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ABSTRACT

In June 1968, juvenile chinook salmon from Little White Salmon National Fish Hatchery, Washington, were marked by freeze branding and released at six different locations in the Columbia River downstream from the hatchery. Marked fish were sampled in the estuary to compare survival of the different groups. Survival was more than doubled by transporting the fish to a point below Bonneville Dam (40 km downstream from Little White Salmon Hatchery) but was not appreciably increased by transporting them farther downstream.

INTRODUCTION

Survival of fall chinook salmon (*Oncorhynchus tshawytscha*) released from hatcheries in the lower Columbia River is low in comparison to that of some stocks of salmon. For example, a recent study by Cleaver (1967) to evaluate salmon hatcheries on the Columbia River indicated that returns to the hatchery of fall chinook salmon of the 1961 brood ranged from 0.001 to 0.16% of the number released—a considerably lower percentage than survival of spring chinook and coho salmon (*Oncorhynchus kisutch*), of which hatchery returns as high as 6% (unpublished hatchery records) are not uncommon. Differences in size and physiological condition of the juvenile fish at time of release probably account for much of the difference in returns to the hatcheries. Spring chinook and coho salmon are reared longer than fall chinook salmon, and are usually 10 to 20 mm longer at time of release which results in a higher average survival when these fish return to the hatchery even though changes in commercial and sport fishing effort occur from year to year.

Many fishery scientists believe that hatchery smolts suffer major mortalities either immediately after release into the river or during migration from the hatchery to the estuary. For example, Ellis and Noble (1960), reported losses of fall chinook salmon of 12.2 to 29.7% between the Klickitat Hatchery and the mouth of the Klickitat River, a distance of only 64 km.

Survival of juvenile hatchery-reared fall chinook salmon between the hatchery and estuary possibly could be increased by transporting them around areas where mortality is presumed high. To examine this possibility, 600,000 juvenile fall chinook from Little White Salmon National Fish Hatchery (on the lower Columbia River) were released in 1968 at five different locations downstream from the hatchery; 3,431 of these marked fish were captured in the estuary of the Columbia River near Astoria, Oregon. Differences in survival of fish from the various release sites were determined from these marked returns and the results provide a basis for considering additional experiments that would provide sufficient information for the development of a transportation system for hatcheries in the lower Columbia River.

METHODS

Juvenile fall chinook salmon from Little White Salmon National Fish Hatchery were divided into six groups—four of about 100,000 fish each and two of about 200,000, marked and released at six points in the Columbia River (Figure 1). About 100,000 were released at the hatchery for passage through Drano Lake which is located at the outlet of the hatchery; about 100,000 were released about 2 km downstream from Bonneville Dam; at Sauvies Island, Oregon, and at Rainier, Oregon; 200,000 salmon were released at Beaver Terminal near the estuary. A sixth (control) group of about 200,000 marked fish was interspersed with the main complement of hatchery fish and released at Cook's Point, the Hatchery's usual release site. Knowledge of the migration rate (20–26 km/day) of fall chinook salmon in the lower river (pers. comm., Howard L. Raymond) permitted us to time releases so that all groups

