

APPENDIX 3C

BACK-CALCULATION TECHNICAL MEMORANDUM, SECOND FOLLOW- UP ANALYSIS, FROM JONES & STOKES, OCTOBER 17, 2003

Technical Memorandum ---

Date: October 17, 2003

To: Ken Carlson, Forrest Olson (Ch2MHill)

From: Erin VanDehey

Subject: Klamath Fish Sampling Scale Back-calculation Memo

METHODS

Jones & Stokes (technical memo from Erin VanDehey to CH2MHill, 8/4/03) analyzed scales from 124 redband trout from three reaches in the Klamath River system (Boyle Full Flow, Boyle Bypass, and Keno Reaches) and performed back-calculation on these scales to estimate the length of these fish at earlier ages. A review of the results indicated that additional scales were needed to meet the sampling requirements (provided by CH2MHill) for age 3 and older fish and improve the estimates of back-calculated lengths for these fish. The following memorandum describes the results of a second analysis with the additional scales.

CH2MHill identified the need for an additional 117 scales (39 from each reach) from age 3 and older fish. The first analysis indicated that the minimum fork length of age 3 fish from all reaches was approximately 230 millimeters. Therefore, for each reach, 39 scale samples were randomly selected from all scale samples taken from fish greater than 230-mm fork length. Random selection of scale samples was not necessary for the Keno Reach because only 39 scale samples from this reach were from fish greater than 230 mm.

The selected scales were mounted on glass slides, digitized, read, and measured using the procedures described in the previous memorandum (8/4/03). The two biologists who read the scales for the first analysis independently examined the additional 117 scales. They marked annuli locations, and estimated the age of each fish. Discrepancies in annuli location and estimated age were resolved through a joint re-examination of the scales in question.

Back-calculation was performed on 241 scales, using the procedures described in the previous memorandum. A revised least-squares linear regression model was generated based on the overall relationship between fork length and scale radius (all scales combined).

RESULTS

Table 1 presents the age distribution of fish based on the first group of scales, the second group of scales, and the combined scales by reach. Because of overlap in the length of fish in successive age groups, the selection of fish greater than 230-mm fork length resulted in the selection of some age-1 and age-2 fish in the second group of samples. However, CH2MHill determined that the resulting sample sizes for age 3 and older fish were adequate for statistical testing purposes. Some uncertainty occurred in reading the scales of older fish (age 4 and 5) because of the lack of distinct separation between annuli and physical warping or abrasion of the scale near the growing edge.

We again observed the presence of distinct zones of thick, widely spaced circuli on the scales of some of the fish from all three reaches. These zones are indicative of increased growth rate, which may be associated with a change in environmental conditions (e.g., food availability, temperature) and/or a behavioral or size-related shift in diet. These distinct zones of thick circuli were most evident in the third growing seasons (age 2+) of individual fish.

The plot of fork length versus scale radius, based on all 241 scales and length data indicates a linear regression model is appropriate model for back calculation purposes. Considerable variance is apparent in both fork length (for a certain scale radius) and scale radius (for a certain fork length). Some of the variance is likely due to reader error associated with uncertainty in locating the annuli of older fish, anomalies encountered in the Klamath system (e.g., zones of thick widely spaced circuli), and the lack of a reference collection of scales or other structures (e.g., otoliths) for verifying scale interpretations. Equal or greater sources of variance are likely due to variation in growth rates of individual fish from year to year and among and within reaches.

Tables 2 and 3 present the results for each group of scale samples, including sample location, capture date, fork length, scale radius and annuli measurements, estimated age at capture, and the back calculated lengths at earlier ages.

Table 1. Age Distribution of Fish from the First, Second, and Combined Scale Samples							
Reach	Age						Total
	0	1	2	3	4	5	
1st Sample							
Boyle Full Flow	0	17	12	6	5	0	40
Boyle Bypass	0	18	18	7	2	0	45
Keno	1	13	12	9	3	1	39
Total	1	48	42	22	10	1	124
2nd Sample							
Boyle Full Flow	0	3	21	10	4	1	39
Boyle Bypass	0	8	21	10	0	0	39
Keno	0	3	9	17	5	5	39
Total	0	14	51	37	9	6	117
Combined							
Boyle Full Flow	0	20	33	16	9	1	79
Boyle Bypass	0	26	39	17	2	0	84
Keno	1	16	21	26	8	6	78
Total	1	62	93	59	19	7	241

Table 2. Fish Capture, Scale, and Age Data from the Initial Group of Scale Samples

