PROGRESS REPORT

SURVIVAL OF FINGERLINGS PASSING THROUGH A PERFORATED BULKHEAD AND MODIFIED SPILLWAY AT LOWER MONUMENTAL DAM

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By

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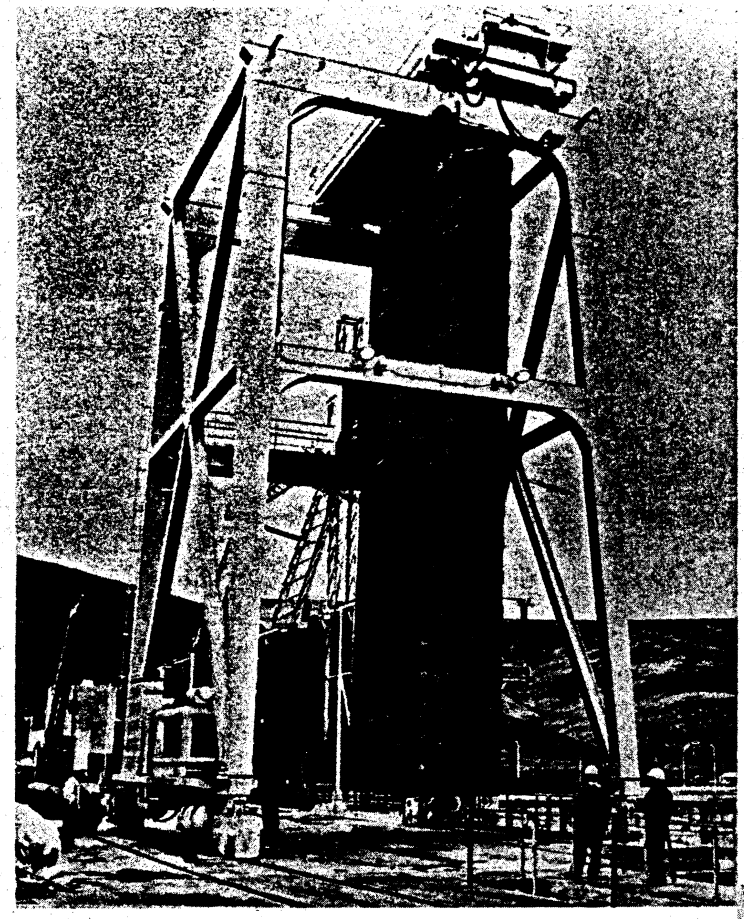
INTRODUCTION

In seeking relief from high nitrogen levels which are believed to be instrumental in recent estimates of severe losses of young salmon and trout in the Snake River, the U. S. Army Corps of Engineers installed perforated bulkheads (fig. 1) in intakes of empty turbine bays of dams in the lower river. Prototype tests previously run at Little Goose indicated that water could be passed through these structures with little increase in nitrogen levels. This implied that up to 65,000 c.f.s. could be diverted from spillways, thus reducing the volume of spill and the level of nitrogen supersaturation caused by plunging flows over the spillway.

The Corps also modified a spillway at Lower Monumental Dam for prototype tests to determine the effectiveness of this modification in reducing nitrogen levels during periods of spilling (fig. 2). Hydraulic model studies indicated that a deflector with three rows of dentates could pass the greatest amount of water without causing significant increases in nitrogen levels. Essentially, the deflector is an addition to the spillway ogee that changes the direction of spilling water from plunging to horizontal; this tends to prevent supersaturation by reducing the pressure gradient that forces gases into solution.



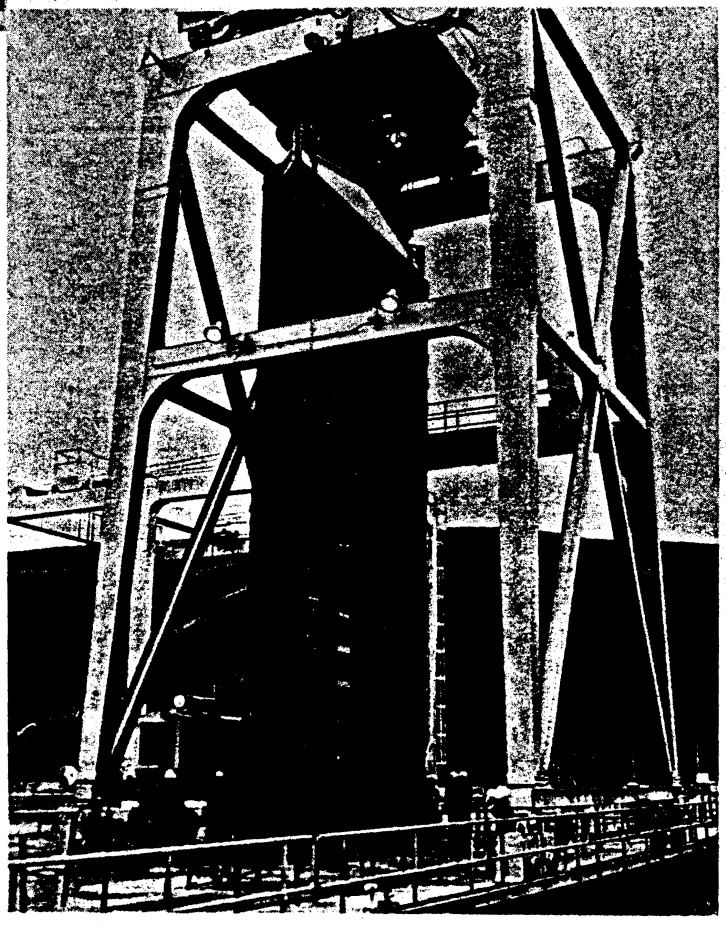


Figure 1.--Perforated bulkhead gate. Upstream view (above) and downstream view (right).

