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**Mainstem Klamath River Fall Chinook Salmon Redd Survey 2012**

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*Abstract.*—This report summarizes the 2012 fall Chinook salmon *Oncorhynchus tshawytscha* redd survey on the mainstem Klamath River and is the 20th such summary provided by the Arcata Fish and Wildlife Office. The survey was conducted over an 8-week period (October 10 to November 28, 2012), covering 114.7 river kilometers (rkm) between the Shasta River (rkm 288.5) and Indian Creek (rkm 173.8). We observed 2,932 and interpolated an additional 458 fall Chinook salmon redds in 2012, which was the highest number for this section of river since annual surveys began in 1993. Redd counts over the previous 19-year history of this survey ranged from 243 (in 1993) to 2,539 (in 2002). The 2012 count was about 3.7 times larger than the prior 19-year mean ( $\bar{x} = 906$ ). Of the five reaches surveyed, China Point (rkm 192.4) to Indian Creek had the most redds ( $n = 1,309$ ; 44.6%) and the least number of redds ( $n = 230$ ; 7.8%) occurred between the Shasta River (rkm 288.4) and Beaver Creek (rkm 261.9) confluences.

### Introduction

The Klamath River drains approximately 14,000 km<sup>2</sup> in Oregon and 26,000 km<sup>2</sup> in California. The majority of the watershed in California is within the boundaries of the Six Rivers, Klamath, and Shasta–Trinity National Forests (Figure 1). The Yurok Tribe's reservation, comprising about 219 km<sup>2</sup>, borders the lower 68 river km (rkm) of the Klamath River. The Hupa Valley Tribe's reservation (365 km<sup>2</sup>) is located on the Trinity River upstream of the confluence of the Klamath and Trinity Rivers. The Karuk Tribe's ancestral territory extends along the Klamath River from Bluff Creek to Southern Oregon. The largest tributaries in the basin include the Trinity, Salmon, Scott, and Shasta rivers. Iron Gate Dam (IGD), located 310.3 rkm upstream of the river mouth, is a barrier to upstream passage of anadromous salmonids. Iron Gate Hatchery, located near the base of IGD, was constructed in 1966 to mitigate for losses in natural fish production that resulted from dam construction (USFWS 1991).

The Klamath River Basin historically supported large runs of Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, and steelhead *O. mykiss*, which

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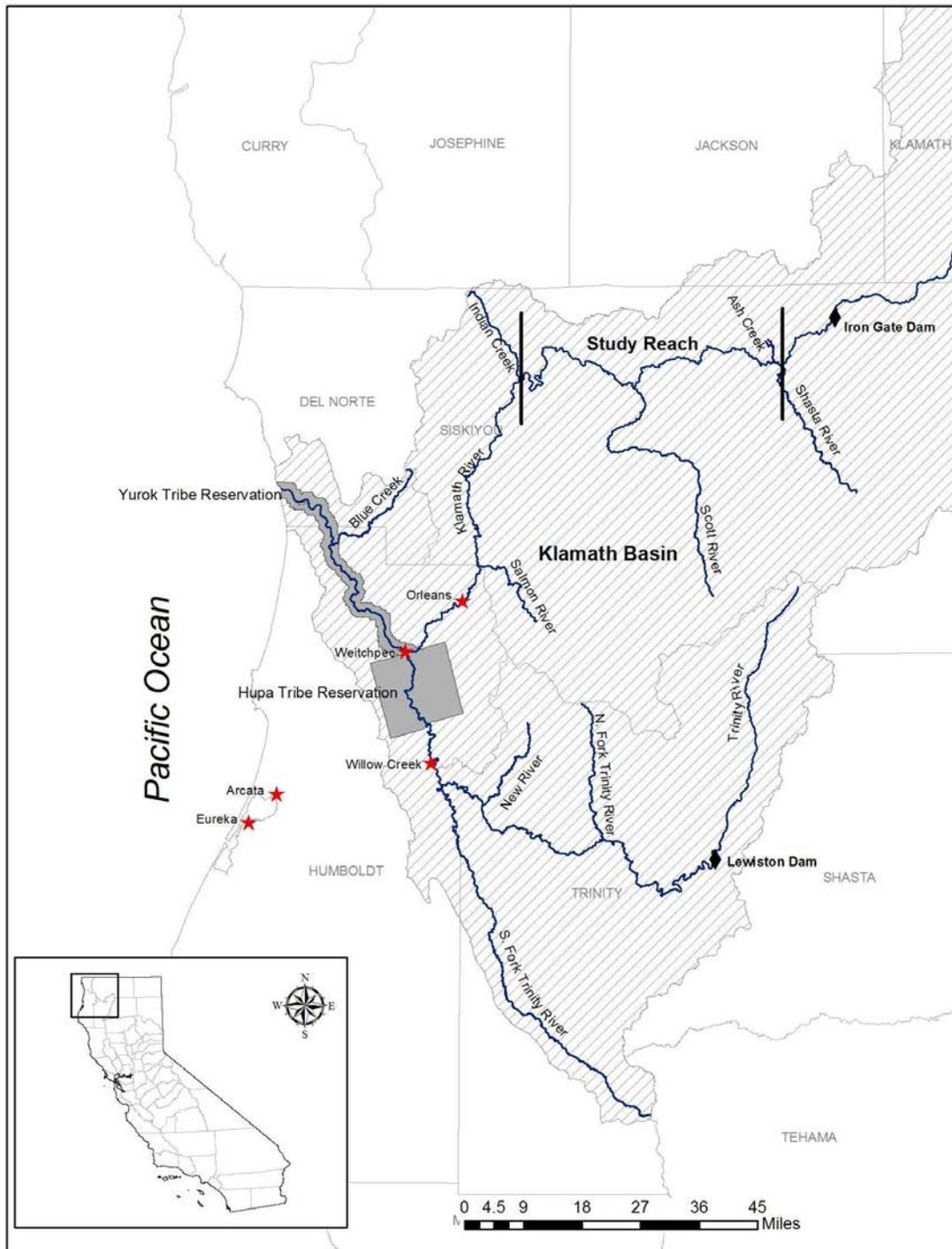


Figure 1. Klamath River Basin, northern California. The mainstem Klamath River redd survey study area extends from the Shasta River to the Indian Creek confluence.

contribute to the economically and culturally important subsistence, sport, and commercial fisheries (Leidy and Leidy 1984). Generations of Native Americans have fished in the drainage, with catches of salmon, steelhead, lamprey, and sturgeon historically providing the mainstay for the tribes. Sport fishing for salmon and steelhead in the drainage may exceed 200,000 angler-days annually (Leidy and Leidy 1984). During the 1980's, the Klamath River stocks accounted for up to 30% of commercial Chinook salmon landings in northern California and southern Oregon, averaging about 450,000 Chinook salmon per year (PFMC 1988). Since 1991, ocean allocations have decreased considerably for a variety of reasons. Some of these reasons include variability in the abundance of Klamath Basin fall Chinook salmon, harvest sharing between tribal and non-tribal fisheries (ocean and in river), and harvest restraints to limit impacts on species listed under the Endangered Species Act. In 2012 the ocean sport and commercial harvest of 3- and 4-year old fall Chinook salmon was 40,335 (KRTT 2013a).

Like populations in other river systems in the Pacific Northwest, Chinook salmon in the Klamath River Basin are susceptible to habitat degradation and over-exploitation, as reflected by declining runs in recent decades (USFWS 1991). Expanded logging and fishing operations, construction of roads and dams, agricultural use, mining, and other forms of anthropogenic development have led to increased concern about the depletion of anadromous salmonid populations and habitat in the basin (Ayres Associates 1999; Flint and Flint 2008).

On October 27, 1986, the United States Congress enacted Public Law 99-552, the Klamath River Fish and Wildlife Restoration Act. Functioning under the guidance of the Klamath River Fishery Management Council (USFWS 1991), this act authorized the Secretary of the Interior to restore anadromous fish populations to optimum levels in the Klamath River Basin through the creation of the Klamath River Basin Conservation Area Restoration Program (KRBCARP). The U.S. Fish and Wildlife Service (USFWS) was funded through the KRBCARP to identify fall Chinook salmon spawning areas and timing and to collect information necessary to estimate the number of natural fall Chinook salmon spawning in the mainstem Klamath River between IGD and the confluence with Indian Creek (rkm 173.8; Figure 1). In 1993, the USFWS started conducting fall Chinook salmon redd surveys to estimate escapement within this section of the mainstem Klamath River. In 2001, the USFWS added carcass mark-recapture methods to better estimate escapement in the more densely used spawning area between IGD and the Shasta River confluence (rkm 288.5; Gough and Williamson 2012). During the five years when both carcass and redd surveys were conducted in this stretch of the river (2001 to 2004, 2006), the ratio of the successfully spawned female escapement estimate to observed redds ranged from 3.3:1 (2002) to 4.8:1 (2003), demonstrating that carcass mark-recapture is a more accurate estimator of escapement in this section of river. Below the Shasta River there are not enough carcasses found to conduct a mark-recapture survey. However, the negative downstream decay of the successfully spawned females–redd ratio within the carcass study area suggests that redd surveys in the less-densely used spawning area below the Shasta River confluence provide a sufficient escapement estimate (Gough and Williamson 2012). This report summarizes the 2012 redd surveys

in the mainstem Klamath River between Shasta River and Indian Creek. The Klamath River Technical Team (KRTT) uses this information to assess basin-wide spawning escapement and to generate stock projections for harvest management (KRTT 2013b).

