulnerable to stranding during normal down-ramping events.

It should be noted that our studies concentrated on cobble bar stranding and did not address side-channel stranding. Numerous researchers have suggested that trapping fish in isolated side-channels and potholes can represent a significant source of fish mortality (Maciolek and Needham 1952; Bauersfeld 1977; 1978; Hunter 1992; Woodin 1984; Olson and Metzgar 1987; Higgins and Bradford 1996; Bradford 1997). The fish are at greater risk of

predation, deteriorating water quality, and desiccation if the area dries up. All of the side channel areas associated with our studies remained flowing at the base flows and so were never isolated. During our original inspection to locate our study sites in May 2002 and the June 2003 re-evaluation of sites, we did not identify any large areas where side channel stranding would be of concern. Our opinion is that the highly confined nature of the stream channel throughout the study area limits the ability of the NFFR to form extensive side channel habitats and so trapping fish in off channel areas during declining flows is probably not a significant source of mortality.

Even after adjusting the stranding densities observed during three years of studies to account for search efficiencies, overnight predation losses and then expanding the estimates to account for the losses over the total available stranding areas, the estimated losses are still extremely small and suggests that stranding does not appear to pose a substantial hazard to the fish and amphibian populations of the NFFR or its food base. Based on the three years of adjusted data, down-ramping from the five monthly recreation flows would be expected to result in annually stranding an estimated 4,922 benthic macroinvertebrates, 2,201 fish, and 9 FYLF tadpoles in the combined Cresta and Rock Creek reaches (Table 13). Our stranding data suggest that most of the macroinvertebrates are crayfish, water boatmen, and pond snails. Most of the fish are stranded during the first two months and were composed primarily of recently-hatched sucker and minnow post-larvae (87 percent of the stranded fish total

The annual estimated loss of nine FYLF tadpoles during the five Cresta Reach recreation flows do not appear to be significant when compared to natural losses expected from tadpole predation by fish, birds, and snakes. Garter snakes, which are commonly observed prowling the margins of our displacement and stranding sites, are known predators on FYLF tadpoles. One snake examined for stomach contents in June 2003 as part of the Cresta Reach frog surveys, contained 23 FYLF tadpoles (Garcia and Associates 2004b).

Our displacement dives suggest that there are hundreds of thousands of non-game post-larvae present along the banks of the NFFR during June and July. The average length of our displacement sites is 392 feet. The average June & July abundance for non-game post-larvae for all twelve displacement survey sites is 1,768 fish. If this mean estimate is accurate, there is an average of 4.51 larvae/per linear foot of habitat along the 70,752-foot long Cresta and Rock Creek reaches (i.e., combined length). This equates to a total abundance estimate of 319,106 larvae present along two reaches during June and July. The combined reach loss of non-game post-larvae during June and July (1,932 fish) would represent a loss of less than one percent (0.61 percent) of the total non-game larvae population. Given the apparent abundance of non-game post-larvae along the margins of the NFFR throughout the Cresta and Rock Creek reaches during June and July, the loss of even several thousand larvae over the course of several flow events would not appear to be a significant loss.

Adult rainbow trout spawner studies conducted during 1981-1985 in the Rock Creek and Cresta reaches of the NFFR (including tributaries) indicated that the average fecundity was 640 eggs per female trout (California Department of Fish and Game 1988). Clark et al. (2001) estimated egg-to-emergent fry survival to be 10 percent for Appalachian Mountain rainbow trout stocks. If we assume a similar survival rate in the NFFR, the total estimated loss of rainbow trout fry in both the Cresta and Rock Creek reaches combined (38 trout fry) is less than the estimated fry production from one spawning pair of rainbow trout (64 trout fry). Hunter (1992) suggested that limited fry stranding will have little effect on resident trout populations because production tends to be limited by adult rearing habitat and not the juvenile to adult survival. In our study area of the NFFR, adult spawning may be limiting the size of the trout populations.

Another approach to putting the estimated stranding losses in perspective is to compare them to the mortality estimates from sport anglers. Creel surveys conducted in the study area during 2004 estimated that anglers using legal gear (i.e., artificial lures and flies) caught and released 581 rainbow trout in the Cresta Reach and 775 rainbow trout in the

Rock Creek Reach (draft data from Meadowbrook Conservation Services, report in preparation). Mortality estimates for rainbow trout caught and released using non-bait terminal gear vary, but a mean hooking mortality of 6.9 percent was reported in Taylor and White (1992). Hooking mortality is positively related to water temperatures. Nuhfer and Alexander (1992) reported that at water temperatures of 14° C only 1 percent of brook trout caught with lures died within 48 hours of being caught; however, the mortality increased rapidly with water temperature and approached 27 percent at 18° Centigrade. Lure and fly hooking mortalities in the Rock Creek-Cresta area of the NFFR can probably be assumed to be higher during the summer when water temperatures regularly exceed 20°C (Table 19).

However, assuming a hooking mortality of 6.9 percent for rainbow trout caught and released using lures and flies, we estimate that legal angling resulted in the loss of 37 catchable-sized rainbow trout in the Cresta Reach and 47 trout in the Rock Creek Reach. If we assume that half the catch are females and again assume 640 eggs per female and a 10 percent egg-to-fry survival, legal angling in the project area during 2004 is estimated to result in a loss of 2,688 rainbow trout fry from the next year's production (42 female trout X 640 eggs/female X 0.10 egg-to-fry survival). The estimated annual loss of 38 rainbow trout fry through stranding from the monthly recreation flows is dwarfed by this estimated loss of future fry through legal angling of adult trout. If one includes the estimated mortality of adult trout to illegal angling (use of bait gear and keeping trout) that has been documented to occur in the study area, the estimated stranding losses of trout fry become even a smaller fraction of the losses of future fry production to angling mortality.

When the total estimates of organisms lost through stranding are compared to the apparent numbers that area present along the river or to losses from angling or predation, the stranding losses appear to be minimal.

In conclusion, three years of evaluations during the summer and fall of 2002 through 2004, have provided no clear evidence that the recreation flows, or the down-ramping following

these flows, have resulted in any substantial and/or consistent effects on the fish or benthic macroinvertebrate resources of the NFFR. The risk to amphibian tadpoles under the existing down-ramping schedule appears to be minimal.

Recommendations

Based upon the consistency of the results of the three years of displacement and stranding studies and the minimal impacts to the aquatic resources of the NFFR from the recreation flows, we recommend that these surveys be suspended. If surveys are considered in future years because of concerns about multiple recreation flows in a single month, we suggest that these studies be limited to the early summer period, which is the time of greatest vulnerability of fish and amphibians to stranding and displacement.

Literature Cited

Adams, S.R., T.M. Keevin, K.J. Killgore, and J.J. Hoover. 1999. Stranding potential of young fishes subjected to simulated vessel-induced drawdown. Transactions of the American Fisheries Society 128:1230-1234.

Arndt, S.K., R.A. Cunjak, and T.J. Benfey. 2002. Effect of summer floods and spatial-temporal scale on growth and feeding of juvenile Atlantic salmon in two New Brunswick streams. Transactions of the American Fisheries Society 131:607-622.

Bauersfeld, K. 1977. Effects of peaking (stranding) of Columbia River dams on juvenile anadromous fishes below the Dalles Dam, 1974 and 1975. Washington Department of Fisheries Technical Report No. 31. 117p.

Bauersfeld, K. 1978. Stranding of juvenile salmon by flow reductions at Mayfield Dam on the Cowlitz River, 1976. Washington Department of Fisheries Technical Report No. 36. Seattle, Washington. 36p.

Beck and Associates. 1989. Skagit River salmon and steelhead fry stranding studies. Report to Seattle City Light, Environmental Affairs Division, Seattle, WA.

Bozek, M.A., and F.J. Rahel. 1991. Assessing habitat requirements of young Colorado River cutthroat trout by use of macrohabitat and microhabitat analysis. Transactions of the American Fisheries Society 120:571-581.

Bradford, M.J. 1997. An experimental study of stranding of juvenile salmonids on gravel bars and in side channels during rapid flow decreases. Regulated Rivers: Research & Management 13:395-401.

Bradford, M.J., G.C. Taylor, J.A. Allan, and P.S. Higgins. 1995. An experimental study of the stranding of juvenile coho salmon and rainbow trout during rapid flow decreases under winter conditions. North American Journal of Fisheries Management 15:473-479.

California Department of Fish and Game. 1988. Rock Creek–Cresta Project (FERC 1962) fisheries management study, North Fork Feather River, California. 1 July 1988 final report prepared by Region 2 Environmental Services and submitted to Pacific Gas and Electric Company.

Carline, R.L., and B.J. McCullough. 2003. Effects of floods on brook trout populations in the Monongahela National Forest, West Virginia. Transactions of the American Fisheries Society 132:1014-1020.

Cobb, D.G., T.D. Galloway, and J.F. Flannagan. 1992. Effects of discharge and substrate stability on density and species composition of stream insects. Canadian Journal of Fisheries and Aquatic Sciences 49:1788-1795.

Crisp, D.T. 1991. Stream channel experiments on downstream movement of recently emerged trout, *Salmo trutta* L. and salmon, *Salmo salar* L. – III. Effects of developmental stage and day and night upon dispersal. Journal of Fish Biology 39:371-381.

Crisp, D.T., and M.A. Hurley. 1991. Stream channel experiments on downstream movement of recently emerged trout, *Salmo trutta* L. and salmon, *Salmo salar* L. – I. Effect of four different water velocity treatments upon dispersal rate. Journal of Fish Biology 39:347-361.

Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5:330-339.

Dolloff, C.A., P.A. Flebbe, and M.D. Owen. 1994. Fish habitat and fish populations in a southern Appalachian watershed before and after Hurricane Hugo. Transactions of the American Fisheries Society 123:668-678.

Erman, D.C., and G.R. Leidy. 1975. Downstream movement of rainbow trout fry in a tributary of Sagehen Creek, under permanent and intermittent flow. Transactions of the American Fisheries Society 104:467-473.

Garcia and Associates. 2004a. Rock Creek-Cresta recreation streamflow monitoring: 2002 macroinvertebrate drift sampling. North Fork Feather River, Plumas County, CA, Rock Creek-Cresta Hydrolelectric Project (FERC No. 1962). November 2004 final draft report prepared for Technical and Ecological Services, Pacific Gas and Electric Company, San Ramon, CA.

Garcia and Associates. 2004b. Results Of 2004 Surveys and Monitoring for Foothill Yellow-Legged Frog (*Rana boylii*) Within the Rock Creek-Cresta Project Area, North Fork Feather River, and 2002-2004 Recreation and Pulse Flow Biological Evaluation Summary. Draft report prepared for Pacific Gas and Electric Company, san Ramon, CA.

Gido, K.B., R.D. Larson, and L.A. Ahlm. 2000. Stream-channel position of adult rainbow trout downstream of Navajo Reservoir, New Mexico, following changes in reservoir release. North American Journal of Fisheries Management 20:250-258.

Gislason, J.C. 1985. Aquatic insect abundance in a regulated stream under fluctuating and stable diel flow patterns. North American Journal of Fisheries Management 5:39-46.

Hamilton, R. and J.W. Buell. 1976. Effects of modified hydrology on Campbell River salmonids. Department of the Environment, Fisheries and Marine Service, Habitat Protection Directorate Technical Report Series No. PAC/T-76-20. Vancouver, British Columbia, Canada.

Harvey, B.C. 1987. Susceptibility of young-of-the-year fishes to downstream displacement by flooding. Transactions of the American Fisheries Society 116:851-855.

Harvey, B.C., R.J. Nakamoto, and J.L. White. 1999. Influence of large woody debris and a bankfull flood on movement of adult resident coastal cutthroat trout (*Oncorhynchus clarki*) during fall and winter. Canadian Journal of Fisheries and Aquatic Sciences 56:2161-2166.

Heggenes, J. 1988. Effects of short-term flow fluctuations on displacement of, and habitat use by, brown trout in a small stream. Transactions of the American Fisheries Society 117:336-344.

Heggenes, J. and T. Traaen. 1988. Downstream migration and critical water velocities in stream channels for fry of four salmonid species. Journal of Fish Biology 32:717-727

Heggenes, J., T.G. Northcote, and A. Peter. 1991. Spatial stability of cutthroat trout (*Oncorhynchus clarki*) in a small coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 48:757-762.

Higgins, P.S., and M.J. Bradford. 1996. Evaluation of a large-scale fish salvage to reduce the impacts of controlled flow reduction in a regulated river. North American Journal of Fisheries Management 16:666-673.

Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: a review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries Technical Report 119.

Hvidsten, N.A. 1985. Mortality of pre-smolt Atlantic salmon, *Salmo salar* L., and brown trout, *S. trutta* L., caused by fluctuating water levels in the regulated River Nidelva, central Norway. Journal of Fish Biology 27:711-718.

Irvine, J.R. 1985. Effects of successive flow perturbations on stream invertebrates. Canadian Journal of Fisheries and Aquatic Sciences 42:1922-1927

Irvine, J.R. 1986. Effects of varying discharge on the downstream movement of salmon fry, *Oncorhynchus tshawytscha* Walbaum. Journal of Fish Biology 28:17-28.

Irvine, J.R. 1987. Effects of varying flows in man-made streams on rainbow trout (*Salmo gairdneri* Richardson) fry. Regulated Streams: Advances in Ecology. Pages 83-97 *in*

J.F. Craig and J.B. Kemper, editors. Regulated Streams: Advances in Ecology, Plenum Press, New York. 431p.

Jowett, I.G., and R.G. Dungey. 2000. Effect of varying flows on benthic macroinvertebrate and salmonid habitat in the Clutha River below Roxburgh Power Station. National Institute of Water and Atmospheric Research ltd. Client Report COE000224.

Jowett, I.G., and J. Richardson. 1989. Effects of a severe flood on instream habitat and trout populations in seven New Zealand rivers. New Zealand Journal of Marine and Freshwater Research 23:11-17.

Jowett, I.G., and J. Richardson. 1994. Comparison of habitat use by fish in normal and flooded river conditions. New Zealand Journal of Marine and Freshwater Research 28:409-416.

Kroger, R.L. 1973. Biological effects of fluctuating water levels in the Snake River, Grand Teton National Park, Wyoming. American Midland Naturalist 89:478-481.

Larimore, R.W. 1975. Visual and tactile orientation of smallmouth bass fry under floodwater conditions. Pages 323-332 *in* H. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Locke, A.G.H. 1987. Microhabitat utilization and preference curve development for rainbow trout fry in four creeks in southwestern Alberta. Final Report of the Fish and Wildlife Division, Alberta Forestry, Lands and Wildlife. Edmonton, Alberta, Canada. 128p.

McCrimmon, H.R. 1954. Stream studies on planted Atlantic salmon. Journal of the Fisheries Research Board of Canada 11:362-403.

Maciolek, J.A., and P.R. Needham. 1952. Ecological effects of winter conditions on trout and trout foods in Convict creek, California, 1951. Transactions of the American Fisheries Society 81:202-217.

Marchetti, M.P., and P.B. Moyle. 2000. Spatial and temporal ecology of native and introduced fish larvae in lower Putah Creek, California. Environmental Biology of Fishes 58:75-87.

Moore, K.M.S., and S.V. Gregory. 1988. Summer habitat utilization and ecology of cutthroat trout fry (*Salmo clarki*) in Cascade Mountain streams. Canadian Journal of Fisheries and Aquatic Sciences 45:1921-1930.

Moyle, P.B. 2002. Inland Fishes of California, 2nd edition. University of California Press, Berkeley, California. 502p.

Murchie, K.J., and K.E. Smokorowski. 2004. Relative activity of brook trout and walleyes in response to flow in a regulated river. North American Journal of Fisheries Management 24:1050-1057.

Muth, R.T., and J.C. Schmulbach. 1984. Downstream transport of fish larvae in a shallow prairie river. Transactions of the American Fisheries Society 113:224-230.

Nuhfer, A.J., and G.R. Alexander. 1992. Hooking mortality of trophy-sized wild brook trout caught on artificial lures. North American Journal of Fisheries Management 12:634-644.

