Final Report

Summary Report of Water Temperature and Juvenile Salmonid Presence/Absence Monitoring, May-November 2006, Mattole River Watershed

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Project Description

During spring 2006 Mattole Salmon Group personnel placed and retrieved 38 continuously recording thermographs (Hobo Water Temp Pro and Hobo Tidbit data loggers, herein referred to as "loggers") in the mainstem Mattole River and selected tributaries to monitor water temperature (Figure 1). In 2006, loggers were placed in all fish-bearing tributaries in the lower Mattole with landowner access permission (thirteen tributaries, from Honeydew Creek [(RM 26.5) to Stansberry Creek (RM 1.3)] and in the lower mainstem Mattole River upstream of each monitored tributary. Additional temperature monitoring devices were placed at areas of interest in the mainstem Mattole River, including at the downstream migrant trap (RM 3.8), the Wingdam (RM 2.9; a restoration site near the MSG Office), and the Ettersburg Bridge (RM 42.3), slightly downstream of the MSG's historical adult trapping location. In the upper Mattole River, loggers were placed in six locations in conjunction with the low-flow monitoring sites near the headwaters. Four of the aforementioned loggers were placed with local schoolchildren as part of a classroom temperature monitoring project. See Table 1 for logger serial numbers, placement dates, locations and results.

In most cases, direct underwater observation counts of juvenile salmonids were conducted at the time of logger placement and retrieval in each lower Mattole tributary. In selected mainstem locations with historical dive observation data, snorkel surveys were also conducted in some cases (see Table 2 for snorkel survey results). The objective of these snorkel surveys was to determine the distribution of three species of juvenile salmonids, and to document their relative abundance. Calibrated temperature loggers were placed between May 11 and July 19, 2006. Loggers were retrieved between September 25 and October 17, 2006.

Background

Water temperature fluctuations can affect salmonids during each phase of their life history. "Most aquatic organisms, including salmon and steelhead, are poikilotherms, meaning their temperature and metabolism are determined by the ambient temperature of water. Temperature therefore influences growth and feeding rates, metabolism, development of embryos and alevins, timing of life history events such as upstream migration, spawning, freshwater rearing, and seaward migration, and the availability of food. Temperature changes can also cause stress and mortality" (Coates, et al. 2002).

The MSG Temperature Monitoring project focuses on the freshwater life stage of juvenile Chinook salmon (*Oncorhynchus tshawytscha*), Coho salmon (*Oncorhynchus kisutch*), and Steelhead trout (*Oncorhynchus mykiss*), as well as adult summer steelhead in the Mattole River. Through monitoring temperatures throughout the watershed in the mainstem and tributaries, the Mattole Salmon Group is attempting to better understand the status and needs of the three anadromous salmonid species in the Mattole watershed.

Elevated water temperatures and excessive sediment in the Mattole River and its key tributaries has resulted in diminished or completely absent minimum threshold habitat conditions for salmonid survival. Adult and juvenile salmonid viability partly depends on the availability of cold water, a scarce but crucial component in this degraded watershed.

Excessively high summertime water temperatures in the Mattole have been identified as a primary limiting factor in the survival of native anadromous fish stocks (Downie et al. 2002, Coates et al. 2002). In laboratory studies, temperatures of 68° F and greater have been documented as being stressful to juvenile coho and Chinook salmon (Brett 1952), and temperatures of 75.0-77.0° F may kill these species (Brungs and Jones 1977, Brett 1952).

Figure 1 shows the criteria used by the Mattole Salmon Group in this report to evaluate suitable thermal habitat at water temperature monitoring locations throughout the watershed. Criteria used to determine temperature suitability includes measures of chronic temperature exposure (MWAT, MWMT) as well as short-term high temperature exposure survival (maximum temperature) and length of temperature stress (days >68°F).

Figure 1. Criteria used to evaluate salmonid habitat in the Mattole River, 2006 MSG Temperature Monitoring Report.

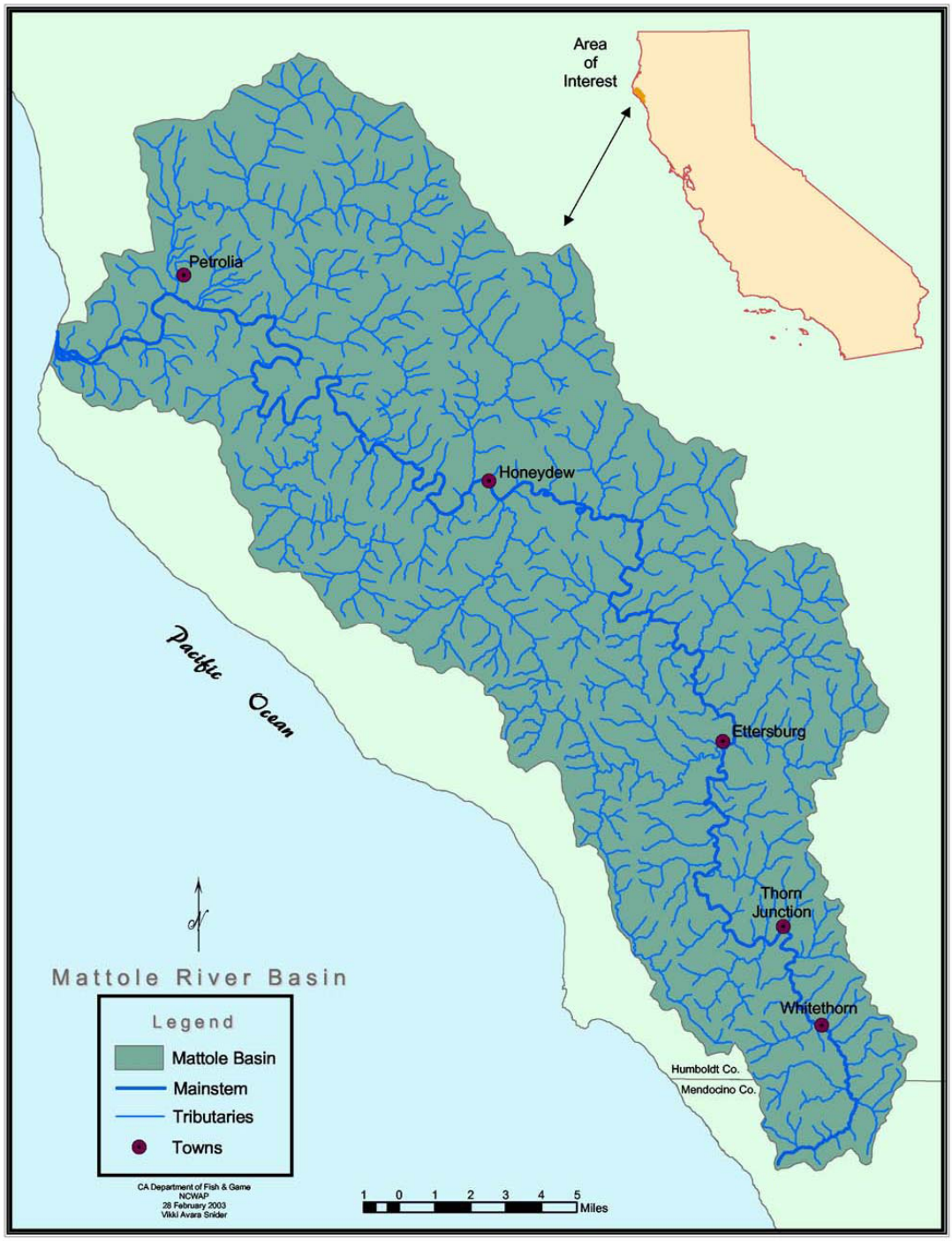
Criteria	Temperature	Reference
Prolonged Temperature Stress	Days >68 F	Brett 1952
Short-term Maximum Temperature (50% survival)	74.7°F (coho) 75.0°F (steelhead)	Brungs and Jones 1977
Maximum Weekly Average Temperature (MWAT)	>63.0°F (coho) >66.0°F (steelhead)	Coates et al. 2002
Maximum Weekly Maximum Temperature (MWMT)	>65°F MWMT (coho)	Welsh et al. 2001

MWMT and MWAT are used as quantitative measures to interpret the results of 2006 Temperature Monitoring in the Mattole. Maximum weekly average temperature (MWAT) is the highest value of the floating weekly average temperature. In other words, MWAT is the greatest mean of daily average temperatures over any 7-day period during the study (Brungs and Jones 1977). Maximum weekly maximum temperature (MWMT) is the highest average of maximum daily temperatures of any 7 days during the study period. MWMT and MWAT are used to evaluate chronic stress due to water temperature exposure, while maximum temperatures are used to evaluate acute thermal stress (50% survival) during short-term high temperature exposure.

Duration as well as severity of exposure to sub-lethal water temperatures affects long-term salmonid survival. Effects are cumulative; the longer the duration of thermal stress at sub-lethal levels, the more negative the effects on long-term survival (Ligon et al., 1999). Duration of exposure to temperature stress in monitoring locations in the Mattole is evaluated based on the number of days maximum daily temperature exceeded >68°F.

Literature used to evaluate thermal habitat suitability for salmonids in the Mattole River and tributaries in this report includes laboratory studies of water temperature effects on salmonids and field studies of salmonid occurrence, abundance, and distribution in the field in relation to high temperature.

Figure 2. Mattole Watershed



Source: Downie et al. 2003

Brett (1952) determined biological temperature thresholds for Chinook and coho salmon based on physiological effects of water temperature in laboratory studies. Observations of salmonids in laboratory conditions indicated an upper lethal water temperature of 77°F for Chinook and coho salmon. Based on responses of fish to laboratory experiments, prolonged exposure to water temperatures greater than 68°F were determined as stressful to salmonids (Brett 1952).

Using upper lethal limit temperature and optimal temperature established in lab studies of coho and steelhead, Brungs and Jones (1977) calculated MWAT and short-term maximum temperature to quantify tolerances of salmonids to chronic and acute temperature exposure in the field during different life stages. Based on their lab results, they concluded growth was the life stage most sensitive to modified temperature due to the many physiological functions required. They determined acute short-term temperature thresholds (50% survival) were 74.7°F for coho and 75.0°F for steelhead. Salmonid distribution (in relation to temperature) observed during later field studies supported the accuracy of their predicted upper short-term thresholds. McCullough (1999) concluded that upper short-term temperatures of approximately 22-24° C (71.6-75.2°F) limit salmonid distribution. However, McCullough (1999) also noted that competitive interactions between fish species can limit salmonids at temperatures 2-4° C lower than the range of total elimination.

A recent study of the distribution of juvenile coho salmon in relation to temperature in 21 tributaries of the Mattole River was completed by the Mattole Salmon Group and Redwood Sciences Laboratory (Welsh et al. 2001). The study found juvenile coho salmon only in tributaries with MWAT values less than 62.2º F, and MWMT values less than 64.6º F. MWAT is determined by the highest average of mean daily temperatures of any 7-day period, and MWMT is determined by the highest average of maximum daily temperatures over any 7-day period. Coho were found in 16 of the 18 streams surveyed including the mainstem Mattole.

Recently, water quality in the Mattole was determined as impaired due to sediment and temperature by the State of California under the Clean Water Act, Section 303 (d). Impacts on the anadromous salmon fishery in the Mattole were identified as the primary adverse effect of elevated sediment load and temperature. All three species of salmonids in the Mattole are listed under the Endangered Species Act. The EPA established Total Maximum Daily Loads (TMDL) for Sediment and Temperature in the Mattole River in 2002. Coates et al. (2002) completed a literature review to determine temperature tolerance criteria for salmonids in the Mattole. MWAT was used as the primary statistical measure for interpretation of stream temperature conditions. Based on past lab and field studies, Coates et al. determined MWAT stream temperature values (See Figure 3) to characterize the temperature quality of surface waters in the Mattole River watershed.

Figure 3. Summary of temperature tolerances of coho salmon and steelhead (Coates et al. 2002).

Descriptor	Coho Salmon	Steelhead
Good	<15° C (<59.0° F)	<17° C (<63.0° F)
Marginal	15°-17° C (59.0°-63.0° F)	17°-19° C (63.0°-66.0° F)
Poor/Unsuitable	>17° C (63.0° F)	>19° C (>66.0° F)

Many of the Mattole's tributaries and portions of its mainstem exceed 80º F during the summer months when the flow is low and solar radiation is high. "However, discrete areas of colder water can be created by tributaries, groundwater seeps, inter-gravel flow, deep pools, and areas separated from currents by obstructions" (Nielsen et al, 1994). Salmonids are able to access these pockets of colder water, called thermal refugia, as an avoidance strategy to survive during periods of elevated temperatures.

"The existence of these thermal refugia allows salmonids to persist in these reaches of otherwise poor or marginal habitat (Coates et al. 2002)." Temperature and dive monitoring in the Mattole has focused on identifying thermal refugia and cool-water tributaries and establishing presence and distribution of salmonids in relation to temperatures throughout the watershed. The decrease in quality and extent of freshwater habitat has inevitably resulted in considerably reduced run strength, particularly for Chinook and coho native to the Mattole River.

Now completing our eleventh year of temperature monitoring in the Mattole's tributaries and mainstem, the Mattole Salmon Group has begun to identify trends in the consistent presence and absence of juvenile salmonids at certain locations in the watershed, and how species presence correlates to summertime water temperatures.

Project Goals

The following goals for water temperature monitoring in the Mattole watershed were identified by staff of the Mattole Salmon Group:

1. Establish reference points, to determine how temperatures at set locations with relatively stable conditions change from year to year.
2. Help determine where and when water temperatures are stressful or lethal to salmonids, and where refugia are located when temperatures spike.
3. Document temperatures prior to and/or subsequent to timber harvest in specific locations.
4. Help determine where instream restoration and revegetation projects are best directed.
5. Monitor and document recovering tributaries.
6. Monitor and document refugia in the lower mainstem Mattole.
7. Locate and document cold-water areas (in predominantly warm reaches of stream), such as seeps and cold stratified pools.
8. Monitor lower and middle river tributaries to establish which tributaries offer cool-water oversummering habitat where the mainstem reaches high temperatures.
9. Monitor temperature at low-flow monitoring locations in the headwaters.
10. Monitor streams to establish to establish coho presence/absence in relation to temperature and other water quality parameters.
11. Monitor streams and mainstem locations to determine Chinook oversummer distribution in relation to temperature and other water quality parameters. Develop threshold temperature standards for Chinook in the Mattole Watershed.

Each monitoring site was chosen according to its ability to meet one or more of the above goals. A major focus of 2006 temperature monitoring was the lower mainstem Mattole and lower river tributaries. The goal was to establish baseline data and evaluate ambient river temperatures in the mainstem, and document conditions and salmonid habitat utilization in tributaries.

Five sites in the upper Mattole River were also chosen for temperature monitoring in conjunction with low-flow monitoring in the headwaters. In recent years, flows in the headwaters of the Mattole have subsided to mere groundwater flows and become a series of disconnected pools. Sites were identified in the upper mainstem with suitable temperatures for juvenile salmonid oversummering and areas where temperature in the upper mainstem exceeds thresholds for juvenile survival.

2006 was the first year the MSG integrated a classroom temperature monitoring project. Three local classrooms were involved in field trips in the spring and fall in which they placed and retrieved temperature loggers in addition to being educated about water temperature, its effects on the salmonid population, and other water quality monitoring.

Procedures

Temperature Logger Calibration

Temperature loggers operate under battery power for the duration of the field season.
Loggers contain a microchip which records electronic data generated by a sensing device. Calibration tests before field placement were done to verify that each device operated within the manufacturer's specified limits (+/- 0.5° C). Monitors that deviated from this range upon testing were not placed in the field. The same calibration process was performed with loggers after they were retrieved. Data that deviated from the acceptable accuracy range were discarded.

Loggers were calibrated using the following procedure:

1. All recording thermometers were launched to record temperature every 10 seconds.
2. All recording thermometers and a laboratory-certified calibration thermometer were placed in an ice chest filled with ice water. The ice water was stirred every two minutes.
3. The time and indicated temperature of the calibration thermometer were recorded every five minutes for 30 minutes.
4. Recording thermometers were taken out of the ice chest.
5. Data were downloaded from each temperature logger and examined to ensure proper function of each recording thermometer. Loggers that recorded temperatures which deviated more than +/- 0.5ºC from the temperatures recorded at the same time by the calibration thermometer were not used in the field.

