APPENDIX A. CACHE CREEK FISH TISSUE DATA

The following tables show average concentrations of mercury in Cache Creek fish (Table A.1) and raw data used to determine the averages (Table A.2). Average concentrations used in this report are weighted by number of fish in the sample. To determine the weighted average concentrations, the concentration measured in each sample was multiplied by the number of fish in the sample. The weighted concentrations were then summed for all samples in a particular classification (i.e., TL3 75-400 mm) and divided by the total number of fish in the classification.

Most data available are for total mercury in fish tissue. For this TMDL, Regional Board staff assumes that mercury measured in fish is methylmercury. This assumption may result in a slight overestimate of mercury concentrations in fish consumed by wildlife. Most mercury (85-100%) in fish muscle is methylmercury [Becker, 1995 #206; Slotton, 2002b #231]. About 15-20% of the fish concentration data used for comparing with safe levels for most wildlife were from analyses of fish fillets. Nearly all of the data for concentrations in larger fish, as consumed by bald eagle and osprey, are from fillets. Because most methylmercury accumulates in muscle, concentrations of methylmercury tend to be slightly higher when measured in fillet versus the whole fish. The estimated daily intakes for wildlife are conservative estimates for birds and mammals eating whole fish. Use of the fillet data to estimate wildlife exposure was necessary because very few fish larger than 200 mm were analyzed for whole body concentrations of mercury.

Table A.1 Average concentrations of Methylmercury in Fish in the Cache Creek Watershed (ppm, wet weight)

	TL2/3 50-150 mm	TL3 150-350 mm (for grebe and merganser exposure estimates)	TL4 150-350 mm (for osprey and otter exposure estimates)	TL3 >150 mm (for bald eagle and human exposure estimates)	TL4 >150 mm (for bald eagle and human exposure estimates)
Cache Creek d/s Clear Lake	0.06	0.09	0.18	0.16	0.31
North Fork Cache Creek	0.07	0.14	0.16	0.19	0.16
Cache Creek, Rumsey to Capay Dam	0.10	0.36	0.46	0.36	0.54
Cache Creek, Capay Dam to Settling Basin	0.08	0.26	0.45	0.28	0.44
Bear Creek u/s Sulphur Creek	0.12	0.24	0.72	0.24	0.72
Bear Creek d/s Sulphur Creek	0.69	1.31	2.91	1.31	3.15

Table A.2. Sources of Cache Creek Fish Data for Mercury

TSM	SWRCB, 2002. State Water Resources Control Board Toxic Substances Monitoring Program electronic data files available at: http://www.swrcb.ca.gov/programs/smw/index.html
UCDavis2	Slotton et al., 1997. Cache Creek Watershed Preliminary Mercury Assessment Using Benthic Macroinvertebrates Final Report. University of California, Davis, Division of Environmental Sciences. June.
UCDavis5	Slotton et al., 2002 Mercury Bioaccumulation and Trophic Transfer in the Cache Creek Watershed, California, in Relation to Diverse Aqueous Mercury Exposure Conditions. Subtask 5B. Final Report, UC Davis, Dept. Environ. Science and Policy and Dept. Wildlife, Fish and Conservation Biol. Prepared for the CALFED Bay-Delta Program. August.
UCDavis9	Slotton et al., 2001 Cache Creek Nature Preserve Mercury Monitoring Program, Second Semi-Annual Data Report (Spring-Summer 2001). Prepared for Yolo County, CA. 20 November.
CDFG	California Department of Fish and Game Moss Landing Marine Laboratory. Sampling conducted in September 2003. Unpublished data provided to the Central Valley Regional Water Quality Control Board
USGS2	Domagalski et al., 2000 Water-Quality Assessment of the Sacramento River Basin, California: Water-Quality, Sediment and Tissue Chemistry, and Biological Data, 1995-1998. Open File Report 00-391. U.S. Department of the Interior, U.S. Geological Survey. Available at http://ca.water.usgs.gov/sac_nawqa/waterindex.html

Table A.3 Fish Tissue Data Used to Calculate Average Concentrations								
ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
Bear Creek Downstream of Sulphur Creek								
UCDavis5	2001	Bear Creek/Mid	California Roach	2	16	41.0	0.438	7.008
UCDavis5	2001	Bear Creek/Mid	California Roach	2	8	42.0	0.591	4.728
UCDavis5	2001	Bear Creek/Mid	California Roach	2	14	45.0	0.438	6.132
UCDavis5	2001	Bear Creek/Mid	California Roach	2	8	54.0	0.570	4.56
UCDavis5	2001	Bear Creek/Mid	California Roach	2	8	54.0	0.584	4.672
UCDavis5	2001	Bear Creek/Mid	California Roach	2	8	54.0	0.603	4.824
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	54.6	0.429	4.29
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	55.0	0.412	4.12
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	55.0	0.426	4.26
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	55.8	0.826	8.26
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	57.0	0.849	8.49
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	57.0	0.595	5.95
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	57.2	0.904	9.04
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	57.6	0.539	5.39
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	57.6	0.585	5.85
UCDavis5	2000	Bear Creek/Mid	California Roach	2	10	57.8	0.571	5.71
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	58.0	0.522	5.22
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	58.0	0.555	5.55
UCDavis5	2001	Bear Creek/1km above Hwy 20	California Roach	2	10	59.0	0.859	8.59
UCDavis5	2001	Bear Creek/1km above Hwy 20	California Roach	2	10	59.0	0.935	9.35
UCDavis5	2001	Bear Creek/1km above Hwy 20	California Roach	2	10	59.0	0.958	9.58
UCDavis5	2001	Bear Creek/Mid	California Roach	2	13	59.0	0.530	6.89
UCDavis5	2001	Bear Creek/Mid	California Roach	2	13	59.0	0.532	6.916
UCDavis5	2001	Bear Creek/Mid	California Roach	2	13	59.0	0.539	7.007
UCDavis5	2000	Bear Creek/gauge	California Roach	2	9	59.1	0.500	4.5
UCDavis5	2000	Bear Creek/gauge	California Roach	2	9	59.1	0.530	4.77
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	60.0	0.446	4.46
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	60.0	0.543	5.43
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	60.0	0.599	5.99
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	60.0	1.062	10.62
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	60.0	1.067	10.67
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	60.0	1.116	11.16
UCDavis5	2000	Bear Creek/Mid	California Roach	2	8	61.1	1.098	8.784
UCDavis5	2000	Bear Creek/Mid	California Roach	2	8	61.6	0.855	6.84
UCDavis5	2000	Bear Creek/Mid	California Roach	2	8	61.6	1.057	8.456
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	62.0	0.713	7.13
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	62.0	0.818	8.18
UCDavis5	2001	Bear Creek/Mid	California Roach	2	10	62.0	0.913	9.13

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2001	Bear Creek/Mid	California Roach	2	4	79.0	0.654	2.616
UCDavis5	2000	Bear Creek/Mid	Green Sunfish	3	1	142.0	2.190	2.19
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	8	90.0	0.681	5.448
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	11	94.0	0.438	4.818
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	1	152.0	0.860	0.86
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	1	214.0	1.325	1.325
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	1	228.0	1.390	1.39
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	1	237.0	1.330	1.33
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	1	245.0	1.300	1.3
UCDavis5	2000	Bear Creek/Mid	Sacramento Sucker	3	1	278.0	1.650	1.65
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	168.0	1.670	1.67
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	182.0	2.460	2.46
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	188.0	2.470	2.47
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	195.0	1.980	1.98
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	217.0	3.135	3.135
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	219.0	2.735	2.735
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	223.0	3.550	3.55
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	224.0	2.790	2.79
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	234.0	3.090	3.09
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	239.0	2.580	2.58
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	247.0	2.985	2.985
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	280.0	3.805	3.805
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	315.0	3.480	3.48
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	329.0	4.055	4.055
UCDavis5	2000	Bear Creek/Mid	Sacramento Pike Minnow	4	1	381.0	6.430	6.43
		TL2/3 50-150 mm	sums		369			256
			average concentration					0.69
		TL3 150-350 mm	sums		6			8
			average concentration					1.31
		TL4 150-3500 mm	sums		14			41
			average concentration					2.91
		TL3 >150 mm	sums		6			8
			average concentration					1.31
		TL4 >150 mm	sums		15			47
			average concentration					3.15

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
Bear Creek Upstream of Sulphur Creek								
UCDavis5	2001	Bear Creek/Upper	California Roach	2	12	39.0	0.105	1.26
UCDavis5	2001	Bear Creek/Upper	California Roach	2	12	46.0	0.087	1.044
UCDavis5	2001	Bear Creek/Upper	California Roach	2	5	47.0	0.101	0.505
UCDavis5	2001	Bear Creek/Upper	California Roach	2	7	47.0	0.105	0.735
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	49.0	0.100	1
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	49.0	0.107	1.07
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	49.0	0.108	1.08
UCDavis5	2001	Bear Creek/Upper	California Roach	2	7	54.0	0.085	0.595
UCDavis5	2001	Bear Creek/Upper	California Roach	2	7	54.0	0.105	0.735
UCDavis5	2001	Bear Creek/Upper	California Roach	2	7	54.0	0.105	0.735
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	57.0	0.088	0.88
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	57.0	0.089	0.89
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	57.0	0.109	1.09
UCDavis5	2000	Bear Creek/Upper	California Roach	2	10	57.3	0.088	0.88
UCDavis5	2000	Bear Creek/Upper	California Roach	2	10	57.3	0.095	0.95
UCDavis5	2000	Bear Creek/Upper	California Roach	2	10	57.4	0.094	0.94
UCDavis5	2000	Bear Creek/Upper	California Roach	2	10	58.2	0.140	1.4
UCDavis5	2000	Bear Creek/Upper	California Roach	2	10	58.2	0.150	1.5
UCDavis5	2000	Bear Creek/Upper	California Roach	2	10	58.3	0.143	1.43
UCDavis5	2001	Bear Creek/Upper	California Roach	2	12	60.0	0.115	1.38
UCDavis5	2001	Bear Creek/Upper	California Roach	2	12	60.0	0.131	1.572
UCDavis5	2001	Bear Creek/Upper	California Roach	2	12	60.0	0.155	1.86
UCDavis5	2001	Bear Creek/Upper	California Roach	2	11	61.0	0.115	1.265
UCDavis5	2001	Bear Creek/Upper	California Roach	2	11	61.0	0.128	1.408
UCDavis5	2001	Bear Creek/Upper	California Roach	2	11	61.0	0.137	1.507
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	64.0	0.121	1.21
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	64.0	0.149	1.49
UCDavis5	2001	Bear Creek/Upper	California Roach	2	10	64.0	0.167	1.67
UCDavis5	2001	Bear Creek/Upper	California Roach	2	5	82.0	0.189	0.945
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	9	116.0	0.073	0.657
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	144.0	0.270	0.27
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	155.0	0.120	0.12
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	158.0	0.090	0.09
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	164.0	0.145	0.145
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	226.0	0.305	0.305
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	236.0	0.265	0.265
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	239.0	0.425	0.425
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	252.0	0.300	0.3

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	252.0	0.340	0.34
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	273.0	0.205	0.205
UCDavis5	2000	Bear Creek/Upper	Sacramento Sucker	3	1	285.0	0.185	0.185
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	202.0	0.490	0.49
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	212.0	0.450	0.45
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	212.0	0.730	0.73
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	225.0	0.350	0.35
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	227.0	0.475	0.475
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	241.0	0.555	0.555
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	242.0	0.785	0.785
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	260.0	0.770	0.77
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	263.0	0.775	0.775
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	271.0	1.035	1.035
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	280.0	1.150	1.15
UCDavis5	2000	Bear Creek/Upper	Sacramento Pike Minnow	4	1	284.0	1.045	1.045
		TL2/3 50-150 mm	sums		224			27
			average concentration					0.12
		TL3 150-350 mm	sums		11			3
			average concentration					0.24
		TL4 150-3500 mm	sums		12			9
			average concentration					0.72
		TL3 >150 mm	sums		10			2
			average concentration					0.24
		TL4 >150 mm	sums		12			9
			average concentration					0.72
North Fork Cache Creek								
UCDavis5	2001	Cache Creek/N.F.	California Roach	2	4	52.0	0.061	0.244
UCDavis5	2001	Cache Creek/N.F.	California Roach	2	5	53.0	0.079	0.395
UCDavis5	2000	Cache Creek/N.F.	California Roach	2	7	55.0	0.082	0.574
UCDavis5	2000	Cache Creek/N.F.	California Roach	2	3	66.7	0.084	0.252
UCDavis5	2000	Cache Creek/N.F.	California Roach	2	2	78.0	0.090	0.18
UCDavis5	2001	Cache Creek/N.F.	Speckled Dace	3	5	53.0	0.056	0.28
UCDavis5	2001	Cache Creek/N.F.	Sacramento Sucker	3	16	56.0	0.059	0.944
UCDavis5	2001	Cache Creek/N.F.	Speckled Dace	3	12	56.0	0.080	0.96
UCDavis5	2001	Cache Creek/N.F.	Speckled Dace	3	12	56.0	0.082	0.984
UCDavis5	2001	Cache Creek/N.F.	Speckled Dace	3	12	56.0	0.084	1.008
UCDavis5	2001	Cache Creek/N.F.	Sacramento Sucker	3	16	57.0	0.063	1.008
UCDavis5	2000	Cache Creek/N.F.	Speckled Dace	3	3	58.0	0.063	0.189

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	15	60.0	0.035	0.525
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	13	64.0	0.079	1.027
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	17	65.0	0.051	0.867
UCDavis5	2000	Cache Creek/N.F.	Speckled Dace	3	2	66.0	0.107	0.214
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	12	73.0	0.051	0.612
UCDavis5	2001	Cache Creek/N.F.	Sacramento Sucker	3	10	73.0	0.040	0.4
UCDavis5	2001	Cache Creek/N.F.	Speckled Dace	3	3	75.0	0.149	0.447
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	3	111.0	0.041	0.123
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	264.0	0.120	0.12
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	290.0	0.055	0.055
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	291.0	0.065	0.065
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	367.0	0.190	0.19
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	368.0	0.190	0.19
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	370.0	0.290	0.29
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	376.0	0.305	0.305
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	385.0	0.345	0.345
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	412.0	0.470	0.47
UCDavis5	2000	Cache Creek/N.F.	Sacramento Sucker	3	1	437.0	0.370	0.37
CDFG	2003	Cache Creek/N.F.	Rainbow trout	3	1	376	0.159	0.159
CDFG	2003	Cache Creek/N.F.	Rainbow trout	3	1	374	0.139	0.139
CDFG	2003	Cache Creek/N.F.	Rainbow trout	3	1	275	0.099	0.099
CDFG	2003	Cache Creek/N.F.	Rainbow trout	3	1	389	0.124	0.124
CDFG	2003	Cache Creek/N.F.	Rainbow trout	3	1	359	0.115	0.115
CDFG	2003	Cache Creek/N.F.	Rainbow trout	3	1	321	0.100	0.100
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	537	0.505	0.505
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	329	0.143	0.143
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	307	0.198	0.198
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	305	0.073	0.073
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	251	0.167	0.167
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	286	0.151	0.151
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	251	0.077	0.077
CDFG	2003	Cache Creek/N.F.	Sacramento Sucker	3	1	199	0.085	0.085
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	188.0	0.150	0.15
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	196.0	0.185	0.185
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	202.0	0.110	0.11
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	214.0	0.125	0.125
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	226.0	0.235	0.235
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	232.0	0.250	0.25
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	236.0	0.115	0.115

UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	240.0	0.260	0.26
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	245.0	0.180	0.18
UCDavis5	2000	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	248.0	0.230	0.23
UCDavis5	2000	Cache Creek/N.F.	Smallmouth Bass	4	1	295.0	0.335	0.335
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	206	0.093	0.093
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	244	0.221	0.221
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	217	0.134	0.134
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	162	0.095	0.095
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	165	0.106	0.106
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	152	0.097	0.097
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	149	0.094	0.094
CDFG	2003	Cache Creek/N.F.	Sacramento Pike Minnow	4	1	159	0.099	0.099
		TL2/3 50-150 mm	sum		169			11
			average concentration					0.07
		TL3 150-350 mm	sum		19			2
			average concentration					0.14
		TL4 150-3500 mm	sum		19			2
			average concentration					0.16
		TL3 >150 mm	sum		24			2
			average concentration					0.19
		TL4 >150 mm	sum		19			2
			average concentration					0.16

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
Lower Cache Creek, Confluence with North Fork to Capay Dam								
TSM	1980	Cache Creek	Green Sunfish	3	12	110.0	0.330	3.96
TSM	1981	Cache Creek	Green Sunfish	3	10	126.0	0.340	3.4
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	251.0	0.395	0.395
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	253.0	0.440	0.44
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	258.0	0.275	0.275
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	261.0	0.410	0.41
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	266.0	0.295	0.295
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	278.0	0.365	0.365
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	279.0	0.395	0.395
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	285.0	0.360	0.36
UCDavis5	2000	Cache Creek/Rumsey	Hardhead	3	1	325.0	0.705	0.705
UCDavis5	2000	Cache Creek/Rumsey	Red Shiner	3	12	36.0	0.103	1.236
UCDavis5	2000	Cache Creek/Rumsey	Red Shiner	3	3	38.0	0.091	0.273
UCDavis5	2000	Cache Creek/Rumsey	Red Shiner	3	10	46.0	0.092	0.92
UCDavis5	2000	Cache Creek/Rumsey	Red Shiner	3	2	50.0	0.069	0.138
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	12	59.0	0.038	0.456
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	8	78.0	0.063	0.504
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	8	82.0	0.060	0.48
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	11	84.0	0.056	0.616
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	5	92.0	0.046	0.23
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	8	96.0	0.050	0.4
UCDavis5	2001	Cache Creek/Rumsey	Sacramento Sucker	3	3	97.0	0.070	0.21
UCDavis5	2001	Cache Creek/Rumsey	Sacramento Sucker	3	3	100.0	0.064	0.192
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	264.0	0.215	0.215
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	298.0	0.155	0.155
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	309.0	0.145	0.145
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	317.0	0.135	0.135
UCDavis5	2001	Cache Creek/Rumsey	Sacramento Sucker	3	1	331.0	0.150	0.15
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	336.0	0.390	0.39
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	342.0	0.245	0.245
UCDavis5	2001	Cache Creek/Rumsey	Sacramento Sucker	3	1	345.0	0.400	0.4
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	375.0	0.270	0.27
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Sucker	3	1	435.0	0.525	0.525
TSM	1989	Cache Creek/d/s Davis Creek	Smallmouth Bass	3	13	107.0	0.040	0.52
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	3	1	142.0	0.090	0.09
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	48.0	0.055	0.55
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	48.0	0.055	0.55

