HORIZONTAL AND VERTICAL DISTRIBUTION OF YEARLING SALMONIDS IN THE UPPER END OF MAYFIELD RESERVOIR

by

John R. Pugh

and

Jim R. Smith

September 1964

FISH-PASSAGE RESEARCH PROGRAM
U.S. Bureau of Commercial Fisheries
Seattle, Washington

INTRODUCTION

Research has indicated that when a typically fast flowing river or stream is changed (by the construction of dams) to a reservoir-type environment, the migration rate of juvenile salmonids is sometimes appreciably delayed. There is also evidence that many young fish fail to pass through these reservoirs.

Until recently, most of the effort to pass young fish safely at high dams has been based on collection bypass systems located at the lower end of reservoirs. Under these conditions, even the most efficient collection system would not serve its purpose if the bulk of the young migrants fail to reach the lower end of the reservoir. Faced with this possibility, fisheries agencies are now considering the feasibility of collecting downstream migrants before they pass beyond the upper end of a reservoir.

In order to determine the type of collection equipment best suited for this purpose, an investigation is currently underway at the upper end of Mayfield Reservoir on the Cowlitz River in southwestern Washington. The purpose of this study is to determine, a seasonal basis, the horizontal and vertical distribution of migrating juvenile salmonids.

MATERIALS AND METHODS

Experimental facilities

The experimental site (fig. 1) was located approximately 6 miles above Mayfield Dam, directly in front of the Washington State Gam Department's Mossyrock Fish Hatchery, where the reservoir is approximately 800 feet wide with depths to 102 feet.

The sampling nets were constructed of monofilament nylon. Each net was comprised of three panels each measuring 12 by 20 feet. The webbing sizes of the three panels by stretched measurement were 7/8-inch, 1-1/8 inches, and 1-3/8 inches. The twine sizes of these panels were 0.15 mm., 0.15 mm., and 0.20 mm. respectively. The panels were sewn together in ascending order by mesh size, forming nets that were 12 feet deep and 60 feet long. Each net was equipped with a lead line to make it hang properly with just enough flotation to make the buoyancy slightly positive.

A 1-inch-diameter polyropylene hawser was stretched across the reservoir perpendicular to the water flow. This hawser served as a visual reference to insure that the sampling nets were always fished in the same reservoir cross section.

An opening was provided in the middle of the hawser to facilitate the passage of boats. The hawser was marked off in 60-foot intervals, the length of each of the sampling nets, and a styrofoam float was attached to the hawser at each mark (fig. 2). A concrete anchor, weighing approximately 100 pounds, was positioned on the bottom of the reservoir directly beneath each

Figure 1.--Experimental site of Mayfield Reservoir (Cowlitz River) distribution study. Buoys are spaced at 60-foot intervals completely across the reservoir. The space between the buoys comprised the 12 horizontal fishing positions.

