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ABUNDANCE OF COHO AND STEELHEAD IN REDWOOD CREEK IN 1994

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31 July 1994

Female coho salmon (Oncorhynchus kisutch) in central California are invariably 3 year olds (Shapovalov and Taft 1954), so any three consecutive year classes can show great and independent variation in abundance; sampling in three consecutive years is necessary to determine coho status. Sampling of Redwood Creek, in Marin County, in 1992 and 1993 showed juvenile coho to be very abundant in those years. Sampling was undertaken in July 1994 to determine the relative strength of the 1994 coho year class.

Methods

In 1992 and 1993 the lagoon was seined, and Redwood Creek was electroshocked at several deep pools immediately upstream of the lagoon (which are too deep to sample effectively) and at 4 stream sites, from near the bridge entrance to Muir Beach, upstream to Muir Woods National Monument. In July 1994 sampling at previous sites was repeated, and three new sites (1,3,4; Table 1) were also electroshocked.

At the 7 upstream electroshock sites, individual biological units (i.e. individual pools, runs, riffles or glides or integrated sequences) were sampled by 2 to 3 passes with a backpack electroshocker (Smith-Root, Type 7, smooth pulse). For sites also sampled in 1992 and 1993, the sampled habitats were picked to be generally representative of those available at the site. For the new sites, we primarily sampled pools, preferred habitat for coho. A block net was used, where necessary, to separate habitat units. Collected fish were measured (standard length), and steelhead (O. mykiss) were separated into young of year and yearling or older age classes based upon length-frequency. For each sampled habitat unit, length, width, mean and maximum depth, substrate composition, escape and overhead cover, and canopy closure were recorded.

Results

Only small changes to the stream channel occurred during the relatively mild winter of 1993-4. However, some filling of pools had occurred at sites 2 and 7 in winter 1993-4. Over 1/3 more total habitat was sampled in 1994, and a higher proportion of pool

habitat was sampled, due to the addition of the three new sites (Table 1).

Juvenile coho were collected at only three of the seven sampled sites in 1994, and only a single coho was collected at the Muir Beach (#7) site (Table 1). Low densities of coho were collected in the upstream portion of Muir Woods National Monument and at a site between the Monument and Kent Canyon. No coho were collected in 1994 at the site between those two, near the Muir Woods National Monument Parking Lot. Overall, only 24 coho were collected in 1994, compared to over 400 in 1992 and in 1993, despite the addition of 3 sites and 1/3 more total sampling.

Overall, young-of-year steelhead in 1994 were 3 times as abundant as in 1992 and about 23% more abundant than in 1993 (Table 1). Yearling and older steelhead were about 2 1/2 times as abundant at the four sites sampled in 1992 and 1993; they were more than 3 times as abundant with the inclusion of the new sites. Two steelhead were also collected by seining in the lagoon, and four steelhead were collected by electroshocking in the pools immediately upstream of the lagoon.

Steelhead young-of-year could easily be separated from yearling at each site by the length frequency pattern (Figure 1). Young-of-year steelhead were larger, on average, at site 7 (upstream of Muir Beach Parking Lot) (Figure 1). Sizes of young-of-year at the site were also bimodal, possibly due to two peaks in spawning activity in the lower portion of the creek. Both young-of-year and yearling steelhead were smallest at sites 1 and 2, the most upstream sites (Muir Woods) (Figure 1).

Young-of-year coho were larger on average than young-of-year steelhead (Figure 1), at least partially reflecting earlier spawning by coho. Unlike steelhead, coho, on average, were larger upstream; in Muir Woods coho young-of-year were intermediate in size between age 0+ and 1+ steelhead.

As in previous years, riffle sculpin (Cottus gulosus) were abundant in Muir Woods National Monument and occurred downstream to site 5. Prickly sculpin (C. asper) occurred as a few individuals at all sites.

The lagoon was shallower than in early summer 1992 and 1993, with sand filling previous scour holes around the concrete blocks in the lower lagoon, and also filling a deep scour hole at the upper end of the lagoon. Despite the shallowness of the lagoon, some juvenile steelhead were present. Threespine stickleback (Gasterosteus aculeatus) were abundant in the lagoon, and a single Staghorn sculpin (Leptocottus armatus) was also collected in the lagoon.

In the deep pools immediately upstream of the lagoon, threespine stickleback, four steelhead, and numerous large prickley sculpins

were collected. Yellowfin goby (Acanthogobius flavimanus), which were present in 1992 and 1993 were not collected.