## Methods

### Survey Reaches

The survey area was divided into six reaches based on accessibility and distance that a single crew could survey in a day (Figure 2; Table 1). Reach 1 (IGD to Shasta River) was not surveyed in 2012 because a carcass mark-recapture estimator is now used to derive the number of fall Chinook salmon that spawn in this reach. This was the seventh year (2005, 2007-2012) since 1993 that this reach was not included in the redd survey. Reach 2 is between the Shasta River and Beaver Creek confluences. The upper 2.8 rkm in Reach 2, from the Shasta River to Ash Creek, was not surveyed because past surveys revealed little to no spawning activity in this section of the river. We assumed no redds were constructed in this short stretch in 2012.

### Data Collection

#### *Redd Data*

Weekly visual redd counts were conducted on the five mainstem reaches from the Shasta River to Indian Creek (Table 1). Two crews, each consisting of a rower and observer, aided by polarized glasses, surveyed the river by cataraft. Rafts were oared downstream and maneuvered in a zigzag pattern over spawning areas in order to sufficiently census redds. Side and split channels were surveyed by foot or floated on alternating weeks. Crews were assigned the same survey reaches throughout the sampling period with the belief that increased familiarity with spawning areas facilitates accurate redd counts.

Flagging was used to mark redd locations. Flags were attached to vegetation on the riverbank just downstream of the last observed redd within a habitat unit. A different flag color was used each week to distinguish redd counts on subsequent surveys. Each flag was labeled with the following information: date, surveyors, location (nearest 0.05 rkm), numbers of old and new redds, and location in channel. GPS coordinates were taken at each lone redd or at the center of a cluster of redds. Reach, flag location, GPS coordinates, numbers of old and new redds, location in channel, distance from bank, and age(s) of redd(s) were recorded on data forms. Redd ages were estimated according to a scale of 1 to 3 where:

- 1 = less than two weeks old, characterized by bright substrate, little or no periphyton, and a well-developed mound;
- 2 = two to four weeks old, characterized by a slightly flattened mound and dulled substrate due to periphyton growth;
- 3 = older than four weeks, identifiable only by the presence of a remnant pit and mound. The brightness of the substrate on age code '3' was typically not distinguishable from that of the surrounding substrate.



Table 1. Location and length of mainstem Klamath River fall Chinook salmon redd survey reaches.

Reach number	Upper boundary		Lower boundary		Reach length (rkm)
	Location	rkm	Location	rkm	
1 <sup>a</sup>	Iron Gate Dam	310.3	Shasta River	288.4	21.9
2 <sup>b</sup>	Shasta River <sup>c</sup>	288.4	Beaver Creek	261.9	26.5
3 <sup>d</sup>	Beaver Creek	261.9	Blue Heron	234.3	27.6
4 <sup>b</sup>	Blue Heron	234.3	Seiad Bar	213.6	20.7
5 <sup>d</sup>	Seiad Bar	213.6	China Point	192.4	21.2
6 <sup>e</sup>	China Point	192.4	Indian Creek	173.8	18.6

<sup>a</sup> Reach 1 not surveyed for redds (escapement in this reach estimated from carcass mark-recapture surveys by USFWS and the Yurok Tribe).

<sup>b</sup> Surveyed by Karuk Tribe crew.

<sup>c</sup> The section of river between Shasta River and Ash Creek (rkm 285.7) was not surveyed because past surveys revealed little to no spawning activity in this area.

<sup>d</sup> Surveyed by USFWS crew.

<sup>e</sup> Reach 6 was split at Gordons Ferry (rkm 185.0) and surveyed by Karuk Tribe and USFWS crews.

Only completed redds, identified by a pit and mound, were counted. Test redds (i.e., those without a completed pit and mound) were not included in the count.

### *Water Quality*

Water temperature was recorded using a HOBO Water Temp Pro v2 Model Number U22-001 (Onset Computer Corporation, Bourne, Massachusetts) placed below the bridge at the Iron Gate Hatchery (rkm 309.9) and below Seiad Valley by the U.S. Geological Survey (USGS) Gaging Station 11520500 (rkm 206.8). Temperatures were recorded at 0.5-hr intervals throughout the survey period. Secchi disk depth was measured each survey as an indicator of water visibility.

### *Discharge*

Mean daily river flow was obtained from the USGS gaging stations 11516530, located in the Klamath River just downstream of IGD, and 11520500, in the Klamath River below Seiad Valley, California.

## Data Analysis

### *Adult and Jack Escapement Estimates*

The total number of single-counted redds in this survey were used to estimate adult and jack (age-2 males) fall Chinook salmon escapement that spawned between the Shasta River and Indian Creek. Assuming each redd represented one male and one female adult salmon, adult escapement ( $N_{adult}$ ) was estimated by multiplying the total redd count ( $R$ ) by two:

$$\hat{N}_{adult} = 2R.$$

The age composition of mainstem Chinook salmon from the IGD–Shasta River carcass survey (KRTT 2013b) was used as a surrogate for apportioning escapement by age class in the mainstem Klamath River below the Shasta River. Jack (age-2 fish) escapement ( $N_{jack}$ ) was estimated by:

$$\hat{N}_{jack} = \frac{\hat{N}_{adult}}{(1 - P_{age2})} - \hat{N}_{adult},$$

where  $P_{age2}$  is the jack proportion based on scale readings from the carcass survey.

### *Redd Densities*

Redd densities were calculated at both the reach and 10-rkm spatial distribution levels in previous years. The latter analysis provides an improved spatial resolution of redd distribution. However, data was lost during Calendar Week (CW) 44 of the redd survey. We were able to estimate of the number of missed redds (see below) but not assign locations. Therefore this year we are only reporting redd distribution at the reach spatial scale.

## Results and Discussion

### **Adult and Jack Escapement**

Correlative measures in both space (adjacent reaches) and time (weeks prior to or after the missing values) were used to estimate the number of redds for CW 44 due to an inability to survey Reach 4 during CW 43 (punctured raft) and a lost data form for CW 44 (Table 2). A model was used to predict the sum of Reach 4 counts for CW 43 and 44. Since the 2012 Klamath river escapement was much larger than usual, we considered only the largest escapements among prior years for construction of our predictive equation (years 2001, 2002, 2003, and 2009). For model selection, we first evaluated the predictive performance of each potential variable separately. Only the sum of Reach 3 counts for CW 43 and 44 and the CW 42 count for Reach 4 were strongly associated with the sum of Reach 4 counts for CW 43 and 44 in prior years. We next evaluated if the model, combining both remaining candidate variables, fit better than each variable on their own (Table 3). Based on Akaike Information Criterion (AIC), the model with both terms fits best. We used the best fitting model to predict the sum of the redd counts for CW 43 and 44 in Reach 4, which resulted in an estimate of 458 (95% CI: 407–508).

Table 2. Weekly count summary of mainstem Klamath River fall Chinook salmon redds, 1993 to 2012 [Ns = no survey, R1 = Iron Gate Dam to Shasta River, R2 = Shasta River to Beaver Creek (note: the 2.8-rkm section from the Shasta River to Ash Creek was not surveyed and assumed to have no redds), R3 = Beaver Creek to Blue Heron river access, R4 = Blue Heron river access to Seiad Bar, R5 = Seiad Bar to China Point, R6 = China Point to Indian Creek].

