PRELIMINARY TESTS WITH LOUVERS IN THE TROY LABORATORY ON THE GRANDE RONDE RIVER

by

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INTRODUCTION

The efficient and low-cost collection of juvenile salmonids has been subject to many years of intensive investigation. That there has been no relaxation in the intensiveness of the effort clearly points out present day limitations in the field of fish collection.

The purpose of the study presented here was to provide a continuation of the vertical louver tests originating at Tracy, California, and particularly to determine response differences, if any, between fish of different river systems such as the Sacramento and the Grande Ronde Rivers. This work was conducted during the spring and summer of 1964 in the newly completed Troy Laboratory (Grande Ronde test facility) constructed on the Grande Ronde River near Troy, Oregon.

DESCRIPTION AND OPERATION OF TEST FACILITY

Physical Description

The facility, designed for use in testing various fish guiding and collecting techniques under near prototype conditions, was constructed on the Grande Ronde River about 40 miles upstream from its confluence with the Sanke River (Fig. 1).

Built of reinforced concrete, the structure is 40 feet wide, 330 feet long, and 13 feet deep (Figs. 2 and 3). It is designed to provide two removable partitions which permit use as a single 40-foot wide channel, or two 20-foot wide channels. It also provides for a third combination of 20-, 11-, and 9-foot wide canals simultaneously.

An island location and a stream gradient of 6 inches per 100 feet for the 1,400 feet of stream to the point of reentry provided as good a site for the test structure as was available on the Grande Ronde River. The facility was constructed within a natural stream channel carrying approximately 40 percent of the flow. At the inlet located 750 feet downstream from the bifurcation of the stream effected by the island, the flow is routed through a trashrack (with bars 4 inches apart) into the desired channel, or channels. Entering flow is controlled by individual roller gates. A uniform channel section extends for 250 feet downstream from the gates. Three stoplog grooves spaced at 5-foot intervals provide for downstream flow control. Perforated-plate screens are used to dissipate surplus water at the flume exit. Each plate screen is 25 feet long, and has a fish trap secured to the downstream end. The screens are hinged at the attachment and at a distance of 18 feet. Geared hoists and cables provide adjustments for the screens at the 18-foot joint and the traps. A vertical drop formed by the inverted screen provides an elevation differential to compensate for the accumulated stream gradient drop between the forebay and afterbay water surfaces.

Two smooth bore hoses, 6 inches in diameter, are attached to each trap. These hoses transport fish concentrated in smaller quantities of water by gravity flow into individual holding tanks through which water is continually passing when the equipment is in use. The holding tanks are mounted upon a floating dock secured at one side of the structure exit. Elevation of the holding tanks is thus controlled by the river water surface of the afterbay.

A shunt rack, just downstream from the flume section and installed as an integral part of the structure, diverts upstream migrants through the unobstructed channel, while a floating log boom shears trees and other heavy debris away from the structure intake channel into the uncontrolled portion of the river.

Light is provided by overhead floodlights. Stoplog control operation and maintenance are expedited by a 4-ton traveling gantry crane spanning the width of the structure. Shop, warehouse, office facilities, and field laboratory, as

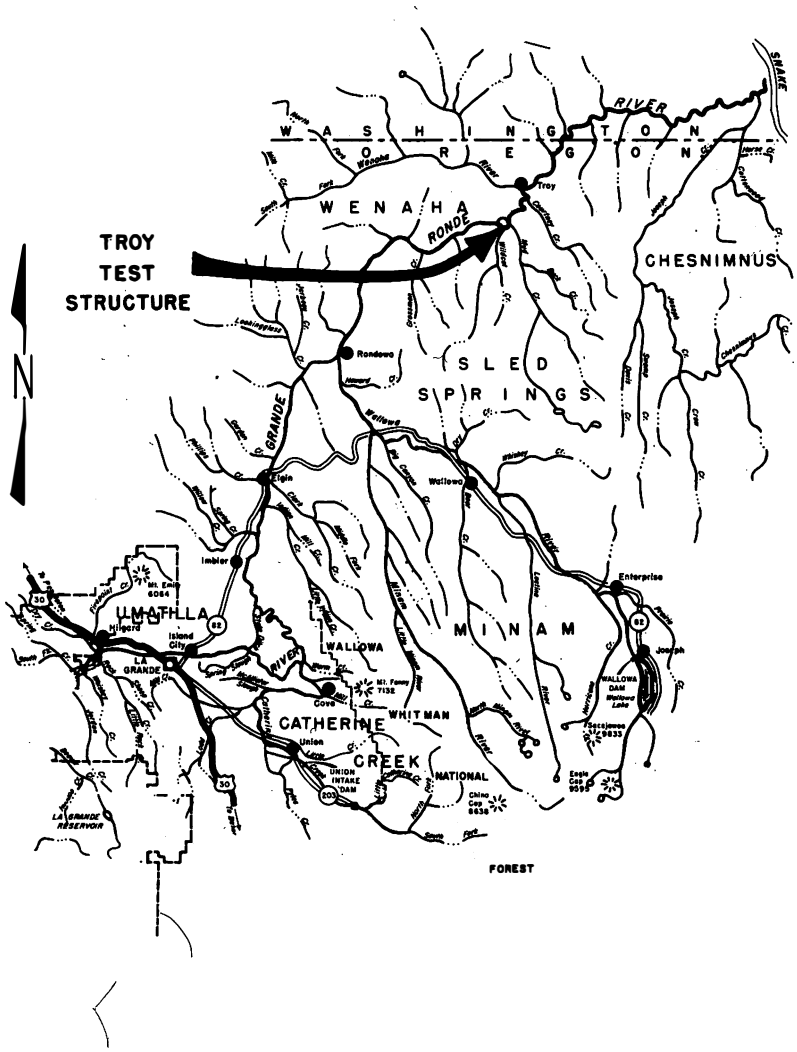


Figure 1.--Location of the Troy Laboratory on the Grande Ronde River in Northeast Oregon.

