

OCCURRENCE OF FINGERLING SALMONIDS IN
TURBINE INTAKE GATEWELLS

by

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INTRODUCTION

One of the general approaches for protecting young migrant salmonids at low-head dams on the Columbia and Snake Rivers is to bypass fingerlings around the turbines. Because of the number and massive dimensions of the hydroelectric projects involved, the installation of conventional guiding methods that screen the entire flow entering turbines does not appear economically feasible at this time.

Application of guiding methods that result in substantial reduction of fingerling mortalities without screening the entire flow may be justified, however. If the natural tendencies of fish to concentrate in discrete areas can be enhanced in existing features of dams, substantial savings in diversion costs may result. The turbine intake gatewells of low-head dams on the Columbia and Snake Rivers may be a natural area where fingerlings accumulate and from which they may be bypassed.

Fingerling salmonids have been observed in turbine intake gatewells of Bonneville Dam^{1/} but no effort has been made to determine how many fish might be accumulating. To obtain information on fish concentrations and clues to factors that may influence their accumulation, exploratory studies were conducted in the gatewells at Bonneville and McNary Dams. Studies at Bonneville Dam were carried out in the spring of 1959 immediately after the release of about 44 million 0-age chinook fingerlings from five hatcheries located between Bonneville and The Dalles Dams. Experiments at McNary Dam were conducted in the spring of 1961 in conjunction with other research activities.

MATERIALS AND METHODS

Bonneville Dam Research Area

Bonneville Dam is the lowermost hydroelectric project on the Columbia River. The powerhouse contains 10 Kaplan turbines, each supplied with water flowing through three intakes. The three turbine intakes supplying each turbine are designated by the letters A, B, and C. Thus the 30 intakes are designated 1-A, 1-B, 1-C, 2-A, . . . 10-C, moving from the south, or Oregon shore toward the north, or Washington shore. A single turbine, together with the three corresponding intakes were examined as a unit in these experiments.

^{1/} U.S. Army Corps of Engineers Annual Report, 1950.

All intakes are equal in size and shape from the mouth downstream to the gatewell (fig. 1). From the gatewell to the wicket gates the A, B, and C intakes differ from one another. Therefore, the amount of water passed by each of the three intakes supplying one turbine may vary.

Intake gatewells provide access to each turbine intake. Large gates can be lowered through the wells from the deck to seal the intakes so the turbines can be unwatered periodically for maintenance. For identifying purposes, the gatewells receive the same number-letter designations as the corresponding turbine intake.

The bottom of each gatewell, at the confluence of the gatewell and the turbine intake, is always open. Consequently, water rises within the gatewells to an elevation approximating that of the forebay. The depth of the water from the surface to the bottom of the gatewell is about 28 feet at Bonneville Dam when the forebay surface is at an elevation of 72 feet. The open area in these gatewells is 21 feet long by 7 feet 3 inches wide.

All gatewells are covered similarly with a combination of concrete slabs and steel grills (fig. 2). Overhead lights that illuminate the deck at night are 300-watt tungsten lamps of clear glass. No light is cast directly upon water in the gatewells, but light is reflected from one wall of some of the wells.

Methods.--During the period beginning May 7 and ending May 18, fish were removed from gatewells 3-B and 3-C by using a large dip net. Except for 3 days, fish were removed from gatewell 3-B once or twice a day. Fish were removed from adjacent gatewells 3-C only twice during this 12-day period so that fish could accumulate. For purposes of this experiment, it was assumed that fish entered turbine intakes 3-B and 3-C at an equal rate and the conditions in the turbine intakes were equal.

The dip net used to remove the fish was constructed of small mesh webbing attached to a pipe frame 7 feet wide by 19 feet 6 inches long. To remove fish from the well, the net was lowered edgewise into the gatewell with the pipe frame flat against one wall. When the net was within approximately 5 feet of the bottom of the well, the frame was turned to a horizontal position and raised through the well for a sample. The operation was continued in a gatewell until less than twelve fish were obtained in a single sample.