Year	Calendar		Reach						Total
	Week	Survey dates	R1	R2	R3	R4	R5	R6	
1993	43	Oct 25 to 29	15	13	30	18	16	81	173
	44	Nov 1 to 5	67	24	4	1	15	5	116
	45	Nov 8 to 12	5	1	18	7	0	1	32
	46	Nov 15 to 18	0	0	4	5	0	0	9
		Reach Total	87	38	56	31	31	87	<b>330</b>
		Percent of Total	26.4%	11.5%	17.0%	9.4%	9.4%	26.4%	
1994	42	Oct 17 to 21	89	28	48	Ns	Ns	98	263
	43	Oct 24 to 28	278	59	77	113	98	124	749
	44	Oct 31 to Nov 4	375	20	46	42	16	33	532
	45	Nov 7 to 11	86	Ns	Ns	Ns	Ns	Ns	86
	46	Nov 14 to 18	3	2	7	4	5	5	26
		Reach Total	831	109	178	159	119	260	<b>1,656</b>
	Percent of Total	50.2%	6.6%	10.7%	9.6%	7.2%	15.7%		
1995	42	Oct 16 to 20	138	12	70	26	30	139	415
	43	Oct 23 to 27	598	82	199	94	91	169	1,233
	44	Oct 30 to Nov 3	727	58	78	35	57	112	1,067
	45	Nov 6 to 10	277	26	49	13	25	50	440
	46	Nov 13 to 17	Ns	Ns	Ns	Ns	Ns	Ns	0
	47	Nov 20 to 24	Ns	Ns	Ns	Ns	Ns	Ns	0
	48	Nov 27 to Dec 1	39	9	14	4	12	3	81
		Reach Total	1,779	187	410	172	215	473	<b>3,236</b>
	Percent of Total	55.0%	5.8%	12.7%	5.3%	6.6%	14.6%		
1996	43	Oct 21 to 25	290	31	96	10	118	39	584
	44	Oct 28 to Nov 1	291	29	25	22	42	92	501
	45	Nov 4 to 8	83	4	24	8	33	59	211
	46	Nov 11 to 15	40	0	6	0	7	23	76
		Reach Total	704	64	151	40	200	213	<b>1,372</b>
	Percent of Total	51.3%	4.7%	11.0%	2.9%	14.6%	15.5%		
1997	42	Oct 16	272	Ns	Ns	Ns	Ns	Ns	272
	43	Oct 20 to 24	252	37	69	89	29	136	612
	44	Oct 27 to 31	424	18	76	52	22	76	668
	45	Nov 3 to 7	70	7	13	16	8	27	141
	46	Nov 10 to 14	2	14	4	5	3	18	46
		Reach Total	1,020	76	162	162	62	257	<b>1,739</b>
	Percent of Total	58.7%	4.4%	9.3%	9.3%	3.6%	14.8%		

Table 2. (Continued). Weekly summary and percent of total of mainstem Klamath River fall Chinook salmon redds 1993 to 2012 [Ns = No Survey, R1 = Iron Gate Dam to Shasta River, R2 = Ash Creek to Beaver Creek (note: the 2.8 rkm section from the Shasta River to Ash Creek was not surveyed and assumed to have no redds), R3 = Beaver Creek to Blue Heron river access, R4 = Blue Heron river access to Seiad Bar, R5 = Seiad Bar to China Point, R6 = China Point to Indian Creek].

Year	Calendar		Reach						Total
	Week	Survey dates	R1	R2	R3	R4	R5	R6	
1998	42	Oct 14 to 15	89	Ns	Ns	Ns	Ns	Ns	89
	43	Oct 19 to 23	180	45	67	15	20	45	372
	44	Oct 26 to 30	368	11	12	14	7	39	451
	45	Nov 2 to 6	226	22	33	10	9	28	328
	46	Nov 9 to 12	135	3	11	3	2	2	156
	47	Nov 15 to 19	12	1	3	0	1	2	19
		Reach Total	1,010	82	126	42	39	116	<b>1,415</b>
	Percent of Total	71.4%	5.8%	8.9%	3.0%	2.8%	8.2%		
1999	41	Oct 13 to 15	98	3	Ns	Ns	Ns	Ns	101
	42	Oct 18 to 22	200	27	31	17	23	39	337
	43	Oct 25 to 27	304	23	20	Ns	Ns	Ns	347
	44	Nov 1 to 5	83	12	9	8	8	19	139
	45	Nov 8 to 12	37	2	2	1	5	11	58
	46	Nov 15 to 19	1	2	0	2	2	0	7
		Reach Total	723	69	62	28	38	69	<b>989</b>
	Percent of Total	73.1%	7.0%	6.3%	2.8%	3.8%	7.0%		
2000	42	Oct 16 to 20	327	92	69	25	10	19	542
	43	Oct 23 to 27	146	62	34	52	10	53	357
	44	Oct 30 to Nov 3	254	42	69	54	20	86	525
	45	Nov 6 to 10	57	12	15	21	2	16	123
	46	Nov 13 to 17	4	0	9	12	0	6	30
	47	Nov 20 to 22	1	Ns	Ns	Ns	Ns	Ns	1
		Reach Total	788	208	196	164	42	180	<b>1,578</b>
	Percent of Total	49.9%	13.2%	12.4%	10.4%	2.7%	11.4%		
2001	42	Oct 15 to 19	92	24	28	21	2	23	190
	43	Oct 22 to 26	168	102	128	59	40	82	579
	44	Oct 29 to Nov 2	323	97	170	102	55	139	886
	45	Nov 5 to 9	155	10	40	12	31	29	277
	46	Nov 12 to 16	75	31	49	22	9	Ns	186
	47	Nov 19 to 23	Ns	Ns	Ns	Ns	Ns	Ns	0
	48	Nov 26 to 30	17	Ns	Ns	Ns	Ns	Ns	17
	49	Dec 3 to 7	Ns	Ns	12	Ns	Ns	5	17
	50	Dec 10 to 14	Ns	5	8	4	3	Ns	20
		Reach Total	830	269	435	220	140	278	<b>2,172</b>
	Percent of Total	38.2%	12.4%	20.0%	10.1%	6.4%	12.8%		
2002	41	Oct 10	8	Ns	Ns	Ns	Ns	Ns	8
	42	Oct 15 to 18	124	90	120	71	61	146	612
	43	Oct 21 to 25	885	198	340	186	141	181	1,931
	44	Oct 29 to Nov 1	549	112	148	90	69	66	1,034
	45	Nov 4 to 8	335	90	62	38	20	21	566
	46	Nov 12 to 15	136	56	39	46	14	65	356
	47	Nov 19 to 22	76	20	10	10	5	15	136
	48	Nov 26 to 29	Ns	Ns	Ns	Ns	Ns	Ns	0
	49	Dec 2 to 6	0	0	7	0	1	1	9
		Reach Total	2,113	566	726	441	311	495	<b>4,652</b>
	Percent of Total	45.4%	12.2%	15.6%	9.5%	6.7%	10.6%		

Table 2. (Continued). Weekly summary and percent of total of mainstem Klamath River fall Chinook salmon redds 1993 to 2012 [Ns = No Survey, R1 = Iron Gate Dam to Shasta River, R2 = Ash Creek to Beaver Creek (note: the 2.8 rkm section from the Shasta River to Ash Creek was not surveyed and assumed to have no redds), R3 = Beaver Creek to Blue Heron river access, R4 = Blue Heron river access to Seiad Bar, R5 = Seiad Bar to China Point, R6 = China Point to Indian Creek.

Year	Calendar		Reach						Total
	Week	Survey dates	R1	R2	R3	R4	R5	R6	
2003	42	Oct 14 to 17	0	Ns	38	22	19	48	127
	43	Oct 20 to 24	563	194	228	178	77	150	1,390
	44	Oct 27 to 31	553	73	103	18	119	99	965
	45	Nov 4 to 7	310	33	97	61	50	74	625
	46	Nov 12 to 15	44	43	14	11	15	48	175
	47	Nov 19 to 22	2	0	4	2	5	7	20
		Reach Total	1,472	343	484	292	285	426	<b>3,302</b>
	Percent of Total		44.6%	10.4%	14.7%	8.8%	8.6%	12.9%	
2004	42	Oct 11 to 15	Ns	0	6	1	3	0	10
	43	Oct 18 to 22	Ns	57	45	27	17	11	157
	44	Oct 25 to 29	Ns	22	37	9	17	25	110
	45	Nov 1 to 5	513	36	27	14	7	10	607
	46	Nov 8 to 12	Ns	2	10	4	4	3	23
	49	Nov 29 to Dec 3	Ns	0	9	0	0	0	9
		Reach Total	513	117	134	55	48	49	<b>916</b>
	Percent of Total		56.0%	12.8%	14.6%	6.0%	5.2%	5.3%	
2005	42	Oct 18 to 20	Ns	12	14	3	3	27	59
	43	Oct 25 to 27	Ns	10	17	15	17	37	96
	44	Nov 1 to 3	Ns	9	8	8	7	20	52
	45	Nov 8 to 10	Ns	Ns	Ns	Ns	Ns	Ns	0
	46	Nov 15 to 17	Ns	8	1	20	1	31	61
		Reach Total	-	39	40	46	28	115	<b>268<sup>a</sup></b>
	Percent of Total <sup>a</sup>	-	14.6%	14.9%	17.2%	10.4%	42.9%		
2006	42	Oct 16 to 20	109	21	41	66	31	155	423
	43	Oct 23 to 27	167	17	30	61	21	55	351
	44	Oct 30 to Nov 3	96	10	33	12	Ns	6	157
	45	Nov 6 to 10	66	3	9	7	19	110	214
	46	Nov 13 to 15	15	6	4	Ns	Ns	Ns	25
	47	Nov 20 to 24	Ns	Ns	Ns	Ns	Ns	Ns	0
	48	Nov 29	Ns	Ns	Ns	Ns	Ns	16	16
		Reach Total	453	57	117	146	71	342	<b>1,186</b>
	Percent of Total		38.2%	4.8%	9.9%	12.3%	6.0%	28.8%	
2007	42	Oct 16 to 18	Ns	24	17	36	5	42	124
	43	Oct 23 to 25	Ns	12	53	15	25	67	172
	44	Oct 30 to Nov 1	Ns	25	32	47	21	90	215
	45	Nov 5 to 8	Ns	27	24	37	8	72	168
	46	Nov 14 to 16	Ns	1	7	3	5	9	25
	47	Nov 21 to 23	Ns	Ns	Ns	Ns	Ns	Ns	0
	48	Nov 28 to 29	Ns	Ns	3	Ns	1	4	8
		Reach Total	-	89	136	138	65	284	<b>712<sup>a</sup></b>
	Percent of Total <sup>a</sup>	-	12.5%	19.1%	19.4%	9.1%	39.9%		

<sup>a</sup> Reach 1 was not surveyed.

