

**Biological Supplement to Redwood National and State Parks
U.S. Army Corps of Engineers Application :
Coho Salmon Utilization of the Redwood Creek Estuary**

Prepared by

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BACKGROUND

Corps Permit Application

The permit application asks the Corps to allow breaching at the mouth of Redwood Creek for the purpose of water elevation management to maintain summer/fall rearing habitat for juvenile trout and salmon in the Redwood Creek estuary while preventing flooding of adjacent private land and county road. It also requests the allowance of breaching/channel alteration to allow the Parks to save the Redwood Information Center (RIC) building and adjoining facilities (underground utilities and sewage treatment mound), if as in December of 1994, the adjacent dunes and beach are eroded because of the southward migration of the mouth and shoreward migration of the channel toward RIC.

Process of Embayment Formation

As stream discharge decreases through the spring months, the straight outflow channel is modified by incoming waves and tidal currents. When prevailing north-northwest winds and high seas occur concurrently with high tides, the outflow channel migrates rapidly to the south. Ocean waves deflect the flow against the shoreward channel bank, eroding the bank while depositing a berm on the seaward side. Sediment deposited by overwash raises the channel bed. The height of the outflow channel restricts the rate of outflow, causing expansion of the embayment when rates of outflow, seepage, and evaporation are less than inflow from stream discharge or wave overwash. Continued onshore sediment transport may cause the outflow channel to completely close. Water levels rise in the embayment, adjacent private properties begin to flood and Hufford Road may be flooded, inhibiting or preventing access to homes adjacent to the north slough.

Breaching

Three events will open the mouth: sufficient rainfall, ocean wave overwash at high tide (both natural events), and artificial breaching. Rainfall and ocean wave overwash over the berm will raise the water level of the estuary to a point where the water will flow over the lowest area of the berm. Water flowing over this low spot will erode sand and over several hours the small channel will enlarge and deepen, thus draining the estuary. Sufficient rainfall to open the mouth generally occurs in the fall with the first large rainstorm. Ocean wave overwash into the estuary will occur in conjunction with the periodic extreme high high tides and heavy seas. The ultimate estuary water elevation before a natural breach is dependent upon the height of the berm. Sand deposition on the berm is a function of ocean onshore sediment transport. When the adjacent private land (pastures) flood (> 6.0 ft. Mean Sea Level) because the berm did not breach naturally, artificial breaching is performed and the estuary water level lowered. The NPS agreed to try to control water levels within the estuary by

artificial breaching in 1982 and continued through January 1994 when our Corps permit expired. The method of channel excavation has switched from manually digging a new channel to the present exclusive use of a bulldozer. The number of manipulations has varied from year to year (Table 1). Any illegal breaching by the public is done with shovels and occurs when the water level is high.

Recent Estuary Water Level Records

Monitoring of south slough water elevations (ft. MSL) for 1993 and 1994 show that in winter, peaks above 6 ft MSL are associated with high tides and streamflows (Figures 2 and 3). In July/August the mouth closed and either naturally breached as in 1993 or remained closed throughout the summer as in 1994. However, when closed in 1994, the water level declined, a result of seepage through the berm and evaporation. Natural and controlled breaches occurred in November, coinciding with the first storms of the year.

COHO SALMON

Coho Salmon Life History and the Redwood Creek Estuary

Coho salmon (*Oncorhynchus kisutch*) are present in the Redwood Creek watershed. The estuary serves as a passageway to the sea for all downstream migrating juveniles and to the spawning grounds for upstream migrating adults. The adults migrate through the estuary in fall and winter on their way to spawn and die in the tributaries of Redwood Creek. Juveniles spend one year in freshwater before migrating downstream through the estuary and into the ocean in spring. The estuary serves as an area for acclimation to saltwater from freshwater (i.e. smoltification).

Though this supplement only addresses coho salmon, other salmonid species, chinook salmon, and steelhead and coastal cutthroat trout utilize the estuary and would be affected by breaching. Adults migrate through the estuary on their spawning migration into the basin, and juveniles use the estuary for rearing, growth, and smolting. The estuary is the sole rearing habitat for juvenile chinook in Redwood Creek and equal numbers of juvenile steelhead rear in the estuary during summer and fall. All are Federal Candidate 2 species.

Adult Coho Salmon and Run Timing

Adult migration through and out of the estuary, and up Redwood Creek is dependent upon the mouth being open to the ocean and sufficient streamflow. If the sand berm has closed the mouth, no fish can enter the creek. If after the mouth is artificially or naturally breached and rainfall has not raised stream flow, upmigrating adult fish are unable to swim upstream over shallow riffles and barriers. They are subject to seal predation in the estuary and illegal fishing (poaching) in lower Redwood Creek before rainstorms raise the streamflows. Current California Department of Fish and Game sportfishing regulations prohibit fall/winter fishing unless Redwood Creek flow is at 300 cfs or above. The regulations were instituted to prevent an inordinate harvest of fish when they are susceptible at low flows, but poaching still occurs in Redwood Creek.

Table 1.

Record of water level manipulations in the Redwood Creek estuary by the National Park Service - Redwood National Park, for the years 1982 to 1994.

Artificial Estuary Water Level Control- Berm Breached		
Year	No. of Manipulations	Notes
1982	20	05/22 through 10/25
1983	22	06/01 - 10/05 Includes 4 times to slow or stop embayment outflow
1984	19	07/22 through 10/26
1985	6	06/29 through 09/16
1986	7	07/22 through 09/18
1987	19	06/01 through 08/11, and 2 on 08/24 and 11/16 by contractor constructing south slough culvert
1988	0	No controlled breaching
1989	4	07/21 through 08/24
1990	3	In the fall, 09/26 - 11/06
1991	0	No controlled breaching
1992	0	No controlled breaching
1993	1 (1)	11/30 (02/23 North Slough channel modified)
1994	1	12/04 Not for water level manipulation, but to stop channel migration erosion toward the Redwood Information Center facility

