FINAL REPORT

EVALUATION OF UPSTREAM PASSAGE OF ADULT SALMONIDS THROUGH THE NAVIGATION LOCK AT BONNEVILLE DAM DURING THE SUMMER OF 1969

by

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FIGURES

TABLES

CONTENTS

EVALUATION OF UPSTREAM PASSAGE OF ADULT SALMONIDS THROUGH THE NAVIGATION LOCK AT BONNEVILLE DAM DURING THE SUMMER OF 1969

INTRODUCTION

The number of adult salmon and steelhead trout that pass upstream past Bonneville Dam through the navigation lock has been a point of conjecture for some time. Increased attention was focused on the question in 1967 when substantially more adult salmon and steelhead were counted over The Dalles Dam, 47 miles upstream, than were counted over Bonneville Dam. By 1968 counts of sockeye salmon at Bonneville and The Dalles Dams were about 108,000 and 117,000, respectively. Junge (personal communication[1/]) estimated the Indian catch between the two dams at 5,000 sockeye. These figures indicate an increase of about 14,000 fish (+14%) between Bonneville and The Dalles Dams. A similar discrepancy existed for steelhead trout with an increase of 37,000 fish (+38%).

Various factors may have contributed to the count discrepancies between the dams. One possibility is that large numbers of sockeye and steelhead passed Bonneville Dam and were not included in the Bonneville count. On February 25, 1969, a diver found a large hole in the barrier beneath the Bradford Island counting station. The size and location of the hole made it a prime spot for large numbers of fish to pass Bonneville Dam without being counted.[2/] Another possible way for fish to bypass the counting stations was to pass through the navigation lock. Because fish passage through the navigation lock was an unassessed source of fish-count error, the Technical Advisory Committee of the Fisheries Engineering Research Program, U.S. Army Corps of Engineers, recommended that the study reported here be initiated. The study was financed by the Corps of Engineers and carried out by the Bureau of Commercial Fisheries.

The objective of this study was to determine the extent of upstream passage of adult sockeye salmon and steelhead trout through the Bonneville navigation lock. The objective was to be achieved by use of a sonar system and a mark and recovery program.

1/ Charles O. Junge, 1969, Oregon Fish Commission Research Division, Clackamas, Oreg.

2/ The hole was screened and a pattern of fish losses, rather than gains resumed between Bonneville and The Dalles Dams in 1969.

EXPERIMENTAL SITE AND EQUIPMENT

Bonneville Dam is on the Columbia River about 145 miles from the ocean. The navigation lock is on the Oregon shore adjacent to the powerhouse section of the dam (fig. 1). The lock is about 500 feet long by 76 feet wide. The minimum level to which the water in the lock can be readily lowered is controlled by the tailwater elevation. Our working depth of 55 feet was predetermined by the maximum tailwater elevation that could be expected. This depth kept the water surface below the concrete lip at the upstream end and gave a fairly uniform depth throughout the lock.

The lock entrance is separated from the tailrace by an abutment, approximately 200 feet wide, extending downstream from the lock entrance about 1,000 feet. The approach channel to the lock--through which the fish must swim to reach the lock entrance--is about 1,100 feet long. Water velocities in the approach channel are variable. When the lock is inoperative, the channel is essentially a dead water area with a large eddy at the lower end. As the water level in the lock is lowered, the water is discharged up through large ports along the bottom of the channel immediately in front of the lock gates. At this point a violent boiling action extends across the surface of the channel and diminishes as the head in the lock is reduced. Simultaneously, a rush of water is sent down the channel and persists with a constantly diminishing velocity until the water level in the lock reaches the level of the tailrace. On August 7, velocity measurements during maximum discharge--at a point in the channel about 500 feet downstream from the lock gates--averaged 1.4 feet per second. At a point 400 feet farther downstream, the velocity measured only 0.6 foot per second.

Sonar system

The sonar system used to detect and record fish within the lock consisted of a recording echo sounder and a special array of five transducers operating at a frequency of 200 kHz with pulse lengths of 0.1 or 0.6 msec. The transducers were arranged in a fan shape to simultaneously cover about 52% of the cross section of the lock. The transducer array and the echo sounder-recorder were mounted on a seine boat.

A sonar evaluation of the numbers of fish in the lock required two sonar runs the length of the lock. The boat traveled along the wall during each run--along one wall on the first pass and along the opposite wall on the return pass. Fish targets recorded on each pass were counted and the average number of fish per cubic yard of water was calculated.

