dichromate oxidation. U. S. Fish Wildl. Ser. Bur., Sportfish Wildl. Res. Report 60.

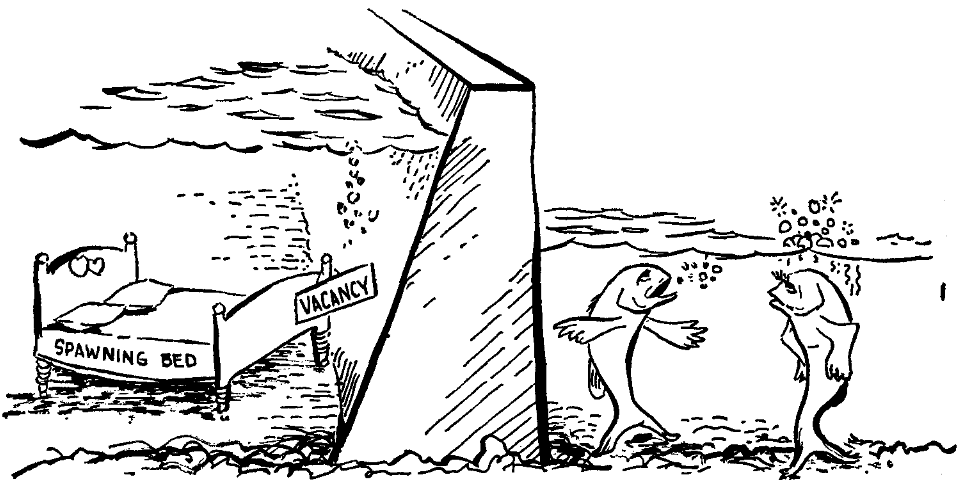
Prather, E. E. 1958. Further experiments on feeds for fathead minnows. Proc. Ann. Conf. Southeastern Assoc. of Game and Fish Commrs. 12:176-178.

———— and H. S. Swingle. 1960. Preliminary results on the production and spawning of white catfish in ponds. Proc. 14th Ann. Conf., Southeast Assoc. Game and Fish Comm., Biloxi, Miss.

Snedecor, G. W. 1959. Statistical methods. Iowa State College Press, Ames, Iowa.

Tiemeier, O. W. 1962. Supplemental feeding of fingerling channel catfish. Prog. Fish-Cult., 24(2):88-90.

Umbreit, W. W., R. H. Burris and J. F. Stauffer. 1957. Manometric techniques. Burgess Publishing Co., Minneapolis, Minn.



A "FISH LOK" FOR PASSING FISHES THROUGH SMALL IMPOUNDMENT STRUCTURES

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ABSTRACT

A method of locking fishes through a model representing a small impoundment structure was tested and found successful. Ten species of fishes were passed both upstream and downstream through two gates which were operated alternately and in such a manner as to provide attracting flows during the entire cycle.

INTRODUCTION

A major problem facing fishery scientists is that dams built to impound water also impound fishes from both sides of the structure. This problem is especially critical where the spawning runs of anadromous species are concerned. Flood control, power, water supply, and other water impounding structures more often than not completely block upstream movement and seriously impede downstream movement of fishes. Many fishways have been built to enable fish to bypass impounding structures. Some of these designs are fairly successful but most are rather specific in that they pass only certain species.

Fish locks have been used much more extensively in Europe than in North America and most of the structures utilizing locks involve relatively high heads of impounded water.[1] The method advocated here is similar to that described by Deelder in use on the Dutch River Meuse.[2]

The purpose of this paper is to describe a method of locking fishes through an impoundment and to present the results of an experimental test. The specific objectives were: (1) To determine whether the method is practical; and (2) To determine whether various species could readily pass through a locking device designed to operate in small impounding structures.

PROCEDURES

The principle of passing fishes through impoundments is the same as used to lock boats up- or down-stream through lock chambers — only with fishes an attraction flow is added. There are five basic steps in the locking cycle (Figure 1).