REDWOOD CREEK ESTUARY South Slough Water Level Record 01/01/93 - 12/31/93

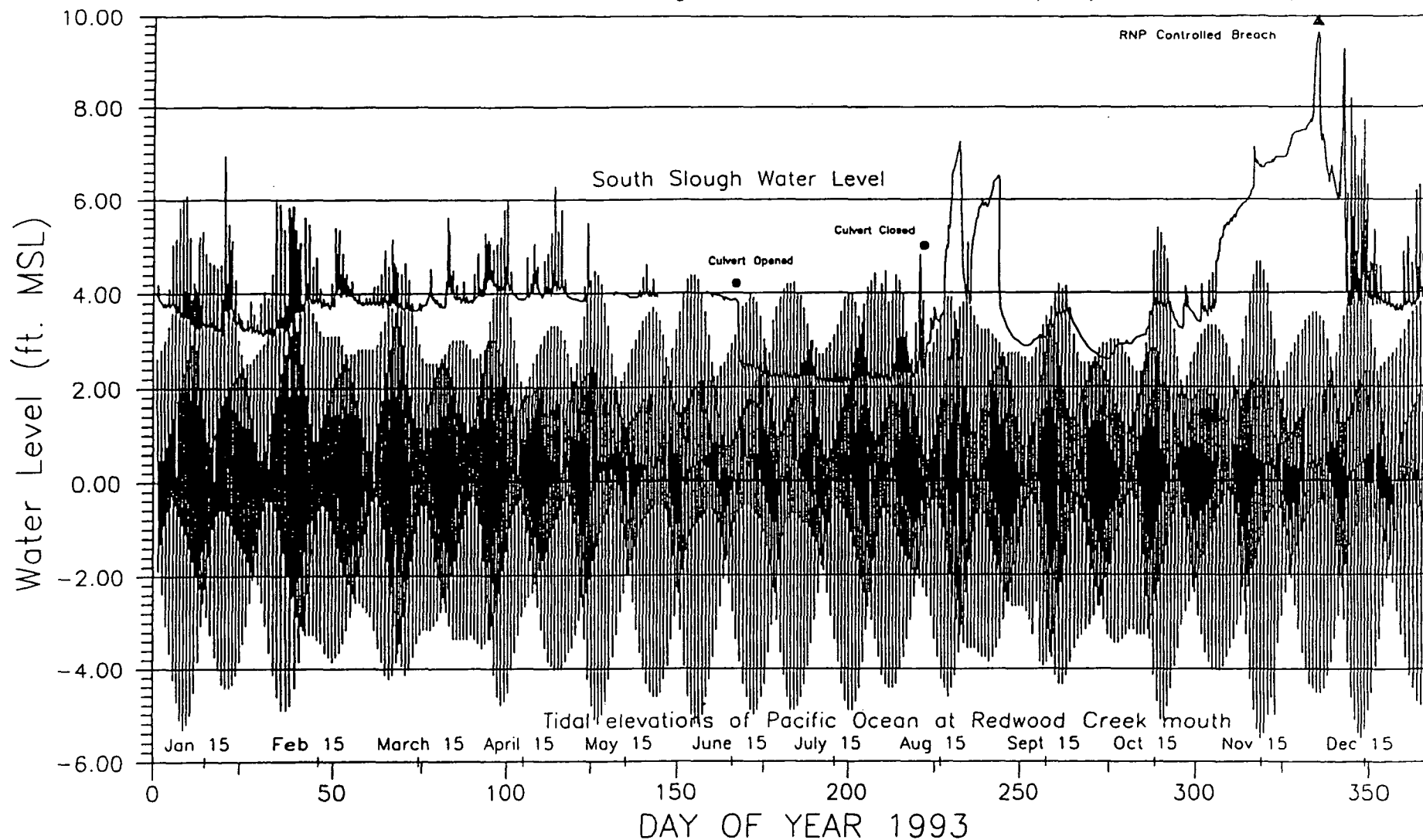


Figure 1. South slough water elevations (ft. Mean Sea Level [MSL]) and calculated tidal elevations of the Pacific Ocean at Redwood Creek for the period of January 1 to December 31, 1993, excluding May 4 to 11 and May 24 to June 7. Tidal elevations are corrected for the coastal locality of Redwood Creek and adjusted to MSL.

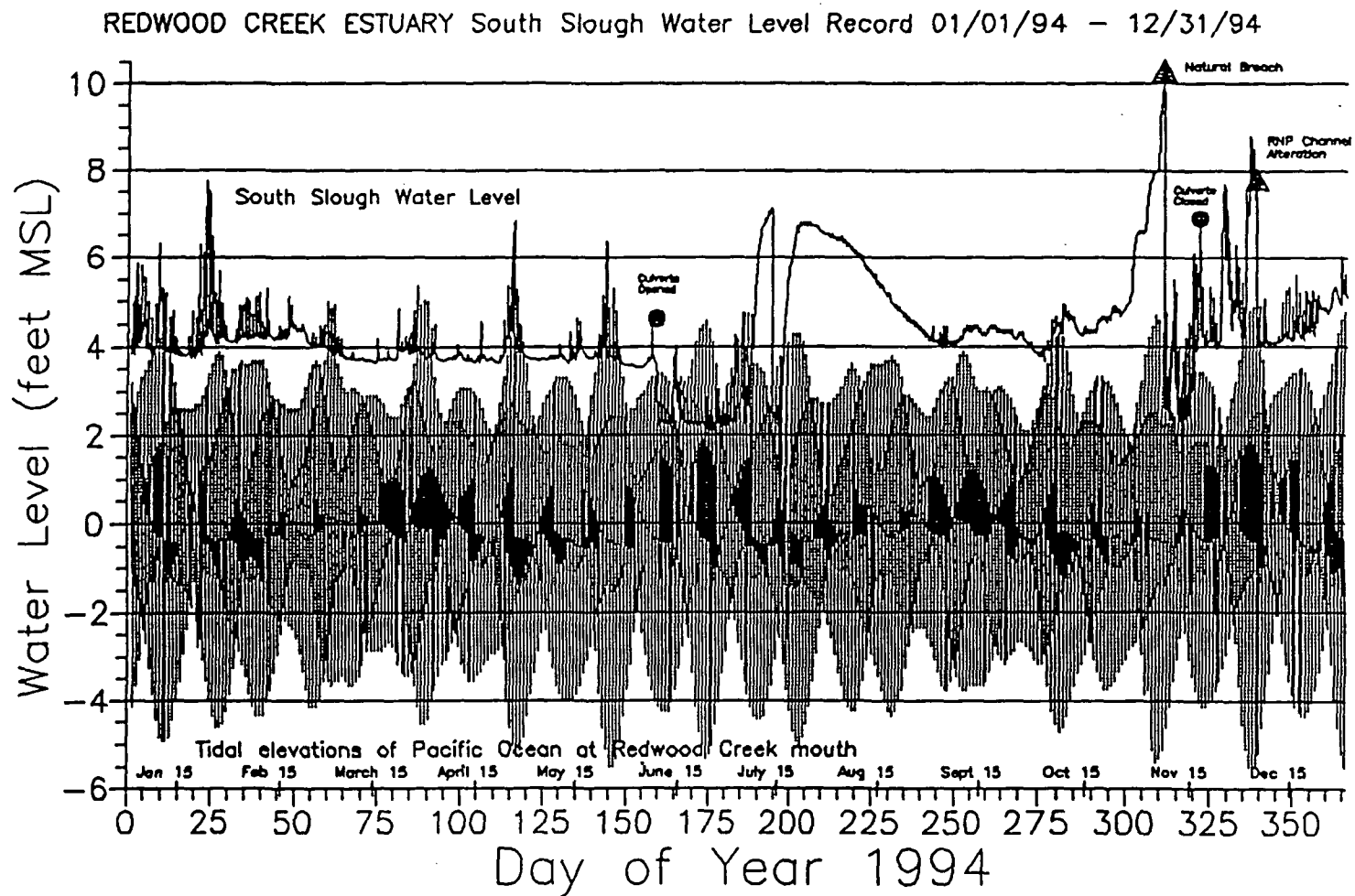


Figure 2. South slough water elevations (ft. Mean Sea Level [MSL]) and calculated tidal elevations of the Pacific Ocean at Redwood Creek for the period of January 1 to December 31, 1994. Tidal elevations are corrected for the coastal locality of Redwood Creek and adjusted to MSL.

