DISTRIBUTION AND ABUNDANCE OF COHO AND STEELHEAD IN REDWOOD CREEK IN FALL 1998

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ABSTRACT: Heavy El Nino storms in 1998 at Redwood Creek resulted in substantial streambed changes, including partial filling of pools. However, unlike the devastating impacts to coho redds and juvenile abundance that occurred in San Mateo and Santa Cruz counties in 1998, coho abundance at Redwood Creek remained relatively high. Coho density was about 1/4 lower than in 1992, 1993, 1995 and 1996, but could be at least partially accounted for by decreased quality of rearing habitat, rather than by destruction of redds or fry. Although stochastic events can weaken coho year classes, for Redwood Creek, the effects of low late summer streamflows and pumping appear to be more important than severe floods.

INTRODUCTION

Previous sampling on Redwood Creek has shown strong juvenile coho (Oncorhynchus kisutch) year classes in 1992, 1993, 1995 and 1996 and very weak year classes in 1988 and 1994 (Hofstra and Anderson 1989; Smith 1994b, 1995a, 1996). Southern wild female coho are exclusively 3 year olds (Shapovalov and Taft 1954). Therefore, the weak year classes in 1988 and 1994 may have resulted from the impacts of the 1976/77 drought and/or the 1982 flood on subsequent years in a 3-year cycle. Similar pronounced and persistent year class variation has been seen in Waddell and Scott creeks in Santa Cruz County (Smith 1994a). However, the Redwood Creek year class rebounded to about half strength in 1997, despite drying of the streambed to isolated pools with poor water quality at the two downstream sites (Smith 1997).

Although a very strong adult coho year class should have spawned in Redwood Creek in winter 1997-98, the severe El Nino storms could have destroyed many of the redds and altered stream habitat conditions. The 1997-98 storms severely impacted juvenile coho abundance in Gazos, Waddell and Scott creeks in San Mateo and Santa Cruz counties (Smith 1998b). Therefore sites sampled in previous years were resampled in Redwood Creek in October 1998 to determine abundance of juvenile coho and steelhead (O. mykiss) and especially to see whether coho year class strength was maintained despite the storms.

METHODS

Electroshock sampling was conducted on 9 October at most of 3 Redwood Creek sites which had been previously sampled from 1992 to 1997 and on 30 October at 2 two additional sites, including one sampled only in 1994 and 1997 (Tables 1 and 2); the remainder of a site sampled on 9 October was also completed on 30 October. At each site most of the same individual pool, glide, run and riffle habitats were sampled. Changes in channel configuration resulted in some changes in habitats sampled, but the amount and composition of sampled habitat remained similar (Tables 1 and 2).

Individual habitats or habitat units (i.e. continuous pool/glide sequences) were block-netted and sampled with 2-3 passes with a backpack electroshocker (Smith-Root, Type 7). Salmonids were measured in 5 mm increments (standard length) and released to the habitat from which they were captured. Steelhead young-of-year (YOY) were distinguished from yearlings and older fish by length frequencies at each site. Sampled habitats were habitat typed, and depths and cover ratings determined. Densities were estimated from the depletion results of the multiple passes.

RESULTS AND DISCUSSION

<u>Habitat Effects of the 1998 Storms</u>

The frequent and sustained floods during winter 1997-8 altered the habitat at most sites by reducing the depth of many pools and reducing the amount of riffle habitat (see Table for changes in types of sample habitats). Previously the channels consisted of alternating scoured pools at bends or structures (in channel wood or alder rootwads in banks) and deposited coarse bed material as riffles. In 1998 it appeared that high sustained flows homogenized much of the channel, filling pools, except those formed at sharp bends or by large structures. Streambed gradient was evened out, and steeper riffles were replaced by shallow run and glide habitat. The degree of streambed change should also have resulted in loss of many early redds to scour and fill.

At Site 2, at the Muir Woods parking lot, the deepest index pool was significantly filled and escape cover lost by the collapse of an undercut bank. A regularly sampled riffle was converted to a run. At site 3, upstream of Kent Canyon, a large deep pool with a central spanning log was converted to two shallow pools separated at the log, and a riffle was converted into a run. At site 5, upstream of the third bridge, pools were also shallower and riffles reduced in length. In addition, a 40 m section of channel was displaced up to 15 m. Site 6, at the eucalyptus grove downstream of the MBCSD well, had the most dramatic habitat change, with the majority of pools partially filled or converted to very shallow glides; the riffle was converted to a run. At site 7, at Pacific Way, depth and cover actually improved in the long pool downstream of the bridge, but two smaller pools upstream of the bridge were made shallower. Pools which lost depth were generally in straight sections of channel, where thalweg meander and alder roots had previously resulted in lateral scour against the bank. Under the sustained high flows present in 1998 the scouring thalweg was apparently much straighter and only larger structures extending into the channel produced pool-forming scour.