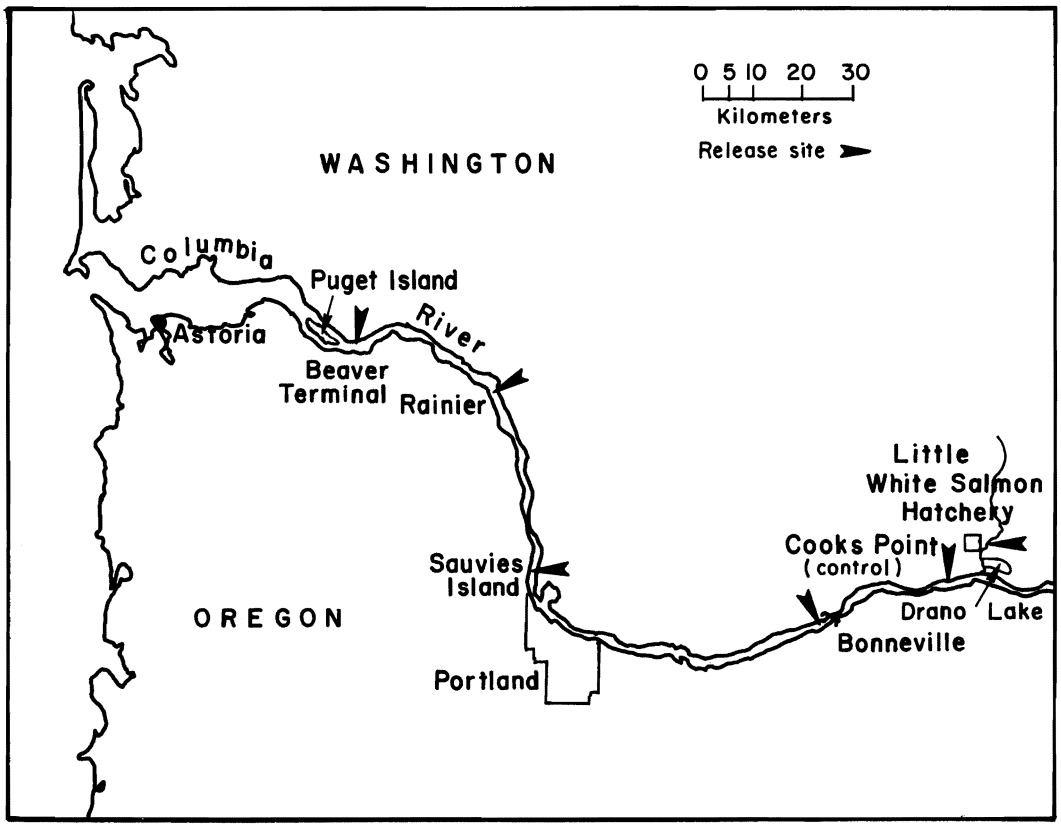

FIGURE 1.—Lower Columbia River, showing release sites and Puget Island, the recovery area.

would arrive at the recovery area (Puget Island) at about the same time. The number of fish, and locations and dates of release, are shown in Table 1.

Each group of fish was marked differently by freeze branding with liquid nitrogen (Mighell, 1969) (Table 1). All fish were branded 3 weeks before release. Before release, the proportion of fish in each group with unidentifiable marks was determined by examining 200 fish from each group; this information was used to adjust the data for marked quality (Table 3). The fork length of 100 fish from each group was also measured.

The test groups released downstream from Bonneville Dam were transported in an insulated tank truck (capacity 18,900 liters, or 5,000 gal), equipped with a filter, refrigeration unit, and two systems of aeration (Figure

TABLE 1.—*Numbers of marked juvenile chinook salmon from Little White Salmon National Fish Hatchery released along the Columbia River in 1968 and type of mark ("T"-shaped brand) used at various release sites*

Release site	Date of release (June)	Number of fish	Type of mark: General location of brand on fish	Type of mark: Orientation "T"-brand on fish
Drano Lake from hatchery	22	107,486	Left dorsal	Upside down (⊥)
Cook's Point (control)[1]	22	217,064	Left dorsal	Erect (T)
2 km downstream from Bonneville Dam	24	101,620	—	—
Sauvies Island, Oregon	25	101,852	Right dorsal	Rotated right (⊣)
Rainier, Oregon	26	99,563	Right dorsal	Upside down (⊥)
Beaver Terminal, Oregon	27	192,622	Right dorsal	Erect (T)

[1] Marked fish released here were the control group.

