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Table 3-9. Typical Exposure Factors for the Columbia River – Fish Over 2 g, Speed 0.1 m/s

Fish Speed 0.1 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
PIER #2	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	67	102	180	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	67	237	310	0.00014
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	67	9	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	67	67	223	0.00277
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	67	48	118	0.00018
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	67	111	197	0.00061
Totals		**2100**		**0.7500**					**0.00441**
PIER #3	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	209	102	226	0.00011
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	209	237	452	0.00021
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	209	9	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	209	67	312	0.00387
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	209	48	118	0.00018
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	209	111	260	0.00081
Totals		**2100**		**0.7500**					**0.00579**
PIER #4	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	351	102	226	0.00011
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	351	237	486	0.00023
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	351	9	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	351	67	312	0.00387
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	351	48	118	0.00018
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	351	111	260	0.00081
Totals		**2100**		**0.7500**					**0.00581**

Fish Speed 0.1 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
PIER #5	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	493	102	226	0.00011
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	493	237	486	0.00023
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	493	9	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	493	67	312	0.00387
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	493	48	118	0.00018
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	493	111	260	0.00081
Totals		**2100**		**0.7500**					**0.00581**
PIER #6	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	635	102	226	0.00011
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	635	237	408	0.00019
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	635	9	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	635	67	312	0.00387
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	635	48	118	0.00018
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	635	111	260	0.00081
Totals		**2100**		**0.7500**					**0.00577**
PIER #7	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	777	102	136	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	777	237	266	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	777	9	73	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	777	67	179	0.00222
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	777	48	82	0.00013
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	777	111	153	0.00048
Totals		**2100**		**0.7500**					**0.00347**

Table 3-10. Typical Exposure Factors for the Columbia River – Fish Over 2 g, Speed 0.8 m/s

Fish Speed 0.8 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
PIER #2	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	67	102	169	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	67	237	304	0.00014
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	67	9	18	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	67	67	134	0.00277
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	67	48	96	0.00018
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	67	111	178	0.00061
Totals		**2100**		**0.7500**					**0.00270**
PIER #3	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	209	102	204	0.00011
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	209	237	446	0.00021
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	209	9	18	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	209	67	134	0.00387
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	209	48	96	0.00018
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	209	111	222	0.00081
Totals		**2100**		**0.7500**					**0.00291**
PIER #4	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	351	102	204	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	351	237	474	0.00022
	Single pile driver: 18- to 24-inch pile (attenuated)	400	15	0.1667	5	351	9	18	0.00011
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	351	67	134	0.00166
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	351	48	96	0.00015
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	351	111	222	0.00069
Totals		**2100**		**0.7500**					**0.00293**

Fish Speed 0.8 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
PIER #5	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	493	102	204	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	493	237	474	0.00022
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1..5	0.1667	5	493	9	18	0.00011
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	493	67	134	0.00166
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	493	48	96	0.00015
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	493	111	222	0.00069
Totals		**2100**		**0.7500**					**0.00293**
PIER #6	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	635	102	204	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	635	237	402	0.00019
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	635	9	18	0.00011
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	635	67	134	0.00166
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	635	48	96	0.00015
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	635	111	222	0.00069
Totals		**2100**		**0.7500**					**0.00289**
PIER #7	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	777	102	125	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	777	237	260	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	777	9	18	0.00011
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	777	67	90	0.00112
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	777	48	71	0.00011
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	777	111	134	0.00042
Totals		2100		**0.7500**					**0.00194**

Table 3-11. Typical Exposure Factors for the Columbia River – Fish Over 2 g, Speed 0.6 m/s

Fish Speed 0.6 m/s dB SELcum Threshold = 183	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
PIER #2	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	67	205	272	0.00013
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	67	446	513	0.00024
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	67	50	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	67	235	302	0.00375
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	67	79	146	0.00023
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	67	209	276	0.00086
Totals		**2100**		**0.7500**					**0.00582**
PIER #3	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	209	205	410	0.00019
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	209	446	655	0.00030
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	209	50	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	209	235	444	0.00551
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	209	79	158	0.00024
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	209	209	418	0.00130
Totals		**2100**		**0.7500**					**0.00817**
PIER #4	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	351	205	410	0.00019
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	351	446	797	0.00037
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	351	50	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	351	235	470	0.00583
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	351	79	158	0.00024
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	351	209	418	0.00130
Totals		**2100**		**0.7500**					**0.00855**

Fish Speed 0.6 m/s dB SELcum Threshold = 183	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
PIER #5	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	493	205	410	0.00019
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	493	446	753	0.00035
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	493	50	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	493	235	470	0.00583
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	493	79	158	0.00024
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	493	209	418	0.00130
Totals		**2100**		**0.7500**					**0.00853**
PIER #6	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	635	205	370	0.00017
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	635	446	611	0.00028
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	635	50	100	0.00062
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	635	235	400	0.00497
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	635	79	158	0.00024
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	635	209	374	0.00116
Totals		**2100**		**0.7500**					**0.00745**
PIER #7	Single pile driver: 18- to 24-inch pile (unattenuated)	150	1.5	0.0625	1	777	205	228	0.00011
	Single pile driver: 36- to 48-inch pile (unattenuated)	150	1.5	0.0625	1	777	446	469	0.00022
	Single pile driver: 18- to 24-inch pile (attenuated)	400	1.5	0.1667	5	777	50	73	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	800	1.5	0.3333	5	777	235	258	0.00320
	Two pile drivers: each with 18- to 24-inch pile (attenuated)	200	0.75	0.0417	5	777	79	102	0.00016
	Two pile drivers: one 18- to 24-inch pile and one 36- to 48-inch pile, or two 36- to 48-inch piles (attenuated)	400	0.75	0.0833	5	777	209	232	0.00072
Totals		**2100**		**0.7500**					**0.00486**

Table 3-12. Typical Exposure Factors for North Portland Harbor – Fish Over 2 g, Speed 0.1 m/s

Fish Speed 0.1 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #1/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	25	71	96	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	25	153	178	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	25	72	97	0.00144
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	25	169	194	0.00289
Totals		**1950**		**0.8125**					**0.00450**
BRIDGE #1/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	60	71	131	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	60	153	213	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	60	72	132	0.00196
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	60	169	229	0.00341
Totals		**1950**		**0.8125**					**0.00559**
BRIDGE #1/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	117	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	117	153	270	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	117	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	117	169	286	0.00426
Totals		**1950**		**0.8125**					**0.00665**
BRIDGE #1/BENT #7	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	187	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	187	153	266	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	187	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	187	169	282	0.00420
Totals		**1950**		**0.8125**					**0.00659**
BRIDGE #1/BENT #8	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	243	71	128	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	243	153	210	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	243	72	129	0.00192
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	243	169	226	0.00336
Totals		**1950**		**0.8125**					**0.00549**

Fish Speed 0.1 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #1/BENT #9	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	284	71	87	0.00005
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	284	153	169	0.00010
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	284	72	88	0.00131
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	284	169	185	0.00275
Totals		**1950**		**0.8125**					**0.00422**
BRIDGE #2/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	31	71	102	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	31	153	184	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	31	72	103	0.00153
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	31	169	200	0.00298
Totals		**1950**		**0.8125**					**0.00469**
BRIDGE #2/BENT #7	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	109	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	109	153	262	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	109	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	109	169	278	0.00414
Totals		**1950**		**0.8125**					**0.00653**
BRIDGE #2/BENT #8	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	187	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	187	153	266	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	187	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	187	169	282	0.00420
Totals		**1950**		**0.8125**					**0.00659**
BRIDGE #2/BENT #9	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	264	71	107	0.00007
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	264	153	189	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	264	72	108	0.00161
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	264	169	205	0.00305
Totals		**1950**		**0.8125**					**0.00484**
BRIDGE #3/BENT #2	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	37	71	108	0.00007
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	37	153	190	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	37	72	109	0.00162
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	37	169	206	0.00307
Totals		**1950**		**0.8125**					**0.00487**

Fish Speed 0.1 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #3/BENT #3	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	115	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	115	153	268	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	15	0.3750	2	115	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	115	169	284	0.00423
Totals		**1950**		**0.8125**					**0.00662**
BRIDGE #3/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	193	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	193	153	260	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1..5	0.3750	2	193	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	193	169	276	0.00411
Totals		**1950**		**0.8125**					**0.00650**
BRIDGE #3/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	270	71	101	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	270	153	183	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	270	72	102	0.00152
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	270	169	199	0.00296
Totals		**1950**		**0.8125**					**0.00466**
BRIDGE #4/BENT #2	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	23	71	94	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	23	153	176	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	23	72	95	0.00141
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	23	169	192	0.00286
Totals		**1950**		**0.8125**					**0.00444**
BRIDGE #4/BENT #3	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	56	71	127	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	56	153	209	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	56	72	128	0.00190
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	56	169	225	0.00335
Totals		**1950**		**0.8125**					**0.00546**
BRIDGE #4/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	105	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	105	153	258	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	105	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	105	169	274	0.00408
Totals		**1950**		**0.8125**					**0.00647**

Fish Speed 0.1 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #4/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	184	71	142	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	184	153	269	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	15	0.3750	2	184	72	144	0.00214
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	184	169	285	0.00424
Totals		**1950**		**0.8125**					**0.00664**
BRIDGE #4/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	259	71	112	0.00007
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	259	153	194	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	15	0.3750	2	259	72	113	0.00168
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	259	169	210	0.00313
Totals		**1950**		**0.8125**					**0.00500**

Table 3-13. Typical Exposure Factors for North Portland Harbor – Fish Over 2 g, Speed 0.8 m/s

Fish Speed 0.8 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #1/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	25	67	92	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	25	153	178	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	25	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	25	66	91	0.00135
Totals		**1950**		**0.8125**					**0.00179**
BRIDGE #1/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	60	67	127	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	60	153	213	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	60	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	60	66	126	0.00188
Totals		**1950**		**0.8125**					**0.00235**
BRIDGE #1/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	117	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	117	153	270	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	117	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	117	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**
BRIDGE #1/BENT #7	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	187	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	187	153	266	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	187	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	187	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**
BRIDGE #1/BENT #8	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	243	67	124	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	243	153	210	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	243	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	243	66	123	0.00183
Totals		**1950**		**0.8125**					**0.00231**

Fish Speed 0.8 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #1/BENT #9	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	284	67	83	0.00005
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	284	153	169	0.00010
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	284	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	284	66	82	0.00122
Totals		**1950**		**0.8125**					**0.00164**
BRIDGE #2/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	31	67	98	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	31	153	184	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	31	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	31	66	97	0.00144
Totals		**1950**		**0.8125**					**0.00189**
BRIDGE #2/BENT #7	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	109	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	109	153	262	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	109	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	109	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**
BRIDGE #2/BENT #8	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	187	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	187	153	266	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	187	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	187	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**
BRIDGE #2/BENT #9	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	264	67	103	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	264	153	189	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	264	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	264	66	102	0.00152
Totals		**1950**		**0.8125**					**0.00197**
BRIDGE #3/BENT #2	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	37	67	104	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	37	153	190	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	37	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	37	66	103	0.00153
Totals		**1950**		**0.8125**					**0.00198**

Fish Speed 0.8 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #3/BENT #3	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	115	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	115	153	268	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	115	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	115	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**
BRIDGE #3/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	193	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	193	153	260	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	193	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	193	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**
BRIDGE #3/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	270	67	97	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	270	153	183	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	270	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	270	66	96	0.00143
Totals		**1950**		**0.8125**					**0.00187**
BRIDGE #4/BENT #2	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	23	67	90	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	23	153	176	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	23	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	23	66	89	0.00132
Totals		**1950**		**0.8125**					**0.00176**
BRIDGE #4/BENT #3	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	56	67	123	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	56	153	209	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	56	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	56	66	122	0.00182
Totals		**1950**		**0.8125**					**0.00229**
BRIDGE #4/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	105	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	105	153	258	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	105	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	105	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**

Fish Speed 0.8 m/s dB SELcum Threshold = 187	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #4/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	184	67	134	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	184	153	269	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	184	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	184	66	132	0.00196
Totals		**1950**		**0.8125**					**0.00248**
BRIDGE #4/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	259	67	108	0.00007
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	259	153	194	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	259	9	18	0.00027
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	259	66	107	0.00159
Totals		**1950**		**0.8125**					**0.00205**

Table 3-14. Typical Exposure Factors for North Portland Harbor – Fish Over 2 g, Speed 0.6 m/s

Fish Speed 0.6 m/s dB SELcum Threshold = 183	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #1/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	25	69	94	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	25	153	178	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	25	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	25	90	115	0.00171
Totals		**1950**		**0.8125**					**0.00233**
BRIDGE #1/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	60	69	129	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	60	153	213	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	60	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	60	90	150	0.00223
Totals		**1950**		**0.8125**					**0.00289**
BRIDGE #1/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	117	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	117	153	270	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	117	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	117	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00338**
BRIDGE #1/BENT #7	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	187	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	187	153	266	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	187	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	187	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00338**
BRIDGE #1/BENT #8	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	243	69	126	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	243	153	210	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	243	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	243	90	147	0.00219
Totals		**1950**		**0.8125**					**0.00284**

Fish Speed 0.6 m/s dB SELcum Threshold = 183	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #1/BENT #9	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	284	69	85	0.00005
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	284	153	169	0.00010
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	284	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	284	90	106	0.00158
Totals		**1950**		**0.8125**					**0.00218**
BRIDGE #2/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	31	69	100	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	31	153	184	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	31	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	31	90	121	0.00180
Totals		**1950**		**0.8125**					**0.00242**
BRIDGE #2/BENT #7	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	109	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	109	153	262	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	109	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	109	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00337**
BRIDGE #2/BENT #8	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	187	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	187	153	266	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	187	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	187	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00338**
BRIDGE #2/BENT #9	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	264	69	105	0.00007
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	264	153	189	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	264	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	264	90	126	0.00188
Totals		**1950**		**0.8125**					**0.00250**
BRIDGE #3/BENT #2	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	37	69	106	0.00007
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	37	153	190	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	37	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	37	90	127	0.00189
Totals		**1950**		**0.8125**					**0.00252**

Fish Speed 0.6 m/s dB SELcum Threshold = 183	**Pile Driver Number, Pile Size and Activity**	**Strikes/ Day**	**Strike Interval**	**Hours of Driving per Day**	**Driving Activity Days per Week[a]**	**Pier Complex Distance from South Shore of Columbia River (m)**	**Threshold Radius**	**Effective Threshold Diameter**	**Weekly Exposure Factor by Pile Driver Number & Pile Size**
BRIDGE #3/BENT #3	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	115	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	115	153	268	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	115	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	115	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00338**
BRIDGE #3/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	193	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	193	153	260	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	193	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	193	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00337**
BRIDGE #3/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	270	69	99	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	270	153	183	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	270	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	270	90	120	0.00179
Totals		**1950**		**0.8125**					**0.00241**
BRIDGE #4/BENT #2	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	23	69	92	0.00006
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	23	153	176	0.00011
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	23	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	23	90	113	0.00168
Totals		**1950**		**0.8125**					**0.00229**
BRIDGE #4/BENT #3	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	56	69	125	0.00008
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	56	153	209	0.00013
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	56	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	56	90	146	0.00217
Totals		**1950**		**0.8125**					**0.00283**
BRIDGE #4/BENT #4	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	105	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	105	153	258	0.00016
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	105	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	105	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00337**

Fish Speed 0.6 m/s dB SELcum Threshold = 183	Pile Driver Number, Pile Size and Activity	Strikes/ Day	Strike Interval	Hours of Driving per Day	Driving Activity Days per Week[a]	Pier Complex Distance from South Shore of Columbia River (m)	Threshold Radius	Effective Threshold Diameter	Weekly Exposure Factor by Pile Driver Number & Pile Size
BRIDGE #4/BENT #5	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	184	69	138	0.00009
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	184	153	269	0.00017
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	184	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	184	90	180	0.00268
Totals		**1950**		**0.8125**					**0.00338**
BRIDGE #4/BENT #6	Single pile driver: 18- to 24-inch pile (unattenuated)	75	1.5	0.0313	1	259	69	110	0.00007
	Single pile driver: 36- to 48-inch pile (unattenuated)	75	1.5	0.0313	1	259	153	194	0.00012
	Single pile driver: 18- to 24-inch pile (attenuated)	900	1.5	0.3750	2	259	15	30	0.00045
	Single pile driver: 36- to 48-inch pile (attenuated)	900	1.5	0.3750	2	259	90	131	0.00195
Totals		**1950**		**0.8125**					**0.00258**

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Table 3-15. Weekly Exposure Factors for the Columbia River and North Portland Harbor and Combined for a Contract Award Date of February 5, 2013

Columbia River					North Portland Harbor					Total				
Week	Year 1	Year 2	Year 3	Year 4	Week	Year 1	Year 2	Year 3	Year 4	Week	Year 1	Year 2	Year 3	Year 4
1	0	0	0.003582	0	1	0	0.01032	0	0	1	0	0.01032	0.00358	0
2	0	0	0	0	2	0	0.01032	0.00664	0.006499	2	0	0.01032	0.0066	0.00650
3	0	0	0	0	3	0	0.01032	0	0	3	0	0.01032	0	0
4	0	0	0	0	4	0	0.00422	0.00664	0.011374	4	0	0.00422	0.00664	0.01137
5	0	0	0	0	5	0	0	0	0.011374	5	0	0	0	0.01137
6	0	0	0	0	6	0	0	0.01221	0	6	0	0	0.01221	0
7	0	0	0	0	7	0	0	0.01221	0.004655	7	0	0	0.01221	0.00466
8	0	0	0	0	8	0	0	0	0	8	0	0	0	0
9	0	0	0.00107	0	9	0	0	0.00500	0	9	0	0	0.00606	0
10	0	0	0	0.00084	10	0	0	0	0	10	0	0	0	0.00084
11	0	0	0	0	11	0	0	0.00500	0	11	0	0	0.00500	0
12	0	0	0.00143	0	12	0	0	0	0	12	0	0	0.001427	0
13	0	0	0	0.00143	13	0	0	0	0	13	0	0	0	0.00143
14	0	0	0	0	14	0	0	0	0	14	0	0	0	0
15	0	0	0	0	15	0	0	0	0	15	0	0	0	0
16	0	0	0	0.00139	16	0	0	0	0	16	0	0	0	0.00139
38	0.00579	0	0	0	38	0.01100	0.01084	0.01145	0	38	0.01679	0.01084	0.01145	0
39	0.00579	0	0	0	39	0.01100	0.01084	0.01145	0	39	0.01679	0.01084	0.01145	0
40	0.00579	0.00488	0	0	40	0	0	0	0	40	0.00579	0.00488	0	0
41	0.00579	0.00347	0	0	41	0.00559	0.00444	0	0	41	0.01138	0.00791	0	0
42	0.00525	0.00347	0	0	42	0	0	0.00653	0	42	0.00525	0.00347	0.00653	0
43	0.00441	0.00347	0	0	43	0	0	0	0	43	0.00441	0.00347	0	0
44	0.00441	0.00512	0	0	44	0.00665	0.00546	0.00659	0	44	0.01107	0.01058	0.00659	0
45	0.00441	0.00581	0	0	45	0	0	0	0	45	0.00441	0.00581	0	0
46	0.00500	0.00581	0	0	46	0.00659	0.00546	0.01183	0	46	0.01160	0.01127	0.01183	0
47	0.00581	0.00581	0	0	47	0	0	0.01183	0	47	0.00581	0.00581	0.01183	0

Columbia River					North Portland Harbor					Total				
Week	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Week**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Week**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
48	0.00581	0.00581	0	0	48	0.00549	0.00647	0	0	48	0.01130	0.01228	0	0
49	0.00581	0.00577	0	0	49	0	0	0.00484	0	49	0.00581	0.00577	0.00484	0
50	0.0058	0.00577	0	0	50	0.00536	0.00631	0.01179	0	50	0.01117	0.01208	0.011789	0
51	0.00252	0.00577	0	0	51	0	0	0.01190	0	51	0.00252	0.00577	0.01190	0
52	0	0.00577	0	0	52	0.01032	0.00664	0.00662	0	52	0.01031	0.01241	0.00662	0
sum	0.07242	0.06674	0.00607	0.00366	**sum**	0.06199	0.09163	0.14251	0.03390	**sum**	0.13441	0.15837	0.14859	0.03756
average	0.00234	0.00215	0.00020	0.00012	**average**	0.00200	0.00296	0.00460	0.00109	**average**	0.00434	0.00511	0.00479	0.00121
median	0	0	0	0	**median**	0	0	0.00484	0	**median**	0	0.00488	0.00484	0
min	0	0	0	0	**min**	0	0	0	0	**min**	0	0	0	0
max	0.00581	0.00581	0.00358	0.00143	**max**	0.01100	0.01084	0.01221	0.01137	**max**	0.01679	0.01241	0.01221	0.01137

4. Anadromous Fish Timing and Abundance

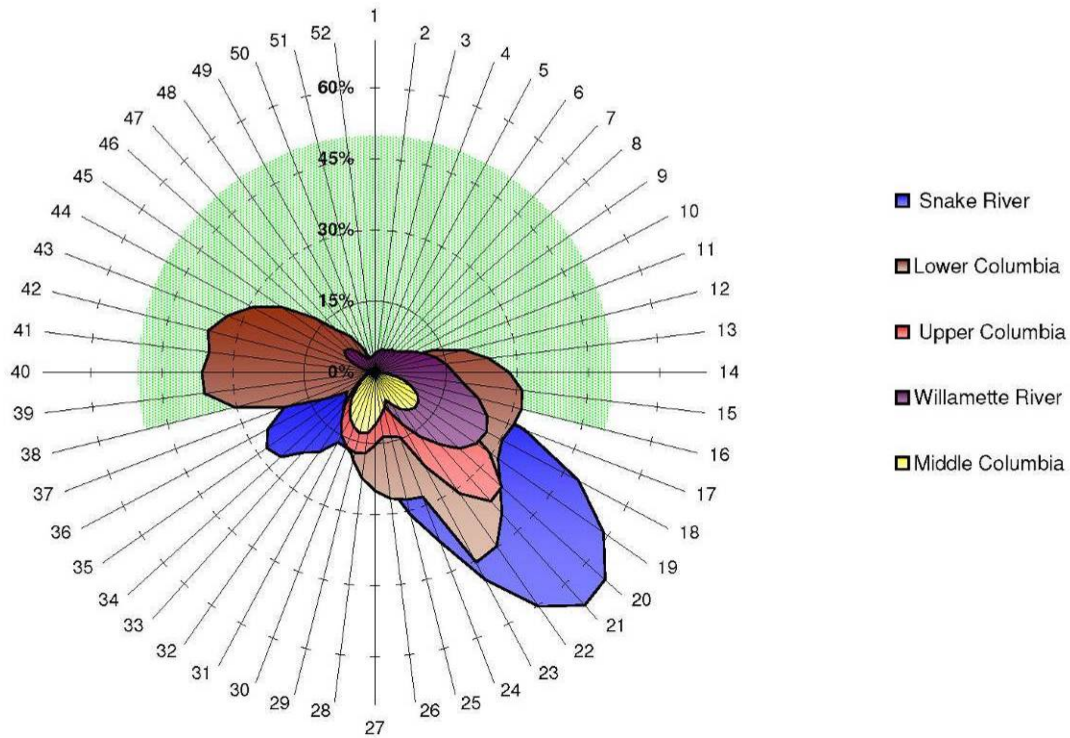
4.1 Introduction

The timing and abundance of anadromous fish that may be present in the CRC project area is fundamental to analyses of effects and to qualifications and estimates of potential take for the ESA consultation. The number of species, their life histories, and the available knowledge about them presents a complex picture that must be understood at several levels. At the landscape level, fish management and conservation efforts in a basin the size of the Columbia River have natural geographic groups. To illustrate this, the timing and relative abundance of subject fish species in the lower, middle, and upper Columbia River, upper Willamette River, and Snake River are summarized in Figure 4-1. Timing is depicted as 52 weeks, and shown as radials. Abundance is the percentage of the “run” that may be expected in any week and is depicted as distance from the center of the figure. At this level, timing patterns indicate weeks of minimal presence, weeks of maximum abundance, and the complexity of time-clustered migrations of fish.

The data in Figure 4-1 represent migratory life stages of five taxonomic species of salmonids and eulachon. The next level of consideration is the ESA-species listing of threatened or endangered as either a Distinct Population Segment (DPS: steelhead and eulachon) or an Evolutionarily Significant Unit (ESU: Pacific salmon).

This section examines the available data for the anadromous adult and juvenile fish species of 10 ESUs and nine DPSs occurring in the CRC project area (Figure 4-2), while subsections provide specific estimates of timing and duration at the CRC project area. Steelhead (anadromous *O. mykiss)* and Chinook (*O. tshawytscha*) present the most complex groups. Timing estimates for eight steelhead DPSs are grouped in Figure 4-3. Spring and fall runs of Lower Columbia River (LCR) Chinook are depicted in Figure 4-5 and represent the level that generates input for hydroacoustic analyses. The natural history and ecology of each species is presented in Section 4 and detailed in Appendix C of the CRC BA. Unique management references (e.g., Group A and B steelhead) and distinctions between natural origin and hatchery populations are discussed with each analysis, as appropriate.

Figure 4-1. Estimated Timing of Anadromous Fish Species Groups in the CRC Project Area



Note: Weeks are radials; abundance is the percent of the run present each week as distance from the center. All ESA-listed salmon and eulachon and life stages are represented. Green shading depicts proposed impact driving period of September 15 through April 15.

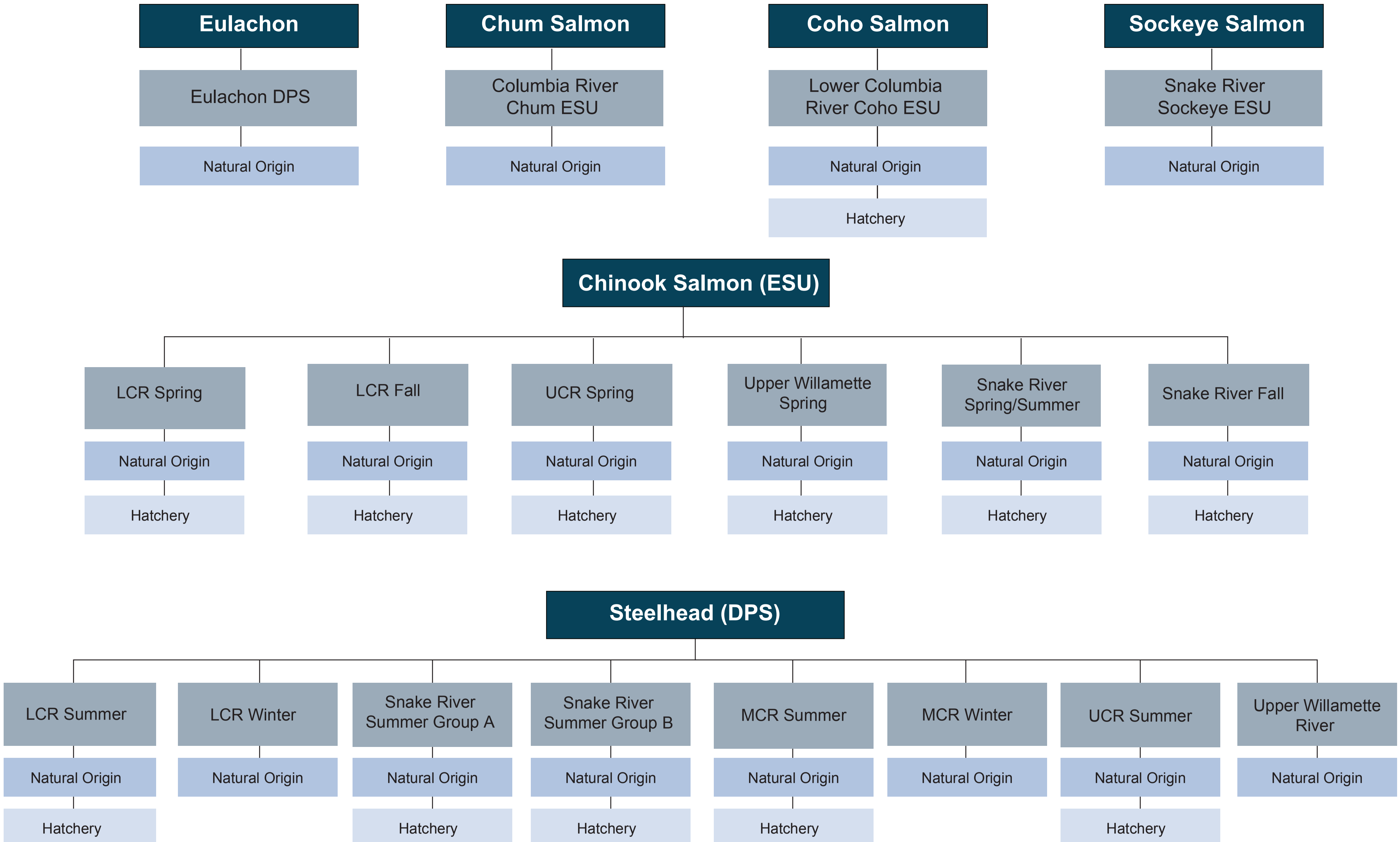


Figure 4-2. Listed Anadromous Fish Species Occurring in the CRC Project Area

Columbia River CROSSING

4.2 Analysis Approach

The history of research, management, and commercial fishing in the Columbia River basin does not provide, as might be expected, a dataset that is similar in format and period of record for every species or species group assessed. Most species/life stages are supported by datasets consisting of daily or weekly counts of fish passing Bonneville Dam or Willamette Falls (Sullivan Dam). Some species were best represented by data from tributaries (e.g., coho counts at Marmot Dam on the Sandy River) when counts at Bonneville were limited or potentially represented patterns not typical of fish most likely to pass through the CRC project area. Eulachon timing is based on the longest period of record for any species, but the data (landings or date of first entry), limited research, and management information allowed only a basic understanding of run timing in the CRC project area to be developed.

The analysis approach initially focused on exploration of the available data and preliminary estimates of the maximum likelihood of species timing and duration at the CRC project area. Maximum likelihood, as used here, means that estimates are based on patterns that represent a better than average or typical year. Initial estimates were based on an average (typical) value for a week during the species migration and on the variability of this value for the period of record. Where possible, the most recent 10-year period was examined.

No species examined showed a consistent pattern of timing or abundance, and most population trends are negative or uncertain (see Section 4 of the CRC BA). However, recent ocean conditions, changes in fisheries management, and conservation efforts suggest that timing and abundance of species during the future, multi-year construction of the CRC project may be at some level not represented by an average condition of the past years. While speculative, it is prudent to consider the potential for increased productivity and returns that may occur, as it did for various Columbia River stocks in 2001–2003 (JCRMS 2009). This potential is addressed by modeling weekly abundance levels greater than the average.

Weekly abundance was translated into run indexes, calculated the percent of the annual total count occurring each week. A set of weekly values was estimated by adding one standard deviation (σ) to the weekly average value across years ($\bar{x}$). The relationship between weeks was modeled to estimate duration and timing patterns by fitting a polynomial curve to $\bar{x} + \sigma$. This standard deviation represents the variation within a given week (across years) for the period of record. In this way, weeks with highly variable run indexes are represented as having greater run indexes than the statistical average for that week. For example, Weeks 21 and 26 could both have average run indexes of 0.400 but generate different weekly values for modeling if σ was 0.002 and 0.120, respectively.

Preliminary curves were reviewed by agency biologists (InterCEP 2010). Review reflected a general agreement on the approach described above and revealed improvements and supplemental data sources to be considered. Additionally, NMFS was interested in an approach that estimated timing and duration based on weekly maximum abundance in the period of record in lieu of using an average plus one standard deviation.

The analysis approach was revised to further emphasize the maximum historic abundance by week. The principal change in approach was using the greatest (most abundant) year in the period of record as the basis for calculating weekly run indexes. Raw weekly abundance was transformed as a fraction of the greatest annual abundance for the period of record. This treatment gives weight to weeks of relatively greater abundance in years with the largest populations. It also minimizes the effect of high weekly abundance in years of low annual abundance on curve fit and overall strength of estimates.

Snake River sockeye adults provide an example of the effect and value of weighting for the purpose of assessing impacts based on the probability of presence. In 1999, the annual total count was 17,863 adults. The run index for week 28 (2,308 adults counted) would be 0.129 based on the 1999 population (calculated as 2,308/17,863) and would have been the largest value for Week 28 in any year from 1999 though 2008. In contrast, the greatest annual sockeye count for the period of record was 213,607 in 2008, nearly 12 times the count of 1999, but shows a run index about six times less (0.021) than the same week in 1999. The value for Week 28 in 1999 is much less, 0.011, when weighted as 2,308/213,607. An example of these calculations is provided in Table 4-1. Note that the run index for Week 28 in 2008 does not change with weighting because it serves as the base population (weight = 1.0).

Information on weekly variation was used to model timing duration and patterns. A polynomial was fit to the weekly $\bar{x}$ plus one, two, or three standard deviations as needed to best fit weighted weekly maximum values for the period of record. Values were normalized to $\bar{x} + \sigma$ to provide a comparison of values and curve fit. An example of relationship between weighted and normalized values fit with a polynomial curve is provided in Figure 4-3. A synthesis of this approach is illustrated in composites for adult and juvenile steelhead DPSs and LCR Chinook in Figure 4-4 and Figure 4-5, respectively.

Table 4-1. Example of Weighted Run Indexes for SR Sockeye Adults in Select Years and Data Series to be Fit with Polynomial Curves

Year	1999	2004	2007	2008	Max	Mean	SD	$\bar{x} + \sigma$	$\bar{x} + 2\sigma$	$\bar{x} + 3\sigma$
(count)	(17,863)	(123,286)	(24,376)	(213,607)		($\bar{x}$)	(σ)			
Week		*Weighted Run Index*								
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.002
23	0.001	0.021	0.004	0.013	0.021	0.008	0.007	0.015	0.022	0.029
24	0.005	0.079	0.018	0.127	0.127	0.047	0.040	0.087	0.127	0.167
25	0.013	0.239	0.041	0.432	0.432	0.140	0.137	0.276	0.413	0.550
26	0.024	0.132	0.028	0.310	0.310	0.104	0.081	0.185	0.266	0.347
27	0.024	0.065	0.013	0.088	0.088	0.046	0.023	0.069	0.093	0.116
28	0.011	0.029	0.006	0.021	0.029	0.015	0.007	0.022	0.029	0.036
29	0.004	0.008	0.002	0.005	0.013	0.005	0.003	0.008	0.011	0.014
30	0.001	0.002	0.001	0.001	0.003	0.002	0.001	0.002	0.003	0.003
31	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.001	0.001
32	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
34	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
36	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
37	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
38	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Maximum values by week from 1999–2008 (all years not shown) are from counts at Bonneville Dam.

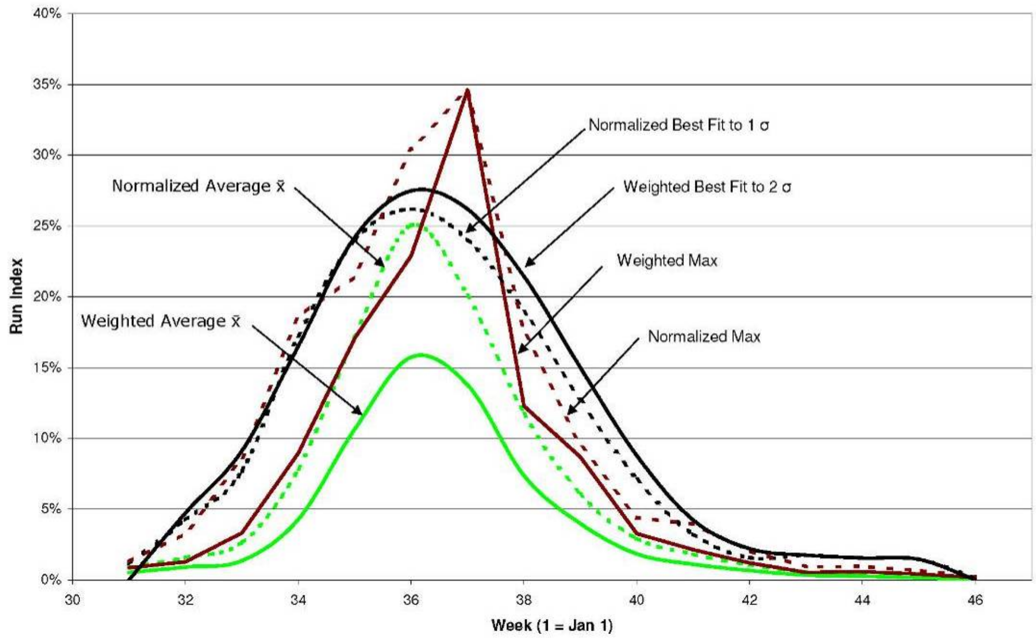


Figure 4-3. Statistical approach illustrated with run timing and duration based on weighted, normalized, and maximum weekly run indexes and the fit of polynomial curves to the average plus one and two standard deviations.

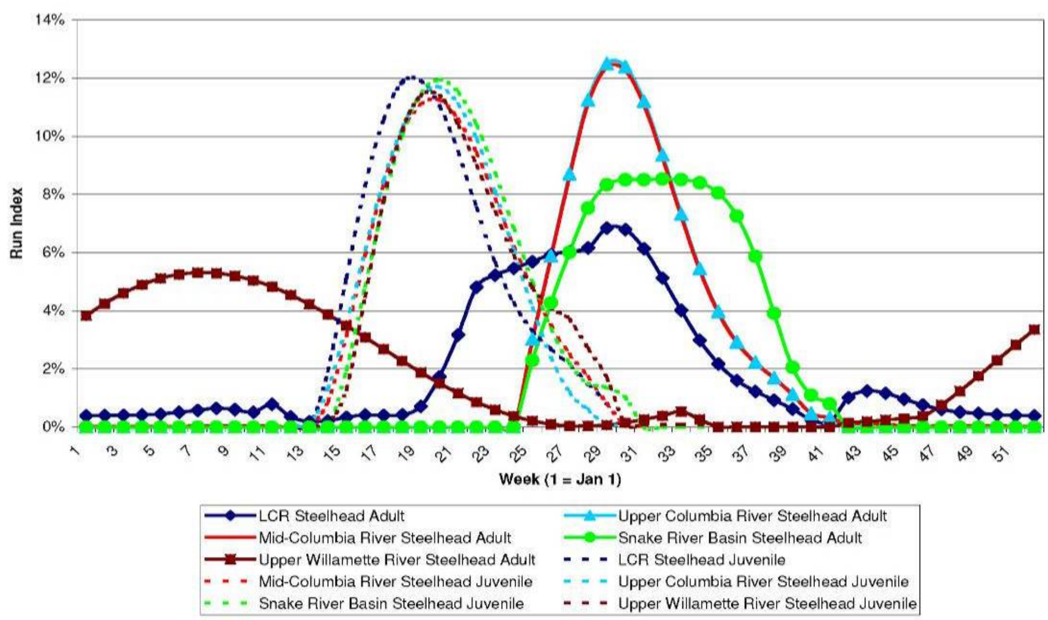


Figure 4-4. Estimated run timing of all ESA-listed steelhead adults and juveniles passing through the CRC project area.

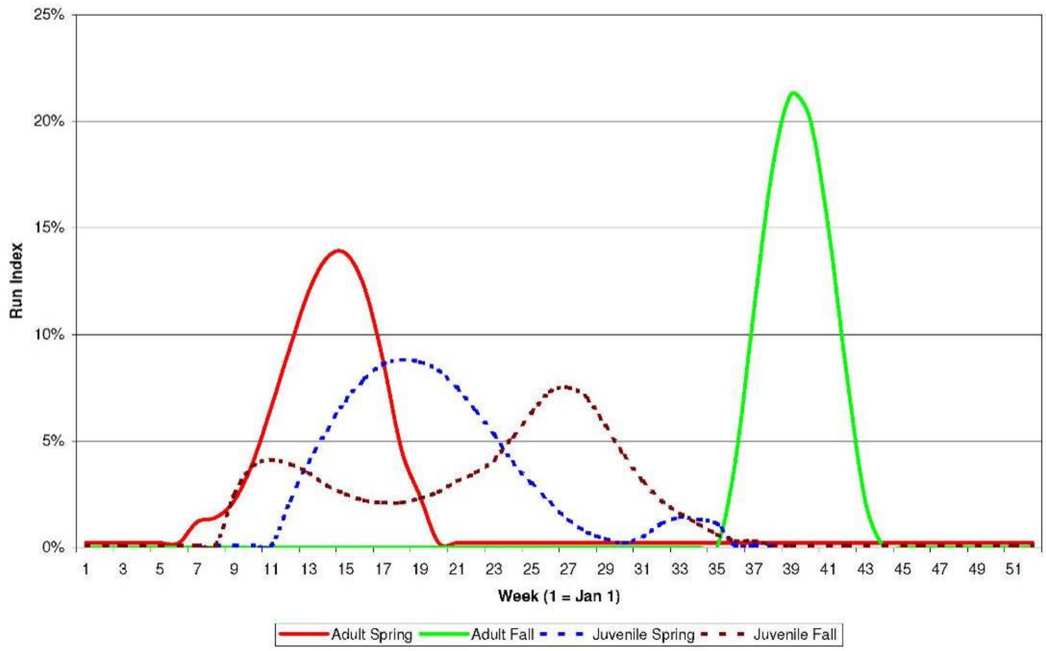


Figure 4-5. Estimated run timing of LCR Chinook adults and juveniles at the CRC project area.

4.3 Presentation Approach

The analysis in the following sections (Sections 4.3.1 through 4.3.36) is presented in a repeating format that begins with a figure showing estimated timing and duration in the CRC project area for the subject species and life stage. The sequence is:

1. **Figure 4-X.** This is the analysis product. All text and figures that follow this first figure for a species/life stage are provided in support of this result and to explain the steps of the analysis. There are 78 figures in this section of this document. The reader is encouraged to carefully match text reference to figures and figure numbers.
2. **Data Sources.** This section provides basic information on the type of data used, alternative sources of data, description of the dataset, and any data treatments applied. Results are presented narratively. First, the peak, duration, and descriptive statistics are provided. The timing curve is presented with the weighted average and maximum run indexes plotted as continuous data to provide a graphic representation of the fit of the polynomial. This figure is typically *the last graph* in the subsection. It important to note that for some species/life stages, the timing at the CRC project area differs from timing at, for example, Bonneville Dam. Shifts in timing are described and reference is made to the result graph, the first figure in the subsection. Use of results is also described.
3. **Data Assumptions.** This section provides declarative statements about data, sources, and use of results that are fundamental to the analysis and must be assumed.
4. **Known Data Gaps.** Here, limitations and unique attributes of the dataset are described. This section complements Data Assumptions.

5. **Data Options.** If the potential exists to improve or supplement the analysis during subsequent review and analysis efforts, further analysis or alternative data sources are described. Statements made here are intended to disclose, where appropriate, actions that could be taken to increase confidence in timing and duration results.

Chinook salmon and steelhead are introduced as groups of ESUs and DPSs, respectively, and then presented in the format described above. The reader is cautioned that the typical format is described here. Some analyses required additional analytical steps and graphic presentation.

Data sources are cited for each species and the corresponding references can be found in Section 10. These include valuable contributions and support from staff of WDFW, ODFW, NMFS, and PGE.

4.3.1 Eulachon – Adult

Figure 4-6 presents the estimated timing and duration of eulachon adults passing through the CRC project area based on historic first arrival to the Sandy River and commercial landings in the Columbia River.

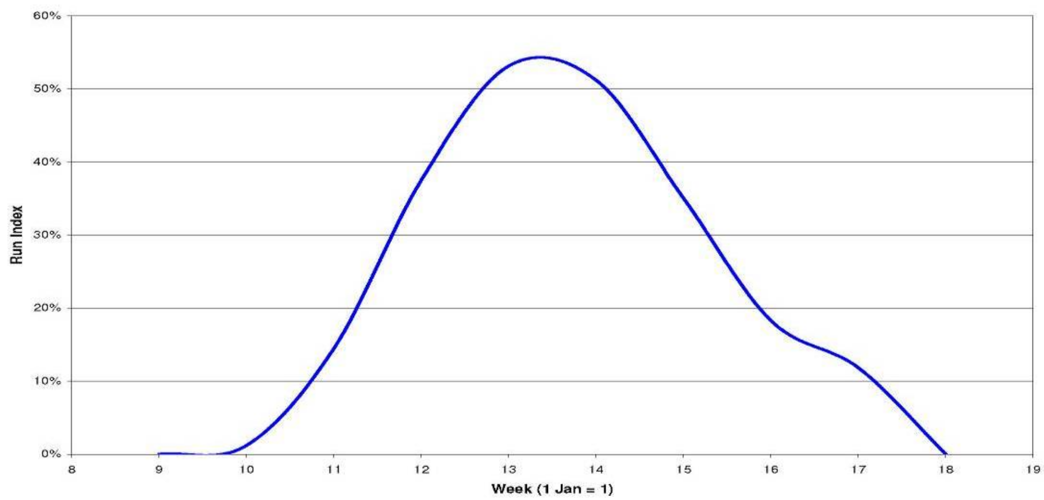


Figure 4-6. Estimated timing and duration of eulachon adults passing through the CRC project area based on historic first arrival to the Sandy River and commercial landings in the Columbia River.

4.3.1.1 Data Sources

The Southern Eulachon DPS (Columbia eulachon or smelt) was listed as a threatened species under the ESA (74 Federal Register [FR] 10857) in 2010 and is likely to be present in the CRC project area as migrant adults and larvae. The Columbia River and its tributaries support the largest eulachon run in the world. Despite its size and the importance of the fishery, estimates of adult spawning stock abundance are unavailable, and the primary information sources on trends in Columbia River eulachon abundance are catch records (NOAA 2008). Further review of the extant literature on eulachon yielded no population estimates, freshwater biomass, or abundance data (e.g., 64 FR 66601; 74 FR 10857; NMFS 2008b; Smith and Saalfeld 1955; JCRMS 2007 and 2009; WDFW and ODFW 2001). For purposes of this analysis, the population of eulachon adults passing the CRC project area is set at 115,000 (WDFW 2009).

Catch (landings) data are available in various forms as early as 1888 (NMFS 2008b) and, absent other metrics, are considered to be a reasonable indicator of trends in abundance for management purposes (JCRMS 2007). However, NOAA (2008) was not confident that landings prior to 2001 provided an accurate index of eulachon abundance. Since implementation of the Joint State Eulachon Management Plan (WDFW and ODFW 2001), fishery landings data have improved as an index of trend in eulachon run size (NOAA 2008).

Landings data are indicators of DPS-scale trends that poorly distinguish between harvest and landing areas. It follows that this unknown level of error reduces confidence in any estimate of adult timing and abundance for that portion of the eulachon population passing through the CRC project area. Eulachon presence and abundance by week is necessary to aid assessment of take that may occur during seasonal CRC in-water activities. The need for weekly or daily data coincident with project schedules and activities limits the use of general timing phenology (e.g., NMFS 2008a, Figure A-3), inter-annual comparisons of landings (JCRMS 2007), or historic annual catch metrics (WDFW 2001) to estimate weekly abundance of eulachon at the CRC project site.

Most eulachon spawn in mainstem and tributary sites downstream of the CRC project area (Howell et al. 2001; JCRMS 2007; WDFW 2009). The single most productive stream, on an annual basis, is the Cowlitz River that joins the Columbia River near RKm 107. There are commercial and recreational fisheries upstream of the CRC project area, but effort and landings are inconsistent and harvest data for commercial zones are useful only to frame general timing and duration (Langness 2009 personal communication). A summary of landings from 1970–2003 in Washington only in Columbia River Commercial Zones 4 and 5 is presented in Table 4-2.

Table 4-2. Date and Statistical Weeks of Eulachon Landings in Washington from Columbia River Commercial Zones 4 and 5, 1970–2003

Year	Date (Weeks)	Notes
1980	Jan 4–Feb 23 (1–8)	Earliest landing
1981	Mar 13 (11)	Only Zone 5. Latest landing.
1984	Jan 10–22 (11)	
1985	Feb 26 (9)	
1987	Feb 11–27 (6–9)	
1991	Feb 11 (6)	
2003	Jan 30–Feb 20 (5–8)	

Source: Unpublished data courtesy of WDFW (Langness 2009 personal communication).

Note: Commercial Zone 4 (Lewis River to Rooster Rock) includes landings that may have occurred from harvest downstream of the CRC project area.

WDFW (2009) considers the Sandy River to be an indicator of eulachon timing and assumes a typical annual population of 115,000. The Sandy River provides the last significant spawning area for eulachon upstream of the CRC project area, although some mainstem and tributary spawning occurs and is known locally (Langness 2009 personal communication). The annual catch record shows eulachon to be absent from the Sandy River in one or more consecutive years (JCRMS 2007; NOAA 2008). Practically, landing records from the Sandy River provide the best available data for adult timing upriver of the CRC. ODFW typically investigates first reports of eulachon presence in the Sandy River and maintains records of first arrival (North 2009 personal communication). Eulachon runs have been recorded 31 of 81 years (1929–2009), with the longest apparent absences being 1958–1970 and 1989–2000. January 23 (Week 4) and April 20 (Week 16) were the earliest and latest landings, respectively. A March timing for first entry is most common (Weeks 9–13); the median entry date was March 24 (Week 12).

First arrival in the CRC project area can be considered the same as first entry to the Sandy River, based on assumed travel rates. The confluence of the Sandy River is approximately 29 RKm (18 RM) upstream of the CRC project area. Absent any eulachon-specific travel rate, a common travel rate for salmon of 2.5 miles (4.0 Km) per day (WDFW 2009) results in a transit time of approximately 12 hours. When using statistical weeks as the minimum time class, or increment, each week is represented as a midpoint (Day 3.5). Thus, travel times of greater than 84 hours are necessary to shift timing (+ or -) by week increments.

The duration and peak timing of eulachon adults was derived from eulachon weight per delivery (catch per unit effort [CPUE]) reported by WDFW and ODFW (2001, Weeks 1–14) and the JCRMS (2007, Weeks 1–8) for Columbia River commercial catch over the period 1988–2007 (Figure 4-7). Despite limitations, this 20-year record provides the only index of week-to-week variability that could be used to estimate run timing pattern and duration for that portion of the eulachon DPS passing upstream of the CRC project area.

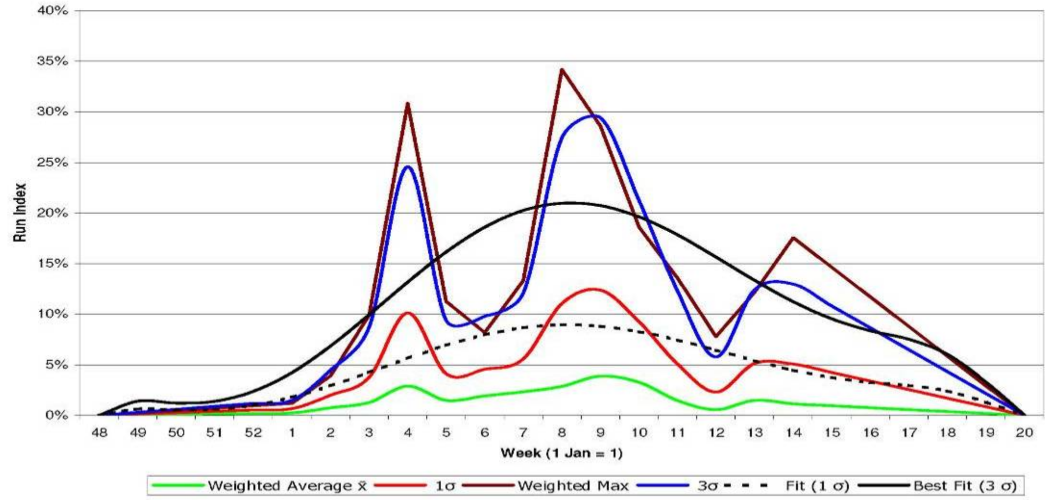


Figure 4-7. Estimated timing and duration of adult eulachon landings in the Columbia River commercial fishery, 1988–2007.

CPUE data for Weeks 9–14 were extrapolated for years 2002–2007 from corresponding weekly data for 1988–2001. Because of the high variability in qualitative and quantitative information reported for abundance and timing, a 6-week extension of the run was added before and after the core 14-week period informed by CPUE data, providing a timing pattern for a 25-week total run duration. Values for extended weeks were based on a geometric decrement from the first and last core week average values for the period of record. Weekly run indexes were developed by fitting a polynomial curve to the weighted mean (0.039 in Week 9) plus 3σ to best fit the maximum weighted CPUE per week (0.315 in Week 8) (Figure 4-8).

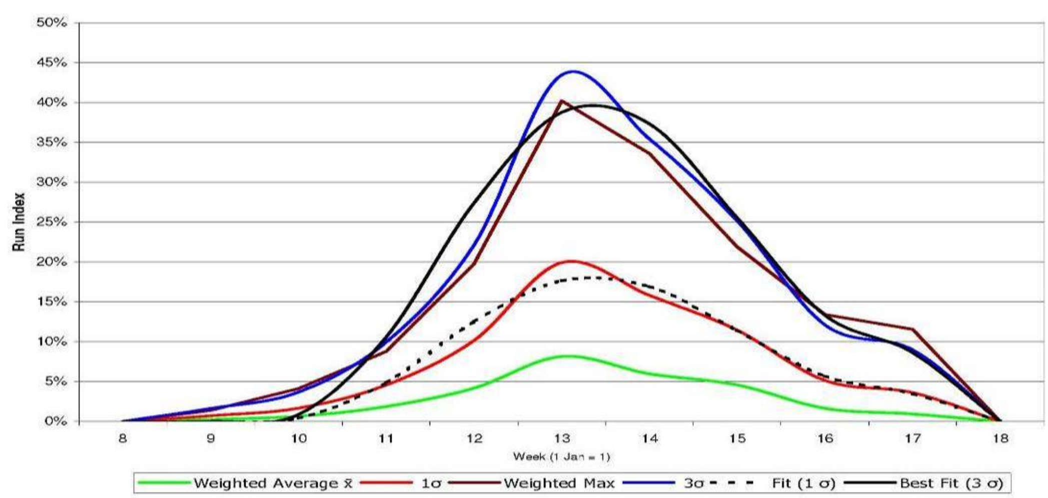


Figure 4-8. Estimated timing and duration of adult eulachon at the CRC project area.

The pattern of timing (best fit curve, Figure 4-8; Figure 4-6) was estimated for the Sandy River by compressing the DPS-scale, 25 week duration curve (Figure 4-7) to 8 weeks duration. Week 9 was selected as a typical first entry based on ODFW data (median is Week 12) adjusted three weeks earlier to allowing for eulachon exploration, staging and reporting lag suggested by several agency reviewers (InterCEP 2010). Thus, peak abundance (0.53) may reasonably be expected in Week 13 based on a weighted average of 0,082 and standard deviation of 0.12, from Week 8 or 9 through Week 18 (Figure 4-6). This timing and duration suggests that both adult and larval eulachon would not be present in late May (Week 21 and beyond), reflecting a possible adaptation or selection against elevated water temperatures.