Discussion

In 1992 and 1993 coho were collected at all four sampled stream sites, and densities were high, except at the nearly dewatered site downstream of the diversions in 1992 (Table 1). In 1994 three additional sites were added in an attempt to locate coho, and relatively low densities were found at two separated upstream sites. The two separated sites probably represent limited and localized coho spawning success in 1993-1994. In previous sampling on Waddell and Scott creeks, in Santa Cruz County, I have found that juvenile coho apparently don't disperse far from their redd site. In upper Muir Woods (site 1) only 7 coho were collected in 175 feet of sampled habitat, despite targeting the relatively scarce pool habitat in the rip-rapped channel. With good hatching success, a single spawning redd should have produced enough young coho to fill the limited available habitat; the low densities observed may have been due to poor hatching success or to mortality or dispersal with the late April storm. The coho were not only in low abundance, but were apparently limited in distribution; no coho were collected at the site near the Muir Woods parking lot (0.4 miles downstream) and at a single pool at the downstream border of the monument. The scarcity of pool habitat in the Upper Muir Woods area probably limits the abundance of coho in that part of the stream in 1994 to only several hundred fish.

The second concentration of coho was found 0.35 miles upstream of Kent Canyon (site 3); 16 coho were collected in 179 feet of sampled habitat. This concentration was apparently also restricted in distribution, as no coho were collected by sampling less than 1/2 mile upstream and downstream of the site. Extensive pool habitat at site 3 should have supported higher coho densities. The relatively low observed densities may reflect either low hatching success or downstream dispersal of fish produced farther upstream, near site 2. Even if densities are much higher closer to site 2, the total abundance of coho in this second "concentration" is probably less than 1000 fish.

None of the seven sites sampled in 1994 was more than 1/2 mile up or downstream from adjacent sites, so it was unlikely that substantial localized concentrations of coho were missed. One half mile upstream of the Upper Muir Woods site habitat becomes too steep for significant coho rearing.

Coho abundance at sampled sites was over 20 times higher in 1992 and 1993 than in 1994 (Table 1), and abundance in 1992 and 1993 probably reflected juvenile populations at or near carrying capacity for available rearing habitat. Microhabitat relationships showed strong

coho dependence upon pool and glide depth and escape cover. Little habitat change occurred between 1993 and 1994, therefore the low abundance of juvenile coho in 1994 must reflect either low adult abundance or poor spawning success. Winter storms were sufficient and early enough to provide adult access and mild enough to prevent substantial redd destruction; the very weak 1994 year class appears to reflect very low numbers of spawning adults.

Since coho females are 3 year olds and attempt spawning only once, coho are extremely sensitive to droughts, floods or other unpredictable events; a major disaster in any year can result in a weak year class or a year class gap every 3 years. In Waddell and Scott creeks, in Santa Cruz County, the 1991 (and 1994?) year classes were gone or extremely weak. This year class gap apparently reflects past drought and flood years. In Scott Creek a strong 1988 year class was blocked from spawning access until mid-March of 1991, resulting in an extremely weak 1991 year class. For Waddell Creek the impact occurred earlier, as the 1988 year class was also extremely weak. The most likely cause(s) for the weak 1988, 1991, 1994 year classes were the 1976 and 1977 drought years and/or the 1982 flood year. In both Santa Cruz and Marin counties, poor winter streamflows in 1975-6 would have restricted adult coho access, and poor summer 1976 streamflows would have greatly reduced rearing habitat. Additionally, very poor spring 1977 streamflows would have restricted spring growth and outmigration by the 1976 year class. Water diversions would have greatly aggrevated the drought effects. Two cycles later, in 1982, the severe January 1982 storm would have destroyed early spawning redds and severely degraded spawning conditions for later-spawning coho. The very weak 1994 Redwood Creek coho year class probably reflects past "disasters"; the observed abundance of juvenile coho in 1994 could have been produced by as few as two successful spawning pairs.

Coho may compete with steelhead, especially for pool habitat. At sites 5, 6 and 7 the loss of coho from 1993 to 1994 averaged 31 fish per hundred feet (range 25-39) and was accompanied by a mean steelhead density increase of 32 fish per hundred feet (range 19-58) (Table 1). However, the changes in steelhead density between the years may merely reflect steelhead adult numbers and spawning success, rather than changes in coho success. At site 2, in Muir Woods, steelhead numbers increased 2 1/2 times between 1992 and 1993, with little change in coho density, and steelhead density changed little from 1993 to 1994, even with the elimination of coho (Table 1).

The increased numbers of yearling steelhead in 1994 probably reflect the doubling of density of young steelhead in 1993 compared to 1992 (Table 1). At sites 3, 4 and 5, which had deep pools with good escape cover, older (age 2 and 3) steelhead were relatively common.