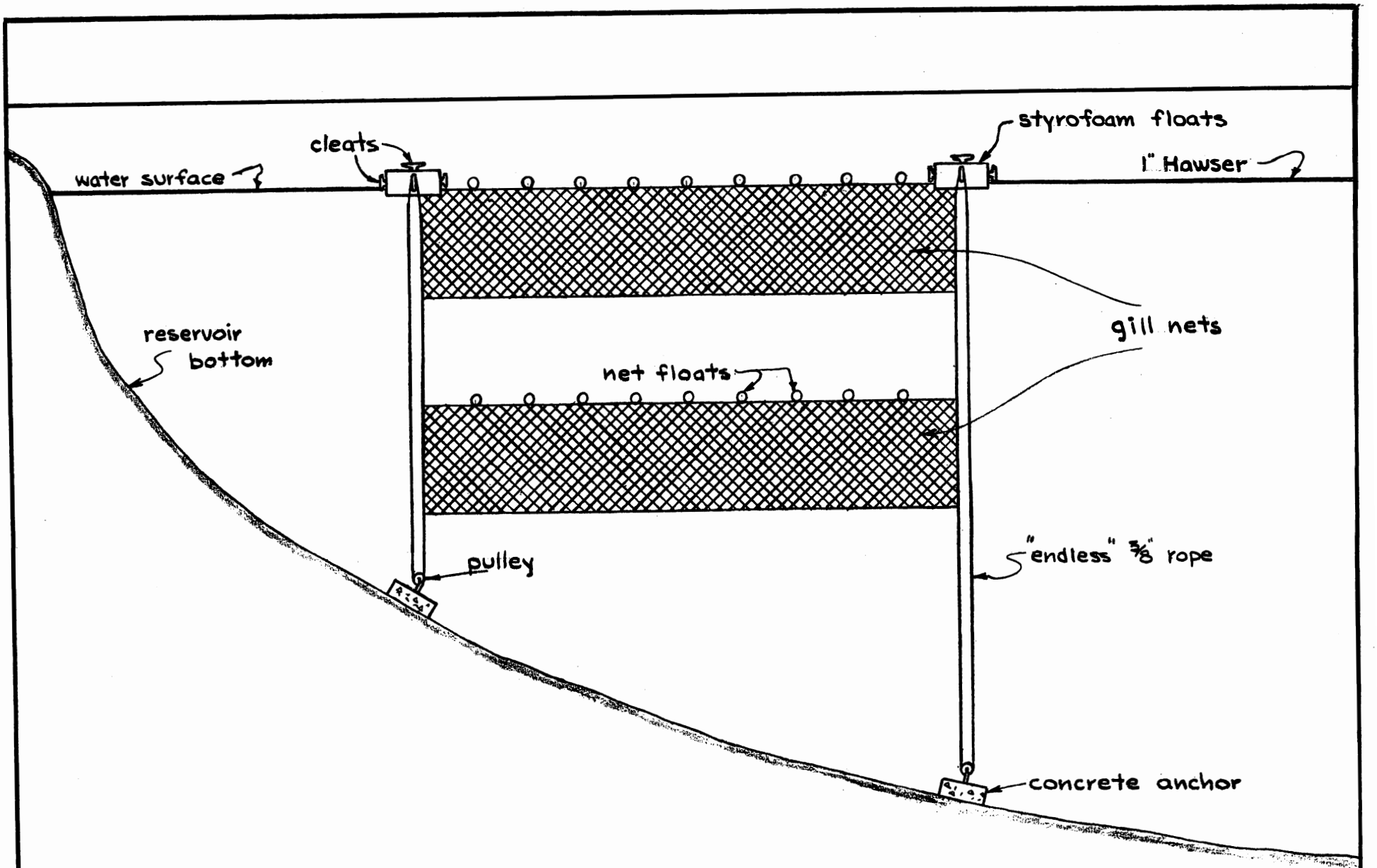

Figure 2.--Diagrammatic sketch of net suspension system used in the Mayfield Reservoir distribution study.

float and each anchor was fitted with a 3/8-inch pulley. At each styrofoam float, a 3/8-inch diameter nylon rope was run from the surface down through the anchor pulley and back to the surface, forming an endless loop. The surface portion of each loop was secured to one of the styrofoam floats. One-half of each loop was marked by knots tied at 12-foot intervals--the depth of the sampling nets. These endless ropes and the positioning of the concrete anchors made it possible to fish the sampling nets at any desired position in the reservoir cross section.

The space between the styrofoam floats constituted the fishing positions. These positions were numbered from 1 through 12 from the right bank (north shore) to the left bank (south shore). Vertically, the fishing positions were assigned letter designations. The number of vertical fishing positions depended upon the depth.