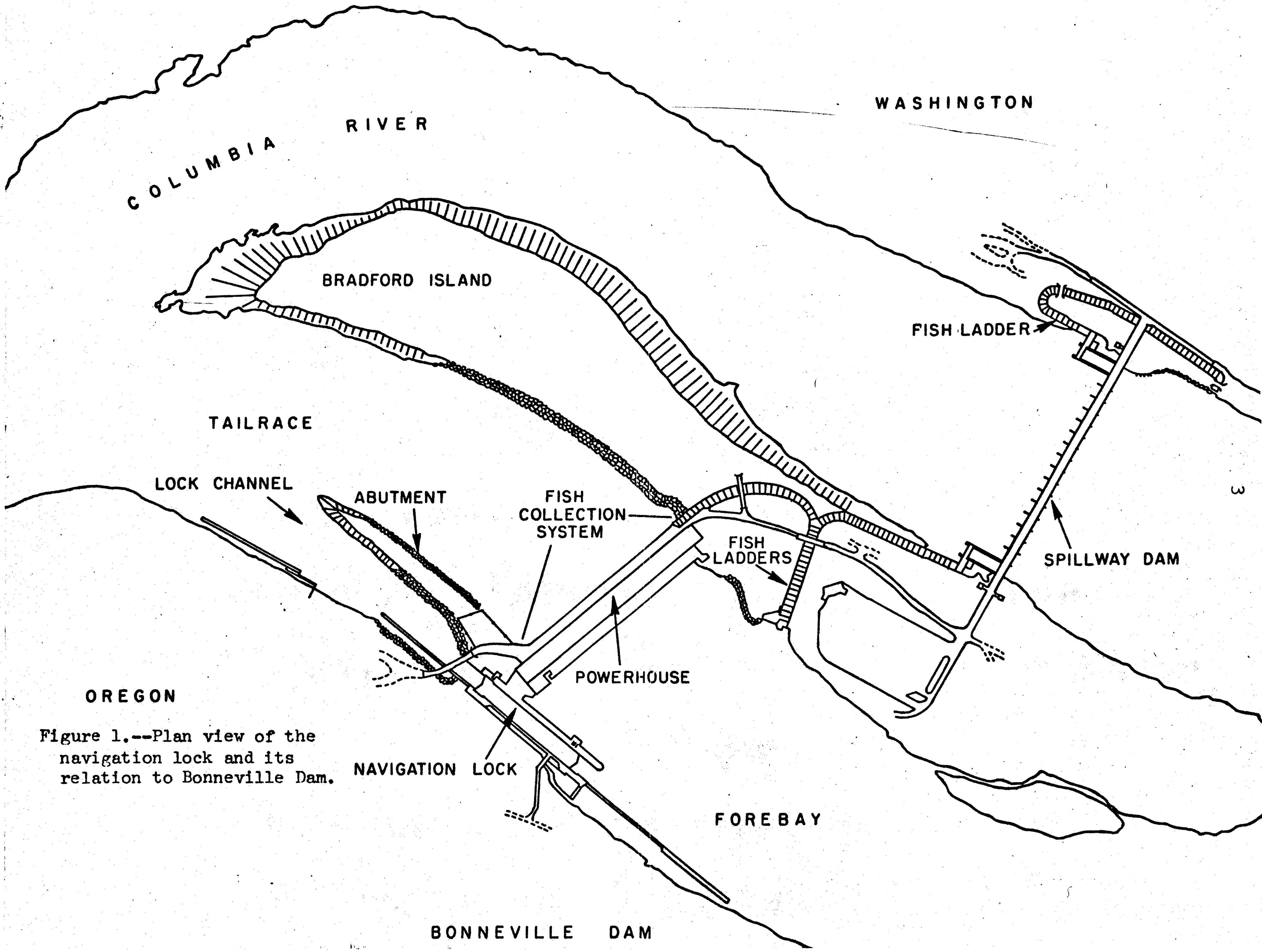

Figure 1.--Plan view of the navigation lock and its relation to Bonneville Dam.

Purse seine and barge

The purse seine was 300 feet long, 55 feet deep, and constructed of 2-1/4-inch stretched measure knotless nylon webbing. The net was bordered along the top by a float line containing sponge floats every 10 inches and along the bottom by a lead line weighing 1.2 lbs. per fathom.