MANAGEMENT IMPLICATIONS

Two (1992 and 1993) of three year classes of coho in Redwood Creek appear to have been very strong, with juvenile abundance probably limited by rearing habitat quality. Unfortunately, the 1994 year class was very weak, and was apparently limited by few adult spawners in winter 1993-1994. This weak year class probably reflects past drought and flood impacts. If the average coho density observed in 1994 sampling (2 per 100 feet) was applied to the 4 miles of potential rearing habitat in Redwood Creek, 1994 coho production would be only about 400 fish. At an adult return rate of 2%, 400 fish would result in only 4 pairs of adult coho in 1996-1997, insufficient to produce a strong year class. Actions, such as augmentation, may need to be taken to prevent extirpation of this weak year class.

The widened, rip-rapped channel in Muir Woods National Monument has few pools because of the channel alteration and because of past removal of logs and downed trees ("woody debris") from the channel. The present policy of leaving new downed wood in the channel will very slowly result in increased habitat, but the altered channel will limit the amount of pool development. A significantly more natural channel, with woody pools, narrower active channel, and undercut banks, would require substantial restoration effort.

LITERATURE CITED

Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Fish and Game Fish Bulletin 98. 303 pp. + apps.

Table 1. Density estimates (number of fish per 100 feet) for coho and steelhead collected on Redwood Creek in 1992, 1993 and 1994. (*Data for site 8 are actual capture totals, not density estimates).

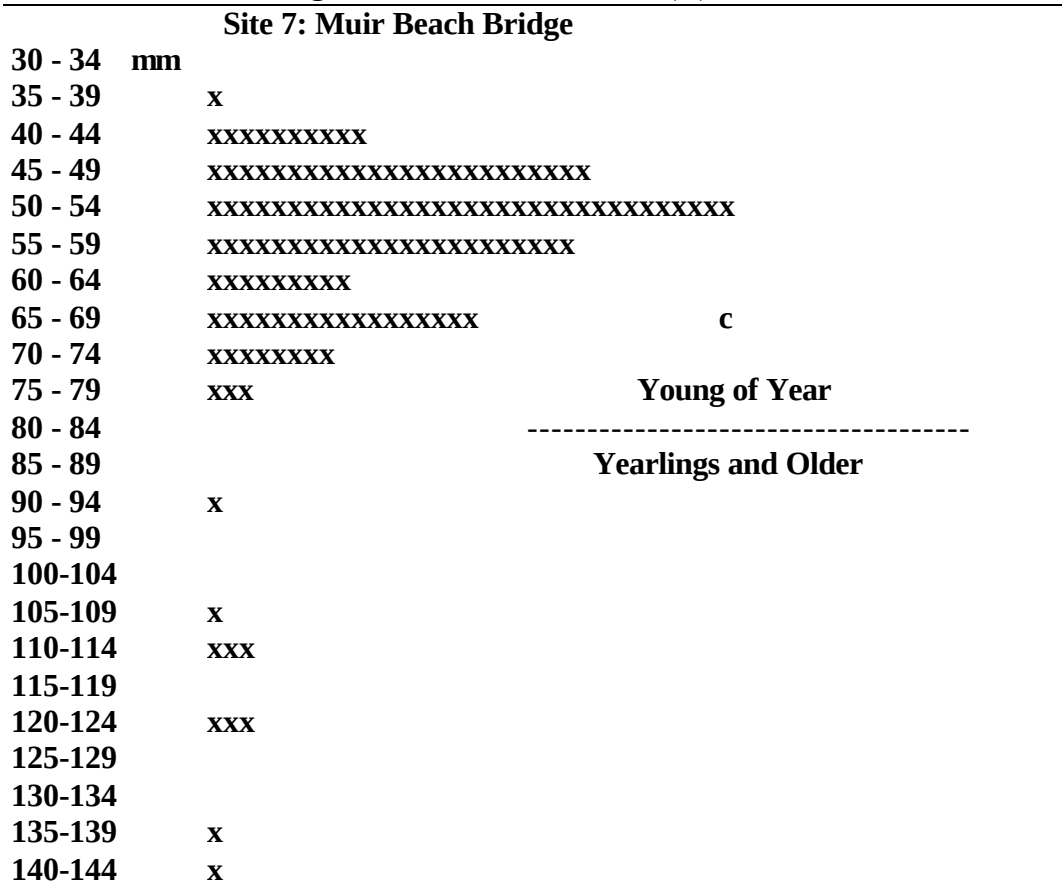
Site	Sample Date	Habitat Types Sampled				Length Sampled (feet)	Density		
		Pol	Gld	Run	Rif		Coho	Steelhead 0+	Steelhead 1/2 +
1. Upper Muir Woods (Miles 3.3 & 3.6)	**26 Jul 94**	**80%**	**20%**			**175**	**4**	**40**	**12**
2. Lower Muir Woods	20 Aug 92	30	53	12	5	302	84	19	8
(Miles 2.5 & 2.8)	24 Jun 93	45	23	22	9	233	91	52	4
	7 Jul 94	**47**	**32**	**15**	**6**	**256**	**0**	**56**	**15**
3. 0.35 Mi > Kent Cyn (Mile 2.1)	**26 Jul 94**	**75**	**13**	**7**	**5**	**179**	**9**	**60**	**9**
4. 0.5 Mi > 3rd bridge (Mile 1.65)	**8 Jul 94**	**84**	**16**	**0**	**0**	**68**	**0**	**61**	**35**
5. >3rd Bridge (Mile 1.25)	19 Sep 92	60	15	7	19	166	30	16	7
	19 Aug 93	63	12	10	15	253	30	26	5
	7 Jul 94	**63**	**10**	**14**	**13**	**136**	**0**	**45**	**14**
6. Downstream of Diversions (Mile 0.85)	19 Sep 92	19	37	dry		250 129 Wet	13	6	1
	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**

