EVALUATION OF ADULT KING SALMON ENUMERATION ON THE FEATHER RIVER

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Abstract. From 1969 to 1971, king salmon population estimates obtained by carcass survey techniques on the Feather River were compared with estimates made by mark and recovery and electronic fish-counter methods. In a low-flow river area, the carcass survey estimates were from six to nine percent lower than the electronic fish count estimates. Also, in the low-flow reach of the river, the carcass survey was from three to 15 percent higher than the mark and recovery estimates. In high-flow river areas, the carcass recovery estimates were from one to six percent lower than mark and recovery values. Under field conditions in the Feather River, the carcass survey method produces valid salmon population estimates.

INTRODUCTION

For 15 years prior to completion of the Oroville Dam Project, the number of king salmon (Oncorhynchus tshawytscha) that spawned in the Feather River was estimated by carcass recovery. During a seven-year study of the effects of the dam on the fishes in the Feather River, the number of spawning salmon will be estimated in essentially the same manner. At the end of the study, these population estimates will then serve as a primary index of satisfactory maintenance of the salmon run.

We examined the early salmon population estimates to find possible effects of flow on salmon. We found that on those years when there were high population estimates we had low flows (Figure 1). Conversely, we found smaller fish population estimates whenever there were high flows during the spawning period. Since flow during a spawning season can not affect the number of adult salmon that spawn that year (except drought of extraordinary proportions), our conclusion was that under some conditions a carcass recovery estimate might be suspect.

Because of the importance of this index, we developed several ways to test the validity of the carcass recovery technique:

a. We conducted population estimates using standard carcass recovery techniques every year of the study.

b. In 1968, we tried to estimate the population from a mark and recapture study. We marked live salmon, released them, and recovered these marks during the carcass recovery survey.

c. We installed an electronic fish counter in the low flow reach of the river to obtain an accurate fish count to compare with carcass recovery estimates.

d. In 1969, 1970 and 1971 we calculated the salmon population from mark and recapture data from release of marked carcasses.

POPULATION ENUMERATION BY CARCASS RECOVERY

Methods

The carcass recovery method or technique (creamer count) was used every fall to estimate salmon abundance from approximately the second week in October to early December. Each survey consisted of eight or more trips down the river. Each trip included that reach of the river from the Fish Barrier Dam near Oroville to Honcut Creek, some 21 miles (Figure 2). On these trips the salmon carcasses were enumerated (cut-in-two), sexed, examined for marks, and an estimate made of degree of successful spawning. In addition, water clarity, flow, and weather conditions were recorded so that a correction might be made for the numbers of salmon missed during the trip.

The river was divided into three sections or statistical areas. Normally each section would take one or two days to complete a trip. The uppermost section, or low-flow reach of the river, extends seven miles from the Fish Barrier Dam at Oroville to the Thermalito Afterbay River Outlet. The middle section extends from the Afterbay Outlet to the highway bridge crossing the river near Gridley. Finally, the lower section covers a distance of six miles from the Gridley Bridge to the mouth of Honcut Creek.

A season population estimate consists of solving a ratio equation where known and unknown parameters from the year in question are compared with known statistics from the previous year. Thus:

$$\frac{\text{Unknown population (P1)}}{\text{Previous year population (P2)}} = \frac{\text{No. present year carcasses (C1)}}{\text{No. previous year carcasses (C2)}}$$

Correction factors are applied to the simple equation above for:

a. Differences in number of trips (T_n).

b. Changes in recovery conditions, e.g. water clarity, flow, etc. (R_n). The final equation is:

$$\frac{P1}{P2} = \frac{C1}{C_2 \frac{(T1)(R1)}{(T2)(R2)}}$$

$$P_1 = \frac{P_2 C_1}{C_2 \frac{(T1)(R1)}{(T2)(R2)}}$$

Results

Population estimates from carcass recovery surveys ranged from 18,144 fish in 1968 to 61,525 fish in 1970. To obtain these estimates we cut between