Test fish

The test fish were wild downstream migrants of the Cowlitz River system. Approximately 7,000 juvenile salmonids were captured. The catch was comprised of 73.5 percent silver salmon (*Oncorhynchus kisutch*), 16.8 percent chinook salmon (*O. tshawytscha*), and 9.7 percent steelhead (*Salmo gairdenerii*). The silver and chinook salmon were members of age group 1 and averaged 136.24 and 132.54 mm. in length respectively. The steelhead were members of age groups 1-plus and averaged 175.93 mm. in length.

Experimental design

The experiment was designed to operate on a 6-day test cycle. Two days were spent sampling the surface layer of water, two day the mid-depths, and two days the bottom area. At least one sampling net was fished on the surface (north shore) every day to monitor fish movement through the experimental area. The number of nets fished daily varied from 5 to 10, depending upon the depth being sampled.

Fishing position 12 (south shore) was always very shallow and so encumbered with briars and sunken debris that it was not feasible to sample the area with the relatively fragile and expensive gill nets. Therefore, after the reservoir was filled later in the season, the position was sampled daily with a sturdy 3 by 3 by 12 foot, 1/2-inch stretched mesh hoop net with a 30-foot lead. Although numerous scrap fish were captured in this fishing position, no salmonids were every taken. Consequently, reference to fishing position 12 has been omitted in the discussion that follows.

Experimental procedure

Setting the sampling nets required two men and two boats. Each man handled one end of each net. One man would tie one end of a net lead line to a knot on one of the endless ropes, and the second man would tie the other end of the lead line to a

corresponding knot on an adjoining endless rope. Each man would then rotate the endless rope he was handling to the next knot and in doing this would pull the net lead line to a depth of 12 feet. The men would then secure each end of the net float line to the knot of their respective endless ropes on the surface and the net would be set. In the deeper portions of the experimental cross section, the investigators would rotate the endless ropes, submerging one net to a previously selected depth. They would then attach more nets between the same pair of endless ropes as desired. The nets were always fished with at least 12 feet of space between them vertically with a maximum of three nets fished in one column of water. In the horizontal plane, the nets were normally fished at least 60 feet apart.

The sampling nets were placed in fishing position each afternoon at 2 p.m. They were allowed to fish through the evening, night, and early morning and were removed at 8 a.m. on the following day. The nets were always set with the smallest mesh (7/8-inch) closest to the shore to enhance the chance of capturing small migrants moving along the bank.

After removal of each net from the water, it was placed in a separate plastic bucket that was numbered to correspond with the position where the net had been fished. When all the nets had been removed from the water they were taken to the shore where they were individually stretched across fiberglas covered railings (fig. 3). This enabled the researchers to observe and record the total number of fish captured, the species of each fish, the position (mesh size) in the net where each fish was captured, and the direction (upstream or downstream) in which each fish was swimming when captured. After removal from the net, each fish was measured and the fork length recorded.

The turbidity of the water was checked daily at three positions across the reservoir. Secchi disk readings ranged from 0.5 to 17.0 feet. The water temperature was also measured daily. The surface temperature ranged from 39 to 52 degrees Fahrenheit.

A series of water velocity readings were taken at the experimental site on July 23, 1964. The readings were taken at 60-foot intervals across the reservoir and at 12-foot intervals of depth. The number of vertical readings was limited by the length of the velocity meter lead cable to a depth of approximately 50 feet. The water velocity across the entire cross section was less than 0.25 f.p.s. On the south shore (fishing positions, 9, 10, and 11), no velocity was detected.

RESULTS AND DISCUSSION

The horizontal and vertical distribution of downstream migrants in Mayfield Reservoir is still being sampled on an intermittent basis. However, sufficent data have been collected and analyzed to indicate certain distribution patterns. It is anticipated that the sampling will continue for at least 1 year

Figure 3.--Mayfield Reservoir sampling net. Nets were stretched across fiberglass-covered railings where investigators could observe the exact position of each fish, species, and direction of travel before removing the fish for measurement.

and it is possible that the distribution of the migrants might change as seasonal environmental changes occur. Therefore, the results as reported here represent the horizontal and vertical distribution of the downstream migrants for the spring (April 6 to June 9, 1964) outmigration period only.