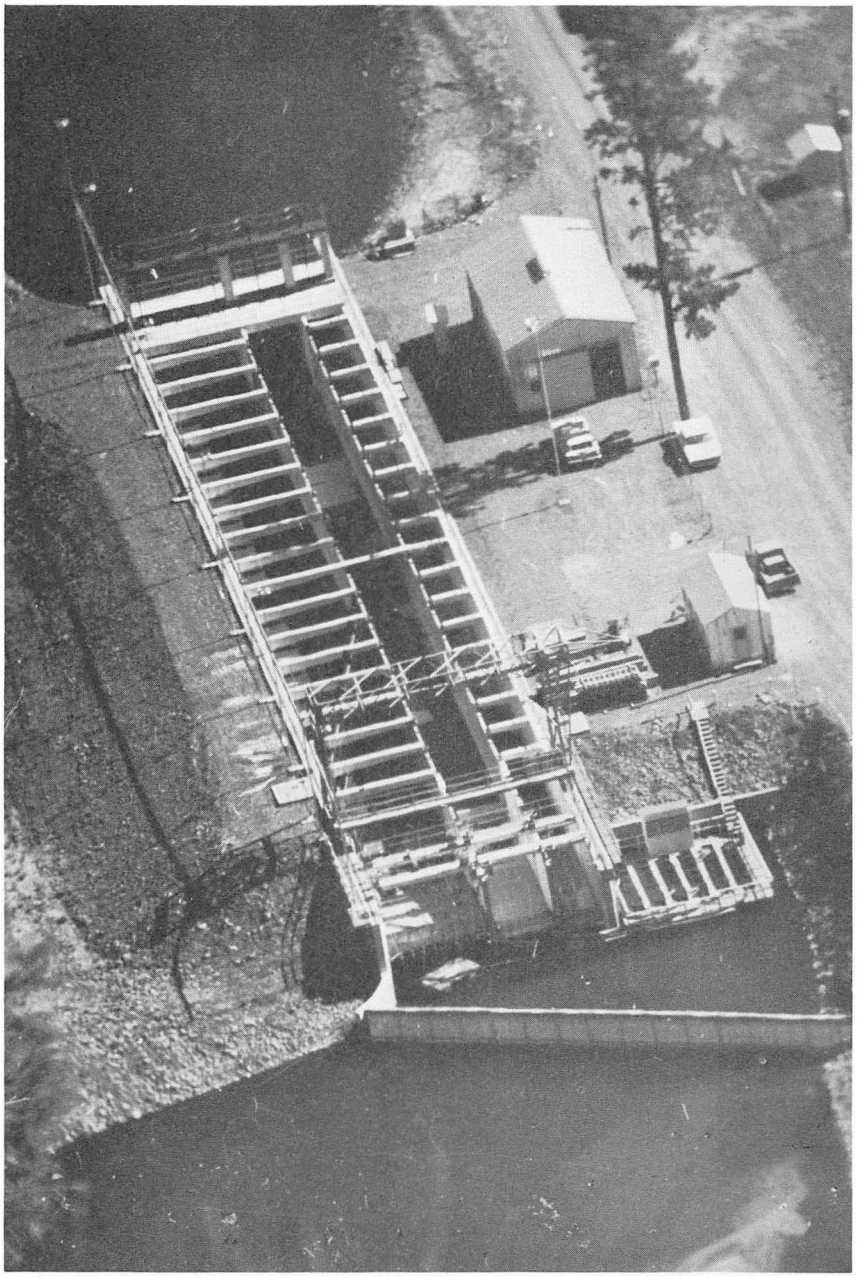
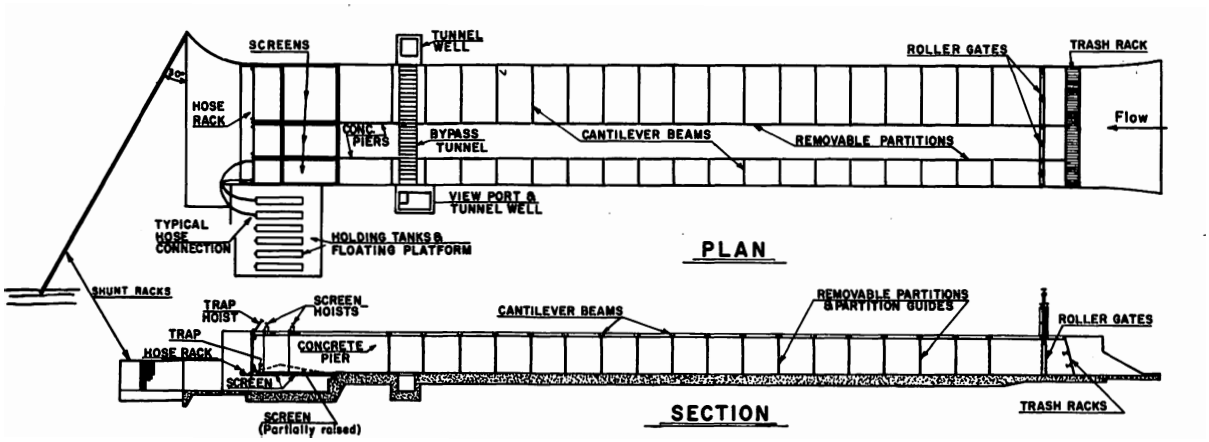


Figure 2.--Troy Laboratory (looking upstream).



DIAGRAMMATIC LAYOUT OF TROY TEST FLUME

Figure 3.--Plan and elevation of Troy Laboratory.

well as limited personnel quarters, are furnished by supplementary buildings.

Water Supply

The Troy Laboratory is a run-of-the-stream installation, and as such, cannot be radically adjusted to alter the channel geometry and hydraulic-flow patterns existing at a specified time, particularly during flood conditions. In this respect, prototype structures generally differ from models in the laboratory, or from small installations operating with superimposed controls.

In the reach of the Grande Ronde River adjacent to the test facility, stream flow is sub-critical and turbulent. During much of the year the water ranges from a definitely muddy to a slightly discolored state. Flash storms over the drainage area can cause rapid increase of flow, carrying suspended material in a degree comparable to the storm's intensity. Visibility, therefore, becomes quite limited.

The relationship between total river flow and that passing through the structure in cubic feet per second for the period of May 8 through July 22, 1964, is shown in Figure 4.

