Table 5.D-49. Water Temperature Thresholds Used for Water Temperature Threshold Analyses, Sacramento River

Species	Life Stage	Period	Location	Threshold (F)		Sources/Notes
				Mean Monthly	7DADM[1]	
Winter-run	Spawning, egg incubation, and alevins	Apr-Oct	Keswick		55.4	USEPA 2003
			Clear Creek		55.4	USEPA 2003
			Balls Ferry		55.4	USEPA 2003
			Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003
	Fry and juvenile rearing and emigration	Jul-Mar	Keswick		61	USEPA 2003; core juvenile rearing[2]
			Clear Creek		61	USEPA 2003; core juvenile rearing
			Balls Ferry		61	USEPA 2003; core juvenile rearing
			Bend Bridge		61	USEPA 2003; core juvenile rearing
			Red Bluff		61	USEPA 2003; core juvenile rearing
			Knights Landing		64	USEPA 2003; non-core juvenile rearing[3]
	Adult Immigration	Dec-Aug	Keswick		68	USEPA 2003
			Bend Bridge		68	USEPA 2003
			Red Bluff		68	USEPA 2003
	Adult Holding	Jan-Aug	Keswick		61	USEPA 2003
			Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
Spring-run	Spawning, egg incubation, and alevins	Aug-Dec	Keswick		55.4	USEPA 2003
			Clear Creek		55.4	USEPA 2003
			Balls Ferry		55.4	USEPA 2003
			Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003
	Fry and juvenile rearing and emigration	Year-round	Keswick		61	USEPA 2003; core juvenile rearing
			Clear Creek		61	USEPA 2003; core juvenile rearing
			Balls Ferry		61	USEPA 2003; core juvenile rearing
			Bend Bridge		61	USEPA 2003; core juvenile rearing
			Red Bluff		61	USEPA 2003; core juvenile rearing
			Knights Landing		64	USEPA 2003; non-core juvenile rearing

Species	Life Stage	Period	Location	Threshold (F)		Sources/Notes
				Mean Monthly	7DADM[1]	
Spring-run (Cont)	Adult Immigration	Mar-Sep	Keswick		68	USEPA 2003
			Bend Bridge		68	USEPA 2003
			Red Bluff		68	USEPA 2003
	Adult Holding	Apr-Sep	Keswick		61	USEPA 2003
			Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
Steelhead	Spawning, egg incubation, and alevins	Nov-Apr	Keswick	53		McCullough 2001
				56		NMFS 2009
			Clear Creek	53		McCullough 2001
				56		NMFS 2009
			Balls Ferry	53		McCullough 2001
				56		NMFS 2009
			Bend Bridge	53		McCullough 2001
				56		NMFS 2009
			Red Bluff	53		McCullough 2001
				56		NMFS 2009
	Kelt Emigration	Feb-May	Keswick		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Bend Bridge		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Red Bluff		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)

Species	Life Stage	Period	Location	Threshold (F)		Sources/Notes
				Mean Monthly	7DADM[1]	
Steelhead (Cont)	Juvenile Rearing	Year-round	Keswick	63		intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan 2000
			Clear Creek	63		intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan 2000
			Balls Ferry	63		intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan 2000
			Bend Bridge	63		intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan 2000
			Red Bluff	63		intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan 2000
Steelhead (Cont)	Smoltification	Jan-Mar	Keswick	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Clear Creek	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Balls Ferry	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Bend Bridge	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988

Species	Life Stage	Period	Location	Threshold (F)		Sources/Notes
				Mean Monthly	7DADM[1]	
			Red Bluff	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
	Smolt Emigration (excludes migrant parr)	Nov-Jun	Keswick		61	USEPA 2003; core location
					64	USEPA 2003; non-core location
			Clear Creek		61	USEPA 2003; core location
					64	USEPA 2003; non-core location
			Balls Ferry		61	USEPA 2003; core location
					64	USEPA 2003; non-core location
			Bend Bridge		61	USEPA 2003; core location
					64	USEPA 2003; non-core location
			Red Bluff		61	USEPA 2003; core location
					64	USEPA 2003; non-core location
	Adult Immigration	Aug-Mar	Keswick		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Bend Bridge		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Red Bluff		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)

Species	Life Stage	Period	Location	Threshold (F)		Sources/Notes
				Mean Monthly	7DADM[1]	
Steelhead (Cont)	Adult Holding	Sep-Nov	Keswick		61	USEPA 2003
			Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
Green Sturgeon	Spawning and Embryo Incubation	Mar-Jul	Bend Bridge	63		Upper end of optimal range for embryonic development (Van Eenennaam 2005)
			Red Bluff	63		
			Hamilton City	63		
	Non-Spawning Adult Presence (Immigration, Pre and Post-Spawn Holding)	Aug-Feb	Bend Bridge	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
			Red Bluff	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
			Hamilton City	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
		Year-round	Knights Landing	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
	Larval to Juvenile Rearing and Emigration	Year-round	Bend Bridge	66		Upper end of optimal range for bioenergetics performance of Age 0/1 sturgeon with full or reduced food supply (Mayfield and Cech 2004)
			Red Bluff	66		
			Hamilton City	66		
			Knights Landing	66		

