JUVENILE STEELHEAD HABITAT SUITABILITY AND REARING CONDITIONS WITHIN THE BIG SUR RIVER LAGOON

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Lagoon habitats associated with coastal streams and rivers along the central California coast have been found to be important for juvenile steelhead rearing prior to migration into coastal marine waters. Bond (2006) described the importance of the Scott Creek lagoon (estuary) in the growth and survival of juvenile steelhead. Juvenile steelhead were found to have faster growth rates and larger size at ocean entry when compared to juveniles that reared further upstream within the freshwater reaches of the Scott Creek system. Juvenile steelhead that reared in the estuarine/lagoon area were larger and comprised 85% of the returning adults despite being used by only 8 to 48% of the juveniles as rearing habitat, demonstrating the important survival contribution of estuarine rearing prior to emigration. Hayes et al. (2008) and Bond et al. (2008) provided further analysis and results from the Scott Creek watershed in comparing steelhead growth differences for those juveniles that reared in the riverine reaches compared to those that reared in the estuarine reach. Juvenile steelhead abundance in the estuarine reach of the Scott Creek watershed was approximately 2,500 fish in 2003, 1,500 fish in 2004, and 540 fish in 2005. The variation in abundance among years was thought to be related to the date the lagoon formed, with greater abundance in those years when the lagoon formed early and reduced abundance when the lagoon formed later in the year. Variation in rearing patterns within and among years contributed to increased diversity in juvenile steelhead rearing and migration patterns. Although representing only 5% of the available habitat area within the watershed the lagoon represented an important habitat for juvenile steelhead rearing and contributed to differential growth and survival of steelhead.

Atkinson (2010) examined juvenile steelhead rearing within the San Gregorio Creek lagoon. Juvenile steelhead were abundant and grew rapidly. Oversummering survival within the lagoon in 2005 was good (2,365 steelhead in July and 2,005 steelhead in October) with a greater decrease in population abundance observed in 2006 (2,802 steelhead in the summer declining to 1,373 in the fall). It was estimated that 55 to 64% (n=22) of the adult steelhead returning to the river had reared in the lagoon as juveniles.

Studies of the habitat conditions and rearing by juvenile steelhead within the Carmel River lagoon (Daniels et al. 2010) showed that water quality conditions, including seasonal stratification, directly affect habitat quality and the abundance of juvenile rearing steelhead within the lagoon. In this study the lagoon was not found to be used extensively by juvenile steelhead for rearing. Seasonal water quality conditions were also found to be a key factor affecting juvenile steelhead rearing within the Mattole River lagoon (Zedonis et al. 2008) with exposure to elevated water temperatures being observed as a major factor. Results of other lagoon surveys, such as that conducted in the Garrapata Creek lagoon (Casagrande and Smith 2006) showed no evidence of extended juvenile steelhead rearing within the lagoon which was hypothesized to reflect highly dynamic and unstable habitat conditions within the lagoon in response to sand bar breaching and other events. These results are consistent with the findings from Smith (1990) that showed that growth of juvenile steelhead was excellent and invertebrate abundance was high when lagoons of Pescadero, San Gregorio, and Wadell creeks were converted to freshwater and poor during periods of persistent vertical stratification of water quality (e.g., low DO in water near the bottom).

Results of field surveys showed no evidence of persistent vertical stratification in water quality within the Big Sur River lagoon. Freshwater entering the lagoon from the river was sufficient to maintain good vertical mixing within the lagoon water column, avoid stratification of water quality, maintain a low salinity freshwater and brackish (e.g., typically less than 2 ppt salinity), and maintain a breach of the sand bar that provided access between the lagoon and coastal waters throughout the summer and fall months (the lagoon sand bar blocked access during only one period while these studies were underway and resulted in a temporary increase in water depth and a reduction in salinity within the lagoon until the sand bar naturally breached).

Daniels et al. (2010) identify good water quality habitat within lagoons for juvenile steelhead rearing as:

- Dissolved oxygen concentrations greater that 5 mg/L;
- Salinity less than 10 ppt. For purposes of this habitat assessment, electrical conductivities within the lower river or lagoon in excess of 1,500 uS/cm (to be conservative a substantially lower salinity than 10ppt was used in this analysis; operational requirement prohibit the El Sur Ranch irrigation wells from operating when salinity levels are increased) were identified as potentially stressful or unsuitable juvenile steelhead rearing habitat;
- Water temperatures within the range of optimal steelhead growth (15-19 C) with maximum temperatures less than 26 C. For purposes of investigation of the Big Sur lagoon, stressful or unsuitable habitat conditions for juvenile steelhead rearing were identified by average daily temperatures greater than 20°C (68°F) or maximum daily (hourly) temperature greater than 24°C (75°F). The assessment of habitat conditions based on water temperature considered both water temperature conditions along the longitudinal gradient of the lower river and lagoon, and the identification of potential cold-water microhabitat pool refugia habitat that may provide suitable areas for juvenile steelhead to over-summer within the lower river and lagoon; and
- Water depths sufficient to reduce stratification and avoid avian predation (areas with depths greater than approximately 1.5 feet).

Habitat Conditions for Juvenile Steelhead Rearing Observed During the Big Sur River Lagoon Studies

For purposes of characterizing habitat conditions within the Big Sur River lagoon the habitat criteria described above (Daniels et al. 2010) were used in combination with results of field studies and measurements made within the lagoon area in 2004, 2006, and 2007 (Hanson Environmental 2004, 2007, 2008). Results of the 2007 studies within the Big Sur River lagoon provide the primary basis for this assessment of habitat conditions since instream flows within the river were the lowest in 2007 among the three years of the field data collections.

The lower Big Sur River (Figure 1) and adjacent habitats support a variety of fish and wildlife species. The Big Sur River provides a migratory corridor, as well as habitat for spawning, egg incubation, and juvenile rearing supporting a population of Central California Coast steelhead (*Oncorhynchus mykiss*). Steelhead inhabiting the Big Sur River have been listed as a threatened species under the federal Endangered Species Act (ESA). El Sur Ranch operates two irrigation wells located adjacent to the Big Sur River (Figure 1). A question has been raised as to whether El Sur Ranch irrigation well operations adversely affect habitat quality and availability for juvenile steelhead and other species inhabiting the lower river and lagoon.

A series of fishery habitat investigations have been designed and implemented to provide site-specific field information on instream habitat conditions within the lower reaches of the Big Sur River and the lagoon throughout the summer and early fall low flow period. These investigations began in 2004 and were continued in 2006 and 2007 to represent a range of hydrologic conditions within the Big Sur River watershed. Field survey data collection activities have been conducted as part of a multidisciplinary investigation integrating surveys of potential changes in aquatic habitat conditions in response to El Sur Ranch irrigation well operations, in addition to changes in surface water hydrology and geohydrology in the basin (SGI 2005, 2007, 2008) to provide information on the potential effects of El Sur Ranch irrigation well operations on surface waters supporting habitat for fish and wildlife

Habitat quality and availability within the lower river and lagoon for juvenile steelhead are influenced by a variety of environmental factors. These factors could include, but are not limited to, seasonal patterns in stream flows, seasonal water temperatures, dissolved oxygen concentrations, electrical conductivity, surface water connectivity among habitat units, habitat diversity, instream cover (large debris and undercut banks), riparian vegetation, substrate, availability of macroinvertebrates as prey, and a variety of other factors. Many of the factors affecting habitat quality and availability for juvenile steelhead rearing are independent of operations of the El Sur Ranch irrigation wells, such as availability of instream cover, riparian vegetation, and substrate. In our studies, it was hypothesized that other environmental parameters, such as water temperature, dissolved oxygen concentrations, electrical conductivity, and habitat connectivity might potentially be affected by irrigation well operations. To evaluate potential adverse effects of irrigation well operations on instream habitat, fishery investigations were designed to meet the following primary objectives:

(1) Determine whether or not seasonal changes occur in the lower Big Sur River and lagoon that would adversely affect habitat quality and availability for juvenile steelhead/rainbow trout (steelhead are characterized by a life history of *O. mykiss* that migrate to the ocean for a part of their life cycle but return to freshwater to spawn; rainbow trout are characterized by a life history of *O. mykiss* that remains within freshwater throughout their life span; for purposes of simplicity the term steelhead is used in this report to represent *O. mykiss* inhabiting the Big Sur River) rearing throughout the summer and fall months;

(2) Determine the geographic distribution of, relative abundance of, and habitat use within the lower Big Sur River by steelhead with respect to instream habitat parameters; and

(3) If seasonal changes in habitat quality or availability are detected within the lower river and/or lagoon, assess the potential effects of El Sur Ranch irrigation well operations on habitat conditions for steelhead and/or other sensitive wildlife. Habitat quality and availability for steelhead within the lower Big Sur River was used as an indicator of changes in overall quality of habitat conditions within the lower river and lagoon and the potential effects of habitat changes on sensitive or protected species.

Precipitation on the Big Sur coast was abnormally low during the winter and spring of 2007 resulting in dry hydrologic conditions and substantially reduced flows (critically dry) within the Big Sur River during the summer and early fall 2007. These unusually low flow conditions in 2007 offered an opportunity to conduct field measurements and investigations to evaluate the potential effects of El Sur Ranch irrigation well operations on habitat conditions within the river under critically dry hydrologic conditions. In response to the low flow conditions within the river during the late-summer 2007 field surveys were designed and implemented, using continuously recording water temperature and dissolved oxygen monitoring equipment, in addition to routine visual observations, grab sample water quality monitoring, and measurements of river flow and water depth potentially affecting fish passage and habitat connectivity. The 2007 surveys provided the best opportunity to test the potential effects of El Sur Ranch well operations on aquatic habitat conditions within the lower river, including simultaneous operation of both irrigation wells for a maximum diversion rate, in combination with critically low flows within the Big Sur River.

For purposes of this characterization, the Big Sur River lagoon has been defined as that aquatic habitat located downstream of the location of passage transect (PT) 5 from the 2007 study (Figure 2). The habitats downstream of transect 5 experience greater tidal effects on changes in water depth and water surface elevation as well as increased electrical conductivity (a measure of salinity) at locations closest to the ocean. The habitat conditions located upstream of transect 5 are characterized as riverine habitat with a more uniform channel width, constant electrical conductivity, and unidirectional downstream flow.

The purpose of this assessment was to characterize primary water quality conditions and habitat conditions that would affect the suitability of habitat within the lagoon for juvenile steelhead rearing. The water quality parameters of greatest interest were water temperature, dissolved oxygen (DO), and electrical conductivity (salinity) and data charactering these parameters was collected throughout the 2007 study period. In addition information was collected on vertical stratification of water quality conditions and freshwater flows entering the lagoon that maintain mixed conditions within the water column, and observations of juvenile steelhead rearing within the lagoon.

Lagoon Characteristics

Results of the 2007 water quality and fishery habitat surveys conducted within the lower reaches of the Big Sur River are summarized below. 2007 represents the third year of investigations within the lower river. Results of previous studies conducted in 2004 and 2006 provide important information on habitat conditions affecting steelhead inhabiting the river and lagoon. Hydrologic conditions within the Big Sur River watershed in 2007 were extremely dry and river flows during September 2007 were classified as critical which offered an opportunity to investigate the characteristics of the lower river and lagoon under critically dry instream flow conditions when habitat conditions for juvenile steelhead rearing would be expected to be most severe. As part of the 2004 and 2007 studies snorkel surveys were conducted to characterize the distribution and relative abundance of juvenile steelhead rearing in the lower river and lagoon (Figure 3). Results of both years of fishery surveys showed that approximately 350 to 400 juvenile steelhead reared in the lower reaches of the river. This density of juvenile steelhead is substantially lower than juvenile densities reported for Scott Creek (Bond 2006, Hayes et al. 2008, Bond et al. 2008) and in San Gregorio lagoon (Atkinson 2010) where estimated juvenile abundance ranged from approximately 550 to 2,500 fish. Based on the good habitat conditions and low density of rearing steelhead it appears that the Big Sur River lagoon is not at carrying capacity for juvenile steelhead rearing under current conditions. Other factors such as lack of access to suitable spawning habitat as a result of both impassable barriers to migration located approximately 6 miles upstream from the lagoon as well as limited amounts of suitable gravel for spawning in the lower reaches of the river may be reducing juvenile rearing densities within the lagoon to levels that appear to be less than carrying capacity.

