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Northwest Fisheries Science Center

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Seattle, Washington

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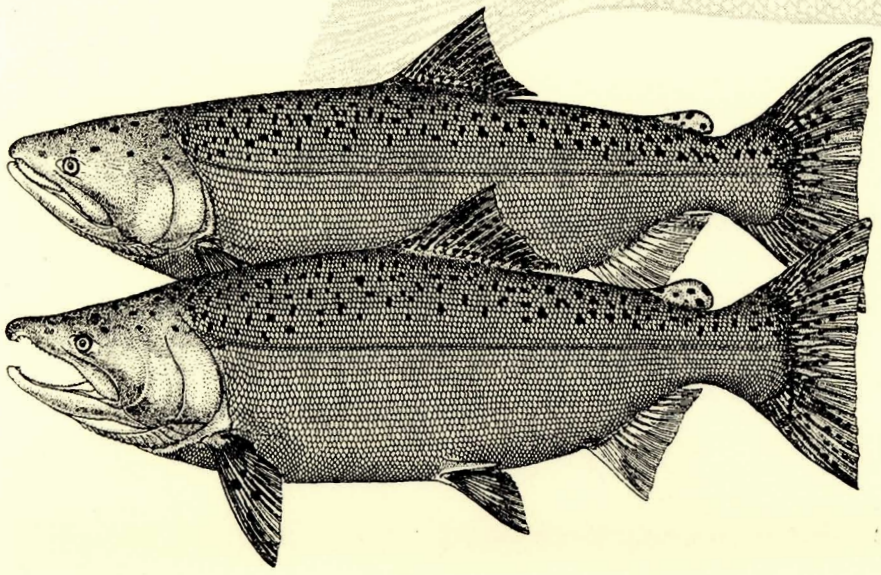

RELATIVE SURVIVAL OF JUVENILE CHINOOK SALMON AFTER PASSAGE THROUGH SPILLBAYS AND THE TAILRACE AT LOWER MONUMENTAL DAM 1994

by
William D. Muir
Robert N. Iwamoto
Chris R. Pasley
Benjamin P.Sandford
Paul A. Ocker
and
Thomas E. Ruehle

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INTRODUCTION

Juvenile salmonids pass Lower Monumental Dam through spillbays, the bypass system, or turbines. Previous studies have indicated that among the different passage routes, survival was highest for fish passing via spillbays and bypasses, with lower survivals through turbines. For example, Long et al. (1975) found that survival for steelhead (*Oncorhynchus mykiss*) passing through a Lower Monumental Dam spillbay equipped with and without a flow deflector was 97.8% and 72.5%, respectively. In contrast, turbine passage survival for yearling coho salmon (*O. kisutch*) at Lower Monumental Dam averaged 80% with a range of 76% to 83%.

Gilbreath et al. (1993) reported that overall recovery for bypass-released groups was 7.6% less than for turbine-released groups and 8.3% less than for tailrace-released groups at Bonneville Dam. High mortality in the bypass-released groups was attributed to predation at the bypass outfall site. Iwamoto et al. (1994) determined that bypass system mortality was insignificant for yearling hatchery spring/summer chinook salmon (*O. tshawytscha*) released just upstream from the last set of PIT-tag detectors in the return-to-the-river line at Lower Granite (100.1% survival) and Little Goose (102.2% survival) Dams. No comparable estimates of bypass passage survival are available for Lower Monumental Dam.

Mortality in tailrace areas downstream from the turbine and spillbay discharges can be substantial. Long et al. (1968) determined that location in the tailrace after turbine passage significantly affected survival--up to 33% additional mortality

of yearling coho salmon was attributed to release location in the back-roll of the turbine discharge boil.

The juvenile salmonid passage facilities at Lower Monumental Dam have been recently upgraded to include submersible traveling screens, vertical barrier screens, raised operating gates, a new collection channel, and a new juvenile bypass facility. The effects of these upgrades on passage survival has not been previously evaluated, and the most recent passage survival data was based on research conducted during the 1960s and 1970s.

In 1994, the National Marine Fisheries Service initiated research to determine juvenile fish passage survival through the facility bypass, spillbay, and tailrace of Lower Monumental Dam. Specific objectives were to: 1) obtain statistically sound survival estimates on the passage of juvenile salmonids through spillbays, with and without flow deflectors, and the facility bypass; and, 2) compare the survival of dam-passage groups with fish released downstream from the dam.

METHODS

Evaluation of Logistics and Feasibility

For assessment of survival estimates with juvenile fish recoveries, we examined the logistics and feasibility of obtaining, marking (with either PIT tags or CWTs), and releasing subyearling and yearling chinook salmon at Lower Monumental Dam, with downstream recaptures by purse seine in the Ice Harbor Dam pool or detection in the bypass system at McNary Dam. We also

examined the possibility of obtaining survival estimates based on adult recoveries of CWT-marked juveniles released at Lower Monumental Dam. For project passage evaluation, we considered release via spillbays, the facility bypass, and at release sites downstream from the dam. Based on the release numbers of fish needed for statistical analyses, the availability of subyearling and yearling chinook salmon became the primary factor limiting the experimental design.

In terms of logistics and feasibility, PIT tagging and release of yearling spring/summer chinook salmon with subsequent detection at McNary Dam emerged as the most practical method for estimation of spillbay and facility bypass survival at Lower Monumental Dam.

Study Criteria

The decision to initiate the research was contingent upon the following criteria: 1) flows passing the project exceeded the bypass trigger of fish to the river; 2) fish were bypassed via the facility bypass system for a minimum of 48 hours to allow a predator population to establish; 3) flow levels were expected to continue above the bypass trigger for a minimum of 4 days to permit the minimum number of releases necessary for statistical purposes; and, 4) new juvenile collection facility and PIT-tag detection systems at McNary Dam were operational.

