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EFFECT OF SODIUM DICHROMATE IN REACTOR COOLING WATER ON YOUNG CHINOOK SALMON

by

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ABSTRACT

Chinook salmon held in mixtures of dechlorinated reactor cooling water and raw Columbia River water suffered no increased mortality and only slight retardation of growth in a 50 per cent mixture during the time when sodium dichromate was not added in the reactor cooling water treatment process. However, upon the addition of 2.0 ppm dichromate [0.7 ppm Cr(VI)], increased mortality resulted in the 10 per cent mixture and growth was retarded in the 3 per cent mixture. In greater concentrations, increased mortalities were detectable four to five weeks after hatching and high death rates continued for many weeks.

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INTRODUCTION

The treatment process for the water used to cool the Hanford reactors has included the addition of two substances, chlorine and sodium dichromate as $Na_2Cr_2O_7.2H_2O$, which are toxic to aquatic life.[1,2] Since the water is heated during its passage through the reactor, and is then held for several hours in an open retention basin before discharge into the river, the free chlorine is reduced to negligible amounts and does not constitute a hazard to river life. The water treatment process has usually included the addition of 2.0 ppm of sodium dichromate. In April of 1952, however, the addition of dichromate was stopped in all areas,[3] for a period of several months. Now, after a period of laboratory and in-pile tests, schedules call for a studied reduction in the addition of dichromate below 2.0 ppm for at least one reactor.[4,5]

The toxicity of the coolant to the 100-F reactor was evaluated during the time when dichromate was absent and again when addition was resumed. Comparison of the results of the two tests provides background information useful in estimating safe levels of dichromate addition.

MATERIALS AND METHODS

The first study, during the period when dichromate was absent, was started on October 30, 1952, when chinook salmon eggs were available. It

was terminated on April 10, 1953, when addition of dichromate to the process water was resumed. Approximately 11,000 eggs, obtained from the Washington State Department of Fisheries hatchery at Soos Creek (Puget Sound drainage), were randomly distributed among troughs with the following conditions.

Columbia River Water [1]	(3 control troughs)
5% [2]	Dechlorinated Reactor Influent [3]
10%	Dechlorinated Reactor Influent
25%	Dechlorinated Reactor Influent
50%	Dechlorinated Reactor Influent

1/ This is water from the 181-F pump house and contains small amounts of the effluents originating from the upstream reactors. Presumably the contribution of effluent water from upstream reactors is less than one per cent.

2/ Percentage figure indicates the amount of the experimental water mixed with Columbia River water.

3/ Reactor influent is the process water which has undergone treatment and is supplied to the reactor as a coolant. In this study, its temperature was adjusted to that of the river water. Residual chlorine was removed by filtration through charcoal.

The eggs and resulting fish were given normal fish-cultural care. Records of mortality and growth were maintained. As the fish increased in size, the numbers held in each trough were reduced to prevent overcrowding.

The second study, during the period when dichromate was added at the rate of [redacted] ppm to the process water, began on November 3, 1953 and was

completed on April 14, 1954. The experiment was conducted for the same number of days as the first test. Equipment and operating procedures were identical, except that approximately 23,000 eggs were used to provide duplicate lots and one new condition, three per cent dechlorinated reactor influent, was added.

RESULTS AND DISCUSSION

Mortalities which occurred during the egg, fry [1], and fingerling [2] stages are shown in Figure 1. None of the lots suffered significant mortalities at any stage during the period when dichromate was absent. When dichromate was added, no significant mortalities occurred in any of the lots during the egg stage. The eggs appear to be quite resistant to many chemicals, however, possibly owing to the protective action of surrounding membranes. During the fry stage, higher mortalities were indicated in concentrations as low as five per cent. Fingerling and total mortalities were significantly greater at the ten per cent and higher levels.

Figure 2 shows cumulative mortality at weekly intervals after hatching for the fish held in the effluent containing dichromate. Not until about four weeks after hatching did mortalities increase above normal in the higher concentrations. Subsequently, they continued high during the latter part of the fry stage and during the fingerling stage.