Figure 4 represents a cross section of the experimental site. It shows the horizontal and vertical distribution by percentage, of the three species combined. Approximately 71.0 percent of all the fish captured were taken in the top 12 feet and 91.0 percent were taken in the top 24 feet. The horizontal and vertical distribution of each of the three species present is shown in figures 5, 6, and 7.

Apparently the downstream migrants were milling about in the experimental area, since 51 percent of the fish captured were headed downstream and 49 percent were headed upstream.

The water temperature was quite uniform at the test site during the experimental period with the surface temperature never exceeding 52° F. Consequently, fish distribution was probably not affected by temperature. Observations indicated that the turbidity of the water did not affect fish distribution; however, turbidity did affect the effectiveness of the sampling nets. Considerably larger catches were taken on days when the water was turbid than on days when the water was clear.

CONCLUSIONS

1. The majority (approximately 91 percent) of the yearling downstream migrants in the upper end of Mayfield reservoir are concentrated in the top 24 feet of water.

2. The downstream migrants are distributed completely across the reservoir with a slightly higher concentration near the shores than in the middle of the reservoir.

3. Juvenile salmonids mill around considerably in the reduced velocities of the upper end of Mayfield Reservoir.

SUMMARY

Gill nets were systematically fished in the upper end of Mayfield Reservoir, near Mossyrock, Washington from April 6 to June 9, 1964, to determine the horizontal and vertical distribution of juvenile salmonids in this area of the reservoir.

Monofilament gill nets of three mesh sizes were used. Each net included one panel of 7/8-inch stretched mesh, one of 1-1/8-inch mesh, and one of 1-3/8-inch mesh. The panels were 12 feet deep and 20 feet long and sewn together to form nets that were 12 feet deep and 60 feet long.

The number of nets fished each day varied from five to ten, depending upon the depth being fished. The experiment was operated

DEPTH	11	10	9	8	7	6	5	4	3	2	1	VERTICAL DISTRIBUTION
	FISHING STATION											
	Percent recovered											
Feet												Percent
0-12	15.8	6.5	5.0	1.9	2.5	1.0	2.6	7.5	5.4	9.7	13.4	71.3
12-24			0.6	1.9	1.6	3.4	1.1	5.5	0.6	4.6		19.3
24-36			0.0	0.1	0.2	0.3	0.3	1.7	1.0	1.5		5.1
36-48						0.3	0.3	0.7	0.5	1.2		3.0
48-60						0.1	0.0	0.2	0.3			0.6
60-72							0.1	0.0				0.1
72-84								0.6				0.6
84-96								0.0				0.0
HORIZONTAL DISTRIBUTION	15.8	6.5	5.6	3.9	4.3	5.1	4.4	16.2	7.8	17.0	13.4	100.0