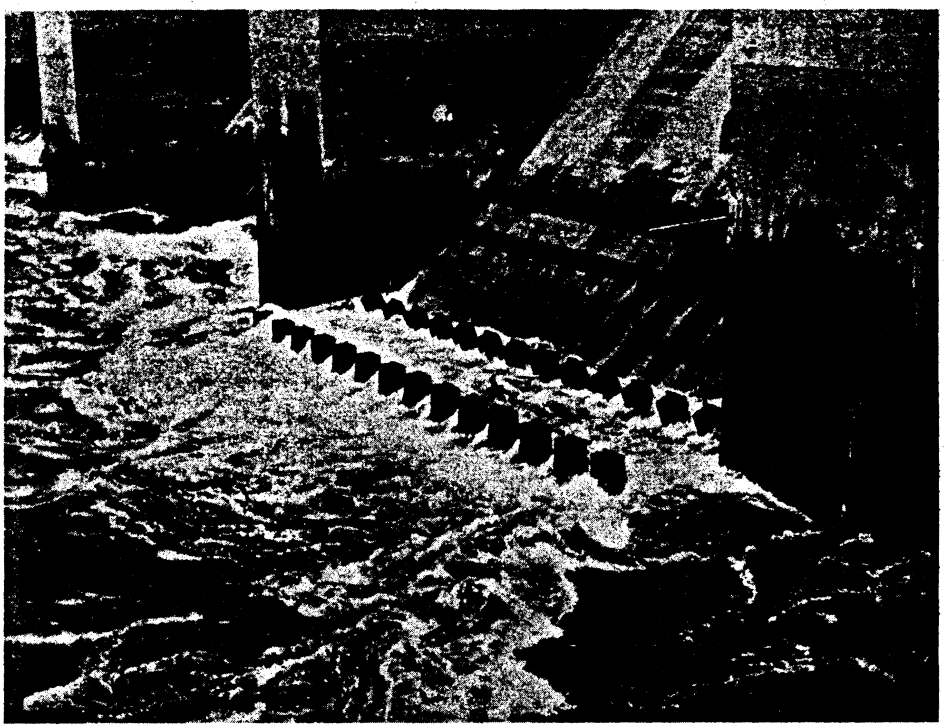


Figure 2.--Flow deflector with dentates in spillway bay at Lower Monumental Dam.

Hydraulic structures designed to ameliorate the problem of nitrogen supersaturation, however, could create problems for migrating fish which may override the intended benefits. In this case there was reason to believe that the structures installed by the Corps might cause death or injury to young fish as they migrate downstream through the structures toward the sea. To investigate the effects of the bulkhead and flow deflector on juvenile salmonids, the National Marine Fisheries Service, under a two-year contract to the Corps of Engineers, began an evaluation of fingerling passage and survival through the bulkhead and flow deflector. This report summarizes the results of tests run the first year in late April and early May 1972.

Experiments

Two experiments were conducted with about equal numbers of test and control fish released upstream and downstream of the structures. Survivors from both groups were recovered from the fingerling bypass system at Ice Harbor Dam and were dipnetted for inspection from gatewells of McNary Dam. Estimates of survival were calculated from the change in ratio of the numbers of test to control fish from the time of release to the time of recovery.

Juvenile fall chinook salmon were used in both experiments; they were progeny of adults that returned to the Klickitat Fish

Cultural Station and were reared by the Washington Department of Fisheries at their Ringold Springs Fish-Rearing Station. These fish ranged in size from 3-1/2 to 5 inches when used in the experiments. All fish were transported to the NMFS fish-holding facility at Ice Harbor Dam where they were marked with cold brands. Each group of fish received a distinguishing brand. After being marked they were transferred to tank trucks and transported to Lower Monumental Dam; here river water was circulated through the tanks for at least eight hours before the fish were released. At the start of a test the fish and water were drained from the tanks through a 3-inch hose.

Release Schedule

For tests on the perforated bulkhead, fish were released simultaneously above and below the structure (fig. 3). The upstream hose through which test fish were released terminated about 30 feet upstream from the bulkhead in intake B of skeleton bay No. 4. Control fish were released through a hose that terminated immediately downstream from the upwelling formed by the discharge from operating turbine No. 2. The fish were released below the turbine rather than below the skeleton unit because the discharge from the skeleton unit was characterized by a strong side current which could have carried fish into the spillway tailrace area. From past experience we know that fish released in the front roll have a higher survival rate than those

