TRANSACTIONS of the AMERICAN FISHERIES SOCIETY

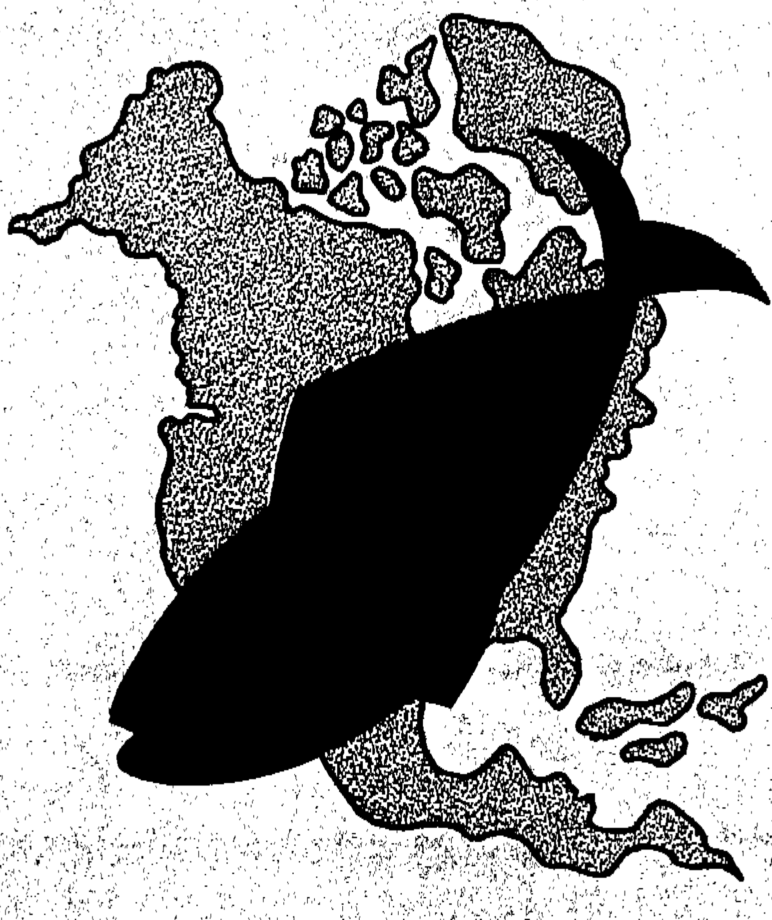

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TABLE 1.—*Weight and length data for six aholehole and regression coefficients for the effect of swimming speed on oxygen consumption as shown in Figure 4*

Fish	Weight (gms)	Fork length (cm)	Fork lengths per revolution	Intercept mgm O_2/hour	Slope
1	9.0	8.2	10.68	0.94	2.12
2	11.9	9.1	9.63	1.16	0.93
3	20.3	10.3	8.50	1.69	0.39
4	27.0	11.7	7.49	2.24	1.59
5	44.4	13.7	6.39	3.27	0.44
6	60.1	14.8	5.92	4.17	0.49

observed might be due to variation in response to the chamber, to variation in individual fish, or to a real change in swimming characteristics with size.

Despite the variation in slope, the extrapolated oxygen consumption at zero swimming appears to be a good statistic. The logarithms of these values are plotted against the logarithms of body weights in Figure 4. The points give a good fit to the line

$$\log Y = \log 0.1664 + 0.7845 \log X$$

Thus it would appear that the extrapolated point serves as an anchor and that variations in swimming characteristics affect the slope of the line originating from this point.

ACKNOWLEDGMENTS

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Observations on the Swimming Ability of Adult American Shad (*Alosa sapidissima*)

INTRODUCTION

For several years the Bureau of Commercial Fisheries, under contract with the U. S. Army Corps of Engineers, has been investigating various factors influencing the behavior of adult salmonids in relation to fish passage problems on the Columbia River and its tributaries (Collins and Elling, 1960). In the course of these investigations, incidental observations were made on the American shad (*Alosa sapidissima*) which utilized the same waterways as the salmonids. Observations presented in this report were made during the period of 18 to 28 July 1961.