1/ The young fish is called a fry upon hatching from the egg. During this stage it is nourished from a yolk sac.

2/ The fry becomes a fingerling when the yolk sac is absorbed and active feeding has started.

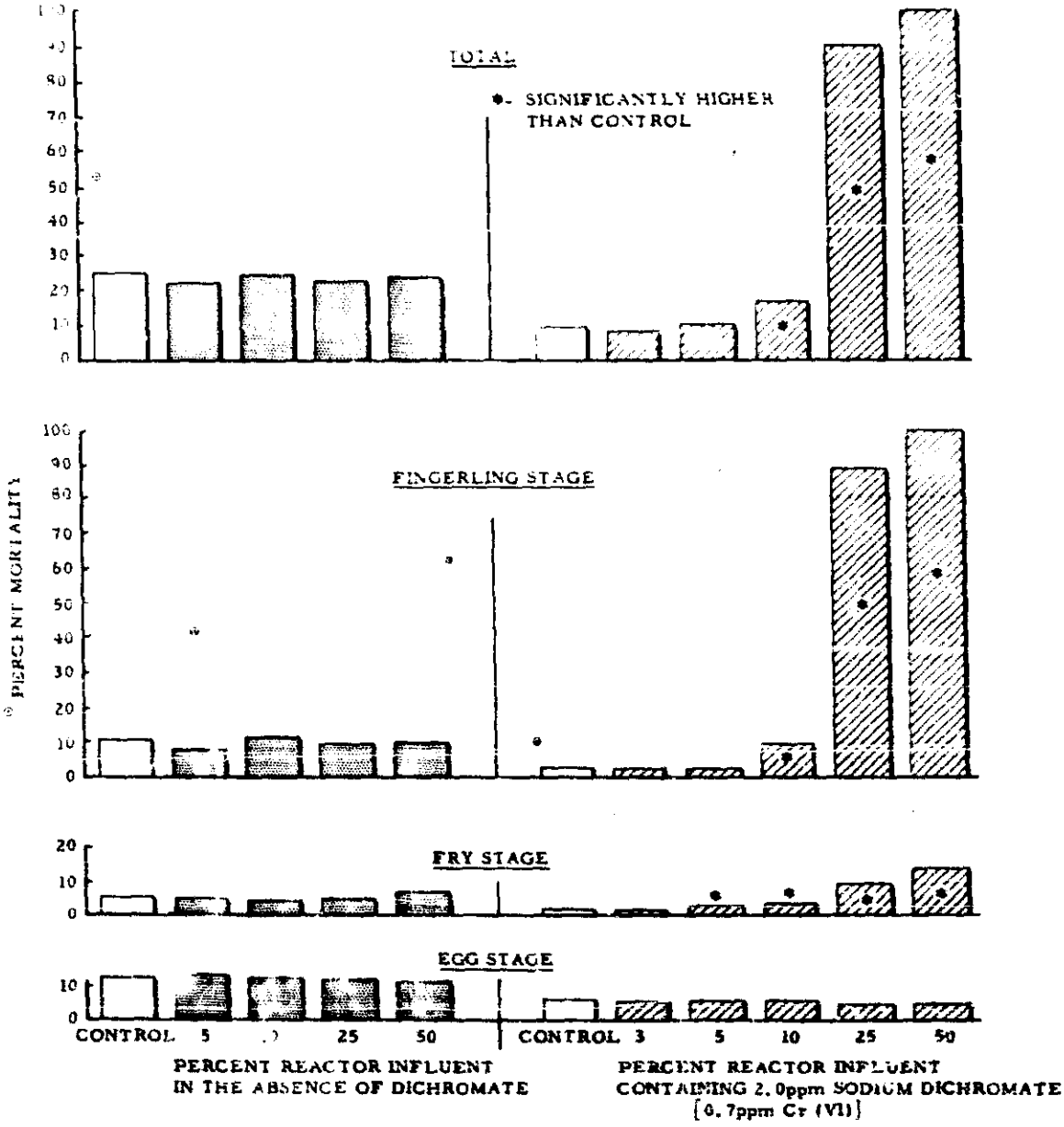

FIGURE 1

SALMON MORTALITY

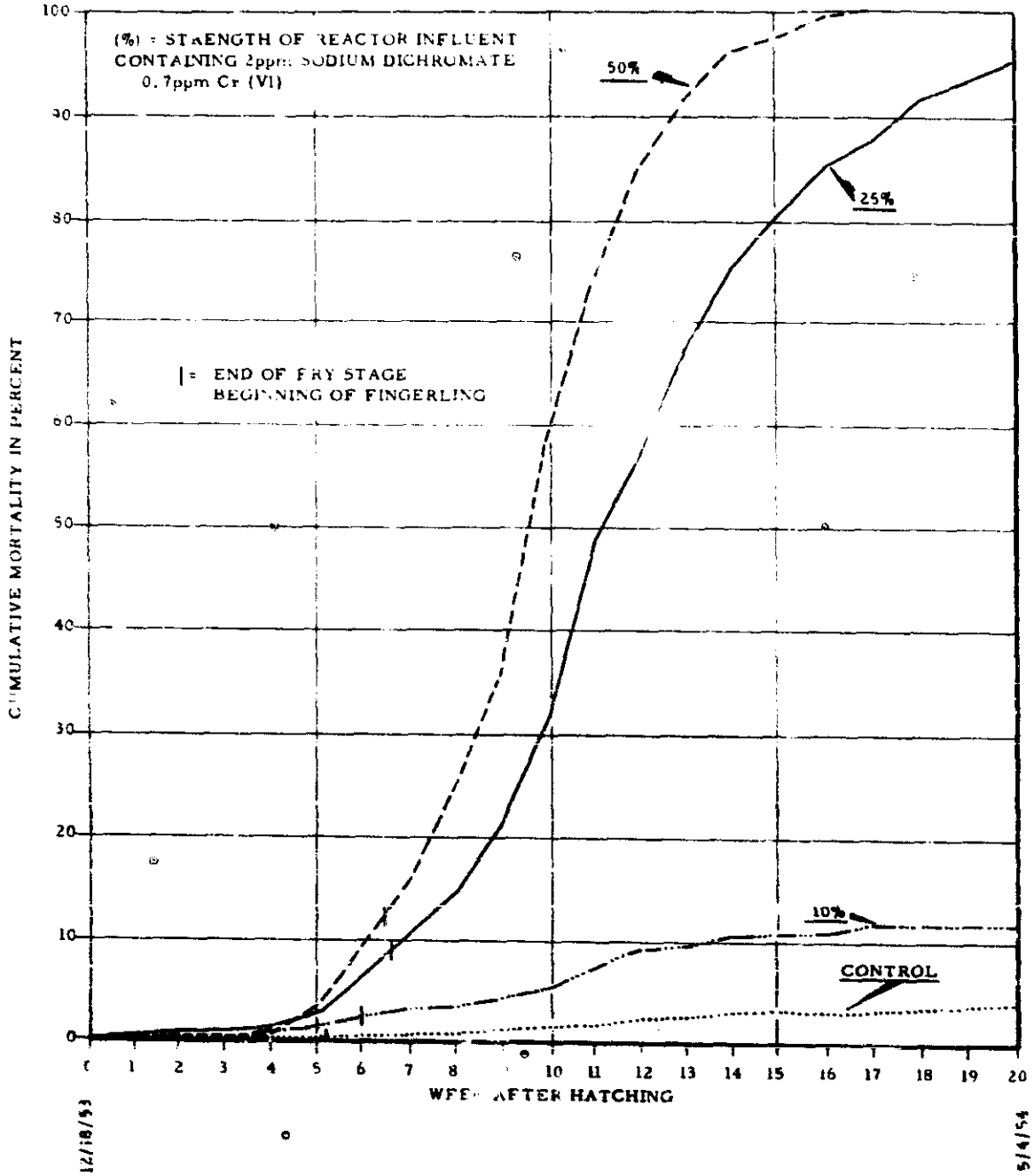

FIGURE 2

CUMULATIVE MORTALITY OF YOUNG SALMON IN THE PRESENCE OF SODIUM DICHROMATE

Figure 3 shows the growth of the salmon which were not exposed to dichromate. Little or no growth retardation occurred at or below the 25 per cent level. Figure 4 shows growth of the salmon which were exposed to the dichromate. Growth was retarded even at the three per cent level. Early development was also retarded in the greater concentrations. Absorption of the yolk, which marked the termination of the fry stage, was delayed several days in the 25 and 50 per cent levels and was slightly retarded even at the 10 per cent level. This delay is indicated by the starting date for the appropriate curve in Figure 4. The fish in the 25 and 50 per cent lots were unable to utilize food normally and actually lost weight. The fish in 10 per cent influent showed little growth.

Water temperatures prevailing during the two experiments are shown in Figure 5. Separate studies have shown that lower temperatures, particularly during the early incubation of the eggs, tend to favor survival. Thus, temperatures encountered during the second year when the dichromate was present were more favorable than during the 1952-53 period when the dichromate was absent.

These tests indicate that in the absence of dichromate the dechlorinated reactor influent is comparatively nontoxic and can be tolerated by young salmon in concentrations as great as 50 per cent for several months without significant effect. When 2.0 ppm of sodium dichromate is added to the process water, however, it becomes sufficiently toxic that at 25 per cent strength appreciable mortality occurs, at 10 per cent strength some mortality and substantial retardation of growth occur, and at 3 per

