Determining Water Temperature Objectives for Streams on Sierra Pacific Lands

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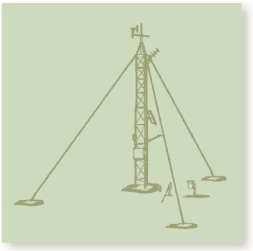

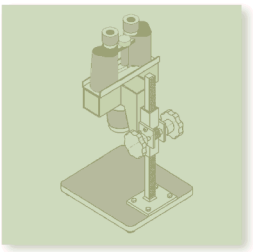

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Introduction

Salmonids are found year-round in streams on Sierra Pacific Industries (SPI) land. Their ability to survive depends heavily on the water temperature of these streams. Stream water temperatures are not constant but in fact can vary considerably over the course of a year because of natural seasonal variations (warmer in summer, colder in winter), because of the variation in natural flow volumes from year to year (depending on annual rainfall and snow- pack), and because of events that change the surrounding riparian ecosystem (natural events such as fire or landslides, and human management activities such as harvesting or water diversion). These varying temperatures can be described in terms of water temperature regimes—observable patterns of changing stream water temperatures over a period of time. Although we cannot control seasonal water temperature patterns, SPI is adopting guidelines that guarantee adequate stream water temperatures are maintained in areas where harvesting and other forest operations take place. Specifically, SPI will describe water temperature objectives for the critical season between July 1 and October 15 when water temperatures are at their peak and cold-water species are most vulnerable (data on file at SPI, Anderson Office).

Water Temperature Requirements of Salmonids

General Requirements

Resident and anadromous salmonids (cold-water fish species present in streams on SPI lands) require water temperatures that are generally below 20˚C (FEMAT 1993, USDI 1996b)

Specific Requirements

Salmonids are affected by water temperatures in various ways (Armour 1991). For instance, rapid changes in temperature (up or down) can severely stress fish and may cause mortality (Bjornn and Reiser 1991). Very high temperatures (>25˚C) can kill fish outright if attained over a short period of time or prolonged for a period of 24 hours or longer. Moderately high temperatures (20-25˚C) may increase energy demands on fish by raising their metabolic rates, and temperatures in this range may also decrease their resistance to disease.

Research suggests that juvenile chinook salmon are stressed if daily maximum temperatures exceed 18˚C for extended periods (Armour 1991) and that eggs and alevins of some anadromous species suffer mortality when water temperatures exceed 15˚C (Boles 1988). Adult and juvenile cold-water fish are believed to tolerate short-term maximum

temperatures up to 23˚C (Bjornn and Reiser 1991) and maximum weekly average temperatures[1] (MWAT) that do not exceed 18˚C (Armour 1991). In general, temperatures below 20˚C will support adult and juvenile anadromous fish during the freshwater phases of their lives (FEMAT 1993). Eggs of spring run chinook salmon may be adversely affected by warm water temperatures. Temperatures of less than 15˚C from mid-September through winter are adequate to support successful incubation (Boles 1988).

Stream Temperature Data Collection on SPI Lands

Field Methods

Summer water temperature measurements were gathered between 1994 and 1999 from over 396 locations on SPI land and represent over 700 summers of data[2]. Because the differences in measurements can be slight, it is important to calibrate recording instruments carefully. The thermographs (Hobo Data Loggers) used to gather these data were calibrated according to the following established protocols:[3]

- Calibrate thermographs before use, both at room temperature and in an ice water bath.
- Use a lower/middle/upper distribution pattern when placing thermographs in a watershed.
- Locate thermographs in riffle thalwags or other areas of mixed water.
- Record temperatures every 2.4 hours.
- Record temperatures during the entire period of interest, at least between July 1 and October 15.

Interpreting Field Data

Data collected by SPI staff biologists, and by biologists from state and federal agencies, from streams on SPI land suggest that water temperatures are highly dependent upon flow volume, which can vary drastically from year to year. For instance, differences in stream temperature of more than10˚F have been measured at the same location from one year to the next. Therefore, water temperature data must be "corrected" for differences in annual flow before they can be compared in a meaningful way.

To do this, historical flow data (from near the turn of the century to the present) from the federal Bureau of Reclamation (USDI 1996a) were obtained for a number of rivers and streams in California. These data were used to characterize the "normality" of the water

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[1] Maximum weekly average temperature is a rolling 7-day average of the average daily temperature.

[2] The summer season, also called the summer field season, usually begins July 1 and ends October 15.