Logger Installation

Instream temperature loggers were placed in or near the thalweg, where water turbulence and mixing was greatest, and at sufficient depth (greater than one foot if possible) to prevent exposure at low flows. Typically, suitable sites were located in runs, riffles, or heads of pools, but not in slack water, backwater pools, at the bottom of pools (except when measuring for stratification) or in shallow riffles that may become exposed. Loggers were also placed out of direct sunlight. Using nylon cord, and in some cases rocks, temperature loggers were secured in locations where they would not be dislodged during high flows and were hidden or camouflaged from human detection.

The Optic Stowaway, Hobo Water Temp Pro, and Tidbit loggers were launched to record hourly temperature for the duration of the field season. On "Rite-in-the-Rain" field forms, the following information was recorded when each logger was placed, and when applicable, when it was

retrieved: time, date, air and water temperature taken by hand-held thermometer, description of general and precise placement location of logger, placement depth of logger, depth of logger upon retrieval, and maximum pool depth at placement location.

Data Management

Each temperature logger was launched with its serial number and placement location recorded. All data was downloaded in Boxcar Pro software and exported to Excel, and data was stored in both formats. Field location, serial number, date of placement, and date of retrieval were recorded in a separate Excel file (Table 1). Data that deviated significantly from the expected range or from previously obtained data from that site was evaluated for accuracy and adherence to placement protocols. In Excel, all data obtained prior to, and following removal from field placement (when the monitor was not in its field position) was discarded and removed from the data file. This process is also known as "trimming" the data. "Trimmed" and "raw" data were stored in separate files.

Boxcar Pro temperature data files were also uploaded into Klamath River Information System for the Mattole River (KRIS Mattole). 2006 Temperature monitoring data were appended to the 2000-2005 temperature source table. New KRIS topics were created with updated information for all 2006 Temperature Monitoring locations. Figures from the KRIS database were used to analyze and interpret results during the 2006 season and over the course of 2000-2006 temperature monitoring in the Mattole.

Snorkel Survey Methods

Our temperature-related snorkel surveys followed a modified ten-pool protocol for determining presence/absence of juvenile coho salmon, as employed by the California Department of Fish and Game (Preston et al. 2002).

The scope of the Mattole Salmon Group's snorkel surveys was limited by project funding and in some streams by lack of landowner permission. It was often unfeasible to survey reaches in the lower, middle and upper areas of a stream. At many monitoring sites only a short stretch of stream could be accessed, sometimes less than ten consecutive pools. In many instances, accessible survey reaches did not contain ten pools with relatively suitable coho habitat. Therefore, when a species was not observed in a sampling that was less complete than that employed in the above-mentioned modified ten-pool protocol, that species could not justifiably be declared "absent" in an entire stream.

Another way in which the Mattole Salmon Group's temperature-related snorkel surveys differed from a standard modified ten-pool protocol, is that when a coho salmon was sighted, the survey continued until ten pools, or the maximum number of pools possible, were surveyed. This allowed for a broader sampling of relative abundance.

Results and Discussion

Basinwide

Floating Weekly Maximum Temperatures in many locations were above thresholds set for coho presence by Welsh et al. (2001). Additionally, Maximum Weekly Average Temperatures in

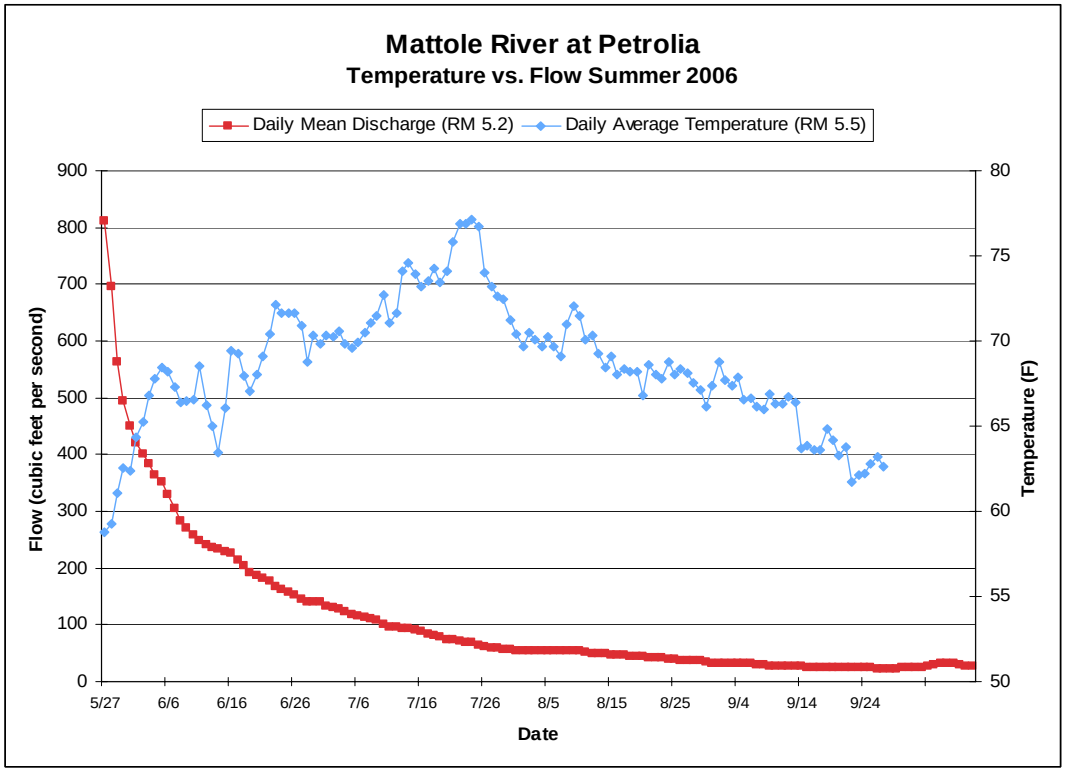
many mainstem monitoring locations, especially in the middle and lower river, indicated unsuitable thermal habitat for steelhead and coho (Coates et al. 2002).

The mouth of the Mattole River remained open to emigrating juveniles until July 23, 2006. Due to one storm event in June 2006, streamflow in early summer was higher than the median streamflow based on 56 years on record (Data from USGS). By September-November 2006, streamflow was lower than the estimated median daily streamflow of the past 56 years. As temperatures peaked, streamflow fell below 100 cubic feet per second in the mainstem Mattole River at Petrolia (See Figure 4).

The highest water temperature recorded at any location this season was 86.85° F, which occurred in the mainstem Mattole River upstream of Saunders Creek (RM 19.9) on July 23rd. In this section of the lower Mattole, the river channel is extremely aggraded and there is lack of any significant riparian vegetation to shelter the river from the heating of solar radiation. In addition the temperature monitoring location upstream of Saunders Creek is near a huge slide. The maximum temperature recorded in 2005 was several degrees lower; in the mainstem Mattole at Squaw Creek, temperature reached a maximum of 80.49° F on 8/9/05. Peak 2006 temperatures were higher than many of other recent years in locations with multiple years of record.

The lowest water temperature was recorded in Lower Mill Creek (RM 2.8+0.1); the maximum temperature reached was 61.93° F on July 23rd. The seasonal maximum temperatures in most monitoring locations were reached between the July 17th and July 25th.

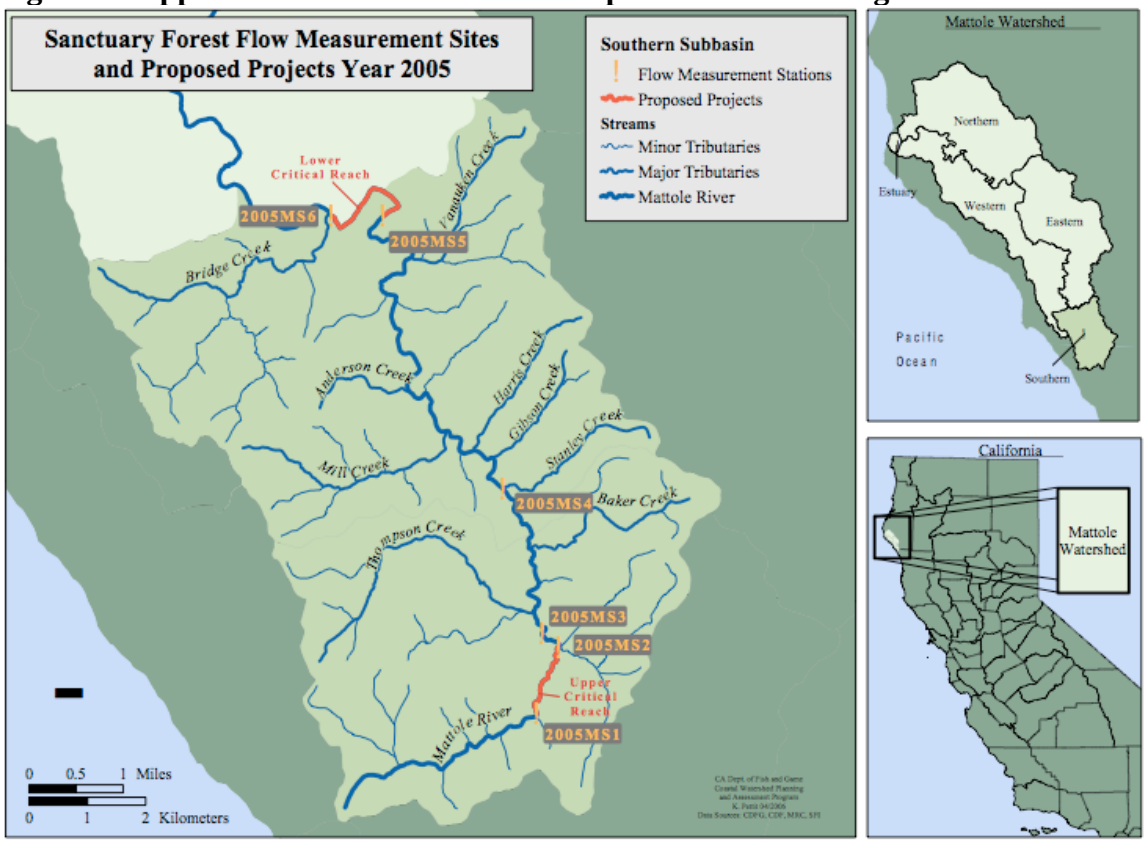
Figure 4. Daily Average Streamflow vs. Daily Average Temperature in the Mattole River at Petrolia (Summer 2006).



Upper Mainstem Mattole

In 2006, upper Mattole temperature monitoring locations were selected in conjunction with the low-flow monitoring of the Mattole headwaters in cooperation with Sanctuary Forest. Five sites were selected (MS-1, MS-3, MS-4, MS-5, and MS-6) (See Figure 5) to determine locations with suitable temperatures for juvenile salmonid oversummering in the upper mainstem (See Table 1). A sixth upper Mattole temperature monitoring site was located in McKee Creek, one of the major upper river tributaries and one that had never been monitored for temperature by the MSG. One additional temperature monitoring site was selected for classroom temperature monitoring with the Whitethorn School. Mattole at Metz Bridge (RM 56.9) was chosen both because of its proximity to the school and its use as an upriver temperature monitoring reference location since 2002. In comparison with temperatures recorded in 2002-2005 in this reference location (RM 56.9), 2006 peak floating weekly maximum temperatures were the highest on record (See Figure 6).

Figure 5. Upper Mattole Low-flow and Temperature Monitoring Locations.



Source: Sanctuary Forest

Figure 6. 2006 floating weekly maximum water temperatures in the Mattole at River Mile 56.9.

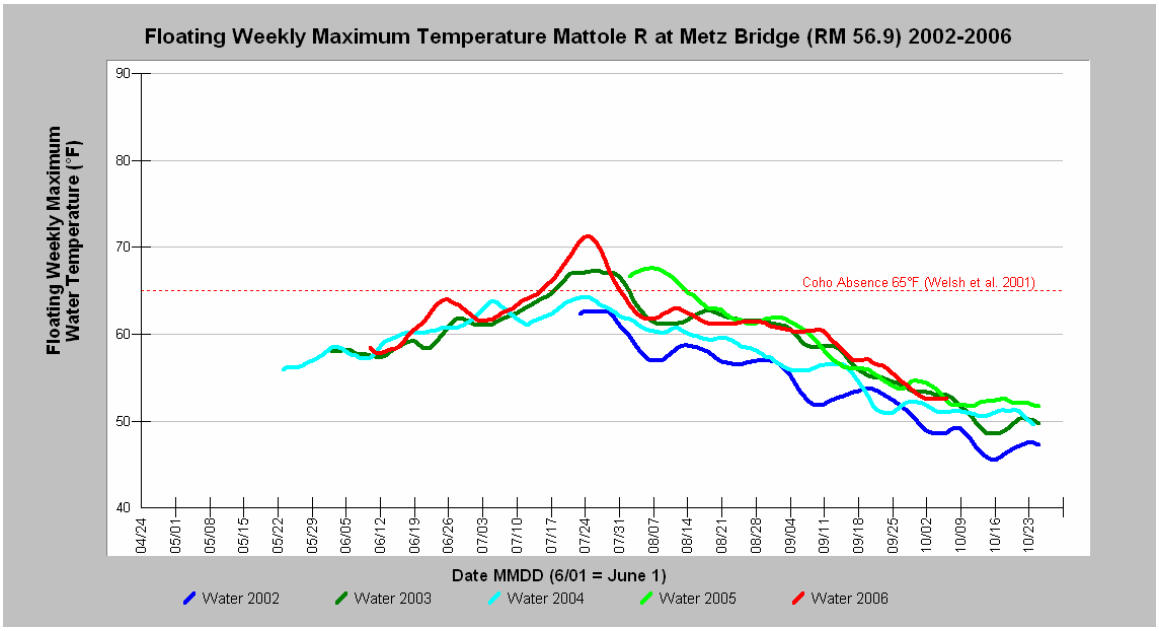
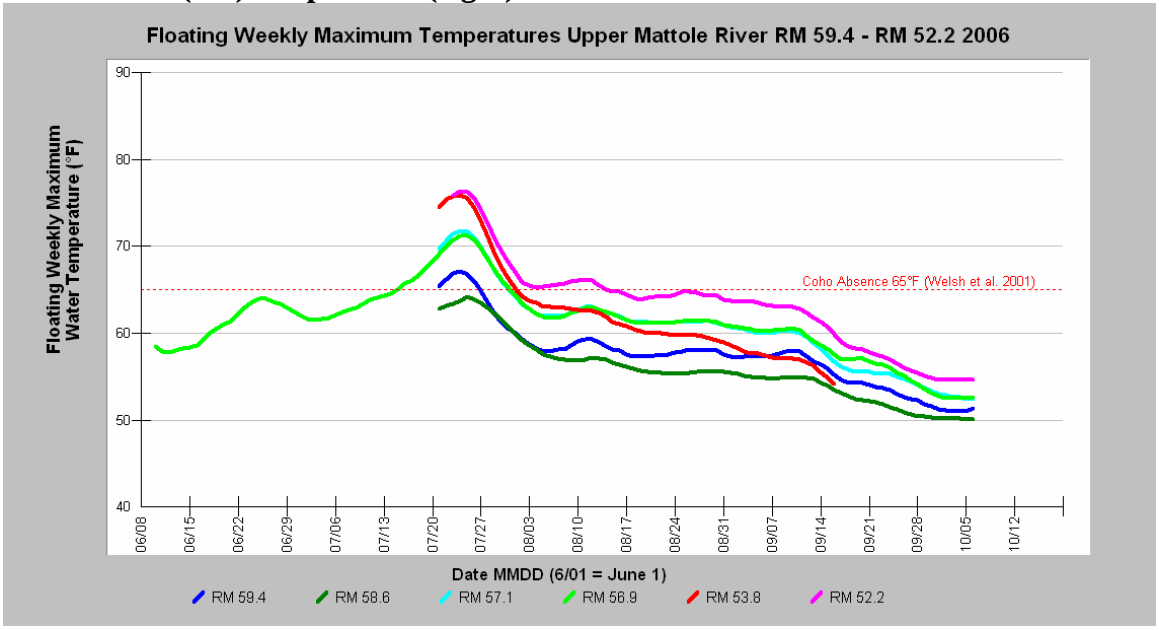


Figure 7. 2006 floating weekly maximum water temperatures at temperature monitoring locations in the Mattole mainstem, River Mile 59.4 to River Mile 52.2. Sites listed downstream (left) to upstream (right). See Table 1 for more information on locations.



