TEMPERATURE - HOLDING EXPERIMENT AT OXBOW DAM

(SUMMARY)

by

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INTRODUCTION

Above-average losses of unspawned adult chinook salmon at the Oxbow Dam holding pond on the Snake River have occurred coincidentally with higher water temperatures in two of the past three operating seasons. In the season when lower water temperatures prevailed, fewer losses occurred. These events suggested that the lower temperatures benefited these fish.

In the fall of 1964 an experiment planned to investigate such benefits was attempted at the Oxbow hatchery. Adult migrants trapped at the dam were held in water cooled by mechanical refrigeration. The results are summarized in this report.

EQUIPMENT AND PROCEDURE

Facility

Fish were held at the hatchery in one of the 100-by 6-foot concrete raceways filled to about 3 feet in depth. The water volume was 1,800 cubic feet, or about 13,500 gallons. To offset solar heating effects, the raceway was shaded. Cooling was by circulating the water through a 30-ton-capacity commercial water chiller. In addition, two smaller 7.5-ton-capacity chillers were installed as standby units. Water temperatures were held about a daily mean of 55° F. Daily variation was within $\pm$ 2° F. New water was supplied to flush the raceway at the maximal rate consistent with the cooling capacity of the 30-ton chiller. At the beginning of the test, 50 gallons per minute passed through the system. As river temperatures declined, this rate was increased to about 80 gallons per minute (Table 1). Mechanical aeration raised the dissolved oxygen content of the water from (about 7 parts per million), the river level, to about 9 parts per million within the raceway. To reduce the accumulation of particulate matter a filter was installed, but after a brief usage, this became inoperable because of clogging by algal material. Despite this, no appreciable buildup of suspended matter was evident. In order to avoid stagnation effects in the raceway, all equipment pumps were operated to circulate the water from the upper to the lower end. Total pumping capacity was about 700 gallons per minute. This in addition to the flushing flow of new water gave a total raceway flow generally above 750 gallons per minute.

Water Qualities

Water qualities were measured for monitoring purposes rather than detailed study, (Table 2). Since maximum accuracy was not a planned requirement, the following methods applicable for simplified usage in the field were employed.

Table 1.--Summary of flushing rate, prophylactic treatment, introduction of fish and mortalities in holding experiment at Oxbox Dam Hatchery.

	Temperature Controlled Raceway							Hatchery Pond			
Date 1964	Flushing Rate	Malachite Green Treatment 1/	Number In 2/ M	F	Mortality M	F	Cumulative Total Living	Number In M	F	Mortality M	F
Sept.	G.p.m.										
1	50	-	-	-	-	-	-	-	-	-	-
2	50	-	-	-	-	-	-	-	-	-	-
3	50	-	-	-	-	-	-	2	2	-	-
10	50	-	-	-	-	-	-	-	-	-	-
11	50	+	2	2	-	-	4	2	2	-	-
12	50	-	-	-	-	-	4	3	1	1	1
13	50	+	-	2	-	-	6	4	1	-	-
14	50	-	1	-	-	-	7	3	5	-	-
15	50	+	1	-	-	-	8	2	5	-	1
16	50	-	1	1	-	-	10	4	6	-	-
17	50	+	3	1	-	-	14	11	8	-	-
18	50	-	3	1	-	-	18	8	13	-	-
19	50	+	1	3	-	-	22	11	13	1	-
20	65	-	2	4	-	-	28	22	13	-	-
21	65	+	5	5	-	-	38	27	29	-	1
22	65	-	8	7	-	-	53	23	27	-	1
23	65	+	1	2	-	-	56	14	12	-	-
24	65	-	4	1	-	-	61	8	15	-	1
25	65	+	3	2	-	-	66	9	8	-	1
26	65	-	-	5	-	-	71	19	11	-	-
27	65	+	2	1	-	-	74	17	6	-	-
28	65	-	3	-	-	-	77	2	4	-	-
29	65	+	2	1	-	-	80	5	4	-	-
30	65	-	-	-	-	-	78 3/	3	4	-	1
Oct.											
1	80	+	4	1	-	2	81	5	7	1	-
2	80	-	-	-	1	2	78	2	3	-	-
3	80	+	-	4	4	22	56	4	4	-	-
4	80	-	-	-	3	6	47	6	3	-	-
5	80	-	-	-	4	5	38	0	0	-	-
6	80	-	-	-	6	-	32	1	1	-	2
7	80	-	-	-	3	4	25	4	-	-	-
8	80	-	-	-	5	2	18	-	-	-	-
9	80	-	-	-	1	4	13	-	-	-	-
10	80	-	-	-	-	-	13	-	-	-	-
11	80	-	-	-	-	1	12	-	-	-	-
12	80	-	-	-	-	-	12	-	-	-	-
13	80	-	-	-	-	1	11	-	-	-	-
14	80	-	-	-	-	-	11	-	-	-	-
15	80	-	-	-	-	-	11 4/	-	-	-	-
Totals:			46	43	27	49	(89)				

