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Further Studies of the Modified Denil Fishway in the Des Moines River

By HARRY M. HARRISON AND EVERETT B. SPEAKER

INTRODUCTION

Iowa law (1950) prescribes no permanent dam or obstruction shall be erected or maintained which is not provided with a fishway, except by written approval of the State Conservation director. This law has been in effect for many years. The purpose of this act of the legislature was to provide free passage of fishes in the inland rivers of the State. It is not the purpose of this paper to discuss the need for fishways, but rather to present some of the data collected in testing the efficiency of a fishway design considered most practical for low-head dams for this State. The fishway upon which these data were gathered is a modified form of the Denil type first developed in Belgium.

In December, 1937, the State Conservation Commission requested that an investigation be conducted by the Iowa Institute of Hydraulic Research (a division of the State University of Iowa) on the problem of developing types of fishways more effective under Iowa conditions than those in use at that time. An exhaustive study was made by the Institute under the direction of McLeod and Nemenyi (1940), and their findings were published in a State University of Iowa engineering bulletin. Subsequent reports include "An Annotated Bibliography of Fishways" by Paul Nemenyi (1941) and a manuscript (MS) on the investigation of fishways conducted at the Iowa Institute of Hydraulic Research.

More than 35 full-scale models were studied by the Institute, including types in common use in the United States; new European fishways and fishways developed in the laboratory at Iowa City. Of the many models studied, a modified form of the Denil type of fishway was found to be most effective on dams of 15 feet or less in height.

In addition to the extensive tests in the Iowa river at Iowa City, a modified-Denil type of fishway was installed in the dam on the Cedar River at the Palisades-Kepler State Park near Mt. Vernon. Observations were made by Aitken (MS) on this fishway throughout the spring and summer of 1940. In 1947, a plan was formulated by Speaker (1947) and others to install a series of fishways in dams on the Cedar River at Cedar Rapids, Waterloo, Cedar Falls, Charles City and Waverly. For reasons not clearly understood at

that time most of these fishways were quite ineffective, and their limited function made it necessary to transfer the study to several units on the Des Moines River. It was later learned that the units were ineffective on the Cedar River because of the lack of a sufficient attraction to the mouth of the fishway.

Modified Denil fishways are installed on dams in the Des Moines River at Des Moines, Fort Dodge, Humboldt and Rutland. All of these dams are constructed of concrete. The Des Moines dam is approximately 8 feet in height; the Fort Dodge dam is 6 feet; Humboldt is 13 feet and Rutland is 15 feet. The slope of all fishways in these dams is 1:4 except for the upper lift at Humboldt in which the slope is 1:6.

The Des Moines dam is 400 feet in length, the Fort Dodge dam is 300 feet; the Humboldt dam is 170 feet and the Rutland dam is 200 feet long. The Des Moines and Fort Dodge dams are equipped with single lift fishways, and the Humboldt and Rutland dams have double lift fishways with resting pools between the two lifts.

Harrison (1948) published a two-year study of fishways in the Des Moines River in the 1948 proceedings of the Iowa Academy of Science. Since that time the Des Moines fishway has been added to the study and two years additional data are available for the other three units. Because of the added information and the fact that very different river conditions have prevailed during the past two years, it is felt these data should be reported to the Academy.

For the most part, the data presented in this paper will be from the work of the past two years, however, for the sake of clarity in discussing the theory associated with maximum use by fish, some of the data secured in 1946-47 will be drawn upon and presented in the graphs and tables.

METHOD AND PROCEDURE

A wooden fish trap was placed at the head of the fishways to intercept the fishes in their upstream movement. These traps were 3 feet deep, 4 feet wide and 8 feet long, constructed of 1 x 4 inch lumber with $\frac{1}{2}$ inch horizontal openings between each board to permit an exchange of fresh water for the entrapped fish and provide a sufficient supply of water for the operation of the fishway. These traps were fitted with slat throats similar to those used in standard commercial fishing gear which permitted the entrance of fishes, but prevented their escape.