[1] 7DADM = Seven Day Average Daily Maximum
[2] Core = "moderate to high density" (USEPA 2003)
[3] Non-core = "low to moderate density" (USEPA 2003)

Table 5.D-50. Water Temperature Thresholds Used for Water Temperature Threshold Analyses, American River

Species	Life Stage	Period	Location	Threshold (°F)		Source/Note
				Mean Monthly	7DADM[1]	
Steelhead	Spawning, egg incubation, and alevins	Dec-May	Hazel Avenue	53		from McCullough 2001
			Watt Avenue	53		from McCullough 2001
	Kelt emigration	Feb-May	Hazel Avenue		68	USEPA 2003
			Watt Avenue	70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Hazel Avenue		68	USEPA 2003
			Watt Avenue	70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Juvenile rearing	Year-round	Hazel Avenue	63		intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005, and Beakes et al. 2014
					69	Sullivan 2000
			Hazel Avenue	63		intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005, and Beakes et al. 2014
					69	Sullivan 2000
	Smoltification	Jan-Mar	Hazel Avenue	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Watt Avenue	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
	Smolt Emigration	Dec-Jun	Hazel Avenue		61	USEPA 2003; core location[2]
			Watt Avenue		64	USEPA 2003; non-core location[3]
	Adult Immigration	Oct-Apr	Hazel Avenue		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Hazel Avenue		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Adult Holding	Oct-Nov	Hazel Avenue		61	USEPA 2003
			Watt Avenue		61	USEPA 2003

[1] 7DADM = Seven Day Average Daily Maximum
[2] Core = "moderate to high density" (USEPA 2003)
[3] Non-core = "low to moderate density" (USEPA 2003)

Table 5.D-51. Conversion Factors (°F) for EPA Seven-Day Average Daily Maximum Water Temperature Thresholds to monthly mean, Sacramento River[1].

Month	Keswick	Clear Creek	Balls Ferry	Bend Bridge	Red Bluff	Wilkins Slough[2]
January	-0.36	-1.01	-0.75	-0.67	-0.86	0.0
February	-0.28	-1.11	-0.86	-0.62	-0.97	-0.3
March	-0.17	-1.29	-0.94	-0.66	-1.23	-0.3
April	-0.25	-1.66	-1.47	-0.95	-1.55	-0.6
May	-0.36	-1.73	-2.18	-1.59	-1.47	-1.4
June	-0.32	-1.55	-2.25	-1.87	-0.96	-1.2
July	-0.36	-1.41	-2.18	-2.01	-0.90	-1.3
August	-0.43	-1.74	-2.06	-1.61	-0.94	-1.3
September	-0.30	-2.00	-1.76	-1.16	-1.70	-2.0
October	-0.25	-1.73	-1.25	-0.91	-1.83	-1.4
November	-0.38	-1.37	-1.10	-0.99	-1.53	-1.3
December	-0.82	-1.42	-1.30	-1.24	-1.48	-1.0

[1] Based on historical data from 2003-2014 for all sites except Wilkins Slough, which is based on historical data from November 2012 through June 2015. For a given location and month, values in this table were added to 7DADM thresholds in Table 5.D-49 such that actual thresholds used in the evaluation for each month were lower than those listed in Table 5.D-49.

[2] Because there is no flow gage at Knights Landing, Wilkins Slough data were used to calculate the conversion factor for Knights Landing

Table 5.D-52. Conversion Factors (°F) for EPA Seven-Day Average Daily Maximum Water Temperature Thresholds to monthly mean, American River[1].

Month	Folsom Dam	Hazel Ave	William P Pond Park	Watt Ave
January	-0.74	-0.44	-1.16	-1.01
February	-0.44	-0.15	-1.28	-1.05
March	-0.55	-0.25	-1.71	-1.29
April	-0.80	-0.40	-2.09	-1.72
May	-0.89	-0.60	-2.32	-2.05
June	-0.55	-0.44	-2.32	-2.55
July	-1.09	-0.50	-2.61	-3.17
August	-2.07	-0.70	-3.01	-3.11
September	-1.54	-0.59	-3.02	-2.52
October	-1.46	-0.60	-2.53	-2.01
November	-1.82	-0.80	-2.01	-1.65
December	-1.10	-0.77	-1.51	-1.26

[1] Based on historical data from 2003-2014. For a given location and month, values in this table were added to 7DADM thresholds in Table 5.D-50 such that actual thresholds used in the evaluation were lower than those listed in Table 5.D-50.

5.D.2.1.2.3 Reclamation Egg Mortality Model

The Reclamation Egg Mortality Model was used to evaluate water temperature-related mortality to pre-spawned eggs, fertilized eggs, and pre-emergent fry of winter-run and spring-run Chinook salmon in the Sacramento River. Attachment 5.D-1, *Reclamation Egg Mortality Model*, describes the details of the model. NMFS believes this model underestimates temperature related