The estimated timing and duration for eulachon reflects a composite history and ecology for entire DPS more than typical migrations of eulachon past the CRC project area. This is unavoidable given that CPUE and landings at this large scale are the only data to represent weekly variation over time. The historical record does indicate eulachon presence well into the summer period. However, initial timing curves derived by shifting the DPS-scale run duration forward to reflect Sandy River entry (InterCEP 2010) suggested eulachon adult presence through August. Several reviewers (InterCEP 2010) commented that summer presence was unlikely. Eulachon are known to cease migratory behaviors at approximately 11.0ºC (Langness 2009 personal communication; Smith and Saalfeld 1955). Water temperature records for the Columbia River from 1999–2007 at Ives Island (RKm 229) indicate temperatures exceeding 11.0ºC in May and nearly always in June (FPC 2010).

First entry (Week 9) is represented by data specific to areas upriver of the CRC project area. Further, first entry in the Sandy River ranged from Weeks 2–16, with an average of Week 12, in 30 reports examined by NOAA (2008) over the period of 1929–2003. The run timing and duration presented here represents eulachon as present in the CRC project area through March and April, but does not support the opinion that December through February may be a typical first arrival with possible peaking in February and March (Langness 2009 personal communication; WDFW 2009).

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented here as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.1.2 Data Assumptions

The few available data for first entry earlier than Week 9 are not sufficient to suggest a central tendency or provide cause for representing a frequent earlier timing in the Sandy River. Commercial catch of eulachon from the Columbia River reflects a broad range of timing, market conditions, fishing effort, and other factors that provide a limited but useful index of variability in Sandy River runs. Shifting and compression of the commercial, fishery-wide timing curve the Sandy River assumes that first report dates are indeed near in time to the first entry of adults.

Landings from the Sandy River are assumed to be reported soon after catch and be from in-river harvest. Adult abundance data provided by WDFW (2009) are assumed to reflect recent production/survival levels that will occur during CRC project construction. Eulachon returns upstream of the CRC project area are assumed to be annual, reasonably indexed by 115,000 adults, and to be declining in proportion to the trend of the DPS (NOAA 2008).

4.3.1.3 Known Data Gaps

Reports of first landings and first entry are available from a variety of sources. However, the errors and biases of each source/dataset cannot be fully known. Abundance cannot be validated with any data available for this analysis except for the overall trend in the DPS (NOAA 2008). The timing and distribution beyond the peak is limited by the fact that data were reported only for the first 8 weeks of the calendar year. Eulachon presence in December or earlier (JCRMS 2007) and travel rates less than 2.5 miles per day may shift timing at the CRC project earlier.

4.3.1.4 Data Options

The timing of first arrival and run duration at the CRC project area could be established with a modest effort in cooperation with state resource agencies. As well, ODFW monitoring of first arrival of eulachon in the Sandy River should be continued and the potential to obtain estimates of the end of spawning should be explored. Estimates of abundance in the Sandy River are possible based on fish per unit weight and estimation of spawner densities. Estimates of timing, duration, and travel velocity in the CRC project area could be refined based on these data, as appropriate. Substitution of limited recent data for the longer period of record containing data of questionable utility (earlier than 2001, per NOAA 2008) might also be considered in alternative analyses.

4.3.2 Eulachon – Larvae

Figure 4-9 presents the estimated timing and duration of eulachon larvae passing through the CRC project area based on historic first arrival to the Sandy River and commercial landings in the Columbia River.

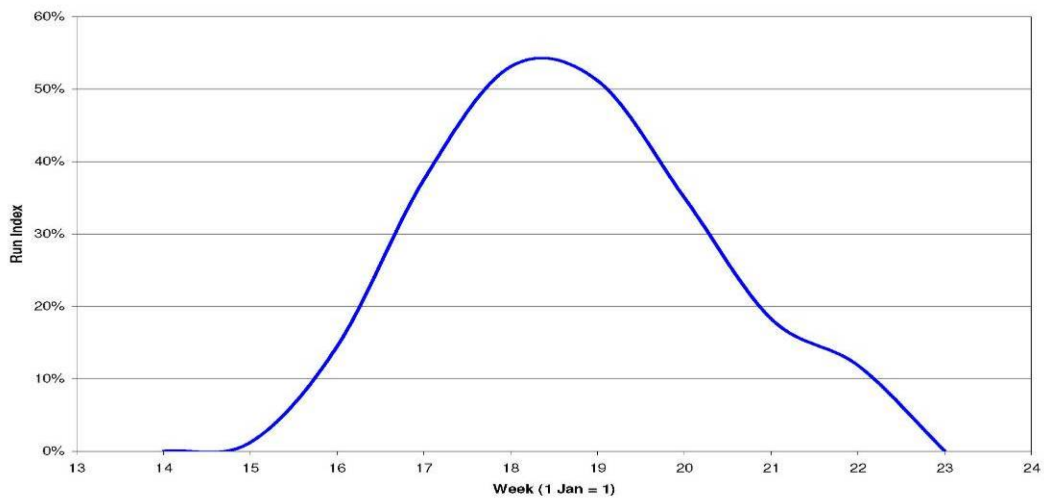


Figure 4-9. Estimated timing and duration of eulachon larvae passing through the CRC project area based on historic first arrival to the Sandy River and commercial landings in the Columbia River.

4.3.2.1 Data Sources

The abundance and timing of larval eulachon in the CRC project area remains uncertain after a review of the literature and discussion with local experts. Smith and Saalfeld (1955) report component studies of larval development, fecundity, and life history of eulachon with timing provided only as a general reference to February and March periods. They establish that larval development is temperature-dependent and that larval “migration” consists of passive drift with currents, as do Wydoski and Whitney (2003) and many investigations cited in NMFS (2008). Larval density is known from studies of distribution and egg deposition at sites predominantly downstream of the CRC project area (Howell et al. 2001; Romano et al. 2002). These studies focused on the potential impacts of dredging within the Columbia River shipping channel, and did not produce timing curves or data that could be used to estimate timing and abundance.

The onset of larval drift can reasonably be expected to follow the timing and pattern of spawning adults, shifted forward in time by the days required for larval development. Larval development may range from 20–40 days (Smith and Saalfeld 1955; Wydoski and Whitney 2003). A midrange development time of 35 days was applied to estimated adult eulachon timing at the CRC project area to produce a 10-week period for larval eulachon beginning in Week 14 (Figure 4-9). This curve is based on the Sandy River as a primary index and production site for upriver eulachon adults (Langness 2009 personal communication). The Hydraulic and Scour Parameters Report developed for the CRC project area (CRC 2008) estimated that at normal flows, the Columbia River moves at approximately 0.6 m/s. At 0.6 m/s, approximately 12 hours are needed for larval eulachon from the Sandy River to reach the CRC project area.

Larval abundance at the CRC project area can be estimated as the product of spawner abundance, fecundity, and survival from egg to larvae. Absent population estimates, the abundance is based on the assumption of 115,000 spawners (WDFW 2009) and a 1:1 sex ratio (57,500 females). Recent investigations of eulachon fecundity suggest a median value of 19,000 (7,000 to 31,000) may be reasonable for Columbia eulachon (Wilson et al. 2006). Egg to larval survival was set at 5 percent, based on the single, overall estimate of 2.9–4.8 percent provided by Lewis et al. 2002 (cited in Wilson et al. 2006). Potential larval through the CRC project area is estimated to be 54,625,000 (57,500 x 19,000 x 0.05). The proportion and number of larval eulachon that may be affected by CRC activities is addressed in Section 5.3.

4.3.2.2 Data Assumptions

Adult timing is assumed to provide a reasonable index of the temporal pattern of larval drift. A 1:1 sex ratio is a default value that may overestimate female spawner abundance. Eulachon sex ratios reported in NMFS (2008) indicate males often exceeding females in proportion. In a typical year, no adverse temperatures are encountered that affect survival in later weeks of the estimated drift period. Larval eulachon are not capable of volitional movements and are swept along soon after emergence at the speed of the current. All upriver larval production is assumed to pass through the CRC project area without significant mortality due to predation or other causes.

4.3.2.3 Known Data Gaps

Larval abundance based on WDFW (2009) could not be validated for this analysis. Fecundity, sex ratio, and survival rates used to estimate larval abundance are general and not specific to the Columbia population.

Egg development time may decrease with increased water temperatures. Thus, the potential for shortening of the 25-week drift duration based on temperature is unknown. Lethal and sublethal temperature thresholds for eulachon larvae are not known and may affect timing and duration even in typical years. Predation and survival rates of larval eulachon during the drift to the CRC project area are not known, but predation and mortality have the potential to reduce abundance.

4.3.2.4 Data Options

Temperature effects should be further researched and, if established, considered as cause to modify drift patterns and run timing estimates. Refinement and addition of information described for adult eulachon in the Sandy River (Section 4.3.1) would increase confidence in larval timing and abundance estimates. Any changes in adult timing estimates require larval timing to be adjusted accordingly.

4.3.3 Columbia River Chum – Adult

Figure 4-10 presents the estimated timing and duration of CR chum adults passing through the CRC project area based on returns to Duncan Creek and the Washougal River, Washington.

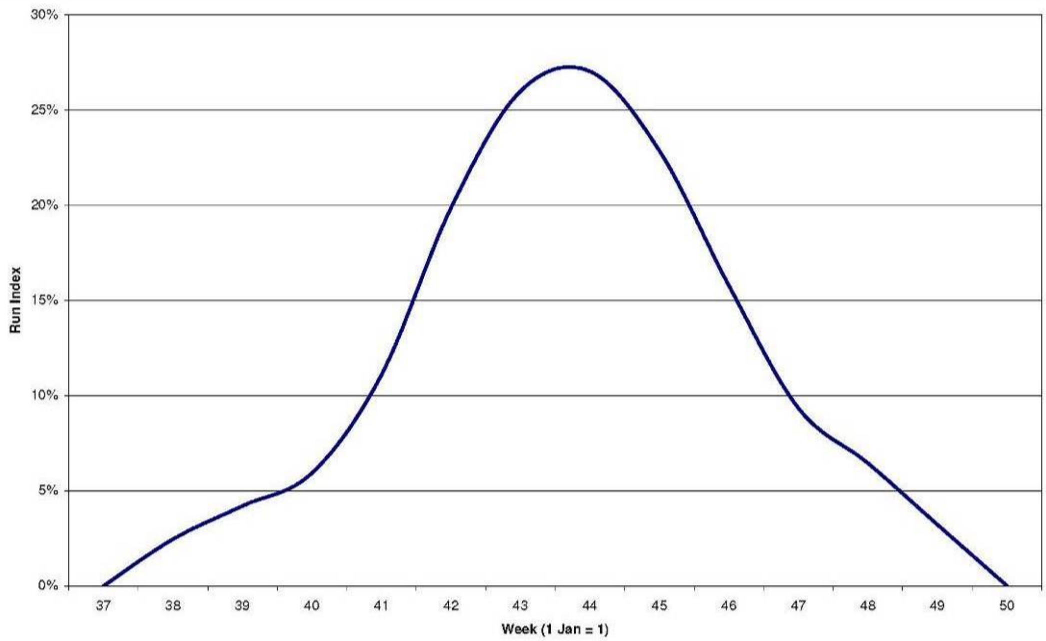
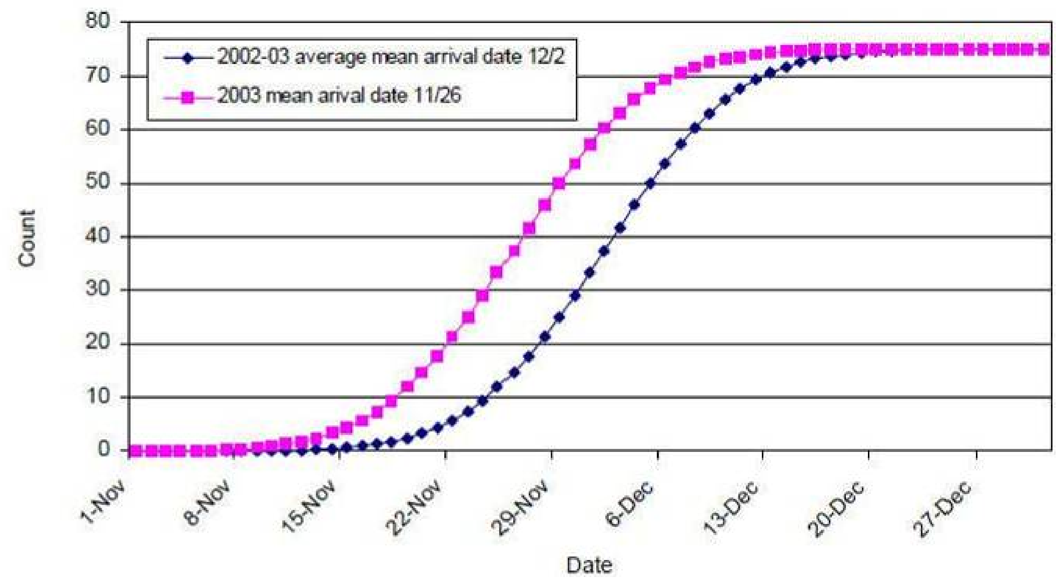


Figure 4-10. Timing and duration of CR Chum adults passing through the CRC project area based on returns to Duncan Creek and the Washougal River, Washington.

4.3.3.1 Data Sources

Columbia River (CR) chum are listed as threatened under the federal ESA (64 FR 14507). CR chum are seasonally present in the action area as adults and fry migrants originating near the CRC project area in tributaries and from mainstem areas upstream to Bonneville Dam. Rawding and Hillson (2003) identified 13 spawning locations for CR chum from the vicinity of I-205 (Woods Landing, RKm 182) upstream to below Bonneville Dam (Ives Island complex, RKm 235). Together with tributary spawning groups (Vigg and Dennis 2009), these are collectively known as the “upriver” portion of the CR chum ESU. CR chum timing must be estimated as a fraction of the total run per week to assess potential take from seasonal construction activities in the CRC project area (Figure 4-10). Chum life history and distribution are presented in Appendix C.

This analysis provided a general timing curve for adult chum from the best available data for the upriver portion of the CR chum ESU (above the Willamette River, RKm 163). Hillson (2006) provides spawner run timing for 2002–2003 and 2003 for the Hamilton Creek and Hardy Creek vicinity (approximately RKm 228) (Figure 4-11). A single cumulative frequency curve by week was generated from Hillson (2006) by averaging 2002–2003 cumulative frequency data by week (Figure 4-12). Those data are represented by the author to be normally distributed about the mean adult arrival date, thus generating the symmetric timing curve presented in (Figure 4-10). Potential timing at the CRC project area was shifted to a peak in Week 44 to reflect a suggestion by WDFW (2009) of peak passage in Week 45, normally distributed from Week 43 through Week 2.



Note: Adapted from Hillson (2006) and unpublished WDFW data.

Figure 4-11. Cumulative frequency curve for CR Chum adults returning to the Hamilton Creek and Hardy Creek area, 2002–2003 and 2003.

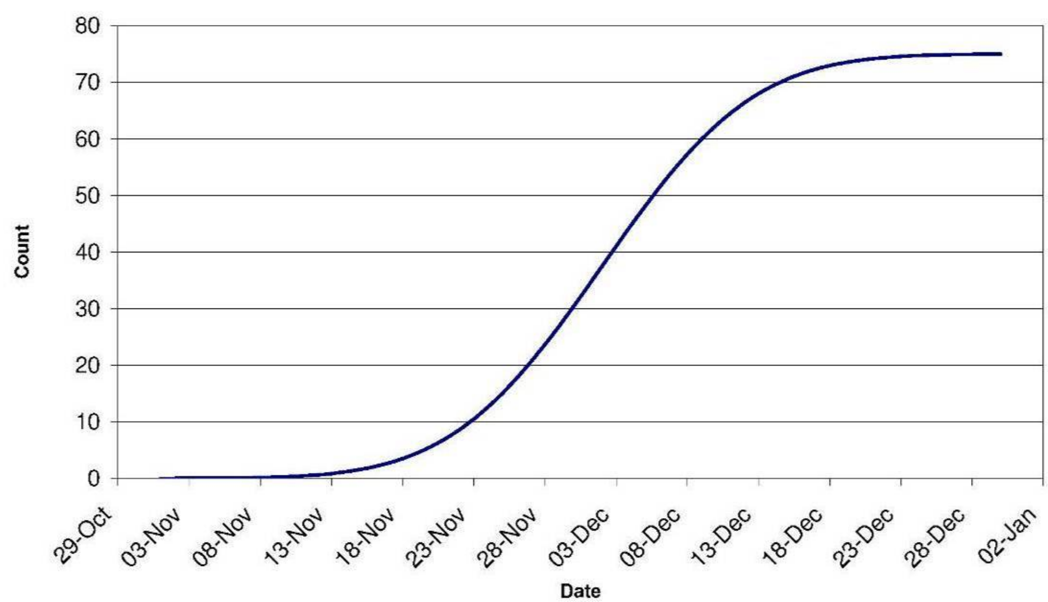


Figure 4-12. Cumulative frequency curve for upriver CR chum adults based on arrivals to the Hamilton Creek and Hardy Creek areas, 2002–2003 and 2003.

Other data from the Hardy Creek and Hamilton Creek spawning channel (Johnson et al. 2008; Vigg 2009) were inspected to assess variation in chum timing. Johnson et al. (2008) provide a simple plot of live counts for the Hamilton Springs group for 1 year (2006) that suggests timing is similar to the normalized curves developed by Hillson (2006) and may be within the weekly timing increment used. Seining data from Rawding and Hillson (2003) for the I-205, Multnomah, and Ives Island mainstem spawning groups produced timing curves similar to, and encompassed by, the timing curve produced by the Hamilton Creek and Hardy Creek group data (Figure 4-10).

Similarly, observations at Bonneville Dam from 2002–2008 (Figure 4-13) indicate peak abundance of some upriver chum in Week 46 and a duration similar to that proposed in Figure 4-10. Bonneville Dam observation data were considered but not used to develop timing estimates. These count data (ranging from 75 to 410) may best represent timing of small group of adults at the upper limits of CR chum distribution. It is reasonable to expect that the central tendency for the more abundant spawning groups below Bonneville Dam would be different and the most appropriate in assessing potential presence at the CRC project area.

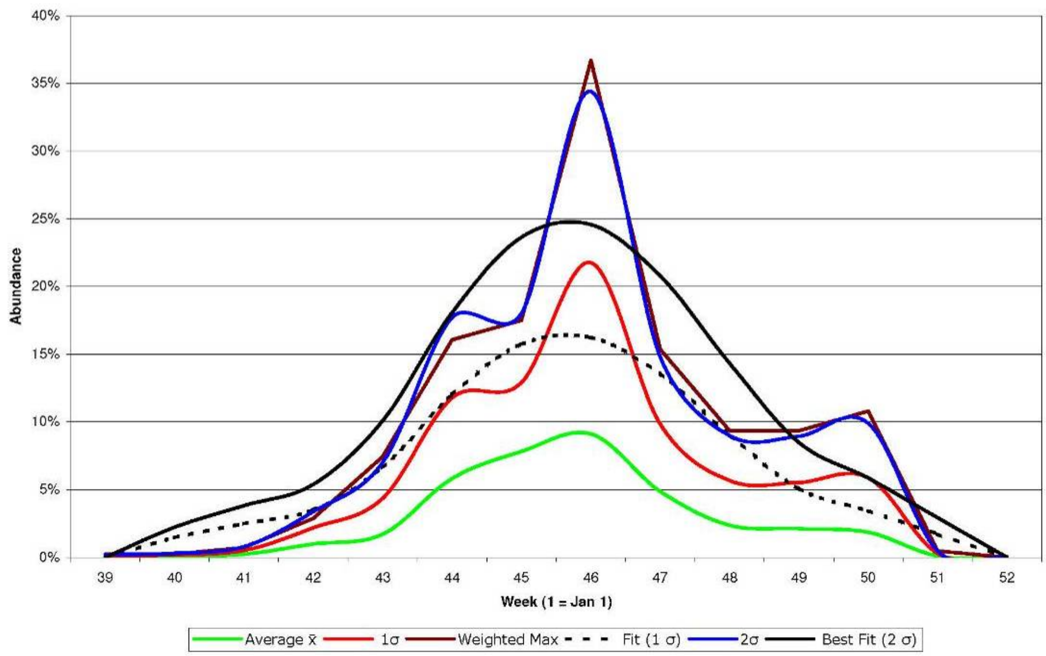


Figure 4-13. CR chum adult passage at Bonneville Dam, 2002–2008. Plot represents the average, minimum, and maximum observations by week.

Statistical comparison of timing datasets was not attempted due to the paucity and form of the available data and differences in sampling methods and effort (e.g., summary data from only one sample year by Johnson et al. 2008 and Rawding and Hillson 2003). Based on qualitative comparisons of the available data, it is reasonable to utilize Hamilton Creek and Hardy Creek data to represent the timing of upriver adult CR chum.

In recent years, upriver CR chum abundance has varied from over 11,000 in 2002 (Rawding et al. 2003) to as few as 1,100 in 2008 (Vigg 2009; Hillson 2009 personal communication). The average abundance of upriver adult chum may be approximately 1,954, calculated as an average of 6 years of bounded population estimates available for 2002 through 2008.

4.3.3.2 Data Assumptions

Cumulative frequency curves produced by Hillson (2006) represent an average of the weekly abundance for the period of record. These data can be used to represent a central tendency of documented chum spawning aggregations that pass through the CRC project area. The normal distribution used by Hillson (2006) is assumed to be appropriate.

The maximum abundance of 11,000 upriver CR chum in 2002 represents an upper level of production and survival that may be possible under recurring conditions. However, this maximum has not been approached recently, and the total abundance of upriver chum appears to be on a declining trend towards a relative minimum.

4.3.3.3 Known Data Gaps

The representative timing curve for adult chum collection efforts for Duncan Creek in 2004–2005 is derived from a cumulative frequency distribution compiled by Hillson (2006) for 2002–2003. Without daily (or periodic) data, descriptive statistics (e.g., variances) cannot be calculated. Daily arrival data exist for 2002–2008 but could not be made available for this analysis (Hillson 2009 personal communication). It is possible that the generalized timing curve may shift in relative abundance by week with the use of daily or weekly data.

4.3.3.4 Data Options

Obtain interim/draft adult population estimates and timing data from WDFW chum stock assessment reports being prepared for publication in 2010. Revise timing curves and recalculate abundance from this larger and more detailed dataset.

4.3.4 Columbia River Chum – Juvenile

Figure 4-14 presents the estimated timing and duration of CR chum juveniles passing through the CRC project area based on Duncan Creek and Washougal River emigration data for 2002–2006.

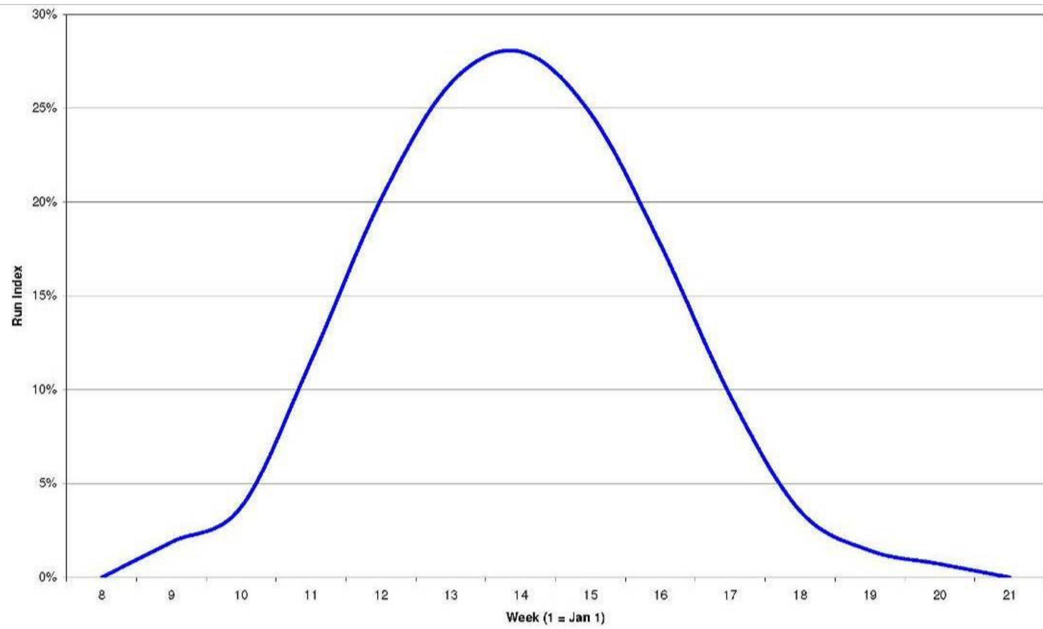


Figure 4-14. Estimated timing and duration of CR chum juveniles passing through the CRC project area based on Duncan Creek and Washougal River emigration data, 2002–2005.

4.3.4.1 Data Sources

The timing and abundance of emigrating CR chum juveniles (fry) can be inferred from limited data published for select tributaries and spawning channels upstream of the CRC project area (Hillson 2002, 2003, 2004, 2006; Johnson et al. 2008; Vigg and Dennis 2009). Hillson's reports provide data from fry counts at weirs at the Duncan Creek spawning channels. These data provide a careful record of recent patterns of chum fry emigration that begins in late February, peaks in late March, and is complete by late May/early June. This temporal pattern encompasses the many fewer observations of Johnson et al. (2008) of chum emigrants from Lower Hamilton and Hardy Creeks.

Duncan Creek data from 2002–2005 were used to index timing of CR chum fry in the CRC project area (Figure 4-14). The timing and duration of chum outmigration was estimated to peak in Week 14, ranging from Week 8–21. A polynomial curve was fit to 2σ (σ = 0.130) greater than the weighted average weekly run index (0.160 in Week 13) to best fit maximum values (0.310 in Week 13) over the 4-year period of record. The maximum and average indexes by week are compared with polynomial curves fit to σ and 2σ in Figure 4-15. Overall, the polynomial fit tends to maintain temporal patterns (e.g., timing peak) but redistributes peak abundance (the percent of the total run by week) to the "tails" of the curve. This analysis approach provides a robust estimate of timing that emphasizes the earliest and latest weeks of species presence and maximum abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

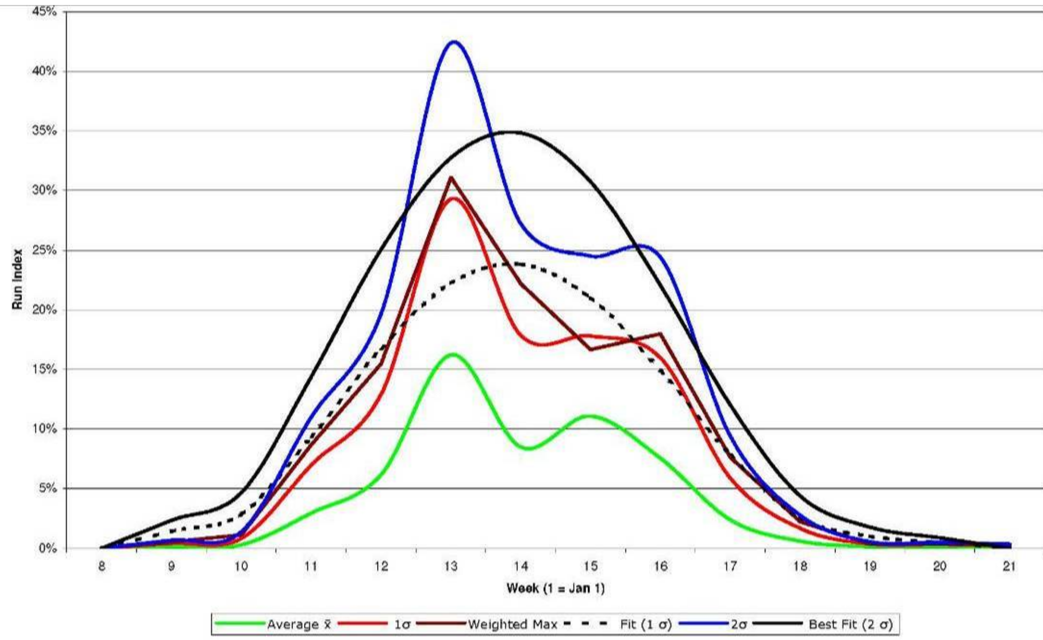


Figure 4-15. Timing and duration of CR Chum juveniles at Duncan Creek, Washougal River, 2002–2006.

The seasonal abundance of CR chum fry upriver of the CRC project area was estimated from a production model originally developed by Hillson (2006) and used by Vigg (2009) for spawning channel improvements at Woods Landing (RKm 182). In keeping with a maximum likelihood approach, a spawner population of 10,000 was halved to get the number of females with a range of fecundities from Hillson (2006). Egg-to-fry survival is based on reported ranges and adjusted lower than that measured in spawning channels (Hillson 2009 personal communication).

As shown in Table 4-3, the potential population of CR chum fry passing through the CRC project area could range from 2,232,000 to 6,500,000, based on a relatively large recent spawning population. However, CR chum spawning populations have been declining and can reasonably be expected to be 10 percent of the modeled population in some years (Rawding and Hillson 2003; Vigg and Dennis 2009).

Table 4-3. Estimated CR Chum Fry Production Upstream of the CRC Project Area

CHUM SPAWNING ESTIMATE	VALUE	
	Range	Midpoint
Females per available area (upper range)	6,000	5,000
Females per available area (lower range)	4,000	
Eggs per Female (upper range)	3,100	3,000
Eggs per Female (lower range)	2,900	
Total Egg Produced (upper range)	18,600,000	15,000,000
Total Egg Produced (lower range)	11,600,000	
Egg-to-Fry Survival (upper-percent)	12%	35%
Egg-to-Fry Survival (lower-percent)	56%	
Total Fry Produced (upper range)	2,232,000	5,250,000
Total Fry Produced (lower range)	6,496,000	

Note: Adapted from Hillson 2006 and Vigg 2009.

4.3.4.2 Data Assumptions

Duncan Creek, low in the Washougal River system, provides a midpoint of travel timing. Fry emigrating from sources upstream or downstream may arrive at the CRC project area earlier or later than Duncan Creek fry. However, chum fry are assumed to travel non-volitionally and at the speed of the current, averaging approximately 0.6 m/s at "normal" flows (CRC 2008). At this rate, elapsed time from the vicinity of Bonneville Dam is approximately 2 days, and differences between emigrant group timings may be only a matter of hours. For statistical purposes, timing data represent a midweek occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area.

Fish behavior, survival to emergence rates, and the fecundity of chum in Duncan Creek provide a realistic index for chum that spawn in flows and substrate with characteristics of lesser quality than the enhanced conditions maintained for the Duncan Creek spawning channels. In particular, it is reasonable to assume that egg-to-fry survival rates under more natural conditions would be consistently lower than Duncan Creek survival rates. Sex ratios can also vary between years and between populations, but tend to approach 1:1 over the long term for chum (Salo 1991).

4.3.4.3 Known Data Gaps

Weekly estimates of chum fry emigration are not available for other upriver groups of CR chum. Similarly, no rigorous, statistical estimates of fry production are available. The best available data are only for select tributary groups. Data for the most recent years (2006–2009) were not available for this analysis.

4.3.4.4 Data Options

Obtain daily weir count data for all years beyond 2005.

4.3.5 Lower Columbia River Coho – Adult

Figure 4-16 presents the estimated timing and duration of Lower Columbia River (LCR) coho adults of natural origin passing through the CRC project area based on returns to the Sandy River for 1999–2007.

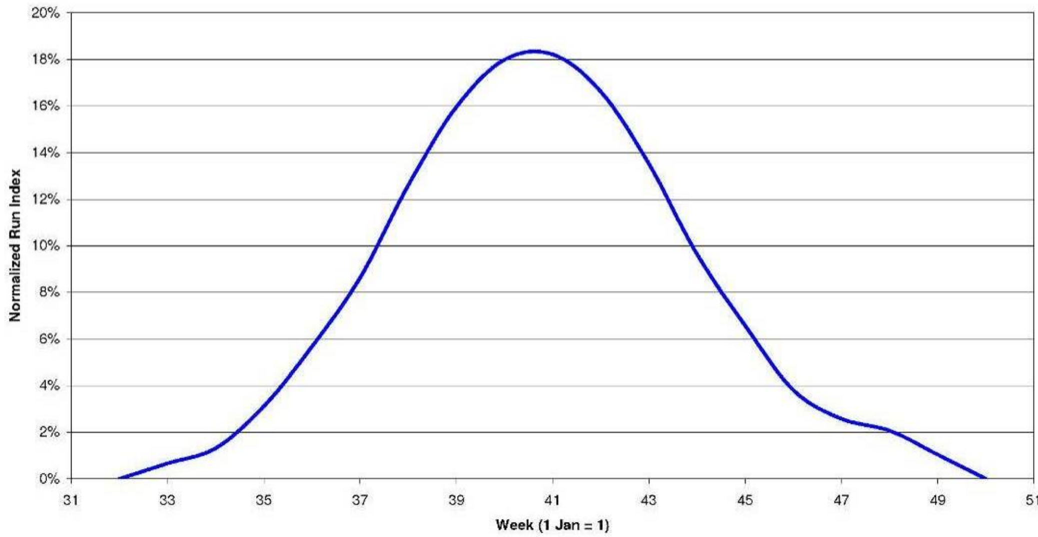


Figure 4-16. Timing and duration of LCR coho adults of natural origin passing through the CRC project area based on returns to the Sandy River, 1999–2007.

4.3.5.1 Data Sources

LCR coho were identified as a separate ESU and listed as threatened in 2005. The ESU includes all naturally spawned populations of coho in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia up to and including the Big White Salmon and Hood Rivers, and includes the Willamette River up to Willamette Falls. The life history and distribution of LCR coho is reviewed in Appendix C.

The best available data to estimate timing of LCR coho adults of natural origin (Figure 4-16) were found to be counts at Marmot Dam (RKm 48) on the Sandy River. Adult return data are also available from the North Fork of the Clackamas River (Wyatt 2009 personal communication) but include a substantial hatchery component, are timed later, and are not likely be present in the project area in any abundance that would represent populations upstream of the CRC project area. Coho adults passing above Bonneville Dam may represent a large portion of the run that passes the CRC project area, dominated by Bonneville Hatchery returns. Bonneville Hatchery returns may average 30,000 fish but are not part of the LCR coho ESU. However, the population of coho passing Bonneville Dam may be composed of approximately 5 percent natural origin fish (WDFW 2009) that cannot be discriminated from hatchery returns. A graphic comparison of Bonneville Dam adult timing (10-year weekly average) with the estimated timing for LCR coho (based on Sandy River returns) indicates an earlier peak and overlapping duration of the upriver component with the modeled timing curve (Figure 4-17).

The Washougal River supports both natural origin and hatchery coho. Coho have been planted in the Washougal basin since 1958, with extensive hatchery coho releases since 1967. The timing of Washougal River coho is generally described to be entry of adults from early September

(Week 36) through December (Week 52). Sandy River data generally reflect this timing duration when shifted earlier in time for passage upstream from the CRC project area (Figure 4-16). However, the early- and late-run coho types are not pronounced in the Sandy River data, and are possibly represented in Weeks 47 and later.

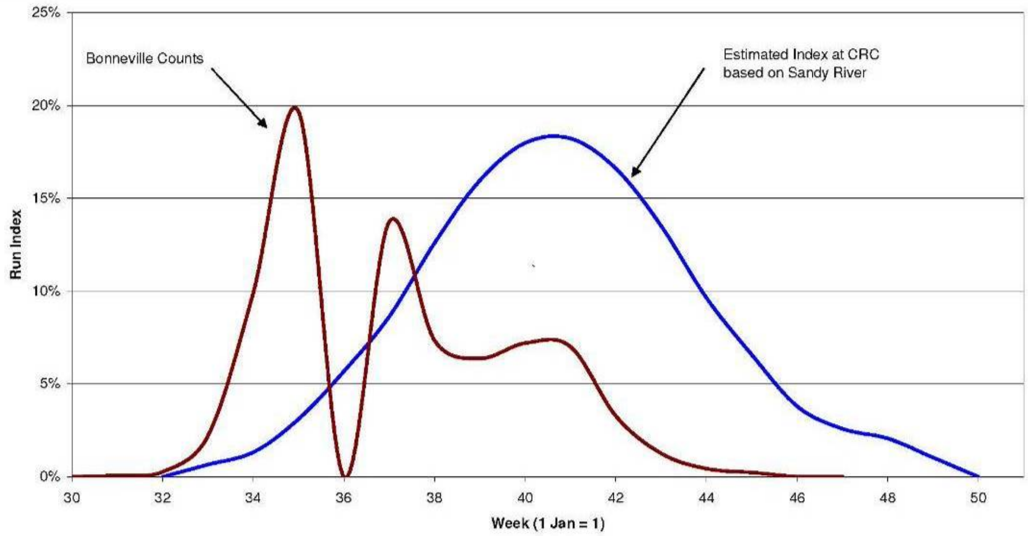


Figure 4-17. Comparison of LCR coho timing at the CRC project area based on Bonneville Dam counts (1998–2008) and Sandy River returns (1999–2007).

The period of record for this analysis is 1999–2007, inclusive. Daily count data at Marmot Dam were obtained from PGE (Wyatt 2009 personal communication). The dataset includes both early- and late-run components and jacks that overlap in timing. Data processing included summing all counts to get total returns, removing negative values, and setting minimum daily counts to one. Hatchery coho timing was compared graphically with that of natural origin fish (Figure 4-18) and appears to be similar. Furthermore, hatchery (adipose-clipped) adults were natural origin brood stock that routinely passed above Marmot Dam (Wyatt 2009 personal communication).

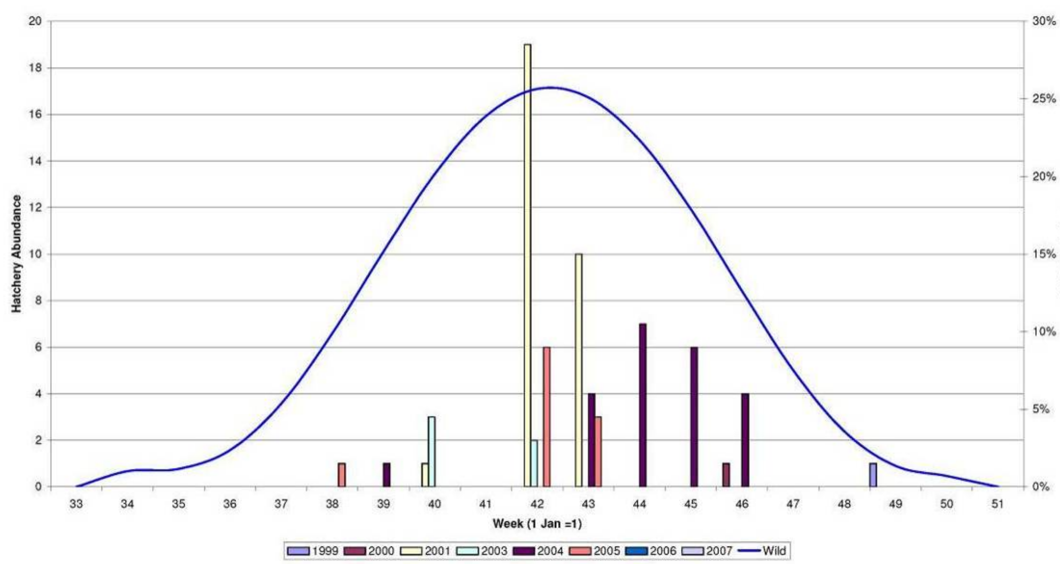


Figure 4-18. Comparison of Sandy River hatchery and natural origin coho timing and abundance, 1999–2007.

Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 33–51. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.31 (Week 42 in 2007). The maximum run index was estimated to be 0.18, based on a weighted mean abundance of 0.11 and σ = 0.11 in Week 42. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-19). Timing at Marmot Dam was shifted earlier to start in Week 32, providing an estimated duration of 19 weeks (Weeks 32–50) peaking in Week 41 (October 10) at the CRC project area (Figure 4-16).

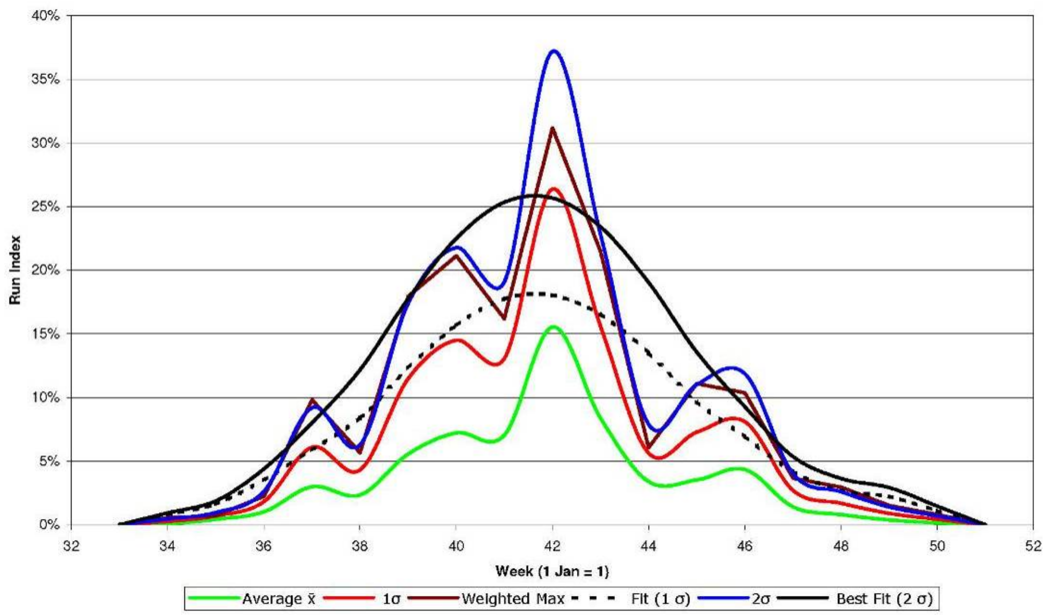


Figure 4-19. LCR coho adults of natural origin passage through the CRC project area based on counts at Marmot Dam, Sandy River (1999–2007).

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. An example of this effect occurs near Weeks 37, 40, 42, and 45 (Figure 4-18), where the maximum run index departs from the average for that week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.5.2 Data Assumptions

There will not be substantial numbers of Clackamas River coho present in the CRC project area. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by the standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak or periodic run timing. Timing duration and overall pattern is reflects both early- and late-run coho

4.3.5.3 Known Data Gaps

Presence of Clackamas River coho in the CRC project area is not documented.

4.3.5.4 Data Options

Examine Washougal hatchery return data for representation of natural-origin timing.

4.3.6 Lower Columbia River Coho – Juvenile

Figure 4-20 presents the estimated timing and duration of LCR coho juveniles of natural origin passing through the CRC project area based on returns to the Sandy River for 1999–2009.

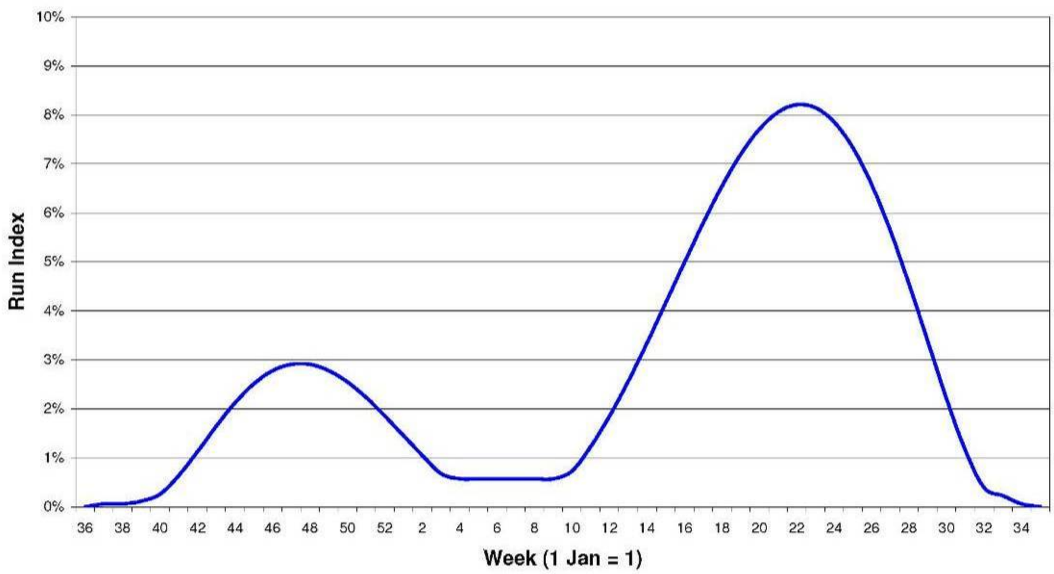


Figure 4-20. Estimated timing and duration of LCR coho juveniles of natural origin passing through the CRC project area.

4.3.6.1 Data Sources

The LCR coho ESU includes all naturally spawned populations in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia up to and including the Big White Salmon and Hood Rivers, and includes the Willamette River and tributaries up to Willamette Falls.

The best available data to estimate timing of LCR coho juveniles of natural origin (Figure 4-21) are counts at the outmigrant trap at the North Fork Dam on the Clackamas River provided by PGE (Wyatt 2009 personal communication). Coho outmigrants in the Clackamas River include a hatchery component of late-run natural origin broodstock that are included for the purposes of estimating general timing and duration. Bonneville Hatchery releases are sufficient to produce average returns of 30,000 adults that are not part of the LCR coho ESU. The use of PIT-tag detections at Bonneville to represent the timing of natural origin juveniles emigrating from tributaries downstream of Bonneville is inappropriate. The ESU does include fish passing Bonneville Dam that are assumed to be approximately 5 percent natural origin (WDFW 2009). However, no datasets were found to represent these upriver populations. Trapping Gibbons Creek (RKm 126) showed peak coho emigration to be in Week 18 in 1998 and 1999, ranging over the period of Weeks 17–23 (USFWS 2003). Gibbons Creek coho may be most representative of juveniles passing the CRC project area. However, the dataset for Gibbons Creek is limited and not appropriate to represent all life histories present. Gibbons Creek coho timing is well represented by the Clackamas dataset in Weeks 17–23 for later-timed emigrants.

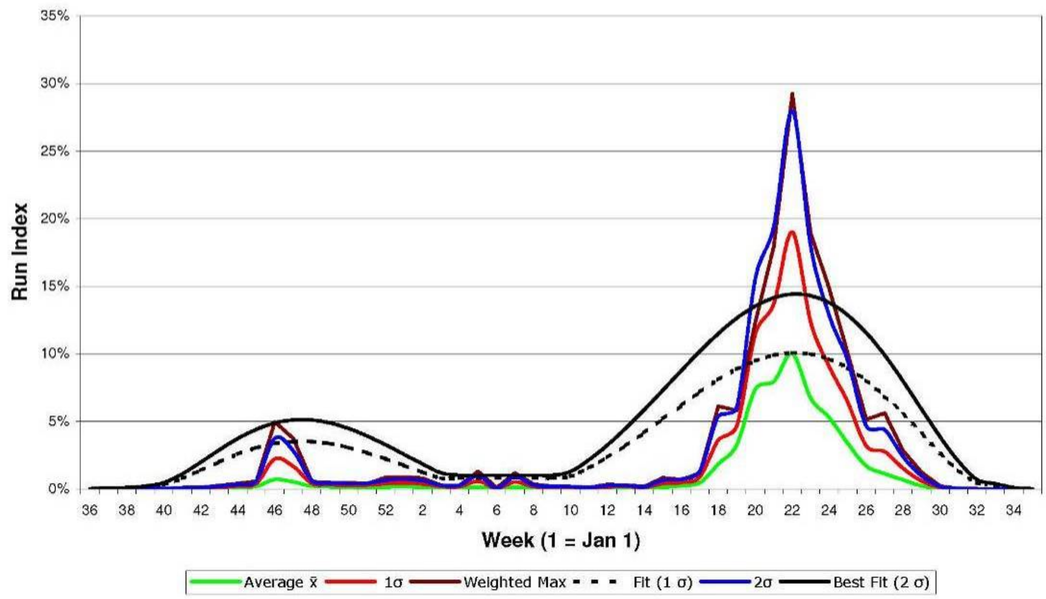


Figure 4-21. Comparison of LCR coho timing at the CRC project area based on passage to the North Fork of the Clackamas River.

The period of record for this analysis is 1999–2000 through the 2008-2009 season. Data processing included summing all counts to get total returns, removing negative values, and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Week 35 through to Week 35 of the following year. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index values observed for the period of record were 0.050 (Week 46), and 0.29 (Week 22). The maximum run index was estimated to be 0.029, based on a weighted mean abundance of 0.0070 and $\sigma = 0.015$ in Week 46, and to be 0.29, based on a weighted mean abundance of 0.10 and $\sigma = 0.090$ in Week 22. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-21). Timing from the North Fork was not shifted and presumed to approximate timing at the CRC project area, providing a bimodal curve and an overall duration of 51 weeks with peaks in Week 46 and Week 22 (Figure 4-20).

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.6.2 Data Assumptions

The duration and pattern of timing of Clackamas River coho juveniles reflects the timing of natural origin coho that may pass through the CRC project area.

4.3.6.3 Known Data Gaps

Presence of Clackamas River coho in the CRC project area is not documented.

4.3.6.4 Data Options

Continue use of existing dataset and estimates.

4.3.7 Lower Columbia River Chinook – Overview of ESU

Figure 4-22 presents the estimated run timing of LCR Chinook adults and juveniles at the CRC project area.

4.3.7.1 Overview

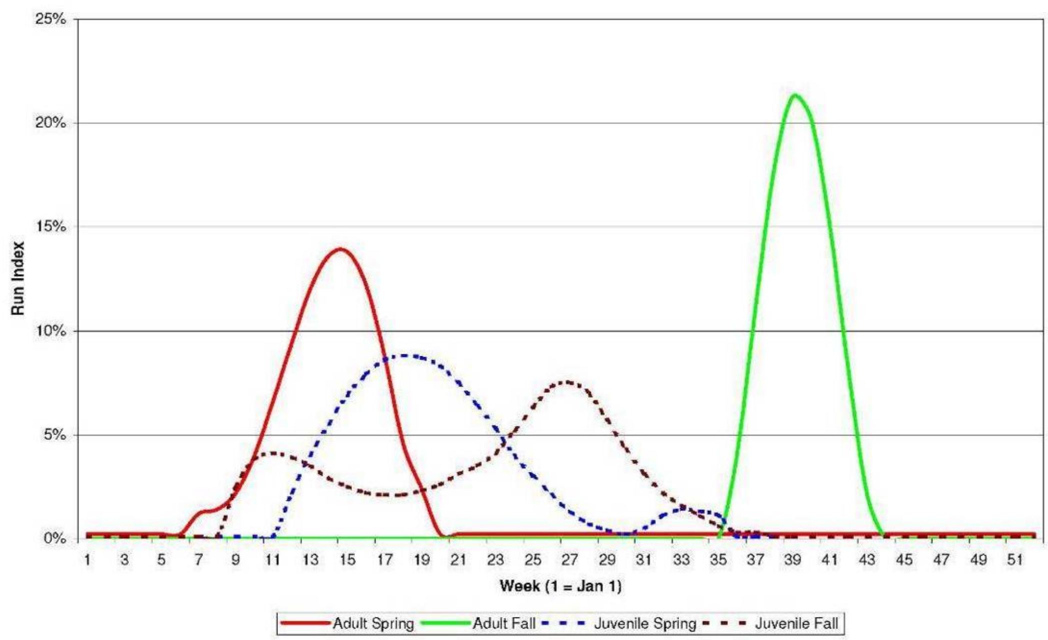


Figure 4-22. Estimated run timing of LCR Chinook adults and juveniles at the CRC project area.

LCR Chinook were listed in March 1999 and re-affirmed as a threatened species in 2005 (70 FR 37160). The ESU includes all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Washington and Oregon east of the Hood and White Salmon Rivers. It also includes the Willamette River up to Willamette Falls, Oregon, exclusive of spring-run Chinook in the Clackamas River, as well as 17 artificial propagation programs. Spring- and fall-runs (races) are recognized as distinct in timing and population structure. This analysis focuses on those Chinook populations most likely to be present in the CRC project area (WDFW 2009). Spring Chinook populations include adults from the Cowlitz, Kalama, and Lewis Rivers that may stray into the CRC project area, and adults and juveniles from the Sandy River. Fall "tule" Chinook include adults and juveniles from the Sandy and Washougal Rivers and production from above Bonneville Dam, known for management purposes as "Bonneville Pool Fall Chinook."

An overview of LCR Chinook timing is presented in Figure 4-22 for all populations. Run timing and analysis details are presented by population and life stage in the following sections. A complete review of LCR Chinook life history is presented in Appendix C.

4.3.8 Lower Columbia River Spring-Run Chinook – Adult

Figure 4-23 presents the estimated timing and duration of LCR spring-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

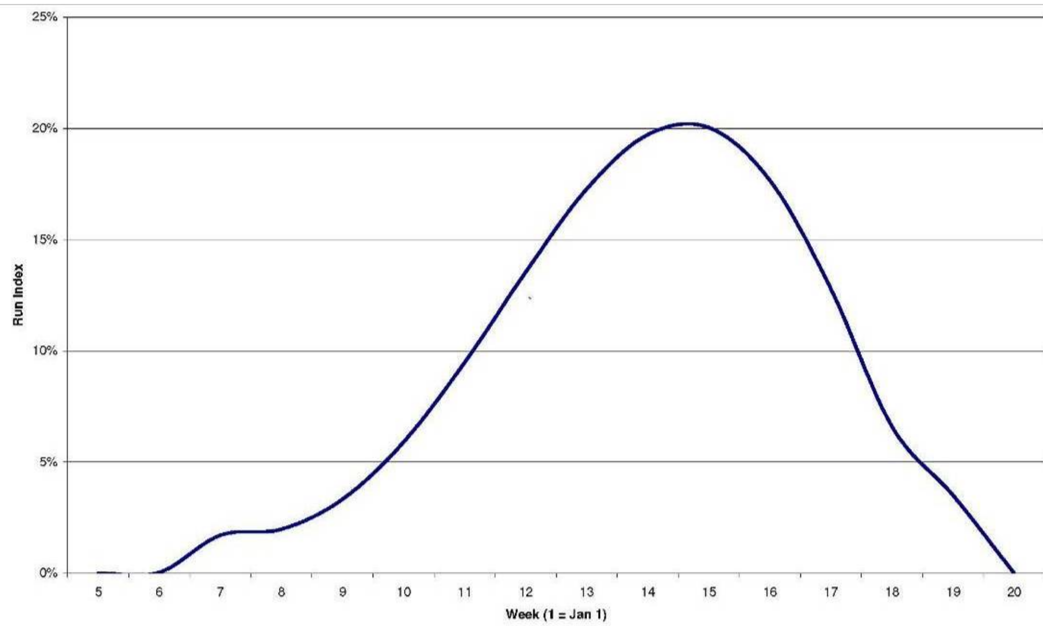


Figure 4-23. Timing and duration of LCR spring-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.8.1 Data Sources

Initial estimates of timing and duration were based solely on counts at Bonneville Dam that resulted in later timing at the CRC project area than expected by reviewers. Sport sampling data supplied by ODFW for the vicinity of the CRC project area indicate first catches (2008–2010) in Week 9, peaking about Week 14 (Brick 2010 personal communication). Allowing for staging and pre-season management protocols, creel data greatly inform estimates of early run timing. However, the stock composition of this popular spring-run Chinook fishery does not represent LCR Chinook exclusively. The best available data to estimate the pattern of run timing of LCR spring-run Chinook adults (Figure 4-23) is still considered to be counts at Bonneville Dam., These datasets provide a long period of record, are stock specific, and inform estimates of duration that is truncated by harvest- and temporal-limited fisheries. In addition, Bonneville data are readily integrated with early season data to provide a contemporary view of timing and duration.