The size of a trap was sufficiently large to hold all the fish caught over a period of a week except during exceptionally heavy runs, at which time they were emptied more frequently. The traps were

Table 1
Principle Species of Fish By Number and Weight Using the Modified Denil Fishways
In the Des Moines River During 1948-49

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THE MODIFIED DENIL FISHWAY

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Species	Fort Dodge				Humboldt				Rutland				Des Moines		TOTALS	
	1948		1949		1948		1949		1948		1949		1948		No.	Lbs.
	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.
Buffalo																
Megastomatobus cyprinella	198	604	16	41	—	—	—	—	75	147	15	25	1	3	305	820
Quillback																
Carpiodes sp.	1115	1071	2315	1899	168	159	24	24	1020	963	695	582	195	164	5532	4862
Common sucker																
Catostomus c. commersonii	6	5	30	24	25	19	143	125	29	27	2	2	—	—	235	202
Silver mullet																
Moxostoma anisurum	5	5	—	—	—	—	—	—	5	4	—	—	—	—	10	9
Golden mullet																
Moxostoma erythrurum	—	—	44	100	—	—	—	—	—	—	—	—	—	—	44	100
Redhorse																
Moxostoma aurelum	382	337	1000	769	13	12	18	13	56	39	13	10	—	—	1482	1180
Carp																
Cyprinus carpio	3338	6748	4381	9143	187	375	587	1023	684	1069	136	159	155	484	9468	19001
Channel Catfish																
Ictalurus lacustris punctatus	331	240	825	745	25	40	175	176	86	43	38	11	469	317	1949	1572
Flathead Catfish																
Pilodictis olivaris	—	—	4	75	—	—	—	—	—	—	—	—	—	—	4	75
Stone Cat																
Noturus flavus	—	—	—	—	—	—	12	—	—	—	—	—	—	—	12	—
Northern Pike																
Esox lucius	20	16	6	7	7	8	1	1	17	40	7	13	—	—	58	85
Smallmouth Bass																
Micropterus d. dolomieu	41	31	—	—	—	—	—	—	—	—	—	—	1	1	42	32
Walleye																
Stizostedion v. vitreum	11	11	1	1	1	1	17	10	1	2	7	7	—	—	38	32
Miscellaneous Species *																
TOTALS	5447	9068	8622	12,804	426	614	977	1372	1973	2334	913	809	821	969	19179	27970

* These species taken singly or in numbers too small to be significant: Hogsucker *Hypentelium nigricans*; Creek chub *Semotilus a. atromaculatus*; Black Bullhead *Ameiurus m. mclasi*; Stonecat *Noturus flavus*; Green sunfish *Lepomis cyanocephalus*; Orange-spotted sunfish *Lepomis humilis*; White Crappie *Pomoxis annularis*; Freshwater drum *Aplodinotus grunniens*.

so constructed they could be disengaged from the fishway and towed into shallow water near shore to facilitate fish removal operations.

Fish that had ascended the fishways were separated into species, counted and weighed. All species except carp and certain of the non-game fishes were released to the water on the up-stream side of the dam. Carp and other coarse fishes were disposed of.

A continuous recording thermometer and stream gauge were used to obtain the mean daily water temperature and water stage fluxuations.

RESULTS

A total of 24 species of fishes were captured in the traps during the 1948-49 operations. Of this number the four dominant kinds, carp, quillback, channel catfish and redhorse, made up about 95% of the catch in numbers and weight. Nine other species listed in Table 1 made up the balance of the catch listed. Eight kinds were taken singly or in numbers too few to be important in the catch composition.

Several species of forage minnows, predominantly Common Shiner, *Notropis cornutus frontalis*; Spotfin, *N. spilopterus*; and Fathead, *Promephales p. promelas*; used the fishways extensively, but because of their small size they were able to escape through the openings in the traps. On May 12, 1949, a steady procession of common and spotfin shiners were observed using the Fort Dodge lift. The run was observed from 10 a.m. until 8 p.m., and from intermittent observations it was conservatively estimated over 50,000 minnows had ascended the fishway.

Some fish collections were made with linear seines below the dams in the vicinity of the lower end of the fishways to determine the relative abundance and species composition of the fishes present. The number and abundance found in these operations compared favorably to the catch in the traps. This information would indicate the fishway is non-selective. Hiner (MS) in his study of the Modified Denil fishway at the outlet of Lake Shetek, Minnesota (headwaters of the west fork of the Des Moines River) found the only fish, other than small cyprinids, that did not use the fishway was the orange-spotted sunfish. In his work he observed bullheads comprised nearly 96% of the total catch of fishes ascending the fishways. Although bullheads were not taken in significant numbers in the 1948-49 work in Iowa, they were important in the catches in 1946-47.

Every year during the four years of study of modified Denil

fishways in the Des Moines River, 1946-49, over 90% of the total years catch of all fish was made between May 1 and July 15. Northern Pike, common sucker and smallmouth bass were the first migrants. Their movements started in April and were usually completed by May 15. It is quite possible reproductive urge prompted their runs. Carp, quillback, redbhorse and catfish used the fishways largely in June and early July. Except for an occasional individual, bigmouth buffalo were taken only in July. All other species were taken in numbers too small to indicate trends in seasonal use.