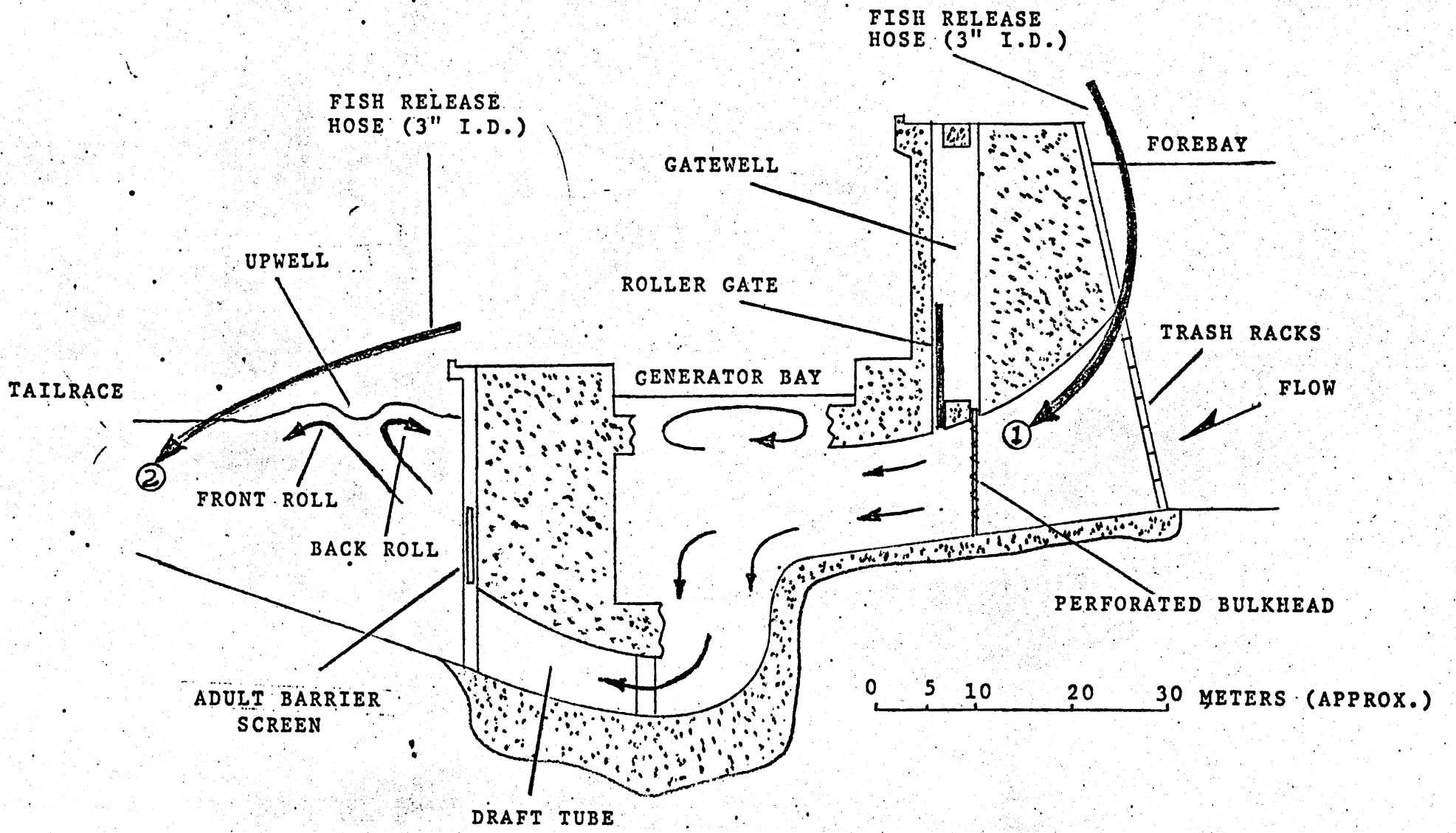


Figure 3.--Typical skeleton bay at Lower Monumental Dam showing approximate upstream (1) and downstream (2) release points to measure survival of juvenile salmon passing through perforated bulkhead.

entering slack water areas where predation is high and downstream movement is delayed. About 60,000 fish (30,000 test and 30,000 control) were used in each of the three releases.

For experiments to evaluate the flow deflector installed in spillway bay No. 2, fish were released at two spillway discharges - 13,100 and 2,800 c.f.s. The test fish were released about 20 feet upstream from the tainter gate and 12 feet above the ogee sill (fig. 4). Control fish were released through a hose that terminated 5 feet above the surface of the tailrace and 75 feet downstream near the center of the spill. Each of three tests involved a release of about 90,000 fish: 30,000 test fish were released in flows of 13,000 c.f.s. and an additional 30,000 at 2,800 c.f.s.; a single control release was made at the 2,800 c.f.s. discharge.

Survival of Fish Passing Through Perforated Bulkhead

Table 1 presents the number of fish recovered at each dam for each release and the averaged data for the perforated bulkhead experiment. Figure 5 presents these data in graphic form for recoveries at Ice Harbor and McNary Dams. Analysis showed (1) that the recovery data for the two dams were statistically independent, and (2) that the survivors from both test and control groups were equally distributed. We therefore combined the recovery data from both dams for further analysis (fig. 6).

From analysis of the combined data, we can be 99 percent confident that fish passing through the perforated bulkhead and