1/ Treatment level 1:2,000,000.
2/ Sexes identified only by superficial appearance when put into raceway.
3/ Two fish jumped out.
4/ Determined to be 4 females and 7 males (10-28-64).

Table 2.--Summary of water quality data for adult chinook holding experiment at Oxbow Dam Hatchery. Quality measurements were made from water within the experimental holding raceway and from supply water pumped from the river.

Date 1964	Temperature		Oxygen (O_2)		Ammonia (NH_3)		Carbon Dioxide (CO_2)		pH		Copper (Cu++)		Resistivity	
	R[1]	S[2]	R[1]	S[2]	R[1]	S[2]	R[1]	S[2]	R[1]	S[2]		S[2]	R[1]	S[2]
Sept.	°F	°F	Ppm	Ppm	Ppm	Ppm	Ppm	Ppm			Ppm	Ppm	Ohms/cm	
1	56	70	8	7	-	-	8	8	8	8	.05	.05	2800	2800
2	55	70	8	-	.25	.25	7	-	8	8	.05	.05	2800	2800
3	55	70	10	-	.15	.07	-	-	-	-	-	-	-	-
10	55	68	9	-	.25	.25	5	-	8	-	.05	.05	2700	-
11	55	69	9	-	.25	-	6	7	8	-	.05	-	2900	2900
12	54	69	7	-	.20	-	8	-	8	-	.00	-	3000	-
13	54	69	8	7	.25	.25	7	7	8	8	.00	-	3000	-
14	55	69	9	-	.20	-	6	-	8	-	.00	-	2800	-
15	55	68	9	-	.25	-	6	-	8	-	.00	-	2900	-
16	54	70	9	-	.25	-	7	-	8	-	.00	-	2900	-
17	54	68	9	-	.25	-	7	-	8	-	.00	-	2900	-
18	54	67	9	-	.25	-	6	-	8	-	.00	-	3000	-
19	55	68	10	7	.25	.20	6	7	8	8	.00	.00	2900	2700
20	55	66	10	-	.25	-	6	-	8	-	.00	-	2900	-
21	55	66	10	-	-	-	-	-	8	-	.00	-	-	-
22	55	64	10	-	-	-	-	-	8	-	.00	-	-	-
23	55	65	9	-	-	-	-	-	8	-	.00	-	-	-
24	55	64	9	-	.15	-	6	-	8	-	.00	-	2700	-
25	55	65	9	-	-	-	-	-	8	-	.00	-	-	-
26	55	65	9	-	-	-	-	-	8	-	.00	-	-	-
27	55	64	9	-	-	-	-	-	8	-	.00	-	-	-
28	55	65	9	-	-	-	-	-	8	-	.00	-	-	-
29	55	64	9	-	-	-	-	-	8	-	.00	-	-	-
30	55	63	9	-	.25	-	-	-	8	-	.00	-	-	-
Oct.														
1	55	63	9	-	-	-	-	-	8	-	.00	-	2600	-
2	55	63	9	-	.15	-	-	-	8	-	.00	-	-	-
3	55	63	9	-	.15	-	7	-	8	-	.00	-	-	-
4	58[3]	63	9	-	.15	-	7	-	8	-	.00	-	-	-
5	59[3]	63	9	-	.15	-	7	-	-	-	.00	-	-	-
6	59[3]	63	9	6	.15	.10	7	7	8	8	.00	.00	2600	2700
7	55	63	9	7	.15	.15	7	7	8	8	.00	.00	2800	2900
8	55	63	9	7	.15	.15	7	7	8	8	.00	.00	2800	2700
9	55	63	9	7	.15	.15	7	7	8	8	.00	.00	2800	2800
10	55	-	10	7	.15	.20	6	7	8	8	.00	.00	2850	2790
11	55	-	-	-	-	-	-	-	-	-	-	-	-	-
12	55	-	10	8	.10	.10	7	6	8	8	.00	.00	2500	2500
13	55	-	9	-	.15	.15	7	-	8	8	.00	.00	2750	2800
14	55	-	9	9	.15	.15	7	7	8	8	.00	.00	2850	2900
15	55	-	-	-	-	-	-	-	-	-	-	-	-	-