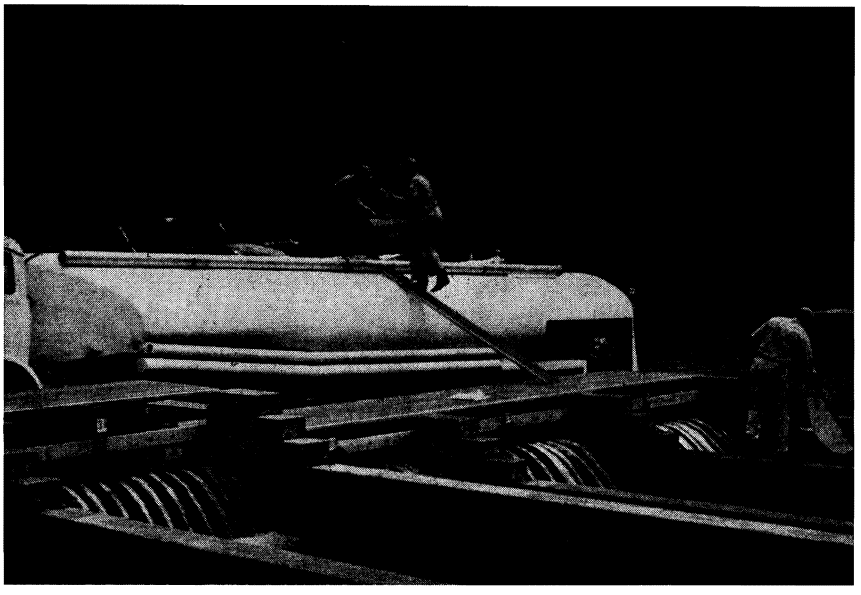

FIGURE 2.—Loading juvenile chinook salmon into an 18,900 liter (5,000-gallon) tank truck at Little White Salmon National Fish Hatchery.

2). Compartments in the tank enabled us to haul each group at the same load density even though the groups varied from 100,000 to 200,000 fish.

Two 100 meter, 19 mm stretch mesh seines were fished on the north and south shores of the Columbia River near Puget Island (Figure 1). The nets were set and pulled every ½ hour for 16 hours a day throughout the study period. Differences in survival of fish from the various release sites were based on the proportions of marked fish from each site caught in the beach seines near Puget Island. With this type of analysis, we must assume: (1) that each group has the same distribution near Puget Island, and (2) that all groups are equally vulnerable to beach seines. In regard to the first assumption, earlier studies of the distribution of migrating juvenile fall chinook salmon indicated that most fish passed through the sampling area and that distribution did not vary between "control" and "test" groups

TABLE 2.—*Numbers of marked juvenile chinook salmon from Little White Salmon National Fish Hatchery recovered in 1968 near Puget Island, by date of recovery and release site*

	Release site					
Date of recovery	Drano Lake	Cook's Point (Control)	Bonneville	Sauvies Island	Rainier	Beaver Terminal
25 June	–	9	–	–	–	–
26 June	2	34	–	–	–	–
27 June	13	33	21	21	9	–
28 June	14	31	57	44	86	634
29 June	22	38	56	59	65	179
30 June	37	39	48	81	65	108
1 July	27	32	68	58	71	73
2 July	34	32	60	43	43	42
3 July	26	38	39	47	33	36
4 July	23	30	45	50	28	30
5 July	18	14	32	42	25	16
6 July	26	27	59	17	23	13
7 July	19	15	38	17	14	8
8 July	12	6	22	14	12	7
9 July	5	4	7	9	5	8
10 July	3	3	10	9	8	3
11–15 July	8	9	6	13	10	2
Total	289	394	568	524	497	1,159

TABLE 3.—*Percentages of marked fish (adjusted and not adjusted for mark quality) recovered near Puget Island and estimates of group survival by release site*

Release site	Adjusted		Not adjusted	
	Recovery (percentage)	Estimated survival[1] (percentage)	Recovery (percentage)	Estimated survival[1] (percentage)
Drano Lake	0.29	47.5	0.27	44.7
Cook's Point (control)	0.19	30.6	0.18	30.0
Below Bonneville Dam	0.59	97.8	0.56	92.8
Sauvies Island	0.58	95.1	0.51	85.4
Rainier, Oregon	0.53	86.3	0.50	82.9
Beaver Terminal	0.61	100.0	0.60	100.0

[1] For comparison with the other group, survival of fish released at Beaver Terminal was assumed to be 100%.

