

TASK 10. SURVEY OF CHINOOK SALMON REDDS, 1990-1991 and 1991-1992

10.1 OBJECTIVES

The objective of this study was to document the spatial and temporal distribution and size of chinook salmon redds in the Lower Mokelumne River during the 1990-1991 and 1991-1992 spawning seasons. At each redd, depth and velocity measurements were taken and substrate composition was characterized visually.

10.2 METHODS

10.2.1 1990-1991

Weekly redd surveys were conducted by EBMUD personnel in the Mokelumne River between Camanche Dam and Elliott Road from 30 October through 21 December 1990 (Hagar 1991). Water temperature was recorded bi-hourly using datapods at two sites: immediately below Camanche Dam and approximately 0.5 km downstream of the Mackville Road bridge. These sites were selected because Camanche Dam is at the upstream extent of the spawning habitat and Mackville Road is in the lower portion, and temperatures at these two sites should encompass the full range of temperature conditions. Flows were obtained from the USGS Gaging Station (#11323500) located just below Camanche Dam.

Weekly surveys consisted of canoeing downstream, identifying sites of salmon redd construction and measuring the water velocity and depth at the redds. Velocity was measured at the upstream edge of each redd using a Teledyne Gurley Flowmeter. Each redd was marked with a numbered rock, and monitored on subsequent surveys to determine the status of activity. When the redds were completed or near completion, their width was measured. The area of a circle (πr^2) was used to estimate the river bottom area occupied by each redd.

At the conclusion of the field studies, each redd was classified as incomplete, complete, or superimposed (multiple redds). Only complete, solitary redds were used in our analysis of redd characteristics; superimposed and incomplete redds were eliminated from the analysis.

Substrate characteristics of each redd were evaluated visually during the surveys by identifying dominant substrate size classes. Upon completion of spawning and fry emergence, substrate samples were collected by BioSystems from 24 redds and particle composition was determined based on sieve analysis. The results of this analysis are included in Task 12.

10.2.2 1991-1992

During the spawning season of 1991-1992, the field surveys (13 November-9 January) conducted by EBMUD were similar to those in 1990 with a few exceptions (Hartwell 1992). Additional physical measurements of the redds and spawning habitat were made to quantify spatial patterns. The distance from the redd to the nearest upstream habitat change (top of habitat) was measured. It was also noted if the redd was on top of a berm (gravel ridge) and the orientation of the berm to streamflow (i.e., perpendicular to the stream= 90° , parallel to streamflow= 0°).

10.3 RESULTS

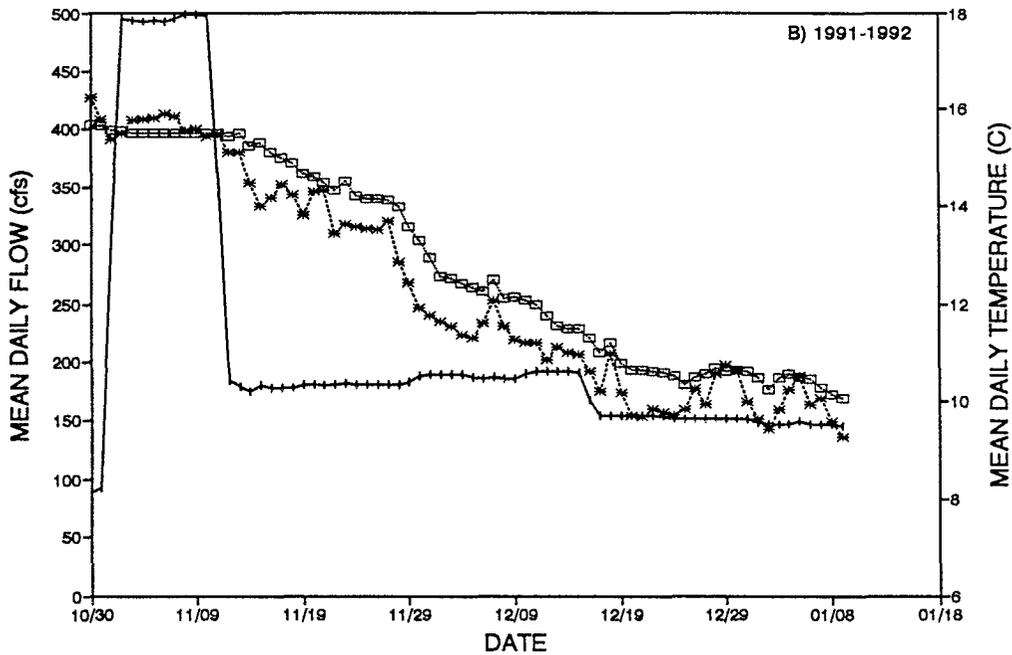
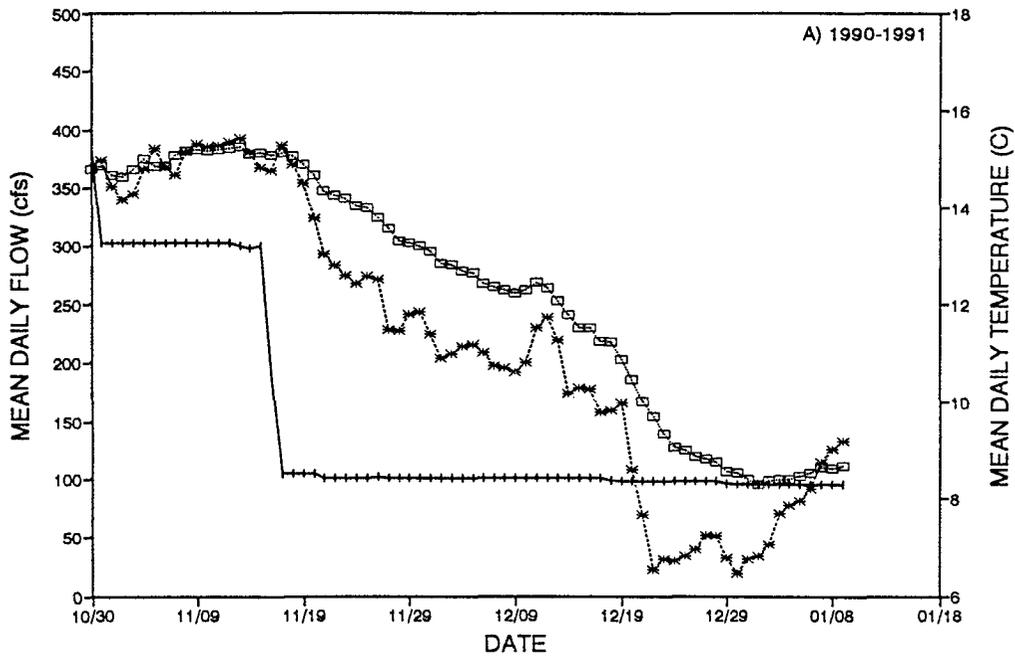
10.3.1 1990-1991

During the 1990 redd surveys, the highest mean daily water temperatures were recorded on 13 November (15.4°C at Camanche and 15.3°C at Mackville). After 13 November, the temperatures gradually decreased through the spawning season (Figure 10-1a). The minimum daily temperature was recorded at both sites during the last weekly survey on 21 December (10.0°C at Camanche and 7.7°C at Mackville).