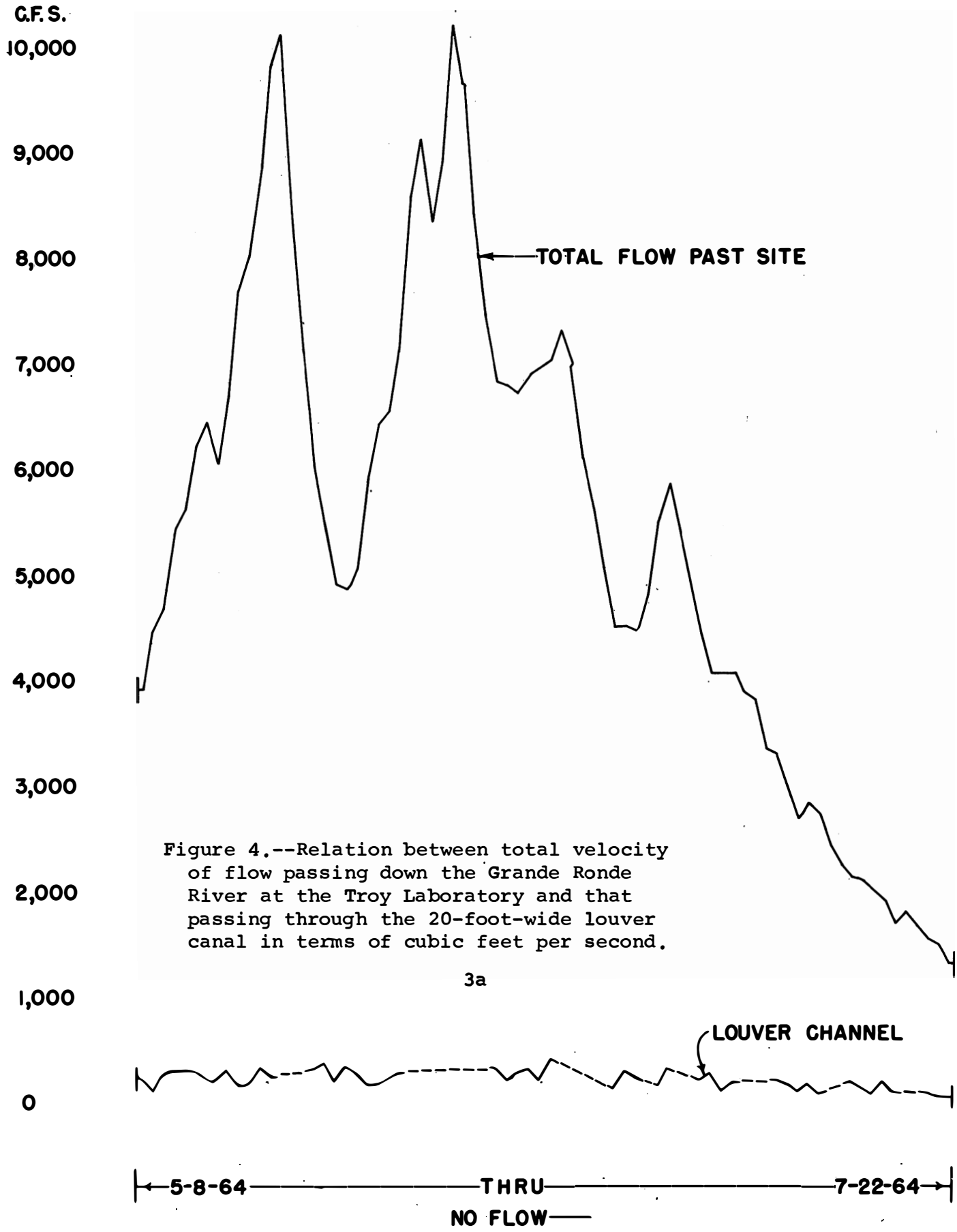


Figure 4.--Relation between total velocity of flow passing down the Grande Ronde River at the Troy Laboratory and that passing through the 20-foot-wide louver canal in terms of cubic feet per second.

VERTICAL LOUVER TESTS

Equipment and Procedure

The louver facility installed in the 20-foot flume channel was fabricated of 2 1/2-inch wide flat bars spaced at 2-inch centers. Every seventh bar was modified to provide a flow-straightening vane extending downstream to aid in channeling and dispersing the streamlines of flow. Individual louver bars were installed at 90° angles to the flow, and the face of the louver line was placed on an angle of 15° to the channel. The upstream end of the louver installation was secured to the south wall of the channel, the downstream end of the louver line being blended into a 6-inch wide bypass secured parallel to the north channel wall. It required 27 feet of vertical walled bypass to pass water and fish across the perforated-plate screen and into the trap. The width of this portion of the bypass varied from 6 inches at the inlet of the perforated-plate screen to 18 inches at the trap.

Test Fish

Spring and fall-run chinook salmon, coho salmon, and steelhead trout spawn in the mainstem and tributaries of the Grande Ronde River upstream from the Troy Laboratory. The natural run of outmigrating juvenile smolts was used in testing the louver structure. An estimate taken between the period of May 8 and July 22, 1964 of the total Grande Ronde River juvenile fish run, including non-migratory species, is shown in Figure 5. The numbers are based on flow volume relationships between main river and flume and numbers of fish caught in the test flume. Seasonal variation of juvenile salmonids is shown in Figure 6.

The size composition of the chinook and coho salmon and steelhead trout caught in the test flume from May 9 to June 23 is shown in Figure 7.

Fish were removed from the holding tanks with fine mesh dipnets and placed in an anesthetizing tank containing MS-222. Following anesthesia, the fish were carefully lifted out with a small seine-type scoop and identified. They were then transferred to a second tank to recover from the anesthesia before being released to continue downstream.

Throughout the test season, sample measurements were frequently taken and in such numbers as to give a reasonably accurate description of the size composition rather than of specific changes in composition.

Experimental Design

Louver testing for the spring of 1964 was designed to provide information on the guiding response of juvenile salmonids to louvers as a factor of color, velocity of approach flow, time of day, and segment of the season for each of