Sample No.	Sample Location	Date	Time	Fish Species	Fish ID No.	Est. Age	Fork Length (mm)	Total Scale Radius (um)	1st Annulus (um)	2nd Annulus (um)	3rd Annulus (um)	4th Annulus (um)	5th Annulus (um)	Estimated Average Fork Length (mm)	Correction Factor	Estimated Length at Age 1 (mm)	Estimated Length at Age 2 (mm)	Estimated Length at Age 3 (mm)	Estimated Length at Age 4 (mm)	Estimated Length at Age 5 (mm)
001	J.C.Boyle FF Cali	06/25/02	0900	Redband trout	2CS	1	164	707	379					185.7994	0.882672388	114.4347678				
002	J.C.Boyle Full Flow	06/25/02	1520	Redband rainbow	9JCBFF(PS)	1	145	545	250					158.065	0.917344131	98.67045203				
003	J.C.Boyle Full Flow	06/25/02	1205	Redband rainbow	6JCBFF(PS)	1	175	840	410					208.569	0.839050866	113.2324315				
004	J.C.Boyle Full Flow	06/25/02	1010	Redband rainbow	1JCBFF(PS)	1	195	675	272					180.321	1.081404828	120.3899879				
006	CGA3	06/25/02	1110	RBT		1	194	779	416					198.1258	0.979175857	133.1485289				
007	J.C.Boyle FF-upper	10/17/02	1225	RBT	JCFFUDM6	1	170	584	318					164.7418	1.031917825	123.0072878				
008	J.C.Boyle FF-upper	10/17/02	1505	RBT	JCFFUDM18	1	183	696	329					183.9162	0.995018383	120.482597				
009	J.C.Boyle FF-upper	10/17/02	1350	RBT	JCFFUDM14	1	168	687	348					182.3754	0.921176869	114.5378423				
010	Boyle Boat	10/17/02	1100	RBT	B7	1	179	670	179					179.465	0.997408966	95.15860028				
011	Boyle FF CA	08/14/02	1715	Redband trout	18BOYLECAEFSC	2	184	911	356	804				220.7242	0.833619512	104.7928084	168.7294243			
012	J.C.Boyle FF Sta 2	05/21/02	1245	Redband trout	1A	1	175	715	463					187.169	0.934983892	134.662551				
013	Boyle Cali	10/18/02	1120	RBT	13DBC	1	183	680	182					181.177	1.010061984	96.88453943				
014	J.C.Boyle FF-CA	10/18/02	1445	RBT	JCFFCADM9	1	146	941	507					225.8602	0.646417563	97.97065796				
015	J.C.Boyle Full Flow	06/25/02	1415	Redband rainbow	7JCBFF(PS)	2	295	1392	333	1008				303.0714	0.973367992	118.5276044	231.0100095			
016	J.C.Boyle FF-upper	10/17/02	1430	RBT	JCFFUDM16	4	277	1083	219	428	702	881		250.1706	1.107244416	113.2199491	152.8380401	204.777547	238.7088307	
017	J.C.Boyle FF-F Ranch	10/15/02	1550	RBT	JCFFDM20	4	285	1578	434	898	1069	1295		334.9146	0.850963201	118.3364744	185.934268	210.8463859	243.7711733	
018	J.C.Boyle - Cali	08/13/02	1155	RB Rainbow	7JCB(PS)	1	180	788	313					199.6666	0.901502805	106.6897919				
019	J.C.Boyle FF-CA	10/18/02	1400	RBT	JCFFCADM4	2	224	951	352	792				227.5722	0.984303004	123.0609081	197.2064848			
020	J.C.Boyle FF, Frane Ranch	08/11/02	1035	Redband trout	1CSJCBFF-FF	1	188	844	415					209.2538	0.898430518	122.0149503				
021	Boyle Cali	10/18/02	1520	RBT	56 DBC	2	248	1124	316	847				257.1898	0.964268412	114.6131363	202.2720777			
022	J.C.Boyle FF-upper	10/17/02	1520	RBT	JCFFUDM21	2	254	1111	309	810				254.9642	0.996218293	117.2168375	202.6636759			
023	J.C.Boyle FF-upper	10/17/02	1345	RBT	JCFFUDM12	2	251	858	221	582				211.6506	1.185916789	121.6705561	194.9640086			
024	JCB Full Flow	10/15/02	1335	RBT	JFFGA7	2	282	1515	425	1024				324.129	0.870023972	119.6465666	208.8664809			
025	J.C.Boyle-upper	10/17/02	1517	RBT	JCFFUDM20	2	246	1126	432	909				257.5322	0.955220357	132.5075948	210.5131817			
026	J.C.Boyle FF-CA	10/18/02	1450	RBT	JCFFCADM10	2	261	1202	510	988				270.5434	0.964725068	146.7086353	225.6555606			
027	J.C.Boyle Full Flow	06/25/02	1445	Redband rainbow	8JCBFF(PS)	2	225	918	308	684				221.9226	1.013866997	119.1198418	184.383677			
028	J.C.Boyle - Cali	08/13/02	1045	RB Rainbow	3JCB(PS)	1	210	937	589					225.1754	0.932606315	154.437554				
029	J.C.Boyle - Cali	08/13/02	1000	RB Rainbow	1JCB(PS)	1	215	869	448					213.5338	1.00686636	142.4299057				
030	J.C.Boyle Full Flow	06/25/02	1135	Redband rainbow	5JCBFF(PS)	4	325	1488	425	718	1071	1369		319.5066	1.017193385	139.8854515	190.9094992	252.3821574	304.2769226	
031	J.C.Boyle Full Flow, Frane Ranch	08/11/02	1635*	RB Rainbow	6JCBFF(PS)	3	285	1158	514	933				263.0106	1.083606516	165.5293475	243.259477			
032	J.C.Boyle Full Flow, Frane Ranch	08/11/02	1535	Redband trout	3CSJCBFF-FF	3	293	1171	438	908				265.2362	1.104675757	154.3746811	243.2613112			
033	J.C.Boyle - Cali	08/13/02	1325*	RB Rainbow	9JCB(PS)	3	245	1109	301	877				254.6218	0.962211405	111.8976812	206.7825025			
034	J.C.Boyle - Cali	08/13/02	1310*	RB Rainbow	8JCB(PS)	1	205	1064	454					246.9178	0.830235811	118.2968138				
035	J.C.Boyle - Cali	08/13/02	1030	RB Rainbow	2JCB(PS)	4	330	1764	320	625	1060	1576		366.7578	0.899776365	107.5637655	154.5464882	221.5546336	301.0401578	
036	J.C.Boyle Full Flow Cali	08/13/02	0800	RBT	JCBCAGA1	3	236	996	191	450	672			235.2762	1.003076384	97.76002503	142.2372344	180.3605567		
037	J.C.Boyle Full Flow Cali	08/13/02	0805	RBT	JCBCAGA2	3	259	1083	246	512	822			250.1706	1.035293516	110.6482368	157.7946753	212.7397728		
038	NA	08/13/02	1350*	NA	10JCBCCPS	2	260	1133	427	847				258.7306	1.004906262	138.5397939	210.7965737			
040	J.C.Boyle FF-CA	08/14/02	1715	Redband trout	17BOYLECAEFS C	2	332	1344	465	1127				294.8538	1.125981758	162.5568604	290.1693273			
043	Boyle Cali	10/18/02	1400	RBT	43 DBC	4	259	1542	408	833	1114	1393		328.7514	0.787829345	106.0501808	163.3726439	201.2729077	238.9034188	
044	J.C.Boyle FF-CA	10/18/02	1405	RBT	JCFFCADM5	3	342	1294	254	699	1136			286.2938	1.194577039	129.3079473	220.3156045	309.6871689		
045	J.C.Boyle Bypass - upper	10/20/02	0905	RBT	JCBUDM13	1	186	738	354					191.1066	0.973278788	122.0158739				
046	J.C.Boyle Bypass - upper	10/20/02	1010	RBT	JCBUDM24	2	169	768	253	593				196.2426	0.861178969	93.07157264	143.1990781			
047	J.C.Boyle Bypass - upper	10/20/02	1205	RBT	JCBUDM49	1	173	698	321					184.2586	0.938897832	112.4012806				
048	J.C.Boyle Bypass - upper	10/20/02	1235	RBT	JCBUDM54	1	156	551	183					159.0922	0.980563472	94.22293236				
049	J.C.Boyle Bypass - upper	10/20/02	1510	RBT	JCBUDM67	1	180	751	356					193.3322	0.931039941	117.0393551				
050	J.C.Boyle Bypass - upper	10/20/02	1540	RBT	JCBUDM71	1	178	641	228					174.5002	1.020056137	105.8763188				
051	Boyle BP upper	10/20/02	1050	RBT	U5CBGA3	2	175	830	368	744				206.857	0.845995059	108.0865284	162.5442455			
052	J.C.Boyle Bypass - lower	10/22/02	1005	RBT	JCBBLDM4	1	172	634	370					173.3018	0.992488249	127.1427071				
053	J.C.Boyle Bypass - lower	10/22/02	1400	RBT	JCBBLDM28	1	168	585	196					164.913	1.018718961	100.1565771				
054	J.C.Boyle Bypass - lower	08/05/02	1655*	RB Rainbow	8JCB(PS)	1	135	612	417					169.5354	0.796293871	108.4165254				
055	Boyle BP lower	10/21/02	1336	RBT	BBPL34	1	162	454	292					142.4858	1.136955402	130.4672241				
056	Boyle BP lower	10/21/02	0930	RBT	BBPL2	1	158	748	217					192.8186	0.819423022	83.50854741				
057	J.C.Boyle BP_upper	08/08/02	1055	Redband trout	2JCBPPEFU	1	134	558	295					160.2906	0.835981648	96.35942469				
058	J.C.Boyle BP_upper	08/08/02	1155	Redband trout	3JCBPPEFU	1	139	576	198					163.3722	0.850817948	83.94050763				
059	Boyle BP upper	10/19/02	1230	RBT	BBPEF4	1	150	648	374					175.6986	0.853734748	109.9523275				

