The Effect of Denil Fishway Length on Passage of Some Nonsalmonid Fishes

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ABSTRACT—This paper documents the success of passage of some nonsalmonid fishes through Denil-type steeppass fishways of varying length and slope. Length ranged from 7.9 m (26 feet) to 20.1 m (66 feet), and slope ranged between 23.3 and 28.7 percent. American shad, Alosa sapidissima*; common carp,* Cyprinus carpio*; chiselmouth,* Acrocheilus alutaceus*; northern squawfish,* Ptychocheilus oregonensis*; Pacific lamprey,* Lampetra tridentata*; and suckers,* Catostomus *sp., were observed at Bonneville and McNary dams on the Columbia River and Little Goose Dam on the Snake River from 1971 to 1979. These fish were successful in ascending the 7.9 m (26-foot) fishway, and all but the common carp ascended the 15.2 m (50-foot) fishway. When the length was extended to 20.1 m (66 feet), no American shad or resident freshwater fish were observed ascending and passing through the Denil. Salmonids and Pacific lamprey, however, were able to successfully pass through all lengths of Denil fishways tested. These observations indicate that Denil ladders of selected length could be used, if desired, to pass salmonid fishes over small barriers while denying upstream access to certain unwanted nonsalmonids.*

Introduction

Steeppass Denil-type fishways have been used in Alaska and the Pacific Northwest to pass migrating adult salmonids over small barriers (Zeimer, 1962, 1965[1]; Washington Department of Fisheries, 1968). Denil fishways ranging from 9.1 m (30 feet) to 27.4 m (90 feet) long and angled at slopes of 19.7-26.2 percent have been used successfully to pass coho salmon, *Oncorhynchus kisutch*; sockeye salmon, *O. nerka*; and pink salmon, *O. gorbuscha,* in Alaska (Ziemer, 1962; footnote 1). The National Marine Fisheries Service (NMFS) has successfully used Denil fishways up to 20.1 m (66 feet) long to pass chinook salmon, *O. tshawytscha*; coho salmon; sockeye salmon; and steelhead, *Salmo gairdneri*, during experiments in the Columbia River Basin, (Ebel, 1974; Slatick, 1975; Slatick et al., 1975; Thompson[2]).

While the NMFS was testing Denil fishways of varying lengths to pass Pacific salmon, many observations were made on the passage of a variety of nonsalmonid fishes, including American shad, *Alosa sapidissima*; common carp, *Cyprinus carpio*; chiselmouth, *Acrocheilus alutaceus*; northern squawfish, *Ptychocheilus oregonensis*; Pacific lamprey, *Lampetra tridentata*; and suckers, *Catostomus* sp. This paper documents the varying degrees of passage success shown by the different species and points out a potential management implication.

Equipment and Procedures

The Denil fishway design used by the NMFS was a Model A described by Ziemer (1962). It was an aluminum flume made of sections that were 3.1 m (10 feet) long, 0.56 m (22 inches) wide, and 0.7 m (27 inches) high containing internal baffles for control of water velocity (Fig. 1). Clearance within the baffles (open area) was 0.36 m (14 inches) by 0.56 m (22 inches). Sections were bolted or welded together to achieve the desired length of ladder. The Denil fishways tested ranged from 7.9 m (26 feet) to 20.1 m (66 feet) long and were inclined at slopes of 23.3-28.7 percent, depending on the experimental site. During operation, the Denils were completely filled with water and carried a flow of approximately 0.16 m^3/second (5.5 $feet^3$/second).

During the experiments, Denils were installed in the regular fishways at Bonneville and McNary Dams on the Columbia River and at Little Goose Dam on the Snake River. At Bonneville Dam, Denil fishways were also operated in the Fisheries Engineering Research Laboratory (Slatick, 1975). Observations on the passage of nonsalmonid fishes occurred over an 8-year period, from 1971 to 1979. Most of the data were obtained between June and August each year when maximum numbers of resident and anadromous nonsalmonid fishes were in the fish ladders.