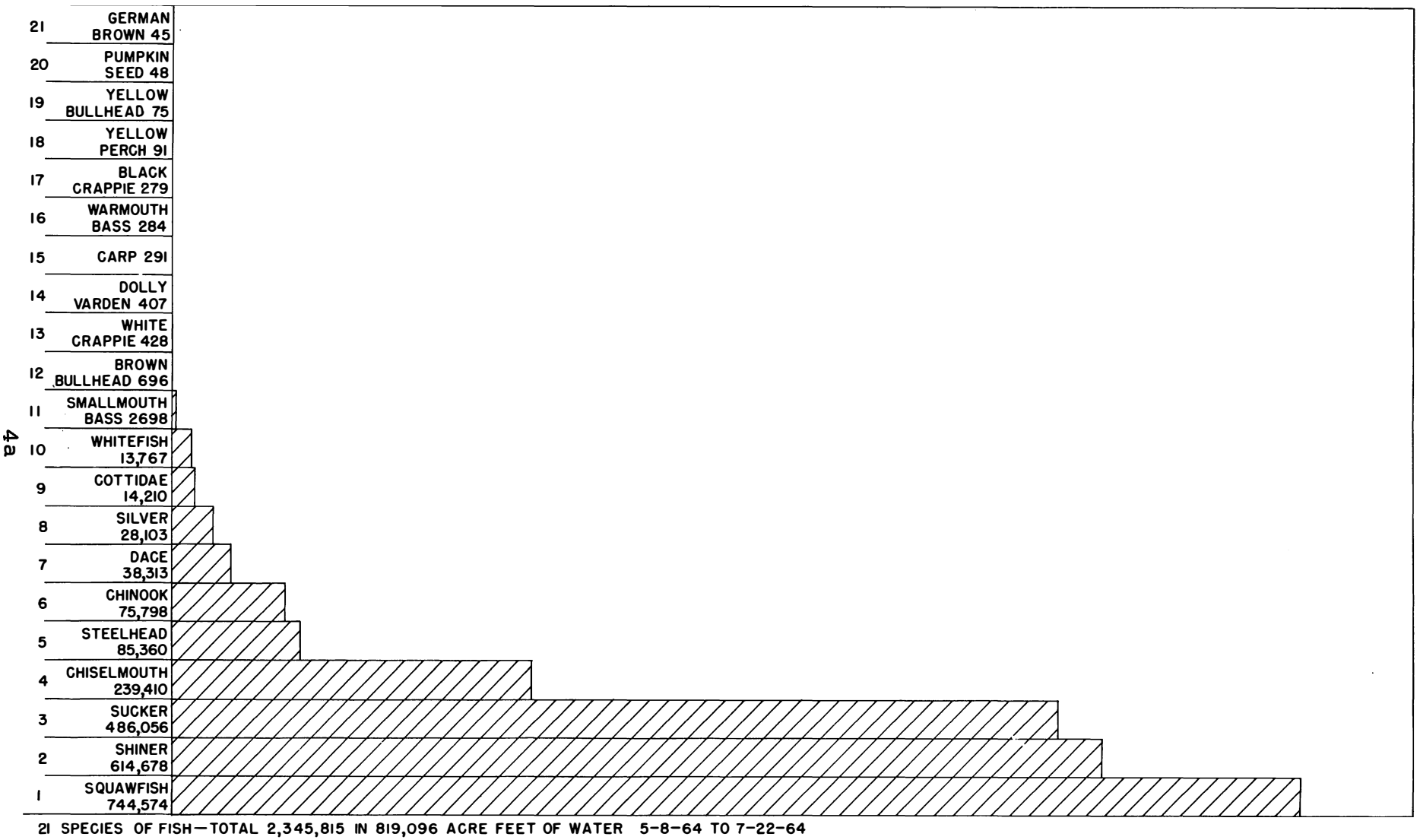


Figure 5.--Estimate of total Grande Ronde River juvenile fish run passing by the Troy Laboratory during the period of May 8 through July 22, 1964.

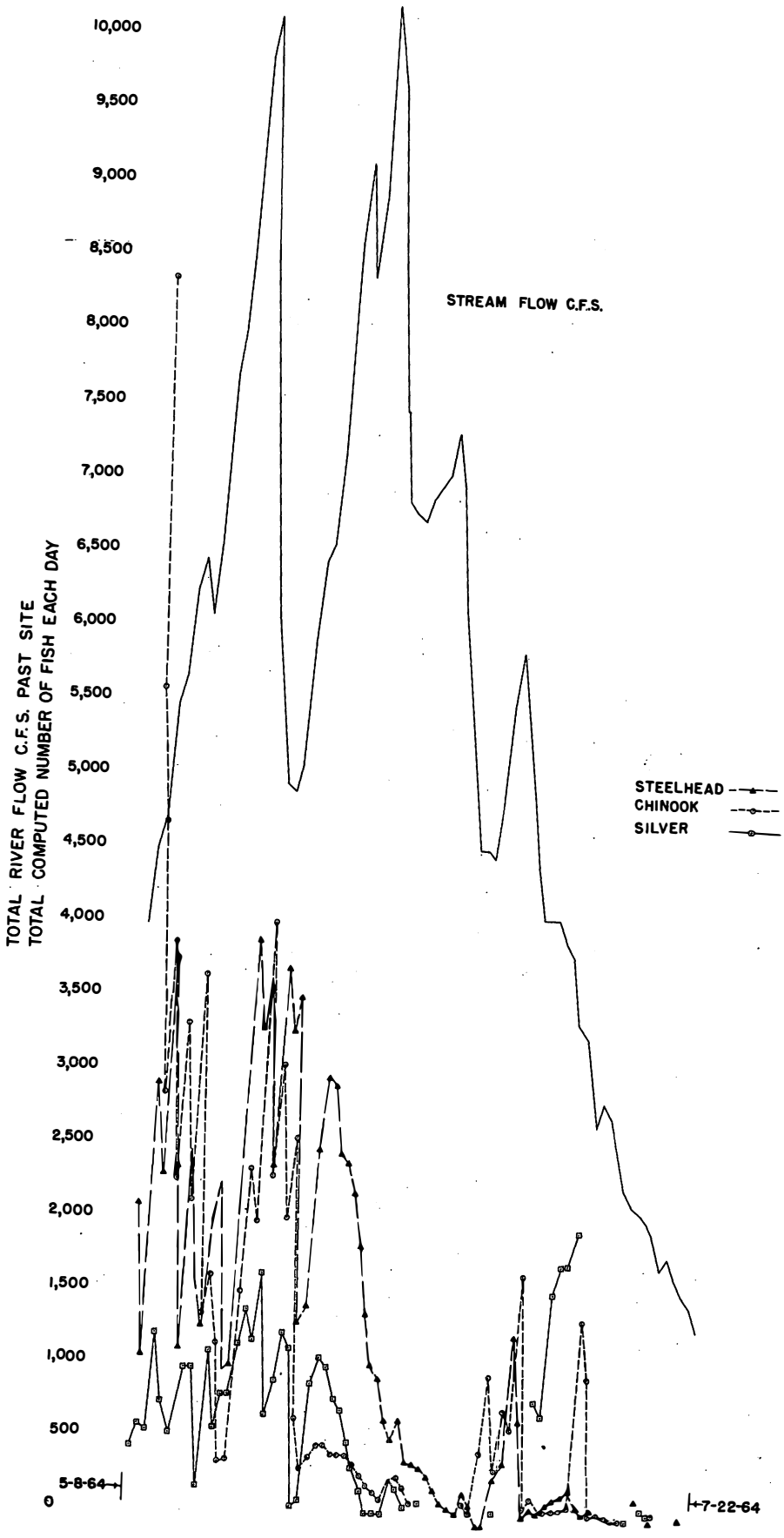


Figure 6.--Grande Ronde River seasonal variation in both flow volume and juvenile migrant salmonids at the Troy Laboratory during the period of May 8 through July 22, 1964.