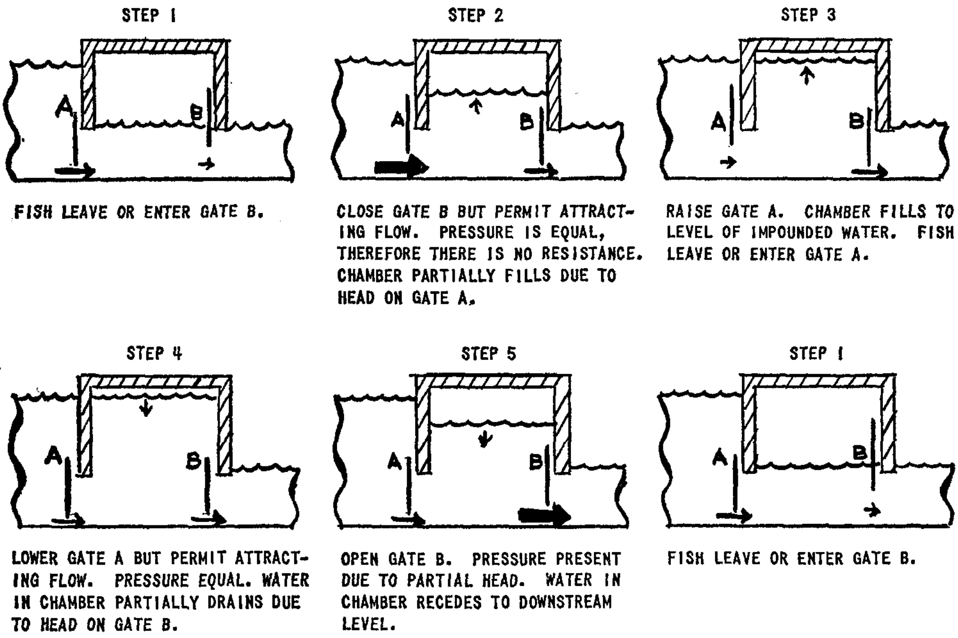

FIGURE 1. Operation of automatic fish-lok. Size of arrow indicates velocity.

To begin the cycle, the downstream gate is open to permit ingress and egress of fishes, and the upstream gate is closed except for a small opening through which water passes to provide an attraction flow. The lock is left open for a desired period after which the downstream gate is closed, except for attraction flow, trapping fishes within the chamber. As the upstream gate is opened, the chamber fills permitting fishes to pass through the upstream gate in either direction.

[1] Clay, C. H., 1961. Design of Fishways and Other Fish Facilities. The Department of Fisheries of Canada, Ottawa, Canada. 301 pp.

[2] Deelder, C. L., 1958. Modern Fish Passes in the Netherlands. The Prog. Fish Culturist, Vol. 20, No. 4, 151-155.

After another "fishing" period, the upstream gate is "closed," the water level lowered and the downstream gate opened to complete the cycle.

The procedure followed was to build a small experimental impounding structure into which the locking device was incorporated, install the structure in a hatchery discharge flume into which several species of fishes were placed, and determine whether or not the fish would pass through the lock.

The flume in which the experiment was conducted measured 4 x 30 feet and carried six inches of flowing water—the effluent from two hatchery raceways and a small drainage ditch. A screen was placed at the downstream end of the flume to retain the fish within the test area. In spite of this precaution, several fish escaped.

The experimental dam and lock chamber were constructed of ½-inch plywood (Figure 2). Holes eight inches square were cut near the bottom of each piece of plywood to serve as lock openings. Each opening was covered with a sliding gate onto which a 3-foot vertical rod was

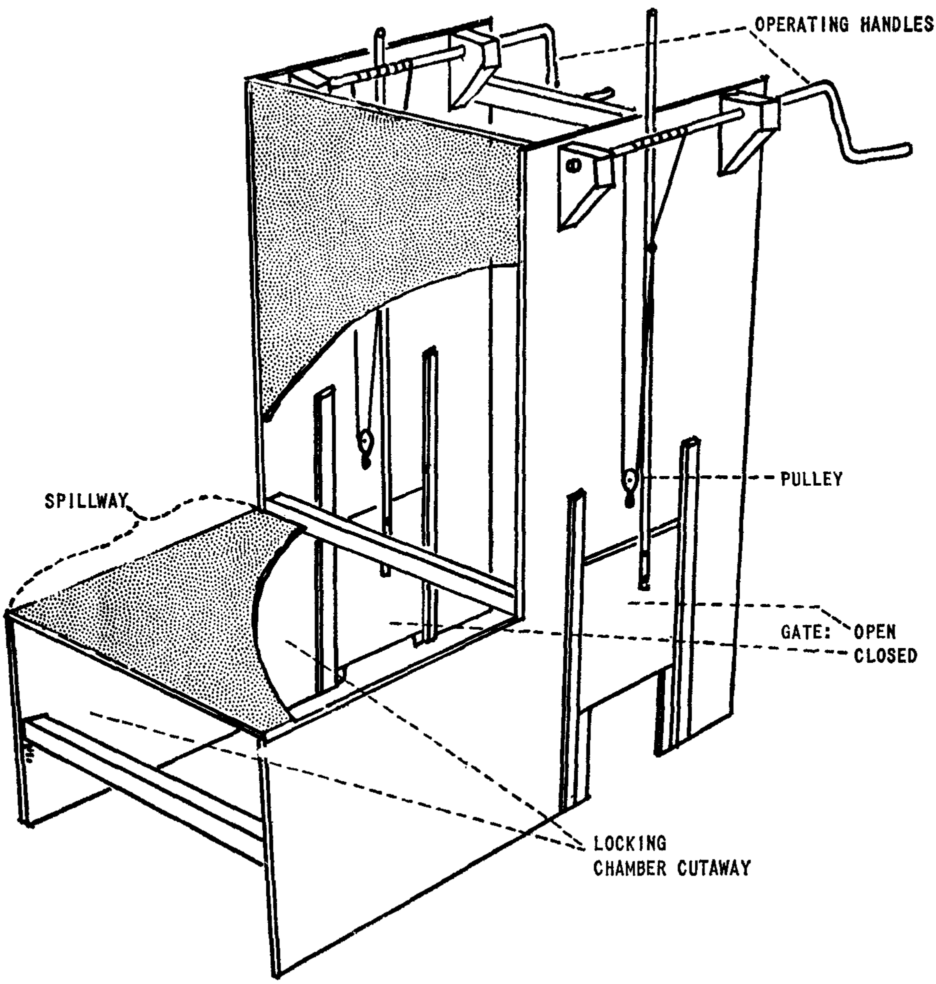

FIGURE 2. Experimental impoundment structure showing locking mechanism.