Table 2. (Continued). Weekly summary and percent of total of mainstem Klamath River fall Chinook salmon redds 1993 to 2012 [Ns = No Survey, R1 = Iron Gate Dam to Shasta River, R2 = Ash Creek to Beaver Creek (note: the 2.8 rkm section from the Shasta River to Ash Creek was not surveyed and assumed to have no redds), R3 = Beaver Creek to Blue Heron river access, R4 = Blue Heron river access to Seiad Bar, R5 = Seiad Bar to China Point, R6 = China Point to Indian Creek].

Year	Calendar		Reach						Total
	Week	Survey dates	R1	R2	R3	R4	R5	R6	
2008	42	Oct 15 to 17	Ns	3	24	13	12	12	64
	43	Oct 21 to 23	Ns	61	24	63	10	60	218
	44	Oct 28 to 30	Ns	30	39	49	36	129	283
	45	Nov 4 to 6	Ns	42	33	23	19	108	225
	46	Nov 11 to 13	Ns	6	4	19	14	31	74
	47	Nov 18 to 20	Ns	5	5	3	1	14	28
	48	Nov 25 to 27	Ns	Ns	Ns	Ns	Ns	Ns	Ns
	49	Dec 2 to 4	Ns	0	6	0	0	0	6
		Reach Total	-	147	135	170	92	354	<b>898</b> <sup>a</sup>
	Percent of Total <sup>a</sup>	-	16.4%	15.0%	18.9%	10.2%	39.4%		
2009	42	Oct 14 to 16	Ns	21	61	42	33	127	284
	43	Oct 20 to 22	Ns	64	103	71	53	247	538
	44	Oct 27 to 29	Ns	30	108	92	69	130	429
	45	Nov 3 to 5	Ns	69	48	110	37	183	447
	46	Nov 10 to 12	Ns	17	14	23	20	31	105
	47	Nov 17 to 19	Ns	0	11	4	6	15	36
	48	Nov 24 to 26	Ns	Ns	Ns	Ns	Ns	Ns	0
	49	Dec. 2 to 4	Ns	0	0	0	0	1	1
		Reach Total	-	201	345	342	218	734	<b>1,840</b> <sup>a</sup>
	Percent of Total <sup>a</sup>	-	10.9%	18.8%	18.6%	11.8%	39.9%		
2010	41	Oct 13 to 15	Ns	0	1	17	6	16	40
	42	Oct 19 to 21	Ns	37	19	36	19	99	210
	43	Oct 26 to 28	Ns	34	18	39	12	44	147
	44	Nov 2 to 4	Ns	14	3	30	5	67	119
	45	Nov 10 to 12	Ns	2	12	15	9	56	94
	46	Nov 16 to 18	Ns	0	0	11	6	10	27
	47	Nov 23 to 25	Ns	Ns	Ns	Ns	Ns	Ns	0
	48	Nov 30 to Dec 2	Ns	0	4	0	4	1	9
		Reach Total	-	87	57	148	61	293	<b>646</b> <sup>a</sup>
	Percent of Total <sup>a</sup>	-	13.5%	8.8%	22.9%	9.4%	45.4%		
2011	41	Oct 12 to 14	Ns	0	5	4	0	7	16
	42	Oct 18 to 20	Ns	2	4	17	14	97	134
	43	Oct 25 to 27	Ns	20	20	29	43	89	201
	44	Nov 1 to 3	Ns	1	22	14	10	80	127
	45	Nov 8 to 10	Ns	11	31	0	16	32	90
	46	Nov 15 to 17	Ns	0	18	8	5	23	54
	49	Nov 29 to Dec 1	Ns	0	5	0	4	0	9
		Reach Total	-	34	105	72	92	328	<b>631</b> <sup>a</sup>
		Percent of Total <sup>a</sup>	-	5.4%	16.6%	11.4%	14.6%	52.0%	
2012	41	Oct 10 to 12	Ns	0	0	5	0	27	32
	42	Oct 16 to 18	Ns	20	6	222	87	540	875
	43	Oct 22 to 25	Ns	96	320	Ns	Ns	440	856
	44	Oct 30 to Nov 1	Ns	83	162	458 <sup>b</sup>	364	195	804
	45	Nov 6 to 8	Ns	28	43	113	21	76	281
	46	Nov 14 to 16	Ns	3	16	8	18	31	76
	48	Nov 27 to 28	Ns	Ns	8	Ns	0	Ns	8
		Reach Total	-	230	555	348	490	1309	<b>2,932</b> <sup>a</sup>
	Percent of Total <sup>a</sup>	-	7.8%	18.9%	11.9%	16.7%	44.6%		

<sup>a</sup> Reach 1 was not surveyed.

<sup>b</sup>The count for this reach was estimated.

Table 3. Model with Akaike Information Criterion (AIC) showing which terms fit best. The smallest term has the best fit.

Terms	AIC	Delta AIC
Sum of calendar week 43 and 44 counts in Reach 3 + calendar week 42 count in Reach 4	25	0
Sum of calendar week 43 and 44 counts in Reach 3	39	14
Calendar week 42 count in Reach 4	41	16

We observed 2,932 and interpolated an additional 458 fall Chinook salmon redds in 2012, representing 6,780 adults in the mainstem Klamath River between the Shasta River and Indian Creek confluences (Reaches 2 to 6; Table 4). Applying the surrogate jack proportion of 9.39% from the IGD–Shasta River carcass survey, jack escapement was estimated to be 703. Carcass mark-recapture methods and carcass scale ages produced estimates of 8,172 adult and 847 jack fall Chinook salmon that spawned between IGD and the Shasta River (Table 4). Our 2012 redd count was the highest in the 20-year history of this survey, with the second highest count in 2002 ( $n = 2,539$ ) and the lowest in 1993 ( $n = 243$ ; Table 2; Figure 3). The total redd count for the five surveyed reaches in 2012 was 3.74 times larger than the previous 19-year mean ( $\bar{x} = 906$ ) for the five surveyed reaches.

Peak redd counts in 2012 occurred during CW 42 for Reach 6, CW 43 for Reaches 2 and 3, and CW 44 for Reach 5 in 2012 (Table 2). We are uncertain if peak counts for Reach 4 were during CW 43 or CW44 because no survey was conducted during these calendar weeks and our estimate of missed redds is for these two weeks combined. In past years, CW 43 was the most common week new redds were observed in for survey reaches 2 thru 6.

The highest concentration of redds was in Reach 6 (70.0 redds/rkm) and the lowest was in Reach 2 (5.6 redds/rkm; Figure 4). The spatial distribution of redds was similar to last year but differed from previous years in that the lowest redd density was found in Reach 2 instead of Reach 5 (23.1 redds/rkm). The highest concentrations of redds within each reach were observed near Beaver Creek (Reach 2; Figure 5), near Little Humbug and Barkhouse Creeks and between McKinney and Kohl Creeks (Reach 3; Figure 6), at the Walker Creek confluence (Reach 4; Figure 7), near Fort Goff Creek (Reach 5; Figure 8), and between China Point and Ottley Gulch (Reach 6; Figure 9).

### Water Quality

Mainstem Klamath River daily mean water temperature decreased from 17.1 to 9.3°C over the survey period (October 10 to November 28, 2012; Figure 10) below the bridge at the Iron Gate Hatchery and from 17.3 to 8.3°C near Seiad Valley (Figure 11). Secchi disk depth readings ranged from 2.4 to 4.0 m ( $\bar{x} = 3.0$  m) during these surveys. The

Table 4. Natural fall Chinook salmon spawning escapement, Klamath River, 2012 (data compiled from CDFG 2013).