From 11 years of Prairie Creek Hatchery trapping records, spawning seasons 1972-73 through 1982-83, from the Lost Man Creek weir, the coho salmon run ranged between early September and mid-February, but generally began in late October/early November and ended in February (Table 2). The peak of the run generally occurred in early November.

Recent run timing of the 1989-90 to 1994-95 spawning seasons for adult coho salmon from the Prairie Creek weir of the CalTrans funded Bypass 101 mitigation project was from late November to early March (Table 3).

However, the weirs were installed to capture fish for propagation and not to count the run. Generally, when enough fish were captured, the weir was removed, but if they continued to trap other species with later runs, e.g. steelhead, the longer period would encompass the coho run. Also, the weirs were not always fishing, they were removed in high flows or had their trapping regulated (e.g. every other day) to allow some fish to pass and spawn naturally upstream.

Though not as precise, spawning/carcass surveys on Lost Man Creek from the 1984-85 through the 1991-92 spawning season show run timing between early December and mid-February (Table 4). However, the runs may have begun earlier as no surveys were conducted in November. Also, the years of drought the area experienced in the 1980's, and the lack of significant storm events that prevented flows sufficient for upstream migration or failed to open the mouth of Redwood Creek at the ocean prevented fish access to Redwood Creek until later in the fall, and probably delayed the onset of adult upward migration some fall years.

Juvenile Coho Salmon and Estuary Utilization

Estuary research was begun in 1980 by Humboldt State University fishery graduate students. Redwood National Park has monitored juvenile salmonid utilization in the estuary from 1982 to 1995. Fish were sampled with a 1/4" mesh beach seine in the embayment to determine growth and estimate populations. A fyke net (hoop net with wings) trapped fish to determine fish utilization in the south slough.

Though juvenile chinook and steelhead are the most numerous salmonid captured, juvenile coho salmon are incidentally caught during the summer. Downstream migration of coho to the ocean from upstream Redwood Creek rearing areas occurs in early spring (March-April). Generally, we intercepted the tailend of the spring outmigration when we begin estuary sampling in June. Our data indicate that these young salmon move directly into the ocean, spending a minimal amount of time in the estuary (Larson, unpublished data).

Juvenile coho salmon may have at one time utilized the south slough as rearing habitat. Young coho were observed in the early 1970's at the U.S. 101 bridge crossing of Strawberry Creek (Steve Sanders, Prairie Creek Hatchery Manager, personal communication). More recently in the summers of 1991 and 1994, small numbers of young-of-the-year wild coho salmon were trapped in the south slough and probably were rearing in the slough.

Table 2. Adult coho salmon trapping data, spawning year, number of coho trapped, range of occurrence, and peak occurrence at the Prairie Creek Hatchery weir located on Lost Man Creek, tributary to Prairie Creek (which is a tributary to Redwood Creek), Humboldt County, California. The data is for the spawning seasons 1972-73 through 1982-83.

YEAR Spawning Season	No. of Coho Salmon Trapped	Range of Occurrence (Dates)	Peak Occurrence (Date)
1972-73	184	11/12/72 - 12/24/72	11/04/72
1973-74	82	09/28/73 - 01/12/74	11/05/73
1974-75	33	11/06/74 - 11/29/74	11/07/74
1975-76	125	10/10/75 - 02/14/76	11/07/75
1976-77	49	11/16/76 - 03/11/77	02/26/77
1977-78	22	09/02/77 - 01/13/78	11/22/77
1978-79	69	10/31/78 - 02/27/79	01/10/79
1979-80	98	10/15/79 - 02/18/80	12/19/79
1980-81	41	11/03/80 - 02/13/81	11/26/80
1981-82	30	10/27/81 - 02/09/82	11/04/81
1982-83	84	10/27/82 - 02/09/83	01/18/83

Table 3. Adult coho salmon trapping data, spawning year, number of coho trapped and range of occurrence at the PCFFA Trinidad Fishermen's Salmon Enhancement/Pacific Coast Fish, Wildlife and Restoration Association weir located on Prairie Creek (which is a tributary to Redwood Creek) at Prairie Creek Redwoods State Park, Humboldt County, California. The data is for the spawning seasons 1989-90 through 1994-95.

YEAR Spawning Season	No. of Coho Salmon Trapped	Range of Occurrence (Dates)
1989-90	152	11/26/89 - 03/13/90
1990-91	79	11/25/90 - 01/18/91
1991-92	70	11/20/91 - 03/06/92
1992-93	92	11/18/92 - 01/07/93
1993-94	78	
1994-95	115	11/18/94 - 02/09/95 ^a

^a Week of

Table 4. Adult coho salmon spawning and carcass survey data for a 2,400 meter reach of Lost Man Creek, located in Redwood National Park, Humboldt County, California for the spawning years 1984-85 through 1991-92.

YEAR SPAWNING SEASON	SURVEY DATE	COHO SALMON		SEASON COHO TOTAL	
		Live Fish	Carcasses	Live Fish	Carcasses
1984-85	02/25/85	0	0	0	0
1985-86	12/18/85	0	0	0	0
1987-88	01/26/88	108	13	136	36
	02/10/88	28	23		
1988-89	12/06/88	36	1	103	41
	01/25/89	64	19		
	02/15/89	3	21		
1989-90	12/05/89	0	0	28	18
	01/23/90	28	18		
	03/22/90	0	0		
1990-91	01/16/91	2	0	4	22
	01/31/91	2	13		
	02/27/91	0	9		
	03/18/91	0	0		
1991-92	01/02/92	1	0	46	17
	01/29/92	26	4		
	02/13/92*	19	13		
	03/03/92*				
	03/24/92	0	0		

* Two days to complete survey

Larson (1987) in his thesis documenting utilization of the Redwood Creek estuary by juvenile salmonids, stated "few wild coho and cutthroat were caught during the 1980 sampling in Redwood Creek". The period of sampling was February through November 1980. Larson documented a landowners breach of the sand berm in July of 1980. Juvenile salmonids were involuntarily forced to enter the ocean. The breach (what we would now refer to as an uncontrolled breach because of the breaching location on the berm and its resulting negative effects) drastically reduced available habitat in area and depth. The fish rearing in the estuary probably experienced reduced ocean survival because of the abrupt transition from fresh to salt water. During 1980, the berm developed and was breached three times.

Salamunovich (1987) studied fish food habits and their interrelationships in lower Redwood Creek from February to December, 1980. He captured only four coho juveniles at an upstream site in "spring", and one, a fin-clipped Prairie Creek Hatchery juvenile, in the north slough on April 12. The coho smolts apparently had all entered the ocean by mid-spring.

McKeon (1985) studied the downstream migration, growth, and condition of juvenile fall chinook salmon in Redwood Creek. Using a downstream migrant weir, lower Redwood Creek was sampled once a week from May 2 to July 24 in 1981; May 3 to August 2 in 1982; May 2 to August 8 in 1983; and on Prairie Creek from May 4 to August 3 in 1983. Of the 4,537 fish captured in the weir during the study, 1 percent (45) were coho salmon. Downstream migration of coho therefore was prior to May.