1/ Raceway.
2/ Snake River.
3/ Elevated temperature due to temporary use of standby chillers.

1. Temperatures were measured with a standard mercury thermometer and an electronic thermometer and were monitored by a conventional 7-day thermograph. Measuring accuracy was within 0. 2° F.

2. Oxygen measurements were made with a field kit manufactured by the Hach Chemical Co. The method was a modification of the standard Winkler titration and was accurate within 0. 5 part per million of dissolved oxygen.

3. Ammonia determinations were by the direct Nesslerization method. Readings were made with a W. A. Taylor Color Comparator, using a color standard slide which covered a range from 0. 0 to 1. 0 part per million of ammonia nitrogen. Presumed accuracy averaged within 0. 1 part per million over the range of the standards.

4. Carbon dioxide was checked with a Hach Chemical Co. field kit, whereby free carbon dioxide was assayed by titration with sodium hydroxide. Stated accuracy was within 1. 0 part per million.

5. pH determinations were made with a Hach field kit, employing colorimetric indicator reactions compared against color standards. This was accurate within 0. 5 pH unit from pH 4. 0 to pH 10. 0.

6. Copper or cupric ion was monitored, since some of the operating equipment had components of metallic copper or copper alloy in contact with the raceway water. The method consisted of colorimetric assay by use of a dithiocarbamate reagent. Readings were compared against a W. A. Taylor color standard slide ranging from 0. 0 to 1. 0 part per million. Presumed accuracy was within 0. 05 part per million.

7. Electrical resistivity was monitored with a standard industrial-type resistance cell. Accuracy was within 100 ohms per cubic centimeter of water. The purpose of this measurement was to indicate undue changes in ionized dissolved solids in the raceway water.

Fish

The fish sample was obtained from the regular hatchery operation at Oxbow Dam. This operation is based on the adult chinook salmon trapped at the dam and transported to the hatchery for holding. As the fish were placed into the pond, each fourth or fifth fish was selected to be put into the experimental facility. This included males and females. It was planned to continue this representative apportionment until about 100 fish were in the raceway. To avoid extra handling and possible surface injuries, it was decided not to mark the fish. Due to the limited numbers in this particular run, a control group was not used.

In the hatchery procedure, while fish were being introduced into the holding pond, malachite green was administered daily to give a routine 1-hour treatment

at a concentration of 1 part per million. To approximate similar prophylactic measures for the experimental fish, it was decided to treat this group with malachite green. Because the relative flushing rate of the raceway was less than that of the pond, the treatment was modified so that the dye concentration in the water was 1 part in 2 million and was administered only on alternate days as fish were introduced.

