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INFLUENCE OF SURFACE-WATER WITHDRAWAL ON JUVENILE STEELHEAD AND THEIR HABITAT IN A SOUTH-CENTRAL CALIFORNIA NURSERY STREAM

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INTRODUCTION

Tributaries and the nursery habitats they possess have a critical role in the ecology of steelhead, *Oncorhynchus mykiss*. Adults migrate into tributaries, where characteristics and conditions are well suited for production of young (Erman and Hawthorne 1976, Montgomery et al. 1999). Parr that emigrate from upstream natal areas during spring to rear in mainstem habitats often return to tributaries in the fall (Hartman and Brown 1987, Bramblett et al. 2002), presumably as an adaptation to environmental conditions for increasing the chance of survival. The presence of diverse age classes of steelhead in tributaries (Roper et al. 1994) indicates the capability to support life history characteristics such as multi-year freshwater residence (Chapman 1958, Narver 1969). Given the functional value of tributaries, protection of such habitats should receive high priority.

The exploitation of surface-water and ground-water resources in coastal basins of south-central California is common and has created much concern for fishery managers. Habitat changes due to streamflow alterations can negatively affect the physicochemical and biological properties of streams (Poff et al. 1997) and are believed to have contributed to the population decline of anadromous salmonids (Hedgecock et al. 1994, Moyle 1994). The ecological concern over such alterations has been sufficient to prompt the American Fisheries Society to render policy regarding this issue (policy statement 9) and considerable efforts to restore stream function and fishery resources (Smith et al. 2000). Given the interest in conserving anadromous salmonids (Nehlsen et al. 1991), understanding how water diversions affect fishery resources is a necessary step for developing reliable mitigation strategies.

The influence of streamflow alterations on anadromous fishes, particularly as related to large water-storage projects (Blahm 1976, Raymond 1988, Mundie 1991), has been documented. However, at smaller scales the influence of surface-water withdrawal and habitat changes on juvenile steelhead, especially in the absence of instream storage facilities, is poorly understood. Without such information, predictions regarding the possible influences of such activities on steelhead and their habitat are tenuous; this uncertainty translates into a risk, particularly for threatened and endangered species. In this note, we report the findings of a study performed in summer 2003 that examined instream habitat characteristics and density of juvenile steelhead (the South Central California Coast Evolutionarily Significant Unit) upstream and downstream of a surface-water pump in a small south-central California tributary stream.

STUDY AREA

See Canyon Creek (35°11'19"N, 120°43'10"W) is a tributary to San Luis Obispo Creek, which itself is a tributary to the Pacific Ocean (Fig. 1). The surrounding area is rural, with a few scattered private residences. Oak, *Quercus* spp., woodland dominates the surrounding hills, whereas riparian areas possess willow, *Salix* spp., alder, *Alnus* spp., and California sycamore, *Platanus racemosa*. Pool, run, and glide are common, and we observed numerous short riffles. A few prickly sculpin, *Cottus asper*, were observed in the study area. Extensive accumulations of large (≥10-cm diameter) and small woody debris are common in the creek channel, the bed of which is mostly cobble and gravel. The depth and width of pools sampled for this study averaged 0.2 and 2.6 m, respectively. Adult steelhead spawn in the study area, as indicated by observation of actively spawning fish and numerous redds. Additional information regarding the San Luis Obispo Creek watershed, including See Canyon Creek, can be found in Spina et al. (2005).

The study reach extends 400 m upstream (reference reach) and 400 m downstream (affected reach) of a surface-water pump, which is located 0.8 km upstream of the intersection of San Luis Bay Drive and See Canyon Road (Fig. 1). The length and boundaries of the study reach were selected based on instream habitat characteristics and the expected downstream extent of effects owing to pump operations, based on preliminary surveys. A diesel generator stationed on the creek bank operates a pump (capacity of 681 L/min) to irrigate grazing land for cattle. The pump intake is screened to exclude fish and is located in the middle of the channel at the bottom of a pool. Based on interviews with the landowner (who operates under a riparian water right) pumping began on or about 26 May and ended on 3 August 2003, in response to a cease-and-desist order issued by the California Department of Fish and Game. During this period, the landowner generally pumped water from the creek 6 days a week, 14 to 16 continuous hours each day, beginning at 1600 hours and ending at 0600 hours.