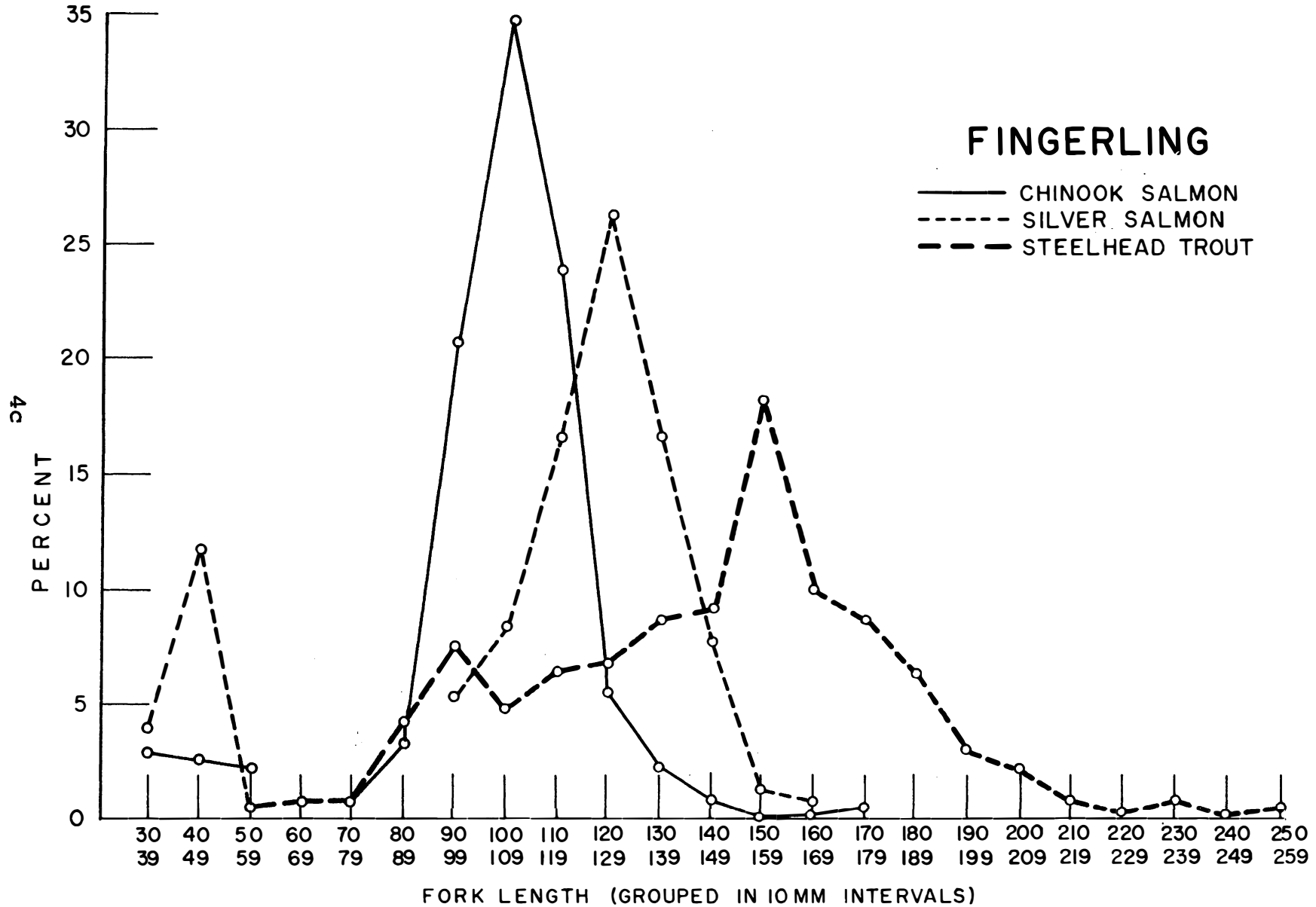


Figure 7.--Size composition of chinook and coho salmon and steelhead trout caught in the Grande Ronde River test facility (Troy Laboratory) from May 9 through June 23, 1964.

three species. The tests were conducted in an open flume under natural light that ranged in intensity from bright daylight to moonless nighttime and heavily overcast sky. Artificial light was largely excluded by shading the windows of buildings surrounding the flume and using flashlights after dark when gathering data or inspecting the flume. The floating live tanks were exposed to artificial light at all hours of darkness; however, the light source was strategically placed behind the flume wall to prevent light diffusion over the test area.

Conduct of Experiment

In preparation for a test cycle, the louvers and supporting structure were painted either black or white to a height above water level. A fast drying glossy paint was used that permitted a change of colors without interrupting the test schedule, and at least one continuous 3-day cycle was completed before changing colors.

The inclined screen was regularly adjusted to maintain a minimum differential of 21 inches between the afterbay water surface and the trap outlet hose. The differential was necessary to establish a gravity flow from the trap at the end of the screen to the live tanks. Screen angles of inclination greater than required to maintain the differential were seldom exceeded by more than a few inches, for it was observed that the porosity efficiency of the screen perforations was inversely related to the screen angle above zero. Suspended debris was considered a constant factor in this relation.

At or near zero elevation, the screen operated efficiently in relatively heavily concentrations of debris for periods of 2.5 hours or longer in approach velocities up to 3.5 feet per second. In contrast, records on June 2 showed that the screens became ineffective within 30 minutes of operation at approach velocities of 3.5 f.p.s. The debris removed from the screen on that date, following 5 hours and 55 minutes of operation, was measured volumetrically and amounted to 23 cubic feet after 7 hours of draining on a corrugated surface.

Tests were interrupted when it became apparent that the screen had to be cleaned of debris to prevent water overflowing the trap compartment. After the debris had been removed, the headgate was reopened to its previous setting, the flow was allowed to stabilize, and testing was resumed.

Water Control

Volume of flow through the flume was regulated by the upstream headgate and the downstream stoplogs. From the beginning of the experiment on May 9 until June 10 the two were used in conjunction to control depth and velocity. During this period, water depth in the approach channel exceeded 8 feet and carried large amounts of debris. To maintain the flows within the porosity capacity of the inclined screens it was necessary to limit the headgate to a partial opening.

This created a submerged weir effect, with accelerated flows beneath the gate and considerable turbulence just downstream.

The required louver approach velocity was obtained by placing stoplogs within guide slots at a point just downstream from the louvers. A spacing of 2 inches to 12 inches was provided between stoplogs and between the bottom stoplog and the flume floor.

After June 10 the operating procedure was changed to include a full headgate opening with closed stoplogs. The bottom space was continued, however, to provide an escape route for the migrants. Not only was the turmoil eliminated by this procedure but the flow pattern took on the appearance of a river-run condition. This change was made possible by a decline in forebay depth to less than 7 feet and a reduction in the amount of suspended debris.

The downstream migrants approached the test facility by an old established island channel that (prior to construction of the facility) carried approximately 40 percent of the total river flow at low-water discharge levels. A floating log boom across the channel entrance constituted the only alteration to former flow pattern except for the reduced flow volume caused by the physical presence of the facility.

Test fish passing through the louvers, or guided into the bypass, were first collected in separate traps located at the lower end of the perforated-plate screen. Guiding efficiencies were expressed as the percent of all fish migrating through the flume that entered the bypass.

Evaluation of the Grande Ronde louver array was based on 29 tests that began on May 9 and ended on June 23, 1964. At the three approach velocities, black louvers were tested for 17 days and white louvers for 12 days. An attempt was made to equalize the time of each test by starting daily at 4:30 p.m. and ending at 7:30 a.m. the following morning. This schedule, however, was frequently interrupted to make necessary adjustments in the water control and fish-collection installations.

The number of fish entering the test facility fluctuated according to natural rate of out-migration. A shortage of fish over much of the season made it impossible to relate the guiding efficiencies to environmental or procedural changes.

RESULTS

Numbers of juvenile salmonids caught during the period from May 9 through June 23 are shown in Table 1. The percentages of fingerlings guided in the tests of louver efficiency are shown in Table 2. These data were tested by four-way analysis of variance with a single observation consisting of the seasonal louver efficiency for each category.

There was a significant difference at the 5 percent level of significance

between louver colors, between water velocities, between light conditions, and between species. There were no significant interactions between these main effects.

Black louvers usually were more efficient than white louvers at night as well as during the day at all water velocities for every species.

Table 1.--Numbers of fingerlings collected during period from May 8-June 24, 1964.

Louver color	Water velocity	Light Condition*	Chinook No. in bypass	Chinook No. thru louvers	Coho No. in bypass	Coho No. thru louvers	Steelhead No. in bypass	Steelhead No. thru louvers
	F. p. s.							
Black	1.5	day	50	8	12	3	31	6
		night	139	34	46	5	98	33
	2.5	day	118	8	26	1	65	9
		night	88	7	37	6	115	30
	3.5	day	139	18	52	8	97	21
		night	138	14	35	4	167	42
White	1.5	day	15	5	7	6	24	11
		night	44	15	9	5	48	26
	2.5	day	41	2	28	9	51	13
		night	80	15	31	3	69	48
	3.5	day	52	10	18	1	49	7
		night	71	20	27	13	61	52
Totals			975	156	328	64	875	298
			1131		392		1173	

*Daylight = 4:30 p.m. to 9:30 p.m. plus 5:00 a.m. to 7:30 a.m.

