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THE EFFECT OF HIGH TEMPERATURE ON THE SURVIVAL OF SACRAMENTO RIVER CHINOOK (KING) SALMON, ONCORHYNCHUS TSHAWYTSCHA, EGGS AND FRY

by

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Anadromous Fisheries Branch

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ABSTRACT

Sacramento River-strain chinook salmon eggs and fry were exposed to various temperatures ranging from 6.4-17.2°C (43.5-63.0°F). Mortalities to the fingerling stange were 80% or more when temperatures during incubation of eggs and development of fry were 15.6-16.1°C (60-61°F) for a prolonged period. Egg and fry mortalities decreased as temperatures decreased below 15.6°C (60°F) and were insignificant when temperatures were between 14.2 and 6.4°C (57.5 and 43.5°F). The results indicated that eggs and fry of Sacramento River chinook salmon are intolerant of high temperature. If river temperatures exceed 14.2°C (57.5°F), abnormally high salmon egg and fry losses can be expected to occur. At least an 80% loss of eggs and fry would probably result if river temperatures were 16.1°C (61°F) and a total loss would probably result if temperatures were above this.

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INTRODUCTION

Under predicted water demands for future years, the temperature of the Sacramento River below Keswick Dam will frequently be too warm in the fall for successful chinook salmon reproduction (Weidlein 1971). The effects of high temperature on survival of other strains of chinook salmon eggs are well documented. American River (California) strain chinook salmon eggs incubated in water above 16.7°C (62°F) experienced a 100% mortality; eggs incubated in 15.6-16.7°C (60-62°F) water had a 50% mortality to the eyed stage, and eggs incubated in 12.8-15.0°C (55-59°F) resulted in a 20% mortality to the eyed stage (Hinze 1959). When American River strain eggs were taken at water temperatures of 15.6-16.7°C (60-62°F) and incubated at 12.8-13.3°C (55-56°F) the loss was about 30% to the eyed stage.

Chinook salmon eggs from various hatcheries in Oregon incubated in water that exceeded 15.6°C (60°F) initially had nearly an 80% mortality to the fingerling stage (Johnson & Brice 1953). Coombs and Burrows (1957) determined the upper threshold temperature for normal development of Entiat River (Washington) chinook salmon eggs to be between 14.2 and 15.6°C (57.5 and 60°F).

Water released from Shasta and Keswick Lakes to the Sacramento River exceeded 14.2°C (57.5°F) in 1976 because both were drawn down in 1976 due to a severe drought. The drought had continued into 1977 and it appeared almost certain that water released from both lakes in fall 1977 would be too warm for successful salmon spawning. These experiments were conducted to determine if Sacramento River strain chinook salmon eggs undergo temperature related mortalities similar to those reported elsewhere, to establish guidelines for maintaining favorable temperatures in the Sacramento River, and to provide a basis for estimating the severity of salmon egg and fry mortalities in the river when temperatures become unfavorable.

METHODS

The experiments were conducted at Coleman National Fish Hatchery near Anderson, California, and were designed to test egg and fry mortality of Sacramento River chinook salmon in relatively warm well water (Well No. 2), relatively cool Battle Creek water, and a blend of Well No. 2 and Battle Creek water mixed equally.

Temperature records were obtained from each of the three troughs by recording thermometers.

Salmon eggs used in the tests were first taken at the hatchery on September 24, 1976 from two females. The eggs were combined and fertilized with milt from two males by the wet method, using a little of the water from each of the troughs that would be used for incubation and rearing of the respective egg lots.

The eggs were divided volumetrically into three lots averaging 2,672 eggs, placed in standard egg baskets and immersed in the troughs immediately after spawning.

On October 22, 1976 more eggs were collected from one female and dry spawned with one male. These eggs were divided by volumne into three lots averaging 956 for incubating and rearing in each of the three test troughs. On November 9, 1976 the last eggs were taken and divided volumetrically into three lots averaging 1,002 eggs. They were taken from two females combined and spawned with one male by the wet method, using water from their respective incubation troughs.

