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

· ·	Tie G	D ' 1	T	Thresho	ld (F)	C AN A
Species	Life Stage	Period	Location	Mean Monthly	7DADM ¹	Sources/Notes
			Keswick		55.4	USEPA 2003
	Spawning, egg	Clear Creek 55.4 Balls Ferry 55.4 Bend Bridge 55.4 Red Bluff 55.4 Keswick 61 USEP Clear Creek 61 USEP Balls Ferry 61 USEP Bend Bridge 61 USEP Red Bluff 61 USEP Knights Landing 64 USEPA Keswick 68 Dec Aug Read Bridge 68 Clear Creek 61 USEP Red Bluff 61 USEP Knights Landing 64 USEPA Clear Creek 61 USEP Clear Creek Clear Creek	USEPA 2003			
	incubation, and	Apr-Oct	Balls Ferry		55.4	USEPA 2003
	alevins		Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003
			Keswick		61	USEPA 2003; core juvenile rearing ²
			Clear Creek		61	USEPA 2003; core juvenile rearing
	Fry and juvenile	T-1 M	Balls Ferry		61	USEPA 2003; core juvenile rearing
Winter-run	rearing and emigration	Jui-Mar	Bend Bridge		61	USEPA 2003; core juvenile rearing
	emigration		Red Bluff		61	USEPA 2003; core juvenile rearing
			Knights Landing		64	USEPA 2003; non-core juvenile rearing ³
			Keswick		68	USEPA 2003
	Adult Immigration	Dec-Aug	Bend Bridge		68	USEPA 2003
	Illingration		Red Bluff		68	USEPA 2003
			Keswick		61	USEPA 2003
	Adult Holding	Jan-Aug	Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
			Keswick		55.4	USEPA 2003
	Spawning, egg		Clear Creek		55.4	USEPA 2003
	incubation, and	Aug-Dec	Balls Ferry		55.4	USEPA 2003
	alevins		Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003
Spring-run			Keswick	Keswick 55.4 U Clear Creek 55.4 U Balls Ferry 55.4 U Bend Bridge 55.4 U Red Bluff 55.4 U Keswick 61 USEPA 2003 Clear Creek 61 USEPA 2003 Balls Ferry 61 USEPA 2003	USEPA 2003; core juvenile rearing	
			Clear Creek		USEPA 2003; core juvenile rearing	
	Fry and juvenile	Vaan name 1	Balls Ferry		61	USEPA 2003; core juvenile rearing
	rearing and emigration	Year-round	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

Appendix 5.D. Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale

C	I :6- C4	Period	Location	Thresho		Sources/Notes
Species	Life Stage	Perioa	Location	Mean Monthly	7DADM ¹	Sources/Notes
			Keswick		68	USEPA 2003
	Adult Immigration	Mar-Sep	Bend Bridge		68	USEPA 2003
Spring-run	Immigration		Red Bluff		68	USEPA 2003
(Cont)			Keswick		61	USEPA 2003
	Adult Holding	Apr-Sep	Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
			IVi -1-	53		McCullough 2001
			Keswick	56		NMFS 2009
			CI C I	53		McCullough 2001
			Clear Creek	56		NMFS 2009
	Spawning, egg	NI A	D-11- F	53		McCullough 2001
	incubation, and alevins	Nov-Apr	Balls Ferry	56		NMFS 2009
	uie viiis		D 1D:1	53		McCullough 2001
			Bend Bridge	56		NMFS 2009
			D - 1 D1CC	53		McCullough 2001
Steelhead			Red Bluff	56		NMFS 2009
					68	USEPA 2003
			Keswick	70	Average of studies	Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
		Feb-May			68	USEPA 2003
	Kelt Emigration		Bend Bridge	70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
					68	USEPA 2003
			Red Bluff	70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)

Appendix 5.D. Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale

G .	T.0. G.	D 1 1	T 4:	Thresho	ld (F)	0 27 4
Species	Life Stage	Period	Location	Mean Monthly	7DADM ¹	Sources/Notes
			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
Steelhead (Cont)	Juvenile Rearing	Year-round	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
			Keswick	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
Steelhead	Smoltification	Jan-Mar	Clear Creek	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
(Cont)	Sillotuneation	Jan-war	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