The purse seine barge was 10 by 20 feet, powered by a 40-hp. outboard motor. The barge was outfitted with an A-frame and a double gypsy winch to purse the net and raise the lead line. The winch was powered by a 6-hp. air-cooled gasoline engine.

Setting and fishing the purse seine involved the following steps: Initially, the seine was carefully stacked on the barge, and the barge and seine boat were positioned against the wall on one side of the lock about 110 feet from the end. (Seine traverses were usually made from the downstream end of the lock but on occasion, sets were made from the upstream end.) The crew of the seine boat then took one end of the float line and held position against the wall; the barge traveled along the wall paying out net as it went. When the barge reached the end of the lock, it turned and traveled along the end to the other side, then turned and proceeded along the side, paying out net to a point opposite the seine boat. By this time, all the net was off the barge and set in roughly a "U" shape which reached from side to side and surface to bottom of the lock (fig. 2). Next, the barge and seine boat, each pulling an end of the float line, proceeded slowly along a lock wall until they reached the opposite end. The two craft then crossed along the end until they met in the middle, and the crew on the seine boat passed their end of the float line to the seine barge. The seine was then pursed to concentrate the fish. Good descriptions of the pursing operation and construction details of the barge and a similar seine are described by Durkin and Park (1967).

Tagging system

Fish were tagged with a Floy model FD-67F tagging gun and anchor tags.[3] The tags were modified by cutting off the flag so there would be little chance of the tags catching in the net. Fish were tagged as they were dipped from the bunt. The tagging was done rapidly without anesthetic. The tags were placed just below and about midway along the dorsal fin. Fish of each catch were identified by varying the color and lengths of tag and by tagging on either the right or left side of the fish. Details of the tag and tagging gun are described by Dell (1968).

3/ Trade names referred to in this publication do not imply endorsement of commercial products by the Bureau of Commercial Fisheries.

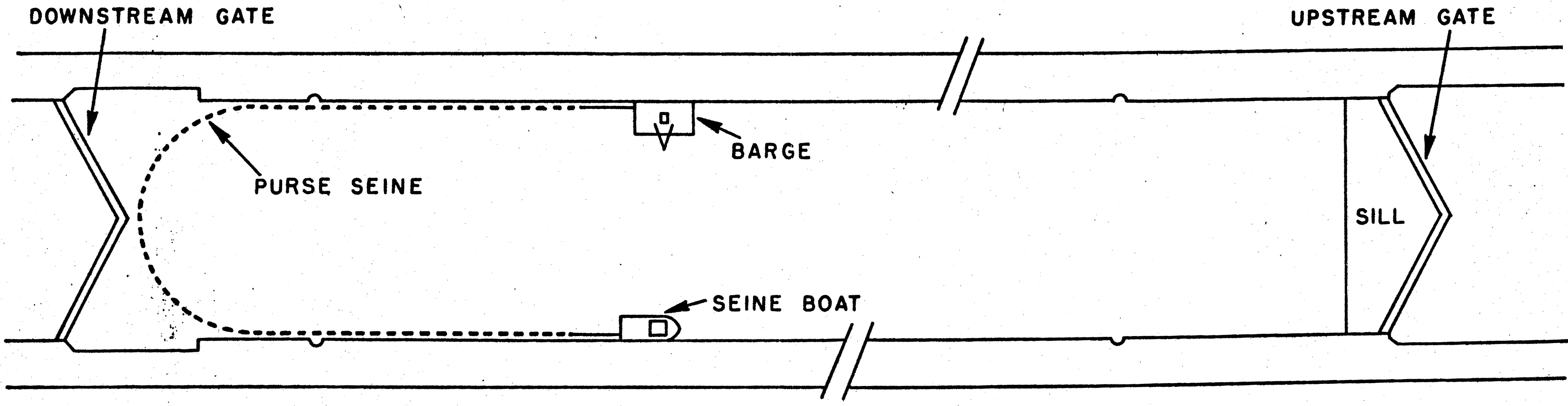

Figure 2.--Plan view of the seine set in the lock. Seine is ready to be towed to the upstream end, closed, and pursed.

EXPERIMENTAL PROCEDURES

Our experimental plan called for the use of the sonar system to detect and record fish within the lock, the purse seine to provide a species breakdown, and the mark and recovery program to provide backup data on the population estimates. Fishing periods were randomly selected to sample all photo periods, i.e., dawn, daylight, dusk, and dark. We planned to fish a photo period for 5 days, be off 2 days, and then repeat the cycle with the next scheduled photo period. During the course of the study, passage during weekdays and weekends was to be studied.