Upon removal, the fingerlings were immediately placed in large receptacles of water, counted, and released into the ice and trash sluiceway which carried the fish through the dam to the tailrace. No attempt was made to identify the species of each fish. However, all fish were categorized by visual estimation

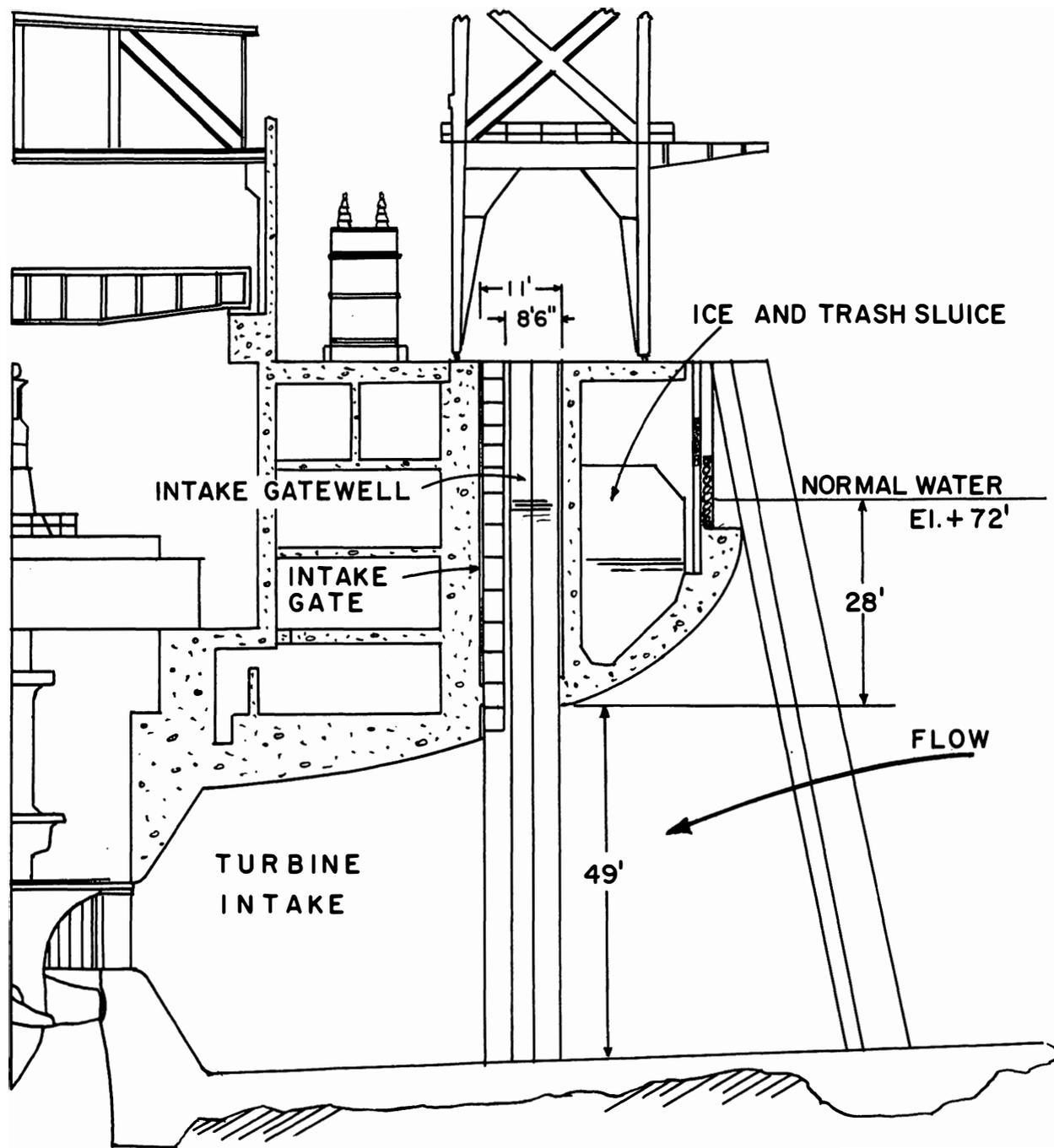


Figure 1.--Turbine intake and gatewell at Bonneville Dam (cross section).

