TESTS ON THE SUITABILITY OF KLAMATH RIVER WATER FOR THE ARTIFICIAL PROPAGATION OF SALMON AND STEELHEAD[1]/

Ref 90822

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INTRODUCTION

A never-ceasing search for water suitable for fish hatchery operations has been conducted throughout the State of California. Almost every natural flow of adequate size within the State has been tested as a potential hatchery water supply at one time or another. The development of the State's water resources, through the building of dams, is opening up another new source of water for fish hatchery operations. Construction of Nimbus Hatchery below Folsom Dam and San Joaquin Hatchery below Friant Dam illustrates this point.

The experiments described herewith were carried out to test the suitability of water from the Klamath River for fish hatchery use in rearing king salmon, (Oncorhynchus tshawytscha), silver salmon (Oncorhynchus kisutch), and steelhead rainbow trout (Salmo g. gairdnerii), in connection with the building of Iron Gate Dam, now under construction by the California-Oregon Power Company.

METHODS AND EQUIPMENT

Experimental hatchery tanks and troughs were set up at a site on the Klamath River, adjacent to the California-Oregon Power Company's No. 2 powerhouse, which is located about 16 miles east of Hornbrook, Siskiyou County.

The installation consisted of two rectangular tanks, 3 feet deep by 4 feet wide by 16 feet long, and two standard California wooden hatchery troughs, 8 inches deep by 16 inches wide by 16 feet long. Water was taken directly from the powerhouse penstock by tapping an existing six-inch irrigation line. Volume was maintained at a flow of approximately 8 to 15 gallons per minute for each hatchery trough and from 15 to 40 gallons per minute for the tanks.

King salmon and steelhead trout eggs used in the experiment were taken from Klamath River fish at Fall Creek Egg Collecting Station. The silver salmon eggs were taken from the Trinity River at Lewiston (Trinity River is a large tributary stream flowing into the Klamath about 80 miles downstream from COPCO No. 2 powerhouse). Hatchery equipment, technique, and procedures were identical to those routinely employed at Mt. Shasta Hatchery and are standard in rearing salmon and steelhead in California hatcheries.

DISCUSSION

Table A-1 of the Appendix is a summary of the egg and fish transactions at the experimental station. Green king salmon eggs, numbering 39,500, taken at Fall Creek Egg Collecting Station, were brought to the experimental hatchery on October 12, 1959. The eggs were divided equally between two standard salmon hatching baskets and the baskets were placed in separate troughs. Daily flushes

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1/ Submitted October 1, 1960.

of malachite green were administered to control fungus growth on the eggs during the incubation period, from October 12, 1959, to January 1, 1960.[2/]

[2/] A stock solution made of 1½ ounces malachite green dissolved in one gallon of water was used. Three ounces of this solution are poured into the head end of the trough. The flow of water is regulated at 6 gallons per minute. (Leitritz, 1959).

After hatching, small white spots, diagnosed as white spot disease, appeared in the yolk sacs of about 50 percent of the king salmon alevins. According to available information, white spot disease can be brought on by several different causes, such as rough handling, low water temperatures, bacterial infection, and malachite green treatments given in water temperatures over 55 degrees after the eggs are eyed. Heavy losses have been reported from white spot disease at other hatcheries after the affected fish swim up and start feeding. Most of the king salmon loss noted during the period from February 20 through March 26, 1960, may be attributed to white spot disease.

Another lot of 30,000 eyed Klamath River king salmon eggs was transferred from Mt. Shasta Hatchery to the experimental station in January, 1960, to be sure that sufficient king salmon would be on hand to continue the experiment in the event that losses from white spot disease continued. As these eggs hatched, a minor infection of white spot disease, which caused negligible loss, appeared. (No white spots occurred on the king salmon eggs of the same lot held at Mt. Shasta Hatchery.)