The period of record for this analysis is 1999–2008. Daily count data were obtained from the University of Washington's Columbia Basin Data in Real Time (DART) (2009) and also provided by WDFW (2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 4–23. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value for the period of record was 0.28 in Week 18. The maximum run index was estimated to be 0.25 based on a weighted mean abundance of 0.11 and $\sigma = 0.075$ in Week 18. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-24). Arrival at the CRC project requires approximately 2 days from the upstream boundary of the LCR Chinook ESU (WDFW 2009). Therefore, for statistical purposes, timing data represent a mid-week occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area. This provides an estimated duration of 16 weeks (Weeks 5–20) peaking in Week 18 at the CRC project area.

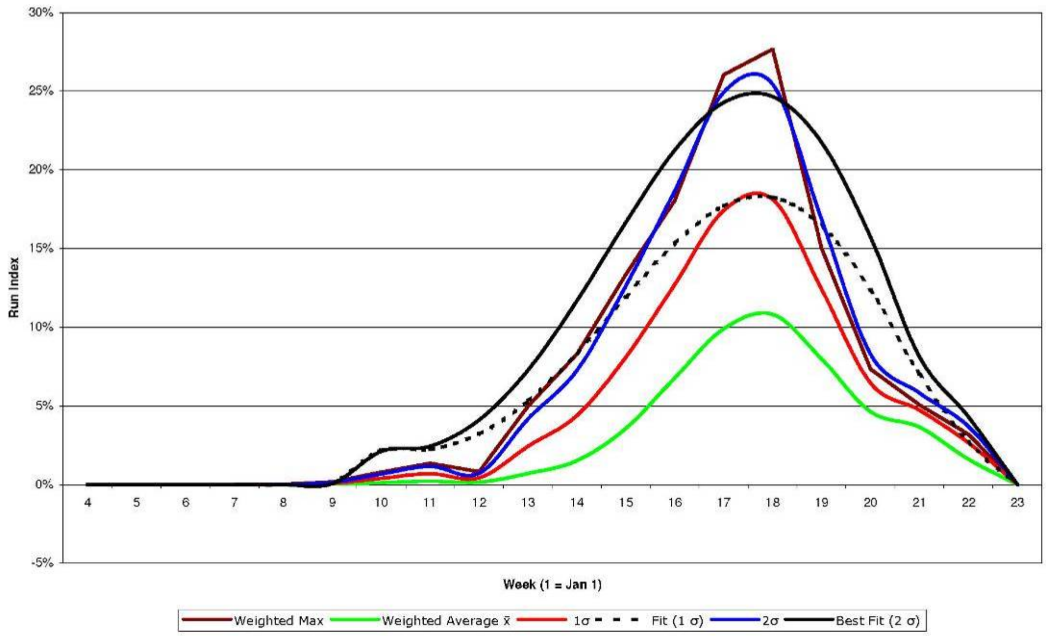


Figure 4-24. LCR spring-run Chinook adult passage through the CRC project area reflecting counts at Bonneville Dam, 1999–2008.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). An example of this effect occurs near Week 12 (Figure 4-24), where the maximum run index departs from the average for that week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.8.2 Data Assumptions

LCR spring-run Chinook are present in the CRC project area in low numbers prior to recent fishery openings. Fish destined for tributaries upstream of Bonneville represent the timing of natural origin fish between Bonneville and the CRC project area. Use of a maximum likelihood approach also may help to represent LCR spring-run Chinook destined for streams below Bonneville. Spring-run Chinook adults from populations below the CRC project area (i.e., Cowlitz, Kalama, and Lewis Rivers) and from the Sandy River may be present at about 2 percent of the annual LCR Chinook population (WDFW 2009). Hatchery production upstream of the CRC project area that is part of the LCR Chinook ESU is not expected to warrant separate timing estimates or to influence timing estimates for natural origin fish. This assumes, specifically, that small populations of LCR spring-run Chinook that are known from anecdotal history or are not otherwise identified in this analysis are represented by the estimated run timing and duration. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by the standard deviation of mean weekly values.

4.3.8.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished. Spring Chinook adults from populations below the CRC project area (i.e., Cowlitz, Kalama, and Lewis Rivers) and from the Sandy River may be present at low but unknown levels of abundance. Spring-run Chinook spawning in mainstem areas is known to occur, but locations of spawning sites and the productivity of spawning groups is not well documented. The population composition represented in early season catches is not known.

4.3.8.4 Data Options

Continue to seek timing data for natural origin and hatchery spring-run Chinook adults that may be present in the CRC project area, particularly for the Sandy River population.

4.3.9 Lower Columbia River Spring-Run Chinook – Juvenile

Figure 4-25 presents the estimated timing and duration of LCR spring-run Chinook juveniles passing through the CRC project area based on tag detections at Bonneville Dam for 1999–2008.

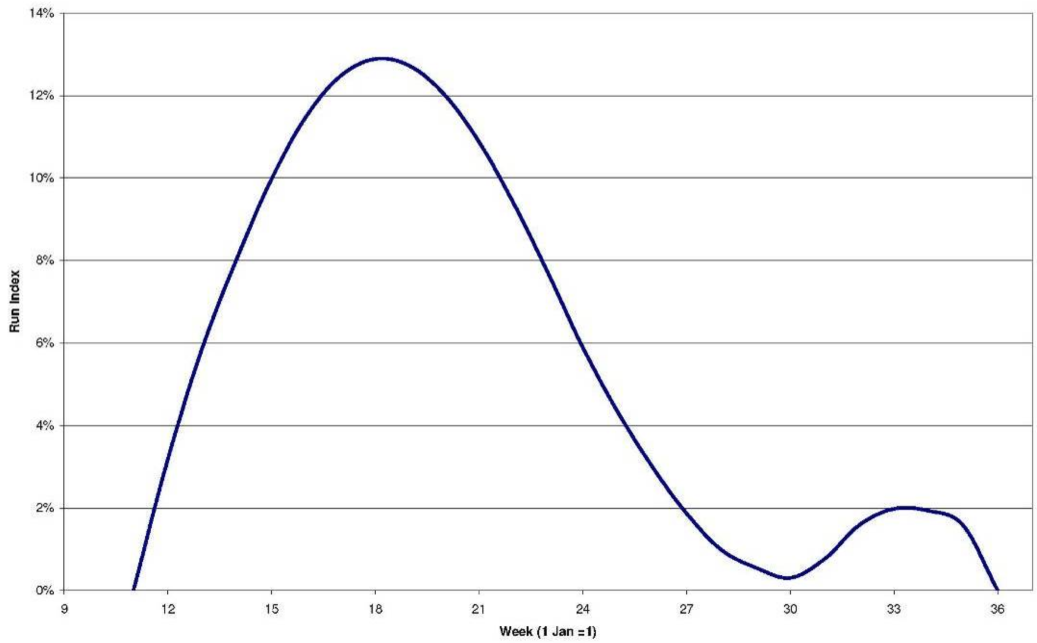


Figure 4-25. Estimated timing and duration of LCR spring-run Chinook juveniles passing through the CRC project area based on tag detections at Bonneville Dam, 1999–2008.

4.3.9.1 Data Sources

The best available data to estimate run timing of LCR spring-run Chinook juveniles (Figure 4-25) are considered to be tag detections at Bonneville Dam. The period of record for this analysis is 1999–2008. Daily count data were obtained from DART (UW 2009) and were also provided by FPAC (2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 11–36. In response to the CRC project team's request for assistance with gathering fish data (CRC 2008), FPAC cautioned that these data are for hatchery fish only and are highly dependent on release dates of major PIT-tagged groups from individual facilities (FPAC 2009). These data do not include fish from below Bonneville Dam. Alternatively, daily passage indexes (expansions from daily sampling at Bonneville Dam) for the run-at-large used for LCR fall-run Chinook (Section 4.3.11) could have been applied. However, stock-specific data were considered by the authors of this report to be preferable to multi-species composites, even with uncertainty about representation of natural origin juveniles. LCR spring-run Chinook life history is detailed in Appendix C.

Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 9–38. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.034 in Week 18. The maximum run index was estimated to be 0.31 based on a weighted mean abundance of 0.13 and σ = 0.1, also in Week 18. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-26). This provides an estimated duration of 26 weeks (Weeks 11–36). The timing curve is bimodal with relative maxima occurring in Week 18 (dominant) and Weeks 33–34 (minor). Arrival at the CRC project area requires less than 1 day from the upstream boundary of the LCR Chinook ESU, based on an average velocity of 0.94 m/s for the period of record (FPAC 2009). For statistical purposes, timing data represent a mid-week occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area.

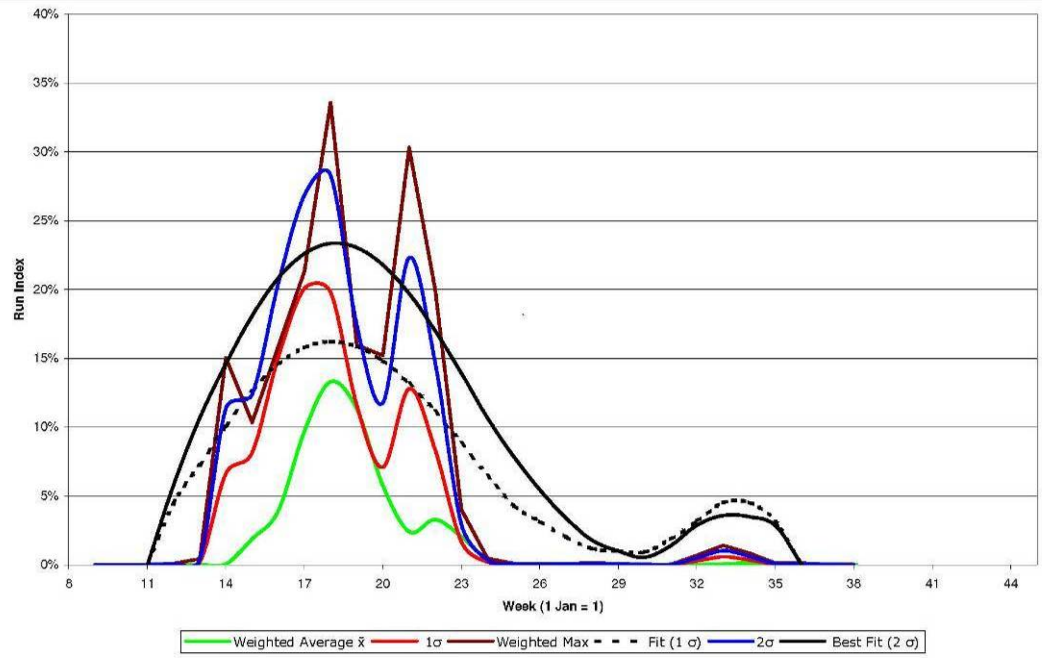


Figure 4-26. LCR spring-run Chinook juvenile passage at Bonneville Dam, 1999–2008.

4.3.9.2 Data Assumptions

PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery LCR spring-run Chinook below Bonneville Dam that can reasonably be expected to be present in the CRC project area. Timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.9.3 Known Data Gaps

Releases of PIT-tagged fish above Bonneville Dam have not been examined for consistency. While passage indexes at Bonneville Dam are based on counts and sampling, they are not population estimates. Thus, the abundance of natural origin fish is not known. These data do not include fish from below Bonneville Dam and may not reflect variation in timing and/or behavior of LCR spring-run Chinook juveniles.

4.3.9.4 Data Options

Seek substitute or supplemental data from studies conducted downstream of Bonneville Dam.

4.3.10 Lower Columbia River Fall-Run Chinook – Adult

Figure 4-27 presents the estimated timing and duration of LCR fall-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

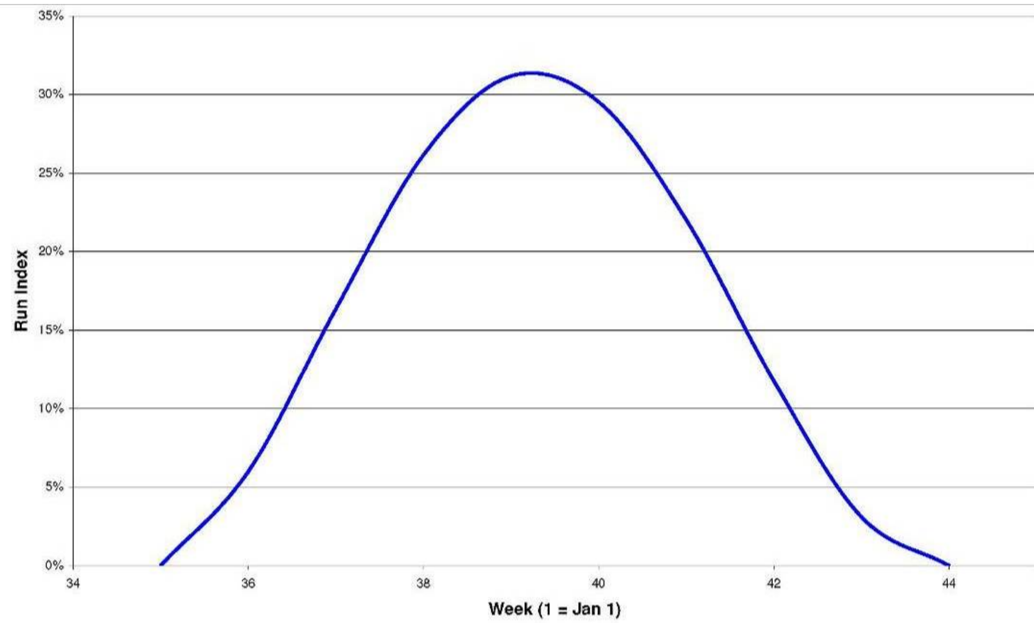


Figure 4-27. Timing and duration of LCR fall-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.10.1 Data Sources

The best available data to estimate run timing of LCR fall-run Chinook adults (Figure 4-27) are considered to be counts at Bonneville Dam for tule Chinook and Bonneville Pool fall-run Chinook components. The period of record for this analysis is 1999–2008. Daily count data were obtained from DART (UW 2009) and were also provided by WDFW (2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 31–44. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.55 in Week 37. The maximum run index was estimated to be 0.31 based on a weighted mean abundance of 0.18 and $\sigma = 0.17$ in Week 37. A polynomial curve was fit to 1σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-28). Timing at Bonneville was shifted earlier to Week 35 on the recommendation of WDFW (2009), providing an estimated duration of 10 weeks (Weeks 35–44) peaking in Week 39 at the CRC project area.

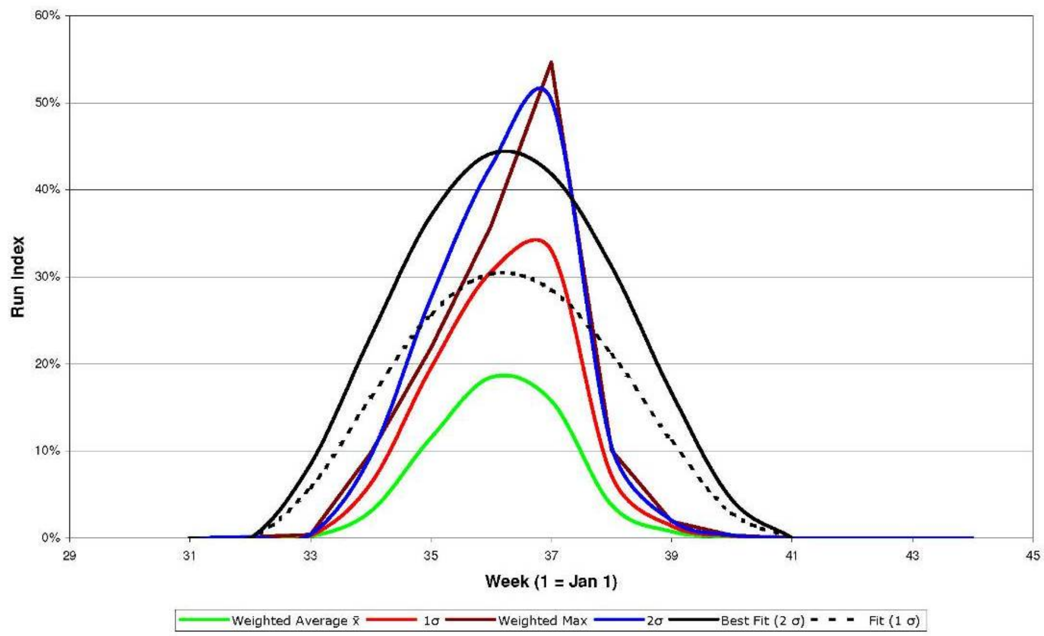


Figure 4-28. LCR fall-run Chinook adult passage through the CRC project area based on returns based on counts at Bonneville Dam, 1999–2008.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. An example of this effect occurs near Week 37 (Figure 4-28), where the maximum run index departs from the average for that week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.10.2 Data Assumptions

Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

A 10-year average return to the Washougal River may be 10,000 fish, with perhaps 20 percent being of natural origin. For the Sandy River, a 10-year average may be 800 fish, all of natural origin. Approximately 13 percent of the Bonneville Pool component is assumed be of natural origin. Timing for hatchery and natural origin fish is assumed to be the same. These assumptions are provided by WDFW (2009).

Timing for Bonneville Pool fall-run Chinook is assumed to be bracketed by the potentially earlier-timed LCR tule component and use of a maximum likelihood approach. In addition, the selection of Weeks 35–44 provides sufficient range to characterize LCR fall-run Chinook run timing. Inspection of 30 years of records found only one year (1979) with fish counted beyond Week 44 (eight fish over Weeks 44–46).

4.3.10.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished. The population of natural origin fish is not known (WDFW 2009).

4.3.10.4 Data Options

Continue use of current dataset.

4.3.11 Lower Columbia River Fall-Run Chinook – Juvenile

Figure 4-29 presents the estimated timing and duration of LCR fall-run Chinook juveniles passing through the CRC project area based on sampling at Bonneville Dam from 1999–2008.

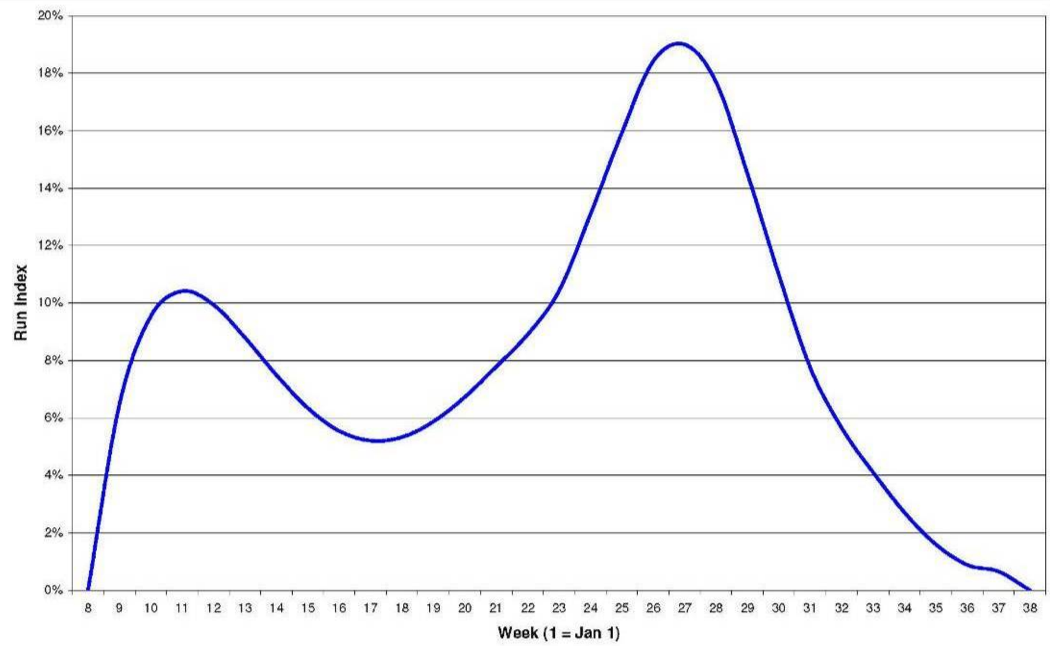


Figure 4-29. Estimated timing and duration of LCR fall-run Chinook juveniles passing through the CRC project area based on sampling at Bonneville Dam, 1999–2008.

4.3.11.1 Data Sources

Stock-specific data for LCR fall-run Chinook juveniles were not available for analysis. In response to the CRC project team's request for assistance with gathering fish data (CRC 2008), FPAC found that PIT-tagged releases of LCR fall-run Chinook juveniles above Bonneville Dam were inconsistent and not useable for estimating run timing (FPAC 2009). Alternatively, daily passage indexes (expansions from daily sampling at Bonneville Dam) are considered useful for run timing information. FPAC (2009) provided data for "run-at-large" timing of juvenile Chinook (yearling and subyearling), steelhead, and sockeye based on daily passage indexes for 1999–2008. These data were used as a surrogate and estimate for LCR Chinook juvenile passage at the CRC project area (Figure 4-29) for releases of PIT-tagged juvenile above Bonneville Dam. Therefore, the run-at-large is used to provide a general index of timing for absent population-specific data.

Fall Chinook emigration is dominated by hatchery production. LCR fall-run Chinook exhibit a consistent ocean-type life history, emigrating as age-0s. These data do not include fish from below Bonneville Dam. These composite frequency data include a pool of populations that generally key on temperature and flows to begin and continue downstream migration.

Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.25 in Week 27. The maximum run index was estimated to be 0.1 based on a weighted mean abundance of 0.09 and $\sigma = 0.079$, also in Week 27. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-30), providing an estimated duration of 39 weeks (Weeks 8–38). The timing curve is bimodal with relative maxima occurring in Weeks 11 and 27 (Figure 4-29). Arrival at the CRC project area requires less than 1 day from the upstream boundary of the LCR Chinook ESU, based on average velocities of 0.9 m/s for the species that comprise the run-at-large (FPAC 2009). For statistical purposes, timing data represent a mid-week occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area.

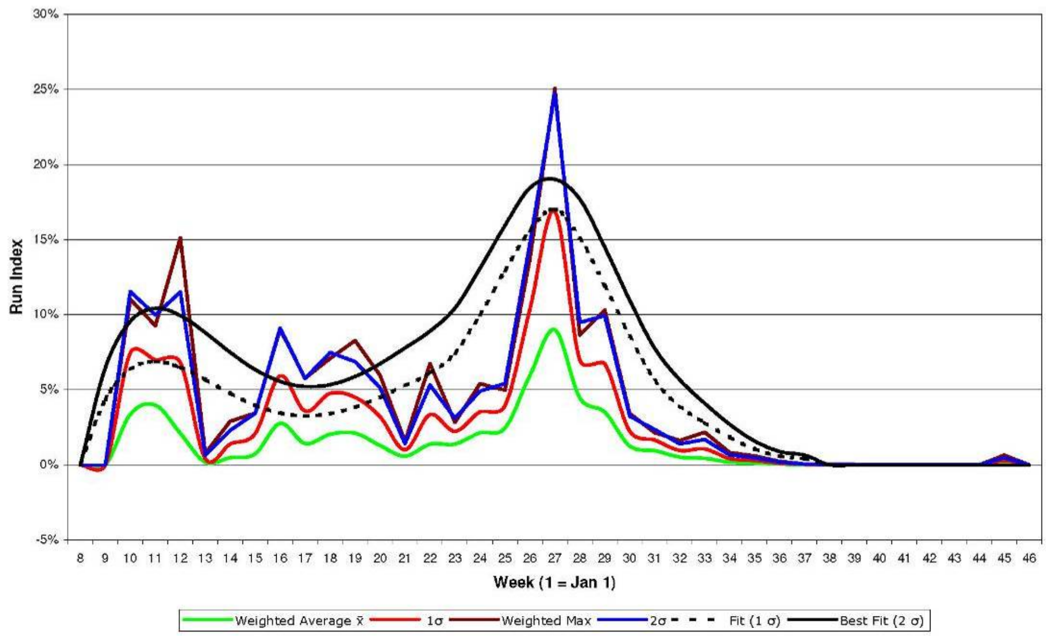


Figure 4-30. Estimated LCR fall-run Chinook juvenile passage at Bonneville Dam, 1999-2008.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.11.2 Data Assumptions

PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery LCR fall-run Chinook below Bonneville Dam that can reasonably be expected to be present in the CRC project area. Timing for hatchery and natural origin fish is assumed to be the same.

Weighting or redistributing weekly abundance based on variation incorporates uncertainty without artificially shifting peak run timing.

4.3.11.3 Known Data Gaps

Inconsistent releases of PIT-tagged fish above Bonneville Dam precluded use of those data as surrogates for natural origin fish. While passage indexes at Bonneville Dam are based on counts and sampling, they are not population estimates. Thus, the abundance of natural origin fish is not known (FPAC 2009). These data do not include fish from below Bonneville Dam.

4.3.11.4 Data Options

Seek substitute data for the juvenile run-at-large provided by FPAC (2009). Conduct additional analyses to validate application of run-at-large as a surrogate for timing of LCR fall-run Chinook juveniles.

4.3.12 Upper Columbia River Spring-Run Chinook – Adult

Figure 4-31 presents the estimated timing and duration of UCR spring-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam for 2001–2008.

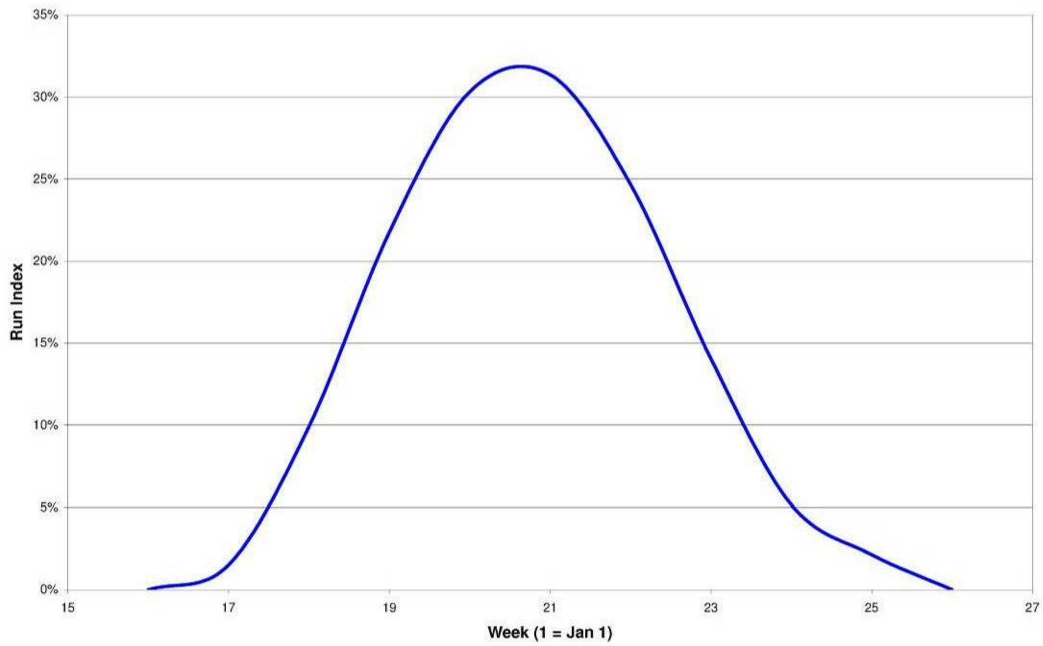


Figure 4-31. Timing and duration of UCR spring-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam, 2001–2008.

4.3.12.1 Data Sources

UCR spring-run Chinook have been listed as endangered under the ESA since 2005 (70 FR 37160). The ESU includes all naturally spawned populations of spring Chinook in all river reaches accessible to spring Chinook in tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington, as well as six artificial propagation programs: the Twisp River, Chewuch River, Methow Composite, Winthrop National Fish Hatchery (NFH), Chiwawa River, and White River hatchery programs. The best available data to estimate run timing of UCR spring-run Chinook adults are considered by the authors of this report to be counts at Bonneville Dam (Figure 4-31). The period of record for this analysis is 2001–2008. Daily count data were obtained from DART (UW 2009) and were also provided by WDFW (2009).

Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 17-27. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.25 in Week 21. The maximum run index was estimated to be 0.31 based on a mean abundance of 0.1 and $\sigma = 0.09$ in Week 21. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-32). Timing at Bonneville Dam was shifted earlier to start in Week 16 on the recommendation of WDFW (2009), providing an estimated duration of 11 weeks (Weeks 16–26) peaking in Week 21 at the CRC project area.

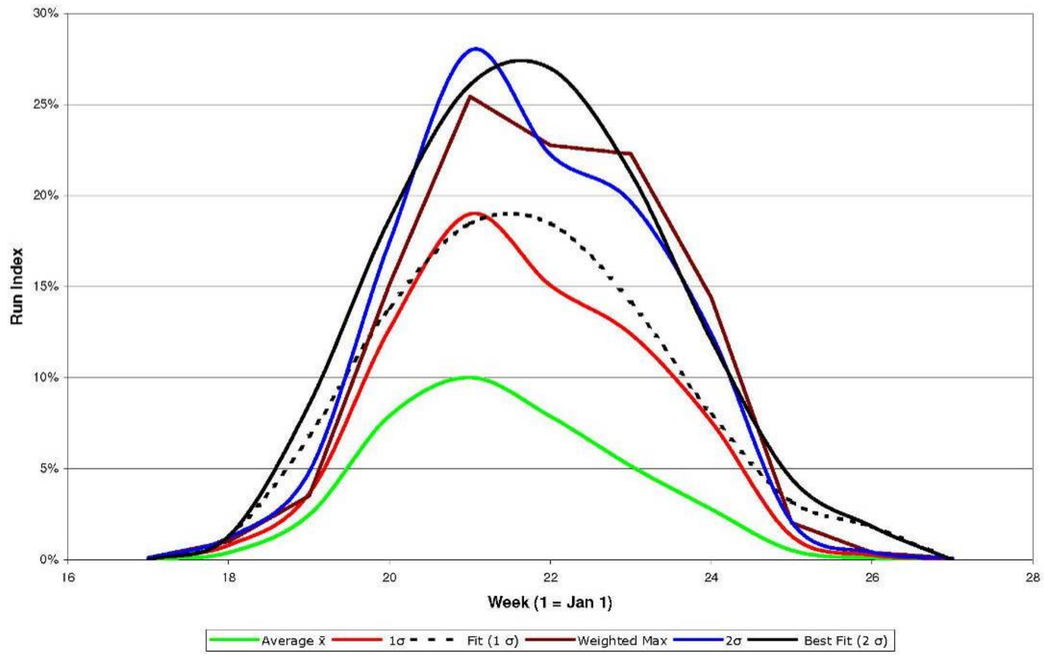


Figure 4-32. UCR spring-run Chinook adult passage through the CRC project area based on counts at Bonneville Dam, 2001–2008.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). Variation in weekly run indexes across years increases the maximum value that might be expected for any week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.12.2 Data Assumptions

Timing of hatchery and natural origin fish is assumed to be the same.

4.3.12.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished.

4.3.12.4 Data Options

Continue use of Bonneville Dam count data to provide consistency.

4.3.13 Upper Columbia River Spring-Run Chinook – Juvenile

Figure 4-33 presents the estimated timing and duration of UCR spring-run Chinook juveniles passing through the CRC project area based on counts at Bonneville Dam for 1998–2008.

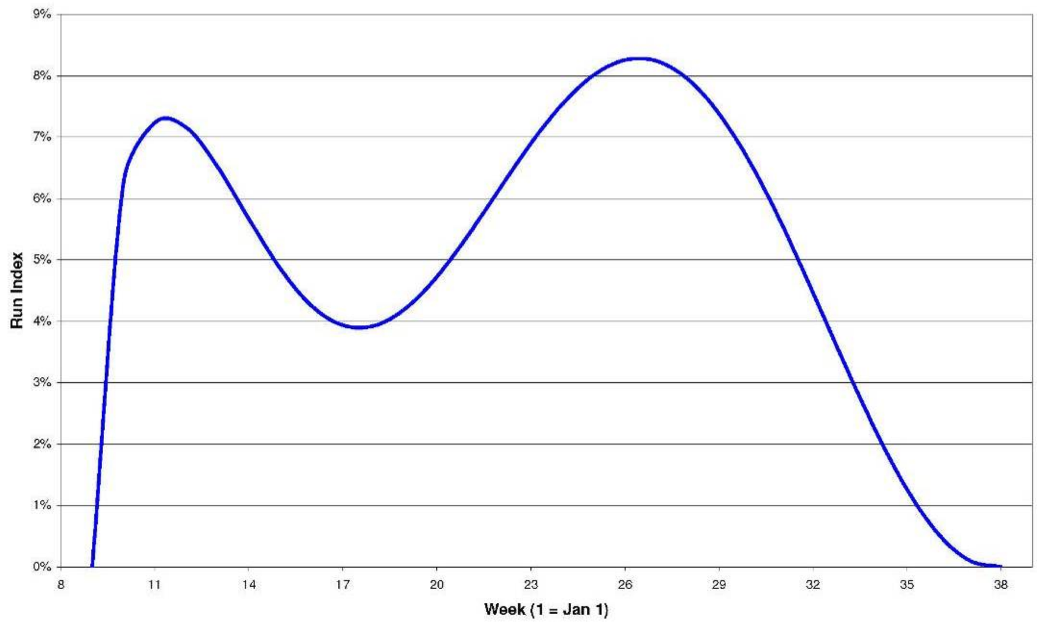


Figure 4-33. Timing and duration of UCR spring-run Chinook juveniles passing through the CRC project area based on counts at Bonneville Dam, 1998–2008.

4.3.13.1 Data Sources

Stock-specific data for UCR spring Chinook juveniles were not available for analysis. In response to the CRC project team's request for assistance gathering fish data (CRC 2009), FPAC provided data for "run-at-large" timing of juvenile Chinook (yearling and subyearling) based on daily passage indexes at Bonneville from 1998–2008. These data were used as a surrogate and estimate for UCR Chinook juvenile passage at the CRC project area (Figure 4-33) from releases of PIT-tagged juveniles above Bonneville Dam.

UCR spring Chinook are characterized by a stream-type life history, typically emigrating as yearlings (age 1+). It is reasonable to expect that there is some variation in the timing, particularly for natural-origin fish, that is not represented in composite data (from multiple ESUs) and combined with hatchery releases for yearling run-at-large. This analysis utilizes the greater duration of the subyearling run-at-large curve to extend the duration of upriver Chinook yearlings (Figure 4-34). The use of subyearling data provides a more robust curve that allows for diversity in life history strategies and variation in hatchery releases that may occur during project construction.

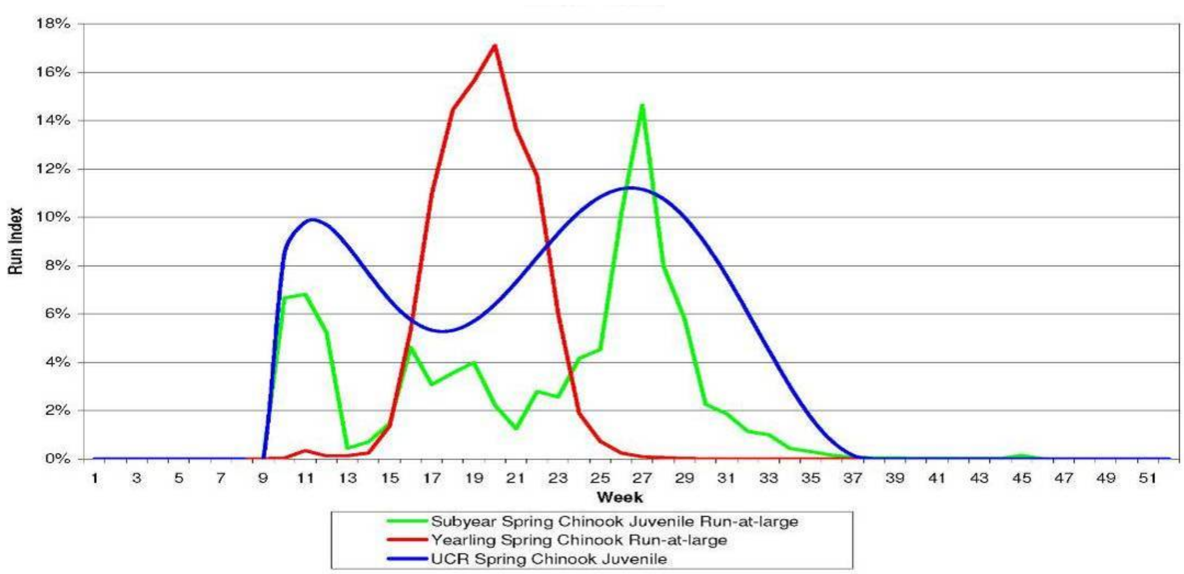


Figure 4-34. Comparison of timing and duration for spring-run Chinook subyearling and yearling run-at-large and weighted maximum run indexes estimated for UCR spring-run Chinook juveniles passing through the CRC project.

The period of record for this analysis is 1999–2008. Daily count data were provided by FPAC (2009) and obtained from DART (UW 2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 9–38. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.25 in Week 27. The maximum run index was estimated to be 0.082 based on a mean abundance of 0.082 and σ = 0.079 in Week 27. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-35). Timing at Bonneville Dam was not shifted, providing an estimated duration of 30 weeks (Weeks 9–38) peaking in Week 27 at the CRC project area.

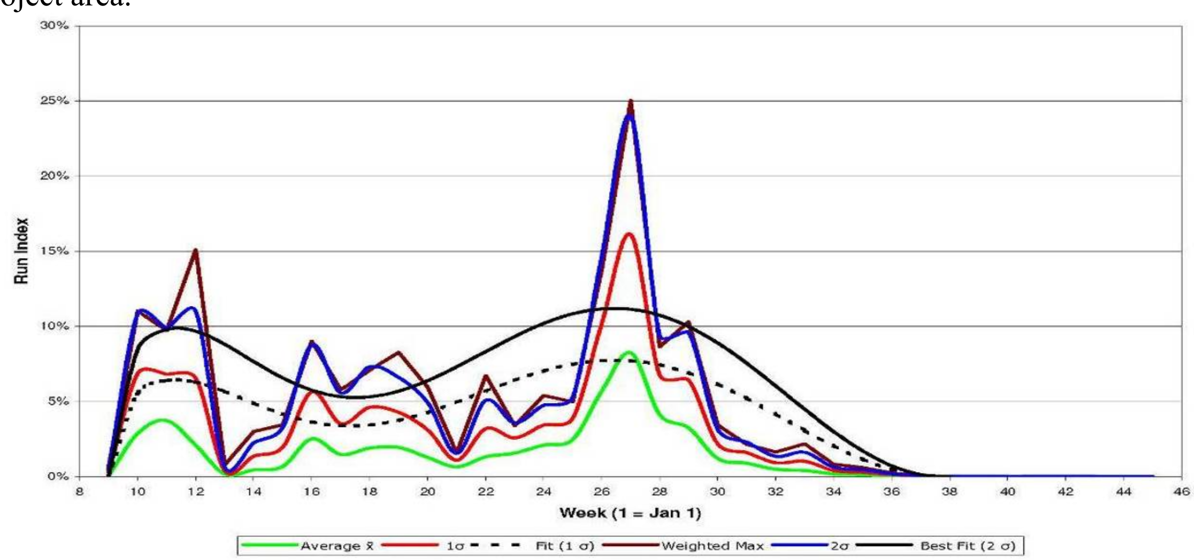


Figure 4-35. UCR spring-run Chinook juvenile passage through the CRC project area based on counts at Bonneville Dam, 2001–2008.

Arrival at the CRC project area requires less than 1 day from Bonneville Dam based on average velocities of 0.9 m/s for the species that comprise the run-at-large (FPAC 2009). For statistical purposes, timing data represent a mid-week occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area.

4.3.13.2 Data Assumptions

Timing of hatchery and natural origin fish is assumed to be the same.

4.3.13.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished.

4.3.13.4 Data Options

Continue use of Bonneville Dam count data to provide consistency.

4.3.14 Upper Willamette River Spring-Run Chinook – Adult

Figure 4-36 presents the estimated timing and duration of UWR spring-run Chinook adults passing through the CRC project area based on counts at Willamette Falls for 2000–2008.

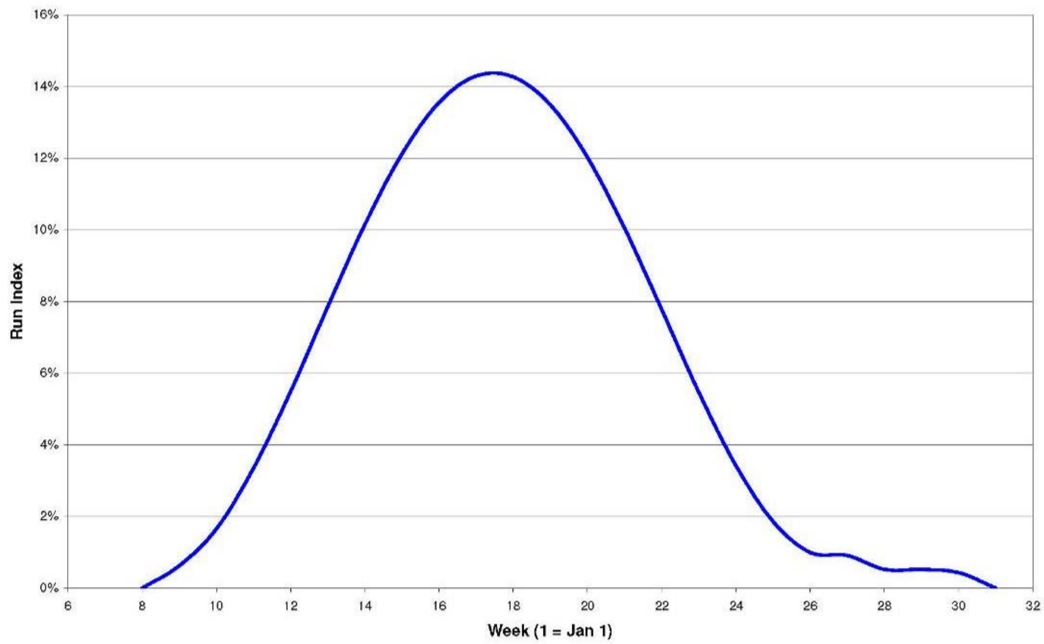


Figure 4-36. Timing and duration of UWR spring-run Chinook adults passing through the CRC project area based on counts at Willamette Falls, 2000–2008.

4.3.14.1 Data Sources

UWR spring-run Chinook were first listed as threatened in 1999 and were re-affirmed as threatened in 2005. The ESU includes all naturally spawned populations in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, Oregon, as well as seven artificial propagation programs. The life history, distribution and general ecology of UWR Chinook is provided in Appendix C. The best available data to estimate run timing of UWR spring-run Chinook adults are considered by the authors of this report to be counts conducted by ODFW at the Willamette Falls fishway for spring-run Chinook components (ODFW 2010). The period of record for this analysis is 2000–2008.

Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 7–34. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.19 in Week 18. The maximum run index was estimated to be 0.14 based on a weighted mean abundance of 0.09 and $\sigma = 0.064$ in Week 18. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-37). Timing at Willamette Falls was shifted earlier to start in Week 8, providing an estimated duration of 24 weeks (Weeks 8–31) peaking in Week 18 (April 29) at the CRC project area.

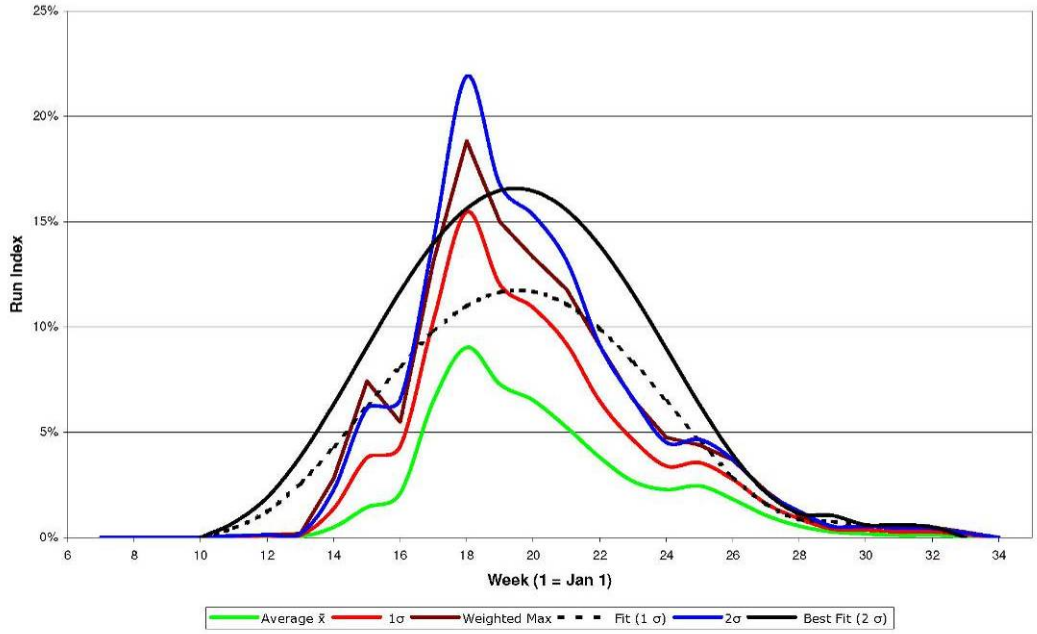


Figure 4-37. UWR spring-run Chinook adult passage through the CRC project area based on returns based on counts at Willamette Falls, 2000–2008. The maximum and average run indexes are shown with a curve fit to the maximum weekly values.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. An example of this effect occurs near Week 17 (Figure 4-37), where the maximum run index departs from the average for that week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario. Equally important is the potential for less than 5 percent of the annual run to occur in the CRC project area (WDFW 2009).

4.3.14.2 Data Assumptions

The timing of natural origin fish is similar to that of hatchery origin fish. Spring-run Chinook timing in the Clackamas River is expected to be similarly timed with returns to Willamette Falls. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.14.3 Known Data Gaps

Timing differences between listed hatchery and natural origin fish and other non-listed hatchery returns cannot be distinguished. Data for the Clackamas River spring-run Chinook population may be available and potentially used to provide a composite timing with UWR populations.

4.3.14.4 Data Options

Data for the Clackamas River spring-run Chinook population may be available and potentially used to provide a composite timing with UWR populations.

4.3.15 Upper Willamette River Spring-Run Chinook – Juvenile

Figure 4-38 presents the estimated timing and duration of Upper Willamette River (UWR) spring-run Chinook juveniles passing through the CRC project area based on detections at Willamette Falls for 2000–2009.

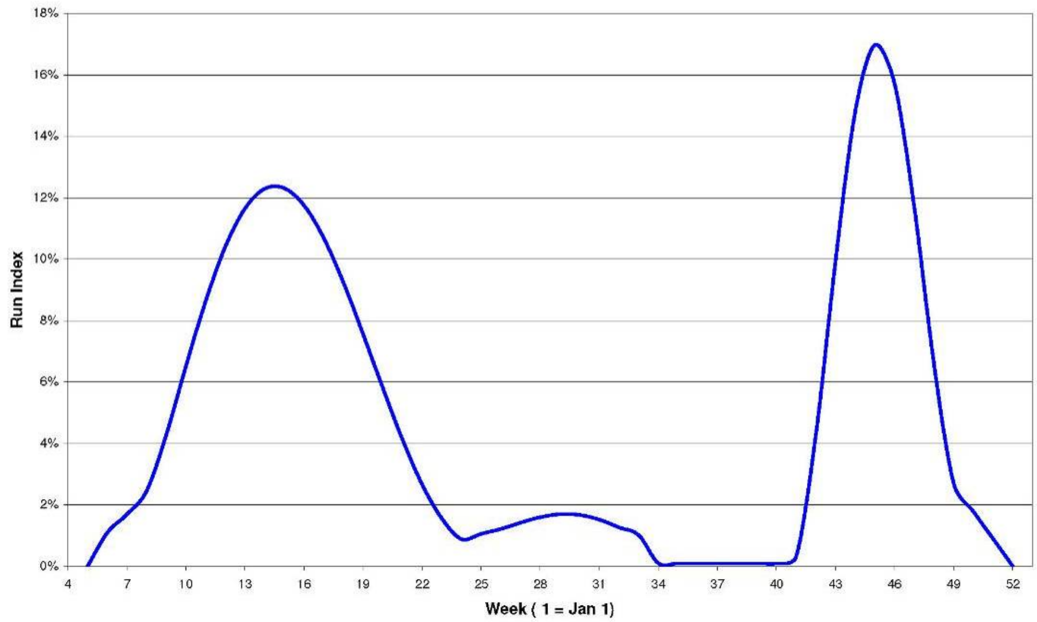


Figure 4-38. Estimated timing and duration of UWR spring-run Chinook juveniles passing through the CRC project area based on detections at Willamette Falls, 2000–2009.

4.3.15.1 Data Sources

Stock-specific data for UWR spring-run Chinook juveniles were available for analysis from PIT-tag detections at Willamette Falls from 2000–2009 (PTAGIS 2010). Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.18 in Week 15, and 0.22 in Week 45. The maximum run index was estimated to be 0.11 (Week 15) and 0.16 (Week 45) based on a weighted mean abundance of 0.026, with $\sigma = 0.058$, and 0.050, with $\sigma = 0.086$, respectively. A polynomial curve was fit to 3σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-39), providing an estimated duration of 52 weeks (Weeks 1–52). The timing curve is bimodal with relative maxima occurring in Weeks 15 and 45, reflecting the potential for UWR juveniles to exhibit both ocean- and stream-type life histories. Arrival at the CRC project area requires less than 1 day from passage at Willamette Falls based on average velocities of 0.9 m/s for LCR spring-run Chinook juveniles (FPAC 2009). For statistical purposes, timing data represent a mid-week occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area unless passage time is at least 3.5 days (84 hrs).

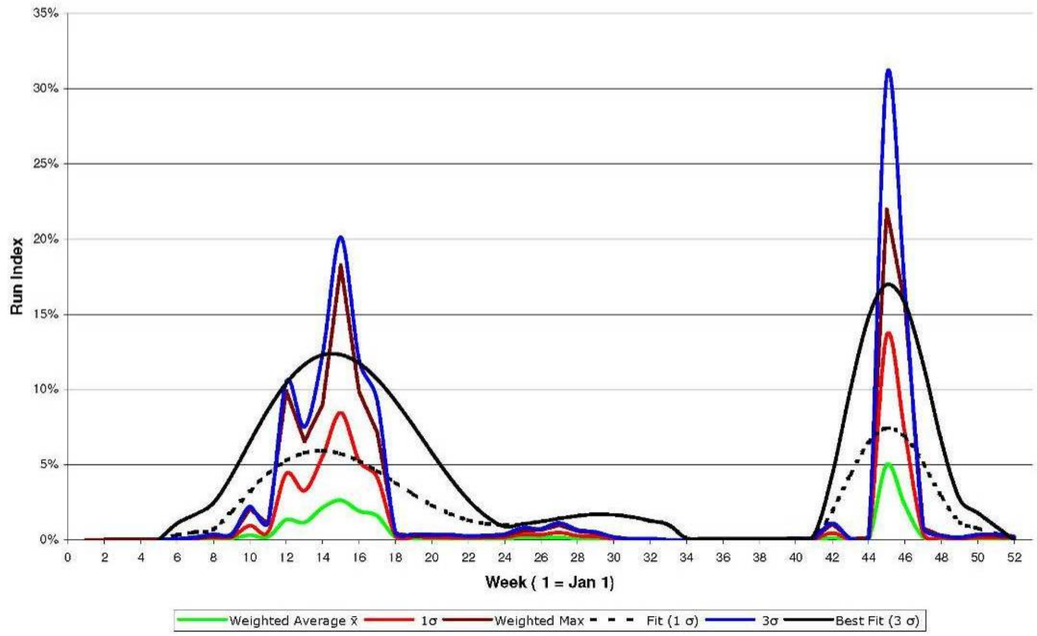


Figure 4-39. Estimated UWR spring-run Chinook juvenile passage at Willamette Falls, 2000–2009.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. These effects are evident in comparison of the curve fit to apparent pulses of juvenile emigration throughout the year (e.g., Weeks 15 and 45).

4.3.15.2 Data Assumptions

Weighting or redistributing weekly abundance based on variation incorporates uncertainty without artificially shifting peak run timing.

4.3.15.3 Known Data Gaps

The abundance, or run size, of natural origin and hatchery juveniles is not known.

4.3.15.4 Data Options

Validate PIT-tag dataset to increase certainty about timing and modality of UWR spring-run Chinook juveniles.

4.3.16 Snake River Spring/Summer-Run Chinook – Adult

Figure 4-40 presents the estimated timing and duration of SR spring/summer-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam from 1999–2008.

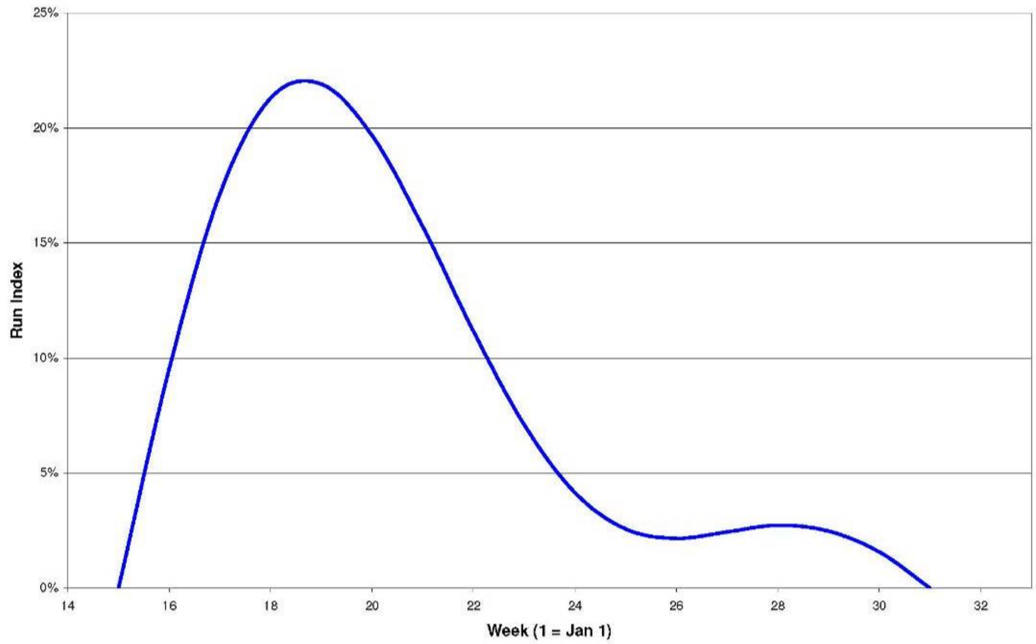


Figure 4-40. Timing and duration of SR spring/summer-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.16.1 Data Sources

The Snake River ESU includes all naturally spawned populations of spring/summer-run Chinook in the mainstem Snake River and the Tucannon, Grande Ronde, Imnaha, and Salmon River subbasins, as well as 15 artificial propagation programs (70 FR 37160). The ESU was originally listed under the ESA in 1992 and was re-affirmed as threatened in 2005. The life history, distribution, and general ecology of SR Chinook are detailed in Appendix C of the BA.