Summer/fall estuary monitoring juvenile coho salmon data for 1988 through 1995 is presented in Table 5. The sampling period extended from June to September or mid October. During summer/fall estuary sampling a juvenile coho was present in late September 1988; they were present June through September in 1989, 1990, and 1991; June through early October in 1992; not present in 1993; present from June through late July in 1994; and only during the month of June in 1995. When captured, sampling has shown they are present in very small numbers (<40) when compared to the population estimates of thousands of individuals of juvenile chinook and steelhead. Because of their low numbers, it was difficult to accomplish a mark and recapture population estimate for coho. The exception was 1995 when the largest numbers were caught, 118 and 65 individuals, and a population estimated at 350 (Table 5).

The large mean fork lengths (mm) of most fish seined in the embayment indicate they were downstream migrating smolts (Table 5). The smaller individuals, most trapped in the south slough were rearing young-of-the-year coho juveniles. No coho were trapped in the north slough.

A note of caution in interpreting the incidence of juvenile coho in the estuary. The system has had hatchery releases from the Prairie Creek Hatchery for decades. When the hatchery closed down in December 1992, the last coho were transferred to Arcata and planted back in Prairie Creek as 1+ fish between period of March 18 to May 7, 1993. Also, releases of young-of-the-year (0+) fish into Prairie Creek from the CalTrans funded hatchbox program to mitigate for the U.S. 101 Bypass construction has occurred since summer of 1990 through the summer of 1994. Their late occurrence

Table 5. Sampling period and dates, number of fish captured and/or estimated, and mean fork lengths (mm) of juvenile coho salmon captured in the Redwood Creek estuary, Humboldt County, California for the years 1988 through 1995. Three day sample dates are population estimate attempts and () are population estimates.

Summary of Juvenile Coho Salmon Occurrence in the Redwood Creek Estuary				
Year	Sample Period	Sample Dates Coho Present	Number of Fish Caught	Mean Fork Length (mm)
1988	06/15/88 to 09/27/88	09/27 28 29/88	1	82.0
1989	06/13/89 to 09/19/89	06/13 14 16/89	4	135.0
		07/11 12 14/89	2	76.0
		08/21 22 24/89	3	141.3
		09/19 20 22/89	2	155.0
1990	06/19/90 to 09/28/90	06/19 20 22/90	4	69.0
		07/06/90	6	105.3
		07/17 18 20/90	31	101.8
		08/06 07 09/90	7	108.7
		08/20 21 23/90	2	125.5
		09/10 11 13/90	10 (28)	136.0
1991	06/06/91 to 10/21/91	06/06/91	2	112.5
		06/24 25 27/91	3	110.7
		07/11/91	2	89.5
		07/22 23 25/91	8	127.9
		07/30/91*	1	77.0
		08/12 13 15/91	3	113.7
		08/21/91*	1	89.0
		09/16 17 19/91	4	134.3

* Trapped in South Slough, all others seined in the embayment.

Table 5. Sampling period and dates, number of fish captured and/or estimated, and mean fork lengths (mm) of juvenile coho salmon captured in the Redwood Creek estuary, Humboldt County, California for the years 1988 through 1995. Three day sample dates are population estimate attempts and () are population estimates. (continued)

Summary of Juvenile Coho Salmon Occurrence in the Redwood Creek Estuary				
Year	Sample Period	Sample Dates Coho Present	Number of Fish	Mean Fork Length (mm)
1992	06/22/92 to 10/05/92	06/22 23 25/92	5	127.1
		07/08/92	2	134.0
		10/05 06 08/92	1	136.0
1993	06/14/93 to 09/29/93	----	0	---
1994	06/06/94 to 10/27/94	06/06/94	25	114.7
		06/23/94 ^a	39	56.2
		07/25 26 28/94	1	144.0
1995	6/14/95 to 09/14/95	06/14/95	118	116.0
		06/26 27 29/95	64 (350)	114.7

^a Trapped in south slough, all others seined in the embayment.

in the estuary some summers were probably related to the release of hatchbox coho by PCFFA in early summer, June and July. In 1996, for the first time in almost 100 years, no fish plants of any species will occur. It is assumed, juvenile coho occurrence in the estuary will approach natural conditions.

References

- Larson, J P. 1987. Utilization of the Redwood Creek estuary, Humboldt County, California by juveniles salmonids. M.S. Thesis, Humboldt State University, Arcata, California. 79 pp.
- McKeon, J.F. 1985. Downstream migration, growth, and condition of juvenile fall chinook salmon in Redwood Creek, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, California. 90 pp.
- Salamunovich, T.J. 1987. Fish food habits and their interrelationships in lower Redwood Creek, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, California. 173 pp.

Table 2. Adult coho salmon trapping data, spawning year, number of coho trapped, range of occurrence, and peak occurrence at the Prairie Creek Hatchery weir located on Lost Man Creek, tributary to Prairie Creek (which is a tributary to Redwood Creek), Humboldt County, California. The data is for the spawning seasons 1972-73 through 1982-83.

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1976-77	49	11/16/76 - 03/11/77	02/26/77
1977-78	22	09/02/77 - 01/13/78	11/22/77
1978-79	69	10/31/78 - 02/27/79	01/10/79
1979-80	98	10/15/79 - 02/18/80	12/19/79
1980-81	41	11/03/80 - 02/13/81	11/26/80
1981-82	30	10/27/81 - 02/09/82	11/04/81
1982-83	84	10/27/82 - 02/09/83	01/18/83

1997 Redwood Creek Estuary Annual Monitoring Report

Redwood National and State Parks
 Division of Resource Management and Science
 Fish and Wildlife Branch

This is an annual summary of Redwood National Park Fish and Wildlife Branch monitoring activities in the Redwood Creek estuary for the calendar year 1997. The purpose of the study is to monitor utilization of the estuary by fish and breaching incidents.

Study Location

The Redwood Creek estuary is located 2.5 miles west of Orick, California at the mouth of Redwood Creek at the Pacific Ocean (Figure 1). Redwood Creek is 108 km long and the basin is 720 km² in size. U.S. Army Corps of Engineers constructed 3.4 miles of flood control levees in 1968 on lower Redwood Creek, which bisect and terminate in the estuary. The estuary consists of the north and south sloughs, and the embayment. The south slough was the last oxbow of the river bypassed by the south levee.

Methods

Fish Monitoring

Population Estimates - The Peterson mark and recapture method (Youngs and Robson 1978) was used to estimate juvenile salmonid fish numbers in the Redwood Creek embayment. A blue mark was applied to the upper or lower caudal fin or anal fin of captured fish using a Panjet needleless injector and Alcian Blue dye. Fish were seined with a 150-long, 15-foot wide, ¼ inch mesh beach seine net deployed off the bow of a 16-foot motor boat. Captured fish were marked the first two days, allowed to mix the third day, and seined on the fourth day to determine the ratio of marked to unmarked fish. The equation for the estimated population is:

$$N = \frac{(m \times c)}{r}$$

Where N = number of fish in population

m = number of marked fish in population (i.e. total fish marked the first two days)

c = number of fish in sample on fourth day

r = number of marked fish in c.

Results were rounded off to the nearest 10.