Study Design

The initial study design included five release locations with approximately 4,500 fish released per location. The five locations were: 1) at a spillbay fitted with a flow deflector; 2) at a spillbay without a flow deflector; 3) through the facility bypass; 4) directly to the facility bypass outfall; and, 5) at a release site 1-2 km downstream from Lower Monumental Dam (Fig. 1). Three replicates of approximately 1,500 fish each for each release location were planned. This study was conducted concurrently with a study to estimate survival of juvenile salmonids passing through dams and reservoirs, including Lower Monumental Dam (Muir et al. 1995).

Fish Collection and Handling

Fish were obtained from the juvenile collection facility at Lower Monumental Dam. A juvenile salmonid separator sorted fish on the basis of size into the two sample holding tanks. One tank collected larger fish, predominantly steelhead, and a second tank collected smaller fish, mostly yearling chinook salmon. Collection rates for each sample holding tank were adjusted to obtain the necessary number of yearling hatchery chinook salmon needed for marking.

Fish sorting and marking were conducted in the sample facility using the same procedures described by Iwamoto et al. (1994). Fish were preanesthetized with benzocaine and alcohol and conveyed to the sample facility via water-filled pipe. During sorting and marking, fish were anesthetized with MS 222

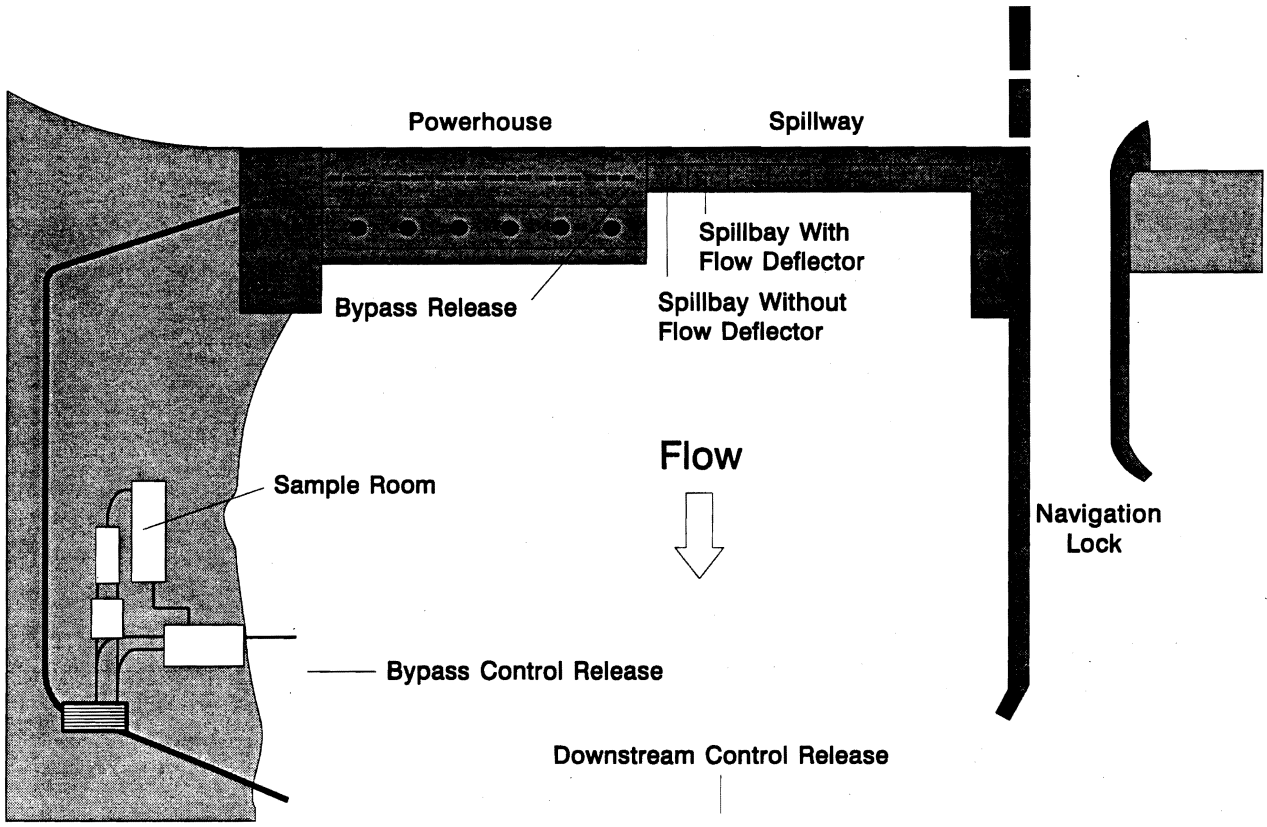

Figure 1. Schematic of Lower Monumental Dam showing locations of release sites.

in a recirculating anesthetic system at a dosage of approximately 50 ppm. Steelhead and chinook salmon rejected for tagging were counted and returned by pipe to a raceway adjacent to the sampling facility for loading onto the next available transport barge. Fish were rejected for tagging by the following criteria: non-target species or race, previously PIT tagged, excessively descaled, and obvious deformities and abnormalities. Prior to tagging, each fish was prescanned to reduce the possibility of double tagging.

Marking Procedures

Fish were PIT tagged using modified hypodermic syringes containing a push rod, terminal air hole, and 12-gauge needle (Prentice et al. 1990, Nielsen 1992). To reduce the incidence of disease transmission, all needles were suspended in 70% ethyl alcohol for a minimum of 10 minutes before loading with a PIT tag. The PIT-tag needle was inserted anteroventrally alongside the midventral line between the ventral and pectoral fins, and the tag was placed into the body cavity posterior to the pyloric caeca (Prentice et al. 1990).