During the study period, there was a stepwise decrease in flow (Figure 10-1a). During the first survey (30 October), flow releases below Camanche Dam were above 380 cfs. During the second and third surveys (7 and 13 November), flows were approximately 300 cfs. On 16 November, flows were reduced to approximately 100 cfs where they remained through the end of the field studies. This flow reduction altered hydrologic conditions (depth and velocity) in the spawning habitat, hence these conditions were evaluated separately. Analysis of variance (ANOVA) was conducted to determine if these differences in hydrologic conditions were significant.

During the eight weekly surveys (30 October-21 December), a total of 115 potential redds were identified. At the conclusion of the field studies, 28 redds were categorized as abandoned or incomplete, 10 redds were excluded from analysis because depth and velocity data were not available, and 14 redds were excluded from analysis because they potentially represented multiple redds superimposed upon each other. Of the remaining 63 redds, 23 redds were constructed in flows in excess of 300 cfs, and 40 redds were constructed in flows of 100 cfs (Table 10.1).

Redds extended from approximately 100 meters downstream of Camanche Dam to approximately 1.5 km above the Elliott Road Bridge, a total distance of approximately 13 km. Over half of the redds (57%) were between Camanche Dam and Mackville Road, approximately 8 km downstream. Forty-three percent of the redds were downstream from the Mackville Road bridge (Figure 10-2a).



—+— CAMANCHE FLOW —□— CAMANCHE TEMP. —*— MACKVILLE TEMP.

Figure 10-1. Flow below Camanche Dam (USGS gage #11323500) and water temperature below Camanche Dam and Mackville Road (EBMUD datapods) during EBMUD redd surveys in A) 1990-1991 and B) 1991-1992.

Table 10.1. Summary of EBMUD redd surveys during the 1990-1991 spawning season¹.

REDD NUMBER	INITIAL REDD LOCATION			DEPTH AT REDDS (cm)		MEAN COLUMN VELOCITY (cm/s)		AREA OF REDD (m ²)	SUBSTRATE ANALYSIS CONDUCTED ² (Y or N)
	DATE	REACH ²	APPROX. CAMANCHE FLOW (cfs)	AT 300 cfs	AT 100 cfs	AT 300 cfs	AT 100 cfs		
4	10/30	1	384	61.0	35.1	54.9	9.0	3	Y
14	11/07	1	300	59.4	36.6	39.6	9.8	0.7	Y
15	11/07	1	300	45.7	24.4	73.2	32.3	8.2	Y
16	11/07	1	300	27.4	9.1	88.4	41.8	0.7	Y
20	11/07	1	300	56.4	36.6	39.6	30.5	NA	Y
21	11/08	2	300	76.2	51.8	73.2	29.8	5.9	Y
22	11/08	2	300	64.0	54.9	39.6	12.1	14.3	N
23	11/08	2	300	50.3	30.5	39.6	27.2	2.6	Y
26	11/08	2	300	47.2	22.9	106.7	37.9	5.4	N
27	11/08	2	300	71.6	67.1	48.8	13.5	27.2	Y
28	11/08	2	300	61.0	54.9	73.2	11.8	3.3	N
30	11/08	2	300	106.7	82.3	64.0	27.2	9.2	N
31	11/08	2	300	80.8	38.1	82.3	29.5	12.7	N
33	11/13	1	300	57.9	39.6	73.2	42.4	7	N
34	11/13	1	300	39.6	16.8	106.7	70.5	5.1	Y
35	11/13	1	300	45.7	25.9	30.5	10.7	0.6	N
37	11/13	1	300	88.4	62.5	73.2	37.4	22.1	N
38	11/13	1	300	64.0	45.7	73.2	19.9	16.4	N
39	11/13	1	300	94.5	79.2	82.3	41.3	12.3	N
40	11/13	1	300	67.1	44.2	73.2	30.5	8.8	Y
41	11/13	1	300	51.8	36.6	82.3	28.9	10.5	Y
43	11/14	1	300	61.0	64.0	64.0	18.5	31.9	N
46	11/14	1	300	88.4	61.0	82.3	40.7	4.8	N
47	11/20	1	100	-	56.4	-	24.4	3	Y
48	11/20	1	100	-	42.7	-	39.6	0.5	Y
49	11/20	1	100	-	38.1	-	36.6	31.3	Y
51	11/20	1	100	-	57.2	-	33.5	0.9	Y
53	11/20	1	100	-	50.3	-	18.3	8.8	Y

Table 10.1 Summary of EBMUD redd surveys during the 1990-1991 spawning season¹ (cont.).

REDD NUMBER	INITIAL REDD LOCATION			DEPTH AT REDDS (cm)		MEAN COLUMN VELOCITY (cm/s)		AREA OF REDD (m ²)	SUBSTRATE ANALYSIS CONDUCTED ² (Y or N)
	DATE	REACH ²	APPROX. CAMANCHE FLOW (cfs)	AT 300 cfs	AT 100 cfs	AT 300 cfs	AT 100 cfs		
54	11/20	1	100	-	57.9	-	48.8	16	Y
55	11/20	1	100	-	61.0	-	39.6	2	Y
56	11/20	1	100	-	39.6	-	57.9	31.3	N
60	11/21	2	100	-	70.1	-	45.7	17.5	Y
61	11/21	2	100	-	41.1	-	57.9	5.1	Y
62	11/21	2	100	-	30.5	-	48.8	2.5	N
63	11/21	2	100	-	33.5	-	21.3	14.1	N
64	11/21	2	100	-	73.2	-	51.8	1.1	N
65	11/21	2	100	-	88.4	-	42.7	33.1	N
68	11/21	2	100	-	51.8	-	42.7	4.1	N
69	11/21	2	100	-	18.3	-	27.4	7.2	N
71	11/21	2	100	-	68.6	-	33.5	16	N
73	11/21	2	100	-	71.6	-	54.9	12.1	N
74	11/21	2	100	-	88.4	-	76.2	8.7	N
75	11/21	2	100	-	67.1	-	54.9	19.4	N
76	11/21	2	100	-	65.5	-	61.0	16.9	N
77	11/28	1	100	-	21.3	-	73.2	4	N
78	11/28	1	100	-	51.8	-	30.5	2.9	N
79	11/28	1	100	-	39.6	-	54.9	1.4	N
80	11/28	1	100	-	24.4	-	97.5	4	N
81	11/28	1	100	-	39.6	-	48.8	23.4	N
84	11/28	1	100	-	42.7	-	73.2	0.7	N
85	11/28	1	100	-	48.8	-	39.6	13.3	N
86	11/28	1	100	-	56.4	-	68.6	8.4	N
89	11/29	2	100	-	53.3	-	30.5	16	N
94	12/05	1	100	-	30.5	-	64.0	17.5	N
97	12/05	1	100	-	36.6	-	39.6	10.9	Y

Table 10.1 Summary of EBMUD redd surveys during the 1990-1991 spawning season¹ (cont.).