The king salmon fry were fed a mixture of 50 percent beef liver and 50 percent ocean fish from swim-up time until they reached the size of three per ounce on August 11, 1960. At this time, they were divided equally into two tanks; the control lot in one tank was continued on a liver-fish diet, while the lot in the other tank was converted to a dry diet. As of the date of this report, fish fed dry food weighed 2.4 per ounce, while those on a diet of wet food weighed 1.7 per ounce. The fish in the control group were noticeably more vigorous and were growing more rapidly but had slightly higher losses.

Periodic prophylactic treatments of copper sulfate and salt were given the king salmon to control external protozoa and gill bacteria. Five microscopic examinations revealed the fish to be extremely clean, except for a moderate quantity of gill bacteria occurring in June in all groups. This was readily controlled by copper sulfate treatment. Table A-2 of the Appendix summarizes, by species, disease control treatments carried on at the hatchery.

Loss in the king salmon from egg to fish was 55 percent, which is high. However, taking into consideration the mortality caused by white spot disease, this loss was not excessive.

20,200 silver salmon eggs taken from the Trinity River were eyed at Mt. Shasta Hatchery and transferred to the experimental station on March 23, 1960. These eggs started hatching prematurely at Mt. Shasta because of a bacterial infection which caused perforation of the outer membrane of the egg. Treatments with malachite green, salt, and sulfamerthiolate failed to control this infection, with a result that only 45 percent of the eggs hatched and only 31 percent of the hatched fry reached the feeding stage. These fish were reluctant to start feeding

on dry food and this loss, coupled with the premature hatch, made the survival rate very poor. A microscopic examination of several stomachs in September revealed that many of these fish were living on natural food in the water supply and were not taking dry food. Growth was uneven because of this, but as of the date of this report, the silver salmon fingerlings averaged 7 fish per ounce, which is an excellent rate of growth.

6,100 steelhead eggs were taken from two females trapped at Fall Creek Egg Collecting Station near CCPCO No. 2 on March 20, 1960. Of these eggs 88 percent hatched and 72 percent of the hatched fry reached the feeding stage.

Both silver salmon and steelhead fingerlings, switched to wet food during June, 1960, due to a diet deficiency, were changed back to dry food in July. During August and September the fish loss remained normal and all groups of fish were feeding well and were in excellent condition.

Winter water temperatures ranged from 58 degrees Fahrenheit in October down to 34 degrees in January. Egg development was retarded during this period. Spring season temperatures increased in March, April, and May from a low of 40 degrees to a high of 60 degrees. The lowest temperature recorded in June, July, and August was 58 degrees, and the highest 73 degrees. Water temperatures dropped to a low of 63 degrees in September.

Maximum and minimum daily water temperatures and mortality are shown in Table A-3 of the Appendix. During periods of high water temperature, the fish showed no visible sign of distress.

Dissolved oxygen tests on water samples taken at the outlet of the experimental hatchery gave the following results:

Date	Dissolved oxygen parts per million	Temperature (degrees F.)
March 1, 1960	9.8	41
May 4, 1960	9.3	53
June 10, 1960	6.8	65
July 6, 1960	6.7	70
August 10, 1960	6.9	72

Apparently the material which discolors Klamath River water during the winter months is in suspension, since very little silt collected on the eggs. The only difficulty encountered was restricted visability in the tanks. From October through March, fish 8 to 12 inches under the surface were difficult to observe. The condition cleared during April through June, but algae in the water during July and August made observation of the fish quite difficult again.

CONCLUSIONS

The experiment showed that steelhead, silver salmon, and king salmon can be reared successfully in Klamath River water under crowded hatchery conditions.

White spot disease, which appeared in the yolk sac of the king salmon alevins, has been found at other hatcheries and has been successfully controlled. In this case, it may have been due to low water temperatures.

Bacterial infection in the silver salmon eggs cannot be attributed to the Klamath River water, since the infection was present on the eggs before they were brought to the experimental station.

Summer water temperatures reached a high of 73 degrees, but dissolved oxygen also remained high and the fish showed no visible signs of distress during this period, so that high temperatures should not create a problem.

External parasites, expected to be a major problem, may be readily controlled by various prophylactic treatments.