<b>Natural Spawning Area</b>	<b>Jacks</b>	<b>Adults</b>	<b>Total</b>
<b>Mainstem Klamath River</b>			
Iron Gate Dam to Shasta River <sup>a</sup>	847	8,172	9,019
Shasta River to Indian Creek <sup>b</sup>	703	6,780	7,483
Bogus Creek Basin	839	11,792	12,631
Shasta River Basin	1,944	27,593	29,537
Scott River Basin	1,783	7,569	9,352
Salmon River Basin	829	3,561	4,390
<b>Misc. Klamath Tributaries upstream of Yurok Reservation</b>			
Yurok Reservation Tributaries	406	761	1,167
<b>Total Natural Klamath Spawners</b>	<b>24,791</b>	<b>18,013</b>	<b>42,804</b>
<b>Mainstem Trinity River</b>			
Misc. Trinity Tributaries	77	520	597
Hoopla Reservation Tributaries	47	316	363
<b>Total Natural Trinity Spawners</b>	<b>7,774</b>	<b>52,687</b>	<b>60,461</b>
<b>Grand Total Natural Spawners</b>	<b>15,705</b>	<b>122,018</b>	<b>137,723</b>

<sup>a</sup> USFWS and Yurok Tribe carcass mark-recapture survey.

<sup>b</sup> USFWS and Karuk Tribe redd survey. Shasta River (rkm 288.4) to Ash Creek (rkm 285.7) not surveyed.

lowest Secchi disk depths were recorded on October 17, October 25, and November 1 (2.43 m), while the highest was measured on November 28 (3.96 m). Water visibility was generally lower during periods of higher discharge, cloud cover, and precipitation.

### Discharge

Daily mean discharge during the 2012 survey period in the mainstem Klamath River ranged from 987 to 1,615 ft<sup>3</sup>/s below IGD (mean = 1,046 ft<sup>3</sup>/s; Figure 10) and from 1,321 to 2,573 ft<sup>3</sup>/s (mean = 1,439 ft<sup>3</sup>/s) near Seiad Valley (Figure 11).

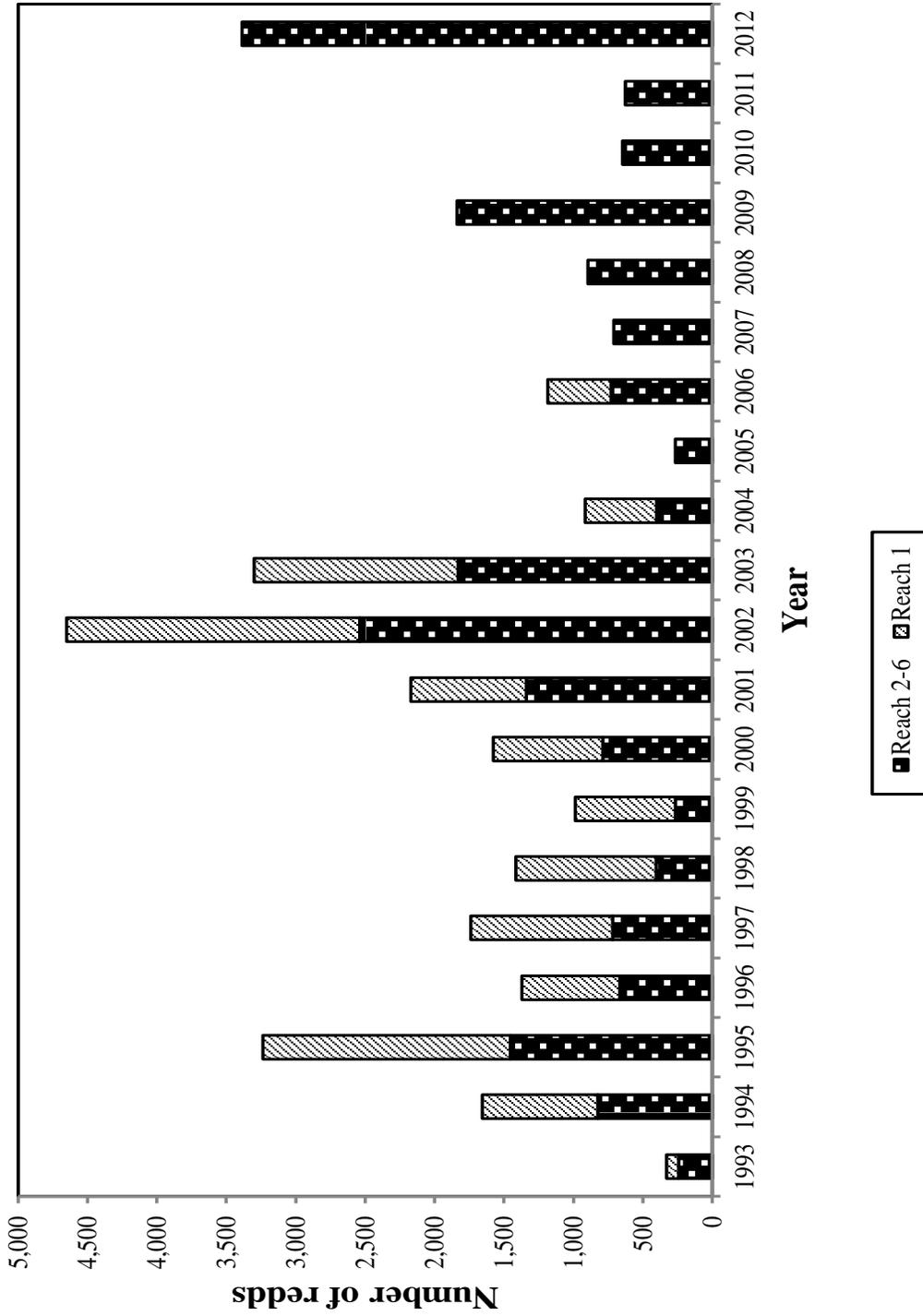


Figure 3. Mainstem Klamath River fall Chinook salmon redd counts 1993 to 2012. Reach 1 was not surveyed in 2005 and 2007 through 2012.

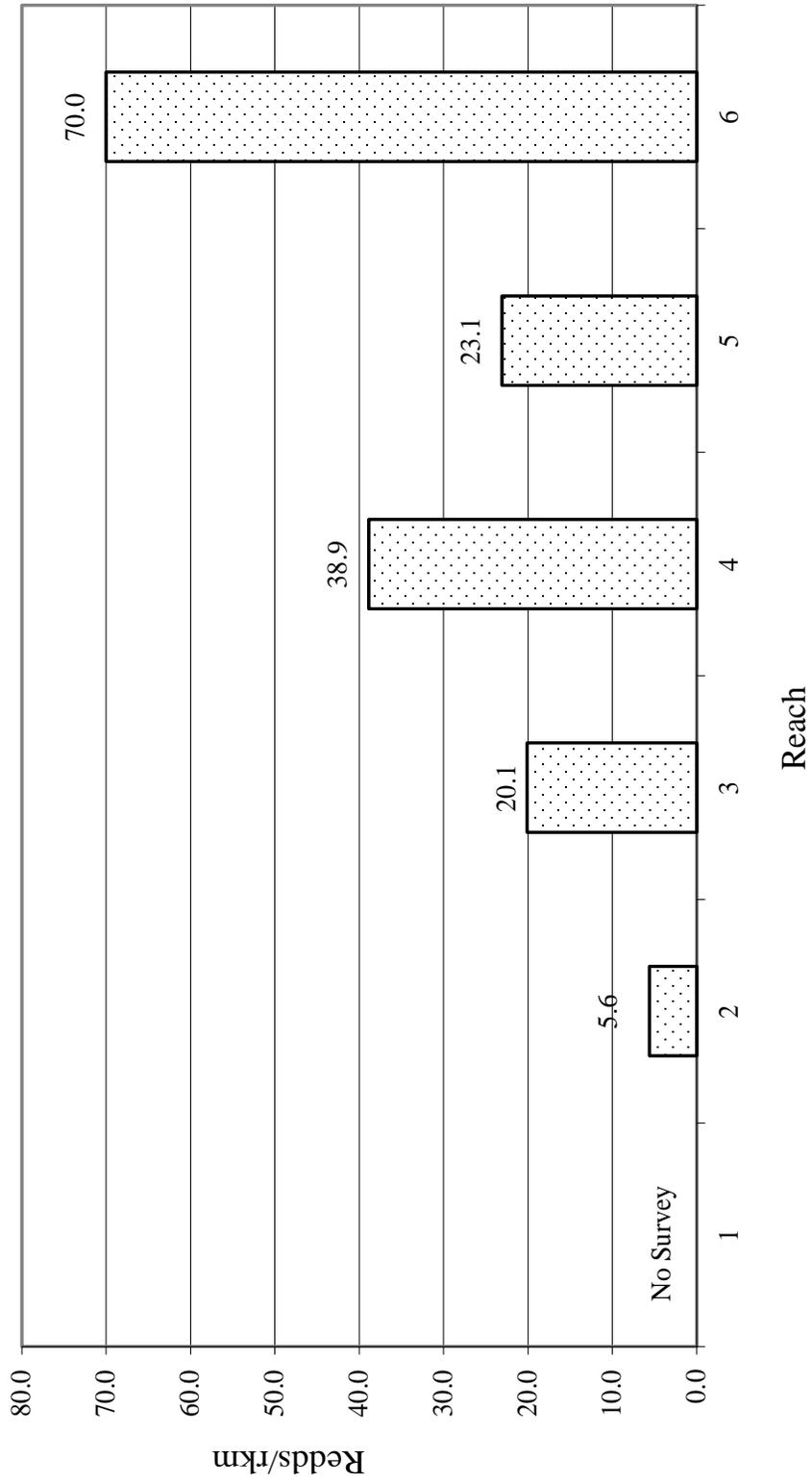


Figure 4. Mainstem Klamath River fall Chinook salmon redd density (redds/rkm) by reach, 2012.