REDD NUMBER	INITIAL REDD LOCATION			DEPTH AT REDDS (cm)		MEAN COLUMN VELOCITY (cm/s)		AREA OF REDD (m ²)	SUBSTRATE ANALYSIS CONDUCTED ³ (Y or N)
	DATE	REACH ²	APPROX. CAMANCHE FLOW (cfs)	AT 300 cfs	AT 100 cfs	AT 300 cfs	AT 100 cfs		
99	12/05	1	100	-	38.1	-	48.8	29.8	N
100	12/06	2	100	-	36.6	-	64.0	21.1	N
103	12/12	1	100	-	39.6	-	54.9	3.5	Y
105	12/13	2	100	-	67.8	-	80.8	3.9	N
109	12/20	1	100	-	36.6	-	48.8	2.6	N
110	12/20	1	100	-	57.9	-	30.5	18.4	Y
111	12/20	1	100	-	30.5	-	48.8	3.4	Y
114	12/21	2	100	-	27.4	-	64.0	8.4	N

¹Fourteen redds were excluded from analysis because they were superimposed, and another 38 redds were excluded because they were abandoned or data were incomplete.

²Reaches are defined as Camanche Dam to Mackville Road (Reach 1) and Mackville Road to Elliott Road (Reach 2)

³Results of detailed substrate analysis are reported in Task 12.

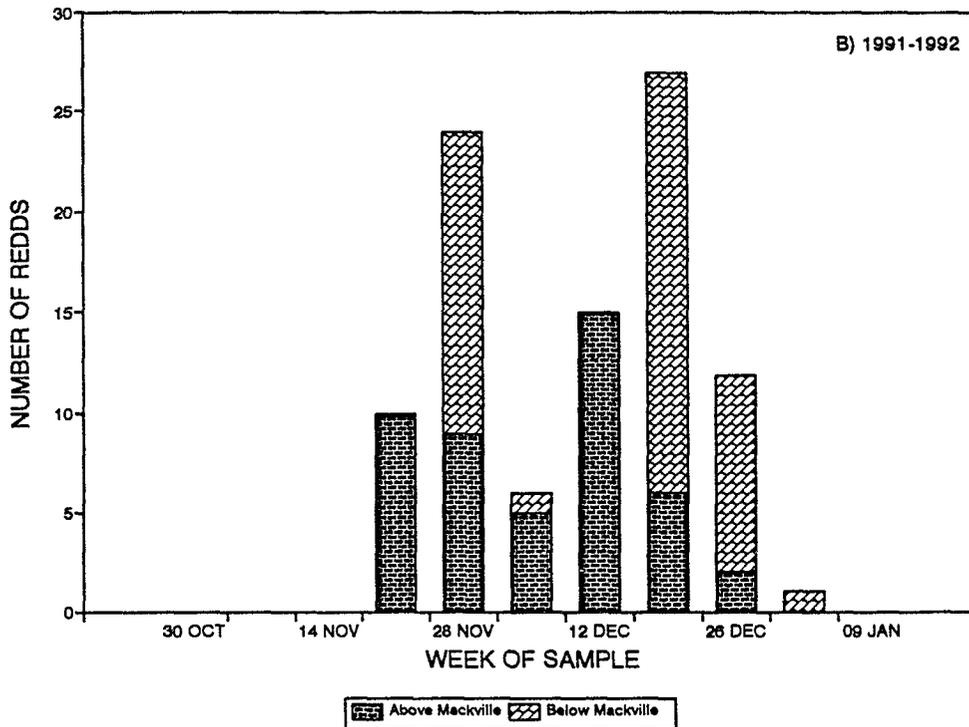
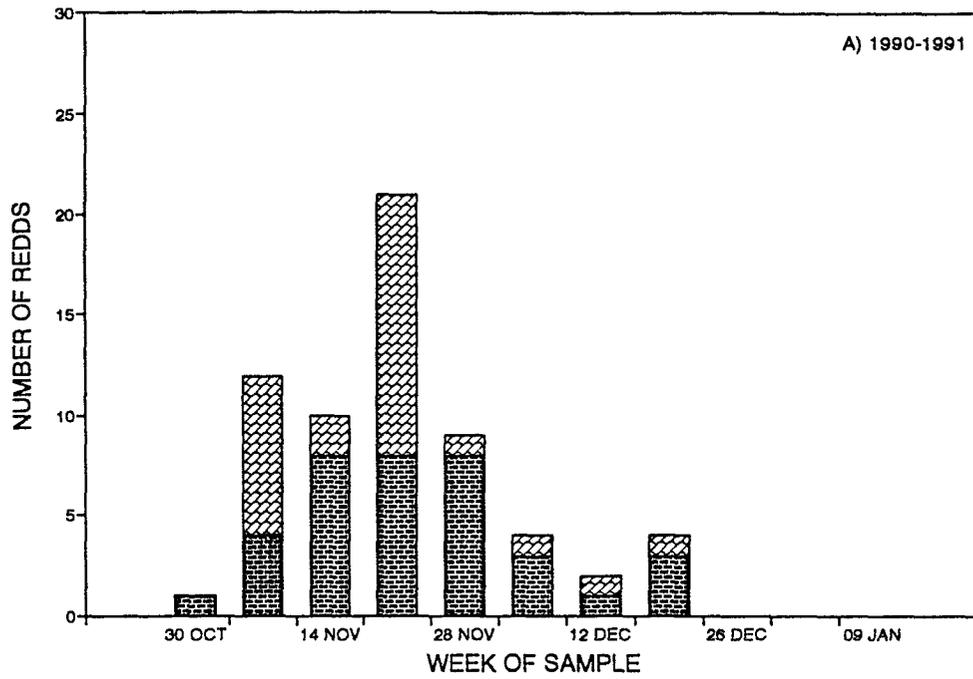


Figure 10-2. The timing and location of salmon redd construction in the Mokelumne River in A) 1990-1991 and B) 1991-1992.