SUMMARY

An experiment was carried out to test the suitability of Klamath River water for fish hatchery use in rearing king and silver salmon and steelhead trout, in connection with the building of Iron Gate Dam, now under construction by the California-Oregon Power Company.

King salmon and steelhead trout eggs were taken from Klamath River fish, while silver salmon eggs came from fish from the Trinity River, a tributary to the Klamath River.

Hatchery equipment and procedures used were standard for California salmon and steelhead hatcheries.

Periodic prophylactic treatments of copper sulfate and salt were used to control external parasites, which were not the problem they were expected to be.

About 50 percent of the king salmon alevins were affected by white spot disease. Mortality in this group of fish amounted to approximately 55 percent from egg to feeding fish.

Silver salmon eggs began hatching prematurely at Mt. Shasta Hatchery because of a bacterial infection before they were moved as eyed eggs to the experimental station. Losses from this infection were so severe that only 45 percent of the eggs hatched and only 31 percent of the hatched fry reached feeding stage.

88 percent of the steelhead eggs hatched and 72 percent of the hatched fry reached the feeding stage.

Water temperatures ranged from 34 degrees Fahrenheit in January to 73 degrees in July.

Dissolved oxygen remained high, even during high water temperatures, and fish showed no sign of distress during these periods.

REFERENCE

Leitritz, Earl
1959. Trout and salmon culture (hatchery methods). Calif. Dept. Fish and Game, Fish Bull. no. 107, 169 pp.

APPENDIX

TABLE A-1

Summary of Egg and Fish Transactions,
Klamath River Experimental Station, 1960

Species	Date	Eggs received	Egg loss	Fish loss	Fish planted
King salmon	October	39,500	2,900	24,486	35,230
	December	30,000*			6,884
Total					42,114
Silver salmon	March	20,200	9,175	7,363	3,662
Steelhead	March	6,100	705	1,524	3,871

*Transferred as eyed eggs from Mt. Shasta Hatchery to insure sufficient fish to complete king salmon experiment for one year.

TABLE A-2

Disease Control Treatments by Species,
Klamath River Experimental Station, 1960

Date	Kind of treatment	Purpose of treatment
	King salmon	
Oct. 12, 1959 to Jan. 1, 1960	Malachite flush (daily)	Fungus on eggs
March 17	Salt bath	Regular prophylactic treatment
April 17	Salt bath	Regular prophylactic treatment
April 25	Copper sulfate dip	Regular prophylactic treatment
April 29	Copper sulfate dip	Regular prophylactic treatment
May 17	Salt bath	Regular prophylactic treatment
May 21	Copper sulfate dip	Regular prophylactic treatment
June 7	Salt bath	Regular prophylactic treatment
June 14	Copper sulfate and salt dip	Bacterial gill infection
June 28	Salt bath	Bacterial gill infection
July 13	Copper sulfate flush	Regular prophylactic treatment
July 19	Salt bath	Regular prophylactic treatment
August 2	Copper sulfate flush	Regular prophylactic treatment
August 27	Copper sulfate flush	Regular prophylactic treatment
September 1	Salt bath	Regular prophylactic treatment
	Silver salmon	
April 28	Salt bath	Regular prophylactic treatment
April 30	Salt bath	Regular prophylactic treatment
May 12	Copper sulfate flush	Regular prophylactic treatment
May 13	Copper sulfate flush	Regular prophylactic treatment
May 17	Salt bath	Regular prophylactic treatment
June 12	Copper sulfate flush	Regular prophylactic treatment
June 17	Salt bath	Regular prophylactic treatment
June 28	Salt bath	Bacterial gill infection
July 13	Copper sulfate flush	Regular prophylactic treatment
July 19	Salt bath	Regular prophylactic treatment
August 2	Copper sulfate flush	Regular prophylactic treatment
August 27	Copper sulfate flush	Regular prophylactic treatment
September 1	Salt bath	Regular prophylactic treatment
	Steelhead	
May 14	Salt bath	Regular prophylactic treatment
June 7	Salt bath	Regular prophylactic treatment
June 12	Copper sulfate flush	Regular prophylactic treatment
June 22	Copper sulfate flush	Bacterial gill infection
June 28	Salt bath	Bacterial gill infection
July 13	Copper sulfate flush	Regular prophylactic treatment
July 19	Salt bath	Regular prophylactic treatment
August 2	Copper sulfate flush	Regular prophylactic treatment
August 27	Copper sulfate flush	Regular prophylactic treatment
September 1	Salt bath	Regular prophylactic treatment