Olson, F.W. 1986. Downramping regime for power operation to minimize stranding of salmonid fry in the Sultan River: Henry M. Jackson hydroelectric project, FERC No. 2157. Unpublished MS. CH2M Hill, Seattle, Washington. 46+p.

Olson, F.W., and R.G. Metzgar. 1987. Downramping to minimize stranding of salmonid fry. Pages 691-701 *in* B.W. Clowes, editor. Waterpower '87, Proceedings of the International Conference on Hydropower. American Society of Civil Engineers, New York.

Olson, F.W. 1990. Downramping regime for power operation to minimize stranding of salmonid fry in the Sultan River. Report prepared by CH2M Hill for the Public Utility District No. 1 of Snohomish County. Everett, WA. 48p + appendices.

Ottaway, E.M., and A. Clarke. 1981. A preliminary investigation into the vulnerability of young trout (*Salmo trutta* L.) and Atlantic salmon (*S. salar* L.) to downstream displacement by high water velocities. Journal of Fish Biology 19:135-145.

Ottaway, E.M., and D.R. Forrest. 1983. The influence of water velocity on the downstream movements of alevins and fry of brown trout, *Salmo trutta* L. Journal of Fish Biology 23:221-227.

Pacific Gas and Electric Company. 2002. Rock Creek-Cresta Hydro Electric Project FERC 1962 Recreation and Pulse Flow Biological Evaluation Study Plan. Final study plan dated 7 March 2002 from Technical and Ecological Services Division, San Ramon, CA.

PacifiCorp. 2004. Application for Relicense, Klamath Hydroelectric Project, FERC No. 2082.

Pearsons, T.N., H.W. Li, and G.A. Lamberti. 1992. Influence of habitat complexity on resistance to flooding and resilience of stream fish populations. Transactions of the American Fisheries Society 121:427-436.

Salamunovich, T. 2004a. Rock Creek-Cresta (FERC No. 1962) Recreation and pulse flow biological evaluation: stranding and displacement studies, year 1 – 2002. October 5, 2004 final report prepared by Thomas R. Payne & Associates for Technical and Ecological Services, Pacific Gas and Electric Company, San Ramon, CA.

Salamunovich, T. 2004b. Rock Creek-Cresta (FERC No. 1962) Recreation and pulse flow biological evaluation: stranding and displacement studies, year 2 – 2003. December 2004 final report prepared by Thomas R. Payne & Associates for Technical and Ecological Services, Pacific Gas and Electric Company, San Ramon, CA.

Saltveit, S.J., J.H. Halleraker, J.V. Arnekleiv, and A. Harby. 2001. Field experiments on stranding in juvenile Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) during rapid flow decreases caused by hydropeaking. Regulated Rivers: Research and Management 17:609-622.

Seegrist, D.W., and R. Gard. 1972. Effects of floods on trout in Sagehen Creek, California. Transactions of the American Fisheries Society 101:478-482.

Shirvell, C.S. 1994. Effect of changes in streamflow on microhabitat use and movements of sympatric juvenile coho salmon (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) in a natural stream. Canadian Journal of Fisheries and Aquatic Sciences 51:1644-1652.

Smith, P.P., and J.B. Atkinson. 1999. Flood and debris-flow effects on Virginia brook trout populations. Proceedings of the Annual Conference of Southeastern Association of Fish and wildlife Agencies 53:91-99.

Snyder, D.E. 1990. Fish larvae – ecologically distinct organisms. Pages 20-23 *in* M.B. Bain, editor. Ecology and assessment of warmwater streams: workshop synopsis. United states Fish and wildlife Service, Biological Report 90(5). 44p.

Stober, Q.J., S.C. Crumley, D.E. Fast, E.S. Killebrew, R.M. Woodin, G. Engman, and G. Tutmark. 1981. The effects of hydroelectric discharge fluctuation on salmon and steelhead in the Skagit River, Washington. Final Report for City of Seattle Department of Lighting. University of Washington, Fisheries Research Institute Report FRI-UW-8218. Seattle Washington. 302p.

Swanson, F.J., S.L. Johnson, S.V. Gregory, and S.A. Acker. 1998. Flood disturbance in a forested mountain landscape. BioScience 48:681-689.

Taylor, M.J., and K.R. White. 1992. A meta-analysis of hooking mortality of nonanadromous trout. North American Journal of Fisheries Management 12:760-767.

Travnichek, V.H., and M.J. Maceina. 1994. Comparison of flow regulation effects on fish assemblages in shallow and deep water habitats in the Tallapoosa River, Alabama. Journal of Freshwater Ecology 9:207-216.

Woodin, R.M. 1984. Evaluation of salmon fry stranding induced by fluctuating hydroelectric discharge in the Skagit River, 1980-1983. Washington Department of Fisheries, Technical Report No. 83. 38p.

Appendix A

Example of displacement survey data sheet

Thomas R. Payne & Associates Displacement Survey Form

Site:_____ Reach: Cresta/Rock Creek Date: _____ / _____ / _____

Est. Q: _____ Air Temp:_____ @ _____ H2O Temp:_____ @ _____ Photo: _____

% Cloudcvr:_____ % Shade:_____ Visibility:_____ _____

North Bank (NB): Length:_____ Search Width:_____ Divers: _____

South Bank (SB): Length:_____ Search Width:_____ _____

Side channel: (NB/SB): Length:_____ Width:_____ Gage Ht: _____

Survey Event: Pre-Recreation Flow / Post-Recreation Flow ***(circle one)***

Keep main banks and and any side channel effort and counts separate

Bank (denote NB/SB)								
Channel (denote main or side)								
Replicate (denote 1 or 2)								
Diver (initials)								
Dive Start Time								
Dive End Time								
Rainbow trout (0 - 4 inch)								
(4-8 inch)								
(8 - 14 inch)								
(>14 inch)								
Nongame post-larvae (<1 inch)								
Pikeminnow/Hardhead (0 - 4 inch)								
(4-8 inch)								
(8 - 14 inch)								
(>14 inch)								
Pikeminnow (0 - 4 inch)								
(4-8 inch)								
(8 - 14 inch)								
(>14 inch)								
Hardhead (0 - 4 inch)								
(4-8 inch)								
(8 - 14 inch)								
(>14 inch)								
Sucker (0 - 4 inch)								
(4-8 inch)								
(8 - 14 inch)								
(>14 inch)								
Smallmouth bass (0 - 4 inch)								
(4-8 inch)								
(8 - 14 inch)								
(>14 inch)								
Other (0 - 4 inch)								
(specify) (4-8 inch)								
(8 - 14 inch)								
(>14 inch)								
Crayfish Tally								

Appendix B

Example of stranding survey data sheets

Thomas R. Payne & Associates Stranding Survey Form

Physical Site Data Sheet

Site:____ Reach Length (ft):___________ Date:____________________ Peak Flow Level (cfs):___________

Surveyors:____

XSEC ID#	Distance from reach top	water edge marker distance ***(measure from previous marker)*** (in inches or tenths of feet) ***(circle one)***										
		1600	**1700**	**1800**	**1900**	**2000**	**2100**		**0700**			
T1	**0**	0										
T2		0										
T3		0										
T4		0										
T5		0										
T6		0										
T7		0										
T8		0										
T9		0										
T10		0										
T11		0										
T12		0										
T13		0										
T14		0										
T15		0										
T16		0										
T17		0										
T18		0										
T19		0										
T20		0										
T21		0										
T22		0										
T23		0										
T24		0										
T25		0										

Site Photograph log: (take photos of stranding bar site from top down; middle up; middle down; bottom up at 1) start of down-ramping and 2) at base flow following down-ramping)

Time:_______ Photo #:_______ Location:_______ View:_______ Time:_______ Photo #:_______ Location:_______ View:_______
Time:_______ Photo #:_______ Location:_______ View:_______ Time:_______ Photo #:_______ Location:_______ View:_______
Time:_______ Photo #:_______ Location:_______ View:_______ Time:_______ Photo #:_______ Location:_______ View:_______
Time:_______ Photo #:_______ Location:_______ View:_______ Time:_______ Photo #:_______ Location:_______ View:_______
Time:_______ Photo #:_______ Location:_______ View:_______ Time:_______ Photo #:_______ Location:_______ View:_______
Time:_______ Photo #:_______ Location:_______ View:_______ Time:_______ Photo #:_______ Location:_______ View:_______

Thomas R. Payne & Associates Stranding Survey Survey Form

Visual assessment for stranded fish, amphibian tadpoles, benthic macroinvertebrates (BMI)

Site:________________________________ Reach: Cresta/Rock Creek Date:________________________ Page: 2 of _________

Surveyors:____

***Be sure to:** 1) include an accurate tally & total of rocks turned over for each survey interval; 2) collect examples of all unidentifiable stranded organisms in alcohol jars (especially small BMI/nonpositive fish id's); 3) record gage height at beginning of each survey interval; 4) clearly indicate (with empty row/drawn line) between the end of one survey and start of next; 5) keep data clearly legible and separate for each hourly survey - use additional data sheets if necessary*

Survey Interval	Exposure Interval	Gage Height	Start Time	End Time	Organism/ Species	Size (mm)	Number	Under Rock? Y/N	Notes	Turned Rock Tally	Total Rocks per interval

Appendix C

Detailed hourly flow charts for monthly survey periods

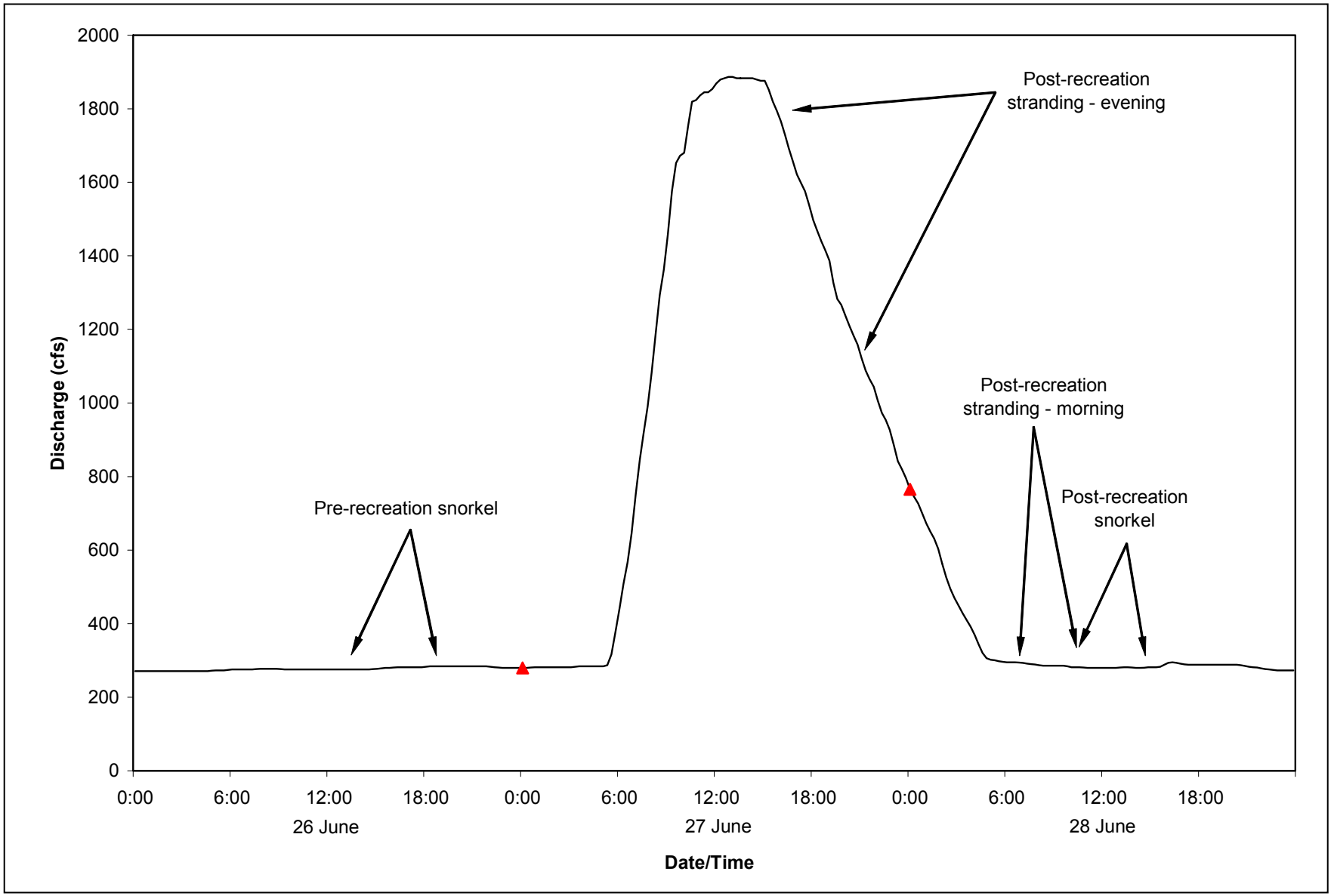

Figure C-1. Hydrograph during the June 2004 stranding and displacement surveys in the Rock Creek Reach of the North Fork Feather River. Data from stream gage NF-57 located 0.6 miles below Rock Creek Dam. Triangles denote midnight (0:00 hour).

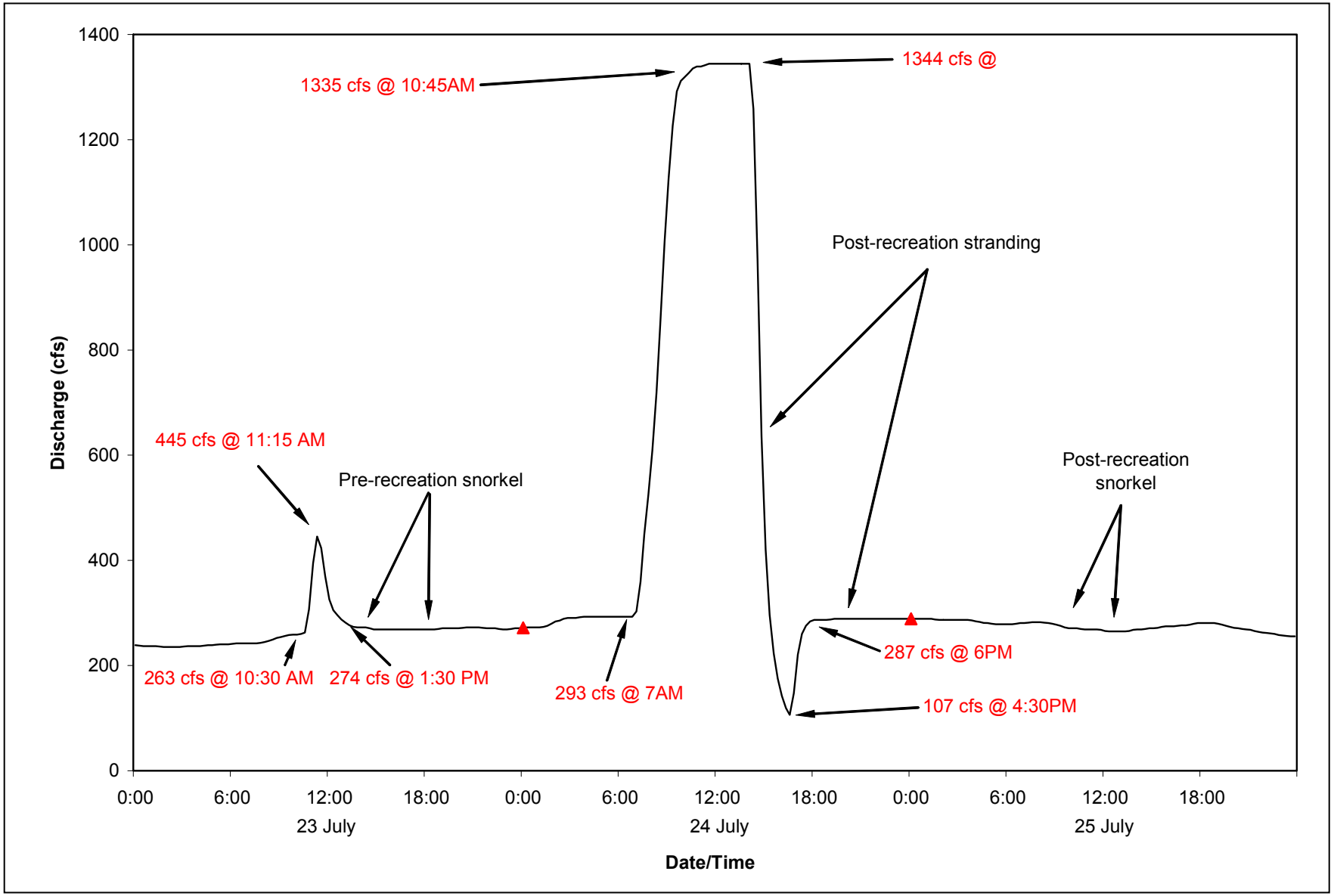

Figure C-2. Hydrograph during the July 2004 stranding and displacement surveys in the Cresta Reach of the North Fork Feather River. Data from stream gage NF-56 located at Arch Rock. Triangles denote midnight (0:00 hour).