Each fish was then scanned for the presence of a PIT tag and examined for injuries, descaling, brands, bleeding, or other abnormalities. Finally, length was measured, and comments were recorded on a digitizing board (Prentice et al. 1990). Tagged fish were returned via water filled pipe to labeled holding tanks (1.8 x 0.9 x 0.6-m aluminum) mounted on trucks until release.

Because of the limited amount of space available for marking, fish were not randomized between treatment and reference groups during marking. Instead, fish were marked by groups into tanks containing one-half of a release group, and randomly designated as a treatment or reference release. Holding tanks were aerated with oxygen or flow-through water. Fish were held for a minimum of 24 hours for recovery and determination of post-tagging mortality. Holding density did not exceed 750 fish per tank.

Release Procedures

After the minimum recovery period, holding tanks containing fish for the spillbay releases were switched from flow-through water to oxygen aeration and transported to the designated release areas on the intake deck of the dam. Test fish were released from holding tanks via hoses (7.6-cm x 24.4-m) extended down into Spillbays 7 (with flow deflector) and 8 (without flow deflector). The terminal end of each hose (no terminal fitting) was attached to a spillbay stoplog supported by 4-m-high legs. Fish entered the designated spillbays approximately 2 m above the spill gate ogee (Fig. 2).

After switching from flow-through water to oxygen aeration, tanks holding downstream reference releases were transported by truck to the south shore tailrace deck. From the tanks, fish

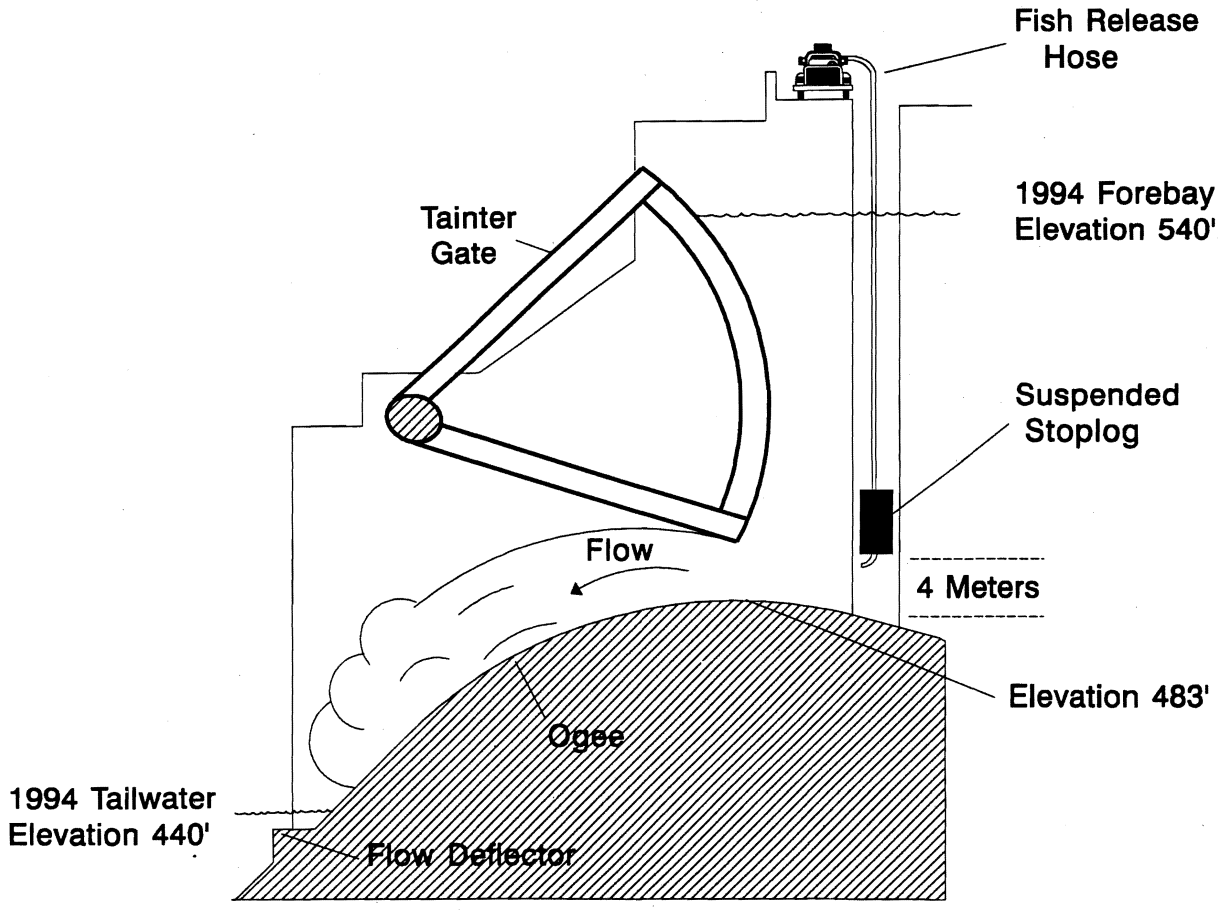

Figure 2. Typical spillbay at Lower Monumental Dam showing location of flow deflector.

were transferred via 7.6-cm x 20-m hose to 1.8 x 0.9 x 0.6-m aluminum tanks on a small barge. Fish were then transported to the downstream release site and released through a 10.1-cm x 80-cm hose. The facility bypass groups were released in the collection channel near Turbine unit 3 in the same manner as spillbay releases. All releases were made between 1600 and 1900 hours. Mortalities were removed from each tank prior to release, scanned, and recorded.