Sample No.	Sample Location	Date	Time	Fish Species	Fish ID No.	Est. Age	Fork Length (mm)	Total Scale Radius (um)	1st Annulus (um)	2nd Annulus (um)	3rd Annulus (um)	4th Annulus (um)	5th Annulus (um)	Estimated Average Fork Length (mm)	Correction Factor	Estimated Length at Age 1 (mm)	Estimated Length at Age 2 (mm)	Estimated Length at Age 3 (mm)	Estimated Length at Age 4 (mm)	Estimated Length at Age 5 (mm)
060	3A JCB By-pass lower	05/24/02	0937	Red Band Trout	3A	2	170	1031	471	734				241.2682	0.704610056	102.4476247	134.1731152			
061	Boyle BP upper	10/19/02	1400	RBT	BBPEF11	1	218	646	313					175.3562	1.243183874	147.1265846				
062	Boyle BP upper	10/19/02	1230	RBT	BBPEF2	2	223	999	423	776				235.7898	0.94575762	129.7377062	186.8932439			
063	Boyle BP upper	10/19/02	1130	RBT	BBPEF1	2	190	816	222	613				204.4602	0.929276211	95.49930011	157.7043063			
064	Boyle BP lower	10/21/02	1210	RBT	BBPL24	1	188	625	289					171.761	1.094544163	125.0383172				
065	Boyle BP lower	10/21/02	1330	RBT	BBPL32	2	207	583	193	462				164.5706	1.257818833	123.0179522	180.9440313			
066	J.C.Boyle BP - lower	08/06/02	1220	Redband trout	3JCBPEFL	1	192	817	442					204.6314	0.938272425	131.7629103				
067	J.C.Boyle Bypass - lower	08/05/02	1620*	RB Rainbow	6JCB(PS)	1	180	826	438					206.1722	0.8730566	122.0066915				
068	J.C.Boyle Bypass - upper	06/08/02	0950	Redband rainbow	1JCB(PS) - Upper	2	165	598	162	299				167.1386	0.987204631	91.31188726	114.4661796			
069	Lower JC Boyle bypass	10/22/02	1430	RBT	LJCBGA10	3	183	827	192	387	615			206.3434	0.886871109	86.58646799	116.1937731	150.8115452		
070	Boyle BP lower	10/22/02	1300	RBT	BPLCS 6	3	216	840	244	479	767			208.569	1.035628497	110.3294392	151.9948449	203.0571293		
071	J.C.Boyle Bypass - lower	10/22/02	1020	RBT	JCBBLDM6	2	224	1022	197	588				239.7274	0.93439465	92.02609964	154.57373			
072	Lower JC Boyle bypass	10/22/02	1450	RBT	LJCBGA12	3	256	810	653	475	199			203.433	1.258399571	222.176233	183.8282678	124.367378		
073	J.C.Boyle Bypass - upper	10/20/02	0935	RBT	JCBUDM19	2	224	909	472	769				220.3818	1.016417871	147.9573068	199.6384965			
074	J.C.Boyle Bypass - upper	10/20/02	1005	RBT	JCBUDM23	2	250	1111	274	658				254.9642	0.980529816	109.4955684	173.9563829			
075	J.C.Boyle Bypass - upper	10/20/02	1220	RBT	JCBUDM 51	4	300	1353	230	375	642	1235		296.3946	1.012164189	105.4037422	130.529706	176.796136	279.5526639	
076	J.C.Boyle Bypass - upper	10/20/02	1050	RBT	JCBUDM 35	3	292	1317	210	534	861			290.2314	1.006093758	101.3267207	157.1335341	213.4570774		
077	J.C.Boyle Bypass - lower	10/22/02	1220	RBT	JCBBLDM 13	3	238	1202	434	627	980			270.5434	0.879710982	122.3341926	151.401251	204.5653525		
078	Lower JC Boyle bypass	10/22/02	0933	RBT	LJCBGA2	3	248	1006	333	549	795			236.9882	1.046465605	127.4287446	166.1262054	210.1983137		
079	Boyle BP lower	10/22/02	1220	RBT	BPLCS 5	3	290	1317	415	619	1041			290.2314	0.999202705	135.7007202	170.5976748	242.7864731		
080	J.C.Boyle Bypass - lower	05/24/02	1415*	RT		5	2	178	906	395	649			219.8682	0.809575919	107.175708	142.3799549			
081	J.C.Boyle Bypass - lower	05/24/02	1430*	RT		6	1	175	797	524				201.2074	0.869749323	134.350004				
082	JCB Bypass - lower	05/24/02	1045	RT	#1	2	194	967	516	882				230.3114	0.842337809	128.962087	181.7423002			
083	J.C.Boyle BP - upper	08/08/02	1615*	Redband trout	1JCBBU-(PS)	2	219	1067	284	778				247.4314	0.885093808	100.3535291	175.2083907			
084	J.C.Boyle BP - lower	08/06/02	1220	Redband trout	4JCBPEFL	2	205	839	202	560				208.3978	0.983695605	97.72366599	158.0139762			
085	J.C.Boyle BP - L	08/06/02	1300	Redband trout	9JCBPEFL	2	223	714	243	484				186.9978	1.192527399	126.8403147	176.0430411			
086	GA1	08/05/02	1300	RBT	LJCBGA1	2	196	906	328	747				219.8682	0.891443146	107.7884915	171.7342044			
087	J.C.Boyle Bypass	06/02/02	2030	Redband trout	9PS	2	240	744	187	606				192.1338	1.249129513	120.8850083	210.4885658			
088	J.C.Boyle BP Lower	08/07/02	1045	Redband trout	4CSJCBPFPL	4	215	1177	228	383	655	1046		266.2634	0.807471098	83.81113965	105.2381927	142.8392149	196.8906842	
089	J.C.Boyle BP Lower	08/07/02	1140	Redband trout	6CSJCBPFPL	2	211	984	391	809				233.2218	0.90471817	119.1515639	183.8946436			
090	Keno Reach, Lower	08/02/02	1030	Redband trout	4KRLEF	1	101	337	123					122.4554	0.824790087	70.78233055				
091	Keno R. Lower EF	08/02/02	0925	Redband trout	1KRLEF	1	124	452	245					142.1434	0.872358477	93.08501133				
092	Keno Reach, Lower	08/02/02	1030	Redband trout	8 KRLEF	0	76	260						109.273	0.695505752					
093	Keno Reach, Lower	08/02/02	1140	Redband trout	13 KRLEF	1	102	466	209					144.5402	0.705686031	70.95094375				
094	Keno Reach, Lower	08/02/02	1235	Redband trout	14KRLEF	1	118	462	175					143.8554	0.82026813	77.69661758				
095	Upper Keno	10/12/02	1500	RBT	KUDM8	2	172	770	227	598				196.585	0.874939594	90.66421548	146.2361788			
096	NA	10/13/02	0930	RBT	KLEF4	1	109	574	191					163.0298	0.668589424	65.16085893				
097	NA	10/13/02	1320	RBT	KLEF48	1	150	673	250					179.9786	0.833432419	89.64482444				
098	NA	10/13/02	1320	RBT	KLEF47	1	129	565	160					161.489	0.798816018	73.61329255				
099	LK ' Lower Keno	10/14/02	1615	RBT	KLDM23	1	121	600	160					167.481	0.722470012	66.57777897				
100	Keno Reach - Lower	06/05/02	1812	Redband rainbow	54KR(EF)	2	187	664	231	384				178.4378	1.047984228	109.3133484	136.7638281			
101	Keno Reach - Lower	06/05/02	1621	Redband rainbow	48KR(EF)	1	143	662	326					178.0954	0.802940447	96.81229611				
102	Keno Reach - Lower	06/05/02	1539	Redband rainbow	39KR(EF)	1	136	443	255					140.6026	0.967265186	104.8679896				
103	Keno Reach - Lower	06/05/02	1302*	Redband rainbow	11KR(EF)	1	103	312	191					118.1754	0.871585795	84.94492593				
104	Keno Reach, Lower	10/14/02	1530	RBT	KLCS6	1	139	509	129					151.9018	0.915064864	79.46954019				
106	Keno Reach	06/05/02	1320*	Redband rainbow	23KR(EF)	2	227	696	205	497				183.9162	1.234257776	123.2492787	184.9503187			
107	LK Lower Keno	10/14/02	1040	RBT	KLDM6	2	256	665	201	464				178.609	1.433298434	142.143359	206.6784809			
108	LK Lower Keno	10/14/02	1130	RBT	KLDM10	2	254	985	194	452				233.393	1.088293136	106.6242141	154.6936866			
109	LK Lower Keno	10/14/02	1232	RBT	KLDM13	1	231	1006	533					236.9882	0.974732075	152.0685359				
110	LK Lower Keno	10/14/02	1345	RBT	KLDM18	3	270	1160	244	672	910			263.353	1.025239887	109.2227011	184.3457185	226.1197328		
111	Keno Lower	10/14/02	1135	RBT	KLGA2	2	221	794	262	585				200.6938	1.101180007	120.7062869	181.5988994			
112	Keno Reach, Lower	10/14/02	1640	RBT	KLCS9	3	224	747	197	365	586			192.6474	1.162746032	114.5158336	147.9582699	191.9509986		
113		10/13/02	1015	RBT	KLEF11	2	290	1254	357	778				279.4458	1.037768326	130.6336542	205.4310138			
114	Keno Reach Upper	10/12/02	1030	Redband rainbow trout	KUDM19	4	277	1064	290	432	693	873		246.9178	1.121830828	128.3475432	155.6196993	205.7466906	240.3170294	