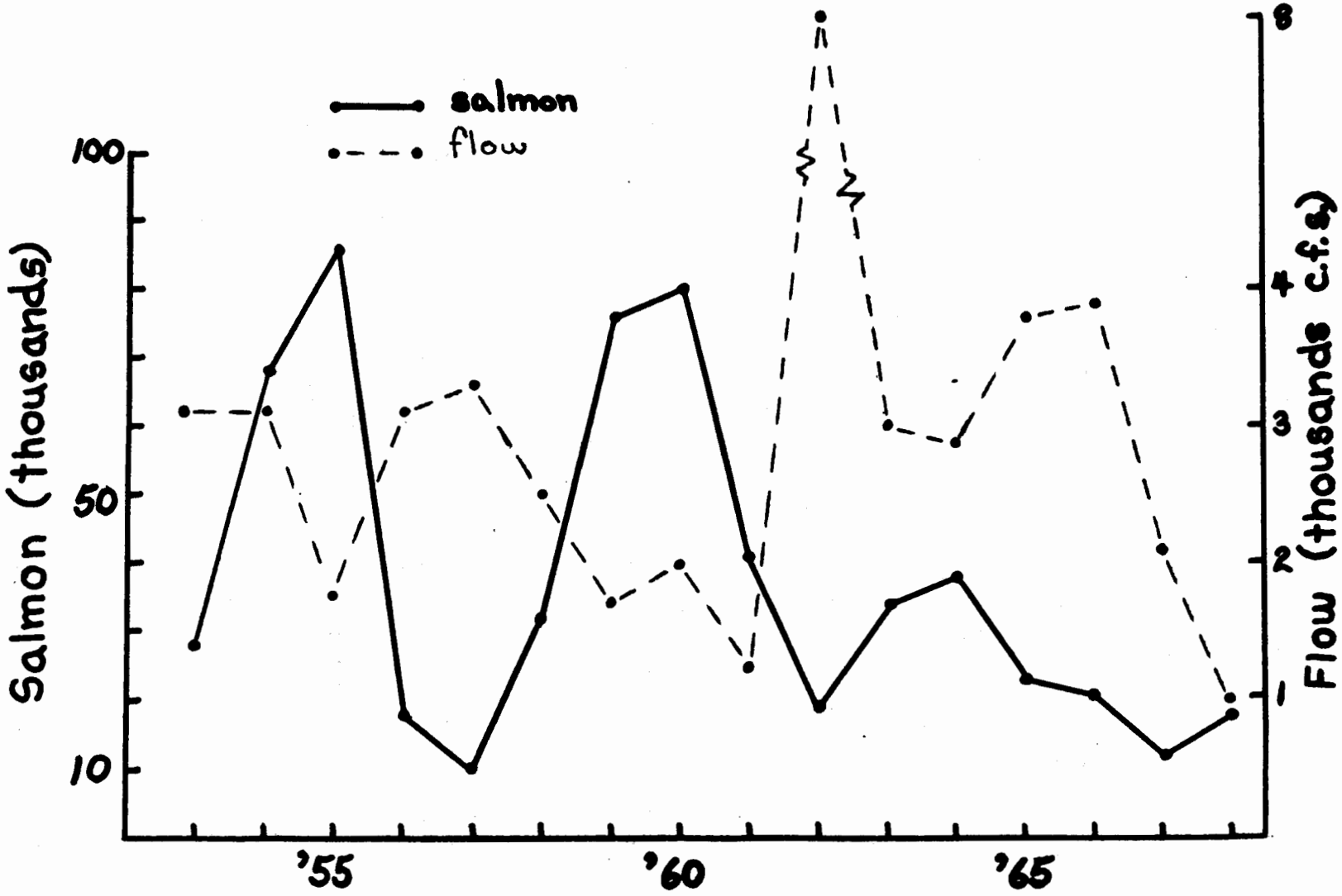

Figure 1: Population levels of king salmon and mean monthly river flows for October - November in the Feather River, 1953-1968.

3,000 and 16,000 carcasses, usually between 20 and 35 percent of the total run for that year.

POPULATION ESTIMATES USING MARK AND RECOVERY TECHNIQUES WITH MARKED LIVE SALMON

In 1968 we constructed a trap in the Feather River approximately one mile above the mouth of Honcut Creek. About 90 percent of the river was blocked off with wire-mesh fencing and stop nets. The weir led to a "pot" that held salmon until they were sexed, measured, and the dorsal fin clipped. The salmon were then released with the hope that these marked fish would be recovered during subsequent carcass recovery surveys.

We marked and released 409 salmon. The carcass survey team examined almost 3500 carcass and reported only 14 of our marked fish among them. This is a remarkably small return, especially when it is compared with the four marked returns out of 179 carcasses removed from the weir.