Data Analysis

At the conclusion of each tagging session, data were electronically transferred to the PIT-Tag Information System (PTAGIS), a database maintained by the Pacific States Marine Fisheries Commission. Data were uploaded to two files: 1) the tagging file, which contained information on the tagging session (date, location, etc.) and individual records for each tagged fish (PIT-tag code, species, rearing type, length (mm), and a comment field for miscellaneous information); and 2) the observation file, which contained records of PIT-tag detections that were collected automatically at McNary and John Day Dams (PIT Tag Work Group 1994).

There were multiple PIT-tag detectors at McNary Dam, and each detector had two or more coils by which the PIT tag could be read. There was one single-coil PIT-tag detector at John Day Dam. Therefore, each record in an observation file included the PIT-tag code, the tagging file in which the PIT-tag code could be found, the observation site, the date and time of the

observation, the number of coils, the ID codes for the coils, and the elapsed time in days between release and detection.

The first step in data analysis was retrieval of data from the PTAGIS tagging and observation files. For each release, a report in the comma-separated variable (CSV) format was generated from each file.

Quality Assurance

Reports from both files were examined for erroneous records, inconsistencies, and data anomalies. Records were eliminated where appropriate. However, a record was kept of all PIT-tag codes eliminated and the reasons for their elimination. Records were eliminated by the following criteria:

1) A detection was recorded for a PIT-tagged fish before its supposed release date.

2) A tag was detected at Lower Monumental Dam.

3) A tag was detected upstream from the release site.

4) A fish died between the time of tagging and data uploading and the time of release (handling mortality).

These data errors could be caused by duplicate PIT tags in the basin or by PIT tag code reading errors. Only a small number of records were eliminated for these reasons.

As a result of this process, all statistical analyses were based on hatchery chinook salmon that were known to be released alive in the intended release group. The process also ensured that fish were handled (and detained) only once, and that data

were internally consistent and logical as to downstream detections.

Statistical Treatment

PIT-tagged fish were detected primarily at McNary Dam, although some were also detected at John Day Dam. A relative survival estimate was calculated for each test group by dividing its detection percentage by the detection percentage of the downstream reference group (Burnham et al. 1987). Differences among detection percentages for each tagged group at McNary and John Day Dam were evaluated by ANOVA using a randomized block design where each release day was considered a block. Treatment means for significant F-tests were ranked by Fisher's protected least significant difference procedures ($p < 0.05$ level).

Visual assessment and chi-square homogeneity tests were used to compare arrival distributions at McNary Dam for each series of releases. P-values were calculated using Monte Carlo approximation of the exact method (Metha and Patel 1992).

RESULTS

Study Criteria

During the 1994 migration, most conditions stipulated in the study proposal necessary to begin the study were not realized. However, because of the fish spill program that began on 11 May (as requested by the National Marine Fisheries Service), the decision was reached to proceed with the spill portion of the study. Since the project was not placed in a bypass mode (i.e.,

transport of smolts continued), the bypass/collection channel and associated reference releases were not made during 1994.

Fish Marking

Fish marking for spillbay and downstream reference releases began on 12 May during the latter part of the yearling hatchery chinook salmon migration (Fig. 3). Target numbers (1,500 per release group) were reached except for the second replicate tagged on 14 May (Table 1). Insufficient numbers of yearling hatchery chinook salmon were available for the 14 May groups, so reduced sample sizes were used. Post-tagging mortality averaged 1.3% for all releases combined (Table 1).

Releases

Because of the danger to boat operators involved with releasing the downstream reference groups during full spill conditions (generally between 1800 and 0600 h), reference releases were made about 1 hour before full spill began during each night of testing. The spillbay releases were made just after full spill began. Spill levels were set at 4.4-4.8 kcfs through spillbays 7 and 8 during each release. To reduce gas supersaturation in the tailrace, spill in spillbay 8 was terminated approximately 15-30 minutes after each test. Total discharge and spill levels at Lower Monumental Dam were similar during all three releases (Table 2).