Floating Weekly Maximum Temperatures in five of six upper Mattole mainstem temperature monitoring sites exceeded 65°F in 2006, indicating unsuitable temperatures for coho rearing (Welsh et al. 2001) (See Figure 7). Temperatures in the upper mainstem exceeded the coho threshold during peak temperatures from mid to late July. The temperature monitoring site where temperatures remained below the coho threshold (MS-3 at RM 58.6, downstream of the

one lane Mendocino County Bridge and Helen Barnum Creek) was located deep in a pool with a MSG habitat enhancement large woody debris structure. This emphasizes the importance of deep pool habitat and cold refugia even in the coolest area of the Mattole mainstem near the headwaters. This temperature monitoring location is also located in the reach of the upper mainstem known as prime juvenile salmonid rearing habitat especially for coho salmon, based on past MSG dive surveys (from Lost River (RM 58.8) to Stanley Creek (RM 57.1)).

2006 maximum weekly average temperatures showed similar results. Only the two most upstream temperature monitoring locations, MS-3 (RM 58.6, 63.41°F) and MS-1 (RM 59.4, 65.27°F) had suitable oversummering temperature for juvenile steelhead (<66.0°F), based on temperature tolerance criteria developed by Coates et al. 2002. MWAT in all sites exceeded 63.0°F, thus were unsuitable for coho (Coates et al. 2002), although MS-3 exceeded the threshold only slightly. Results indicate only sites upstream of Stanley Creek (RM 57.1) provided favorable rearing habitat for juvenile salmonids in 2006.

Maximum temperatures exceeded 75.0°F, the short-term lethal temperature for survival in the two upper mainstem temperature monitoring locations downstream of RM 54.0. Interestingly, during dive surveys of the upper mainstem in 2006, coho were only observed upstream of RM 54.0 (Vanauken Creek). Maximum temperatures in the four other upper mainstem monitoring locations did not exceed 75.0°F, although maximum temperatures in the two furthest upstream sites were the coolest.

Only one site in the upper mainstem did not reach 68°F (the deep pool with LWD structure, MS-3 at RM 58.6). MS-1, the furthest upstream, only exceeded 68°F on 2 of 84 days monitored. Other sites exceeded 68°F for only a short time period during peak temperatures, usually one to two weeks. Salmonids were exposed to prolonged stress during peak temperatures in all sites except for deep pool that was present in that location.

Snorkel surveys in the upper headwaters in summer 2006 confirmed the presence of coho in reaches from RM 58.8 to RM 54.0, indicating the possibility that coho may be able to persist in a reach if floating weekly maximum temperatures do not exceed 65°F for a lengthy time period.

In comparison with 2005, 2006 temperatures were warmer. MWAT remained below 66.0°F at all monitoring sites upstream of Thorn Junction (RM 52.7) in 2005, indicating temperatures were suitable for juvenile steelhead. In 2006, some sites upstream of McKee Creek had MWATs as high as 69°F. In 2005, four of nine temperature monitoring sites (RM ~55.1, 55.8, 56.2, and 57.1) showed suitable MWATs for coho (<63.0°F, Coates et al. 2002). In 2006, no monitoring sites had a MWAT suitable for coho (<63.0°F).

The upper Mattole provides the majority of thermally suitable mainstem oversummering habitat for juvenile salmonids. Temperatures in the upper river are significantly cooler than in the lower mainstem due to a variety of reasons including aggradation, insufficient habitat, and riparian dysfunction in the lower river. Salmonids in the upper Mattole were exposed to acute temperature stress in sites downstream of RM 54. Temperatures above or near juvenile salmonid MWAT and MWWT thresholds indicates oversummering salmonids in most areas of the upper mainstem experience stress due to chronic exposure to warmer than optimal rearing

temperatures. Some locations in the upper mainstem, especially upstream of RM 54.0, showed suitable temperatures for juvenile survival and growth. Only the uppermost temperature monitoring locations were suitable for coho; more areas are thermally suitable for steelhead survival due to their greater temperature tolerance.

Despite favorable temperatures in the uppermost mainstem, issues with low-flow have depleted available habitat in the coolest areas of the mainstem. In recent years, many of the coolest areas of the upper mainstem have dried to a series of disconnected pools. Further effort is underway to monitor flow in addition to dissolved oxygen and other water quality parameters to further quantify risks to salmonids in these critical rearing reaches.

Lower Mainstem Mattole

Seventeen sites in the Mattole were monitored to establish typical ambient water temperatures throughout the middle and lower mainstem. Sites were upstream of tributaries or in areas of interest like the downstream migrant trap. In comparison to the upper mainstem, floating weekly maximum temperatures in the middle and lower mainstem were significantly higher. All sites in the mainstem downstream of RM 52.2 exceeded 65°F MWMT for the majority of the time period monitored, indicating lack of suitable coho habitat (See Figure 8-9).

2006 maximum weekly average temperatures (MWAT) in mainstem Mattole temperature monitoring sites downstream of river mile 52.2 also indicated lack of favorable oversummering habitat for juvenile salmonids. MWATs in all seventeen sites in the middle and lower mainstem exceeded threshold temperatures for both juvenile coho and steelhead presence (>63.0-66.0°F MWAT, Coates et al. 2002). MWMTs and MWATs above threshold temperatures suggest juvenile salmonids are unlikely to persist in the mainstem downstream of river mile 52.2 due to chronic temperature stress and indicate the importance of thermal refugia and tributaries for oversummering. Maximum weekly average temperatures in the lower and middle Mattole temperature monitoring sites ranged from 70.37°F (Mattole at Wingdam deep (RM 2.9)) to 78.45°F (Mattole upstream of Saunders Creek, (RM 20)) in summer 2006.

Temperatures in the deep location of the Wingdam (70.37°F MWAT) were notably cooler than in the shallow location (73.32°F MWAT). The Wingdam pool is the result of several bank deflector structures originally intended to curb erosion and one of few lower mainstem locations that provides favorable oversummering habitat for salmonids. While maximum summer temperatures in the shallow location at the Wingdam (79.70°F) exceeded the short-term lethal temperatures for juvenile salmonids (>75.0°F, Brett 1952) by several degrees, maximum summer temperatures deep in the Wingdam pool (72.52°F) did not exceed lethal temperatures. Although the mainstem channel near the Wingdam is aggraded as is the rest of the lower mainstem, the deep pool there provides cooler temperatures, cover from predators, habitat complexity, and riparian shading.

During dive surveys of the Wingdam since 2000, juvenile salmonids including Chinook and steelhead as well as adult summer steelhead have been observed more often and in greater numbers than at other lower river temperature logger locations. Results of temperature and dive

monitoring at the Wingdam indicate the importance of habitat improvement to create refugia in the lower river, where both cool water and complex habitat is lacking.

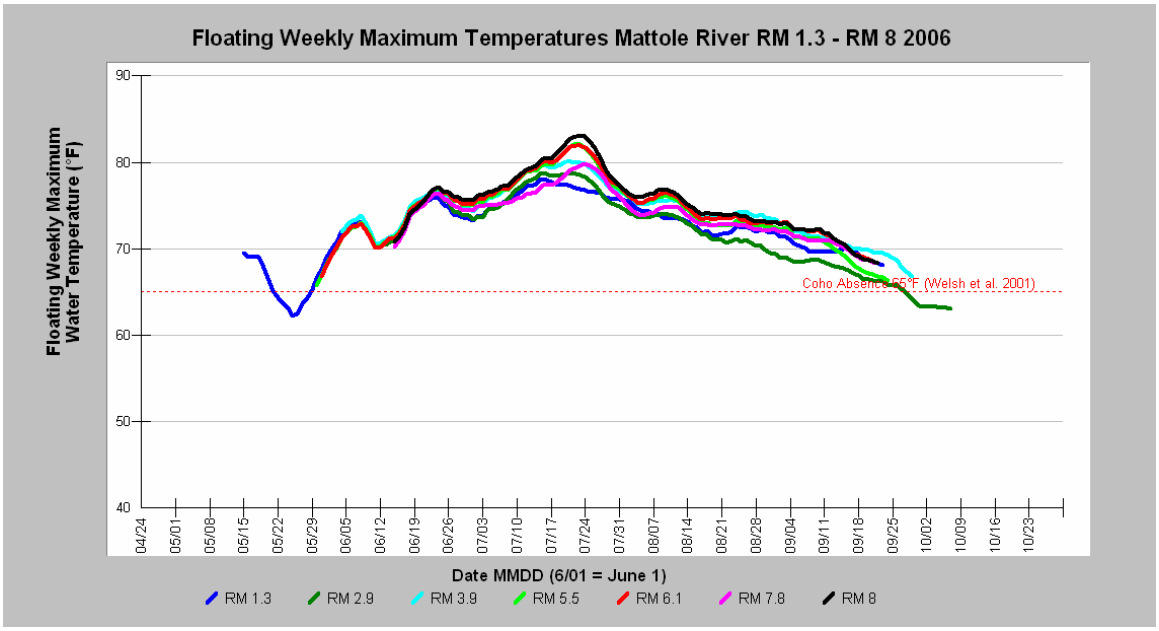


Figure 8. 2006 floating weekly maximum water temperatures at temperature monitoring locations in the Mattole mainstem, River Mile 1.3 to River Mile 8. Sites listed downstream (left) to upstream (right). See Table 1 for more information on locations.

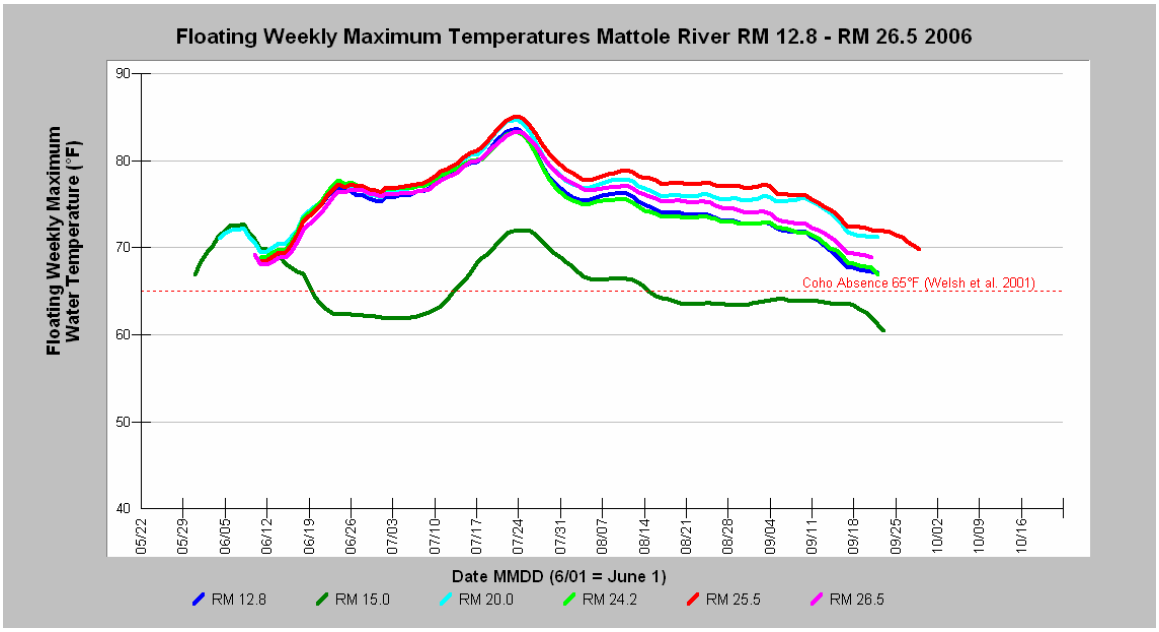


Figure 9. 2006 floating weekly maximum water temperatures at temperature monitoring locations in the Mattole mainstem, River Mile 12.8 to River Mile 26.5. Sites listed downstream (left) to upstream (right). See Table 1 for more information on locations.

The highest maximum temperature of any location was 86.85°F upstream of Saunders Creek at RM 20. Maximum temperatures recorded in fourteen of sixteen Mattole mainstem monitoring sites downstream of the Ettersburg Bridge (RM 42.3) to Stansberry Creek (RM 1.3) exceeded 75.0°F, the threshold for short-term maximum temperature survival, indicating acute temperature stress and possible lethal effects on salmonids (50% survival, Brungs and Jones 1977). Temperatures in middle to lower mainstem sites exceeded 68°F for a significant time period in summer 2006, thus salmonids were exposed to prolonged as well as acute temperature stress (See Table 1).

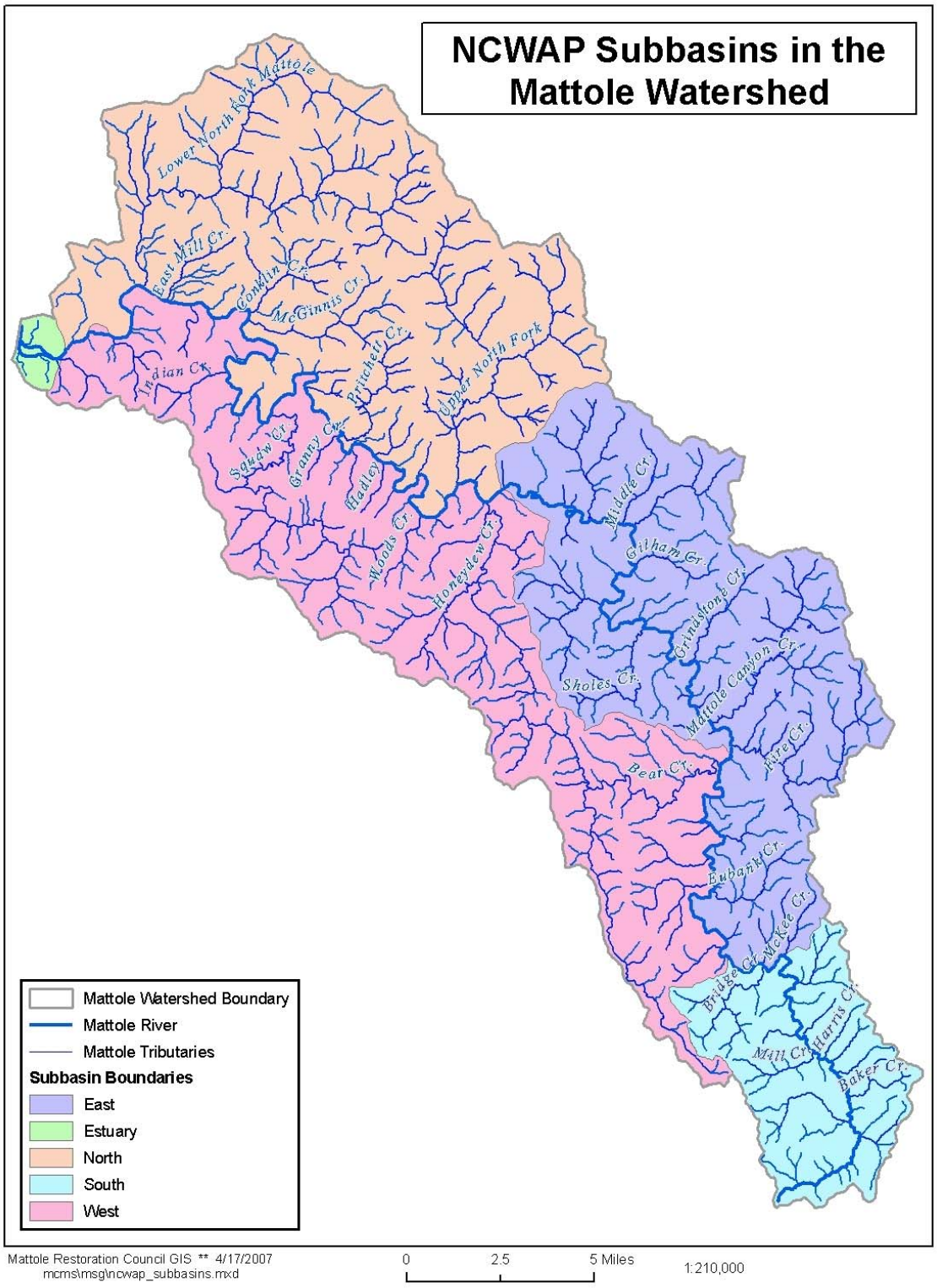
2006 Temperature Monitoring results indicate the importance of thermal refugia such as cold pools, seeps, and cool-water tributaries for salmonids oversummering in the middle to lower mainstem. The lowest maximum temperature recorded in the lower mainstem was 72.52°F in the deep section of a stratified pool at the Wingdam (RM 2.9). The shallow logger at the Wingdam recorded a maximum of 79.70°F, over a 7°F difference. The only two lower/middle mainstem monitoring sites where maximum temperature did not exceed 75.0°F were located in pools (RM 2.9 at the Wingdam and RM 15 upstream of Squaw Creek). The lowest floating weekly maximum temperatures of all sites in the lower river were also recorded in the pool upstream of Squaw Creek (RM 15, 69.61°F MWAT) at the Wingdam (RM 2.9, 70.37°F MWAT). The two coolest sites in the lower mainstem were warmer than thresholds for juvenile salmonid oversummering, suggesting the importance of cool-water tributaries for salmonids oversummering in the Mattole.