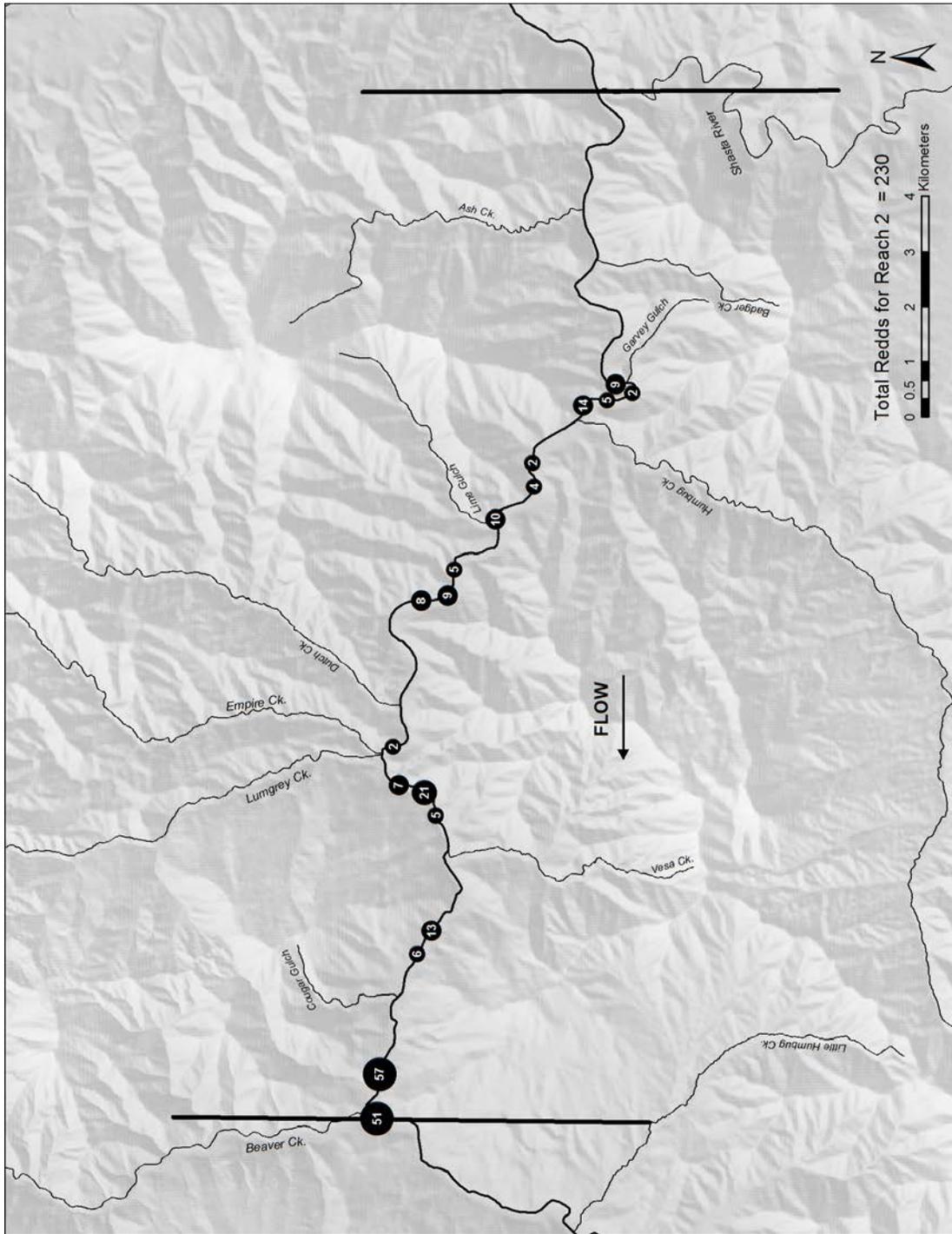


Figure 5. Redd distribution in Reach 2, (Shasta River to Beaver Creek), mainstem Klamath River, 2012.

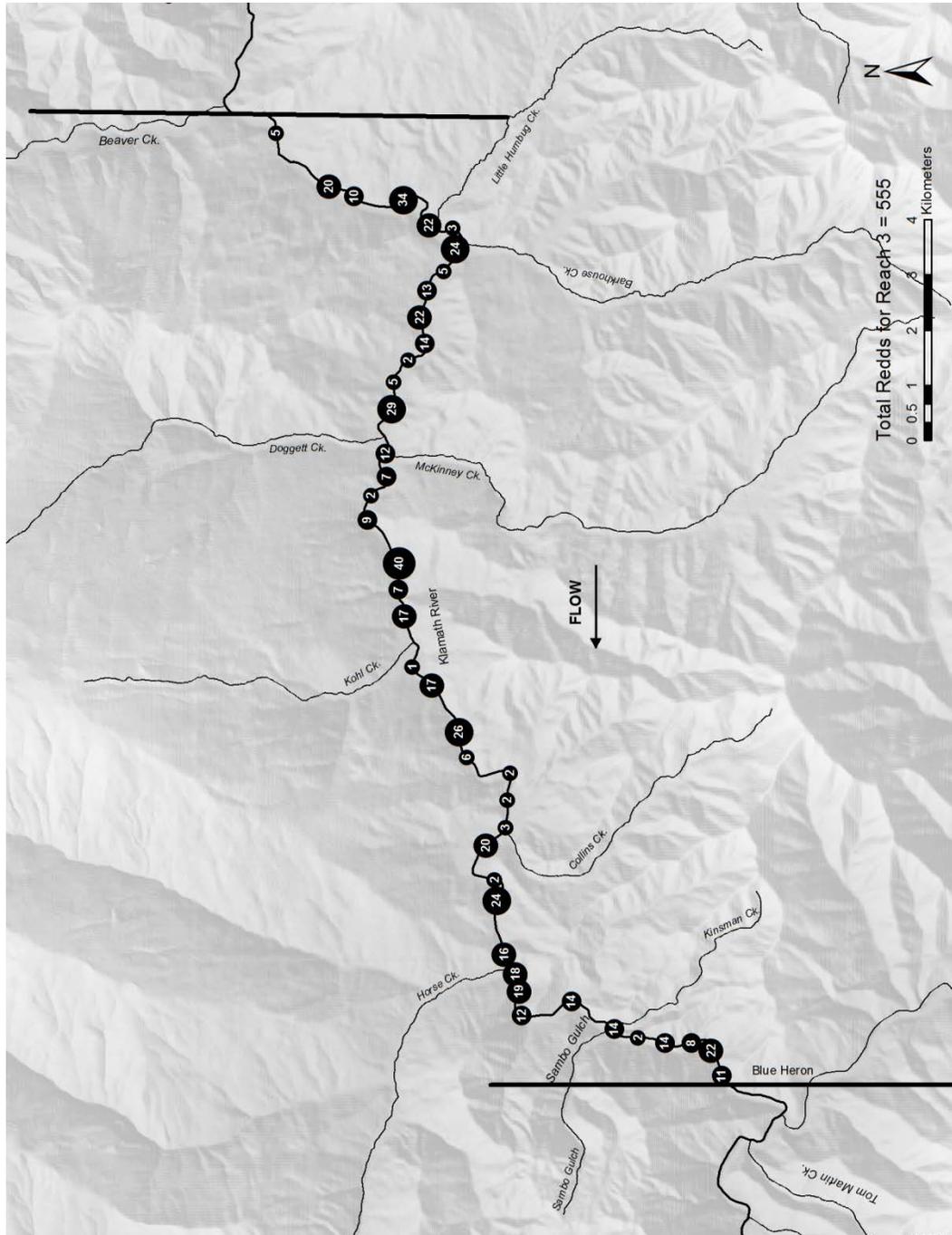


Figure 6. Redd distribution in Reach 3 (Beaver Creek to Blue Heron), mainstem Klamath River, 2012.