METHODS

The study reach was inspected on 7 July to note characteristics of the instream habitat (e.g., wetted channel width, whether surface water was present and flowing) and to estimate stream discharge in affected and reference reaches. Stream discharge was measured before (at two locations in the affected reach, during 1550-1615 hours) and after (in two locations within the affected and reference reaches, 1941-1955 hours, and 1847-1909 hours) pumping began using the method for streamflow measurement described in Platts et al. (1983[1]) and an electronic current meter, which was calibrated

[1]Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U. S. Forest Service General Technical Report INT-138.

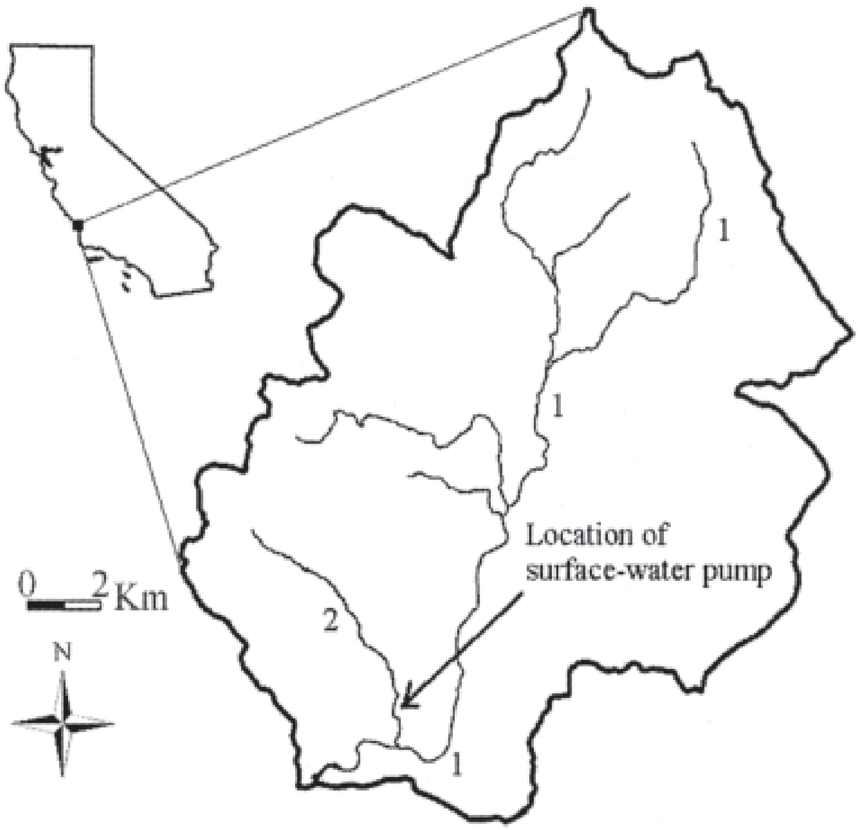

Figure 1. San Luis Obispo Creek watershed showing San Luis Obispo Creek (#1 on map), See Canyon Creek (#2), other principal streams, and the location of the surface-water pump. The study area extended 400 m upstream and 400 m downstream of the pump.

prior to use according to manufacturer guidelines. Because measurements during preliminary surveys indicated that pumping did not reduce discharge in the reference reach, we use the measurements of stream discharge taken in the reference reach after pumping began to characterize discharge for this reach. The measurements of stream discharge were averaged for each reach and time period. A similar visual inspection of the instream characteristics was performed during a pumping event on 28 and 30 July, but streamflow measurements were not repeated.

To estimate pool-specific mean density of juvenile steelhead upstream and downstream of the pump, 9 pools were sampled within both the reference and affected reaches (total of 18 pools). The first nine pools located upstream and downstream of the subject pump were selected for sampling, except two particular pools located upstream of the pump were excluded from sampling. Capturing fish in these specific pools using electrofishing was likely to be extremely challenging and inefficient due to the extensive accumulations of woody debris. The mean depth and surface area (± 1SD) of the pools sampled were 0.2 (0.05) m and 34.9 (13.6) m^2, respectively in the reference reach, and 0.2 (0.5) m and 27.0 (9.1) m^2, respectively in the affected reach. These measurements were taken when the pump was not operating (during 4 to 7 August).