The population 95% confidence interval is determined by multiplying the square root of the variance of N by 1.96 and adding and subtracting it to N. The variance of N is:

$$V(N) = \frac{(N)^2 (N - m) (N - c)}{(m \times c) (N - 1)}$$

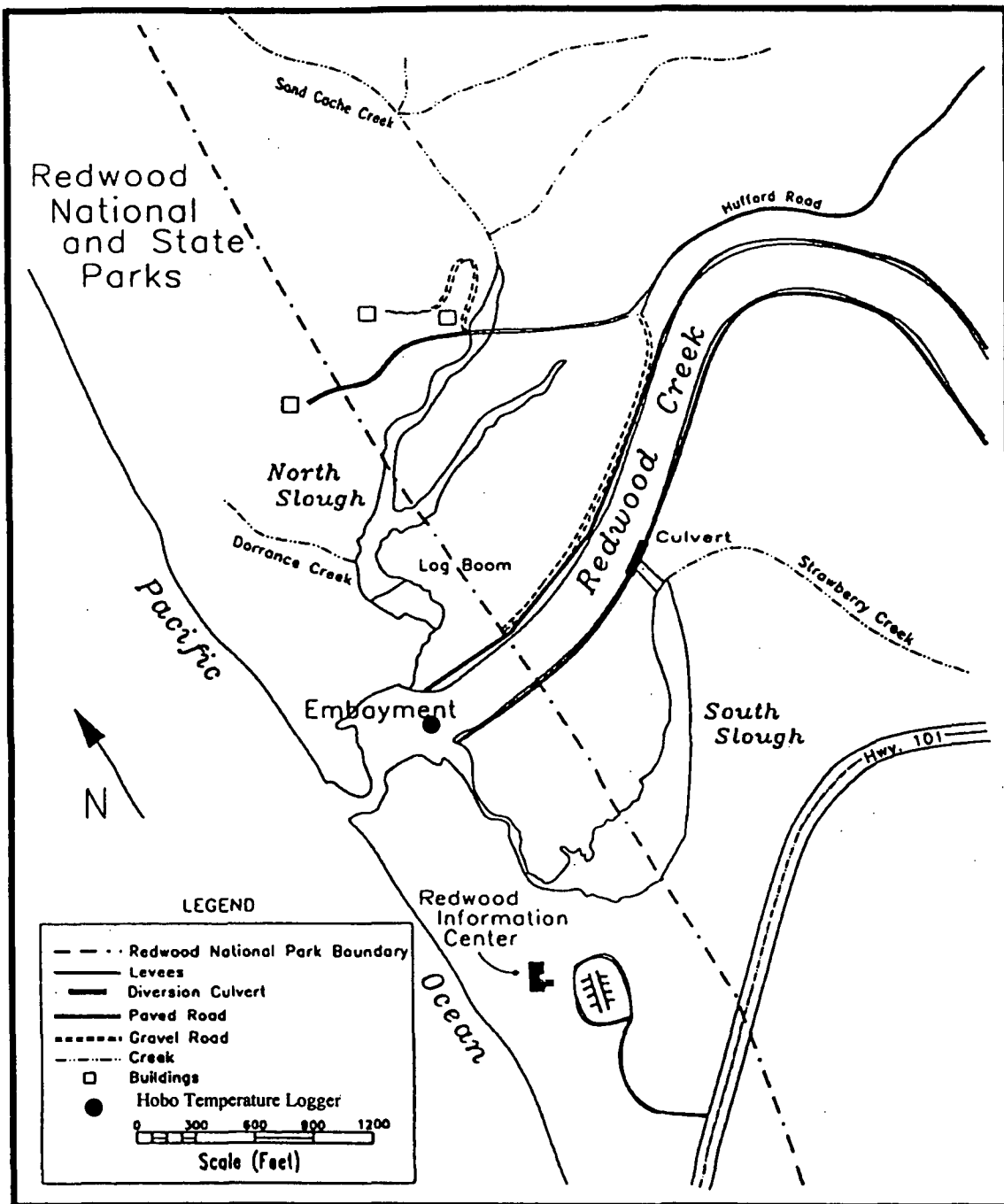


Figure 1. Map of the Redwood Creek Estuary, Humboldt County, California, including the embayment, and north and south sloughs.

Growth Estimates - Fork length (mm) measurements were obtained from 200 each chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*), and weight measurements were taken from 30 juveniles of each species. Measurements were done in conjunction with the fish marking. Other salmonid species, coastal cutthroat trout (*O. clarki*) and coho salmon (*O. kisutch*), though not as numerous as chinook or steelhead, are also measured.

Water Quality Monitoring

Water temperature (C°) was measured in the Redwood Creek embayment. A HOBOTM temperature logger located in the middle of the Redwood Creek channel between the ends of the north and south flood control levees one foot from the bottom recorded water temperature every 48 minutes (Figure 1).

Estuary Water Levels

South slough water elevations (feet Mean Sea Level [MSL]) at the Redwood Creek estuary, were recorded at 30 minute intervals by a continuous recording gage using a pressure transducer and ENMOS logger. The gage site is located at the end of the Redwood Information Center boardwalk trail.

Results

Fish Monitoring

Presence - Four salmonid species were seined in the Redwood Creek embayment; chinook and coho salmon, and steelhead and coastal cutthroat trout. No half-pounder or adult sized steelhead were captured. Eight other fish species were captured, and 14 bird species observed. A complete list of all fish and other species captured or observed in and around the Redwood Creek estuary is presented in Table 1.

Population Estimates - Three population estimates were done during in the summer and fall of 1997 on the weeks of June 16, July 21, and September 15, 1997 (Table 2 and Appendix I). Initial estimates in June of chinook salmon and steelhead trout juveniles were 41,020 and 12,770 respectively. The second estimate in July (where the mouth of the creek had completely closed), populations of chinook and steelhead had declined to 15,040 and 12,640, respectively. The third estimate in September where the mouth had remained closed, chinook and steelhead declined further to 2,690 and 4,420, respectively.

Twenty-eight coho salmon smolts were captured the first sample period in June and none the rest of the summer. A total of 42 coastal cutthroat trout were captured, 7 in June, 36 in July, and 1 in September.

Growth Estimates - Three growth estimates were done in conjunction with the population estimates (Table 3 and Appendix II). Chinook salmon mean fork length increased from 78.5 to 102.0 mm, an increase of 23.5 mm, between June and September sample dates. Mean weight rose from 5.8 to 11.3 g, and increase of 5.5g. Steelhead trout mean fork length increased from 117.2 to 137.1 mm, an increase of 19.9 mm, between June and September. Mean weight rose from 6.3 to 16.0g, an increase of 9.7 g.

Table 1. List of salmonid and non-salmonid fish and aquatic species seined; and birds, mammals, and sensitive plants observed in the Redwood Creek estuary, Redwood National Park, Humboldt County, California during the summer/fall 1997 sampling.