Using a standard ratio computation, a population estimate of 100,000 fish is obtained with the carcass recovery team data, and an estimate of 17,500 fish from the weir-caught carcass data. The former estimate obviously was erroneous.

For whatever reason, the carcass survey crew did not find our marked salmon. We abandoned the technique of tagging or marking live fish in future population studies on the Feather River.

KING SALMON POPULATION ESTIMATES WITH ELECTRONIC FISH COUNTER

Methods

For three spawning seasons, 1969-70-71, we installed an electronic fish counting system across the upper-river area. A weir, made up of 4-foot-high by 10-foot-long wood framed wire fence sections, was constructed across the river. These sections were assembled into a V-shape with an apex of the V pointing upstream.

The counter was of Irish manufacture, Cybertronic Model 404-Ic, Marine Electric, Killeybegs, Donegal, Ireland. It was a single tunnel system adjusted to count fish longer than 26 inches. Length discrimination was checked several times and the device was accurate to within one-eighth inch. The tunnel was of plywood, square in cross-section, and four feet long (18 x 18 x 48 inches). This tunnel was set into the apex of the V-shaped fence. Counting error, checked with visual counts, was very small. The machine was more reliable than the human eye. Except for the first year of operation, machine error was limited to the occasions when two or more fish swam through the tunnel simultaneously.

Results

1969

The weir was installed during the third week in August, and the counter on August 20. Troubles of several kinds were encountered and a population estimate was not possible.

1970-1971

The counter was very reliable during these two seasons. We estimated an adult salmon population of 15,218 in 1970, and 15,951 in 1971. Our error estimates for these two years were higher than desired. We could eliminate

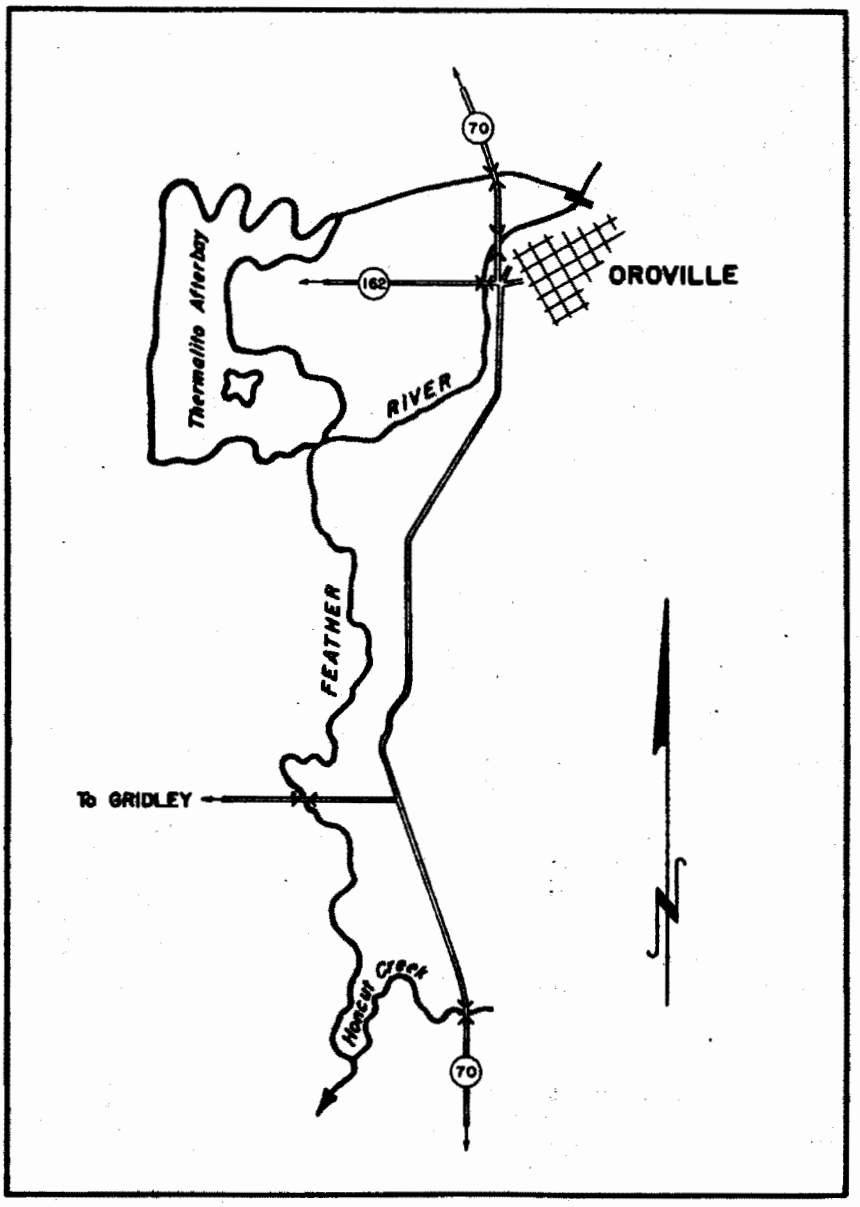

Figure 2: Map of salmon spawning area on the Feather River.