During 4 to 7 August, we used the removal-depletion method (Riley and Fausch 1992) and one backpack electroshocker to collect steelhead from the 18 pools. To ensure that no fish left or entered the sample unit during the survey, we enclosed each sample unit with block nets, and used cobbles and small boulders to secure the net lead line to the channel bed and eliminate voids between the net and channel bed. Other than installing block nets at unit boundaries, we did not disturb the sample unit prior to electrofishing. A minimum of three passes with the electroshocker was performed in an upstream direction and the entire area of each sample unit (including steelhead sheltering areas such as cobbles and woody debris) was systematically shocked during the first pass and each successive pass to maintain constant effort among the passes. After electrofishing a unit, the depth (mm) and width (m) of the sample unit were measured at randomly selected locations using a random-numbers table and the *x-y* coordinate method (Whalen and Parrish 1999).

Steelhead were measured (mm, fork length) and scales were removed from 43 individuals prior to release for the purposes of characterizing the age-at-length relationship for the collected individuals and then generating age-specific density estimates. The specific lengths of steelhead in which scales were removed for analysis were chosen based on our knowledge of the age-at-length relationship for juvenile steelhead in the region (Spina 2003), and we removed scales from a slightly broader range of fish lengths (i.e., surrounding an expected age break) than was suggested by our prior knowledge. Length-frequency distributions were prepared to identify two age categories (age-0, and age-1 and older) (Fig. 2), and the age breaks in the distribution were validated with scale readings using standard methods (Jerald 1983).

MicroFish 3.0 (Van Deventer and Platts 1989[2]) was used to compute maximum-likelihood estimates of fish abundance for the two age categories in each sample unit. When steelhead were captured only during the first and not successive passes, MicroFish sets the population estimate for the subject unit to the total catch because maximum-likelihood estimation is not possible in this situation. Pool-specific density estimates (number of fish/m^2) were calculated for each age category using the estimate of fish abundance divided by the area of each sampled unit. The fact that we captured few fish in some pools should not decrease confidence in our findings for at least a few reasons. First, we believe fish did not leave sample units during the electrofishing surveys owing to the block nets. Second, we maintained constant effort among the passes by, in part, ensuring that the entire sample unit (including locations that did not

[2]Van Deventer, J.S., and W.S. Platts. 1989. Microcomputer software system for generating population statistics from electrofishing data–user's guide for MicroFish 3.0. U.S. Forest Service, General Technical Report INT-254, Ogden, Utah, USA.