Water temperature

Results of water temperature monitoring within the Big Sur River during the 2004 and 2006 studies showed that late summer and early fall water temperatures within the lagoon were within the range considered to be suitable for juvenile rearing habitat. Observations made during the dry year 2004 snorkel surveys showed that the juvenile steelhead inhabiting the lower reaches of the river and lagoon appeared to be growing at a rate comparable or greater than that reported for many other California rivers, showed evidence of smolting characteristics, and appeared active and in good condition (Hanson Environmental 2005). The observations of the 2004 and 2007 snorkel surveys are consistent and support the general finding that water temperatures were suitable for juvenile rearing. Results of our studies showed evidence of a localized area in the vicinity of Creamery Meadow (primarily along the right bank of the river) upstream of the lagoon where water temperatures were observed to be cooler than those observed either upstream or downstream. The cooler temperatures were attributed to localized groundwater upwelling into the river. It was hypothesized that this localized area of cooler water temperatures might provide a thermal refuge for juvenile steelhead, if needed, in response to elevated water temperatures in the lower river. During our studies, which included a summer under critically low flow conditions, water temperatures were suitable for juvenile steelhead rearing throughout the lower river and lagoon and hence there was no biological benefit to steelhead to preferentially inhabit the localized area where coldwater upwelling was detected.

Results of water temperature monitoring in the lower Big Sur River during the 2007 study are similar and consistent with results from the earlier surveys. Hourly and average daily water temperatures measured at each location during 2007 are shown in Figures 4 through 13, extending from passage transects (PT) 1 through 5. For reference a horizontal line has been included on each temperature graph showing the average daily temperature criterion of 20°C (68°C) and the hourly criterion of 24°C (75°C) selected for use in this study to assess the suitability of water temperatures for juvenile steelhead rearing.

Results of the 2007 water temperature monitoring showed a typical pattern of daily variation in temperatures which were within the range of 5-7°C (9-13°F) (daily minimum to daily maximum) or less. The results also show a general pattern of seasonally declining water temperatures between early September and early October reflecting seasonal cooling in atmospheric temperatures (particularly cooling at night during the fall) with a corresponding trend of reduced river temperatures. Both average daily and maximum hourly water temperatures at all location monitored within the lagoon during the 2007 study were within the range suitable for juvenile steelhead rearing.

Dissolved oxygen concentrations

Results of monitoring during the 2004 surveys showed evidence of localized reductions in dissolved oxygen concentrations in the vicinity of Creamery Meadow, located upstream of the lagoon, that are the result of localized groundwater upwelling along the right bank of the river. Evidence of localized groundwater upwelling was consistent with observations of reduced water temperatures in the same areas as reduced dissolved oxygen concentrations. Under conditions of higher river flows, such as those during the 2006 studies, the higher flows reduce the influence of localized groundwater upwelling on changes in dissolved oxygen by providing greater dilution and more rapid mixing.

Results of dissolved oxygen measurements during periodic water quality surveys (grab samples) during 2007 are presented in Figures 14 through 18 for the lagoon area (PT1 through PT5). Results of the 2007 habitat and water quality monitoring are consistent with findings of the 2004 and 2006 studies in showing that dissolved oxygen concentrations were above 6 mg/L consistently at PT1, PT2, and PT3 (main lagoon sites) and would not adversely affect habitat quality and availability for steelhead rearing within the lower river or lagoon. Dissolved oxygen levels in 2007 were observed to be less than 6 mg/L during one survey at PT4 and PT5, located downstream of the area where groundwater upwelling has been detected, that would adversely affect local dissolved oxygen concentrations. Groundwater upwelling was observed to result in cooler water temperatures and reduced dissolved oxygen concentrations within a very localized area of the river channel (localized to the right bank of the river and not extending either across the entire river channel with the exception of one survey date in early September 2007, or more than several hundred feet downstream) before mixing with surface water within the river channel had completely occurred. Dissolved oxygen concentrations at PT4 (Figure 17) and PT 5 (Figure 18) were less than 6 mg/L on the left bank, center, and right bank measurements on September 5, 2007. The flow in the river on September 5 was the lowest of any of the flows measured during the 2007 surveys. The flow at velocity transect VT1 was 1.62 cfs, the flow at VT2 was 1.34 cfs, and the flow at VT3 was 0.35 cfs (Hanson Environmental 2008). Under these extremely low-flow conditions the effects of groundwater upwelling were most pronounced. Dissolved oxygen concentrations increased to above 6 mg/L by the next survey (September 12, 2007) when flow at VT1 was 5.03 cfs (Hanson Environmental 2008) and dissolved oxygen concentrations remained above 6 mg/L over the remainder of the 2007 study period. Dissolved oxygen concentrations are typically higher during years when river flows are high and are decreased when river flows are critically low. Results of these studies are also consistent with the hypothesis that localized groundwater upwelling results in locally reduced dissolved concentrations in the vicinity of Creamery Meadow upstream of the upper lagoon and that these effects are greater when river flows are low.

Electrical conductivity

Results of habitat surveys and snorkel surveys conducted within the lower river and lagoon during 2004 showed that juvenile steelhead inhabited salinities ranging from freshwater in the upper reaches of the river to brackish water habitat within the lagoon. Salinities were typically lower in the river and lagoon during 2006 when flows were higher with the brackish waters of the lagoon extending further upstream when river flows are low, e.g., 2004 and 2007. The distribution of salinity within the lower river is also affected by opening and closing of the lagoon connection to the ocean by formation of the sand bar. Juvenile steelhead have a relatively high tolerance to salinity and have been reported to rear in estuaries and lagoons prior to emigrating to the ocean.

During the 2007 study period, electrical conductivity (a measure of salinity) was measured during the periodic water quality surveys as shown in Figures 19 through 23 for passage transects 1 through 5. During the surveys electrical conductivity in the lagoon increased in late-September but appeared to be related to waves overtopping the sand bar and was independent of irrigation well operations. Electrical conductivity at locations upstream of the lagoon remained constant throughout the study period. Based on results of the 2007 studies and similar results from the 2004 and 2006 studies, there was no evidence that salinities in the lagoon or lower river exceeded the suitable range for juvenile steelhead rearing.

Distribution and relative abundance (density) of steelhead

Conditions were ideal for snorkel surveys during October 2007. Visibility was 12-20 feet and the river was less than 30 feet wide in most areas which allowed for total lateral coverage. The exceptions were in subreach D (Figure 3) where instream brush filled the channel, and in the lagoon (subreach A) where the river width exceeded the effective visibility. The potential for avoidance and counting more than once was high in these two reaches. Characteristics of each survey reach are summarized in Table 1.

Four species of fish were observed during snorkel surveys in October 2007. In order of abundance, steelhead (*O. mykiss*), three-spine stickleback (*Gasterosteus aculeatus*), riffle sculpin (*Cottus gulosus*), and starry flounder (*Platichthys stellatus*) were observed. Additionally, signal crayfish (*Pacifasticus leniusculus*) were observed. Thus, the classical coastal stream fish assemblage was observed during these surveys.

A total of 380 steelhead were observed during the October 2007 snorkel survey. Juvenile steelhead were observed in all subreaches (Figures 24 and 25) with the exception of subreach H (Figure 3). The steelhead observed rearing in the river and lagoon were almost exclusively juveniles including young-of-year (YOY) and yearlings (Figure 26; Table 2). Observed densities were highest from the lagoon through mile 0.24 upstream from the lagoon above which densities sharply declined in subreach C (Table 3). Subreaches A, B, D and F possessed both the highest numbers and highest relative densities of steelhead (0.03 - 0.49 individuals per linear foot (No/ft)). Reaches C, E, G, and H had relatively low densities of steelhead (0.0-0.007/ft). As in 2004, the lagoon reach had the highest density of juvenile steelhead. The number of steelhead observed in the lagoon reach was 2.5 times greater than all other reaches combined.

In general, the highest observed steelhead densities were in habitat units with extensive cover combined with deep water where large schools were observed (primarily within the lagoon). Peak densities (0.05-0.49 individuals per linear ft) occurred in subreaches A through F (Figure 3; Table 3) where most of the preferred rearing habitat occurred (the availability of deeper pools and instream cover was greater in the lower reaches of the river when compared to stream habitat conditions located further upstream). Localized densities within subreaches were often 10 times greater than the overall average as young steelhead tended to congregate in tight schools in specific areas of habitat units (e.g., non-random habitat use). The primary habitat utilized by juvenile steelhead included cover in the form of large woody debris (LWD) or instream brush located adjacent to deep pools

(>3 feet of water). We hypothesize that the distribution of juvenile steelhead within and between subreaches was primarily a reflection of available habitat. Preferred habitat appeared to be deep water pools combined with a cover component such as that observed within the lagoon. Available cover appeared to be limiting in several of the subreaches surveyed and observed steelhead densities were correspondingly low. No obvious limiting factors to juvenile steelhead survival were observed during the surveys. Spawning habitat was marginal throughout the sample reach due to substrate size and abundant fines.

Classical smolting characteristics (e.g., silvery scales with minimal parr marks) were observed in all steelhead within the lagoon (subreach A). Approximately 70% were fully smolted and the remaining were silvery parr. All steelhead observed upstream of the lagoon reach were parr.

YOY and yearling steelhead were observed during the surveys. Estimated lengths ranged from 60-300 mm with the majority of juvenile steelhead ranging in length between 100 mm and 200 mm. Length frequency distributions varied significantly between reaches, with the majority of the steelhead (100-300 mm) inhabiting the lagoon.

One wild adult steelhead approximately 650 mm in length was observed during the survey. The adult steelhead was observed in subreach F (Figure 3) holding in a lateral scour depression. The adult steelhead appeared emaciated but did not look as though it had spawned as there were no abrasions on the caudal fin. The adult may have been attracted into the river by increased flow caused by early October rains in the area as there was evidence of recent increased flows on the stream banks.

SUMMARY OF FINDINGS

Based on field observations and measurements made during the late summer and early fall of three years having substantially differing instream flows, including 2007 which was a critically dry summer, it was concluded that the lower river and lagoon are in good condition, provide suitable habitat for juvenile steelhead rearing and migration, and supported populations of juvenile steelhead that were healthy and in good physical condition. The juvenile steelhead observed in 2004 experienced good oversummer survival and good growth. A similar number of juvenile steelhead were observed inhabiting the lower river and lagoon during the critically low flow summer of 2007 and were in good condition. There was no evidence from this study that water quality conditions, physical habitat, fish or avian predation, or connectivity among habitats was limiting the population of juvenile steelhead inhabiting and rearing within the lower Big Sur River and lagoon.

Results of studies conducted in 2004, 2006, and 2007 provide important information on habitat conditions affecting steelhead and other aquatic resources inhabiting the river and lagoon. Results of habitat surveys and snorkel surveys conducted within the lower river during 2004 showed that juvenile steelhead inhabited salinities ranging from freshwater in the upper reaches of the river to brackish water habitat within the lagoon. Salinities were typically lower in the river during 2006 when flows were higher with the brackish waters of the lagoon extending further upstream when river flows are low. Observations during the three years of study showed that salinity/electrical conductivity within the lagoon was influenced by coastal waves overtopping the sand bar and introducing saltwater (and kelp and other marine vegetation) into the lagoon, closure of the lagoon mouth, and surface flow within the river. The EC at the two locations within the lagoon closest to the ocean was significantly higher ($P<0.05$) than EC measured in the river upstream of the lagoon.

Juvenile steelhead were observed inhabiting the lower river in 2007 with the greatest densities in the lower portion of the river and lagoon where habitat conditions (pool depth, cover, etc.) appeared to be most suitable. A total of 380 steelhead, including young-of-the-year and yearlings (demonstrating successful spawning and egg incubation in the river) and one adult were observed in the study reach. The juvenile steelhead all appeared to be healthy and in good condition with those fish inhabiting the lagoon area showing evidence of smolting in preparation for migration to the ocean. As a result of the critical hydrologic conditions that were observed in September 2007, naturally occurring habitat conditions for juvenile steelhead rearing were at or near worst possible conditions. There was no evidence from the 2004, 2006, or 2007 studies that indicated that that habitat conditions within the lagoon were a limiting factor affecting the ability of juvenile steelhead to successfully rear within the lower reaches of the Big Sur River.