RESULTS AND DISCUSSION

Fish were first placed into the raceway on September 11, 1964. In the following 20 days, a total of 80 fish were introduced. In the morning of the 21st day, October 1, two dead fish were removed from the raceway. All other fish appeared normal. Later that same day, five new fish were added. The next day, October 2, three fish were found dead. The remaining fish appeared responsive and seemed normal. Early in the morning of October 3, prior to the usual inspection, four additional new fish were placed into the raceway. A little later, nine dead fish were discovered. That afternoon, the malachite green treatment was applied. Within 2 hours, several more fish were dead, others dying, and most of the group appeared lethargic. As an effort to improve presumed poor conditions, new water was flushed through the raceway which raised the temperature 2° to 4° F. Following this, the fish seemed more active. By the end of the day, however, 26 dead fish had been removed. No more fish were added to the raceway, and the malachite green treatments were discontinued. Mortalities continued to occur over the next 11 days. Of a total of 89 fish introduced, 76 died and 2 were lost in accidents, leaving 11 surviving fish (Fig. 1).

On October 4, pathologists from the Oregon Fish Commission visited the site and examined some of the fish which had died recently. No external or internal evidence of disease was present, and subsequent laboratory tests did not indicate any disease pathogens. However, some field observations made at that time noted an atypical appearance of the gills of the fish, which suggested possible effects from some external environmental factor.

Field measurements of water qualities did not indicate changes or deteriorations which would directly account for the heavy mortalities. Ammonia levels, as measured in the raceway, did not exceed the values observed for the inlet water from the Sanke River, which has been reported to contain up to 0.96 part per million of ammonia nitrogen (Robeck et al, 1954). While the analytical method may have lacked highly quantitative accuracy at the indicated low level of ammonia content, previous use of the technique in other applications had demonstrated its sensitivity to relative changes in ammonia up to 1 part per million. Ellis (1948) states that detrimental effects on fish may be expected if ammonia levels are at 2.5 parts per million or higher. More recent work (McKee and Wolf, 1963) reports that toxic effects have been noted at lower ammonia concentrations in connection with low dissolved oxygen, a condition not observed in this experiment.