Ambient temperatures recorded suggest lack of suitable thermal habitat for all species of juvenile salmonids in the mainstem downstream of the Ettersburg Bridge (RM 42.3). Juvenile salmonids in the middle and lower river encounter acute as well as chronic temperature stress. Their long-term survival is threatened by exposure to lethal temperatures and/or decreased growth rates due to high metabolic demands at higher water temperatures. Both sites in the lower mainstem with maximum temperatures below 75.0°F (the threshold for short-term maximum temperature survival) were located at the bottom of deep pools in the lower mainstem. Thermal refugia such as stratified pools, cold seeps or cool-water tributaries are essential for salmonid survival in the lower and middle Mattole over the summer months.

Tributaries

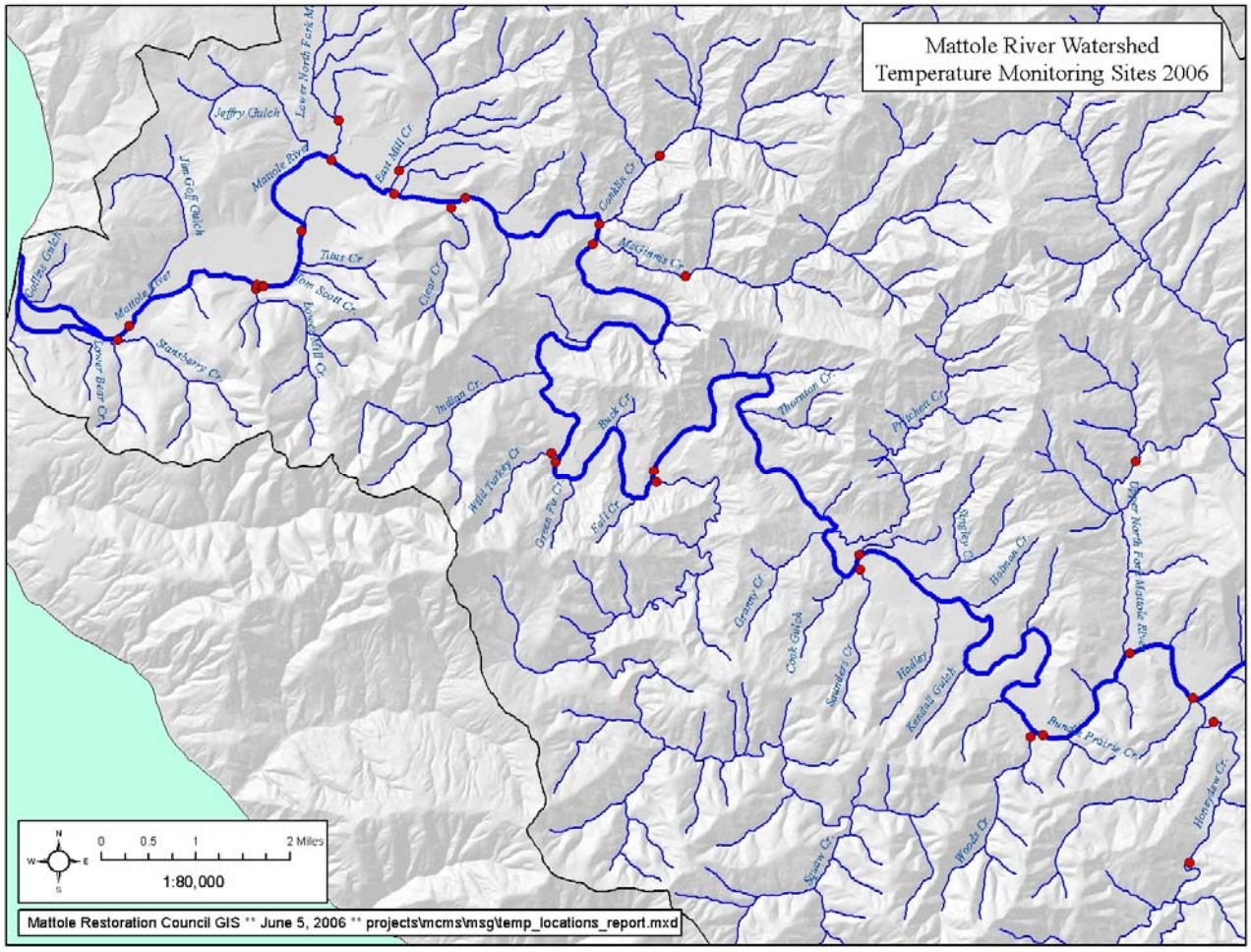
Tributaries are discussed by subbasin (See Figure 10). River Mile is also listed after each tributary. Please see map for further details.

Figure 10. Mattole Watershed Subbasins



Map courtesy Mattole Restoration Council GIS.

Figure 11. 2006 Mattole Watershed Temperature Monitoring Sites



Map: Mattole Restoration Council GIS.

Western Sub-basin

Stansberry Creek (RM 1.3)

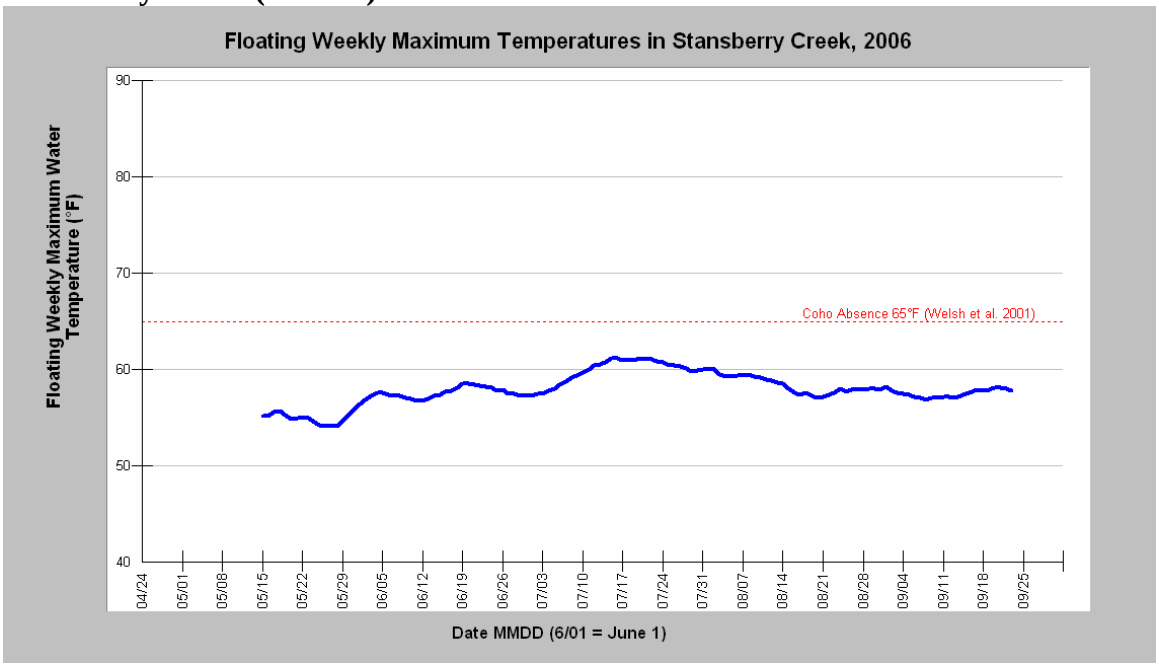


Figure 12. Floating Weekly Maximum Temperatures in Stansberry Creek, 2006.

2006 was the first year of temperature monitoring in Stansberry Creek. Floating Weekly Maximum water temperature did not exceed 65°F, indicating temperatures were suitable for coho salmon rearing (Welsh et al. 2001) (See Figure 12). Maximum weekly average temperature (MWAT) also indicated favorable thermal habitat for both juvenile coho and steelhead. The MWAT (58.86°F) in Stansberry Creek was the lowest MWAT recorded in any 2006 temperature monitoring site. Based on temperature tolerance criteria developed for the Mattole Watershed by Coates et al. (2002), Stansberry Creek was the only 2006 temperature monitoring site with "good" thermal habitat for both coho (<59.0°F MWAT) and steelhead (<63.0°F MWAT). The maximum temperature recorded was 62.10°F, confirming even the warmest temperatures in Stansberry Creek were favorable for salmonid oversummering.

Despite thermally suitable habitat for coho, only steelhead were observed during 2006 dive surveys. Divers observed 13 (<4") steelhead, 6 (4"-8"), and 1 (>8") steelhead on 5/11/06. The last 100' of Stansberry Creek was dry during the fall survey on 9/27/06; despite this, more steelhead were observed than in the spring (97 (<4") SH and 5 (4"-8") SH). Historical data also indicates only steelhead reside in Stansberry Creek.

Recently, approximately the last one hundred feet of Stansberry Creek upstream of the confluence were restored as part of a fish passage project. The stream bed was re-routed and graded, a new culvert was installed, and willows and alders were planted in the riparian area. During high flows, salmonid access to Stansberry Creek is unrestricted for all size-classes of salmonids. However, during low flows, a gap between the confluence and the new culvert presents a barrier to juveniles and is a candidate for a habitat improvement project. Temperatures in 2006 indicated Stansberry Creek is a cool-water source for the Mattole

mainstem and thermally suitable as oversummering habitat. However, access issues impede unrestricted use of Stansberry Creek by juvenile salmonids.

Lower Mill Creek (RM 2.8)

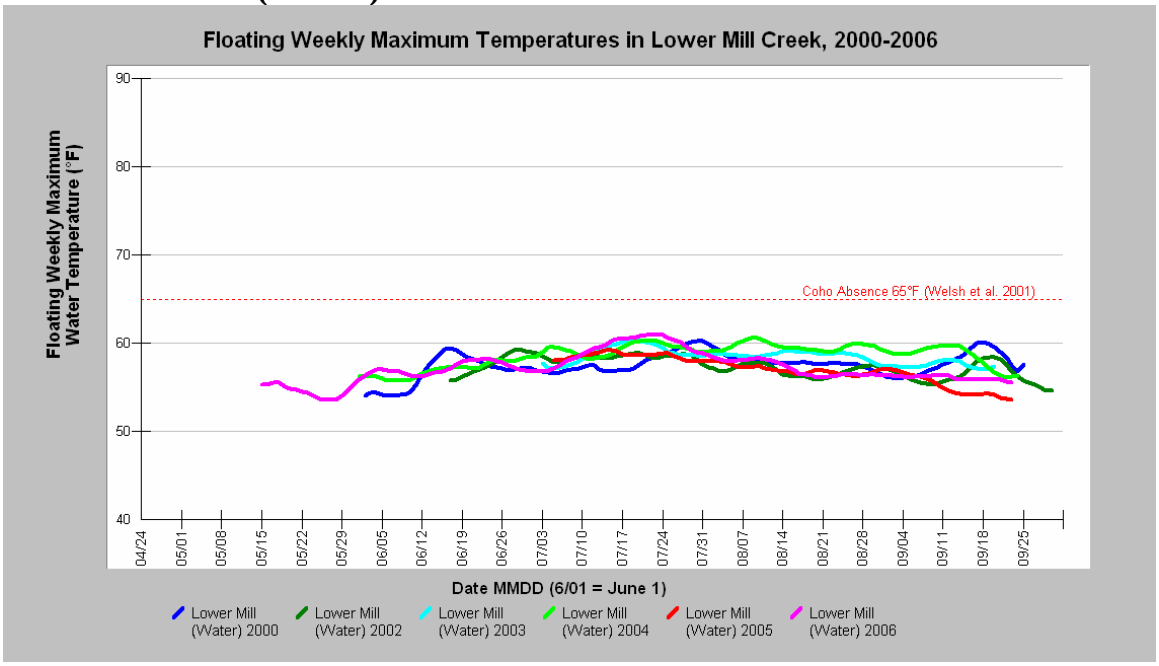


Figure 13. Floating Weekly Maximum Temperatures in Lower Mill Creek, 2000-2006.

The MSG has monitored temperature in Lower Mill Creek every year since 2000. Maximum floating weekly maximum water temperature (MWMT) did not exceed 65°F, the coho threshold determined by Welsh et al. (2001), during any of the six years monitored (See Figure 13). Maximum floating weekly average temperature (MWAT), another measure of chronic temperature stress, also indicated favorable thermal habitat for juvenile salmonids in Lower Mill Creek. The MWAT of 59.57°F recorded in 2006 was well below thresholds for both coho (<63.0°F) and steelhead (<66.0°F) (Coates et al. 2002).

Of the coho-bearing streams in the lower Mattole, Mill Creek is the coolest and contains arguably the best oversummering habitat for coho and steelhead. The lowest maximum temperature (61.93°F) of any 2006 temperature monitoring site was recorded in lower Mill Creek.

A significant portion (222 acres, 17%) of the drainage remains old growth. The BLM owns 51% or 678 acres of the Mill Creek subshed. The Mill Creek Conservancy also acts to minimize impacts to the Mill Creek Forest and Lower Mill Creek, protecting valuable salmonid habitat and scarce old growth in the lower Mattole. Temperatures are cool enough to be suitable for coho salmon rearing (See Figure 10), and lower Mill Creek maintains sufficient flow in the summer to provide habitat. The creek bed is also mainly cobble and gravel with little fine sediment in comparison to other lower Mattole tributaries.

A possible limiting factor to juvenile utilization of oversummering habitat in lower Mill Creek is an old sediment screen about a half mile up the creek. The structure was constructed in the 1980s to recruit spawning gravel for adult salmon in the lower reach of the creek. Prior to 2005, many redds were observed in the recruited gravels behind the lowest weir but the creek had down cut enough to leave two of the structures with passage issues. Boulder step pools were installed in summer of 2005 to mitigate this problem, allowing passage upstream for adult spawners.

While upstream-migrating adults are now able to access upper reaches of Lower Mill Creek at higher flows, the structure confines oversummering juveniles to the reach below the screens. Once juvenile salmonids have migrated downstream of the screen, they are no longer able to access the upper sections of the creek. Removal of the screen would provide unimpeded access to juvenile salmonids, allowing utilization of many more feet of cool-water coho habitat for oversummering juveniles seeking refuge from high summer temperatures in the lower mainstem.

Juvenile coho have been observed in Lower Mill Creek consistently during MSG dive surveys. In 2006, MSG divers observed one juvenile coho during the spring dive on 5/11. The MSG has also observed coho in lower Mill Creek during dive surveys in 2002-2004. One adult coho was also observed in the creek during a spawner survey. Steelhead were observed in greater numbers in the fall dive in 2006 (3 (<4") SH on 5/11, 83 (<4") SH and 1 (4"-8") SH on 9/27).

Clear Creek (RM 6.1)

Clear Creek was monitored for three consecutive years, from 2000-2002, and in 2006. All years indicated thermally suitable habitat for coho (<65°F MWMT, Welsh et al, 2001) (See Figure 14). Based on 2006 Maximum Weekly Average Temperature (60.86°F), thermal habitat in Clear Creek is good for steelhead (<63.0°F MWAT) and marginal for coho salmon (59.0-63.0°F MWAT) according to temperature tolerance criteria developed by Coates et al. (2002). In the lower Mattole, Clear Creek is among the coolest tributaries for salmonid oversummering. 2006 was the warmest of all years monitored; the maximum temperature reached was 63.26°F on 7/18/06.