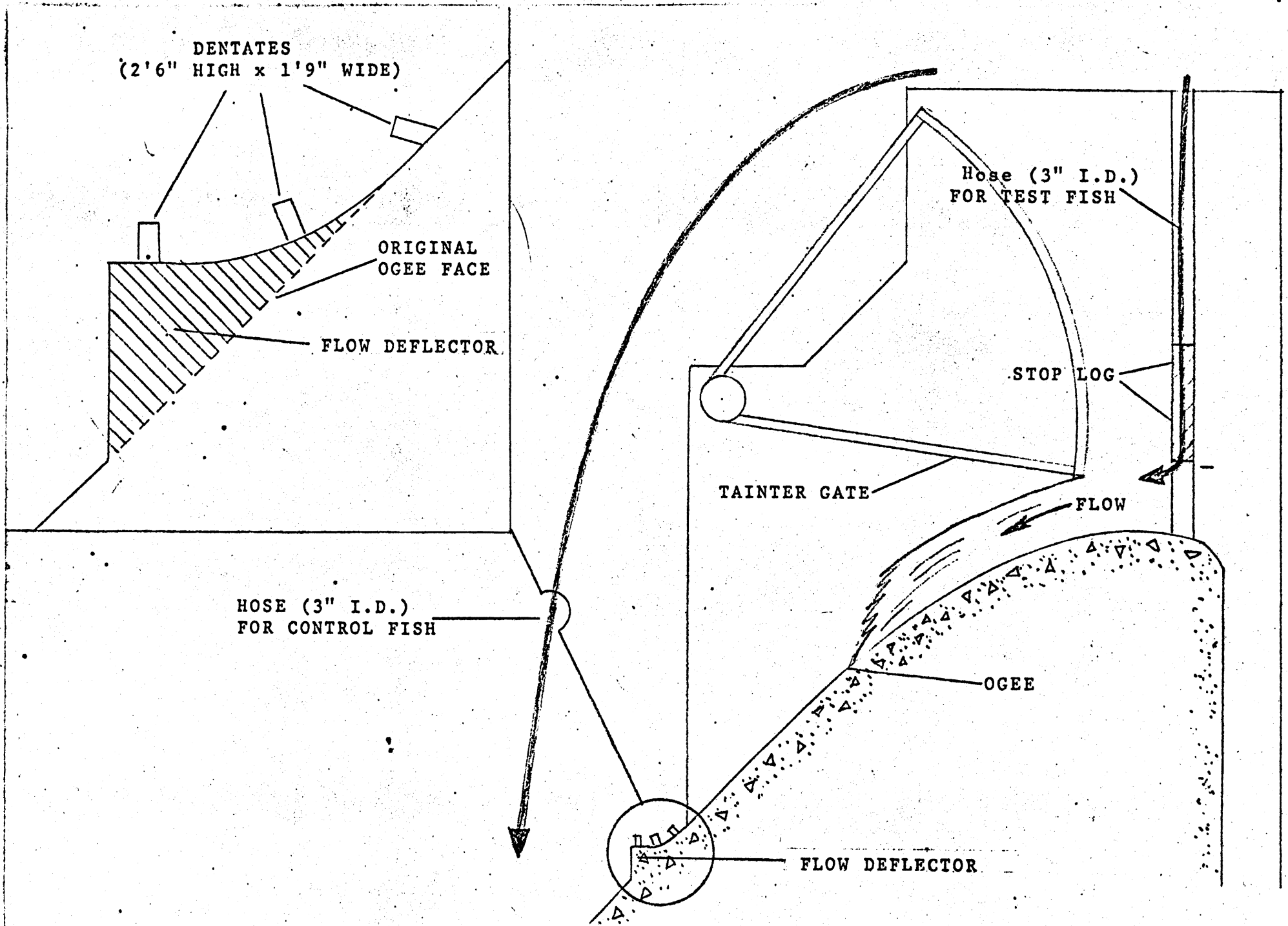


Figure 4. -- Spillway Bay No. 2, Lower Monumental Dam, equipped with experimental flow deflector for hydraulic and biological evaluation.

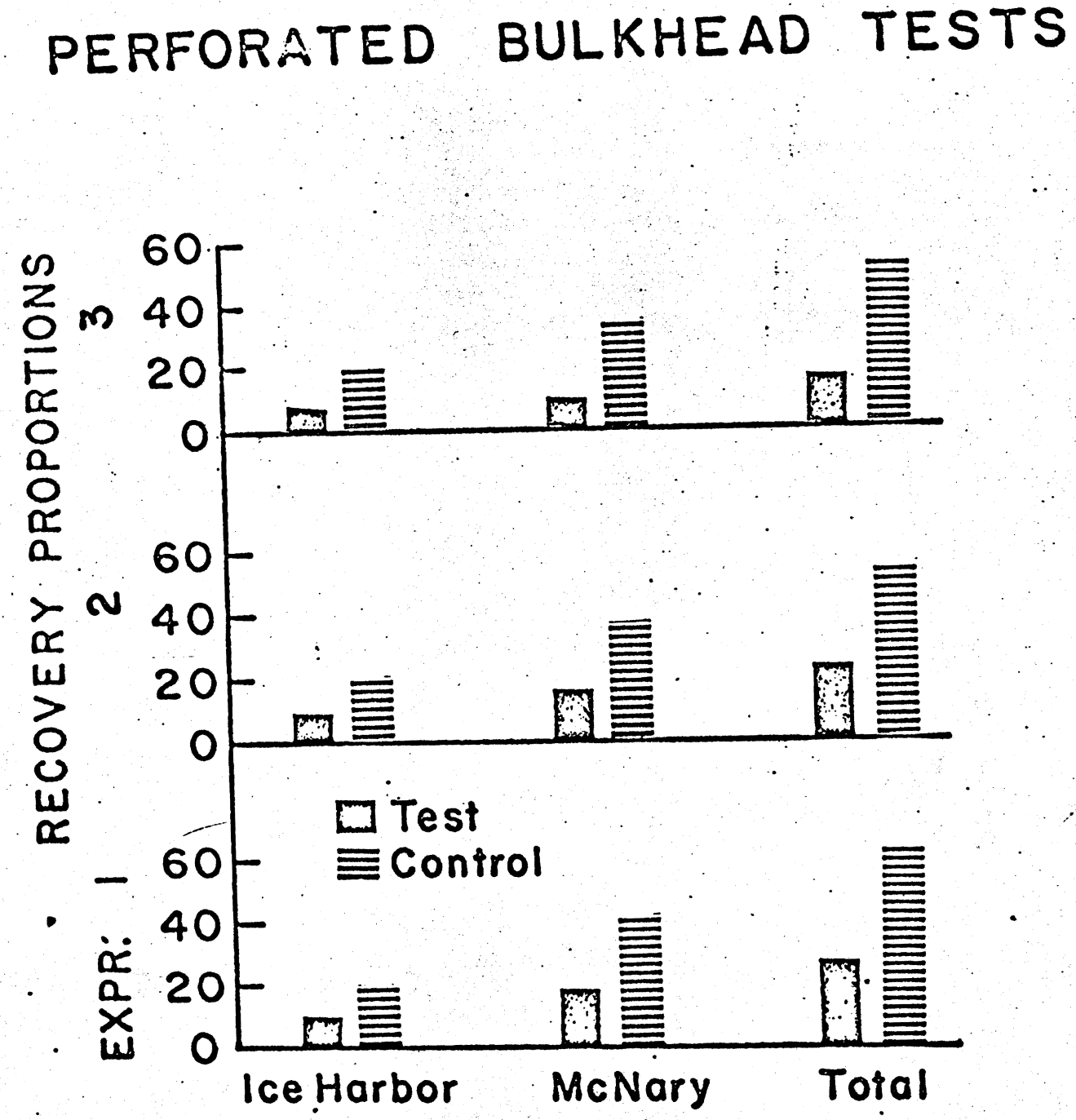


Figure 5.—Relative recovery of test and control fall chinook fingerlings released at Lower Monumental Dam during perforated bulkhead study.