A precise count of the eggs was made at the eyed stage. Dead eggs and fry were counted and removed frequently thereafter. Egg and fry mortalities were recorded separately for each egg lot until losses subsided and the surviving fry appeared to be feeding and growing normally.

RESULTS

The September 24 spawned eggs had a total mortality of 82% in the well water, 31% in the blended water, and 13% in Battle Creek water (Figures 1-3). Post-hatching mortality accounted for 55% of the total mortality in the well water and was relatively minor in the blended water and Battle Creek water.

The October 22 dry-spawned eggs had a total mortality of 88% in the well water, 6% in the blended water, and 10% in Battle Creek water. Post-hatching mortality accounted for 50% of the total mortality in the well water.

The eggs spawned on November 9 had an 80% total mortality in the well water, 9% in the blended water, and 3% in the Battle Creek water. Post-hatching mortality in the well water accounted for 47% of the total mortality.

Temperature of the well water varied considerably and, although it reached a high of 17.2°C (63°F), it was generally lower than expected from September 24-October 28 (Figure 1). This was because Battle Creek water entered the well water system due to an error and lowered the temperature before the water reached the test trough. The Battle Creek water was shut off on October 28 and thereafter temperatures ranging from 15.6-16.1°C (60-61°F) were maintained.

Temperatures of the blended water fluctuated from 15.6-10.0°C (60-50°F) during September, 14.4-11.1°C (58-52°F) in October, and then declined, remaining near 10°C (50°F) in December (Figure 2).

Battle Creek daily temperatures reached a maximum of 15.6°C (60°F) on October 1. By mid-October Battle Creek temperatures had dropped below 12.8°C (55°F) and continued to decline in November. By December temperatures had stabilized near 7.2°C (45°F) (Figure 3).

DISCUSSION

Although the three lots of eggs held in the well water varied in their initial temperature exposures, they had similar mortality curves and nearly equal total mortalities. Mortality was attributed mainly to high temperature which prevailed during most of the test. The high mortalities in the well water were attributed to white spot disease (coagulated-yolk disease). This condition is apparently associated with high temperature (Johnson & Brice 1953; Donaldson 1955; Hinze 1956).