Despite the evidence of substantial streambed alteration at all sites, the stream banks were stable, and no riparian trees were undermined or fell into the channel. The only new tree in the channel at the five sample sites was at site 3, upstream of Kent Canyon, where a large California bay fell from high on the terrace. In contrast, the 1998 storms in San Mateo and Santa Cruz county streams resulted in a large number of riparian trees, including alders and redwoods, falling into or across the streams (Smith 1998b). The flooding in those counties appears to have been more severe than in Marin County in 1998, but the stream banks and upper slopes are also sandier, steeper and more erodable. The amount of added wood in some stream sections on Gazos, Waddell and Scott creeks amounted to more than one-third of preexisting wood, with a corresponding increase in pool frequency and complexity (Smith 1998b).

Coho

Juvenile coho abundance in 1998 was about 1/4 less than in 1992 and 1995, the previous year classes in this 3-year coho cycle (Table 1). Abundance was also about 1/4 less than in 1993 and 1996, the other strong year classes. Site density in 1998 was relatively high compared to previous years at site 7, Pacific Way (Table 2), where habitat also somewhat improved in 1998. Density was relatively low at 3 of the other 4 sites (Table 2), where significant pool filling occurred. By far the lowest density was at site 6, downstream of the MBCWD well, where pools were mostly filled in 1998.

The relatively small reduction in overall coho density in 1998, despite the heavy storms, was rather surprising. In Gazos, Waddell and Scott creeks, in San Mateo and Santa Cruz counties, the expected juvenile coho densities were reduced by over 90 percent by destruction of redds (Smith 1998b). In fact, more coho were captured in two pools on Redwood Creek at Muir Woods (61) than the combined capture total of 30 sites (51) on the 3 southern streams. However, another possible factor in the poor spawning success of coho in Santa Cruz County may be the effect of high El Nino ocean temperatures upon egg viability. Egg viability at California hatcheries appears to have been reduced in 1998 (Bill Cox, CDFG pathologist, pers. comm.), and at the Big Creek Hatchery on the southernmost coho stream (Scott Creek) there was almost no successful egg survival from 7 early coho females spawned in the hatchery (Dave Streig, Big Creek Hatchery, pers. comm.). If there was an effect of ocean temperatures upon egg survival, it does not appear to have affected Redwood Creek fry production. It appears that substrate quality and coho spawner abundance at Redwood Creek were sufficient to withstand the impacts of ocean temperatures and floods on egg viability and redd and fry survival. Even when spawners are rare, such as in 1996-97, Redwood Creek coho redds can show good survival in floods (Smith 1997).

As in previous years, coho were larger than YOY steelhead (Figure 1), reflecting earlier coho spawning and emergence. Coho at sites 2 and 3 were similar in size, but coho progressively increased in average size at sites 5, 6 and 7 (Figure 2). This pattern is also the same as in previous years (Smith 1995a, 1996 and 1997), and may reflect warmer water and earlier emergence downstream. Coho were generally larger than in 1997 (Figure 3), when low streamflows probably reduced aquatic insect abundance and availability. The difference was least at site 5, upstream of the third bridge, which is very heavily shaded, and probably provides fewer aquatic insects in summer in all years.

Steelhead

Young-of-year steelhead outnumbered coho at 4 of the 5 sampled sites (Table 2), and their overall density was almost 50 percent higher than that of coho (Table 1). Since steelhead are more current oriented than coho, both the increased flows in summer 1998 and the reduction in depth of some of the pools are probably factors in the higher relative abundance of steelhead compared to coho.

Steelhead YOY were smallest at site 7, Pacific Way, where flows were lowest and most steelhead came from pools shared with abundant, larger coho (Figure 4). YOY steelhead were also somewhat smaller at site 5, upstream of the third bridge, which has much denser shading. YOY steelhead were larger than in 1997 (Figure 5), reflecting higher insect abundance and better fast-water feeding, due to higher summer streamflows in 1998.

Yearling and older steelhead were quite rare, as in previous years (Table 1); apparently most Redwood Creek steelhead grow sufficiently in their second spring to smolt as yearlings. The 4 fish captured that were larger than 150 mm (160-220 mm) came from the deepest pools and were sexually mature males.

Sampling Mortality

No coho were killed during the capture of 340 fish by electroshock sampling in 1998. Four of 490 captured YOY steelhead died (0.8 %). Sampling during cool-water conditions in October may have been a factor in the low overall sampling mortality rate (0.5 %).