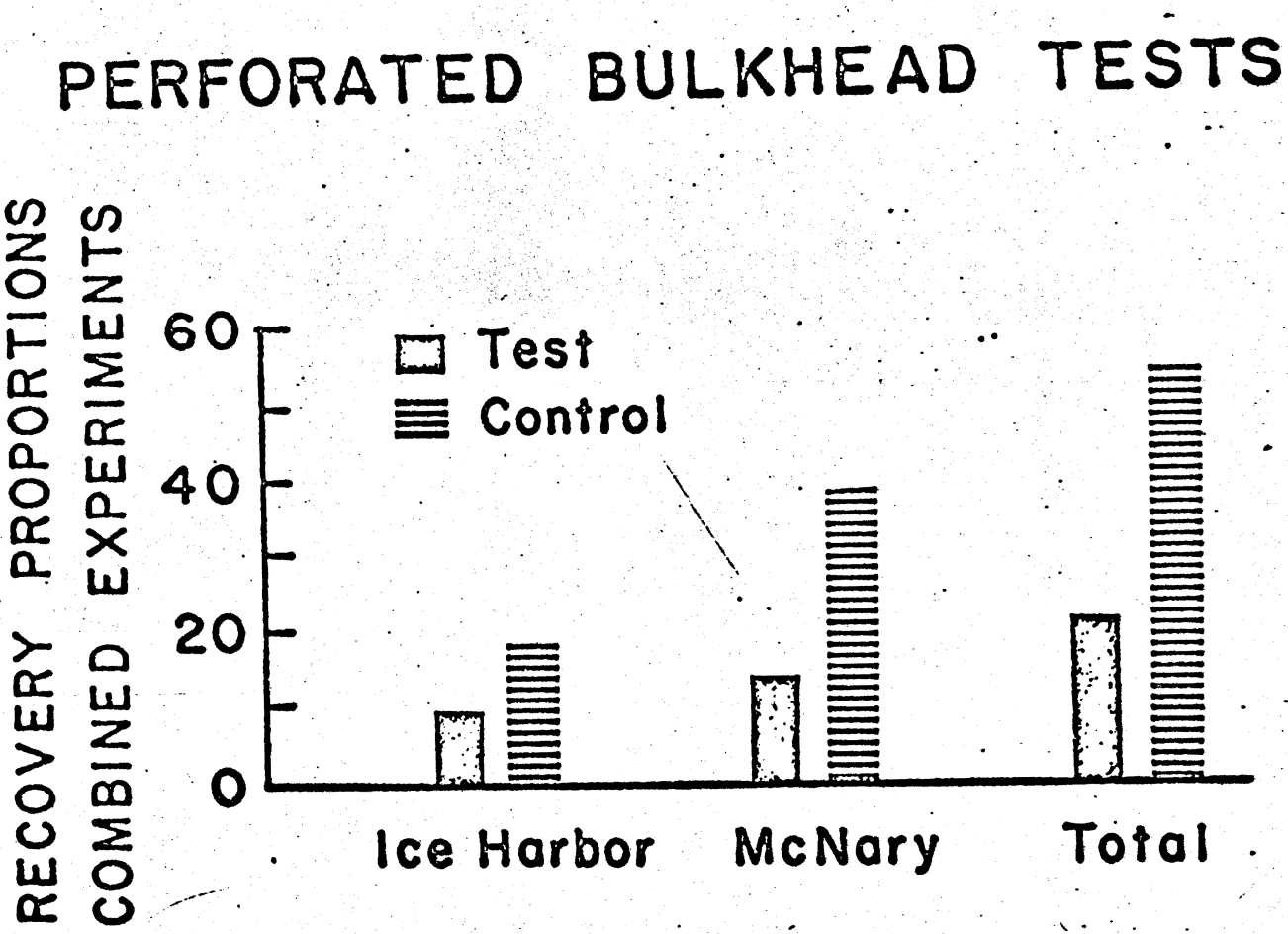


Figure 6.—Averaged data showing relative recovery of test and control fall chinook fingerlings released at Lower Monumental Dam during perforated bulkhead study.

associated water passages incurred a mortality of 50 percent or more.

The high mortality obtained from passage through the perforated bulkhead may be partly caused by factors other than those directly associated with the perforated bulkhead, i.e., shear planes and zones of reduced pressure. Potential extraneous causes of fish mortality may include (1) debris lodged in the perforations of the bulkhead, (2) exposed concrete reinforcing bars in the generator bays, and (3) predators, such as squawfish, in the slack water areas of the tailrace.

The design and dimensions of the perforations may tend to cause debris to lodge and accumulate in them. Whereas the minimum slot dimension of the perforations is 4 inches, that of the trash racks at the mouth of the intakes is 6 inches. Thus, debris that passes through the trash racks can be too large to pass through the perforations. Although inspection of the test bulkhead at the completion of the experiment showed no signs of accumulated debris, it is possible the perforations were backwashed and cleared of debris when flow through the intake was stopped to remove the bulkhead. Lowering the roller gate to stop flow through the intake could cause a momentary flow reversal through the perforations.