During the 1948-49 study a total of 19,179 fish weighing 27,970 pounds were secured in the fishway traps. Comparing this with Harrison's (1948) earlier work at which time 10,443 fish weighing 12,241 pounds were taken, a great increase in catch for the 1948-49 work in manifested. The increase in catch is only partly explained by the fact that one more unit was in operation. The real reason for the increase is explained by certain circumstances connected with the Fort Dodge installation. When first installed, the mouth of this fishway opened into shallow water, and for this reason was not used by the fish in 1946. Due to the scouring action at the mouth of the fishway, a deep pool was created. A sand bar was subsequently formed between the foot of the fishway and the base of the dam. This bar acted as a lead to guide or direct fish into the deepened pool. When fish were motivated to ascend the stream, they were already collected at the fishway. Concurrent with the formation of the bar and the scouring of the pool the catch at Fort Dodge increased progressively from no fish in 1946 to 1,480 fish in 1947 to 5,447 in 1948 to 8,622 in 1949.

That which motivates warm water fish to reflect migratory tendencies, is not yet wholly understood. Schmassmann (1933) in Switzerland found little fish movement before the water temperature had reached the middle sixties in F° and has prepared curves to show very strong variation of migration of summer spawning fish with water temperature. Hiner (MS) in Minnesota and McLeod and Nemenyi (1940) in Iowa concur with Schmassmann in his temperature finding, but the latter investigators also point out some evidence to indicate that fish travel when the stage of the stream increases.

On the basis of our present studies it appears that both the function of temperature and stream stage have an important effect upon the upstream movement of fishes. Figures 1 to 4 show that little movement occurred before the water temperature reached 65°F. and after that the time periods of greatest use occurred while the stream

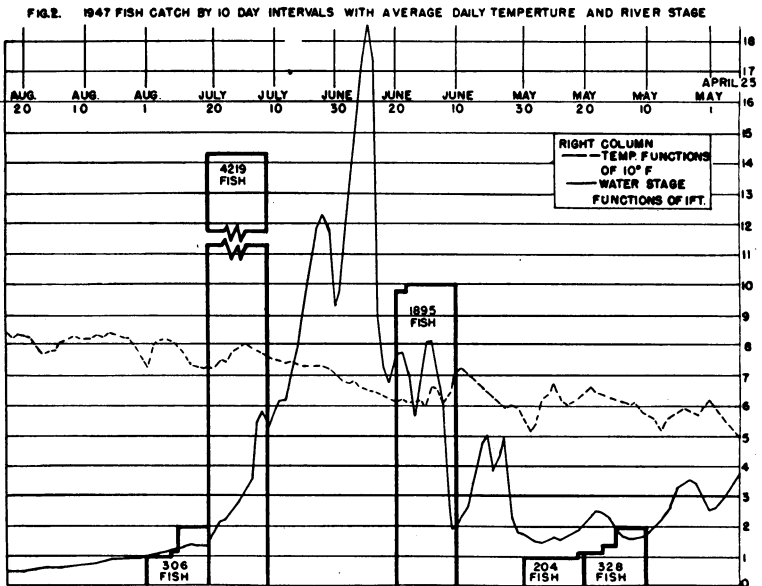
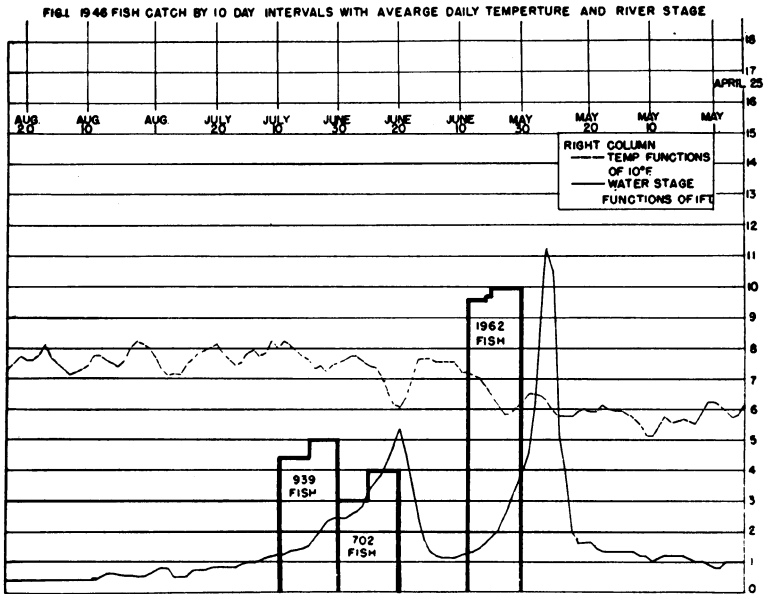