One coho was observed during the spring dive on 6/3/06, while steelhead were observed in both spring and fall. Dive surveys in 2001-2002 did not verify the presence of coho, although temperature monitoring indicated Clear Creek was thermally suitable for coho. Archival MSG survey data also confirms coho and steelhead presence. Clear Creek is a small creek, but it maintains enough flow to support salmonid habitation throughout the summer. Although no old-growth remains, only 4% of the drainage is grassland. Most of the subshed is mature forest, and Clear Creek is relatively shaded. Numerous larger rocks and large wood provide habitat and cover to oversummering salmonids. While temperature criteria characterize Clear Creek as marginal for coho, it provides more favorable coho habitat than most other creeks in the lower Mattole, especially when habitat characteristics in addition to temperature are considered.

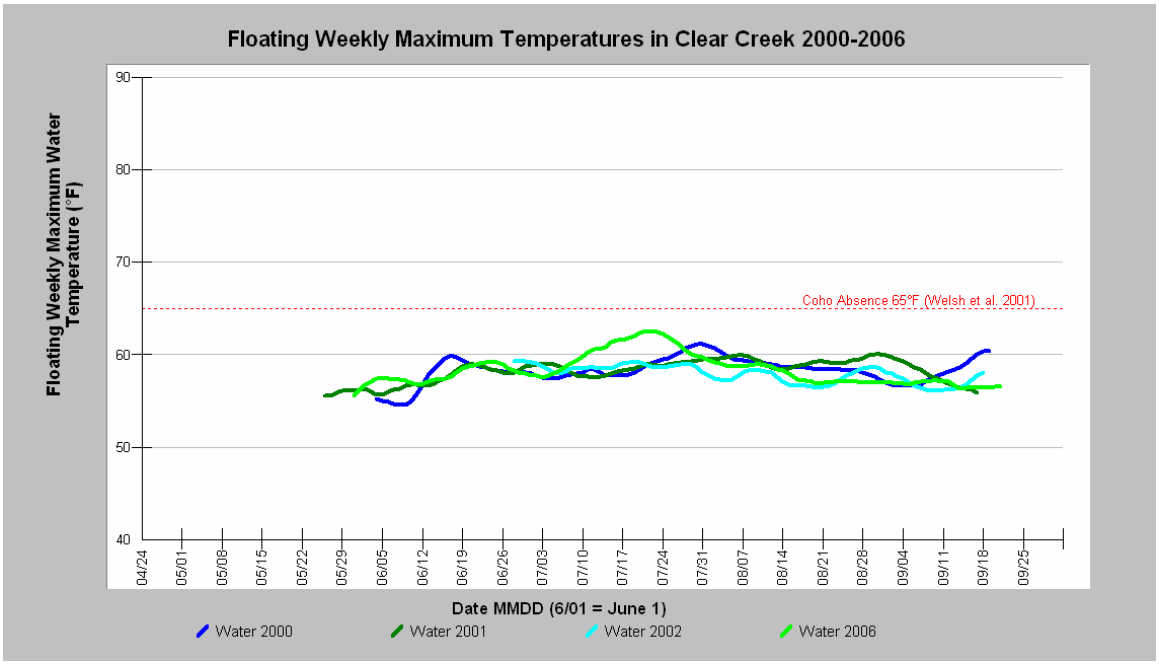


Figure 14. Floating Weekly Maximum Temperatures in Clear Creek, 2000-2002 and 2006.

Squaw Creek (RM 14.9)

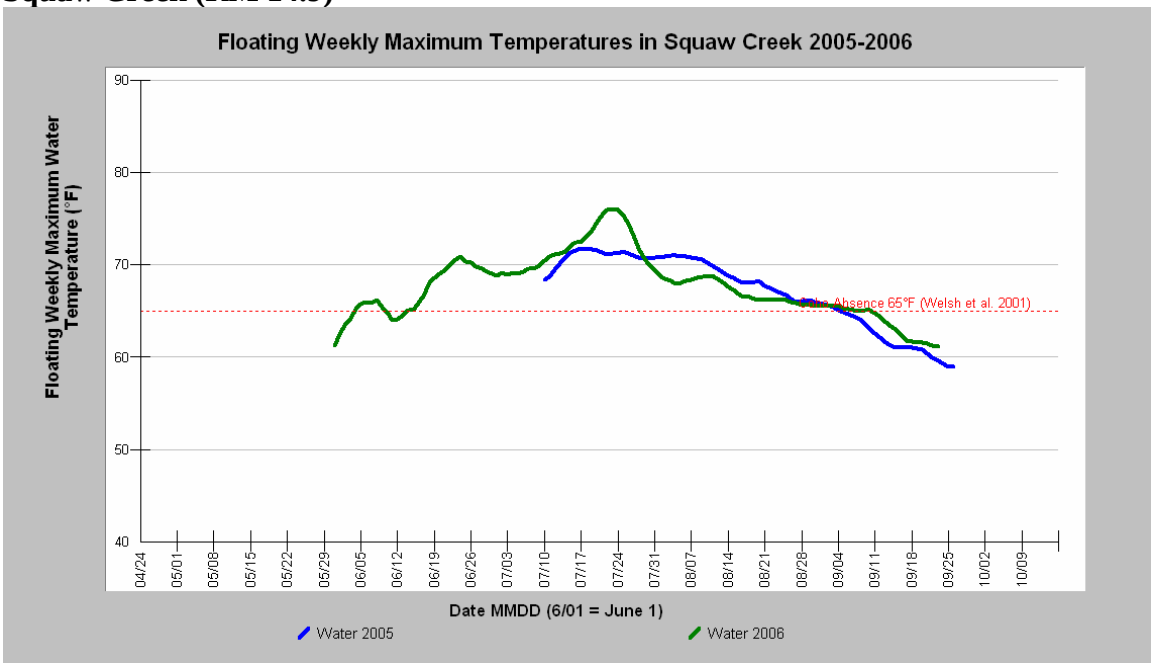


Figure 15. Floating Weekly Maximum Temperatures in Squaw Creek, 2005-2006.

Squaw Creek temperatures exceeded thresholds for juvenile salmonid oversummering in 2005 and 2006. Maximum floating weekly maximum water temperature (MWMT) exceeded 65°F in both years, indicating temperatures were higher than suitable for coho salmon rearing (Welsh et al. 2001) (See Figure 15). Maximum weekly average temperatures also indicated temperatures were warmer than ideal for juvenile salmonids. In 2005 the MWAT in Squaw Creek was

66.92°F, exceeding thresholds for both coho and steelhead (<63.0-66.0°F MWAT, Coates et al. 2002). The 2006 MWAT in Squaw Creek (72.61°F) was significantly warmer than in 2005.

The maximum temperature recorded in 2006 was 77.86°F, several degrees above the short-term maximum temperature threshold for salmonid survival (75.0°F, Brett 1952) and the maximum in 2005 (73.26°F). Maximum temperature exceeded 68°F on 50 of 122 days monitored in 2006, indicating prolonged as well as acute temperature stress for salmonids oversummering in Squaw Creek.

Squaw Creek is one of the larger lower river tributaries, and it has some favorable salmonid habitat attributes, including bedrock pools and riparian shading. Much of the drainage is forested with 11% remaining old growth; only 13% is grasslands. A sizeable amount (39%) of the subshed is owned by the BLM

Despite temperatures above the coho threshold during the two years on record, coho were observed in both 2006 and past MSG surveys. During the spring dive on 6/11/06, both Chinook salmon (3) and coho (1) were observed.

During the late summer of 2006, a habitat improvement project occurred in the last 200 feet of Squaw Creek. Four structures consisting of large wood and boulder were constructed and anchored. The difference in steelhead utilization of Squaw Creek in spring before the structures were built and in fall after they were completed was substantial. While only 44 (<4") steelhead and 8 (4"-8") steelhead were observed in the spring, over a thousand <4" steelhead (1022), 5 (4"-8") steelhead, and 2 (>8") steelhead were observed on 9/27/06. No Chinook or coho were observed in the fall. Pipe trap data from 2006 and prior years as well as past survey data have confirmed the presence of coho, Chinook and steelhead in Squaw Creek.

Saunders Creek (RM 19.9)

Saunders Creek was monitored in 2001, 2002, and 2006. Maximum floating weekly maximum water temperature (MWMT) did not exceed 65°F in 2001 or 2002, indicating suitable temperatures for coho salmon rearing (Welsh et al. 2002) (See Figure 16). 2006 temperatures were higher than those recorded in 2001-2002, exceeding the coho threshold during peak temperatures in mid-July. In 2006, the maximum weekly average temperature in Saunders Creek (67.71°F) was warmer than thresholds for both coho (>63.0°F MWAT) and steelhead (>66.0°F MWAT) (Coates et al. 2002). Temperatures in Saunders Creek surpassed 68°F on 12 of 117 days monitored in 2006, confirming prolonged exposure to temperature stress for salmonids during the peak of summer heat.

Due to a culvert replacement in 2006, access for both juveniles and adults to upper reaches of Saunders Creek is now unimpeded. Past MSG surveys indicate only steelhead have inhabited Saunders Creek in recent years. Steelhead were the only species observed during juvenile dive surveys in 2001-2002 and 2006. 40 steelhead (<4") were observed during the spring dive on 5/31.

While Saunders Creek maintains relatively cool temperatures during the summer and appears to offer suitable oversummering habitat for steelhead and even coho during some years, low-flow

during the late summer months pose a threat to oversummering juveniles. There was no fall dive in Saunders Creek in 2006 due to lack of water in the creek. Most of Saunders Creek was flowing subsurface by midsummer; divers noted only a trickle during the Summer Steelhead Dive on July 14. The second peak of temperatures in 2006 (See Figure 14) corresponds to air temperatures when the temperature logger went dry. Divers counted 19 (<4") steelhead in two isolated pools remaining on September 26; the rest of the creek was dry up to the culvert. Water conservation measures such as water storage during the wet months may offer the possibility of higher flows during the summer and are essential for Saunders Creek to offer salmonid oversummering habitat.

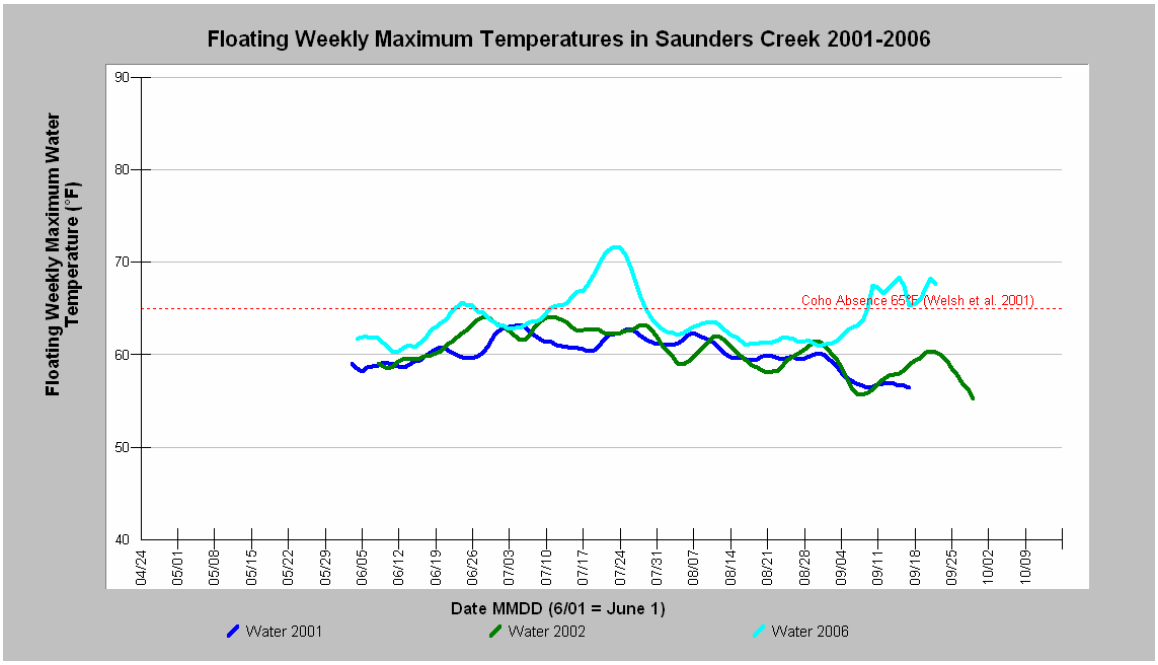


Figure 16. Floating weekly Maximum Temperatures in Saunders Creek, 2001, 2002, and 2006.

Woods Creek (RM 24.1)

Temperature monitoring in Woods Creek occurred in 2000-2002 and in 2006. In 2001 and 2002, maximum floating weekly maximum temperatures remained below the coho threshold (See Figure 17). Maximum floating weekly maximum water temperature (MWMT) exceeded 65°F in 2000 and 2006, indicating temperatures were higher than suitable for coho salmon rearing (Welsh et al. 2001). However, 2000 and 2006 temperatures exceeded the coho threshold for only a short period during peak temperatures in mid-July. 2006 MWAT (64.70°F) indicated temperatures in Woods Creek were warmer than ideal for coho (>63.0°F) but suitable for steelhead (>66.0°F). The maximum temperature reached in Woods Creek in 2006 was 69.47°F on July 24, well below short-term lethal temperature (75.0°F, Brett 1952). Maximum temperatures in Woods Creek exceeded 68°F on only 4 of 109 days of monitoring.

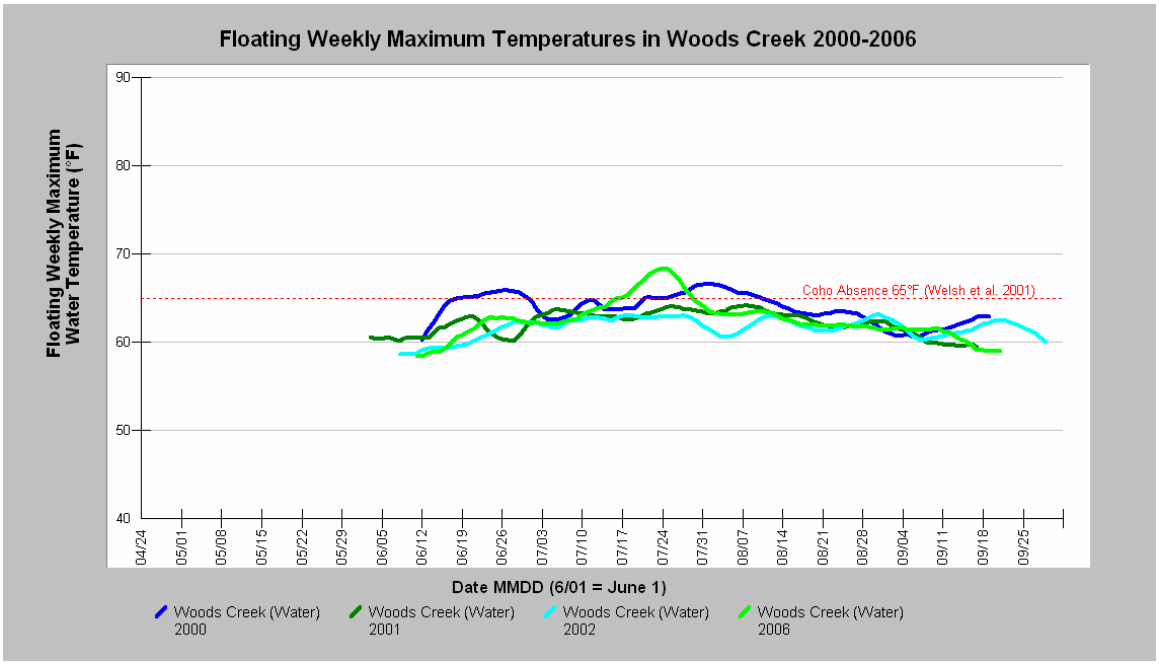


Figure 17. Floating Weekly Maximum Temperatures in Woods Creek, 2000-2002 and 2006.

In addition to relatively cool summer temperatures, the lower reach of Woods Creek appears to have other attributes of favorable salmonid habitat, including cobble and gravel with lack of significant amounts of fine sediment as well as riparian shading and rootwads for cover. The subshed is mainly forested, with 0% grassland and 3% old growth. 76% of the drainage is owned by the BLM.