The first redd activity was documented during the first survey (30 October). Based on field surveys, the peak in redd construction was during the third week of November, when 33 percent of the redds were found (Figure 10-2a). Most of the redds found during the surveys were constructed during November in both the river section between Camanche Dam and Mackville Road (78%) and in the section between Mackville Road and Elliott Road (89%).

The reduction in flow on 16 November resulted in a significant decrease in the depth at which the redds were constructed (F-value=10.23, $p < 0.05$) (Figure 10-3a). During the higher flow releases, most of the redds (65%) were at a depth between 45 and 75 cm (range=27-107 cm). After flow was reduced to 100 cfs, the depth at most of the redds constructed during the higher flows (52%) decreased below 45 cm (range=9-82 cm). During the reduced flow (100 cfs), most redds (65%) were constructed at a depth of 30-60 cm (range=18-88 cm) (Figure 10-3a).

The reduction in flow also resulted in a significant decrease in the velocity at which redds were constructed (F-value=14.38, $p < 0.05$) (Figure 10-4a). Prior to flow reductions, the velocity at most redds (61%) was between 60 and 90 cm/sec (range=31-107 cm/sec). After flow reductions, the velocity at most of these redds (96%) decreased below 45 cm/sec. The velocity at most of the redds constructed after the flow reduction (65%) was between 30 and 60 cm/sec (range= 18-97 cm/sec) (Figure 10-4a).

The frequency distribution of redd area is illustrated in Figure 10-5a. Mean redd size was 10.6 m² and ranged from 0.5 to 33.1 m².

Substrate samples were collected from 24 redds identified during these surveys (Table 10.1). The results of the substrate analysis are provided in Task 12. Generally, the results indicate that the gravel used for spawning in the Mokelumne River was of suitable size for egg incubation and survival; however, a high percentage of fines were found in over 70 percent of the redds.

10.3.2 1991-1992

During the spawning season of 1991-92, nine weekly redd surveys were conducted from 13 November 1991 through 9 January 1992. The highest mean daily temperature at both sites was recorded during the first survey (15.5° C at Camanche and 15.1° C at Mackville). Throughout the study, temperature gradually decreased to approximately 10° C during the last survey (Camanche 10.1° C and Mackville 9.3° C) (Figure 10-1b).

Flow releases below Camanche Dam were maintained at approximately 200 cfs from the beginning of the surveys (13 November) through 15 December (Figure 10-1b). On 16 December, flows were reduced to 160 cfs where they remained through the end of the study (Figure 10-1b). As in 1990, the depth and velocity conditions at the redds before and after the flow reduction were evaluated separately.

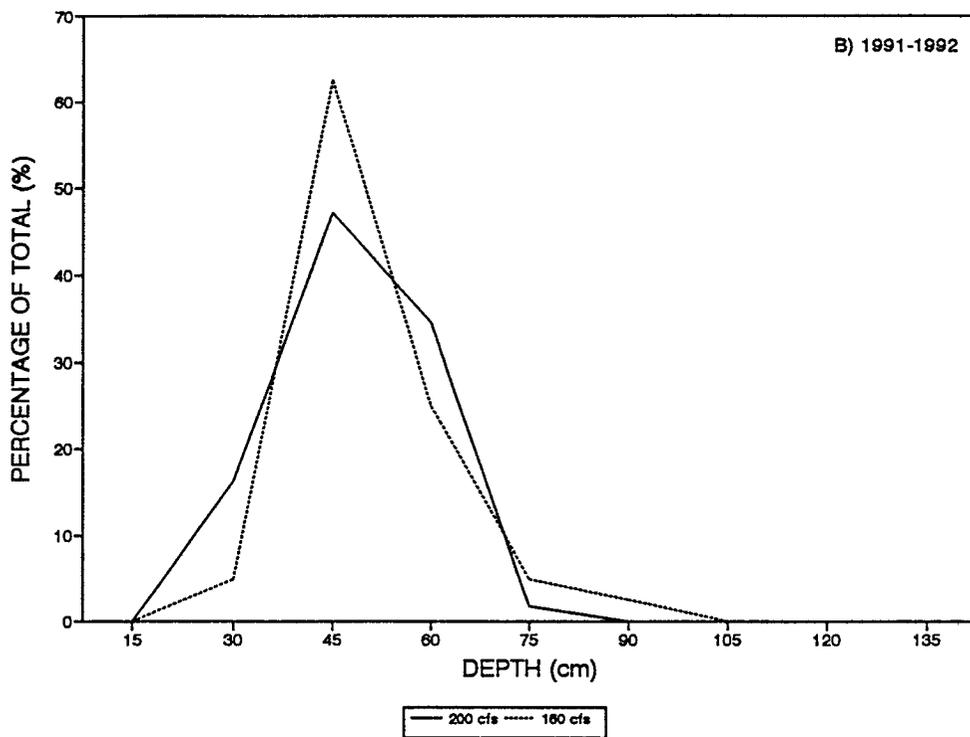
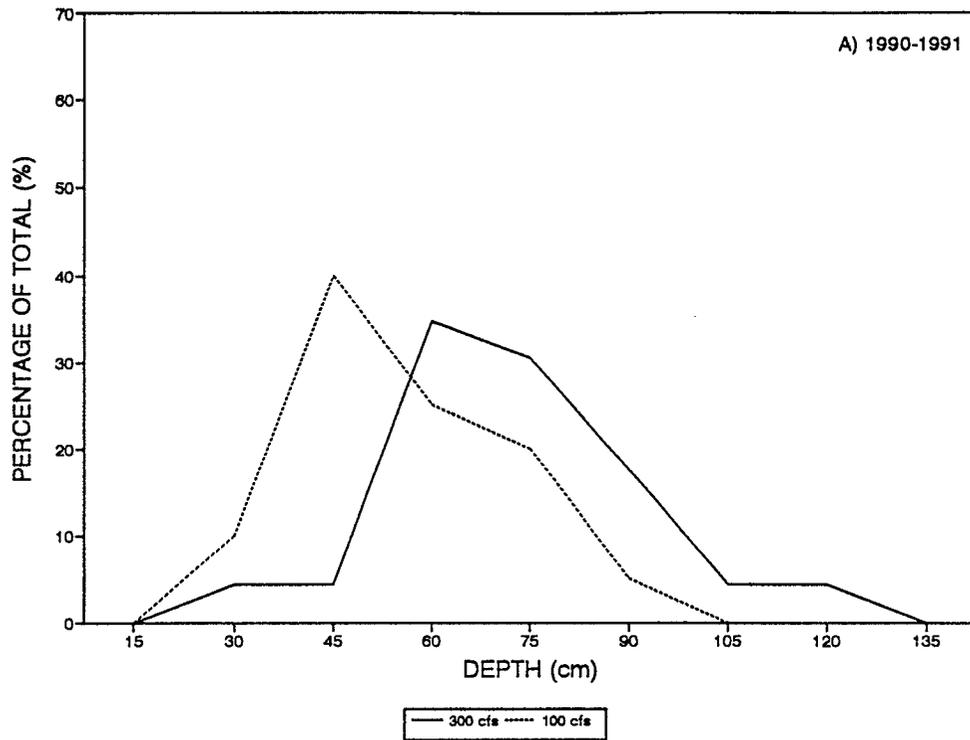


Figure 10-3. Percentage distribution of the depth (cm) of redds at two flows during EBMUD redd surveys in A) 1990-1991 and B) 1992-1992.