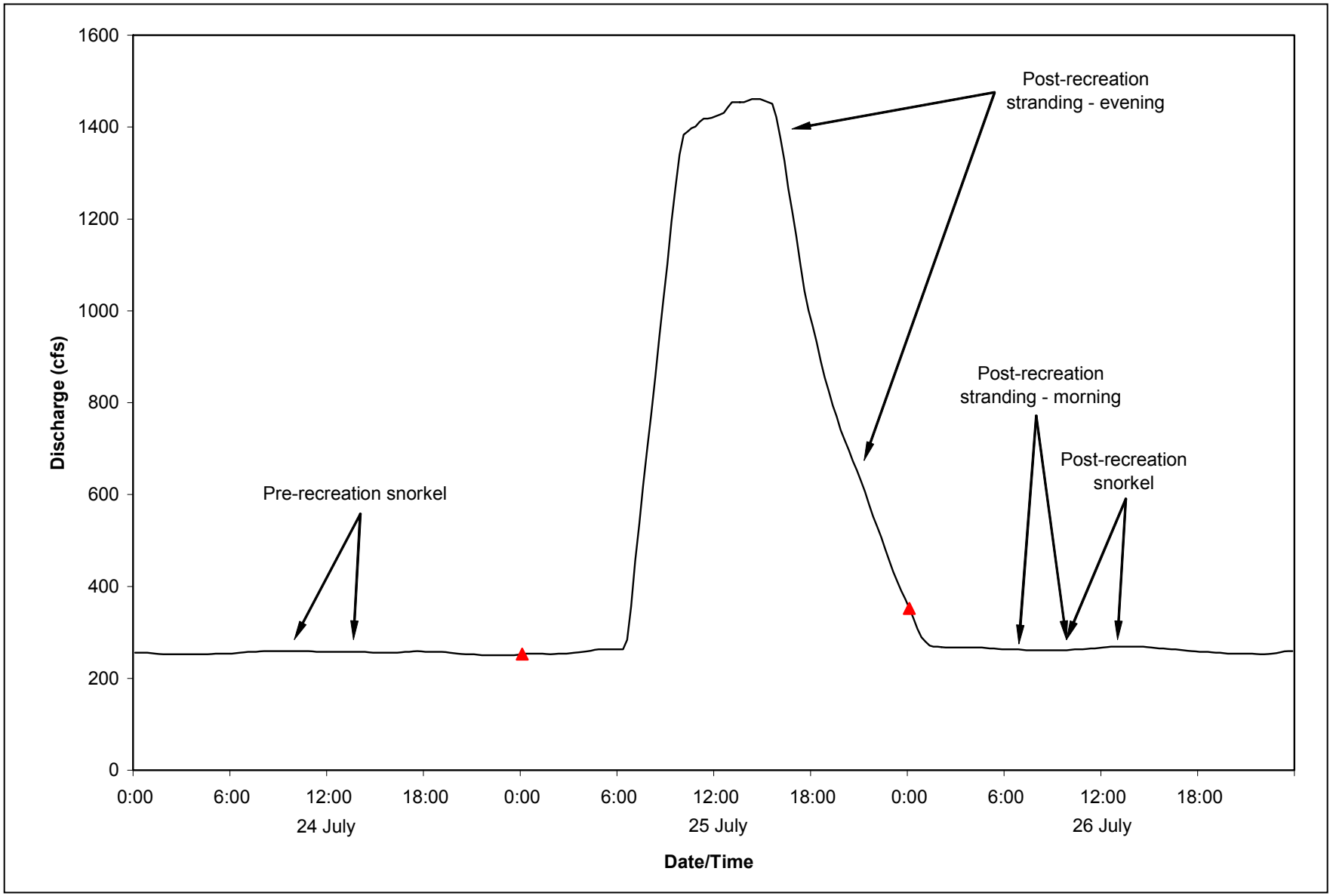

Figure C-3. Hydrograph during the July 2004 stranding and displacement surveys in the Rock Creek Reach of the North Fork Feather River. Data from stream gage NF-57 located 0.6 miles below Rock Creek Dam. Triangles denote midnight (0:00 hour).

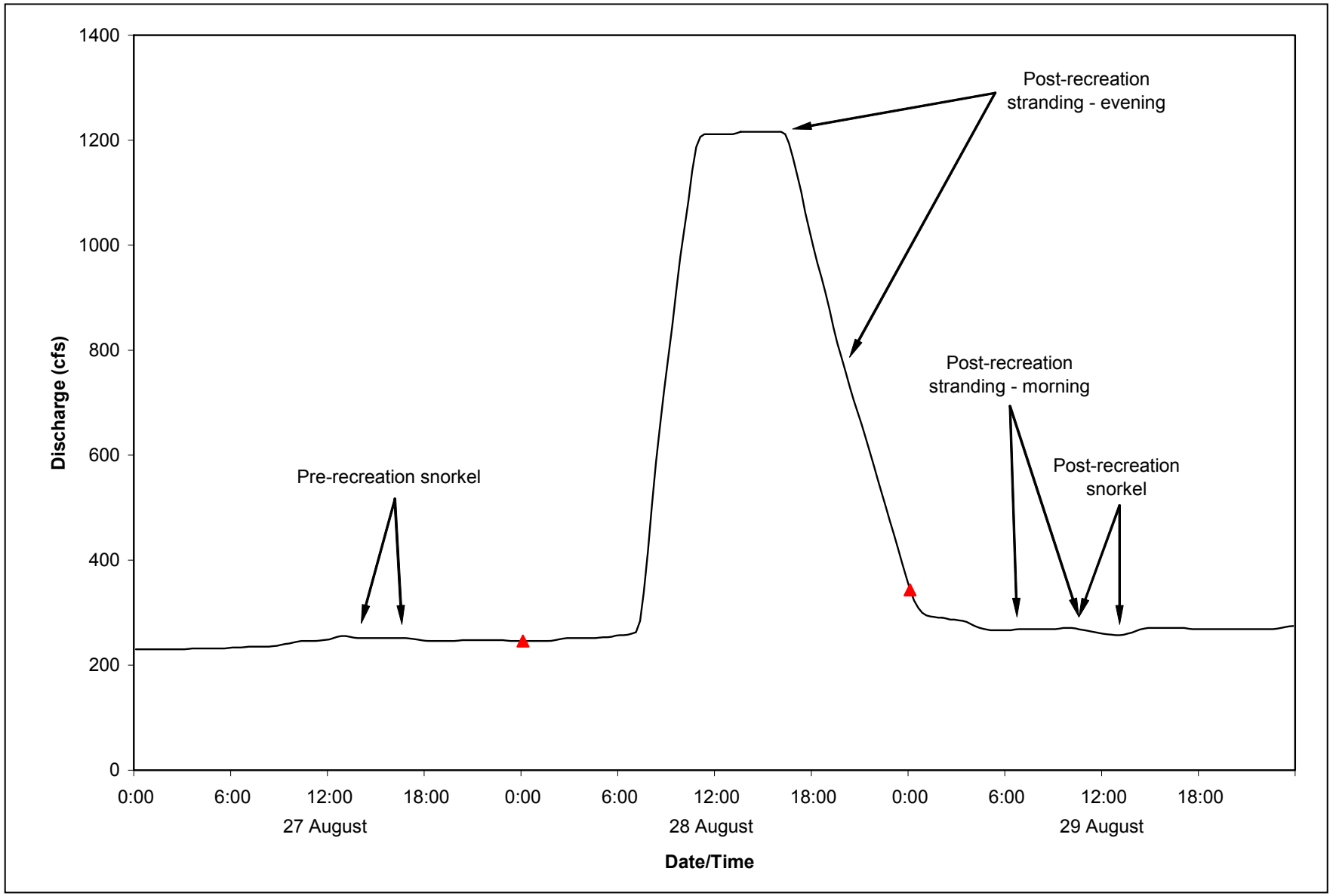

Figure C-4. Hydrograph during the August 2004 stranding and displacement surveys in the Cresta Reach of the North Fork Feather River. Data from stream gage NF-56 located at Arch Rock. Triangles denote midnight (0:00 hour).

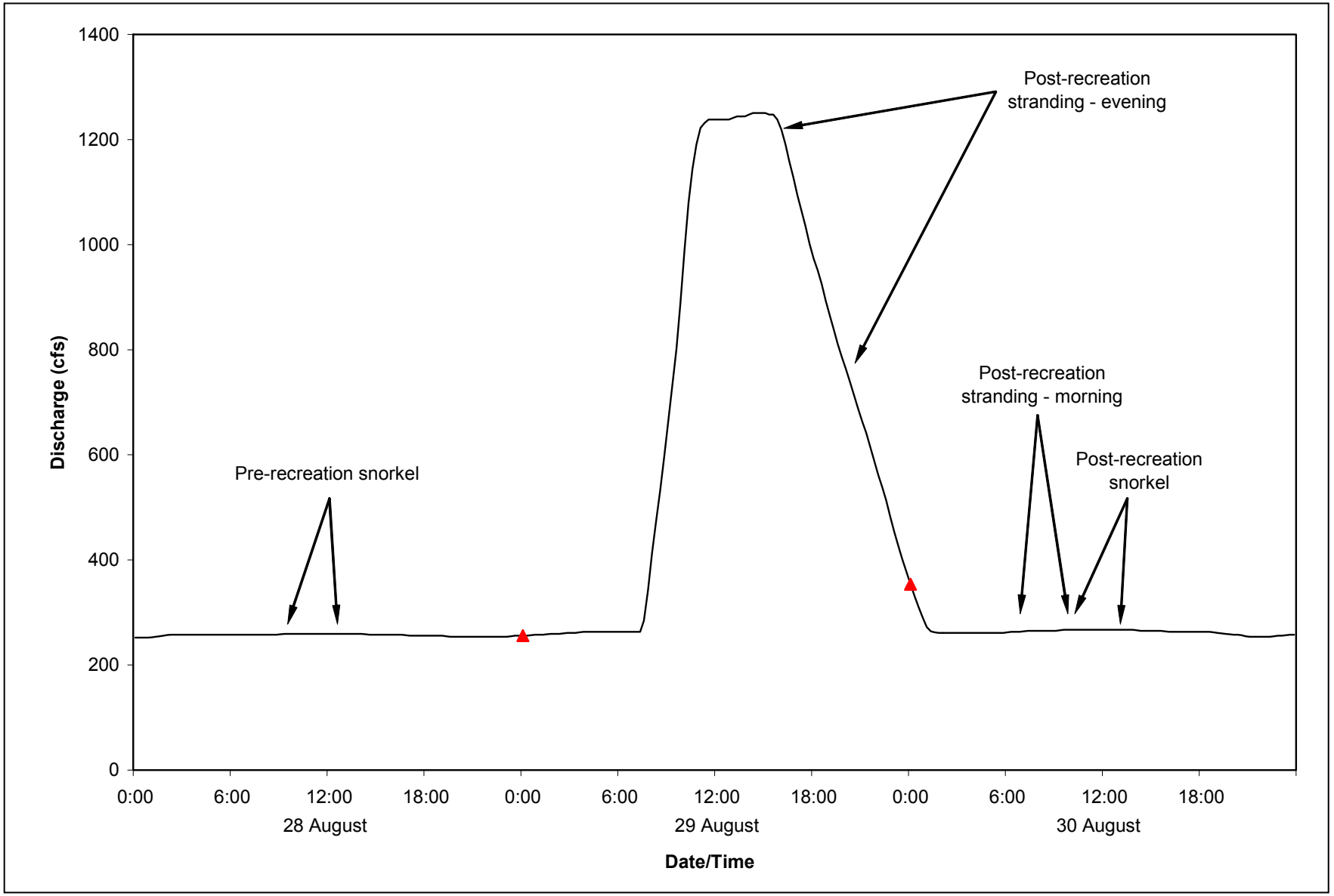

Figure C-5. Hydrograph during the August 2004 stranding and displacement surveys in the Rock Creek Reach of the North Fork Feather River. Data from stream gage NF-57 located 0.6 miles below Rock Creek Dam. Triangles denote midnight (0:00 hour).

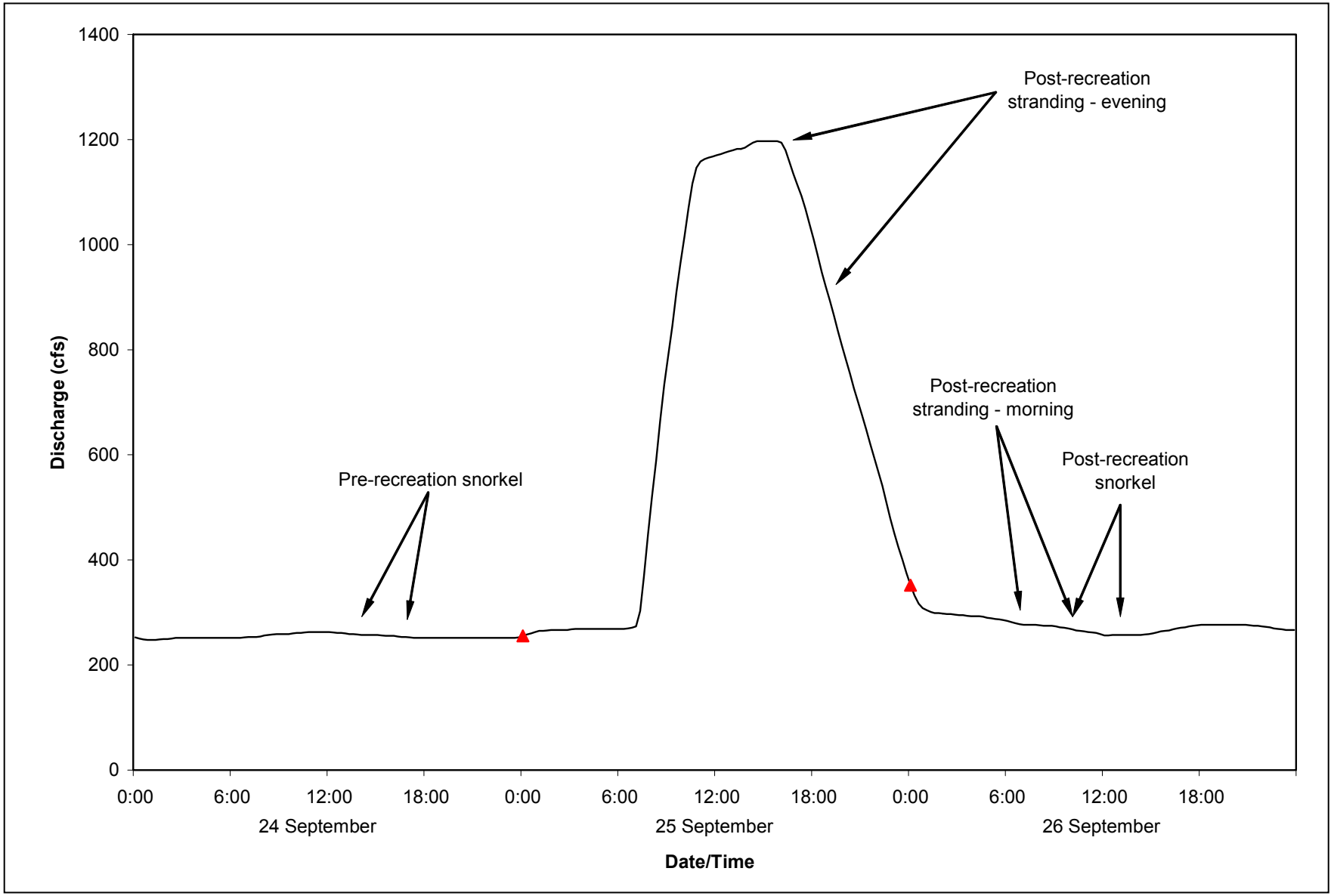

Figure C-6. Hydrograph during the September 2004 stranding and displacement surveys in the Cresta Reach of the North Fork Feather River. Data from stream gage NF-56 located at Arch Rock. Triangles denote midnight (0:00 hour).