Sample No.	Sample Location	Date	Time	Fish Species	Fish ID No.	Est. Age	Fork Length (mm)	Total Scale Radius (um)	1st Annulus (um)	2nd Annulus (um)	3rd Annulus (um)	4th Annulus (um)	5th Annulus (um)	Estimated Average Fork Length (mm)	Correction Factor	Estimated Length at Age 1 (mm)	Estimated Length at Age 2 (mm)	Estimated Length at Age 3 (mm)	Estimated Length at Age 4 (mm)	Estimated Length at Age 5 (mm)
115	Keno Reach Upper	10/12/02	1230	Redband rainbow trout	KUDM5	3	289	1003	308	568	765			236.4746	1.22211857	143.5874441	197.9863859	239.2040456		
116	Keno Reach	08/01/02	1020	RB Rainbow	1KRL(PS)	2	215	1113	192	541				255.3066	0.842124724	82.21781576	132.5337575			
117	LKGA1	08/01/02	1430*	RBT	LKGA1	3	243	962	269	502	841			229.4554	1.059029336	117.3550651	159.5993217	221.0619955		
118	LKGA2	08/01/02	1445*	RBT	LKGA2	3	212	953	218	442	648			227.9146	0.930172968	94.95447505	130.6254922	163.4300883		
119	LK Keno Reach Lower	10/14/02	1630	RBT	KLDM25	3	386	1028	213	552	949			240.7546	1.603292315	162.2958299	255.3457853	364.3157921		
120	Keno Reach - Upper	10/11/02	1010	Redband trout	KUEF1	4	311	1627	333	796	1035	1360		343.3034	0.905904223	110.3125008	182.1195427	219.1862446	269.5907556	
121	Keno Reach, Upper	10/12/02	1155	Redband trout	KUCS2	3	345	1519	164	787	1129			324.8138	1.06214699	98.60738983	211.8934386	274.0825698		
122	Keno upper	10/12/02	1535	RBT	KUDM9	4	377	1542	206	403	710	1294		328.7514	1.146763177	114.7086564	153.3848501	213.6568878	328.3111877	
123	Keno Reach, Lower	08/02/02	1115	Redband trout	9KRLEF	2	222	721	283	568				188.1962	1.179619992	133.5454871	191.1015058			
124	Keno Reach, Lower	08/01/02	1025	Redband trout	1CSKRL	2	234	1346	271	749				295.1962	0.792693131	88.11275619	152.9816888			
125	Keno Reach, Lower	08/01/02	1350	RB Rainbow	3KRL(PS)	3	240	1199	151	462	765			270.0298	0.888790793	80.53528907	127.857355	173.9621331		
127	Keno Reach - Lower	08/01/02	1435	RB Rainbow	5KRL(PS)	5	334	1575	176	369	814	985	1333	334.401	0.998800841	94.77840916	127.780387	203.8730303	233.1131247	292.6192816
128	Keno Reach - Lower	06/06/02	1520	Redband Rainbow	6KRL(PS)	3	245	1315	199	469	820			289.889	0.845151075	83.52611172	122.592375	173.3785173		
129	Keno Reach - Lower	06/06/02	1300	Redband Rainbow	5KRL(PS)	2	225	1055	239	529				245.377	0.916956357	96.9019305	142.4269797			
130	Keno Reach - Lower	06/06/02	1205	Redband Rainbow	4KRL(PS)	2	250	1001	262	650				236.1322	1.058728966	116.0529991	186.3797059			