Exposed reinforcing bars in the generator bays of skeleton units is another potential source of fish mortality (figs. 7 and 8). The likelihood of young salmon striking these bars is not known and

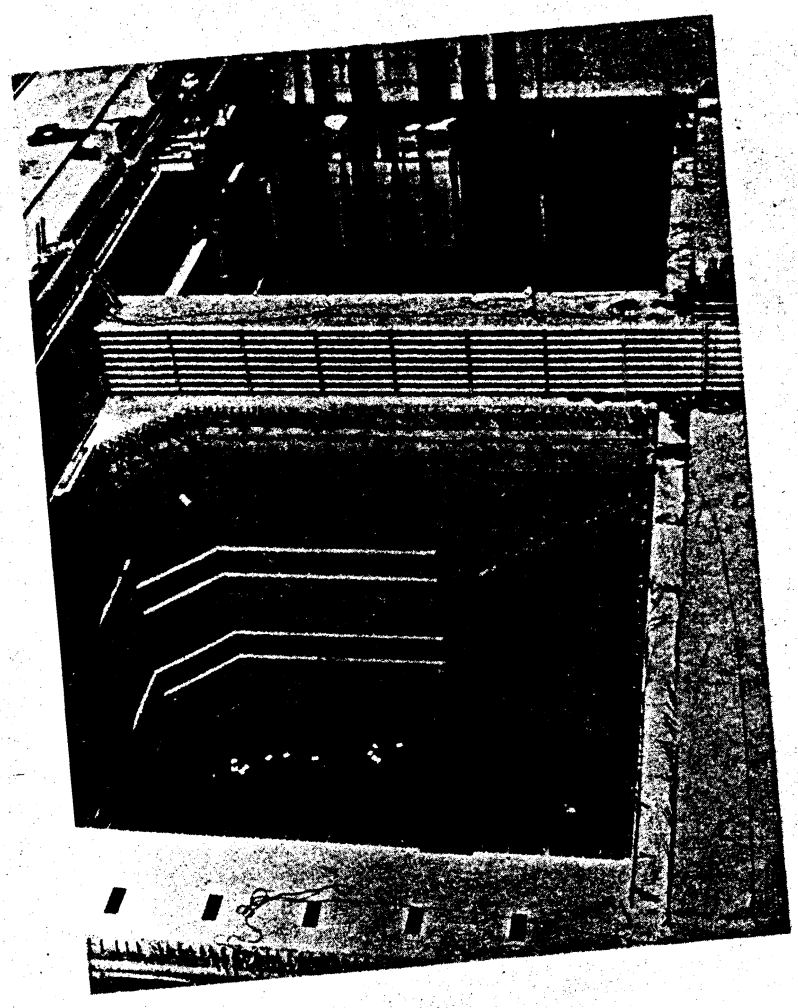


Figure 7.--Unwatered generator bay of skeleton unit at Lower Monumental Dam showing steel reinforcement bars.

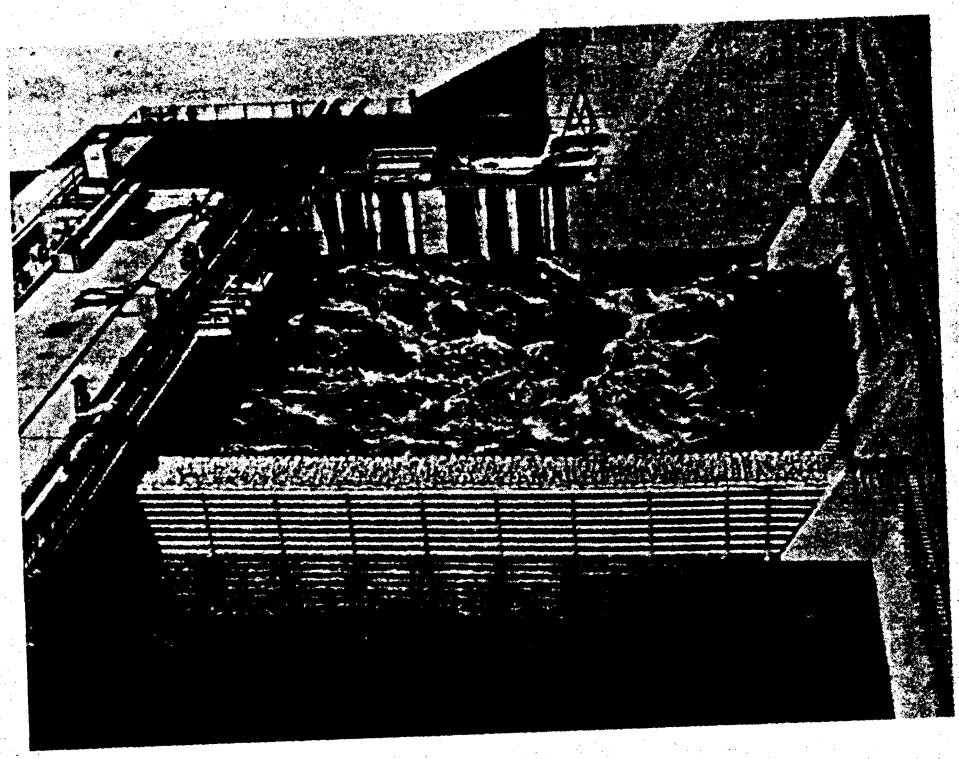


Figure 8.--Generator bay of skeleton unit during operation. Note that reinforcement bars are inundated.

would depend upon the velocity of the water circulating in the generator bay and the length of time fish spend in the bay before sounding to pass out through the draft tubes.

Squawfish predation in slack water areas immediately downstream of dams can be a significant source of mortality especially if many fish were stunned or injured but not killed by passage through the bulkhead. In 1968, research at Ice Harbor Dam showed that losses from predation on fish entering slack water areas can be as high as 32 percent. In the perforated bulkhead experiment, no effort was made to determine if significant numbers of squawfish were present or what percentage of young salmonids were exposed to the squawfish.