	1997 Estuary Sampling Dates		
	June 16, 17, 19	July 21,22, 24	Sept 15, 16, 18
Salmonid Fish			
Coastal Cutthroat Trout	X	X	X
Steelhead Trout	X	X	X
Chinook Salmon	X	X	X
Coho Salmon	X		
Non-Salmonid Fish			
Surf Smelt	X		
Night Fish	X	X	
Three Spine Stickleback	X	X	X
Staghorn Sculpin	X	X	X
Prickly Sculpin	X		
Shiner Surfperch	X		
Starry Flounder	X	X	X
Humboldt Sucker	X	X	X
Other Aquatic Species			
Jelly Fish	X		
<i>Corophium</i> (benthic amphipod)		X	
Crab		X	
Sensitive Plants			
Pink Sand Verbena			X
Birds			
Brown Pelican	X	X	X
Double Crested Cormorant		X	X
Black Crowned Night Heron	X		
Turkey Vulture	X	X	
Osprey	X	X	
Northern Harrier		X	
Killdeer	X	X	
Gulls	X	X	X
Caspian Tern	X	X	
Violet Green Swallow	X		
Barn Swallow	X		
Corvids (Crows and Ravens)		X	
American Goldfinch		X	
Mammals			
Harbor Seal	X		

Table 2. Population estimates and 95 percent confidence intervals for chinook salmon, steelhead trout, coastal cutthroat trout, and coho salmon seined in the Redwood Creek estuary, Humboldt County, California. Mouth denotes if Redwood Creek mouth was open or closed to the ocean.

DATE (1997)	Mouth of Creek (Open or Closed)	Chinook Salmon		Steelhead Trout	
		Population Estimate	95% Confidence Interval	Population Estimate	95% Confidence Interval
June 16, 17, 18	OPEN	41,020	33,000 – 49,040	12,770	2,780 – 22,770
July 21, 22, 24	CLOSED	15, 040	8,160 – 21,910	12,640	8,440 – 16,850
Sept 15, 16, 18	CLOSED	2,690	210 – 5,230	4,420	1,090 – 7,740
		Cutthroat Trout		Coho Salmon	
June 16, 17, 18	OPEN	7 ^a	---	28 ^a	---
July 21, 22, 24	CLOSED	36 ^a	---	0	---
Sept 15, 16, 18	CLOSED	1 ^a	---	0	---
a. Actual count of fish captured in seine net hauls. No marked fish were recaptured.					

Table 3. Mean fork length (mm) and weight (g), standard deviation, range, and sample numbers of juvenile chinook and coho salmon and steelhead and coastal cutthroat trout seined in the Redwood Creek estuary, Humboldt County, California, during summer and fall sample dates of 1997. Mouth denotes if Redwood Creek mouth was open or closed to the ocean.

Redwood Creek Estuary Summer/Fall 1997							
DATE	MOUTH	Mean Fork Length (mm) (No. Sampled)	Std. Dev. (mm)	Range (mm)	Mean Weight (g) (No. Sampled)	Std Dev. (g)	Range (g)
CHINOOK SALMON							
6/16,17,19	OPEN	78.5 (242)	7.5	56 - 97	5.8 (30)	1.2	4.0 - 9.7
7/21,22,24	CLOSED	86.9 (235)	4.8	72 - 99	7.8 (30)	1.2	5.8 - 11.0
9/15,16,18	CLOSED	102.0 (204)	6.5	82 - 120	11.3 (30)	2.1	7.1 - 16.9
COHO SALMON							
6/16,17,19	OPEN	104.9 (28)	8.5	84 - 123	10.4 (5)	1.4	8.8 - 11.9
7/21,22,24	CLOSED	---	---	---	---	---	---
9/15,16,18	CLOSED	---	---	---	---	---	---
STEELHEAD TROUT							
6/16,17,19	OPEN	117.2 (224)	13.8	86 - 192	14.8 (31)	6.3	7.1 - 29.0
7/21,22,24	CLOSED	136.0 (212)	21.6	57 - 179	27.3 (30)	11.5	7.5 - 54.2
9/15,16,18	CLOSED	137.1 (200)	30.2	77 - 200	15.8 (30)	16.0	5.2 - 83.8
CUTTHROAT TROUT							
6/16,17,19	OPEN	201.6 (7)	44.1	168 - 291	53.9 (2)	17.6	41.4 - 66.3
7/21,22,24	CLOSED	223.8 (36)	44.6	165 - 365	---	---	---
9/15,16,18	CLOSED	261.0 (1)	---	---	---	---	---

Coho salmon smolt mean fork length during the week of June 16 was 104.9 mm (n = 28) and average weight was 10.4 g (n = 5). Cutthroat trout mean fork length increased from 201.6 to 223.8 mm from June to July, and a single individual caught in September was 261 mm. Cutthroat trout ranged in size from 165 to 365 mm.

Water Quality Monitoring

In 1997, water temperature (°C) was the only water quality parameter monitored in the Redwood Creek estuary. A HOBO temperature logger recorded water temperature every 48 minutes from July 24 through September 22, 1997 (Figure 2). The maximum and minimum water temperature were 21.2 and 15.6 °C. The average water temperature for the period of 60 days was 19.0 °C.

Estuary Water Levels

South Slough Water Level Gaging - South slough water elevations (feet Mean Sea Level [MSL]) in the Redwood Creek estuary, were recorded for the period March 3 to December 31, 1997, excluding December 1 through December 16, 1997 (Figure 3). A bad battery caused the December failure.

The mouth of Redwood Creek appeared to close completely on July 19 and remained closed for 64 days until it breached on September 21. During the closure period, the water elevation remained near 6.0 ft MSL. Prior to the breach, the water elevation peaked at 8.94 ft MSL on September 19. The uncontrolled breach on September 21 occurred at 6:55 am. In the course of 8.5 hours the water level elevation fell from 8.62 to 3.5 ft MSL, a drop of 5.12 ft. At 5:54 am the following morning, the low elevation was at 2.71 ft, at total decrease of 5.91 ft. The embayment level most likely went lower, but because of the hydraulic nickpoints in south slough channel and south slough culverts, which limit slough drainage, the gage could not record a lower elevation. In October the hydraulic nickpoint established itself at 2.79 ft MSL and later when the culverts were closed in November, the hydraulic nickpoint rose to 4.49 ft MSL.

Rainfall measured at the Redwood Creek stream gage below the confluence of Prairie Creek recorded three rainfall events in the week prior to the breach. During the evening and morning of September 13-14, 0.68 inches of rain fell; on September 15, 0.36 inches fell; and on September 17, 1.24 inches fell, for a total of 2.28 inches in the week prior to the breach. No rain had fallen for some time prior to these events. Stream flow rose from less than 16.5 cubic feet per second (cfs) to 32 cfs on September 14, peaking at 573 cfs on September 17, and was declining from 67 to 49 cfs during September 21, the day of the breach.

On September 21, the high tide was 2.3 ft MSL at 3:56 am, the low at -1.7 ft MSL at 9:32 am, and the high high tide at 3.3 ft MSL at 3:40 p.m.