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	48.0	0.058	0.58
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	55.0	0.113	1.13
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	56.0	0.110	1.1
UCDavis5	2001	Cache Creek/Rumsey	Speckled Dace	3	9	56.0	0.054	0.486
UCDavis5	2001	Cache Creek/Rumsey	Speckled Dace	3	9	56.0	0.060	0.54
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	11	57.0	0.072	0.792
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	59.0	0.062	0.62
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	59.0	0.062	0.62
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	10	59.0	0.075	0.75
UCDavis5	2001	Cache Creek/Rumsey	Speckled Dace	3	12	59.0	0.098	1.176
UCDavis5	2001	Cache Creek/Rumsey	Speckled Dace	3	12	59.0	0.103	1.236
UCDavis5	2001	Cache Creek/Rumsey	Speckled Dace	3	12	59.0	0.118	1.416
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	2	73.0	0.141	0.282
UCDavis5	2000	Cache Creek/Rumsey	Speckled Dace	3	9	76.0	0.133	1.197
TSM	1981	Cache Creek	Sucker	3	6	345.0	0.470	2.82
UCDavis5	2000	Cache Creek/Rumsey	Channel Catfish	4	1	381.0	0.225	0.225
TSM	1978	Cache Creek	Largemouth Bass	4	3	268.0	0.610	1.83
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	166.0	0.180	0.18
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	189.0	0.445	0.445
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	220.0	0.290	0.29
TSM	1988	Cache Creek	Sacramento Pike Minnow	4	8	235.0	0.330	2.64
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	241.0	1.390	1.39
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	288.0	0.445	0.445
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	314.0	0.655	0.655
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	315.0	0.575	0.575
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	324.0	0.430	0.43
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	336.0	0.450	0.45
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	355.0	0.740	0.74
UCDavis5	2000	Cache Creek/Rumsey	Sacramento Pike Minnow	4	1	459.0	1.325	1.325
TSM	1988	Cache Creek	Smallmouth Bass	4	12	130.0	0.150	1.8
TSM	1982	Cache Creek	Smallmouth Bass	4	12	137.0	0.170	2.04
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	158.0	0.180	0.18
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	158.0	0.220	0.22
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	180.0	0.255	0.255
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	180.0	0.260	0.26
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	229.0	0.290	0.29
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	239.0	0.340	0.34
TSM	1979	Cache Creek	Smallmouth Bass	4	2	242.5	0.680	1.36
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	250.0	0.325	0.325

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	251.0	0.370	0.37
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	278.0	0.490	0.49
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	281.0	0.535	0.535
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	281.0	0.900	0.9
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	283.0	0.335	0.335
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	292.0	0.465	0.465
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	307.0	0.735	0.735
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	311.0	0.555	0.555
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	332.0	0.780	0.78
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	344.0	0.720	0.72
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	378.0	0.860	0.86
UCDavis5	2000	Cache Creek/Rumsey	Smallmouth Bass	4	1	403.0	1.515	1.515
UCDavis5	2000	Cache Creek/Rumsey	White Catfish	4	1	172.0	0.295	0.295
UCDavis5	2000	Cache Creek/Rumsey	White Catfish	4	1	186.0	0.180	0.18
		TL2/3 50-150 mm	sum		222			23
			average concentration					0.10
		TL3 150-350 mm	sum		23			8
			average concentration					0.36
		TL4 150-3500 mm	sum		41			19
			average concentration					0.46
		TL3 >150 mm	sum		25			9
			average concentration					0.36
		TL4 >150 mm	sum		43			23
			average concentration					0.54
Cache Creek: Clear Lake to North Fork								
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Bluegill	3	1	118.0	0.055	0.055
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Bluegill	3	1	120.0	0.060	0.06
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Bluegill	3	1	149.0	0.075	0.075
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Bluegill	3	1	152.0	0.070	0.07
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Bluegill	3	1	156.0	0.095	0.095
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Bluegill	3	1	158.0	0.095	0.095
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	3	1	135.0	0.090	0.09
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	3	1	146.0	0.080	0.08
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	3	1	162.0	0.095	0.095
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	3	1	163.0	0.090	0.09
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	3	1	168.0	0.070	0.07

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	8	105.0	0.049	0.392
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	4	149.0	0.069	0.276
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	222.0	0.090	0.09
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	256.0	0.095	0.095
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	257.0	0.110	0.11
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	285.0	0.105	0.105
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	290.0	0.105	0.105
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	386.0	0.190	0.19
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	404.0	0.360	0.36
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	414.0	0.350	0.35
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	418.0	0.320	0.32
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Sacramento Sucker	3	1	429.0	0.275	0.275
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	184.0	0.160	0.16
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	205.0	0.110	0.11
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	272.0	0.140	0.14
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	330.0	0.270	0.27
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	352.0	0.295	0.295
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	375.0	0.295	0.295
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	400.0	0.450	0.45
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	444.0	0.665	0.665
UCDavis5	2000	Cache Creek/Clear Lake Outflow	Largemouth Bass	4	1	517.0	0.625	0.625
UCDavis5	2000	Cache Creek/Clear Lake Outflow	White Catfish	4	1	187.0	0.100	0.1
		TL2/3 50-150 mm	sum		17			1
			average concentration					0.06
		TL3 150-350 mm	sum		11			1
			average concentration					0.09
		TL4 150-3500 mm	sum		6			1
			average concentration					0.18
		TL3 >150 mm	sum		16			3
			average concentration					0.16
		TL4 >150 mm	sum		10			3
			average concentration					0.31
Lower Cache Creek, Capay Dam to the Cache Creek Settling Basin								
UCDavis5	2000	Cache Creek/Solano Concrete	Bluegill	3	1	109.0	0.350	0.35
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Bluegill	3	1	157.0	0.290	0.29
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Bluegill	3	1	169.0	0.280	0.28

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Brown Bullhead	3	1	260.0	0.220	0.22
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Brown Bullhead	3	1	293.0	0.280	0.28
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Brown Bullhead	3	1	310.0	0.310	0.31
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Brown Bullhead	3	1	316.0	0.270	0.27
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Carp	3	1	202.0	0.280	0.28
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Carp	3	1	210.0	0.270	0.27
UCDavis9	2001	Cache Creek/u/s Preserve	Fathead Minnow	3	1	66.0	0.09	0.09
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Green Sunfish	3	14	65.0	0.07	0.98
UCDavis9	2001	Cache Creek/u/s Preserve	Green Sunfish	3	17	75.0	0.08	1.36
UCDavis9	2001	Cache Creek/u/s Preserve	Green Sunfish	3	10	89.0	0.07	0.7
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Green Sunfish	3	8	95.0	0.08	0.64
UCDavis5	2000	Cache Creek/Solano Concrete	Green Sunfish	3	1	119.0	0.270	0.27
UCDavis5	2000	Cache Creek/Solano Concrete	Green Sunfish	3	1	126.0	0.395	0.395
UCDavis5	2000	Cache Creek/Solano Concrete	Green Sunfish	3	1	130.0	0.210	0.21
UCDavis5	2000	Cache Creek/Solano Concrete	Green Sunfish	3	1	137.0	0.210	0.21
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Mosquitofish	3	3	42.0	0.06	0.18
UCDavis9	2001	Cache Creek/u/s Preserve	Mosquitofish	3	2	48.0	0.13	0.26
UCDavis5	2001	Cache Creek/Solano Concrete	Red Shiner	3	13	36.0	0.115	1.495
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	12	37.0	0.106	1.272
UCDavis9	2001	Cache Creek/u/s Preserve	Red Shiner	3	17	40.0	0.05	0.85
UCDavis9	2001	Cache Creek/u/s Preserve	Red Shiner	3	17	40.0	0.05	0.85
UCDavis9	2001	Cache Creek/u/s Preserve	Red Shiner	3	17	40.0	0.06	1.02
UCDavis5	2000	Cache Creek/Solano Concrete	Red Shiner	3	9	42.0	0.164	1.476
UCDavis5	2000	Cache Creek/Solano Concrete	Red Shiner	3	9	42.0	0.165	1.485
UCDavis5	2000	Cache Creek/Solano Concrete	Red Shiner	3	9	42.0	0.170	1.53
UCDavis5	2001	Cache Creek/Solano Concrete	Red Shiner	3	6	42.0	0.131	0.786
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	43.0	0.115	1.15
UCDavis5	2000	Cache Creek/Solano Concrete	Red Shiner	3	9	43.0	0.060	0.54
UCDavis5	2000	Cache Creek/Solano Concrete	Red Shiner	3	9	43.0	0.070	0.63
UCDavis5	2000	Cache Creek/Solano Concrete	Red Shiner	3	9	43.0	0.081	0.729

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	44.0	0.127	1.27
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	44.0	0.144	1.44
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Red Shiner	3	39	44.0	0.03	1.17
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Red Shiner	3	39	44.0	0.04	1.56
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Red Shiner	3	39	44.0	0.04	1.56
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	46.0	0.068	0.68
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	46.0	0.084	0.84
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	46.0	0.090	0.9
UCDavis5	2000	Cache Creek/Solano Concrete	Red Shiner	3	9	47.0	0.181	1.629
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	48.0	0.138	1.38
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	48.0	0.147	1.47
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Red Shiner	3	10	48.0	0.177	1.77
UCDavis9	2001	Cache Creek/u/s Preserve	Red Shiner	3	13	51.0	0.05	0.65
UCDavis9	2001	Cache Creek/u/s Preserve	Red Shiner	3	13	51.0	0.07	0.91
UCDavis9	2001	Cache Creek/u/s Preserve	Red Shiner	3	13	51.0	0.07	0.91
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Red Shiner	3	12	58.0	0.04	0.48
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Red Shiner	3	12	58.0	0.05	0.6
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Red Shiner	3	12	58.0	0.05	0.6
UCDavis9	2001	Cache Creek/d/s Gordon Slough	Sacramento Sucker	3	13	42.0	0.04	0.52
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	12	45.0	0.038	0.456
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	18	45.0	0.039	0.702
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	17	48.0	0.066	1.122
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	17	48.0	0.071	1.207
UCDavis9	2001	Cache Creek/u/s Preserve	Sacramento Sucker	3	18	54.0	0.05	0.9
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	5	67.0	0.066	0.33
UCDavis5	2001	Cache Creek/Solano Concrete	Sacramento Sucker	3	6	76.0	0.060	0.36
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	8	85.0	0.072	0.576
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	9	107.0	0.094	0.846
UCDavis5	2001	Cache Creek/Solano Concrete	Sacramento Sucker	3	3	140.0	0.123	0.369

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	202.0	0.120	0.12
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	211.0	0.145	0.145
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	256.0	0.160	0.16
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	257.0	0.195	0.195
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	267.0	0.150	0.15
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	1	271.0	0.210	0.21
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	1	273.0	0.185	0.185
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	1	329.0	0.500	0.5
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	1	330.0	0.460	0.46
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	338.0	0.245	0.245
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	340.0	0.275	0.275
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	1	348.0	0.370	0.37
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Sacramento Sucker	3	1	357.0	0.535	0.535
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	381.0	0.310	0.31
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Sacramento Sucker	3	1	393.0	0.290	0.29
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	401.0	0.295	0.295
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Sucker	3	1	406.0	0.350	0.35
UCDavis5	2000	Cache Creek/Solano Concrete	Speckled Dace	3	10	50.0	0.101	1.01
UCDavis5	2000	Cache Creek/Solano Concrete	Speckled Dace	3	10	50.0	0.103	1.03
UCDavis5	2000	Cache Creek/Solano Concrete	Speckled Dace	3	10	50.0	0.112	1.12
UCDavis5	2001	Cache Creek/Solano Concrete	Speckled Dace	3	6	52.0	0.097	0.582
UCDavis9	2001	Cache Creek/u/s Preserve	Speckled Dace	3	8	61.0	0.1	0.8
UCDavis9	2001	Cache Creek/u/s Preserve	Speckled Dace	3	8	61.0	0.12	0.96
UCDavis9	2001	Cache Creek/u/s Preserve	Speckled Dace	3	8	61.0	0.12	0.96
UCDavis5	2000	Cache Creek/Solano Concrete	Channel Catfish	4	1	326.0	0.225	0.225
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Channel Catfish	4	1	332.0	0.570	0.57
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Channel Catfish	4	1	351.0	0.280	0.28
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Channel Catfish	4	1	353.0	0.460	0.46

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	Channel Catfish	4	1	470.0	0.330	0.33
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	193.0	0.300	0.3
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	209.0	0.405	0.405
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	218.0	0.265	0.265
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	221.0	0.435	0.435
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	231.0	0.465	0.465
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	235.0	0.335	0.335
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	249.0	1.060	1.06
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	262.0	0.575	0.575
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	264.0	0.405	0.405
UCDavis5	2000	Cache Creek/Solano Concrete	Sacramento Pike Minnow	4	1	281.0	0.535	0.535
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	151.0	0.365	0.365
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	156.0	0.455	0.455
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	160.0	0.240	0.24
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	163.0	0.375	0.375
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	168.0	0.375	0.375
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	194.0	0.430	0.43
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Smallmouth Bass	4	1	211.0	0.430	0.43
UCDavis5	2000	Cache Creek/btwn Yolo and Settling Basin	Smallmouth Bass	4	1	227.0	0.350	0.35
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	246.0	0.490	0.49
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	251.0	0.550	0.55
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	259.0	0.485	0.485
UCDavis5	2000	Cache Creek/Solano Concrete	Smallmouth Bass	4	1	271.0	0.405	0.405
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	White Crappie	4	1	207.0	0.480	0.48
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	White Crappie	4	1	238.0	0.510	0.51
UCDavis2	1995	Cache Creek/btwn Road 102 and I-5	White Crappie	4	1	272.0	0.650	0.65
		TL2/3 50-150 mm	sum		239			19
			average concentration					0.08
		TL3 150-350 mm	sum		20			5
			average concentration					0.26
		TL4 150-3500 mm	sum		27			12
			average concentration					0.45

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
		TL3 >150 mm	sum		25			7
			average concentration					0.28
		TL4 >150 mm	sum		30			13
			average concentration					0.44

ProjID	Year	SiteName	Common Name	Trophic Level	Number	Length (mm)	Hg Concentration (ppm wet wt)	Weighted Hg Concentration (ppm wet wt)
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	183	0.601	0.601
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	170	0.641	0.641
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	130	0.325	0.325
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	125	0.297	0.297
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	168	0.497	0.497
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	93	0.255	0.255
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	85	0.124	0.124
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	130	0.278	0.278
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	148	0.347	0.347
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	124	0.355	0.355
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	145	0.568	0.568
CDFG	2003	Cache Creek Settling Basin	Bluegill	3	1	127	0.329	0.329
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	115	0.140	0.140
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	145	0.200	0.200
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	104	0.103	0.103
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	130	0.157	0.157
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	122	0.125	0.125
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	144	0.280	0.280
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	116	0.220	0.220
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	110	0.204	0.204
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	131	0.183	0.183
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	120	0.160	0.160
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	120	0.126	0.126
CDFG	2003	Cache Creek Settling Basin	Carp	3	1	142	0.242	0.242
CDFG	2003	Cache Creek Settling Basin	Largemouth Bass	4	1	230	0.660	0.660
CDFG	2003	Cache Creek Settling Basin	Largemouth Bass	4	1	160	0.403	0.403

APPENDIX B. TOTAL MERCURY, METHYLMERCURY AND TSS CONCENTRATIONS IN WATER

Table B.1 summarizes the raw data for each area of the watershed as well as provides r and p-values for total mercury, suspended solid, and flow regression analyses. Table B.2 lists raw data for total mercury, methylmercury, and TSS used for calculating loads in the Cache Creek watershed. Total mercury and TSS were also used to develop Hg/TSS ratios for identifying mercury sources. Table B.3 lists sample site coordinates.

Table B.1. Cache Creek Data Analysis

South Fork Cache Creek				
	THg	TMeHg	TSS	Hg/TSS
Mean	10.2	0.13	40.4	0.35
Median	7.6	0.12	22.0	0.25
Min	0.3	0.02	1.0	0.11
Max	34.9	0.47	195.0	2.42
N	25	16	23	23
	THg vs. Flow		TSS vs. Flow	
r	0.32		0.29	
p	0.003		0.0085	
	Y=0.0053x+5.6344		Y=0.0279x+18.159	

North Fork Cache Creek				
	THg	TMeHg	TSS	Hg/TSS
Mean	72.9	0.08	342.8	0.42
Median	5.1	0.07	23.0	0.27
Min	1.3	0.02	0.9	0.03
Max	1381.0	0.19	4500	2.02
N	29	13	27	26
	THg vs. Flow		TSS vs. Flow	
r	0.05		0.12	
p	0.25		0.08	

Harley Gulch				
	THg	TMeHg	TSS	Hg/TSS
Mean	5944.1	2.01	743.8	65.87
Median	254	0.56	3.9	45.16
Min	29.5	0.07	1.4	1.66
Max	80596.9	8.56	6700	228.0
N	20	10	17	17
	THg vs. Flow		TSS vs. Flow	
r	0.09		0.85	
p	0.21		<0.001	
			Y=86.187x-396.03	

Davis Creek				
	THg	TMeHg	TSS	Hg/TSS
Mean	10.6	0.34	2.1	5.69
Median	7.4	0.27	1.1	5.79
Min	3.1	0.02	1.0	2.68
Max	29.8	0.74	4.3	9.88
N	6	3	5	5
	THg vs. Flow		TSS vs. Flow	
r	0.02		0.37	
p	0.79		0.27	

Bear Creek				
	THg	TMeHg	TSS	Hg/TSS
Mean	280.6	0.64	117.5	3.66
Median	81.9	0.82	29.3	2.17
Min	18.5	0.47	1.7	0.97
Max	1290.2	2.79	670.0	12.85
N	16	17	15	15
	THg vs. Flow		TSS vs. Flow	
r	0.02		0.09	
p	0.09		0.29	

Sulphur Creek				
	THg	TMeHg	TSS	Hg/TSS
Mean	1716.7	3.26	126.1	64.58
Median	1051	0.76	55.5	17.09
Min	376	0.06	4.2	2.24
Max	8401.7	20.6	510	384.35
N	23	17	19	19
	THg vs. Flow		TSS vs. Flow	
r	0.03		0.1	
p	0.41		0.18	

Cache Creek at Rumsey				
	THg	TMeHg	TSS	Hg/TSS
Mean	161.2	0.2	243.6	0.74
Median	17.6	0.17	71.0	0.28
Min	2.3	0.04	0.6	0.14
Max	2247.6	0.78	1650.0	3.95
N	65	17	26	26
	THg vs. Flow		TSS vs. Flow	
r	0.57		0.58	
p	<0.001		<0.001	
	Y=0.1245x-75.233		Y=0.1099x-18.733	

Cache Creek at Yolo/Rd 102				
	THg	TMeHg	TSS	Hg/TSS
Mean	204.8	0.27	507.4	0.73
Median	29.3	0.19	111.0	0.40
Min	1.2	0.07	0.1	0.06
Max	1295	1.08	2556.8	10.82
N	44	21	39	39
	THg vs. Flow		TSS vs. Flow	
r	0.88		0.69	
p	<0.001		<0.001	
	Y=0.0665x-14.419		Y=0.1272x+67.743	

Cache Creek Settling Basin Outflow				
	THg	TMeHg	TSS	Hg/TSS
Mean	205.9	0.32	532.7	0.39
Median	67.5	0.32	360	0.37
Min	11.2	0.20	41	0.03
Max	984.6	0.44	1900	0.66
N	18	2	15	15
	THg vs. Flow		TSS vs. Flow	
r	0.83		0.81	
p	<0.001		<0.001	
	Y=0.0451x-41.464		Y=0.082x+6.0433	