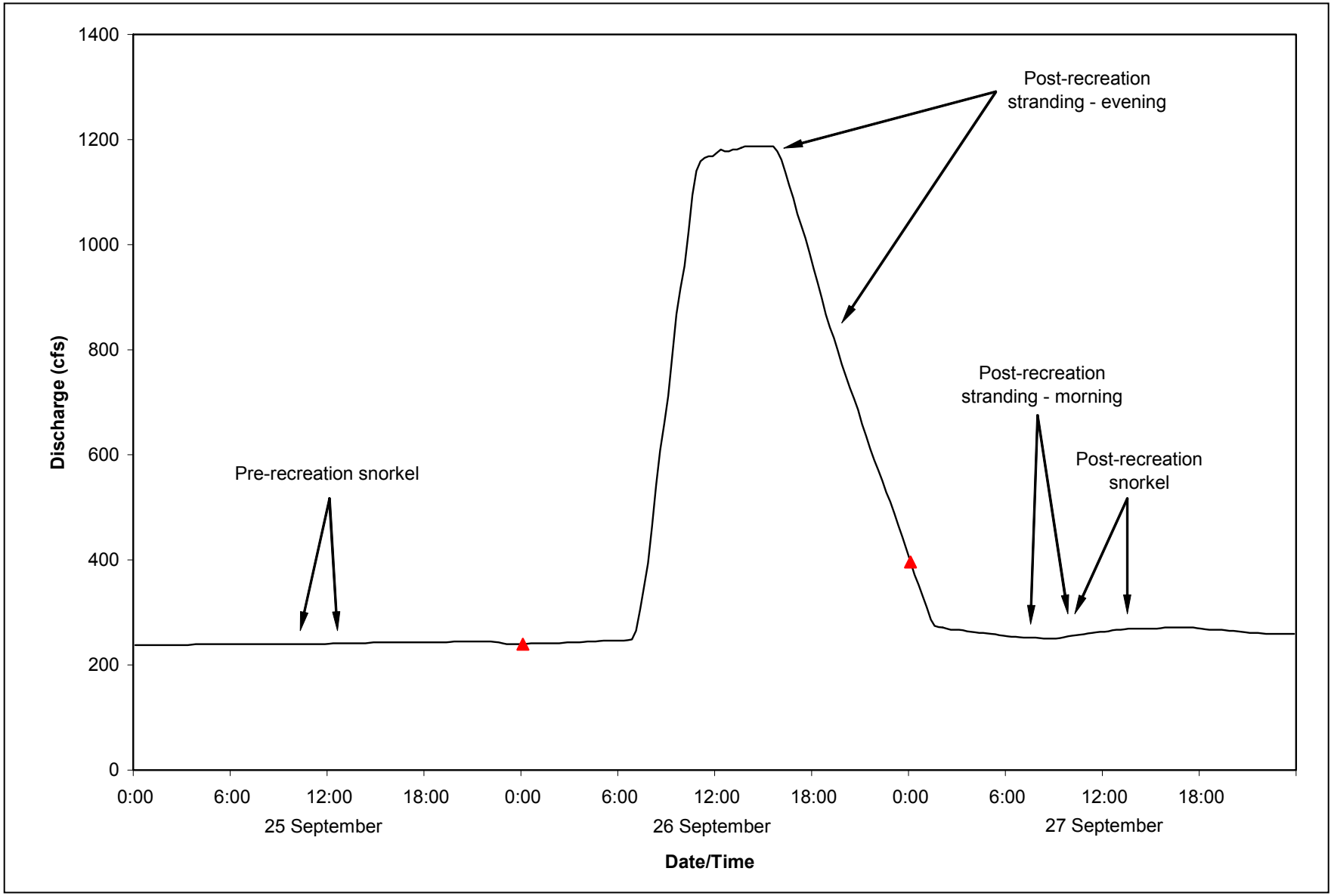

Figure C-7. Hydrograph during the September 2004 stranding and displacement surveys in the Rock Creek Reach of the North Fork Feather River. Data from stream gage NF-57 located 0.6 miles below Rock Creek Dam. Triangles denote midnight (0:00 hour).

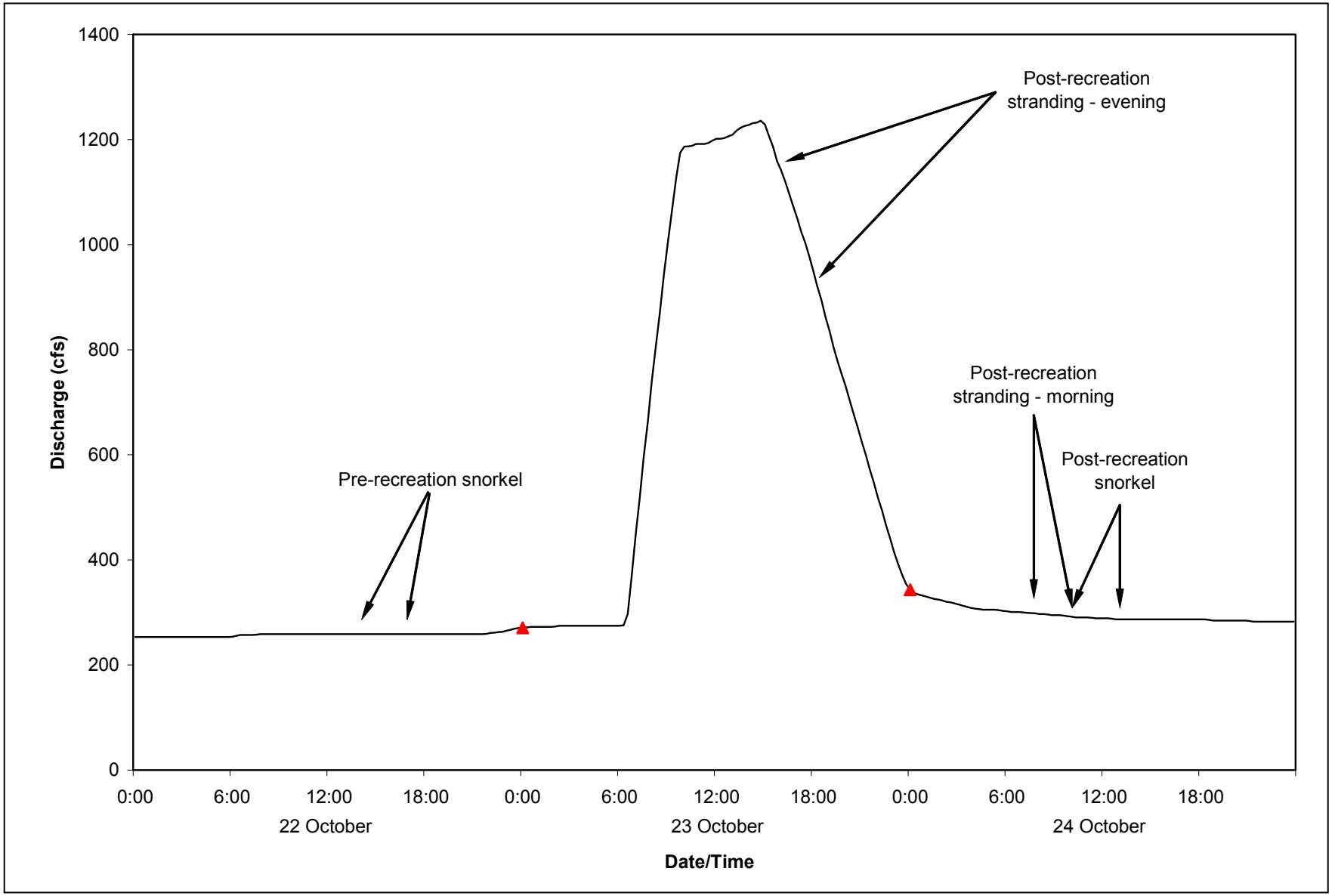

Figure C-8. Hydrograph during the October 2004 stranding and displacement surveys in the Cresta Reach of the North Fork Feather River. Data from stream gage NF-56 located at Arch Rock. Triangles denote midnight (0:00 hour).

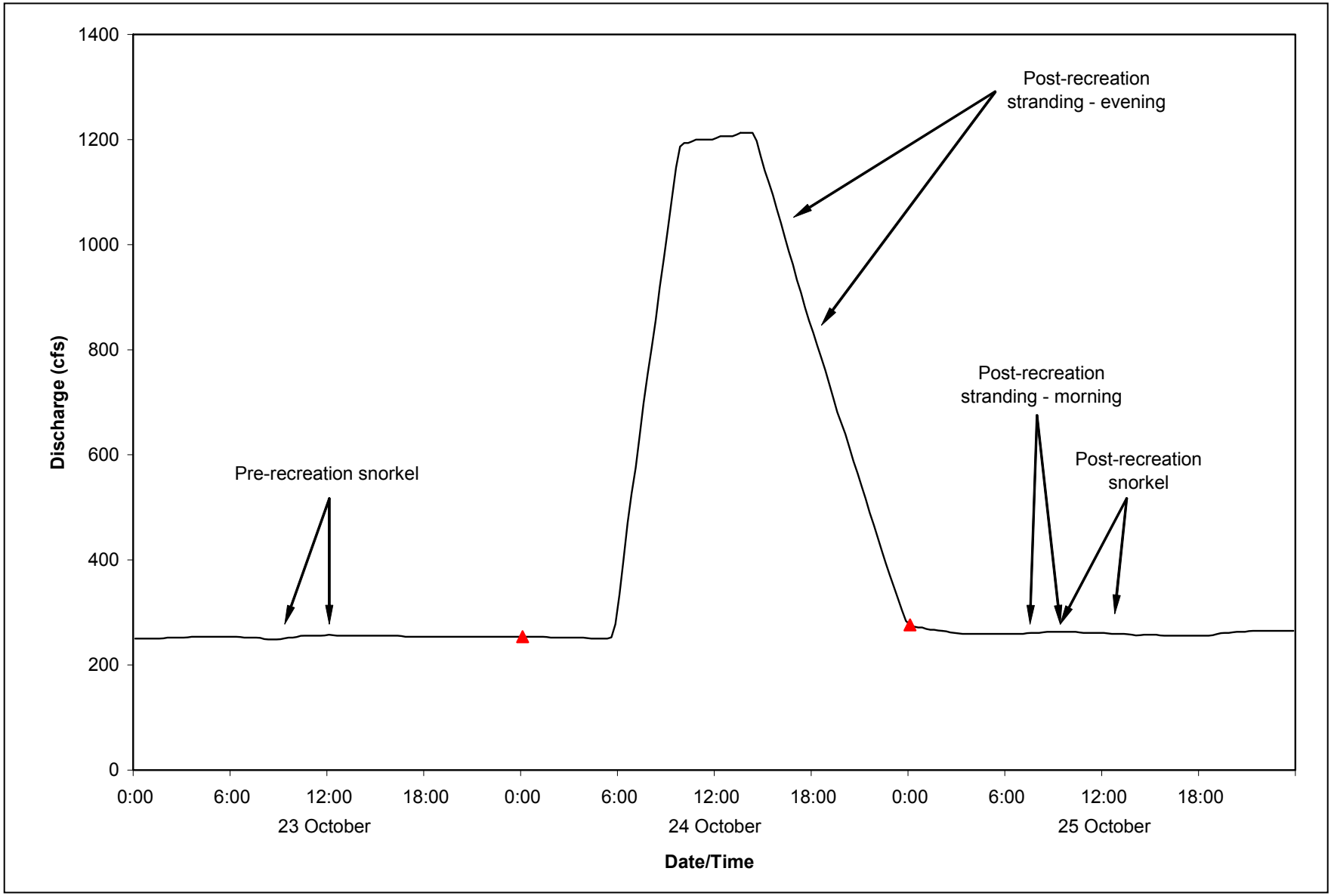

Figure C-9. Hydrograph during the October 2004 stranding and displacement surveys in the Rock Creek Reach of the North Fork Feather River. Data from stream gage NF-57 located 0.6 miles below Rock Creek Dam. Triangles denote midnight (0:00 hour).

Appendix D

Displacement survey data

Table D-1. Comparison of the June 2004 displacement snorkel surveys counts before and after a six-hour long 1600 cfs recreation flow at each of the study sites located in the Rock Creek Reach of the NFFR. There was no recreation flow for the Cresta Reach during June 2004. Numbers recorded are means of two replicate counts.

	Rock Creek Reach							
Site	Abandoned CG [2/]		Indian Jim School		Chambers Creek		Milk Ranch Creek [2/]	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	280	280	280	280	280	280	280	280
Date	26-Jun-04	28-Jun-04	26-Jun-04	28-Jun-04	26-Jun-04	28-Jun-04	26-Jun-04	28-Jun-04
Time	15:46	11:47	17:35	13:45	15:02	14:20	17:00	13:15
Air Temp (*C)	27.5	32	29	32	30	26	26.2	24
Water Temp (*C)	20.5	20	21	20.5	20.5	21	19	20
% Cloudcover	0	80	0	80	0	50	0	15
% Shade	30	75	50	15	5	95	0	5
Visibility (ft)	7.0	7.0	7.0	6.5	4.5	8.0	5.5	5.0
Survey Area (ft^2)	6,258	6,258	5,460	5,460	3,996	3,996	5,868	5,868
RBT 0-4"	64.5	101.5	2.5	3	21.5	19	18	37
RBT 4-8"	2	0.5	0	0	1.5	1	1	0
RBT 8-14"	0.5	0.5	0	0	0.5	0	0	0
RBT >14"	0	0.5	0	0	0	0	0	0
Nongame fry	3,800	3,029.5	3,308	5,793.5	1,729.0	3,544.5	1,010	1,357.0
PKM/HH 0-4"	0	0	0	0	0	0	0	0
PKM/HH 4-8"	23	39.5	9.5	16	0	0	2.5	9
PKM/HH 8-14"	0	0	0	0	0	1	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	12.5	0	0	0	0	0
PKM 8-14"	1.5	0	0	0.5	0	0	3	0
PKM > 14"	0	0.5	0	1.5	0.5	0	0	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	1	0	0	0	0	0
HH 8-14"	2	3.5	1.5	0	0	0	0	0
HH > 14"	1.5	1	0	0	0	0	0	0
	23	39.5	23	16	0	0	2.5	9
SKR 0-4"	0	0	0	0	0	0	0	0
SKR 4-8"	3.5	1.5	2	0.5	0	0	0	0
SKR 8-14"	0	0	0	0	0.5	0	0	0.5
SKR > 14"	2	1.5	0.5	2	0	0	4.5	2.5
SMB 0-4"	0	0.5	0.5	0	0	1	1	1.5
SMB 4-8"	0	0	0	0	0	0	0.5	1
SMB 8-14"	0	0	0	0	0	0	0	0
SMB > 14"	0	0	0	0	0	0	0	0
	0	0.5	0.5	0	0	1	1.5	2.5
SCLPN 0-4"	0.5	0.5	0.5	0	0	0	0	0
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0.5	0	0	0	0	0
Crayfish tally	8	7.5	4	1.5	2	4	4.5	2