FIG 3 1948 FISH CATCH BY 10 DAY INTERVALS WITH AVEARGE DAILY TEMPERATURE AND RIVER STAGE

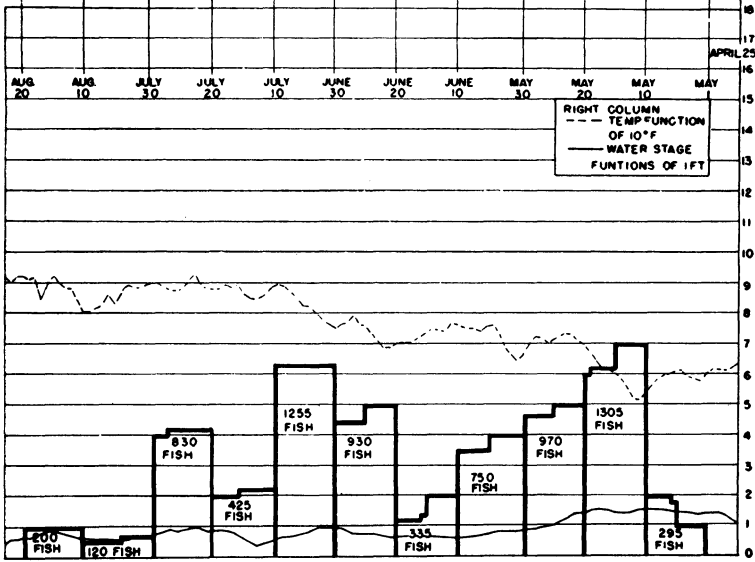
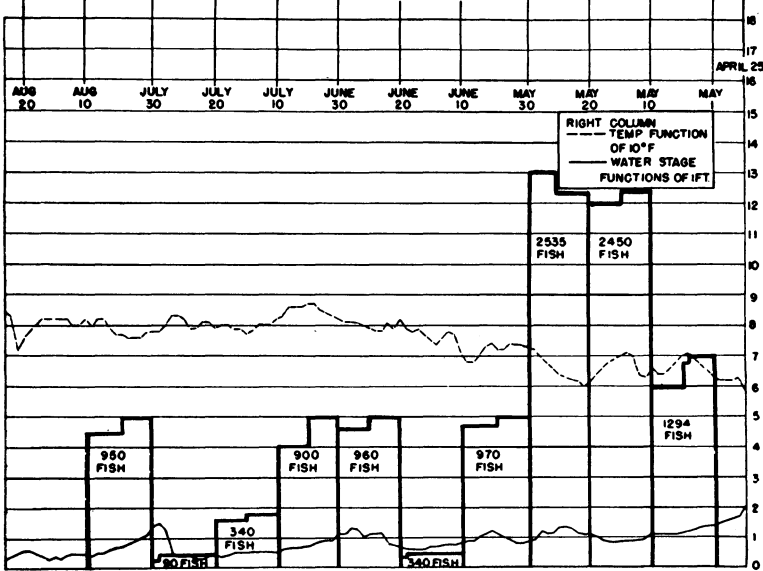


FIG 4 1948 FISH CATCH BY 10 DAY INTERVALS WITH AVEARGE DAILY TEMPERATURE AND RIVER STAGE



stage was relatively high or on the rise. In a few instances the histograms representing the fishway catches lag behind the river rise by several days. This can be explained by the fact the traps could not be operated at periods of extremely high water. Sufficient evidence was obtained from superficial observations, however, to indicate fish had entered the traps during the rise in the river stage. A further instance demonstrating the importance of rising water level with increased upstream movement can be cited in the case of the Fort Dodge fishway. Here artificial increases in stage frequently result from the operation of an upstream hydroelectric plant. Increased fish activity at the fishway has been observed repeatedly with each of these artificial rises due to opening the flood gates at the upper dam.

CONCLUSIONS

1. From the studies conducted, the modified Denil fishway as described by McLeod and Nemenyi will function if properly installed.
2. Strong attraction to the fishway entrance is a must if fishways are successful.
3. The fishway is apparently non-selective with respect to species and size in that it passes fish in relative numbers to their size and abundance in the stream.
4. Periods of greatest use tend to follow or coincide with increased water stage after the temperature reaches 65° F.
5. The fishways were used in this study principally during May to mid-July.

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