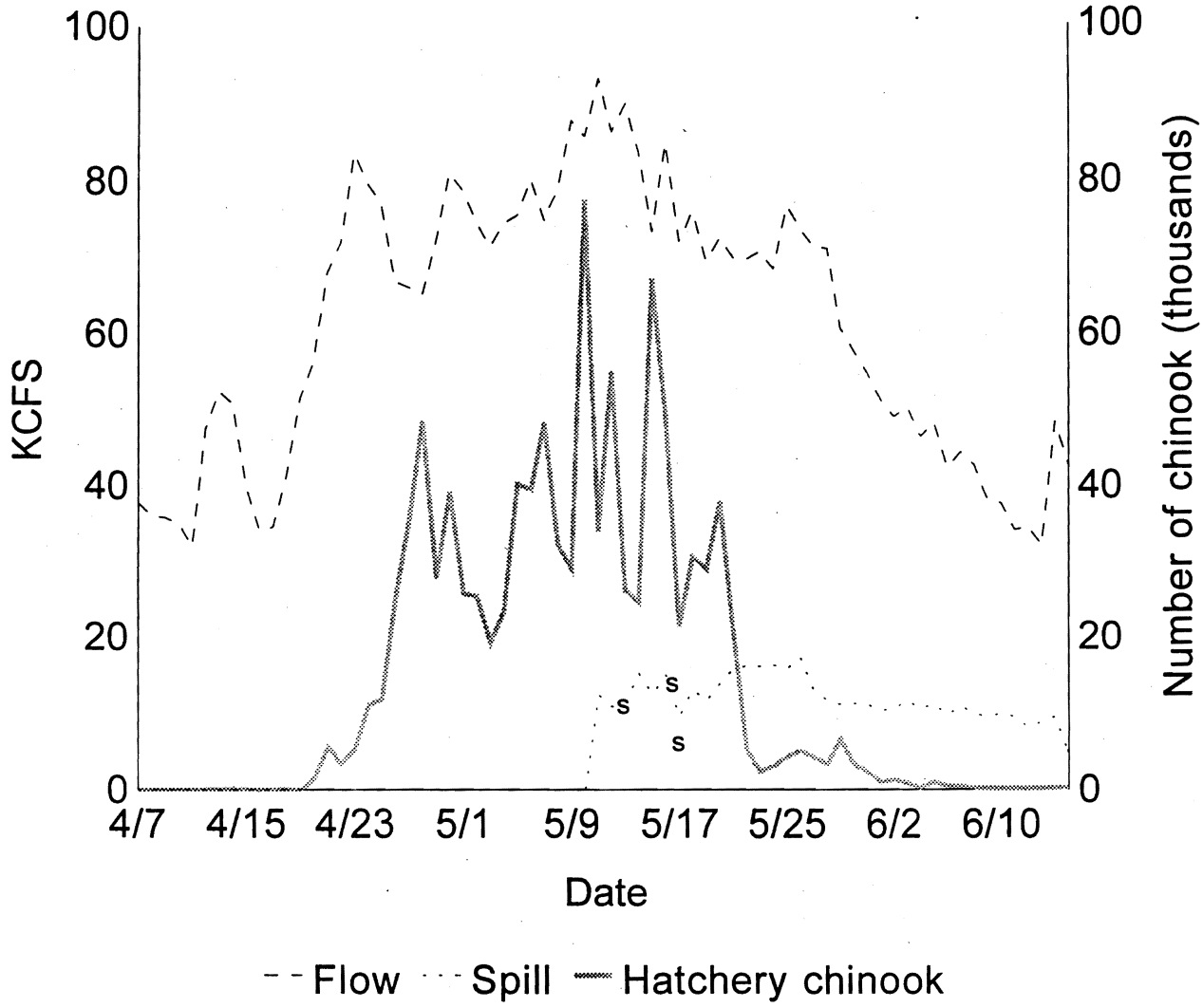

Figure 3. Flow, spill, and passage distribution of yearling hatchery and wild chinook salmon at Lower Monumental Dam. Dates of spillway releases (s) are indicated.

Table 1. Number of yearling hatchery chinook salmon PIT tagged and released at Lower Monumental Dam, 1994 for spillbay survival estimation.

Release site	Replicate	Date released	Number PIT tagged	Number mortalities	Number eliminated	Number released
Spillbay 8	1	13 May	1,500	54	2	1,444
Spillbay 8	2	15 May	1,252	10	2	1,240
Spillbay 8	3	17 May	1,502	27	2	1,473
Total			4,254	91	6	4,157
Spillbay 7	1	13 May	1,500	11	5	1,484
Spillbay 7	2	15 May	1,263	16	3	1,244
Spillbay 7	3	17 May	1,502	13	11	1,478
Total			4,265	40	19	4,206
Downstream	1	13 May	1,524	12	4	1,508
Downstream	2	15 May	1,254	13	1	1,240
Downstream	3	17 May	1,504	7	2	1,495
Total			4,282	32	7	4,243
Grand total			12,801	163	32	12,606

Table 2. Conditions at Lower Monumental Dam during release of PIT-tagged yearling hatchery chinook salmon into spillbays 7 and 8 and at a downstream reference release site on three dates during 1994. (Conditions shown are for the hour of release, not daily average as shown in Figure 3).

Date	13 May	15 May	17 May
Turbine discharge (kcfs)	72.0	60.0	39.9
Units in operation	1,2,3,5,6	1,2,3,6	1,2,3
Spillbay 7 spill (kcfs)	4.4-4.8	4.4-4.8	4.4-4.8
Spillbay 8 spill (kcfs)	4.4-4.8	4.4-4.8	4.4-4.8
Total spill (kcfs)	19.0	15.0	11.0
Forebay elevation (ft)	537.4	537.4	537.1
Tailrace elevation (ft)	440.6	439.3	438.7

Survival Estimation

The majority of downstream PIT-tag detections occurred at McNary Dam, with only a small number observed at John Day Dam (Table 3). PIT-tagged fish were not routinely returned to the river via slide gate at McNary Dam during 1994, and at John Day Dam only smolts sampled during smolt monitoring activities were interrogated for PIT-tags. Percentages of PIT-tagged smolts released at Lower Monumental Dam and detected at McNary or John Day Dams were high for all releases, ranging from 42.6 to 55.1% (Table 4).

Arrival distributions at McNary Dam of PIT-tagged smolts for each release date indicated that release groups were fairly well mixed (Figs. 4, 5, and 6). However, chi-square analyses of the arrival distributions revealed significant differences between groups for all three release dates (Table 5). This was caused by the slightly earlier arrival of reference groups for all three release dates. Arrival distributions of the two spillbay groups alone were not significantly different (Table 5).

Relative survivals averaged 0.984 for fish released into Spillbay 8 (without a flow deflector) and 0.927 for fish released into Spillbay 7 (with a flow deflector), respectively (Table 4). However, the difference was not statistically significant ($F = 3.80$, 2 df, $P = 0.1190$) (Table 6).

Table 3. Number of PIT-tagged yearling hatchery chinook salmon released at Lower Monumental Dam and detected at McNary (MCN) or John Day JDA) Dams, 1994 for spillbay survival estimation. The combined total detections include only fish used in survival analysis.