Table B.2. Raw Data for Calculating Loads

Project ID[1]	Site Name	Date	THg (ng/L)	TSS (mg/L)	MeHg (ng/L)	Flow (cfs)
Clear Lake Outflow (South Fork Cache Creek)						
CALFED1C	Cache Creek at Lower Lake	2/29/00	17.5		0.13	1998.5
CALFED1C	Cache Creek at Lower Lake	3/17/00	25.60		0.05	999.3
CVRWQCB	Clear Lake Outflow	2/27/96	7.38	22.1		1920
CVRWQCB	Clear Lake Outflow	4/2/96	12.18	46.4		956
CVRWQCB	South Fork us Confluence	4/2/96	12.9	70		956
CVRWQCB	Clear Lake Outflow	4/3/96	12	45.1		1950
CVRWQCB	Clear Lake Outflow	4/4/96	5.41	18.7		2200
CVRWQCB	Clear Lake Outflow	6/11/96	11.06	17.8		775
CVRWQCB	Clear Lake Outflow	12/23/96	12.09	5		7
CVRWQCB	S.F. confluence	1/26/97	34.85	195		3790
CVRWQCB	Clear Lake Outflow	6/11/97	4.08	20		512
CVRWQCB	South Fork us Confluence	1/16/98	32.46	189		679
CALFED5B	Clear Lake Outflow	01/31/00	7.5	22.00	0.11	3.5
CALFED5B	Clear Lake Outflow	03/02/00	10.9	41.50	0.15	2000
CALFED5B	Clear Lake Outflow	04/17/00	6.9	34.40	0.47	1000
CALFED5B	Clear Lake Outflow	06/13/00	3.5	14.24	0.12	645
CALFED5B	Clear Lake Outflow	08/10/00	7.6	33.36	0.18	500
CALFED5B	Clear Lake Outflow	10/11/00	4.4	15.85	0.03	250
CALFED5B	Clear Lake Outflow	11/07/00	0.3	2.64	0.02	5
CALFED5B	Clear Lake Outflow	12/11/00	0.5	0.99	0.02	10
CALFED5B	Clear Lake Outflow	01/11/01	7.6	48.87	0.05	10
CALFED5B	Clear Lake Outflow	02/13/01	3.5	8.37	0.09	7
CALFED5B	Clear Lake Outflow	03/22/01	8.8	44.83	0.14	7.5
CALFED5B	Clear Lake Outflow	05/03/01	2.5	17.61	0.26	10
CALFED5B	Clear Lake Outflow	06/07/01	2.5	14.98	0.13	150

[1] Several projects collected water quality data and are identified as followed:
CALFED1C – (Domalgalski, etal., 2002)
CALFED5A – (Suchanek, etal., 2002)
CALFED5B – (Slotton, etal., 2002a)
CVRWQCB (Foe and Croyle, 1998)
CVRWQCB2 – Data collected by Sacramento River Mercury TMDL Regional Board staff
USACE–US Army Corps of Engineers NAWQA data accessed at http://infotrek.er.usgs.gov/pls/nawqa.home

Project ID	Site Name	Date	THg (ng/L)	TSS (mg/L)	MeHg	Flow (cfs)
North Fork Cache Creek						
CALFED1C	N. Fork Cache Cr at Hwy 20	2/27/00	23.70		0.08	2224.9
CALFED1C	N. Fork Cache Cr at Hwy 20	3/16/00	5.05		<0.02	449.1
CVRWQCB	North Fork	2/21/96	67.19	516		3900
CVRWQCB	North Fork	2/22/96	37.43	241.1		3400
CVRWQCB	North Fork	2/23/96	25.01	175.6		3250
CVRWQCB	North Fork	2/27/96	57.28	194.7		2450
CVRWQCB	North Fork	4/2/96	4.34	16.6		99
CVRWQCB	N.F. confluence	4/2/96	3.93	20.5		9
CVRWQCB	North Fork	4/3/96	2.59	75		99
CVRWQCB	North Fork	4/4/96	2.25			99
CVRWQCB	North Fork	6/11/96	2.4	3.82		99
CVRWQCB	North Fork	12/23/96	8.13	23		99
CVRWQCB	North Fork	1/26/97	104.3	935		3500
CVRWQCB	North Fork	1/26/97	125.2	1050		3500
CVRWQCB	North Fork	6/11/97	broke	9		150
CVRWQCB	N.F. confluence	1/16/98	61.02	446		7
CVRWQCB	North Fork	2/2/98	1381	4500		2000
CALFED5B	N Fk Cache	01/31/00	149.0	801.00	0.17	156
CALFED5B	N Fk Cache	03/02/00	16.7	130.00	0.07	2230
CALFED5B	N Fk Cache	03/16/00	4.1	20.27	0.05	306
CALFED5B	N Fk Cache	04/17/00	3.5	11.70	0.02	12
CALFED5B	N Fk Cache	06/13/00	1.8	6.61	0.08	30
CALFED5B	N Fk Cache	08/10/00	2.2	2.66	0.19	10
CALFED5B	N Fk Cache	10/11/00	2.6	1.93	0.04	7
CALFED5B	N Fk Cache	11/07/00	1.3	1.06	0.02	8
CALFED5B	N Fk Cache	12/11/00	1.8	0.88	0.03	10
CALFED5B	N Fk Cache	01/11/01	9.5	31.04	0.06	9
CALFED5B	N Fk Cache	02/13/01	2.6	4.11		9
CALFED5B	N Fk Cache	03/22/01	2.3	4.25	0.09	16
CALFED5B	N Fk Cache	05/03/01	5.1	35.03	0.07	740
Harley Gulch						
CALFED1C	Harley Gulch	2/27/00	243		0.07	8.48
CALFED1C	Harley Gulch	3/15/00	144		0.09	0.71
CVRWQCB	Harley Gulch	4/2/96	29.47	1.8		5
CVRWQCB	Harley Gulch	1/16/98	78.47	47.3		6.04
CVRWQCB2	Harley Gulch	11/20/01	456	2		0.05
CVRWQCB2	Harley Gulch	12/03/01	196	2		2
CVRWQCB2	Harley Gulch	01/02/02	602.6	71		33
CALFED5B	Harley Gulch	01/31/00	831.0	45.70	0.98	4.5
CALFED5B	Harley Gulch	02/14/00	493.0	111.40	0.35	12
CALFED5B	Harley Gulch	03/02/00	101.0	3.90	0.12	1.3
CALFED5B	Harley Gulch	04/17/00	140.0	3.10	0.45	1.7
CALFED5B	Harley Gulch	06/13/00	197.0	3.20	7.76	0.1
CALFED5B	Harley Gulch	01/11/01	365.5	1.75	1.09	3.5
CALFED5B	Harley Gulch	02/13/01	168.5	1.37	0.66	1.5
CALFED5B	Harley Gulch	05/03/01	265.0	3.37	8.56	0.1
Harley Gulch West Branch (Mine Side, upstream of East Branch confluence)						
CALFED5A	Mine-side trib at confluence	2/14/00	2070			3.78
CVRWQCB	Harley G. West (31a)	2/2/98	359448	6700		1.45
CVRWQCB	Harley G. West (31a)	2/16/98	146039	5400		3.89
CVRWQCB2	West Branch u/s Confluence w East Branch	12/3/01	889	8.2		
CVRWQCB2	West Branch u/s Confluence w East Branch	01/02/02	2976.35	238		

Project ID	Site Name	Date	THg (ng/L)	TSS (mg/L)	MeHg	Flow (cfs)
Harley Gulch East Branch (Non-mine side, upstream of West Branch confluence)						
CALFED5A	S. Side (non-mine) trib	2/14/00	135			22.75
CVRWQCB	Harley G. East (31b)	2/2/98	925.2	3800		5.07
CVRWQCB	Harley G. East (31b)	2/16/98	58.93	110		13.62
CVRWQCB2	East Branch u/s of confluence	12/3/01	23.7	3.6		
CVRWQCB2	East Branch u/s of confluence	01/02/02	43.07	51		
Harley Gulch (Miscellaneous sites upstream and downstream of Abbott and Turkey Run mines). Note: These samples were not used in calculating mercury loads, but were used in determining numeric targets.						
CALFED5A	Mine-side trib W of Hwy 20	2/14/00	1930			4.58
CALFED5A	Turkey Run S Fk: from piles	2/14/00	6350			0.05
CALFED5A	Turkey Run N Fk: from spring etc	2/14/00	404			0.15
CALFED5A	Turkey Run spring to 705	2/14/00	4			0.05
CALFED5A	Mine-side trib. Above TR Mine input	2/14/00	1650			2.54
CALFED5A	Mine-side trib btw main Abbott piles	2/14/00	1911			2.94
CALFED5A	Mine-side trib btw main Abbott piles	2/14/00	1528			
CALFED5A	Mine-side trib above all main Abbott piles	2/14/00	181			2.04
CVRWQCB2	East Branch Harley Gulch @ Hwy 20	12/3/01	23.7	1		
CVRWQCB2	West Branch d/s Hwy 20 Box Culvert	12/3/01	664	60		
CVRWQCB2	Tributary Below Turkey Run Mine	12/3/01	907	16		
CVRWQCB2	West Branch d/s Abbot Mine Tailings Pipe	12/3/01	609	4.8		
CVRWQCB2	West Branch u/s Abbot Mine Tailings Pipe	12/3/01	58	2.2		
CVRWQCB2	East Branch Harley Gulch @ Hwy 20	01/02/02	45.93	98		
CVRWQCB2	Tributary Below Turkey Run Mine	01/02/02	2272.14	39		
CVRWQCB2	West Branch d/s Abbot Mine Tailings Pipe	01/02/02	4494.31	269		
CVRWQCB2	West Branch u/s Abbot Mine Tailings Pipe	01/02/02	250.39	16		
Davis Creek						
CVRWQCB	Davis Creek	4/2/96	8.58	3.2		193
CVRWQCB2	Davis Creek at the Mouth	2/27/02	3.12	1		1.5
CVRWQCB2	Davis Creek at the Dam	2/27/02	9.88	1		1.5
CALFED5B	Davis Creek below DCR	03/10/00	29.8	4.26	0.27	48.0
CALFED5B	Davis Creek below DCR	06/13/00	6.3	1.09	0.74	0.1
CALFED5B	Davis Creek below DCR	11/06/00	5.9	BD	0.02	0.03
Bear Creek (Total mercury and TSS values)						
CVRWQCB	Bear Creek	2/21/96	758.59	349		891
CVRWQCB	Bear Creek	2/22/96	128	71		404
CVRWQCB	Bear Creek	2/23/96	65.43	29.3		331
CVRWQCB	Bear Creek	2/27/96	52.61	13.8		110
CVRWQCB	Bear Creek	4/2/96	61.65	23		170
CVRWQCB	Bear Creek	4/3/96	21.84	1.7		54
CVRWQCB	Bear Creek	4/4/96	20.11	2.4		259
CVRWQCB	Bear Creek	6/11/96	18.53	19.2		18

Project ID	Site Name	Date	THg (ng/L)	TSS (mg/L)	MeHg	Flow (cfs)
CVRWQCB	Bear Creek	12/23/96	109.76	46		183.72
CVRWQCB	Bear Creek	1/26/97	1290.2	670		500
CVRWQCB	Bear Creek	6/11/97	20.01	12		6
CVRWQCB	Bear Creek	1/16/98	98.41	62		1372
CVRWQCB	Bear Creek	2/2/98	142	95		2380
CVRWQCB	Bear Creek	2/2/98	984			2380
CVRWQCB2	Bear Ck at Gage	01/02/02	699.64	366		1630
CALFED5B	Bear Creek@Cache	07/12/01	18.8	2.07		2.5
Bear Creek (Methylmercury values)						
CALFED5B	Bear Creek (mid)	01/31/00			0.58	
CALFED5B	Bear Creek (mid)	03/02/00			0.26	230
CALFED5B	Bear Creek (mid)	04/17/00			0.35	72
CALFED5B	Bear Creek (mid)	06/14/00			0.17	3
CALFED5B	Bear Creek (mid)	08/10/00			1.09	1
CALFED5B	Bear Creek (mid)	10/11/00			0.13	3.1
CALFED5B	Bear Creek (mid)	11/07/00			0.32	3
CALFED5B	Bear Creek (mid)	12/11/00			0.22	3.5
CALFED5B	Bear Creek (mid)	01/11/01			0.47	29
CALFED5B	Bear Creek (mid)	02/13/01			0.71	
CALFED5B	Bear Creek (mid)	03/22/01			0.33	
CALFED5B	Bear Creek (mid)	05/03/01			0.19	3.5
CALFED5B	Bear Creek (mid)	06/07/01			2.79	3.5
CALFED5B	Bear Creek@Cache	07/12/01			0.82	2.5
CALFED5B	Bear Creek (mid)	07/12/01			1.14	2.5
CALFED5B	Bear Creek abv. Hwy 20	08/23/01			0.81	3
CALFED5B	Bear Creek (mid)	08/23/01			0.58	3.5
Sulphur Creek						
CVRWQCB	Sulfur Creek (13)	1/26/97	5316.4	320		4.21
CVRWQCB	Sulfur Creek (13)	2/2/98	1142.1	510		6.32
CVRWQCB	Sulfur Creek (13)	2/2/98	8401.7	510		6.32
CVRWQCB	Sulfur Creek (13)	2/16/98	1964.7	140		16.98
CVRWQCB2	Sulphur Ck at Gage	11/20/01	1768	4.6		0.48
CVRWQCB2	Sulphur Ck at Gage	01/02/02	4118.73	396		163
CALFED5B	Sulfur Ck	01/31/00	1560.0	49.50	2.46	4.5
CALFED5B	Sulfur Ck	02/14/00	974.0	114.70	0.48	12.0
CALFED5B	Sulfur Ck	03/02/00	376.0	22.00	0.22	1.3
CALFED5B	Sulfur Ck	04/17/00	430.0	14.10	0.66	1.7
CALFED5B	Sulfur Ck	06/14/00	676.0	10.14	0.76	0.5
CALFED5B	Sulfur Ck	08/10/00	690.0	59.43	4.04	90.0
CALFED5B	Sulfur Ck	10/11/00	676.0	13.93	1.57	0.5
CALFED5B	Sulfur Ck	11/07/00	1320.0	4.23	1.30	0.1
CALFED5B	Sulfur Ck	01/11/01	3070.0	55.47	0.92	6.3
CALFED5B	Sulfur Ck	02/13/01	906.0	7.79	0.41	1.5
CALFED5B	Sulfur Ck	05/03/01	557.0	10.08	0.15	0.1
CALFED5B	Sulfur Ck	07/12/01	1180.0	88.63	18.20	0.2
CALFED5B	Sulfur Ck	08/23/01	1051.0	65.08	20.60	0.2
CALFED1C	Sulfur Ck	01/31/00	1560.0		2.5	28
CALFED1C	Sulfur Ck	02/27/00	542.0		0.3	38
CALFED1C	Sulfur Ck	03/15/00	528.0		0.1	7
CALFED1C	Sulfur Ck	06/13/00	676.0		0.8	5
Cache Creek at Rumsey						
CALFED1C	Cache Creek at Rumsey	2/28/00	40.60		0.13	2143.7
CALFED1C	Cache Creek at Rumsey	3/16/00	10.60		0.07	1543.8
CALFED1C	Cache Creek at Rumsey	6/13/00	5.60		0.2	1220

Project ID	Site Name	Date	THg (ng/L)	TSS (mg/L)	MeHg	Flow (cfs)
CVRWQCB	Rumsey	2/21/96	1296.09	1244.2		9986
CVRWQCB	Rumsey	2/22/96	1132.99	374.6		5866
CVRWQCB	Rumsey	2/23/96	987.12	300.7		5933
CVRWQCB	Rumsey	2/27/96	35.26	208.2		4871
CVRWQCB	Rumsey	4/2/96	30.77	106.3		2076
CVRWQCB	Rumsey	4/3/96	15.85	77.2		2053
CVRWQCB	Rumsey	4/4/96	7.83	31		2273
CVRWQCB	Rumsey	6/11/96	6.7	26.3		750
CVRWQCB	Rumsey	12/23/96	121.76	420		369
CVRWQCB	Rumsey	1/26/97	1142	1650		9000
CVRWQCB	Rumsey	6/11/97	5.13	19		668
CVRWQCB	Rumsey	2/2/98	74.4	300		4958
CALFED5B	Cache Ck at Rumsey	01/31/00	273.0	775.00	0.78	190
CALFED5B	Cache Ck at Rumsey	03/02/00	40.0	277.00	0.22	4121
CALFED5B	Cache Ck at Rumsey	03/16/00	8.3	37.40	0.10	1525
CALFED5B	Cache Ck at Rumsey	04/17/00	43.3	179.00	0.41	1920
CALFED5B	Cache Ck at Rumsey	06/14/00	5.6	23.72	0.20	1220
CALFED5B	Cache Ck at Rumsey	08/10/00	5.6	32.16	0.23	520
CALFED5B	Cache Ck at Rumsey	10/11/00	5.7	14.13	0.11	340
CALFED5B	Cache Ck at Rumsey	11/07/00	2.4	1.53	0.05	20
CALFED5B	Cache Ck at Rumsey	12/11/00	2.3	0.57	0.04	30
CALFED5B	Cache Ck at Rumsey	01/11/01	24.9	87.37	0.04	906
CALFED5B	Cache Ck at Rumsey	02/13/01	37.5	52.49	0.28	668.0
CALFED5B	Cache Ck at Rumsey	03/22/01	5.3	8.40	0.10	191.0
CALFED5B	Cache Ck at Rumsey	05/03/01	11.3	64.70	0.30	800.0
CALFED5B	Cache Ck at Rumsey	06/07/01	5.4	23.83	0.17	800.0
USACE	Rumsey	2/9/96	39.44			4426
USACE	Rumsey	3/7/96	39			5046
USACE	Rumsey	4/25/96	7.11			913
USACE	Rumsey	5/29/96	7.15			3705
USACE	Rumsey	6/26/96	4.59			700
USACE	Rumsey	7/9/96	6.02			752
USACE	Rumsey	8/28/96	2.71			509
USACE	Rumsey	9/17/96	2.68			418
USACE	Rumsey	10/22/96	3.94			210
USACE	Rumsey	11/18/96	6.48			125
USACE	Rumsey	12/13/96	21.1			311
USACE	Rumsey	1/15/97	21.42			2594
USACE	Rumsey	2/19/97	23.79			2471
USACE	Rumsey	3/19/97	8.75			338
USACE	Rumsey	4/21/97	8.06			512
USACE	Rumsey	5/27/97	5.07			570
USACE	Rumsey	6/24/97	7.14			650
USACE	Rumsey	7/22/97	6.83			620
USACE	Rumsey	8/20/97	6.05			400
USACE	Rumsey	9/16/97	4.6			257
USACE	Rumsey	10/16/97	3.73			79
USACE	Rumsey	11/18/97	21.16			10
USACE	Rumsey	12/7/97	69.66			389
USACE	Rumsey	12/14/97	17.57			67
USACE	Rumsey	12/18/97	11.78			119
USACE	Rumsey	1/4/98	124.85			584
USACE	Rumsey	1/4/98	304.58			584
USACE	Rumsey	1/4/98	627.21			584
USACE	Rumsey	1/12/98	196.58			1224
USACE	Rumsey	1/12/98	308.74			1224
USACE	Rumsey	1/12/98	464.45			1224