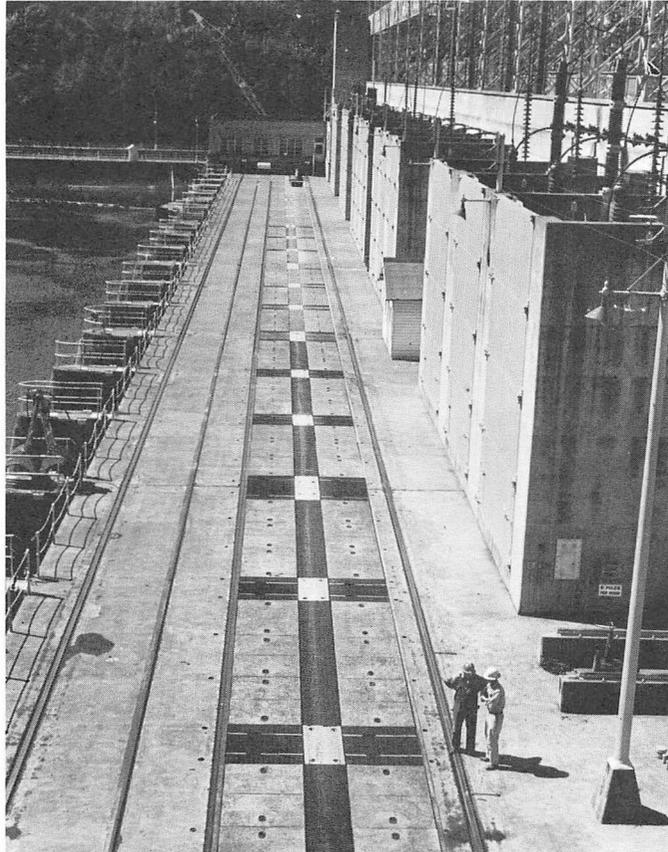


Figure 2.--Concrete slab and steel grill covers on intake gatewells at Bonneville Dam.

into two age groups; i.e., fish of the year and fish over 1 year of age.

McNary Dam Research Area

McNary Dam will be the fourth dam upstream on the Columbia River when John Day Dam is completed. The powerhouse contains 14 Kaplan turbines of a general design and conformation as those at Bonneville. For these studies, the same number-letter system was used to designate turbines and turbine intakes.

The intake gatewells at McNary Dam are 20 feet long by 17.5 feet wide. As shown in figure 3, a gate stored in the downstream slot reduces the open area in the well to 20 by 13 feet, except for the zone above the top of the gates. The submerged opening of the gatewells, approximately 62 feet below the surface of the forebay, is partially closed with a concrete beam.

All gatewells of McNary receive the discharge of transformer cooling water. Each set of three gatewells is served by a single supply. The supply is divided into three parts, each of which discharges into a gatewell approximately 4 feet above the normal surface of the water. Theoretically, the A and C gatewells each receive 25 percent of the total, while the B gatewells receive 50 percent. The actual quantity of water discharging into the gatewells was not measured, but considerable variation was noted by visual observation.

The covering over the gatewells at McNary differ from those at Bonneville. All A and C wells are covered with six removable concrete slabs separated by a section of concrete. All B wells have a section of steel grill in place of one of the concrete slabs (fig. 4). The effect is that the A and C wells are darkened while the section of steel grill over the B wells admits light. At night, overhead 400-watt mercury-vapor lamps with prism lenses throw light directly through the grill, and daylight filters through during the day. Half of the 14 B wells at McNary allow light from the mercury-vapor lamps to shine directly upon the water but in the other half, the light is cast upon one wall of the gatewell.

During the period from April 11 to May 26, a condition existed that may have influenced the number of fish entering gatewells 6-A, 6-B, and 6-C. An experiment conducted during this period by staff members of the University of Washington incorporated lights at the surface of the forebay immediately upstream of intake 6-B (Fields, 1962). It is possible that the lights may have changed the distribution of fish and consequently the number of fish entering these three gatewells.