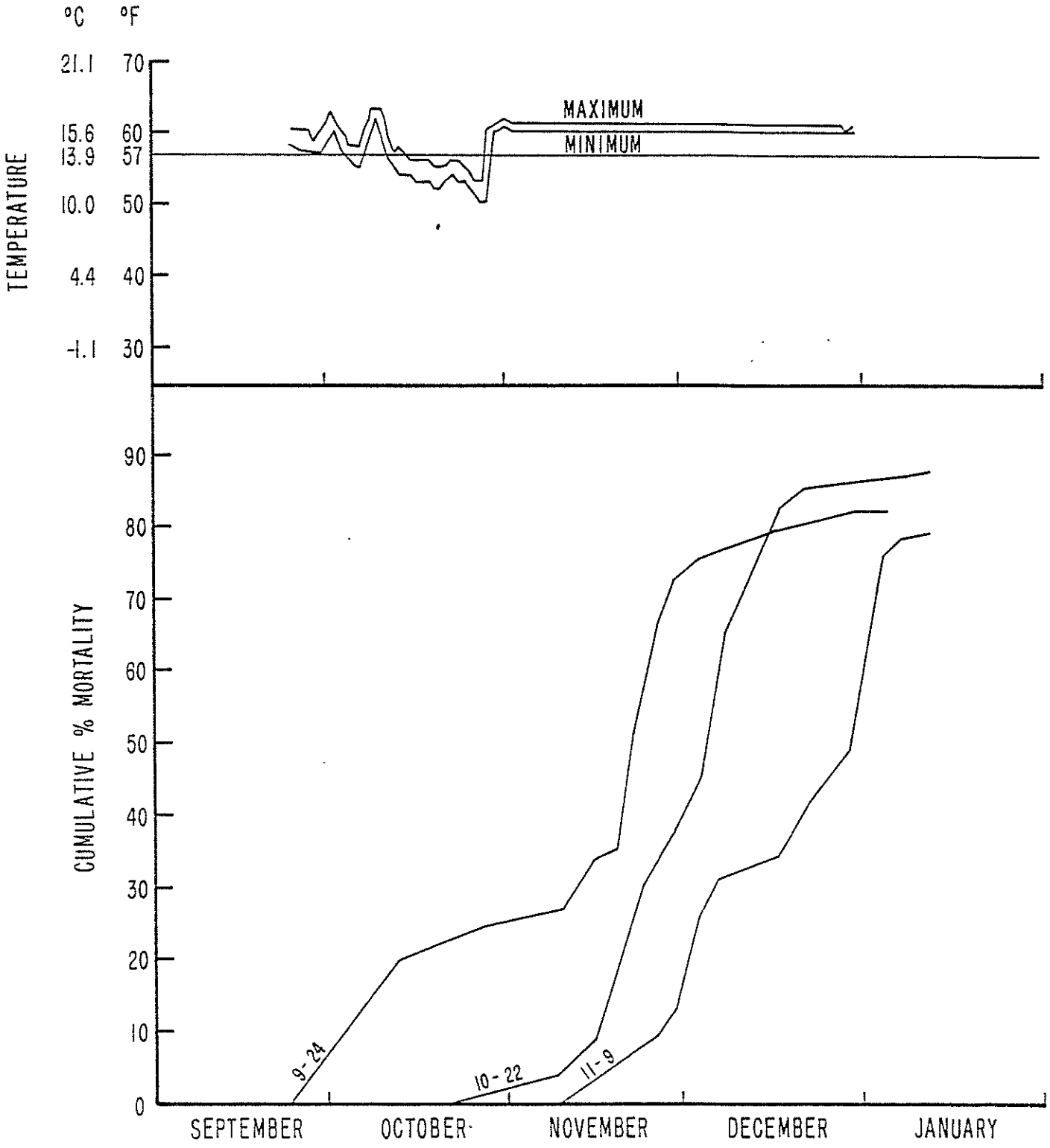

FIGURE 1. Temperature of well no. 2 water and cumulative mortality of chinook salmon eggs and fry - Coleman Hatchery 1976.