MSG divers observed 2 coho salmon in 2001 during juvenile dive surveys in Woods Creek. On 6/7/06, MSG divers observed 8 (<4") coho salmon, indicating that coho persist in Woods Creek. The coho were observed in September 2001, but no coho were observed during the fall 2006 dive. Interestingly, temperatures did not exceed the coho threshold established by Welsh et al. in 2001, while 2006 temperatures did exceed 65°F MWMT. It is unknown if coho found in Woods Creek came from coho spawning in the creek or if juvenile coho seeking refuge from the warm temperatures prevalent in the lower mainstem Mattole oversummer in Woods Creek.

Dive surveys also indicated steelhead presence in Woods Creek. 101 (<4") steelhead and 2 (4"-8") steelhead were observed on 6/7/06, while 437 (<4") and 7 (4"-8") steelhead were observed on 9/25/06. More steelhead were observed in Woods Creek in 2006 than during the 2001-2002 juvenile dive surveys.

Honeydew Creek (RM 26.5)

2006 was the first year of temperature monitoring in Honeydew Creek since before 2000. Upper and lower reaches of Honeydew Creek were selected for temperature and dive monitoring. Maximum floating weekly maximum water temperature (MWMT) exceeded 65°F in both

locations, indicating temperatures were higher than suitable for coho salmon rearing (Welsh et al. 2001) (See Figure 18). Maximum weekly average temperatures in both upper and lower Honeydew Creek exceeded thresholds for coho (<63.0°F) and steelhead (<66.0°F).

The lower reach of Honeydew Creek was noticeably warmer than the upper reach. The MWAT in upper Honeydew Creek was 68.08°F; in lower Honeydew Creek it was 69.54°F. Maximum temperatures in lower Honeydew reached 78.36°F, while maximum temperature in upper Honeydew was several degrees cooler (75.38°F). Maximum temperatures in both the upper and lower reach were warm enough to be lethal (>75.0°F, Brungs and Jones 1977). Salmonids also experienced more prolonged temperature stress in the lower site. Temperatures exceeded 68°F in 82 of 109 days at the lower site, while temperatures measured at the upper site were warmer than 68°F in 28 of 107 days in the upper site.

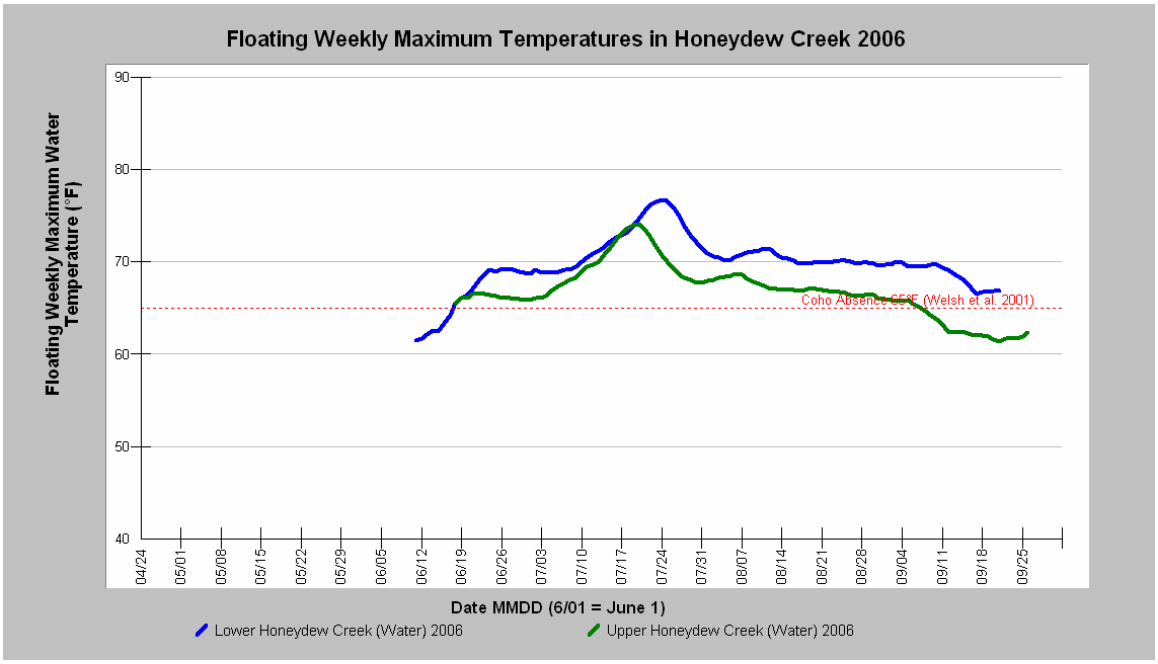


Figure 18. Floating Weekly Maximum Temperatures in Honeydew Creek 2006.

Fall salmonid counts in Honeydew Creek were also significantly different in the two reaches. During the fall dive on 9/30, 682 (<4") steelhead were observed in the upper reach, while only 3 Additionally, 8 young-of-the-year steelhead mortalities were observed in the lower reach, although the cause of death is unknown.

Although temperatures are warmer than ideal for salmonids, past survey data indicates steelhead, Chinook, and coho utilize Honeydew Creek. It is also notable that 22% (448 acres) of the Honeydew Creek drainage remains old growth and 71% (7,786 acres) of the subshed is owned by the BLM. Due the large proportion of its watershed in the King Range National Conservation Area, Honeydew Creek is one of the least impacted of Mattole tributaries by human land practices.

Northern Sub-basin

East Mill Creek (RM 5.4)

For the most part, temperatures in East Mill Creek were suitable for coho salmon rearing. Floating weekly maximum water temperature slightly exceeded 65°F in 2003 and 2004 during peak temperatures, indicating temperatures were warmer than suitable for coho (Welsh et al. 2001) (See Figure 19). In 2005 and 2006, temperatures remained just below the coho threshold. The maximum weekly average temperature in East Mill Creek was 61.98°F in 2006, indicating suitable thermal habitat for both coho (<63.0°F) and steelhead (<66.0°F). Maximum temperature (65.15°F) recorded in East Mill Creek was well below lethal temperatures for salmonids

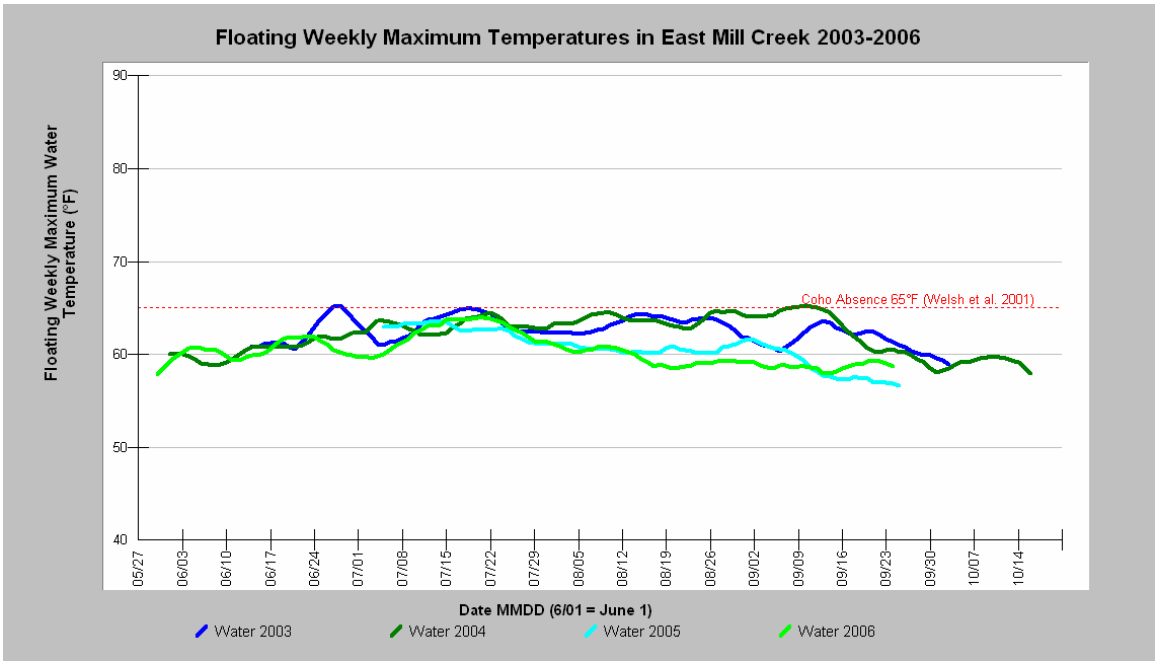


Figure 19. Floating Weekly Maximum Temperatures in East Mill Creek, 2003-2006.

Coho salmon have been documented in East Mill Creek during spring dives in 2003, 2004 and 2006. There were no dives in East Mill in 2005. Consistent observations of less than ten coho indicate East Mill Creek supports a very small population of coho juveniles in some years. It is unknown if these juveniles come from spawners in East Mill Creek or are coho from the Mattole mainstem seeking refuge in the cool temperatures and relatively good fish habitat found in East Mill Creek in comparison to the lower mainstem Mattole. Juvenile steelhead presence in East Mill Creek has also been documented by MSG snorkel surveys.

Despite a significant percentage of grasslands (29%) and many residents settled along the creek, East Mill Creek remains one of the coolest lower river tributaries. Consistent observation of juvenile salmonids in addition to cold temperatures indicate East Mill Creek offers a cool refuge and is valuable oversummering habitat in the lower Mattole. A barrier removal project is scheduled to make more of East Mill Creek accessible to coho and steelhead.

Conklin Creek (RM 7.8)

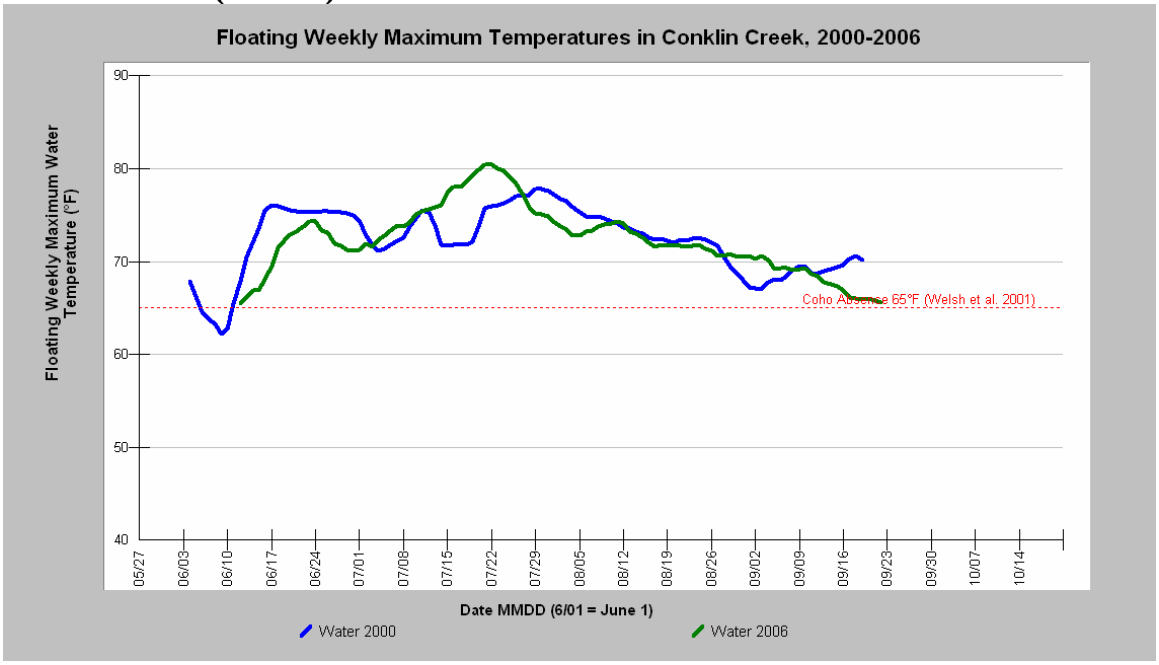


Figure 20. Floating Weekly Maximum Temperatures in Conklin Creek, 2000 & 2006.

Maximum floating weekly maximum water temperature (MWMT) exceeded 65°F in both 2000 and 2006, indicating temperatures were not suitable for coho salmon rearing (Welsh et al. 2001) (See Figure 20). MWAT recorded in Conklin Creek was 67.76°F, exceeding threshold temperatures for coho (<63.0°F) and steelhead (<66.0°F) (Coates et al. 2002). The maximum temperature recorded in Conklin Creek was 82.66°F, well above short-term maximum lethal temperature (>75.0°F) for juvenile salmonids (Brungs and Jones 1977). Salmonids oversummering in Conklin Creek were exposed to prolonged as well as acute temperature stress; temperatures in the creek were warmer than 68°F during 92 of 109 days monitored.

Divers from the Mattole Salmon Group have not observed either coho or Chinook salmon in Conklin Creek despite multiple years of juvenile dive surveys. However, juvenile steelhead presence has been documented by MSG divers and historical accounts by longtime residents. Two large slides occurred in the Conklin Creek subshed during the storms of winter 2005, creating massive sediment accumulation in Conklin Creek. This disturbance drastically degraded fish habitat in the creek, filling in pool habitat and causing most of Conklin Creek's flow to go subsurface. In 2006, MSG divers saw only 14 steelhead in ten pools upstream of Conklin Creek's confluence with the Mattole during the spring dive, and 16 steelhead in four pools remaining by the time of the fall dive.

Wild Turkey Creek (RM 12.7)

Wild Turkey Creek was monitored for temperature in 2005 and 2006. Both years indicated suitable MWMT for coho (Welsh et al. 2001) (See Figure 21). 2006 MWAT recorded in Wild Turkey was very cool (61.80°F), indicating marginal thermal habitat for coho (59.0°F-63.0°F) and good thermal habitat for steelhead (<63.0°F) (Coates et al. 2002). Maximum temperature

recorded was 65.10°F, indicating lack of acute or prolonged temperature stress for salmonids oversummering in the creek.

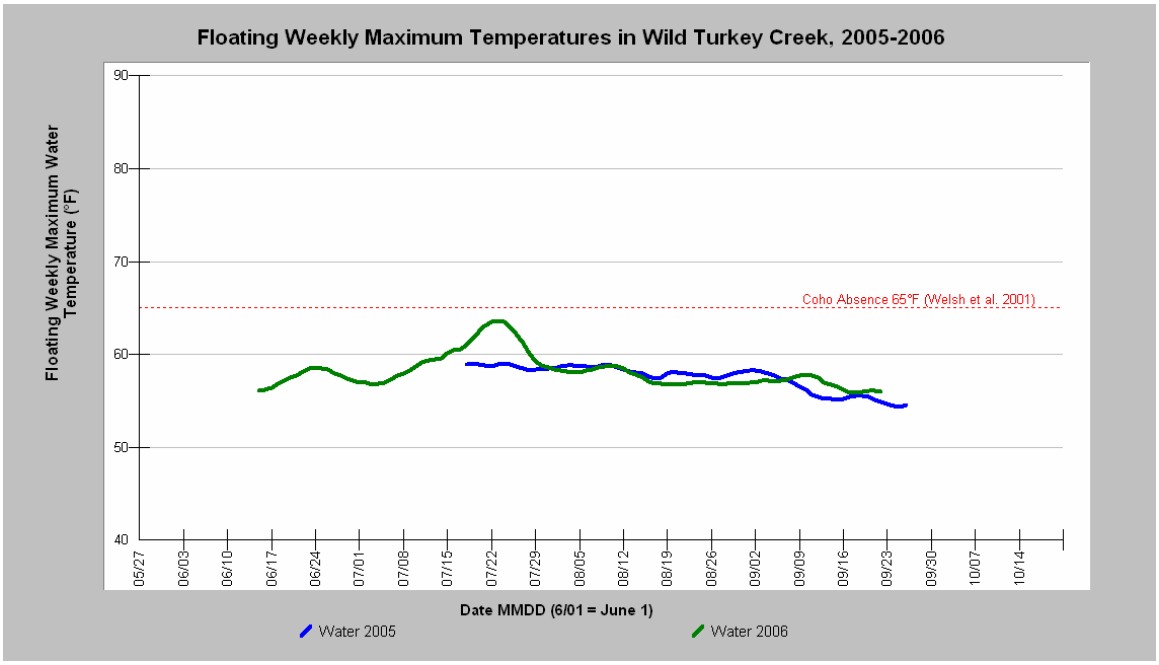


Figure 21. Floating Weekly Maximum Temperatures in Wild Turkey Creek, 2005-2006.