TABLE A-3

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish losses		
	High	Low	King salmon	Silver salmon	Steelhead
October, 1959					
13	56	51			
14	56	51			
15	56	51			
16	57	51			
17	57	51			
18	57	52			
19	58	52			
20	58	52			
21	57	53			
22	57	52			
23	57	53			
24	58	52			
25	58	52			
26	58	52			
27	57	53			
28	57	53			
29	57	53			
30	56	52			
31	57	53			
November, 1959					
1	55	52			
2	54	51			
3	53	51			
4	51	49			
5	51	49			
6	52	51			
7	51	49			
8	51	47			
9	49	47			
10	49	47			
11	49	47			
12	49	46			
13	48	46			
14	48	46			
15	48	45			
16	47	44			
17	47	44			
18	46	43			
19	46	43			
20	45	43			
21	45	43			
22	44	42			
23	45	43			
24	45	42			
25	45	42			
26	45	42			

TABLE A-3 -- Continued

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish Losses		
	High	Low	King salmon	Silver salmon	Steelhead
November, 1959-Cont'd.					
27	44	41	500 (eggs)		
28	44	41			
29	44	41			
30	44	41			
December, 1959					
1	44	41			
2	44	41			
3	43	41			
4	43	41			
5	43	41			
6	43	40			
7	42	40			
8	42	40			
9	40	39			
10	40	39			
11	41	39			
12	41	39			
13	40	39			
14	40	39			
15	40	39			
16	39	37			
17	39	37			
18	39	37			
19	39	37			
20	39	37			
21	39	37	2,000 (eggs)		
22	39	37			
23	38	36			
24	38	37			
25	37	36			
26	38	36			
27	38	35			
28	38	36			
29	38	35			
30	37	35			
31	37	36			
January, 1960					
1	37	34			
2	37	35			
3	37	35			
4	36	34			
5	35	34			
6	35	34			
7	37	35			
8	37	35			
9	36	35			

TABLE A-3 - Continued

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish Losses		
	High	Low	King salmon	Silver salmon	Steelhead
January, 1960-Cont'd.					
10	36	35			
11	37	36			
12	37	35			
13	37	35			
14	36	35			
15	37	35			
16	37	35			
17	37	35			
18	36	36	500		
19	37	36			
20	37	36			
21	37	36			
22	37	36			
23	37	36			
24	38	36			
25	38	37			
26	38	36			
27	39	37			
28	39	37			
29	39	37	900 (eggs)		
30	39	37			
31	39	38			
February, 1960					
1	38	38			
2	39	38			
3	40	38			
4	39	38			
5	40	39	10		
6	40	39			
7	40	39			
8	40	39			
9	40	40			
10	41	40			
11	42	40			
12	43	40	15		
13	42	40			
14	42	40			
15	41	41	25		
16	42	40			
17	41	37	25		
18	42	39	15		
19	42	40			
20	39	39	75*		
21	39	38	35		
22	39	38	56		
23	39	37	34		
24	42	39	75		