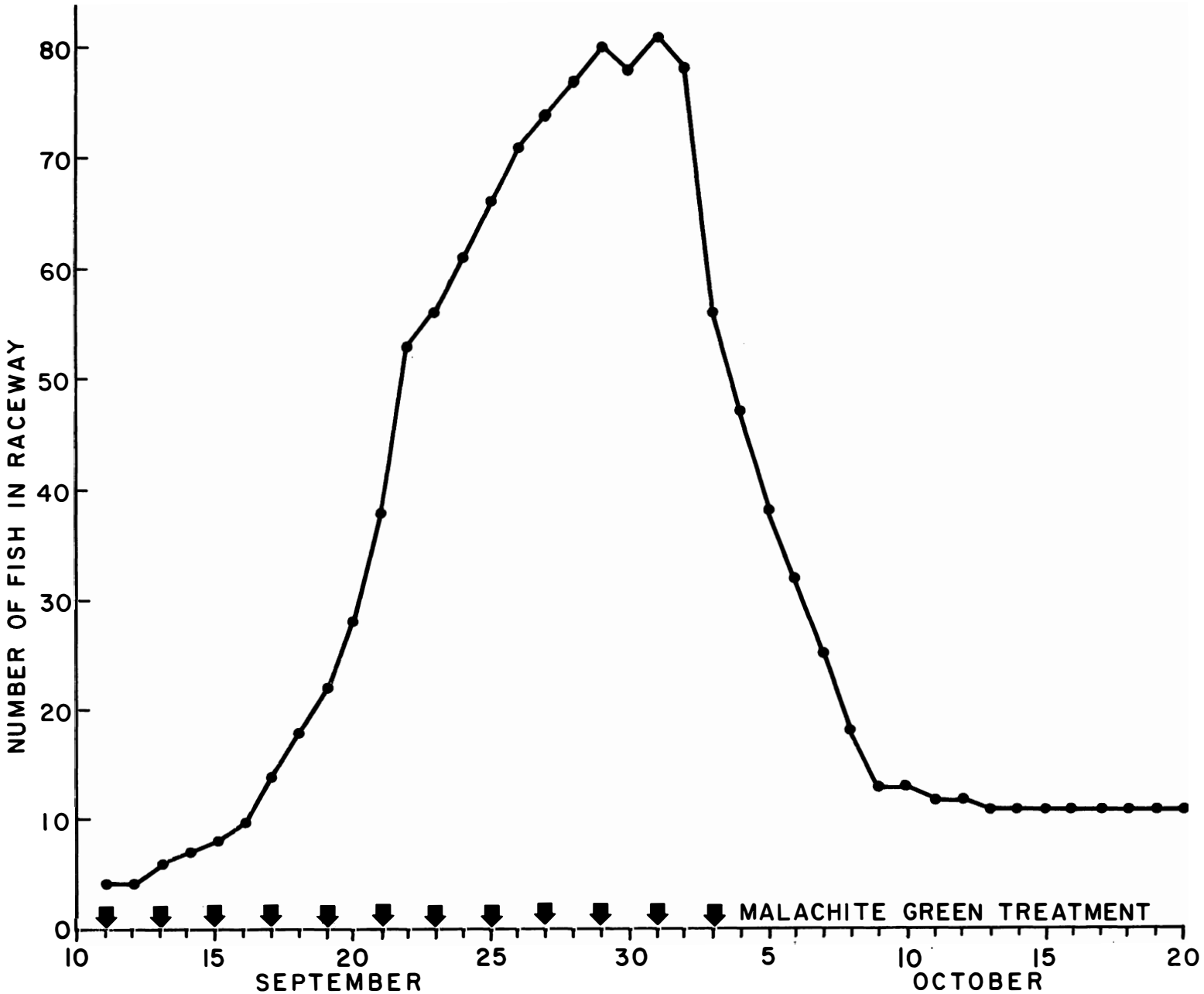

Figure 1.--Number of adult chinook in the experimental raceway holding facility at Oxbow Dam Hatchery.