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-1. Comparison of the June 2004 displacement snorkel surveys counts before and after a six-hour long 1600 cfs recreation flow at each of the study sites located in the Rock Creek Reach of the NFFR. There was no recreation flow for the Cresta Reach during June 2004. Numbers recorded are means of two replicate counts. (continued)

	Rock Creek Reach			
Site	Telephone/Cable Box		Gage	
Event	Pre	Post	Pre	Post
Discharge (cfs)[1/]	280	280	280	280
Date	26-Jun-04	28-Jun-04	26-Jun-04	28-Jun-04
Time	16:57	10:30	14:11	10:57
Air Temp (*C)	30.5	25.5	31	24
Water Temp (*C)	22	19	21	20.5
% Cloudcover	0	5	0	80
% Shade	60	10	0	10
Visibility (ft)	6.0	5.0	6.2	6.0
Survey Area (ft^2)	7,968	7,896	5,208	5,208
RBT 0-4"	12	15.5	105.5	150
RBT 4-8"	0	0	0	0
RBT 8-14"	0	0	0	0
RBT >14"	0	0	0	0
Nongame fry	3,564	1,983	4,585	2,670
PKM/HH 0-4"	0	0	0	0
PKM/HH 4-8"	0.5	0	11	15.5
PKM/HH 8-14"	0	0	0	0
PKM/HH > 14"	0	0	0	0
PKM 0-4"	0	0	0	0
PKM 4-8"	0	0	0	0
PKM 8-14"	0	5	0.5	4
PKM > 14"	0	0.5	0	0
HH 0-4"	0	0	0	0
HH 4-8"	0	0	0	0
HH 8-14"	0	2.5	2	1
HH > 14"	0.5	0	0	0
	0.5	0	11	15.5
SKR 0-4"	0	0	0	0
SKR 4-8"	0	0	0	0
SKR 8-14"	0	0	0.5	0.5
SKR > 14"	0.5	0	0.5	0.5
SMB 0-4"	1	7	0	0
SMB 4-8"	5	14.5	0	0
SMB 8-14"	1	2	0	0
SMB > 14"	0	0	0	0
	7	23.5	0	0
SCLPN 0-4"	0	0	0	0.5
BRN 0-4"	0	0	0	0
snake	0	0	0	0
Crayfish tally	5	4.5	5.5	3.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-2. Comparison of the July 2004 displacement snorkel surveys counts before and after a six-hour long 1200 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts.

	Cresta Reach							
Site	Poison Oak [2/]		Flagged Fir		Bear Creek		Shady Rest	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	269	268	269	268	269	268	269	268
Date	23-Jul-04	25-Jul-04	23-Jul-04	25-Jul-04	23-Jul-04	25-Jul-04	23-Jul-04	25-Jul-04
Time	14:15	12:17	15:05	10:10	17:47	12:18	14:35	9:38
Air Temp (*C)	29	32.5	35.5	22	32.5	26.5	37	25.5
Water Temp (*C)	25	22	22	20.5	23.5	21	24	22
% Cloudcover	0	0	0	0	0	0	0	0
% Shade	0	0	10	40	0	10	5	5
Visibility (ft)	8.0	7.5	7.0	7.2	8.0	6.5	6.3	11.0
Survey Area (ft^2)	7,080	7,080	4,080	4,080	4,224	4,224	5,616	5,616
RBT 0-4"	25	23.5	3.5	1.5	40	43.5	51.5	46
RBT 4-8"	0	0	0	0	0.5	0	0.5	1.5
RBT 8-14"	0	0	0	0	0	0	1	0.5
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	0.0	0.0	4,610	4,168	0	0	0	0
PKM/HH 0-4"	266.5	79.5	0	19	456.5	512	4202.5	4690
PKM/HH 4-8"	1	3	0	0	0	0	0	0
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	12.5	0	0	0	0	0
PKM 4-8"	0	0	0	0	0	0	0	0
PKM 8-14"	0.5	5	0	0	0	0	0	0
PKM > 14"	0	0	0	0	0	0.5	0	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	0	0
HH 8-14"	0	0	0	0	0	0	0.5	0
HH > 14"	0	0	1	1	0	0	0	0
SKR 0-4"	28	22	28	18.5	119.5	84	206	105
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0.5	0	0	0.5	0	0	0.5
SKR > 14"	0	0	1	0	0	1	2	3
SMB 0-4"	12	16.5	47.5	50	15	11.5	82.5	31
SMB 4-8"	1	1	2.5	3	0	0	0	0
SMB 8-14"	0.5	0.5	2.5	2	0	0	2	2
SMB > 14"	0	0	1	0	0	0	0	0
SCLPN 0-4"	0	0	0	0	0	0	0	0
BRN 0-4"	0	0	0	0	0	0	0	0.5
snake	0	0	0	0	0	0	0	0
Crayfish tally	35	17	5	1.5	5	1.5	17.5	2

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-2. Comparison of the July 2004 displacement snorkel surveys counts before and after a six-hour long 1200 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Cresta Reach				Rock Creek Reach			
Site	Arch Rock		Grizzly Creek		Abandoned CG [2/]		Indian Jim School	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	269	268	269	268	258	267	258	267
Date	23-Jul-04	25-Jul-04	23-Jul-04	25-Jul-04	24-Jul-04	26-Jul-04	24-Jul-04	26-Jul-04
Time	14:15	9:30	17:30	11:40	9:26	11:55	9:30	10:55
Air Temp (*C)	28	27	34	31	26	26	26	32
Water Temp (*C)	23	20	21.5	21	22	22	20.5	21
% Cloudcover	0	0	0	0	50	0	40	0
% Shade	0	10	0	0	10	25	20	10
Visibility (ft)	7.0	8.0	6.5	7.5	6.5	10.0	7.0	8.5
Survey Area (ft^2)	5,532	5,532	4,032	4,032	6,120	6,120	5,508	5,508
RBT 0-4"	2.5	2	1	0	13	14	0	0
RBT 4-8"	0	0	0	0	0	0.5	0	0
RBT 8-14"	1	0	0	0	0	0.5	0	0
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	525	600	50	1,038	1,241	1,326	1,990.5	2,565.0
PKM/HH 0-4"	3700	3890	1707.5	619	59	13.5	26.5	35.5
PKM/HH 4-8"	0	0	0	0	0.5	12	13.5	0
PKM/HH 8-14"	0.5	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0.5	0	1	0	0	0	0	0
PKM 8-14"	0	0.5	0	0	0	10	0	1.5
PKM > 14"	0.5	0	0	0	0	0	1.5	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	0	0
HH 8-14"	0	0	0	0	2	0	0	0
HH > 14"	0	0.5	0	0	0	0.5	4.5	3.5
SKR 0-4"	665	359	125.5	145	14	34	54	92.5
SKR 4-8"	0	0	0	0	0	0	0.5	0
SKR 8-14"	0	0	0	0	1.5	1.5	0	0
SKR > 14"	2.5	1.5	0	0	0	0.5	1.5	2.5
SMB 0-4"	30.5	38	99.5	85	0	0	0	1
SMB 4-8"	4	4	0.5	2	0	0	2.5	0
SMB 8-14"	3.5	1	0	0.5	0	0	0	0
SMB > 14"	1	0	0	0	0	0	0	0
SCLPN 0-4"	0	0	0	0	0	1	0	0
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	4	3	0.5	0	15.5	6	7.5	5.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-2. Comparison of the July 2004 displacement snorkel surveys counts before and after a six-hour long 1200 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Rock Creek Reach							
Site	Chambers Creek		Milk Ranch Creek [2/]		Telephone/Cable Box		Gage	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	258	267	258	267	258	267	258	267
Date	24-Jul-04	26-Jul-04	24-Jul-04	26-Jul-04	24-Jul-04	26-Jul-04	24-Jul-04	26-Jul-04
Time	11:40	12:58	13:35	12:22	10:50	12:10	10:03	9:26
Air Temp (*C)	30.5	34	32	29.5	30	30.5	28	26
Water Temp (*C)	21.5	23	22	22	22	21.5	22	21
% Cloudcover	10	0	0	0	20	0	85	0
% Shade	5	0	0	5	10	20	5	10
Visibility (ft)	6.5	10.5	7.5	8.0	6.0	8.2	6.0	7.5
Survey Area (ft^2)	3,996	3,996	5,904	5,904	8,136	8,136	5,028	5,028
RBT 0-4"	4.5	7.5	7	8	0.5	2.5	11.5	17.5
RBT 4-8"	1.5	0	0	0.5	0.5	0	0	0
RBT 8-14"	1.5	0	0	1	0	0	0	0
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	3,356.5	2,208	490	442.5	2,354	2,648	0	0
PKM/HH 0-4"	162	70.5	1057	1013.5	0	0	259	273
PKM/HH 4-8"	1.5	30.5	3	8.5	2.5	5.5	22.5	1.5
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	6	0	1	0	0	0
PKM 8-14"	0	0	0	0	0.5	0	0	2.5
PKM > 14"	0	0	0	0	2	0.5	0.5	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	2	0	0	0	0	0
HH 8-14"	0	0	0	0.5	0.5	0	2	5.5
HH > 14"	0	0	0	0	1	1.5	0	0
SKR 0-4"	33	29	2	6.5	3.5	19.5	41	24
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0	0	0	0	0	0	1.5
SKR > 14"	0	0	1	0	0	0	0	0
SMB 0-4"	5.5	2	2	4	26	20	1	1.5
SMB 4-8"	0	0	0	0.5	10	13	0	1
SMB 8-14"	0	0	0	0	6	5.5	0	0
SMB > 14"	0	0	0	0	0.5	0	0	0
SCLPN 0-4"	0.5	0.5	0.5	0.5	0	0	0	0
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	5	2	5	3	10	4	11.5	4.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-3. Comparison of the August 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts.

	Cresta Reach							
Site	Poison Oak [2/]		Flagged Fir		Bear Creek		Shady Rest	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	251	262	251	262	251	262	251	262
Date	27-Aug-04	29-Aug-04	27-Aug-04	29-Aug-04	27-Aug-04	29-Aug-04	27-Aug-04	29-Aug-04
Time	17:00	10:30	15:03	11:42	16:23	13:00	15:00	11:15
Air Temp (*C)	30	24	30	27.5	31	29.5	33.5	28
Water Temp (*C)	21	19	20	20	21.5	20	21.5	19.5
% Cloudcover	0	0	0	0	0	0	0	0
% Shade	50	0	5	5	5	5	40	25
Visibility (ft)	7.0	9.0	8.5	7.7	10.5	9.0	10.7	8.5
Survey Area (ft^2)	7,092	7,092	4,044	4,044	4,068	4,068	5,724	5,724
RBT 0-4"	12	15.5	0.5	1	15	19	17.5	23
RBT 4-8"	0.5	0	0	0	0	0	1	0
RBT 8-14"	0.5	1	0	0	0	0	5	4
RBT >14"	0.5	2	0	0	0	0	1.5	0.5
Nongame fry	0.0	0.0	0	0	0	0	0	0
PKM/HH 0-4"	34.5	38.5	557	735.5	152.5	152.5	562.5	344.5
PKM/HH 4-8"	0	4.5	0	3	0	0	0	0
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	0	0	0	0	0	1
PKM 8-14"	0	0	0	0	0	0	7.5	0
PKM > 14"	0	0	0	0	0	0	0	0.5
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	0	0
HH 8-14"	0	0	0	0	0	0	3.5	1
HH > 14"	0	0	0	0	0	0	1	1
SKR 0-4"	1	1.5	2.5	1	27.5	49.5	0.5	0.5
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	1	0	0	0	0	0	1	1
SKR > 14"	0	1	0	0	0	0	4.5	4
SMB 0-4"	1	1	3	1.5	1	1	18	12
SMB 4-8"	1.5	0	1.5	1	0.5	0	6	2.5
SMB 8-14"	0	0	0	0.5	0	0	3	3.5
SMB > 14"	0	0	0	0.5	0	0	0.5	0.5
SCLPN 0-4"	0	0	0	0	0.5	0.5	0	0
BRN 0-4"	0	0	0	0	0	0	0	0.5
snake	1.5	0.5	0	0	0	0	0	0
Crayfish tally	14	6	1	1	1.5	2	11	1.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-3. Comparison of the August 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Cresta Reach				Rock Creek Reach			
Site	Arch Rock		Grizzly Creek		Abandoned CG [2/]		Indian Jim School	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	251	262	251	262	259	267	259	267
Date	27-Aug-04	29-Aug-04	27-Aug-04	29-Aug-04	28-Aug-04	30-Aug-04	28-Aug-04	30-Aug-04
Time	13:51	10:00	15:27	11:57	9:35	11:32	10:59	12:34
Air Temp (*C)	32	24	26	31	25.5	28	27	24.5
Water Temp (*C)	21	18	21	20.5	17.5	20.5	20	20.5
% Cloudcover	0	0	0	0	0	0	0	0
% Shade	10	15	0	0	75	40	20	35
Visibility (ft)	6.5	8.0	7.0	6.5	9.0	9.5	10.5	10.0
Survey Area (ft^2)	5,676	5,676	4,080	4,080	5,916	5,916	5,724	5,724
RBT 0-4"	0	0	0	0	5	4	0	0
RBT 4-8"	0	0	0	0	0	0.5	0	0
RBT 8-14"	0	0	0	0	0	0	0	0
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	0	0	0	0	0	0	0.0	0.0
PKM/HH 0-4"	696	626.5	0	0	913.5	753	939.5	1131
PKM/HH 4-8"	0	0	0	0	17	45.5	1.5	9.5
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	0	0	0	0	2	0
PKM 8-14"	0	0	1	0	0	0	0	0.5
PKM > 14"	0	0	0	1.5	0	0	0	0.5
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	5	0
HH 8-14"	0	1	0.5	0	0	0	2	3
HH > 14"	1	0	0	1.5	0.5	0	0	0
SKR 0-4"	14.5	1	0	0	0	2.5	1.5	7
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0.5	0	0	0	0	0	0
SKR > 14"	0	0.5	0.5	0	2.5	1	0	1
SMB 0-4"	3.5	2.5	19	15.5	0	0	0	0
SMB 4-8"	1	0	0.5	0.5	0	0	0	0
SMB 8-14"	0	0	0	1	0	0	0	0
SMB > 14"	0	0	0.5	0	0	0	0	0
SCLPN 0-4"	0	0	0	0	0	1	0	0
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	3	2	1	0.5	6.5	7.5	2	4.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-3. Comparison of the August 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Rock Creek Reach							
Site	Chambers Creek		Milk Ranch Creek [2/]		Telephone/Cable Box		Gage	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	259	267	259	267	259	267	259	267
Date	28-Aug-04	30-Aug-04	28-Aug-04	30-Aug-04	28-Aug-04	30-Aug-04	28-Aug-04	30-Aug-04
Time	11:25	12:47	12:55	13:12	10:44	11:40	10:45	10:29
Air Temp (*C)	27	32.5	30.5	29	20	23.5	24.5	22.5
Water Temp (*C)	20.5	21	21	21.5	19	20	20	20.5
% Cloudcover	0	0	0	0	0	0	0	0
% Shade	20	0	5	15	80	0	15	0
Visibility (ft)	9.0	10.5	8.0	7.0	7.3	7.3	6.5	9.0
Survey Area (ft^2)	4,140	4,140	6,264	6,264	7,992	7,992	5,268	5,268
RBT 0-4"	1	2.5	2	0.5	1.5	0.5	3	6
RBT 4-8"	0	0.5	0	0	0	0	0.5	2
RBT 8-14"	0	0.5	0	0	0	0	0	0.5
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	0.0	0	0	0.0	0	0	0	0
PKM/HH 0-4"	2072.5	1485	444.5	368	131	152	176	169.5
PKM/HH 4-8"	73	65.5	18	28	69.5	32.5	11.5	4
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	15	2.5	0	0	2.5	12
PKM 8-14"	0.5	0	4.5	3	12	4.5	3.5	5.5
PKM > 14"	1	0	0	0	0	1	0	2
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	6	2	0	0	1	6
HH 8-14"	0	1	2	1	4	4.5	5	4
HH > 14"	0	0	0	0	0.5	0.5	0	5
SKR 0-4"	2	3.5	0	0.5	0	0	4.5	4.5
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0	0	0.5	0	0	0.5	1
SKR > 14"	0	0	0	2	0	0	3.5	3.5
SMB 0-4"	0.5	0.5	2	2	16.5	25.5	0	0
SMB 4-8"	0	0	0	0	7.5	3	0	0
SMB 8-14"	0	0	0.5	0	6	4	0	0
SMB > 14"	0	0	0	0	0	0	0	0
SCLPN 0-4"	0	0.5	0.5	0	0	0	1.5	1
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	0.5	3	2.5	5	7	3.5	13	3

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-4. Comparison of the September 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts.