The best available data to estimate run timing of SR spring/summer-run Chinook adults at the CRC project area (Figure 4-40) are considered by the authors of this report to be counts at Bonneville Dam. SR Chinook are counted as part of similarly timed adults from other populations above Bonneville. As returns to the Columbia River, the SR natural origin component of this group has ranged between approximately 5,300 in 1999 and 60,400 fish in 2001, and averaging around 29,000 between 2002–2008 (JCRMS 2009).

The period of record for this analysis is 1999–2008. Daily count data were obtained from DART (UW 2009) and provided by WDFW (2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 16–33. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.26. The maximum run index was estimated to be 0.22 based on a weighted mean abundance of 0.11 and $\sigma = 0.09$ in Week 19. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-41). Timing at Bonneville Dam was shifted earlier to start in Week 15 on the recommendation of WDFW (2009), providing an estimated duration of 17 weeks (Weeks 15–31) peaking in Week 19 (May 7) at the CRC project area (Figure 4-40).

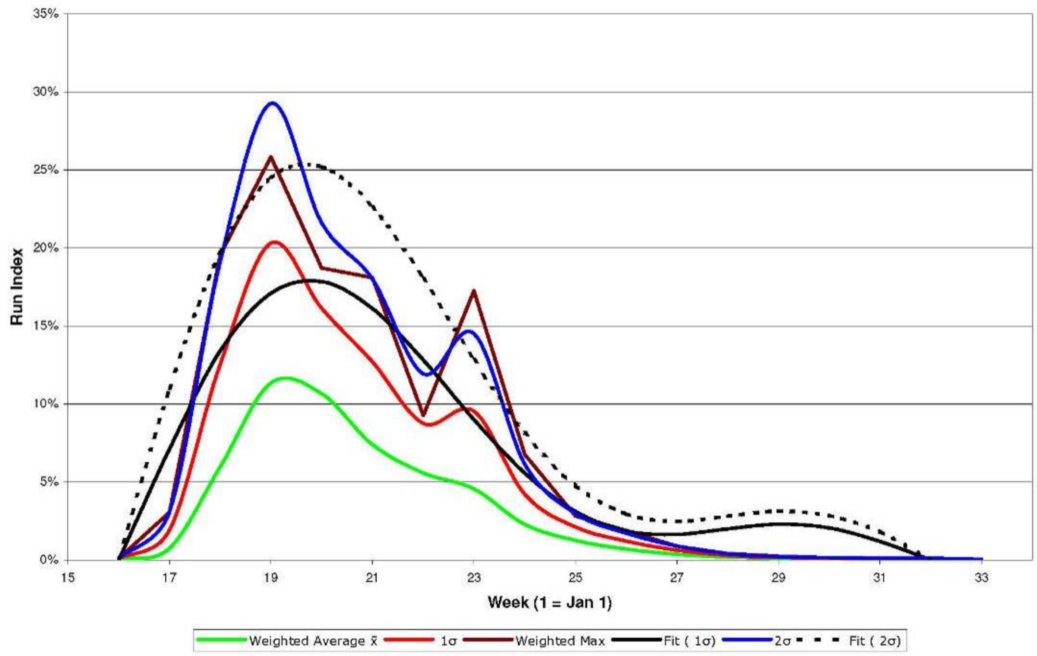


Figure 4-41. SR spring/summer-run Chinook adult passage through the CRC project area based on returns at Bonneville Dam, 1999–2008.

4.3.16.2 Data Assumptions

The timing of natural origin fish is assumed to be similar to that of hatchery fish. The timing of SR spring-run Chinook is assumed to be proportional to and represented by counts of the larger spring-run Chinook count group. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.16.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished, nor can potentially distinct timing of fish destined for the Snake River.

4.3.16.4 Data Options

Passage counts and investigations of SR fall-run Chinook have been conducted over many years and at many facilities and sites upstream of Bonneville Dam. However, aggregation and interpretation of these datasets would likely not provide the temporal relevance and consistency for estimating timing of spring/summer-run counts at the CRC project area. Reliance on Bonneville count data is warranted. Continue use of Bonneville count data to provide consistency.

4.3.17 Snake River Spring/Summer-Run Chinook – Juvenile

Figure 4-42 presents the estimated timing and duration of SR spring/summer-run Chinook juveniles passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

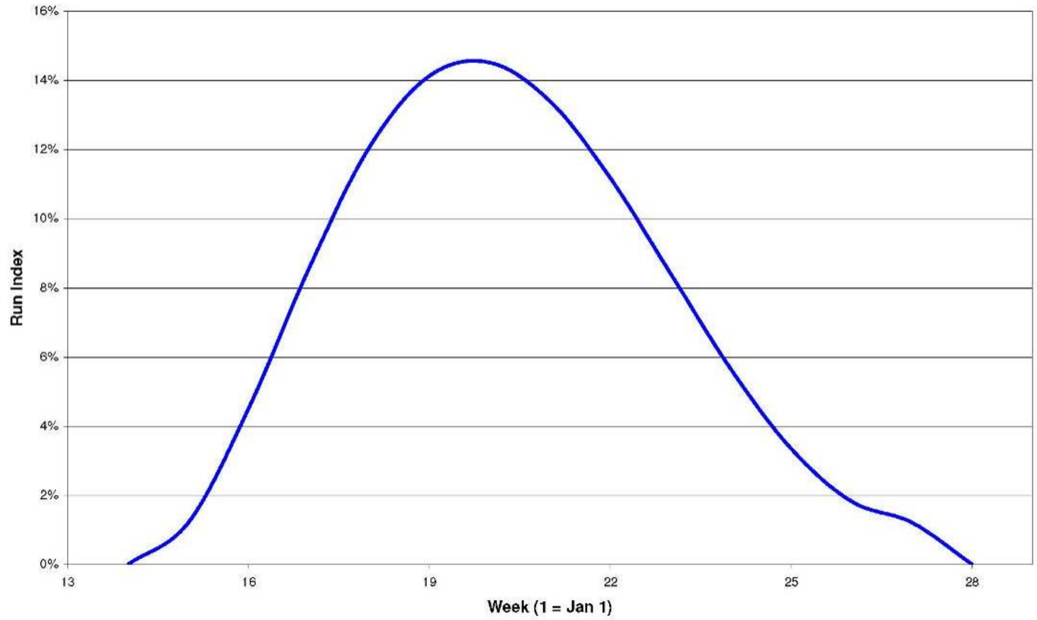


Figure 4-42. Timing and duration of SR spring/summer-run Chinook juveniles passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.17.1 Data Sources

Stock-specific data for SR spring/summer-run juveniles were made available for analysis in response to the CRC project team's request for assistance gathering fish data (CRC 2009). FPAC (2009) compiled data from releases of PIT-tagged hatchery and natural origin fish from throughout the Snake River basin, excluding experimental releases directly from dams that may not be representative. Data were available for analysis from PIT-tag detections at Bonneville Dam from 1999–2008. Daily detection data were originally drawn from DART (UW 2009).

Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 13–39. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.38. The maximum run index was estimated to be 0.15 based on a mean abundance of 0.13 and $\sigma = 0.12$ in Week 19. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-43). Timing at Bonneville Dam was not shifted, providing an estimated duration of 15 weeks (Weeks 14–28) peaking in Week 19 (May 7) at the CRC project area (Figure 4-42).

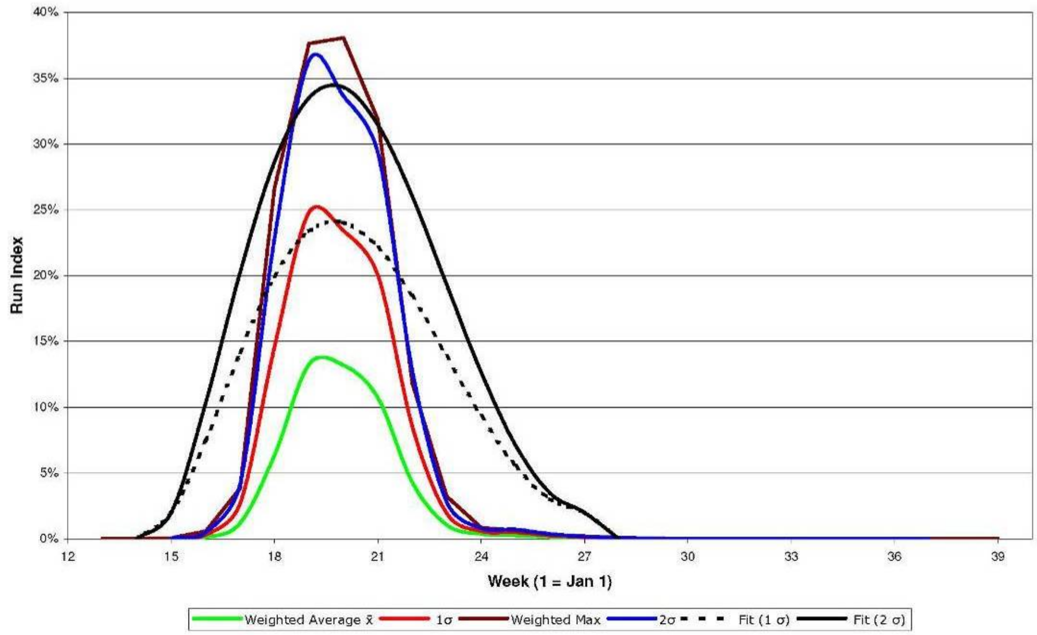


Figure 4-43. SR spring/summer-run Chinook juvenile passage through the CRC project area based on returns at Bonneville Dam, 1999–2008.

4.3.17.2 Data Assumptions

The timing of natural origin fish is assumed to be similar to that of hatchery fish. The timing of SR spring-run Chinook is assumed to be proportional to and represented by counts of the larger spring-run Chinook count group. Data reviewed, supplied, and used in this analysis is assumed to represent the range of life histories that spring-run Chinook juveniles may express. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.17.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished, nor can potentially distinct timing of fish that may delay emigration from the Snake River.

4.3.17.4 Data Options

Passage counts and investigations of SR fall-run Chinook have been conducted over many years and at many facilities and sites upstream of Bonneville Dam. However, aggregation and interpretation of these datasets would likely not provide the temporal relevance and consistency for estimating timing of spring/summer-run counts at the CRC project area. Reliance on Bonneville count data is warranted. Continue use of Bonneville count data to provide consistency.

4.3.18 Snake River Fall-Run Chinook – Adult

Figure 4-44 presents the estimated timing and duration of SR fall-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

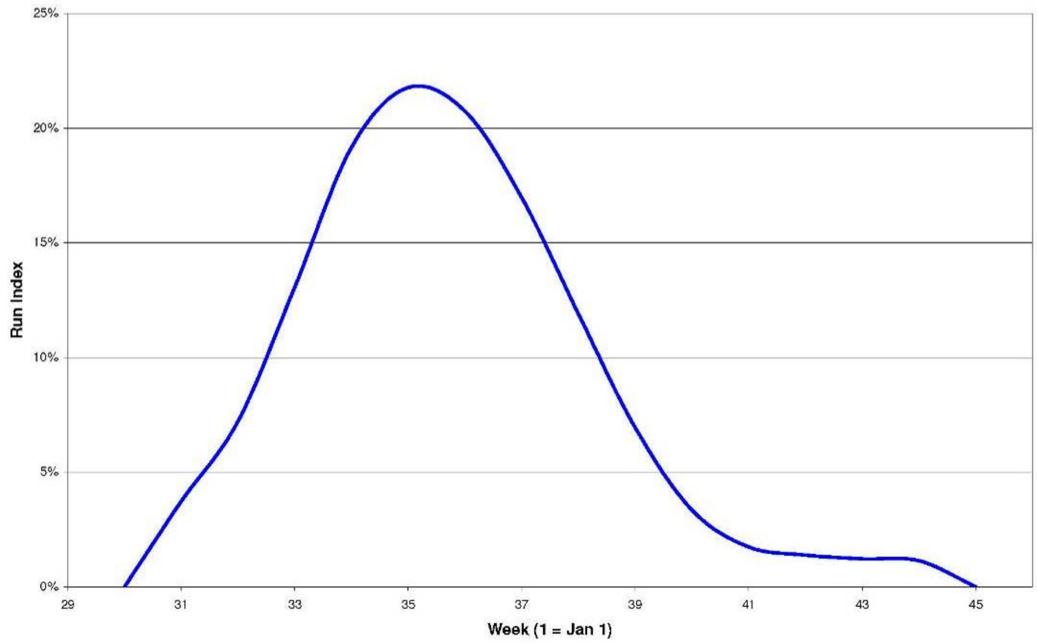


Figure 4-44. Timing and duration of SR fall-run Chinook adults passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.18.1 Data Sources

Fall Chinook in the Snake River system were first listed as a threatened species in 1992 and were re-affirmed as threatened in 2005 (70 FR 37160). The ESU includes all naturally spawned populations of fall-run Chinook in the mainstem Snake River below Hells Canyon Dam and in the Tucannon, Grande Ronde, Imnaha, Salmon, and Clearwater Rivers. Four artificial propagation programs are included in the listing: the Lyons Ferry Hatchery, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery, and Oxbow Hatchery fall-run Chinook hatchery programs. The life history, distribution, and general ecology of SR Chinook are detailed in Appendix C.

The best available data to estimate run timing of SR fall-run Chinook adults (Figure 4-44) are considered to be counts at Bonneville. SR fall-run Chinook are counted as part of similarly timing adults from other populations above Bonneville dam that are collectively known as Upriver Bright (URB) Chinook. As returns to the Columbia River, the SR natural origin component of this group (SRW) has ranged between approximately 2,500 in 1999 and 14,300 in 2001, and averaging around 6,000 between 1998–2007 (JCRMS 2009).

The period of record for this analysis is 1999–2008. Daily count data were obtained from DART (UW 2009) and were also provided by WDFW (2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 31–46. Data series were constructed for the maximum and mean run indexes across years for each statistical week.

The maximum weighted run index (weekly) observed for the period of record was 0.35. The maximum run index was estimated to be 0.22 based on a weighted mean abundance of 0.16 and σ = 0.092 in Week 37. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-45). Timing at Bonneville Dam was shifted earlier to start in Week 30 on the recommendation of WDFW (2009), providing an estimated duration of 16 weeks (Weeks 30–45) peaking in Week 35 (September 3) at the CRC project area (Figure 4-44).

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented here as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. An example of this effect occurs in the weeks preceding or following peak abundance near Week 35 (Figure 4-44). This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

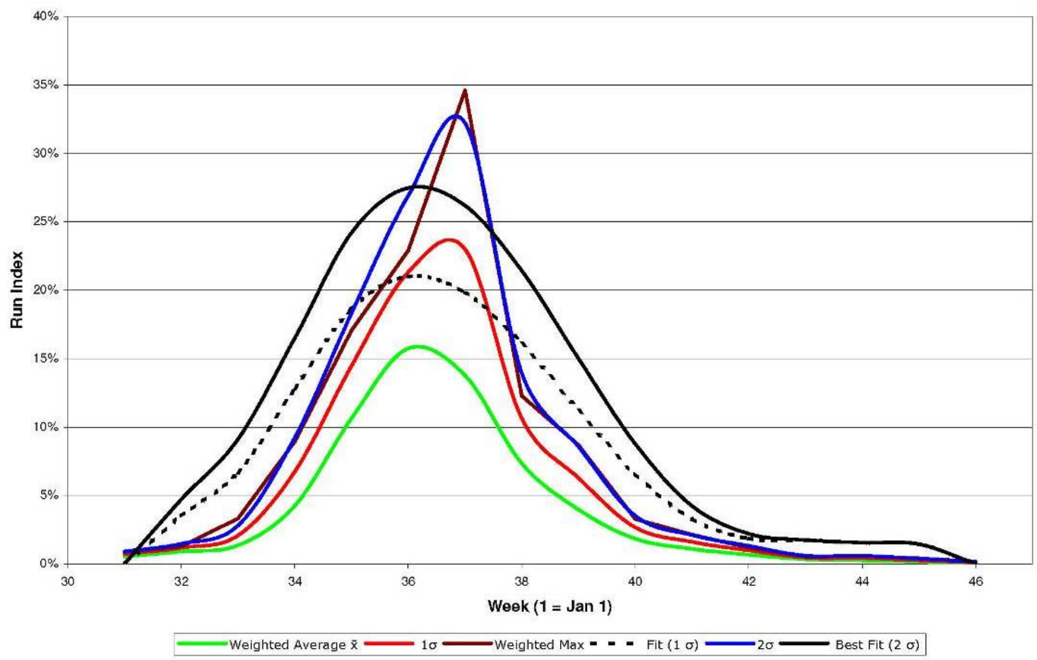


Figure 4-45. SR fall-run Chinook adult passage through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.18.2 Data Assumptions

The timing of natural origin fish is assumed to be similar to that of hatchery fish. The timing of SR fall-run Chinook is assumed to be proportional to and represented by the larger Chinook count group. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviations of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.18.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished, nor can potential distinct timing of fish destined for the Snake River.

4.3.18.4 Data Options

Passage counts and investigations of SR fall-run Chinook have been conducted over many years and at many facilities and sites upstream of Bonneville Dam. However, aggregation and interpretation of these datasets would likely not provide the temporal relevance and consistency for estimating timing at the CRC project area. Reliance on Bonneville count data is warranted.

4.3.19 Snake River Fall-Run Chinook – Juvenile

Figure 4-46 presents the estimated timing and duration of SR fall-run Chinook juveniles passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

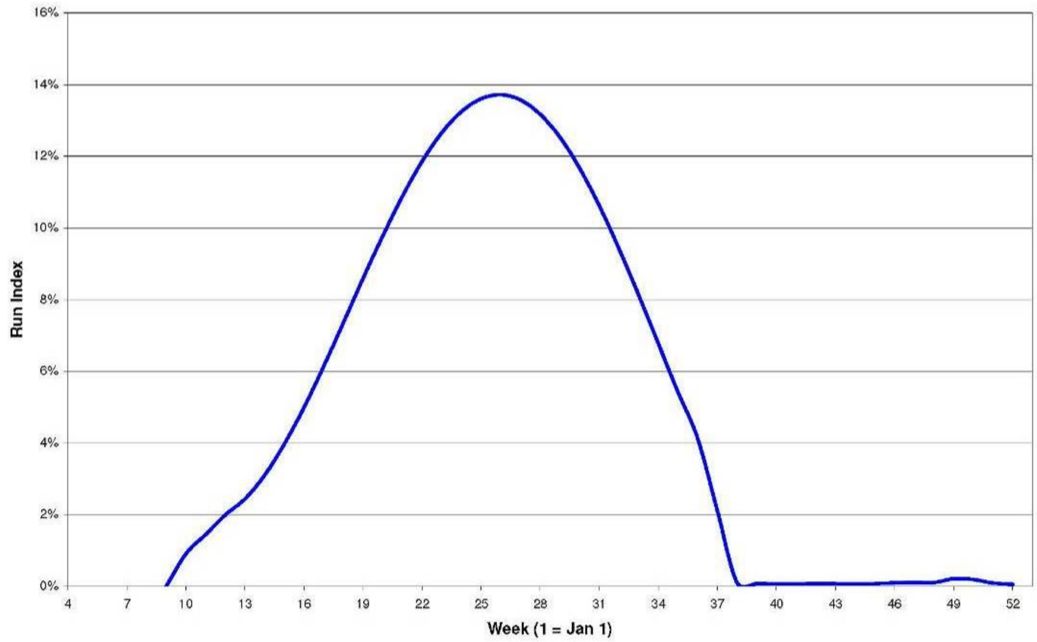


Figure 4-46. Timing and duration of SR fall-run Chinook juveniles passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.19.1 Data Sources

The best available data to estimate run timing of SR fall-run Chinook juveniles (Figure 4-46) are considered to be PIT-tag detections at Bonneville. Stock-specific data were made available for analysis in response to the CRC project team's request for assistance gathering fish data (CRC 2009). FPAC (2009) compiled data from releases of PIT-tagged hatchery and natural origin fish from throughout the Snake River basin, excluding experimental releases directly from dams that may not be representative. Daily detection data were originally drawn from DART (UW 2009) for the period 1999–2008.

Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 9–52. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index (weekly) observed for the period of record was 0.15. The maximum run index was estimated to be 0.13 based on a mean abundance of 0.029 and $\sigma = 0.078$ in Week 28. A polynomial curve was fit to the maximum weekly run index (Figure 4-47). Timing at Bonneville Dam was not shifted, providing an estimated duration of 44 weeks (Weeks 9–52) peaking in Week 26 at the CRC project area (Figure 4-46). The modality and substantial weekly variation in detections provides a challenge for fitting a polynomial curve.

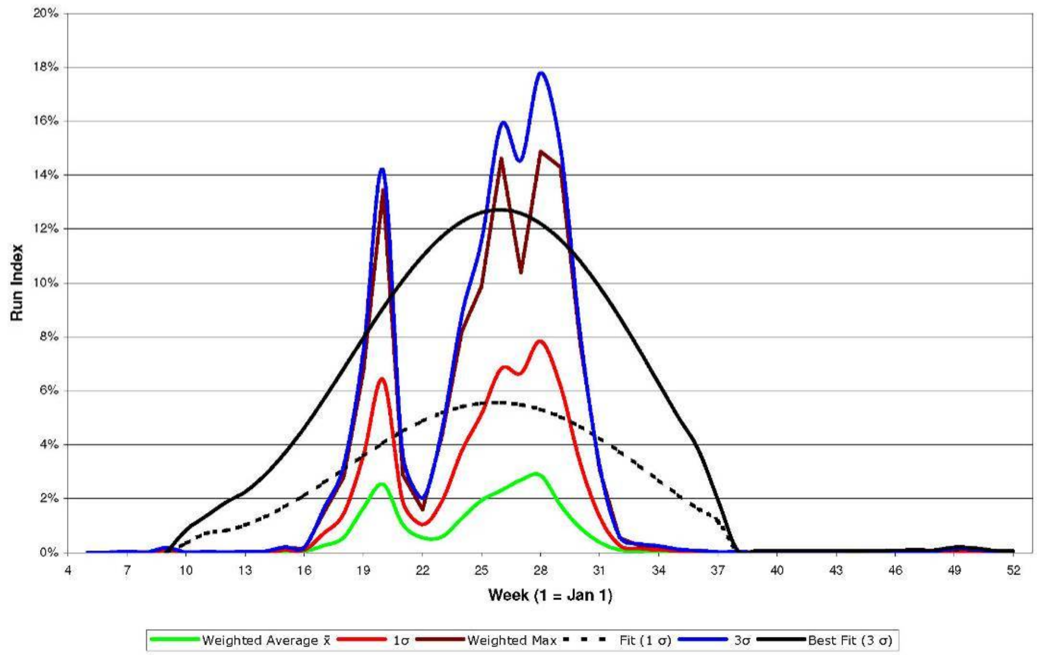


Figure 4-47. SR fall-run Chinook juvenile passage through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.19.2 Data Assumptions

The timing of natural origin fish is assumed to be similar to that of hatchery fish. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviations of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing. A departure from modality with a polynomial curve provides a basis for impact assessment that assumes a broad range of potential timing for shorter duration modes.

4.3.19.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished without accurate hatchery release data and a thorough understanding of release history.

4.3.19.4 Data Options

Passage counts and investigations of SR fall-run Chinook have been conducted over many years and at many facilities and sites upstream of Bonneville Dam. However, aggregation and interpretation of these datasets would likely not provide the temporal relevance and consistency for estimating timing at the CRC project area. Reliance on Bonneville count data is warranted.

4.3.20 Columbia Basin Steelhead – Overview of DPS

Figure 4-48 presents the estimated run timing of ESA-listed steelhead adults and juveniles passing through the CRC project area.

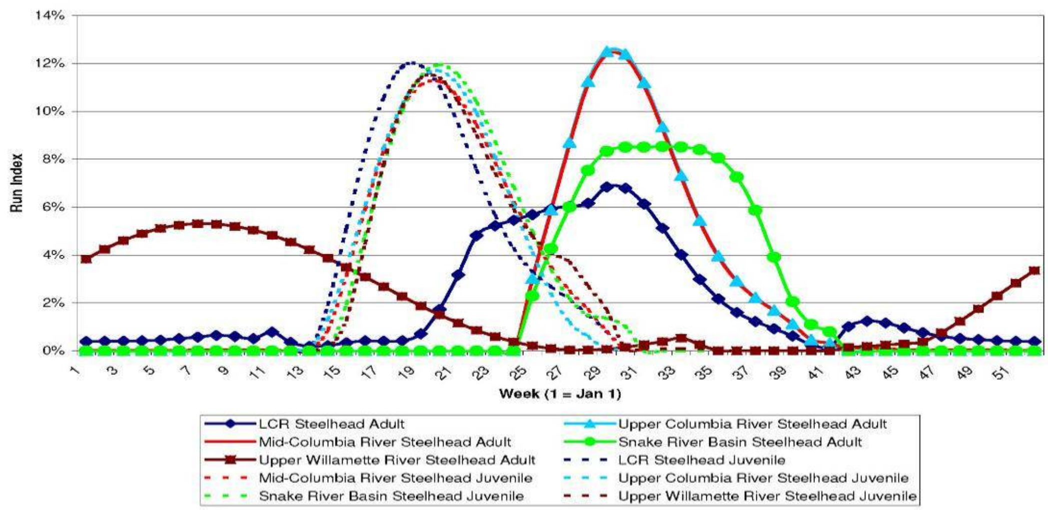


Figure 4-48. Estimated run timing of ESA-listed steelhead adults and juveniles passing through the CRC project area.

4.3.20.1 Overview

In the Columbia Basin, anadromous steelhead (*O. mykiss)* present a complex group of five DPS typically composed of winter and summer runs (races) of both hatchery and natural origin (Figure 4-48). The following analyses focus on the timing and abundance of listed steelhead populations most likely to be present in the CRC project area and that may be separately recognized for management purposes (e.g., Group A and B summer-run; see WDFW 2009). Each DPS is summarized below while detailed run timing and analyses by DPS and life stage are presented in the following sections. The natural history and ecology of Columbia Basin steelhead is provided in Appendix C.

Lower Columbia River Steelhead

Lower Columbia River (LCR) steelhead were first listed as a threatened species in 1998 and were re-affirmed as such in 2006 (71 FR 834). The DPS includes all naturally spawned populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington (inclusive), and the Willamette and Hood Rivers in Oregon (inclusive), as well as 10 artificial propagation programs. Winter and summer runs are recognized as distinct in timing and population structure, with summer-run fish familiarly known as “Skamania stock” and being of largely hatchery origin. Natural origin fish pass Bonneville Dam, allowing use of count data to estimate timing. Juvenile outmigration is based on PIT-tagged fish released upstream of Bonneville Dam as far as the eastern boundary of the ESU (FPAC 2009). These data are presumed to represent the timing of juveniles downstream of Bonneville to the CRC project area. Data on juveniles is restricted by limited tagging efforts and recent program initiation, but it is sufficient to distinguish summer and winter outmigrations.

Middle Columbia River Steelhead

Middle Columbia River (MCR) steelhead were first listed as a threatened species in 1999; this status was re-affirmed in 2006 (71 FR 834). The DPS consists of all naturally spawned steelhead populations below natural and manmade impassable barriers in streams from above the Wind River in Washington and the Hood River in Oregon (exclusive), upstream to and including the Yakima River in Washington. Also included are seven artificial propagation programs. Winter run adult timing is similar to that for LCR winter-run steelhead and draws from the same Bonneville count data. Summer run adults are considered part of "Group A" steelhead identified by timing and lengths of less than 78 cm in counting operations at Bonneville Dam. Group A steelhead form a composite group that includes fish from the UCR and SR DPSs for which abundance is not known (WDFW 2009). Detection of both hatchery and natural origin PIT-tagged juveniles at Bonneville is the basis for estimating timing of downstream migrant steelhead (FPAC 2009).

Upper Columbia River Steelhead

Upper Columbia River (UCR) steelhead have been the subject of a series of ESA listings and court decisions. The DPS was provided endangered status protections in 1997, was then upgraded to threatened in 2006, returned to endangered by a 2007 U.S. District Court decision, and finally upgraded to threatened again in 2009 by U.S. District Court order (74 FR 42605). The DPS includes all naturally spawned steelhead populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well six artificial propagation programs. Summer steelhead in this DPS are part of Group A. Detection of both hatchery and natural origin PIT-tagged juveniles at Bonneville is used to estimate timing of downstream migrant steelhead (FPAC 2009).

Snake River Steelhead

Snake River (SR) steelhead were listed as a threatened species 1997 and were re-affirmed as threatened in 2006. The DPS includes all naturally spawned steelhead populations below natural and manmade impassable barriers in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho, as well six artificial propagation programs. Summer-run steelhead are composed of Group A fish, similar in size and timing to those in the MCR and UCR DPSs, and Group B steelhead greater than 78 cm that are unique to the Snake River. Detection of PIT-tagged juveniles at Bonneville is used to estimate timing of downstream migrant steelhead (FPAC 2009).

Upper Willamette River Steelhead

The Upper Willamette River (UWR) steelhead DPS was first listed as a threatened species in 1999 and retained this status in 2006 (71 FR 834). The DPS includes all naturally spawned steelhead below impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River (inclusive). Both winter and summer runs occur, with adults overlapping in March through May. Only 5 percent of the summer run is considered to be of natural origin (Melcher 2010 personal communication). Absent data, outmigration of juveniles is characterized by the juvenile run-at-large derived by FPAC (2009) for Columbia River salmonids upstream of the CRC project area.

The potential for UWR steelhead to be present in the CRC project area is unknown. However, their natural tendency for straying and other exploratory behaviors suggests that adults and juveniles of this DPS could reasonably be expected to be present infrequently and in low abundance.

4.3.21 Lower Columbia River Summer-Run Steelhead – Adult

Figure 4-49 presents the estimated timing and duration of LCR summer-run steelhead of both hatchery and natural origin passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

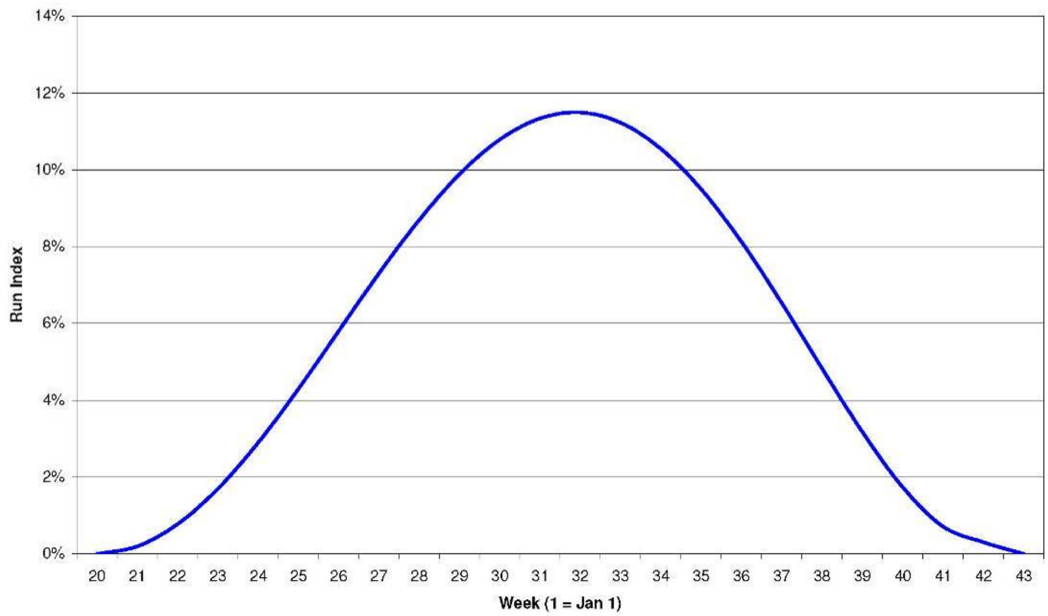


Figure 4-49. Timing and duration of LCR summer-run steelhead of natural origin passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.21.1 Data Sources

Stock-specific data for LCR summer-run steelhead are not available beyond Week 23 because data are artificially truncated by the end of count period at Bonneville Dam. To represent later-timed LCR summer-run steelhead, the timing of MCR summer-run steelhead was combined with LCR summer-run steelhead. This composite curve (Figure 4-49) is based on the observation of ODFW (InterCEP 2010) that the timing of small populations of summer-run steelhead in the Hood River and Fifteen Mile Creek (part of the LCR ESU) are better represented by MCR steelhead timing. The best available data to estimate run timing of LCR summer-run steelhead adults are considered by the authors of this report to be counts at Bonneville Dam. The period of record for this analysis is 1999–2008. Daily count data were obtained from DART (UW 2009) and also provided by WDFW (2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 13–27. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.4. The maximum run index was estimated to be 0.52 based on a weighted mean abundance of 0.2 and $\sigma = 0.11$ in Week 26. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-50). Timing at the Bonneville Dam was shifted earlier to start in Week 10, providing an estimated duration of 15 weeks (Weeks 10–24) clearly peaking in Week 23 (June 4) at the CRC project area (Figure 4-49).

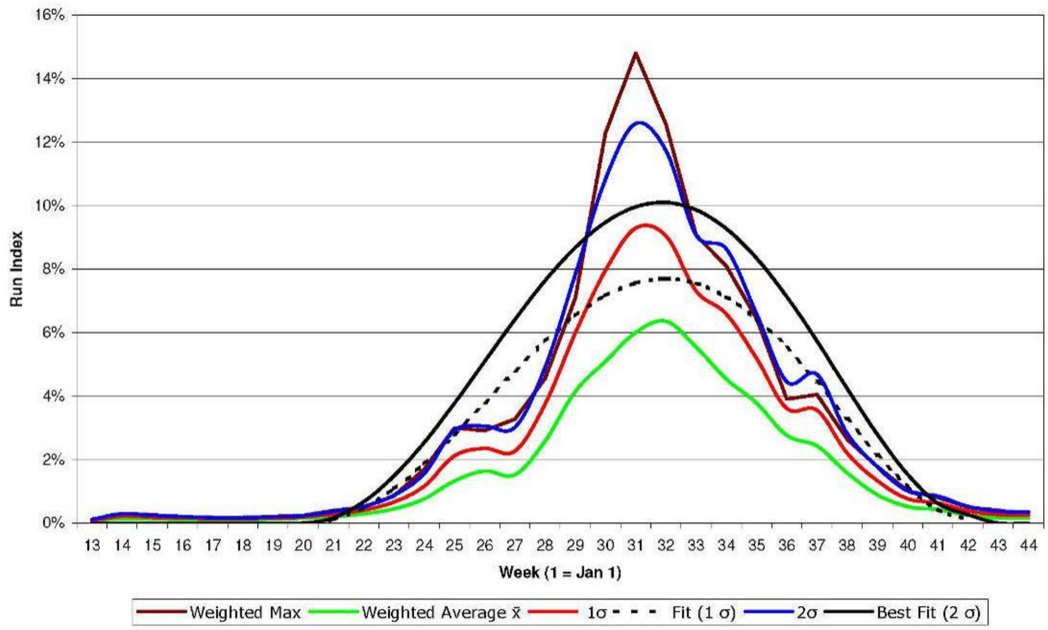


Figure 4-50. LCR summer-run steelhead adult passage through the CRC project area based on counts at Bonneville Dam, 1999–2008.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario, up to and including the estimated peak of the run.

4.3.21.2 Data Assumptions

Bonneville Dam counts represent the timing and duration of fish entering tributaries downstream to the CRC project area.

4.3.21.3 Known Data Gaps

The population of natural and hatchery origin fish is not known (WDFW 2009).

4.3.21.4 Data Options

Continue use of estimated timing and duration.

4.3.22 Lower Columbia River Summer-Run Steelhead – Juvenile

Figure 4-51 presents the estimated timing and duration of LCR summer-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam for 2000–2008.

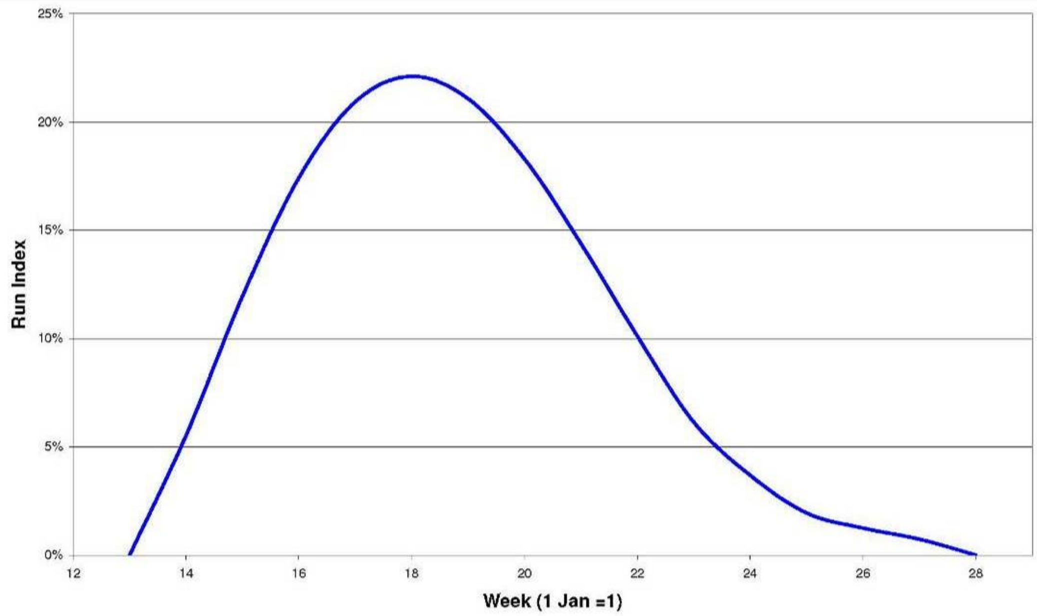


Figure 4-51. Estimated timing and duration of LCR summer-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam, 2000–2008.

4.3.22.1 Data Sources

Review of the literature and regional fish tag data repositories revealed limited information about juvenile steelhead in the lower Columbia River or those passing Bonneville Dam that was not related to or part of a long record of juvenile fish passage at Bonneville Dam (StreamNet 2009; PTAGIS 2010). Therefore, daily detections of LCR summer-run steelhead juveniles at Bonneville were used to estimate timing of juveniles at the CRC project area (Figure 4-51). These detections are primarily for hatchery fish. However, FPAC (2009) found that nearly all stock-specific timing of steelhead juveniles above the CRC project area reflected the timing of a steelhead "run-at-large" that composites all steelhead. The run-at-large is derived from expansions of daily sampling of the juvenile run at Bonneville and is considered by the authors of this report to be useful for run timing information. Only LCR winter-run steelhead juveniles were not well represented, peaking slightly later than the run-at-large. Based on the analysis by FPAC (2009), PIT tag detections specific to LCR summer-run steelhead were used for estimation of timing and duration. The period of record for this analysis is 2000–2008.

Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.32 in Week 18. The maximum run index was estimated to be 0.22 based on a weighted mean abundance of 0.077 and $\sigma = 0.1$, also in Week 18. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-52), providing an estimated duration of 16 weeks (Weeks 13–28). Arrival at the CRC project area requires less than 1 day from the upstream boundary of the LCR summer-run steelhead DPS, based on average velocities of 0.9 m/s for the species that comprise the run-at-large (FPAC 2009). For statistical purposes, timing data represent a midweek occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area (Figure 4-51).

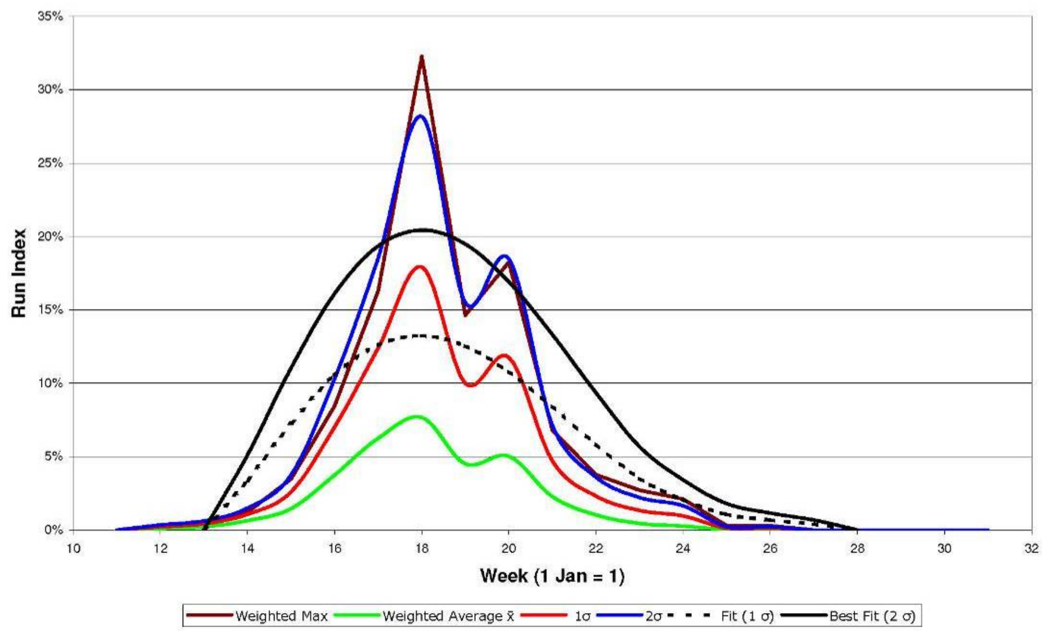


Figure 4-52. Estimated LCR summer-run steelhead juvenile passage at Bonneville Dam, 2000–2008.

4.3.22.2 Data Assumptions

PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery LCR summer-run steelhead below Bonneville Dam that can reasonably be expected to be present in the CRC project area. Timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.22.3 Known Data Gaps

PIT tag detections at Bonneville Dam are based on counts and sampling; they are not population estimates. Thus, the abundance, or juvenile run size, is not known (FPAC 2009). Data used in this analysis cannot and do not include fish originating from below Bonneville Dam.

4.3.22.4 Data Options

Seek data for juveniles emigrating from streams between Bonneville Dam and the CRC project area. Augment current dataset and revise analysis as appropriate.

4.3.23 Lower Columbia River Winter-Run Steelhead – Adult

Figure 4-53 presents the estimated timing and duration of LCR winter-run steelhead adults passing through the CRC project area based on counts at Bonneville Dam for 1992–2008.

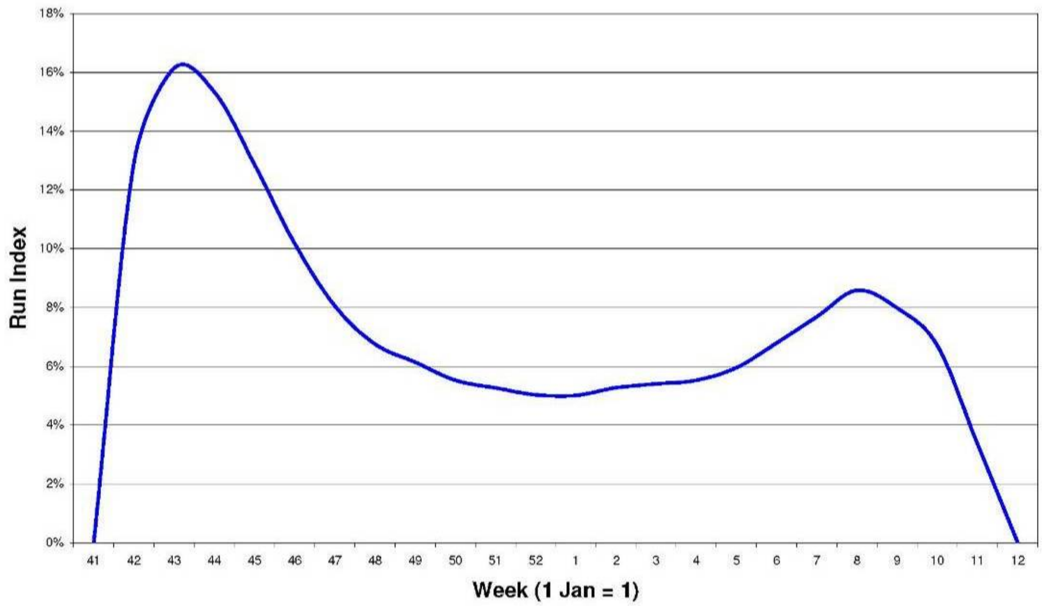


Figure 4-53. Estimated timing and duration of LCR winter-run steelhead adults passing through the CRC project area based on counts at Bonneville Dam, 1992–2008.

4.3.23.1 Data Sources

The abundance of adult winter-run steelhead in the LCR DPS is separately accounted and forecast for tributaries above and below Bonneville Dam. From 2001–2008, run sizes above and below Bonneville have ranged from 1,335 and 27,963 fish to 807 and 13,773 fish, respectively (JCRMS 2009). The best available data to estimate run timing of LCR winter-run steelhead adults (Figure 4-53) are considered by the authors of this report to be counts at Bonneville Dam. The period of record for this analysis is for the counting period of November 1–March 31 from 1992–2008.

Daily count data for run years 2002–2003 through 2007–2008 are Bonneville count data from DART (UW 2009). Data for 1992–1993 through 2000–2001 were provided by WDFW (2009). Data processing included discounting Bonneville count data by 40 percent to compensate for similarly timed MCR steelhead (WDFW 2009), removing negative values, and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 41–12. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index values observed for the period of record were 0.21 in Week 46, and 0.074 in Week 10. The maximum run index was estimated to be 0.16 based on a weighted mean abundance of 0.043 and $\sigma = 0.056$ in Week 46; and 0.086 based on a weighted mean abundance of 0.036 and $\sigma = 0.021$ in Week 10. A polynomial curve was fit to 3σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-54). Timing at the Bonneville dam was shifted earlier to start in Week 41 based on travel of 2.5 miles (4.0 Km) per day (WDFW 2009), providing an estimated duration of 24 weeks (Weeks 41–12) peaking in Week 43 at the CRC project area; a second relative maximum occurs in about Week 8. This bimodal pattern is consistent across years in the period of record. The biological and/or environmental causes of this modality are speculative and beyond the scope of this analysis.

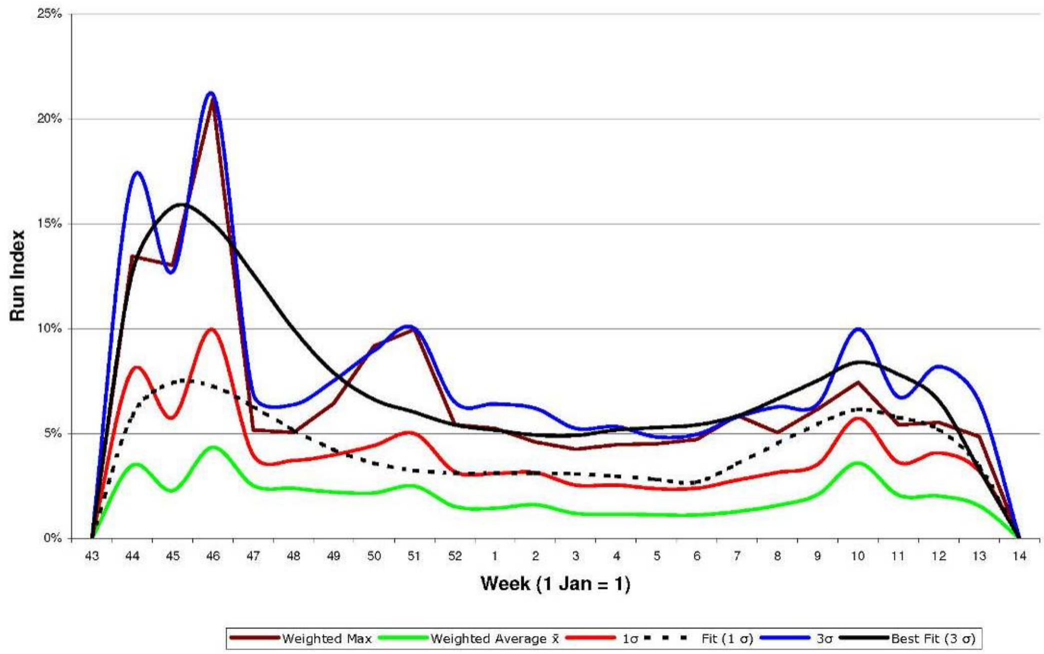


Figure 4-54. LCR winter-run steelhead adult passage through the CRC project area based on counts at Bonneville Dam, 1992–2008.

4.3.23.2 Data Assumptions

The timing of natural origin fish between Bonneville Dam and the CRC project area is represented by fish destined for tributaries upstream of Bonneville. Hatchery production upstream of the CRC project area that is part of the LCR steelhead DPS is from the Washougal River facilities. These hatchery returns are not expected to warrant separate timing estimates or to influence timing estimates for natural origin fish. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.23.3 Known Data Gaps

Data specific to the Washougal and Sandy Rivers were not available.

4.3.23.4 Data Options

Verify assumptions in WDFW data for the Sandy and Washougal River returns. Augment the dataset with returns for the Sandy and Washougal Rivers and revise estimates, as appropriate.

4.3.24 Lower Columbia River Winter-Run Steelhead – Juvenile

Figure 4-55 presents the estimated timing and duration of LCR winter-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam for 2005–2008.

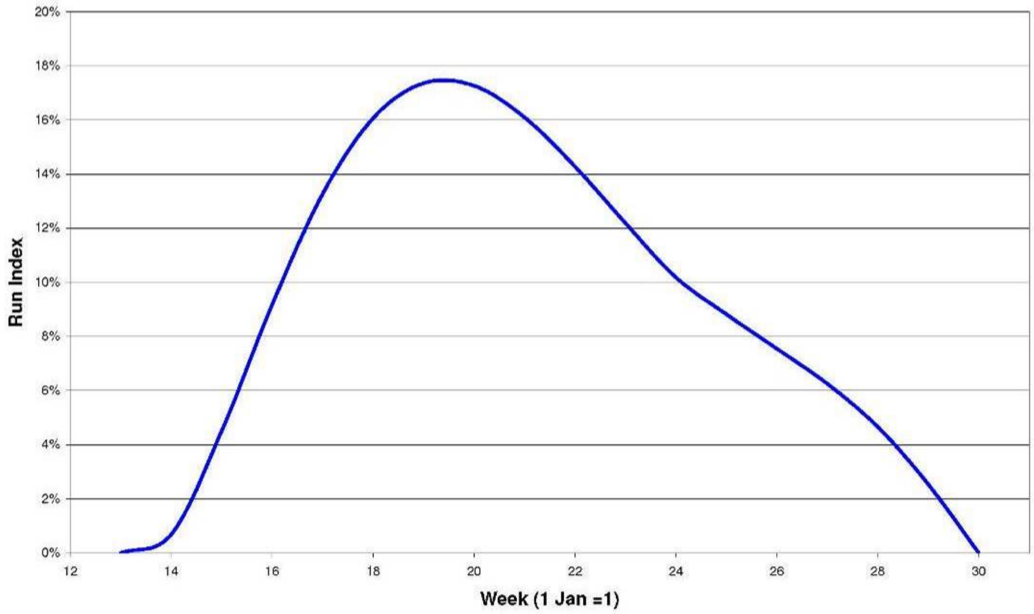


Figure 4-55. Estimated timing and duration of LCR winter-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam, 2005–2008.

4.3.24.1 Data Sources

Review of the literature and regional fish tag data repositories revealed limited information about juvenile steelhead in the lower Columbia River or those passing Bonneville Dam that was not related to or part of a long record of juvenile fish passage at Bonneville Dam (StreamNet 2009; PTAGIS 2010). Therefore, daily detections of LCR winter-run steelhead juveniles at Bonneville were used to estimate timing of juveniles at the CRC project area (Figure 4-55). Additionally, FPAC (2009) found that nearly all stock-specific timing of steelhead juveniles reflected the timing of a steelhead “run-at-large” that composites all steelhead emigrants originating in the Columbia River upstream of the CRC project area (FPAC 2009). The run-at-large is derived from expansions of daily sampling of the juvenile run at Bonneville Dam and is considered by the authors of this report useful for run timing information. The period of record for this analysis is 2005–2008. Only LCR winter-run steelhead juveniles were not well represented, peaking slightly later than the run-at-large.

Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.31 in Week 20. The maximum run index was estimated to be 0.17 based on a weighted mean abundance of 0.096 and $\sigma = 0.15$, in Week 20. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-56), providing an estimated duration of 18 weeks (Weeks 13–30) peaking in Week 19. Arrival at the CRC project area may take less than 24 hrs from passage at Bonneville, based on an average travel rate of 0.9 m/s (FPAC 2009). For statistical purposes, timing data represent a midweek occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area unless passage time is at least 3.5 days (84 hrs).

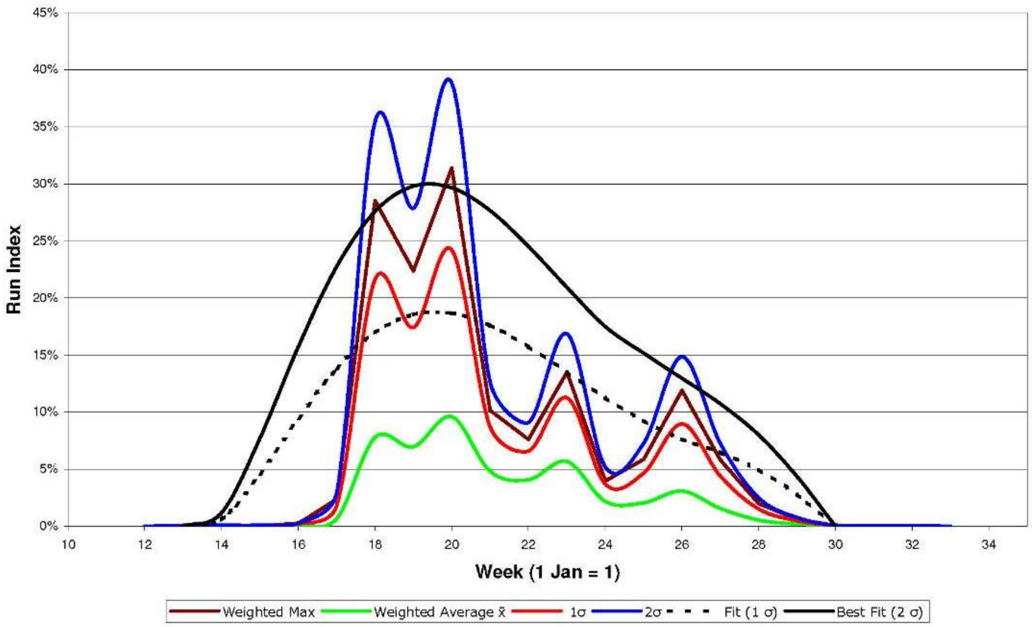


Figure 4-56. Estimated LCR winter-run steelhead juvenile passage at Bonneville Dam, 2005–2008.