Although Wild Turkey Creek maintains cool temperatures and continuous summer flow, it has limited utility as oversummering habitat for salmonids as it is discontinuous with the mainstem at low flows. At high flows, salmonids are able to access the creek and spawn there. Juveniles may become trapped in the creek to oversummer. Since the temperatures are cool, salmonids trapped in the creek are likely to survive oversummering in the creek, then migrate downstream during higher flow. Salmonid utilization of this cool water source as a refuge from high temperatures in the mainstem is restricted by the gravel bar. The gravel bar obstructing the confluence prevents cool water inputs from Wild Turkey Creek to reach the lower Mattole. One danger is that salmonids may become trapped in isolated pools near the confluence. Approximately 150 steelhead were observed in two isolated pools without any riparian cover in 2006. There were no 2006 dives in Wild Turkey Creek. Past data on salmonid utilization of Wild Turkey Creek indicates only steelhead are known to reside there.

Upper North Fork (RM 25.5)

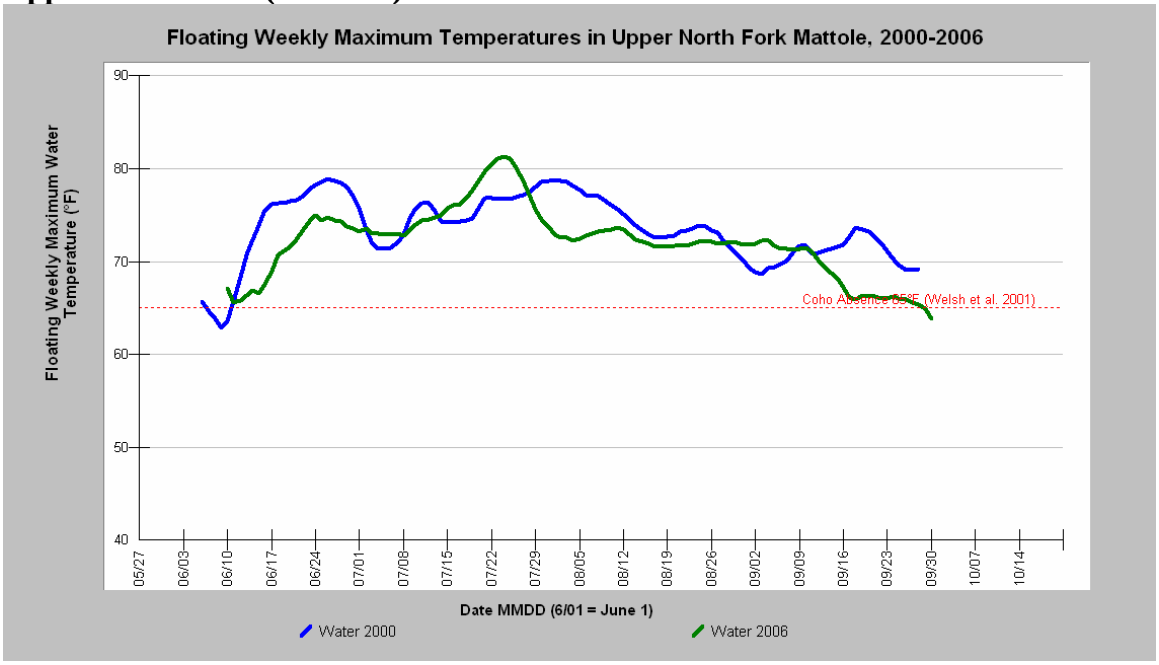


Figure 22. Floating Weekly Maximum Temperatures in the Upper North Fork Mattole, 2000 & 2006.

Maximum floating weekly maximum water temperature (MWMT) exceeded 65°F in 2000 and 2006, indicating temperatures were not suitable for coho salmon rearing (Welsh et al. 2001) (See Figure 22). 2006 MWAT in the Upper North Fork was 74.77°F, also suggesting temperatures were unsuitable for coho (>63.0°F) as well as steelhead (>66.0°F). Salmonids oversummering in the Upper North Fork were subject to prolonged temperature stress for the majority of the summer; temperature in the Upper North Fork exceeded 68°F on 96 of 109 days monitored. The maximum temperature in the Upper North Fork was 83.02°F, well above short-term lethal temperature for juvenile salmonids (75.0°F, Brungs and Jones 1977) and comparable to mainstem maximum temperatures in many locations.

The Upper North Fork Mattole is a large subshed relative to other tributaries to the Mattole (16,696 acres). Much of the Upper North Fork Mattole is very remote and there are few road access points. Most of the subshed was previously logged; now 2% old growth remains and 20% of the drainage is grassland. A small percentage (1%) of the drainage is owned by the BLM. Numerous slides in tributaries to the Upper North Fork and the Upper North Fork itself contribute sediment, and a layer of fine sediment is noticeable in some pools and near its confluence with the mainstem Mattole. The channel is highly aggraded in most areas, but steep bedrock canyon walls and mature forest shade some areas.

Past survey data from the Upper North Fork indicates Chinook and steelhead presence. Longtime residents report observing salmon spawning in the Upper North in the early 1980s. During the spring and fall 2006 snorkel surveys, divers identified only steelhead, although divers noted 2 unidentified salmonids were possible Chinook.

Eastern Sub-basin

McGinnis Creek (RM 8.0)

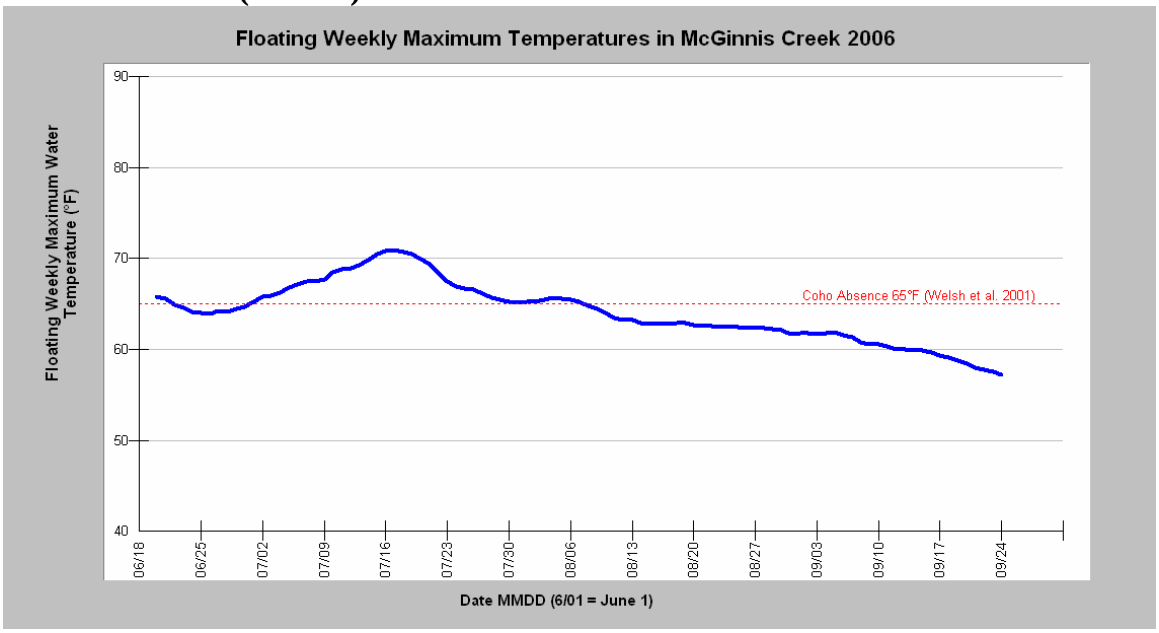


Figure 23. Floating Weekly Maximum Temperatures in McGinnis Creek, 2006.

2006 was the first year of MSG temperature and dive monitoring of McGinnis Creek. Maximum floating weekly maximum water temperature (MWMT) in McGinnis Creek exceeded 65°F in 2006, indicating temperatures were not suitable for coho salmon rearing (Welsh et al. 2001) (See Figure 23). MWMT exceeded the coho threshold for the duration of July. The maximum temperature recorded in McGinnis was 72.14°F on 7/18. Coates et al. (2002) would characterize McGinnis Creek (66.11°F MWAT) as poor thermal habitat for steelhead (>66.0°F MWAT). However, temperatures in the creek are much more favorable for oversummering salmonids than in the nearby mainstem Mattole. The temperature logger in the Mattole just upstream of McGinnis recorded a maximum temperature of 84.95°F.

Only steelhead are known to reside in McGinnis Creek according to past MSG monitoring. The average parcel size in the drainage is relatively large (81 acres). Much of the upper drainage is timberland, while the lower reach is ranchland. The lower section is heavily impacted by sediment and contains little favorable salmonid habitat. In both the spring and fall of 2006, McGinnis Creek at its confluence with the Mattole was a small trickle with much of the flow subsurface below fine sediment.

One hundred (<4") steelhead were observed during the fall snorkel survey on 10/5/06. There was no spring dive. Neither coho salmon nor Chinook salmon juveniles were observed during snorkel surveys in the McGinnis Creek reach.

Southern Sub-basin

McKee Creek (RM 52.8)

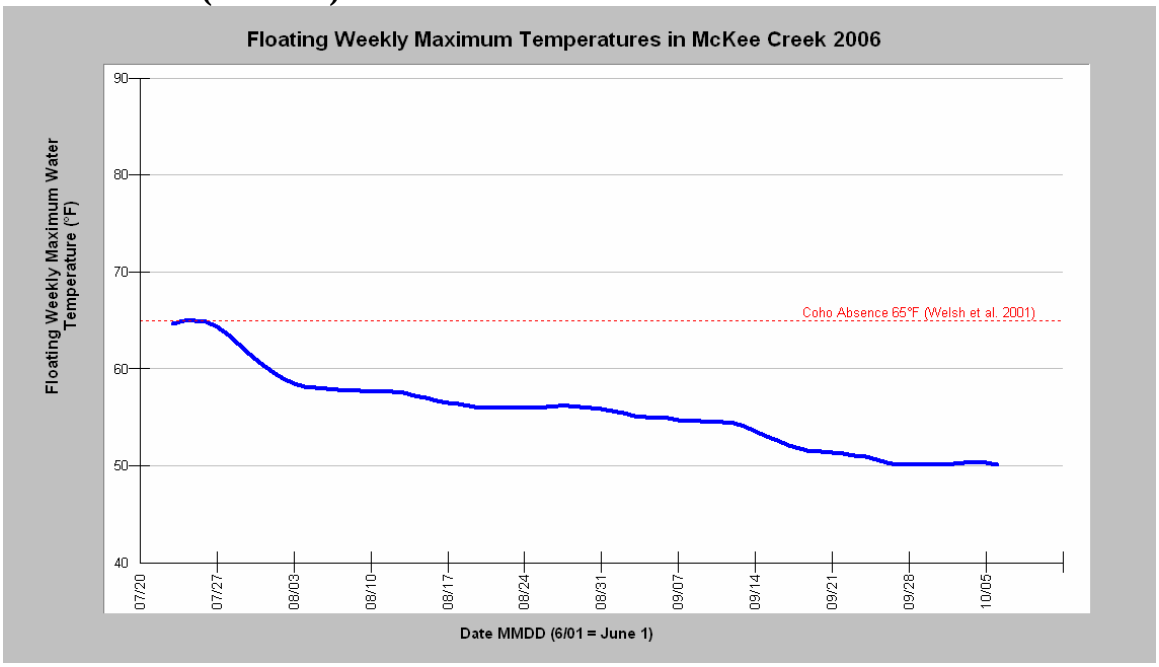


Figure 24. Floating Weekly Maximum Temperatures in McKee Creek 2006.

2006 was the first year of MSG temperature monitoring in McKee Creek. Maximum floating weekly maximum water temperature (MWMT) did not exceed 65°F in 2006, indicating temperatures were suitable for coho salmon rearing (Welsh et al. 2001) (See Figure 24). 2006 MWAT was 64.61°F, suitable habitat for steelhead (<66.0°F) but warmer than ideal for coho (<63.0°F) according to temperature tolerance criteria developed by Coates et al. 2002. Weekly average temperatures except for the peak week of summer heat were within the range suitable for coho. The maximum temperature recorded in McKee Creek in 2006 was 65.41°F, well below short-term lethal temperatures for salmonids.

Despite favorable temperatures, McKee Creek provides limited habitat for juvenile salmonids during the later part of the summer and in early fall before the rains. While the creek still had significant flows in July, by October McKee had dried to a series of disconnected pools. Other water quality factors such as dissolved oxygen may threaten juvenile salmonids during times of low flow in the creek.

Past data indicates Chinook, coho, and Chinook utilize McKee Creek. There was no dive in 2006, although steelhead were observed in the pool with the temperature logger during placement and retrieval.

Conclusion

Temperature has been determined to be a major limiting factor to salmonid abundance and survival in the Mattole Watershed. An increase in stream temperatures in the Mattole basin during the last four decades as a result of channel aggradation, widening, and the removal of

riparian cover is a key factor restricting salmonid distribution and abundance in their historical range. The life stage of salmonids most vulnerable to increased temperature is the growth phase (Brungs and Jones 1977). Juvenile salmonids in the Mattole during the summer months are exposed to increased water temperature, low flows and lack of riparian shading. Summer water temperatures in some reaches of the lower Mattole regularly reach 78.0°F, and temperatures over 66.0°F in many tributary locations are not uncommon.

Lack of oversummering habitat and energetic constraints to feeding and growth due to high water temperatures have contributed to reduced run strength for two species of salmon present in the Mattole River. Downstream Migrant data on Chinook salmon indicates Chinook salmon are migrating to the ocean at substandard size for ocean survival (MSG 2006, Reimers 1973).

Juvenile coho have the lowest tolerance to high temperature of any anadromous species in the Mattole Watershed (Coates et al. 2002). Only fifteen coho salmon were observed during dive surveys in the Mattole and selected tributaries in 2006. All coho observed in 2006 were observed during the spring dives; by fall, no coho were observed in any location. The lower river tributaries where coho were observed in 2006 included Lower Mill Creek (RM 2.8), East Mill Creek (RM 5.4), Clear Creek (RM 6.1), Squaw Creek (RM 14.9), and Woods Creek (RM 24.1). These tributaries are the coolest and have the most presence of riparian cover and pool habitat of any tributaries in the lower Mattole.

The criteria developed by Welsh et al. (2001) correctly identified coho presence in eight of twelve streams where juvenile dive surveys and temperature monitoring were conducted in the lower Mattole in 2006. The two streams with coho that exceeded the threshold determined by Welsh et al. (65.0°F MWMT) did so only by a small increment and were likely to contain other habitat characteristics favorable for salmonid utilization, such as significant percentage of mature forest in the drainage, lack of fine sediment aggradation, presence of deep cold pools, and riparian cover.

Squaw Creek was the only tributary where juvenile Chinook were observed during dive surveys in 2006. Chinook were also observed in the mainstem Mattole by the MSG at the downstream migrant trap and in the Mattole Estuary. Current efforts to expand dive monitoring in the Mattole estuary, headwaters, and tributaries throughout the watershed aim to gain more understanding of the effects of elevated temperature and low streamflow on juvenile Chinook oversummer survival and distribution.

Temperature is important in determining the distribution and habitat utilization by juvenile coho in the lower Mattole Watershed, but other factors also play an important role. An illustration of this is Stansberry Creek, which despite the lowest MWAT of any site monitored in 2006, did not contain coho in the ten pools surveyed in 2006.

Because of the seasonal and year to year variability of mouth closure of the Mattole, it is essential for juvenile coho survival that the coolest and best of the lower Mattole tributaries are protected with reference to their favorable characteristics for salmonid oversummering.

Tributaries monitored in 2006 where temperatures were warm enough to be lethal (75°F, Brett 1952) to juvenile salmonids included Conklin Creek (RM), Squaw Creek (RM 14.9), the Upper

North Fork Mattole (RM 25.5), and Honeydew Creek (RM 26.5). Characteristics common to these streams include a high occurrence of channel aggradation, a high percentage of grasslands and road density and/or slides in the subbasins.

Floating Weekly Maximum Temperatures in five of six upper Mattole mainstem temperature monitoring sites exceeded suitable temperatures for coho rearing (Welsh et al. 2001). The temperature monitoring site where temperatures remained below the coho threshold (MS-3 at RM 58.6) was located deep in a pool with a MSG habitat enhancement large woody debris structure. This emphasizes the importance of deep pool habitat, cool refugia, and habitat restoration even in the coolest area of the Mattole mainstem near the headwaters.