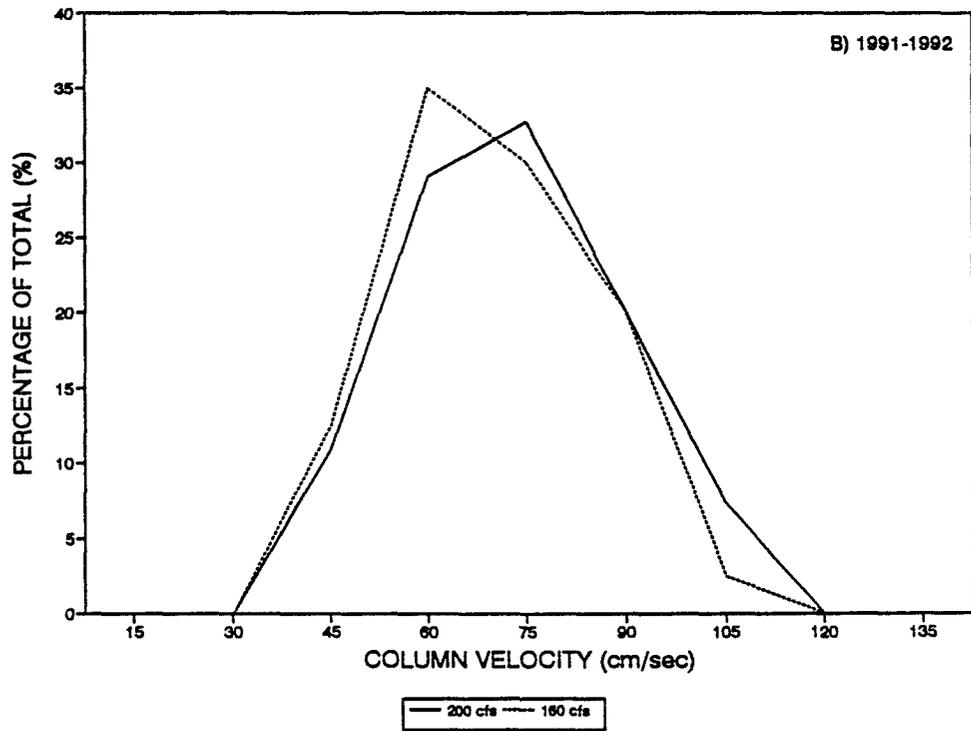
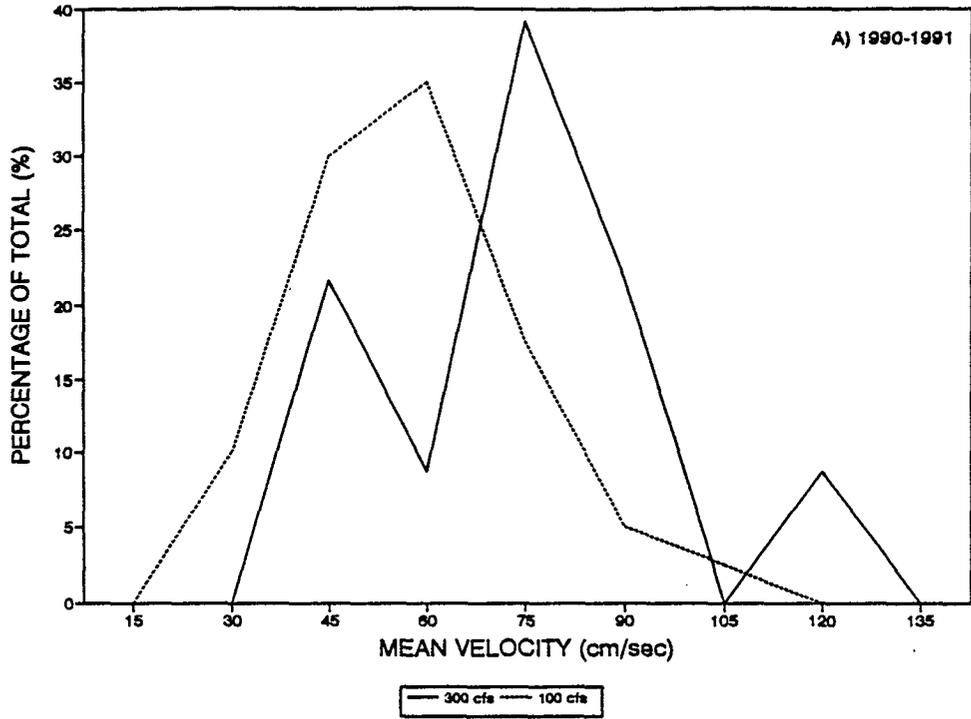


Figure 10-4. Percentage distribution of velocity at the upstream edge of salmon redds at two flows during EBMUD redd surveys in A) 1990-1991 and B) 1991-1992.