	Cresta Reach							
Site	Poison Oak [2/]		Flagged Fir		Bear Creek		Shady Rest	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	255	260	255	260	255	260	255	260
Date	24-Sep-04	26-Sep-04	24-Sep-04	26-Sep-04	24-Sep-04	26-Sep-04	24-Sep-04	26-Sep-04
Time	14:30	10:16	14:15	10:00	16:24	12:43	14:20	10:27
Air Temp (*C)	22	20.5	23.5	16.5	25.5	22.5	31	19
Water Temp (*C)	17.5	16	17	17	18	17	18	16
% Cloudcover	0	20	0	30	0	30	0	60
% Shade	30	5	0	80	10	30	10	0
Visibility (ft)	10.5	11.0	8.0	7.0	9.5	8.5	12.0	8.5
Survey Area (ft^2)	7,128	7,128	3,984	3,984	4,272	4,272	5,808	5,808
RBT 0-4"	3.5	3	1	0.5	8	6	7.5	6.5
RBT 4-8"	0	0	0	0	1	1.5	2.5	1.5
RBT 8-14"	1	0.5	0	0	1	1	2.5	3.5
RBT >14"	0	1	0	0	0	0	1	0.5
Nongame fry	0.0	0.0	0	0	0	0	0	0
PKM/HH 0-4"	0.5	1.5	224	85	53	9	107.5	76.5
PKM/HH 4-8"	0	0	2.5	0	0	0	0	0
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	0	0	0	0	0	0
PKM 8-14"	0.5	0	0.5	0	0	0	0.5	0
PKM > 14"	0	0	1	0	0	0	1	0.5
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	0	0
HH 8-14"	0	0	0	0.5	0	0	0	0.5
HH > 14"	0	0	1	0.5	0	0	0	0.5
SKR 0-4"	0	0	0	0	2	2.5	0	0
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0	0	0	0	0	0	1
SKR > 14"	0	0	0.5	0.5	0	0	0	0
SMB 0-4"	0	0.5	2	0	0	0	2.5	0
SMB 4-8"	0	0	2	1	0	0	2	1.5
SMB 8-14"	0	0	1	0.5	0	0	2.5	0.5
SMB > 14"	0	0	0	0	0	0	0.5	0
SCLPN 0-4"	0	0	0	0	0	0.5	0	0.5
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0.5	0	0	0	0.5	0	0	0
Crayfish tally	54	9	8.5	3	11	4.5	32	4

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-4. Comparison of the September 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Cresta Reach				Rock Creek Reach			
Site	Arch Rock		Grizzly Creek		Abandoned CG [2/]		Indian Jim School	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	255	260	255	260	240	264	240	264
Date	24-Sep-04	26-Sep-04	24-Sep-04	26-Sep-04	25-Sep-04	27-Sep-04	25-Sep-04	27-Sep-04
Time	14:45	11:30	15:47	11:50	12:40	11:28	10:17	10:00
Air Temp (*C)	27	21	32	22	25	20	20	18
Water Temp (*C)	18.5	16.5	17	16	17	16.5	16.5	16
% Cloudcover	0	40	0	70	0	0	0	0
% Shade	30	10	0	10	0	10	30	100
Visibility (ft)	11.5	8.0	11.5	8.5	12.0	13.2	10.0	11.0
Survey Area (ft^2)	5,736	5,736	4,200	4,200	6,516	6,516	5,616	5,616
RBT 0-4"	0	0	0	0	2.5	4.5	0	0
RBT 4-8"	0	0.5	0	0	2.5	0.5	0	0
RBT 8-14"	1	0	0	0	0	0	0	0
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	0	0	0	0	0	0	0.0	0.0
PKM/HH 0-4"	543.5	358	10.5	14.5	183.5	194.5	401	438.5
PKM/HH 4-8"	0	0	0	0	15	8	12	5
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	1	0	2.5	0	0	0
PKM 8-14"	0	0	1	1.5	0	0	0	0
PKM > 14"	0	0	0	0	0	0	0	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	2	0	0	0
HH 8-14"	0.5	0	1	2.5	0	0.5	0	1.5
HH > 14"	0	0	2.5	0.5	0	0	0.5	0
SKR 0-4"	5.5	1	0	0	1	0	0	0
SKR 4-8"	0	0	0	0	0	0.5	0	0
SKR 8-14"	0	0	0	0	2	0.5	0	0
SKR > 14"	0.5	5	1	1	4	4	0.5	1
SMB 0-4"	0.5	0	0.5	3	0	0	0	0
SMB 4-8"	0.5	1	0.5	0	0	0	0	0
SMB 8-14"	1	1	0.5	1	0	0	0	0
SMB > 14"	0.5	0	0	0	0	0	0	0
SCLPN 0-4"	0	0	1	0	1	0	0	0.5
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	9	4.5	6.5	2.5	19	19.5	6.5	8.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-4. Comparison of the September 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Rock Creek Reach							
Site	Chambers Creek		Milk Ranch Creek [2/]		Telephone/Cable Box		Gage	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	240	264	240	264	240	264	240	264
Date	25-Sep-04	27-Sep-04	25-Sep-04	27-Sep-04	25-Sep-04	27-Sep-04	25-Sep-04	27-Sep-04
Time	12:18	12:21	12:29	12:51	10:30	10:08	10:20	10:20
Air Temp (*C)	24	28	29	25	16	17	17.5	17
Water Temp (*C)	18.5	17	17	17	16.5	15	17	16
% Cloudcover	0	0	0	0	0	0	0	0
% Shade	30	5	5	20	75	40	10	10
Visibility (ft)	13.5	9.5	9.0	9.5	12.0	10.1	9.4	10.0
Survey Area (ft^2)	4,164	4,164	6,084	6,084	7,956	7,956	5,100	5,100
RBT 0-4"	2	2	0.5	0	1	1	6	4
RBT 4-8"	1.5	1	0	0	0	0	0	1
RBT 8-14"	0	0	0.5	0	0	0	0	0.5
RBT >14"	0	0	0	0	0.5	0.5	0	0.5
Nongame fry	0	0	0	0.0	0	0	0	0
PKM/HH 0-4"	1305.5	1143.5	243	155	18.5	28	86	61
PKM/HH 4-8"	7	9	30	21.5	21	23	15	10.5
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	0	0	0.5	0	0	0
PKM 8-14"	0	1	0	0.5	4	1.5	1	1
PKM > 14"	0	0.5	0.5	0	0.5	1	0	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	0	0
HH 8-14"	0	0	0	1	8.5	2.5	1.5	0.5
HH > 14"	0	0	0	0	2	1	0	0.5
SKR 0-4"	1.5	1.5	0	0	0	0	2.5	0.5
SKR 4-8"	0.5	0	0	0	0	0	0	0
SKR 8-14"	0	0	0	0	0	0	0	0
SKR > 14"	0	0	0	0	0.5	0	3	3.5
SMB 0-4"	0.5	1	1	1	8	8.5	0	0
SMB 4-8"	0	0	0	0	1.5	3	0	0
SMB 8-14"	0	0	0	0	5.5	1.5	0	0
SMB > 14"	0	0	0	0	0	0.5	0	0
SCLPN 0-4"	0	0	0	0	0	0.5	0	0
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	7	4.5	9	7	15	10	9.5	4.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-5. Comparison of the October 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts.

	Cresta Reach							
Site	Poison Oak [2/]		Flagged Fir		Bear Creek		Shady Rest	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	259	289	259	289	259	289	259	289
Date	22-Oct-04	24-Oct-04	22-Oct-04	24-Oct-04	22-Oct-04	24-Oct-04	22-Oct-04	24-Oct-04
Time	15:23	10:02	14:20	11:21	16:52	11:55	14:15	9:50
Air Temp (*C)	18	11	20	10	15.5	10.5	18	12
Water Temp (*C)	12.5	11	13	11.5	12.5	11.5	14	11
% Cloudcover	95	65	80	40	95	80	100	70
% Shade	40	35	0	20	0	85	70	50
Visibility (ft)	7.5	7.0	8.0	7.0	7.0	7.0	7.0	6.0
Survey Area (ft^2)	7,212	7,212	4,188	4,188	4,260	4,260	5,724	5,724
RBT 0-4"	4	9.5	0	0	1	0	1.5	1.5
RBT 4-8"	2.5	2	0	0	0	0	0	2
RBT 8-14"	0	0	0	0	0.5	0	0.5	2
RBT >14"	0	0	0	0	0	0	0.5	0.5
Nongame fry	0.0	0.0	0	0	0	0	0	0
PKM/HH 0-4"	2.5	0.5	10.5	42.5	0	10.5	0	0
PKM/HH 4-8"	0	0	1	0	0	0	0	0
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	6.5
PKM 4-8"	0	0	0	0	0	0	0	0
PKM 8-14"	0	0	0	0	0	0	0	0
PKM > 14"	0	0	0	0	0	0	0	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	0	0
HH 8-14"	0	0	0	0	0	0	0	0.5
HH > 14"	0	0	0	0	0	0	0	0
SKR 0-4"	0	0	0	0	0	0	0	0
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0	0	0	0	0	0	0
SKR > 14"	0	0	0	0	0	0	0.5	0
SMB 0-4"	0	0	0	0	0	0	1.5	1
SMB 4-8"	0	0	0	0	0	0	0	0
SMB 8-14"	0	0	0.5	0	0	0	0	0
SMB > 14"	0	0	0	0	0	0	0	0
SCLPN 0-4"	0	0.5	0	0	0	0	0	0
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	19	9	8.5	4.5	6	1.5	9.5	6

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-5. Comparison of the October 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Cresta Reach				Rock Creek Reach			
Site	Arch Rock		Grizzly Creek		Abandoned CG [2/]		Indian Jim School	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	259	289	259	289	255	261	255	261
Date	22-Oct-04	24-Oct-04	22-Oct-04	24-Oct-04	23-Oct-04	25-Oct-04	23-Oct-04	25-Oct-04
Time	14:18	12:35	15:39	12:15	11:30	11:30	11:05	10:25
Air Temp (*C)	20	16	18	12	11	15	10	11
Water Temp (*C)	12.5	12.5	12	11.5	12.5	12	12.5	11.5
% Cloudcover	100	100	100	30	100	70	100	70
% Shade	0	0	0	60	0	70	0	40
Visibility (ft)	6.5	6.5	5.5	4.5	7.5	8.0	6.3	7.0
Survey Area (ft^2)	5,760	5,760	4,212	4,212	6,120	6,120	5,664	5,664
RBT 0-4"	0	0	0	0	0	0	0	0
RBT 4-8"	0	0	0	0	1	0.5	0	0
RBT 8-14"	0	0	0	0	0	0	0	0
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	0	0	0	0	0	0	0.0	0.0
PKM/HH 0-4"	138.5	53.5	0	0	43.5	77	118	124
PKM/HH 4-8"	0	0	0	0	9	14	0	1.5
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0.5	0	0	0
PKM 4-8"	0	0	0	0	0	0	0	0
PKM 8-14"	0	0	0	0	0	0	0	0
PKM > 14"	0	0	0	0	0	0	0	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	2	1.5
HH 8-14"	0	0	0	0.5	0	0	0.5	0
HH > 14"	0	0	0	0	0	0	0	0
SKR 0-4"	0	0	0	0	1	0.5	0	0
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0	0	0	0	0	0	0
SKR > 14"	0	0.5	0	0	0	0	0	0.5
SMB 0-4"	0	0	0	0.5	0	0	0	0
SMB 4-8"	0	0	0	0	0	0	0	0
SMB 8-14"	0	0.5	0	0	0	0	0	0
SMB > 14"	0	0	0	0	0	0	0	0
SCLPN 0-4"	0	0	0	0	0	0	0.5	0.5
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	6.5	3.5	4.5	1.5	20.5	7	15	5.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Table D-5. Comparison of the October 2004 displacement snorkel surveys counts before and after a six-hour long 1000 cfs recreation flow at each of the study sites located in the Cresta and Rock Creek Reaches of the NFFR. Numbers recorded are means of two replicate counts. (continued)

	Rock Creek Reach							
Site	Chambers Creek		Milk Ranch Creek [2/]		Telephone/Cable Box		Gage	
Event	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Discharge (cfs)[1/]	255	261	255	261	255	261	255	261
Date	23-Oct-04	25-Oct-04	23-Oct-04	25-Oct-04	23-Oct-04	25-Oct-04	23-Oct-04	25-Oct-04
Time	12:00	11:43	11:04	11:36	10:16	9:53	9:34	9:37
Air Temp (*C)	9.5	13.5	10	12	12	11	9.5	9
Water Temp (*C)	11.5	11.5	12	12	12	11.5	12	12
% Cloudcover	100	70	100	55	100	90	100	75
% Shade	0	30	0	25	0	0	0	25
Visibility (ft)	4.0	8.5	6.0	6.0	6.5	6.5	5.5	6.0
Survey Area (ft^2)	4,140	4,140	6,084	6,084	7,800	7,800	5,544	5,544
RBT 0-4"	2	2	0	0	0	0	0.5	0
RBT 4-8"	0.5	0.5	0	0.5	0	0	1	1.5
RBT 8-14"	0	0	0	0.5	0	0	0	0
RBT >14"	0	0	0	0	0	0	0	0
Nongame fry	0	0	0	0.0	0	0	0	0
PKM/HH 0-4"	103	122	34.5	37	0.5	0	0	5
PKM/HH 4-8"	0	0	1	7	0.5	2.5	3	3.5
PKM/HH 8-14"	0	0	0	0	0	0	0	0
PKM/HH > 14"	0	0	0	0	0	0	0	0
PKM 0-4"	0	0	0	0	0	0	0	0
PKM 4-8"	0	0	0	0	0	0	0	0
PKM 8-14"	0	0	0	0	0	0	0.5	0
PKM > 14"	0	0	0	0	0	0	0	0
HH 0-4"	0	0	0	0	0	0	0	0
HH 4-8"	0	0	0	0	0	0	0	0
HH 8-14"	0	0	0	0.5	0	0	0	0
HH > 14"	0	0	0	0	0	0	0	0
SKR 0-4"	0	0	0	0	0	0	0	0
SKR 4-8"	0	0	0	0	0	0	0	0
SKR 8-14"	0	0	0	0	0	0	0	0.5
SKR > 14"	0	0	0	0	0	0	0	1
SMB 0-4"	0	0	0	0	0	0.5	0	0
SMB 4-8"	0	0	0	0	0	0	0	0
SMB 8-14"	0	0	0	0	0	0	0	0
SMB > 14"	0	0	0	0	0	0	0	0
SCLPN 0-4"	0.5	0.5	0	0	0	0	0	0.5
BRN 0-4"	0	0	0	0	0	0	0	0
snake	0	0	0	0	0	0	0	0
Crayfish tally	15.5	7.5	5.5	1	13	2.5	14.5	5.5

1/ Discharge data from PG&E gages NF-56 (Cresta) and NF-57 (Rock Creek)

2/ Site includes side channel

RBT = rainbow trout; nongame fry = post-larval suckers/minnows <25 mm TL; PKM/HH = indistinguishable small minnows; PKM = Sacramento pikeminnow; HH =Hardhead; SKR = Sacramento sucker; SMB = smallmouth bass; SCLPN = unidentified sculpin; BRN = brown trout

Appendix E

Stranding survey data

Table E-1. Results of the June 2004 stranding surveys at the five study sites located in the Rock Creek Reach of the NFFR. There was no recreation flow in the Cresta Reach in June 2004.