The objective of the primary study on salmonids was to gain further knowledge of the maximum water velocities that could be negotiated. The presence of shad during the experiments, however, also made it possible to obtain information on the swimming ability of this species. Specifically, this report covers the channel distances negotiated by the American shad in water velocities ranging from 11.4 to 13.6 feet per second.

Although velocities of this magnitude may not often be encountered by American shad ascending the rivers and fishways at existing dams, a knowledge of their swimming ability in these higher velocities is meaningful. The continuing effort to develop more efficient and economical fish passage facilities in the Columbia River drainage requires a thorough knowledge of the physical requirements and swimming abilities of the various species of fish involved.

Even though American shad in the Columbia River are not at present regarded with the

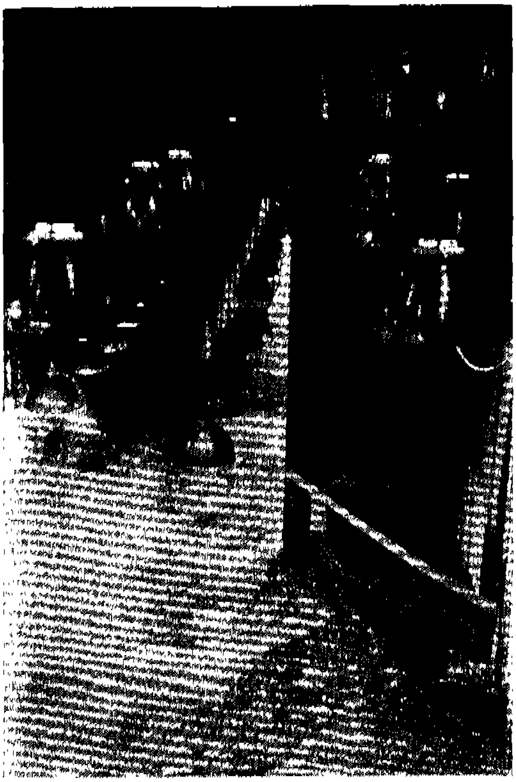

FIGURE 1.—View of introductory area and channel during the 11.4-foot-per-second velocity tests.

same esteem as salmon and trout, large numbers of these fish ascend this drainage annually, and they must be considered in the design and operation of fish passage facilities that may be utilized by them. By the same token, information on the swimming abilities of American shad may be of use on the East Coast, where efforts are currently under way to rehabilitate shad runs by providing passage to production areas that have been lost due to dams or other resource developments.

METHODS AND MATERIALS

The observations were made at the Fisheries–Engineering Research Laboratory at Bonneville Dam on the Columbia River. The laboratory is basically a large tank, approximately 181 feet long by 24 feet wide, located on the right bank of the river adjacent to the Washington shore fish ladder. The fish enter and pass through the laboratory via short fish ladders connected with the Washington shore fish ladder. Passage is volitional, and the fish are not handled at any time.

The arrangement of the laboratory during these experiments was the same as that employed in earlier velocity experiments conducted in 1957 (Weaver, 1963). Testing facilities for fish consisted of a channel 85 feet long by 5 feet wide (Figure 1). The velocity of the flow in the channel was regulated by the slope of the channel floor and the head on the channel. Four different velocity conditions were tested. Average velocities during the tests, based upon measurements taken at the downstream end of the channel, were 11.4, 12.6, 13.2, and 13.6 feet per second. More extensive measurements made within the channel after the tests were completed revealed that velocities were generally somewhat lower (up to 1 foot per second) in the upper reaches of the channel. Depths of water in the channel were 2.1, 1.8, 1.8, and 1.6 feet, respectively, for the above velocity conditions.