Problems encountered

In actual practice, we encountered two problems which necessitated modification of the experimental plan. First and foremost, we found it extremely difficult to get time in the lock to do our work. Our second problem arose because the sonar did not perform as expected.

Use of the lock by commercial traffic, which had priority, was extensive and unpredictable. Meetings were held with the tug companies involved; they agreed to cooperate to the best of their ability without seriously disrupting their operation. Daily consultation with the dispatcher for each tug company provided information on expected times of traffic on the following day, and we scheduled our crews accordingly. The tug companies were not always able to follow their predicted schedules. Consequently, we were not always able to sample on each day.

We were unable to obtain accurate fish counts with the sonar system for several reasons primarily associated with entrained air in the water. We found it necessary to wait an impractical length of time for the water in the lock to stabilize and allow us to obtain a scatter-free recording. The problem was compounded by the introduction of additional air from the outboard motors on our boat. Modifications and improvements were made on the sonar system and its use throughout the study, but we were unable to obtain satisfactory results.

Tagging and recovery

The purse seine operated effectively in conjunction with our mark and recovery program. To sample the population in the lock, an actual lockage was simulated because it was impossible to seine with a tug and barge in the lock. The lock gates were left open for 15 minutes while the seine boat and barge entered the lock. The gates were then closed and the water raised until it was at our working depth of 55 feet. We then made the first seine set and identified, counted, and marked the catch. The marked fish were released back into the lock, and a period of 15-20 minutes was allowed for the fish to redistribute. The seining operation was repeated and the fish were identified, counted, examined for tags, and released back into the lock. The water was then raised to forebay level and the upstream gates were opened for 15 minutes and then closed. Then the water level in the lock was lowered until it was 55 feet deep; the seine was operated a third time; and the catch was identified, counted, examined for marks, and released.

Analysis

Because data obtained from the sonar system were unsatisfactory, assessment of fish passage through the lock is based soley on data obtained from purse seine catches. Difficulties in securing use of the lock for study purposes caused so many deviations from our experimental design, it was impossible to analyse the data on the basis of photoperiod or weekend vs. weekdays. Analysis of the data was further complicated by the very small numbers of fish captured in the lock.

The analysis involved three major assumptions. First, it was assumed that equal numbers of fish entered the lock during simulated and actual lockages. Second, because we were unable to provide any photoperiod comparisons, it was assumed that we could give all population estimates equal weight regardless of time of day. Third, it was assumed that marked fish behaved the same as unmarked fish.

The population of fish in the lock during each test was determined by the Petersen method of estimating populations by recovery of marked fish (Ricker, 1958). Fish that were marked and released from the first seine catch provided the known populations of marked fish in the lock. Population estimates were based on the ratio of marked to unmarked fish in the second seine catch. Population estimates in the lock were made before and after opening the upstream gates. The estimate of the number of fish remaining in the lock after the upstream gates had been opened and closed was based on the third seine catch divided by the catch efficiency of the seine. The catch efficiency was determined for each test by averaging the percentage of the estimated population captured in the first two seine hauls.

The relation of numbers of fish of each species passing through the lock to the numbers counted over the dam involved several steps. First, the number of fish calculated in the lock during a test was multiplied by the number of upstream lockages during that test day. The resulting sums were then added for all the test days. The grand total was then divided by the total number of fish of the same species counted over the dam on corresponding days.

In this report, all the salmonids in the lock when the downstream gates were closed were considered to have passed upstream when the upstream gates were opened. We know this assumption is not absolutely true because the third seine hauls showed that some fish remained in the lock. However, no tagged fish were ever recovered in the lock after the day they were tagged. This would seem to indicate that fish leave the lock within 24 hours--perhaps during normal lockages as the result of the disturbances caused by tugs and barges leaving the lock.

UPSTREAM PASSAGE OF ADULT FISH THROUGH THE LOCK

Finite estimates of the numbers of fish passing through the lock should be accepted with caution because of the small numbers of fish captured. However, fish passage through the lock can be assessed on a gross basis. The relatively smooth walls and floor of the lock and the large size of the net which extended from the water surface to the bottom and from side to side permitted a thorough sampling of the population. Complete seining of the lock together with the rather consistent percentage of recapture for the marked fish assures that if large numbers of salmonids were present, their presence would be known.