Project ID	Site Name	Date	THg (ng/L)	TSS (mg/L)	MeHg	Flow (cfs)
USACE	Rumsey	1/20/98	49.58			2657
USACE	Rumsey	1/29/98	369.6			3763
USACE	Rumsey	2/3/98	2247.6			10552
USACE	Rumsey	3/26/98	22.9			4038
USACE	Rumsey	4/14/98	21.6			3831
Cache Creek Settling Basin Inflow						
CALFED1C	Cache Ck into Settling Basin	3/1/00	205.50		0.58	4746.5
CALFED1C	Cache Ck into Settling Basin	3/18/00	24.25		0.09	901.1
CALFED1C	Cache Ck below Hwy 505	6/13/00	11.20		0.27	30
CALFED1C	Cache Ck into Settling Basin	6/13/00	17.70		0.26	57
CVRWQCB	Rd 102	2/21/96	940.82	2556.8		9580
CVRWQCB	Rd 102	2/22/96	336.52	836.67		7270
CVRWQCB	Rd 102	2/23/96	258.17			5830
CVRWQCB	Rd 102	2/27/96	90.34	352.2		4460
CVRWQCB	Rd 102	4/2/96	256.56	1327.3		2310
CVRWQCB	Rd 102	4/3/96	61.77	177.1		2050
CVRWQCB	Rd 102	4/4/96	34.41	106.3		2110
CVRWQCB	Rd 102	6/11/96	16.19	36.4		52
CVRWQCB	Rd 102	12/23/96	8.29	20		106
CVRWQCB	Rd 102	1/6/97	768.5	920		6820
CVRWQCB	Rd 102	1/20/97	40.7	160		2920
CVRWQCB	Rd 102	1/26/97	1295	1900		19800
CVRWQCB	Rd 102	2/2/97	145.5	515		6370
CVRWQCB	Rd 102	2/23/97	36.6	575		731
CVRWQCB	Rd 102	5/6/97	13.1	22		128
CVRWQCB	Rd 102	6/11/97	6.8	25		122
CVRWQCB	Rd 102	10/29/97	4.3	18		120
CVRWQCB	Rd 102	2/2/98	469.2	1500		7040
CVRWQCB	Rd 102	2/2/98	519.85	1500		7040
CVRWQCB	Rd 102	2/8/98	886	1800		16983
CVRWQCB	Rd 102	2/14/98	922.3	2400		9870
CVRWQCB	Rd 102	2/16/98	501	770		7262
CVRWQCB	Rd 102	2/22/98	1098	2400		
CALFED5B	Cache btw Yolo & SBasin	01/31/00	5.4	9.05	0.18	160
CALFED5B	Cache btw Yolo & SBasin	03/02/00	151.0	421.75	0.35	4345
CALFED5B	Cache Ck below Hwy 505	03/16/00	16.6	53.20	0.15	1800
CALFED5B	Cache Ck below Hwy 505	04/17/00	43.4	162.00	1.08	1500
CALFED5B	Cache btw Yolo & SBasin	04/17/00	154.0	276.00	0.51	700
CALFED5B	Cache Ck below Hwy 505	06/14/00	11.2	12.98	0.27	30
CALFED5B	Cache btw Yolo & SBasin	06/14/00	17.7	36.94	0.26	57
CALFED5B	Cache Ck below Hwy 505	08/10/00	2.4	2.71	0.14	10
CALFED5B	Cache btw Yolo & SBasin	08/10/00	10.6	79.63	0.48	28
CALFED5B	Cache Ck below Hwy 505	10/11/00	2.0	4.38	0.19	35
CALFED5B	Cache Ck below Hwy 505	10/11/00	2.2	3.22	0.19	35
CALFED5B	Cache btw Yolo & SBasin	10/11/00	5.5	25.08	0.18	75
CALFED5B	Cache Ck below Hwy 505	11/07/00	1.2	0.11	0.07	25
CALFED5B	Cache btw Yolo & SBasin	11/07/00	1.8	1.36	0.09	30
CALFED5B	Cache Ck below Hwy 505	12/11/00	1.4	1.10	0.09	35
CALFED5B	Cache Ck below Hwy 505	01/11/01	5.2	9.82	0.09	68
CALFED5B	Cache Ck below Hwy 505	02/13/01	19.9	110.98	0.23	257
Cache Creek Settling Basin Outflow						
CVRWQCB	Settling Basin (1)	01/21/97	14.2	41.0		2670
CVRWQCB	Settling Basin (1)	05/27/97	30.1	57.0		146
CVRWQCB	Settling Basin (1)	12/23/96	29.1	62.0		106
CVRWQCB	Settling Basin (1)	01/20/97	26.7	72.0		2920

Project ID	Site Name	Date	THg (ng/L)	TSS (mg/L)	MeHg	Flow (cfs)
CVRWQCB	Settling Basin (1)	06/11/97	30.8	89.0		122
CVRWQCB	Settling Basin (1)	05/06/97	63.1	140.0		128
CVRWQCB	Settling Basin (1)	02/02/97	71.8	235.0		6370
CVRWQCB	Settling Basin (1)	02/14/98	129.1	360.0		9870
CVRWQCB	Settling Basin (1)	02/16/98	145.1	370.0		7262
CVRWQCB	Settling Basin (1)	02/23/97	17.1	515.0		731
CVRWQCB	Settling Basin (1)	02/02/98	161.8	570.0		7040
CVRWQCB	Settling Basin (1)	01/06/97	246.4	680.0		6820
CVRWQCB	Settling Basin (1)	02/22/98	615.5	1400.0		15400
CVRWQCB	Settling Basin (1)	01/26/97	984.6	1500.0		19800
CVRWQCB	Settling Basin (1)	02/08/98	957.0	1900.0		16983
CVRWQCB	Settling Basin (1)	10/29/97	12.3			120
CALFED1C	Cache Creek out of Settling Basin	03/01/00	160.5		0.4	4746
CALFED1C	Cache Creek out of Settling Basin	03/18/00	11.2		0.2	901

Table B.3 Sample Site Coordinates

Site	Latitude	Longitude
Clear Lake Outflow	38.92328	122.56553
South Fork us Confluence	38.98039	122.50346
North Fork Cache Cr at Hwy 20	38.98833	122.54018
North Fork confluence	38.98103	122.50456
Harley Gulch West Branch u/s confluence	39.01050	122.43390
Harley Gulch East Branch u/s confluence	39.01019	122.43314
Harley Gulch at Gauge	39.01001	122.43401
Davis Creek at the mouth	38.93063	122.37839
Davis Creek at the Dam	38.86289	122.35491
Bear Creek at Gauge	38.95786	122.34259
Bear Creek u/s Cache Ck confluence	38.92708	122.33346
Sulphur Creek	39.03993	122.40834
Cache Creek at Rumsey	38.89809	122.23682
Cache Ck Settling Basin Inflow (Rd 102)	38.72650	121.70973
Cache Ck Settling Basin Outflow	38.67801	121.67249

APPENDIX C. PEREGRINE FALCON AND BALD EAGLE EXPOSURE PARAMETERS USED IN CALCULATION OF THE NUMERIC TARGETS

Peregrine Falcons in the Cache Creek Watershed

Peregrine falcons are listed as endangered by the State of California. Once considered endangered on a national scale, the species was removed from the federal Threatened and Endangered Species list in 1999.

Within the US Bureau of Land Management's Cache Creek Natural Area, (CCNA encompasses Cache Creek watershed south of Clear Lake and Indian Valley Reservoir to the south end of Cache Creek canyon), peregrine falcons are known to utilize the area while foraging or migrating. According to area wildlife biologists with CDFG, there are no known nest sites within this area (USBLM, 2002) (P. Pridmore, CDFG, personal communication to J. Cooke, 4/03). Staff of the University of California Santa Cruz Predatory Bird Research Group (SCPBRG) also reported having no records of nesting peregrine falcons in the Cache Creek area (Linthicum, 2003).

Peregrine falcon populations in the west continue to rise. A peregrine census has not been conducted for over ten years. R. Jurek, peregrine expert for CDFG, speculated that almost every peak in the Coast Range could have a nesting pair of peregrine falcons (R. Jurek, CDFG, personal communication to J. Cooke, 4/03).

Regional Board staff concluded that peregrine falcons most likely utilize the Cache Creek watershed during migration, foraging in the winter, and for occasional foraging from nest sites outside of the watershed. It is possible that peregrine falcons could nest in the Cache Creek area, but no nest sites are known. Because peregrine falcons are found in the Cache Creek watershed, this species was included in the list of species potentially at risk for adverse effects of mercury exposure. Peregrine falcons take primarily avian prey, including birds that eat fish or other organisms in the aquatic food web. Peregrines are exposed to mercury mainly through the piscivorous bird portion of their diet.

Peregrine Falcon Exposure Parameters

Regional Board staff used data collected outside of the Cache Creek area to derive assumptions about peregrine body weights, consumption rates, and percent of prey that is piscivorous. Assumed prey and bodyweight parameters were used along with existing concentrations of mercury in Cache Creek to calculate estimates of daily intake of methylmercury by peregrine falcons in the Cache Creek area. Individual assumptions and sources of information are presented below.

- BODYWEIGHT. The bodyweight used (890 g) is the average of bodyweights of female peregrine falcons cited in the American Ornithologists' Union Birds of North America (BNA) volume on peregrine falcons (White et al., 2002). The bodyweight of female falcons was selected because the embryo is the most sensitive life stage to adverse effects of methylmercury.

- CONSUMPTION RATE. The consumption rate used is total consumption for female peregrine falcons, expressed as a percentage of total bodyweight. The value used, 15% of bodyweight, is the average of consumption rates in the BNA volume (White et al., 2002).

- MERCURY CONCENTRATION IN PISCIVOROUS BIRDS. No data are available for concentrations of mercury in piscivorous birds in the Cache Creek watershed. Regional Board staff used a standard assumption of ten-fold biomagnification in mercury concentration between trophic level 3 fish and piscivorous birds (D. Russell, USFWS, personal communication to J. Cooke, 4/03). For example, if the average, existing concentration of methylmercury in TL3 fish is 0.12 ppm, the assumed methylmercury concentration in flesh of piscivorous birds is 1.2 ppm.

- PERCENT PISCIVOROUS PREY IN PEREGRINE DIET. Peregrine falcons consume a wide variety of bird species, ranging in size from warblers to small geese. Prey differs by availability, region, season, and hunting techniques favored by individual birds. The peregrine diet is comprised of an estimated 77-99% birds, occasionally mammals (especially bats) and rarely amphibians, fish and insects (White et al., 2002). Peregrine falcons prefer open areas with good visibility for hunting.

  Birds feeding within the aquatic food web may be partially or almost completely piscivorous. Birds that are mainly piscivorous, such as gulls, terns, herons, and grebes, would generally be the largest source of methylmercury in the peregrine diet. This is because methylmercury concentrations magnify with successive levels of the aquatic food web. A lesser source of mercury to peregrines would generally be birds such as many sandpipers and ducks, whose food includes crustaceans and aquatic insects. For the purposes of estimating peregrine mercury exposure, Regional Board staff defines "piscivorous" birds as species whose diet is mainly fish or fish plus other aquatic organisms such as amphibians and crustaceans. Using this definition, peregrine prey species that are piscivorous are: herons, gulls, terns, mergansers, grebes, scaup, greater and lesser yellowlegs, spotted sandpiper, clapper rail, willet, dowitchers, and godwits.

  Because no site-specific diet information is available, Regional Board staff examined several sources to derive an estimate of percent piscivorous prey based on best professional judgement. Regarding feeding habits of foraging peregrines, R. Jurek, peregrine expert for CDFG noted that any peregrines in the Cache Creek area would feed inland rather than traveling to the coast. Likely prey items include pigeons, swallows, bats, killdeer, grebes and migrating shorebirds (R. Jurek, personal communication to J. Cooke, 4/03).

  The SCPBRG, which houses a database of prey remains from peregrine nests in California, had no data for nests in the Cache Creek region (Linthicum, 2003). One nest in the north Delta contained remains of blackbird, starling, meadowlark, killdeer, pigeon, green-winged teal, and small rodents. This nest did not contain remains of piscivorous birds, however, the record does not encompass the full nesting and fledgling period.

  The SCPBRG does have records of prey remains collected in 1979-1991 from four peregrine eyries in Lake, Napa and Sonoma Counties. Twelve percent of prey remains from these eyries were birds feeding within the aquatic food web, including piscivorous species (gulls, dowitcher, yellowlegs, and dunlin) and species feeding on aquatic invertebrates and other aquatic organisms (TL2 prey), including red know, phalaropes, plovers and sandpipers. Only seven percent of the prey remains were from piscivorous birds.

  A qualitative list of prey taken by three pairs of peregrine falcons nesting and/or hunting in the San Francisco/Oakland area identifies 34 bird species taken by one or more pairs (Bell et al., 1996). Four prey species on this list were considered piscivorous (willet, greater yellowlegs, western gull, and Bonaparte's gull).

A study of prey remains at three peregrine falcon nests on the Atlantic Coast and Delaware Bay found that an average of 36% by frequency of prey species were piscivorous (52% by biomass) (Steidl et al., 1997). Over half of the piscivorous prey was one species, willet, which eats a combination of trophic level 2 and 3 aquatic species (fish, polychaete worms, clams, gastropods, and amphipods).

At peregrine falcon nests along the Yukon River in Alaska studied over two years, piscivorous prey averaged 32% by frequency and 41% by biomass (species were lesser yellowlegs, spotted sandpiper, mew gull, scaup, Bonaparte's gull, and horned grebe) (Hunter et al., 1988). Lesser yellowlegs, which eats fish and trophic level 2 and 3 invertebrates, comprised a majority of piscivorous prey.

Regional Board staff is assuming that the diet of peregrine falcons feeding in the Cache Creek area includes 15% piscivorous prey. This assumption is less than the piscivorous diets of peregrines in coastal New Jersey or Alaska. Piscivorous prey, particularly shorebirds, however, is likely to be less available in the Cache Creek watershed. Staff considers this assumption to adequately protect peregrines for two reasons.

1. Like other wildlife species of concern, methylmercury intake by peregrine falcon is estimated as if the peregrines were consuming 15% piscivorous prey year-round in the Cache Creek watershed. While it is possible for peregrines to nest in the watershed, year-round use has not been documented. Peregrines at inland eyries in Napa, Lake and Sonoma Counties appeared to consume little piscivorous bird prey.

2. We are assuming the concentration of mercury in piscivorous birds to be ten times the trophic level 3 fish concentration (equates to 0.9 and 1.2 ppm mercury in piscivorous birds in the upper and lower Cache Creek watershed, respectively). While this biomagnification assumption is appropriate for birds that eat mainly TL3 fish, it may overestimate mercury concentrations in birds that eat a combination of fish and aquatic invertebrates. Average concentrations of mercury in breast tissue of western grebes on Clear Lake were 2.0 ppm wet wt (CDFG, 1984d). The mercury levels in Clear Lake grebe represent a 13-fold concentration over mercury concentrations in trophic level 3 fish from Clear Lake (0.15 ppm wet wt).

Bald Eagles

Bald eagles are listed federally as threatened and by the State of California as endangered. The upper Cache Creek watershed, including Clear Lake, hosts the second largest wintering population of bald eagles in California. An active nest was recently found in a remote section of the Cache Creek canyon (USBLM, 2002). Because of their protected status and the fact that eagles are year-round residents of Cache Creek, derivation of the numeric target for Cache Creek should ensure that bald eagles are protected.

Biologists making qualitative observations of foraging bald eagles have reported that eagles in winter depend heavily on large, non-game fish (USBLM, 2002). The primary game fish in Cache Creek are catfish and bass. Large, non-game fish readily available in Cache Creek include carp, bluegill, Sacramento sucker, and Sacramento pikeminnow. No quantitative records of bald eagle prey in the Cache Creek watershed are available.

Total bald eagle consumption rate was assumed to be 504 g/day and was the same as that used in the Great Lakes Water Quality Initiative (GLWQI) (USEPA, 1995a). To calculate prey proportions for bald eagles in Cache Creek, Regional Board staff used a report of prey remains collected at 56 bald eagle nests in Northern California (Jackman et al., 1999). Watersheds containing nest sites included the Pit, McCloud, Upper Sacramento, Trinity, Klamath, Feather, American and Eel rivers. To calculate prey proportions, we focused first on the percent biomass of fish, piscivorous birds, and other bird and mammalian prey (Table 1 of the Jackman paper). Birds on the prey list identified by Regional Board staff as piscivorous were western, pied-billed, eared and other unidentified grebes; gulls and common mergansers. To be conservative, entries of "other diving ducks" and "other birds" were assumed piscivorous. Of the total diet, piscivorous birds comprised 7.7%, fish were 71.2% and non-piscivorous birds, mammals, reptiles and invertebrates were 21.1%. The portions of bald eagle diet assumed to be piscivorous birds and fish were then calculated as:

(0.077) x (504 g/day)=39 g/day of piscivorous bird prey.
(0.712) x (504 g/day)=359 g/day of fish prey.

The second step was to determine the proportions of TL3 and TL4 species that comprised the fish prey. The Great Lakes Water Quality Initiative assumed a TL3/TL4 proportion of 80/20 percent. Using Table 1 of the Jackman paper, we assigned the listed fish species a trophic level classification of 3 or 4. Sacramento pikeminnow, channel and other catfish, crappie, largemouth bass, and Sacramento perch were classified as TL4. Entries of "other sunfish", "unidentified minnows" and "other fish" likely included some TL4 fish, so these were also considered TL4. Of fish prey found at all Northern California nests, the proportion of TL3/TL4 fish was 90/10. The TL3/TL4 ratio varied by site (Table 3, Jackman et al., 1999), from approximately 95/5 at nests at Union Valley Reservoir and Butte Valley Reservoir, to about 40/60 at a nest on Oroville Reservoir. Given the range in TL3/TL4 proportions, Regional Board staff considered it appropriate to assume the GLWQI ratio of 80/20. This ratio is believed to be sufficiently protective of bald eagle in the Cache Creek drainage, given that eagles there are observed to heavily utilize large, non-game fish. The consumption rates for TL3 and TL4 fish consumed by eagles were calculated as follows:

Total fish consumption rate = 359 g/day
TL3 fish consumption rate = (.8) x (359 g/day) = 287 g/day
TL4 fish consumption rate = (.2) x (359 g/day) = 72 g/day.

References

Bell DA, Gregoire DP, Walton BJ, 1996. Bridge use by peregrine falcons in the San Francisco Bay Area. In: Raptors in Human Landscapes (Bird D, Varland D, Negro J, eds). London: Academic Press; 15-24.

CDFG, 1984d. Pesticide Laboratory Report L-85-84. Analysis of western grebe and coot samples received on 5 March 1984 for mercury., California Department of Fish and Game. Analytical report prepared by: Ed Littrell, Associate Wildlife Biologist, Pesticide Investigation Unit, Environmental Services Branch for: Larry Week, Associate Fisheries Biologist, Region 3 Headquarters in Yountville, CA., 1-4. 25 June.

Hunter RE, Crawford JA, Ambrose RE, 1988. Prey selection by peregrine falcons during the nestling stage. Journal of Wildlife Management 52:730-736.

Jackman RE, Hunt WG, Jenkins JM, Detrich PJ, 1999. Prey of nesting bald eagles in Northern California. J. Raptor Research 33:87-96.

Linthicum J, 2003. Personal communications from Janet Linthicum, University of California Santa Cruz Predatory Bird Research Group, to Janis Cooke, Central Valley Regional Water Quality Control Board, regarding nesting sites and prey remains for peregrine falcons in the Cache Creek, Napa Valley and Delta areas. April.