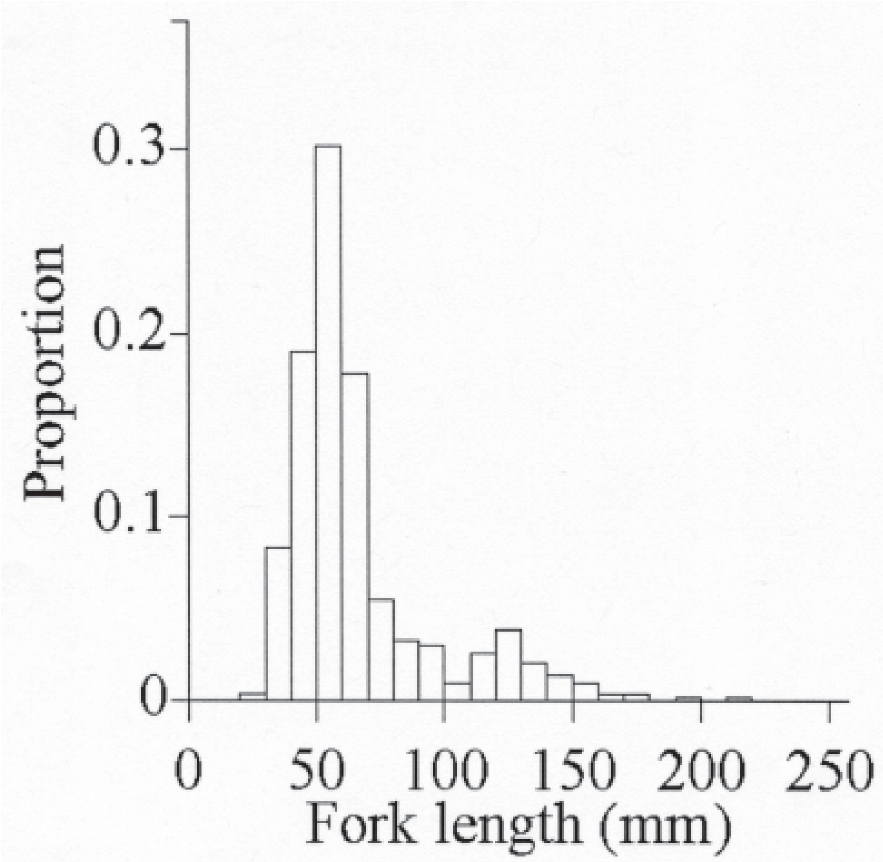

Figure 2. Length-frequency distribution of steelhead collected from pools in the study area of See Canyon Creek during 4 to 7 August 2003 (n = 672). The break between age-0 and age-1 and older steelhead was assigned at 100 mm and was validated with results of scale readings.

produce fish on a previous pass) was thoroughly shocked. Third, we constantly monitored electrofishing voltage and amperage, and when necessary rotated new batteries into the surveys, to maintain electrofishing efficiency. Fourth, conditions were ideal for electrofishing; discharge was relatively low and water clarity was unlimited even in the deepest pools. Overall, the fact that we collected few juvenile steelhead in some pools is a reflection of the low abundance of fish in the subject pools.

RESULTS

After pumping began on 7 July, flowing water within the reach extending 100 m downstream of the pump was eliminated, resulting in dewatered runs, riffles, and glides and pronounced reductions in pool depth (on average 7.6 cm) within this specific area. Although surface water persisted farther downstream, reductions in wetted width ranged from 50.8 cm to 91.4 cm (Fig. 3). Before pumping, estimated discharge in the affected reach was 2.8 L/s, then decreased to 1.4 L/s after pumping began and was much less than the reference discharge (8.5 L/s). On 28 and 30 July, we again observed that flowing water was lacking within the reach extending 100 m downstream of the pump, and instream habitat had been dewatered (i.e., little to no surface water). Two dead steelhead were found in the dewatered reach on 30 July.

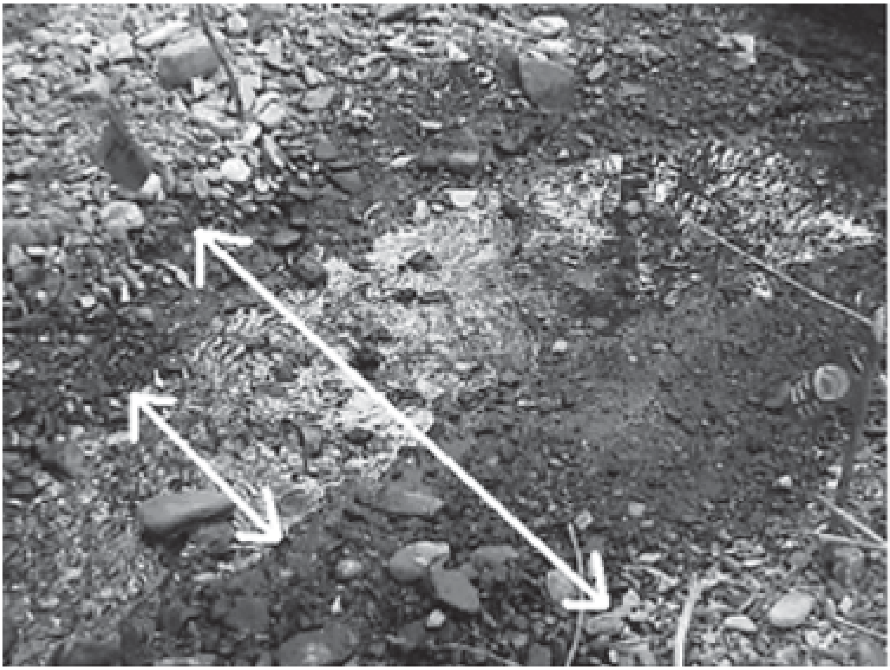

Figure 3. Example of the reduction in wetted channel width observed during July 2003 inspections. Arrows show wetted width before (long arrow, 119 cm) and during (short arrow, 45 cm) withdrawal of surface water.