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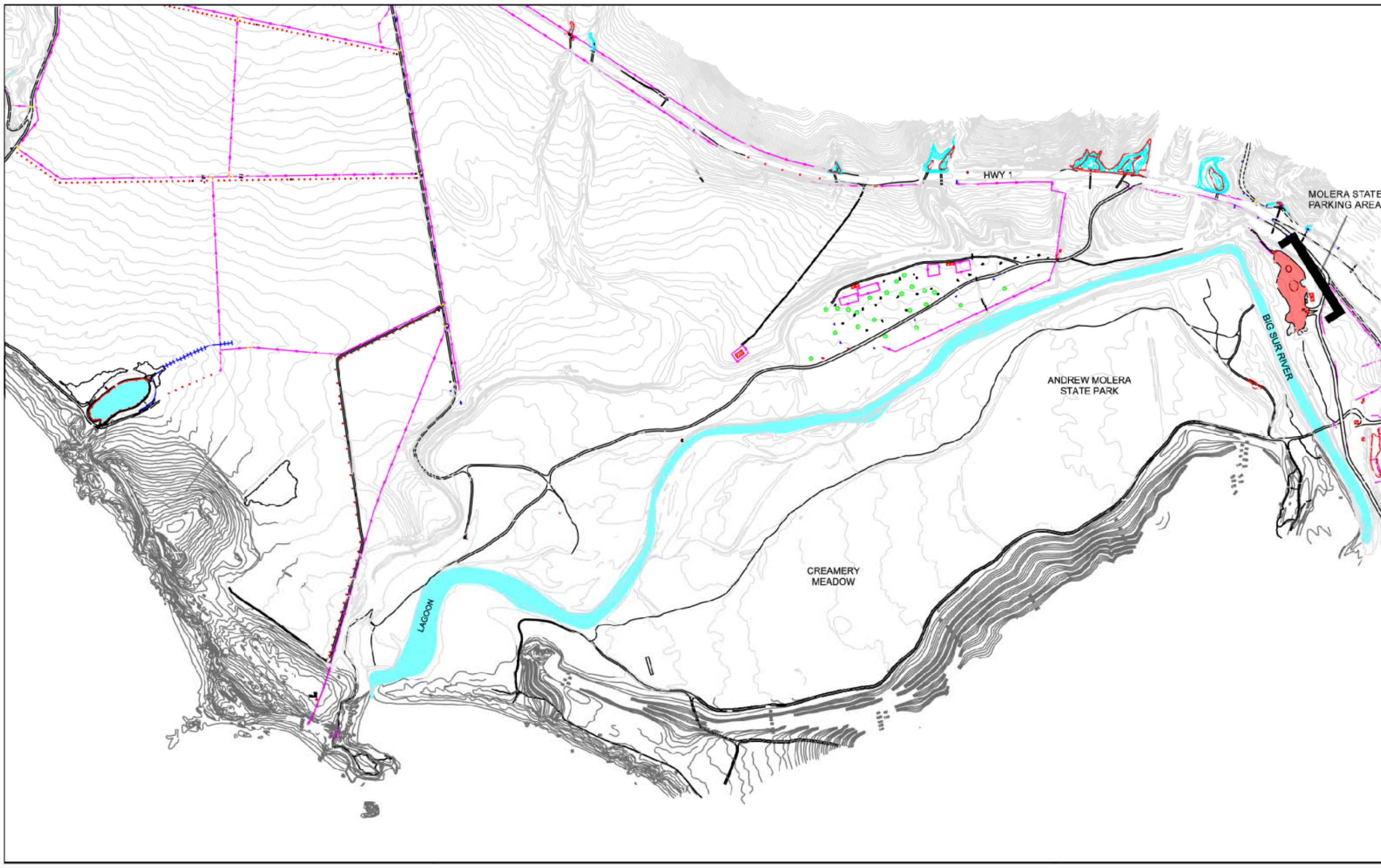

FIGURE 1. The lower Big Sur River and surrounding area.

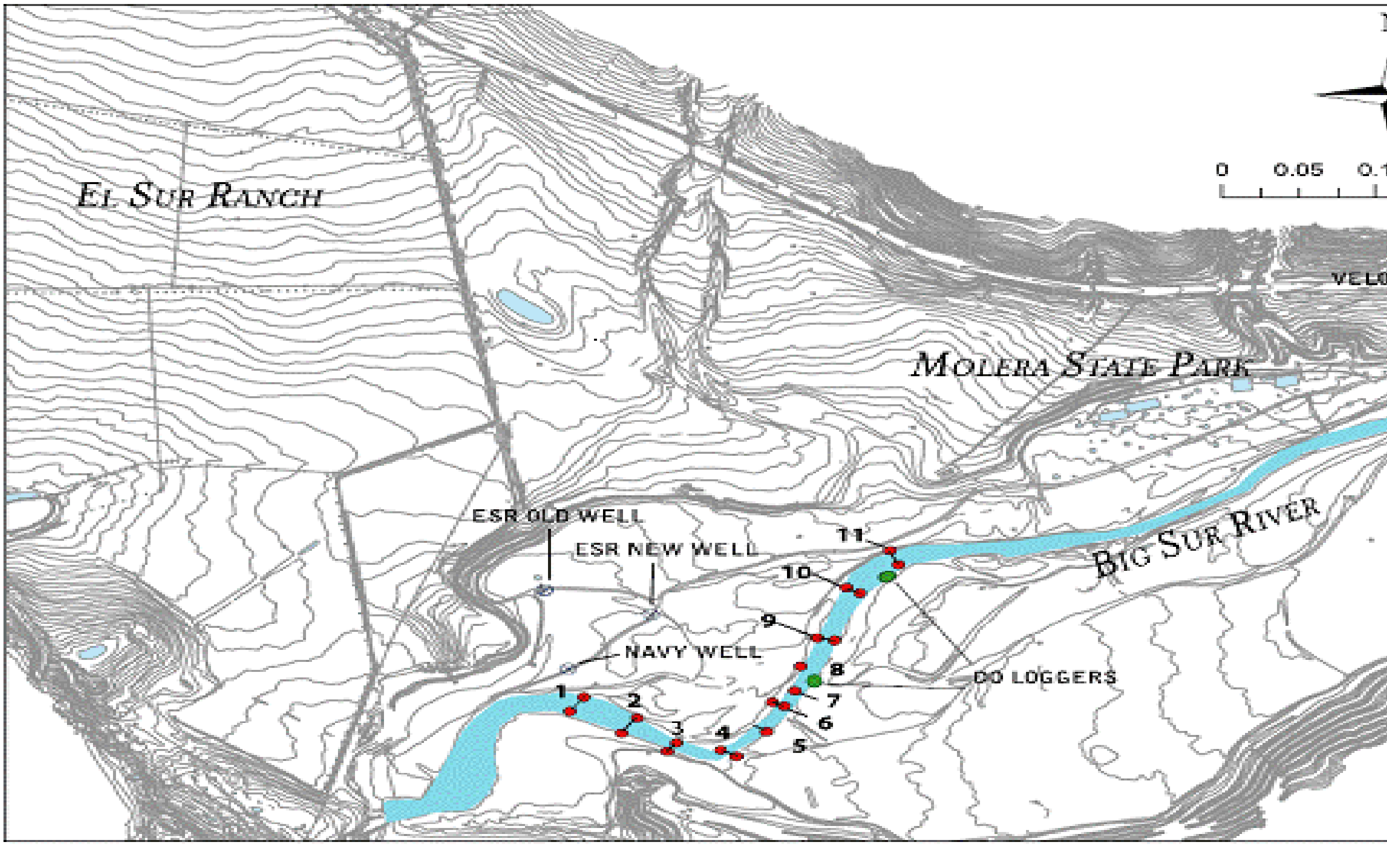

FIGURE 2. Passage transects monitored during the 2007 study period.

FIGURE 3. Subreach locations for snorkel surveys conducted on the Big Sur River, CA. Upper subreach boundaries are shown with the subreach letter.

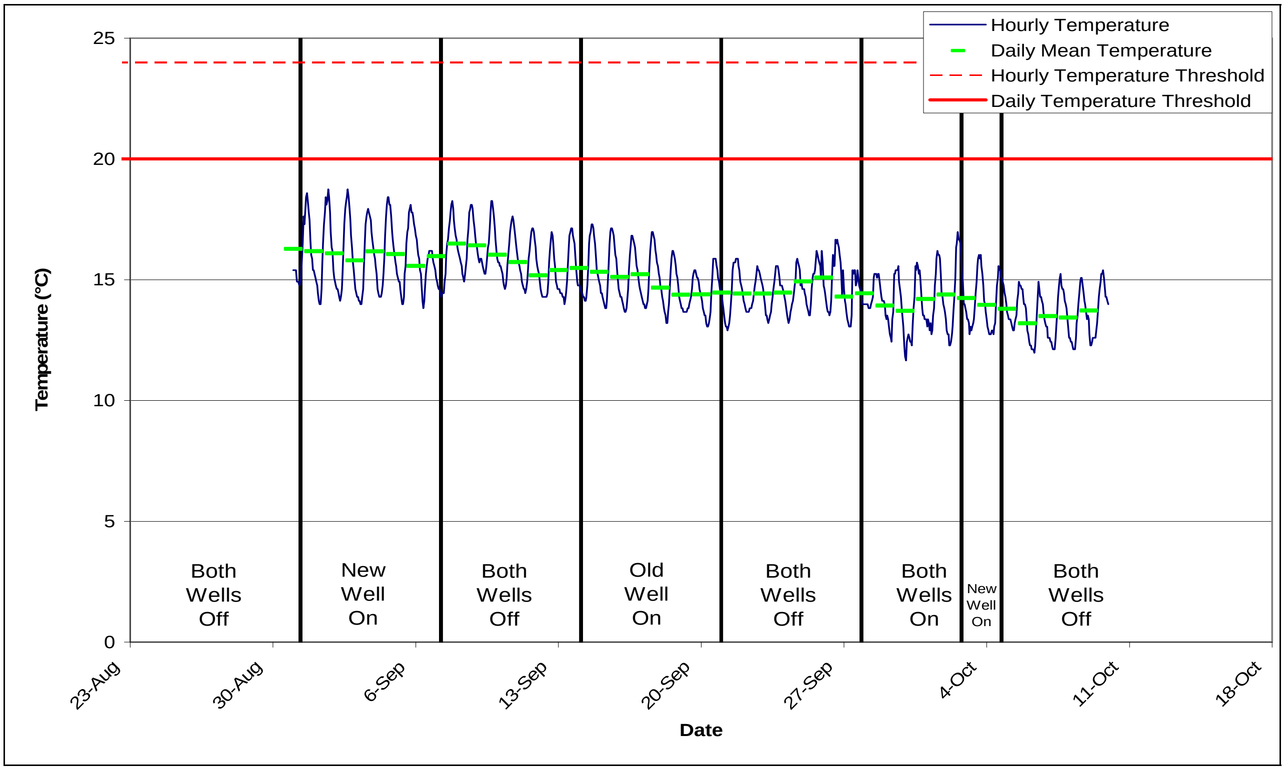

FIGURE 4. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 1, right bank.

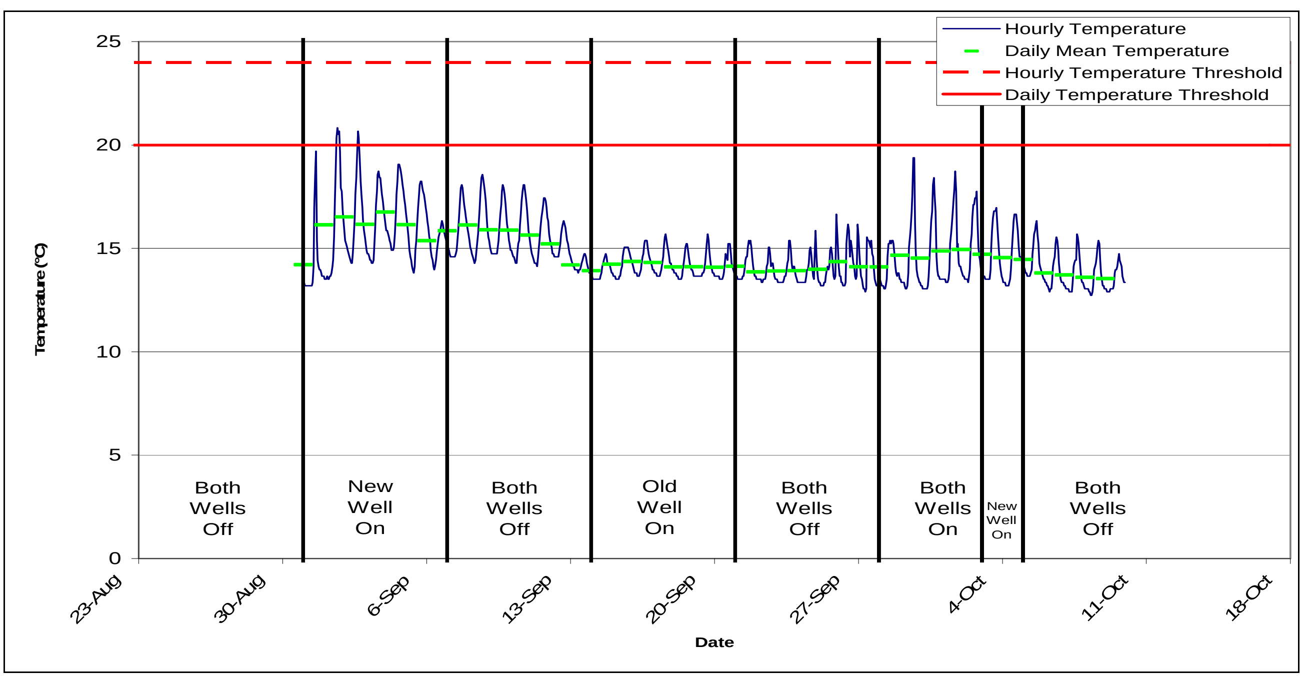

FIGURE 5. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 1, left bank.