Controlled Breaching Activities

In 1997 Redwood National Park did not breach the berm or manipulate the Redwood Creek channel. One instance of illegal breaching activity was observed on July 28, 1997 around 5 p.m. Three persons (one at a time) were observed trying to dig through the berm. The following morning a channel approximately 30 feet long and 8 inches wide was still present. The park fishery biologist

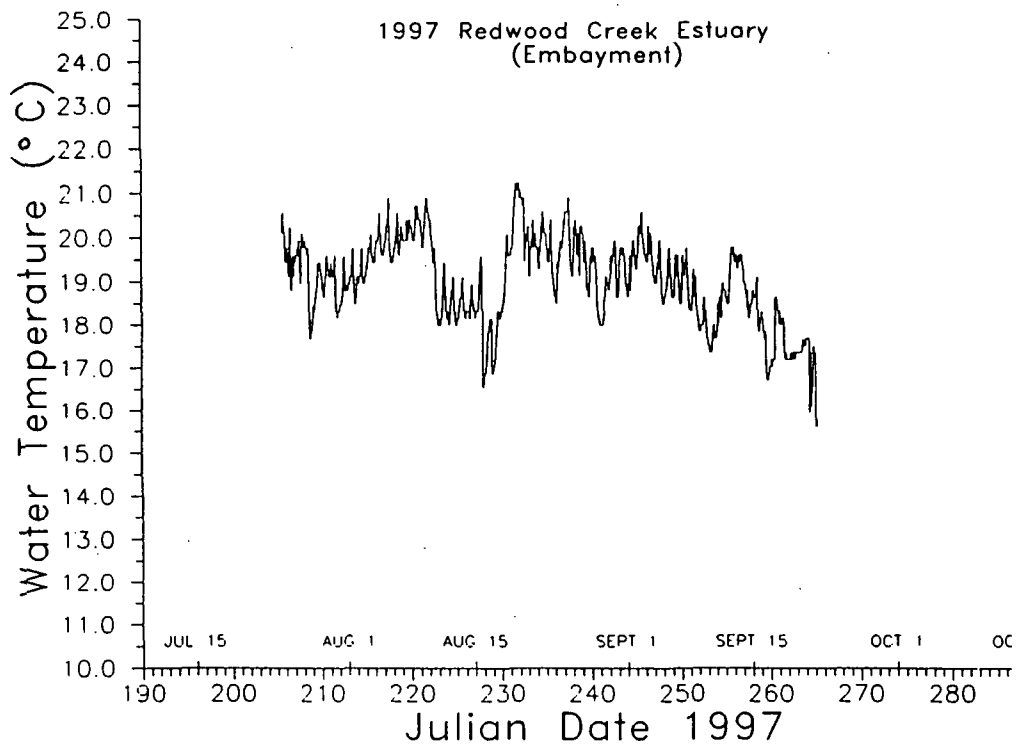


Figure 2. Redwood Creek estuary water temperatures (°C) measured by a HOBO temperature logger located in the middle of the Redwood Creek channel between the ends of the north and south flood control levees. The temperature logger, located one foot from the bottom, recorded water temperature every 48 minutes from July 24 through September 22, 1997.

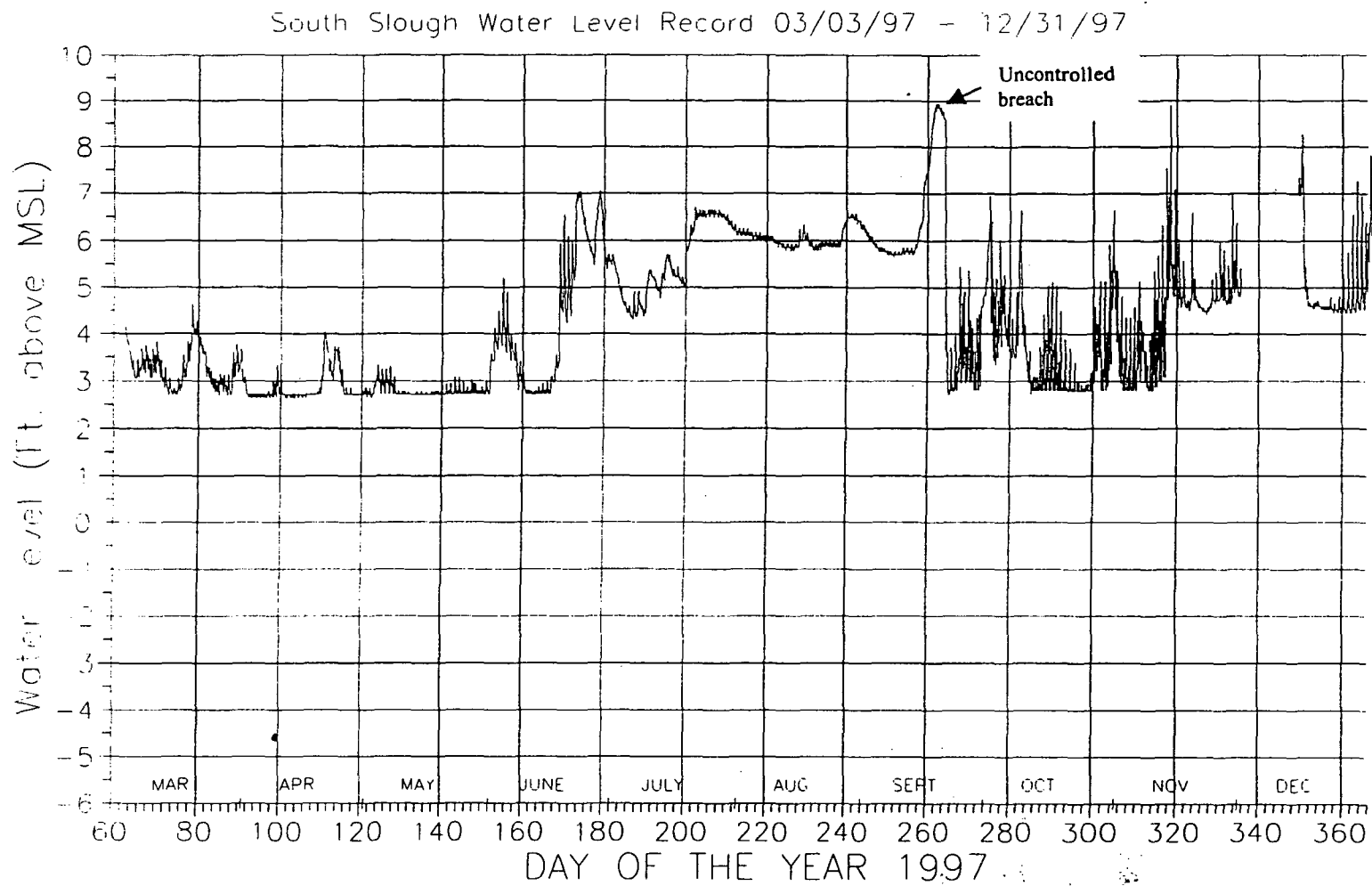


Figure 3. South slough water elevations (feet Mean Sea Level [MSL]) of the Redwood Creek estuary, Humboldt County for the period March 3 to December 31, 1997, excluding December 1 through December 16, 1997. The uncontrolled breach occurred on September 21, 1997.

pushed sand in the excavation with his feet. The channel, 30 feet short of the berm crest, was not long enough to breach the berm.

South Slough Culvert Gates

The three south slough culvert gates were opened on June 25 and closed on November 13, 1997.