Normally, tests were made in the channel by releasing individual fish into the introductory area (Figure 1). As they moved upstream through the channel, the fish were followed by observers stationed on walkways above. Although some of the American shad observed during these experiments entered the laboratory in this manner, a larger number entered by drifting downstream from the main fish ladder through the exit ladder of the laboratory. After entering in this fashion, the shad continued downstream through the test channel, and accumulated in the introductory area. Even though there were areas where these fish could remain in relatively calm water, they were continually entering the test channel and attempting to swim back upstream. The observations of swimming ability presented here consist of the distances which the shad attained in these attempts to negotiate the channel.

The water velocity in the channel was reduced at the end of each day to give shad, accumulating in the introductory pool, the opportunity to pass through the channel and leave the laboratory. Although many shad were noted swimming up the channel when the flow was reduced, they seemed to have no great desire to leave the laboratory and

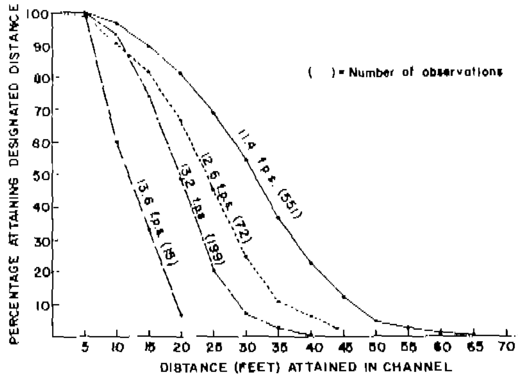

FIGURE 2.—Performance of shad in flows of 11.4, 12.6, 13.2, and 13.6 feet per second. Data are plotted at 5-foot intervals.

TABLE 1.—*Distances attained by shad in flows of 11.4, 12.6, 13.2, and 13.6 feet per second*

Water velocity ft/sec	Date	Water temperature (F)	Number of observations	Distance attained	
				Mean (feet)	Maximum (feet)
	July 21	70	62	27.2	54
	22	70	193	29.2	59
11.4	23	70	160	32.0	65
	24	69	106	30.5	63
	25	69	30	29.9	60
	Total		551	30.1	65
	25	69	18	19.1	41
12.6	26	69	29	24.8	43
	27	69	25	24.8	44
	Total		72	23.4	44
	18	70	72	18.8	35
13.2	19	70	127	18.8	40
	Total		199	18.8	40
13.6	28	69	15	11.7	20

return to the Washington shore ladder. Each morning shad were present in the flow introduction pool (upstream end of the channel). As soon as the velocity was increased, they began falling back downstream through the channel. It is believed that some of these fish remained in the laboratory for several days and could have contributed to daily observations.

The upstream and downstream movement of shad in the laboratory was similar to their general behavior in the Washington shore ladder during the same period. Although large numbers of shad could be observed in the ladder pools and considerable to-and-fro movement was evident in the fishway, few shad were being counted out of the ladder at the upstream end. It is believed, however, that even though many shad did not continue their movement upstream through the ladder, this phenomenon was due to something other than a lack of ability to negotiate the ascent. Similar upstream–downstream passage was reported by Talbot (1953) and also noted by Bell and Holmes (unpublished) while studying the passage of shad in the fish ladders at Bonneville Dam.

The American shad observed in this study were from the latter part of the run, and it is possible that some had reached sexual maturity and were preparing to spawn in the ladder pools. The peak of the migration had occurred during the first week of July. At this time, counts at the upstream end of the Washington shore ladder exceeded 10,000 shad per day. When these observations on shad were in progress, counts averaged less than 200 fish per day.

RESULTS AND CONCLUSIONS

The distances attained by shad in their attempts to ascend the channel varied inversely with the velocity of the flow (Figure 2). Mean distances attained by groups of fish tested in the four velocities ranged from 11.7 feet in the 13.6 ft/sec velocity to 30.1 feet in the 11.4 ft/sec velocity (Table 1). None of the shad negotiated the entire 85-foot channel. Maximum distances attained ranged from 20 feet at 13.6 ft/sec to 65 feet at 11.4 ft/sec.