[3] Guidelines established by the 3FC Group for the calibration and placement of data-recording equipment.

flow each year for the past 90 years. These *normality ratings* rank water flow in terms of how often during a set number of years you'd expect to see that particular rate of water flow (usually expressed as a percentage of the total number of years). For instance, 1994 was the 7th year of a long drought; the exceptionally low water flow seen that year occurred only 4 or 5 years out of the 90 years for which data were gathered, or in 5% of the total number of years (USDI 1996a). On the other extreme, 1995 was an above-average precipitation year with heavy water flows that occurred in only about 6% of the total years (USDI 1996a). In contrast to these extremes, years 1996 through 1999 were relatively "average" precipitation years, meaning that these rates of water flow occurred with the most frequency during the 90 years of data gathering.

After correcting SPI water temperature data using these normality ratings, they can be accurately evaluated. To be most relevant, they must be compared with data of similar origin from "reference streams," which are streams known to support high-quality water temperature regimes.

Reference Data

Data from other research studies can provide information about acceptable water temperature regimes for salmonids. Research conducted on three Northern California streams (Deer, Mill, and Antelope) and summarized as a part of the Sierra Nevada Ecosystem Project (SNEP) indicates that the water temperature regimes of these streams, presented in Table 1, are of sufficient quality to support relatively healthy populations of chinook salmon and steelhead (SNEP 1996). The quality of these three streams was classified as "good to excellent" by SNEP.

Table 1. **Water Temperature Data From Deer, Mill, and Antelope Creeks**[4]

Position	Stream	Year	Elevation	MaxTemp	MWAT>=64	%Time Exceed68	FallDays MaxTemp>60
201450	Antelope	92	1300	74.8	43	24.2	0
201450	Antelope	93	1300	70.2	2	1.1	0
201450	Antelope	94	1300	70.5	17	6.9	7
201450	Antelope	95	1300	66.7	0	0	5
201450	Antelope	97	1300	72	36	14	7
201450	Antelope	98	1300	70	1	4.2	2
201456	Deer	92	1700	76.1	47	30.5	6
201456	Deer	95	1700	67.6	0	0	6
201456	Deer	96	1700	72.8	41	14.1	0
201456	Deer	97	1700	70.2	43	8.7	3
201456	Deer	98	1700	70.1	20	4.9	4
201451	Mill	92	2100	71.1	14	5.3	3
201451	Mill	93	2100	64.4	0	0	0
201451	Mill	95	2100	61.9	0	0	0

[4] Data from SPI, the California Department of Fish and Game, and the USDA Lassen National Forest.

Position	Stream	Year	Elevation	MaxTemp	MWAT>=64	%Time Exceed68	FallDays MaxTemp>60
201454	Mill	96	2100	67	0	0	0
201451	Mill	97	2100	68.2	0	0.1	0
201451	Mill	98	2100	65.2	0	0	1
201455	Deer	93	2900	66	0	0	0
201455	Deer	94	2900	69.8	5	1.2	0
201455	Deer	95	2900	62.2	0	0	0
201409	NF Ante.	97	3000	62.9	0	0	0
201409	NF Ante.	98	3000	62.1	0	0	0
201331	Deer	96	3800	61.7	0	0	0
201331	Deer	98	3800	62.2	0	0	0
201339	SF Ante.	96	3800	56.2	0	0	0
201339	SF Ante.	98	3800	55.6	0	0	0
201452	Mill	93	3900	64.4	0	0	0
201452	Mill	94	3900	68.4	0	0.2	0
201452	Mill	95	3900	62.8	0	0	0
201338	NF Ante.	96	4800	66.4	0	0	0
201338	NF Ante.	98	4800	62.8	0	0	0

The data from these "reference streams" show the same patterns of seasonal and yearly change characterized by SPI data. In addition, they indicate that elevation is a significant factor affecting water temperature regimes.

Developing Water Temperature Objectives for Streams on SPI Lands

Based on its own research, the conclusions reached by SNEP researchers, and the data from reference streams, SPI has adopted the following water temperature objectives for stream locations at or above 2,000 feet (the approximate elevation of the lowest SPI lands) in elevation during normal flow years[5]:

- Maximum water temperatures will not exceed 23˚C (73˚F) between July 1 and September 15.
- MWAT water temperatures will not exceed 18˚C (64˚F) for more than two or three weeks between July 1 and September 15.
- Water temperatures will not exceed 20˚C (68˚F) for more than 10% of the time period between July 1 and September 15.
- Water temperatures will not exceed 15˚C (60˚F) between September 15 and December 31.

[5] Here, a normal flow year is defined as one in which the mean July flow is within 20% of the mean July flow calculated using Bureau of Reclamation flow data for the Trinity, Sacramento, and Feather rivers from 1911 to 1999.

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