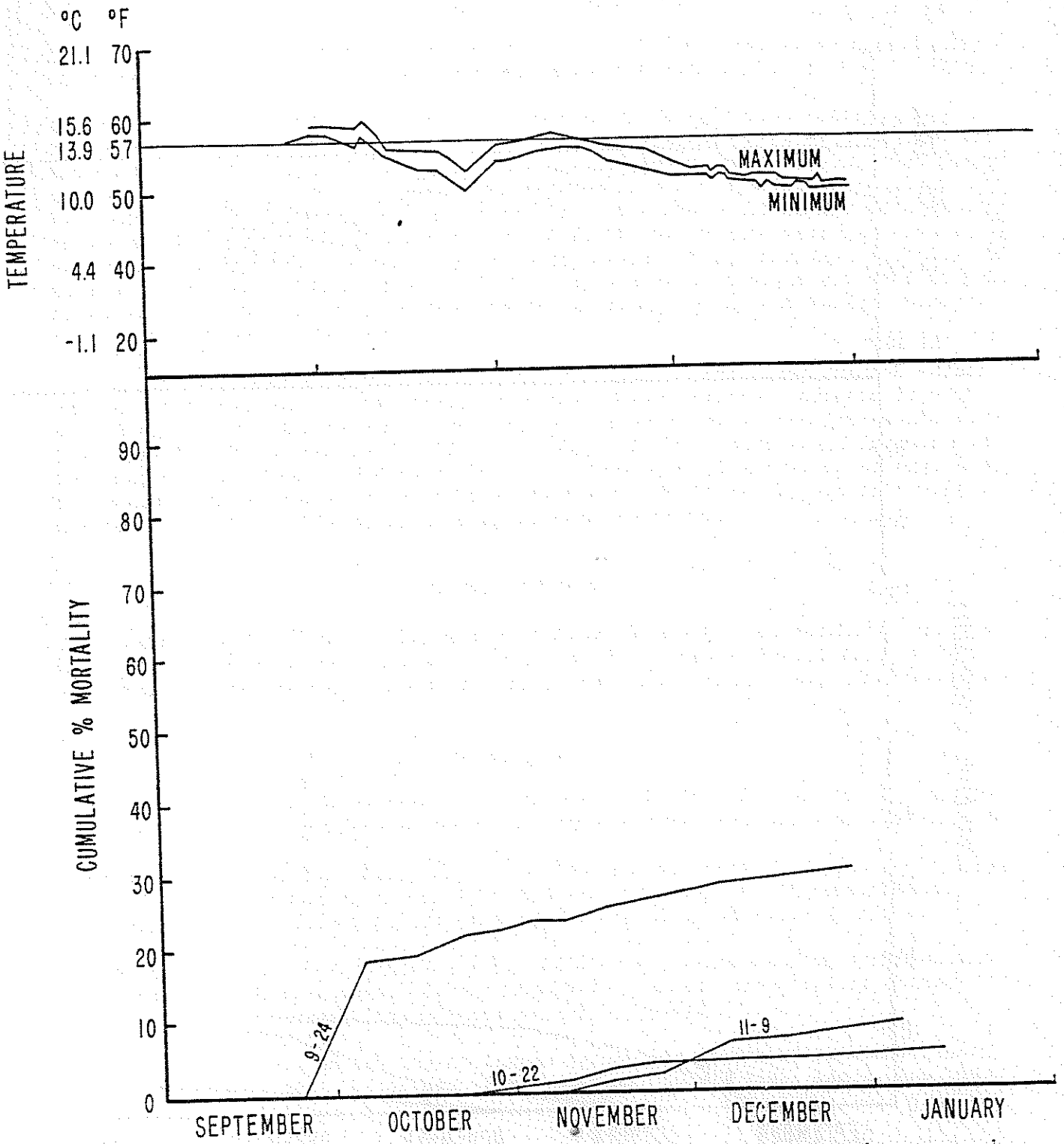

FIGURE 2. Temperature of blended well no. 2 and Battle Creek water and cumulative mortality of chinook salmon eggs and fry - Coleman Hatchery 1976.