Steidl RJ, Griffin CR, Augspurger TP, Sparke DW, Niles LJ, 1997. Prey of peregrine falcons from the New Jersey coast and associated contaminant levels. Northeast Wildlife 52:11-19.

USBLM, 2002. Cache Creek Coordinated Resource Management Plan/Environmental Assessment. Draft for Public Review., United States Department of the Interior, Bureau of Land Management, Ukiah Field Office. September.

USEPA, 1995a. Great Lakes Water Quality Initiative Technical Support Document for Wildlife Criteria. Washington. DC., Environmental Protection Agency. Office of Water. EPA/820/B-95/009, 9-36. March.

White CM, Clum NJ, Cade TJ, Hunt WG, 2002. Peregrine Falcon (*Falco peregrinus*). In: The Birds of North America, No. 660 (Poole A, Gill F, eds): Philadelphia: The Academy of Natural Sciences; Washington D.C.: The American Ornithologists' Union.

APPENDIX D. ANNUAL SULFATE LOADS TO CACHE CREEK

The presence of sulfate enables sulfate-reducing bacteria to methylate mercury as part of the complex methylmercury cycle. A simple mass balance (flow x concentration) was completed to identify areas in the Cache Creek watershed that have a high load of sulfate and thus a high methylation potential.

Table D-1. Yearly Sulfate Loads Using Mean Mercury Concentrations (x 10^6 kg/yr)

Water Year	Clear Lake Outflow	North Fork Cache Creek	Harley Gulch (a)	Bear Creek	Sulphur Creek	Sum of Tributaries	Rumsey	Settling Basin Inflow	Contribution of Mercury from Tributaries to Rumsey
1996	7.0	3.0	0.6	0.7	0.4	11.3	38.2	23.8	30%
1997	7.0	4.1	0.6	0.8	0.4	12.5	38.0	24.9	33%
1998	12.0	3.8	1.0	3.3	0.7	20.1	59.1	51.3	34%
1999	5.2	2.7	0.4	0.7	0.3	9.1	27.1	109.8	33%
2000	3.4	2.0	0.3	0.8	0.3	6.4	24.8	8.0	26%
Avg	**6.9**	**3.1**	**0.6**	**1.2**	**0.4**	**11.9**	**37.4**	**43.5**	**31.2%**

a) Harley Gulch flows between water years 1996 and 1999 are estimated from Q = CIA flow estimate equation.

APPENDIX E. US FISH AND WILDIFE SERVICE COMMENTS ON THE DRAFT CACHE CREEK TMDL NUMERIC TARGETS

The draft Cache Creek, Bear Creek, and Harley Gulch TMDL for Mercury contained the following proposed fish tissue targets for methylmercury:

> The preliminary numeric targets identified for Cache Creek and Bear Creek are in the form of average methylmercury concentrations in trophic level 3 and 4 fish consumed by raptors and humans:
>
> 0.10 mg/kg wet weight in trophic level 3 (TL3) fish
> 0.28 mg/kg wet weight in trophic level 4 (TL4) fish.
>
> These target concentrations are the averages in fish greater than 180 mm in length. TL3 fish species include bullhead, sunfish, and suckers. TL4 species include catfish, bass, and Sacramento pikeminnow. For humans, the targets would permit safe consumption of about 19-28 gm/day of Cache or Bear Creek fish (2.5 to 3.5 meals/month).

The draft Cache Creek, Bear Creek, and Harley Gulch TMDL for Mercury report was released in February 2004. In March 2004, the US Fish and Wildlife Service (USFWS) provided a review and recommendations on the proposed targets. Regional Board staff incorporated the USFWS recommendations into revised numeric targets, which are provided in this report. The USFWS comments follow this page.

U.S. Department of the Interior
Fish and Wildlife Service

Evaluation of Numeric Wildlife Targets for Methylmercury in the Development of Total Maximum Daily Loads for the Cache Creek and Sacramento-San Joaquin Delta Watersheds

Prepared By:

Daniel Russell
U.S. Fish and Wildlife Service
Environmental Contaminants Division
Sacramento Fish and Wildlife Office

Sacramento, California
March, 2004

ACKNOWLEDGMENT

The Service would like to gratefully acknowledge the U.S. Environmental Protection Agency and the California Regional Water Quality Control Board - Central Valley Region for their support during the preparation of this report. Of particular note was the assistance provided by Dr. Janis Cooke of the Regional Board, whose scientific expertise and insights proved invaluable in the development of this evaluation.

This document was prepared for the U.S. Environmental Protection Agency under Inter-Agency Agreement No. DW-14-95556801-0.

Literature citation should read as follows:

U.S. Fish and Wildlife Service. 2004. Evaluation of Numeric Wildlife Targets for Methylmercury in the Development of Total Maximum Daily Loads for the Cache Creek and Sacramento-San Joaquin Delta Watersheds. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Environmental Contaminants Division. Sacramento, California. 28 pp.

TABLE OF CONTENTS

Section

List of Tables

I. Introduction

The State of California's Regional Water Quality Control Board - Central Valley Region (RWQCB) is in the process of drafting Total Maximum Daily Loads (TMDLs) for mercury in two watersheds: Cache Creek and the Sacramento-San Joaquin Delta (Delta). For the Cache Creek watershed, the TMDL considers the main stem of Cache Creek from Clear Lake Dam to the Cache Creek Settling basin, as well as two tributaries: Bear Creek and Harley Gulch. The TMDL for the Delta, which extends from the confluence of the two rivers inland as far as Sacramento and Stockton, includes consideration of seven sub-regions. For both TMDLs, the RWQCB is developing numeric targets, expressed as fish tissue methylmercury concentrations, for the protection of both human and wildlife health.

The approach used by the RWQCB in developing these numeric targets for wildlife is similar to the one recently used by the U.S. Fish and Wildlife Service (Service) (2003) for evaluating the U.S. Environmental Protection Agency's (EPA) new Clean Water Act Section 304(a) human health criterion for methylmercury (U.S. Environmental Protection Agency, 2001). Because of methylmercury's propensity to accumulate in biological tissues and biomagnify as it is passed up through successively higher trophic levels of a food chain, both approaches acknowledged the need to consider the trophic level composition of a wildlife species' diet in order to define protective limiting concentrations of methylmercury. However, whereas the Service's approach developed targets based solely on trophic level, the RWQCB's approach takes the additional step of developing numeric targets in consideration of the specific size classes and species of fish consumed by wildlife species of concern.

The Service's evaluation of these draft TMDLs began by performing a parallel derivation of targets using the methodology mentioned above (U.S. Fish and Wildlife Service, 2003), modified to incorporate the RWQCB's concept of trophic level relationships between prey items, and its consideration of prey size classes. This parallel derivation was done for the wildlife species of concern identified in the Cache Creek/Bear Creek watersheds, using information presented by the RWQCB on existing fish tissue mercury concentrations. The resulting targets were then compared to the RWQCB's proposed targets, including an evaluation of the Harley Gulch portion of the TMDL. Finally, the conclusions from this comparative analysis were discussed with regard to their implications for the Delta TMDL.

II. Evaluating the Cache Creek / Bear Creek Wildlife Targets

II.A. <u>Selection of Species of Concern</u>

The Cache Creek, Bear Creek, and Harley Gulch TMDL (Cache Creek TMDL) correctly points out that wildlife currently thought to be most likely at risk from mercury in an aquatic environment are terrestrial species that are primarily or exclusively piscivorous, ingesting methylmercury that has bioaccumulated and biomagnified in their aquatic prey. While a variety of aquatic-dependent terrestrial species may be exposed to methylmercury through their diets (*e.g.*, reptiles and amphibians), research into the effects of methylmercury on wildlife has generally focused on birds and mammals that prey directly on fish and other aquatic organisms. This focus has likely been due to the fact that piscivorous birds and mammals are generally higher order predators than aquatic-dependent reptiles and amphibians, which may result in a greater potential for dietary exposure and subsequent toxicity. This same concept of greater potential risk to higher order piscivorous species may also hold for those top predators that in turn prey on piscivorous wildlife (*e.g.*, a peregrine falcon preying on piscivorous waterfowl), due to the successive trophic level biomagnification mentioned above. Based on these concepts and a knowledge of the wildlife species present in the Cache Creek/Bear Creek area, the RWQCB selected a number of piscivorous birds and mammals to represent at-risk wildlife. While it is possible there are other piscivorous species which forage in this area, the Service agrees with the RWQCB's choices listed below:

Mink (*Mustela vison*)
River Otter (*Lutra canadensis*)
Belted Kingfisher (*Ceryle alcyon*)
Common Merganser (*Mergus merganser*)
Western Grebe (*Aechmophorus occidentalis*)
Double-crested Cormorant (*Phalacrocorax auritus*)
Osprey (*Pandion haliaetus*)
Bald Eagle (*Haliaetus leucocephalus*)
Peregrine Falcon (*Falco peregrinus*)

II.B. Average Concentration Trophic Level Approach

Once a decision has been made to develop wildlife targets based on dietary exposure to methylmercury, a relatively simple equation can be used to calculate a protective concentration for the overall diet of a given species. Given sufficient methylmercury toxicity data to determine a dietary dose at which no adverse effects to an organism are expected, a protective methylmercury concentration in the overall diet can be calculated using Equation 1, based on information about that organism's body weight and daily food consumption:

$$\mathbf{WV} = \frac{\mathbf{RfD \times BW}}{\mathbf{FIR}} \qquad \mathbf{(1)}$$

where,
WV = Wildlife Value (mg/kg in diet)
RfD = Reference Dose (mg/kg of body weight/day)
BW = Body Weight (kg) for species of concern
FIR = Total Food Ingestion Rate (kg of food/day) for species of concern

The WV represents the concentration of methylmercury, as an average in all the prey consumed, necessary to keep the organism's daily ingested amount at or below a sufficiently protective reference dose. Reference doses (RfD) may be defined as the daily exposure to a toxicant at which no adverse effects are expected. In effect, Equation 1 converts a protective RfD into an overall dietary concentration (in mg/kg in diet).

For certain piscivorous species, a calculated WV may be acceptable to use as the protective wildlife target. This situation exists when the food consumed by the species of concern is sufficiently uniform so that methylmercury concentrations in the individual prey items are expected to be roughly equivalent. One example of this situation is when the species' diet is comprised of equivalently sized fish from the same trophic level. Trophic levels are general classifications applied to the various biotic components of a food chain, and organisms are placed in these classifications depending on what they consume. Stated in its most simplistic form, trophic level 1 plants are consumed by trophic level 2 herbivores, which are consumed by trophic level 3 predators, which are then consumed by the top predators in trophic level 4. Although the bioaccumulation of methylmercury may vary between fish species, it may be assumed that those fish occupying similar ecological niches (*e.g.*, trophic level 3 fish feeding on the same trophic level 2 prey base) will contain similar tissue concentrations of methylmercury. Trophic levels used in this evaluation were based on definitions provided in Volume II of *Trophic Level and Exposure Analyses for Selected Piscivorous Birds and Mammals* (U.S. Environmental Protection Agency, 1995a):

Trophic Level 1 - Aquatic Plants (*e.g.*, periphyton, phytoplankton)
Trophic Level 2 - Herbivores and Detritivores (*e.g.*, copepods, water fleas)
Trophic Level 3 - Predators on trophic level 2 organisms (*e.g.*, minnows, sunfish, suckers)
Trophic Level 4 - Predators on trophic level 3 organisms (*e.g.*, adult trout, bass, pike)

In contrast to wildlife species with uniform diets, many predators that feed from aquatic ecosystems are more opportunistic and will consume prey from more than one trophic level. Because of methylmercury biomagnification, aquatic food chains do not attain a steady-state condition whereby aquatic biota from all trophic positions exhibit the same tissue concentrations. Instead, organisms higher on the aquatic food chain contain greater concentrations than those lower on the food chain. Although Equation 1 can be used to calculate a protective WV for wildlife species with multi-trophic level diets, based solely on a total daily food ingestion rate, this value is actually dependent on the amount of prey consumed from each trophic level *and* the methylmercury concentrations in each of the trophic levels from which they feed. In this situation, the trophic level composition of the diet becomes the driving factor influencing the amount of methylmercury ingested on a daily basis. Without an understanding of the dietary composition for these wildlife species, it is impossible to determine limiting concentrations for each trophic level necessary to maintain a protective WV.

The Average Concentration Trophic Level (TL) Approach is one method by which the principles of trophic transfer can be used to estimate trophic level-specific limiting concentrations for these wildlife species. Food web dynamics in real-world ecosystems are generally more complex than the simple linear food chain model described above (*i.e.*, TL1 → TL2 → TL3 → TL4); however, the methodology employed in this approach is based on the assumption that the general concepts underlying this food chain model remain valid for considering the trophic transfer of methylmercury in aquatic biota. The construct of this approach and its underlying assumptions are outlined below.

As mentioned above, the WV represents an average concentration of methylmercury in the overall diet necessary to keep the organism's daily ingested amount at or below a sufficiently protective reference dose. Another way the WV can be expressed is by the equation:

$$\mathbf{WV = (\%TL2 \times FDTL2) + (\%TL3 \times FDTL3) + (\%TL4 \times FDTL4)} \qquad \textbf{(2)}$$

where,
%TL2 = Percent of trophic level 2 biota in diet
%TL3 = Percent of trophic level 3 biota in diet
%TL4 = Percent of trophic level 4 biota in diet
FDTL2 = concentration in food (FD) from trophic level 2
FDTL3 = concentration in food from trophic level 3
FDTL4 = concentration in food from trophic level 4

Determining the dietary percentage for the various trophic levels may be accomplished by reviewing the scientific literature for a particular species or extrapolated from information about a similar species. However, before all the trophic level concentrations can be determined, Equation 2 must be rearranged so that it can be solved for one of the trophic levels (*e.g.*, FDTL2). This requires that the other trophic level components of the equation be expressed as a function of the one to be solved (*i.e.*, FDTL3 = FDTL2 × some linkage value). With methylmercury, these linkage values can be derived from the relationships of bioaccumulation and biomagnification between trophic levels, expressed as **food chain multipliers** (FCM_x):

FCM3 = Food chain multiplier from TL2 to TL3 biota
FCM4 = Food chain multiplier from TL3 to TL4 biota

The FDTL3 and FDTL4 terms can then be expressed as functions of FDTL2:

FDTL3 = FDTL2 × FCM3
FDTL4 = FDTL2 × FCM3 × FCM4

This allows Equation 2 to be rearranged, substituting food chain multiplier equivalents, as:

$$\mathbf{WV = (\%TL2 \times FDTL2) + (\%TL3 \times FDTL2 \times FCM3) + (\%TL4 \times FDTL2 \times FCM3 \times FCM4)} \qquad \textbf{(3)}$$

This equation can then be solved for the concentration in the lowest trophic level:

$$\mathbf{FDTL2 = WV / [(\%TL2) + (\%TL3 \times FCM3) + (\%TL4 \times FCM3 \times FCM4)]} \qquad \textbf{(4)}$$

Once the concentration in trophic level 2 is determined, the remaining trophic level concentrations can be calculated using the food chain multiplier relationships:

$$\mathbf{FDTL3 = FDTL2 \times FCM3} \qquad \textbf{(5)}$$

$$\mathbf{FDTL4 = FDTL3 \times FCM4} \qquad \textbf{(6)}$$

Food chain multipliers can be determined several ways, depending on the information available. For example, bioaccumulation factors (BAFs) are numeric values showing the amount of contaminant uptake into biota, relative to concentrations in the water column. These BAFs can be determined for each trophic level of aquatic biota. The food chain multiplier for any given trophic level is the ratio of the BAF for that trophic level to the BAF for the trophic level directly below.

For example: BAF for water to trophic level 4 = 680,000
BAF for water to trophic level 3 = 160,000

FCM4 = 680,000/160,000 = 4.25

Any methylmercury concentration estimated for trophic level 3 biota can then multiplied by the FCM4 to estimate the expected concentration in trophic level 4 biota.

If sufficient data on existing fish tissue methylmercury concentrations are available, food chain multipliers can also be established using the ratio of these concentrations between trophic levels.

For example: Average tissue concentration in TL4 fish = 0.15 mg/kg
Average tissue concentration in TL3 fish = 0.05 mg/kg

FCM4 = 0.15/0.05 = 3

Both of these approaches to determining food chain multipliers assume there is a direct consumption link between the trophic levels, with methylmercury concentrations in the higher trophic level fish resulting from ingesting the concentrations found in fish from the next lower trophic level. Because of this assumption, using either approach to calculate methylmercury targets for specific trophic levels requires that the resultant limiting concentrations be applied to the appropriate food chain cohorts (*e.g.*, a limiting concentration for TL3 must be applied to the species and size class of fish that would be consumed by larger predatory TL4 fish). This distinction is important because some TL3 fish will grow as large or larger than co-occurring TL4 fish, and the relationship between these fish may not be one of predator and prey. As an example in the Cache Creek TMDL points out, a 250 mm sunfish (TL3) is too large to be consumed by a 250 mm smallmouth bass (TL4).

Therefore, using existing fish tissue data to calculate a concentration ratio between trophic levels may not necessarily represent a food chain multiplier. In the example mentioned above, the ratio between methylmercury concentrations in same-size bass and sunfish (*i.e.*, TL4 concentration/ TL3 concentration) would only represent the concentration relationship between similarly sized fish feeding at different positions in the food chain. In effect, these data simply provide a **trophic level ratio** (TLR) rather than a food chain multiplier. However, substituting trophic level ratios in place of food chain multipliers in the Average Concentration TL Approach (*e.g.*, WV = [%TL3 × FDTL3] + [%TL4 × FDTL3 × TLR]) is an equally valid way to develop fish tissue targets, with the following caveats: 1) the fish prey of the wildlife species of concern must be approximately the same size, regardless of trophic level, and 2) the resultant limiting concentrations calculated with these trophic level ratios are applied to the appropriate size classes of fish (*i.e.*, using the example of bass and sunfish provided above, the limiting concentration for TL3 must be applied to fish 250 mm or larger, *not* to the small individuals that would be preyed upon by large TL4 fish).

Both caveats stem from the general trend of increasing tissue methylmercury concentrations with increasing fish size (Wiener and Spry, 1996). Because of this size-concentration relationship, a trophic level ratio based on the concentrations in similarly sized TL3 and TL4 fish will be smaller than a ratio based on concentrations in small TL3 fish and the TL4 fish that prey on them (*i.e.*, a food chain multiplier). If the wildlife target is based on a concentration ratio between large, similarly sized TL3 and TL4 fish, but the TL3 component of the wildlife species' diet is actually comprised of small fish, the contribution to the daily ingested dose from the TL3 component is overestimated. This overestimation would then result in a target concentration for TL3 that is larger than it should be for the small prey fish consumed, and a target concentration for TL4 that is smaller than it should be for the large predatory fish consumed.

Food chain multipliers and trophic level ratios are only necessary when determining targets for those wildlife species that feed from different trophic levels. As discussed above, trophic level ratios may be more appropriate when the wildlife species' prey base is comprised of similarly sized fish, regardless of the trophic level. In contrast, food chain multipliers may be more appropriate when the wildlife species consumes a broad size range of fish, including small TL3 fish and the larger TL4 fish that prey on them.