Appendix 5.D. Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale

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

Appendix 5.D. Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale

Cuasias	I ifo Store	Period	Location	Thresho		Sources/Notes	
Species	Life Stage	reriou	Location	Mean Monthly	7DADM ¹	Sources/Notes	
a. 11 1	Adult Holding		Keswick		61	USEPA 2003	
Steelhead (Cont)		Sep-Nov	Balls Ferry		61	USEPA 2003	
(Cont)			Red Bluff			USEPA 2003	
	Spawning and		Bend Bridge	63			
	Embryo	Mar-Jul	Red Bluff	63		Upper end of optimal range for embryonic development (Van Eenennaam 2005)	
	Incubation		Hamilton City	63		(Vali Eelielillaalii 2003)	
			Bend Bridge	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles	
	Non-Spawning	Aug-Feb		73		Houston 1988; Erickson et al. 2002	
			Red Bluff	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles	
	Adult Presence			73		Houston 1988; Erickson et al. 2002	
Green Sturgeon	(Immigration, Pre and Post- Spawn Holding)		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	
		Year-round	Bend Bridge	66			
	Larval to		Red Bluff	66		Upper end of optimal range for bioenergetics	
	Juvenile Rearing and Emigration		Hamilton City	66		performance of Age 0/1 sturgeon with full or reduced food supply (Mayfield and Cech 2004)	
	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		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

C	I :6- 64	D 1 1	T 42	Threshold	(°F)	C AN 4	
Species	Life Stage	Period	Location	Mean Monthly	7DADM ¹	Source/Note	
	Spawning, egg		Hazel Avenue	53		from McCullough 2001	
	incubation, and alevins	Dec-May	Watt Avenue	53		from McCullough 2001	
			Hazel Avenue		68	USEPA 2003	
	IZ alta anni a matica n		Watt Avenue	70		Average of studies cited in Richter and Koln 2005 (for upper end of suboptimal range)	
	Kelt emigration	Feb-May	Hazel Avenue		68	USEPA 2003	
			Watt Avenue	70		Average of studies cited in Richter and Koln 2005 (for upper end of suboptimal range)	
Steelhead	Juvenile rearing		Hazel Avenue	63		intermediate value of ranges of optimal grow from Grabowski 1973; Hokanson et al. 197 Wurtsbaugh and Davis 1977; Myrick and Co 2005, and Beakes et al. 2014	
		Year-round			69	Sullivan 2000	
			Hazel Avenue	63		intermediate value of ranges of optimal grow from Grabowski 1973; Hokanson et al. 197 Wurtsbaugh and Davis 1977; Myrick and Co 2005, and Beakes et al. 2014	
					69	Sullivan 2000	
	G 1::G ::	Jan-Mar	Hazel Avenue	54		Zaugg and Wagner 1973; Adams et al. 197 Zaugg 1981; Hoar 1988	
	Smoltification	Jan-Mar	Watt Avenue	54		Zaugg and Wagner 1973; Adams et al. 197 Zaugg 1981; Hoar 1988	
	Smolt Emigration	Dec-Jun	Hazel Avenue		61	USEPA 2003; core location ²	
	Smort Emigration	Dec-Juli	Watt Avenue		64	USEPA 2003; non-core location ³	
					68	USEPA 2003	
	Adult	Oct-Apr	Hazel Avenue	70		Average of studies cited in Richter and Kolr 2005 (for upper end of suboptimal range)	
	Immigration				68	USEPA 2003	
			Hazel Avenue	70		Average of studies cited in Richter and Kolr 2005 (for upper end of suboptimal range)	
	Adult Holding	Oct-Nov	Hazel Avenue		61	USEPA 2003	
	Adult Holding	Oct-Nov	Watt Avenue		61	USEPA 2003	

ToADM = Seven Day Average Daily Maximum
 Core = "moderate to high density" (USEPA 2003)
 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 River¹.

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.

Table 5.D-52. Conversion Factors (°F) for EPA Seven-Day Average Daily Maximum Water Temperature Thresholds to monthly mean, American River¹.

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

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