(pers. comm., Carl W. Sims). The second assumption also seems reasonable. The similarity of dates of arrival and departure of groups from the sampling area (Table 2) would seem to indicate equality of fishing effort. As the groups were reared in the same hatchery and were of similar length, no reason exists to expect differences among groups in vulnerability to beach seines.

Chi-square and Z tests based on data shown in Tables 1 and 2 were used to determine whether the Drano Lake and Bonneville releases yielded significantly greater returns than the "control release" at Cook's Point and whether the Sauvies Island and Beaver Terminal releases gave significantly greater returns than the Bonneville release.

SURVIVAL OF EXPERIMENTAL GROUPS TO PUGET ISLAND

Recoveries of chinook salmon migrants at Puget Island showed that survival was more than doubled by transporting the fish below Bonneville Dam but was not appreciably increased by transporting them farther downstream (Table 3). Fish that passed through Drano Lake survived better than those transported and released in the river a short distance downstream from the lake. Chi-square and Z values (Table 4) substantiate these conclusions.

Adjustments for mark quality to the number of fish released in each group (Table 1) did not change survival figures greatly except in the Sauvies Island release; adjustment increased the survival figure for this group by nearly 10%.

Mean lengths of fish in the test groups ranged from 67.8 to 74.4 mm. Mean length of the control group was 70.5 mm. These differences in size were not considered to affect significantly the survival of the various groups in this experiment. Mean lengths of the groups of fish at the time of capture in the estuary were 3.6 to 10.2 mm greater than at the time of release, which gives some indication that larger fish may have survived better. Differences in growth rates of groups and in time between release and recapture, however, could account for much of the variability in mean size at time of recapture. A comparison of length-frequency polygons constructed from measurements at time of release and recapture did not indicate that the distribution was skewed towards larger fish.

I conclude that downstream survival of juvenile salmon from Little White Salmon Hatchery can be substantially increased by transporting fish downstream from Bonneville Dam and that survival of juveniles released directly into Drano Lake is better than survival of fish transported to Cook's Point for release. The homing success of the stock must be considered, however. Juvenile chinook salmon transported downstream from the hatchery may be less likely to return to the hatchery to spawn than those released at the hatchery. One solution to the problem (if a problem

TABLE 4.—*Chi-square and Z values for hypotheses tested*

Hypotheses	Chi-square[1]	Z[2]
Returns from Drano Lake release are significantly greater than returns from Cook's Point (control) release	26.3	5.13
Returns from Bonneville release are significantly greater than returns from control release	326.98	18.08
Returns from Rainier, Oregon, release are greater than returns from Bonneville release	3.40	1.84
Returns from Beaver Terminal release are greater than returns from Bonneville release	2.02	1.42

[1] χ^2 at 95 per cent level (df, 1), 3.84.
[2] Z at 95 per cent level, 1.96.

exists) might be to establish a collection site downstream from Bonneville Dam where returning adults tagged at the hatchery before release could be captured for spawn taking.

The eventual success of any transportation system will be influenced by the commercial and sport fishery catch (as well as other causes of ocean mortality) and the number of adults returning to the hatchery. Experiments are underway to determine whether certain tributaries in the lower Columbia River can be used as homing stations for returning adults that were transported and released there as juveniles. Other experiments are being planned to determine whether a desirable ratio between fish transported downstream and released and fish released at the hatchery can be established that will increase commercial catch while still maintaining sufficient returns to the hatchery for spawn.

ACKNOWLEDGMENT

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