Maximum temperature exceeded lethal temperatures for juvenile salmonids (>75°F, Brett 1952) in fourteen of sixteen temperature monitoring sites in the mainstem Mattole River downstream of river mile 26.6 (upstream of confluence with Honeydew Creek), and one at river mile 42.3 (Ettersburg Bridge). Sites where temperatures were did not reach lethal limits to salmonid survival in the lower mainstem included two sites which were both deep in pools, upstream of Squaw Creek (RM 15) and at the Wingdam (RM 2.9).

Temperatures recorded at the Wingdam structure emphasize the importance of continued habitat enhancement in the lower Mattole River for juvenile salmonid survival during the peak heat of the summer months. Temperatures deep in the Wingdam pool remained below lethal levels for juvenile salmonids despite lethal temperatures at the surface and at most lower mainstem temperature monitoring locations. More habitat enhancement structures such as this would offer better oversummering habitat than now exists. Recent habitat improvements implemented by the MSG include large wood structures constructed in Squaw Creek and the Mattole Estuary. Deep pools, riparian cover, and cool-water tributaries are essential refuges for juvenile salmonids from unsuitably high temperatures in the lower and middle mainstem Mattole River during the summer months.

Recommendations

- Give monitoring and restoration priority to streams in which temperatures remain cold, yet coho are not present.
- Continue dive surveys to monitor Chinook and coho presence in creeks and mainstem locations throughout the Mattole Watershed over multiple study years to establish a baseline of salmonid habitat distribution in comparison to temperature trends.
- Continue monitoring temperatures, delineating specific goals for each logger placement.
- Implement pre- and post-project monitoring of restoration sites.
- Continue to study specific cold areas (pools and seeps), observing the dynamics of the channel morphology/temperature relationship through time. Expand cold-water monitoring sites in areas throughout the Mattole watershed.
- Locate and establish Mattole temperature monitoring reference locations.
- Expand tributary monitoring to tributaries throughout the watershed
- Monitor temperature in critical upper mainstem rearing habitat, in addition to flow and other water quality criteria.
- Monitor coho, Chinook, and steelhead presence in the Mattole Estuary via dive surveys to determine survival, distribution, and abundance over the summer months.

- Conduct water quality investigations to elucidate water quality factors in addition to temperature affecting salmonid oversummering in the mainstem Mattole River and tributaries throughout the watershed.
- Utilize temperature data to determine areas where restoration activities can be conducted to enhance habitat in areas which support water temperatures favorable for salmonid oversummering.
- Enhance pool habitat in the middle and lower river to expand oversummering habitat for juvenile salmonids.

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Table 1. 2006 Mattole Salmon Group Temperature Monitoring: funding sources, serial numbers, location, and dates of placement. Date and value of recorded max temperature, days >68F, Maximum Weekly Average Temperature and week of are also provided in Table 1.

Funding Source	Serial #	River Mile	Location	Date In	juvenile salmonids (spring)	Date Out	juvenile salmonids (fall)	max. temp., degrees F	Date of max temp	days>68/ total days	MWAT	Week beginning	Notes
BLM	891552	1.3+0.2	Stansberry Creek	5/11/06	SH	9/27/06	SH	62.10	7/18/06	0/138	58.86	7/13/06	last 100' us confluence dry in fall
BLM	575786	1.3	Mattole us Stansberry Cr.	5/11/06	N/A	9/27/06	N/A	79.35	7/17/06	124/138	72.00	7/19/06	no dive
BLM	575798	2.8+0.1	Lower Mill Creek	5/11/06	SS, SH	9/29/06	SH, UN	61.93	7/25/06	0/140	59.57	7/20/06	UN possible SS
BLM	575792	2.8	Mattole us L. Mill Creek	5/11/06	N/A	9/27/06	SH	N/A	N/A	N/A	N/A	N/A	logger malfunction
BLM/ONS	568291	2.9	Mattole @ Wingdam (shallow)	6/9/06	N/A	10/11/06	SH	79.70	7/24/06	92/123	73.32	7/21/06	placed with Mattole Elementary
BLM/ONS	891612	2.9	Mattole @ Wingdam (deep)	6/9/06	N/A	10/17/06	SH	72.52	7/2/06	61/127	70.37	7/21/06	placed with Mattole Elementary
BLM/ONS	575793	3.9	Mattole @ DSMT	5/31/06	N/A	10/3/06	N/A	81.20	7/17/06	117/124	73.66	7/20/06	KS, SS, SH @ trap
BLM	575775	4.7+0.5	Lower North Fork	5/28/06	SH	10/12/06	SH	N/A	N/A	N/A	N/A	N/A	logger out of water
BLM	575787	4.7	Mattole us L. North Fork	5/31/06	N/A	10/12/06	N/A	82.40	7/24/06	133/133	75.44	7/20/06	SH along LB
BLM	891613	5.4+~0.2	East Mill Creek	5/26/06	SS, SH	9/28/06	SH	65.15	7/18/06	0/118	61.98	7/18/06	SH along LB
BLM	884733	5.5	Mattole us East Mill Creek	5/26/06	N/A	9/28/06	N/A	83.65	7/24/06	108/124	75.93	7/20/06	logger moved us on 6/10
BLM	895564	6.1+0.2	Clear Creek	5/27/06	SS, SH	9/25/06	SH	63.26	7/21/06	0/120	60.86	7/18/06	SS in pool 11
BLM	575782	6.1	Mattole us Clear Creek	5/27/06	N/A	9/25/06	N/A	84.00	7/24/06	111/120	75.86	7/20/06	no dive
BLM	893659	7.8+~0.2	Conklin Creek	6/8/06	SH	9/26/06	SH	82.66	7/24/06	92/109	67.76	7/19/06	2 massive slides in winter 2006

BLM	891511	7.8	Mattole us Conklin Creek	6/11/06	N/A	9/26/06	N/A	81.42	7/24/06	102/106	73.22	7/21/06	no dive
BLM	989872	8+~1.0	McGinnis Creek	6/16/06	N/A	10/5/06	SH	72.14	7/18/06	17/110	66.11	7/14/06	no spring dive
BLM	884719	8	Mattole us McGinnis Creek	6/11/06	N/A	9/26/06	N/A	84.95	7/23/06	102/106	76.63	7/20/06	no dive
BLM	895562	12.7+~0.1	Wild Turkey Creek	6/11/06	N/A	9/26/06	N/A	65.15	7/24/06	0/106	61.80	7/20/06	SH observed in isolated pools
BLM	882012	12.8	Mattole us Wild Turkey Creek	6/11/06	N/A	9/26/06	N/A	85.67	7/23/06	93/106	77.97	7/21/06	creek isolated from mainstem
BLM	895563	14.9+~0.1	Squaw Creek	5/27/06	SS, KS, SH	9/27/06	SH	77.86	7/23/06	50/122	72.61	7/21/06	more fish observed post-restoration work
BLM	884753	15	Mattole us Squaw Creek	5/27/06	N/A	9/27/06	N/A	74.08	6/11/06	28/122	69.61	7/22/06	no dive
BLM	575780	19.9+0.1	Saunders Creek	5/31/06	SH	9/26/06	SH	73.86	7/23/06	12/117	67.71	7/22/06	out of water, creek dry except for 2 isolated pools, data discarded after 9/4
BLM	575777	20	Mattole us Saunders Creek	5/31/06	N/A	9/26/06	N/A	86.85	7/23/06	117/127	78.45	7/21/06	no dive
BLM	893658	24.1+~0.1	Woods Creek	6/7/06	SS, SH	9/25/06	SH, UN	69.47	7/24/06	4/109	64.70	7/21/06	65 SH observed in isolated pool, confluence dry in fall
BLM	575774	24.2	Mattole us Woods Creek	6/7/06	N/A	9/25/06	N/A	85.04	7/23&24/06	99/109	78.15	7/21/06	no dive
BLM	882000	25.5+~1.0	Upper North Fork	6/6/06	SH, UN	10/4/06	SH	83.02	7/24&25/06	96/119	74.77	7/21/06	UN possible KS
BLM	893657	25.5	Mattole us U. North Fork	6/7/06	N/A	10/3/06	N/A	86.71	7/24/06	113/117	77.57	7/21/06	no dive
BLM		26.5+~2.5	Honeydew Creek (upper)	6/14/06	SH	9/30/06	SH	75.38	7/20/06	28/107	68.08	7/17/06	only dove 1 pool in spring

BLM	86474	26.5+~1.0	Honeydew Creek (lower)	6/7/06	SH	9/25/06	SH	78.36	7/24/06	82/109	69.54	7/21/06	huge slide us snorkel reach
BLM	575781	26.5	Mattole us Honeydew Creek	6/6/06	N/A	9/25/06	N/A	84.72	7/24/06	107/110	77.55	7/21/06	no dive
BLM/ONS	891576	42.3	Mattole ds Ettersburg bridge	6/6/06	N/A	10/3/06	N/A	84.32	7/25/06	91/118	77.60	7/22/06	placed with Ettersburg School
BLM/ONS	688889	52.2	MS-6, us Bridge Creek	7/19/06	N/A	10/10/06	N/A	78.11	7/25/06	10/82	73.06	7/22/06	
BLM/ONS	819412	52.8+~0.1	McKee Creek	7/19/06	N/A	10/10/06	N/A	65.41	7/24,25,26/06	0/82	64.61	7/22/06	creek dried to isolated pools in fall
BLM/ONS	918955	53.8	MS-5, us McKee Creek at Bell's	7/17/06	N/A	10/13/06	N/A	78.01	7/21/06	12/61	71.97	7/22/06	data discarded after 9/16 due to restoration project
BLM/ONS	881989	56.9	Mattole ds Metz Bridge	6/6/06	N/A	10/10/06	N/A	73.08	7/25/06	8/125	69.42	7/22/06	no dive
BLM/ONS	787075	57.1	MS-4, ds Stanley Cr. at Falls	7/17/06	N/A	10/10/06	N/A	73.88	7/25/06	8/84	69.71	7/22/06	no dive
BLM/ONS	618860	58.6	MS-3, ds Mend.Cty Bridge	7/17/06	N/A	10/10/06	N/A	65.03	7/22/06	0/84	63.41	7/22/06	no dive
BLM/ONS	701105	59.4	MS-1, ds Big Alder Creek	7/17/06	N/A	10/10/06	N/A	68.72	7/25/06	2/84	65.27	7/21/06	no dive

Key:
MWATs colored RED are considered unsuitable for juvenile coho and steelhead presence. Coates et. al. (2002) found that juvenile coho and steelhead are unlikely to persist in areas where Maximum Weekly Average Temperatures (MWAT) exceeds 63.0- 66.0° F. PURPLE indicates temperature monitoring locations where MWATs exceeded the threshold for coho presence (63.0°F), but remained below the threshold for steelhead (>66.0°F). BLUE indicate temperature monitoring locations where MWAT was suitable to support coho and steelhead (>63.0°F).

Maximum Temperatures colored RED exceeded short-term maximum temperature thresholds (50% survival) for acute temperature stress to salmonids (>75.0°F).

N/A= not available, + denotes tributary mileage, LB= Left Bank, RB=Right Bank, us=upstream, ds=downstream

Table 2. 2006 Mattole Salmon Group Juvenile Dive Surveys in Association with Temperature Monitoring. Serial number, location, and dates of survey. Species and size class of juvenile salmonids observed and number of pools surveyed are provided in Table 2.

Spring Dives

Serial #	River Mile	Location	Date	personnel	SH <4''	SH 4-8''	SH >8''	KS <4''	KS 4-8''	SS <4''	SS 4-8''	ND <4''	ND 4-8''	# Pools	Comments
891552	1.3+0.2	Stansberry Creek	5/11	K.M., M.R.	13	6	1	0	0	0	0	0	0	10	1st 7 pools in restored creek bed
575798	2.8+0.1	Lower Mill Creek	5/11	K.M., M.R.	3	0	0	0	0	1	0	0	0	4	SS in pool 4
575792	2.8	Mattole us L. Mill Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No Dive
568291	2.9	Mattole @ Wingdam	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No Dive
575775	4.7+ 0.5	Lower North Fork	6/1	A.B., K.M.	39	5	0	0	0	0	0	0	0	10	sediment
891613	5.4+ 0.2	East Mill Creek	6/10	A.B., K.M.	105	1	0	0	0	4	0	1	0	5	5 pools
895564	6.1+0.1	Clear Creek	6/3	A.B., M.R.	41	1	0	0	0	1	0	0	0	11	SS us spanner in 11th pool
893659	7.8 +~0.2	Conklin Creek	6/8	A.B., J.G.	14	0	0	0	0	0	0	0	0	10	2 massive slides us, loads of sediment in creek
989872	8 + 1.0	McGinnis Creek	6/16	K.M.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No Dive
895562	12.7+~0.1	Wild Turkey Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No Dive
895563	14.9+~0.1	Squaw Creek	6/11	A.B., K.M.	44	8	0	3	0	1	0	0	0	10	pre-structures
575780	19.9+0.1	Saunders Creek	5/31	K.M., A.B., D.F.	40	0	0	0	0	0	0	0	0	10	
893658	24.1+~0.1	Woods Creek	6/7	A.B., J.G.	101	2	0	0	0	8	0	0	0	10	SS ds bridge

882000	25.5+~1.0	Upper North Fork	6/6	A.B.	7	0	0	0	0	0	0	2	0	5	ND possible KS
891582	26.5+~2.5?	Honeydew Creek (upper)	6/14	K.M.	5	0	0	0	0	0	0	0	0	1	pool w/logger
86474	26.5+~1.0	Honeydew Creek (lower)	6/3	A.B., M.R.	18	0	0	0	0	0	0	0	0	10	huge slide us near county road work

Fall Dives

Serial #	River Mile	Location	Date	personnel	SH <4"	SH 4-8"	SH >8"	KS <4"	KS 4-8"	SS <4"	SS 4-8"	ND <4"	ND 4-8"	# Pools	Comments
891552	1.3+0.2	Stansberry Creek	9/27	A.B., M.R.	97	5	0	0	0	0	0	0	0	10	last 100' before confluence dry
575798	2.8+0.1	Lower Mill Creek	9/27	A.B., M.R.	83	1	0	0	0	0	0	0	0	10	
575792	2.8	Mattole us L. Mill Creek	10/17	A.B.	18	38	0	0	0	0	0	0	0	1	pool us confluence filled in, now ds confluence
575775	2.9	Lower North Fork	10/12	A.B., N.A.	382	49	1	0	0	0	0	0	0	10	frogs, sticklebacks
891613	4.7+ 0.5	East Mill Creek	10/26	A.B., D.W.	158	9	0	0	0	0	0	0	0	10	
895564	5.4+ 0.2	Clear Creek	9/25	A.B., M.R.	12	4	0	0	0	0	0	0	0	10	9 (0"-4") SH in pool 11, frogs
893659	6.1+0.1	Conklin Creek	9/26	A.B., N.A.	16	0	0	0	0	0	0	0	0	4	only 4 pools deep enough to dive, much of flow subsurface
989872	7.8 +~0.2	McGinnis Creek	10/5	K.M., N.A.	100	0	0	0	0	0	0	0	0	10	one sculpin
895562	8 + 1.0	Wild Turkey Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No Dive, SH juveniles observed in isolated pools

895563	12.7+~0.1	Squaw Creek	9/27	A.B., M.R.	1022	5	2		0	0	0	0	0	10	post-structures
575780	14.9+~0.1	Saunders Creek	9/26	A.B., N.A.	19	0	0	0	0	0	0	0	0	2	only 2 isolated pools, rest of creek dry
893658	19.9+0.1	Woods Creek	9/25	A.B., M.R.	437	7	0	0	0	0	0	1	0	10	numerous frogs
882000	24.1+~0.1	Upper North Fork	10/4	A.B.	5	1	0	0	0	0	0	0	0	10	numerous frogs
891582	25.5+~1.0	Honeydew Creek (upper)	9/30	K.M., A.B.	682	40	0	0	0	0	0	0	0	10	sculpin, stickleback
86474	26.5+~2.5?	Honeydew Creek (lower)	9/25	A.B., M.R.	3	0	0	0	0	0	0	0	0	10	8 (0"-4") SH morts
568291	26.5+~1.0	Mattole @ Wingdam	10/17	A.B.	31	48	7	0	0	0	0	0	0	1	wingdam nearly isolated from mainstem