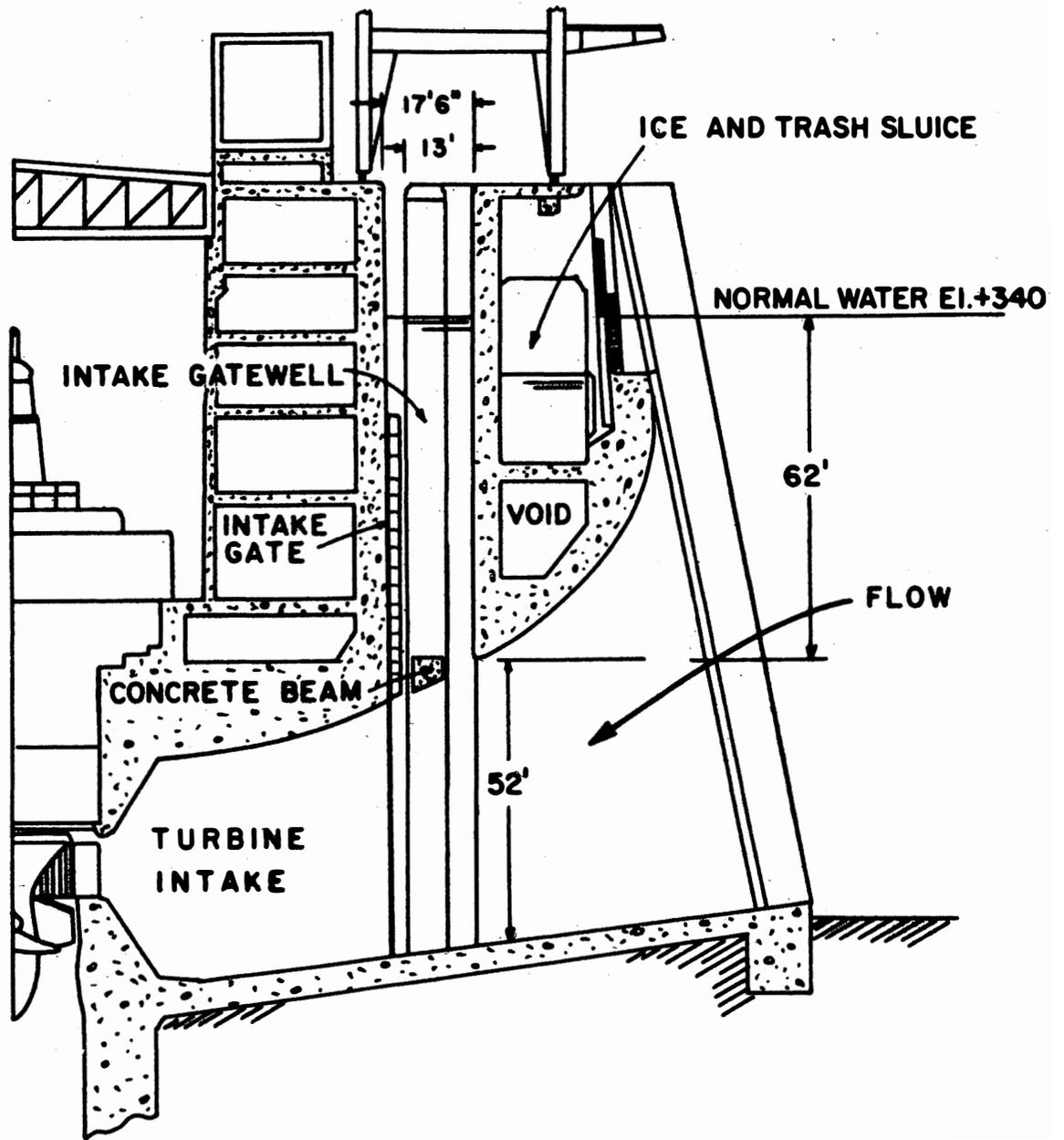


Figure 3.--Turbine intake and gatewell at McNary Dam (cross section).