TABLE A-3 - Continued

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish losses		
	High	Low	King salmon	Silver salmon	Steelhead
February, 1960-Cont'd.					
25	45	40	25		
26	42	38			
27	40	36			
28	41	37	1,570		
29	41	37	210		
March, 1960					
1	41	40	1,000		
2	41	40	600		
3	40	40	550		
4	41	40	425		
5	42	40	625		
6	42	40	475		
7	42	40	540		
8	41	40	425		
9	41	40	320		
10	42	40	300		
11	42	40	350		
12	43	42	270		
13	44	42	200		
14	43	41	150		
15	42	42	150		
16	42	40	130		
17	44	42	175		
18	45	42	100		
19	46	43	150		
20	49	40	200		
21	49	44	600		
22	54	46	280		
23	51	47	175		
24	51	48	240		
25	51	48	155		
26	50	47	110	210 (eggs)	
27	50	47	90	175 (eggs)	
28	49	49	40		
29	49	47	60	200 (eggs)	15 (eggs)
30	50	48	60		
31	50	48	45		
April, 1960					
1	50	49	55	1,200 (eggs)	
2	53	48	35	500 (eggs)	
3	52	48	35		
4	52	50	75	2,500 (eggs)	190 (eggs)
5	54	50	35	600 (eggs)	
6	53	50	25		
7	54	50	0		
8	54	52	0		
9	54	50	175	1,700 (eggs)	

TABLE A-3 - Continued

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish losses		
	High	Low	King salmon	Silver salmon	Steelhead
April, 1960-Cont'd.					
10	54	50	65	200 (eggs)	100 (eggs)
11	52	50	160	50 (eggs)	
12	52	50	55		
13	54	50	197		
14	52	52	55		
15	52	50	55	50 (eggs)	400 (eggs)
16	54	52	35		
17	54	50	35		
18	54	52	25		
19	54	52	15	50 (eggs)	
20	54	50	25		
21	53	50	20		
22	54	51	15	50 (eggs)	
23	54	51	25	1,690 (eggs)	
24	55	50	22	90	
25	55	51	28	150	130
26	52	50	11	160	15
27	51	50	11	190	5
28	51	50	2	120	
29	52	50	8	75	4
30	52	50	12	130	7
May, 1960					
1	53	51	3	60	5
2	53	51	3	75	75
3	53	51	2	100	5
4	53	49	3	50	25
5	54	51	1	120	10
6	54	51	0	150	5
7	54	52	0	110	5
8	55	52	3	150	5
9	56	53	0	150	5
10	56	53	0	175	3
11	58	53	2	150	5
12	58	53	1	150	25
13	58	53	2	100	25
14	59	57	2	50	
15	59	57	3	50	32
16	59	57	5	30	20
17	58	56	0	20	10
18	58	57	1	30	40
19	60	58	5	15	10
20	58	56	4,805**	40	20
21	58	57	10	20	10
22	57	55	2	35	15
23	56	55	1	25	10
24	56	55	4	50	15
25	55	54	4	17	8
26	55	54	1	23	7

TABLE A-3 - Continued

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish losses		
	High	Low	King salmon	Silver salmon	Steelhead
May, 1960-Cont'd.					
27	56	54	4	135	8
28	58	55	4	162	6
29	59	55	10	130	4
30	59	56	1	103	4
31	58	56	3	100	7
June, 1960					
1	60	58	6,000***	150	7
2	63	59	1	200	10
3	64	60	4	300	10
4	64	60	4	400	10
5	65	60	5	400	20
6	64	60	10	200	20
7	64	61	10	200	20
8	64	62	5	200	15
9	68	64	5	75	20
10	65	63	10	50	15
11	65	62	25	35	20
12	65	63	15	100	15
13	66	63	19	50	10
14	67	63	15	40	10
15	65	63	15	10	5
16	68	64	15	10	10
17	68	64	15	20	10
18	69	65	15	30	10
19	68	65	20	20	5
20	69	67	25	30	25
21	68	67	20	32	29
22	67	66	5	26	23
23	68	67	16	25	28
24	67	66	21	24	33
25	67	66	29	117	13
26	68	66	28	125	15
27	68	66	33	123	12
28	68	66	20	125	15
29	68	66	20	200	35
30	69	66	20	110	10
July, 1960					
1	69	66	20	5	80
2	69	66	5	5	80
3	69	66	5	10	120
4	69	67	5	15	40
5	70	67	10	5	10
6	70	67	20	5	10
7	70	68	10	5	10
8	70	68	18	5	3
9	70	68	5	5	5
10	70	68	2	10	5
11	70	68	5	10	5