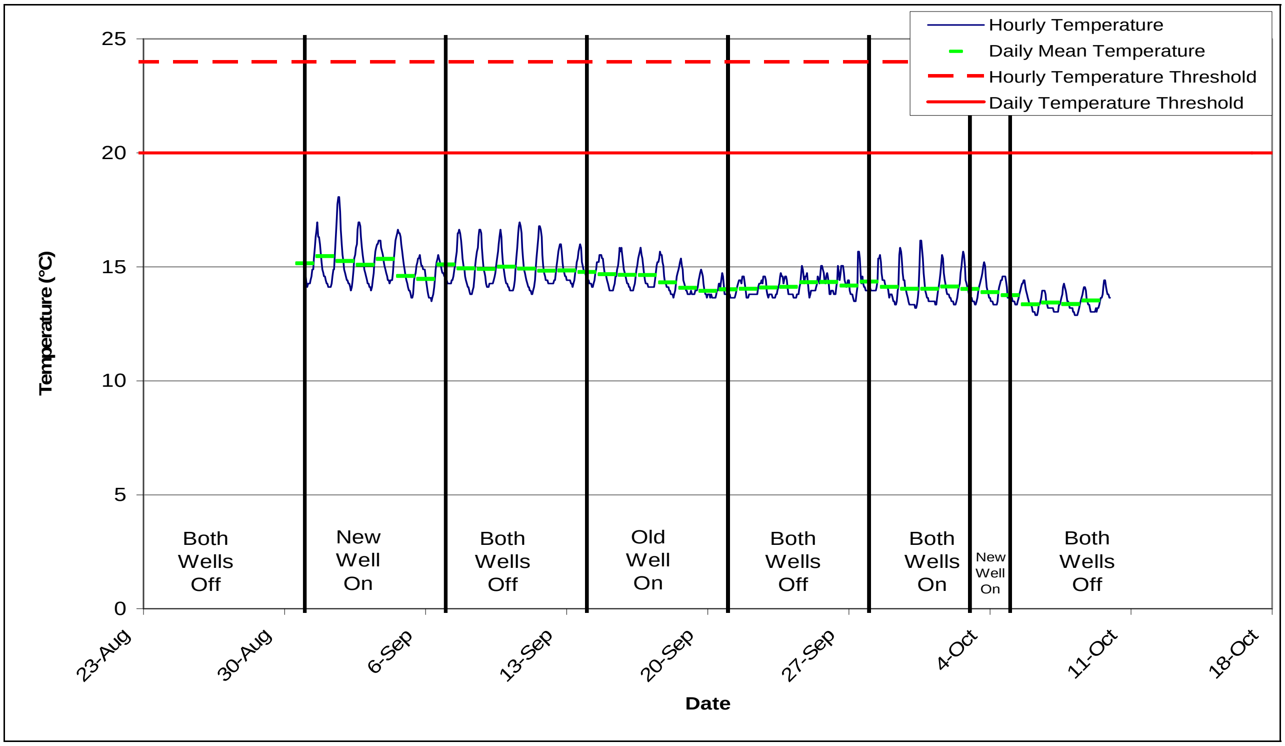

FIGURE 6. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 2, right bank.

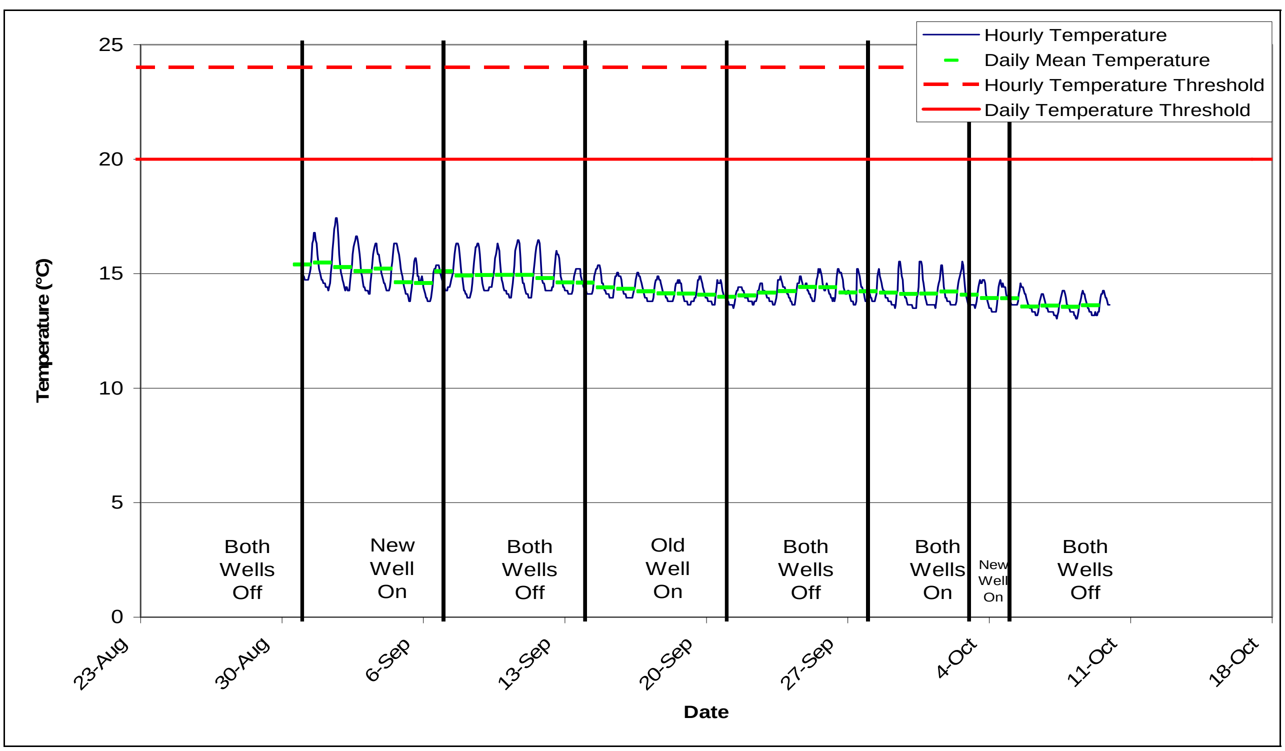

FIGURE 7. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 2, left bank.

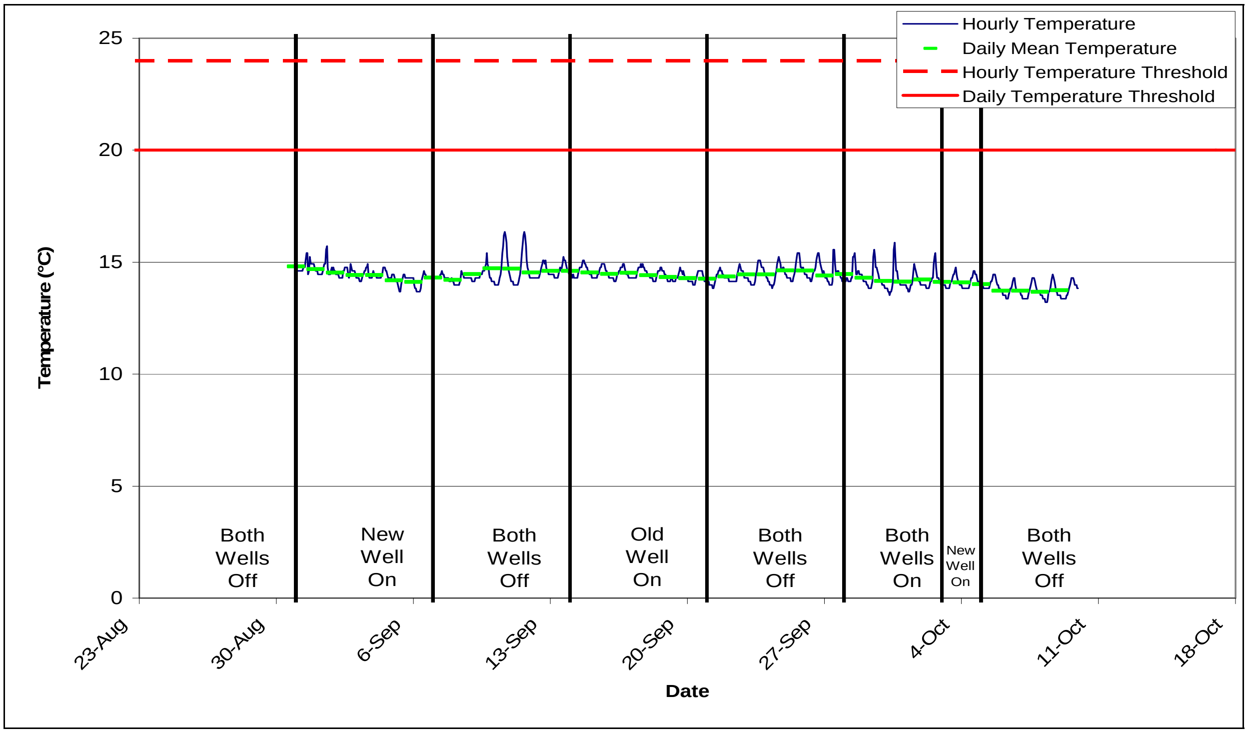

FIGURE 8. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 3, right bank.

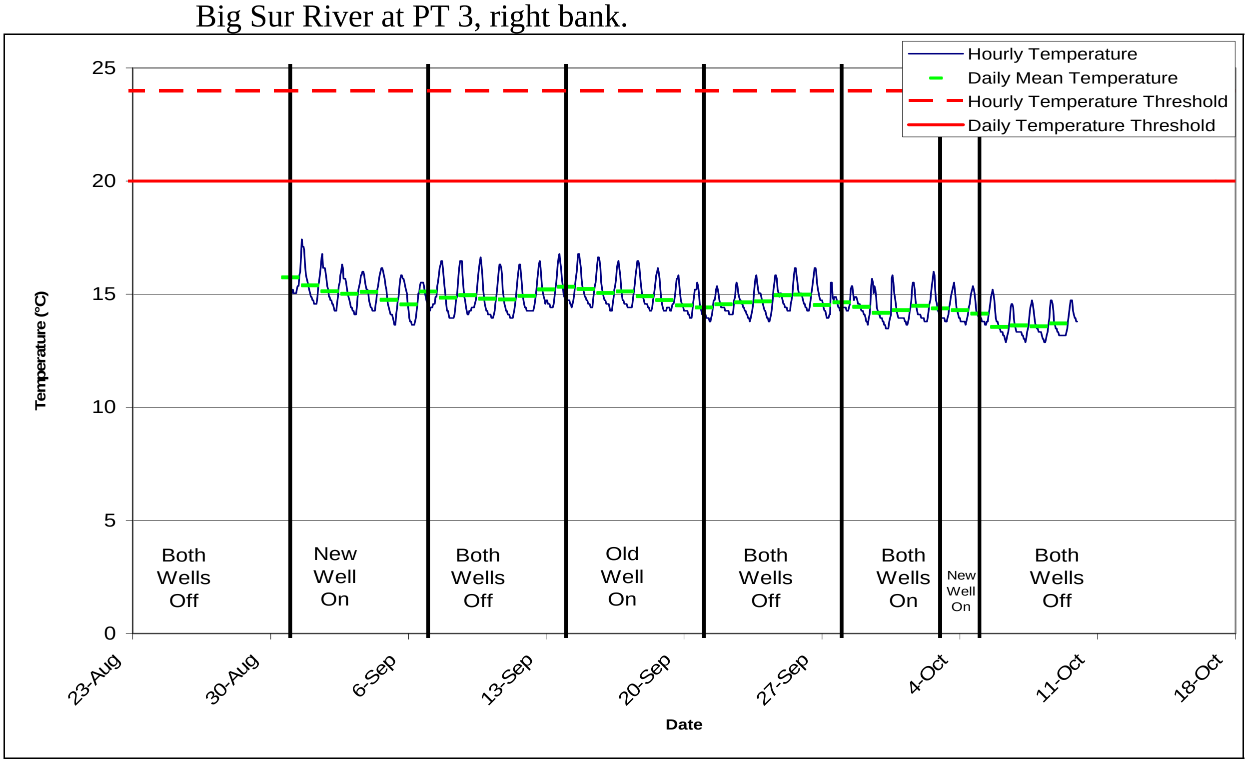

FIGURE 9. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 3, left bank.