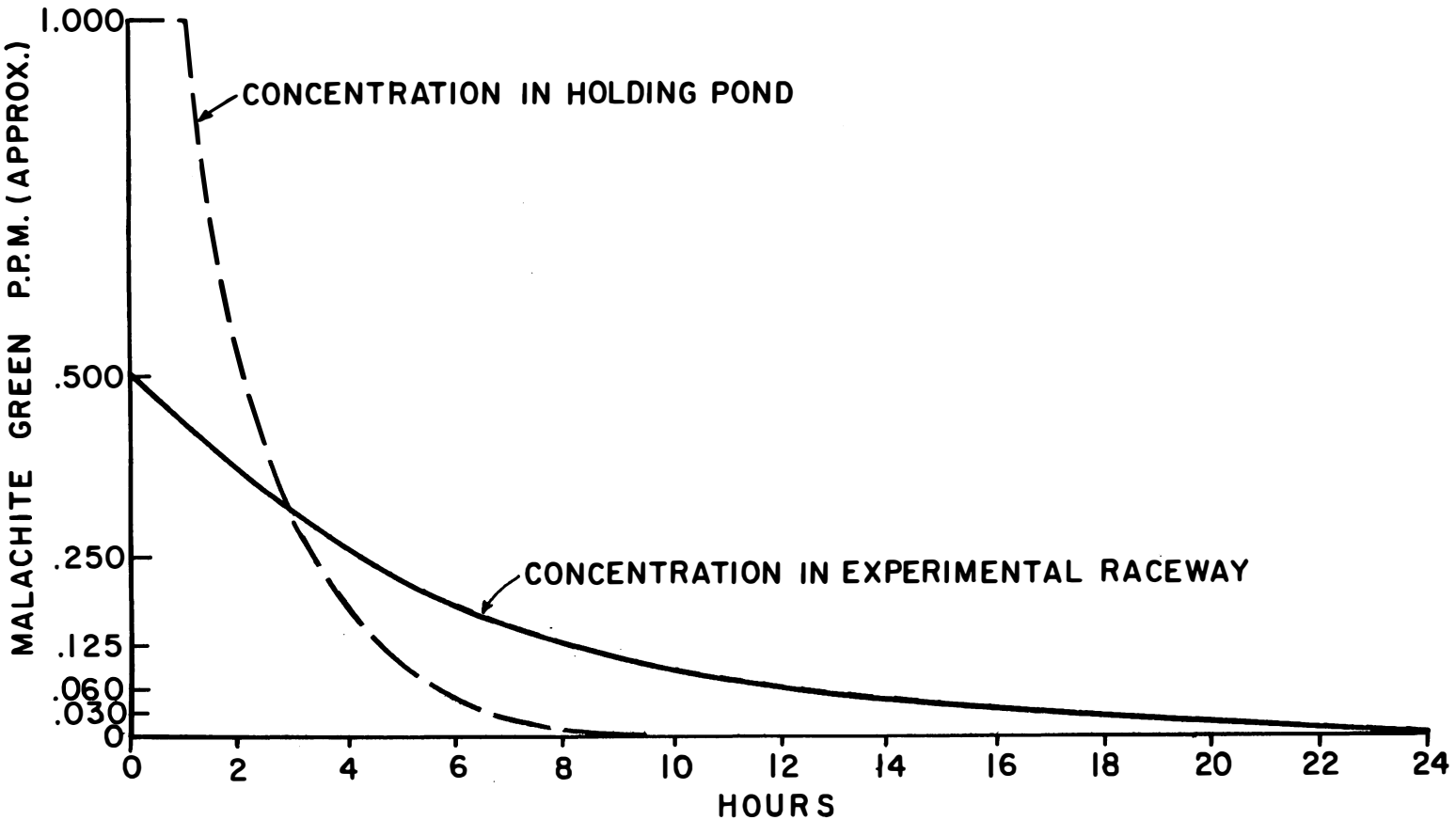

Figure 2.--Relative exposure of fish to malachite green dye in the hatchery pond and the experimental raceway. Points on dilution curves indicate time of flushing by one volume of water, based on estimated flows. Concentration values indicate relative levels and are not calculated.

To check the possibility of an accumulative toxic effect due to undetected low-level presence of copper and zinc, some laboratory tests of the raceway water were made using a Perkin-Elmer atomic absorbtion spectrophotometer. Neither metal was detected at a sensitivity level of 1 part per billion.

The malachite green treatment of the raceway, though planned to approximate the treatment administered to the hatchery pond, may have resulted in a greater exposure of the experimental fish to the dye. Even though the raceway treatments were half as frequent and the initial concentration less than that used in the pond, relative differences in flushing rates apparently subjected the experimental fish to longer exposure periods at higher concentrations. This is indicated by Figure 2. Estimating 20 water renewals in 24 hours for the hatchery pond, the malachite green could have been cleared from the pond in 9 hours. In the raceway, estimating six renewals in 24 hours, some malachite green still could have been present after 24 hours. Though the dilution curves in Figure 2 were not calculated to show the exact dye concentrations, the relative values for the treatments indicate that for other than the first 2-1/2 hours after application, the experimental fish were exposed to higher concentrations for longer periods. No direct evidence shows that this manner of exposure to malachite green caused the fish loss, but it should be considered, particularly since the gills of the fish seemed to have been affected by some unidentified factor. An apparent scarcity of specific information on the toxicology of the dye suggest that controlled testing is needed to define malachite green effects on adult salmon.

Although the loss of fish prevented a measure of benefits to be gained from lowered temperature, support for the initial premise is indicated by the evident successful holding this season in the hatchery pond. Water temperatures have been consistently lower than they were last year, and relatively fewer mortalities have occurred.

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