Sockeye salmon

The majority of the 1969 sockeye salmon run of 53,000 fish passed Bonneville Dam during the course of this study. Our first complete seining operation took place on June 25; the last time any sockeye were captured was on July 17. During this period, we sampled 13 days and estimated that 213 sockeye passed upstream through the lock. Comparable passage over the dam on these days was 24,726 (table 1). The number calculated to have passed through the lock was only 0.86% of the number counted over the dam.

Table 1.--Data summary and population estimates for sockeye salmon passage through the Bonneville navigation lock

Date	Marked fish in lock (M)1/	Catch in second set			Population estimate (N)2/	Number of upstream lockages (L)3/	Daily fish passage through lock4/	Daily fish counts5/
		Total (C)	Marked fish (R)	Recaptures				
	Number	Number	Number	Percent	Number	Number	Number	Number
June 25	7	6	2	29	31	3	93	1,149
July 1	4	6	3	75	7	5	35	3,441
2	2	4	2	100	4	7	28	4,065
3	0	0	0	-	0	8	0	4,466
7	0	0	0	-	0	4	0	2,925
8	1	1	1	100	1	7	7	2,266
9	2	2	1	50	3	4	12	2,074
10	1	2	1	100	2	4	8	1,435
11	0	0	0	-	0	6	0	1,248
13	0	0	0	-	0	8	0	782
15	1	0	0	0	1	4	4	424
16	1	2	1	100	2	9	18	295
17	1	0	0	0	1	8	8	156
TOTAL							213	24,726

1/ Fish from first seine set.

2/ $N = \frac{(M)\ (C+1)}{R+1}$.

3/ Data taken from Corps of Engineers records.

4/ Equals (N)(L).

5/ Data taken from Corps of Engineers records.

Steelhead trout

The run of summer steelhead past Bonneville Dam was approximately 133,000 during 1969. The population in the lock was sampled on 34 days between June 25 and September 16. A total of 524 steelhead were estimated to have passed through the lock, whereas 46,947 were counted over the dam in the same period (table 2). Calculated passage through the lock was only 1.1% of the number counted over the dam.

Other species

Incidental to the main objective of studying passage of sockeye and steelhead, data were also obtained on other species of fish in the lock. During the 34 days of testing from June 25 until September 16, 745 chinook salmon were estimated to have passed through the lock. Passage over the dam during the same period was 58,020 (table 3). Estimated passage through the lock was 1.3% of those counted over the dam.

Shad were taken in relatively large numbers in comparison to the number of salmonids captured. However, they did not appear to pass as consistently upstream as did the salmonids. The catches in the lock after the upstream gates were opened and closed often were nearly as large or larger than the catch made before the upstream gates were opened. The catch of shad per set ranged from 0 to 253 and averaged 26 fish.

CONCLUSIONS

The following conclusions are drawn from the study of upstream passage of adult salmonids through the navigation lock at Bonneville Dam during the summer of 1969:

1. Few adult sockeye salmon, chinook salmon, and steelhead trout pass upstream through the navigation lock at Bonneville Dam. The small numbers of fish captured in the lock preclude firm numerical determinations, but apparently less than 2% of the run was involved for each species in 1969.

2. If the percentage of sockeye salmon and steelhead trout utilizing the lock in 1968 was similar in magnitude to that observed in 1969, fish passing through the lock did not significantly contribute to the discrepancies between the fish counts at Bonneville and The Dalles Dams.

3. Water velocities in the channel leading into the lock entrance were not of sufficient velocity or duration to attract large numbers of salmonids into the lock.

Table 2.--Data summary and population estimates for steelhead trout passage through the Bonneville navigation lock