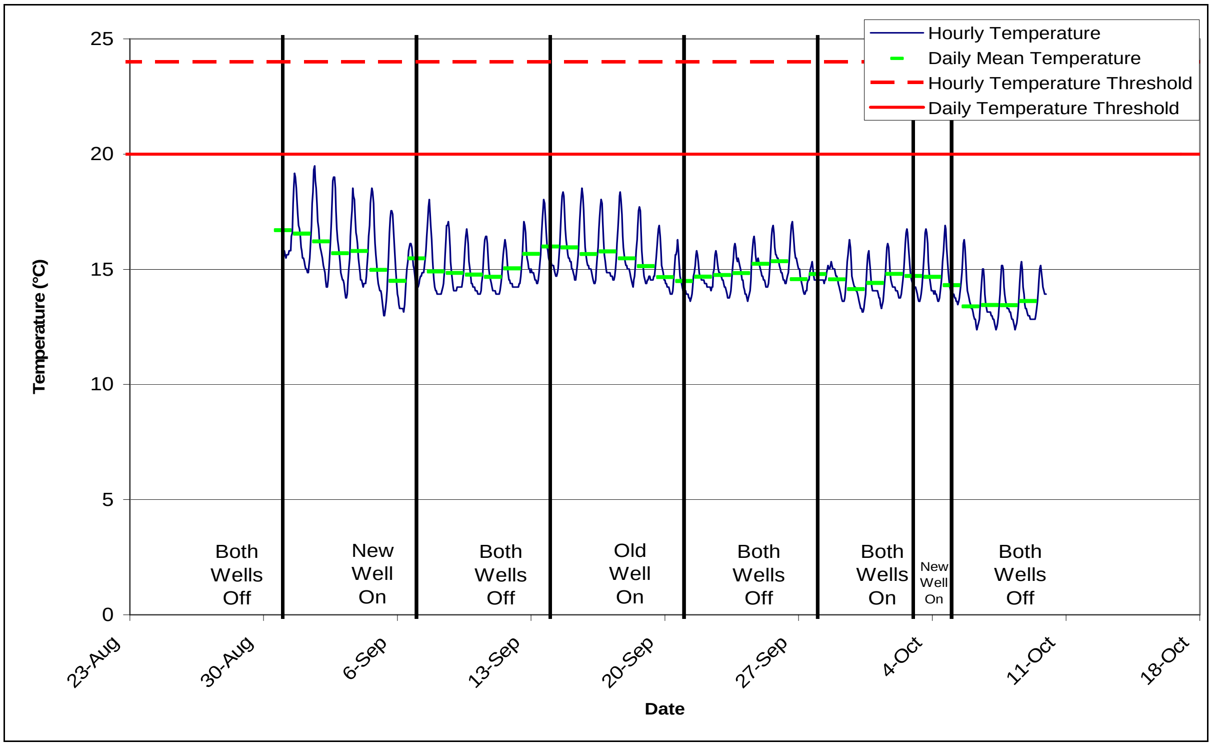

FIGURE 10. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 4, right bank.

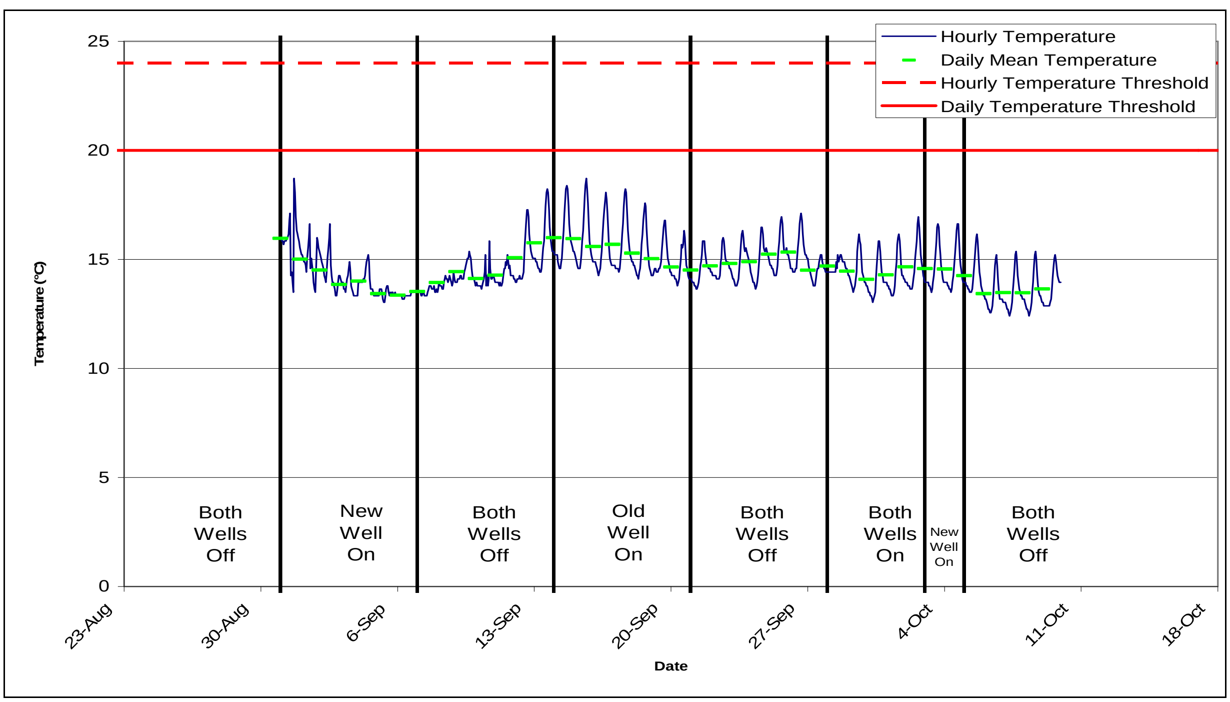

FIGURE 11. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 4, left bank.

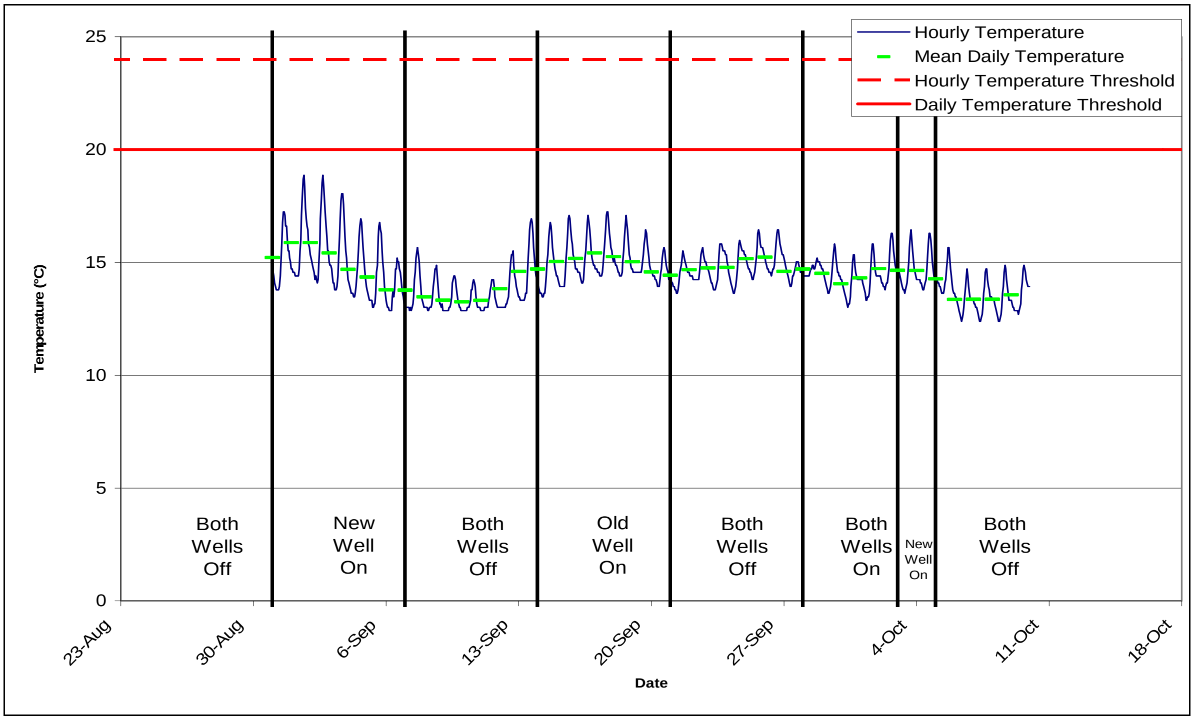

FIGURE 12. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 5, right bank.

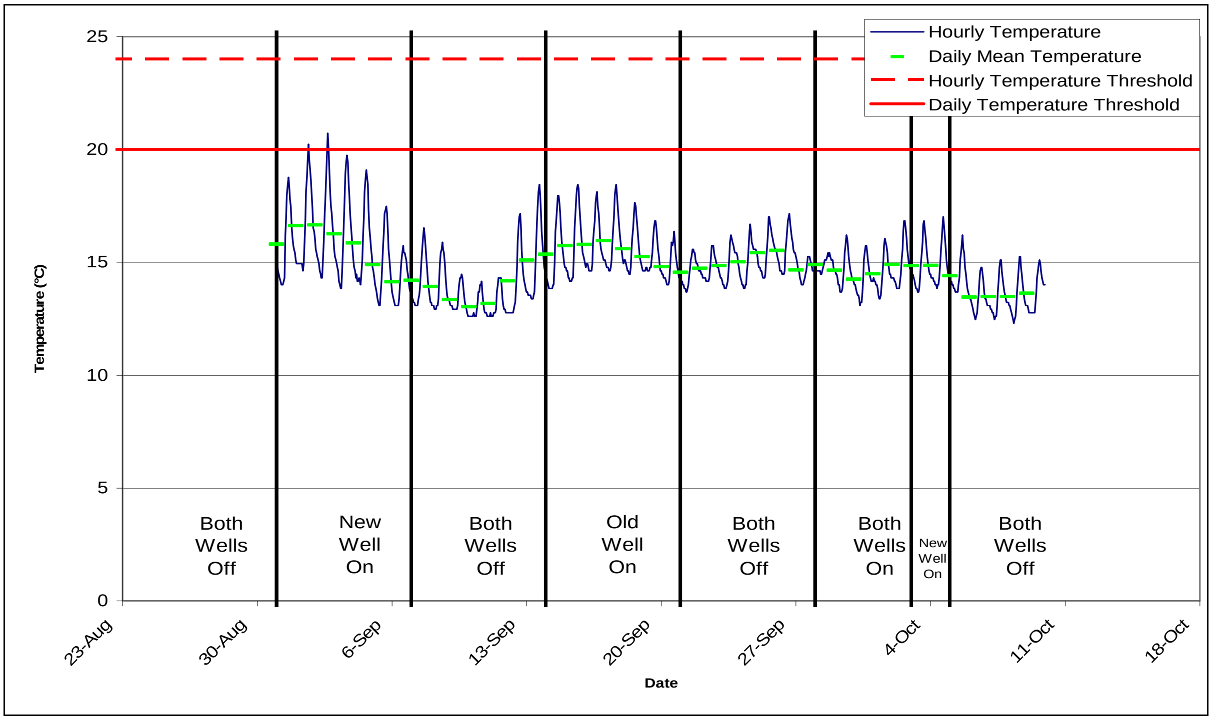

FIGURE 13. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 5, left bank.