III. Calculating Wildlife Targets with Average Concentration TL Approach

In order to perform the Average Concentration TL Approach for the Cache Creek TMDL wildlife species, WVs for each species were generated. This required species-specific information on average adult female body weights (kg) and daily food ingestion rates (FIR *in* kg of food/day). It also required determining protective RfDs for each of the two taxonomic groups considered (birds and mammals). Once the WVs were determined, information about the appropriate food chain multipliers, trophic level ratios, biomagnification factors, and the trophic level dietary composition for each species allowed for the calculation of trophic level-specific methylmercury concentrations. These were then compared with targets proposed for the Cache Creek TMDL. All of these parameters are discussed below.

III.A. Reference Doses

In order to calculate the Cache Creek/Bear Creek wildlife targets, the RWQCB used a methylmercury RfD of **0.018 mg/kg-bw/day for mammalian species** and **0.021 mg/kg-bw/day for avian species**. These RfDs are based on test doses generated by controlled feeding studies using mink (Wobeser *et al.*, 1976a,b) and mallard ducks (Heinz, 1979). Reference doses are derived by applying various uncertainty factors to suitable test doses to estimate the daily exposure at which no adverse effects are expected. For the species considered in the Cache Creek/Bear Creek area, the Service agrees that the above RfDs are appropriate for determining avian and mammalian wildlife targets. A full discussion of the development of these RfDs can be found in the Service's recent evaluation of the human health methylmercury criterion (U.S. Fish and Wildlife Service, 2003).

III.B. Adult Female Body Weights

Because the most sensitive endpoints for toxicity of methylmercury in birds and mammals relate to reproduction, the focus of the Average Concentration TL Approach is to establish WVs based on preventing adverse impacts from maternally ingested methylmercury, that could potentially affect the reproductive viability of the species. For some of the wildlife species examined in the Cache Creek TMDL, the RWQCB presented body weights averaged from data for adult males and females. As body weight influences the estimation of total food ingestion, with both factors affecting the estimation of WVs, the Service believes it more appropriate to use the best available information for adult female body weights. A comparison between wildlife body weights used by the RWQCB and those recommended by the Service are presented in Table 1.

Table 1. Adult Female Body Weights (kg) for Cache Creek / Bear Creek Wildlife Species

	RWQCB	USFWS
Mink	0.80	**0.60**
River Otter	7.40	**6.70**
Belted Kingfisher	0.15	0.15
Common Merganser	1.23	1.23
Western Grebe	1.48	**1.19**
Double-crested Cormorant	1.74	1.74
Osprey	1.50	**1.75**
Bald Eagle	4.60	**5.25**
Peregrine Falcon	0.89	0.89

The Service's values for female mink and river otter are from Volume II of *Trophic Level and Exposure Analyses for Selected Piscivorous Birds and Mammals* (U.S. Environmental Protection Agency, 1995a). Body weight for the female western grebe comes from Storer and Nuechterlein (1992). The value for female osprey is an approximation from data presented in Poole *et al.* (2002), and based on the fact that female osprey may be close to 25 percent larger than males. Female bald eagles are also substantially larger than male eagles. The Service value is based on data for female eagles presented by Dunning (1993) and the U.S. Environmental Protection Agency (1995a).

III.C. Food Ingestion Rates

The Service calculated total food ingestion rates (FIR) for each wildlife species examined in the Cache Creek/Bear Creek area, and then compared these values with those presented by the RWQCB. For some species, the Service's values differed from the RWQCB's values, although not substantially in most cases. Most of these differences were due only to the fact that the

Service used an alternate body weight for the species in calculating the FIR. Both the Service and RWQCB values are presented in Table 2, followed by a brief discussion for each species where the values differed.

Table 2. Total Food Ingestion Rates (kg/day) for Cache Creek / Bear Creek Wildlife Species

	RWQCB	USFWS
Mink	0.160	**0.140**
River Otter	1.220	**1.124**
Belted Kingfisher	0.075	**0.068**
Common Merganser	0.302	0.302
Western Grebe	0.374	**0.296**
Double-crested Cormorant	0.390	0.390
Osprey	0.300	**0.350**
Bald Eagle	0.504	**0.566**
Peregrine Falcon	0.134	0.134

For the mink, river otter, western grebe, and osprey values, the differences in FIRs from those used by the RWQCB are solely a result of using lower body weights to represent adult females. The Service used the same original source allometric equations (U.S. Environmental Protection Agency, 1993) to calculate these recommended FIRs as those used by the RWQCB. The RWQCB value for the belted kingfisher FIR came from Volume VI of the Mercury Study Report to Congress (U.S. Environmental Protection Agency, 1997), which cited two other references as sources for this value - U.S. Environmental Protection Agency, 1993 and 1995b. However, neither of these two source documents present an FIR for kingfishers of 0.075 kg/day. The 1995 source, Volume I of *Trophic Level Exposure Analyses for Selected Piscivorous Birds and Mammals*, actually presents a value of 0.067 kg/day, essentially the same as what we present here.

The RWQCB FIR value for the bald eagle comes from the Great Lakes Water Quality Initiative's *Technical Support Document for Wildlife Criteria* (TSD) (U.S. Environmental Protection, 1995c), which was based on an average body weight of 4.6 kg for male and female eagles, as well as on a specific dietary composition of fish (92%) and birds (8%). Dietary composition, the amount of each food type consumed on a daily basis, is a critical component in determining FIR, as different foods provide different amounts of gross energy (*e.g.*, kcal/g food matter) to the consumer, and the species' assimilation efficiency for different foods may also vary substantially.

The Service's bald eagle FIR was based on the same dietary composition used by the RWQCB: 71.2% fish, 22.8% birds, and 6% mammals (Jackman *et al.*, 1999). The FIR was calculated using the methodology in the TSD, wherein the animal's free-living metabolic rate (FMR) is divided by the metabolizable energy (ME) from the animal's prey. The FMR was determined by Nagy's (1987) allometric equation relating FMR for birds to body weight:

FMR (kcal/day) = 2.601 × body weight (g)$^{0.640}$

FMR = 2.601 × 5250$^{0.640}$

FMR = 625 kcal/day

According to the *Wildlife Exposure Factors Handbook* (U.S. Environmental Protection Agency, 1993), metabolizable energy equals the gross energy (GE) of the food in kcal/g wet weight times the assimilation efficiency (AE) of the consumer. The Handbook gives a GE value of 1.2 kcal/g for bony fishes and 1.7 kcal/g for small mammals, while bird GEs are given as either 1.9 (passerines, gulls, terns) or 2.0 (mallard). Although the majority of avian prey species identified in the Jackman *et al*. (1999) study used to determine the eagle's dietary composition are more closely related to mallards than to the other bird types, the lower value was used in this analysis because the GE for mallards was for consumption of flesh only. Also, because the mammal contribution to the overall diet is small (6%), the mammal GE is similar to that used for birds, and the AEs for birds and mammals are identical, these two taxa were grouped together for determining the FIR. The AEs for eagles consuming birds and fish are given as 78 and 79 percent, respectively.

ME_{fish} = 1.2 kcal/g × 0.79 = **0.948 kcal/g fish**

ME_{birds} = 1.9 kcal/g × 0.78 = **1.482 kcal/g birds (and mammals)**

Following the process in the TSD, if:

Y = grams of birds consumed, and
2.472Y = grams of fish consumed (*i.e.*, 71.2% fish ÷ 28.8% birds = 2.472)

then the FIR for each food can be determined by the equation:

FMR = [Y(g) × 1.482(kcal/g birds] + [2.472Y(g) × 0.948 kcal/g fish]

625 kcal/day = 1.482Y + 2.343Y
625 kcal/day = 3.825Y

Y = 163 g birds consumed/day
2.472Y = 403 g fish consumed/day

The total FIR for bald eagles becomes:

FIR = [163 g birds + 403 g fish]/day
FIR = 566 g wet weight/day

FIR for bald eagle = 0.566 kg wet weight/day

III.D. Calculation of Wildlife Values

Having determined the appropriate reference doses, body weights, and food ingestion rates for all species of concern, the next step in the Average Concentration TL Approach was to calculate WVs for each species, presented in Table 3. This was done using Equation 1, described previously:

$$\mathbf{WV} = \frac{\mathbf{RfD \times BW}}{\mathbf{FIR}}$$

Table 3. Wildlife Values (mg/kg in diet) for Cache Creek / Bear Creek Wildlife Species

Species	RfD (mg/kg/day)	Body Weight (kg)	FIR (kg/day)	WV (mg/kg in diet)
Mink	0.018	0.60	0.140	0.077
River Otter	0.018	6.70	1.124	0.107
Belted Kingfisher	0.021	0.15	0.068	0.046
Common Merganser	0.021	1.23	0.302	0.085
Western Grebe	0.021	1.19	0.296	0.084
Double-crested Cormorant	0.021	1.74	0.390	0.094
Osprey	0.021	1.75	0.350	0.105
Bald Eagle	0.021	5.25	0.566	0.195
Peregrine Falcon	0.021	0.89	0.134	0.139

III.E. Trophic Level Dietary Composition

As discussed previously, the trophic level composition of a wildlife species' diet is the critical factor influencing how much methylmercury is ingested on a daily basis. While WVs provide information about the methylmercury concentration in the overall diet necessary to maintain the daily ingested amount at a protective reference dose, an understanding of the animal's dietary composition is essential for determining what the concentrations need to be in the prey from each trophic level. With the exception of a further refinement in the dietary composition for the bald eagle and peregrine falcon, the Service agrees with the trophic level breakdown for each species presented in the Cache Creek TMDL. The RWQCB presented its dietary compositions in terms of ingestion rates (*i.e.*, g/day, wet weight), whereas they are presented here as percentage breakdowns in Table 4.

Table 4. Trophic Level Compositions (% of overall diet, expressed as decimal fractions) for Cache Creek / Bear Creek Wildlife Species

Species	TL3	TL4	OB omnivorous birds	PB piscivorous birds	OF other foods
Mink	1.00	--	--	--	--
River Otter	0.80	0.20	--	--	--
Belted Kingfisher	1.00	--	--	--	--
Common Merganser	1.00	--	--	--	--
Western Grebe	1.00	--	--	--	--
Double-crested Cormorant	1.00	--	--	--	--
Osprey	0.90	0.10	--	--	--
Bald Eagle	0.58	0.13	0.13	0.05	0.11
Peregrine Falcon	--	--	0.10	0.05	0.85

* - The term 'OF' represents dietary items not expected to contribute significant dietary methylmercury, and is presented in the table only to provide the full dietary composition assessment for each species. These OF items include plants, terrestrial insects, or avian prey not dependent on aquatic biota. The term is not included in the equation to determine trophic level concentration values because the assumed absence of significant methylmercury in these food items would only result in a zero value for that component of the equation:

[%OF × FD OF (methylmercury concentration in other foods)]
[%OF × 0] = 0

The trophic level composition for the bald eagle was derived from the previously mentioned study by Jackman *et al*. (1999), a full analysis of which can be found in the Service's evaluation of the EPA's human health criterion document (U.S. Fish and Wildlife Service, 2003). Our breakdown for the fish component of the diet is similar to the one used by the RWQCB in the TMDL. However, the Service took a different approach to the eagle's avian prey. Of the 41 bird species identified in the Jackman *et al*. (1999) study (22.8% of total biomass in overall bald eagle diet), the two most commonly seen in prey remains were American coot (*Fulica americana*) and mallard (*Anas platyrhynchos*), representing 4.2 and 3.2 percent, respectively, of the total estimated biomass. Several of the species identified are exclusively terrestrial (*e.g.*, mountain quail [*Oreortyx pictus*]); however, the majority are dependent on the aquatic ecosystem. Several of these aquatic-dependent species are primarily piscivorous: western grebe (*Aechmophorus occidentalis*), gull (*Larus* spp.), pied-billed grebe (*Podilymbus podiceps*), and common merganser (*Mergus merganser*). These piscivorous birds accounted for approximately 5 percent of the total estimated biomass of the bald eagle diet. Eagles also consumed waterfowl (*e.g.*, *Anas* spp., diving ducks, coots) that depend to varying degrees on prey that are considered trophic level 2 organisms (*e.g.*, aquatic invertebrates and zooplankton). These birds contributed approximately 13 percent (including the 4.2% and 3.2% represented by American coots and mallards) to the total estimated biomass in the overall bald eagle diet.

For the peregrine falcon, the Service took a non-empirical approach. The RWQCB assumed the diet of peregrine falcons in the Cache Creek/Bear Creek area includes 15 percent piscivorous avian prey. The Service agrees with the use of this percentage value in the TMDL to account for aquatic-dependent birds in the falcon's diet; however, we believe that a substantial portion of this amount would actually be comprised of omnivorous birds, *i.e.*, those that would be consuming primarily TL2 organisms.

However, the Service also notes that both piscivorous and omnivorous birds may potentially contribute substantially more to the falcon's diet. In order to determine the most accurate representation of risk in the Cache Creek/Bear Creek area, peregrine falcon feeding ecology studies should be conducted. Until such studies can be conducted, however, the Service's target analysis remains based on the assumption of 15 percent aquatic-dependent avian prey.

IV. Determining Trophic Level-Specific Methylmercury Concentrations

As discussed, there are several iterations of the Average Concentration TL Approach that can be used to develop limiting methylmercury concentrations that should be protective of wildlife, each one dependent on the dietary habits of the species of concern. When the diet of a species consists of similar prey from the same trophic level, a WV calculated with Equation 1 is sufficient to use as the protective target. In contrast, when the diet consists of prey from different trophic levels, multiple targets must be determined by considering the dietary trophic level composition and by incorporating either food chain multipliers (FCM) or trophic level ratios (TLR) into Equations 3 or 8. It may also be necessary to form a hybrid calculation, combining information about FCMs and TLRs in one equation. All of these iterations were necessary, each discussed below, to develop targets for the various wildlife species examined here. Values used in all target calculations were not rounded; however, all final targets were rounded to two significant digits.

IV.A. Using Wildlife Values Only to Determine Wildlife Targets

Five of the species examined in the Cache Creek/Bear Creek area (mink, belted kingfisher, common merganser, western grebe, and double-crested cormorant) are assumed to have diets comprised solely of TL3 aquatic biota. While it is possible that any of the four birds in this group may occasionally consume TL2 organisms, the predominant prey for each species remains TL3 fish. Mink are more opportunistic than these avian species with regard to prey selection, and non-aquatic organisms (*e.g.*, birds, reptiles, insects) may provide a substantial contribution to the overall diet (U.S. Environmental Protection Agency, 1995a). However, it is also reasonable to assume that the mink diet can be comprised entirely of TL3 aquatic prey (*e.g.*, small fish, crayfish). For all five of these species then, the WVs calculated with the appropriate reference doses, body weights, and food ingestion rates (Table 3) can serve as protective wildlife targets. A comparison between the "safe concentrations" determined by the RWQCB and the WVs calculated by the Service are presented in Table 5 below. As before, any differences between individual species values are due to alternate assumptions about body weights for females and the subsequent changes in FIR values.

Table 5. Comparison of Wildlife Targets (*in* mg/kg) for Five Cache Creek / Bear Creek Wildlife Species

Species	RWQCB "Safe Concentrations" in TL3 Fish	USFWS Wildlife Values in TL3 Fish
Mink	0.090	0.077
Belted Kingfisher	0.042	0.046
Common Merganser	0.086	0.085
Western Grebe	0.090	0.084
Double-crested Cormorant	0.094	0.094

As the Cache Creek TMDL points out, there can be wide variations in prey size between these species. According to the TMDL, the belted kingfisher generally consumes TL3 fish less than 105 mm in length, while a double-crested cormorant may eat a 400 mm TL3 fish. Although it is possible that these two prey fish have bioaccumulated equal amounts of methylmercury in their tissues, there is a greater likelihood that the larger fish has built up higher tissue levels. This proportional bioaccumulation can be observed in the fish tissue data presented in Appendix A of the Cache Creek TMDL report. Thus, taking the WV calculated for TL3 fish consumed by kingfishers (0.046 mg/kg) and applying it to larger TL3 prey of the three other bird species may be overly stringent. Conversely, taking the WV calculated for TL3 fish consumed by cormorants (0.094 mg/kg) and applying it to small TL3 fish (<105 mm) would allow concentrations that may place the kingfisher at risk for adverse effects from methylmercury toxicity.

For these five species, the RWQCB addresses the issue of proportional bioaccumulation by delineating two different prey size categories: TL2-3 fish <105 mm, and TL3 fish 75-400 mm. With this delineation, the RWQCB would apply its protective concentration for kingfishers to fish in the smaller size category, while the other species would be considered protected if their "safe concentrations" were achieved in fish from the larger size category. However, a further review of the dietary habits for all five species suggests an alternate delineation for setting targets may be more appropriate.

Although kingfishers generally capture fish less than 105 mm (Hamas, 1994), they can occasionally consume fish as long as 180 mm (U.S. Environmental Protection Agency, 1995a). Conversely, although double-crested cormorants are known to consume fish upwards of 400 mm in length, the fish commonly selected are less than 150 mm (Hatch and Weseloh, 1999). Supporting this observation, the U.S. Environmental Protection Agency (1995b) reported findings showing that up to 95 percent of the fish eaten by cormorants were less than 150 mm in length. Similarly, the TMDL report presents a size range of 50-200 mm for fish consumed by mink. However, female mink capture smaller fish than males, and data from lower Michigan streams and rivers indicated that most fish consumed by both male and female mink were between 50-150 mm in length (U.S. Environmental Protection Agency, 1995a). These findings suggest a more suitable prey size category for setting protective concentrations for these three species would be TL3 fish between 50-150 mm.

For the remaining two species in this group, the common merganser and western grebe, the Service suggests a prey size category of 150-300 mm. As noted in the TMDL report, most of the fish consumed by common mergansers are between 100-300 mm in length, with fish up to 360 mm occasionally taken. Also, mergansers will "...choose disproportionately more large fish compared with available sizes" (Mallory and Metz, 1999). No information could be found on the size of fish taken by western grebes; however, with a body size and foraging strategy similar to the common merganser, it may be assumed that western grebes consume similar sized fish. With these alternate delineations, and the WVs calculated by the Service, the wildlife targets for these five species could be set based on the lowest protective concentration for each size category.

To sufficiently protect mink, belted kingfisher, and double-crested cormorant, **TL3 fish less than 150 mm in length should have methylmercury concentrations no greater than 0.05 mg/kg, wet weight**.

To sufficiently protect the common merganser and western grebe, **TL3 fish between 150-300 mm in length should have methylmercury concentrations no greater than 0.08 mg/kg, wet weight**.

The fish tissue methylmercury concentration data presented in the TMDL's Appendix A was not grouped by these proposed size categories, so it was not possible for this evaluation to verify whether existing conditions match the expected concentration ratio between these targets (*i.e.*, 0.08/0.05 = 1.6). However, by examining the data using the RWQCB's size categories (TL3 fish 75-400mm and TL2-3 fish <105 mm), one finds similar concentration ratios (1.13 in lower Bear Creek to 2.3 in the middle reach of Cache Creek). This suggests that the proportional bioaccumulation expected with the Service's proposed size categories is similar enough to "real world" conditions so that attainment of the target in one size category is likely to result in attainment in the other size category. However, a further examination of the existing data based on the proposed size categories may reveal the need for additional refinement of the targets.

