Underwater Separation of Juvenile Salmonids by Size

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ABSTRACT—Juvenile salmonids collected at dams on the Snake and Columbia Rivers require separation by size prior to transportation. A method of separating most of the smaller downstream migrating juvenile Pacific salmon, Oncorhynchus *spp., from the larger steelhead,* Salmo gairdneri, *at hydroelectric dams is described. The device utilizes behavioral responses that allow fish to remain in water during the separation process. This system is presently being installed at collector dams on the Columbia and Snake River.*

Introduction

Improving the survival of downstream migrating Pacific salmon, *Oncorhynchus* spp., and steelhead, *Salmo gairdneri*, is a primary goal of the research being conducted on the Snake and Columbia Rivers by the National Marine Fisheries Service. Beginning in 1971, transportation of these fish around low-head hydroelectric dams has been an important part of this effort. Transportation began by collecting the migrants at Little Goose Dam on the Snake River and hauling them by truck to release sites below Bonneville Dam, the dam furthest downstream on the Columbia (Fig. 1). This program was expanded to include Lower Granite Dam on the Snake River in 1975, and McNary Dam on the Columbia River in 1978. Barging as an additional means of transportation (McCabe et al., 1979) also began in 1978.

Each of these collector dams is equipped with a fish bypass system (Matthews et al., 1977; Smith and Farr, 1975) that diverts fish from turbine intakes to raceways where they are held for later transportation. Prior to entering the raceways, the fish must pass through a separator that grades them by size. The separator is necessary because of the stress placed on fish when different sizes are held together. Steelhead for example, are generally larger as smolts than chinook salmon, *Oncorhynchus tshawytscha*, or other salmon species. Recent data from stress studies conducted at Lower Granite and Little Goose Dams on the Snake River indicate that stress levels of chinook salmon held or transported alone were significantly lower than those of chinook salmon held or transported with steelhead[1]. Not only are most of the larger steelhead separated from the smaller salmon, but other large fish and floating debris are removed from the system and returned to the river.

Separation was originally accomplished by a dry-type separator (Fig. 2).

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[1]D. L. Park, G. M. Matthews, T. E. Ruehle, J. R. Smith, J. R. Harmon, B. H. Monk, and S. Achord. 1983. Evaluation of transportation and related research on Columbia and Snake Rivers, 1982. Unpubl. manuscr., 47 p., on file at the Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Prep. for U.S. Army Corps of Engineers, Portland, Oregon, under Contract DACW68-78-C-0051.)

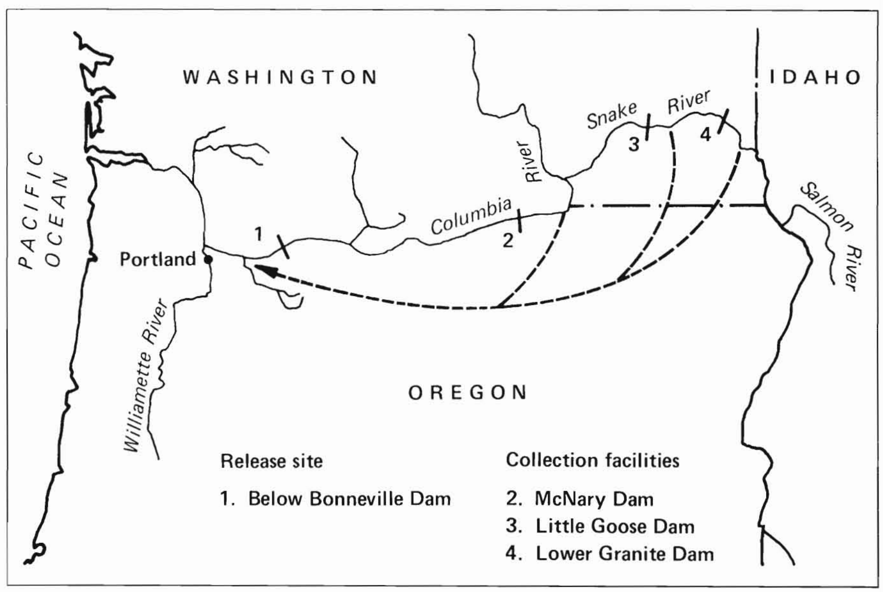

Figure 1.—Locations of fish collection facilities, transportation route, and release site.