MANAGEMENT IMPLICATIONS

Droughts and floods have resulted in weak and missing coho year classes in southern streams, with impacts persisting in subsequent year classes in the 3 year cycle (Smith 1998a, 1998b). Considering the strong Redwood Creek coho year class in 1998, despite the severe storms, the weak 1988 and 1994 year classes most likely to reflect the impact of drought in 1976-77 and 1988, rather than the impact of the 1982 flood. For Redwood Creek coho, low late summer streamflows and groundwater pumping, which have substantially reduced fish populations at downstream sites in 3 of the last 7 years, appear to be a much bigger threat than floods.

In general, large wood is scarce in the channel of Redwood Creek, restricting the depth and complexity of pools. The 1998 storms added little, and furthermore, the lack of wood appeared to result in a significant loss in depth of many pools during the 1998 storms. Pool habitat could be increased and maintained by anchoring logs or pulling streamside alders into the channel.

ACKNOWLEDGMENTS

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Table 1. Habitats sampled and estimated mean densities (number of fish per 100 feet) for coho and steelhead on Redwood Creek in 1988 (Hofstra and Anderson 1989) and 1992-1998.

Number of Sites	Sample Date	Habitat Types Sampled				Length Sampled (feet)	Density		
		Pol	Gld	Run	Rif		Coho	Steelhead 0 +	Steelhead 1/2+
4 sites	Oct 88					436+	5	--16--	
4 sites	Jun-Sep 92	37	40	5	7	1032	45	23	4
4 sites	Jun-Aug 93	48	25	18	9	951	46	56	4
7 sites	Jul 94	58	25	12	6	1287	2	69	14
5 sites	Oct 94	83	10	4	3	1018	2	34	6
4 sites	Aug 95	41	30	19	10	796	42	97	4
3 sites	NOV 96	51	31	11	7	604	39	33	11
5 sites	Sep-Oct 97	72	18	9	1	984	23	15	5
5 sites	Oct 98	58	25	15	1	1174	32	47	4

Table 2. Density estimates (number of fish per 100 feet) for coho and steelhead collected on Redwood Creek in each year from 1992 through 1998 at the 5 sites sampled in 1998.

Site		Sample Date	Habitat Types Sampled				Length Sampled (feet)	--- Density --- Coho	Steelhead	
			Pol	Gld	Run	Rif			0 +	1/2 +
2.	Lower Muir Woods	20 Aug 92	30	53	12	5	302	84	19	8
	(Miles 2.5 & 2. 8)	24 Jun 93	45	23	22	9	233	91	52	4
		7 Jul 94	47	32	15	6	256	0	56	12
		30 Oct 94	75	25			220	1	14	16
		22 Aug 95	37	30	21	11	276	45	57	6
		2 NOV 96	43	30	12	14	206	37	29	7
		27 Sep 97	54	19	21	6	216	41	32	8
		9 Oct 98	55	17	28		219	32	54	5
	Site Mean (excluding 1994)							54	41	7
3.	0.35 mi >	26 Jul 94	75	13	7	5	179	9	60	9
	Kent Cyn	30 Oct 94	86	0	8	6	148	10	19	7
	(mile 2.1)	5 Oct 97	83	5	13	0	191	50	15	6
		30 Oct 98	62	17	20	0	258	48	40	4
5.	>3rd Bridge	19 Sep 92	60	15	7	19	166	30	16	7
	(Mile 1.25)									
		19 Aug 93	63	12	10	15	253	30	26	5
		7 Jul 94	63	10	14	13	136	0	45	14
		30 Oct 94	53	25	15	7	177	0	20	8
		22 Aug 95	75		16	10	127	43	51	7
		2 NOV 96	65	28	8		160	54	27	13
		27 Sep 97	65	35			210	26	7	6
		30 Oct 98	52	26	17	5	220	20	23	8
	Site Mean (excluding 1994)							37	25	8

Table 2 (continued)