IV.B. Using Food Chain Multipliers to Determine Wildlife Targets

In contrast to the five wildlife species from the previous section, several of the TMDL's other species of concern feed on fish from both trophic level 3 and 4. For these three species, river otter, osprey, and bald eagle, an alternate iteration of the Average Concentration TL Approach must be used in order to develop trophic level-specific methylmercury targets. As discussed previously, this process may require the use of FCMs, TLRs, or a combination of the two, depending on the particular dietary habits of the species.

The TMDL report presents size ranges for the fish consumed by these three species: river otter (100-400 mm), bald eagle (75-500+ mm), and osprey (100-450 mm). Although bald eagles and osprey are known to consume fish at the lower end of these ranges, the majority of prey fish will be greater than 150 mm in length (Jackman *et al*., 1999; U.S. Environmental Protection Agency, 1995a). In effect, the size of fish consumed by adults of either bird species does not vary significantly, regardless of whether the fish is considered TL3 or TL4. It is likely there is no predator-prey relationship between the TL4 and TL3 fish consumed by either bird, as TL3 fish of this size are likely too large to be preyed upon by similar sized TL4 fish. Therefore, it may be more appropriate to use TLRs in developing targets for these avian species.

The river otter diet is less homogenous in terms of prey size than the diets of either bald eagle or osprey. Fish consumed by otters range from 20-500 mm in length, with the majority less than 150 mm (U.S. Environmental Protection Agency, 1995a). It is likely these small fish are predominantly TL3 species, although some may be considered TL2. While some of the larger fish consumed by otters may be considered TL3 (*e.g.*, Sacramento sucker), otters commonly capture large TL4 species. It is likely that a predator-prey relationship exists between the fish captured by otters, with the large TL4 fish preying on the smaller TL3 fish. Therefore, the food chain multiplier approach may be more appropriate for establishing trophic level-specific methylmercury targets for otters.

As explained previously, FCMs can be determined using information about BAF ratios or by examining data on existing fish tissue methylmercury concentrations. The fish tissue methylmercury dataset presented in the TMDL's Appendix A was used by the RWQCB to develop concentration relationships between TL3 and TL4 fish. Using data from both TL3 and TL4 fish in the size range of 75-400 mm, the RWQCB calculated an average TL4/TL3 ratio of approximately 3 (*i.e.*, the average concentration for all TL4 fish was about three times the average concentration for all TL3 fish). However, using this size range for both trophic levels does not represent a distinct "TL4 predator-TL3 prey" relationship, as any TL3 fish larger than 150 mm would likely not be preyed upon by any but the largest TL4 fish. Therefore, the average TL4/TL3 ratio of 3 should not be used as the FCM value.

Although the Appendix A dataset was not grouped in a way to determine a TL3 → TL4 food chain multiplier (FCM4), it can be used to develop a rough estimate. By taking the average concentrations in TL4 fish greater than 180 mm and the average concentrations for TL2-3 fish less than 105 mm, a closer approximation of the "TL4 predator-TL3 prey" relationship can be calculated. The subsequent ratios calculated for the five waterbodies sampled range from 3.48 to 6.86, with an average of 5.4.

These ratio values may be slightly exaggerated, due to the exclusion of data for fish between 105-180 mm. To further refine the FCM4 value of 5.4, alternate size categories could allow for consideration of the data from the 105-180 mm fish. In keeping with the size categories proposed earlier, the Service suggests a demarcation point of 150 mm be used to separate the fish tissue data (*i.e.*, TL4 predator fish greater than 150 mm and TL3 prey fish less than 150 mm). In effect, the inclusion of these data is likely to raise slightly the average concentrations for the TL3 prey fish and lower the average concentrations for the TL4 predator fish, resulting in a lower overall FCM4. Based on the above, the Service proposes using **a value of 5 as the FCM4**. The RWQCB may wish to re-examine the available fish tissue data using the alternate size categories, as this may indicate the need to refine this value. However, we believe this is a reasonable value based on the existing category ratios with which to determine protective wildlife targets for the river otter.

The river otter's WV is 0.107 mg/kg and its dietary composition is assumed to be 80 percent TL3 fish and 20 percent TL4 fish. Because TL2 fish are not a component of the otter's diet, Equation 3 can be modified as:

$$WV = (\%TL3 \times FDTL3) + (\%TL4 \times FDTL4)$$

Substituting the FCM4 equivalent, this can further be arranged as:

$$WV = (\%TL3 \times FDTL3) + (\%TL4 \times FDTL3 \times FCM4)$$

Then, substituting the above values:

$$0.107 = (0.80 \times FDTL3) + (0.20 \times FDTL3 \times 5)$$

Solving this equation for FDTL3:

$$FDTL3 = 0.107/[(0.80) + (1.0)]$$

FDTL3 = 0.107/1.8 **= 0.0594 mg/kg**

Once the FDTL3 concentration is calculated, the FDTL4 concentration can be determined using the FCM4 relationship:

$$FDTL4 = FDTL3 \times FCM4$$
$$FDTL4 = 0.0594 \text{ mg/kg} \times 5$$
FDTL4 = 0.2972 mg/kg

Thus, to sufficiently protect river otters, **TL3 fish less than 150 mm in length and TL4 fish greater than 150 mm in length should have methylmercury concentrations no greater than 0.06 and 0.30 mg/kg, wet weight, respectively.**

IV.C. Using Trophic Level Ratios to Determine Wildlife Targets

As previously discussed, adult bald eagles and osprey primarily capture large fish (> 150 mm) from both trophic level 3 and 4. The likelihood of a predator-prey relationship between these fish is small, which supports the use of TLRs instead of FCMs in determining wildlife targets. However, in addition to fish, the bald eagle diet can include avian prey that may also be feeding from the aquatic environment. This potential for methylmercury exposure via consumption of omnivorous or piscivorous birds requires consideration of other biomagnification dynamics, in addition to TL3/TL4 concentration relationships, when calculating protective targets. Therefore, using the Average Concentration TL Approach based solely on a TLR between TL3 and TL4 fish is only appropriate when determining targets for osprey.

In developing its wildlife targets, the RWQCB used the dataset of fish tissue methylmercury concentrations from six Cache Creek and Bear Creek sub-watersheds (Appendix A) to calculate an average TLR of 2.5 between TL3 and TL4 fish. This average TLR is based on combined data for four different fish size categories, two used for wildlife exposure estimates (TL3 fish 75-400 mm; TL4 fish 75-400 mm) and two used for human exposure estimates (TL3 fish >180 mm; TL4 fish >180 mm). The categories for the wildlife exposure estimates are based on a broad range of prey sizes consumed by all the various wildlife species of concern, both avian and mammalian, while the human exposure categories are based on legal catch sizes for anglers.

While the Service understands the rationale for delineating these separate exposure categories, we believe the size range selected for the wildlife exposure estimates may not provide the best estimation of trophic level ratios. Combining tissue concentration data from all fish in the 75-400 mm range may have artificially raised the TL4/TL3 ratios, due to the fact that there is likely some degree of predator-prey biomagnification in fish of these sizes (*i.e.*, large TL4 fish will readily consume TL3 fish from the small end of this size range). In effect, some of the concentration relationships observed in these data may represent food chain multipliers rather than just the ratios between similarly sized fish. The Service believes refining the size range for the wildlife exposure estimates may provide a more accurate representation of the concentration relationships between similarly sized fish feeding at different positions in the food chain.

As an alternative, the Service suggests a more appropriate size range to consider for determining TLRs for both humans and wildlife would be 150 mm and larger. While very large TL4 fish may occasionally consume fish at the bottom of this range, the small probability of this occurring should minimize the introduction of concentration ratios based on predator fish-prey fish biomagnification. In addition, although fish 150-180 mm are below the legal angling limit, the Service feels that using a range of 150 mm or larger would eliminate the need for separate human and wildlife exposure categories.

Using fish tissue data from just the wildlife exposure categories, the RWQCB calculated an average TLR of approximately 3 for the six sub-watersheds. As discussed, the Service believes this value may be exaggerated due to the broad size category examined, and should be disregarded when determining wildlife targets using the TLR approach. In contrast, the RWQCB's average TLR using data from only the human exposure categories (*i.e.*, TL3 fish >180 mm; TL4 fish >180 mm) was approximately 2.1.

However, it appears as though the "human exposure" TLR for several of the sub-watersheds sampled may have been incorrectly calculated, resulting in an inadvertent increase in the average TLR for all sub-watersheds. As an example, Table A.1 in the TMDL's Appendix A presents data for Bear Creek, downstream of Sulphur Creek. According to this table, the average concentrations for TL3 and TL4 fish greater than 180 mm in this water body were 0.88 and 3.25 mg/kg, respectively. Thus, the TLR based on these averages would be approximately 3.7 (*i.e.*, 3.25 / 0.88 = 3.69). This average concentration of 0.88 mg/kg for TL3 fish was apparently based on a weighted methylmercury concentration of 23 mg/kg in 26 TL3 fish over 180 mm in length, according to summary data presented in Table A.3 of this Appendix. However, the summary data appear to conflict with the individual data points in the body of Table A.3, which indicate that a *total* of 26 TL3 fish were sampled from this sub-watershed, and many of these were clearly well below 180 mm long.

It is not possible from this dataset to determine exactly how many TL3 fish were over 180 mm, as two of the samples involved multiple fish (*i.e.*, 8 fish, average length of 90 mm; 11 fish, average length of 94 mm). However, if we assume none of the fish from these composite samples met the size criterion, the data table indicates that only 5 of the 26 TL3 fish sampled were longer than 180 mm. The weighted concentration in these five fish was 6.995 mg/kg, resulting in an average concentration of 1.399 mg/kg in each of the five fish. Using this average concentration, the TLR for this sub-watershed would be approximately 2.3 instead of 3.7 (*i.e.*, 3.25 / 1.399 = 2.32).

Using the assumptions that composite samples with a reported length less than 180 mm contained *no fish greater than this length*, and that those composite samples with a reported length greater than 180 mm contained *no fish less than this length*, the Service reviewed the data in Table A.3 and calculated average concentrations and TLRs for all six sub-watersheds. Based on this review, we believe that average concentrations may have been miscalculated for four of the six sub-watersheds. For three of these (Bear Creek, downstream of Sulphur Creek; North Fork Cache Creek; South Fork Cache Creek), the recalculated average concentrations resulted in lower TLRs than those based on the RWQCB's calculated concentrations. Recalculations for the fourth sub-watershed, Cache Creek from the Capay Dam to the Settling Basin, resulted in a higher TLR.

The Service recognizes that the RWQCB may have reviewed Table A.3 using different assumptions, and that an analysis of the full dataset might serve to validate the average concentrations used by the RWQCB to determine TLRs. However, we believe the data presented support the need for a lower average TLR than the one used in the TMDL to calculate targets. Based on our recalculations of the data, **the average TLR between similar sized TL3 and TL4 fish for all six sub-watersheds is 1.7**. Although the Service did not recalculate an average TLR using the tissue concentration data from all fish greater than 150 mm in length, it is reasonable to assume this value would not change significantly with these additional data. The average TLR value of 1.7 was used to calculate protective wildlife targets for osprey.

The osprey's WV is 0.105 mg/kg and its dietary composition is assumed to be 90 percent TL3 fish and 10 percent TL4 fish. Because TL2 fish are not a component of the osprey's diet, Equation 3 can be modified as:

$$WV = (\%TL3 \times FDTL3) + (\%TL4 \times FDTL4)$$

Substituting the TLR equivalent, this can further be arranged as:

$$WV = (\%TL3 \times FDTL3) + (\%TL4 \times FDTL3 \times TLR)$$

Then, substituting the above values:

$$0.105 = (0.90 \times FDTL3) + (0.10 \times FDTL3 \times 1.7)$$

Solving this equation for FDTL3:

FDTL3 = 0.105/[(0.90) + (0.17)]
FDTL3 = 0.105/1.07 **= 0.09813 mg/kg**

Once the FDTL3 concentration is calculated, the FDTL4 concentration can be determined using the TLR relationship:

FDTL4 = FDTL3 × TLR
FDTL4 = 0.09813 mg/kg × 1.7
FDTL4 = 0.1668 mg/kg

Thus, to sufficiently protect osprey, **TL3 fish and TL4 fish greater than 150 mm in length should have methylmercury concentrations no greater than 0.10 and 0.17 mg/kg, wet weight, respectively.**

IV.D. Using Food Chain Multipliers, Trophic Level Ratios, and Biomagnification Factors to Determine Wildlife Targets

Developing wildlife targets for the two remaining species of concern in the Cache Creek/Bear Creek area, bald eagle and peregrine falcon, required further modifications to the Average Concentration TL Approach. Both species may consume a wide variety of avian prey, including aquatic-dependent birds which may be omnivorous or piscivorous. Methylmercury biomagnification from the aquatic food chain into these prey birds can be a significant source of dietary exposure for eagles and falcons, and must be incorporated into the equations to calculate protective targets. To do this, the previously described Equation 2 must be modified with additional terms, presented below as Equation 7:

$$\mathbf{WV = (\%TL2 \times FDTL2) + (\%TL3 \times FDTL3) + (\%TL4 \times FDTL4) + (\%OB \times FDOB) + (\%PB \times FDPB)} \quad \mathbf{(7)}$$

where,
%OB = percent of omnivorous birds (TL2-consumers) in diet
FDOB = methylmercury concentration in omnivorous bird prey
%PB = percent of piscivorous birds (TL3 fish-consumers) in diet
FDPB = methylmercury concentration in piscivorous bird prey

Because the Average Concentration TL Approach is based on methylmercury concentrations in aquatic organisms from various trophic levels, the terms FDOB and FDPB must incorporate the biomagnification of methylmercury from the aquatic trophic levels into the tissues of these prey birds. In effect:

FDOB = FDTL2 (concentration in TL2 organisms) × **MOB** (*i.e.*, some biomagnification factor [BMF] representing biomagnification into omnivorous bird prey)

FDPB = FDTL3 (concentration in TL3 organisms) × **MPB** (*i.e.*, some biomagnification factor [BMF] representing biomagnification into piscivorous bird prey)

These two terms, MOB and MPB, are linkage values similar to FCMs. Therefore, Equation 7 can be revised using these biomagnification equivalents:

$$WV = (\%TL2 \times FDTL2) + (\%TL3 \times FDTL3) + (\%TL4 \times FDTL4) + (\%OB \times FDTL2 \times MOB) + (\%PB \times FDTL3 \times MPB)$$

However, this equation must undergo further modification so that it can be solved for the concentration in trophic level 2 (FDTL2). Although TL2 aquatic organisms are rarely, if ever, preyed upon by bald eagles or peregrine falcons, the need to express the equation in terms of FDTL2 is because the methylmercury concentration in these organisms is the only common connection between omnivorous and piscivorous birds (*i.e.*, the birds do not prey on one another and they feed on different prey bases). So, in effect, the equation must be modified in order to calculate the concentration in TL2 biota needed to result in protective concentrations in omnivorous birds (FDOB) and piscivorous birds (FDPB). This requires two additional steps.

First, the FDTL3 component in the equation must be expressed as a function of FDTL2. As explained previously, the relationship between these two values is one of predator-prey biomagnification, so a **food chain multiplier** is needed. Thus, FDTL3 becomes FDTL2 × FCM3.

Next, the FDTL4 component must be expressed as a function of FDTL2. Although one could apply an additional FCM to account for the biomagnification of TL4 fish consuming TL3 fish (*e.g.*, FDTL4 = FDTL2 × FCM3 × FCM4), the bald eagle consumes roughly the same size fish from both trophic level 3 and 4. Therefore, a **trophic level ratio** should be applied instead. Thus, FDTL4 becomes FDTL2 × FCM3 × TLR.

Having determined the various equivalency terms, Equation 7 can be fully expressed as a function of FDTL2, presented below as Equation 8:

$$WV = (\%TL2 \times FDTL2) + (\%TL3 \times FDTL2 \times FCM3) + (\%TL4 \times FDTL2 \times FCM3 \times TLR) + (\%OB \times FDTL2 \times MOB) + (\%PB \times FDTL2 \times FCM3 \times MPB) \quad \textbf{(8)}$$

Once the WV equation was expressed in terms of the concentration in TL2 organisms, it could then be further simplified to calculate targets for both the bald eagle and peregrine falcon. Acknowledging that TL2 organisms make no contribution to the eagle's diet (*i.e.*, %TL2 = 0), this component of the equation can be removed when calculating targets for this species. Thus, although the equation is still solved for FDTL2, bald eagle targets were determined by Equation 9, below:

$$WV = (\%TL3 \times FDTL2 \times FCM3) + (\%TL4 \times FDTL2 \times FCM3 \times TLR) + (\%OB \times FDTL2 \times MOB) + (\%PB \times FDTL2 \times FCM3 \times MPB) \quad \textbf{(9)}$$

Solving the equation for FDTL2 allows for the calculation of the remaining aquatic trophic level and bird prey concentrations, using food chain multipliers, trophic level ratios, and biomagnification factors:

FDTL3 = FDTL2 × FCM3
FDTL4 = FDTL3 × TLR
FDOB = FDTL2 × MOB
FDPB = FDTL3 × MPB

Similarly, assuming peregrine falcons would not be consuming any prey from trophic levels 2, 3, or 4, all three components can be removed from the equation. Thus, peregrine falcon targets were determined by Equation 10, below:

$$\mathbf{WV = (\%OB \times FDTL2 \times MOB) + (\%PB \times FDTL2 \times FCM3 \times MPB) \qquad (10)}$$

Solving the equation for FDTL2 allows for the calculation of the bird prey concentrations, using biomagnification factors:

FDOB = FDTL2 × MOB
FDPB = FDTL2 × FCM3 × MPB

The final step necessary before performing the calculations for both species was to assign values for the concentration relationship terms FCM3, TLR, MOB, and MPB. As previously described, a TLR value of 1.7 has been determined from the data presented in the TMDL's Appendix A. This value was used to calculate targets for the bald eagle.

For the TMDL, the RWQCB used a value of 10 to account for the biomagnification from TL3 fish into piscivorous bird prey consumed by bald eagles and peregrine falcons. This biomagnification value is the same as the MPB term in our equations. Although this value of 10 has been used by the Service previously when considering bald eagle targets, and was discussed with RWQCB staff earlier in 2003, a subsequent analysis by the Service resulted in a refinement of this value, as well as the development of a value to account for the biomagnification from TL2 organisms into omnivorous bird prey. The complete analysis to derive these two values are not presented here; however, for a detailed explanation, the reader is directed to our recent evaluation of the EPA's human health criterion for methylmercury (U.S. Fish and Wildlife Service, 2003). The final MOB (10) and MPB (12.5) values determined in that effort were used here to calculate targets for the bald eagle and peregrine falcon.

