PROGRESS REPORT

RESEARCH ON FINGERLING MORTALITY IN KAPLAN TURBINES - 1968

by

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Introduction

This is a preliminary report[1/] of research conducted in the spring of 1968 at Ice Harbor Dam by the Bureau's Fingerling-Passage program, located at Pasco, Washington.

The research this year provides strong evidence of the interrelationship between turbine losses and losses from predation that occur in discrete areas of the tailrace.

1/ The results reported here are based on a portion of the data. Although preliminary, we expect only minor changes in numerical values when the analysis is completed.

Field Conditions

This year there was very little spillway operation; a condition that will exist in the future. Consequently, a large slack-water area existed below the spillway.

The turbine discharge divides at the upwelling in the tailrace into two major flows. Most of the water moves downstream as a "frontroll" discharge to form the main river. A portion of the discharge forms the "backroll"; i.e., it flows upstream till it reaches the dam. The backroll-flows from all units then move along the dam to enter the slack-water area below the spillway.

Methods and Procedures

The fish used were 1+ coho reared at Leavenworth Hatchery. Methods of handling and marking have been reported previously. Tests were conducted from March 27 to May 10, 1968.

The method in use to measure turbine losses employs the release of test fish through the turbine and the release of control fish in the tailrace. The ratio of survivors of the test and control groups provides a measure of the turbine mortality. This ratio was determined by sampling several miles downstream.

Test fish were released in intake B of unit No. 2 about ten feet below the ceiling. The turbine was operated at 115 percent overload for all tests. Tailrace controls were released (1) into the backroll flows, and (2) into the main flows moving downstream.

Gear for sampling the survivors of test and control fish included (a) purse seines, and (b) beach seines, both deployed about 6.5 miles below Ice Harbor Dam, and (c) dip nets for sampling the gatewells of McNary Dam, about 45 miles below Ice Harbor Dam.

In addition, a purse seine was used in the slack-water area in the tailrace of Ice Harbor Dam to obtain samples of predator fish, and a migrant-dipper trap was placed in the tailrace to sample test and control fish found in the backroll flows.

Comparison of Sampling Methods

The purse seine and beach seine catches made 6.5 miles below Ice Harbor Dam, and the gatewell catches from McNary Dam were compared to determine if selectivity varied among the recovery methods.

The ratio of fish from the ~~one~~ Two test and two control groups was comparable in the catches made by all three recovery methods (table 1). Therefore, all catch data were combined for subsequent analysis.

Table 1.--Raw data-fish releases for eight days and fish recoveries for season. The ratio of recaptured fish from two test and two control groups was comparable for each of three fish-recovery methods.

RELEASE DATE	MARK	NUMBER RELEASED	TYPE	RECOVERIES PURSE SEINE	BEACH SEINE	McNARY GATEWELL	TOTAL
3-28	141	14000	T	154	258	1203	1615
3-28	261	14001	T	186	332	1106	1624
3-28	321	9741	B_2	121	232	659	1012
3-28	323	4251	B_2	38	88	277	403
4-1	142	10795	T	482	324	565	1371
4-1	262	11996	T	450	395	642	1487
4-1	322	7964	B_2	408	312	587	1307
4-1	3122	3989	B_1	165	116	242	523
4-2	143	10799	T	401	405	785	1591
4-2	263	11989	T	429	455	760	1644
4-2	313	7990	F	428	422	664	1514
4-2	3123	3998	B_1	138	173	199	510
4-3	144	10792	T		572	480	1052
4-3	264	11998	T	519	595	600	1714
4-3	314	7998	F	432	489	419	1340
4-3	334	3678	B_1	157	222	4	383
4-4	241	10799	T	414	425	661	1500
4-4	361	11951	T	401	447	629	1477
4-4	411	7998	F	505	471	667	1643
4-4	431	3996	B_1	152	142	181	475

Table 1.--Raw data-fish releases for eight days and fish recoveries for season. The ratio of recaptured fish from two test and two control groups was comparable for each of three fish-recovery methods. -- continued.

RELEASE DATE	MARK	NUMBER RELEASED	TYPE	PURSE SEINE	BEACH SEINE	McNARY GATEWELL		TOTAL	
4-5	242	10795	T	575	687	469		1731	
4-5	362	11994	T	639	737	471		1847	
4-5	412	7994	F	570	703	516		1789	
4-5	432	3996	B_1	212	271	181		664	
4-9	243	10798	T	258	815	697		1770	
4-9	363	11996	T	—	995	763		1758	
4-9	413	7997	F	233	923	630		1786	
4-9	433	3998	B_1	52	219	163		434	
4-10	244	10697	T	176	514	533		1223	
4-10	364	11685	T	206	570	515		1291	
4-10	414	7675	F	174	469	463		1106	
4-10	434	3909	B_1	51	146	111		308	

TYPE: T, TURBINE TEST RELEASE
B_2, BACKROLL RELEASE
B_1, BACKROLL RELEASE
F, FRONTROLL RELEASE

Comparison of Control Groups

The control groups released in the backroll suffered a statistically significant loss of 33 percent by comparison with the control groups released in the frontroll, or main river flows (table 2). This loss was presumed to be from predation.