fastened. The opening mechanism consisted simply of a piece of rope, a pulley, and a horizontally mounted piece of thin-wall conduit assembled in such a manner that when the conduit was rotated, the gate was either raised or lowered—depending upon the direction of rotation. One end of the impounding structure was cut to a height of 20 inches and when covered served as a spillway for excess discharge. The other end, containing the gates and the operating mechanism, extended to the top of the flume so that the gates could be operated from concealment behind a canvas screen.

Eight species of fishes for use in the experiment were collected from the Marion Hatchery effluent and placed together in the flume just prior to testing. During the first phase of the test, the fish moved freely through the gates. As the fishes became acclimated to movements of the gates and fluctuation of the water, they became placid and movement within the flume practically ceased. In the second phase, artificial stimuli were applied to move fish through the lock. Most of the stimuli consisted of the mere appearance of a person at the edge of the flume to cause the fish to seek hiding. Later in the experiment, most of the fish entered the spillway section of the impoundment and had to be forcefully driven out. In the third operational phase which passed fish only upstream through the impoundment, the cover that formed the spillway section was removed. Fish still moved through the lock after the cover was removed from the spillway section, but with much less tendency to hide inside. The spillage of water into and out of the locking chamber had no apparent effect on fish passage.

RESULTS AND DISCUSSION

The purpose of the experiment was to determine whether fish would pass through the lock. The data show that eight species of fishes passed open gates with no apparent artificial stimulus (Table 1). The utilization of artificial stimulation in the second and third phase of testing was irrelevant as fish must be stimulated either naturally or artificially to effect voluntary movement of any kind. Any movement of a fish through an open gate was therefore considered a successful passage whether stimuli were applied or not.

Ten species of fishes successfully passed through the impoundment. The ease with which passage was made was evident in that fishes often positioned themselves in the lock opening until chased out by the closing gate. In some instances, several passes in and out of the locking chamber were made by a single fish during a single phase of the locking cycle. Fishes such as bluegill *Lepomis macrochirus* Rafinesque, redbreast sunfish *Lepomis auritus* (Linnaeus), and green sunfish *Lepomis cyanellus* Rafinesque passed through the gates as easily as rheotrophic species.

One of the advantages of the "fish lok" is that the locking chamber can be constructed as a room incorporated in a dam, as a culvert-like cylinder passing through a dam, in a flume, or in overflows which incorporate stop logs for water-level control.

Other desirable features are that downstream minimum flows may be maintained by adjustment of the attraction flow through the gates, and that the quantity of water required to operate the locks is much less than required by other types of fishway.

It has been demonstrated that with considerable modification, the basic design utilized here will pass fishes through power impoundments.

CONCLUSIONS

1. The method tested is practical for passing fishes both upstream and downstream through small impounding structures.
2. The "fish lok" is not selective as to species of fish.

TABLE 1

NUMBER AND SPECIES OF FISHES PASSING THROUGH THE "FISH LOK" UNDER VARIOUS CONDITIONS, JUNE 2 AND 3, 1966.

NUMBER OF 10-MINUTE LOCKING CYCLES		3.5				2.0				0.5	
SPILLWAY TOP		CLOSED				CLOSED				OPEN	
		WITHOUT STIMULUS				WITH STIMULUS				WITH STIMULUS	
	NUMBER OF	UPSTREAM GATE		DOWNSTREAM GATE		UPSTREAM GATE		DOWNSTREAM GATE		UPSTREAM GATE	DOWNSTREAM GATE
SPECIES	FISH IN FLUME	OUT	IN	IN	OUT	OUT	IN	IN	OUT	OUT	IN
Brook trout	4	4	6	9	3	8	11	3	-	2	5
Brown trout	1	-	-	-	-	1	2	-	-	1	1
Rainbow trout	3	-	3	-	1	1	4	-	-	3	3
Largemouth bass	2	1	1	-	-	2	1	-	-	3	3
Bluegill	2	-	-	-	1	1	-	1	1	1	1
Redbreast sunfish	2	-	-	-	-	-	-	-	-	2	2
Green sunfish	1	-	-	-	-	-	-	-	-	1	1
Hog sucker	3	1	3	2	3	-	1	-	-	-	1
White sucker	2	3	2	2	2	2	4	-	-	-	-
Bluehead chub	1	1	2	5	3	-	-	-	-	-	-
Unidentified passes		1	1	4	3	11	-	2	-	-	-