Table 3. Fish Capture, Scale, and Age Data from the Second Group of Scale Samples

Sample No.	Sample Location	Date	Time	Fish Species	Fish ID No.	Est. Age	Fork Length (mm)	Total Scale Radius (um)	1st Annulus (um)	2nd Annulus (um)	3rd Annulus (um)	4th Annulus (um)	5th Annulus (um)	Estimated Average Fork Length (mm)	Correction Factor	Estimated Length at Age 1 (mm)	Estimated Length at Age 2 (mm)	Estimated Length at Age 3 (mm)	Estimated Length at Age 4 (mm)	Estimated Length at Age 5 (mm)
131	Keno Reach Upper	6/4/02	0.61875	Redband trout	2KRCS	2	293	1291	342	877				285.7802	1.025263	126.426674	220.332606			
132	1 LK(GA)	6/6/02		RBT		2	263	1225	179	592				274.481	0.958172	91.4151632	159.163287			
133	Keno Reach Lower	6/6/02	16:30	Redband trout	7KRL(PS)	3	240	1107	386	629	753			254.2794	0.943844	123.496469	162.761875	182.798544		
134	Keno Reach Lower	6/6/02	10:30	Redband trout	1KRL(PS)	2	245	1020	255	580				239.385	1.023456	110.960023	167.905111			
135	Keno Reach Lower	6/6/02	11:20	Redband trout	2 KRL(PS)	2	275	1117	267	707				255.9914	1.074255	118.674436	199.595904			
136	Keno Reach Lower	6/6/02	11:45	Redband trout	3 KRL (PS)	3	270	1099	496	688	975			252.9098	1.067574	159.790463	194.882057	247.336679		
137	Lk Lower Keno	10/14/02	10:00	RBT	KLDM 2	2	256	1254	255	747				279.4458	0.916099	99.3206983	176.484078			
138	Lk Lower Keno	10/14/02	12:45	RBT	KLDM 14	2	298	1331	320	628				292.6282	1.018357	121.739497	175.437059			
139	Lk Lower Keno	10/14/02	13:00	RBT	KUDM 15	2	246	809	186	509				203.2618	1.210262	116.916377	183.840952			
140	Lk Lower Keno	10/14/02	12:30	RBT	KLDM 12	3	266	1132	281	751	1001			258.5594	1.028777	116.116224	198.895748	242.927409		
141	Lk Lower Keno	10/14/02	11:45	RBT	KLDM 11	3	261	1110	224	500	964			254.793	1.024361	105.621653	154.023937	235.395893		
142	Lk Lower Keno	10/14/02	11:30	RBT	KLDM 9	3	246	878	149	384	520			215.0746	1.143789	103.24962	149.266547	175.897619		
143	Lk Lower Keno	10/14/02	10:15	RBT	KLDM3	2	206	897	237	696				218.3274	0.943537	99.387857	173.531756			
144	Keno Reach Lower	10/14/02	10:40	RBT	KLCS 1	3	278	911	195	446	661			220.7242	1.25949	123.61268	177.734492	224.093813		
145	Keno Reach Upper	10/12/02	10:32	Redband trout	KUDM 2	3	254	1145	257	572	1024			260.785	0.973982	105.929741	158.454664	63.0760742		
146	Keno Reach Upper	10/2/02	12:15	Redband trout	KUDM 4	1	244	1089	492					251.1978	0.971346	144.722213				
147	Keno Reach Lower	10/14/02	10:50	Redband trout	KLGA1	1	222	812	497					203.7754	1.089435	163.248963				
148	Keno Reach Upper	10/12/02	4:05	Redband trout	KUDM 12	3	264	1269	252	714	1149			282.0138	0.936124	101.011006	175.053204	244.76826		
149	Keno Reach Upper	6/4/02	11:54	Redband trout	1 KRCS	5	389	1955	258	633	846	1268	1665	399.457	0.973822	106.079011	168.598381	204.109383	274.464514	340.651687
150	Keno Reach Upper	6/4/02	17:00	Redband trout	3 KR (PS)	3	354	1637	536	1016	1500			345.0154	1.026041	160.600271	244.916229	329.93482		
151	Lk Lower Keno	10/14/02	15:30	RBT	KLDM 20	1	226	1073	624					248.4586	0.909608	156.079503				
152	Keno Reach Upper	7/31/02	9:15	Redband trout	1 KRU (PS)	4	397	2053	223	765	1376	1692		416.2346	0.953789	98.1817086	186.684175	286.453561	338.052785	
153	Keno Reach Upper	6/3/02	15:50	Redband trout	2KR	3	353	1520	373	844	1198			324.985	1.086204	139.706035	227.29231	293.121485		
154	Lk Lower Keno	10/14/02	13:30	RBT	KUDM 17	3	339	1183	229	519	762			267.2906	1.268283	131.858008	194.8257	247.588283		
155	Keno Reach Upper	10/12/02	9:45	Redband trout	KUCS1	3	342	1197	417	618	779			269.6874	1.268135	172.65834	216.296383	251.250239		
156	Keno Reach Upper	10/12/02	13:45	Redband trout	KUCS4	3	384	1659	575	818	1443			348.7818	1.100975	179.680201	225.482518	343.28683		
157	Keno Reach Upper	10/13/02	13:00	Redband trout	KUDM 3	4	386	1895	360	537	1330	1738		389.185	0.991816	125.358629	155.413041	290.0636	359.341567	
158	Keno Reach Upper	12/12/02	16:00	Redband trout	KUDM 10	3	309	1232	192	478	975			275.6794	1.120867	109.431835	164.31308	259.683636		
159	Keno Reach Upper	10/12/02	16:00	Redband trout	KUDM 11	3	343	1478	263	603	1285			317.7946	1.079313	118.494159	181.318839	307.337755		
160	Lk Lower Keno	10/14/02	11:15	RBT	KLAM 8	3	452	1655	532	859	1395			348.097	1.298489	202.355691	275.048201	394.201674		
161	Keno Reach Upper	6/4/02	18:40	Redband trout	4 KR (PS)	5	466	1659	158	591	816	1010	1351	348.7818	1.336079	122.666204	221.709198	273.174957	317.549878	395.549095
162	Keno Reach Upper	6/4/02	12:10	Redband trout	1 KR(PS)	3	413	2002	610	1313	1646			407.5034	1.013488	171.475156	293.452142	351.230715		
163	Keno	6/4/02		RBT	1 KRGA	4	470	2197	335	844	1625	2058		440.8874	1.066032	130.176344	223.07121	365.607341	444.631854	
164	Keno Reach Lower	8/1/02	13:45	Redband trout	2 CS KRL	5	403	2502	218	623	1118	1819	2093	493.1034	0.817273	83.4293331	140.09576	209.354727	307.436618	345.773904
165	Keno Reach Upper	7/31/02	10:00	Redband trout	2 KRU(PS)	4	430	1842	246	665	1308	1596		380.1114	1.131247	120.903414	202.050951	326.580466	382.357293	
166	Keno Reach Upper	10/12/02	13:10	Redband trout	KUCS 3	5	476	1960	300	489	963	1365	1640	400.313	1.18907	138.075946	176.550431	273.041999	354.876619	410.858014
167	Keno Reach Upper	6/3/02	16:30	Redband trout	3 KR	4	469	1918	207	725	1464	1716		393.1226	1.193012	119.539092	225.33731	376.273377	427.74278	
168	Lk Lower Keno	10/14/02	15:00	RBT	KLDM 19	5	426	1896	166	476	888	1402	1774	389.3562	1.094114	101.949745	160.016553	237.189215	333.467731	403.147901
169	Lk Lower Keno	10/14/02	10:45	RBT	KLDM 7	2	228	955	215	640				228.257	0.998874	101.454641	174.132719			
170	JC Boyle Bypass	10/22/02	13:55	RBT	JCBBLDM 26	2	230	1038	255	797				242.4666	0.948584	102.84266	190.862172			
171	Lower JC Boyle Bypass	10/22/02	12:30	RBT	LJCBGA5	2	301	1269	458	882				282.0138	1.067324	152.809368	230.285112			
172	JC Boyle Bypass Upper	10/20/02	8:40	RBT	JCBUDM 9	3	265	1053	193	450	888			245.0346	1.08148	105.771548	153.354934	234.450355		
173	JC Boyle Bypass Upper	10/20/02	9:30	RBT	JCBUDM 18	3	261	1010	312	559	912			237.673	1.098147	129.774015	176.210717	242.575721		
174	Lower JC Boyle Bypass	10/22/02	13:55	RBT	LJCBGA9	2	258	1009	382	844				237.5018	1.086308	141.39314	227.313984			
175	JC Boyle Bypass Upper	10/20/02	9:25	RBT	JCBUDM 17	3	281	958	258	439	611			228.7706	1.228305	133.799966	171.861689	208.030841		
176	JC Boyle Bypass Upper	10/19/02	14:00	RBT	BBPEF10	1	231	842	428					208.9114	1.105732	152.629261				
177	JC Boyle Bypass Upper	10/20/02	8:15	RBT	JCBUDM 4	1	238	965	394					229.969	1.034922	136.830983				
178	JC Boyle Bypass Upper	6/8/02		RBT	1 JC BB(GA)	2	242	994	291	739				234.9338	1.030077	118.026476	197.030941			
179	JC Boyle Bypass Upper	8/7/02	15:20	Rainbow	2 JCBBU(PS)	3	315	1419	309	699	1103			307.6938	1.023745	120.455684	188.809092	259.616213		
180	JC Boyle Bypass Upper	10/20/02	8:10	RBT	JCBUDM 3	2	241	1148	503	932				261.2986	0.922316	139.154127	206.893475			
181	JC Boyle Bypass Upper	10/20/02	11:50	RBT	JCBUDM 46	1	256	1194	565					269.1738	0.951058	153.585468				