	Cresta Reach					Rock Creek Reach			
Site	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
Study Site Length (ft)					49	447	475	658	411
Search Area (ft^2)					718.1	8,841.2	20,989.3	10,695.4	9,634.6
Search Area (acres)					0.016	0.203	0.482	0.246	0.221
Mean width (ft)					14.54	19.78	44.19	16.25	23.44
Rocks Turned					86	356	1,385	897	1,004

Expo = Exposed on surface Conc = concealed under rock

	Poison Oak		Fir		Shady Rest		Arch Rock		Rock Crest		Abandoned CG		Indian Jim		Telephone		Gage	
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Benthic Macroinvertebrates																		
Pacifastacus leniusculus (crayfish)											1		5	2			2	
Corbicula fluminea (clam)														4				
Tropisternus sp. larva													1					
Agabus sp. adult														1				
unid'd Carabidae larva												1						
Siphlonurus sp. larva															1			
Ameletus sp. larva																	6	2
Tipula sp. larva													1					
Simulium sp. larva															2			
Fish																		
Cyprinid/Catostomid postlarvae (10-24.5 mm TL)											40	2	23	3	6	4	8	8
SKR fry (25-31.5 mm TL)													4	4	2	1	0	2
Amphibian tadpoles																		
Rana boylei tadpole																		
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Total Organisms									0	0	41	3	34	14	11	5	16	12

	Cresta Reach					Rock Creek Reach			
Site Totals	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
BMI/1000ft^2					0.000	0.226	0.667	0.280	1.038
fish/1000ft^2					0.000	4.750	1.620	1.215	1.868
YLF tad/1000ft^2					0.000	0.000	0.000	0.000	0.000
Organisms/1000ft^2					0.000	4.977	2.287	1.496	2.906
trout/1000ft^2					0.000	0.000	0.000	0.000	0.000

Reach Totals	Cresta Reach	Rock Creek Reach	All Sites
BMI/1000ft^2		0.570	0.570
fish/1000ft^2		2.103	2.103
YLF tad/1000ft^2		0.000	0.000
Organisms/1000ft^2		2.673	2.673
trout/1000ft^2	0.000	0.000	0.000

Table E-2. Results of the July 2004 stranding surveys at each of the nine study sites located in the Cresta and Rock Creek Reaches of the NFFR.

	Cresta Reach					Rock Creek Reach			
Site	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
Study Site Length (ft)	435	340	468	453	49	437	450	680	422
Search Area (ft^2)	9,109.8	5,935.0	7,968.3	11,086.7	525.7	7,663.6	17,745.0	10,609.8	8,220.4
Search Area (acres)	0.209	0.136	0.183	0.255	0.012	0.176	0.407	0.244	0.189
Mean width (ft)	20.94	17.46	17.03	24.47	10.64	17.54	39.43	15.60	19.48
Rocks Turned	1,530	994	495	329	89	834	400	1,867	1,145

Expo = Exposed on surface Conc = concealed under rock

	Poison Oak		Fir		Shady Rest		Arch Rock		Rock Crest		Abandoned CG		Indian Jim		Telephone		Gage	
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Benthic Macroinvertebrates																		
Pacifastacus leniusculus (crayfish)		16				5		1			2		1			1	1	
Corbicula fluminea (clam)																1		
unid'd mayfly larva						1												
Sigara sp. adult (water boatmen)							16							1				
Sialis sp. larva (alder flies)		18																
Neohermes sp. larva (dobson flies)		1																
Holorusia sp. larva (crane flies)																1		
Caloparyphus sp. Larva (soldier fly)															1			
Fish																		
Sacramento pikeminnow fry (32 mm TL)								1										
Hardhead fry (29-30 mm TL)								1							1			
Sacramento sucker fry (25.5-28 mm TL)													2					
Smallmouth bass fry (27-51 mm TL)							18	6										
Amphibian tadpoles																		
Rana boylei tadpole																		
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Total Organisms	0	35	0	0	0	6	34	9	0	0	2	0	3	1	2	3	1	0

	Cresta Reach					Rock Creek Reach			
Site Totals	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
BMI/1000ft^2	3.842	0.000	0.753	1.533	0.000	0.261	0.113	0.377	0.122
fish/1000ft^2	0.000	0.000	0.000	2.345	0.000	0.000	0.113	0.094	0.000
YLF tad/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Organisms/1000ft^2	3.842	0.000	0.753	3.879	0.000	0.261	0.225	0.471	0.122
trout/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Reach Totals	Cresta Reach	Rock Creek Reach	All Sites
BMI/1000ft^2	1.701	0.201	0.850
fish/1000ft^2	0.762	0.067	0.368
YLF tad/1000ft^2	0.000	0.000	0.000
Organisms/1000ft^2	2.463	0.268	1.217
trout/1000ft^2	0.000	0.000	0.000

Table E-3. Results of the August 2004 stranding surveys at each of the nine study sites located in the Cresta and Rock Creek Reaches of the NFFR.

	Cresta Reach					Rock Creek Reach			
Site	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
Study Site Length (ft)	435	327	482	463	51.2	436	450	651	435
Search Area (ft^2)	6,856.5	5,592.1	6,011.0	10,646.3	443.6	6,798.1	16,440.0	8,617.5	8,826.5
Search Area (acres)	0.157	0.128	0.138	0.244	0.010	0.156	0.377	0.198	0.203
Mean width (ft)	15.76	17.10	12.47	22.99	8.66	15.59	36.53	13.24	20.29
Rocks Turned	654	1,441	525	526	43	413	1,728	191	995

Expo = Exposed on surface Conc = concealed under rock

	Poison Oak		Fir		Shady Rest		Arch Rock		Rock Crest		Abandoned CG		Indian Jim		Telephone		Gage	
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Benthic Macroinvertebrates																		
Pacifastacus leniusculus (crayfish)													1		1			2
Lymnaea sp. (pond snail)	33	8													1			
Physa sp. (pond snail)	5	2																
Corbicula fluminea (Asian clam)																		
Sigara sp. (water boatmen)	1				1											4		
Tropisternus sp. (water scavenger beetle)		1																
Lampyridae larva (fireflies)	1																	
Fish																		
Sacramento pikeminnow fry (31 mm TL)													1					
Amphibian tadpoles																		
Rana boylei tadpole																		
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Total Organisms	40	11	0	0	1	0	0	0	0	0	0	0	2	0	2	4	0	2

	Cresta Reach					Rock Creek Reach			
Site Totals	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
BMI/1000ft^2	7.438	0.000	0.166	0.000	0.000	0.000	0.061	0.696	0.227
fish/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.061	0.000	0.000
YLF tad/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Organisms/1000ft^2	7.438	0.000	0.166	0.000	0.000	0.000	0.122	0.696	0.227
trout/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Reach Totals	Cresta Reach	Rock Creek Reach	All Sites
BMI/1000ft^2	1.787	0.219	0.869
fish/1000ft^2	0.000	0.024	0.014
YLF tad/1000ft^2	0.000	0.000	0.000
Organisms/1000ft^2	1.787	0.243	0.883
trout/1000ft^2	0.000	0.000	0.000

Table E-4. Results of the September 2004 stranding surveys at each of the nine study sites located in the Cresta and Rock Creek Reaches of the NFFR.

	Cresta Reach					Rock Creek Reach			
Site	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
Study Site Length (ft)	434	327	482	463	52.4	450	450	654	430
Search Area (ft^2)	7,226.9	5,459.6	4,988.7	12,040.2	473.2	6,038.8	15,913.8	9,544.8	7,783.0
Search Area (acres)	0.166	0.125	0.115	0.276	0.011	0.139	0.365	0.219	0.179
Mean width (ft)	16.65	16.70	10.35	26.00	9.03	13.42	35.36	14.59	18.10
Rocks Turned	1,530	225	262	1,296	75	709	837	415	155

Expo = Exposed on surface Conc = concealed under rock

	Poison Oak		Fir		Shady Rest		Arch Rock		Rock Crest		Abandoned CG		Indian Jim		Telephone		Gage	
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Benthic Macroinvertebrates																		
Pacifastacus leniusculus (crayfish)			1		2			2				1	1	1		1	1	1
Aeshna sp. naiad (dragonfly)			1															
Centroptilum sp . nymph (mayfly)							1											
Sigara sp. nymphs & adult (water boatmen)							19	1										
Prosimulim sp. larva (blackflies)											1							
Lymnaea sp. (snail)																		
Corbicula fluminea (Asian clam)			1				1										1	
Acari (water mite)			8															
Fish																		
Sacramento pikeminnow fry																		
Hardhead fry																		
Sacramento sucker fry																		
Smallmouth bass fry																		
Amphibian tadpoles																		
Rana boylei tadpole																		
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Total Organisms	0	0	11	0	2	0	21	3	0	0	1	1	1	1	0	1	2	1

	Cresta Reach					Rock Creek Reach			
Site Totals	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
BMI/1000ft^2	0.000	2.015	0.401	1.993	0.000	0.331	0.126	0.105	0.385
fish/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
YLF tad/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Organisms/1000ft^2	0.000	2.015	0.401	1.993	0.000	0.331	0.126	0.105	0.385
trout/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Reach Totals	Cresta Reach	Rock Creek Reach	All Sites
BMI/1000ft^2	1.245	0.201	0.648
fish/1000ft^2	0.000	0.000	0.000
YLF tad/1000ft^2	0.000	0.000	0.000
Organisms/1000ft^2	1.245	0.201	0.648
trout/1000ft^2	0.000	0.000	0.000

Table E-5. Results of the October 2004 stranding surveys at each of the nine study sites located in the Cresta and Rock Creek Reaches of the NFFR.

	Cresta Reach					Rock Creek Reach			
Site	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
Study Site Length (ft)	452	325	450	450	51.4	439	465	650	447
Search Area (ft^2)	7,507.9	5,638.8	4,963.8	10,773.8	438.8	5,459.9	16,629.5	8,274.5	7,649.9
Search Area (acres)	0.172	0.129	0.114	0.247	0.010	0.125	0.382	0.190	0.176
Mean width (ft)	16.61	17.35	11.03	23.94	8.54	12.44	35.76	12.73	17.11
Rocks Turned	615	837	90	599	65	63	1,015	336	353

Expo = Exposed on surface Conc = concealed under rock

	Poison Oak		Fir		Shady Rest		Arch Rock		Rock Crest		Abandoned CG		Indian Jim		Telephone		Gage	
	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc	Expo	Conc
Benthic Macroinvertebrates																		
Pacifastacus leniusculus (crayfish)					1										1			
Fish																		
Sacramento pikeminnow fry																		
Hardhead fry																		
Sacramento sucker fry																		
Smallmouth bass fry																		
Amphibian tadpoles																		
Rana boylei tadpole																		
Total Organisms	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0

	Cresta Reach					Rock Creek Reach			
Site Totals	Poison Oak	Fir	Shady Rest	Arch Rock	Rock Crest	Abandoned CG	Indian Jim	Telephone	Gage
BMI/1000ft^2	0.000	0.000	0.201	0.000	0.000	0.000	0.000	0.121	0.000
fish/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
YLF tad/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Organisms/1000ft^2	0.000	0.000	0.201	0.000	0.000	0.000	0.000	0.121	0.000
trout/1000ft^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Reach Totals	Cresta Reach	Rock Creek Reach	All Sites
BMI/1000ft^2	0.035	0.026	0.030
fish/1000ft^2	0.000	0.000	0.000
YLF tad/1000ft^2	0.000	0.000	0.000
Organisms/1000ft^2	0.035	0.026	0.030
trout/1000ft^2	0.000	0.000	0.000

Appendix F

Total stranding area survey data

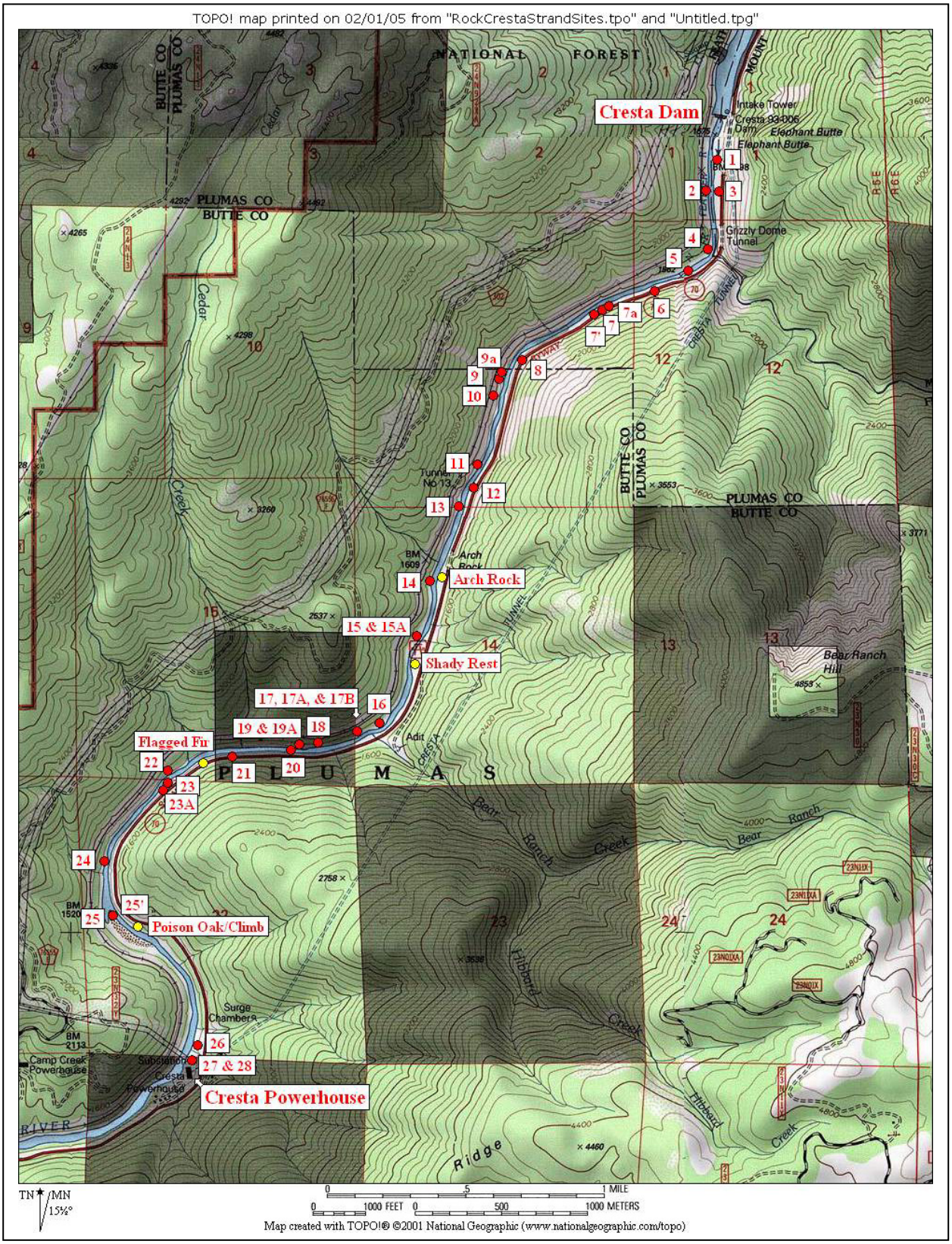

Figure F-1. Location of stranding sites identified in Cresta Reach, June 2004

Table F-1. Stranding sites identified in Cresta Reach, which in addition to the four monthly stranding survey sites, were used to estimate total stranding area. Information includes Site ID, location (north bank, south bank, or mid-channel), length, area, varial zone (lateral) gradient; stranding potential, date & flow level when measured. measured flow with * denote sites inundated at all three recreation flow levels