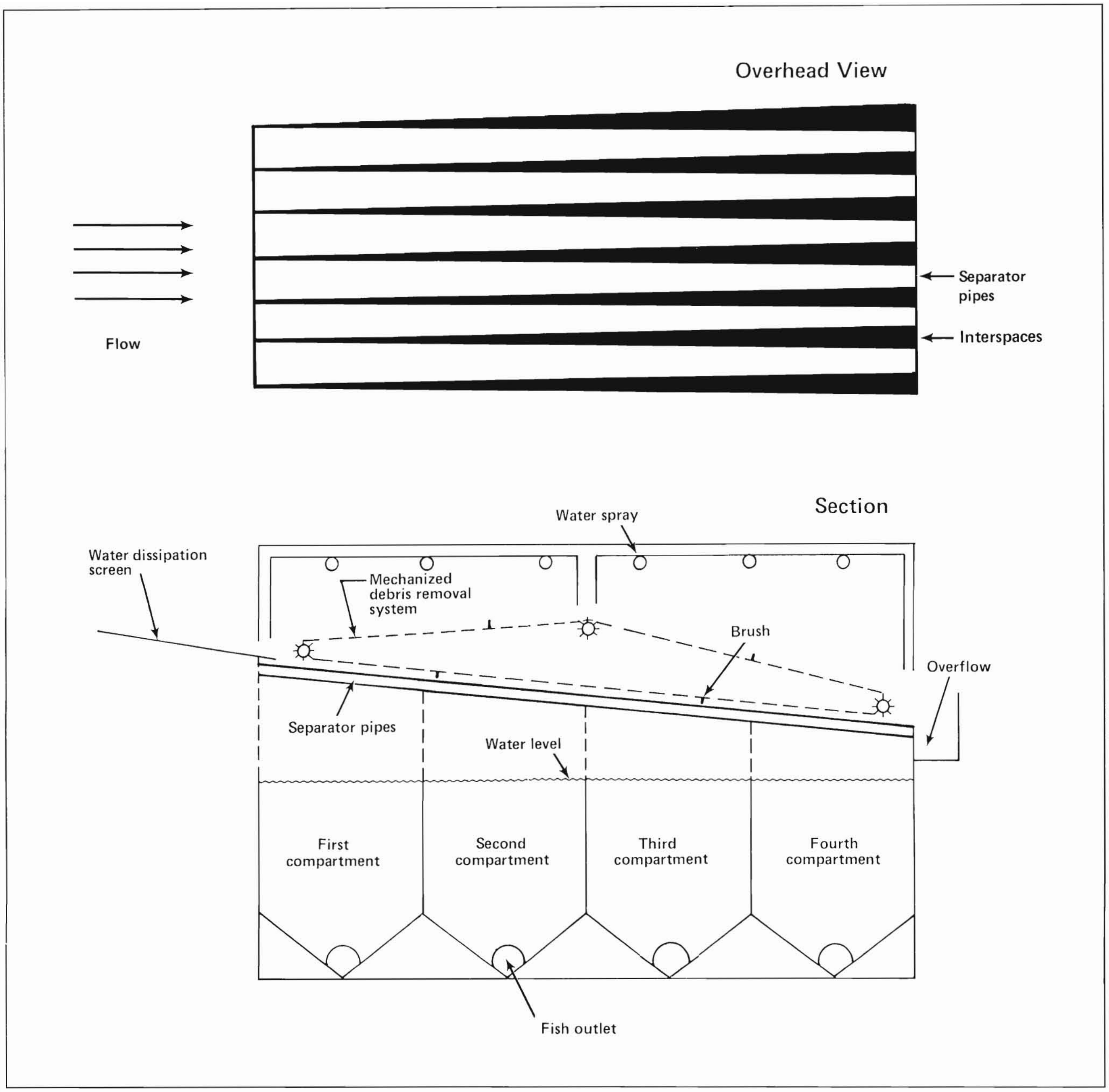

Figure 2.—Side view of dry-type separators at collection facilities prior to 1982.

These early models employed sloping pipes which fanned out so that the spaces between the pipes gradually increased. Fish separated simply by falling through the gaps formed by the diverging pipes, with the smallest fish entering the first compartment, slightly larger fish entering the next compartment, and so on. A fine spray of water was directed onto the pipes from above to aid movement of fish. Large fish and debris remained on top of the pipes to ultimately fall into a channel leading back to the river. A mechanized brush system was employed to aid movement of the large fish and debris.