Sample No.	Sample Location	Date	Time	Fish Species	Fish ID No.	Est. Age	Fork Length (mm)	Total Scale Radius (um)	1st Annulus (um)	2nd Annulus (um)	3rd Annulus (um)	4th Annulus (um)	5th Annulus (um)	Estimated Average Fork Length (mm)	Correction Factor	Estimated Length at Age 1 (mm)	Estimated Length at Age 2 (mm)	Estimated Length at Age 3 (mm)	Estimated Length at Age 4 (mm)	Estimated Length at Age 5 (mm)
182	JC Boyle Bypass Upper	10/20/02	14:40	RBT	BBPCS 17	2	230	785	290	560				199.153	1.154891	132.12992	185.5136			
183	Lower JC Boyle Bypass	8/7/02	13:17	Redband trout	BCSJCBPF FL	2	227	1070	237	838				247.945	0.915526	96.4372575	190.636787			
184	Lower JC Boyle Bypass	10/22/02	15:15	RBT	LJCBGS13	2	272	1147	355	921				261.1274	1.041637	130.764003	231.697809			
185	JC Boyle Bypass Upper	10/20/02	8:05	RBT	JCBUDM 2	2	253	1191	254	662				268.6602	0.94171	101.936154	167.714221			
186	JC Boyle Bypass Upper	10/20/02	8:17	RBT	JCBUDM 5	1	234	839	446					208.3978	1.122853	158.452684				
187	Lower JC Boyle Bypass	10/22/02	14:10	RBT	JCBBLDM 31	3	267	1118	479	680	975			256.1626	1.042307	152.97498	188.842005	241.482664		
188	Lower JC Boyle Bypass	8/7/02	13:25	Rainbow	4 JCBBL (PS)	2	236	1269	460	1039				282.0138	0.836838	120.097201	203.048648			
189	JC Boyle Bypass Upper	10/20/02	10:58	RBT	UJCBGS 4	1	238	987	340					233.7354	1.018245	125.212621				
190	Lower JC Boyle Bypass	10/22/02	9:55	RBT	JCBBLDM 3	2	253	1047	374	774				244.0074	1.036854	133.536194	204.539942			
191	Lower JC Boyle Bypass	12/22/02	14:04	RBT	JCBBLDM 30	3	256	1059	202	626	943			246.0618	1.040389	103.355785	178.876377	235.338706		
192	Lower JC Boyle Bypass	10/22/02	14:50	RBT	JCBBLDM 36	3	255	1399	315	796	1186			304.2698	0.838072	99.4699277	168.48281	224.439202		
193	JC Boyle Bypass Upper	10/20/02	10:20	RBT	JCBUDM 25	2	242	1108	247	645				254.4506	0.951069	101.809431	166.612969			
194	JC Boyle Bypass Upper	10/20/02	10:30	RBT	JCBUDM 31	2	243	907	173	544				220.0394	1.104348	104.226788	174.369651			
195	JC Boyle Bypass Upper	10/20/02	14:50	RBT	JCBUDM 65	1	246	764	300					195.5578	1.25794	146.073263				
196	Lower JC Boyle Bypass	10/22/02	10:45	RBT	JCBBLDM 9	2	256	1124	456	953				257.1898	0.995374	142.167455	226.860232			
197	JC Boyle Bypass Upper	10/20/02	11:30	RBT	JCBUDM 42	1	230	830	388					206.857	1.111879	145.863655				
198	JC Boyle Bypass Upper	10/20/02	9:55	RBT	BBPCS 5	2	235	1191	413	748				268.6602	0.874711	118.494109	168.660527			
199	JC Boyle Bypass Upper	10/20/02	11:15	RBT	JCBUDM 39	3	251	1291	222	658	1184			285.7802	0.878297	90.2603378	155.819265	234.910997		
200	JC Boyle Bypass Upper	10/20/02	14:38	RBT	JCBUDM 64	3	239	1114	201	644	977			255.4778	0.935502	92.7757942	163.725765	217.058361		
201	JC Boyle Bypass Upper	10/20/02	16:00	RBT	JCBUDM 75	2	273	1461	362	1069				314.8842	0.866985	109.87774	214.816264			
202	JC Boyle Bypass Upper	10/20/02	10:55	RBT	JCBUDM 36	1	231	1071	534					248.1162	0.931015	145.407659				
203	Lower JC Boyle Bypass	10/22/02	13:20	RBT	LJCBGA 6	2	264	1070	392	758				247.945	1.064752	140.410372	207.126897			
204	JC Boyle Bypass Upper	10/20/02	11:44	RBT	UJCBGA 6	2	244	810	365	587				203.433	1.199412	152.623989	198.209325			
205	Lower JC Boyle Bypass	12/22/02	14:15	RBT	JCBBLDM 33	2	244	1024	287	759				240.0698	1.016371	115.75999	197.889277			
206	JC Boyle Bypass Upper	10/20/02	14:25	RBT	UJCBGS 10	2	260	949	354	623				227.2298	1.144216	143.445569	196.139925			
207	Lower JC Boyle Bypass	10/22/02	15:01	RBT	JCBBLDM 38	2	231	977	408	756				232.0234	0.995589	134.016865	193.331682			
208	JC Boyle Bypass Upper	10/20/02	11:25	RBT	JCBUDM 41	3	261	1071	244	550	896			248.1162	1.051926	112.065725	167.173208	229.484283		
209	JC Boyle Full Flow	10/15/02	12:50	RBT	JFFGA3	2	241	1200	157	679				270.201	0.891929	81.7358019	161.44425			
210	JC Boyle Full Flow	8/11/02	16:40	RBT	JCBFFGA 2	5	369	2254	280	611	1209	1746	1985	450.6458	0.818825	92.2791092	138.679623	222.508951	297.787126	331.290821
211	JC Boyle Full Flow Cali	6/25/02	10:05	Redband trout	4CS	4	282	1296	405	607	868	1083		286.6362	0.983825	131.928047	165.951093	209.911565	246.124213	
212	JC Boyle Full Flow Cali	10/18/02	13:20	RBT	33 DBC	3	338	1129	370	767	986			258.0458	1.309845	167.797693	256.823142	305.932899		
213	JC Boyle Full Flow Frane Ranch	8/11/02	11:50	Redband trout	2 CSJCBFF-FF	3	263	1174	319	680	892			265.7498	0.989653	118.1386	179.302302	215.221152		
214	JC Boyle Full Flow Frane Ranch	10/15/02	15:37	RBT	JCFFDM 18	2	285	1628	432	1191				343.4746	0.829756	115.10321	222.922327			
215	JC Boyle Full Flow Frane Ranch	10/15/02	15:00	RBT	JCFFDM 13	2	283	1325	347	809				291.601	0.970504	120.504985	197.266434			