Release site	Replicate	Date released	Number released	Number detected at MCN	Number detected at JDA	Combined
Spillbay 8	1	13 May	1,444	725	4	727
Spillbay 8	2	15 May	1,240	632	0	631
Spillbay 8	3	17 May	1,473	697	1	697
Total			4,157	2,054	5	2,055
Spillbay 7	1	13 May	1,484	701	6	704
Spillbay 7	2	15 May	1,244	625	1	625
Spillbay 7	3	17 May	1,478	629	4	629
Total			4,206	1,955	11	1,958
Downstream	1	13 May	1,508	732	5	735
Downstream	2	15 May	1,240	682	2	683
Downstream	3	17 May	1,495	707	3	710
Total			4,243	2,121	10	2,128

Table 4. Survival estimates for PIT-tagged yearling hatchery chinook salmon for spillbay and downstream reference releases at Lower Monumental Dam, 1994.

Release site	Replicate	Release date	Percent detected	Relative survival	Standard error (%)
Spillbay 8	1	13 May	50.3	1.033	---
Spillbay 8	2	15 May	50.9	0.924	---
Spillbay 8	3	17 May	47.3	0.996	---
Mean			49.5	0.984	0.033
Spillbay 7	1	13 May	47.4	0.973	---
Spillbay 7	2	15 May	50.2	0.912	---
Spillbay 7	3	17 May	42.6	0.896	---
Mean			46.7	0.927	0.023
Downstream	1	13 May	48.7	----	---
Downstream	2	15 May	55.1	----	---
Downstream	3	17 May	47.5	----	---
Mean			50.4	----	---

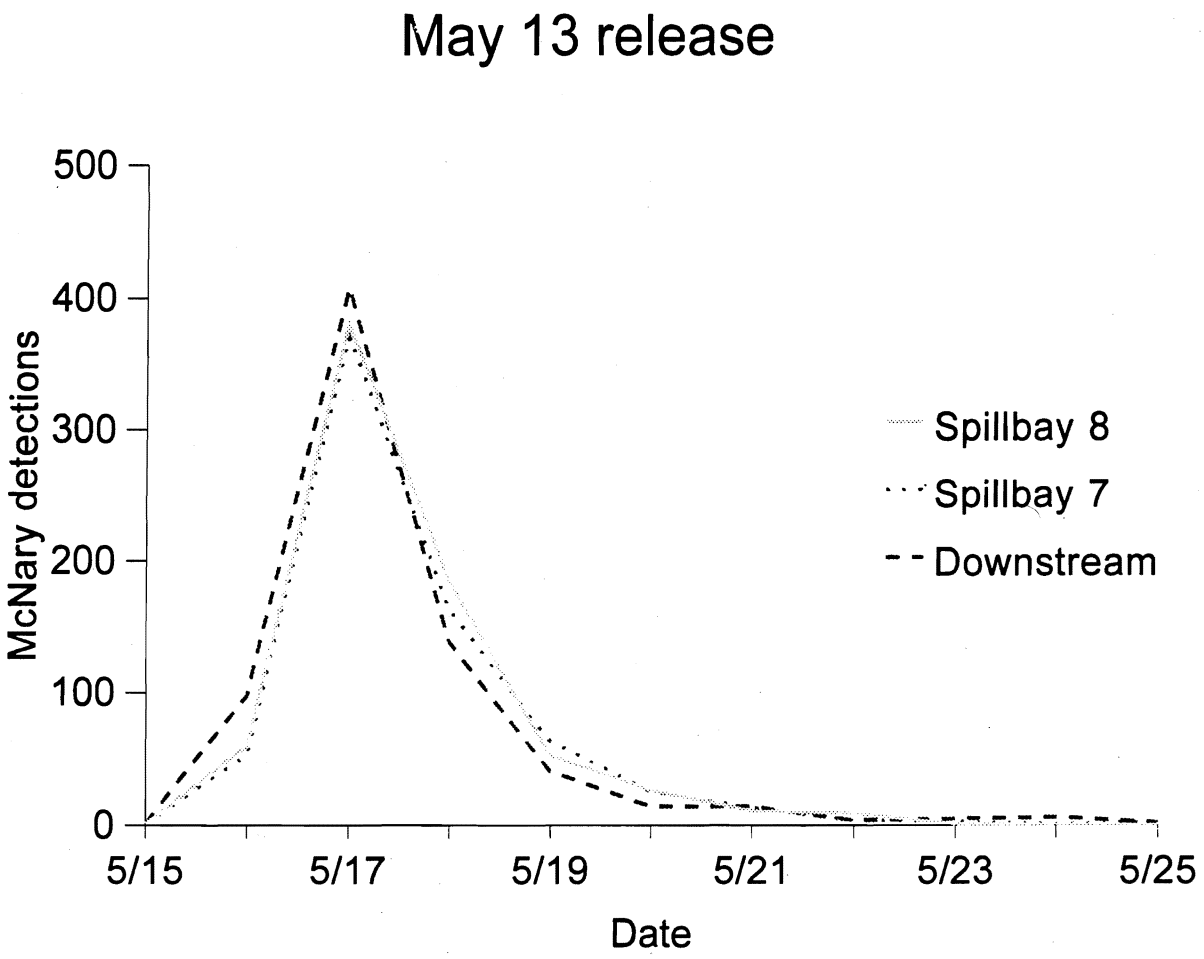

Figure 4. Arrival distributions at McNary Dam of test groups of fish released at Lower Monumental Dam on 13 May 1994.