Although effective as a separator, the dry-type separator was believed to cause its own stress by keeping the fish out of water during the separation process. The system also required constant attention

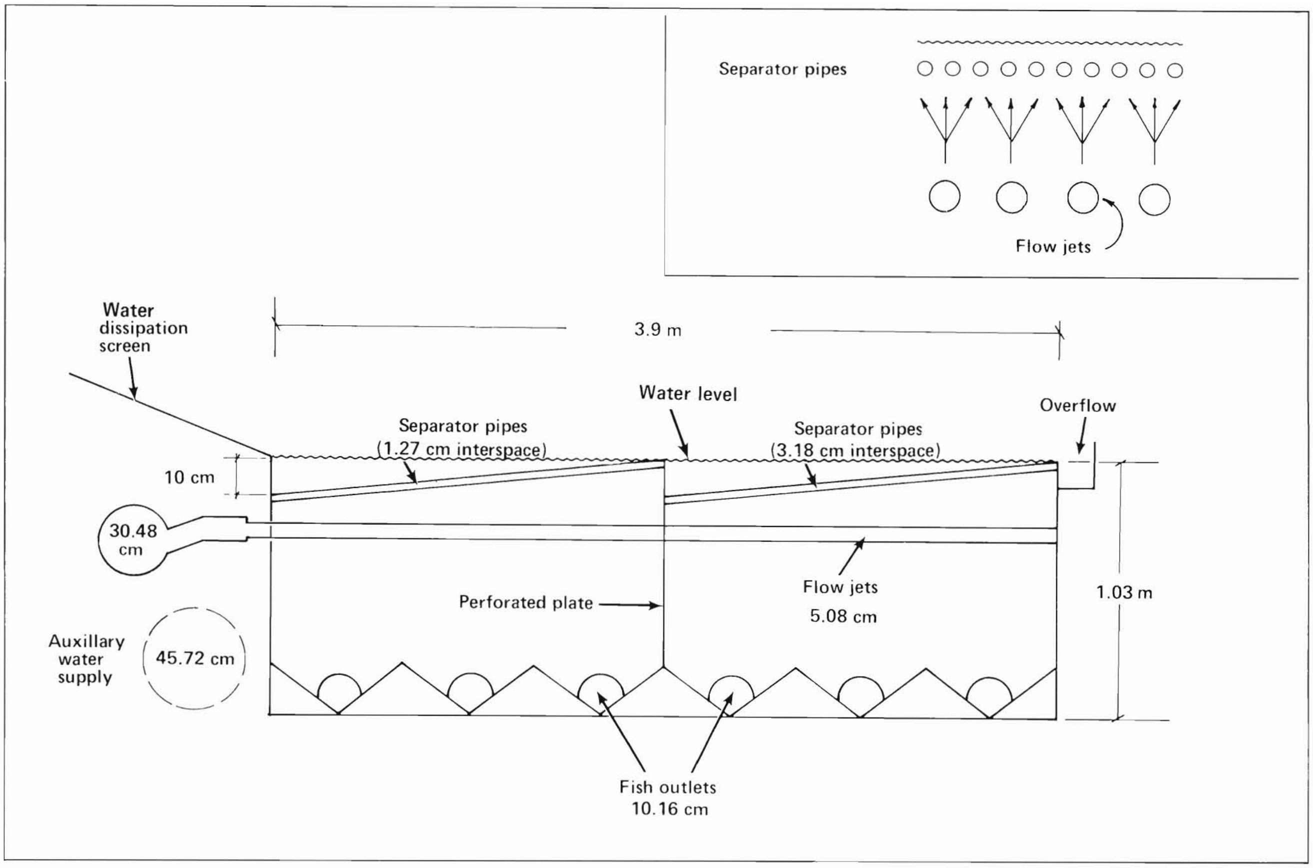

Figure 3.—Side view of prototype wet separator at Little Goose Dam, 1981.

to prevent debris from wedging between the separator pipes and possibly trapping fish. To alleviate stress on the fish, we developed a device for separating them underwater (wet-type). Initial model studies at Lower Granite Dam in 1980 were followed by tests of a prototype at Little Goose Dam in 1981. This report describes the wet separator and the results obtained during the model studies and tests.

Design and Evaluation of the Wet Separator

The prototype wet separator is illustrated in Figures 3 and 4. Two observed reactions of smolting salmonids were considered in its design: Their normal response to orient into a water flow and their tendency to sound, or dive, as an avoidance reaction. The stimulus for the first reaction is created by water jets flowing from holes in plastic pipes placed beneath the grid of submerged separator pipes in each compartment (Fig. 3 inset). This configuration produces an attraction flow toward the separator pipes.