During the electrofishing surveys, we collected a total of 672 juvenile steelhead, 413 individuals from the reference reach and 259 from the affected reach. Mean density (± 1SD) of age-0 steelhead was 0.8 (0.9) fish/m^2 in the affected reach and 1.2 (0.5) fish/m^2 in the reference reach. Mean density of age-1 and older steelhead was 0.1 (0.2) fish/m^2 in the affected reach and 0.1 (0.1) fish/m^2 in the reference reach. Densities of both age groups were lowest in affected pools nearest the pump, and in the case of age-1 and older steelhead, no individual was collected or observed in the four affected pools nearest the pump (Fig. 4).

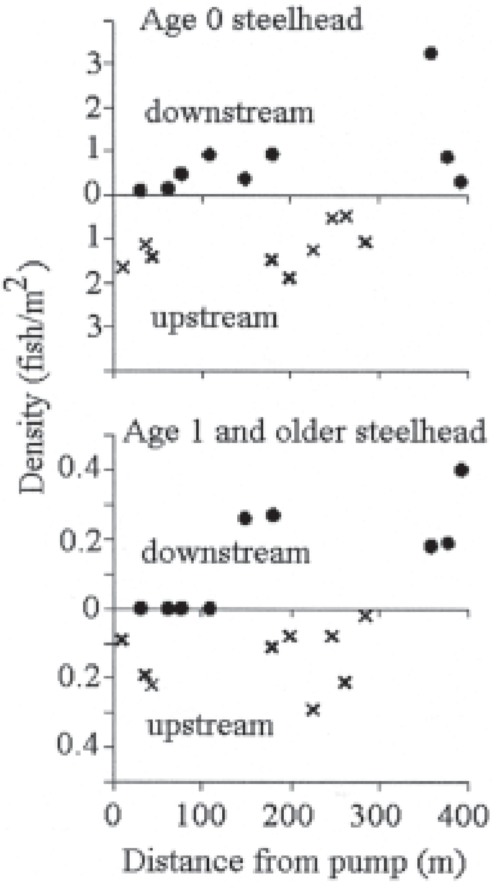

Figure 4. Relationship between density of age-0 and age-1 and older steelhead in pools upstream (reference reach) and downstream (affected reach) of the pump, and distance from the pump (located at distance zero).

DISCUSSION

Our findings corroborate those of other investigators reporting decreased abundance of aquatic organisms downstream of water-withdrawal locations where habitat quality and quantity have been reduced (Vinyard 1996, McIntosh et al. 2003). In our study, we neither collected nor observed age-1 and older steelhead in the four affected pools nearest the pump, which were within the localized area where the most notable reductions in living space, and the dead steelhead, were observed. The reduction in living space probably exposes steelhead (and possibly other aquatic organisms that we did not consider) to abiotic and biotic conditions that are unfavorable for survival and growth (Cushman 1985). The loss of depth alone may reduce the chance of survival, especially for larger juveniles, based on the value of deep water for bigger fish (Power et al. 1989, Harvey and Stewart 1991).

We do not know whether a difference in steelhead density between the two reaches existed prior to the pumping, but we did not detect a difference in mean density between reaches, only a decreased density of steelhead (e.g., age-1 and older individuals) in affected pools nearest the pump was documented. Although the physical characteristics of the four pools offer an alternative hypothesis for the absence of age-1 and older steelhead within the localized area, our site-specific observations and general knowledge of habitat use in juvenile steelhead (e.g., Spina 2003) lead us to believe that physical characteristics of the four pools (including the amount and type of cover) were suitable for older juveniles and were similar to those of other sampled pools. Two pools possessed substantial overhanging and instream branches that provided shade and shelter, and area and mean depth of the four pools were similar to other sampled pools. The physical characteristics of the four pools seem unlikely to fully explain the absence of age-1 and older juvenile steelhead.

We conclude that pump operation created unfavorable instream conditions that lead to the absence of age-1 and older steelhead in affected pools nearest the pump. Although landowners possessing a riparian water right have certain entitlements to stream water, our findings indicate the fishery resource and their habitat were not adequately considered, perhaps not at all, in the execution of that right. The results of our study underscore the need to ensure anthropogenic activities are sufficiently evaluated and balanced against the habitat requirements of anadromous salmonids, even when the scale and potential consequence of an activity are perceived as small or negligible.

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