Night = 9:30 p.m. to 5:00 a.m.

Table 2. --Percentages of juvenile salmonids guided in tests of louver efficiency.

Louver color	Water velocity	Light condition[1]	Species: Chinook	Species: Coho	Species: Steelhead
	F. p. s.		Percent[2]	Percent	Percent
Black	1. 5	day	86. 2	80. 0	83. 8
		night	80. 3	90. 2	74. 8
	2. 5	day	93. 7	96. 3	87. 8
		night	92. 6	86. 0	79. 3
	3. 5	day	88. 5	86. 7	82. 2
		night	90. 8	89. 7	79. 9
White	1. 5	day	75. 0	53. 8	68. 6
		night	74. 6	64. 3	64. 9
	2. 5	day	95. 3	75. 7	79. 7
		night	84. 2	91. 2	59. 0
	3. 5	day	83. 9	94. 7	87. 5
		night	78. 0	67. 5	54. 0

[1]Daylight = 4:30 p. m. to 9:30 p. m. plus 5:00 a. m. to 7:30 a. m.
Night = 9:30 p. m. to 5:00 a. m.

[2]Numbers of fish observed from May 8 to June 24, 1964 were summed and the percentages shown above were calculated from those sums. The percentages shown above were converted to arcsin values (Snedecor, 1957) which were used in a four-way analysis of variance test.

Daylight guiding was genereally better than night guiding, and water velocities of 2.5 f.p.s. produced a higher guiding effect at 3.5 f.p.s. than those at 1.5 f.p.s. Table 3 shows the average percentage guidance values that were compared for each main effect.

Steelhead Trout

Throughout the test season 714 steelhead trout were captured when the black louver structure was in place. Of those, 573 were guided into and through the bypass while 141 escaped between the louvers for a total efficiency of 80 percent. White louvers, in contrast, guided 302 out of 459 steelhead trout through the bypass for a total efficiency of 66 percent. This difference in response due to louver color exceeds the differences displayed by either chinook or coho salmon. The total efficiencies due to velocity effects were 72 percent at 1.5 f.p.s. and 75 percent at 2.5 and 3.5 f.p.s. The numbers of steelhead guided through the bypass and the numbers passing through the louver system are shown in Table 4.

The relation of steelhead trout size to louver guiding can be examined on a gross basis by comparing the size of those guided through the bypass to those passing through the louver system (Fig. 8). Of the guided fish only 30 percent were smaller than 140 mm. as compared to 60 percent of those passing through the louver system.

Fingerling Coho Salmon

Throughout the season 208 of 235 were guided by black louvers for a total efficiency of 88 percent. White louvers, in contrast, guided 120 of 157 for at total efficiency of 76 percent. The total efficiencies due to velocity effects were 80 percent at 1.5 f.p.s. and 85 percent at 2.5 and 3.5 f.p.s. The data pertaining to coho are given in Table 5.

Table 3. --Average percentages that were compared in the analysis of variance test. They can be calculated from values shown in Table 1.

		(Percent)
Louver color:	Black	86.04
	White	75.11
Water velocity:	1.5 f.p.s.	74.71
	2.5 f.p.s.	85.07
	3.5 f.p.s.	81.95
Light condition:	Day	83.30
	Night	77.85
Species:	Chinook	85.26
	Coho	81.34
	Steelhead	75.13

Table 4. --Fingerling steelhead trout guiding efficiency of the test louver structure, May 9 - June 23, 1964.

	Approach Velocity								
	1.5			2.5			3.5		
Louver color	Test no.	No. fish through Bypass	No. fish through Louvers	Test no.	No. fish through Bypass	No. fish through Louvers	Test no.	No. fish through Bypass	No. fish through Louvers
Black	1	10	6	2	80	13	4	68	26
	3	40	11	11	6	5	5	47	5
	9	12	4	12	68	18	10	23	4
	14	51	11	23	10	2	13	105	20
	22	8	6	24	16	1	21	17	5
	25	8	1				26	4	3
Total fish:		129	39		180	39		264	63
Efficiency:		77%			79%			88%	
White	8	12	2	6	43	19	7	9	15
	17	48	26	16	61	28	15	83	25
	18	12	8	19	14	12	20	16	14
	27	0	1	29	2	2	28	2	5
Total fish:		72	37		120	61		110	59
Efficiency:		66%			66%			65%	

Table 5. --Fingerling Coho salmon guiding efficiency of the Grande Ronde River louver structure, May 9 - June 23, 1964.

	Approach Velocity (f. p. s.)								
	1.5			2.5			3.5		
Louver Color	Test	No. fish through Bypass	Louvers	Test	No. fish through Bypass	Louvers	Test	No. fish through Bypass	Louvers
Black	1	8	1	2	16	2	4	17	2
	3	25	2	11	9	0	4	8	4
	9	9	0	12	26	5	10	7	0
	14	14	4	23	6	0	13	53	5
	22	0	1	24	6	0	21	0	1
	25	2	0				26	2	0
Total fish:		58	8		63	7		87	12
Efficiency:		88%			90%			88%	
White	8	2	0	6	27	6	7	14	1
	17	13	11	16	28	6	15	20	7
	18	1	0	19	2	0	20	6	5
	27	0	0	29	2	0	28	5	1
Total fish:		16	11		59	12		45	14
Efficiency:		59%			83%			76%	