Site		Sample Date	Habitat Types Sampled				Length Sampled (feet)	--- Density --- Coho	Steelhead 0 +	Steelhead 1/2 +
			Pol	Gld	Run	Rif				
6.	Downstream of	19 Sep 92	19	37	dry		250	13	6	1
	Diversion						129 wet			
	(Mile 0.85)	14 NOV 92					250	4	6	0.4
		24 Jun 93	55	29	9	7	210	25	90	3
		10 Sep 93	51	34	9	6	221	16	72	4
		7 Jul 94	41	36	17	6	231	0	148	9
		30 Oct 94	isolated pools				231	0	0	0
		23 Aug 95	39	36	19	6	209	56	132	3
		2 NOV 96	44	36	13	7	228	28	45	9
		27 Sep 97	isolated pools				251	0	2	0.8
		9,30 Oct 98	58	36	6		267	11	35	1
Site Mean (excluding 1992, 1994 and 1997)								33	83	5
7.	1st Bridge	23 Jul 92	39	56	2	4	314	54	49	1
	(Mile 0.35)	14 Aug 92								
		14 NOV 92	39	56	2	4	314	33	29	2
		8 Jun 93	27	35	32	5	255	39	55	4
		10 Sep 93	26	49	16	9	271	14	34	1
		8 Jul 94	14	46	30	10	242	0.4	75	4
		30 Oct 94	isolated pools				242	0	6	0.4
		23 Aug 95	13	55	19	13	184	54	142	0.5
		27 Sep 97	87	13			115	0	12	5
		9 Oct 98	66	30	5		210	46	84	4
Site Mean (excluding 1994 and 1997)								34	68	1

Figure 1. Standard lengths (mm) of young of year coho and steelhead from Redwood Creek in October 1998.

	Coho (n = 340)	Steelhead (n = 490)
35 - 39		3
40 - 44		******24
45 - 49		************50
50 - 54		************************97
55 - 59	******25	***************************110
60 - 64	*********************84	*********************84
65 - 69	**********************90	*************53
70 - 74	*********************86	**********40
75 - 79	*********36	***15
80 - 84	****16	*7
85 - 89	2	6
90 - 94	1	1

Figure 2. Standard lengths (nun) of coho at site 2 (Muir Woods), site 3 (> Kent Canyon), site 5 (3rd Bridge), site 6 (below well) and site 7 (Pacific Way) in October 1998.

	Site 2	Site 3	Site 5	Site 6	Site 7
55 - 59	**7	***10	*3	2	*3
60 - 64	******19	**************44	*5	**6	***10
65 - 69	*****17	************36	*****17	*5	*****15
70 - 74	****12	********26	***9	***10	******19
75 - 79	**6	*5	**6	*3	******18
80 - 84	*3	*4	1	1	**7
85 - 89		2			
90 - 94		1			

Figure 3. Standard lengths (mm) of coho at site 2 (Muir Woods) and site 5 (Third Bridge) in November 1996, September 1997 and October 1998 and site 3 (above Kent Canyon) in October 1997 and 1998.

Muir Woods

	1996	1997	1998
40 - 44		*2	
45 - 49		**4	
50 - 54	****8	**************29	
55 - 59	*********19	*************27	***7
60 - 64	************24	********16	*********19
65 - 69	******13	**5	********17
70 - 74	***6		******12
75 - 79	1		***6
80 - 84	1	1	1

Above Kent Canyon

	1997	1998
45 - 49	**5	
50 - 54	********16	
55 - 59	************24	*****10
60 - 64	********16	**********************44
65 - 69	****9	******************36
70 - 74	*3	*************26
75 - 79		**5
80 - 84		**4
85 - 89		*2
90 - 94		1
95 - 99	1	

Above Third Bridge

	1996	1997	1998
50 - 54	1		
55 - 59	**4	*3	*3
60 - 64	***********22	********16	**5
65 - 69	********17	*********19	********17
70 - 74	********16	**5	****9
75 - 79	*3	1	***6
80 - 84		1	1

Figure 4. Standard lengths (mm) of young-of-year steelhead at sites 2, 3, 5, 6 and 7 in October 1998.

	Site 2	Site 3	Site 5	Site 6	Site 7
35 - 39	1				2
40 - 44	2				*******22
45 - 49	*3	2	*5	*4	************36
50 - 54	****14	***9	***9	*******22	**************43
55 - 59	********25	*****17	******19	********26	*******23
60 - 64	********25	*****17	***10	******19	****13
65 - 69	***11	*******21	*4	****12	*5
70 - 74	****12	****14	3	**6	*5
75 - 79	**7	*5			*3
80 - 84	1	*5		1	
85 - 89	*4	1		1	
90 - 94	1				

Figure 5. Standard lengths (mm) *for* young of the year steelhead in 1997 and 1998 at sites 2 and 3/5.

	----- Site 2 ---		--Sites 3 & 5 --	
	1997	1998	1997	1998
35 - 39	*3	1		
40 - 44	*****10	*2	*2	
45 - 49	*******14	*3	******12	***7
50 - 54	******12	*******14	*****10	*********18
55 - 59	*3	************25	****9	******************38
60 - 64	1	************25	2	*************27
65 - 69		*****11	**5	************25
70 - 74		******12	1	********16
75 - 79		***7		**5
80 - 84		1		**5
85 - 89		5		1
90 - 94		1		