Discussion

The mean length of salmonid fish residing in the estuary increased during the summer indicating the estuary provided rearing habitat. The large size and appearance of the coho captured were indicative of smolts migrating downstream. Their absence the rest of the summer indicates we must have intercepted the last portion of the downstream coho smolt migration.

Downstream migration trapping on Prairie Creek (above Streeflow Creek) from February 20 through June 19, 1997 captured 25,994 0+ (young-of-the-year) chinook salmon (Klatte and Roelofs 1997). When expanded to account for trapping efficiency, they estimated 44,982 0+ chinook salmon migrated out of Prairie Creek above Streeflow Creek. Though this figure only reflects the Prairie Creek watershed, and not the rest of Redwood Creek, it is similar to the high estuary population estimate from the week of June 16, 41,020 chinook (95 % confidence interval of 33,000 to 49,040). Once the embayment closed, populations of both chinook and steelhead declined. Since they could not migrate to the ocean because the mouth was closed, the decline was most likely due to mortality. One of the contributing factors could have been poor water quality.

Water temperatures in the Redwood Creek estuary were warm. Water temperatures measured, ranging between 21.2 and 15.6 °C, were not optimum, nor in the preferred range for rearing salmonids. Preferred water temperatures for rearing steelhead trout and chinook salmon are 7.8 to 14.6 °C (optimum 10.1 °C) and 7.3 to 14.6 °C (optimum 12.2 °C), respectively (Reiser and Bjorn 1979). During the period when the estuary was closed fish could not migrate to the cooler ocean waters, nor would there have been much input of cooler ocean water into the estuary, except by wave overwash across the berm. Upstream, the water was even warmer. Water temperatures measured in the mainstem upstream of Prarie Creek reached 24.4°C (Anderson 1997). The degraded water quality may have contributed to the decline in the chinook and steelhead populations when the mouth was closed.

It is difficult to determine if the uncontrolled breach which occurred on September 21 was a natural or human caused event. All traces of human excavation would have been erased as the channel widened and deepened during the ensuing outflow. Given the rain the week before the event, it is likely that it was a natural event or if a human-caused event, the berm would have probably breached naturally in the near future.

The park did not have an U.S. Army Corps of Engineers Section 404 permit to breach the berm to prevent any negative effects from an uncontrolled breach. The park's application was still under review by the Corps and the permit (No. 21881N), was not granted until January of 1998. Another

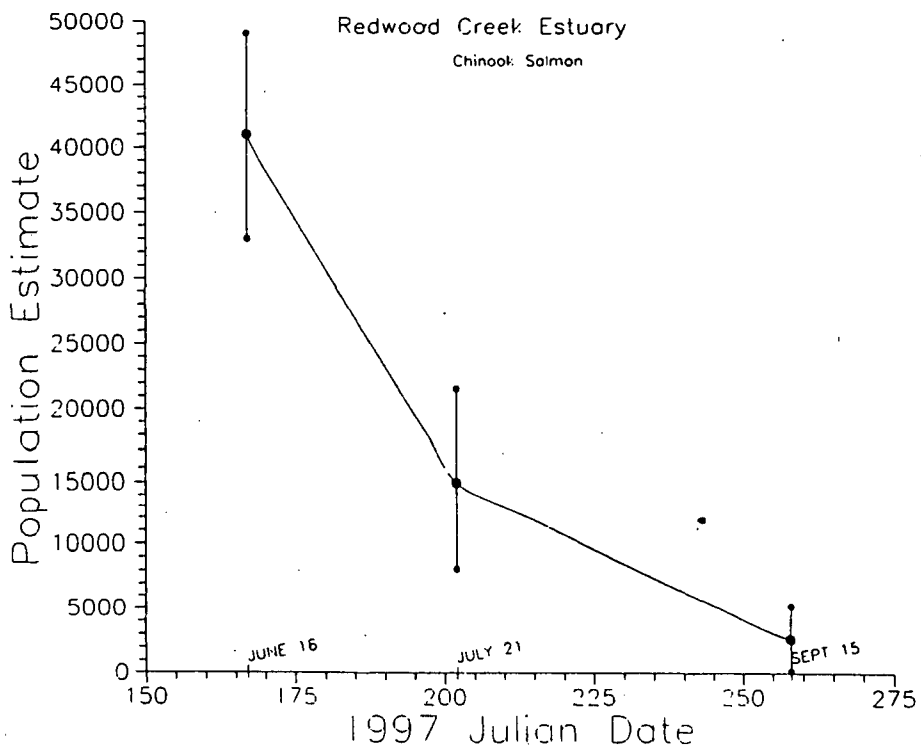
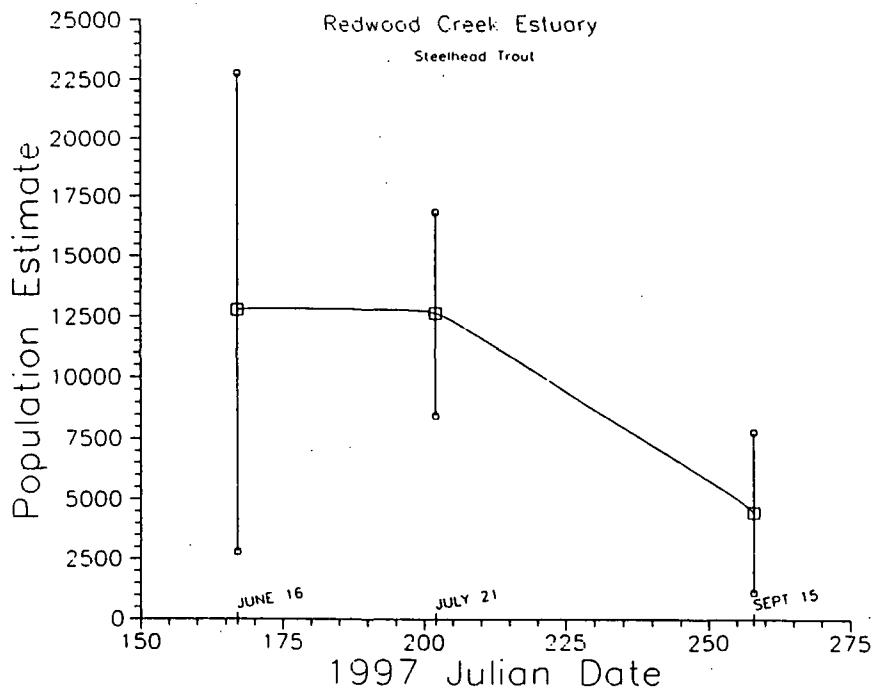
Corps permit (No. 21969N) issued in 1996 was only for manipulating an already open channel to save the Redwood Information Center from channel erosion. Both permits were not valid until Section 7 consultation with the National Marine Fisheries Service was completed and a biological and conference opinion issued on June 16, 1998.

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Appendix I. Population estimates and 95 percent confidence intervals for juvenile chinook salmon and steelhead trout in the Redwood Creek estuary, Humboldt County, California, summer/fall 1997.



Appendix II. Mean fork length (mm) of juvenile chinook and coho salmon, steelhead and coastal cutthroat trout seined in the Redwood Creek estuary, Humboldt County, California, during summer and fall 1997.