Sample No.	Sample Location	Date	Time	Fish Species	Fish ID No.	Est. Age	Fork Length (mm)	Total Scale Radius (um)	1st Annulus (um)	2nd Annulus (um)	3rd Annulus (um)	4th Annulus (um)	5th Annulus (um)	Estimated Average Fork Length (mm)	Correction Factor	Estimated Length at Age 1 (mm)	Estimated Length at Age 2 (mm)	Estimated Length at Age 3 (mm)	Estimated Length at Age 4 (mm)	Estimated Length at Age 5 (mm)	
216	JC Boyle Full Flow Cali	10/18/02	14:15	RBT	77 C	1	240	1003	525					236.4746	1.014908	156.946412					
217	UPPER	10/17/02	14:10	RBT	JCFFUDM 15	2	249	999	277	707				235.7898	1.056025	118.468511	196.208872				
218	JC Boyle Full Flow	6/7/02		RBT	G JCB-FF(GA)	3	269	1207	384	593	946			271.3994	0.991159	129.348054	164.812521	224.711837			
219	JC Boyle Full Flow	10/15/02	13:40	RBT	JFFGA 12	3	306	1397	485	882	1079			303.9274	1.006819	148.800858	217.230748	251.187141			
220	JC Boyle Full Flow Cali	8/13/02	12:25	RBT	JCBCAGA4	3	407	1686	278	910	1368			353.4042	1.151656	129.393828	254.001144	344.302015			
221	JC Boyle Full Flow	10/15/02	14:45	RBT	J77GA10	3	367	1586	388	993	1336			336.2842	1.091339	143.169028	256.205537	320.290699			
222	JC Boyle Full Flow	8/13/02	11:17	Redband trout	3CSJCBFF-FF CA	2	261	1473	219	640				316.9386	0.823503	84.2063472	143.560516				
223	JC Boyle Full Flow Frane Ranch	10/15/02	12:00	RBT	JCFFDM 7	2	254	1139	280	731				259.7578	0.977834	110.198955	185.698689				
224	JC Boyle Full Flow	10/15/02	10:50	RBT	J77GA1	2	244	1088	354	932				251.0266	0.972009	121.856629	218.040373				
225	JC Boyle Full Flow Cali	8/13/02	11:05	Redband trout	2CSJCBFF-FF CA	2	233	1025	259	546				240.241	0.969859	105.81341	153.466871				
226	UPPER	10/17/02	15:30	RBT	JCFFUDM 23	3	297	1305	178	706	1086			288.177	1.030617	98.1503597	191.311504	258.359298			
227	JC Boyle Full Flow	6/25/02	11:50	RBT	CGA4	2	254	1059	405	867				246.0618	1.032261	138.423103	220.069168				
228	JC Boyle Full Flow	6/7/02		RBT	4 JCB-FF(GA)	2	295	1394	337	1162				303.4138	0.97227	119.059657	256.383009				
229	JC Boyle Full Flow Cali	10/18/02	15:55	RBT	61 DBC	2	287	1103	246	544				253.5946	1.131728	120.954742	178.692766				
230	JC Boyle Full Flow Frane Ranch	10/15/02	11:50	RBT	JCFFDM 6	2	298	1281	460	925				284.0682	1.049044	150.551431	234.063714				
231	JC Boyle Full Flow	6/25/02	10:44	Redband trout	3 JCBFF (PS)	3	319	1329	538	722	1109			292.2858	1.091398	171.20382	205.583715	277.893603			
232	JC Boyle Full Flow Frane Ranch	10/15/02	10:50	RBT	JCFFDM 4	3	268	1261	272	783	1105			280.6442	0.954946	106.311633	189.853347	242.496072			
233	JC Boyle Full Flow Frane Ranch	8/11/02	16:23	RBT	5JCBFF(PS)	3	310	1243	368	737	1024			277.5626	1.116865	142.693598	213.249098	268.125598			
234	JC Boyle Full Flow	10/15/02	14:15	RBT	JFFGA9	2	250	1113	546	959				255.3066	0.979215	154.947228	224.183198				
235	JC Boyle Full Flow Frane Ranch	10/15/02	15:40	RBT	JCFFDM 19	4	306	1377	261	632	945	1184		300.5034	1.018291	111.446077	176.123054	244.46099	272.354026		
236	JC Boyle Full Flow	10/15/02	13:20	RBT	JFFGA6	2	273	1097	337	850				252.5674	1.0809	132.361992	227.292647				
237	JC Boyle Full Flow	6/7/02		RBT	7 JCB-FF(GA)	2	271	1253	294	935				279.2746	0.970371	111.683697	218.171445				
238	JC Boyle Full Flow	6/7/02		RBT	5 JCB-FF(GA)	2	263	1194	480	910				269.1738	0.977064	143.566837	215.494372				
239	JC Boyle Full Flow Cali	10/18/02		RBT	JCFFCA 1 EF	1	247	890	391					217.129	1.137573	149.818538					
240	JC Boyle Full Flow	8/11/02	15:52	RBT	4 JCBFF(PS)	2	280	1162	422	935				263.6954	1.061831	145.47873	238.734692				
241	JC Boyle Full Flow	10/15/02	13:15	RBT	JFFGA 5	2	304	1025	288	781				240.241	1.265396	144.339419	251.140866				
242	JC Boyle Full Flow Cali	8/13/02	9:30	Redband trout	1 CS JCBFF-FF CA	2	254	1361	388	964				297.7642	0.853024	111.905314	196.023032				
243	JC Boyle Full Flow	5/23/02		RBT		6	233	1143	504	829				260.4426	0.894631	135.130241	184.907505				
244	JC Boyle Full Flow Frane Ranch	10/15/02	15:35	RBT	JCFFDM 17	1	243	1614	702					341.0778	0.712447	131.762449					
245	JC Boyle Full Flow	6/7/02	17:00	Redband trout	4 JCB-FF(PS)	4	325	1366	274	471	1066	1261		298.6202	1.088339	121.534595	158.24035	269.102911	305.436019		
246	JC Boyle Full Flow	5/23/02		RBT		2	4	325	1896	362	735	1370	1693	389.3562	0.834711	105.787464	159.090121	249.83325	295.990779		
247	JC Boyle Full Flow Cali	8/13/02	14:48	RBT	11 JCBC (PS)	2	280	1415	463	1028				307.009	0.912025	131.355915	219.574306				