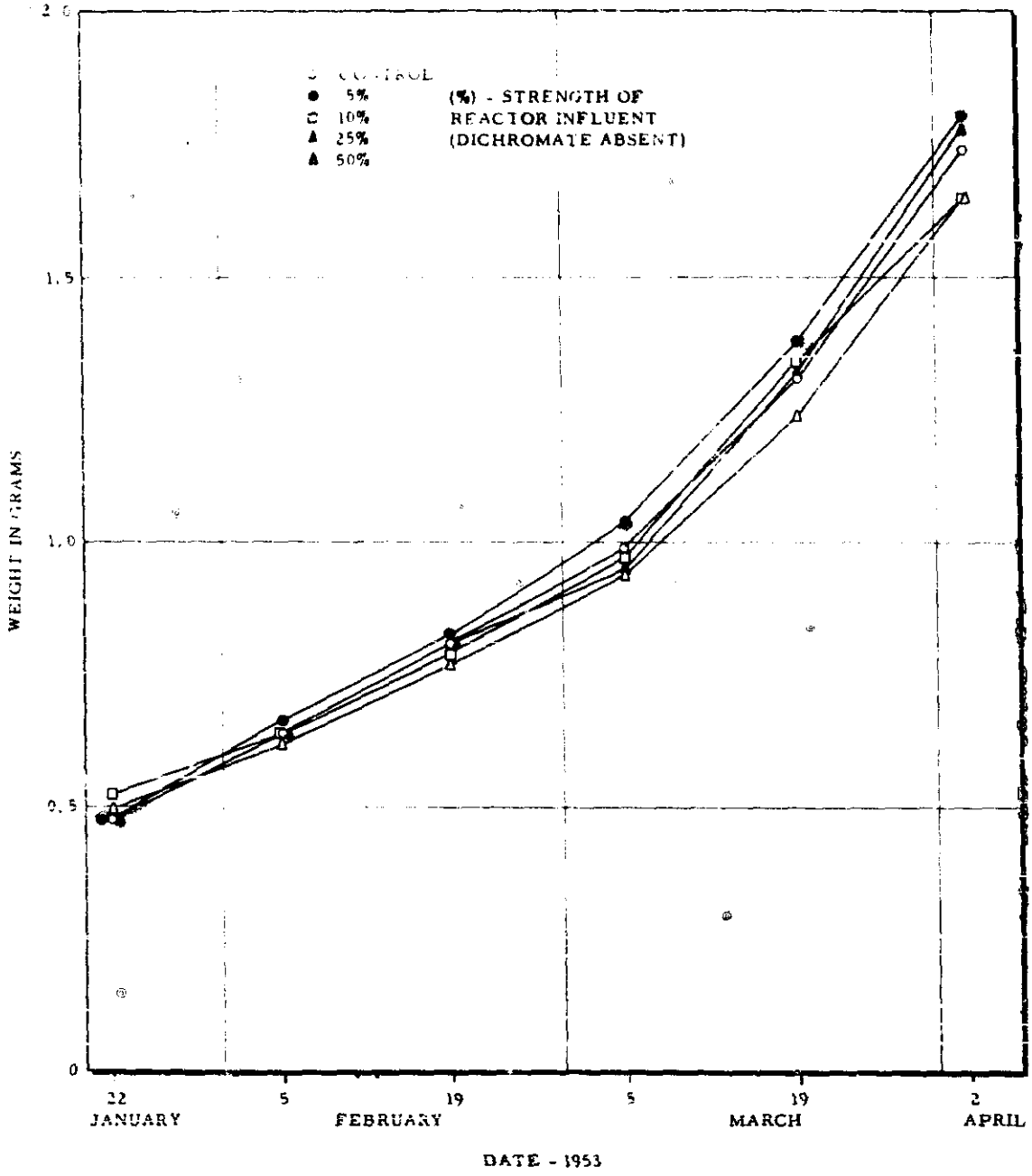

FIGURE 3

GROWTH OF YOUNG SALMON IN THE ABSENCE OF DICHROMATE

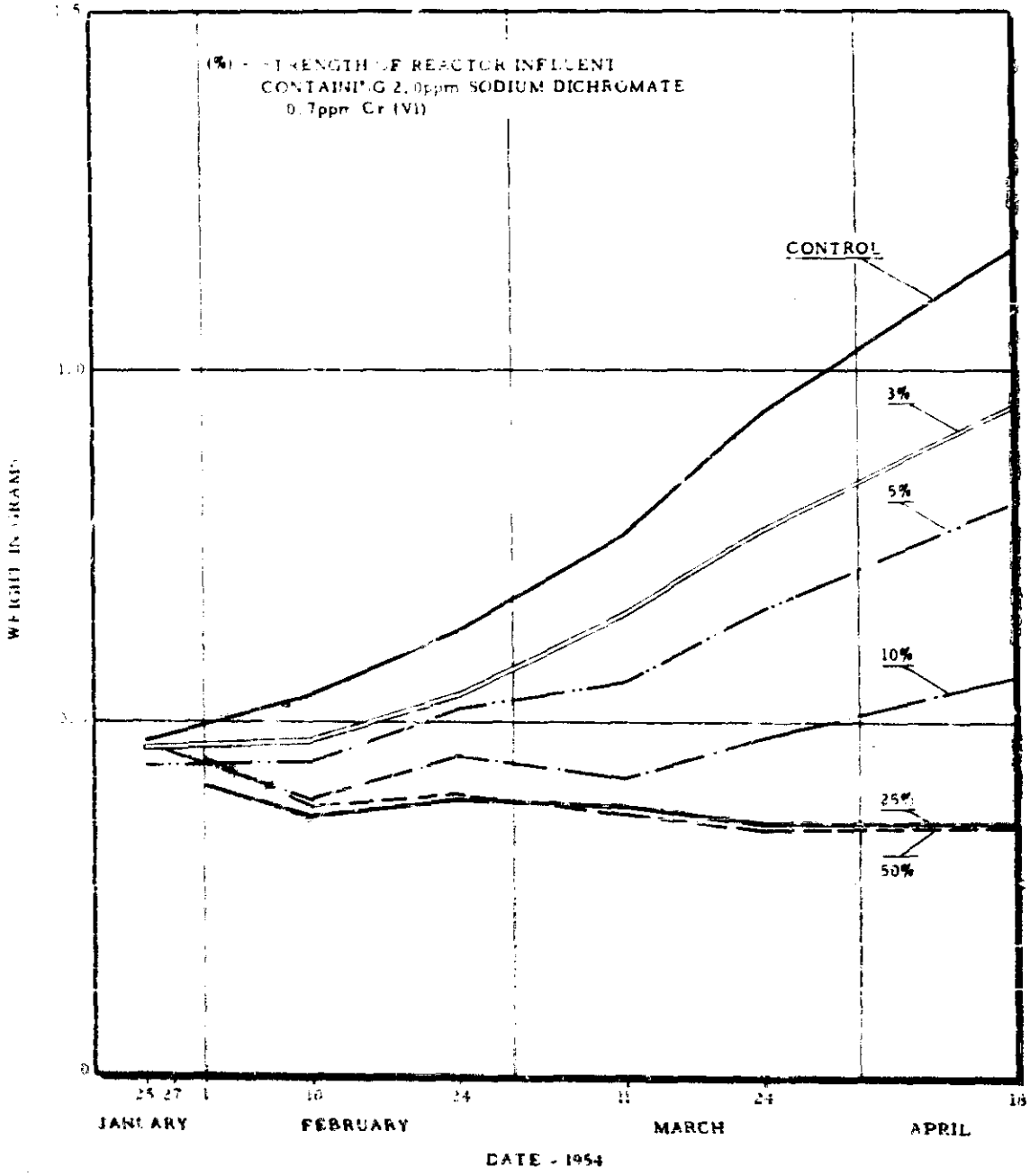

FIGURE 4

GROWTH OF YOUNG SALMON IN THE PRESENCE OF SODIUM DICHROMATE

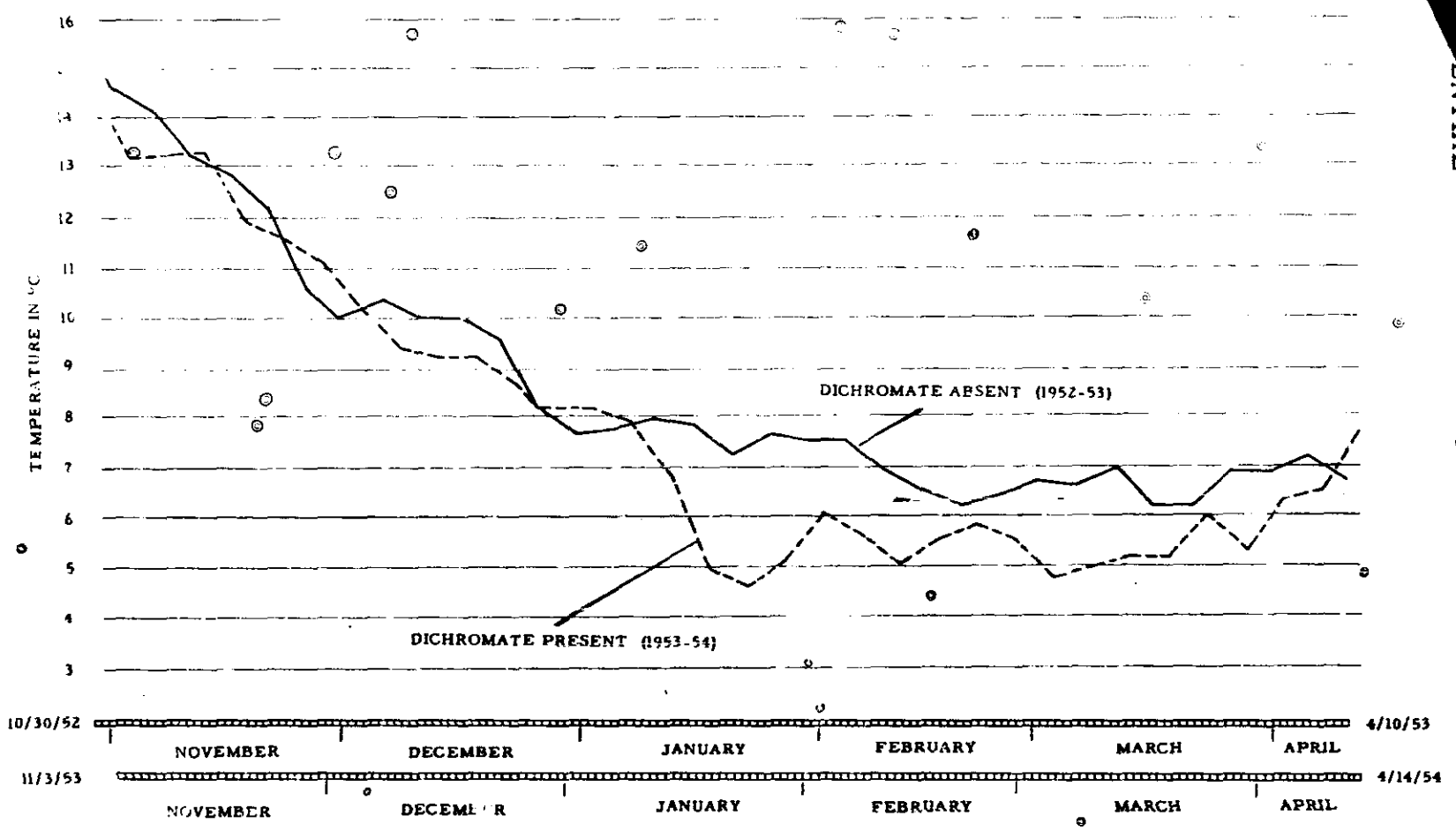

FIGURE 5

WATER TEMPERATURES DURING PERIOD OF TESTS

cent strength [0.06 ppm of sodium dichromate or 0.02 ppm Cr(VI)] significant retardation of growth occurs. During the period of minimum flow for the Columbia River, which occurs during the winter months, the concentration of reactor effluent