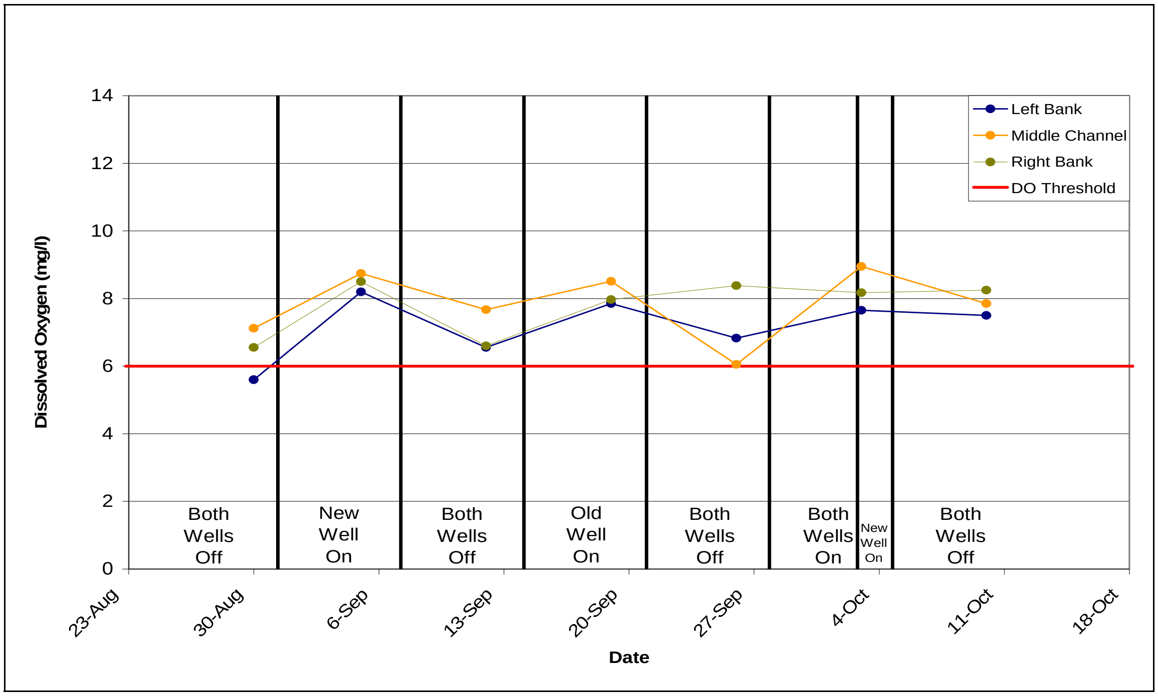

Figure 14. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 1.

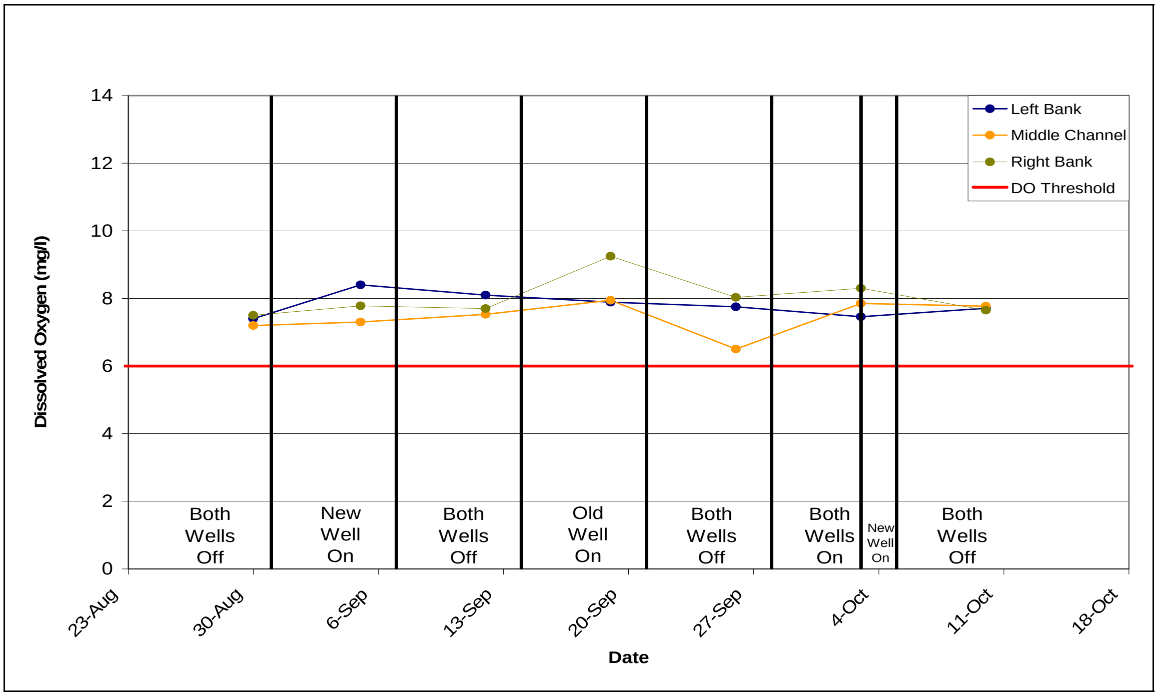

Figure 15. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 2.

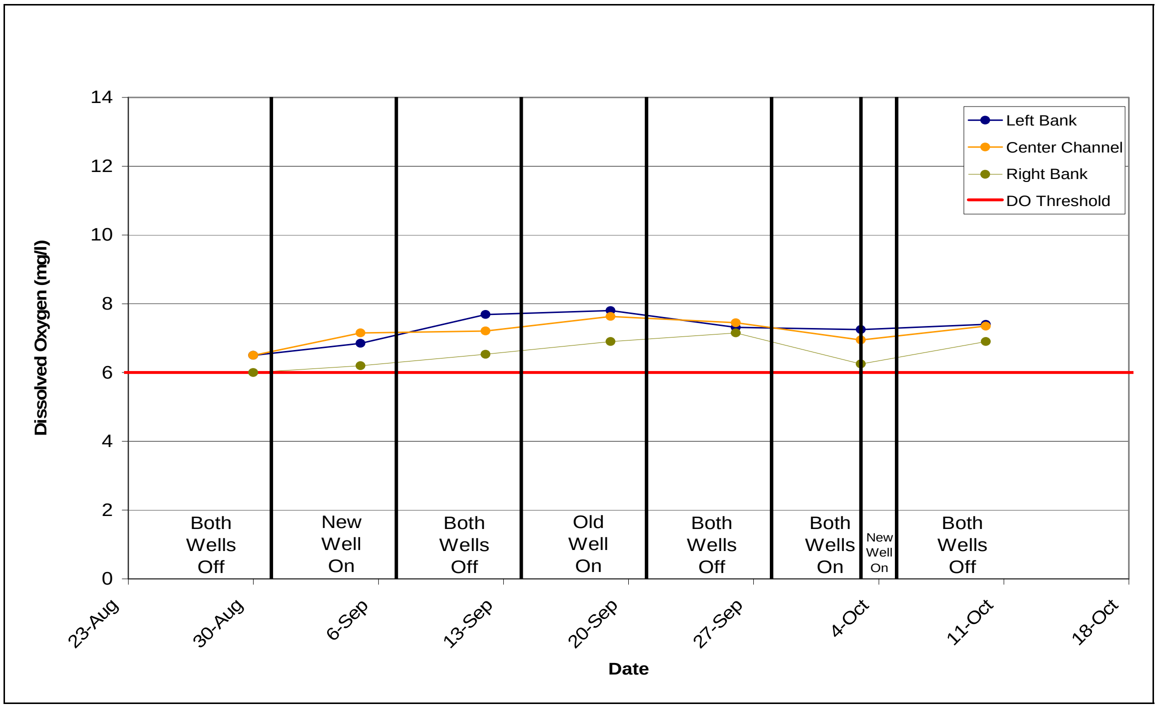

Figure 16. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 3.

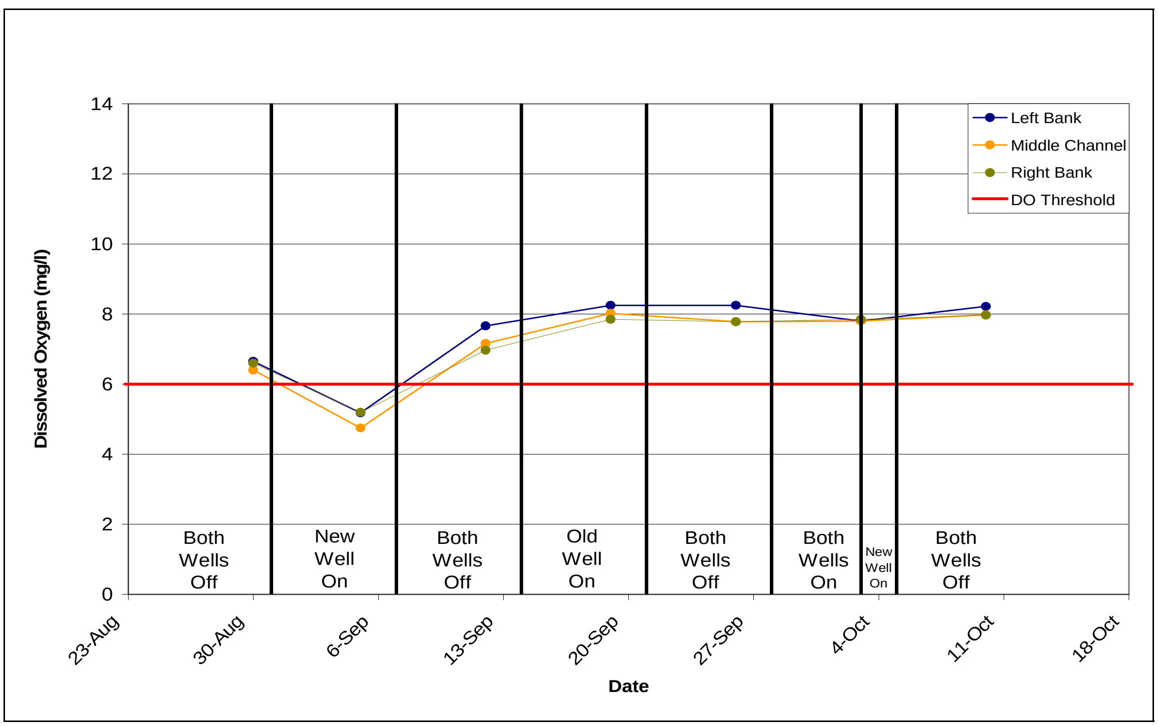

Figure 17. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 4.

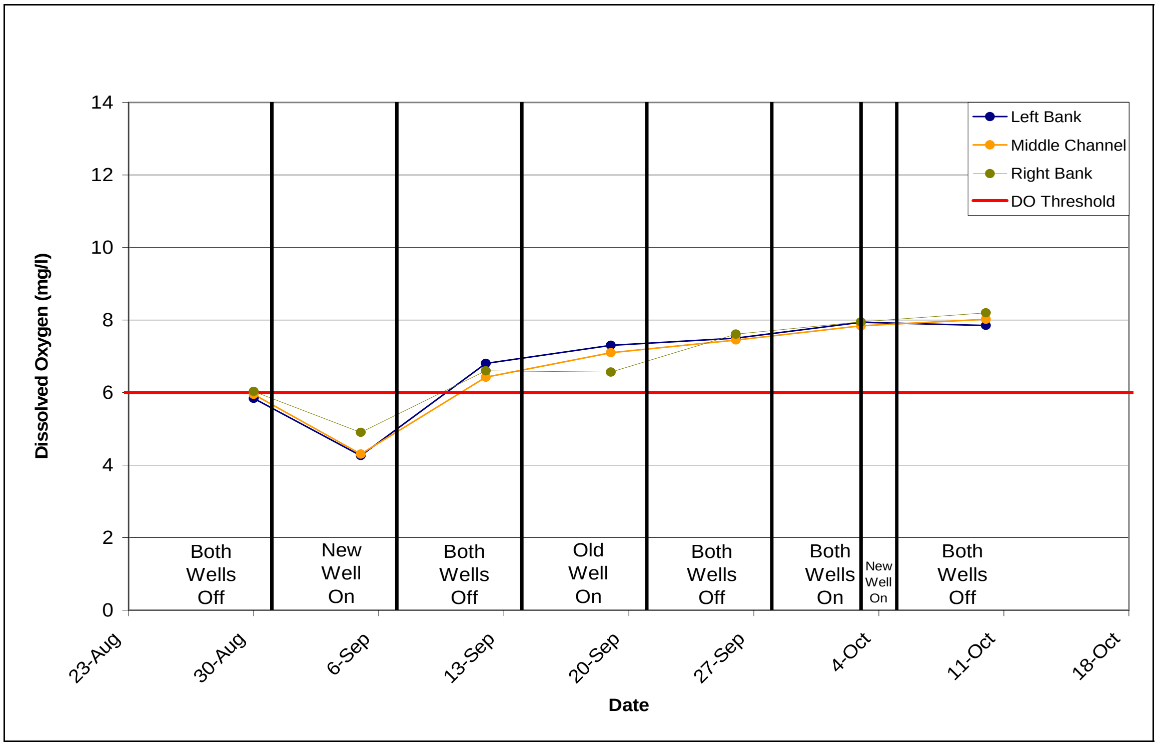

Figure 18. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 5.