Evidence of Predation

Both seagulls and fish were obviously feeding upon experimental fish in the slack water areas. Purse seine catches in the area took mostly squawfish. Up to 37 percent of the squawfish taken immediately after the day's release of coho had identifiable coho in their stomachs. A total of 54 percent had fish in their stomachs.

Comparison of Test and Control Groups

The test groups suffered a statistically significant loss of 32 percent by comparison with the frontroll controls; a loss of the same magnitude as the backroll control groups (table 2).

Table 2.--Raw data-season's recovery of test and control fish for eight test days. Ratio of recovered fish show a total loss of about 32 percent of the fish passed through the turbines and 33 percent of the control groups released into the backroll, by comparison with control groups released into the frontroll.

RELEASE DATE	NUMBER RELEASED	RECOVERY BY TYPE OF RELEASE TURBINE	FRONTROLL	BACK ROLL 1	BACK ROLL 2
-28	14000	1615			
3-28	14001	1624			
3-28	9741				1012
3-28	4251				403
4-1	10795	1371			
4-1	11996	1487			
4-1	7964				1307
4-1	3989			523	
4-2	10799	1591			
4-2	11989	1644			
4-2	7990		1514		
4-2	3998			510	
4-3	10792	1052			
4-3	11998	1714			
4-3	7998		1340		
4-3	3678			383	
4-4	10799	1500			
4-4	11951	1477			
4-4	7998		1643		
4-4	3996			475	

Table 2.--Raw data-season's recovery of test and control fish for eight test days. Ratio of recovered fish show a total loss of about 32 percent of the fish passed through the turbines and 33 percent of the control groups released into the backroll, by comparison with control groups released into the frontroll. -- Continued.

RELEASE DATE	NUMBER RELEASED	RECOVERY BY TYPE OF RELEASE			
		TURBINE	FRONTROLL	BACKROLL 1	BACKROLL 2
4-5	10795	1731			
4-5	11994	1847			
4-5	7994		1789	664	
4-5	3996				
4-9	10798	1770			
4-9	11996	1758			
4-9	7997		1786		
4-9	3998			434	
4-10	10697	1223			
4-10	11685	1291			
4-10	7675		1106		
4-10	3909			308	

Assessment of Turbine Loss

A group of fish passing through a turbine enter either the backroll or frontroll flows, or the group may divide, a percentage entering both flows. The parameters determining the destination of a fish are (1) the segment of flow containing the fish approaching the turbine, and (2) the turbine load at the time.

The total loss of test fish in this experiment (32 percent) presumably included both losses from the turbine and losses from predation. If a turbine loss of less than 32 percent and greater than 0.0 percent is presumed, then only a portion of the survivors of test fish were entering the backroll flows, where they suffered an additional loss from predation at a 33 percent rate. The block diagram in figure 1 gives an example of how turbine and predation losses can combine to affect total survival.

The mortality occurring in the turbine was estimated by assessing the mortality due to predation; e.g., the total loss (32 percent), less predation loss, equals turbine loss.

Determining the loss due to predation required an estimate of the number of test fish entering the backroll. The dipper trap was used to sample fish in the backroll. The control groups released directly into the backroll provided an estimate of the efficiency of the trap; e.g., if 10 percent of the backroll controls were taken by the trap, then the