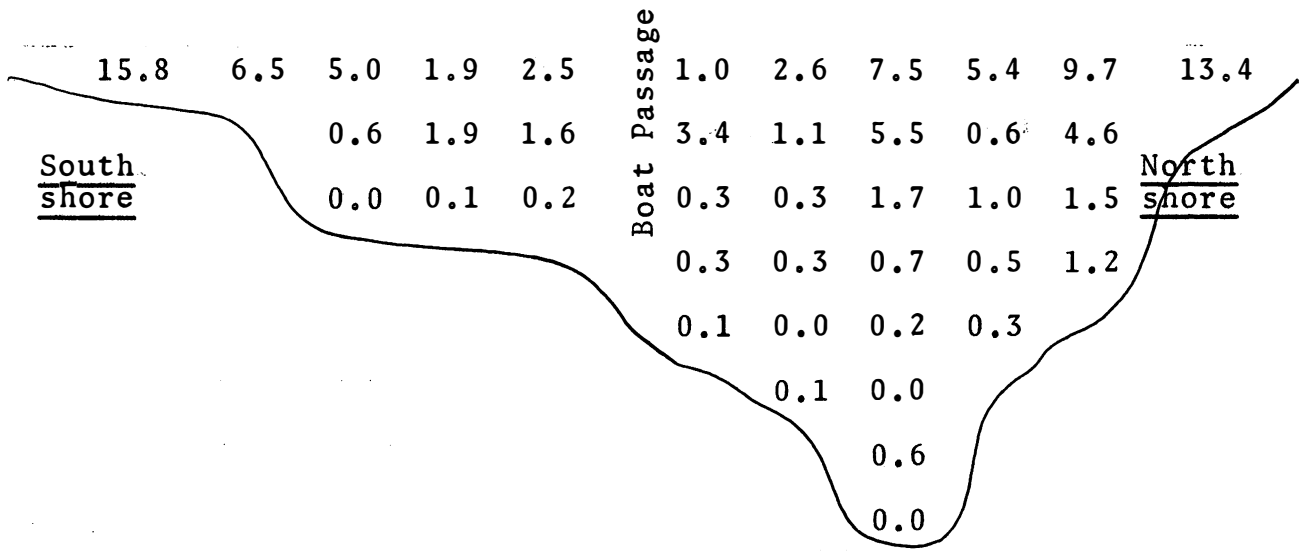

Figure 4.--Horizontal and vertical distribution (by percentage) of the three species (silvers, chinook, steelhead) combined in the upper end of Mayfield Reservoir (Cowlitz River) from April 6 to June 9, 1964.

DEPTH	FISHING STATION 11	10	9	8	7	6	5	4	3	2	1	VERTICAL DISTRIBUTION
Feet						Percent recovered						Percent
0-12	12.6	6.5	4.1	1.4	1.9	1.0	2.6	9.0	5.4	11.2	13.5	69.2
12-24			0.7	2.2	1.4	3.7	1.2	6.7	0.2	5.5		21.6
24-36				0.0	0.1	0.3	0.3	2.2	1.0	1.6		5.5
36-48						0.3	0.2	0.5	0.4	1.2		2.6
48-60						0.1	0.0	0.2	0.2			0.5
60-72							0.1	0.0				0.1
72-84								0.5				0.5
84-96								0.0				0.0
HORIZONTAL DISTRIBUTION	12.6	6.5	4.8	3.6	3.4	5.4	4.4	19.1	7.2	19.5	13.5	100.0