Fingerlings moving through the bypass system enter the separator compartments at the surface after moving down an inclined screen. Their response to swim into the flow from the water jets, as well as their tendency to sound, allows smaller fish to pass volitionally through the spaces between the first set of separator pipes. Larger fish tend to move along these pipes and eventually enter the next compartment which has wider pipe spacing. If the fish are too large to pass through the pipes in the second compartment, they pass over the end of the separator and return to the river or, if desired, they can be diverted into a collection raceway.

Water flowing up from the jets tends to keep debris from accumulating on the separation pipes. It also contributes to the flow required to move floating debris along the surface of one compartment to the next and eventually off the end of the separator.

Individual pipes, each with air-operated gate valves and a maximum head of 60.96 cm (24 inches), supply water to the flow jets and the auxiliary water supply to the compartments. Flow jets consist of 0.476 cm (3/16-inch) holes at 10.16 cm (4-inch) centers in the top of 5.08 cm (2-inch) diameter pipes. These pipes are set at 15.24 cm (6-inch) intervals across the width of each compartment.

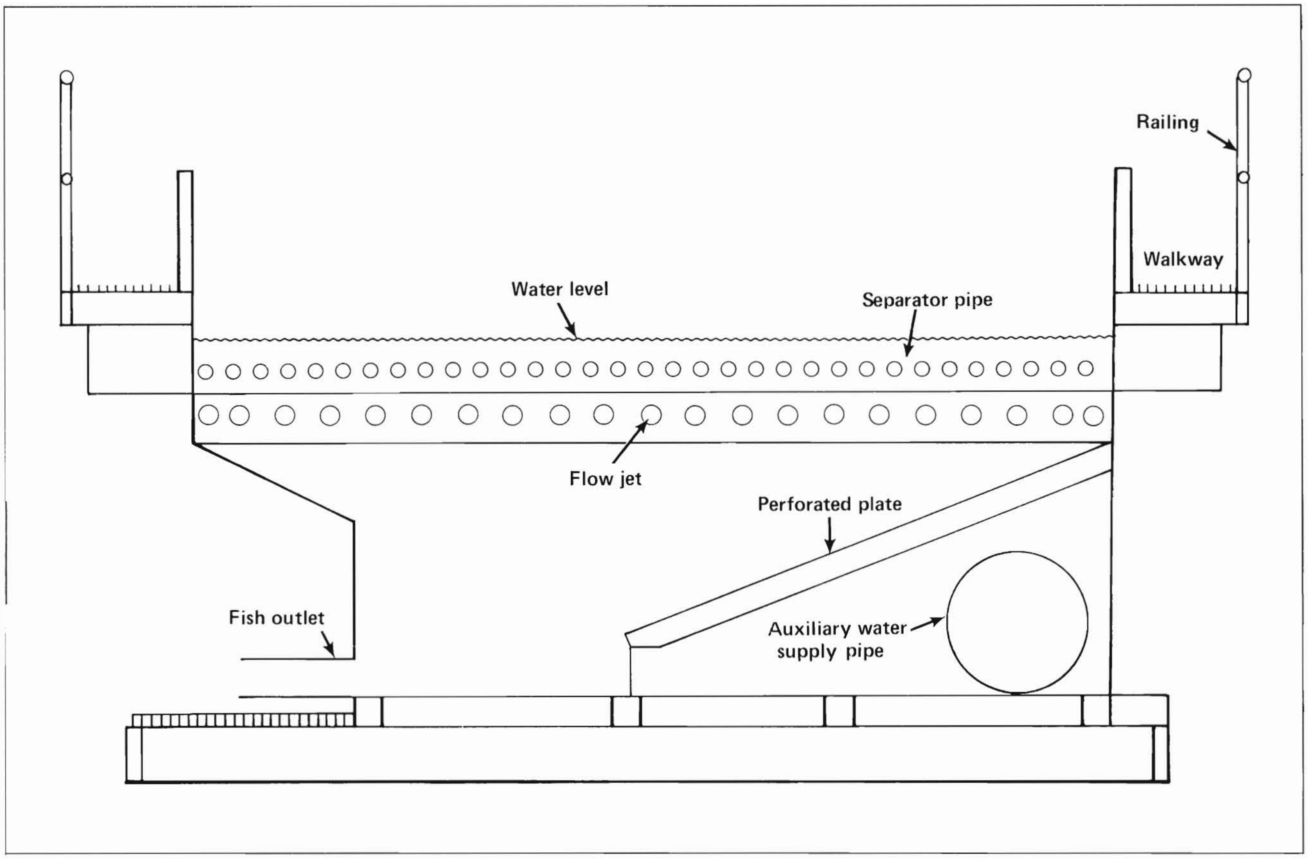

Figure 4.—End view of prototype wet separator at Little Goose Dam, 1981.