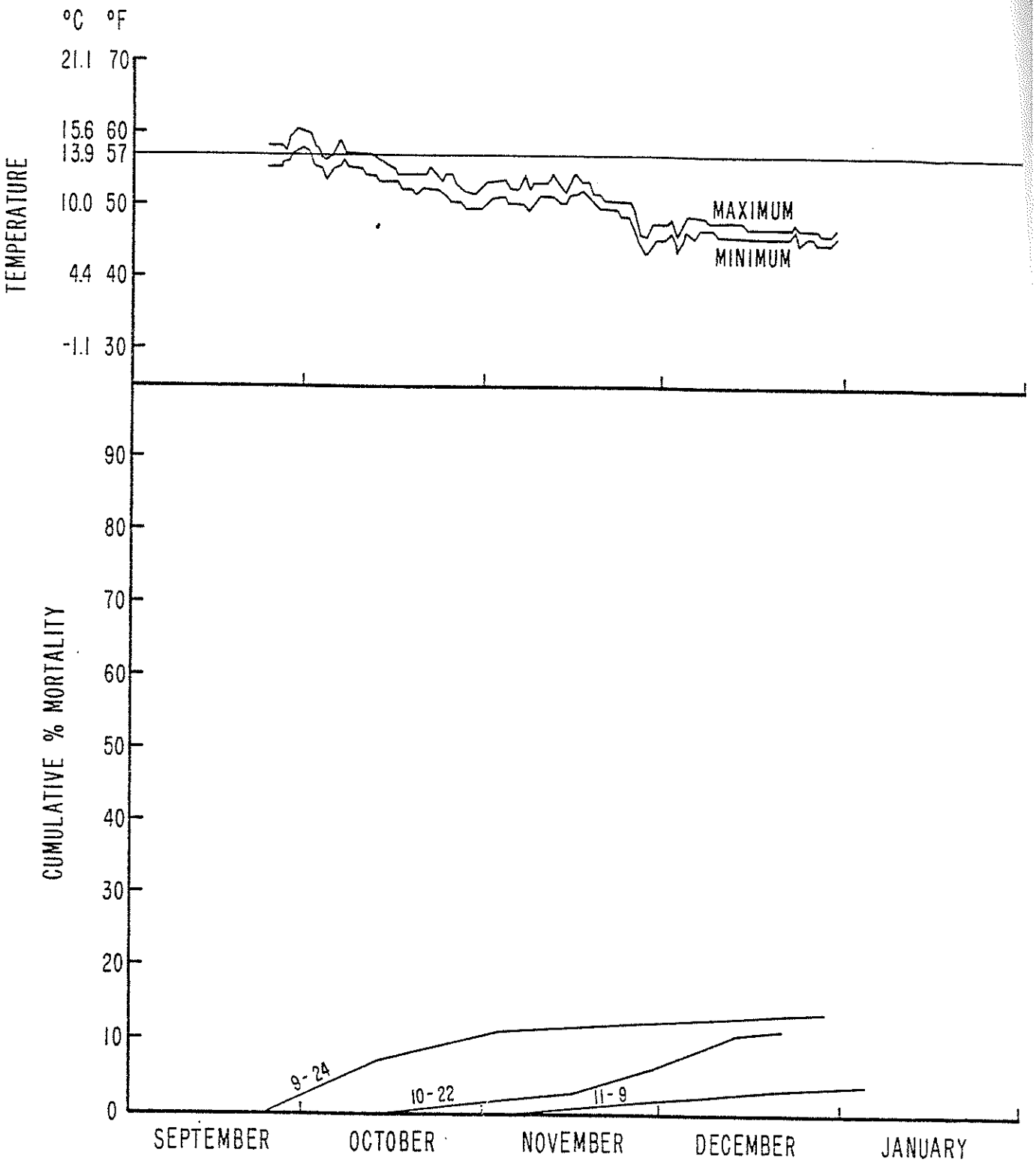

FIGURE 3. Temperature of Battle Creek water and cumulative mortality of chinook salmon eggs and fry - Coleman Hatchery 1976.

In the blended water, only the eggs fertilized on September 24 had an abnormally high mortality (31%). This was attributed to the 13.3-15.6°C (56-60°F) temperatures that prevailed during the initial incubation period.

The eggs spawned on October 22 and November 9 developed normally in the blended water because incubation temperatures were more favorable, 10.0-13.9°C (50-57°F).

Although excessive mortalities did not occur in the Battle Creek water, the September 24 and October 22 spawned eggs showed a slightly greater loss than the November 9 spawned eggs (Figure 3). This was attributed to initially high temperatures during incubation of the earlier spawned eggs and possibly high river temperatures that prevailed in September 1976 while the adult salmon were maturing in the river. River temperatures of 15.6°C (60°F) and higher were recorded in September and may have affected egg or sperm quality of the earliest arriving salmon. Fertility of the September 24 eggs in all three troughs appeared to be slightly lower than the eggs spawned later, as indicated by the losses noted at the first picking of dead eggs.

The results of these experiments indicated that Sacramento River chinook salmon were no more tolerant of high temperature than other strains. Abnormally high salmon egg and fry losses can be expected if temperatures in the Sacramento River below Keswick Dam exceed 14.2°C (57.5°F). Egg and fry losses would increase as temperatures increased above this level. At least an 80% mortality of eggs and fry would occur if temperatures in the river were 16.1°C (61°F) and total egg mortality would probably occur in temperatures above this.

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