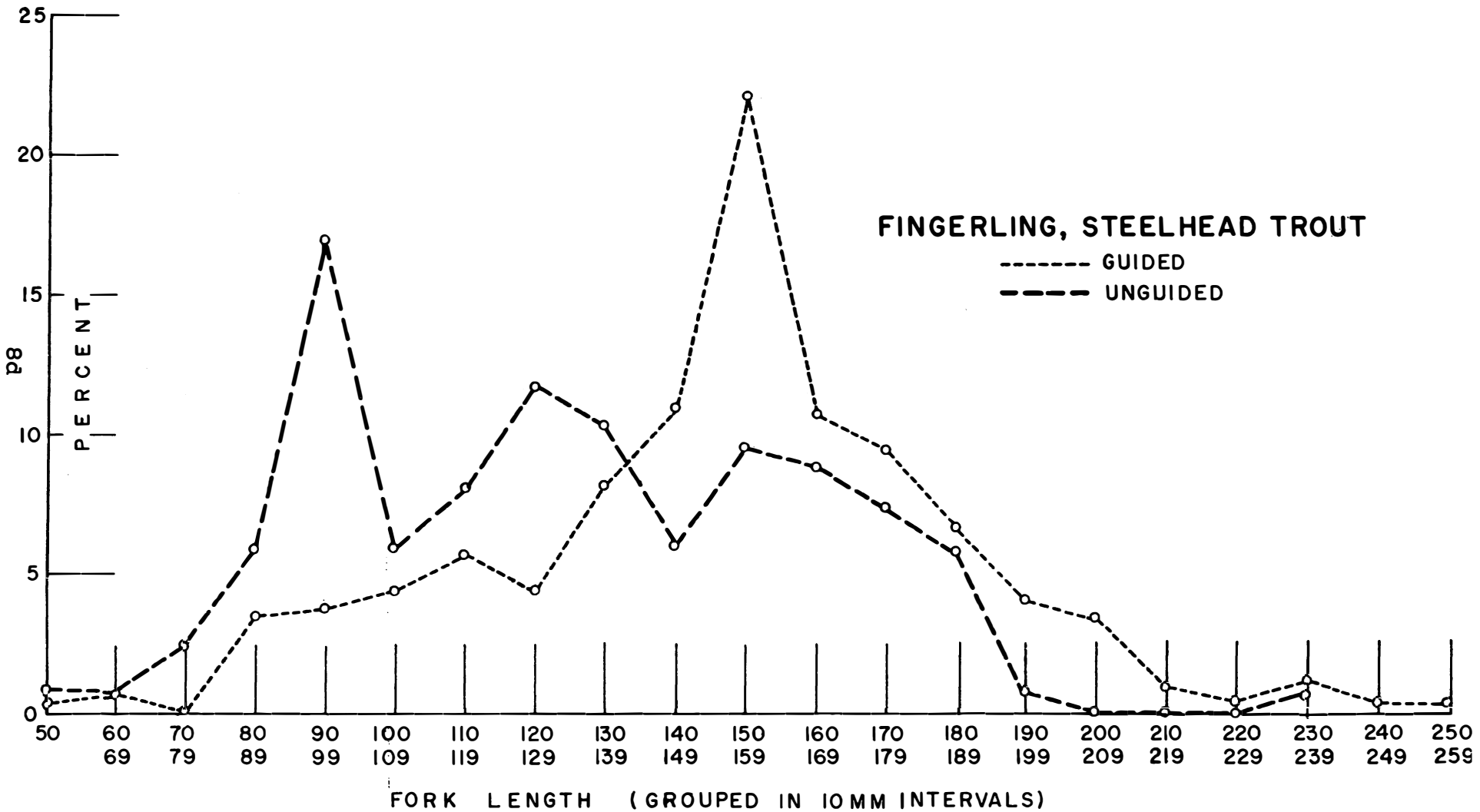


Figure 8.--Size composition of the steelhead trout tested in the louver system in the Troy Laboratory, May 9 through June 23, 1964.

A sample of 136 guided and 32 unguided fish collected intermittently throughout the test season provided the only available basis for determining the effects of size on guiding. Figure 9 shows the two groups to be bimodally distributed, with modes differeing by 10 mm. The computed mean length of the two groups were 108 mm. for the unguided fish and 118 mm. for the guided ones. Of the two samples only 19 percent of the guided fish were smaller than 100 mm., whereas 37 percent of the unguided fish were smaller than 100 mm.

Fingerling Chinook Salmon

Throughout the entire test season, black louvers guided 672 of 761 for a total efficiency of 88 percent. In contrast, white louvers guided 303 of 370 for a total efficiency of 82 percent. At 1.5 f.p.s. approach velocity, 248 of 310 were guided for a total efficiency of 80 percent. At 2.5 and 3.5 f.p.s., 727 of 821 were guided for a total efficiency of 89 percent. Table 6 presents the number of chinook fingerlings guided and not guided during the season.

Samples of 221 guided fish and 50 unguided fish taken throughout the test season provided the only basis for examining the effects of size on guiding. The mean length of the sample of guided fish was 100.03 mm. as compared to 89.28 mm. for the sample of unguided fish. Of the guided fish only 7 percent were less than 90 mm. as compared to 34 percent for those not guided (Fig. 10).

DISCUSSION

The comparisons made in this study indicate several areas in which future research might prove useful. Judging from differences established for guidance between black and white louvers and daylight and night catches, vision probably plays an important part in the response of juvenile salmoids to louvers. Examination of methods to increase the contrast between louvers and the surrounding water throughout a 24-hour period should lead to improved guiding efficiency.

The best guidance efficiency in this study was obtained for chinook and the least for steelhead. By contrast, louver tests carried out on Umatilla River with juvenile steelhead provided guiding efficiencies of over 98 percent with louvers spacing of 2 inches (Bates, 1961). The Canadian Puntlage River louver tests provided efficiencies of 86 percent with wild steelhead smolts and 98 percent with hatchery smolts (Ruggles, 1964). This indicates the possibility that the Grande Ronde River steelhead were not readily accepting the 6-inch louver bypass. For this reason the bypass width will be extended to 2 feet in future tests.

Table 6. --Fingerling chinook salmon guiding efficiency of the Grande Ronde River louver structure, May 9 - June 23, 1964.

	Approach Velocity (f. p. s.)								
	1.5			2.5			3.5		
Louver Color	Test no.	No. fish through Bypass	Louvers	Test no.	No. fish through Bypass	Louvers	Test no.	No. fish through Bypass	Louvers
Black	1	67	17	2	138	12	4	91	6
	3	49	14	11	4	0	5	42	8
	9	13	0	12	50	2	10	12	2
	14	52	11	23	6	0	13	125	16
	22	3	0	24	8	1	21	5	0
	25	5	0				26	2	0
Total fish:		189	42		206	15		277	32
Efficiency:		82%			93%			90%	
White	8	12	3	6	69	6	7	43	12
	17	38	16	16	45	10	15	73	16
	18	9	1	19	5	1	20	4	1
	27	0	0	29	2	0	28	3	1
Total fish:		59	20		121	17		123	30
Efficiency:		75%			88%			80%	