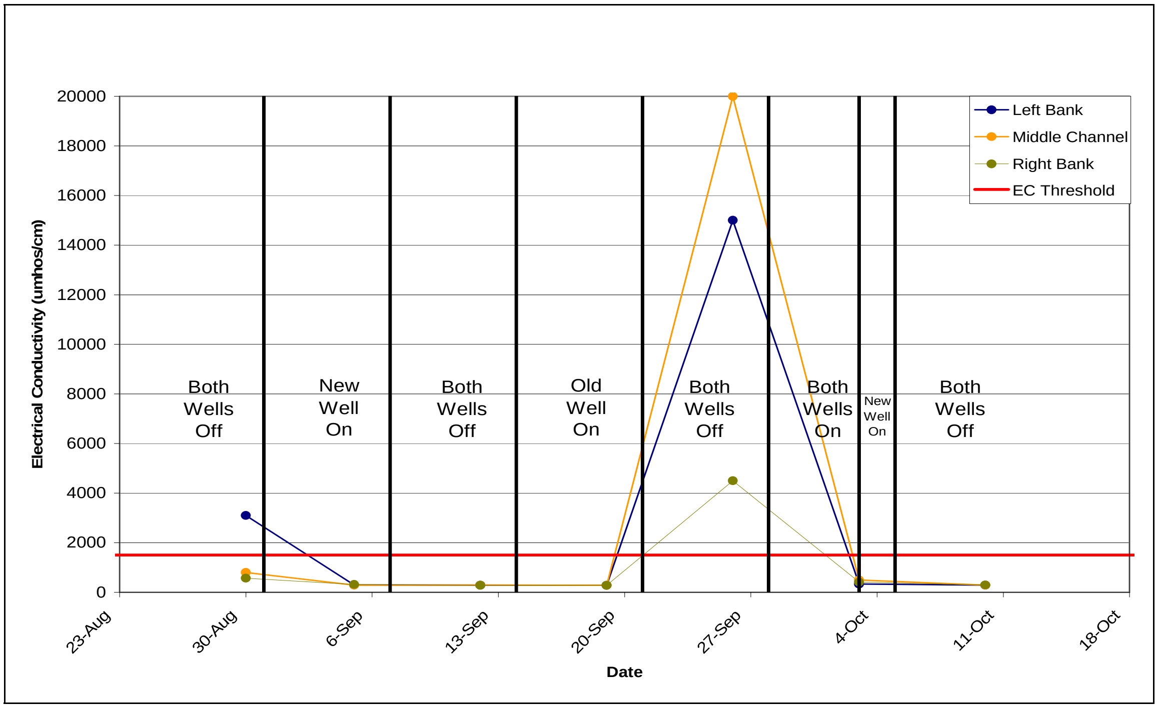

Figure 19. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 1.

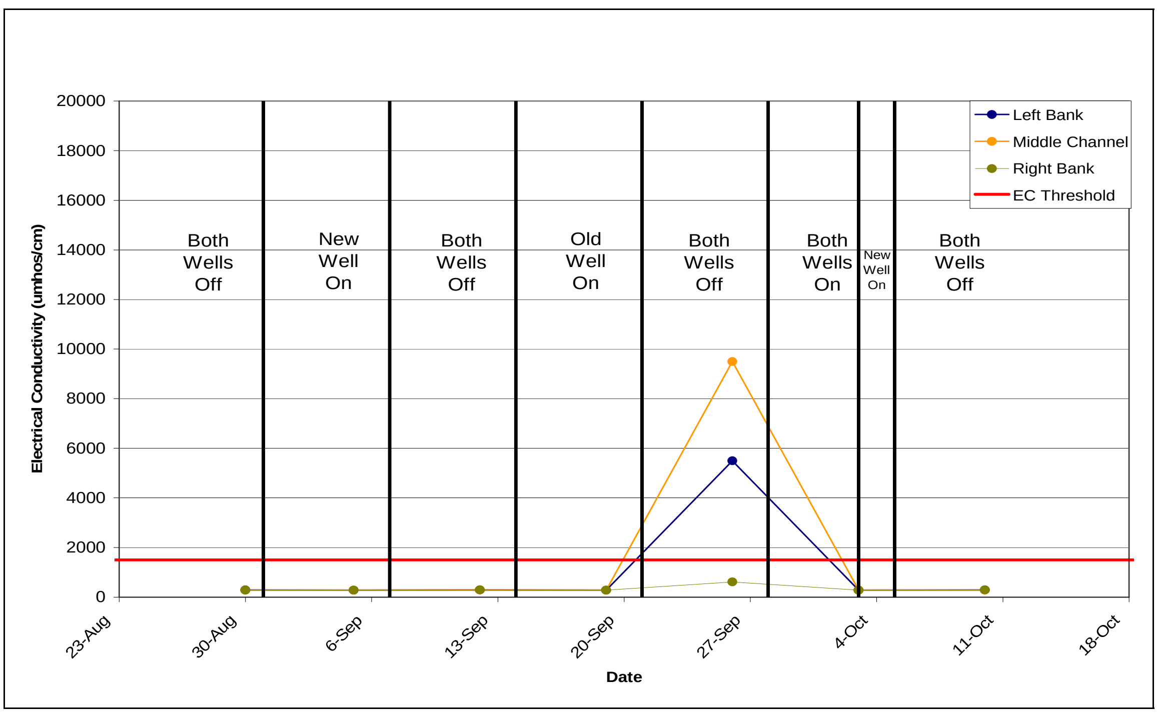

Figure 20. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 2.

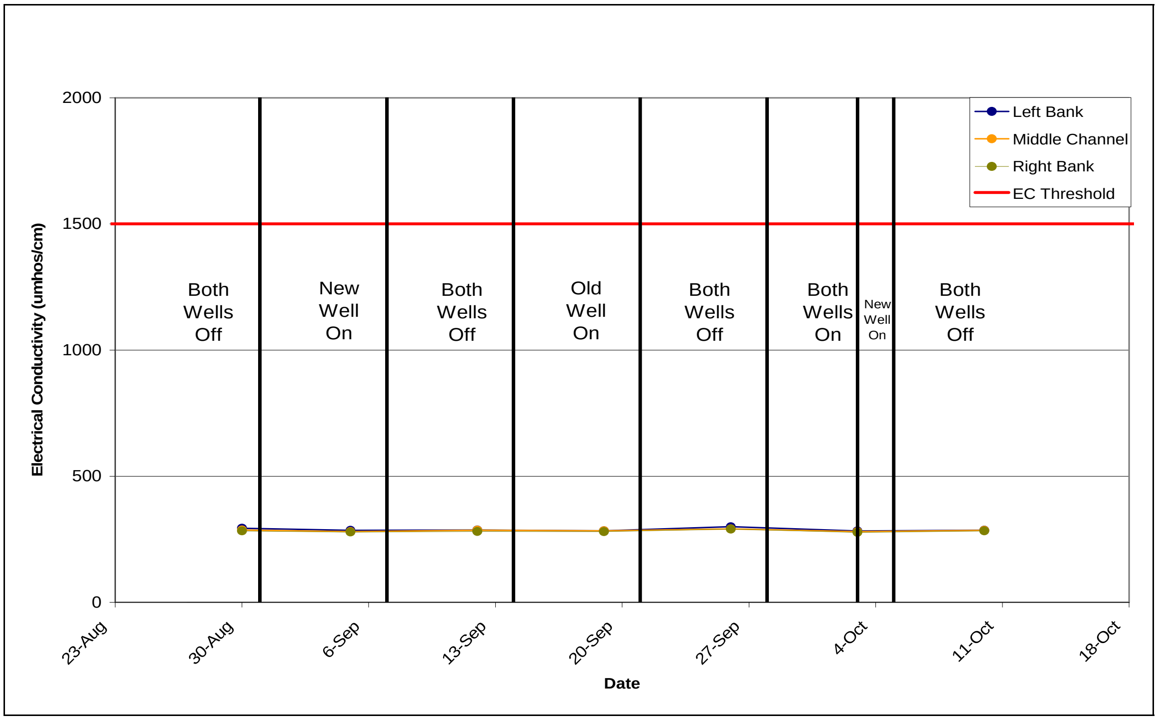

Figure 21. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 3.

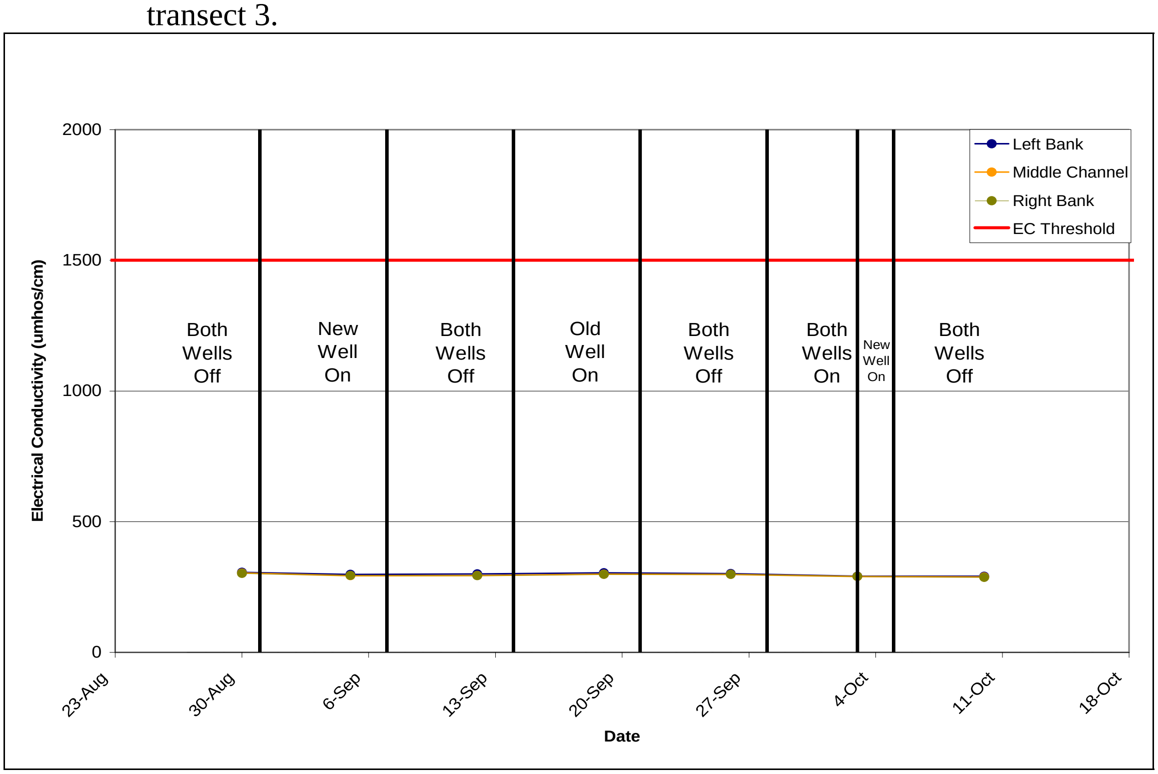

Figure 22. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 4.

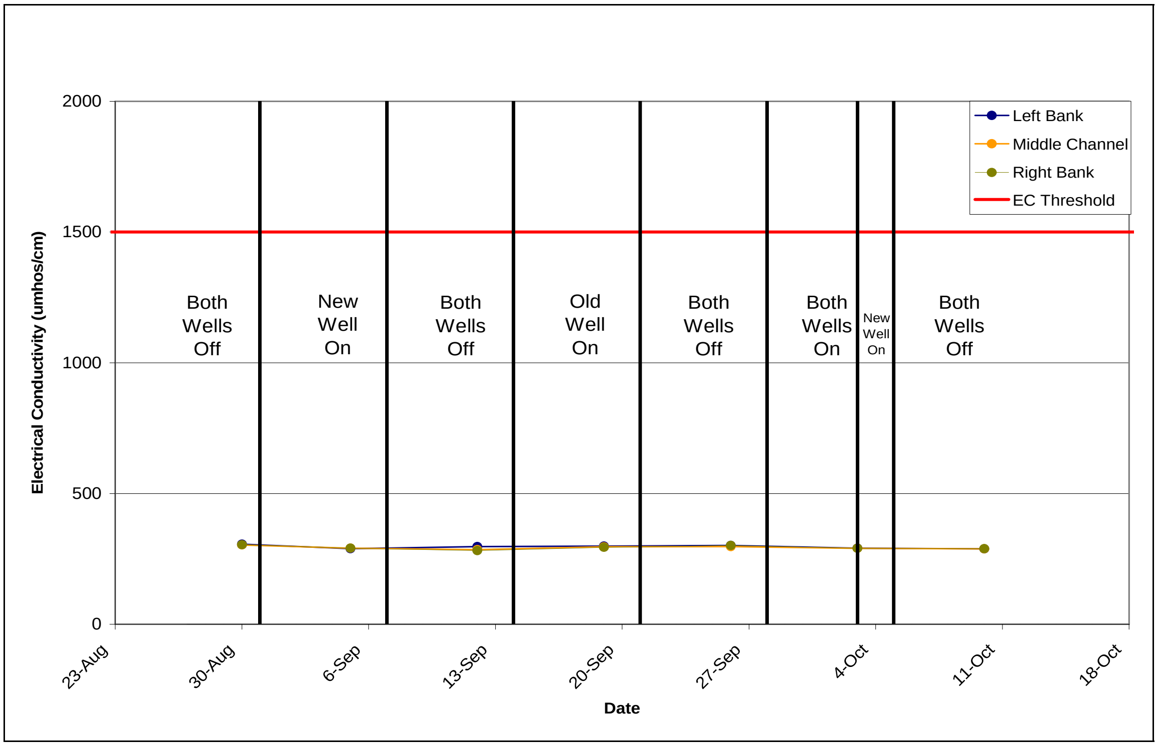

Figure 23. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 5.