4.3.24.2 Data Assumptions

PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery LCR winter-run steelhead below Bonneville Dam that can reasonably be expected to be present in the CRC project area. Timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.24.3 Known Data Gaps

PIT tag detections at Bonneville Dam are based on counts and sampling; they are not population estimates. Thus, the abundance (juvenile run size) is not known (FPAC 2009). Data used in this analysis cannot and do not include fish originating from below Bonneville Dam.

4.3.24.4 Data Options

Seek data for juveniles emigrating from streams between Bonneville Dam and the CRC project area. Augment current dataset and revise analysis as appropriate.

4.3.25 MCR, UCR, and SR Summer-Run Steelhead – Adult, Natural Origin, Group A

Figure 4-57 presents the estimated timing and duration of summer-run steelhead Group A adults of natural origin passing through the CRC project area based on counts at Bonneville Dam for 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR summer-run steelhead.

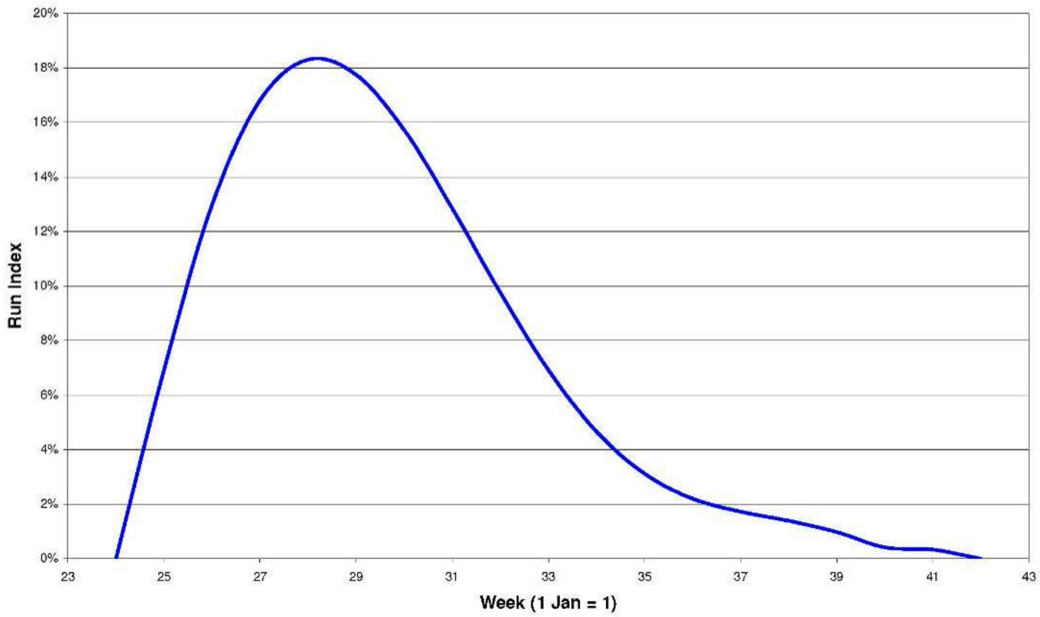


Figure 4-57. Timing and duration of summer-run steelhead Group A adults of natural origin passing through the CRC project area based on counts at Bonneville Dam, 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR summer-run steelhead.

4.3.25.1 Data Sources

The best available data to estimate run timing of MCR, UCR, and SR Group A steelhead adults (Figure 4-57) are considered to be to be counts at Bonneville Dam. The period of record for this analysis is 1999–2008. Daily count data were obtained for Weeks 27–44 (July 1–October 30) from DART (UW 2009) and WDFW (2009). Data processing included discounting Bonneville data by the hatchery to natural origin ratio, removing negative values, and setting minimum daily counts to one. On the recommendation of WDFW (2009), the timing of all three DPSs is considered the same, and the abundance is equally represented by discounted daily counts.

Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 26–44. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.19. The maximum run index was estimated to be 0.18 based on a weighted mean abundance of 0.076 and $\sigma = 0.044$ in Week 30. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-58). Timing at the Bonneville Dam was shifted earlier to start in Week 24, providing an estimated duration of 19 weeks (Weeks 24–42) peaking in Week 28 at the CRC project area (Figure 4-57).

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). Variation in weekly run indexes further increases the maximum value that might be expected for any week. This analysis may provide a simple maximum likelihood approach. However, certainty about timing and presence is limited by the artificial bounds of the count period, particularly for the early part of the run (prior to Week 26). Use of these results in effects analyses can be expected to estimate a modest level of effect, not an average or least-effect scenario for the count period.

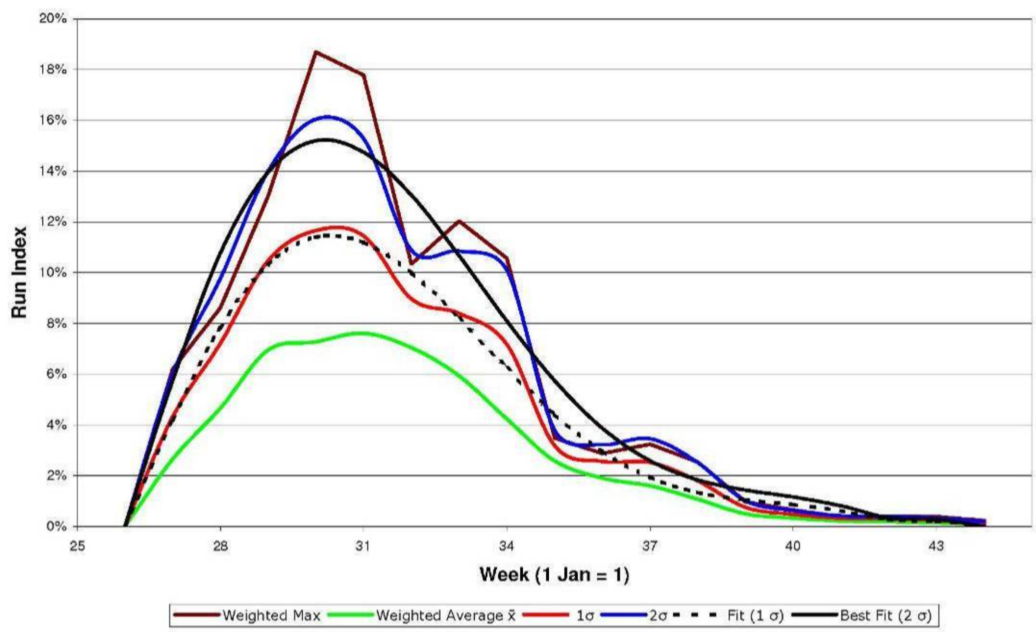


Figure 4-58. Summer-run steelhead Group A adults of natural origin passing through the CRC project area based on returns at Bonneville Dam, 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR Group A steelhead.

4.3.25.2 Data Assumptions

Potential distinctions in run timing and duration between natural origin Group A summer-run steelhead are minimal. Similarly, abundance and run timing preceding the count period are reasonably represented by count data and modeled results.

4.3.25.3 Known Data Gaps

Abundance and timing preceding Week 26 are not known. The population of natural origin fish is not known (WDFW 2009).

4.3.25.4 Data Options

Increase certainty about timing of the early part of the run by augmenting dataset with returns prior to Week 26, if possible. Validate data and calculations provided by WDFW (2009).

4.3.26 MCR, UCR, and SR Summer-Run Steelhead – Adult, Hatchery, Group A

Figure 4-59 presents the estimated timing and duration of summer steelhead Group A adults of hatchery origin passing through the CRC project area based on counts at Bonneville Dam for 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR summer-run steelhead.

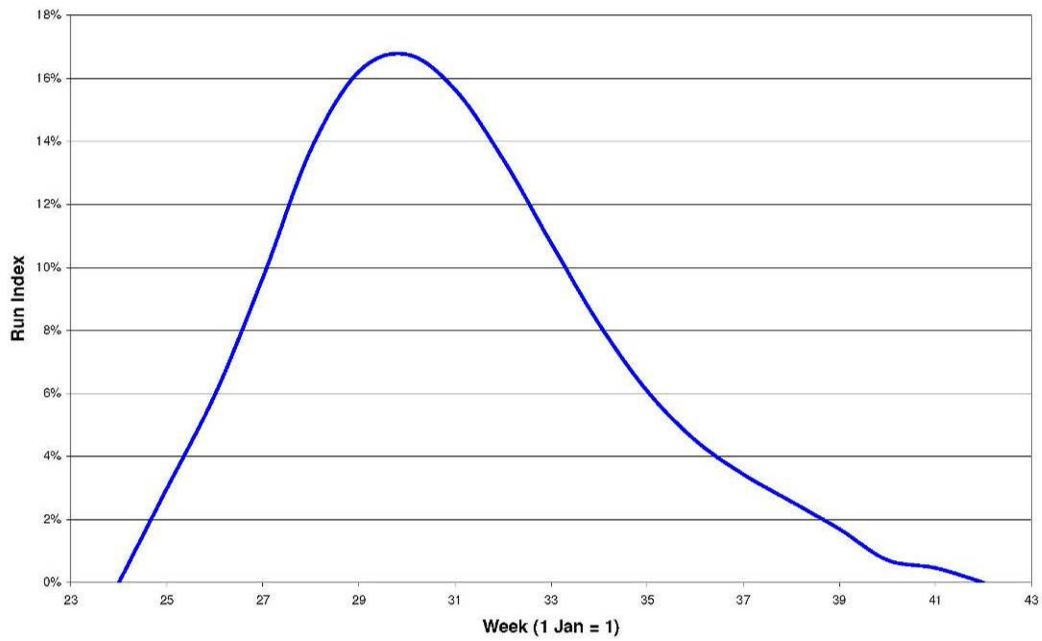


Figure 4-59. Timing and duration of summer-run steelhead Group A adults of hatchery origin passing through the CRC project area based on counts at Bonneville Dam, 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR summer-run steelhead.

4.3.26.1 Data Sources

The best available data to estimate run timing of MCR, UCR, and SR Group A steelhead adults (Figure 4-59) are considered to be counts at Bonneville Dam. The period of record for this analysis is 1999–2008. Daily count data were obtained for Weeks 26–45 (July 1–October 30) from DART (UW 2009) and WDFW (2009). Data processing included discounting Bonneville data by the hatchery to natural origin ratio, removing negative values, and setting minimum daily counts to one. On the recommendation of WDFW (2009), the timing of all three DPSs is considered the same, and the abundance is equally represented by discounted daily counts.

The maximum weighted run index value observed for the period of record was 0.16. The maximum run index was estimated to be 0.17 based on a weighted mean abundance of 0.071 and $\sigma = 0.036$ in Week 30. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-60). Timing at the Bonneville Dam was shifted earlier to start in Week 24 based on movement of 2.5 miles (4.0 km) per day (WDFW 2009), providing an estimated duration of 19 weeks (Weeks 24–42) peaking in Week 30 (July 22) at the CRC project area. Timing for hatchery Group A adults differs slightly due to variation in daily hatchery to natural origin ratios. Even though estimated run indexes for natural origin and hatchery Group A fish differ (peaks of 0.18 in Week 28 vs. 0.17 in Week 30, respectively), the overall timing is quite similar.

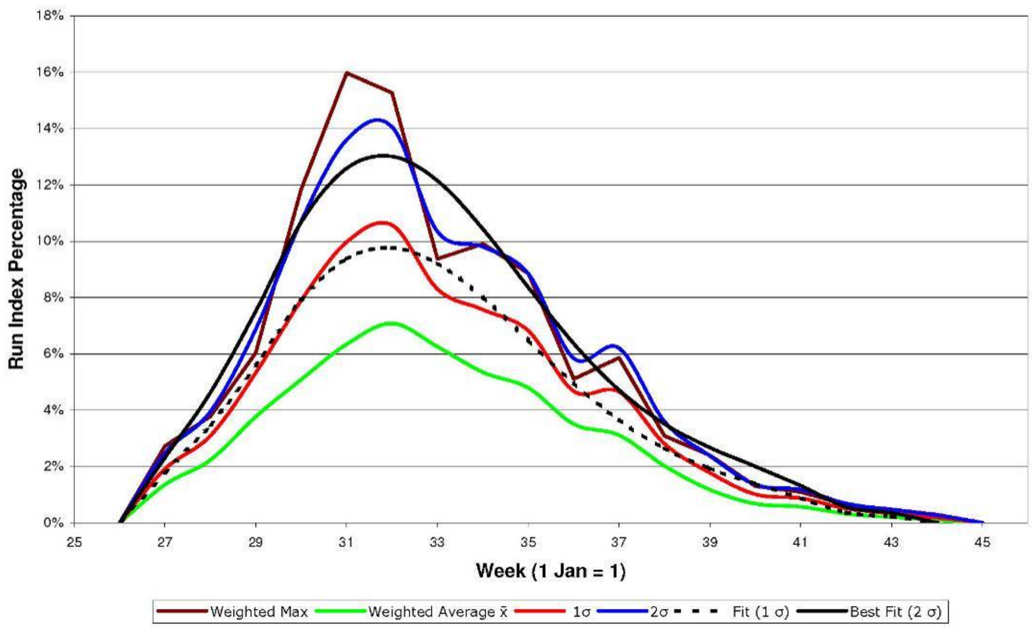


Figure 4-60. Summer-run steelhead hatchery Group A adults passing through the CRC project area based on returns past Bonneville Dam, 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR Group A steelhead.

4.3.26.2 Data Assumptions

Distinctions in run timing and duration between Group A summer-run steelhead populations are minimal. Similarly, abundance and run timing preceding the count period is reasonably represented by modeled results.

4.3.26.3 Known Data Gaps

Abundance and timing preceding Week 26 is not known. The population of hatchery and natural origin fish is not known (WDFW 2009).

4.3.26.4 Data Options

Increase certainty about timing of the early part of the run by augmenting dataset with returns prior to Week 26, if possible. Validate data and calculations provided by WDFW (2009).

4.3.27 MCR, UCR, and SR Summer-Run Steelhead – Juvenile, Group A

Figure 4-61 presents the estimated timing of Group A summer-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam for 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR summer-run steelhead.

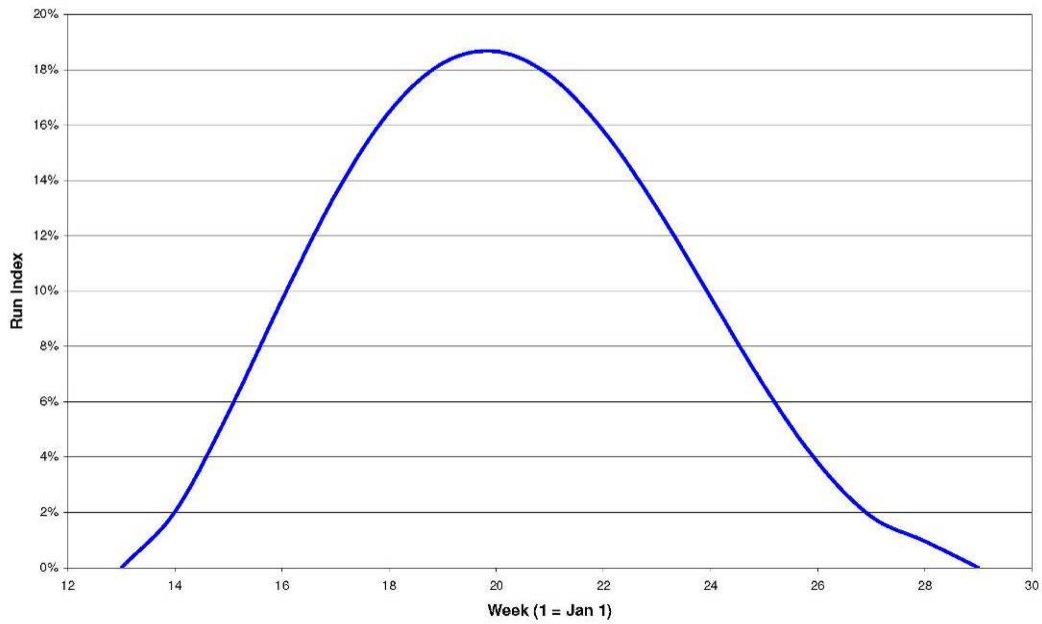


Figure 4-61. Estimated timing of Group A summer-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam, 1999–2008. Timing and duration are presumed identical for MCR, UCR, and SR summer-run steelhead.

4.3.27.1 Data Sources

Stock-specific data for Group A summer-run steelhead juveniles were not available for analysis. Instead, data supplied by FPAC (2009) in response to the CRC project team's request for assistance gathering fish data were used to represent juvenile migrants from the MCR, UCR, and SR DPSs (CRC 2008). These data rely on all releases of hatchery and natural origin fish in their respective regions, excluding experimental releases at dams. FPAC (2009) found that PIT-tagged steelhead juveniles reflected the timing of a steelhead "run-at-large" that composites all steelhead emigrants originating upriver of Bonneville (FPAC 2009). The run-at-large is derived from expansions of daily sampling of the juvenile run at Bonneville and is considered useful for run timing information. However, data specific to the region and DPS are considered preferable by the authors of this report and serve as the basis for this analysis.

Weekly PIT tag detections provided by FPAC (2009) were normalized as the percentage of the annual total. Normal values (run indexes) allow comparison of timing between years without the need to address between-year variation in numbers of detections. Detection data include both natural-origin and hatchery fish without distinction. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The period of record for this analysis is 1999–2008. The maximum weighted run index value observed for the period of record was 0.43 in Week 20. The maximum run index was estimated to be 0.19 based on a weighted mean abundance of 0.068 and σ = 0.13, also in Week 20.

A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-62), providing an estimated duration of 17 weeks (Weeks 13–29), peaking in Week 20 (May 17). Arrival at the CRC project area may take from 12–24 hrs from passage at Bonneville, based on a travel rate of 0.79–1.23 m/s (FPAC 2009). For statistical purposes, timing data represent a midweek occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area unless passage time is at least 3.5 days (84 hrs).

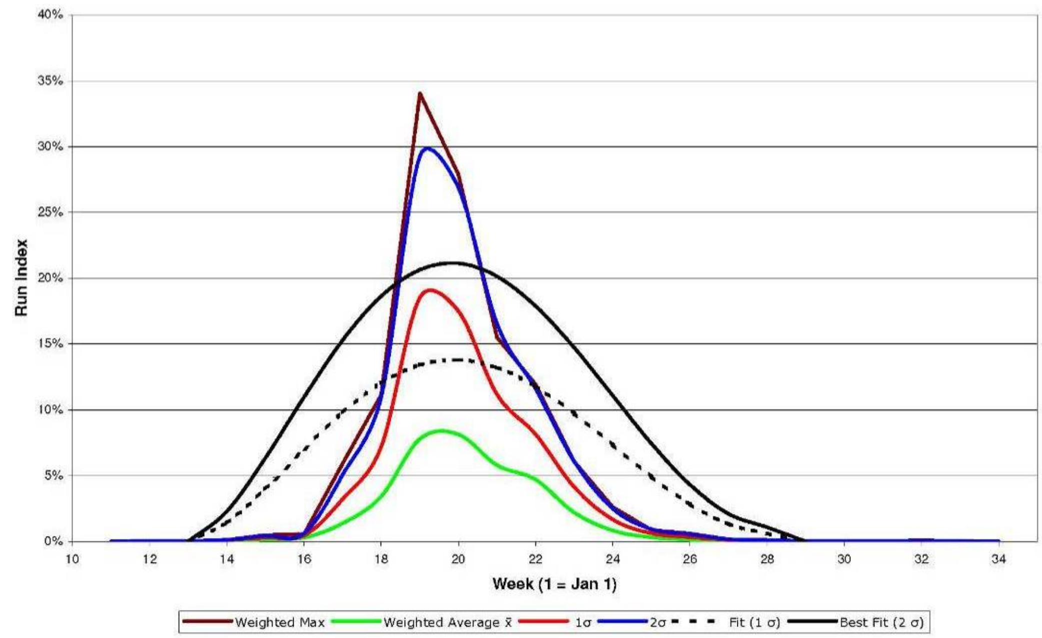


Figure 4-62. Estimated Group A summer-run steelhead juvenile passage at Bonneville Dam, 1999–2008.

The maximum and average run indexes are shown with a curve fit to the maximum weekly values. Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. These influences on timing estimation are most evident in Weeks 19 and 22, where the maximum values are markedly greater than the mean, and the best-fit polynomial distributes abundance before and after the relative maximums (Figure 4-61). This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.27.2 Data Assumptions

Timing and peak emigration of juveniles is similar across subject DPSs. PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery Group A summer-run steelhead juveniles that may be present in the CRC project area. Travel rates from Bonneville Dam to the Columbia River estuary are constant. Timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.27.3 Known Data Gaps

The proportion of hatchery to natural origin fish was not evaluated, and the abundance of MCR, UCR, and SR Group A summer-run steelhead juveniles is not known (FPAC 2009). While passage indexes at Bonneville are based on counts and sampling, they are not population estimates.

4.3.27.4 Data Options

Continue use of Bonneville PIT tag data that are specific to Group A summer-run steelhead juveniles. If necessary, individual tag detections can be assigned to origin or source.

4.3.28 Snake River Summer-Run Steelhead – Adult, Natural Origin, Group B

Figure 4-63 presents the estimated Timing and duration of SR summer-run steelhead Group B adults of natural origin passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

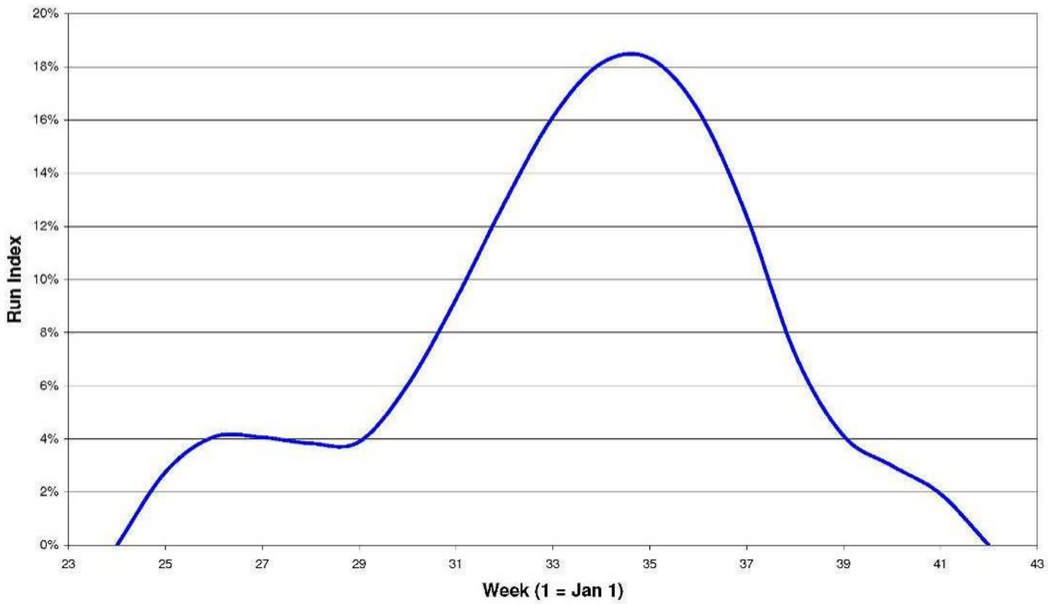


Figure 4-63. Timing and duration of SR summer-run steelhead Group B adults of natural origin passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.28.1 Data Sources

SR summer-run steelhead identified as Group B are greater than 78 cm in length and are offset from SR Group A fish in timing. These fish primarily return to tributaries in the Salmon and Clearwater Rivers in Idaho. Natural origin Group B steelhead are likely to peak in about Week 35 (Figure 4-63), similar to the Group B hatchery component (see Section 4.3.29). Hatchery and natural origin Group A steelhead adults are estimated to peak earlier, between Weeks 29 and 30 (Sections 4.3.25 and 4.3.26 address Group A summer-run steelhead adults). Natural origin fish passing Bonneville have ranged from a low count of 3,700 in 1999 to 32,300 in 2002, and may be 20 percent or less of the total run (natural origin plus hatchery) in recent years (JCRMS 2009).

The best available data to estimate run timing of SR Group B steelhead adults are considered by the authors of this report to be counts at Bonneville Dam. The period of record for this analysis is 1999–2008. Daily count data were obtained for Weeks 26–44 from DART (UW 2009) and WDFW (2009). Data processing included discounting Bonneville data by the natural origin to hatchery ratio, removing negative values, and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period. Data series were constructed for the maximum and mean run indexes across years for each statistical week.

The maximum weighted run index value observed for the period of record was 0.25. The maximum run index was estimated to be 0.18 based on a weighted mean abundance of 0.078 and $\sigma = 0.069$ in Week 37. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-64). Timing at the Bonneville

Dam was shifted earlier to start in Week 24, providing an estimated duration of 19 weeks (Weeks 24–42) peaking in Week 35 (August 27) at the CRC project area (Figure 4-63).

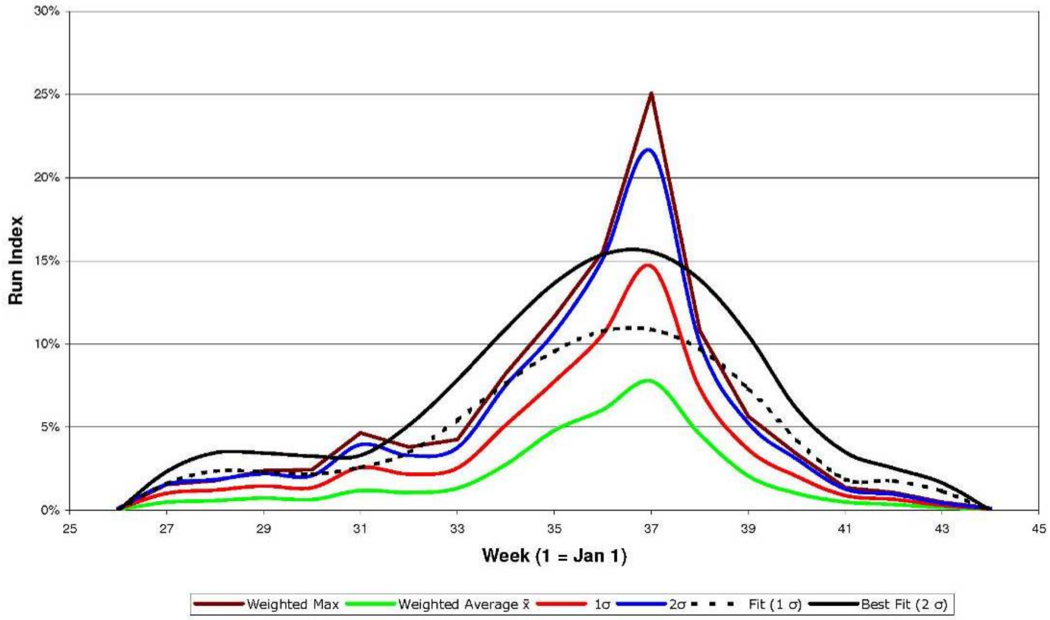


Figure 4-64. SR summer-run steelhead Group B adult passage through the CRC project area based on hatchery returns past Bonneville Dam, 1999–2008.

4.3.28.2 Data Assumptions

Group B steelhead are accurately distinguished from Group A during overlapping timing based on size (+/- 78 cm). Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by the standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.28.3 Known Data Gaps

None.

4.3.28.4 Data Options

Continue reliance on Bonneville Dam count data to estimate timing and duration.

4.3.29 Snake River Summer-Run Steelhead – Adult, Hatchery, Group B

Figure 4-65 presents the estimated timing and duration of SR summer-run steelhead Group B adults of hatchery origin passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

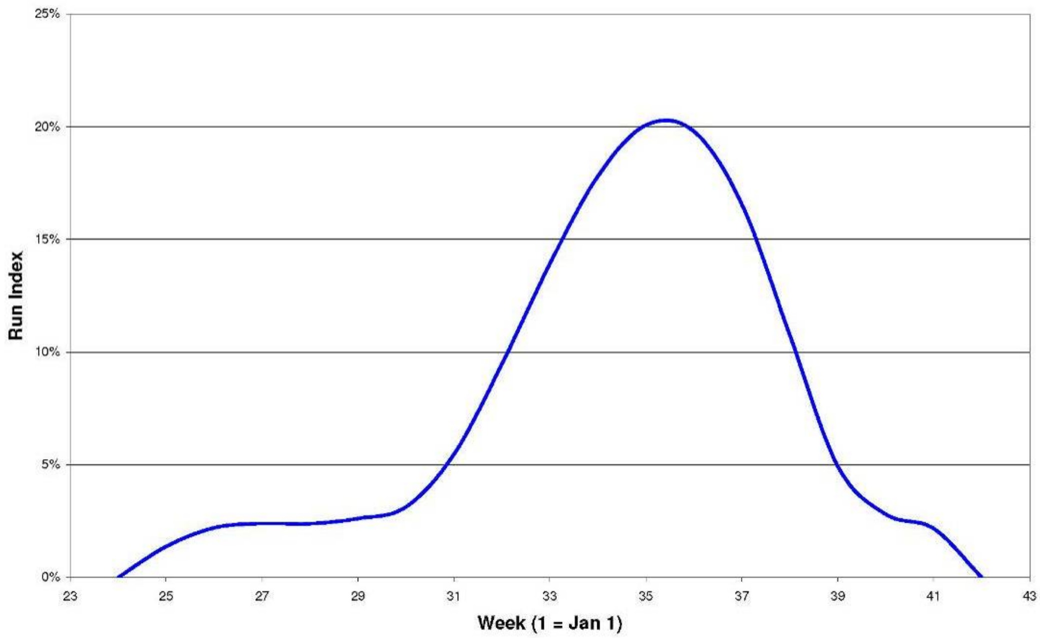


Figure 4-65. Timing and duration of SR summer-run steelhead Group B adults of hatchery origin passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.29.1 Data Sources

SR summer-run steelhead identified as Group B are greater than 78 cm in length and are offset from SR Group A fish in timing. These fish, unique to the Snake River, peak in about Week 35 (Figure 4-65). Hatchery fish passing Bonneville have ranged from a low count of 18,400 in 1999 to 97,600 in 2002 (JCRMS 2009) and have been 80 percent or more of the total run (hatchery plus natural origin) in recent years.

The best available data to estimate run timing of SR Group B steelhead adults are considered by the authors of this report to be counts at Bonneville Dam. The period of record for this analysis is 1999–2008. Data processing included discounting Bonneville data by the hatchery to natural origin ratio, removing negative values, and setting minimum daily counts to one. Data series were constructed for the maximum and mean run indexes across years for each statistical week.

The maximum weighted run index value observed for the period of record was 0.24. The maximum run index was estimated to be 0.2 based on a weighted mean abundance of 0.12 and $\sigma = 0.067$ in Week 36. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-66). Timing at the Bonneville dam was shifted earlier to start in Week 24, providing an estimated duration of 19 weeks (Weeks 24–42) peaking in Week 35 (August 27) at the CRC project area (Figure 4-65).

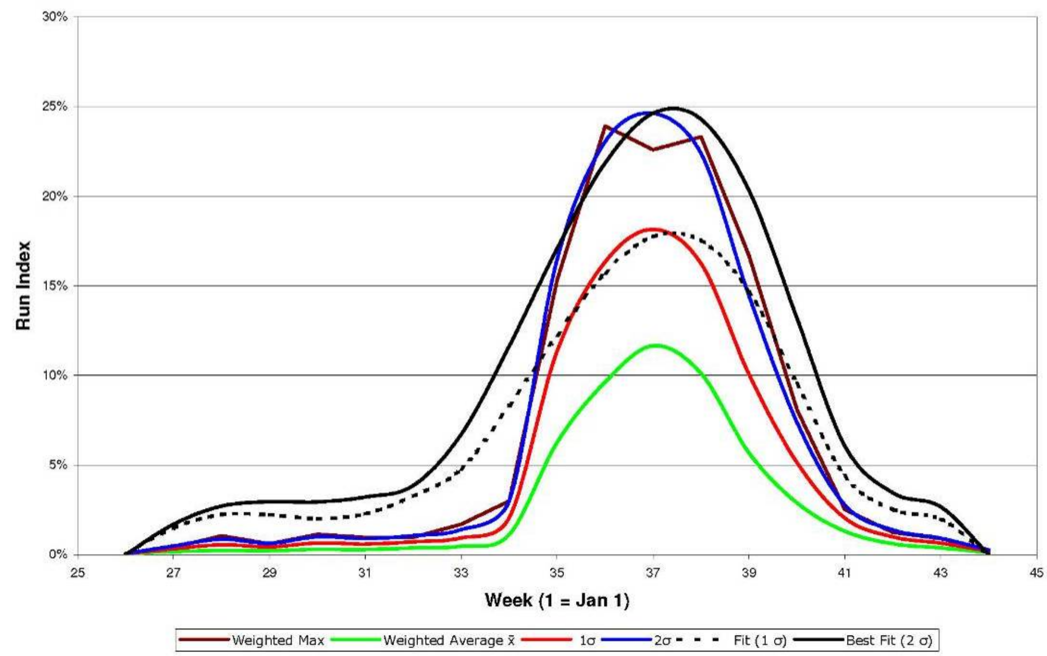


Figure 4-66. SR summer-run steelhead Group B adult passage through the CRC project area based on hatchery returns past Bonneville Dam, 1999–2008.

4.3.29.2 Data Assumptions

Group B steelhead are accurately distinguished from Group A during overlapping timing based on size (+/- 78 cm). Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.29.3 Known Data Gaps

None.

4.3.29.4 Data Options

Continue reliance on Bonneville count data to estimate timing and duration.

4.3.30 Snake River Summer-Run Steelhead – Juvenile, Group B

Figure 4-67 presents the estimated timing and duration of SR summer-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam for 1999–2008.

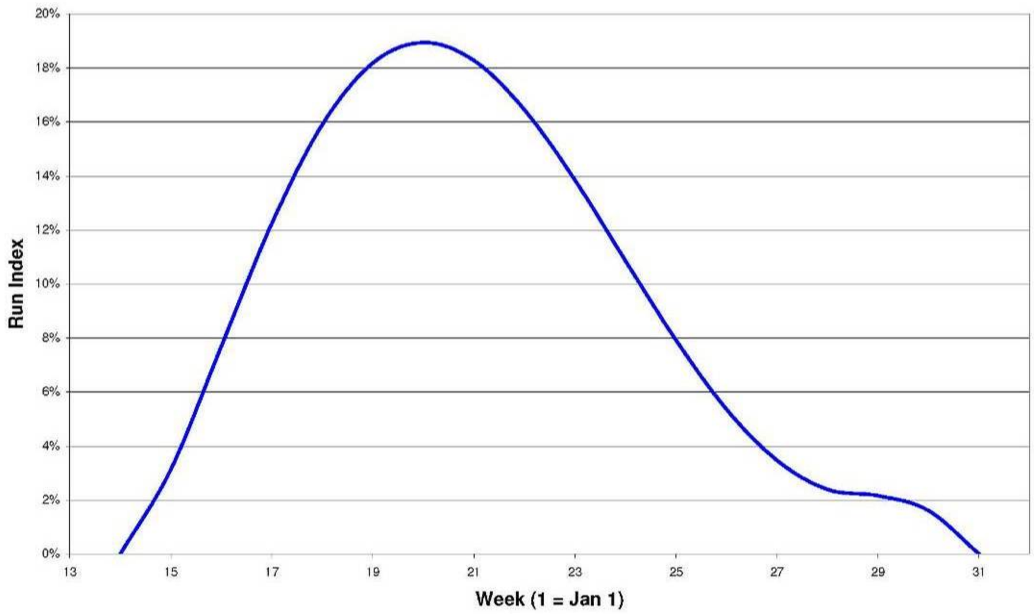


Figure 4-67. Estimated timing and duration of SR summer-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam, 1999–2008.

4.3.30.1 Data Sources

In response to the CRC project team's request for assistance selecting fish data (CRC 2008), FPAC found that PIT-tagged SR steelhead juveniles reflected the timing of a steelhead "run-at-large" that composites all steelhead DPS emigrants (FPAC 2009). Stock-specific data for SR juveniles were considered by the authors of this report the best available for estimating timing and duration (Figure 4-67).

Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.43 in Week 20 (2008). The maximum run index was estimated to be 0.19 based on a weighted mean abundance of 0.068 and $\sigma = 0.13$, also in Week 20. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-68), providing an estimated duration of 18 weeks (Weeks 14–31) peaking in Week 20 (May 17). Arrival at the CRC project area may take less than 1 day from passage at Bonneville based on velocities of 0.88–1.19 m/s (FPAC 2009). For statistical purposes, timing data represent a mid-week occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area unless passage time is at least 3.5 days (84 hrs).

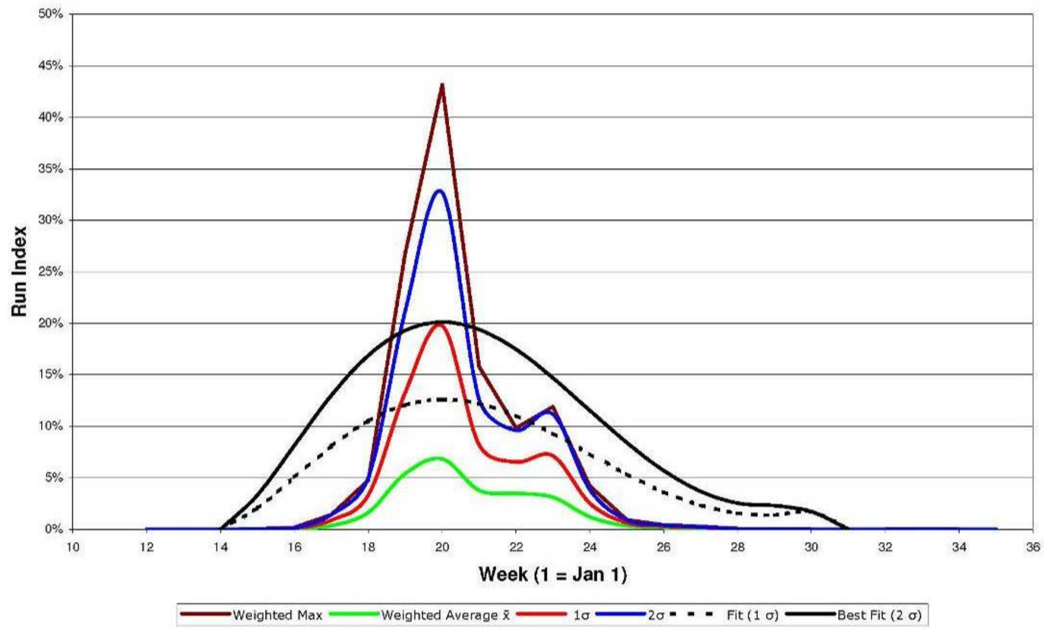


Figure 4-68. Estimated SR summer-run steelhead juvenile passage at Bonneville Dam, 1999-2008.

4.3.30.2 Data Assumptions

PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery-released SR summer-run steelhead juveniles that may be present in the CRC project area. Travel rates from Bonneville Dam to the Columbia River estuary are constant. Timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.30.3 Known Data Gaps

The proportion of hatchery to natural origin fish was not evaluated in this analysis. The abundance of SR summer-run steelhead juveniles is not known (FPAC 2009).

4.3.30.4 Data Options

Continue use of Bonneville Dam PIT tag data that are specific to SR summer-run steelhead juveniles. If necessary, individual tag detections can be assigned to specific origins or source.

4.3.31 Middle Columbia River Winter-Run Steelhead – Adult

Figure 4-69 presents the estimated timing and duration of MCR winter-run steelhead passing through the CRC project area based on counts at Bonneville Dam for 1992–1993 through 2007–2008.

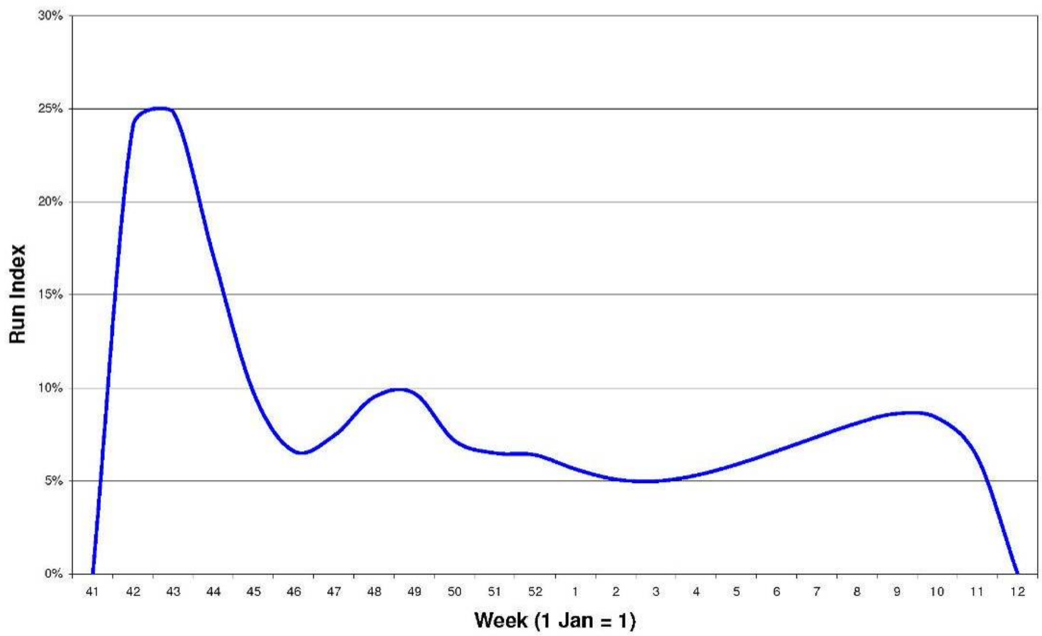


Figure 4-69. Timing and duration of MCR winter-run steelhead passing through the CRC project area based on counts at Bonneville Dam, 1992–1993 through 2007–2008.

4.3.31.1 Data Sources

The best available data to estimate run timing of MCR winter-run steelhead adults (Figure 4-69) are considered by the authors of this report to be counts at Bonneville Dam. The period of record for this analysis is for the counting period of November 1–March 31 from 1992–2008. Daily count data for run years 2002–2003 through 2007–2008 are Bonneville count data from DART (UW 2009). Data for 1992–1993 through 2000–2001 were provided by WDFW (2009). Data processing included discounting Bonneville count data by 60 percent to compensate for similarly timed LCR winter-run steelhead (WDFW 2009), removing negative values, and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 43–14. Data series were constructed for the maximum and mean run indexes across years for each statistical week.

The maximum weighted run index values observed for the period of record were 0.19, in Week 46, and 0.065, in Week 10. The maximum run indexes were estimated to be 0.25 based on a weighted mean abundance of 0.046 and $\sigma = 0.059$ in Week 43, and 0.086, based on a weighted mean abundance of 0.031, and $\sigma = 0.019$, in Week 9. A polynomial curve was fit to 3σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-70). Timing at the Bonneville dam was shifted earlier to start in Week 41, providing an estimated duration of 24 weeks (Weeks 41–12) peaking in Weeks 42–43 at the CRC project area. A second relative maximum occurs in about Week 10. This bimodal pattern is consistent across years in the period of record. The biological and/or environmental causes of this modality are speculative and beyond the scope of this analysis.

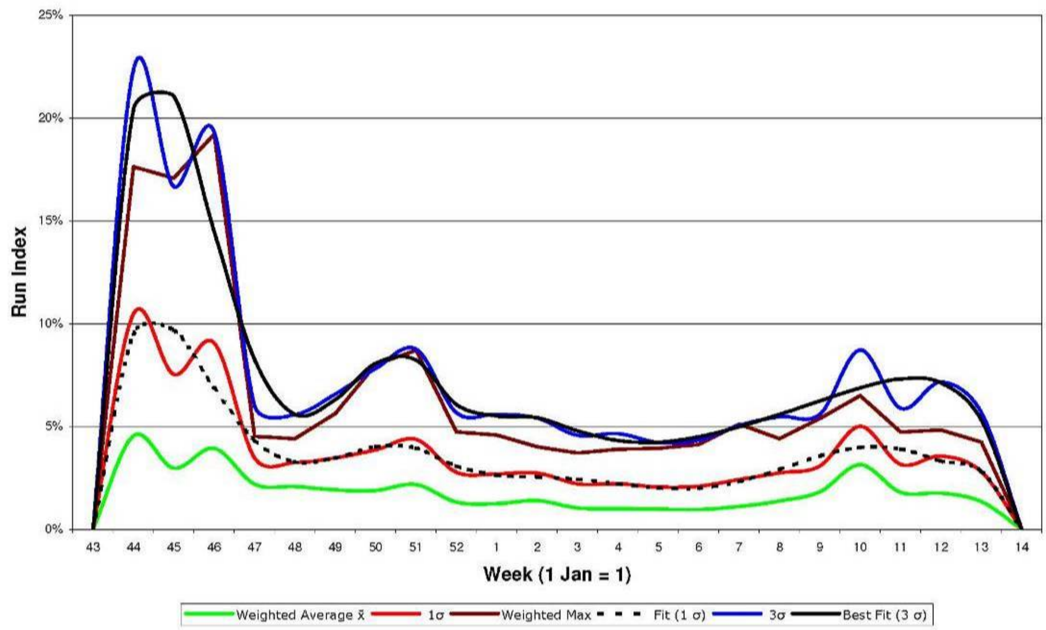


Figure 4-70. MCR winter-run steelhead adult passage at Bonneville Dam, 1992–2008.

4.3.31.2 Data Assumptions

Adult MCR winter-run steelhead of the DPS are assumed to pass Bonneville at the same time as LCR winter-run steelhead destined for Bonneville Pool streams. Run sizes and history of MCR winter-run steelhead are not reported by JCRMS (2009). Run counts at Bonneville suffice as a lower estimate of population abundance for the period of record; however, some hatchery production upstream of the CRC project area is part of the MCR steelhead (FPAC 2009). These hatchery returns are not expected to warrant separate timing estimates or to influence timing estimates for natural origin fish. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.31.3 Known Data Gaps

Timing differences between hatchery and natural origin fish cannot be distinguished. The abundance and run history of natural origin fish are not known.

4.3.31.4 Data Options

Identify and compile abundance data and run history comparable to other steelhead DPSs under analysis. Compile return data for artificial production facilities listed as part of the MCR DPS. Compare timing with natural origin fish and revise estimates as appropriate.

4.3.32 Middle Columbia River Winter-Run Steelhead – Juvenile

Figure 4-71 presents the estimated timing and duration of MCR winter-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam for 2005–2008.

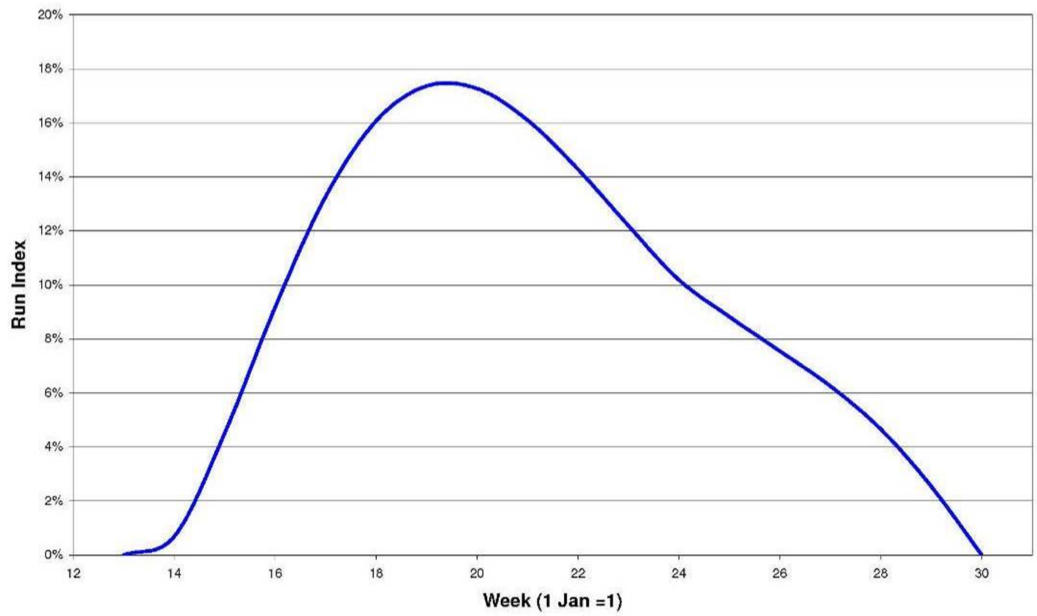


Figure 4-71. Estimated timing and duration of MCR winter-run steelhead juveniles passing through the CRC project area based on detections at Bonneville Dam, 2005–2008.

4.3.32.1 Data Sources

Stock-specific data for MCR steelhead juveniles were not available for analysis. Review of the literature and regional fish tag data repositories revealed limited information about the timing of juvenile steelhead emigrating from middle Columbia River tributaries or those passing Bonneville Dam (StreamNet 2009; PTAGIS 2010). FPAC (2009) did not recognize juveniles from this DPS as distinct, although WDFW (2009) provided general recommendations on an approach to estimate adult timing. Alternatively, surrogate datasets were considered by the authors of this report. FPAC (2009) found that nearly all stock-specific timing of steelhead juveniles reflected the timing of a steelhead "run-at-large" that composites all steelhead emigrants originating in the Columbia upstream of the CRC project area. Only LCR winter-run steelhead juveniles were not well represented, peaking slightly later than the run-at-large. The run-at-large is derived from expansions of daily sampling of the juvenile run at Bonneville and is considered by the authors of this report useful for run timing information. Therefore, absent DPS-specific data, the Bonneville steelhead run-at-large was used as a surrogate dataset to estimate timing of MCR steelhead juveniles at the CRC project area (Figure 4-71). The period of record for this analysis is 1999–2008.

Weekly run indexes provided by FPAC (2009) for winter- and summer-run steelhead juvenile stocks (LCR, summer-run MCR, UCR, and SR) were used as a basis for estimating timing of MCR winter-run juveniles. These data are normalized weekly averages and independent timing distributions that group tightly between Weeks 16 and 26 (Figure 4-72). Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 12–33.

Data series were constructed for the maximum and mean run indexes across years for each statistical week.

The maximum weighted run index values observed for the period of record were 0.31, in Week 20. The maximum run index was estimated to be 0.17 based on a weighted mean abundance of 0.096 and $\sigma = 0.15$ in Week 20. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-71). Timing at the Bonneville dam was shifted earlier to start in Week 13, providing an estimated duration of 18 weeks (Weeks 13-30) peaking in Week 19 at the CRC project area.

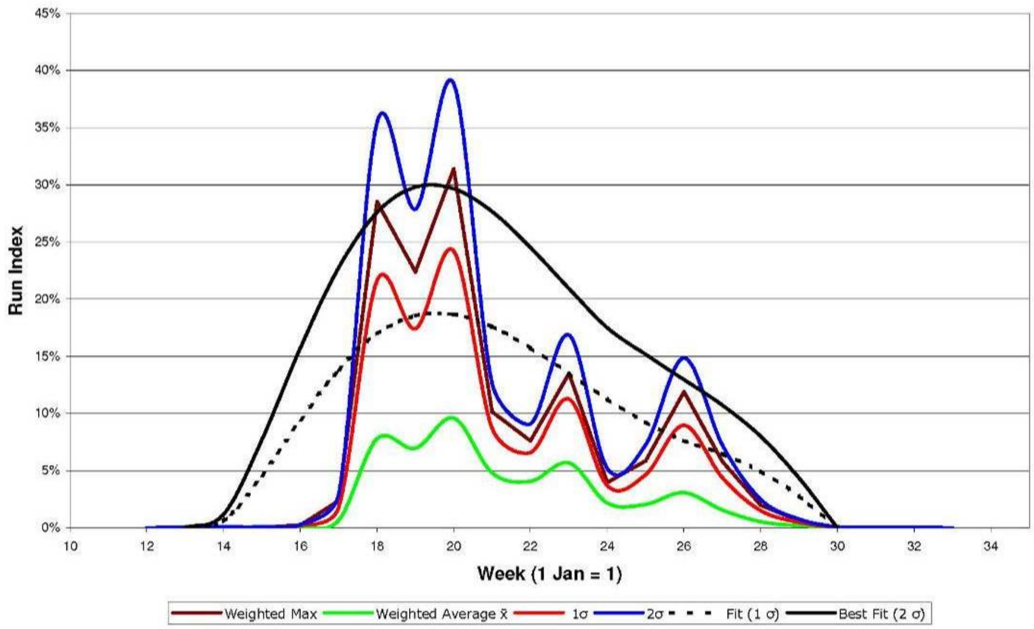


Figure 4-72. Estimated MCR winter-run steelhead juvenile passage at Bonneville Dam, 2005–2008.

4.3.32.2 Data Assumptions

PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery MCR winter-run steelhead that can reasonably be expected to be present in the CRC project area. Timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation between average timing of similar, within-basin stocks incorporates uncertainty without artificially shifting run timing.

4.3.32.3 Known Data Gaps

Daily detection data for MCR winter-run steelhead juveniles. The abundance of natural origin fish is not known (FPAC 2009).

4.3.32.4 Data Options

Continue use of Bonneville PIT tag data that are specific to Group A summer-run steelhead juveniles. If necessary, individual tag detections can be assigned to origin or source.

Seek substitute data for the juvenile run-at-large provided by FPAC (2009). Conduct additional analyses to validate application of run-at-large data as a surrogate for timing of MCR winter-run steelhead juveniles.

4.3.33 Upper Willamette River Steelhead – Adult

Figure 4-73 presents the estimated timing and duration of UWR steelhead passing through the CRC project area based on counts at Willamette Falls for 2000–2008.

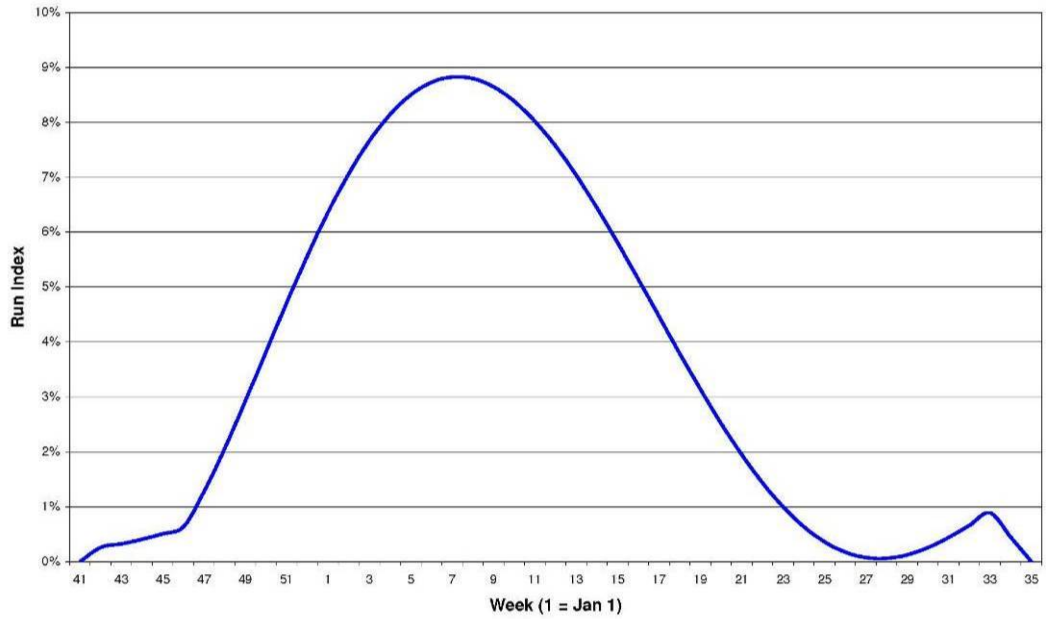


Figure 4-73. Timing and duration of UWR steelhead passing through the CRC project area based on counts at Willamette Falls, 2000–2008.