Site ID	Location	Length (ft)	Area (ft2)	Gradient (%)	Strand Potential	Date Measured	Measured Flow	1600 cfs AREA	1200 cfs AREA	1000 cfs AREA
1	SB	274	3,547.90	38.39	Moderate	27-Jul	1200	4,218.67	3,547.90	3,244.16
2	NB	249	1,905.05	39.31	Low	27-Jul	1200	2,265.22	1,905.05	1,741.95
3	SB	299	2,837.85	85.69	Moderate	27-Jul	1200	3,374.38	2,837.85	2,594.89
4	NB	708	4,595.85	36.77	Moderate	26-Jul	1200	5,464.74	4,595.85	4,202.39
5	MC	486	17,630.30	24.14	High	26-Jul	1200	20,963.50	17,630.30	16,120.93
6	SB	157	1,840.60	25.04	Moderate	26-Jul	1200	2,188.59	1,840.60	1,683.02
7a	SB	54	504.80	26.87	Moderate	27-Jul	1200	600.24	504.80	461.58
7	SB	76	882.65	30.78	Low	27-Jul	1200	1,049.52	882.65	807.08
7'	SB	135	2,504.70	19.87	Low	27-Jul	1200	2,978.24	2,504.70	2,290.27
8	SB	46	427.90	26.94	Low	27-Jul	1200	508.80	427.90	391.27
9a	NB	30	227.00	15.00	Low	27-Jul	1200	269.92	227.00	207.57
9	NB	84	1,140.85	24.53	High	27-Jul	1200	1,356.54	1,140.85	1,043.18
10	NB	142	2,168.45	25.78	Moderate	27-Jul	1200	2,578.42	2,168.45	1,982.80
10'	NB	30	450.00	4.00	Moderate	27-Jul	1200	535.08	450.00	411.47
11	NB	200	1,895.00	28.27	Moderate	27-Jul	1200	2,253.27	1,895.00	1,732.76
12	NB	167	2,527.65	16.75	Moderate	28-Sep	1600*	2,527.65	2,527.65	2,527.65
13	NB	33	372.45	42.14	Low	28-Sep	1000	484.33	407.32	372.45
14	NB	116	775.60	38.42	Low	28-Sep	1000	1,008.58	848.22	775.60
15	NB	150	5,828.70	6.18	High	27-Sep	1000	7,579.58	6,374.43	5,828.70
15A	MC	459	14,485.80	6.18	High	27-Sep	1000	18,837.19	15,842.08	14,485.80
16	NB	320	2,794.95	28.90	Low	27-Sep	1000	3,634.53	3,056.64	2,794.95
17	NB	141	1,206.05	15.15	Low	28-Sep	1000	1,568.34	1,318.97	1,206.05
17A	NB	220	10,629.45	5.72	High	28-Sep	1600*	10,629.45	10,629.45	10,629.45
17B	NB	158	3,830.45	10.03	High	28-Sep	1600*	3,830.45	3,830.45	3,830.45
18	NB	102	1,414.20	13.54	Low	28-Sep	1000	1,839.01	1,546.61	1,414.20
19	NB	119	2,655.50	9.47	Low	28-Sep	1000	3,453.19	2,904.13	2,655.50
19A	NB	141	1,541.40	6.25	Moderate	28-Sep	1000	2,004.42	1,685.72	1,541.40
20	MC	108	1,330.90	14.64	Moderate	28-Sep	1000	1,730.69	1,455.51	1,330.90
21	SB	253	3,481.20	22.99	High	28-Sep	1000	4,526.92	3,807.14	3,481.20
22	NB	100	2,723.10	5.74	Moderate	28-Sep	1600*	2,723.10	2,723.10	2,723.10
23	MC	91	3,776.50	5.82	High	28-Sep	1000	4,910.92	4,130.09	3,776.50
23A	NB	15	225.00	3.00	Moderate	28-Sep	1600*	225.00	225.00	225.00
24	NB	111	2,282.55	5.65	High	28-Sep	1600*	2,282.55	2,282.55	2,282.55
25	MC-N	1253	15,808.40	16.45	Moderate	28-Sep	1000	20,557.09	17,288.51	15,808.40
25'	MC-S	1154	11,702.70	32.91	Low	28-Sep	1000	15,218.08	12,798.40	11,702.70
26	SB	87	1,525.55	23.20	High	29-Sep	1000	1,983.81	1,668.38	1,525.55
27	SB	83	1,202.85	15.48	High	29-Sep	1000	1,564.17	1,315.47	1,202.85
28	SB	144	9,955.90	8.42	High	29-Sep	1000	12,946.55	10,888.05	9,955.90

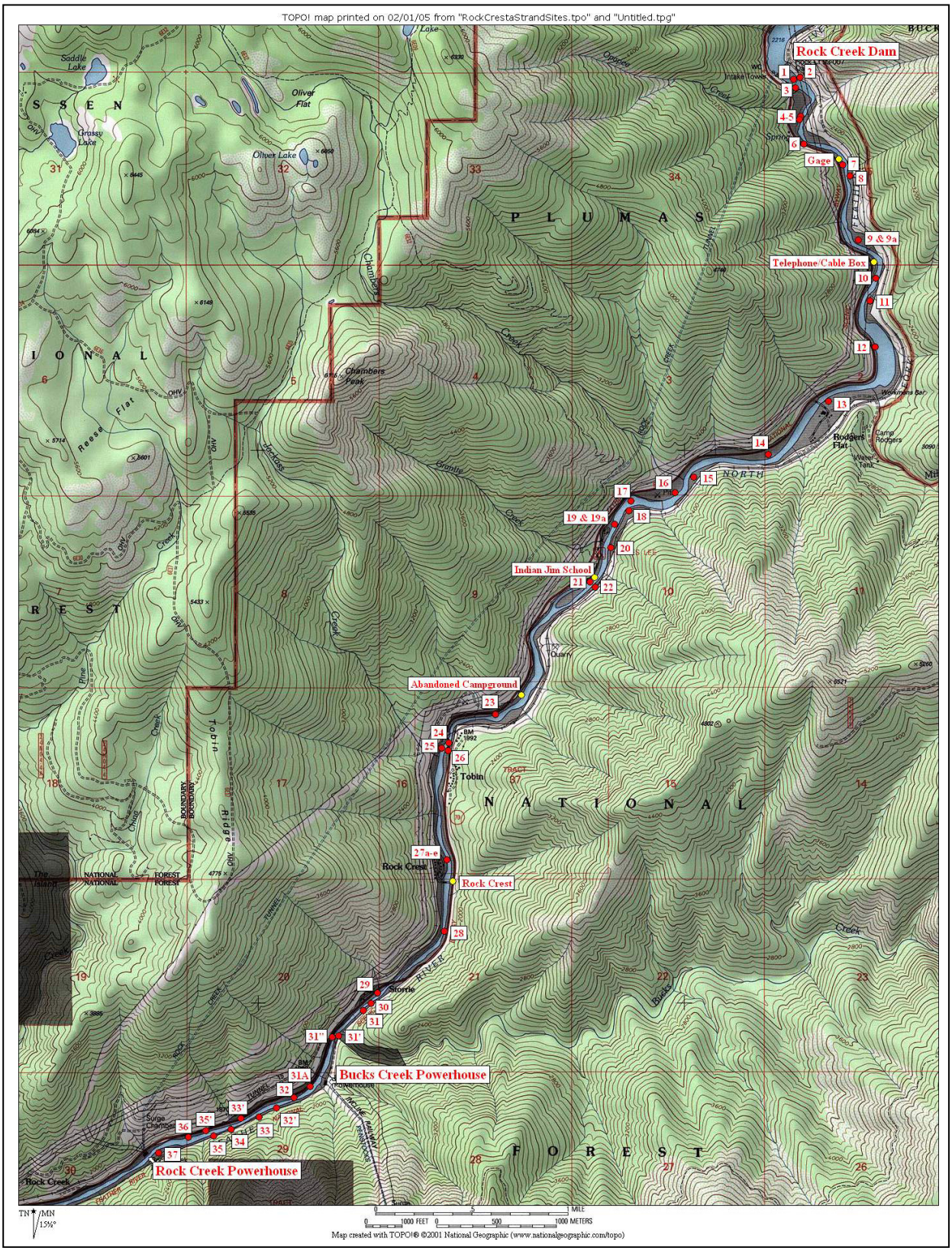

Figure F-2. Location of stranding sites identified in the Rock Creek Reach, June 2004

Table F-2. Stranding sites identified in Rock Creek Reach, which in addition to the four monthly stranding survey sites, were used to estimate total stranding area. Information includes Site ID, location (north bank, south bank, or mid-channel), length, area, varial zone (lateral) gradient; stranding potential, date & flow level when measured. measured flow with * denote sites inundated at all three recreation flow levels

Site ID	Location	Length (ft)	Area (ft2)	Gradient (%)	Strand Potential	Date Measured	Measured Flow	1600 cfs AREA	1200 cfs AREA	1000 cfs AREA
1	MC	287	4,994.71	10.00	Low	30-Jun	1600	4,994.71	4,315.43	4,025.74
2	SB	97	1,504.50	9.69	High	30-Jun	1600	1,504.50	1,299.89	1,212.63
3	NB	118	3,810.15	9.88	High	28-Jun	1600	3,810.15	3,291.97	3,070.98
4/5	NB	402	9,995.25	13.56	High	28-Jun	1600	9,995.25	8,635.90	8,056.17
6	SB	315	5,992.10	16.21	Moderate	30-Jun	1600	5,992.10	5,177.17	4,829.63
7	NB	307	5,285.60	25.48	Moderate	28-Jun	1600	5,285.60	4,566.76	4,260.19
8	SB	170	2,817.35	31.66	Low	30-Jun	1600	2,817.35	2,434.19	2,270.78
9	SB	858	49,316.50	10.99	High	30-Jun	1600	49,316.50	42,609.46	39,749.10
9a	MC	366	13,222.10	15.08	Moderate	30-Jun	1600	13,222.10	11,423.89	10,657.01
10	MC	265	23,541.95	18.65	High	29-Jun	1600	23,541.95	20,340.24	18,974.81
11	SB	505	11,833.65	9.78	High	27-Sep	1000	14,681.95	12,685.20	11,833.65
12	NB	922	59,924.70	7.16	High	29-Jun	1600	59,924.70	51,774.94	48,299.31
13	SB	276	6,671.60	17.20	Moderate	30-Jun	1600	6,671.60	5,764.26	5,377.31
14	NB	589	22,798.30	5.83	High	29-Jun	1600	22,798.30	19,697.73	18,375.43
15	SB	691	28,168.35	9.59	High	30-Jun	1600	28,168.35	24,337.45	22,703.69
16	NB	113	455.50	60.08	Low	28-Jun	1600	455.50	393.55	367.13
17	MC	262	2,481.42	20.00	Low	30-Jun	1600	2,481.42	2,143.95	2,000.02
18	SB	534	8,931.85	16.30	Moderate	30-Jun	1600	8,931.85	7,717.12	7,199.07
19	NB	423	12,266.30	13.93	High	29-Jun	1600	12,266.30	10,598.08	9,886.64
19a	MC	353	37,755.50	3.23	High	29-Jun	1600	37,755.50	32,620.75	30,430.93
20	SB	302	8,799.55	11.65	High	30-Jun	1600	8,799.55	7,602.81	7,092.44
21	NB	766	40,674.50	7.42	High	28-Jun	1600	40,674.50	35,142.77	32,783.65
22	SB	578	20,974.60	6.99	High	30-Jun	1600	20,974.60	18,122.05	16,905.53
23	NB	106	1,833.40	17.36	Low	28-Jun	1600	1,833.40	1,584.06	1,477.72
24	NB	55	550.00	5.00	Moderate	29-Jun	1600*	550.00	550.00	550.00
25	NB	93	2,917.90	12.30	High	1-Jul	1600*	2,917.90	2,917.90	2,917.90
26	SB	62	784.45	26.53	Low	29-Jun	1600	784.45	677.76	632.27
27a	NB	22	244.90	33.14	Moderate	29-Jun	1600	244.90	211.59	197.39
27b	NB	36	583.90	24.01	Low	29-Jun	1600	583.90	504.49	470.62
27c	NB	58	574.35	33.89	Low	29-Jun	1600	574.35	496.24	462.93
27d	NB	103	1,690.40	25.58	High	29-Jun	1600	1,690.40	1,460.51	1,362.46
27e	NB	42	493.00	26.75	Low	29-Jun	1600	493.00	425.95	397.36
28	SB	78	1,394.90	25.06	High	29-Jun	1600	1,394.90	1,205.19	1,124.29
29	NB	136	2,942.80	28.92	Moderate	29-Jun	1600	2,942.80	2,542.58	2,371.90
30	SB	98	1,596.25	26.43	Low	1-Jul	1600*	1,596.25	1,596.25	1,596.25
31	SB	90	2,336.30	8.74	High	1-Jul	1600*	2,336.30	2,336.30	2,336.30
31'	SB	39	437.75	31.38	Low	29-Jun	1600	437.75	378.22	352.83
31"	NB	45	638.10	18.18	Moderate	29-Jun	1600	638.10	551.32	514.31
31A	NB	149	1,689.05	18.92	Moderate	22-Jul	1600	1,689.05	1,459.34	1,361.37
32	NB	252	5,013.30	15.15	Low	22-Jul	1600	5,013.30	4,331.49	4,040.72
32'	SB	53	613.95	26.96	Low	22-Jul	1600	613.95	530.45	494.84
33	SB	285	5,176.45	16.86	Moderate	22-Jul	1600	5,176.45	4,472.45	4,172.22
33'	NB	74	961.30	19.12	Low	29-Jun	1600*	961.30	961.30	961.30
34	SB	145	2,721.45	17.79	Moderate	22-Jul	1600	2,721.45	2,351.33	2,193.49
35	SB	163	5,777.65	4.91	High	1-Jul	1600*	5,777.65	5,777.65	5,777.65
35'	NB	50	300.00	10.00	Low	1-Jul	1600*	300.00	300.00	300.00
36	NB	267	4,560.10	20.28	Low	29-Jun	1600	4,560.10	3,939.93	3,675.44
37	SB	186	3,042.55	18.11	Low	22-Jul	1600	3,042.55	2,628.76	2,452.30

Appendix G

Comments and Responses

Comments received from California Sportfishing Protection Alliance
June 20, 2005

Comment 1: My concern is that the methodologies used in the Stranding (Displacement) Study were not sufficient to determine if displacement occurred. As you are well aware fish will move in relation to feeding, cover, time of day and numerous other factors. Just because fish were found in the same or close to the same sites before and after whitewater flows does not prove or disprove displacement. Without a means of identifying the specific fish, I do not think there is scientific evidence to support conclusions regarding the occurrence or non-occurrence of displacement.

Response: *The 2004 fish stranding and displacement report has been modified to reflect changes, if any, in the number of fish observed before and after flow events and does not present any conclusions that they were necessarily the same fish.*

Comment 2: The subsequent use of these data and conclusions in the "Angler Mortality" study raises additional concerns and questions regarding that study and its conclusions.

Response: *The "Angler Mortality" analysis comparison utilized stranding data, and not displacement data.*

Comment 3: These concerns are part of the reason I had requested an analysis and review of this issue and the methodologies by the "Peer Review Committee".

Response: *Acknowledged.*

Comment 4: This issue is displacement only and does not refer to stranding where the methodologies appear more robust and directed to the specific answer.

Response: *Acknowledged.*

Comment 5: I am in the process of looking at the 2002 drift study data regarding capture of fish in the drift nets and may need to talk to the Ganda people to understand what they observed and collected and what they believed was happening.

Response: *As was previously provided to CSPA via email (June 2, 2005), and included in the "Condition 17 Recreation and Pulse Flow Biological Evaluation Findings and Initial Determination" binder, results of the fish collected as part of the 2002 benthic drift study are presented on pages 65-71 of the 2004 fish stranding and displacement report in greater detail than was originally presented by GANDA in their 2002 report.*