TABLE A-3 - Continued

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish Losses		
	High	Low	King salmon	Silver salmon	Steelhead
July, 1960-Cont'd.					
12	70	68	1	10	10
13	70	68	5	10	10
14	70	68	2	5	5
15	70	68	0	5	2
16	71	68	5	10	5
17	71	68	0	15	2
18	72	69	3	15	1
19	72	69	3	15	1
20	73	70	0	20	2
21	72	70	0	20	2
22	72	70	1	15	2
23	72	70	2	10	2
24	72	70	0	40	3
25	72	70	0	40	
26	72	70	2	30	
27	72	70	1	10	2
28	72	70	0	15	2
29	72	70	0	5	3
30	72	70	1	7	7
31	72	70	0	4	6
August, 1960					
1	72	70	2	6	8
2	72	70	0	5	5
3	72	70	0	5	5
4	72	70	0	8	13
5	72	70	1	2	15
6	72	70	1	5	8
7	72	70	1	1	13
8	72	70	1	3	10
9	72	70	2	3	6
10	72	70	4	2	1
11	71	70	1	0	0
12	71	70	0 WF****	2	2
			0 DF****		
13	72	70	2 WF	2	2
			0 DF		
14	70	70	0 WF	1	0
			1 DF		
15	70	69	1 WF	0	1
			0 DF		
16	69	68	1 WF	0	5
			0 DF		
17	69	68	1 WF	2	0
			0 DF		
18	70	68	2 WF	0	0
			4 DF		
19	69	68	2 WF	1	0
			1 DF		

TABLE A-3 - Continued

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish losses		
	High	Low	King salmon	Silver salmon	Steelhead
August, 1960-Cont'd.					
20	69	68	1 WF 3 DF	0	1
21	69	68	3 WF 3 DF	0	5
22	69	68	6 WF 5 DF	1	1
23	67	66	4 WF 2 DF	0	2
24	67	66	4 WF 2 DF	0	1
25	67	66	4 WF 4 DF	1	1
26	67	66	4 WF 4 DF	0	3
27	67	66	4 WF 3 DF	1	0
28	67	66	6 WF 15 DF	1	5
29	67	65	0 WF 2 DF	1	6
30	65	64	1 WF 0 DF	0	5
31	64	62	1 WF 0 DF	1	2
September, 1960					
1	64	63	1 WF 1 DF	2	1
2	64	63	1 WF 3 DF	0	2
3	64	63	4 WF 0 DF	1	1
4	65	64	1 WF 0 DF	0	1
5	64	63	1 WF 0 DF	0	1
6	64	63	1 WF 0 DF	1	0
7	65	63	0 WF 0 DF	0	2
8	64	63	0 WF 0 DF	0	0
9	64	63	0 WF 0 DF	0	0
10	64	63	3 WF 1 DF	1	1
11	64	63	0 WF 0 DF	0	2

TABLE A-3 - Continuec

Daily Water Temperatures and Fish Losses,
Klamath River Experimental Station

Date	Temperature		Fish losses		
	High	Low	King salmon	Silver salmon	Steelhead
September, 1960-Cont'd.					
12	64	63	1 WF 0 DF	0	0
13			1/0 WF-DF		
14			0/2 WF-DF		
15			0/2 WF-DF	4	
16			0/2 WF-DF		2
17			1/2 WF-DF	1	2
18			0/0 WF-DF		
19			0/0 WF-DF		
20			0/0 WF-DF	1	1
21			0/0 WF-DF		1
22			0/0 WF-DF		
23			0/0 WF-DF		1
24			0/0 WF-DF		

*Losses from February 20 through March 26 in king salmon were mainly due to coagulated yolk sacs.

**Fish reweighed; adjusted loss.

***Water supply failure loss.

****WF = wet food; DF = dry food.

FIGURE A-5

IRON GATE SALMON & STEELHEAD HATCHERY
Trapped Silver Salmon 1963-64