As previously discussed, food chain multipliers can be determined by several methods, including using existing tissue concentration data to calculate ratios between organisms in different trophic levels. Although the TMDL's Appendix A provides concentration data separated into TL2/3 and TL3 categories, the small fish classified as TL2 (California roach) is more likely closer to a TL3 organism, based on its dietary habits (Moyle, 2002). Lacking any other tissue concentration data with which to calculate FCM ratios, the Service relied instead on draft national bioaccumulation factors presented in Appendix A of the EPA's human health methylmercury criterion document (U.S. Environmental Protection Agency, 2001). Although these values remain *draft* only, they were empirically derived from national data. The ratio between the draft national BAFs for TL3 (680,000) and TL2 (120,000) is approximately 5.7. This FCM3 value was used by the Service in our aforementioned human health criterion evaluation (U.S. Fish and Wildlife Service, 2003), and was used here for the calculation of bald eagle and peregrine falcon targets. Therefore:

FCM3 = 5.7
TLR = 1.7
MOB = 10
MPB = 12.5

Bald Eagle: The bald eagle's WV is 0.195 mg/kg, with a dietary composition assumed to be 58 percent TL3 fish, 13 percent TL4 fish, 13 percent omnivorous birds, and 5 percent piscivorous birds. Using Equation 9, the eagle's WV can be represented as:

$$WV = (\%TL3 \times FDTL2 \times FCM3) + (\%TL4 \times FDTL2 \times FCM3 \times TLR) + (\%OB \times FDTL2 \times MOB) + (\%PB \times FDTL2 \times FCM3 \times MPB)$$

Inserting the dietary composition and concentration relationship values:

$$0.195 = (0.58 \times FDTL2 \times 5.7) + (0.13 \times FDTL2 \times 5.7 \times 1.7) + (0.13 \times FDTL2 \times 10) + (0.05 \times FDTL2 \times 5.7 \times 12.5)$$

Solving this equation for FDTL2:

$$FDTL2 = 0.195/[(0.58 \times 5.7) + (0.13 \times 5.7 \times 1.7) + (0.13 \times 10) + (0.05 \times 5.7 \times 12.5)]$$

$$FDTL2 = 0.195/[(3.306) + (1.2597) + (1.3) + (3.5625)]$$
$$FDTL2 = 0.195/9.4282$$

$$FDTL2 = 0.02068$$

Then, using the other concentration relationship values, protective targets can be calculated for the prey consumed by bald eagles:

FDTL3 = FDTL2 × FCM3
FDTL3 = 0.02068 mg/kg × 5.7 = 0.117876 mg/kg

FDTL4 = FDTL3 × TLR
FDTL4 = 0.117876 mg/kg × 1.7 = 0.2003 mg/kg

FDOB = FDTL2 × MOB
FDOB = 0.02068 mg/kg × 10 = 0.2068 mg/kg

FDPB = FDTL3 × MPB
FDPB = 0.117876 mg/kg × 12.5 = 1.47345 mg/kg

Thus, to sufficiently protect bald eagles, **TL3 and TL4 fish greater than 150 mm in length should have methylmercury concentrations no greater than 0.12 and 0.20 mg/kg, wet weight, respectively. In addition, omnivorous and piscivorous avian prey of bald eagles should have methylmercury concentrations in muscle tissue no greater than 0.21 and 1.47 mg/kg, wet weight, respectively.**

Peregrine Falcon: The peregrine falcon's WV is 0.139 mg/kg, with a dietary composition assumed to include 10 percent omnivorous birds and 5 percent piscivorous birds. Using Equation 10, the falcon's WV can be represented as:

$$WV = (\%OB \times FDTL2 \times MOB) + (\%PB \times FDTL2 \times FCM3 \times MPB)$$

Inserting the dietary composition and concentration relationship values:

$$0.139 = (0.10 \times FDTL2 \times 10) + (0.05 \times FDTL2 \times 5.7 \times 12.5)$$

Solving this equation for FDTL2:

$$FDTL2 = 0.139/[(0.10 \times 10) + (0.05 \times 5.7 \times 12.5)]$$

$$FDTL2 = 0.139/[(1) + (3.5625)]$$
$$FDTL2 = 0.139/4.5625$$
$$FDTL2 = 0.0304$$

Then, using the other concentration relationship values, protective targets can be calculated:

$$FDTL3 = FDTL2 \times FCM3$$
$$\mathbf{FDTL3 = 0.0304\ mg/kg \times 5.7 = 0.17328\ mg/kg}$$

$$FDOB = FDTL2 \times MOB$$
$$\mathbf{FDOB = 0.0304\ mg/kg \times 10 = 0.3040\ mg/kg}$$

$$FDPB = FDTL3 \times MPB$$
$$\mathbf{FDPB = 0.17328\ mg/kg \times 12.5 = 2.166\ mg/kg}$$

Thus, to sufficiently protect peregrine falcons, **omnivorous and piscivorous avian prey of peregrine falcons should have methylmercury concentrations in muscle tissue no greater than 0.30 and 2.17 mg/kg, wet weight, respectively.**

Assigning a protective value to the TL3 fish consumed by the falcon's piscivorous avian prey is more problematic than with bald eagles, as the variety of piscivorous birds captured by falcons would require a broader size range of fish. For example, the gulls and small herons in the falcon's diet may be primarily consuming TL3 fish less than 150 mm in length, while the larger mergansers and western grebes may be eating TL3 fish up to 350 mm in length. However, if we consider the protective TL3 fish tissue target calculated for the bald eagle (*i.e.*, 0.12 mg/kg in TL3 fish greater than 150 mm), we see that this target would result in methylmercury concentrations in large piscivorous prey (*i.e.*, 1.5 mg/kg) sufficiently protective of the peregrine falcon.

V. Summary of the USFWS-Derived Cache Creek / Bear Creek Wildlife Targets

Using various iterations of the Average Concentration TL Approach and all the various exposure parameters described above, protective targets for wildlife species of concern in the Cache Creek/Bear Creek area are presented below in Table 6.

In order to sufficiently protect all nine of the wildlife species of concern, the most stringent of the targets must be determined. If the proportional bioaccumulation estimated between concentrations in the two TL3 fish categories is a reasonable assumption (*i.e.*, concentrations in TL3 fish 150-300 mm in length will be approximately 1.6 times those in TL3 fish less than 150 mm), then the TL3 target concentration of 0.8 mg/kg calculated for mergansers and grebes should be adequate to protect all wildlife species considered. However, the limited size range for this target (150-300 mm) may be unnecessarily restrictive for monitoring compliance with the TMDL.

Alternatively, the targets developed for osprey should provide the same level of protection for all species, and may provide additional feedback on the validity of the assumptions used in this evaluation. Because osprey generally consume larger TL3 fish than either the merganser or grebe, the concentration value of 0.10 mg/kg in all TL3 prey fish greater than 150 mm should correspond to the 0.08 mg/kg target for the 150-300 mm size range. Also, setting a 0.17 mg/kg target for TL4 fish greater than 150 mm provides an additional monitoring component, as well as providing confirmation of the assumed TLR value used in the analyses. As the trophic level concentrations determined for osprey should be protective of all species considered, **the Service recommends TL3 fish and TL4 fish greater than 150 mm in length should have methylmercury concentrations no greater than 0.10 and 0.17 mg/kg, wet weight, respectively.**

Table 6. USFWS-Derived Protective Targets (*in* mg/kg, wet weight) for Cache Creek / Bear Creek Wildlife Species of Concern

	TL3 Fish < 150 mm	TL3 Fish > 150 mm	TL4 Fish > 150 mm	Omnivorous Birds	Piscivorous Birds
Mink	0.05				
River Otter	0.06		0.30		
Belted Kingfisher	0.05				
Common Merganser		0.08 (150-300 mm)			
Western Grebe		0.08 (150-300 mm)			
Double-crested Cormorant	0.05				
Osprey		0.10	0.17		
Bald Eagle		0.12	0.20	0.21	1.50
Peregrine Falcon				0.30	2.17

VI. Comparison with the RWQCB-Derived Cache Creek / Bear Creek Targets

For this TMDL effort, the RWQCB developed numeric targets for both wildlife and human health protection. Based on the wildlife species of concern, and various assumptions regarding dietary trophic level composition and prey size classes, the RWQCB arrived at five different "safe concentrations" of methylmercury in fish tissue and one "safe concentration" for methylmercury in the muscle tissue of piscivorous avian prey. Then, after comparing these "safe concentrations" with safe levels calculated for human consumers, the RWQCB determined two target concentrations that were intended to be protective of all wildlife and human consumers in the Cache Creek/Bear Creek watershed: **0.10 and 0.28 mg/kg, wet weight, in TL3 and TL4 fish greater than 180 mm in length, respectively**. These values were based on exposure estimates for osprey, bald eagle, and human consumption, and the presumption was made that reaching these targets would also result in attainment of "safe concentrations" for all other wildlife species.

As noted above in Table 6., the Service developed numeric targets in a parallel derivation for the same wildlife species considered by the RWQCB, using different fish prey size classes and bird prey categories. Based on an analysis of the existing fish tissue mercury data and a consideration of proportional bioaccumulation with fish size, the Service also determined two targets that should serve to protect all wildlife species foraging in Cache and Bear Creeks: **0.10 and 0.17 mg/kg, wet weight, in TL3 and TL4 fish greater than 150 mm in length, respectively**. These values were based on exposure estimates for osprey, with the lower TL4 fish value resulting from a re-examination of the average TLR between TL4 and TL3 fish (2.5) used by the RWQCB. As discussed previously, the Service's average TLR (1.7) was recalculated using data for fish greater than 180 mm in length. A complete recalculation using all existing data for fish greater than 150 mm in length may indicate the need to revise the 1.7 TLR value; however, the Service believes that this additional data would not result in a significantly different ratio, and that any revised value would be highly unlikely to approach the TLR used by the RWQCB.

VII. Evaluating the RWQCB-Derived Harley Gulch Wildlife Target

The RWQCB's TMDL report describes Harley Gulch as "...an ephemeral stream with some pools that remain wet through the year," with limited habitat for piscivorous birds and mammals. During two stream surveys in 2003, RWQCB staff observed only small TL2 or TL3 fish in the small standing pools, along with turtles, newts, and invertebrates. The TMDL report goes on to state that the wildlife species likely foraging from this stream include kingfisher, raccoon, and various small herons, and suggests it is unlikely that these species forage exclusively from this waterbody due to the mobility of these predators and the ephemeral character of the stream.

Based on these evaluations, the RWQCB determined that only a methylmercury target in small fish was necessary to protect piscivorous wildlife likely to forage in Harley Gulch. For its numeric target, the RWQCB used the kingfisher exposure estimates from the Cache Creek/Bear Creek analysis and determined a "safe concentration" of **0.04 mg/kg, wet weight, in fish less than 105 mm in length**. The kingfisher's small body size and dietary dependence on small fish likely results in the greatest potential for exposure to methylmercury; therefore, a target determined to protect kingfisher from methylmercury toxicity would likely be protective of the small herons and raccoons foraging from the same prey base.

The Service agrees with the RWQCB's assessment, and our parallel derivation provided similar target concentrations for wildlife species consuming small fish. For kingfisher, mink, and cormorant, the Service calculated a protective target of **0.05 mg/kg, wet weight, in TL3 fish less than 150 mm in length**. Because of the different size ranges considered, the Service believes these two values are essentially the same and that either concentration would be an adequate target to protect wildlife feeding from Harley Gulch.

VIII. Implications for the Sacramento-San Joaquin Delta Wildlife Targets

The draft version of the Delta TMDL reviewed by the Service presents the same approach for developing numeric wildlife targets as the one used in the Cache Creek TMDL, wherein protective limiting concentrations in fish tissue are determined by considering the trophic level composition of the wildlife species' diet. Although this preliminary draft was not as fully developed as the draft Cache Creek TMDL, the RWQCB had completed the process of selecting wildlife species of concern and using the dietary model to calculate numeric targets. The Service reviewed these targets and supporting analyses; however, for the reasons outlined below, we did not perform an in-depth evaluation or parallel target derivation such as presented above for the Cache Creek TMDL.

The wildlife species selected for the Delta TMDL were the same as those considered in the Cache Creek TMDL, and the RWQCB used the same body weights, trophic level dietary compositions, food ingestion rates, and reference doses in its calculation of numeric targets. For each of these variables, with the exception of the RWQCB's choice of reference doses, the Service presented alternative analyses in our evaluation of the Cache Creek/Bear Creek targets. Therefore, the Service's recommendations regarding these input variables would not change in an evaluation of the Delta wildlife targets.

The Delta TMDL development also used the same fish prey size classes as in the Cache Creek TMDL. These size classes are used both for determining target compliance points and for calculating the trophic level ratios (TLRs) necessary for wildlife species with multi-trophic level diets. The Service's recommendations in the Cache Creek evaluation regarding alternative size classes would therefore also apply to the Delta TMDL.

The draft TMDL report presents an average Delta-wide TLR value of 3.2, based on existing fish tissue mercury concentrations for various sub-regions. This value was used in calculating targets for the river otter, bald eagle, and osprey. Although the Delta TMDL's preliminary draft provided average fish tissue concentrations by size class for each sub-region, from which the Delta-wide TLR was calculated, the full fish tissue dataset was not available for Service review. There is no indication that the 'size class-specific' average concentrations are incorrect; however, the Service recommends the RWQCB review its dataset to confirm the values presented. As was seen in the Cache Creek/Bear Creek evaluation, miscalculations of average fish tissue concentrations can result in a TLR that may underestimate a protective target concentration (*e.g.*, a TL4 fish tissue concentration *higher* than it should be).

As discussed in the Cache Creek/Bear Creek evaluation, consideration of the dietary composition for any given wildlife species dictates how both the Service's and RWQCB's dietary models are used to calculate targets. In either model, targets for wildlife species feeding exclusively from one trophic level can be calculated with a simple equation, using body weight, food ingestion rate, and a protective reference dose. Target calculation for species feeding from multiple trophic levels requires a modification of the basic dietary model, using information about the concentration relationships between the trophic levels. For the Delta TMDL's multi-trophic level consumers (river otter, bald eagle, osprey), the RWQCB used the TLR relationship between TL4 and TL3 fish. This was the same approach used by the RWQCB for the Cache Creek/Bear Creek targets; however, for our evaluation of those targets, the Service recommended alternate modifications for each of the multi-trophic level consumers. These alternatives included using food chain multipliers (FCMs), TLRs, or a combination of both FCMs and TLRs in conjunction with biomagnification factors (BMFs). As the same wildlife species from the Cache Creek TMDL were considered in the Delta TMDL, the Service believes the RWQCB should use these alternative models when deriving targets for the Delta.

Finally, the Service recommends that the RWQCB consider some additional wildlife species as it develops targets for the Delta TMDL. Several tern species (*Sterna* spp.), all of which are exclusively piscivorous on small TL3 fish, forage in various Delta waters. Using the basic dietary model for these species could conceivably result in lower targets than the one calculated for kingfisher. Of particular interest to the Service is the California least tern (*Sterna antillarum browni*). This species is listed as endangered under the federal Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 *et seq*., as amended), and is known to breed within the legal boundary of the Delta. The least tern was one of the species examined in the Service's recent evaluation of the human health methylmercury criterion (U.S. Fish and Wildlife Service, 2003). For that effort, we calculated a protective fish tissue target (0.030 mg/kg, wet weight, in small TL3 fish). Because this target concentration is intended for very small fish (< 50 mm), it remains to be determined how it might affect the RWQCB's targets for fish in larger size classes. If the RWQCB's dataset of existing fish tissue mercury concentrations has sufficient information on this small size class, it may be possible to extrapolate concentrations in large fish corresponding to the 0.030 mg/kg target.

IX. Discussion

The recommendations and Service-derived numeric targets presented in this evaluation are intended to assist the RWQCB in its development of final TMDLs for the Cache Creek and Sacramento-San Joaquin Delta watersheds. The Service targets were based, in part, on a cursory review of the available fish tissue data and the trophic level ratios these data generated. We recognize that a comprehensive review by the RWQCB of existing tissue data for both watersheds may result in slightly different ratios and subsequent targets. However, the Service-derived targets were also based on modifications to the RWQCB's basic dietary exposure model, as well as on input parameters for the various wildlife species of concern that differed slightly from those used by the RWQCB. We believe these variations provide a more accurate measure of dietary exposure for the wildlife species of concern, and should therefore be considered by the RWQCB in its determination of final wildlife targets.

Throughout the development of this evaluation, staff from the Service and RWQCB have worked closely to share information and insights on the approaches presented. We believe this cooperative effort has been an invaluable asset toward achieving the goal of protective wildlife targets. The Service remains available to assist the RWQCB in any way as it completes the TMDLs for the Cache Creek and Sacramento-San Joaquin Delta watersheds.

X. References

Dunning, J. B. 1993. CRC handbook of avian body masses. CRC Press, Boca Raton, FL.

Hamas, M.J. 1994. Belted Kingfisher (*Ceryle alcyon*). *In* The Birds of North America, No. 84 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.

Hatch, J.J. and D.V. Weseloh. 1999. Double-crested Cormorant (*Phalacrocorax auritus*). *In* The Birds of North America, No. 441 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA.

Heinz G.H., 1979. Methylmercury: reproductive and behavioral effects on three generations of mallard ducks. J. Wildl. Manage. 43(2):394-401.

Jackman, R.E., W.G. Hunt, J.M. Jenkins, and P.J. Detrich. 1999. Prey of nesting bald eagles in northern California. Journal of Raptor Research 33(2): 87-96.

Mallory, M. and K. Metz. 1999. Common Merganser (*Mergus merganser*). *In* The Birds of North America, No. 442 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA.

Moyle, P.B. 2002. Inland Fishes of California. University of California Press, Berkeley and Los Angeles, CA. 446 pp.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecol. Monogr. 57:111-128.

Poole, A.F., R.O. Bierregaard, and M.S. Martell. 2002. Osprey (*Pandion haliaetus*). *In* The Birds of North America, No. 683 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA.

Storer, R.W. and G.L. Nuechterlein. 1992. Western and Clark's Grebe. *In* The Birds of North America, No. 26 (A. Poole, P. Stettenheim, and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.

U.S. Environmental Protection Agency. 1993. Wildlife Exposure Factors Handbook, Volume I. EPA/600/R-93/187a. Office of Research and Development. Washington, DC

_____. 1995a. Trophic Level and Exposure Analyses for Selected Piscivorous Birds and Mammals, Volume II: Analyses of Species in the Conterminus United States. Office of Water. Washington, DC

_____. 1995b. Trophic Level and Exposure Analyses for Selected Piscivorous Birds and Mammals, Volume I: Analyses of Species in the Great Lakes Basin. Office of Water. Washington, DC

_____. 1995c. Great Lakes Water Quality Initiative Technical Support Document for Wildlife Criteria. EPA-820-B-95-009. Office of Water. Washington, DC

_____. 1997. Mercury Study Report to Congress Volume VI: An Ecological Assessment for Anthropogenic Mercury Emissions in the United States. EPA-452/R-97-008. Office of Research and Development. Washington, DC

_____. 2001. Water Quality Criterion for the Protection of Human Health: Methylmercury. EPA-823-R-01-001. Office of Water. Washington, DC.

U.S. Fish and Wildlife Service. 2003. Evaluation of the Clean Water Act Section 304(a) human health criterion for methylmercury: protectiveness for threatened and endangered wildlife in California. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Environmental Contaminants Division. Sacramento, California. 96 pp + appendix.

Wiener, J. G. and D. J. Spry, 1996. Toxicological significance of mercury in freshwater fish, Chapter 13 *in* W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood (eds.), Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. Special Publication of the Society of Environmental Toxicology and Chemistry, Lewis Publishers, Boca Raton Florida, USA. 494 pp.

Wobeser, G., N.O. Nielsen, and B. Schiefer. 1976a. Mercury and mink I. The use of mercury contaminated fish as food for ranch mink. Can. J. Comp. Med. 40:30-33.

Wobeser, G., N.O. Nielsen, and B. Schiefer. 1976b. Mercury and mink II. Experimental methyl mercury intoxication. Can. J. Comp. Med. 40:34-45.