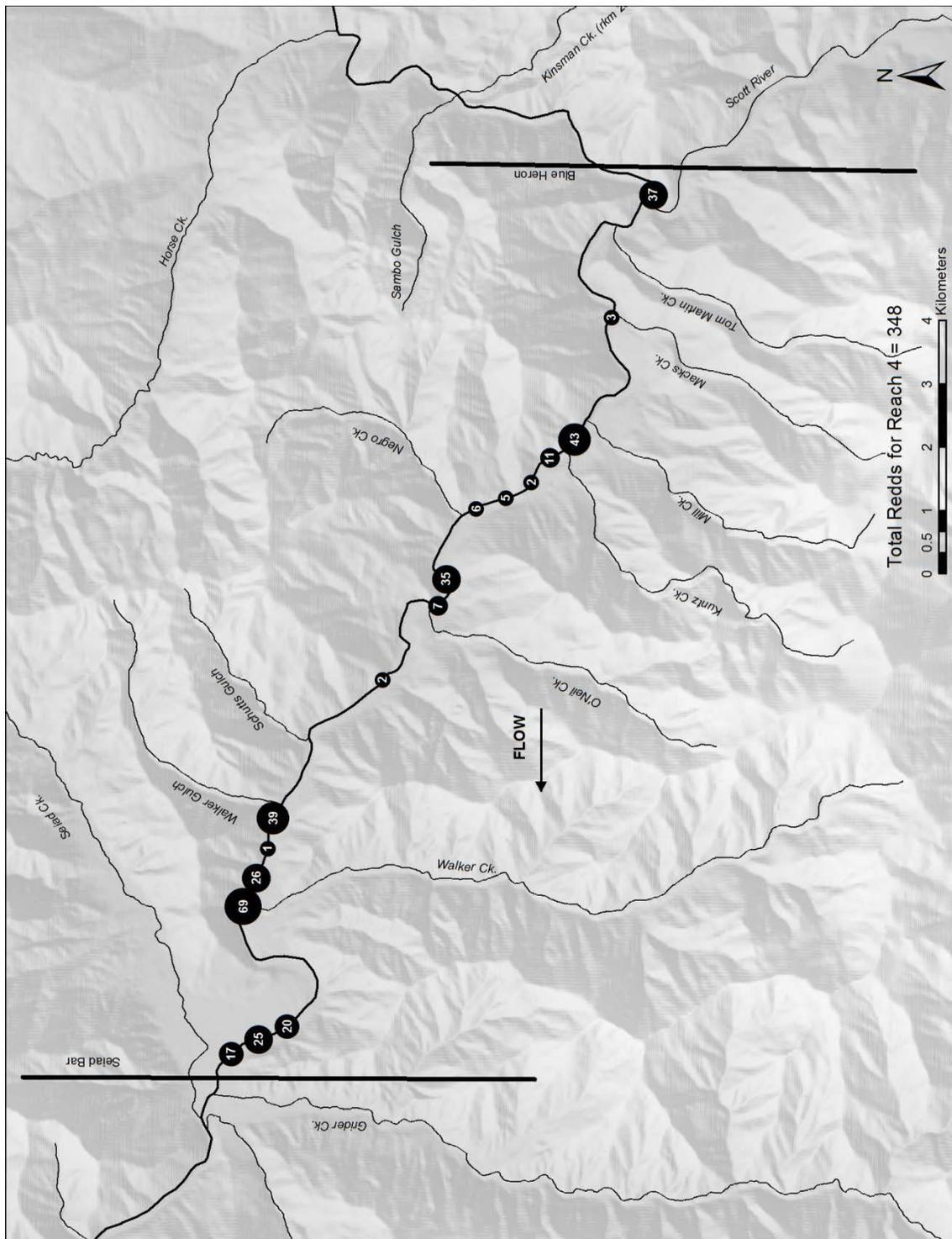


Figure 7. Redd distribution in Reach 4 (Blue Heron to Seiad Bar), mainstem Klamath River, 2012.



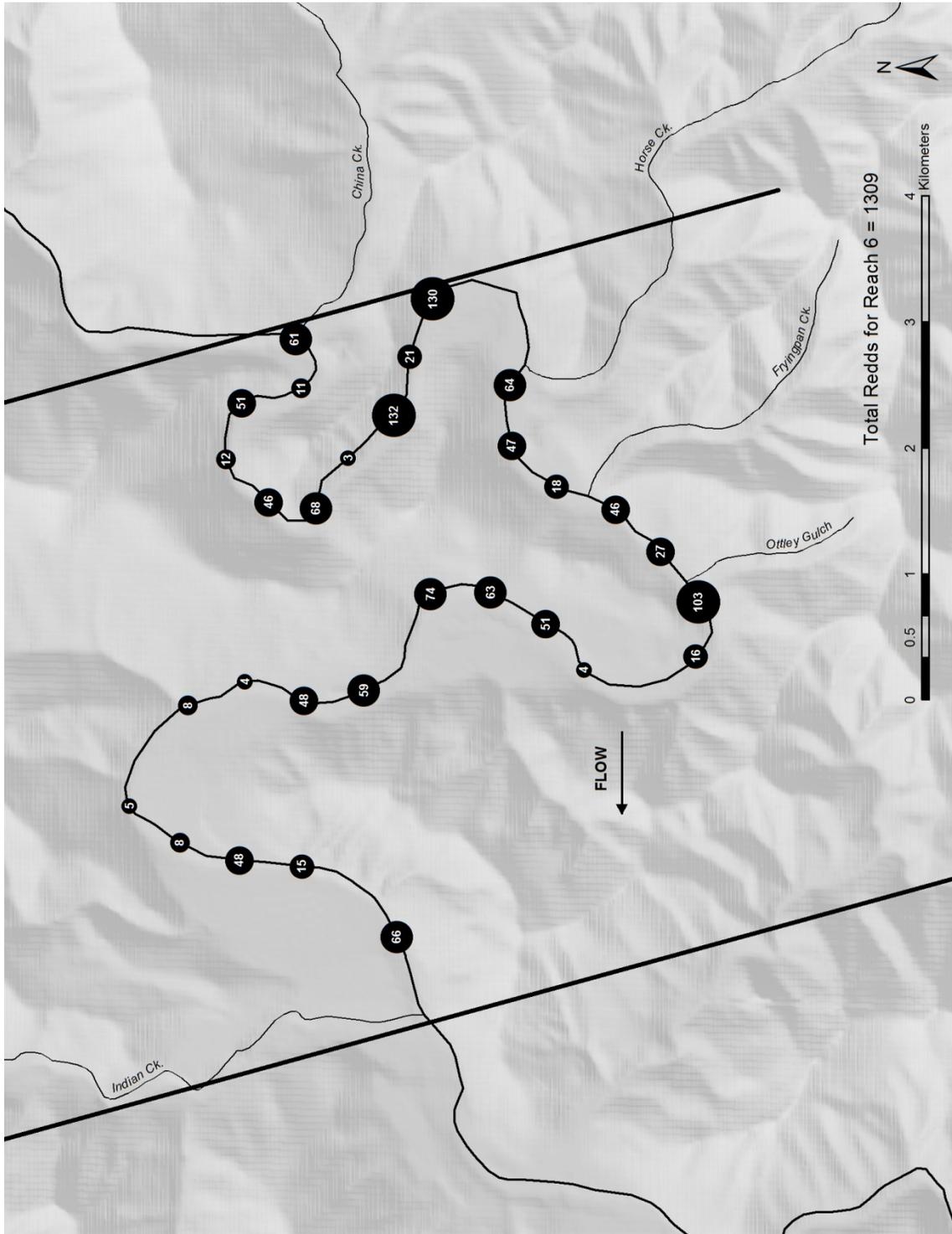


Figure 9. Redd distribution in Reach 6 (China Point to Indian Creek), mainstem Klamath River, 2012.