Separator pipes are metal tubes covered with plastic for smoothness (overall outside diameter = 2.22 cm or ⅞-inch). Initially, the interspace was 1.59 cm (⅝ inch) in the first compartment and 3.175 cm (1¼-inches) in the second. Later the interspace in the first compartment was reduced to 1.27 cm (½ inch) to minimize the numbers of small steelhead in the first compartment. Spacers are used to maintain gap size. Each grid of separator pipes is adjustable vertically to achieve the desired slope and water depth at the downstream end. Submergence ranged from about 10 cm at the upstream end of the separator pipes to approximately 1 cm at the downstream end.

Evaluation of both the model and prototype separators used river run fish passing through the fingerling bypasses and was based on counts of juvenile chinook salmon and steelhead observed in the two hoppers. There was effective separation in the model studies conducted at Lower Granite Dam, but separation with the prototype at Little Goose Dam was less effective.

At Lower Granite Dam, 90 percent of the smaller chinook salmon went into the first compartment and 88 percent of the steelhead into the second compartment[2]. During these tests, the quantity of water from the dissipation screens and flow jets remained constant, and the auxiliary water supply was adjusted so that a uniform flow occurred along the surface of the separator and off the downstream end.

At Little Goose Dam, correct separation of chinook salmon into the first compartment of the prototype separator averaged only 73 percent (range 60-82 percent) (Table 1). Lack of adequate control of the water flow into the prototype separator resulted in surges of water that carried chinook salmon beyond the first compartment and appeared to be the main reason for the poor separation. The prototype separator was actually part of the fish collection system at Little Goose Dam, and its water came from the upwell that dissipated energy from the bypass pipe

[2] D. L. Park, J. R. Smith, G. M. Matthews, T. E. Ruehle, J. R. Harmon, S. Achord, B. H. Monk, and M. H. Gessel. 1982. Transportation operations and research on the Snake and Columbia Rivers, 1981. Unpubl. manuscr., 34 p., on file at the Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Prep. for U.S. Army Corps of Engineers, Portland, Oregon, under Contract DACW68-78-C-0051.)

Table 1.—Numbers and percentages of juvenile chinook salmon that were separated with the prototype wet separator at Little Goose Dam, 1981.

Date	Number of fish collected: Total (24 h)	Second hopper	First hopper	Percentage separation
2 May	25,444	5,772	19,672	77.3
4 May	15,086	5,174	9.912	65.7
11 May	3,527	1,266	2,261	64.1
12 May	1,168	201	967	82.8
13 May	1,389	555	834	60.0
18 May	1,954	649	1,305	66.8
19 May[1]	2,472	485	1,987	80.4
20 May[1]	3,321	642	2,679	80.7
Total	54,361	14,744	39,617	
			Grand average =	72.9

[1]Gap size in first hopper was reduced from 1.59 to 1.27 cm to minimize numbers of small steelhead in the first hopper.

carrying fish and water from the forebay to the tailrace of the dam. Because of the short distance from the lower end of the bypass to the upwell, it was very difficult to smooth out flows, and there was considerable surging in the upwell that resulted in variable water volumes being delivered to the separator. At times, the dissipator screen and separator pipes were nearly dry, and at other times heavy surges of water carried both small and large fish completely across the separator.

Fish collection facilities at Little Goose Dam are being redesigned and relocated farther away from the dam. The new facilities will be similar to those at Lower Granite Dam with better control of water entering the separator. The better control should result in more uniform flows along the surface of the separator; therefore, the separation of chinook salmon from steelhead should be more effective than that measured in 1981.

Because of the importance of reducing stress on young salmon and the demonstrated potential of the wet separator, fishery agencies have requested that the U.S. Army Corps of Engineers incorporate effective wet separators in the fingerling collection systems at Lower Granite, Little Goose, and McNary Dams as quickly as possible.

Acknowledgments

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