Survival of Fish Passing Through the Flow Deflector

Tables 2 and 3 present the number of fish recovered at each dam for each release and the averaged data for the flow deflector experiment. Figure 9 presents recoveries at Ice Harbor and McNary Dams in graphic form. Analysis showed (1) that the recovery data for the two dams were statistically independent, and (2) that the survivors from both the test and control groups were equally distributed. These data were again combined for the summary analysis (fig. 10).

It was apparent from inspection of the data that there was no significant difference between mortality in the two spillway discharges tested. We therefore combined the data for the two discharges for further analysis.

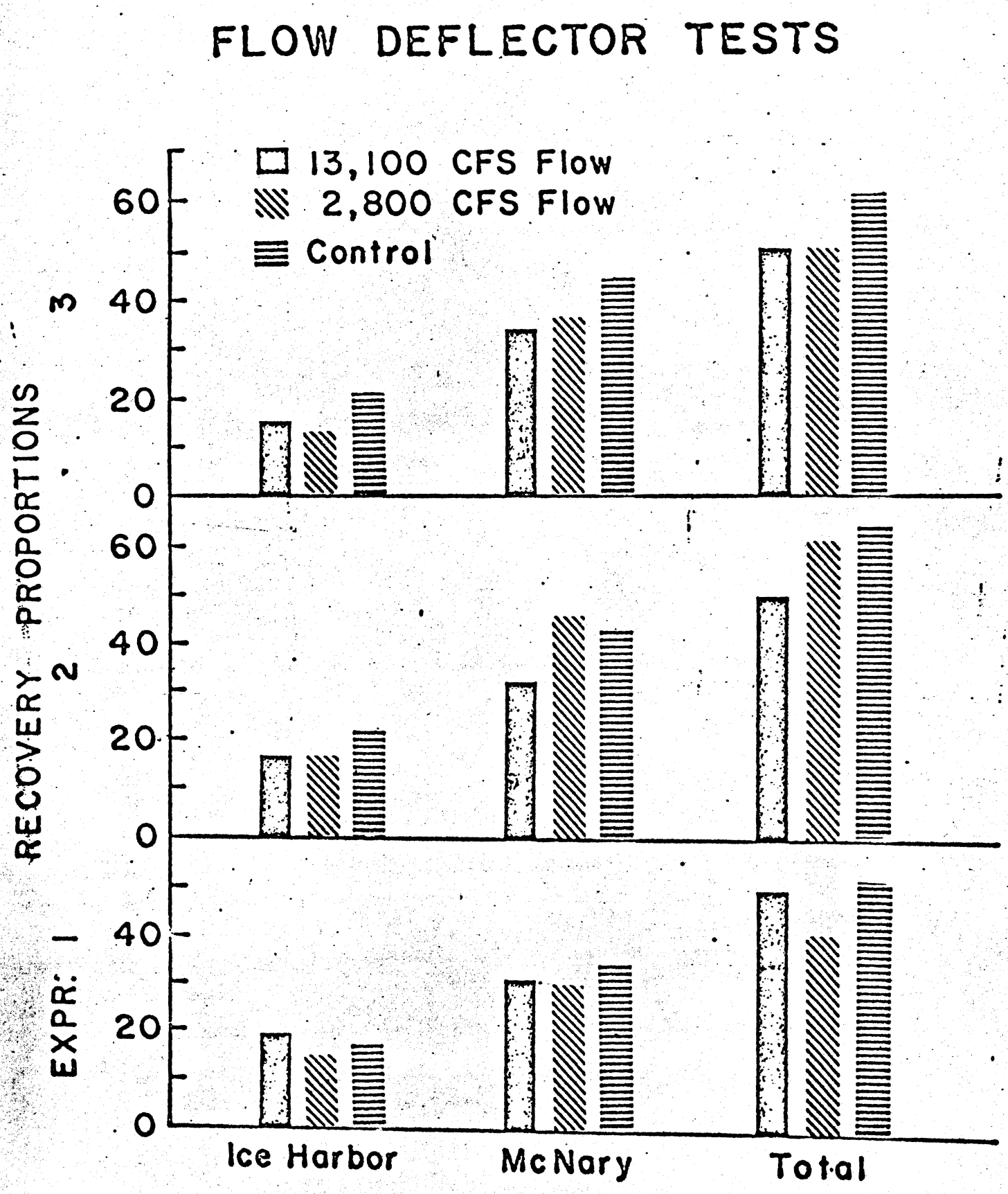


Figure 9.—Relative recovery of test and control fall chinook fingerlings released at Lower Monumental Dam during flow deflector studies.