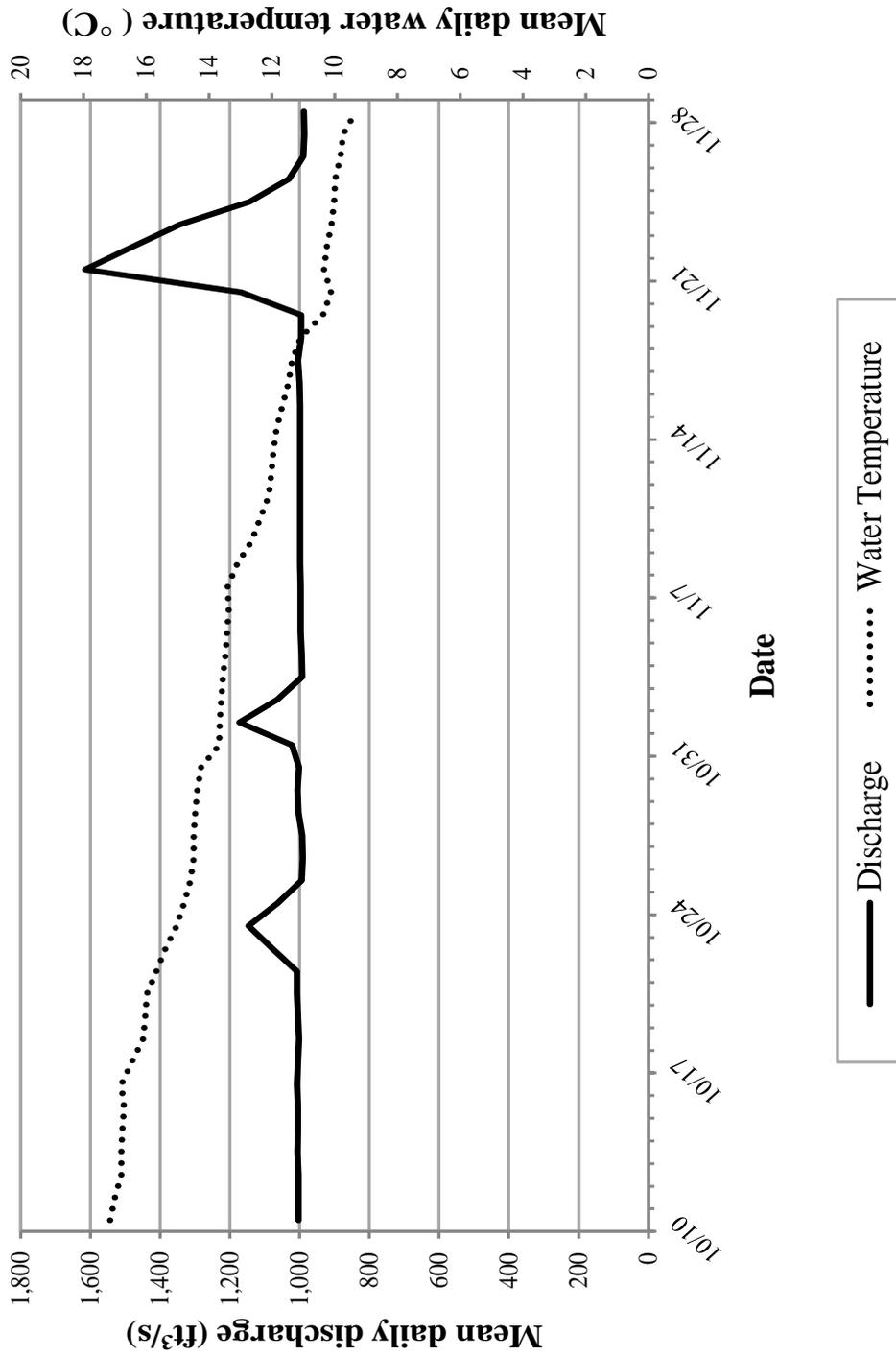


Figure 10. Water temperatures (°C) at rkm 309.9 and discharge (ft³/s) below Iron Gate Dam (USGS Gaging Station 11516530) October 10 to November 28, 2012.

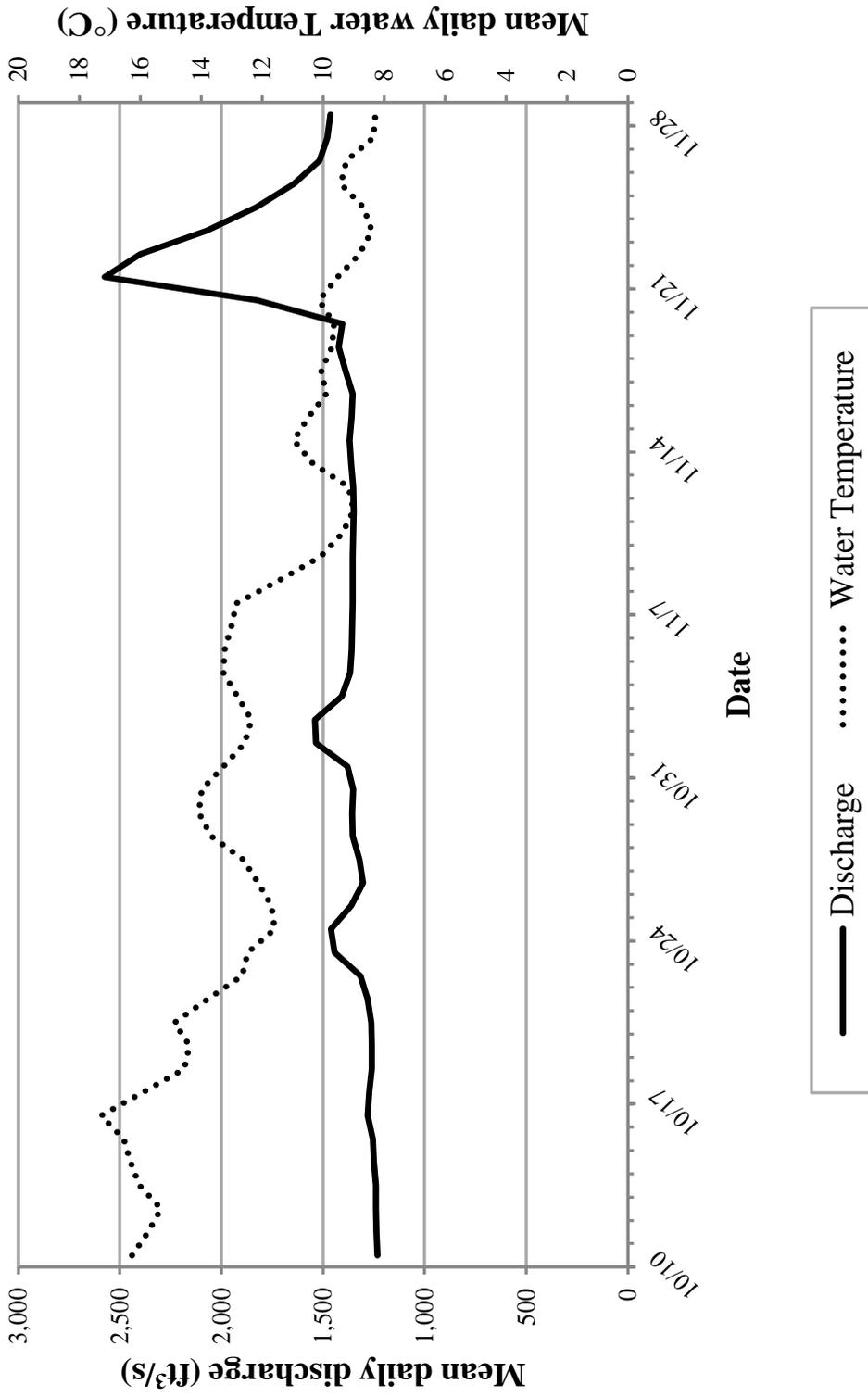


Figure 11. Water temperatures (°C) at rkm 206.8 and discharge (ft³/s) near Seiad Valley (USGS Gaging Station 11520500) October 10 to November 28, 2012.

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### **Literature Cited**

- Ayres Associates. 1999. Geomorphic and sediment evaluation of the Klamath River, California, below Iron Gate Dam. Prepared for U.S. Fish and Wildlife Service, Yreka, California, by Ayres Associates, Fort Collins, Colorado.
- CDFG (California Department of Fish and Game). 2013. Klamath River basin fall Chinook salmon spawner escapement, in-river harvest and run-size estimates, 1978-2012. Available from W. Sinnen, CDFG, 5341 Ericson Way, Arcata, California 95521.
- Flint, L.E., and A.L. Flint. 2008. A basin-scale approach to estimating stream temperatures of tributaries to the Lower Klamath River, California. *Journal of Environmental Quality* 37:57-68.
- Gough, S.A., and S.C. Williamson. 2012. Fall Chinook salmon run characteristics and escapement for the main-stem Klamath River, 2001 - 2010. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2012-14, Arcata, California.
- KRTT (Klamath River Technical Team). 2013a. Ocean abundance projections and prospective harvest levels for Klamath River fall Chinook, 2012 season. Available from U.S. Fish and Wildlife Service, 1829 South Oregon Street, Yreka, California, 96097.
- KRTT (Klamath River Technical Team). 2013b. Klamath River fall Chinook salmon age-specific escapement, river harvest, and run size estimates, 2012 run. Available from the Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.
- Leidy, R.A., and G.R. Leidy. 1984. Life stage periodicities of anadromous salmonids in the Klamath River Basin, northwestern California. U.S. Fish and Wildlife Service, Division of Ecological Services, Sacramento, California.
- PFMC (Pacific Fishery Management Council). 1988. Review of 1988 ocean salmon fisheries. Portland, Oregon.
- USFWS (United States Fish and Wildlife Service). 1991. Annual report: Klamath River fisheries assessment program, 1989. Coastal California Fishery Resource Office, Arcata, California.