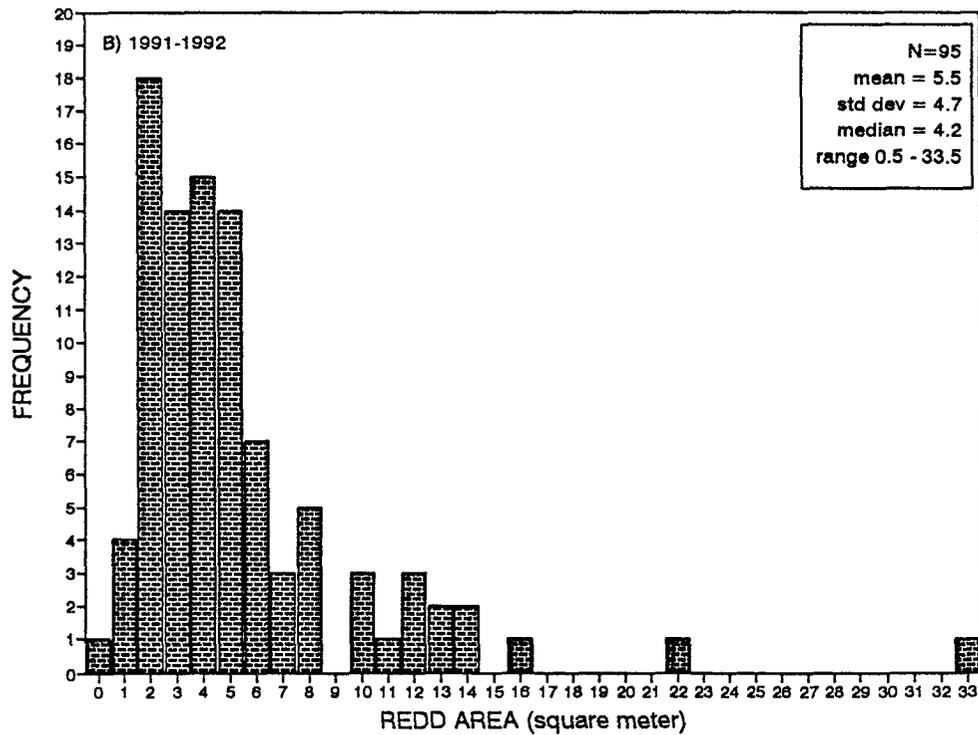
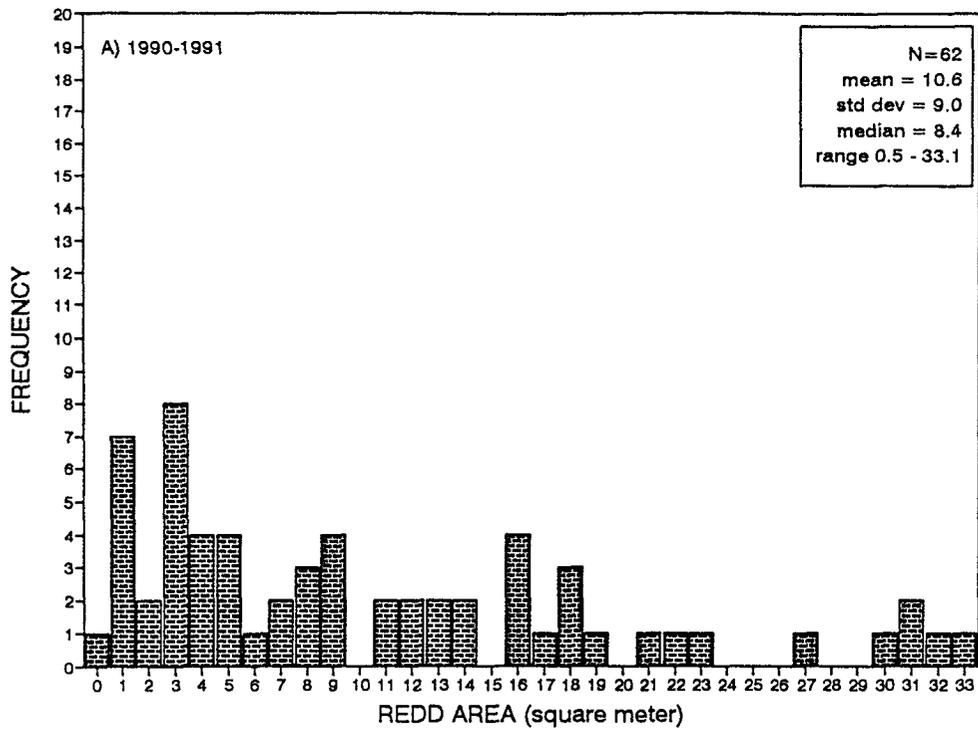


Figure 10-5. Frequency distribution of chinook salmon redd sizes during spawning surveys on the Mokelumne River, A) 1990-1991 and B) 1992-1992.

A total of 127 redds were found between 13 November and 2 January. No new redds were documented during the 9 January survey. At the conclusion of the field surveys, 27 redds were categorized as incomplete or abandoned, and five were categorized as superimposed (multiple redds). Of the remaining 95 complete redds (Table 10.2), 58 percent were found prior to the reduction in flow and 42 percent afterwards.

Redds extended from approximately 100 m below Camanche Dam to approximately 4 km above Elliott Road, a distance of approximately 11 km. Approximately half (49%) of the redds were between Camanche Dam and Mackville Road, and half (51%) were downstream from the Mackville Road bridge (Figure 10-2b).

The first redd activity was observed during the first survey on 13 November, and the first redds (N=10) to be completed were found on 20 November. Based on the field surveys, there were two peaks in redd construction (Figure 10-2b). One peak, during the fourth week of November, accounted for 25 percent of the total redds and a second peak, during the third week of December, accounted for 28 percent.

There was no significant change in the depth of redd construction as a result of the flow reduction in mid-December (F-value=2.59, $p > 0.05$) (Figure 10-3b). Most redds were constructed at a depth of between 30 and 60 cm at flows of 200 cfs (82%, mean=40.1 cm) and 160 cfs (88%, mean=43.5 cm). The range of depths at which redds were constructed at 200 cfs (18-61 cm) was similar to the range at 160 cfs (24-76 cm).

There was also no significant change in the velocity at the redds constructed after the flow reduction in mid-December (F-value= 0.66, $p > 0.05$) (Figure 10-4b). At 200 cfs, the velocity at most redds (62%, mean=64.9 cm/sec) was between 60 and 75 cm/sec (range= 32-98 cm/sec). At 160 cfs, the velocity at most redds (65%, mean=62.2 cm/sec) was between 45 and 75 cm/sec (range of 34-97 cm/sec).

The frequency distribution of redd area is illustrated in Figure 10-5b. Mean redd size in 1991 was 5.5 m² and ranged from 0.5 to 33.5 m². Redds measured in 1991 were significantly smaller than those measured in 1990 (t-test, $t=4.64$, $df=155$, $p < 0.01$).

Of the completed solitary redds, most (55%) were at the top of the habitat; almost all (98%) were in the upper 10 m of spawning habitat (Figure 10-6). In addition, most redds (86%) were on berms. These berms generally were oriented perpendicular (70-90°) to streamflow (Figure 10-7).

Substrate sieve analysis was conducted on ten of the redds included in this analysis (Table 10.2). As in 1990, substrate analysis indicated that the gravels used by spawning salmon were of suitable size, but a high percentage of fines were found in over 20 percent of the redds (see Task 12).

Table 10.2. Summary of EBMUD redd surveys during the 1991-1992 spawning season¹.