may approach 0.8 per cent [equivalent to 0.016 ppm sodium dichromate or 0.006 ppm Cr(VI)] when uniformly dispersed throughout the river.

While these studies strongly pointed to the dichromate present in the influent as the cause of the toxicity, the evidence was somewhat circumstantial. A test which determined the toxicity of sodium dichromate per se was run in 1955,(6) which showed that survival of young salmon and trout was affected at 0.08 ppm Cr(VI) and that growth was slightly retarded at about 0.02 ppm Cr(VI).

ACKNOWLEDGMENTS

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BIBLIOGRAPHY

1. Doudoroff, P. and M. Katz, "Critical review of literature on the toxicity of industrial wastes and their components to fish. I. Alkalies, acids, and inorganic gases," Sewage and Ind. Wastes 22, No. 11 (1950).

2. Doudoroff, P. and M. Katz, "Critical review of literature on the toxicity of industrial wastes and their components to fish," Sewage and Ind. Wastes 25, No. 7 (1953).

3. Purcell, R. H., "Final report, PT-105-53-P sodium dichromate elimination tests," Document HW-24009 (1952) (SECRET).

4. de Halas, D. R., "Final report, effects of various small dichromate concentrations on front process tube corrosion," Document HW-30884 (1954) (SECRET).

5. Miller, H. R. and D. R. de Halas, "Production test 105-542-E, reduction of the amount of dichromate added to pile cooling water," Document HW-31577 (1954) (SECRET).

6. Olson, P. A. and R. F. Foster, "Effect of chronic exposure to sodium dichromate on young chinook salmon and rainbow trout," in "Biology Research - Annual Report 1955," Document HW-41500, p. 35 (1956) (UNCLASSIFIED).