4.3.33.1 Data Sources

UWR steelhead are composed of winter and summer runs (represented together in (Figure 4-73) that overlap in timing in March–May (Weeks 9–22). The summer-run duration is estimated to be Weeks 9–35 (Figure 4-74). Winter-run fish begin passing Willamette Falls in Week 43 and continue into Week 20 of the next year (Figure 4-75). The proportion of the summer run that is naturally spawned is not known precisely, but is estimated at about 5 percent (Melcher 2010 personal communication). Winter and summer run abundance (counts) are plotted in Figure 4-76 with the curve based on weekly total natural origin steelhead abundance shown in Figure 4-77.

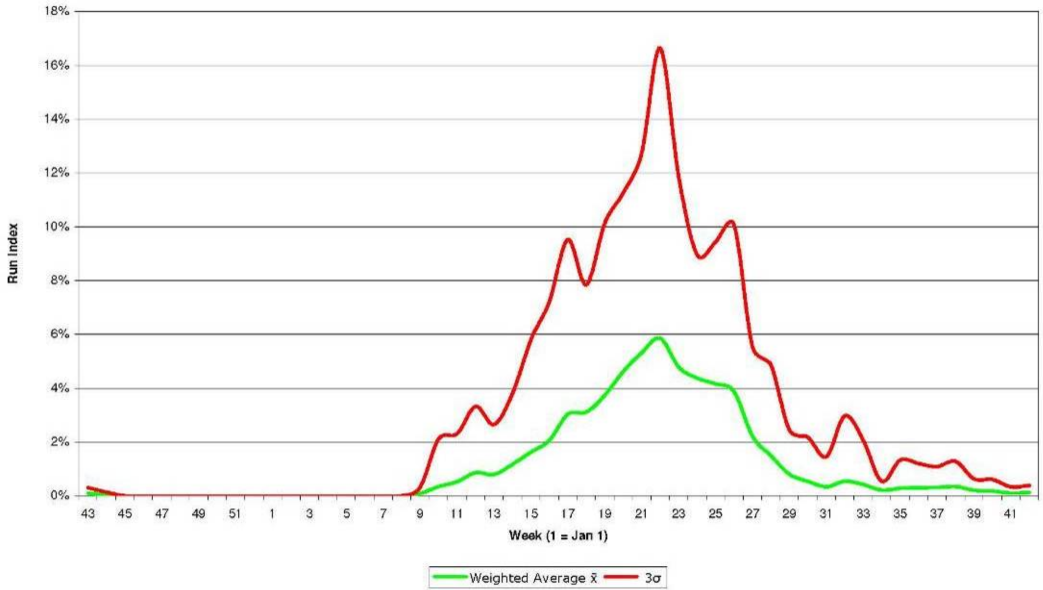


Figure 4-74. UWR summer-run steelhead adults passing the Willamette Falls, 2000–2008. The maximum value is one standard deviation greater than the mean weekly index.

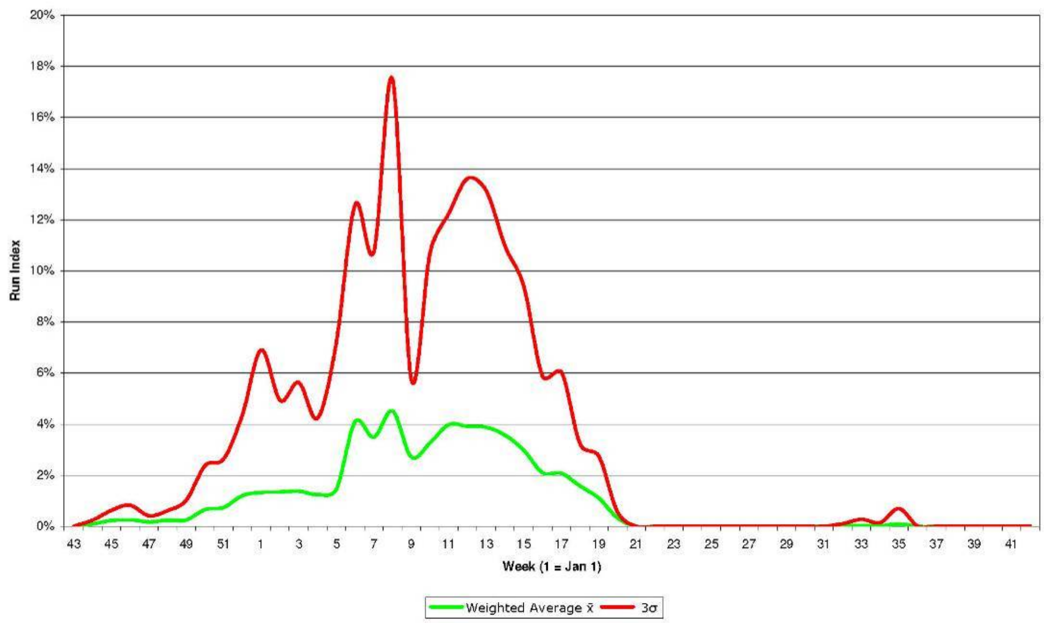


Figure 4-75. UWR winter-run steelhead adults passing the Willamette Falls, 2000–2008. The maximum value is one standard deviation greater than the mean weekly index.

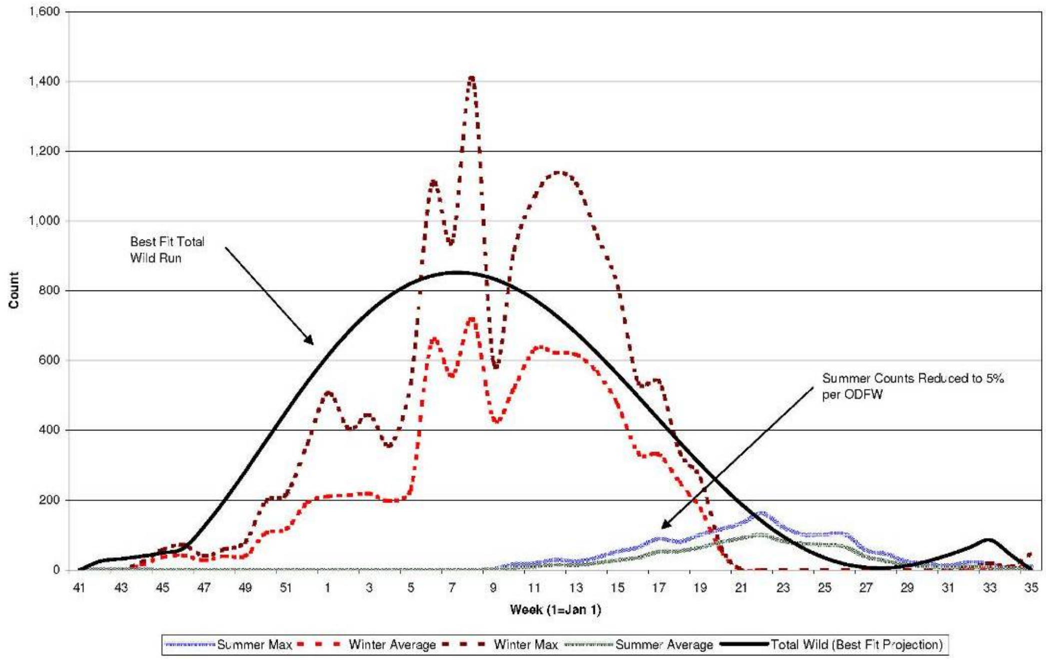


Figure 4-76. UWR winter- and summer-run steelhead adults passing the Willamette Falls, 2000–2008.

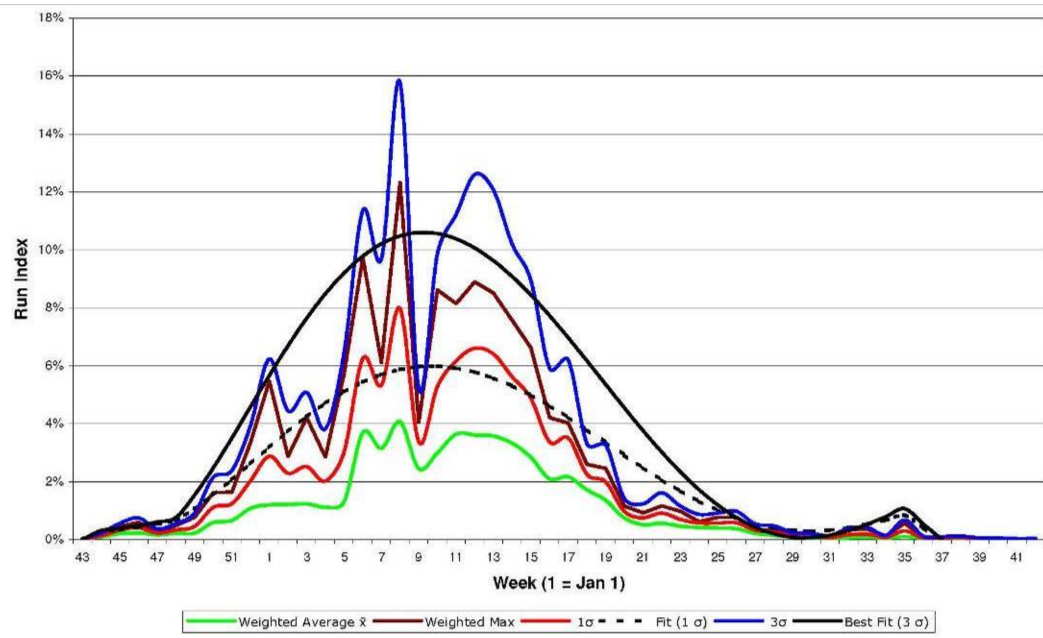


Figure 4-77. UWR steelhead adult passage based on counts of winter- and summer-run adults at Willamette Falls, 2000–2008. The maximum and average run indexes are shown with a curve fit to the maximum weekly values.

The potential for UWR steelhead adults to be present in the CRC project area is unknown. However, a natural tendency for straying and other exploratory behaviors suggests that adult and juvenile individuals of this DPS could reasonably be expected to be present infrequently and in low abundance. The best available data to estimate run timing of UWR steelhead adults are considered by the authors of this report to be counts at Willamette Falls (Figure 4-73). The period of record for this analysis is 2000–2008. Daily count data were available as records by ODFW (2010) and also from ODFW staff (Melcher 2010 personal communication).

Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 43–37. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.12. The maximum run index was estimated to be 0.088 based on a weighted mean abundance of 0.041 and $\sigma = 0.04$ in Week 8. A polynomial curve was fit to 3σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-77). Timing was shifted earlier to start in Week 41, providing an estimated duration of 47 weeks (Weeks 41–35) peaking in Week 7 (February 12) for all natural origin steelhead at the CRC project area (Figure 4-73).

4.3.33.2 Data Assumptions

UWR summer-run steelhead return as a constant proportion of the fish identified as summer run over the count period. Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by the standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.33.3 Known Data Gaps

The proportion of the summer run that is naturally spawned is best professional judgment. The summer steelhead timing and distribution is not known separate from the vastly more abundant hatchery origin fish except as a constant percentage of the summer run. Timing differences between hatchery and natural origin fish cannot be distinguished. The population of natural origin fish is not known.

4.3.33.4 Data Options

Continue use of current dataset.

4.3.34 Upper Willamette River Steelhead – Juvenile

Figure 4-78 presents the estimated timing and duration of UWR steelhead juveniles passing through the CRC project area based on LCR steelhead juvenile passage at Bonneville for 2000–2008.

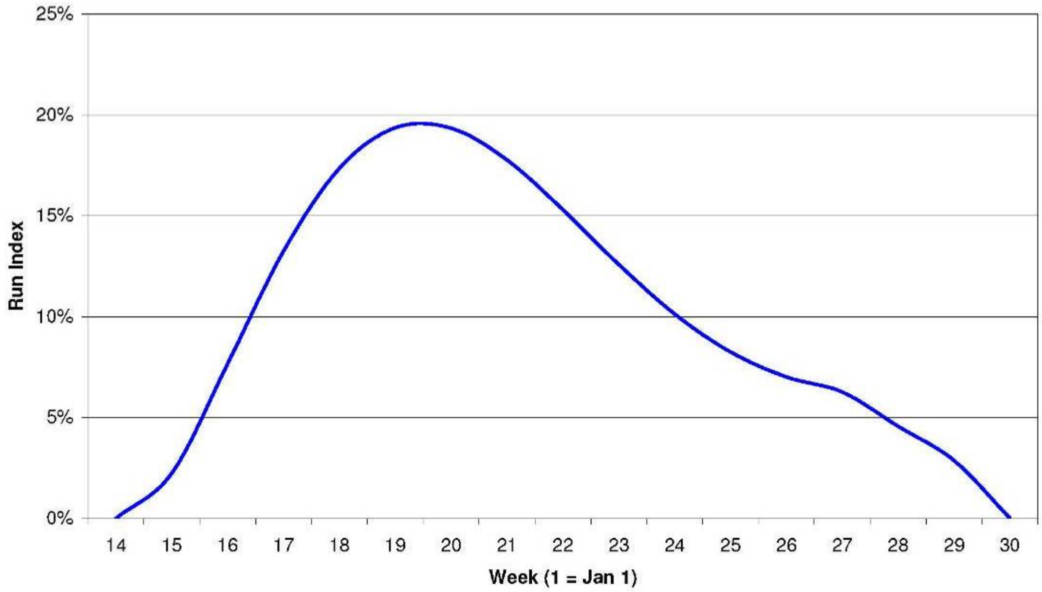


Figure 4-78. Estimated timing and duration of UWR steelhead juveniles passing through the CRC project area based on LCR steelhead juvenile passage at Bonneville, 2000–2008.

4.3.34.1 Data Sources

Stock-specific data for UWR steelhead juveniles were not available for analysis. Review of the literature and regional fish tag data repositories revealed limited information about juvenile steelhead in the lower Willamette River (e.g., North et al. 2002; StreamNet 2009) or passing Willamette Falls (e.g., FPC 2010; PTAGIS 2010). Alternatively, surrogate datasets were considered. FPAC (2009) found that nearly all stock-specific timing of steelhead juveniles reflected the timing of a steelhead "run-at-large" that composites all steelhead emigrants originating in the Columbia River upstream of the CRC project area (FPAC 2009); only LCR winter-run steelhead juveniles were not well-represented, peaking slightly later than the run-at-large. The run-at-large is derived from expansions of daily sampling of the juvenile run at Bonneville and is considered by the authors of this report useful for run timing information. Therefore, absent DPS-specific data, weekly detections of LCR summer- and winter-run steelhead juvenile at Bonneville were pooled and used as a surrogate dataset to estimate timing of UWR steelhead juveniles at the CRC project area (Figure 4-78). The period of record for this analysis is 2000–2008.

Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.32. The maximum run index was estimated to be 0.19 based on a weighted mean abundance of 0.061 and $\sigma = 0.1$, in Week 20 (Figure 4-79).

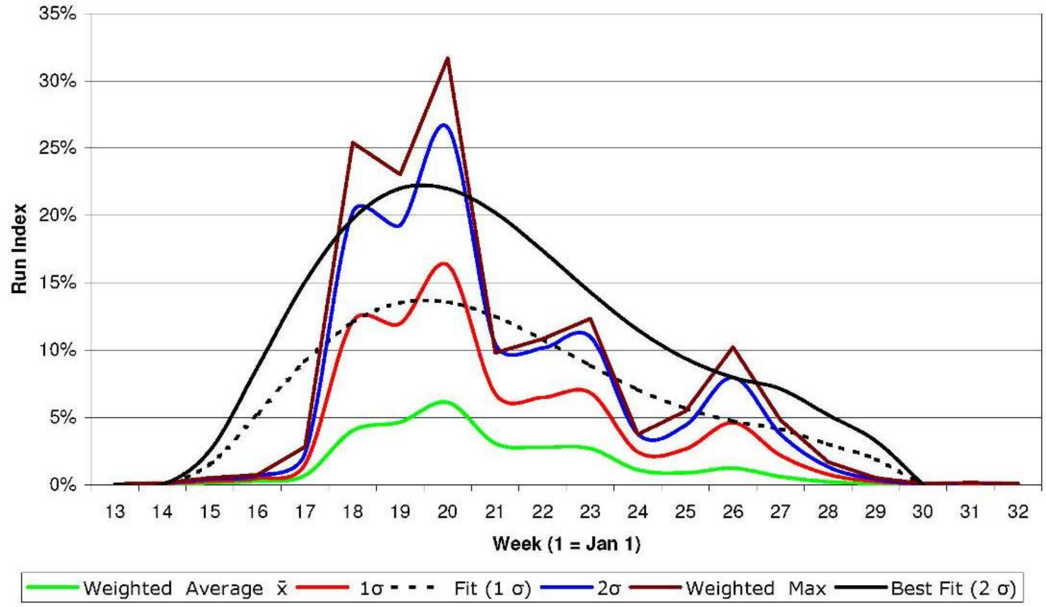


Figure 4-79. Estimated timing of UWR steelhead juvenile passage based on PIT detections of LCR steelhead juvenile detections at Bonneville.

A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-78), providing an estimated duration of 17 weeks (Weeks 14–30), peaking in Week 20. Arrival at the CRC project area may take 1–2 days from passage at Bonneville, based on an average travel rate for the run-at-large of 0.9 m/s (FPAC 2009). For statistical purposes, timing data represent a midweek occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area unless passage time is at least 3.5 days (84 hrs).

4.3.34.2 Data Assumptions

UWR steelhead juveniles have life histories and timing and are genetically closer to LCR steelhead than to upriver DPSs that dominate the FPAC (2009) run-at-large timing. Summer-run juvenile counts are expected to be much less than winter-run juveniles based on the ratio of natural origin to hatchery adults (see Section 4.3.33). They emigrate at similar or overlapping times with winter-run juveniles and timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.34.3 Known Data Gaps

DPS-specific data for the timing of juvenile emigration are needed. The abundance of natural origin fish is not known.

4.3.34.4 Data Options

Obtain DPS-specific data and revise timing distribution. Passage facilities at Willamette Falls are equipped with PIT detectors and requests for data have been made.

4.3.35 Snake River Sockeye – Adult

Figure 4-80 presents the estimated timing and duration of Snake River (SR) sockeye adults passing through the CRC project area based on counts at Bonneville Dam for 1999–2008.

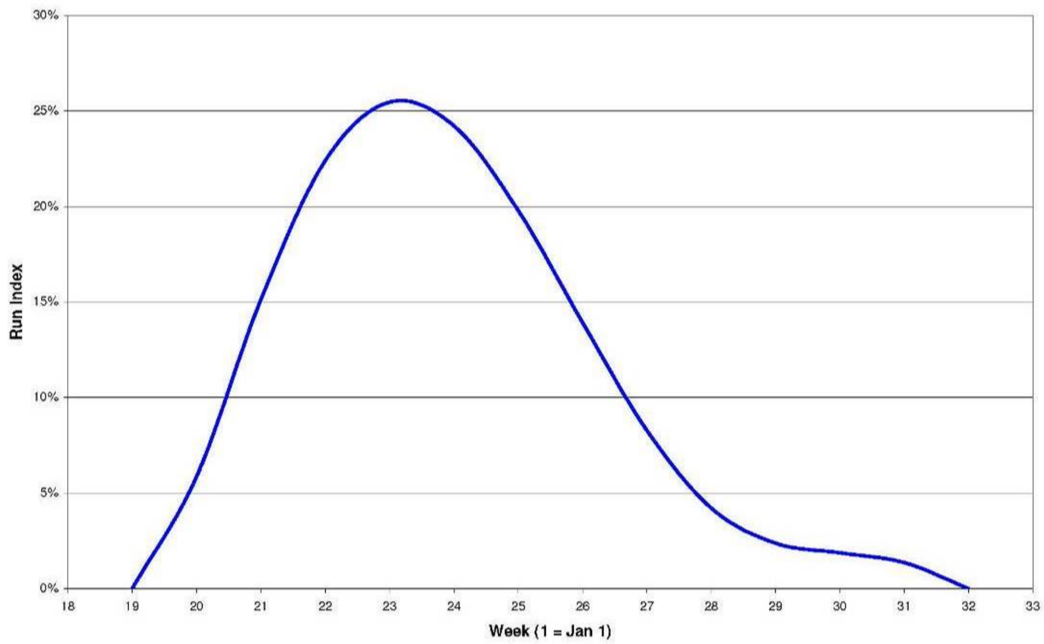


Figure 4-80. Timing and duration of SR Sockeye adults passing through the CRC project area based on counts at Bonneville Dam, 1999–2008.

4.3.35.1 Data Sources

SR sockeye were first listed as an endangered species in 1991 and were re-affirmed as endangered in 2005. The ESU includes all anadromous and residual sockeye from the Snake River basin, Idaho, as well as artificially propagated sockeye from the Redfish Lake captive propagation program. The best available data to estimate run timing of SR sockeye adults (Figure 4-80) are considered to be counts at Bonneville Dam. The period of record for this analysis is 1999–2008. Daily count data were obtained from DART (UW 2009) and also provided by WDFW (2009). Data processing included removing negative values and setting minimum daily counts to one. Daily counts were summed by statistical week (Week 1 including January 1) for the count period of Weeks 21–34.

Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum weighted run index value observed for the period of record was 0.43. The maximum run index was estimated to be 0.25 based on a weighted mean abundance of 0.14 and $\sigma = 0.14$ in Week 25. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-81). Timing at the Bonneville Dam was shifted earlier to start in Week 19, providing an estimated duration of 14 weeks (Weeks 19–32) peaking in Week 23 (June 4) at the CRC project area.

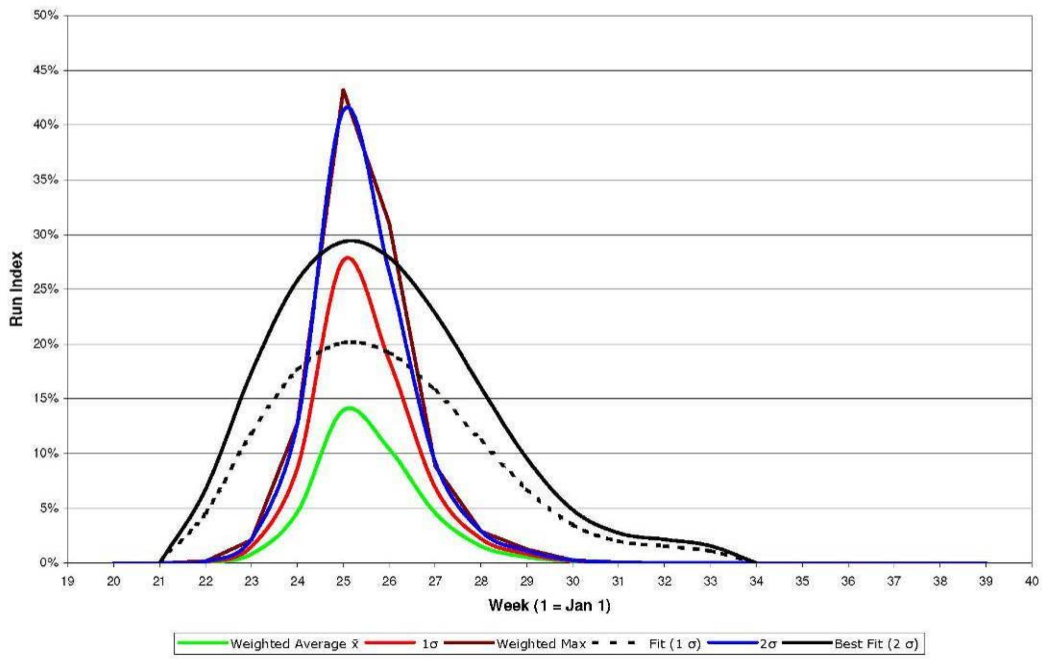


Figure 4-81. SR Sockeye adult passage through the CRC project area based on counts at Bonneville Dam, 1999–2008.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.35.2 Data Assumptions

Sockeye counts at Bonneville Dam include adults from populations in the Middle and Upper Columbia domains (e.g., Wenatchee River and the Similkameen/Lake Osoyoos group) that are significantly larger than the listed ESU in the Snake River. For the analysis period, SR sockeye ranged from 20 to 1,007 fish at the mouth of the Snake River, while sockeye counts at Bonneville Dam ranged from 17,877 to more than 213,000. It must be assumed that SR sockeye are distributed in time in some proportion to other populations and that any unique run timing is bracketed by the larger composite counts at Bonneville Dam.

Estimates of run timing based on maximum values from raw data may emphasize extreme values and mask uncertainty indicated by standard deviation of mean weekly values. Conversely, weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.35.3 Known Data Gaps

Timing differences between SR sockeye cannot be distinguished from other sockeye populations above Bonneville Dam.

4.3.35.4 Data Options

Continue use of Bonneville count data.

4.3.36 Snake River Sockeye – Juvenile

Figure 4-82 presents the estimated timing and duration of SR sockeye juveniles passing through the CRC project area based on PIT tag detections at Bonneville Dam for 1999–2008.

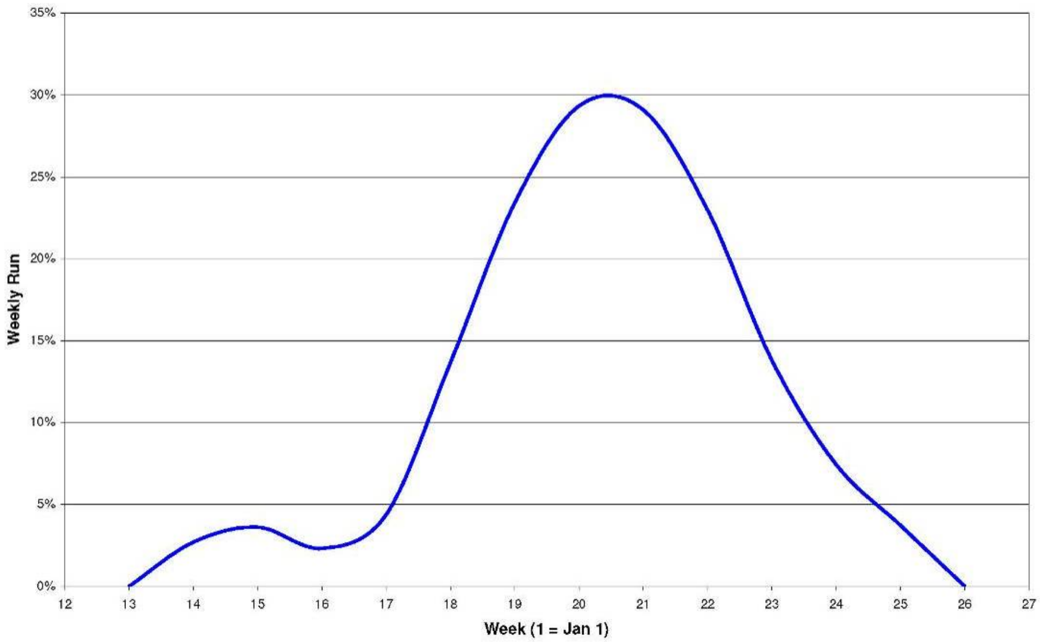


Figure 4-82. Estimated timing and duration of SR Sockeye juveniles passing through the CRC project area based on PIT tag detections at Bonneville Dam, 1999–2008.

4.3.36.1 Data Sources

In response to the CRC project team's request for assistance selecting fish data (CRC 2008), FPAC (2009) found that PIT-tagged SR sockeye juveniles reflected the timing of a composite sockeye "run-at-large" that pools all sockeye emigrants. Bonneville PIT tag detections indicate that SR juveniles may emigrate several weeks later than MCR and UCR juveniles (FPAC 2009). However, detection data are limited in proportion to overall low abundance, particularly for migration years 2001, 2004, and 2005, when fewer than 20 fish were detected at Bonneville. Even with limitations, stock-specific data for SR sockeye juveniles were considered the best available for estimating timing and duration (Figure 4-82).

The period of record for this analysis is 1999–2008. Data series were constructed for the maximum and mean run indexes across years for each statistical week. The maximum run index value observed for the period of record was 1.00 in 2005, when only five juveniles were detected, all in Week 23. Excluding 2005, the maximum observed run index was 0.58 in Week 23. The maximum weighted run index value for the period of record was 0.58. The maximum run index was estimated to be 0.29 based on a weighted mean abundance of 0.13 and $\sigma = 0.17$, also in Week 23. A polynomial curve was fit to 2σ greater than the average weekly run index to best fit weekly variation of maximum values (Figure 4-83), providing an estimated duration of 14 weeks (Weeks 13-26). Arrival at the CRC project area may take from 1 to 2.5 days passage from Bonneville, based on velocities of 0.63–1.41 m/s (FPAC 2009). For statistical purposes, timing data represent a midweek occurrence. Thus, no shifts in timing are needed to index arrival and passage through the CRC project area unless passage time is at least 3.5 days (84 hrs).

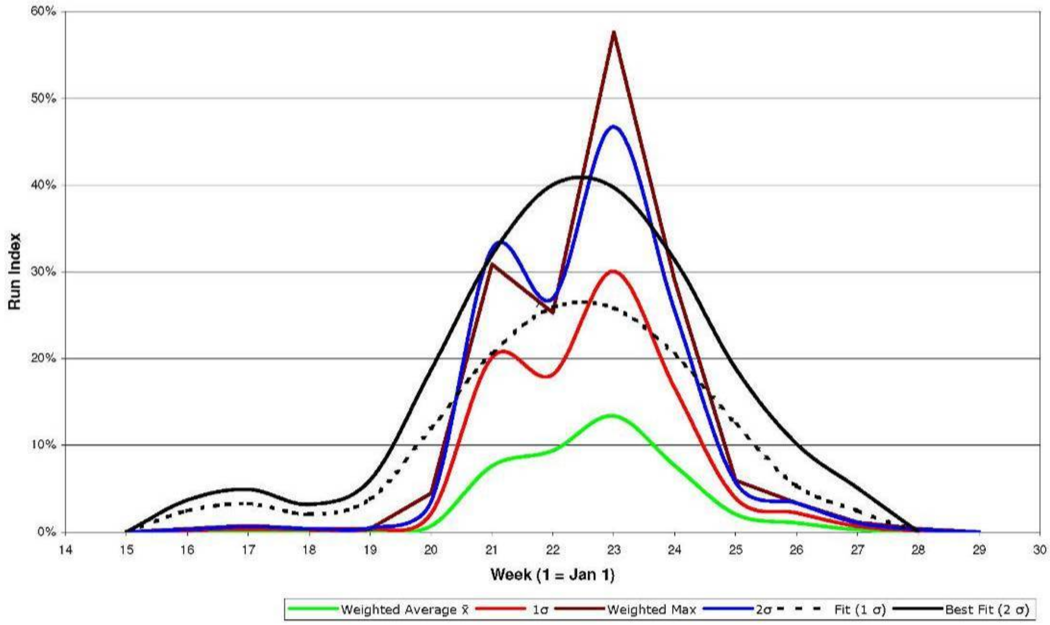


Figure 4-83. Estimated SR Sockeye juvenile passage at Bonneville Dam, 1999–2008.

Polynomial curves tend to maintain temporal patterns in run timing (e.g., peak, modality) but redistribute abundance (represented as the run index). High variation in weekly run indexes further increases the maximum value that might be expected for any week. These influences on timing estimation are most evident in Week 23 where the best-fit polynomial markedly distributes abundance before and after this highly variable peak. This analysis approach provides a simple maximum likelihood emphasis on the earliest and latest weeks of species presence and treatment of uncertainty by increasing estimates of abundance. Use of these results in effects analyses can be expected to estimate a maximum level of effect, not an average or least-effect scenario.

4.3.36.2 Data Assumptions

PIT-tagged fish released above Bonneville Dam are representative of the timing of natural origin and hatchery SR sockeye that may be present in the CRC project area. Travel rates from Bonneville Dam to the Columbia River estuary are constant. Timing for hatchery and natural origin fish is assumed to be the same. Weighting or redistributing weekly abundance based on variation (σ) incorporates uncertainty without artificially shifting peak run timing.

4.3.36.3 Known Data Gaps

The abundance of SR sockeye juveniles is not known (FPAC 2009).

4.3.36.4 Data Options

Continue use of Bonneville PIT tag data that are specific to SR sockeye.

5. Calculated Impacts to Listed Fish Runs

This section presents the results from the using weekly exposure factors to assess impacts to fish runs. Details on how exposure factors are calculated are discussed in Section 3 of this document. Run timing and run indexes proportion of a run by week are discussed in Section 4.

CRC calculated exposure factors for 13 separate construction schedules that varied with the potential bridge construction contract award dates, as discussed in Section 3 of this document. For the purpose of analysis, these award dates occurred approximately 1 month apart between February 5, 2013 and February 1, 2014. If the contracts are awarded earlier or later than the scheduled dates, impact pile driving scenarios and impacts would not be likely to change substantially.

Potential impacts to listed salmon and eulachon in the project area were estimated based on magnitude of exposure in relation to estimated proportion of the fish runs in the project area during impact pile driving. Table 5-1 summarizes the estimated abundance and proportion of the ESU/DPS and life stage by week of the year.

5.1 Example Calculation of Fish Exposure

This example illustrates how weekly exposure factors interact with weekly run percentage for a given ESU/DPS and life stage, the following. The example answers these questions: How does the model calculate potential exposure to noise levels over the onset of injury threshold for adult chum during Week 44 in the first year of in-water construction (2013) if the contract award date is February 5, 2013? What is the modeled impact to adult chum during this week?

The model calculates the exposure in Week 44 by using this equation:

Weekly Fish Exposure = Weekly Proportion of Run x Weekly Exposure Factor

From Table 3-2, the weekly exposure factor for adult fish (over 2 g, speed 0.1 m/s) in Week 44 of Year 1 is 0.0044. From Table 5-1, the estimated proportion of the Columbia River chum adults modeled to be in the project area during this week is 0.1716 (17.16 percent, or approximately 343 out of an estimated total population of 1,997). Therefore, the model predicts that proportion of chum exposed to noise levels above the onset of injury threshold during this week is:

$$0.0044 \times 0.1716 = 0.00076 \text{ (0.076 percent)}$$

It is important to note that for the Columbia River chum ESU, this impacted value includes only the proportion of the ESU that spawns upriver of the project and not the entire ESU. Therefore, a much smaller proportion of the entire ESU will likely be exposed.

To obtain annual exposure factors and annual percentage of run impacted, the model repeats the calculation for each week of 2013. In weeks with no pile driving, the exposure factor is zero. To obtain total project exposure factors, the model adds all weekly exposure factors and percentage of runs impacted together for the entire project.

Based on the February 5, 2013 award date scenario, the weekly exposure factor presented in Table 3-2 in 2013 is zero for Weeks 1–16 and Week 52 (e.g., no impact pile driving those weeks); therefore, the exposure to Columbia River chum is zero for these weeks. For Weeks 51–37 (late December through early September of the following year, adult chum salmon are not present with the exception of the one fish allotted to each week as an assumption in the analysis (Table 5-1). Therefore, exposure to impact pile driving, if it occurs during these weeks is negligible.

In contrast, Weeks 47–50 have the highest exposure factors in 2013 at 0.00581, but due to varying population proportions, the weekly impact to the run also vary. Weeks 47–50 are estimated to contain 5.96, 4.11, 2.05, and 0.05 percent of the run, respectively. When multiplied by the exposure factor of 0.00581, the percentage of the run that is estimated to be impacted during those weeks is 0.0346, 0.0239, 0.0119, and 0.0003 percent of the run, for a total of 0.1053 percent of the run impacted during those four week.

To find which year of construction has the biggest impact to chum, repeat the calculations in the first part of this example for each construction year from 2014 through 2016 using the appropriate weekly exposure factor for each week and each year. Calculations for the adult chum in the example result in impact pile driving in year 2013 exposing 0.433 percent of the adult chum that spawn above the project area. In year 2014, 2015, and 2016, the percent of chum exposed is 0.393, 0.122, and 0.001 percent, respectively. Therefore, under this scenario, impact pile driving activities occurring in 2013 have the highest percentage of impact. The cumulative percentage[16] of adult chum exposure to noise levels above the onset of injury threshold from pile driving based on this scenario is 0.949 percent.

The same weekly exposure factor for Week 44 is used to calculate proportions of the other runs exposed in the project area.

[16] Cumulative percentage is defined as the sum of the four annual run exposures through the life of the project. This metric is used to present a total potential impact to the reader rather than average annual exposure or total number of individuals. Average annual exposure factors are not selected for presentation of results because the construction scenarios tend to have higher exposure during the first and second years of construction, with fewer exposures in the third and fourth years. Comparing across years and across scenarios was deemed by the authors as not appropriate for comparisons due to the number of variables. Total number of individuals potentially impacted was not chosen due to the wide variation in estimated/modeled annual abundances. For example, a cumulative exposure percentage of 0.808 for CR chum adults is approximately 16 individuals, while a cumulative exposure percentage of 0.118 for LCR steelhead adults represents approximately 203 individuals.

Table 5-1. Estimated Weekly Abundance and Proportion of Fish Run Through the CRC Project Area by ESU/DPS and Life Stage

	CR Adult Chum		UCR Spring Chinook Adult		LCR Chinook Adult		SR Fall Chinook Adult		SR Spring Summer Chinook Adult		UWR Chinook Adult		LCR Steelhead Adult	
Week	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion
1	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	657	0.0038
2	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	687	0.0040
3	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	703	0.0041
4	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	719	0.0042
5	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	776	0.0045
6	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	884	0.0052
7	1	0.0005	1	0.0003	7	0.0005	1	0.0002	1	0.0000	1	0.0001	999	0.0058
8	1	0.0005	1	0.0003	8	0.0006	1	0.0002	1	0.0000	1	0.0001	1,114	0.0065
9	1	0.0005	1	0.0003	12	0.0009	1	0.0002	1	0.0000	34	0.0044	1,043	0.0061
10	1	0.0005	1	0.0003	21	0.0015	1	0.0002	1	0.0000	90	0.0116	882	0.0051
11	1	0.0005	1	0.0003	34	0.0024	1	0.0002	1	0.0000	183	0.0237	1,355	0.0079
12	1	0.0005	1	0.0003	48	0.0034	1	0.0002	1	0.0000	300	0.0388	610	0.0036
13	1	0.0005	1	0.0003	61	0.0043	1	0.0002	1	0.0000	429	0.0555	323	0.0019
14	1	0.0005	1	0.0003	69	0.0049	1	0.0002	1	0.0000	555	0.0718	374	0.0022
15	1	0.0005	1	0.0003	70	0.0050	1	0.0002	1	0.0000	663	0.0858	591	0.0034
16	1	0.0005	1	0.0003	62	0.0044	1	0.0002	1,838	0.0663	741	0.0959	725	0.0042
17	1	0.0005	34	0.0104	45	0.0032	1	0.0002	3,299	0.1189	782	0.1012	704	0.0041
18	1	0.0005	226	0.0694	24	0.0017	1	0.0002	4,101	0.1479	780	0.1009	732	0.0043
19	1	0.0005	496	0.1523	13	0.0009	1	0.0002	4,218	0.1521	737	0.0954	1,231	0.0072
20	1	0.0005	692	0.2125	1	0.0001	1	0.0002	3,787	0.1365	657	0.0850	2,974	0.0173
21	1	0.0005	715	0.2196	1	0.0001	1	0.0002	3,021	0.1089	549	0.0710	5,444	0.0317
22	1	0.0005	563	0.1729	1	0.0001	1	0.0002	2,149	0.0775	425	0.0550	8,266	0.0482
23	1	0.0005	320	0.0983	1	0.0001	1	0.0002	1,366	0.0493	299	0.0387	8,962	0.0522
24	1	0.0005	118	0.0362	1	0.0001	1	0.0002	798	0.0288	187	0.0242	9,366	0.0546
25	1	0.0005	49	0.0150	1	0.0001	1	0.0002	493	0.0178	102	0.0132	9,770	0.0569
26	1	0.0005	1	0.0003	1	0.0001	1	0.0002	415	0.0150	55	0.0071	10,174	0.0593
27	1	0.0005	1	0.0003	1	0.0001	1	0.0002	469	0.0169	50	0.0065	10,477	0.0611
28	1	0.0005	1	0.0003	1	0.0001	1	0.0002	525	0.0189	29	0.0038	10,576	0.0616
29	1	0.0005	1	0.0003	1	0.0001	1	0.0002	475	0.0171	28	0.0036	11,749	0.0685
30	1	0.0005	1	0.0003	1	0.0001	1	0.0002	300	0.0108	24	0.0031	11,647	0.0679
31	1	0.0005	1	0.0003	1	0.0001	171	0.0285	1	0.0000	1	0.0001	10,530	0.0614
32	1	0.0005	1	0.0003	1	0.0001	331	0.0551	446	0.0161	1	0.0001	8,802	0.0513
33	1	0.0005	1	0.0003	1	0.0001	599	0.0997	1	0.0000	1	0.0001	6,887	0.0401
34	1	0.0005	1	0.0003	1	0.0001	878	0.1461	1	0.0000	1	0.0001	5,129	0.0299
35	1	0.0005	1	0.0003	1	0.0001	998	0.1661	1	0.0000	1	0.0001	3,736	0.0218
36	1	0.0005	1	0.0003	556	0.0395	950	0.1581	1	0.0000	1	0.0001	2,759	0.0161
37	1	0.0005	1	0.0003	1,516	0.1078	778	0.1295	1	0.0000	1	0.0001	2,108	0.0123
38	31	0.0155	1	0.0003	2,427	0.1725	545	0.0907	1	0.0000	1	0.0001	1,598	0.0093
39	53	0.0265	1	0.0003	2,894	0.2057	318	0.0529	1	0.0000	1	0.0001	1,068	0.0062
40	75	0.0376	1	0.0003	2,742	0.1949	153	0.0255	1	0.0000	1	0.0001	453	0.0026
41	141	0.0706	1	0.0003	2,046	0.1454	80	0.0133	1	0.0000	1	0.0001	306	0.0018
42	252	0.1262	1	0.0003	1,094	0.0778	63	0.0105	1	0.0000	1	0.0001	1,737	0.0101
43	330	0.1652	1	0.0003	289	0.0205	56	0.0093	1	0.0000	1	0.0001	2,141	0.0125
44	343	0.1718	1	0.0003	1	0.0001	52	0.0087	1	0.0000	1	0.0001	2,001	0.0117
45	290	0.1452	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	1,656	0.0097
46	200	0.1002	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	1,306	0.0076
47	119	0.0596	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	1,045	0.0061
48	82	0.0411	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	895	0.0052
49	41	0.0205	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	819	0.0048
50	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	729	0.0042
51	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	693	0.0040
52	1	0.0005	1	0.0003	1	0.0001	1	0.0002	1	0.0000	1	0.0001	664	0.0039
Totals	**1,997**	**1.0000**	**3,256**	**1.0000**	**14,069**	**1.0000**	**6,010**	**1.0000**	**27,736**	**1.0000**	**7,729**	**1.0000**	**171,576**	**1.0000**

Table 5-1. Continued

Week	MCR Steelhead Adult		UCR Steelhead Adult		SR Basin Steelhead Adult		UWR Steelhead Adult		SR Adult Sockeye		LCR Adult Coho		Eulachon Adult	
	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion
1	31	0.0003	1	0.0000	1	0.0000	370	0.0383	1	0.0055	1	0.0000	1	0.0000
2	28	0.0003	1	0.0000	1	0.0000	410	0.0425	1	0.0055	1	0.0000	1	0.0000
3	28	0.0003	1	0.0000	1	0.0000	445	0.0461	1	0.0055	1	0.0000	1	0.0000
4	29	0.0003	1	0.0000	1	0.0000	473	0.0490	1	0.0055	1	0.0000	1	0.0000
5	32	0.0003	1	0.0000	1	0.0000	494	0.0512	1	0.0055	1	0.0000	1	0.0000
6	36	0.0004	1	0.0000	1	0.0000	507	0.0525	1	0.0055	1	0.0000	1	0.0000
7	40	0.0004	1	0.0000	1	0.0000	513	0.0532	1	0.0055	1	0.0000	1	0.0000
8	44	0.0005	1	0.0000	1	0.0000	511	0.0530	1	0.0055	1	0.0000	1	0.0000
9	46	0.0005	1	0.0000	1	0.0000	502	0.0520	1	0.0055	1	0.0000	1	0.0000
10	45	0.0005	1	0.0000	1	0.0000	487	0.0505	1	0.0055	1	0.0000	625	0.0054
11	34	0.0004	1	0.0000	1	0.0000	466	0.0483	1	0.0055	1	0.0000	7,478	0.0650
12	1	0.0000	1	0.0000	1	0.0000	439	0.0455	1	0.0055	1	0.0000	19,377	0.1685
13	1	0.0000	1	0.0000	1	0.0000	408	0.0423	1	0.0055	1	0.0000	27,444	0.2386
14	1	0.0000	1	0.0000	1	0.0000	374	0.0388	1	0.0055	1	0.0000	26,427	0.2298
15	1	0.0000	1	0.0000	1	0.0000	337	0.0349	1	0.0055	1	0.0000	18,071	0.1571
16	1	0.0000	1	0.0000	1	0.0000	298	0.0309	1	0.0055	1	0.0000	9,430	0.0820
17	1	0.0000	1	0.0000	1	0.0000	259	0.0268	1	0.0055	1	0.0000	6,104	0.0531
18	1	0.0000	1	0.0000	1	0.0000	220	0.0228	1	0.0055	1	0.0000	1	0.0000
19	1	0.0000	1	0.0000	1	0.0000	182	0.0189	1	0.0055	1	0.0000	1	0.0000
20	1	0.0000	1	0.0000	1	0.0000	146	0.0151	6	0.0331	1	0.0000	1	0.0000
21	1	0.0000	1	0.0000	1	0.0000	113	0.0117	15	0.0829	1	0.0000	1	0.0000
22	1	0.0000	1	0.0000	1	0.0000	83	0.0086	22	0.1215	1	0.0000	1	0.0000
23	1	0.0000	1	0.0000	1	0.0000	58	0.0060	25	0.1381	1	0.0000	1	0.0000
24	1	0.0000	1	0.0000	1	0.0000	37	0.0038	23	0.1271	1	0.0000	1	0.0000
25	2,849	0.0300	2,848	0.0303	3,576	0.0229	21	0.0022	19	0.1050	1	0.0000	1	0.0000
26	5,537	0.0583	5,536	0.0590	6,672	0.0427	10	0.0010	13	0.0718	1	0.0000	1	0.0000
27	8,182	0.0862	8,181	0.0871	9,388	0.0601	4	0.0004	8	0.0442	1	0.0000	1	0.0000
28	10,573	0.1113	10,572	0.1126	11,760	0.0753	4	0.0004	5	0.0276	1	0.0000	1	0.0000
29	11,746	0.1237	11,745	0.1251	13,018	0.0834	7	0.0007	2	0.0110	1	0.0000	1	0.0000
30	11,644	0.1226	11,643	0.1240	13,281	0.0851	15	0.0016	2	0.0110	1	0.0000	1	0.0000
31	10,527	0.1109	10,526	0.1121	13,280	0.0851	26	0.0027	1	0.0055	1	0.0000	1	0.0000
32	8,799	0.0927	8,798	0.0937	13,316	0.0853	38	0.0039	1	0.0055	1	0.0000	1	0.0000
33	6,884	0.0725	6,883	0.0733	13,292	0.0851	52	0.0054	1	0.0055	227	0.0047	1	0.0000
34	5,126	0.0540	5,125	0.0546	13,123	0.0841	26	0.0027	1	0.0055	454	0.0094	1	0.0000
35	3,733	0.0393	3,732	0.0397	12,572	0.0805	1	0.0001	1	0.0055	1,070	0.0222	1	0.0000
36	2,756	0.0290	2,755	0.0293	11,332	0.0726	1	0.0001	1	0.0055	1,952	0.0406	1	0.0000
37	2,105	0.0222	2,104	0.0224	9,169	0.0587	1	0.0001	1	0.0055	2,966	0.0617	1	0.0000
38	1,595	0.0168	1,594	0.0170	6,110	0.0391	1	0.0001	1	0.0055	4,327	0.0900	1	0.0000
39	1,065	0.0112	1,064	0.0113	3,206	0.0205	1	0.0001	1	0.0055	5,483	0.1140	1	0.0000
40	450	0.0047	449	0.0048	1,718	0.0110	1	0.0001	1	0.0055	6,176	0.1284	1	0.0000
41	303	0.0032	302	0.0032	1,254	0.0080	1	0.0001	1	0.0055	6,254	0.1300	1	0.0000
42	126	0.0013	1	0.0000	1	0.0000	15	0.0016	1	0.0055	5,700	0.1185	1	0.0000
43	129	0.0014	1	0.0000	1	0.0000	19	0.0020	1	0.0055	4,638	0.0964	1	0.0000
44	90	0.0009	1	0.0000	1	0.0000	24	0.0025	1	0.0055	3,307	0.0688	1	0.0000
45	52	0.0005	1	0.0000	1	0.0000	29	0.0030	1	0.0055	2,257	0.0469	1	0.0000
46	36	0.0004	1	0.0000	1	0.0000	37	0.0038	1	0.0055	1,304	0.0271	1	0.0000
47	40	0.0004	1	0.0000	1	0.0000	74	0.0077	1	0.0055	885	0.0184	1	0.0000
48	51	0.0005	1	0.0000	1	0.0000	120	0.0124	1	0.0055	710	0.0148	1	0.0000
49	52	0.0005	1	0.0000	1	0.0000	170	0.0176	1	0.0055	355	0.0074	1	0.0000
50	39	0.0004	1	0.0000	1	0.0000	222	0.0230	1	0.0055	1	0.0000	1	0.0000
51	35	0.0004	1	0.0000	1	0.0000	274	0.0284	1	0.0055	1	0.0000	1	0.0000
52	35	0.0004	1	0.0000	1	0.0000	324	0.0336	1	0.0055	1	0.0000	1	0.0000
Totals	**94,965**	**1.0000**	**93,892**	**1.0000**	**156,102**	**1.0000**	**9,650**	**1.0000**	**181**	**1.0000**	**48,100**	**1.0000**	**115,000**	**1.0000**

Table 5-1. Continued

Week	CR Juvenile Chum		UCR Spring Chinook Juvenile		LCR Chinook Juvenile		SR Fall Chinook Juvenile		SR Spring Summer Chinook Juvenile		UWR Chinook Juvenile		LCR Steelhead Juvenile	
	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion
1	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
2	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
3	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
4	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
5	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
6	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	5	0.0050	1	0.0005
7	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	7	0.0070	1	0.0005
8	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	11	0.0110	1	0.0005
9	12	0.0120	1	0.0010	26	0.0132	1	0.0010	1	0.0010	19	0.0190	1	0.0005
10	24	0.0240	41	0.0410	39	0.0197	4	0.0040	1	0.0010	29	0.0290	1	0.0005
11	74	0.0740	47	0.0470	42	0.0212	6	0.0060	1	0.0010	38	0.0380	1	0.0005
12	129	0.1290	47	0.0470	61	0.0309	9	0.0090	1	0.0010	46	0.0460	1	0.0005
13	169	0.1690	43	0.0430	75	0.0379	11	0.0110	1	0.0010	51	0.0510	1	0.0005
14	180	0.1800	37	0.0370	84	0.0425	13	0.0130	1	0.0010	54	0.0540	38	0.0193
15	159	0.1590	32	0.0320	94	0.0475	17	0.0170	12	0.0120	54	0.0540	101	0.0514
16	114	0.1140	28	0.0280	101	0.0511	22	0.0220	43	0.0430	52	0.0520	163	0.0830
17	62	0.0620	26	0.0260	107	0.0541	27	0.0270	82	0.0820	47	0.0470	208	0.1059
18	23	0.0230	26	0.0260	109	0.0551	32	0.0320	116	0.1160	41	0.0410	233	0.1186
19	9	0.0090	28	0.0280	110	0.0556	37	0.0370	136	0.1360	33	0.0330	234	0.1191
20	5	0.0050	31	0.0310	109	0.0551	43	0.0430	140	0.1400	26	0.0260	217	0.1105
21	1	0.0010	35	0.0350	106	0.0536	47	0.0470	129	0.1290	18	0.0180	186	0.0947
22	1	0.0010	40	0.0400	99	0.0501	52	0.0520	107	0.1070	12	0.0120	148	0.0754
23	1	0.0010	45	0.0450	94	0.0475	55	0.0550	81	0.0810	7	0.0070	111	0.0565
24	1	0.0010	49	0.0490	92	0.0465	58	0.0580	54	0.0540	4	0.0040	84	0.0428
25	1	0.0010	53	0.0530	93	0.0470	59	0.0590	32	0.0320	5	0.0050	65	0.0331
26	1	0.0010	54	0.0540	94	0.0475	60	0.0600	17	0.0170	5	0.0050	53	0.0270
27	1	0.0010	54	0.0540	88	0.0445	59	0.0590	12	0.0120	6	0.0060	42	0.0214
28	1	0.0010	53	0.0530	77	0.0389	58	0.0580	1	0.0010	8	0.0080	29	0.0148
29	1	0.0010	48	0.0480	61	0.0309	54	0.0540	1	0.0010	7	0.0070	16	0.0081
30	1	0.0010	43	0.0430	45	0.0228	51	0.0510	1	0.0010	7	0.0070	1	0.0005
31	1	0.0010	37	0.0370	36	0.0182	46	0.0460	1	0.0010	7	0.0070	1	0.0005
32	1	0.0010	29	0.0290	33	0.0167	41	0.0410	1	0.0010	6	0.0060	1	0.0005
33	1	0.0010	22	0.0220	30	0.0152	35	0.0350	1	0.0010	4	0.0040	1	0.0005
34	1	0.0010	15	0.0150	24	0.0121	29	0.0290	1	0.0010	1	0.0010	1	0.0005
35	1	0.0010	8	0.0080	17	0.0086	24	0.0240	1	0.0010	1	0.0010	1	0.0005
36	1	0.0010	4	0.0040	4	0.0020	18	0.0180	1	0.0010	1	0.0010	1	0.0005
37	1	0.0010	1	0.0010	4	0.0020	9	0.0090	1	0.0010	1	0.0010	1	0.0005
38	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
39	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
40	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
41	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
42	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	19	0.0190	1	0.0005
43	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	44	0.0440	1	0.0005
44	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	65	0.0650	1	0.0005
45	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	75	0.0750	1	0.0005
46	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	69	0.0690	1	0.0005
47	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	52	0.0520	1	0.0005
48	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	29	0.0290	1	0.0005
49	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	12	0.0120	1	0.0005
50	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	8	0.0080	1	0.0005
51	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	4	0.0040	1	0.0005
52	1	0.0010	1	0.0010	1	0.0005	1	0.0010	1	0.0010	1	0.0010	1	0.0005
Totals	**1,000**	**1.0000**	**1,000**	**1.0000**	**1,977**	**1.0000**	**1,000**	**1.0000**	**1,000**	**1.0000**	**1,000**	**1.0000**	**1,964**	**1.0000**

Table 5-1. Continued

	MCR Steelhead Juvenile		UCR Steelhead Juvenile		SR Basin Steelhead Juvenile		UWR Steelhead Juvenile		SR Juvenile Sockeye		LCR Juvenile Coho		Eulachon Juvenile	
Week	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion	Est. Abundance	Est. Proportion
1	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	10	0.0100	1	0.0000
2	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	7	0.0070	1	0.0000
3	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	5	0.0050	1	0.0000
4	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	4	0.0040	1	0.0000
5	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	4	0.0040	1	0.0000
6	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	4	0.0040	1	0.0000
7	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	4	0.0040	1	0.0000
8	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	4	0.0040	1	0.0000
9	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	4	0.0040	1	0.0000
10	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	5	0.0050	1	0.0000
11	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	9	0.0090	1	0.0000
12	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	13	0.0130	1	0.0000
13	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	18	0.0180	1	0.0000
14	17	0.0087	13	0.0130	1	0.0000	1	0.0010	17	0.0170	23	0.0230	1	0.0000
15	62	0.0316	35	0.0350	1,243	0.0197	13	0.0130	22	0.0220	29	0.0290	296,941	0.0054
16	116	0.0591	61	0.0610	3,052	0.0485	45	0.0450	14	0.0140	35	0.0350	3,553,481	0.0651
17	164	0.0835	85	0.0850	4,862	0.0772	78	0.0780	27	0.0270	40	0.0400	9,207,639	0.1686
18	199	0.1013	103	0.1030	6,315	0.1003	102	0.1020	84	0.0840	46	0.0460	13,040,883	0.2387
19	218	0.1110	114	0.1140	7,222	0.1147	114	0.1140	143	0.1430	50	0.0500	12,557,433	0.2299
20	221	0.1125	117	0.1170	7,524	0.1195	114	0.1140	180	0.1800	54	0.0540	8,586,762	0.1572
21	208	0.1059	111	0.1110	7,258	0.1153	104	0.1040	178	0.1780	56	0.0560	4,481,116	0.0820
22	185	0.0942	99	0.0990	6,534	0.1038	90	0.0900	141	0.1410	57	0.0570	2,900,701	0.0531
23	154	0.0784	81	0.0810	5,498	0.0873	74	0.0740	85	0.0850	57	0.0570	1	0.0000
24	122	0.0621	61	0.0610	4,315	0.0685	59	0.0590	46	0.0460	55	0.0550	1	0.0000
25	94	0.0479	41	0.0410	3,144	0.0499	48	0.0480	23	0.0230	51	0.0510	1	0.0000
26	69	0.0351	24	0.0240	2,129	0.0338	41	0.0410	1	0.0010	46	0.0460	1	0.0000
27	49	0.0249	12	0.0120	1,377	0.0219	37	0.0370	1	0.0010	39	0.0390	1	0.0000
28	34	0.0173	6	0.0060	951	0.0151	27	0.0270	1	0.0010	32	0.0320	1	0.0000
29	16	0.0081	1	0.0010	859	0.0136	17	0.0170	1	0.0010	23	0.0230	1	0.0000
30	1	0.0005	1	0.0010	645	0.0102	1	0.0010	1	0.0010	15	0.0150	1	0.0000
31	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	8	0.0080	1	0.0000
32	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	3	0.0030	1	0.0000
33	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	2	0.0020	1	0.0000
34	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	1	0.0010	1	0.0000
35	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	1	0.0010	1	0.0000
36	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	1	0.0010	1	0.0000
37	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	1	0.0010	1	0.0000
38	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	1	0.0010	1	0.0000
39	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	1	0.0010	1	0.0000
40	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	2	0.0020	1	0.0000
41	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	4	0.0040	1	0.0000
42	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	8	0.0080	1	0.0000
43	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	11	0.0110	1	0.0000
44	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	15	0.0150	1	0.0000
45	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	17	0.0170	1	0.0000
46	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	19	0.0190	1	0.0000
47	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	20	0.0200	1	0.0000
48	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	20	0.0200	1	0.0000
49	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	19	0.0190	1	0.0000
50	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	18	0.0180	1	0.0000
51	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	16	0.0160	1	0.0000
52	1	0.0005	1	0.0010	1	0.0000	1	0.0010	1	0.0010	13	0.0130	1	0.0000
Totals	1,964	1.0000	1,000	1.0000	62,964	1.0000	1,000	1.0000	1,000	1.0000	1,000	1.0000	54,625,000	1.0000

5.2 Fish Exposure by Construction Scenario

The results above and in Table 5-2 are based on an in-water impact pile driving schedule using one contract award date of February 5, 2013. Because the actual award date for construction is unknown, the exact schedule for impact pile driving is unknown. The CRC project modeled an additional 12 potential award dates, resulting in 13 in-water impact pile driving scenarios. The range and the maximum potential impact to each species and life history stage for each of the 13 impact pile driving scenarios was calculated.