REDD NUMBER	INITIAL REDD LOCATION			DEPTH AT REDDS (cm)		MEAN COLUMN VELOCITY (cm/s)		AREA OF REDD (m ²)	SUBSTRATE ANALYSIS CONDUCTED ³ (Y or N)
	DATE	REACH ²	APPROX. CAMANCHE FLOW (cfs)	AT 200 cfs	AT 160 cfs	AT 200 cfs	AT 160 cfs		
1	11/20	1	200	18.3	-	48.8	-	5.3	Y
2	11/20	1	200	33.5	-	54.9	-	5.3	N
3	11/20	1	200	24.4	-	54.9	-	10.2	Y
4	11/20	1	200	24.4	-	64.0	-	2.2	N
6	11/20	1	200	36.6	-	64.0	-	3.6	N
7	11/20	1	200	42.7	-	39.6	-	13.0	Y
10	11/20	1	200	54.9	-	64.0	-	3.1	N
11	11/20	1	200	39.6	-	88.4	-	4.3	N
12	11/20	1	200	36.6	-	48.8	-	3.2	N
13	11/20	1	200	39.6	-	73.2	-	12.2	N
14	11/27	1	200	24.4	-	48.8	-	12.0	N
15	11/27	1	200	27.4	-	88.4	-	3.6	Y
16	11/27	1	200	21.3	-	97.5	-	4.5	N
17	11/27	1	200	27.4	-	54.9	-	0.5	N
18	11/27	1	200	33.5	-	64.0	-	5.3	Y
19	11/27	1	200	39.6	-	39.6	-	5.6	N
24	11/27	1	200	42.7	-	54.6	-	8.4	N
25	11/27	1	200	30.5	-	32.3	-	7.7	N
26	11/27	1	200	42.7	-	73.5	-	21.5	N
29	11/27	2	200	33.5	-	82.6	-	4.3	Y
31	11/27	2	200	42.7	-	60.4	-	5.2	N
33	11/27	2	200	45.7	-	43.9	-	3.7	N
34	11/27	2	200	42.7	-	74.1	-	2.5	Y
35	11/27	2	200	45.7	-	45.1	-	3.9	Y
36	11/27	2	200	45.7	-	47.5	-	16.2	N
37	11/27	2	200	42.7	-	53.3	-	14.5	N
40	11/27	2	200	27.4	-	69.2	-	1.9	Y

Table 10.2. Summary of EBMUD redd surveys during the 1991-1992 spawning season¹ (cont.).

REDD NUMBER	INITIAL REDD LOCATION			DEPTH AT REDDS (cm)		MEAN COLUMN VELOCITY (cm/s)		AREA OF REDD (m ²)	SUBSTRATE ANALYSIS CONDUCTED ² (Y or N)
	DATE	REACH ³	APPROX. CAMANCHE FLOW (cfs)	AT 200 cfs	AT 160 cfs	AT 200 cfs	AT 160 cfs		
41	11/27	2	200	42.7	-	77.7	-	2.9	N
42	11/27	2	200	61.0	-	76.8	-	5.3	N
43	11/27	2	200	39.6	-	92.7	-	2.2	N
44	11/27	2	200	57.9	-	58.2	-	6.9	N
45	11/27	2	200	42.7	-	78.9	-	9.9	N
46	11/27	2	200	45.7	-	61.3	-	33.5	N
47	11/27	2	200	45.7	-	80.2	-	2.3	N
49	12/04	2	200	48.8	-	77.7	-	5.5	N
54	12/04	1	200	45.7	-	62.5	-	5.7	N
55	12/04	1	200	33.5	-	91.7	-	1.3	N
56	12/04	1	200	33.5	-	65.8	-	0.9	N
57	12/04	1	200	48.8	-	89.3	-	2.2	N
58	12/04	1	200	42.7	-	39.9	-	4.7	N
59	12/12	1	200	18.3	-	43.0	-	1.3	N
62	12/12	1	200	39.6	-	58.2	-	7.8	N
65	12/12	1	200	48.8	-	72.5	-	5.5	N
66	12/12	1	200	48.8	-	46.6	-	13.8	N
67	12/12	1	200	33.5	-	68.0	-	2.5	N
69A	12/12	1	200	45.7	-	60.7	-	2.2	N
69B	12/12	1	200	51.8	-	54.6	-	1.9	N
70	12/12	1	200	36.6	-	88.4	-	3.4	N
71	12/12	1	200	39.6	-	63.1	-	2.7	N
72	12/12	1	200	48.8	-	79.9	-	1.9	N
73	12/12	1	200	48.8	-	53.3	-	10.5	N
75	12/12	1	200	45.7	-	92.7	-	2.7	N
76	12/12	1	200	51.8	-	74.1	-	1.8	N
80	12/12	1	200	39.6	-	72.5	-	2.3	N

Table 10.2. Summary of EBMUD redd surveys during the 1991-1992 spawning season¹ (cont.).

REDD NUMBER	INITIAL REDD LOCATION			DEPTH AT REDDS (cm)		MEAN COLUMN VELOCITY (cm/s)		AREA OF REDD (m ²)	SUBSTRATE ANALYSIS CONDUCTED ³ (Y or N)
	DATE	REACH ²	APPROX. CAMANCHE FLOW (cfs)	AT 200 cfs	AT 160 cfs	AT 200 cfs	AT 160 cfs		
81	12/12	1	200	54.9	-	57.0	-	5.4	N
82	12/18	2	160	-	42.7	-	80.8	2.8	N
83	12/18	2	160	-	42.7	-	69.5	3.9	N
84	12/18	2	160	-	36.6	-	50.0	5.8	N
85	12/18	2	160	-	39.6	-	43.0	4.1	N
86	12/18	2	160	-	27.4	-	57.3	1.9	N
87	12/18	2	160	-	42.7	-	50.0	4.2	Y
88	12/18	2	160	-	51.8	-	43.0	3.2	N
89	12/18	2	160	-	39.6	-	46.6	2.6	N
90	12/18	2	160	-	36.6	-	59.4	3.0	N
91	12/18	2	160	-	54.9	-	71.0	2.6	N
92	12/18	2	160	-	36.6	-	64.9	5.6	N
93	12/18	2	160	-	48.8	-	50.0	5.5	N
94	12/18	2	160	-	24.4	-	88.4	4.4	N
97	12/18	2	160	-	39.6	-	61.9	4.1	N
98	12/18	2	160	-	33.5	-	61.9	7.9	N
99	12/18	2	160	-	42.7	-	57.0	4.6	N
100	12/18	2	160	-	39.6	-	44.5	11.7	N
103	12/18	2	160	-	33.5	-	96.9	1.5	N
104	12/18	2	160	-	36.6	-	84.7	7.9	N
105	12/18	2	160	-	39.6	-	80.8	4.7	N
106	12/18	2	160	-	39.6	-	63.4	6.1	N
107	12/18	1	160	-	33.5	-	51.2	6.9	N
108	12/18	1	160	-	39.6	-	33.8	1.9	N
109	12/18	1	160	-	54.9	-	84.7	3.6	N
110	12/18	1	160	-	33.5	-	50.0	2.0	N
111	12/18	1	160	-	36.6	-	66.4	5.5	N

Table 10.2. Summary of EBMUD redd surveys during the 1991-1992 spawning season¹ (cont.).