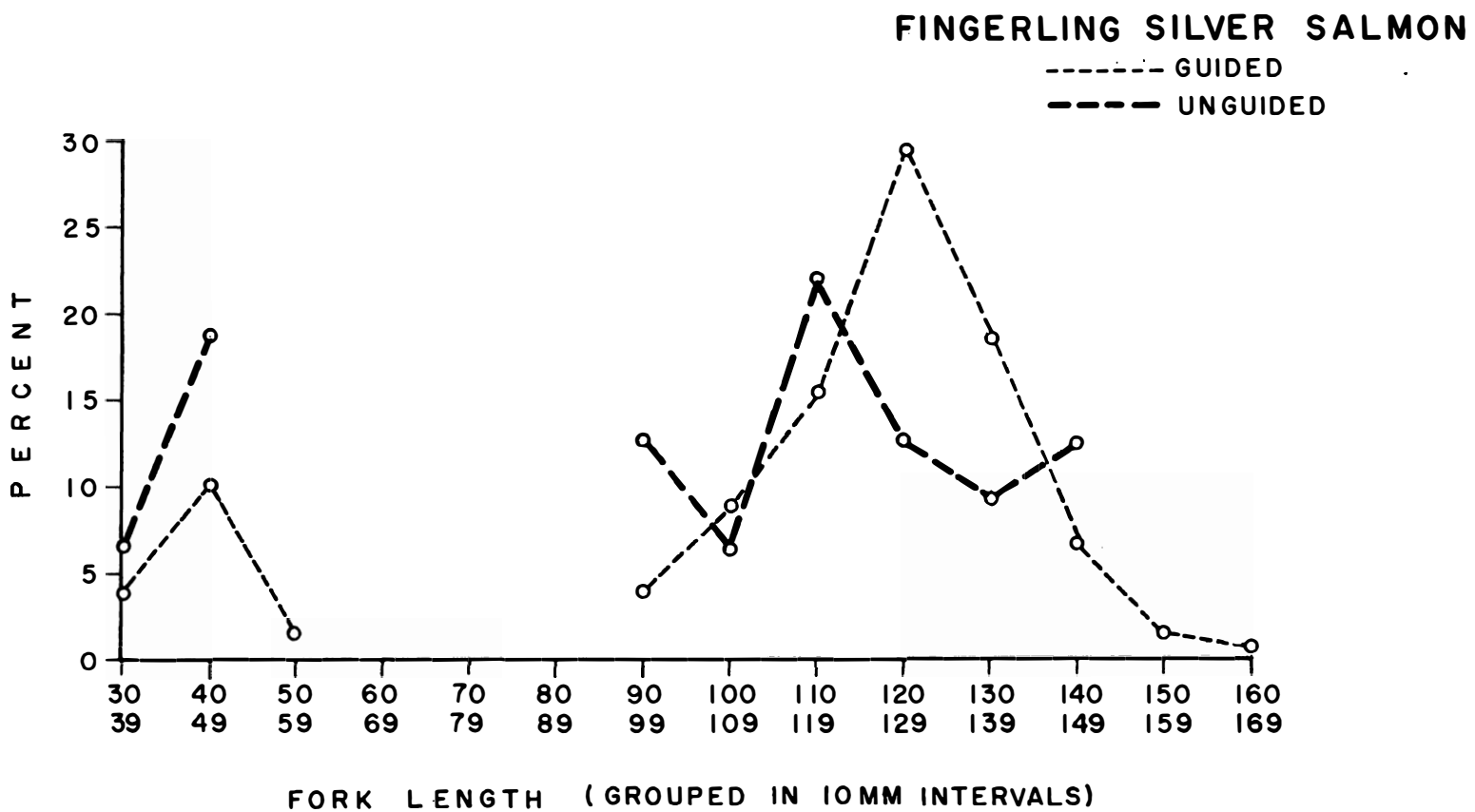


Figure 9.--Size composition of the coho (silver) salmon tested in the louver system in the Troy Laboratory, May 9 through June 23, 1964.

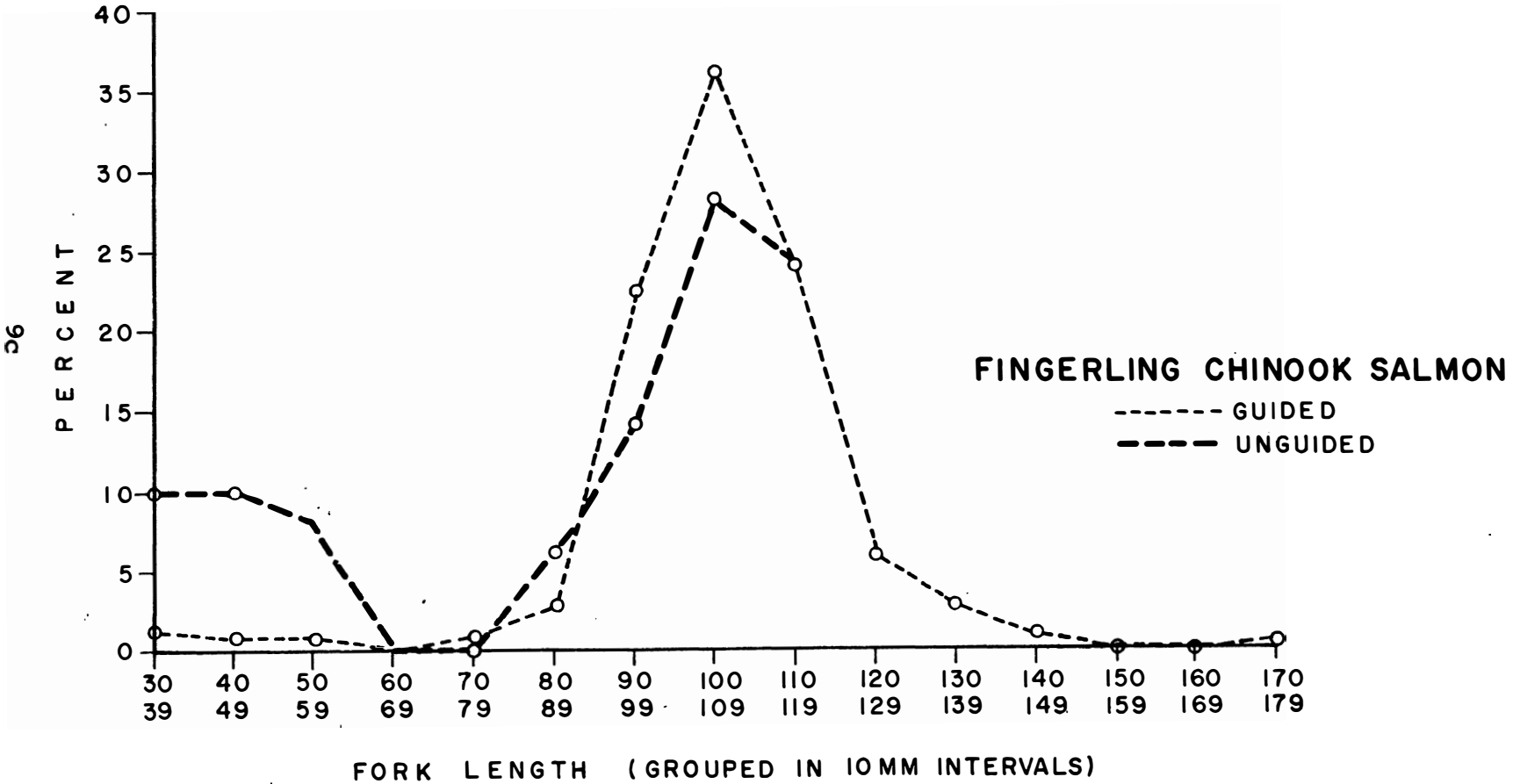


Figure 10.--Size composition of the chinook salmon tested in the louver system in the Troy Laboratory, May 9 through June 23, 1964.

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ADDENDUM

Since this report was prepared, the bypass has been enlarged from 6 inches to 24 inches. Testing during the period October 17 to 21 resulted in virtually 100 percent guidance at approach velocities of 1.5, 2.5, and 3.5 feet per second.

The testing has continued with no reduction in the efficiency. This high efficiency with a wider bypass points even more strongly to the critical nature of relationships between the bypass and approach.