Similar to the adult Columbia River chum example, the model was used to calculate the range and maximum potential exposure from impact pile driving for each of the 13 construction scenarios.

Table 5-2 through Table 5-12 show the results of potential impacts to salmon and eulachon ESUs/DPSs by life stage, based on the modeled pile driving schedules prepared for this analysis. These tables present the ESU/DPS and life stage potentially impacted, the estimated/modeled abundance, and the annual impact by percentage of run and calculated for individuals (Percent of Run x Annual Abundance). The tables are presented in chronological order by contract award date: February 5, 2013, March 1, 2013, April 1, 2013, etc. For example, Table 5-2 shows the potential impacts from a modeled pile-driving scenario if the contract were awarded on February 5, 2013. The table presents potential impacts by year of construction. Due to the variations in schedules and fish presence in the area, no single scenario resulted in the most or fewest impacts to the 14 ESUs/DPSs.

Impacts listed in these tables are based only on those fish that occur within or pass through the affected area. For those fish migrating to or from the Middle Columbia, Upper Columbia, or Snake River subbasins, this accounts for 100 percent of the population. The adult runs on the top and the juvenile runs are on the bottom portion of each table.

For those fish moving to or from the Upper Willamette subbasin, the proportion of the overall ESU or DPS that actually passes through the project has not been calculated although it is estimated to be much lower than 50 percent, and likely closer to 5–20 percent. Potential impacts to an overall ESU or DPS could be discounted by the percent of the run that does not pass through the project area. Estimated individual impacts shown in these analyses do not reflect this discounting.

Similarly, fish runs that originate and return to the Lower Columbia subbasin, such as CR chum, LCR coho, and eulachon, have populations that originate above and below the project area. For those fish in which the entire population does not occur within or pass through the project area (e.g., runs originating in the lower Columbia River), impacts identified will be overestimated if applied to the entire population. Quantification of the discounts applied to these runs has not been completed in this document. Further coordination and agreement with resource agency representatives and fishery specialist must occur before valid discounts could be applied to each ESU/DPS and life stage.

Table 5-2. Summary of Impact Analysis for Impact Driving (Based on Contract Award Dates of February 5 and March 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	8.647	0.433%	7.856	0.393%	2.439	0.122%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.070	0.002%	0.074	0.002%	0.043	0.001%	0.012	0.000%
LCR Chinook Adult	14,069	66.808	0.475%	36.666	0.261%	18.755	0.133%	0.156	0.001%
SR F Chinook Adult	6,010	8.043	0.134%	4.018	0.067%	2.937	0.049%	0.012	0.000%
SR SS Chinook Adult	27,736	0.070	0.000%	0.074	0.000%	0.043	0.000%	1.869	0.007%
UWR Chinook Adult	7,729	0.070	0.001%	0.074	0.001%	0.672	0.009%	1.259	0.016%
LCR Steelhead Adult	171,576	79.136	0.046%	76.328	0.044%	44.748	0.026%	8.740	0.005%
MCR Steelhead Adult	94,965	25.596	0.027%	13.700	0.014%	9.901	0.010%	0.320	0.000%
UCR Steelhead Adult	93,892	22.843	0.024%	10.650	0.011%	8.345	0.009%	0.012	0.000%
SRB Steelhead Adult	156,102	81.678	0.052%	38.419	0.025%	29.157	0.019%	0.012	0.000%
UWR Steelhead Adult	9,650	4.952	0.051%	10.708	0.111%	10.977	0.114%	5.405	0.056%
SR Sockeye Adult	181	0.070	0.038%	0.074	0.041%	0.043	0.024%	0.012	0.007%
LCR Coho Adult	48,100	209.531	0.436%	144.112	0.300%	54.340	0.113%	0.012	0.000%
Eulachon Adult	115,000	0.070	0.000%	0.074	0.000%	30.339	0.026%	38.392	0.033%
CR Chum Juvenile <2g	1,000	0.083	0.008%	0.080	0.008%	0.298	0.030%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.035	0.003%	0.035	0.004%	0.071	0.007%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.035	0.002%	0.035	0.002%	0.104	0.005%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.035	0.003%	0.035	0.004%	0.025	0.003%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.035	0.003%	0.035	0.004%	0.018	0.002%	0.030	0.003%
UWR Chinook Juv >2g	1,000	0.900	0.090%	0.869	0.087%	0.323	0.032%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.035	0.002%	0.035	0.002%	0.018	0.001%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.035	0.002%	0.035	0.002%	0.018	0.001%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.035	0.003%	0.035	0.004%	0.018	0.002%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	0.035	0.000%	0.035	0.000%	0.018	0.000%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.035	0.003%	0.035	0.004%	0.018	0.002%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.035	0.003%	0.035	0.004%	0.018	0.002%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.405	0.041%	0.451	0.045%	0.178	0.018%	0.050	0.005%
Eulachon Juv <2g	54,625,000	0.083	0.000%	0.080	0.000%	0.026	0.000%	4791.614	0.009%

Table 5-3. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of April 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	8.647	0.433%	7.721	0.387%	2.441	0.122%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.070	0.002%	0.073	0.002%	0.045	0.001%	0.012	0.000%
LCR Chinook Adult	14,069	66.808	0.475%	35.358	0.251%	18.757	0.133%	0.156	0.001%
SR F Chinook Adult	6,010	8.043	0.134%	3.928	0.065%	2.939	0.049%	0.012	0.000%
SR SS Chinook Adult	27,736	0.070	0.000%	0.073	0.000%	0.045	0.000%	1.869	0.007%
UWR Chinook Adult	7,729	0.070	0.001%	0.073	0.001%	0.674	0.009%	1.259	0.016%
LCR Steelhead Adult	171,576	79.136	0.046%	75.670	0.044%	45.795	0.027%	8.740	0.005%
MCR Steelhead Adult	94,965	25.596	0.027%	13.469	0.014%	9.950	0.010%	0.320	0.000%
UCR Steelhead Adult	93,892	22.843	0.024%	10.436	0.011%	8.347	0.009%	0.012	0.000%
SRB Steelhead Adult	156,102	81.678	0.052%	37.599	0.024%	29.158	0.019%	0.012	0.000%
UWR Steelhead Adult	9,650	4.952	0.051%	10.741	0.111%	11.566	0.120%	5.405	0.056%
SR Sockeye Adult	181	0.070	0.038%	0.073	0.040%	0.045	0.025%	0.012	0.007%
LCR Coho Adult	48,100	209.531	0.436%	140.194	0.291%	54.342	0.113%	0.012	0.000%
Eulachon Adult	115,000	0.070	0.000%	0.073	0.000%	30.341	0.026%	38.392	0.033%
CR Chum Juvenile <2g	1,000	0.083	0.008%	0.080	0.008%	0.300	0.030%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.035	0.003%	0.035	0.003%	0.072	0.007%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.035	0.002%	0.035	0.002%	0.105	0.005%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.035	0.003%	0.035	0.003%	0.026	0.003%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.035	0.003%	0.035	0.003%	0.018	0.002%	0.030	0.003%
UWR Chinook Juv >2g	1,000	0.900	0.090%	0.864	0.086%	0.324	0.032%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.035	0.002%	0.035	0.002%	0.018	0.001%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.035	0.002%	0.035	0.002%	0.018	0.001%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.035	0.003%	0.035	0.003%	0.018	0.002%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	0.035	0.000%	0.035	0.000%	0.018	0.000%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.035	0.003%	0.035	0.003%	0.018	0.002%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.035	0.003%	0.035	0.003%	0.018	0.002%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.405	0.041%	0.453	0.045%	0.186	0.019%	0.050	0.005%
Eulachon Juv <2g	54,625,000	0.083	0.000%	0.080	0.000%	0.028	0.000%	4791.614	0.009%

Table 5-4. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of May 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	8.647	0.433%	4.377	0.219%	2.455	0.123%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.070	0.002%	0.056	0.002%	0.059	0.002%	0.012	0.000%
LCR Chinook Adult	14,069	66.808	0.475%	18.281	0.130%	18.771	0.133%	0.156	0.001%
SR F Chinook Adult	6,010	8.043	0.134%	2.933	0.049%	2.953	0.049%	0.012	0.000%
SR SS Chinook Adult	27,736	0.070	0.000%	0.056	0.000%	0.059	0.000%	1.869	0.007%
UWR Chinook Adult	7,729	0.070	0.001%	0.056	0.001%	0.688	0.009%	1.259	0.016%
LCR Steelhead Adult	171,576	79.136	0.046%	55.208	0.032%	56.333	0.033%	8.740	0.005%
MCR Steelhead Adult	94,965	25.596	0.027%	10.369	0.011%	10.367	0.011%	0.320	0.000%
UCR Steelhead Adult	93,892	22.843	0.024%	8.284	0.009%	8.361	0.009%	0.012	0.000%
SRB Steelhead Adult	156,102	81.678	0.052%	29.149	0.019%	29.173	0.019%	0.012	0.000%
UWR Steelhead Adult	9,650	4.952	0.051%	10.453	0.108%	18.329	0.190%	5.405	0.056%
SR Sockeye Adult	181	0.070	0.038%	0.056	0.031%	0.059	0.033%	0.012	0.007%
LCR Coho Adult	48,100	209.531	0.436%	69.495	0.144%	54.356	0.113%	0.012	0.000%
Eulachon Adult	115,000	0.070	0.000%	0.056	0.000%	30.355	0.026%	38.392	0.033%
CR Chum Juvenile <2g	1,000	0.083	0.008%	0.057	0.006%	0.318	0.032%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.035	0.003%	0.026	0.003%	0.079	0.008%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.035	0.002%	0.026	0.001%	0.112	0.006%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.035	0.003%	0.026	0.003%	0.033	0.003%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.035	0.003%	0.026	0.003%	0.026	0.003%	0.030	0.003%
UWR Chinook Juv >2g	1,000	0.900	0.090%	0.603	0.060%	0.331	0.033%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.035	0.002%	0.026	0.001%	0.026	0.001%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.035	0.002%	0.026	0.001%	0.026	0.001%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.035	0.003%	0.026	0.003%	0.026	0.003%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	0.035	0.000%	0.026	0.000%	0.026	0.000%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.035	0.003%	0.026	0.003%	0.026	0.003%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.035	0.003%	0.026	0.003%	0.026	0.003%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.405	0.041%	0.365	0.036%	0.216	0.022%	0.050	0.005%
Eulachon Juv <2g	54,625,000	0.083	0.000%	0.057	0.000%	0.046	0.000%	4791.614	0.009%

Table 5-5. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of June 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	8.488	0.425%	4.386	0.220%	2.455	0.123%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.062	0.002%	0.065	0.002%	0.059	0.002%	0.012	0.000%
LCR Chinook Adult	14,069	30.319	0.216%	18.290	0.130%	18.854	0.134%	0.156	0.001%
SR F Chinook Adult	6,010	3.774	0.063%	2.943	0.049%	2.953	0.049%	0.012	0.000%
SR SS Chinook Adult	27,736	0.062	0.000%	0.065	0.000%	0.059	0.000%	1.869	0.007%
UWR Chinook Adult	7,729	0.062	0.001%	0.065	0.001%	0.774	0.010%	1.259	0.016%
LCR Steelhead Adult	171,576	72.933	0.043%	61.613	0.036%	60.970	0.036%	8.740	0.005%
MCR Steelhead Adult	94,965	12.398	0.013%	10.647	0.011%	10.552	0.011%	0.320	0.000%
UCR Steelhead Adult	93,892	9.282	0.010%	8.293	0.009%	8.361	0.009%	0.012	0.000%
SRB Steelhead Adult	156,102	33.213	0.021%	29.158	0.019%	29.173	0.019%	0.012f	0.000%
UWR Steelhead Adult	9,650	6.606	0.068%	14.208	0.147%	19.426	0.201%	5.405	0.056%
SR Sockeye Adult	181	0.062	0.034%	0.065	0.036%	0.059	0.033%	0.012	0.007%
LCR Coho Adult	48,100	142.165	0.296%	69.505	0.145%	54.356	0.113%	0.012	0.000%
Eulachon Adult	115,000	0.062	0.000%	0.065	0.000%	30.355	0.026%	38.392	0.033%
CR Chum Juvenile <2g	1,000	0.071	0.007%	0.071	0.007%	0.355	0.036%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.031	0.003%	0.031	0.003%	0.079	0.008%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.031	0.002%	0.031	0.002%	0.146	0.007%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.031	0.003%	0.031	0.003%	0.033	0.003%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.031	0.003%	0.031	0.003%	0.026	0.003%	0.030	0.003%
UWR Chinook Juv >2g	1,000	0.906	0.091%	0.608	0.061%	0.398	0.040%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.031	0.002%	0.031	0.002%	0.026	0.001%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.031	0.002%	0.031	0.002%	0.026	0.001%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.031	0.003%	0.031	0.003%	0.026	0.003%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	0.031	0.000%	0.031	0.000%	0.026	0.000%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.031	0.003%	0.031	0.003%	0.026	0.003%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.031	0.003%	0.031	0.003%	0.026	0.003%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.436	0.044%	0.404	0.040%	0.202	0.020%	0.050	0.005%
Eulachon Juv <2g	54,625,000	0.071	0.000%	0.071	0.000%	0.046	0.000%	4791.614	0.009%

Table 5-6. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of July 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	4.208	0.211%	4.402	0.220%	2.455	0.123%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.046	0.001%	0.081	0.003%	0.059	0.002%	0.012	0.000%
LCR Chinook Adult	14,069	19.131	0.136%	18.312	0.130%	19.405	0.138%	0.156	0.001%
SR F Chinook Adult	6,010	2.844	0.047%	2.958	0.049%	2.953	0.049%	0.012	0.000%
SR SS Chinook Adult	27,736	0.046	0.000%	0.081	0.000%	0.059	0.000%	1.869	0.007%
UWR Chinook Adult	7,729	0.046	0.001%	0.081	0.001%	4.484	0.058%	1.259	0.016%
LCR Steelhead Adult	171,576	46.884	0.027%	73.867	0.043%	58.952	0.034%	8.740	0.005%
MCR Steelhead Adult	94,965	10.147	0.011%	11.140	0.012%	10.314	0.011%	0.320	0.000%
UCR Steelhead Adult	93,892	8.478	0.009%	8.309	0.009%	8.361	0.009%	0.012	0.000%
SRB Steelhead Adult	156,102	29.916	0.019%	29.173	0.019%	29.173	0.019%	0.012	0.000%
UWR Steelhead Adult	9,650	5.931	0.061%	21.767	0.226%	18.581	0.193%	5.405	0.056%
SR Sockeye Adult	181	0.046	0.025%	0.081	0.045%	0.059	0.033%	0.012	0.007%
LCR Coho Adult	48,100	68.033	0.141%	69.520	0.145%	54.356	0.113%	0.012	0.000%
Eulachon Adult	115,000	0.046	0.000%	0.081	0.000%	225.989	0.197%	38.392	0.033%
CR Chum Juvenile <2g	1,000	0.049	0.005%	0.093	0.009%	2.223	0.222%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.022	0.002%	0.039	0.004%	0.432	0.043%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.022	0.001%	0.039	0.002%	0.562	0.028%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.022	0.002%	0.039	0.004%	0.083	0.008%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.022	0.002%	0.039	0.004%	0.026	0.003%	0.030	0.003%
UWR Chinook Juv >2g	1,000	0.588	0.059%	0.628	0.063%	0.669	0.067%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.022	0.001%	0.039	0.002%	0.026	0.001%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.022	0.001%	0.039	0.002%	0.026	0.001%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.022	0.002%	0.039	0.004%	0.026	0.003%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	0.022	0.000%	0.039	0.000%	0.026	0.000%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.022	0.002%	0.039	0.004%	0.026	0.003%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.022	0.002%	0.039	0.004%	0.026	0.003%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.345	0.035%	0.439	0.044%	0.256	0.026%	0.050	0.005%
Eulachon Juv <2g	54,625,000	0.049	0.000%	0.093	0.000%	0.046	0.000%	4791.614	0.009%

Table 5-7. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of August 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	1.589	0.080%	4.417	0.221%	2.612	0.131%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.029	0.001%	0.096	0.003%	0.059	0.002%	0.012	0.000%
LCR Chinook Adult	14,069	19.114	0.136%	18.593	0.132%	32.404	0.230%	0.156	0.001%
SR F Chinook Adult	6,010	2.826	0.047%	2.973	0.049%	5.800	0.096%	0.012	0.000%
SR SS Chinook Adult	27,736	0.029	0.000%	0.096	0.000%	7.769	0.028%	1.869	0.007%
UWR Chinook Adult	7,729	0.029	0.000%	1.090	0.014%	9.765	0.126%	1.259	0.016%
LCR Steelhead Adult	171,576	26.991	0.016%	90.813	0.053%	57.928	0.034%	8.740	0.005%
MCR Steelhead Adult	94,965	9.339	0.010%	11.821	0.012%	18.147	0.019%	0.320	0.000%
UCR Steelhead Adult	93,892	8.461	0.009%	8.324	0.009%	16.699	0.018%	0.012	0.000%
SRB Steelhead Adult	156,102	29.899	0.019%	29.189	0.019%	61.149	0.039%	0.012	0.000%
UWR Steelhead Adult	9,650	4.731	0.049%	29.306	0.304%	14.436	0.150%	5.405	0.056%
SR Sockeye Adult	181	0.029	0.016%	0.096	0.053%	0.059	0.033%	0.012	0.007%
LCR Coho Adult	48,100	48.419	0.101%	69.535	0.145%	76.999	0.160%	0.012	0.000%
Eulachon Adult	115,000	0.029	0.000%	22.397	0.020%	306.648	0.267%	38.392	0.033%
CR Chum Juvenile <2g	1,000	0.025	0.003%	0.609	0.061%	3.129	0.313%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.013	0.001%	0.196	0.020%	0.308	0.031%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.013	0.001%	0.238	0.012%	0.757	0.038%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.013	0.001%	0.061	0.006%	0.147	0.015%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.013	0.001%	0.048	0.005%	0.137	0.014%	0.030	0.003%
UWR Chinook Juv >2g	1,000	0.145	0.014%	0.816	0.082%	0.700	0.070%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.013	0.001%	0.048	0.002%	0.674	0.034%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.013	0.001%	0.048	0.002%	0.438	0.022%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.013	0.001%	0.048	0.005%	0.255	0.026%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	0.013	0.000%	0.048	0.000%	9.053	0.014%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.013	0.001%	0.048	0.005%	0.143	0.014%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.013	0.001%	0.048	0.005%	0.139	0.014%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.160	0.016%	0.480	0.048%	0.370	0.037%	0.050	0.005%
Eulachon Juv <2g	54,625,000	0.025	0.000%	0.114	0.000%	20847.833	0.038%	4791.614	0.009%

Table 5-8. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of September 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	1.577	0.079%	4.163	0.208%	5.403	0.271%	0.153	0.008%
UCR SP Chinook Adult	3,256	0.017	0.001%	0.095	0.003%	0.074	0.002%	0.012	0.000%
LCR Chinook Adult	14,069	19.102	0.136%	19.620	0.139%	60.065	0.427%	2.162	0.015%
SR F Chinook Adult	6,010	2.815	0.047%	2.973	0.049%	6.130	0.102%	0.092	0.002%
SR SS Chinook Adult	27,736	0.017	0.000%	0.095	0.000%	0.074	0.000%	0.012	0.000%
UWR Chinook Adult	7,729	0.017	0.000%	9.388	0.121%	0.367	0.005%	0.510	0.007%
LCR Steelhead Adult	171,576	18.734	0.011%	85.813	0.050%	71.943	0.042%	8.316	0.005%
MCR Steelhead Adult	94,965	8.907	0.009%	11.101	0.012%	20.146	0.021%	0.625	0.001%
UCR Steelhead Adult	93,892	8.449	0.009%	8.323	0.009%	17.527	0.019%	0.316	0.000%
SRB Steelhead Adult	156,102	29.887	0.019%	29.188	0.019%	61.134	0.039%	1.279	0.001%
UWR Steelhead Adult	9,650	1.535	0.016%	31.298	0.324%	15.322	0.159%	5.105	0.053%
SR Sockeye Adult	181	0.017	0.009%	0.095	0.053%	0.074	0.041%	0.012	0.007%
LCR Coho Adult	48,100	48.407	0.101%	67.304	0.140%	171.675	0.357%	6.334	0.013%
Eulachon Adult	115,000	0.017	0.000%	416.343	0.362%	10.272	0.009%	28.859	0.025%
CR Chum Juvenile <2g	1,000	0.009	0.001%	4.583	0.458%	0.127	0.013%	0.290	0.029%
UCR SP Chinook Juv >2g	1,000	0.007	0.001%	0.558	0.056%	0.059	0.006%	0.046	0.005%
LCR Chinook Juv >2g	1,977	0.007	0.000%	0.922	0.047%	0.070	0.004%	0.065	0.003%
SR F Chinook Juv >2g	1,000	0.007	0.001%	0.162	0.016%	0.036	0.004%	0.012	0.001%
SR SS Chinook Juv >2g	1,000	0.007	0.001%	0.071	0.007%	0.033	0.003%	0.005	0.001%
UWR Chinook Juv >2g	1,000	0.118	0.012%	1.207	0.121%	0.381	0.038%	0.049	0.005%
LCR Steelhead Juv >2g	1,964	0.007	0.000%	0.339	0.017%	0.033	0.002%	0.005	0.000%
MCR Steelhead Juv >2g	1,964	0.007	0.000%	0.211	0.011%	0.033	0.002%	0.005	0.000%
UCR Steelhead Juv >2g	1,000	0.007	0.001%	0.145	0.015%	0.033	0.003%	0.005	0.001%
SRB Steelhead Juv >2g	62,964	0.007	0.000%	2.689	0.004%	0.033	0.000%	0.005	0.000%
UWR Steelhead Juv >2g	1,000	0.007	0.001%	0.073	0.007%	0.033	0.003%	0.005	0.001%
SR Sockeye Juv >2g	1,000	0.007	0.001%	0.126	0.013%	0.033	0.003%	0.005	0.001%
LCR Coho Juv >2g	1,000	0.065	0.006%	0.522	0.052%	0.250	0.025%	0.032	0.003%
Eulachon Juv <2g	54,625,000	0.009	0.000%	1845.998	0.003%	0.068	0.000%	0.009	0.000%

Table 5-9. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of October 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	1.577	0.079%	3.965	0.199%	7.916	0.396%	0.358	0.018%
UCR SP Chinook Adult	3,256	0.017	0.001%	0.090	0.003%	0.078	0.002%	0.012	0.000%
LCR Chinook Adult	14,069	19.102	0.136%	53.742	0.382%	22.157	0.158%	0.094	0.001%
SR F Chinook Adult	6,010	2.815	0.047%	7.088	0.118%	3.895	0.065%	0.063	0.001%
SR SS Chinook Adult	27,736	0.017	0.000%	7.848	0.028%	0.078	0.000%	0.012	0.000%
UWR Chinook Adult	7,729	0.017	0.000%	11.030	0.143%	0.371	0.005%	0.510	0.007%
LCR Steelhead Adult	171,576	18.734	0.011%	83.890	0.049%	93.068	0.054%	10.030	0.006%
MCR Steelhead Adult	94,965	8.907	0.009%	23.565	0.025%	13.172	0.014%	0.410	0.000%
UCR Steelhead Adult	93,892	8.449	0.009%	21.426	0.023%	9.614	0.010%	0.012	0.000%
SRB Steelhead Adult	156,102	29.887	0.019%	75.769	0.049%	33.922	0.022%	0.012	0.000%
UWR Steelhead Adult	9,650	1.535	0.016%	23.526	0.244%	19.110	0.198%	5.128	0.053%
SR Sockeye Adult	181	0.017	0.009%	0.090	0.049%	0.078	0.043%	0.012	0.007%
LCR Coho Adult	48,100	48.407	0.101%	126.377	0.263%	112.406	0.234%	3.354	0.007%
Eulachon Adult	115,000	0.017	0.000%	373.745	0.325%	10.277	0.009%	28.859	0.025%
CR Chum Juvenile <2g	1,000	0.009	0.001%	4.225	0.422%	0.133	0.013%	0.290	0.029%
UCR SP Chinook Juv >2g	1,000	0.007	0.001%	0.600	0.060%	0.061	0.006%	0.046	0.005%
LCR Chinook Juv >2g	1,977	0.007	0.000%	1.113	0.056%	0.072	0.004%	0.065	0.003%
SR F Chinook Juv >2g	1,000	0.007	0.001%	0.201	0.020%	0.038	0.004%	0.012	0.001%
SR SS Chinook Juv >2g	1,000	0.007	0.001%	0.158	0.016%	0.035	0.004%	0.005	0.001%
UWR Chinook Juv >2g	1,000	0.118	0.012%	1.216	0.122%	0.934	0.093%	0.087	0.009%
LCR Steelhead Juv >2g	1,964	0.007	0.000%	0.684	0.035%	0.035	0.002%	0.005	0.000%
MCR Steelhead Juv >2g	1,964	0.007	0.000%	0.456	0.023%	0.035	0.002%	0.005	0.000%
UCR Steelhead Juv >2g	1,000	0.007	0.001%	0.272	0.027%	0.035	0.004%	0.005	0.001%
SRB Steelhead Juv >2g	62,964	0.007	0.000%	9.301	0.015%	0.035	0.000%	0.005	0.000%
UWR Steelhead Juv >2g	1,000	0.007	0.001%	0.165	0.017%	0.035	0.004%	0.005	0.001%
SR Sockeye Juv >2g	1,000	0.007	0.001%	0.150	0.015%	0.035	0.004%	0.005	0.001%
LCR Coho Juv >2g	1,000	0.065	0.006%	0.531	0.053%	0.350	0.035%	0.038	0.004%
Eulachon Juv <2g	54,625,000	0.009	0.000%	23686.108	0.043%	0.074	0.000%	0.009	0.000%

Table 5-10. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of November 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	1.577	0.079%	7.190	0.360%	9.079	0.455%	0.506	0.025%
UCR SP Chinook Adult	3,256	0.017	0.001%	0.085	0.003%	0.082	0.003%	0.014	0.000%
LCR Chinook Adult	14,069	19.102	0.136%	59.899	0.426%	22.828	0.162%	1.587	0.011%
SR F Chinook Adult	6,010	2.815	0.047%	7.097	0.118%	3.587	0.060%	0.400	0.007%
SR SS Chinook Adult	27,736	0.017	0.000%	5.978	0.022%	0.082	0.000%	0.014	0.000%
UWR Chinook Adult	7,729	0.017	0.000%	11.105	0.144%	0.376	0.005%	0.527	0.007%
LCR Steelhead Adult	171,576	18.734	0.011%	83.820	0.049%	95.730	0.056%	12.261	0.007%
MCR Steelhead Adult	94,965	8.907	0.009%	22.179	0.023%	12.395	0.013%	1.438	0.002%
UCR Steelhead Adult	93,892	8.449	0.009%	19.535	0.021%	8.384	0.009%	0.991	0.001%
SRB Steelhead Adult	156,102	29.887	0.019%	69.831	0.045%	29.196	0.019%	3.761	0.002%
UWR Steelhead Adult	9,650	1.535	0.016%	16.531	0.171%	14.599	0.151%	5.283	0.055%
SR Sockeye Adult	181	0.017	0.009%	0.085	0.047%	0.082	0.045%	0.014	0.008%
LCR Coho Adult	48,100	48.407	0.101%	185.915	0.387%	126.396	0.263%	6.990	0.015%
Eulachon Adult	115,000	0.017	0.000%	434.125	0.377%	10.281	0.009%	28.961	0.025%
CR Chum Juvenile <2g	1,000	0.009	0.001%	4.595	0.460%	0.139	0.014%	0.299	0.030%
UCR SP Chinook Juv >2g	1,000	0.007	0.001%	0.490	0.049%	0.063	0.006%	0.053	0.005%
LCR Chinook Juv >2g	1,977	0.007	0.000%	0.963	0.049%	0.074	0.004%	0.071	0.004%
SR F Chinook Juv >2g	1,000	0.007	0.001%	0.190	0.019%	0.040	0.004%	0.014	0.001%
SR SS Chinook Juv >2g	1,000	0.007	0.001%	0.149	0.015%	0.037	0.004%	0.006	0.001%
UWR Chinook Juv >2g	1,000	0.118	0.012%	1.115	0.112%	1.081	0.108%	0.123	0.012%
LCR Steelhead Juv >2g	1,964	0.007	0.000%	0.664	0.034%	0.037	0.002%	0.006	0.000%
MCR Steelhead Juv >2g	1,964	0.007	0.000%	0.439	0.022%	0.037	0.002%	0.006	0.000%
UCR Steelhead Juv >2g	1,000	0.007	0.001%	0.262	0.026%	0.037	0.004%	0.006	0.001%
SRB Steelhead Juv >2g	62,964	0.007	0.000%	8.825	0.014%	0.037	0.000%	0.006	0.000%
UWR Steelhead Juv >2g	1,000	0.007	0.001%	0.155	0.016%	0.037	0.004%	0.006	0.001%
SR Sockeye Juv >2g	1,000	0.007	0.001%	0.149	0.015%	0.037	0.004%	0.006	0.001%
LCR Coho Juv >2g	1,000	0.065	0.006%	0.530	0.053%	0.503	0.050%	0.051	0.005%
Eulachon Juv <2g	54,625,000	0.009	0.000%	16777.894	0.031%	0.080	0.000%	0.011	0.000%

Table 5-11. Summary of Impact Analysis for Impact Driving (Based on a Contract Award Date of December 1, 2013)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	8.725	0.437%	8.886	0.445%	2.436	0.122%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.069	0.002%	0.076	0.002%	0.041	0.001%	0.012	0.000%
LCR Chinook Adult	14,069	64.470	0.458%	48.548	0.345%	18.773	0.133%	0.156	0.001%
SR F Chinook Adult	6,010	7.923	0.132%	6.228	0.104%	2.934	0.049%	0.012	0.000%
SR SS Chinook Adult	27,736	7.807	0.028%	0.076	0.000%	0.041	0.000%	1.869	0.007%
UWR Chinook Adult	7,729	4.920	0.064%	0.076	0.001%	0.847	0.011%	1.259	0.016%
LCR Steelhead Adult	171,576	79.777	0.046%	85.183	0.050%	42.615	0.025%	8.740	0.005%
MCR Steelhead Adult	94,965	25.015	0.026%	20.229	0.021%	9.819	0.010%	0.320	0.000%
UCR Steelhead Adult	93,892	22.531	0.024%	17.006	0.018%	8.343	0.009%	0.012	0.000%
SRB Steelhead Adult	156,102	80.382	0.051%	60.590	0.039%	29.154	0.019%	0.012	0.000%
UWR Steelhead Adult	9,650	5.555	0.058%	9.200	0.095%	9.970	0.103%	5.405	0.056%
SR Sockeye Adult	181	0.069	0.038%	0.076	0.042%	0.041	0.023%	0.012	0.007%
LCR Coho Adult	48,100	202.389	0.421%	175.738	0.365%	54.338	0.113%	0.012	0.000%
Eulachon Adult	115,000	87.107	0.076%	0.076	0.000%	39.187	0.034%	38.392	0.033%
CR Chum Juvenile <2g	1,000	1.339	0.134%	0.083	0.008%	0.370	0.037%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.134	0.013%	0.036	0.004%	0.088	0.009%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.373	0.019%	0.036	0.002%	0.118	0.006%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.101	0.010%	0.036	0.004%	0.027	0.003%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.139	0.014%	0.036	0.004%	0.016	0.002%	0.030	0.003%
UWR Chinook Juv >2g	1,000	1.071	0.107%	0.924	0.092%	0.330	0.033%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.514	0.026%	0.036	0.002%	0.016	0.001%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.361	0.018%	0.036	0.002%	0.016	0.001%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.208	0.021%	0.036	0.004%	0.016	0.002%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	8.183	0.013%	0.036	0.000%	0.016	0.000%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.144	0.014%	0.036	0.004%	0.016	0.002%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.091	0.009%	0.036	0.004%	0.016	0.002%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.459	0.046%	0.436	0.044%	0.168	0.017%	0.050	0.005%
Eulachon Juv <2g	54,625,000	22199.603	0.041%	0.083	0.000%	0.022	0.000%	4791.614	0.009%

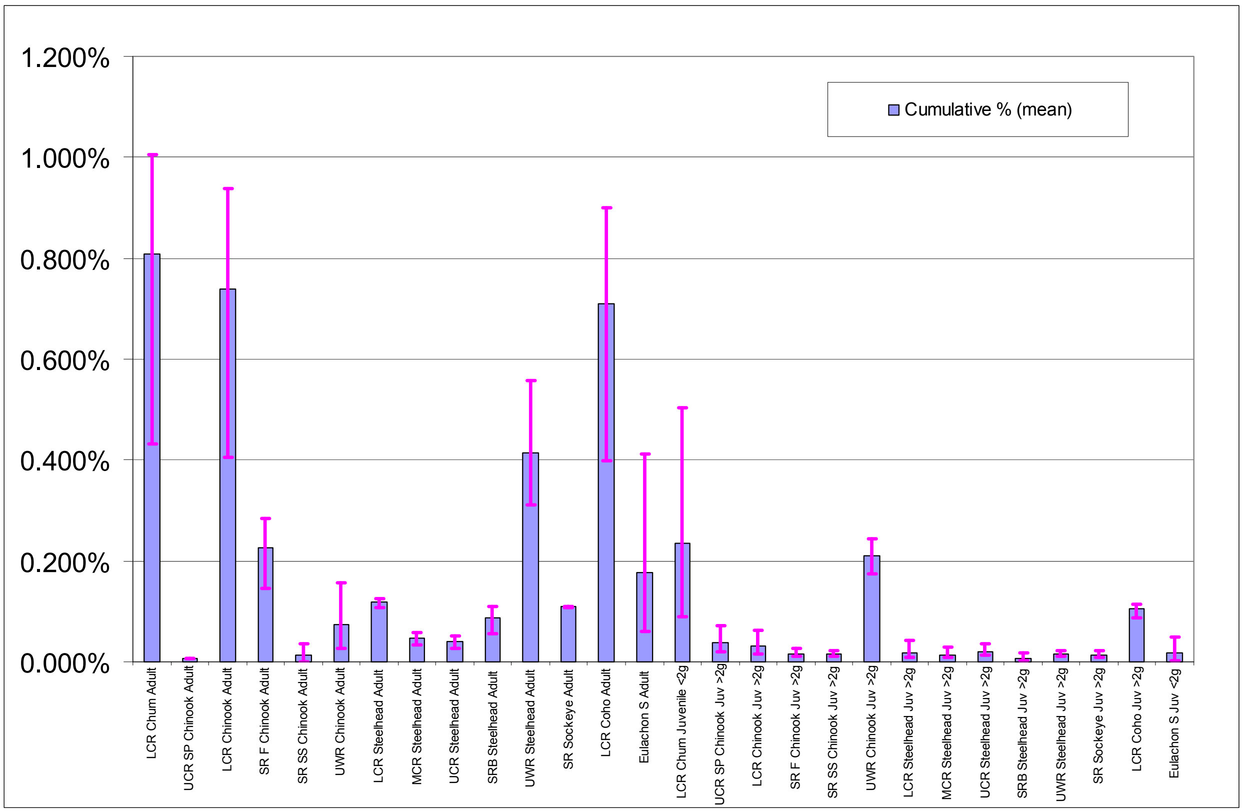
Table 5-12. Summary of Impact Analysis for Impact Driving (Based on Contract Award Dates of January 1 and February 1, 2014)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1 %	Year 2 Individual	Year 2 %	Year 3 Individual	Year 3 %	Year 4 Individual	Year 4 %
CR Chum Adult	1,997	8.585	0.430%	8.420	0.422%	2.436	0.122%	0.012	0.001%
UCR SP Chinook Adult	3,256	0.069	0.002%	0.076	0.002%	0.041	0.001%	0.012	0.000%
LCR Chinook Adult	14,069	65.081	0.463%	42.994	0.306%	18.773	0.133%	0.156	0.001%
SR F Chinook Adult	6,010	7.621	0.127%	4.911	0.082%	2.934	0.049%	0.012	0.000%
SR SS Chinook Adult	27,736	0.069	0.000%	0.076	0.000%	0.041	0.000%	1.869	0.007%
UWR Chinook Adult	7,729	0.069	0.001%	0.076	0.001%	0.847	0.011%	1.259	0.016%
LCR Steelhead Adult	171,576	78.182	0.046%	81.165	0.047%	42.615	0.025%	8.740	0.005%
MCR Steelhead Adult	94,965	24.362	0.026%	16.623	0.017%	9.819	0.010%	0.320	0.000%
UCR Steelhead Adult	93,892	21.574	0.023%	13.457	0.014%	8.343	0.009%	0.012	0.000%
SRB Steelhead Adult	156,102	76.812	0.049%	46.503	0.030%	29.154	0.019%	0.012	0.000%
UWR Steelhead Adult	9,650	5.156	0.053%	10.249	0.106%	9.970	0.103%	5.405	0.056%
SR Sockeye Adult	181	0.069	0.038%	0.076	0.042%	0.041	0.023%	0.012	0.007%
LCR Coho Adult	48,100	206.598	0.430%	160.505	0.334%	54.338	0.113%	0.012	0.000%
Eulachon Adult	115,000	0.069	0.000%	0.076	0.000%	39.187	0.034%	38.392	0.033%
CR Chum Juvenile <2g	1,000	0.082	0.008%	0.083	0.008%	0.370	0.037%	0.443	0.044%
UCR SP Chinook Juv >2g	1,000	0.035	0.003%	0.036	0.004%	0.088	0.009%	0.062	0.006%
LCR Chinook Juv >2g	1,977	0.035	0.002%	0.036	0.002%	0.118	0.006%	0.123	0.006%
SR F Chinook Juv >2g	1,000	0.035	0.003%	0.036	0.004%	0.027	0.003%	0.025	0.002%
SR SS Chinook Juv >2g	1,000	0.035	0.003%	0.036	0.004%	0.016	0.002%	0.030	0.003%
UWR Chinook Juv >2g	1,000	0.884	0.088%	0.904	0.090%	0.330	0.033%	0.079	0.008%
LCR Steelhead Juv >2g	1,964	0.035	0.002%	0.036	0.002%	0.016	0.001%	0.100	0.005%
MCR Steelhead Juv >2g	1,964	0.035	0.002%	0.036	0.002%	0.016	0.001%	0.072	0.004%
UCR Steelhead Juv >2g	1,000	0.035	0.003%	0.036	0.004%	0.016	0.002%	0.040	0.004%
SRB Steelhead Juv >2g	62,964	0.035	0.000%	0.036	0.000%	0.016	0.000%	1.789	0.003%
UWR Steelhead Juv >2g	1,000	0.035	0.003%	0.036	0.004%	0.016	0.002%	0.031	0.003%
SR Sockeye Juv >2g	1,000	0.035	0.003%	0.036	0.004%	0.016	0.002%	0.013	0.001%
LCR Coho Juv >2g	1,000	0.407	0.041%	0.453	0.045%	0.168	0.017%	0.050	0.005%
Eulachon Juv <2g	54,625,000	0.082	0.000%	0.083	0.000%	0.022	0.000%	4791.614	0.009%

5.3 Cumulative Percentage Impacts and Analysis

Figure 5-1 provides a comparison of mean cumulative percent of potential impacts for each ESU/DPS and life stage. As noted previously, CR chum adults appear to be the most impacted, at mean of 0.808 cumulative percent (range = 0.432 to 1.004). Also based on the calculations performed, 9 of the 14 adult runs are estimated to experience less than a mean 0.2 cumulative percent of potential impact and 11 of the 14 juvenile fish runs are estimated to have less than a mean 0.1 cumulative percent of potential impact. The exceptions include CR chum, UWR Chinook, and LCR coho juveniles.

Figure 5-1. Mean Cumulative Percent Impact by ESU/DPS and Life Stage



Note: The pink lines represent the minima and maxima (range) of cumulative percent impacts by ESU/DPS and life stage based on the 13 scenarios calculated.

Key: LCR = Lower Columbia River; UCR = Upper Columbia River; SR = Snake River; UWR = Upper Willamette River; SRB = Snake River Basin; SP= Spring-Run; F= Fall-Run; Juv = Juvenile.

Table 5-13 presents the modeled impacts by ESU/DPS and life stage for all scenarios, as well as summaries of impacts and a ranking of impacts by scenario from most to least severe. The summary columns present the cumulative estimated individuals that may be impacted and the cumulative percentage of runs over the 4-year construction period. To obtain the cumulative percentage value, the percentages of a run potentially impacted each year were added together. By dividing the cumulative percentage by the construction period, one can obtain an average for the construction period. Estimated impacts to individual numbers are presented with the caveat that those numbers are based on population estimates that vary from year to year. Both cumulative individuals and cumulative percentages for potential impacts are presented to provide an impression of the minimum and maximum potential impacts based on the different pile-driving scenarios.

For example, Table 5-13 shows the potential impacts to all fish runs and life stages for all 13 pile-driving scenarios. Cumulative impacts for all four construction years are presented, in addition to the mean, minimum, and maximum proportion of the adult chum exposed under any of the 13 scenarios. Using CR chum adults as an example, the results show that for Year 1 of construction, exposure ranges from 0.079 to 0.437 percent or approximately 2 to 9 individuals for any of the 13 award dates. In Year 2, potential exposure ranges from 0.199 to 0.445 percent of the chum run, or approximately 4 to 9 individuals. In Year 3, exposure ranges from 0.122 to 0.455 percent of the chum run or approximately 2 to 9 individuals. In Year 4, exposure ranges from 0.001 to 0.025 percent or approximately 0 to 1 individual. Note: these minimum and maximum values represent the worst case in any of the 4 years with any of the schedules.

To determine the overall exposure, the analysis looked at cumulative statistics for each of the 13 schedules. The results show the highest exposure (December 1, 2013 award date) is 1.004 percent or approximately 20 adult chum being exposed over the 4-year period. The lowest exposure (August 1, 2013 award date) is 0.432 percent or approximately nine adult chum being exposed over the 4-year period. The mean cumulative exposure over the 4-year period is 0.808 percent or approximately 16 individuals.