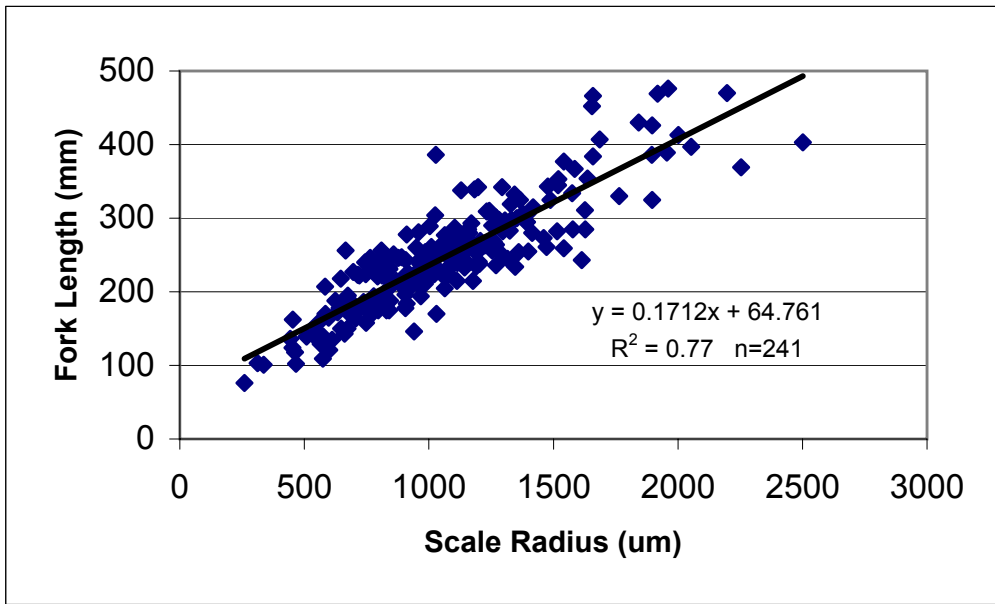


Figure 1. Fork Length-Scale Radius Regression Based on All Scale Samples