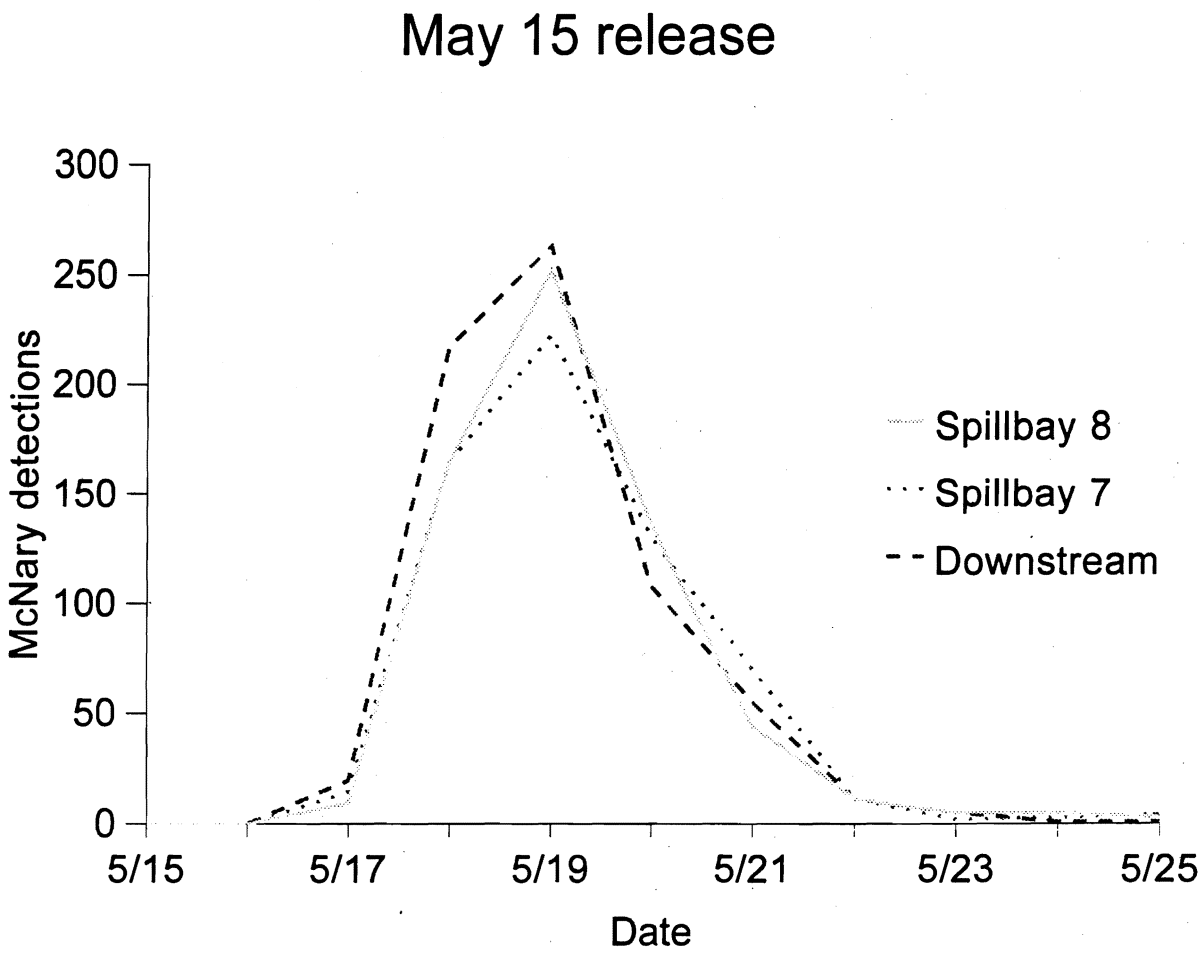

Figure 5. Arrival distributions at McNary Dam of test groups of fish released at Lower Monumental Dam on 15 May 1994.