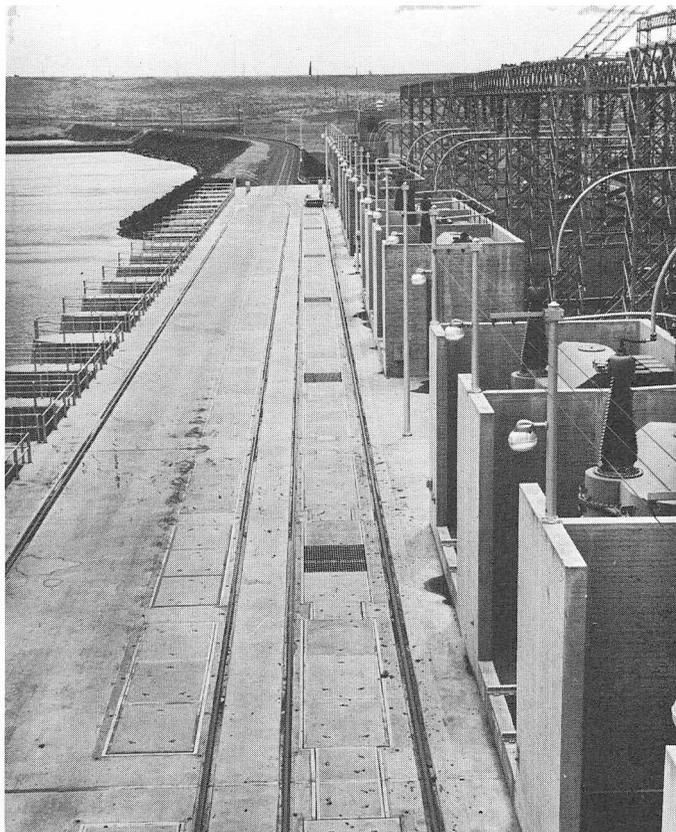


Figure 4.--Concrete slab and steel grill on intake gatewells at McNary Dam.

Methods.--The dip net used at Bonneville Dam in 1959 to obtain fish from gatewells was employed at McNary Dam. As the McNary gatewells were wider than at Bonneville, the efficiency of the dip net for removing all fish was probably reduced. No measure of the efficiency was made.

The gatewell was fished until less than 50 fish were caught in one sample. Except for three cases, a minimum of three samples were obtained in each gatewell. The exceptions occurred when less than 50 fish were captured in the initial two hauls.

Fish were removed from 25 of the 42 gatewells at McNary during the period beginning May 15 and ending May 28. Captured fish were immediately placed in receptacles of water, counted, and released into the ice and trash sluiceway. Because very few fish-of-the-year were found, no effort was made to separate the migrants by age groups. Individual fish were not identified by species, but chinook (*Oncorhynchus tshawytscha*) and sockeye (*O. nerka*) salmon, and steelhead trout (*Salmo gairdneri*) were represented in the catches.

RESULTS

Bonneville Dam

Table 1 shows the daily catch record of fish of the year and of fish over a year old from wells 3-B and 3-C. In the first 5 days, between May 7 and 11, 6,438 fish were removed from gatewell 3-B. After May 11, it appears that fewer fish entered the gatewell since only 87 fish were removed on May 12, and a total of only 520 fish removed during the 7-day period from May 12 to May 18. On May 12, immediately following the first reduced catch in gatewell 3-B, 368 fish were removed from gatewell 3-C.

The daily removal of fish from gatewell 3-B did not allow fish to accumulate. Therefore, the number of fish removed are interpreted to be a general indication of the number entering gatewell B for the periods of time between samples (about 20 to 24 hours). If the fish entered well 3-C at the same rate as well B, the data suggest a high rate of exit.

McNary Dam

A total of 9,378 fingerling salmonids were removed from 25 intake gatewells at McNary Dam. A majority of these gatewells were fished only once over a 13-day period.

A comparison of the number of fish recovered from sets of three adjacent gatewells (A, B, and C) on the same day (May 27) in turbine units 1, 4, and 10 indicate that the B gatewells contained significantly more fish than the adjacent A and C gatewells (table 2).

Table 1.--Number of fingerlings removed from adjacent intake gatewells of Bonneville Dam between May 7 and May 18, 1959.