Observations

Resident freshwater fish observed in the fish ladders at Bonneville Dam

[1]Ziemer, G. L. 1965. Steeppass fishway development. Addenda to Inf. Leafl. 12. Unpubl. manuscr., 5 p. Alaska Dep. Fish Game, Juneau, AK 99801.

[2]Thompson, C. S. 1976. Evaluation of the adult salmonid trap installed in the Bradford Island "A" branch fishladder, Bonneville Dam. Unpubl. manuscr., 48 p., append. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Prep. for U.S. Army Corps Engr., Portland, Oreg. under Contract DACW57-75-F-0547.)

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included common carp, northern squawfish, and suckers. Both suckers and northern squawfish were reported passing through a 7.9 m long (26-foot) Denil with a slope of 24 percent at Bonneville Dam in 1971 (Slatick, 1975). In 1979, the slope was increased to 27.8 percent, and common carp, northern squawfish, and suckers were observed passing through the Denil.

Figure 1.—View, above, is of 15.2 m (50-foot) long steeppass Denil-type fishway in operation at Little Goose Dam. At left is a view of the unwatered 9.1 m (30-foot) long Denil fishway in the Fisheries Engineering Research Laboratory at Bonneville Dam.

A longer 15.2 m (50-foot) Denil (28.7 percent slope) was used at Little Goose Dam on the Snake River, and northern squawfish, suckers, and chiselmouth were seen successfully passing over this fishway over a 5-year period. Common carp, however, were observed entering the Denil, but proceeded only a short distance before either jumping out or turning around and descending the ladder.

The length of a Denil apparently affected the passage of carp; carp readily passed the shorter fishway at Bonneville Dam but rejected the longer fishway at Little Goose Dam. Although the Denil fishways were located at two different dams, similar conditions existed: Carp were present in the regular fish ladders, Denil slopes were identical, and the observations were conducted during the summer. The only known difference other than location was the length of the Denil.

An even longer Denil adversely affected passage of both northern squawfish and suckers. These fish, which had readily ascended the 15.2 m (50-foot) fishway at Little Goose Dam, rejected the 20.1 m (66-foot) Denil (27.3 percent slope) at Bonneville Dam (footnote 2). It must be emphasized that these species often take up residence in main fishways at dams and may or may not be actively migrating during the summer. These observations imply only that those freshwater species which passed over the Denil fishways have the physical ability to do so.

American shad and Pacific lamprey are the only two anadromous nonsalmonid species which migrate up the Columbia River past the hydroelectric dams. During the observation period, American shad were abundant in the Columbia River to above McNary Dam and were beginning to appear at Little Goose Dam 112 km (70 miles) up the Snake River. Pacific lamprey were indigenous to the Snake River. Observations were made on the ability of these fish to pass over Denils of

varying length and slope. Several hundred shad were seen passing through a 7.9 m (26-foot) long Denil fishway inclined at slopes of 24 and 28.7 percent at Bonneville Dam and a 11.9 m (30-foot) long Denil with a 23.3 percent slope at McNary Dam. A few shad were seen passing through the 15.2 m (50-foot) long Denil (28.7 percent slope) at Little Goose Dam, but none passed through the 20.1 m (66-foot) long Denil (27.3 percent slope) used at Bonneville Dam. Pacific lamprey successfully passed through Denil fishways of all combinations of length and slopes used. Lampreys passed through the longest (20.1 m) Denil tested at a rate of up to 1,372 individuals in a 24-hour period (footnote 2).

Conclusions

Our observations indicate that American shad, common carp, chiselmouth, northern squawfish, Pacific lamprey, and suckers can ascend and pass through a Denil steeppass fishway of acceptable length and slope. The data also show that Denils ≥ 15 m long are unacceptable to common carp, and Denils >20 m long are unacceptable to northern squawfish, American shad, and suckers. Since migrating adult Pacific salmon, steelhead, and Pacific lamprey successfully pass through Denil fishways of up to 27 m in length, Denil ladders of selected lengths could be used, if desired, to pass salmonid fishes over small barriers, while denying upstream access to selected species of unwanted nonsalmonids, with the exception of Pacific lamprey.

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