Considering the possibility that many of these observations may have been made when the shad were in a weakened or declining physical condition (from repeated exhaustive swimming efforts or factors associated with spawning), performance levels shown may be somewhat less than would have occurred under more favorable circumstances. Although shad appear to be capable of swimming modest distances in relatively high velocities, even the lowest of the four velocities tested might present a serious barrier for some shad if a passage of more than a few feet were required.

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Observations on Size Distribution and Spawning Behavior of Threadfin Shad[1]

INTRODUCTION

The original range of the threadfin shad (*Dorosoma petenense*) is being expanded by acclimatization of the fish to more northern waters and by introducing them into other waters (Parsons and Kimsey, 1954; Haskell, 1959; Kimsey, 1954; King, et al., unpublished; and Minckley and Krumholtz, 1960). Introductions of the threadfin shad into other waters has been mainly to furnish forage for other fishes. It has been acclaimed as the ideal forage fish (Parsons and Kimsey, 1954) because it does not grow too large to be utilized such as does the gizzard shad (*Dorosoma cepedianum*), which is also prone to overpopulate a body of water (Miller, 1960). Parsons and Kimsey (1954) state that the threadfin shad seldom reaches 7 inches in length while Shelton (unpublished) states that its maximum size is 8.0 inches. McConnell and Gerdes (1964) reported threadfin shad up to approximately 175 mm or 6.9 inches in total length from Pena Blanca Lake in Arizona. Inasmuch as the introduction of threadfin shad to other waters is based partly on the assumption that this fish does not reach a large size, data on the size distribution of the threadfin shad collected from some Louisiana waters, which are within their original range, as well as some observations on their spawning behavior in Louisiana are presented.

[1] This report is a contribution of Louisiana Federal Aid in Fish Restoration Project F-I-R and Contribution No. 157 of the Oklahoma Fishery Research Laboratory, a cooperative unit of the Oklahoma Department of Wildlife Conservation and the University of Oklahoma Biological Survey.

TABLE 1.—*Size distribution of threadfin shad collected from some Louisiana waters*

Total length in inches (class center)	Body of water and collecting method		
	Bogue Falaya River 1-inch mesh trammel net	Lake Bistineau rotenone	Clear Lake rotenone
0.5	–	–	–
1.0	–	2	–
1.5	–	17,040	7
2.0	–	41,126	2,948
2.5	–	61,420	10,525
3.0	–	24,577	5,208
3.5	–	2,202	16,969
4.0	–	506	19,315
4.5	–	182	713
5.0	–	–	35
5.5	–	–	–
6.0	17	–	–
6.5	299	–	–
7.0	592	–	–
7.5	217	–	–
8.0	16	–	–
8.5	–	–	–

METHODS

The size distribution of threadfin shad shown in Table 1 collected from the Bogue Falaya River are fish which were gilled in the one-inch-square mesh inside wall of a 100-yard trammel net set overnight in the river on 3 April 1956, near Covington, Louisiana. The Bogue Falaya River is located in southeast Louisiana and is a small stream which flows into the Tchenfuncta River which in turn empties into Lake Ponchartrain, a large estuary. The Tchenfuncta River below its confluence with the Bogue Falaya River is large, deep, and sluggish, greatly affected by tides in Lake Ponchartrain.

Fish population samples from Lake Bistineau, a 17,200-acre artificial impoundment, taken during August and September 1956 (Lambou, 1959 and 1962) and Clear Lake, a 115-acre oxbow, taken during September and October 1956 (Lambou and Geagan, 1961) by rotenone poisoning yielded estimates of the size distribution of threadfin shad in these lakes. The threadfin shad shown in Table 1 are the estimated total number occurring in the samples.

RESULTS

The size distribution of the specimens (size range: 1.0–5.0 inches in total length) from Lake Bistineau and Clear Lake are typical of