Date	Marked fish in lock (M)1/	Catch in second set: Total (C)	Catch in second set: Marked fish (R)	Catch in second set: Recaptures	Population estimate (N)2/	Number of upstream lockages (L)3/	Daily fish passage through lock4/	Daily fish counts5/
	Number	Number	Number	Percent	Number	Number	Number	Number
June 25	0	0	0	-	0	3	0	200
July 1	1	1	0	0	2	5	10	579
2	1	0	0	0	-	7	-	-
3	0	0	0	-	0	8	0	924
7	0	0	0	-	0	4	0	1,105
8	0	0	0	-	0	7	0	1,353
9	0	0	0	-	0	4	0	1,268
10	0	0	0	-	0	4	0	1,628
11	0	0	0	-	0	6	0	1,958
13	0	0	0	-	0	8	0	1,971
15	1	2	1	100	2	4	8	3,416
16	0	1	0	-	-	9	-	-
17	0	0	0	-	0	8	0	2,188
22	2	4	2	100	4	10	40	3,596
24	1	2	1	100	2	12	24	2,879
25	2	2	1	50	3	5	15	2,119
28	2	2	1	50	3	9	27	1,708
29	0	0	0	-	0	8	0	2,021
30	1	2	1	100	2	9	18	2,530
August 1	1	1	1	100	1	8	8	996
5	1	2	1	100	2	3	6	1,084
8	0	1	0	-	-	6	-	-
11	3	7	2	67	8	5	40	1,102
13	2	3	1	50	4	9	36	1,759
14	4	3	2	50	6	12	48	742
15	9	6	3	33	16	12	192	789
18	0	0	0	-	0	7	0	1,087
19	1	2	0	0	3	8	24	830
20	1	2	1	100	2	11	22	829
26	1	1	1	100	1	6	6	1,136
28	0	0	0	-	0	6	0	752
September 4	0	1	0	-	0	5	0	2,145
5	0	0	0	-	0	7	0	1,490
16	0	0	0	-	0	9	0	763
TOTAL							524	46,947

1/ Fish from first seine set. 2/ $N = \frac{(M)(C+1)}{R+1}$. 3/ Data taken from Corps of Engineers records.

4/ Equals (N)(L). 5/ Data taken from Corps of Engineers records.

Table 3.--Data summary and population estimates for chinook salmon passage through the Bonneville navigation lock

Date	Marked fish in lock (M)1/	Catch in second set: Total (C)	Catch in second set: Marked fish (R)	Catch in second set: Recaptures	Population estimate (N)2/	Number of upstream lockages (L)3/	Daily fish passage through lock4/	Daily fish counts5/
	Number	Number	Number	Percent	Number	Number	Number	Number
June 25	0	0	0	-	0	3	0	1,806
July 1	0	0	0	-	0	5	0	2,200
2	1	0	0	0	-	7	-	-
3	0	0	0	-	0	8	0	2,678
7	0	0	0	-	0	4	0	1,474
8	0	0	0	-	0	7	0	1,627
9	1	1	1	100	1	4	4	1,076
10	2	1	1	50	2	4	8	1,290
11	0	0	0	-	0	6	0	1,470
13	0	0	0	-	0	8	0	1,190
15	0	0	0	-	0	4	0	1,528
16	0	0	0	-	0	9	0	1,393
17	0	1	0	-	-	8	-	-
22	0	0	0	-	0	10	0	1,248
24	0	0	0	-	0	12	0	1,105
25	0	1	0	-	-	5	-	-
28	1	2	1	100	2	9	18	817
29	0	0	0	-	0	8	0	845
30	7	4	3	43	9	9	81	1,038
August 1	0	0	0	-	0	8	0	543
5	1	3	1	100	2	3	6	664
8	0	0	0	-	0	6	0	437
11	2	4	2	100	4	5	20	688
13	5	5	2	40	10	9	90	750
14	6	4	3	50	8	12	96	582
15	1	0	0	0	-	12	-	-
18	1	0	0	0	-	7	-	-
19	2	2	1	50	3	8	24	962
20	12	5	3	25	18	11	198	871
26	6	4	2	33	10	6	60	2,212
28	0	0	0	-	0	6	0	1,826
September 4	2	2	1	50	3	5	15	7,812
5	4	9	2	50	14	7	98	6,801
16	1	4	1	100	3	9	27	11,087
TOTAL							745	58,020

1/ Fish from first seine set. 2/ $N = \frac{(M)\ (C+1)}{R+1}$ 3/ Data taken from Corps of Engineers records.

4/ Equals (N) (L). 5/ Data taken from Corps of Engineers records.

ACKNOWLEDGMENTS

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LITERATURE CITED

Dell, Michael B.
1968. A new fish tag and rapid cartridge-fed applicator. Trans. Amer. Fish. Soc. 97: 57-59.

Durkin, Joseph T. and Donn L. Park.
1967. A purse seine for sampling juvenile salmonids. Prog. Fish-Cult. 29: 56-59.

Ricker, W. E.
1958. Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Bd. Canada, 119, 300 p.