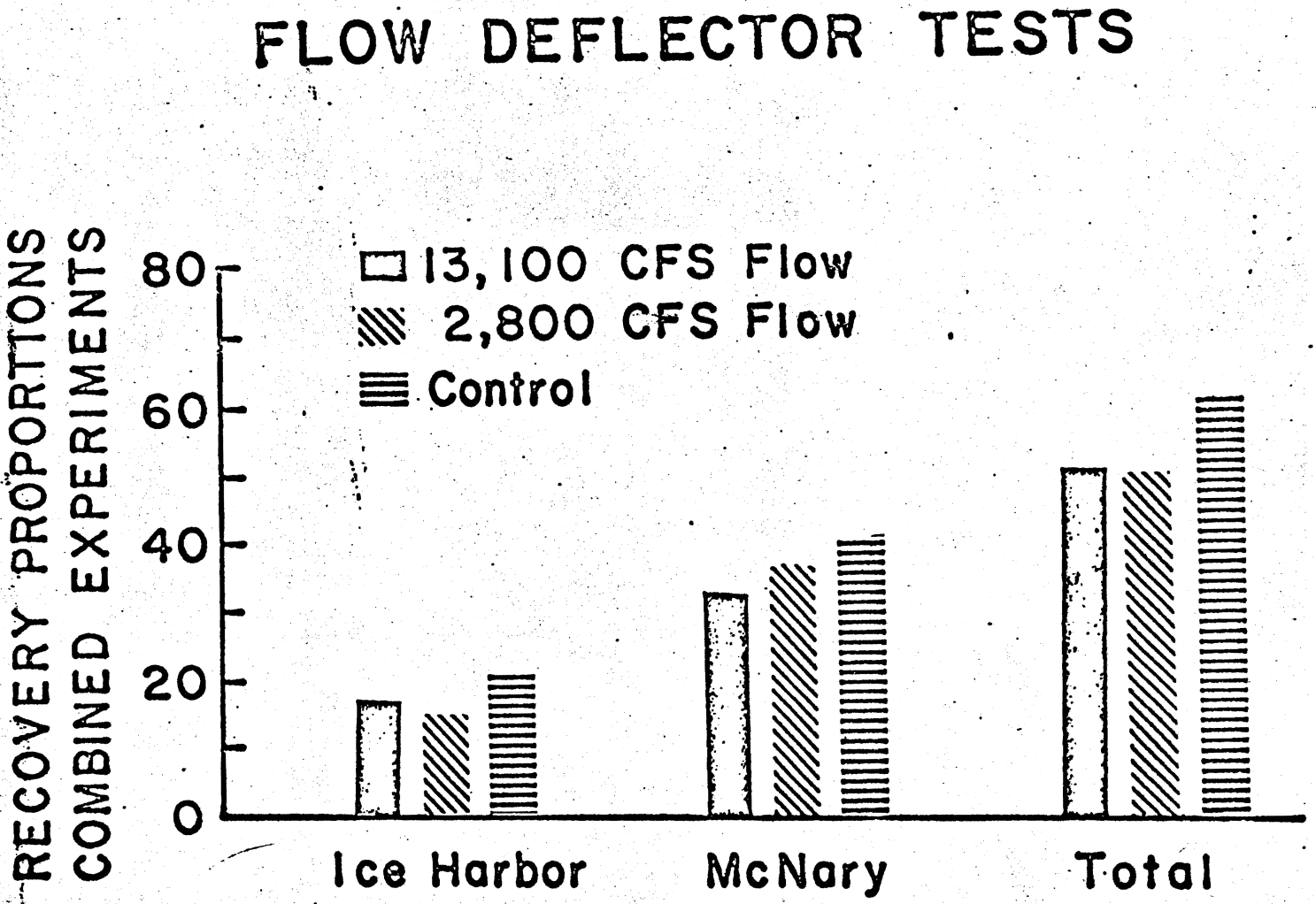


Figure 10.—Averaged data showing relative recovery of test and control fall chinook fingerlings released at Lower Monumental Dam during flow deflector studies.

The general level of mortality indicated by the ratio of test to control fish that were recovered was 15 percent. Analysis of the combined data showed, however, that the percent of fish recovered was loo low to detect a mortality of 15 percent or less at a confidence level greater than 80 percent.

Inspection of respective survival rates from the bulkhead and spillway tests suggests that survival was much higher through the flow deflector than through the perforated bulkhead and associated water passages. Direct comparison between relative survival in the flow deflector and perforated bulkhead tests requires that control releases from these tests be comparable. Analysis of the proportion and distribution of control recoveries from the respective tests showed that the rate of recapture was essentially the same and that these recoveries could therefore be combined. This then permitted a comparative analysis of test recoveries from bulkhead and spillway tests. The comparison showed that we could be 95 percent confident that survival of fish passing through the flow deflector was 30 percent or greater than that of fish passing through the perforated bulkhead. We concluded, therefore, that fish were much safer in passing through flow deflectors than through perforated bulkheads and the associated water passages.

Table 2.--Number and relative survival of test and control fall chinook fingerlin
released at Lower Monumental Dam during the flow deflector study. Spil
with deflector was discharging 2800 c.f.s.

Recovery sites	MARKED FISH RECOVERED AND SURVIVAL								
	Release no. 1			Release no. 2			Release no. 3		
	Test (no.)	Control (no.)	Relative survival (%)	Test (no.)	Control (no.)	Relative survival (%)	Test (no.)	Control (no.)	Relative survival (%)
Ice Harbor Dam	40	52	76.9	48	64	75.0	43	57	75.4
McNary Dam	84	101	83.2	128	124	103.2	119	151	78.8
Total	124	153	81.0	176	188	93.6	162	208	77.9

Table 1.--The number and relative survival of test and control fall chinook finge
released at Lower Monumental Dam during the perforated bulkhead study.

Recovery sites	MARKED FISH RECOVERED AND SURVIVAL									
	Release no. 1			Release no. 2			Release no. 3			
	Test (no.)	Control (no.)	Relative survival (%)	Test (no.)	Control (no.)	Relative survival (%)	Test (no.)	Control (no.)	Relative survival (%)	T (n
Ice Harbor Dam	28	58	48.3	29	51	56.9	19	50	38.0	
McNary Dam	48	118	40.7	57	102	55.9	26	103	25.2	1
Total	76	176	43.2	86	153	56.2	45	153	29.4	2

Table 3.--Number and relative survival of test and control fall chinook fingerling released at Lower Monumental Dam during flow deflector study. Spillway with deflector was discharging 13,100 c.f.s.

Recovery sites	MARKED FISH RECOVERED AND SURVIVAL									
	Release no. 1			Release no. 2			Release no. 3			
	Test (no.)	Control (no.)	Relative survival (%)	Test (no.)	Control (no.)	Relative survival (%)	Test (no.)	Control (no.)	Relative survival (%)	Te (n
Ice Harbor Dam	55	52	105.8	46	64	71.9	51	57	89.3	1
McNary Dam	93	101	92.1	96	124	77.4	115	151	76.2	3
Total	148	153	96.7	142	188	75.5	166	208	79.8	4