REDD NUMBER	INITIAL REDD LOCATION			DEPTH AT REDDS (cm)		MEAN COLUMN VELOCITY (cm/s)		AREA OF REDD (m ²)	SUBSTRATE ANALYSIS CONDUCTED ³ (Y or N)
	DATE	REACH ²	APPROX. CAMANCHE FLOW (cfs)	AT 200 cfs	AT 160 cfs	AT 200 cfs	AT 160 cfs		
113	12/18	1	160	-	39.6	-	72.5	3.1	N
114	12/26	2	160	-	48.8	-	47.5	1.8	N
116	12/26	2	160	-	48.8	-	71.0	6.8	N
117	12/26	2	160	-	76.2	-	57.0	4.9	N
118	12/26	2	160	-	51.8	-	84.7	3.4	N
119	12/26	2	160	-	70.1	-	52.4	3.7	N
120	12/26	2	160	-	36.6	-	48.8	2.3	N
121	12/26	2	160	-	57.9	-	78.9	13.3	N
122	12/26	2	160	-	39.6	-	84.7	3.1	N
123	12/26	2	160	-	51.8	-	39.3	6.4	N
124	12/26	2	160	-	51.8	-	61.9	9.9	N
125	12/26	1	160	-	36.6	-	64.9	6.5	N
126	12/26	1	160	-	42.7	-	50.0	1.1	N
127	1/02	2	160	-	61.0	-	62.5	3.7	N

¹Redds # 5, 8, 9, 20, 21, 23, 27, 28, 30, 32, 38, 39, 48, 50, 51, 52, 53, 60, 61, 63, 64, 68, 74, 95, 101, 112, and 115 were considered incomplete, and redd #22, 77A, 78, 96 and 102 were considered superimposed (multiple redds).

²Reaches are defined as Camanche Dam to Mackville Road (Reach 1), and Mackville Road to Elliott Road (Reach 2).

³Results of detailed substrate analysis are reported in Task 12.

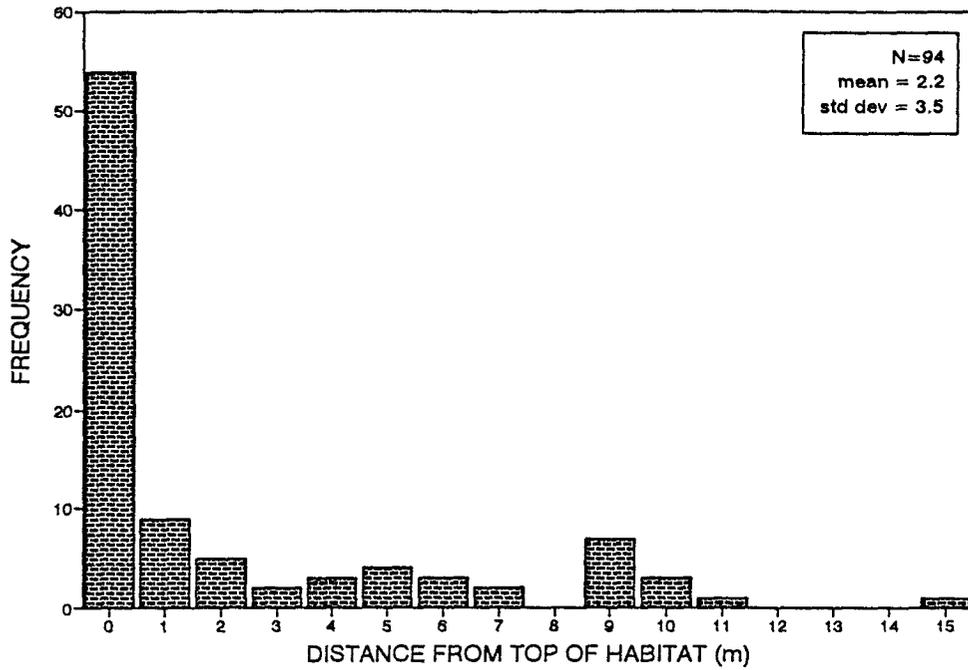


Figure 10-6. Frequency distribution of redd distance from top of habitat during spawning surveys on the Mokelumne River, 1991-1992.

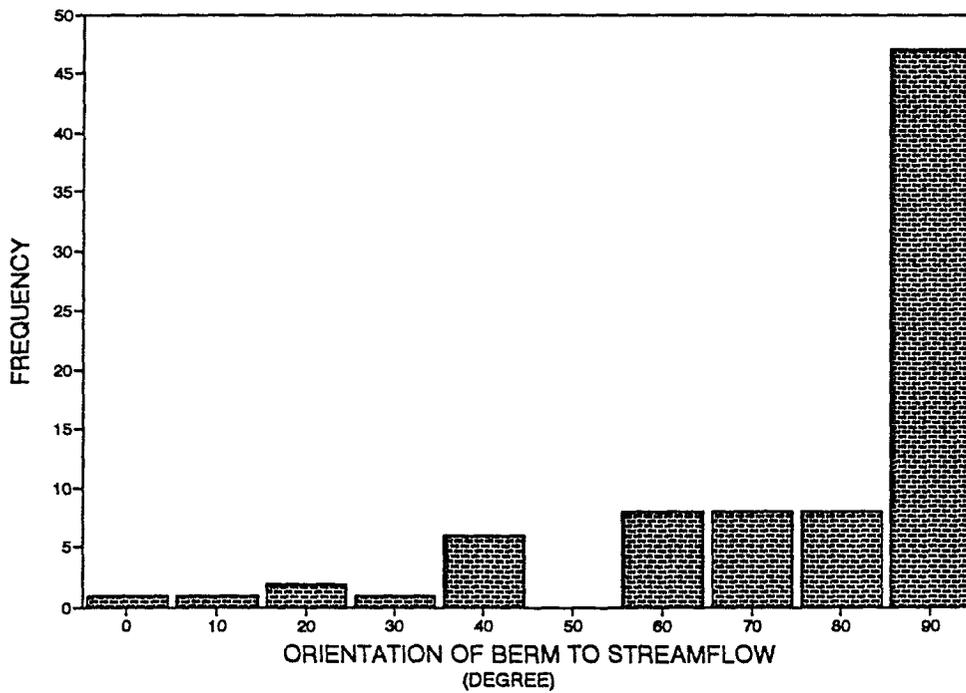


Figure 10-7. Frequency distribution of berm orientation to streamflow during redd surveys on the Mokelumne River, 1991-1992. Only berms with redds (N=82) are included.