TABLE 1. Locations of snorkel surveys conducted on the Big Sur River, CA, 2007.

<table>
<tr><th>Reach</th><th colspan="2">Lower boundary (lat/long)</th><th colspan="2">Upper boundary (lat/long)</th><th>Bottom (river mile)</th><th>Top (river mile)</th><th>Length (feet)</th></tr>
<tr><td>A</td><td>36 16.857</td><td>121 51.600</td><td>36 16.942</td><td>121 51.391</td><td>0.0</td><td>0.11</td><td>553</td></tr>
<tr><td colspan="8">Comments: Subreach A was a lagoon characterized by deeper slow moving water and fine substrate (silt/clay/detritus). Brushy instream cover was most abundant in this reach.</td></tr>
<tr><td>B</td><td>36 16.942</td><td>121 51.391</td><td>36 17.017</td><td>121 51.300</td><td>0.11</td><td>0.24</td><td>738</td></tr>
<tr><td colspan="8">Comments: Subreach B was a glide/run complex with lateral scour and instream brush in many areas. Filamentous green algae are abundant in the margins and in the slow sections.</td></tr>
<tr><td>C</td><td>36 17.017</td><td>121 51.300</td><td>36 17.105</td><td>121 51.237</td><td>0.24</td><td>0.43</td><td>1024</td></tr>
<tr><td colspan="8">Comments: Subreach C was a four tiered riffle glide series and contained the first potential spawning habitat. Particle size dist. looked good but there were substantial fines in the gravel. The reach was less than 2 feet deep for the most part with little in the way of cover.</td></tr>
<tr><td>D</td><td>36 17.105</td><td>121 51.237</td><td>36 17.119</td><td>121 51.134</td><td>0.43</td><td>0.47</td><td>197</td></tr>
<tr><td colspan="8">Comments: Subreach D is a slow, mid stream pool with brush and LWD across the entire channel. Substrate consists of silt, sand, and detritus. Rearing habitat is abundant.</td></tr>
<tr><td>E</td><td>36 17.119</td><td>121 51.134</td><td>36 17.183</td><td>121 50.990</td><td>0.47</td><td>0.65</td><td>950</td></tr>
<tr><td colspan="8">Comments: Subreach E is a three tiered run/riffle series with small to medium substrate and no instream brush. Velocity refugia were also lacking. Riparian vegetation was more abundant than in 2004.</td></tr>
<tr><td>F</td><td>36 17.183</td><td>121 50.990</td><td>36 17.256</td><td>121 50.778</td><td>0.65</td><td>0.87</td><td>1146</td></tr>
<tr><td colspan="8">Comments: Subreach F is a three tiered glide riffle series with small to medium substrate. The river has widened in this reach and is <1 foot deep. There was little in the way of rearing habitat. Riparian vegetation has grown into the channel as compared to the 2004 surveys.</td></tr>
<tr><td>G</td><td>36 17.256</td><td>121 50.778</td><td>36 17.273</td><td>121 50.695</td><td>0.87</td><td>0.93</td><td>312</td></tr>
<tr><td colspan="8">Comments: Subreach G was a medium gradient riffle with medium to large substrate. Depths of >3feet were present in 2 lateral scour pools but there was no cover.</td></tr>
<tr><td>H</td><td>36 17.273</td><td>121 50.695</td><td>36 17.235</td><td>121 50.660</td><td>0.93</td><td>1.04</td><td>306</td></tr>
<tr><td colspan="8">Comments: Subreach H was a glide/high gradient riffle complex with predominately large substrate. Depth was >3feet below the HG riffle but very little instream brush was present.</td></tr>
</table>

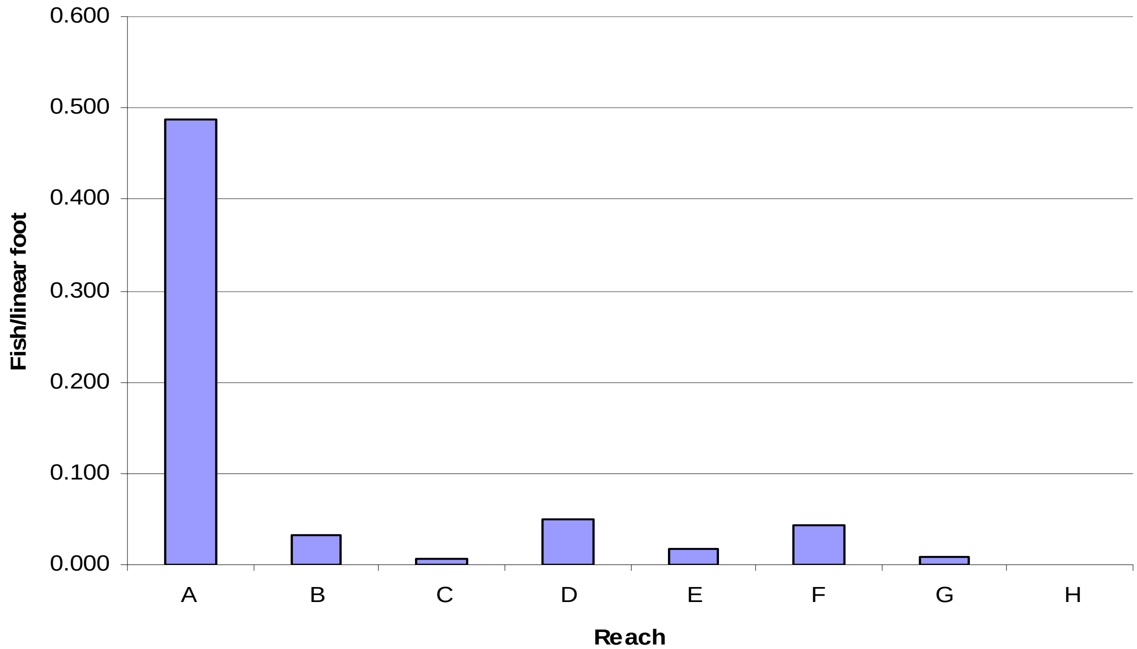

FIGURE 24. *O. mykiss* densities by reach, Big Sur River, October, 22, 2007.

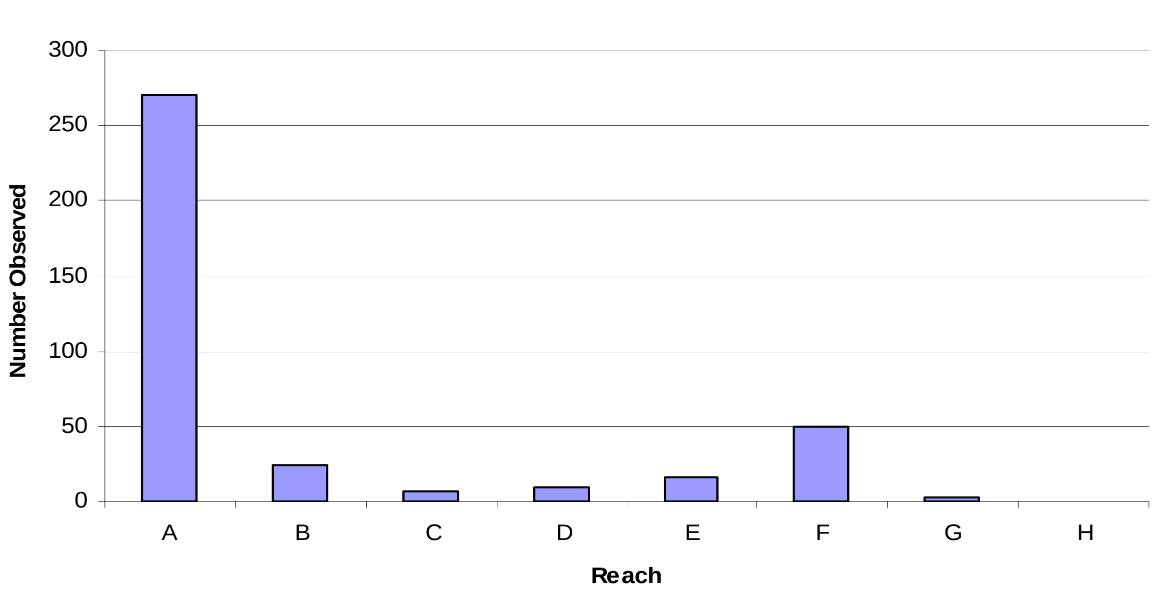

FIGURE 25. Total *O. mykiss* by reach, Big Sur River, CA, October, 22, 2007.

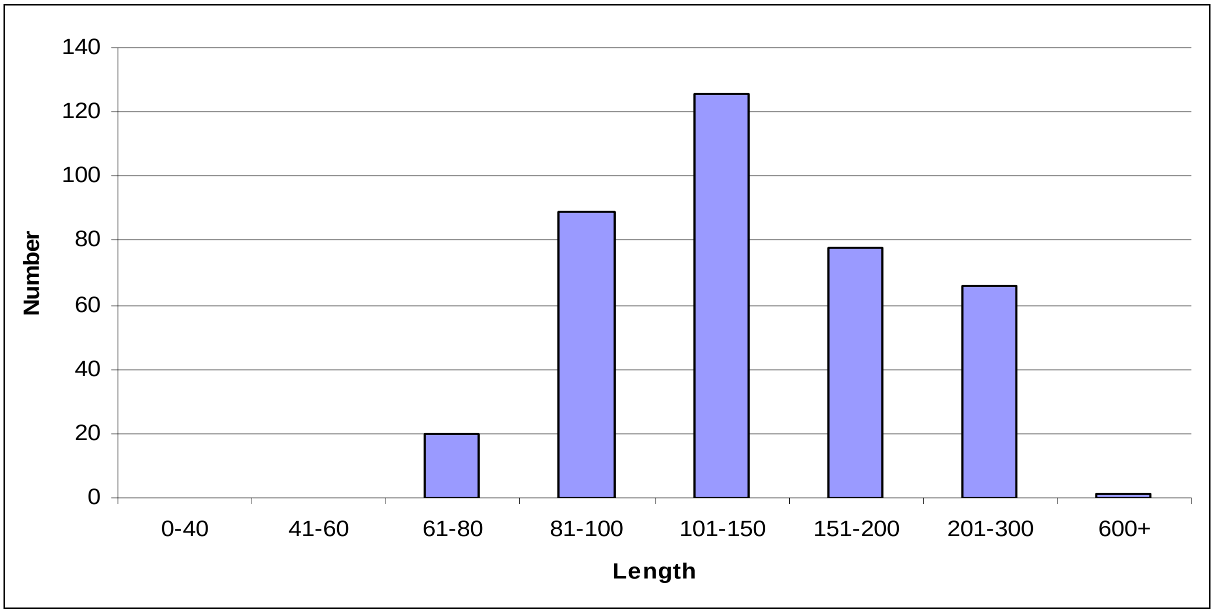

FIGURE 26. Length frequency distribution (*O. mykiss*), Big Sur River, CA, October, 22, 2007.

TABLE 2. Length Frequency Distribution of *O. mykiss*. Big Sur River, CA (October 22, 2007)

Length	Number
0-40	0
41-60	0
61-80	20
81-100	89
101-150	126
151-200	78
201-300	66
600+	1

TABLE 3. *O. mykiss* densities by subreach. Big Sur River, CA (October 22, 2007.

Subreach	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Total	270	24	7	10	16	50	3	0
Length (ft)	553	738	1024	197	950	1146	312	306
Fish/linear foot	0.488	0.033	0.007	0.051	0.017	0.044	0.010	0.000

See Figure 3 for reach locations