almost all error due to equipment failure, if very heavy fence material were used in the weir panels.

POPULATION ESTIMATES USING MARK AND RECOVERY TECHNIQUES WITH MARKED CARCASSES

We made population estimates from marked and unmarked carcass recoveries in all three sections of the river in 1969 and 1970. In addition we conducted a mark and recovery program in the low-flow reach of the river in 1971. These studies were conducted concurrent with the regular carcass recovery effort. Each of these years we marked carcasses that were considered in good condition; that is, the carcasses were fresh, dead fish. Every effort was made to release tagged fish in moving water so that they could drift downstream. The tags were hog rings attached around the lower jaw. A bright streamer (surveyors' tape), approximately four-inches long, was tied to the hog ring. Each week a different color streamer material was used; thus, in succeeding weeks we could determine how many weeks the marks had been out.

In 1971, in the upper reach of the river, we also recorded on the streamer the riffle where the carcass was released. Upon recovery, then, we could determine how far the carcass had drifted downstream.

RESULTS

Population Estimates

The population estimates were made using the standard formula $N = \frac{nt}{s}$, where:

N = the population estimate for the year in question.
n = the number of carcasses found during the recovery period.
t = the number of tagged carcasses released.
s = the number of tagged fish recovered.

The population estimates for low-flow reach of the river were 19,850 fish in 1969, 17,925 fish in 1970, and 21,069 fish in 1971.

Estimates of numbers of king salmon in the two high-flow reaches of the river, combined together here for later comparison with the carcass recovery estimates, were 40,226 fish in 1969 and 42,313 fish in 1970.

DISCUSSION

I decided not to select one standard or control but instead to compare creamer estimates to each alternative method. Because of suspect data, however, I will exclude comparison of the tagged live-fish study.

Although the electronic fish counter operated for three seasons in the low-flow area, fish population comparisons were possible for only two seasons. During these two seasons, the creamer survey estimates were smaller than fish-counter estimates (Table 1). Creamer survey results were an underestimate of 5.9 to 9.0 percent.

In contrast, in the low-flow river area, the creamer fish population estimates are from 3.2 to 15.2 percent higher than mark and recovery estimates (Table 2). Conversely, in the high-flow area, carcass recovery gave lower estimates than did marked carcass recovery estimates. This underestimate was from 1.5 to 6.4 percent (Table 2).

Table 1. Comparison of king salmon population estimates by carcass recovery and electronic fish counter methods.

Year	River section	Carcass recovery estimate	Electronic counter estimate	Difference	Percent difference
1970	Low flow	19,855	21,110	(-)1,255	(-)5.9
1971	Low flow	21,741	23,879	(-)2,138	(-)9.0

Table 2. Comparison of king salmon population estimates by carcass recovery and mark and recovery methods.

Year	River section	Carcass recovery estimate	Mark and recover estimate	Difference	Percent difference
1969	Low flow	22,878	19,850	(+)3,028	(+)15.2
1970	Low flow	19,855	17,925	(+)1,930	(+)10.8
1971	Low flow	21,741	21,069	(+) 672	(+) 3.2
1969	High flow	37,700	40,226	(-)2,566	(-) 6.4
1970	High flow	41,670	42,313	(-) 643	(-) 1.5

It is reasonable to assume that the carcass recovery estimate will result in a maximum error of 15 percent in a low-flow area (400 cfs) and six percent in a high-flow area (approx. 3000 cfs). Under excellent carcass collection conditions in the Feather River, these errors are undoubtedly well within the inherent experimental error of either control method. However, under more difficult recovery conditions (changes in trips or river conditions, flow, etc.), creamer count population estimates might result in errors of greater magnitude.

I conclude that, under the conditions tested here in the Feather River, the carcass survey (creamer count) method gives valid population estimates.