Table 5-13. Summary of Analysis for Impact Driving by ESU/DPS and Life Stage (Based on All Contract Award Dates)

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
CR Chum Adult	1,997	8.725	0.437	8.886	0.445	2.436	0.122	0.012	0.001	20.059	1.004	12/01/13	1	Mean	16.131	0.808
		8.585	0.430	8.420	0.422	2.436	0.122	0.012	0.001	19.453	0.974	01/01/14	2	Min	8.630	0.432
		8.585	0.430	8.420	0.422	2.436	0.122	0.012	0.001	19.453	0.974	02/01/14	2	Max	20.059	1.004
		8.647	0.433	7.856	0.393	2.439	0.122	0.012	0.001	18.954	0.949	02/05/13	4			
		8.647	0.433	7.856	0.393	2.439	0.122	0.012	0.001	18.954	0.949	03/01/13	4			
		8.647	0.433	7.721	0.387	2.441	0.122	0.012	0.001	18.820	0.942	04/01/13	6			
		1.577	0.079	7.190	0.360	9.079	0.455	0.506	0.025	18.352	0.919	11/01/13	7			
		8.647	0.433	4.377	0.219	2.455	0.123	0.012	0.001	15.491	0.776	05/01/13	8			
		8.488	0.425	4.386	0.220	2.455	0.123	0.012	0.001	15.341	0.768	06/01/13	9			
		1.577	0.079	3.965	0.199	7.916	0.396	0.358	0.018	13.816	0.692	10/01/13	10			
		1.577	0.079	4.163	0.208	5.403	0.271	0.153	0.008	11.296	0.566	09/01/13	11			
		4.208	0.211	4.402	0.220	2.455	0.123	0.012	0.001	11.077	0.555	07/01/13	12			
		1.589	0.080	4.417	0.221	2.612	0.131	0.012	0.001	8.630	0.432	08/01/13	13			
UCR SP Chinook Adult	3,256	0.070	0.002	0.073	0.002	0.045	0.001	0.012	0.000	0.199	0.006	04/01/13	1	Mean	0.198	0.006
		0.070	0.002	0.074	0.002	0.043	0.001	0.012	0.000	0.198	0.006	02/05/13	2	Min	0.196	0.006
		0.070	0.002	0.074	0.002	0.043	0.001	0.012	0.000	0.198	0.006	03/01/13	2	Max	0.199	0.006
		0.062	0.002	0.065	0.002	0.059	0.002	0.012	0.000	0.198	0.006	06/01/13	4			
		0.046	0.001	0.081	0.003	0.059	0.002	0.012	0.000	0.198	0.006	07/01/13	5			
		0.017	0.001	0.085	0.003	0.082	0.003	0.014	0.000	0.198	0.006	11/01/13	6			
		0.017	0.001	0.095	0.003	0.074	0.002	0.012	0.000	0.198	0.006	09/01/13	7			
		0.069	0.002	0.076	0.002	0.041	0.001	0.012	0.000	0.198	0.006	12/01/13	8			
		0.069	0.002	0.076	0.002	0.041	0.001	0.012	0.000	0.198	0.006	01/01/14	9			
		0.069	0.002	0.076	0.002	0.041	0.001	0.012	0.000	0.198	0.006	02/01/14	9			
		0.070	0.002	0.056	0.002	0.059	0.002	0.012	0.000	0.197	0.006	05/01/13	11			
		0.017	0.001	0.090	0.003	0.078	0.002	0.012	0.000	0.196	0.006	10/01/13	12			
		0.029	0.001	0.096	0.003	0.059	0.002	0.012	0.000	0.196	0.006	08/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
LCR Chinook Adult	14,069	64.470	0.458	48.548	0.345	18.773	0.133	0.156	0.001	131.947	0.938	12/01/13	1	Mean	103.859	0.738
		65.081	0.463	42.994	0.306	18.773	0.133	0.156	0.001	127.004	0.903	01/01/14	2	Min	57.004	0.405
		65.081	0.463	42.994	0.306	18.773	0.133	0.156	0.001	127.004	0.903	02/01/14	2	Max	131.947	0.938
		66.808	0.475	36.666	0.261	18.755	0.133	0.156	0.001	122.385	0.870	02/05/13	4			
		66.808	0.475	36.666	0.261	18.755	0.133	0.156	0.001	122.385	0.870	03/01/13	4			
		66.808	0.475	35.358	0.251	18.757	0.133	0.156	0.001	121.078	0.861	04/01/13	6			
		66.808	0.475	18.281	0.130	18.771	0.133	0.156	0.001	104.016	0.739	05/01/13	7			
		19.102	0.136	59.899	0.426	22.828	0.162	1.587	0.011	103.416	0.735	11/01/13	8			
		19.102	0.136	19.620	0.139	60.065	0.427	2.162	0.015	100.949	0.718	09/01/13	9			
		19.102	0.136	53.742	0.382	22.157	0.158	0.094	0.001	95.095	0.676	10/01/13	10			
		19.114	0.136	18.593	0.132	32.404	0.230	0.156	0.001	70.267	0.499	08/01/13	11			
		30.319	0.216	18.290	0.130	18.854	0.134	0.156	0.001	67.619	0.481	06/01/13	12			
		19.131	0.136	18.312	0.130	19.405	0.138	0.156	0.001	57.004	0.405	07/01/13	13			
SR F Chinook Adult	6,010	7.923	0.132	6.228	0.104	2.934	0.049	0.012	0.000	17.098	0.284	12/01/13	1	Mean	13.598	0.226
		7.621	0.127	4.911	0.082	2.934	0.049	0.012	0.000	15.479	0.258	01/01/14	2	Min	8.767	0.146
		7.621	0.127	4.911	0.082	2.934	0.049	0.012	0.000	15.479	0.258	02/01/14	2	Max	17.098	0.284
		8.043	0.134	4.018	0.067	2.937	0.049	0.012	0.000	15.010	0.250	02/05/13	4			
		8.043	0.134	4.018	0.067	2.937	0.049	0.012	0.000	15.010	0.250	03/01/13	4			
		8.043	0.134	3.928	0.065	2.939	0.049	0.012	0.000	14.922	0.248	04/01/13	6			
		8.043	0.134	2.933	0.049	2.953	0.049	0.012	0.000	13.941	0.232	05/01/13	7			
		2.815	0.047	7.097	0.118	3.587	0.060	0.400	0.007	13.899	0.231	11/01/13	8			
		2.815	0.047	7.088	0.118	3.895	0.065	0.063	0.001	13.861	0.231	10/01/13	9			
		2.815	0.047	2.973	0.049	6.130	0.102	0.092	0.002	12.009	0.200	09/01/13	10			
		2.826	0.047	2.973	0.049	5.800	0.096	0.012	0.000	11.612	0.193	08/01/13	11			
		3.774	0.063	2.943	0.049	2.953	0.049	0.012	0.000	9.682	0.161	06/01/13	12			
		2.844	0.047	2.958	0.049	2.953	0.049	0.012	0.000	8.767	0.146	07/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
SR SS Chinook Adult	27,736	7.807	0.028	0.076	0.000	0.041	0.000	1.869	0.007	9.792	0.035	12/01/13	1	Mean	3.865	0.014
		0.029	0.000	0.096	0.000	7.769	0.028	1.869	0.007	9.763	0.035	08/01/13	2	Min	0.198	0.001
		0.017	0.000	7.848	0.028	0.078	0.000	0.012	0.000	7.955	0.029	10/01/13	3	Max	9.792	0.035
		0.017	0.000	5.978	0.022	0.082	0.000	0.014	0.000	6.091	0.022	11/01/13	4			
		0.070	0.000	0.073	0.000	0.045	0.000	1.869	0.007	2.057	0.007	04/01/13	5			
		0.070	0.000	0.074	0.000	0.043	0.000	1.869	0.007	2.056	0.007	02/05/13	6			
		0.070	0.000	0.074	0.000	0.043	0.000	1.869	0.007	2.056	0.007	03/01/13	6			
		0.062	0.000	0.065	0.000	0.059	0.000	1.869	0.007	2.056	0.007	06/01/13	8			
		0.046	0.000	0.081	0.000	0.059	0.000	1.869	0.007	2.055	0.007	07/01/13	9			
		0.069	0.000	0.076	0.000	0.041	0.000	1.869	0.007	2.055	0.007	01/01/14	10			
		0.069	0.000	0.076	0.000	0.041	0.000	1.869	0.007	2.055	0.007	02/01/14	10			
		0.070	0.000	0.056	0.000	0.059	0.000	1.869	0.007	2.054	0.007	05/01/13	12			
		0.017	0.000	0.095	0.000	0.074	0.000	0.012	0.000	0.198	0.001	09/01/13	13			
UWR Chinook Adult	7,729	0.029	0.000	1.090	0.014	9.765	0.126	1.259	0.016	12.142	0.157	08/01/13	1	Mean	5.716	0.074
		0.017	0.000	11.105	0.144	0.376	0.005	0.527	0.007	12.024	0.156	11/01/13	2	Min	2.072	0.027
		0.017	0.000	11.030	0.143	0.371	0.005	0.510	0.007	11.929	0.154	10/01/13	3	Max	12.142	0.157
		0.017	0.000	9.388	0.121	0.367	0.005	0.510	0.007	10.283	0.133	09/01/13	4			
		4.920	0.064	0.076	0.001	0.847	0.011	1.259	0.016	7.101	0.092	12/01/13	5			
		0.046	0.001	0.081	0.001	4.484	0.058	1.259	0.016	5.870	0.076	07/01/13	6			
		0.069	0.001	0.076	0.001	0.847	0.011	1.259	0.016	2.250	0.029	01/01/14	7			
		0.069	0.001	0.076	0.001	0.847	0.011	1.259	0.016	2.250	0.029	02/01/14	7			
		0.062	0.001	0.065	0.001	0.774	0.010	1.259	0.016	2.160	0.028	06/01/13	9			
		0.070	0.001	0.073	0.001	0.674	0.009	1.259	0.016	2.075	0.027	04/01/13	10			
		0.070	0.001	0.074	0.001	0.672	0.009	1.259	0.016	2.074	0.027	02/05/13	11			
		0.070	0.001	0.074	0.001	0.672	0.009	1.259	0.016	2.074	0.027	03/01/13	11			
		0.070	0.001	0.056	0.001	0.688	0.009	1.259	0.016	2.072	0.027	05/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
LCR Steelhead Adult	171,576	79.777	0.046	85.183	0.050	42.615	0.025	8.740	0.005	216.314	0.126	12/01/13	1	Mean	203.278	0.118
		78.182	0.046	81.165	0.047	42.615	0.025	8.740	0.005	210.701	0.123	01/01/14	2	Min	184.471	0.108
		78.182	0.046	81.165	0.047	42.615	0.025	8.740	0.005	210.701	0.123	02/01/14	2	Max	216.314	0.126
		18.734	0.011	83.820	0.049	95.730	0.056	12.261	0.007	210.544	0.123	11/01/13	4			
		79.136	0.046	75.670	0.044	45.795	0.027	8.740	0.005	209.340	0.122	04/01/13	5			
		79.136	0.046	76.328	0.044	44.748	0.026	8.740	0.005	208.952	0.122	02/05/13	6			
		79.136	0.046	76.328	0.044	44.748	0.026	8.740	0.005	208.952	0.122	03/01/13	6			
		18.734	0.011	83.890	0.049	93.068	0.054	10.030	0.006	205.722	0.120	10/01/13	8			
		72.933	0.043	61.613	0.036	60.970	0.036	8.740	0.005	204.256	0.119	06/01/13	9			
		79.136	0.046	55.208	0.032	56.333	0.033	8.740	0.005	199.417	0.116	05/01/13	10			
		46.884	0.027	73.867	0.043	58.952	0.034	8.740	0.005	188.442	0.110	07/01/13	11			
		18.734	0.011	85.813	0.050	71.943	0.042	8.316	0.005	184.806	0.108	09/01/13	12			
		26.991	0.016	90.813	0.053	57.928	0.034	8.740	0.005	184.471	0.108	08/01/13	13			
MCR Steelhead Adult	94,965	25.015	0.026	20.229	0.021	9.819	0.010	0.320	0.000	55.383	0.058	12/01/13	1	Mean	45.374	0.048
		24.362	0.026	16.623	0.017	9.819	0.010	0.320	0.000	51.124	0.054	01/01/14	2	Min	31.921	0.034
		24.362	0.026	16.623	0.017	9.819	0.010	0.320	0.000	51.124	0.054	02/01/14	2	Max	55.383	0.058
		25.596	0.027	13.700	0.014	9.901	0.010	0.320	0.000	49.517	0.052	02/05/13	4			
		25.596	0.027	13.700	0.014	9.901	0.010	0.320	0.000	49.517	0.052	03/01/13	4			
		25.596	0.027	13.469	0.014	9.950	0.010	0.320	0.000	49.335	0.052	04/01/13	6			
		25.596	0.027	10.369	0.011	10.367	0.011	0.320	0.000	46.652	0.049	05/01/13	7			
		8.907	0.009	23.565	0.025	13.172	0.014	0.410	0.000	46.054	0.049	10/01/13	8			
		8.907	0.009	22.179	0.023	12.395	0.013	1.438	0.002	44.919	0.047	11/01/13	9			
		8.907	0.009	11.101	0.012	20.146	0.021	0.625	0.001	40.778	0.043	09/01/13	10			
		9.339	0.010	11.821	0.012	18.147	0.019	0.320	0.000	39.626	0.042	08/01/13	11			
		12.398	0.013	10.647	0.011	10.552	0.011	0.320	0.000	33.917	0.036	06/01/13	12			
		10.147	0.011	11.140	0.012	10.314	0.011	0.320	0.000	31.921	0.034	07/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
UCR Steelhead Adult	93,892	22.531	0.024	17.006	0.018	8.343	0.009	0.012	0.000	47.892	0.051	12/01/13	1	Mean	38.122	0.041
		21.574	0.023	13.457	0.014	8.343	0.009	0.012	0.000	43.386	0.046	01/01/14	2	Min	25.160	0.027
		21.574	0.023	13.457	0.014	8.343	0.009	0.012	0.000	43.386	0.046	02/01/14	2	Max	47.892	0.051
		22.843	0.024	10.650	0.011	8.345	0.009	0.012	0.000	41.851	0.045	02/05/13	4			
		22.843	0.024	10.650	0.011	8.345	0.009	0.012	0.000	41.851	0.045	03/01/13	4			
		22.843	0.024	10.436	0.011	8.347	0.009	0.012	0.000	41.638	0.044	04/01/13	6			
		8.449	0.009	21.426	0.023	9.614	0.010	0.012	0.000	39.501	0.042	10/01/13	7			
		22.843	0.024	8.284	0.009	8.361	0.009	0.012	0.000	39.500	0.042	05/01/13	8			
		8.449	0.009	19.535	0.021	8.384	0.009	0.991	0.001	37.359	0.040	11/01/13	9			
		8.449	0.009	8.323	0.009	17.527	0.019	0.316	0.000	34.615	0.037	09/01/13	10			
		8.461	0.009	8.324	0.009	16.699	0.018	0.012	0.000	33.496	0.036	08/01/13	11			
		9.282	0.010	8.293	0.009	8.361	0.009	0.012	0.000	25.948	0.028	06/01/13	12			
		8.478	0.009	8.309	0.009	8.361	0.009	0.012	0.000	25.160	0.027	07/01/13	13			
SRB Steelhead Adult	156,102	80.382	0.051	60.590	0.039	29.154	0.019	0.012	0.000	170.138	0.109	12/01/13	1	Mean	135.071	0.086
		76.812	0.049	46.503	0.030	29.154	0.019	0.012	0.000	152.481	0.098	01/01/14	2	Min	88.274	0.056
		76.812	0.049	46.503	0.030	29.154	0.019	0.012	0.000	152.481	0.098	02/01/14	2	Max	170.138	0.109
		81.678	0.052	38.419	0.025	29.157	0.019	0.012	0.000	149.266	0.096	02/05/13	4			
		81.678	0.052	38.419	0.025	29.157	0.019	0.012	0.000	149.266	0.096	03/01/13	4			
		81.678	0.052	37.599	0.024	29.158	0.019	0.012	0.000	148.448	0.095	04/01/13	6			
		81.678	0.052	29.149	0.019	29.173	0.019	0.012	0.000	140.011	0.090	05/01/13	7			
		29.887	0.019	75.769	0.049	33.922	0.022	0.012	0.000	139.589	0.089	10/01/13	8			
		29.887	0.019	69.831	0.045	29.196	0.019	3.761	0.002	132.674	0.085	11/01/13	9			
		29.887	0.019	29.188	0.019	61.134	0.039	1.279	0.001	121.487	0.078	09/01/13	10			
		29.899	0.019	29.189	0.019	61.149	0.039	0.012	0.000	120.248	0.077	08/01/13	11			
		33.213	0.021	29.158	0.019	29.173	0.019	0.012	0.000	91.556	0.059	06/01/13	12			
		29.916	0.019	29.173	0.019	29.173	0.019	0.012	0.000	88.274	0.056	07/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics	Statistics: Cumulative Individual	Statistics: Cumulative %
UWR Steelhead Adult	9,650	4.731	0.049	29.306	0.304	14.436	0.150	5.405	0.056	53.879	0.558	08/01/13	1	Mean	39.946	0.414
		1.535	0.016	31.298	0.324	15.322	0.159	5.105	0.053	53.260	0.552	09/01/13	2	Min	30.129	0.312
		5.931	0.061	21.767	0.226	18.581	0.193	5.405	0.056	51.685	0.536	07/01/13	3	Max	53.879	0.558
		1.535	0.016	23.526	0.244	19.110	0.198	5.128	0.053	49.299	0.511	10/01/13	4			
		6.606	0.068	14.208	0.147	19.426	0.201	5.405	0.056	45.646	0.473	06/01/13	5			
		4.952	0.051	10.453	0.108	18.329	0.190	5.405	0.056	39.139	0.406	05/01/13	6			
		1.535	0.016	16.531	0.171	14.599	0.151	5.283	0.055	37.948	0.393	11/01/13	7			
		4.952	0.051	10.741	0.111	11.566	0.120	5.405	0.056	32.665	0.339	04/01/13	8			
		4.952	0.051	10.708	0.111	10.977	0.114	5.405	0.056	32.042	0.332	02/05/13	9			
		4.952	0.051	10.708	0.111	10.977	0.114	5.405	0.056	32.042	0.332	03/01/13	9			
		5.156	0.053	10.249	0.106	9.970	0.103	5.405	0.056	30.780	0.319	01/01/14	11			
		5.156	0.053	10.249	0.106	9.970	0.103	5.405	0.056	30.780	0.319	02/01/14	11			
		5.555	0.058	9.200	0.095	9.970	0.103	5.405	0.056	30.129	0.312	12/01/13	13			
SR Sockeye Adult	181	0.070	0.038	0.073	0.040	0.045	0.025	0.012	0.007	0.199	0.110	04/01/13	1	Mean	0.198	0.109
		0.070	0.038	0.074	0.041	0.043	0.024	0.012	0.007	0.198	0.110	02/05/13	2	Min	0.196	0.108
		0.070	0.038	0.074	0.041	0.043	0.024	0.012	0.007	0.198	0.110	03/01/13	2	Max	0.199	0.110
		0.062	0.034	0.065	0.036	0.059	0.033	0.012	0.007	0.198	0.110	06/01/13	4			
		0.046	0.025	0.081	0.045	0.059	0.033	0.012	0.007	0.198	0.109	07/01/13	5			
		0.017	0.009	0.085	0.047	0.082	0.045	0.014	0.008	0.198	0.109	11/01/13	6			
		0.017	0.009	0.095	0.053	0.074	0.041	0.012	0.007	0.198	0.109	09/01/13	7			
		0.069	0.038	0.076	0.042	0.041	0.023	0.012	0.007	0.198	0.109	12/01/13	8			
		0.069	0.038	0.076	0.042	0.041	0.023	0.012	0.007	0.198	0.109	01/01/14	9			
		0.069	0.038	0.076	0.042	0.041	0.023	0.012	0.007	0.198	0.109	02/01/14	9			
		0.070	0.038	0.056	0.031	0.059	0.033	0.012	0.007	0.197	0.109	05/01/13	11			
		0.017	0.009	0.090	0.049	0.078	0.043	0.012	0.007	0.196	0.108	10/01/13	12			
		0.029	0.016	0.096	0.053	0.059	0.033	0.012	0.007	0.196	0.108	08/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
LCR Coho Adult	48,100	202.389	0.421	175.738	0.365	54.338	0.113	0.012	0.000	432.477	0.899	12/01/13	1	Mean	341.057	0.709
		206.598	0.430	160.505	0.334	54.338	0.113	0.012	0.000	421.452	0.876	01/01/14	2	Min	191.922	0.399
		206.598	0.430	160.505	0.334	54.338	0.113	0.012	0.000	421.452	0.876	02/01/14	2	Max	432.477	0.899
		209.531	0.436	144.112	0.300	54.340	0.113	0.012	0.000	407.995	0.848	02/05/13	4			
		209.531	0.436	144.112	0.300	54.340	0.113	0.012	0.000	407.995	0.848	03/01/13	4			
		209.531	0.436	140.194	0.291	54.342	0.113	0.012	0.000	404.079	0.840	04/01/13	6			
		48.407	0.101	185.915	0.387	126.396	0.263	6.990	0.015	367.708	0.765	11/01/13	7			
		209.531	0.436	69.495	0.144	54.356	0.113	0.012	0.000	333.394	0.693	05/01/13	8			
		48.407	0.101	67.304	0.140	171.675	0.357	6.334	0.013	293.720	0.611	09/01/13	9			
		48.407	0.101	126.377	0.263	112.406	0.234	3.354	0.007	290.544	0.604	10/01/13	10			
		142.165	0.296	69.505	0.145	54.356	0.113	0.012	0.000	266.038	0.553	06/01/13	11			
		48.419	0.101	69.535	0.145	76.999	0.160	0.012	0.000	194.966	0.405	08/01/13	12			
		68.033	0.141	69.520	0.145	54.356	0.113	0.012	0.000	191.922	0.399	07/01/13	13			
Eulachon Adult	115,000	0.017	0.000	434.125	0.377	10.281	0.009	28.961	0.025	473.384	0.412	11/01/13	1	Mean	202.948	0.176
		0.017	0.000	416.343	0.362	10.272	0.009	28.859	0.025	455.491	0.396	09/01/13	2	Min	68.872	0.060
		0.017	0.000	373.745	0.325	10.277	0.009	28.859	0.025	412.898	0.359	10/01/13	3	Max	473.384	0.412
		0.029	0.000	22.397	0.020	306.648	0.267	38.392	0.033	367.466	0.320	08/01/13	4			
		0.046	0.000	0.081	0.000	225.989	0.197	38.392	0.033	264.507	0.230	07/01/13	5			
		87.107	0.076	0.076	0.000	39.187	0.034	38.392	0.033	164.761	0.143	12/01/13	6			
		0.069	0.000	0.076	0.000	39.187	0.034	38.392	0.033	77.723	0.068	01/01/14	7			
		0.069	0.000	0.076	0.000	39.187	0.034	38.392	0.033	77.723	0.068	02/01/14	7			
		0.070	0.000	0.073	0.000	30.341	0.026	38.392	0.033	68.875	0.060	04/01/13	9			
		0.070	0.000	0.074	0.000	30.339	0.026	38.392	0.033	68.874	0.060	02/05/13	10			
		0.070	0.000	0.074	0.000	30.339	0.026	38.392	0.033	68.874	0.060	03/01/13	10			
		0.062	0.000	0.065	0.000	30.355	0.026	38.392	0.033	68.874	0.060	06/01/13	12			
		0.070	0.000	0.056	0.000	30.355	0.026	38.392	0.033	68.872	0.060	05/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics	Statistics: Cumulative Individual	Statistics: Cumulative %
CR Chum Juv <2g	1,000	0.009	0.001	4.595	0.460	0.139	0.014	0.299	0.030	5.042	0.504	11/01/13	1	Mean	2.344	0.234
		0.009	0.001	4.583	0.458	0.127	0.013	0.290	0.029	5.009	0.501	09/01/13	2	Min	0.901	0.090
		0.009	0.001	4.225	0.422	0.133	0.013	0.290	0.029	4.657	0.466	10/01/13	3	Max	5.042	0.504
		0.025	0.003	0.609	0.061	3.129	0.313	0.443	0.044	4.206	0.421	08/01/13	4			
		0.049	0.005	0.093	0.009	2.223	0.222	0.443	0.044	2.808	0.281	07/01/13	5			
		1.339	0.134	0.083	0.008	0.370	0.037	0.443	0.044	2.235	0.223	12/01/13	6			
		0.082	0.008	0.083	0.008	0.370	0.037	0.443	0.044	0.978	0.098	01/01/14	7			
		0.082	0.008	0.083	0.008	0.370	0.037	0.443	0.044	0.978	0.098	02/01/14	7			
		0.071	0.007	0.071	0.007	0.355	0.036	0.443	0.044	0.941	0.094	06/01/13	9			
		0.083	0.008	0.080	0.008	0.300	0.030	0.443	0.044	0.905	0.090	04/01/13	10			
		0.083	0.008	0.080	0.008	0.298	0.030	0.443	0.044	0.903	0.090	02/05/13	11			
		0.083	0.008	0.080	0.008	0.298	0.030	0.443	0.044	0.903	0.090	03/01/13	11			
		0.083	0.008	0.057	0.006	0.318	0.032	0.443	0.044	0.901	0.090	05/01/13	13			
UCR SP Chinook Juv >2g	1,000	0.007	0.001	0.600	0.060	0.061	0.006	0.046	0.005	0.714	0.071	10/01/13	1	Mean	0.377	0.038
		0.007	0.001	0.558	0.056	0.059	0.006	0.046	0.005	0.670	0.067	09/01/13	2	Min	0.202	0.020
		0.007	0.001	0.490	0.049	0.063	0.006	0.053	0.005	0.612	0.061	11/01/13	3	Max	0.714	0.071
		0.013	0.001	0.196	0.020	0.308	0.031	0.062	0.006	0.579	0.058	08/01/13	4			
		0.022	0.002	0.039	0.004	0.432	0.043	0.062	0.006	0.555	0.056	07/01/13	5			
		0.134	0.013	0.036	0.004	0.088	0.009	0.062	0.006	0.320	0.032	12/01/13	6			
		0.035	0.003	0.036	0.004	0.088	0.009	0.062	0.006	0.221	0.022	01/01/14	7			
		0.035	0.003	0.036	0.004	0.088	0.009	0.062	0.006	0.221	0.022	02/01/14	7			
		0.035	0.003	0.035	0.003	0.072	0.007	0.062	0.006	0.204	0.020	04/01/13	9			
		0.031	0.003	0.031	0.003	0.079	0.008	0.062	0.006	0.203	0.020	06/01/13	10			
		0.035	0.003	0.035	0.004	0.071	0.007	0.062	0.006	0.203	0.020	02/05/13	11			
		0.035	0.003	0.035	0.004	0.071	0.007	0.062	0.006	0.203	0.020	03/01/13	11			
		0.035	0.003	0.026	0.003	0.079	0.008	0.062	0.006	0.202	0.020	05/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
LCR Chinook Juv >2g	1,977	0.007	0.000	1.113	0.056	0.072	0.004	0.065	0.003	1.257	0.064	10/01/13	1	Mean	0.624	0.032
		0.013	0.001	0.238	0.012	0.757	0.038	0.123	0.006	1.131	0.057	08/01/13	2	Min	0.296	0.015
		0.007	0.000	0.963	0.049	0.074	0.004	0.071	0.004	1.115	0.056	11/01/13	3	Max	1.257	0.064
		0.007	0.000	0.922	0.047	0.070	0.004	0.065	0.003	1.063	0.054	09/01/13	4			
		0.022	0.001	0.039	0.002	0.562	0.028	0.123	0.006	0.747	0.038	07/01/13	5			
		0.373	0.019	0.036	0.002	0.118	0.006	0.123	0.006	0.650	0.033	12/01/13	6			
		0.031	0.002	0.031	0.002	0.146	0.007	0.123	0.006	0.331	0.017	06/01/13	7			
		0.035	0.002	0.036	0.002	0.118	0.006	0.123	0.006	0.312	0.016	01/01/14	8			
		0.035	0.002	0.036	0.002	0.118	0.006	0.123	0.006	0.312	0.016	02/01/14	8			
		0.035	0.002	0.035	0.002	0.105	0.005	0.123	0.006	0.298	0.015	04/01/13	10			
		0.035	0.002	0.035	0.002	0.104	0.005	0.123	0.006	0.297	0.015	02/05/13	11			
		0.035	0.002	0.035	0.002	0.104	0.005	0.123	0.006	0.297	0.015	03/01/13	11			
		0.035	0.002	0.026	0.001	0.112	0.006	0.123	0.006	0.296	0.015	05/01/13	13			
SR F Chinook Juv >2g	1,000	0.007	0.001	0.201	0.020	0.038	0.004	0.012	0.001	0.258	0.026	10/01/13	1	Mean	0.167	0.017
		0.007	0.001	0.190	0.019	0.040	0.004	0.014	0.001	0.250	0.025	11/01/13	2	Min	0.119	0.012
		0.013	0.001	0.061	0.006	0.147	0.015	0.025	0.002	0.246	0.025	08/01/13	3	Max	0.258	0.026
		0.007	0.001	0.162	0.016	0.036	0.004	0.012	0.001	0.217	0.022	09/01/13	4			
		0.101	0.010	0.036	0.004	0.027	0.003	0.025	0.002	0.188	0.019	12/01/13	5			
		0.022	0.002	0.039	0.004	0.083	0.008	0.025	0.002	0.169	0.017	07/01/13	6			
		0.035	0.003	0.036	0.004	0.027	0.003	0.025	0.002	0.122	0.012	01/01/14	7			
		0.035	0.003	0.036	0.004	0.027	0.003	0.025	0.002	0.122	0.012	02/01/14	7			
		0.035	0.003	0.035	0.003	0.026	0.003	0.025	0.002	0.120	0.012	04/01/13	9			
		0.031	0.003	0.031	0.003	0.033	0.003	0.025	0.002	0.120	0.012	06/01/13	10			
		0.035	0.003	0.035	0.004	0.025	0.003	0.025	0.002	0.120	0.012	02/05/13	11			
		0.035	0.003	0.035	0.004	0.025	0.003	0.025	0.002	0.120	0.012	03/01/13	11			
		0.035	0.003	0.026	0.003	0.033	0.003	0.025	0.002	0.119	0.012	05/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
SR SS Chinook Juv >2g	1,000	0.013	0.001	0.048	0.005	0.137	0.014	0.030	0.003	0.227	0.023	08/01/13	1	Mean	0.146	0.015
		0.139	0.014	0.036	0.004	0.016	0.002	0.030	0.003	0.221	0.022	12/01/13	2	Min	0.116	0.012
		0.007	0.001	0.158	0.016	0.035	0.004	0.005	0.001	0.205	0.021	10/01/13	3	Max	0.227	0.023
		0.007	0.001	0.149	0.015	0.037	0.004	0.006	0.001	0.199	0.020	11/01/13	4			
		0.035	0.003	0.035	0.003	0.018	0.002	0.030	0.003	0.118	0.012	04/01/13	5			
		0.031	0.003	0.031	0.003	0.026	0.003	0.030	0.003	0.117	0.012	06/01/13	6			
		0.035	0.003	0.035	0.004	0.018	0.002	0.030	0.003	0.117	0.012	02/05/13	7			
		0.035	0.003	0.035	0.004	0.018	0.002	0.030	0.003	0.117	0.012	03/01/13	7			
		0.022	0.002	0.039	0.004	0.026	0.003	0.030	0.003	0.117	0.012	07/01/13	9			
		0.035	0.003	0.036	0.004	0.016	0.002	0.030	0.003	0.117	0.012	01/01/14	10			
		0.035	0.003	0.036	0.004	0.016	0.002	0.030	0.003	0.117	0.012	02/01/14	10			
		0.035	0.003	0.026	0.003	0.026	0.003	0.030	0.003	0.116	0.012	05/01/13	12			
		0.007	0.001	0.071	0.007	0.033	0.003	0.005	0.001	0.116	0.012	09/01/13	13			
UWR Chinook Juv >2g	1,000	0.118	0.012	1.115	0.112	1.081	0.108	0.123	0.012	2.437	0.244	11/01/13	1	Mean	2.113	0.211
		1.071	0.107	0.924	0.092	0.330	0.033	0.079	0.008	2.404	0.240	12/01/13	2	Min	1.741	0.174
		0.118	0.012	1.216	0.122	0.934	0.093	0.087	0.009	2.354	0.235	10/01/13	3	Max	2.437	0.244
		0.884	0.088	0.904	0.090	0.330	0.033	0.079	0.008	2.198	0.220	01/01/14	4			
		0.884	0.088	0.904	0.090	0.330	0.033	0.079	0.008	2.198	0.220	02/01/14	4			
		0.900	0.090	0.869	0.087	0.323	0.032	0.079	0.008	2.172	0.217	02/05/13	6			
		0.900	0.090	0.869	0.087	0.323	0.032	0.079	0.008	2.172	0.217	03/01/13	6			
		0.900	0.090	0.864	0.086	0.324	0.032	0.079	0.008	2.167	0.217	04/01/13	8			
		0.906	0.091	0.608	0.061	0.398	0.040	0.079	0.008	1.990	0.199	06/01/13	9			
		0.588	0.059	0.628	0.063	0.669	0.067	0.079	0.008	1.965	0.197	07/01/13	10			
		0.900	0.090	0.603	0.060	0.331	0.033	0.079	0.008	1.914	0.191	05/01/13	11			
		0.118	0.012	1.207	0.121	0.381	0.038	0.049	0.005	1.755	0.176	09/01/13	12			
		0.145	0.014	0.816	0.082	0.700	0.070	0.079	0.008	1.741	0.174	08/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics	Statistics: Cumulative Individual	Statistics: Cumulative %
LCR Steelhead Juv >2g	1,964	0.013	0.001	0.048	0.002	0.674	0.034	0.100	0.005	0.834	0.042	08/01/13	1	Mean	0.371	0.019
		0.007	0.000	0.684	0.035	0.035	0.002	0.005	0.000	0.731	0.037	10/01/13	2	Min	0.186	0.009
		0.007	0.000	0.664	0.034	0.037	0.002	0.006	0.000	0.714	0.036	11/01/13	3	Max	0.834	0.042
		0.514	0.026	0.036	0.002	0.016	0.001	0.100	0.005	0.666	0.034	12/01/13	4			
		0.007	0.000	0.339	0.017	0.033	0.002	0.005	0.000	0.384	0.020	09/01/13	5			
		0.035	0.002	0.035	0.002	0.018	0.001	0.100	0.005	0.188	0.010	04/01/13	6			
		0.031	0.002	0.031	0.002	0.026	0.001	0.100	0.005	0.187	0.009	06/01/13	7			
		0.035	0.002	0.035	0.002	0.018	0.001	0.100	0.005	0.187	0.010	02/05/13	8			
		0.035	0.002	0.035	0.002	0.018	0.001	0.100	0.005	0.187	0.010	03/01/13	8			
		0.022	0.001	0.039	0.002	0.026	0.001	0.100	0.005	0.187	0.009	07/01/13	10			
		0.035	0.002	0.036	0.002	0.016	0.001	0.100	0.005	0.187	0.009	01/01/14	11			
		0.035	0.002	0.036	0.002	0.016	0.001	0.100	0.005	0.187	0.009	02/01/14	11			
		0.035	0.002	0.026	0.001	0.026	0.001	0.100	0.005	0.186	0.009	05/01/13	13			
MCR Steelhead Juv >2g	1,964	0.013	0.001	0.048	0.002	0.438	0.022	0.072	0.004	0.571	0.029	08/01/13	1	Mean	0.276	0.014
		0.007	0.000	0.456	0.023	0.035	0.002	0.005	0.000	0.503	0.026	10/01/13	2	Min	0.159	0.008
		0.007	0.000	0.439	0.022	0.037	0.002	0.006	0.000	0.489	0.025	11/01/13	3	Max	0.571	0.029
		0.361	0.018	0.036	0.002	0.016	0.001	0.072	0.004	0.486	0.025	12/01/13	4			
		0.007	0.000	0.211	0.011	0.033	0.002	0.005	0.000	0.256	0.013	09/01/13	5			
		0.035	0.002	0.035	0.002	0.018	0.001	0.072	0.004	0.160	0.008	04/01/13	6			
		0.031	0.002	0.031	0.002	0.026	0.001	0.072	0.004	0.160	0.008	06/01/13	7			
		0.035	0.002	0.035	0.002	0.018	0.001	0.072	0.004	0.160	0.008	02/05/13	8			
		0.035	0.002	0.035	0.002	0.018	0.001	0.072	0.004	0.160	0.008	03/01/13	8			
		0.022	0.001	0.039	0.002	0.026	0.001	0.072	0.004	0.160	0.008	07/01/13	10			
		0.035	0.002	0.036	0.002	0.016	0.001	0.072	0.004	0.159	0.008	01/01/14	11			
		0.035	0.002	0.036	0.002	0.016	0.001	0.072	0.004	0.159	0.008	02/01/14	11			
		0.035	0.002	0.026	0.001	0.026	0.001	0.072	0.004	0.159	0.008	05/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics		
															Cumulative Individual	Cumulative %
UCR Steelhead Juv >2g	1,000	0.013	0.001	0.048	0.005	0.255	0.026	0.040	0.004	0.355	0.036	08/01/13	1	Mean	0.192	0.019
		0.007	0.001	0.272	0.027	0.035	0.004	0.005	0.001	0.318	0.032	10/01/13	2	Min	0.127	0.013
		0.007	0.001	0.262	0.026	0.037	0.004	0.006	0.001	0.312	0.031	11/01/13	3	Max	0.355	0.036
		0.208	0.021	0.036	0.004	0.016	0.002	0.040	0.004	0.301	0.030	12/01/13	4			
		0.007	0.001	0.145	0.015	0.033	0.003	0.005	0.001	0.190	0.019	09/01/13	5			
		0.035	0.003	0.035	0.003	0.018	0.002	0.040	0.004	0.128	0.013	04/01/13	6			
		0.031	0.003	0.031	0.003	0.026	0.003	0.040	0.004	0.128	0.013	06/01/13	7			
		0.035	0.003	0.035	0.004	0.018	0.002	0.040	0.004	0.128	0.013	02/05/13	8			
		0.035	0.003	0.035	0.004	0.018	0.002	0.040	0.004	0.128	0.013	03/01/13	8			
		0.022	0.002	0.039	0.004	0.026	0.003	0.040	0.004	0.127	0.013	07/01/13	10			
		0.035	0.003	0.036	0.004	0.016	0.002	0.040	0.004	0.127	0.013	01/01/14	11			
		0.035	0.003	0.036	0.004	0.016	0.002	0.040	0.004	0.127	0.013	02/01/14	11			
		0.035	0.003	0.026	0.003	0.026	0.003	0.040	0.004	0.127	0.013	05/01/13	13			
SRB Steelhead Juv >2g	62,964	0.013	0.000	0.048	0.000	9.053	0.014	1.789	0.003	10.902	0.017	08/01/13	1	Mean	4.376	0.007
		8.183	0.013	0.036	0.000	0.016	0.000	1.789	0.003	10.024	0.016	12/01/13	2	Min	1.875	0.003
		0.007	0.000	9.301	0.015	0.035	0.000	0.005	0.000	9.348	0.015	10/01/13	3	Max	10.902	0.017
		0.007	0.000	8.825	0.014	0.037	0.000	0.006	0.000	8.875	0.014	11/01/13	4			
		0.007	0.000	2.689	0.004	0.033	0.000	0.005	0.000	2.734	0.004	09/01/13	5			
		0.035	0.000	0.035	0.000	0.018	0.000	1.789	0.003	1.877	0.003	04/01/13	6			
		0.031	0.000	0.031	0.000	0.026	0.000	1.789	0.003	1.876	0.003	06/01/13	7			
		0.035	0.000	0.035	0.000	0.018	0.000	1.789	0.003	1.876	0.003	02/05/13	8			
		0.035	0.000	0.035	0.000	0.018	0.000	1.789	0.003	1.876	0.003	03/01/13	8			
		0.022	0.000	0.039	0.000	0.026	0.000	1.789	0.003	1.876	0.003	07/01/13	10			
		0.035	0.000	0.036	0.000	0.016	0.000	1.789	0.003	1.876	0.003	01/01/14	11			
		0.035	0.000	0.036	0.000	0.016	0.000	1.789	0.003	1.876	0.003	02/01/14	11			
		0.035	0.000	0.026	0.000	0.026	0.000	1.789	0.003	1.875	0.003	05/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics	Cumulative Individual	Cumulative %
UWR Steelhead Juv >2g	1,000	0.013	0.001	0.048	0.005	0.143	0.014	0.031	0.003	0.235	0.023	08/01/13	1	Mean	0.149	0.015
		0.144	0.014	0.036	0.004	0.016	0.002	0.031	0.003	0.227	0.023	12/01/13	2	Min	0.117	0.012
		0.007	0.001	0.165	0.017	0.035	0.004	0.005	0.001	0.212	0.021	10/01/13	3	Max	0.235	0.023
		0.007	0.001	0.155	0.016	0.037	0.004	0.006	0.001	0.206	0.021	11/01/13	4			
		0.035	0.003	0.035	0.003	0.018	0.002	0.031	0.003	0.119	0.012	04/01/13	5			
		0.031	0.003	0.031	0.003	0.026	0.003	0.031	0.003	0.118	0.012	06/01/13	6			
		0.035	0.003	0.035	0.004	0.018	0.002	0.031	0.003	0.118	0.012	02/05/13	7			
		0.035	0.003	0.035	0.004	0.018	0.002	0.031	0.003	0.118	0.012	03/01/13	7			
		0.022	0.002	0.039	0.004	0.026	0.003	0.031	0.003	0.118	0.012	07/01/13	9			
		0.007	0.001	0.073	0.007	0.033	0.003	0.005	0.001	0.118	0.012	09/01/13	10			
		0.035	0.003	0.036	0.004	0.016	0.002	0.031	0.003	0.118	0.012	01/01/14	11			
		0.035	0.003	0.036	0.004	0.016	0.002	0.031	0.003	0.118	0.012	02/01/14	11			
		0.035	0.003	0.026	0.003	0.026	0.003	0.031	0.003	0.117	0.012	05/01/13	13			
SR Sockeye Juv >2g	1,000	0.013	0.001	0.048	0.005	0.139	0.014	0.013	0.001	0.212	0.021	08/01/13	1	Mean	0.133	0.013
		0.007	0.001	0.149	0.015	0.037	0.004	0.006	0.001	0.199	0.020	11/01/13	2	Min	0.099	0.010
		0.007	0.001	0.150	0.015	0.035	0.004	0.005	0.001	0.197	0.020	10/01/13	3	Max	0.212	0.021
		0.007	0.001	0.126	0.013	0.033	0.003	0.005	0.001	0.171	0.017	09/01/13	4			
		0.091	0.009	0.036	0.004	0.016	0.002	0.013	0.001	0.156	0.016	12/01/13	5			
		0.035	0.003	0.035	0.003	0.018	0.002	0.013	0.001	0.101	0.010	04/01/13	6			
		0.031	0.003	0.031	0.003	0.026	0.003	0.013	0.001	0.100	0.010	06/01/13	7			
		0.035	0.003	0.035	0.004	0.018	0.002	0.013	0.001	0.100	0.010	02/05/13	8			
		0.035	0.003	0.035	0.004	0.018	0.002	0.013	0.001	0.100	0.010	03/01/13	8			
		0.022	0.002	0.039	0.004	0.026	0.003	0.013	0.001	0.100	0.010	07/01/13	10			
		0.035	0.003	0.036	0.004	0.016	0.002	0.013	0.001	0.100	0.010	01/01/14	11			
		0.035	0.003	0.036	0.004	0.016	0.002	0.013	0.001	0.100	0.010	02/01/14	11			
		0.035	0.003	0.026	0.003	0.026	0.003	0.013	0.001	0.099	0.010	05/01/13	13			

ESU/DPS and Life Stage	Annual Abundance	Year 1 Individual	Year 1%	Year 2 Individual	Year 2%	Year 3 Individual	Year 3%	Year 4 Individual	Year 4 %	Total Individual	Total %	Scenario Date	Rank	Statistics	Statistics: Cumulative Individual	Statistics: Cumulative %
LCR Coho Juv >2g	1,000	0.065	0.006	0.530	0.053	0.503	0.050	0.051	0.005	1.149	0.115	11/01/13	1	Mean	1.062	0.106
		0.459	0.046	0.436	0.044	0.168	0.017	0.050	0.005	1.112	0.111	12/01/13	2	Min	0.869	0.087
		0.405	0.041	0.453	0.045	0.186	0.019	0.050	0.005	1.094	0.109	04/01/13	3	Max	1.149	0.115
		0.436	0.044	0.404	0.040	0.202	0.020	0.050	0.005	1.092	0.109	06/01/13	4			
		0.345	0.035	0.439	0.044	0.256	0.026	0.050	0.005	1.090	0.109	07/01/13	5			
		0.405	0.041	0.451	0.045	0.178	0.018	0.050	0.005	1.085	0.108	02/05/13	6			
		0.405	0.041	0.451	0.045	0.178	0.018	0.050	0.005	1.085	0.108	03/01/13	6			
		0.407	0.041	0.453	0.045	0.168	0.017	0.050	0.005	1.078	0.108	01/01/14	8			
		0.407	0.041	0.453	0.045	0.168	0.017	0.050	0.005	1.078	0.108	02/01/14	8			
		0.160	0.016	0.480	0.048	0.370	0.037	0.050	0.005	1.059	0.106	08/01/13	10			
		0.405	0.041	0.365	0.036	0.216	0.022	0.050	0.005	1.036	0.104	05/01/13	11			
		0.065	0.006	0.531	0.053	0.350	0.035	0.038	0.004	0.984	0.098	10/01/13	12			
		0.065	0.006	0.522	0.052	0.250	0.025	0.032	0.003	0.869	0.087	09/01/13	13			
Eulachon Juv <2g	54,625,000	22,199.603	0.041	0.083	0.000	0.022	0.000	4791.614	0.009	26991.322	0.049	12/01/13	1	Mean	10251.969	0.019
		0.025	0.000	0.114	0.000	20847.833	0.038	4791.614	0.009	25639.586	0.047	08/01/13	2	Min	1846.083	0.003
		0.009	0.000	23686.108	0.043	0.074	0.000	0.009	0.000	23686.199	0.043	10/01/13	3	Max	26991.322	0.049
		0.009	0.000	16777.894	0.031	0.080	0.000	0.011	0.000	16777.993	0.031	11/01/13	4			
		0.083	0.000	0.080	0.000	0.028	0.000	4791.614	0.009	4791.804	0.009	04/01/13	5			
		0.071	0.000	0.071	0.000	0.046	0.000	4791.614	0.009	4791.803	0.009	06/01/13	6			
		0.083	0.000	0.080	0.000	0.026	0.000	4791.614	0.009	4791.803	0.009	02/05/13	7			
		0.083	0.000	0.080	0.000	0.026	0.000	4791.614	0.009	4791.803	0.009	03/01/13	7			
		0.049	0.000	0.093	0.000	0.046	0.000	4791.614	0.009	4791.802	0.009	07/01/13	9			
		0.082	0.000	0.083	0.000	0.022	0.000	4791.614	0.009	4791.802	0.009	01/01/14	10			
		0.082	0.000	0.083	0.000	0.022	0.000	4791.614	0.009	4791.802	0.009	02/01/14	10			
		0.083	0.000	0.057	0.000	0.046	0.000	4791.614	0.009	4791.801	0.009	05/01/13	12			
		0.009	0.000	1845.998	0.003	0.068	0.000	0.009	0.000	1846.083	0.003	09/01/13	13			

6. Monitoring – Underwater Noise

The project will conduct underwater noise monitoring to test the effectiveness of noise attenuation devices. Testing will occur according to an Underwater Noise Monitoring Plan based on the most recent version of the Underwater Noise Monitoring Plan Template[17]. This template was developed in cooperation with the NMFS, USFWS, and WSDOT, and has been approved by NMFS and USFWS for use in Section 7 ESA consultations for transportation projects in Washington State. The plan will be prepared by the construction team, with review and approvals by FHWA, FTA, NMFS, USFWS, and the contract managers.

Testing will occur according to protocols outlined in the Underwater Noise Monitoring Plan. Underwater noise monitoring will occur as follows:

- Hydroacoustic monitoring will occur for a representative number of piles per structure (minimum of five piles installed with an impact hammer).
- Monitoring will occur for piles driven in water depths that are representative of typical water depths found in the areas where piles will be driven.
- Ambient sound levels will be measured as outlined in the template in the absence of pile driving.

A report that analyzes the results of the monitoring effort will be submitted to the Services as outlined in the monitoring plan template.

This requirement for preparation and adherence to this plan is being placed in the project's minimization measures, as discussed in Section 7 of this document.

[17] Available at: http://www.wsdot.wa.gov/Environment/Air/Noise.htm.

7. Minimization Measures

The CRC project received input and refined project designs several times to minimize impacts to listed species in the action area while still ensuring project constructibility. The CRC team also met with regulatory agencies during regular pre-BA and agency coordination meetings and with construction experts on several occasions to refine its construction techniques. Through this process, the CRC team has developed and refined project timing that minimizes impacts to listed species and is feasible to construct. These refinements are outlined below:

4. Original design for bridge foundation was to impact drive 96, 8-foot-diameter steel piles to support the bridge pier system. Piles were to be driven for a 2-3 year period with no in-water work window (IWWW) restrictions.

1. Revised design for bridge foundation to install drilled shafts for permanent piles rather than impact hammer pile driving. A total of 108, 10-foot-diameter drilled shafts in-water (now reduced to approximately 92) would support the piers. Temporary pilings to support the necessary work platforms and work bridges would be installed by impact hammer with no IWWW restrictions.

2. Revised design so that the temporary pilings to support the work platforms and bridges would be installed by impact hammer during the proposed “hydroacoustic in-water work window” (HIWWW) of 20 weeks (discrete 2-week periods throughout calendar year).

3. Revised design so that the temporary pilings to support the work platforms and bridges would be installed by impact hammer during proposed HIWWW of 23 weeks (October to mid-February).

4. Current design calls for installation of the temporary pilings to support the work platforms and work bridges by vibratory means, then “proofing” the piles by impact hammer to verify load-bearing capacity and conformance to DOT specifications. Propose HIWWW of 31 weeks (September 15 through April 15).

By integrating the changes outlined above, the schedule for construction of the CRC project has changed appreciably. Based on the above construction scenarios, timelines for overall construction schedules are listed below:

- Scenario #1 (driving 96-inch piles year-round) = 34 months.
- Scenario #2 (drilled shafts, temporary piles, no IWWW) = 44 months.
- Scenario #3 (drilled shafts 20-week ‘floating’ HIWWW for temporary piles) = 48 to 58 months.
- Scenario #4 (drilled shafts, 23-week HIWWW for temporary piles) = 52 to 63 months.
- Scenario #5 (drilled shafts, vibrate then proof within 31-week HIWWW for temporary piles) = 48 to 56 months.

7.1 Hydroacoustics

7.1.1 Minimization Measure 1 – Drilled Shafts for Foundations

Permanent foundations for each in-water pier will be installed by means of drilled shafts. This approach significantly reduces the amount of impact pile driving, the size of piles, and amount of in-water noise.

7.1.2 Minimization Measure 2 – Piling Installation with Impact Hammers

Installation of piles using impact driving may only occur between September 15 and April 15 of the following year. On an average workday, six piles will be installed using vibratory installation to set the piles; then impact driving to drive the piles to refusal per project specifications to meet load-bearing capacity requirements. This method reduces the number of daily pile strikes over 90 percent. No more than two impact pile drivers may be operated simultaneously within the same waterbody channel.

In waters with depths more than 0.67 meter (2 feet), a bubble curtain or other sound attenuation measure will be implemented for impact driving of pilings. If a bubble curtain or similar measure is used, it will distribute small air bubbles around 100 percent of the piling perimeter for the full depth of the water column. Any other attenuation measure (e.g., temporary noise attenuation pile) must provide 100 percent coverage for the full depth of the pile.

A performance test of the noise attenuation device in accordance with the approved hydroacoustic monitoring plan shall be conducted prior to any impact pile driving. If a bubble curtain or similar measure is utilized, the performance test shall confirm the calculated pressures and flow rates at each manifold ring.

7.1.3 Minimization Measure 3 – Impact Pile Installation Hydroacoustic Performance Measure

Sound pressure levels from an impact hammer will be measured in accordance with the hydroacoustic monitoring plan. Recording and calculation of accumulated sound exposure levels shall be performed. Analysis of the data shall be used to calculate exposure factors as defined in Section 3.2 of this document. Exposure factors shall be calculated using the moving fish model, based on a fish of over 2 grams with a movement rate of 0.1 meters per second. Exposure factors shall account for all attenuated and unattenuated impact pile driving in both the mainstem Columbia River and North Portland Harbor. The accumulated sound exposure level shall be recorded.

The following thresholds shall not be exceeded:

1. The maximum weekly exposure factor shall not exceed 0.18649, based on one calendar week. The weekly exposure factor is defined as the proportion of channel affected by impact pile driving as measured by accumulated sound exposure level multiplied by the proportion of a 24-hr day affected multiplied by the proportion of calendar week affected.

2. The maximum yearly (calendar year) total exposure factor shall not exceed 0.20218. The maximum yearly exposure factor is the sum of all weekly exposure factors in one calendar year.

3. The average yearly exposure factor shall not exceed 0.12009 per calendar year of construction. The average yearly exposure factor is the mean value of all yearly total exposure factors.
4. A total exposure factor of 0.48036 shall not be exceeded throughout the construction period of the project. The total exposure factor equals the sum of all weekly exposure factors throughout the project.

One 12-hour rest period will occur each workday in which no impact pile driving will occur. In addition, to limit the exposure of migrating fish that may be present in the behavioral disturbance zone,[18] impact striking of piles that produce hydroacoustic levels over 150 dB RMS will not occur for more than 12 hours per workday. Unattenuated pile striking may occur to meet the requirements of the hydroacoustic monitoring plan or account for malfunction of the noise attenuation device, but will not occur for more than 300 impact pile strikes per week in the mainstem Columbia River and no more than 150 impact pile strikes per week in North Portland Harbor. To ensure that this measure is not being exceeded, an approved hydroacoustic monitoring plan will be in place to test a representative number of piles installed during the project (see Section 7.1.5, Minimization Measure 5).

If the predicted accumulated sound exposure level exceeds the levels described above, then the Services will be contacted within 24 hours to determine a course of action, so that incidental take estimates are not exceeded. Necessary steps may include modifications to the noise attenuation system or method of implementation.

7.1.4 Minimization Measure 4 – Hydroacoustic Monitoring

The project will conduct underwater noise monitoring to test the effectiveness of noise attenuation devices. Testing will occur according to an underwater noise monitoring plan based on the most recent version of the Underwater Noise Monitoring Plan Template.[19] This template was developed in cooperation with the NMFS, USFWS, and WSDOT, and has been approved by NMFS and USFWS for use in Section 7 consultation for transportation projects in Washington State.

Testing will occur according to protocols outlined in the Underwater Noise Monitoring Plan (WSDOT 2008). Underwater noise monitoring will occur as follows:

- Hydroacoustic monitoring will occur for a representative number of piles per structure (minimum of five piles installed with an impact hammer).
- Monitoring will occur for piles driven in water depths that are representative of typical water depths found in the areas where piles will be driven.
- Ambient sound levels will be measured as outlined in the template in the absence of pile driving.

A report that analyzes the results of the monitoring effort will be submitted to the Services as outlined in the monitoring plan template.

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[18] Behavioral disturbance is expressed in dB RMS re: 1 μPa.

[19] Available at: http://www.wsdot.wa.gov/Environment/Air/Noise.htm.

Unattenuated impact pile driving for obtaining baseline sound measurements will be limited to the number of piles necessary to obtain an adequate sample size for the project, as defined in the final Hydroacoustic Monitoring Plan.

7.1.5 Minimization Measure 5 – Biological Monitoring

A qualified biologist will be present during all impact pile driving operations to observe and report any indications of dead, injured, or distressed fishes, including direct observations of these fishes or increases in bird foraging activity.

8. Discussion of Model Assumptions

Several assumptions were integrated into the approach and analyses of this report. The majority of these assumptions relate to fish movement in the project area.

The conveyer belt analogy of fish moving through the area of effect, as used in the moving fish model, assumes fish swim in a straight line. Additionally, the model does not account for differential fish distribution across the Columbia River's wide channel (with some variation in velocities across the channel) or changes to fish transits rates on a daily or seasonal basis.

Therefore, the assumptions in Table 8-1 regarding fish movement through the project area were evaluated to determine if channel use or transit rate by time of day or season required weighting to assess fish run impacts more accurately. For example, if subyearling salmon only use nearshore areas, the area of the cross-sectional of the channel where exposure would be modeled would only include depths of 20 feet or less. Because many anecdotal references, but few published or gray literature sources addressing this topic exist, the CRC project made final model assumptions based on input from NMFS at the December 15 pre-consultation meeting.

Table 8-1. Feedback on Fish Channel Use and Movement Assumptions

Assumption Evaluated	NMFS Recommendation (Yes/No/Unknown)	Revised Assumption	Notes
1. Channel use by subyearlings is primarily near-shore.	No	Channel use by yearlings is uniform.	Juveniles are conceivably near shore, but subyearlings (<62 mm) generally go where the flow is. Multiple studies show young use the nearshore, but others show they are in the channel.
2. Channel use by yearlings is uniform.	Yes	No change	Agreement. Incorporated into impact model.
3. Channel use by adults is uniform.	Unknown	No change	CRC apportioned 72.7 percent of runs to the Columbia River and 27.3 percent of runs to North Portland Harbor to reflect this. CRC will continue to track research on this topic.
4. Migration is uniform throughout a 24-hr day.	Unknown	No change	CRC will continue to track research on this topic.
5. Fish swim in a straight line.	Yes	No change	Although all agreed this is not a likely scenario, the group (consisting of NMFS and CRC) agreed to keep this assumption in the model.

For the current analysis, it was assumed that all ESUs/DPSs and life stages utilize the river cross-channel equally and their timing is uniform throughout the day. The assumptions for adult cross-channel use and differential use of the channel on a daily basis may change as more data becomes available.

8.1 Recap of Key Assumptions

These assumptions used to prepare the analyses presented in this report are discussed below.

- Instantaneous velocities of all life stages in the project area.
    - Assumption: Assumed fish speeds through the project area are discussed in Section 4 of this document. The CRC team assumed that adult salmon traveled at approximately 0.1 m/s; juvenile chum and eulachon traveled with the current at a speed of 0.6 m/s; and other juveniles traveled at speeds of 0.8 m/s. The difference in threshold diameters and exposure factors between stationary fish and fish moving at 0.1 m/s are negligible. If adult fish moved faster than 0.1 m/s, exposure and impacts would decrease. Juvenile chum and eulachon are most affected by the currents within the Columbia River. During low flows and high incoming tidal influence, travel rates would likely decrease. Other over-estimates of impact driving time may counteract slightly slower fish speeds at specific times.
- Knowledge of specific channel usage by all fish.
    - Assumption: Without specific, quantifiable documentation of channel usage by each ESU/DPS and life stage, the impact assessment model used the assumption that fish presence was uniform in the channel. Although in many cases, it is expected that certain fish may tend to travel in certain portions of the channel preferentially, the authors of this report could not verify and quantify the extent of the preference. The overlap between channel usage and driving at a specific pier location could provide detailed estimates of impacts, but it could also result in false precision. Because the modeled pile driving sequence is based on a small number of possible scenarios for construction, utilizing the scenarios here in an effort to pinpoint specific impacts on specific runs at specific locations was not be attempted. Actual construction sequencing will likely differ. By assuming equal channel usage at this time, the modeled impacts presented in this document may be used as estimates, rather than as detailed, but inaccurate, forecasted results.
- Knowledge of typical and atypical behaviors around pile driving.
    - Assumption: Although commonly thought that fish avoid impact pile driving noise, anecdotal evidence suggests that fish do not routinely avoid pile driving. The reasons for this are unclear, but could result from this type of noise being novel or that sound travels in such a way that fish cannot sense the direction of the noise's origin. For this model, it was assumed that all fish travel in a straight line through the project area, and are neither deterred nor enticed by the impact driving noise.
- Modeled information on additive noise due to multiple pile drivers in proximity and farther apart.
    - Assumption: Hydroacoustic information when more than one pile driver is in operation is not available. This project assumed that sound from two or more pile drivers would not be additive.

Without proposed pile driving sequences for both North Portland Harbor and the Columbia River, and without specific information on fish usage of North Portland Harbor, it is not possible to accurately estimate impacts to listed fish that use one channel preferentially. In the absence of specific channel usage information, the CRC project team suggests using the modeled impacts from the Columbia River construction to estimate impacts from both North Portland Harbor and Columbia River activities. The reasons for this include:

- The Columbia River impacts assume that 100 percent of a run passing through the area uses the Columbia River and that all impacts occur in the Columbia River
- Construction impacts are generally in proportion to the width of both water bodies, so when additional construction impacts in North Portland Harbor are calculated they will include factors for the additional width of North Portland Harbor.

9. Conclusions

The CRC project team has developed unique analytical tools and comprehensive fish run timing for the project area. The CRC project developed calculations to determine “exposure factors” that combine project variables such as numbers of impact pile strikes, timing of pile strikes, fish speeds, fish mass, and pile driving locations in the Columbia River or North Portland Harbor. Exposure factors were calculated for daily, weekly, annual, and project-life periods. The project utilized fish timing information from resource agency staff and coordinated extensively with these staff to develop acceptable analysis methods for determining effects on fish populations and to minimize construction impacts.

The CRC team made several assumptions in the absence of defensible data in the form of primary literature or recent research. Among these assumptions were:

- Unattenuated pile strike numbers (totaling 300 strikes one day per week).
- Days of impact pile driving in the Columbia River (varied between 138 and 142).
- Fish speed through the project area.
- Fish distribution in the channel in the project area.

In these instances, the project used values that would result in slight overestimates of impacts. Assumptions were discussed with NMFS, ODFW, WDFW, and FPAC representatives on several occasions between August 2009 and the present. Those representatives concurred with the assumptions used in the model presented in the report. These conservative assumptions were used in the absence of site-specific, species-specific data to allow regulatory agencies to err on the side of caution when analyzing impacts.

The CRC team calculated potential impacts on listed salmon and eulachon ESUs/DPSs and life stages that occur in the project area. Based on the exposure to fish in the project area from hydroacoustic noise, impacts to any single ESU/DPS and life stage of listed salmonids and eulachon will be no more than 0.475 percent in a given year and no more than 1.004 percent (cumulative) over a four-year construction period. Most runs experience relatively no impacts in any year. Most impacts appear to occur to those fish that originate and return to the lower Columbia River, rather than those runs that migrate into the middle or upper Columbia River and its tributaries. Columbia River chum adults appear to be the most impacted, at mean of 0.808 cumulative percent (range = 0.432 to 1.004). Also based on the calculations performed, 9 of the 14 adult runs are estimated to experience less than a mean 0.2 cumulative percent of potential impact and 11 of the 14 juvenile fish runs are estimated to have less than a mean 0.1 cumulative percent of potential impact. The exceptions include CR chum, UWR Chinook, and LCR coho juveniles.

Impacts to listed fish are unavoidable but have been reduced through minimization measures related to timing, extent, and duration of pile driving. A monitoring program will be put in place during construction to validate the assumptions made in this report, and to document pile strike noise.

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