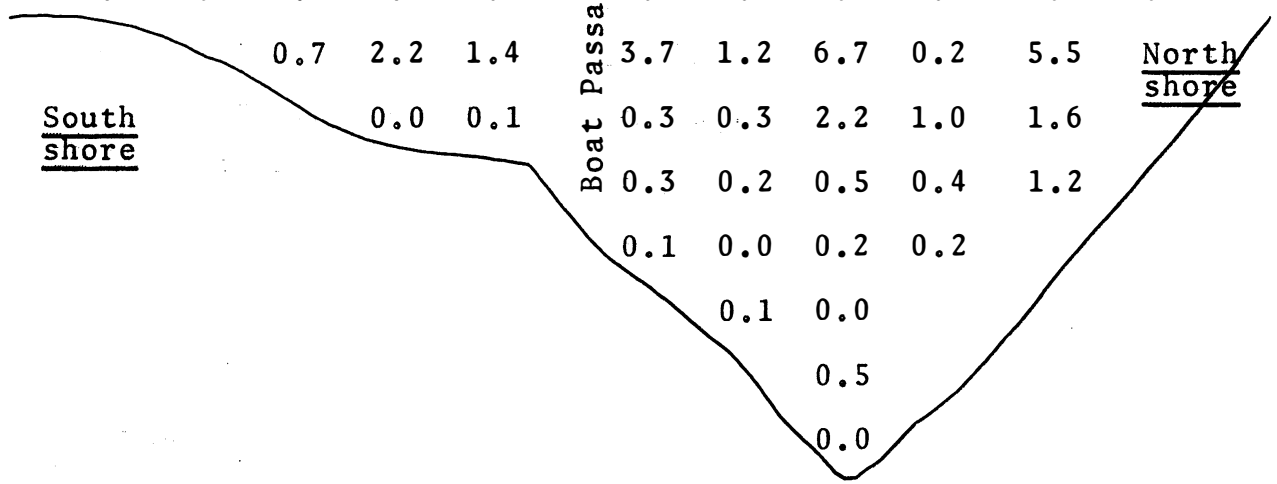

Figure 5.--Horizontal and vertical distribution (percentages) of juvenile silver salmon in the upper end of Mayfield Reservoir (Cowlitz River) from April 6 to June 9, 1964.

DEPTH	FISHING STATION 11	10	9	8	7	6	5	4	3	2	1	VERTICAL DISTRIBUTION
	Percent recovered											
Feet												Percent
0-12	25.3	7.9	5.5	1.8	3.4	0.7	1.7	2.8	4.3	4.6	13.9	71.9
12-24			0.6	1.2	2.4	3.0	0.7	3.3	1.6	2.7		15.5
24-36	South shore			0.4	0.5	0.1	0.1	1.0	1.4	1.3	North shore	4.8
36-48						0.3	0.6	0.9	1.0	1.8		4.6
48-60						0.2	0.0	0.6	0.9			1.7
60-72							0.4	0.0				0.4
72-84								1.1				1.1
84-96								0.0				0.0
HORIZONTAL DISTRIBUTION	25.3	7.9	6.1	3.4	6.3	4.3	3.5	9.7	9.2	10.4	13.9	100.0

Boat Passage

Figure 6.--Horizontal and vertical distribution (percentages) of juvenile chinook salmon in the upper end of Mayfield Reservoir (Cowlitz River) from April 6 to June 9, 1964.

DEPTH	FISHING STATION 11	10	9	8	7	6	5	4	3	2	1	VERTICAL DISTRIBUTION
Feet	Percent recovered											Percent
0-12	24.2	5.8	10.6	5.0	4.3	1.2	4.4	3.5	7.5	7.9	11.3	85.7
12-24	South shore		0.0	1.1	1.4	1.1	0.6	1.1	0.6	2.1	North shore	8.0
24-36				0.0	0.2	0.2	0.8	0.4	0.6	0.6		2.8
36-48						1.1	0.2	0.5	0.2	0.5		2.5
48-60						0.3	0.0	0.0	0.0			0.3
60-72							0.2	0.0				0.2
72-84							0.0	0.5				0.5
84-96								0.0				0.0
HORIZONTAL DISTRIBUTION	24.2	5.8	10.6	6.1	5.9	3.9	6.2	6.0	8.9	11.1	11.3	100.0

Boat Passage

Figure 7.--Horizontal and vertical distribution (percentages) of steelhead in the upper end of Mayfield Reservoir (Cowlitz River) from April 6 to June 9, 1964

on a 6-day cycle. Two days were utilized to sample the surface layer of water, 2 days to sample the mid-depths, and 2 days to sample the bottom area. Each sampling period consisted of approximately 18 hours.

The results indicate that during the spring out-migration period, approximately 91 percent of the fingerling migrants are concentrated in the top 24 feet of water, and a slightly higher percentage are concentrated nearer the banks than in the middle of the reservoir. There appears to be extensive milling in the upper end of Mayfield Reservoir, since 51 percent of the fish were swimming downstream when captured and 49 percent were headed upstream.

The distribution of yearling salmonids in the upper end of Mayfield Reservoir will be sampled on an intermittent basis until April 1965 to determine if seasonal environmental changes affect fish distribution. In the spring of 1965, small mesh trawls will be employed to sample the distribution of age group 0 (less than 90.0 mm.) fish.