Date (1959)	Gatewell 3-B		Gatewell 3-C	
	0-year	1+ year	0-year	1+ year
May 7	1309	349	<u>1/</u>	<u>1/</u>
8	2143	188	<u>1/</u>	<u>1/</u>
9	873	70	<u>1/</u>	<u>1/</u>
10	<u>1/</u>	<u>1/</u>	<u>1/</u>	<u>1/</u>
11	1432	74	<u>1/</u>	<u>1/</u>
12	70	17	227	141
13	62	41	<u>1/</u>	<u>1/</u>
14	63	54	<u>1/</u>	<u>1/</u>
15	45	30	91	51
16	<u>1/</u>	<u>1/</u>	<u>1/</u>	<u>1/</u>
17	<u>1/</u>	<u>1/</u>	<u>1/</u>	<u>1/</u>
18	73	65	<u>1/</u>	<u>1/</u>
Total	6070	888	318	192

1/ Gatewell not sampled.

Initial catches of fish made over a 4- to 5-day period in adjacent gatewells of units 3, 6, and 12 indicate that the B gatewells of these units also contained significantly more fish than the adjacent A and C gatewells. However, changes may have occurred in the gatewells during this time period. In addition, the numbers of fish in gatewells 6-A, 6-B, and 6-C may have been influenced by light experiments (Fields, 1962) in the forebay immediately upstream of 6-B.

Table 2.--Number of fish removed from turbine intake gatewells during initial sampling at McNary Dam between May 15 and 27, 1961.

Day of initial catch (May 1961)	Turbine no.	Gatewell		
		A	B	C
15	6	<u>1</u> /	1643 ² /	
16	12	<u>1</u> /	<u>1</u> /	4 <u>1</u> /
17	6	<u>1</u> /	<u>1</u> /	45 ² /
20	6	77 ² /	<u>1</u> /	<u>1</u> /
20	3	<u>1</u> /	2159	<u>1</u> /
21	12	2	245	<u>1</u> /
21	3	58	<u>1</u> /	<u>1</u> /
27	1	38	272	61
27	4	17	713	32
27	10	21	621	11

1/ Gatewell not fished.

2/ Numbers of fish may have been influenced by light guiding experiments upstream from gatewell 6-B (Fields, 1962).

The difference in numbers of fish between B gatewells and the adjacent A and C wells may be partially explained by the condition of the fish found in them. All B wells contained thin and apparently starved fish whereas no obviously thin fish were noted in the A and C wells. This suggests that fish remained longer in the B wells. One of the physical differences between gatewells at McNary Dam is the amount of light within the wells. The steel grill on B wells admitted more light than the covers on the A or C wells.

From the numbers of fish captured in each B gatewell across the powerhouse section, it appears that the wells in the center portion accumulated more fish (fig. 5) than the end portions during this experiment.