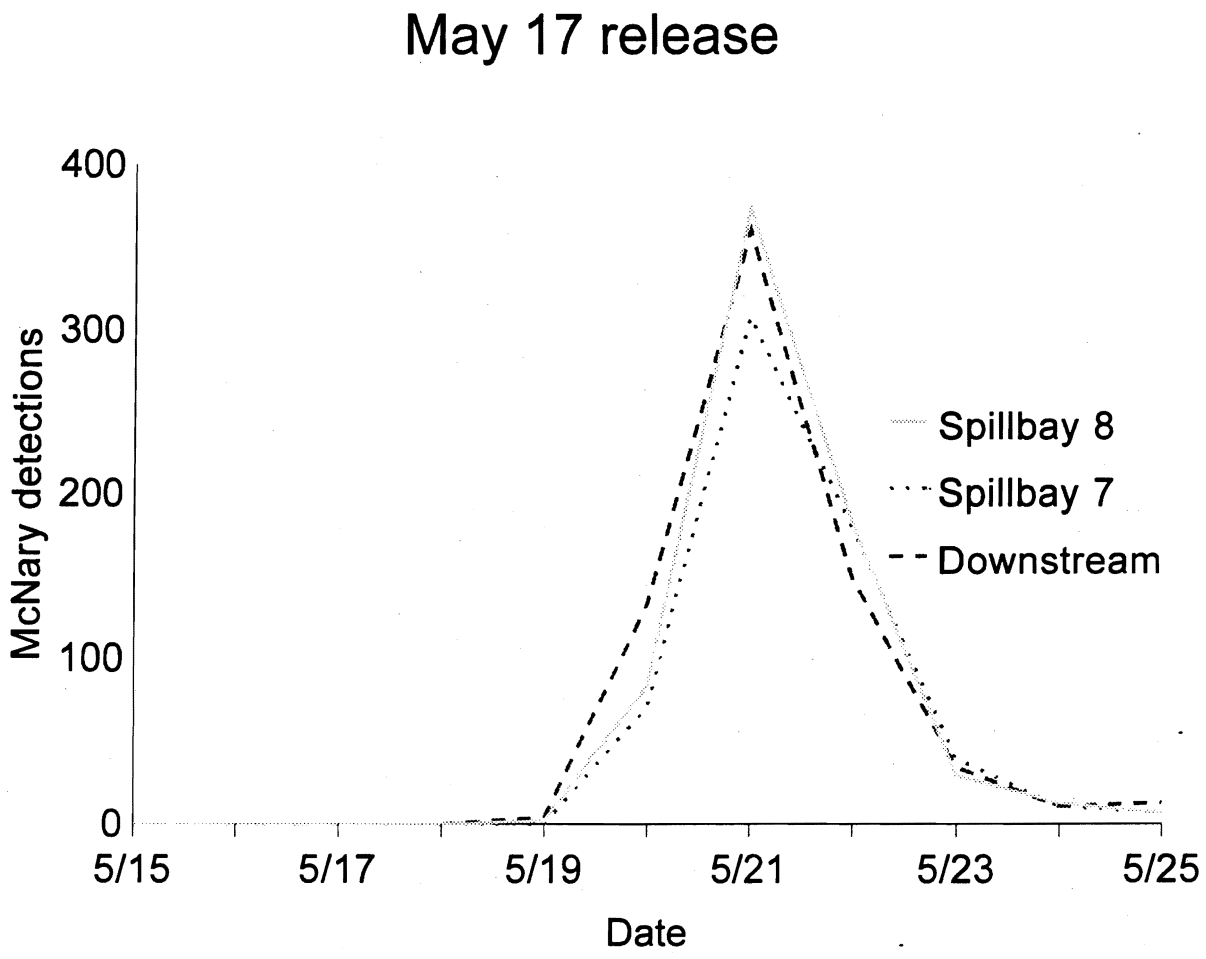

Figure 6. Arrival distributions at McNary Dam of test groups of fish released at Lower Monumental Dam on 17 May 1994.

Table 5. Chi-square comparisons of arrival distributions at McNary Dam of PIT-tagged yearling hatchery chinook salmon groups released on the same day at Lower Monumental Dam, 1994.

Release date	Groups	Chi-square	df	p-value
13 May	All	61.22	28	<0.0001
	Spill only	12.70	13	0.4745
15 May	All	36.75	24	0.0237
	Spill only	13.81	12	0.2841
17 May	All	53.19	26	0.0002
	Spill only	17.29	13	0.1361

Table 6. Analysis of variance (ANOVA) of detection percentages for fish released into Spillbay 7, Spillbay 8, and a reference release site downstream from Lower Monumental Dam, 1994.

Source	SS	df	MS	F	p-value
Blocks	58.75	2	29.38		
Treatments	21.95	2	10.97	3.80	0.1190
Error	11.56	4	2.89		
Total	92.26	8			

DISCUSSION

The results from this study showed that passage survival through spillbays equipped with and without flow deflectors was not significantly different at the $p < 0.05$ level. However, relative survival estimates for fish released into the two spillbays were different enough (0.927 vs 0.984) to warrant further study, using larger sample sizes and/or more replication. (For this study, sample size was determined assuming binomial sampling variability in recovery proportions. For future studies, sample size would be determined using observed empirical variability). This information is needed for future decisions regarding the addition of flow deflectors to the spillbays at Ice Harbor Dam and at other dams with non-deflector spillbays.

Chi-square analysis revealed significant differences between arrival distributions at McNary Dam for spillbay and downstream reference release groups. However, visual inspection of the data indicated these differences were small implying fish were fairly well mixed. No significant differences were found between spillbay groups after removal of downstream reference release groups from the analysis.

Survival of steelhead after passage through spillbays at Lower Monumental Dam without a flow deflector (Spillbay 8) was estimated at 72.5% at a discharge of 4,800 cfs through the spillbay during release (Long et al. 1975). In comparison, survival for steelhead passing through a spillbay equipped with a flow deflector (Spillbay 7) was significantly higher at 97.8% at

the same discharge. For coho salmon at Lower Monumental Dam, no detectable mortality was found in groups released to a spillbay equipped with a flow deflector (Long and Ossiander 1974). Similar high survival estimates were reported by Holmes (1952) and Schoeneman et al. (1961) for subyearling chinook salmon at Bonneville Dam and McNary Dam. Recently, Ledgerwood et al. (1990) found no detectable mortality for subyearling chinook salmon passing via a spillbay at Bonneville Dam, and Iwamoto et al. (1994) found no detectable mortality for yearling chinook salmon released into a spillbay with a flow deflector at Little Goose Dam.

During 1994, turbine mortality at Lower Monumental Dam was estimated at 13.9% for yearling hatchery chinook salmon (Muir et al. 1995), leaving bypass mortality as the only route of passage not evaluated at this project. Considering the results reported by Gilbreath et al. (1993) for bypass survival at Bonneville Dam, this route of passage should be evaluated at Lower Monumental Dam to optimize survival for fish arriving at this project.

CONCLUSIONS

1. No statistically significant differences in survival were found between groups released to Spillbay 7 (with a flow deflector) and Spillbay 8 (without a flow deflector) at the $p < 0.05$ level. However, the differences observed between the two conditions warrant further testing with increased replication

to better define whether the addition of flow deflectors would benefit juvenile salmon passage.

RECOMMENDATIONS

1. Spillbay evaluation should be repeated in future years to determine if there are differences in survival between the two types of spillbays by increasing the number of replicates.

2. Bypass releases should be made during future years if conditions warrant to evaluate this route of passage.

ACKNOWLEDGMENTS

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