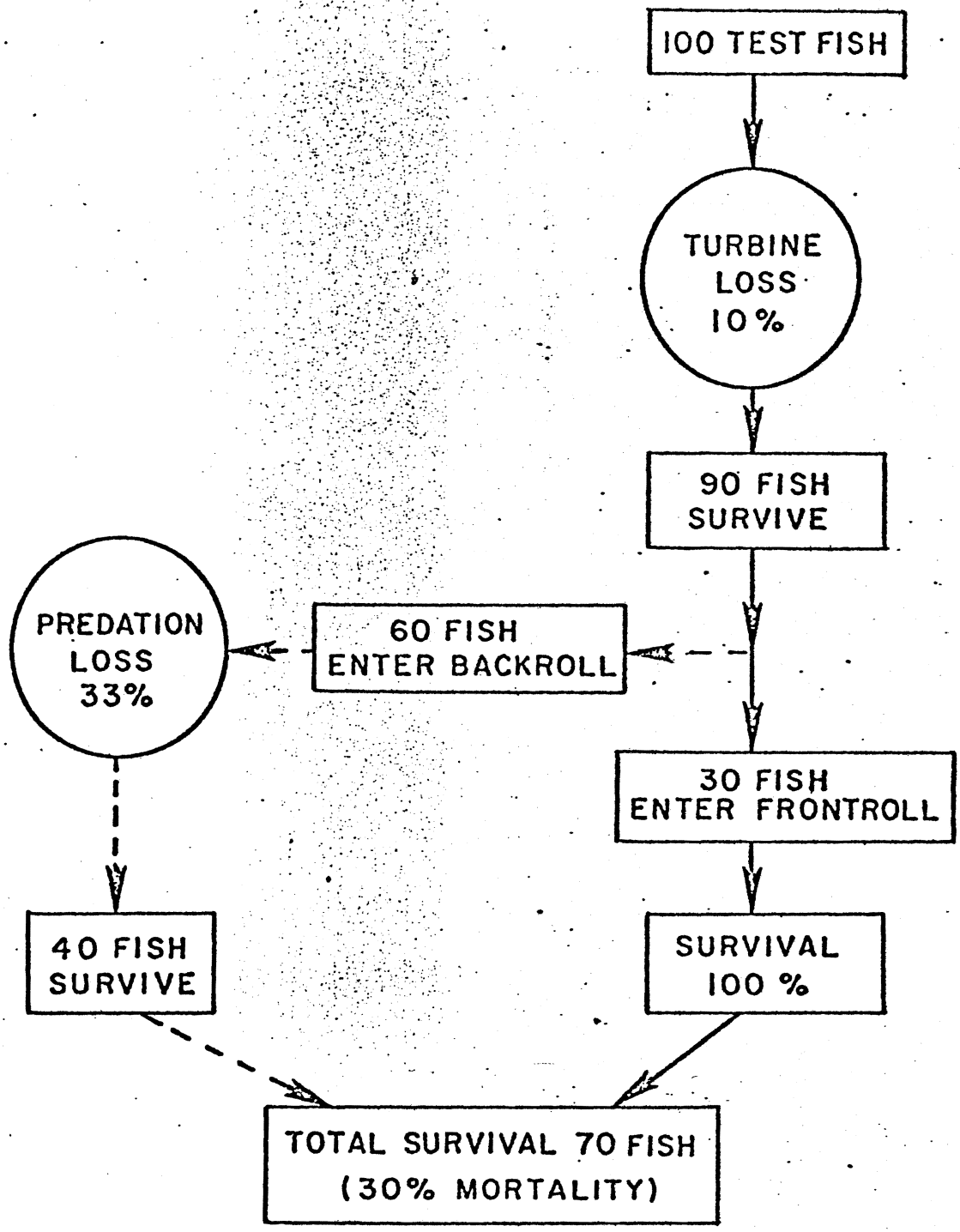

Figure 1.--Total loss of fish includes turbine mortality and predation mortality. Total loss from predation depends upon division of fish between backroll and frontroll flows in the tailrace.

number of test fish caught was taken as 10 percent of the number of test fish in the backroll. Only the test fish in the backroll were exposed to the 33 percent rate of predation.

A complication arose when we found that different release locations of controls in the backroll produced different estimates of trap efficiencies (thus, resulting in different estimates of the percent of test fish entering the backroll). Tests were run, therefore, with several release locations in the backroll. The extremes of trap-efficiency estimates were used to compute a maximum and a minimum turbine loss. Results imply that turbine mortality lies between 10 and 19 percent (table 3).

Discussion

The loss of test fish (32 percent) is not necessarily comparable to the loss of naturally distributed fish that pass through turbines. Although the turbine loss on test fish is presumed similar for that of naturally distributed fish, the predation loss varies with the exit point of fish at the tailrace; i.e., the percentage of fish that enter the backroll. Because the test fish were released in a discrete portion of the intake flows, we must presume the division of this group between the backroll and frontroll flows is different from that of naturally distributed fish.

Table 3. Raw data estimation of number of test fish entering backroll. Dipper trap samples of control and test fish in backroll indicate a minimum predation loss of 13 percent and a maximum predation loss of 22 percent of the test fish. Therefore, the turbine loss falls between 10 and 19 percent.

TEST No.	RELEASE LOCATION	NUMBER RELEASED	NUMBER RECOVERED	% REC'Y.
1	UNIT 2-3 SURFACE/AWAY	1799	169	9.3
	UNIT 2 MID-DEPTH/SOUTH	1796	49	2.7
	STANDARD CONTROL	1277	140	10.9
	TURBINE	1296	39	3.0
2	UNIT 2 MID-DEPTH/NORTH	1728	136	7.8
	UNIT 2 SURFACE/SOUTH	1797	108	6.0
	STANDARD CONTROL	1296	183	14.1
	TURBINE	1297	53	4.0
3	UNIT 1-2 SURFACE/AWAY	2184	63	2.8
	UNIT 2 DEEP/NORTH	1578	85	5.3
	STANDARD CONTROL	2168	350	16.1
	TURBINE	1222	45	3.6

Implications

The results obtained this year imply that bypassing fish around turbines may be the best approach to the problem of protecting these fish. Even if turbines were made completely safe, significant numbers of fingerlings may be placed in backroll flows to suffer losses from predation. Fingerlings bypassed around turbines, however, also can be bypassed around concentrations of predators.