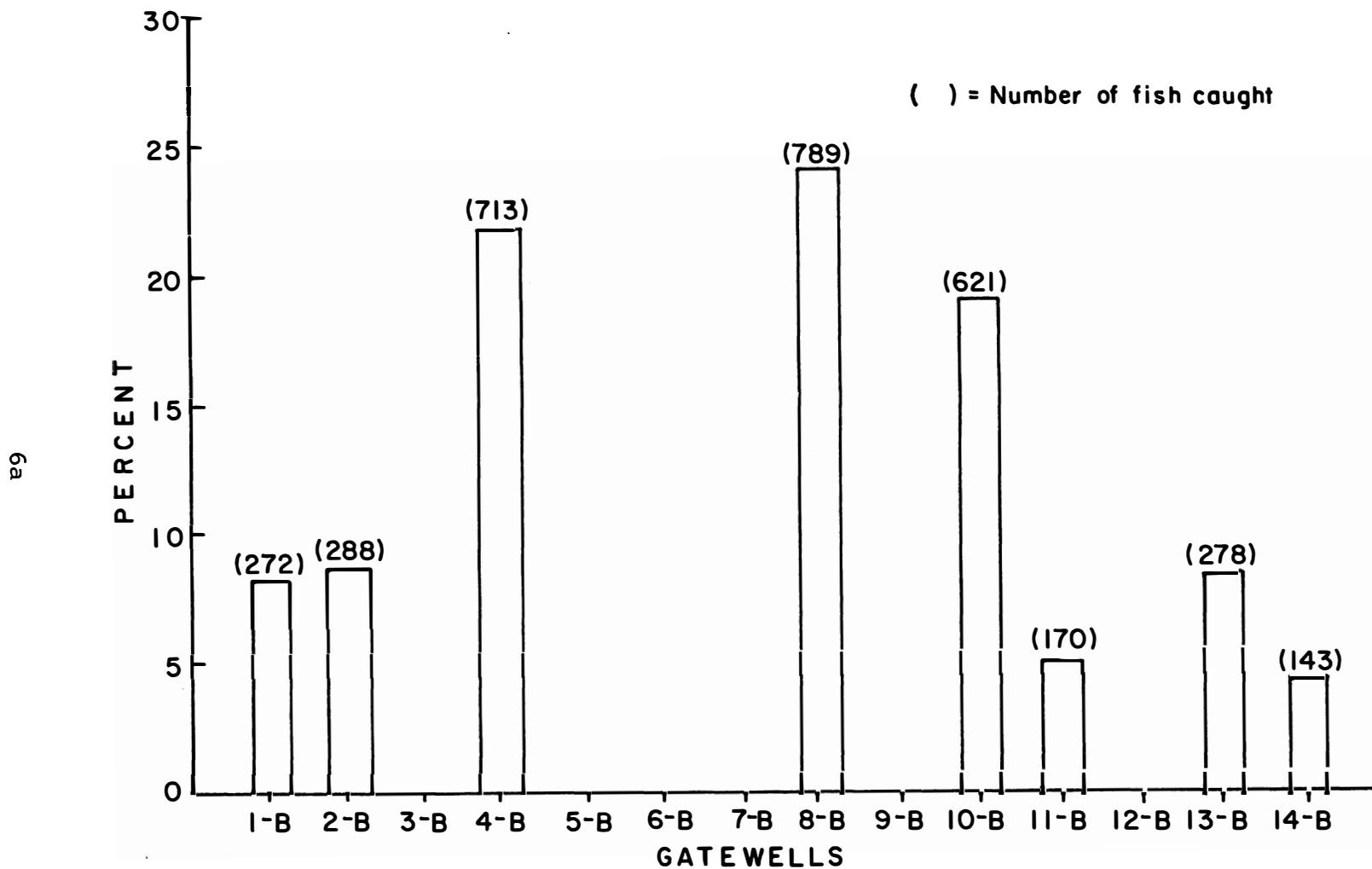


Figure 5.--Catches of fingerling salmonids made in B gatewells in 2-day period showing distribution of fish across powerhouse section.

DISCUSSION

The natural tendency of fish to enter intake gatewells provides an opportunity for attempts to bypass fingerlings around turbines. The number of fingerlings entering gatewells might be increased when more information on this behavior pattern is obtained. A research program to utilize gatewells for collecting and diverting fish around turbines would include experiments to: (1) Enhance the percentage of fingerlings that enter gatewells, (2) prevent fish from escaping from gatewells into the turbine intakes, and (3) divert fish from the gatewells into a transportation system such as the ice and trash sluiceways.

Fingerling salmonids were removed from turbine intake gatewells at Bonneville Dam in 1959 to obtain information on the size of the fish concentrations and clues to factors that may influence their accumulation in these areas. Fish were removed daily from one gatewell immediately following the release of 44 million hatchery fish into the Bonneville forebay. A total of 6,438 fish were removed from that gatewell (3-B) over a 5-day period.

In 1961 9,378 fingerling salmonids were removed from 25 intake gatewells at McNary Dam. Results indicate that for each set of three gatewells (A, B, and C), the center, or B gatewell, contained significantly more fish than the adjacent A and C gatewells. An undetermined percentage of fish from the B wells were thin and emaciated, suggesting a possible delay and accumulation, while none from the A and C wells were found in a similar condition. One factor common to only the B gatewells at McNary was the steel grill cover which allowed light from overhead lamps to penetrate into the wells during the night, and daylight to penetrate during the day. Initial catches from 8 of the 14 B gatewells were larger in wells nearest the center of the powerhouse.

LITERATURE CITED

- Fields, Paul E., Richard Gregory, Richard Lichtenheld, Richard Snyder, and Don Kenoyer.
1962. Guiding migrant salmonids. University of Washington, College of Fisheries, Contribution No. 139 (March), p. 19-22.