Table 1 (continued)

Site	Sample Date	Habitat Types Sampled				Length Sampled	Density		
		Pol	Gld	Run	Rif	(feet)	Coho	Steelhead 0+	1/2+
7. 1st Bridge (Mile 0.35)	23 Jul 92	39	56	2	4	314	54	49	1
	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**
8. * Pools Above Delta (Mile 0.15)	23 Jul 92	70	30			200	59	22	3
	14 Aug 92	70	30			200	6	2	3
	14 NOV 92	70	30			200	0	0	0
	4 Jun 93	99				50	29	14	4
	8 Jun 93	70	30			200	17	6	2
	19 Aug 93	70	30			200	6	16	0
	10 Sep 93	70	30			200	4	9	0
	8 Jul 94	**60**	**40**			**160**	**0**	**1**	**3**
Stream Totals Upstream of Site 8									
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	July 94	58	25	12	6	1287	2	69	14

Figure 1.

Standard Lengths of steelhead and coho (C) at sites on Redwood Creek in July 1994.



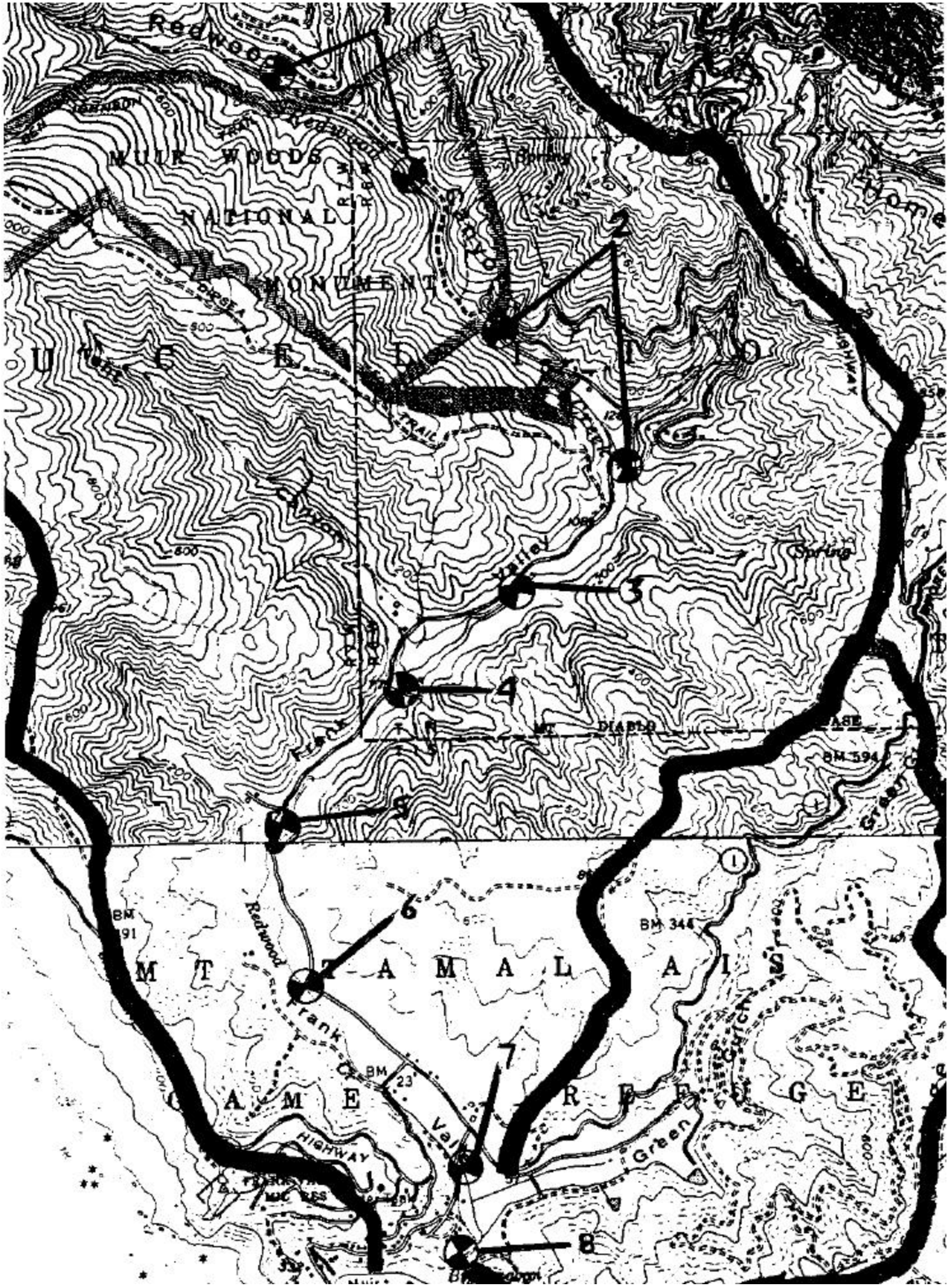
Site 5:

Third Bridge (x), Site 4: 0.5 mi > Bridge (o) and Site 3: 0.35 mi > Kent Canyon (k)

30 - 34	**mm**	**xxxxo**		
35 - 39		**xxokkkkkkkkk**		
40 - 44		**xxxxxxookkkkkkkkkkkkkk**		
45 - 49		**xxxxxxxxxxxxxoooooooooookkkkkkkkkkkkkkkkkkkkkkkkkkkkkk**		
50 - 54		**xxxxxxxxxxxxxoooooooookkkkkkkkkkkkkkkkkkkkkk**		
55 - 59		**xxxxxxxxxxxxoooooookkkkkkkkkkkkk**		**cccccc**
60 - 64		**xxxxxookkkkkkk**		**cccc**
65 - 69		**xxxxok**		**ccc**
70 - 74				**c**
75 - 79			**Young of Year**	**c**
80 - 84			--------------------------------	**c**
85 - 89		**kkk**	**Yearlings and Older**	
90 - 94		**xookkk**		
95 - 99		**xxxoooook**		
100-104		**xxxxxoookkkkkk**		
105-109		**xoook**		
110-114		**xxook**		
115-119		**xxxo**		
120-124		**X**		
125-129		**xxoo**		
130-134		**X**		
135-139				
140-144		**o**		
145-149		**o**		
150-154		**X**		
155-159		**oo**		
175-179		**o**		
185-189		**o**		
195-199		**ok**		
240-244		**k**		

Sites 1 (o) and 2 (x) : Muir Woods

25 - 29	**mm**	**o**		
30 - 30		**xx**		
35 - 39		**xxxxxxxxxxoooooooooooooo**		
40 - 44		**xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxooooooooo+20**		
45 - 49		**xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxooooooooo**		
50 - 54		**xxxxxxxxxxxxxxxooooooo**		
55 - 59		**xxxxxxxxxxxxoooo**	**Steelhead**	
60 - 64		**xx**	**Young of Year**	
65 - 69		**o**	-----------------------------	**c**
70 - 74		**xxxoooo**	**Yearlings**	**cc**
75 - 79		**xxxxxo**		**cc**
80 - 84		**xooo**		**cc**
85 - 89		**xxxxoooooo**		
90 - 94		**xxx**		
95 - 99		**xxxxxxo**		
100-104		**xxx**		
105-109		**x**		
110-114		**o**		
125-129		**xo**		


Redwood
MUIR WOODS
NATIONAL
MONUMENT
Creek
TRAIL
Canyon
Valley
Spring
DIABLO
BASE
BM 594
BM 346
BM 191
Redwood
Frank
Creek
BM 23
Valley
HIGHWAY
Green
Gulch
MT TAMALPAIS
AMERICAN
REFUGE
1
2
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