Monitoring Tailrace Egress in the Stilling Basin and the Bypass System Outfall at John Day Dam, 2000

Final Report of Research for 2000

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EXECUTIVE SUMMARY

In 2000, the U. S. Geological Survey (USGS) used radio telemetry to examine the movements and behavior of yearling and subyearling chinook salmon (*Oncorhynchus tshawytscha*) and yearling steelhead (*O. mykiss*) in the tailrace of John Day Dam (JDA). Study objectives were to describe the behavior of radio-tagged juvenile salmonids released at the study sites (three spillbays and the juvenile bypass outfall) to determine: 1) residence time in the tailrace, 2) relationships between route of passage into the tailrace and residence time, and 3) hydraulic conditions likely experienced by fish.

Test Conditions

Test conditions during the day were 30% of total river flow as spill and 0% of total river flow as spill, randomly assigned in three-day blocks. At night, test conditions were 60% of total river flow as spill. The study design did not allow separation of spill volume and diel effects because the variables were confounded. Fish could not be released during 0% spill, therefore, comparisons were between the proposed 30% and 60% spill conditions. The combination of spill levels and diel periods provided a set of two unique test conditions: daytime 30% (D30%) spill and nighttime 60% (N60%) spill.

The average actual spill during releases of yearling chinook and steelhead was 30% during proposed D30% spill. During proposed N60% spill, actual spill averaged 52% (yearling chinook salmon releases) and 41% (steelhead releases). The average actual spill during subyearling chinook salmon releases was 30% during proposed D30% spill and 54% during proposed N60% spill.

Number of Fish Released

During the spring outmigration at JDA we released 144 yearling chinook salmon and 138 yearling steelhead. Sample sizes were approximately equal at spillbays 2 and 10 and at the juvenile bypass system. Fish were not released from spillbay 18 during the final four releases due to reduced discharge.

We released 150 subyearling chinook salmon during the summer outmigration at JDA. During D30% spill, sample sizes were equal at spillbays 2, 10, and the juvenile bypass. During N60% spill, sample sizes at spillbays 2, 10, 14, and the juvenile bypass were approximately equal.

Percentage of Radio-Tagged Fish Detected

During the spring outmigration, 97% of the radio-tagged yearling chinook were detected at exit station 1 (tip of the navigation lock peninsula), 66% at exit station 2 (dredge island) and 60% at exit station 3 (5.3 km downriver). We detected 90% of the released yearling steelhead at exit station 1, 64% at exit station 2, and 65% at exit station 3. During the summer outmigration, 92% of the radio-tagged subyearling chinook were detected at exit station 1, 40% at exit station 2, and 80% at exit station 3.

Residence Times

Comparisons of release sites within each spill condition indicated that spillway passage generally resulted in more rapid tailrace egress than did bypass passage. This trend, however, was not always statistically significant. Residence time differences between the two spill regimes were most evident for fish released through the juvenile bypass. The residence times of

spillway fish were generally similar during D30% and N60% spill. Fish released through the bypass had consistently longer residence times during N60% compared to D30% spill. The relative strength of this trend depended upon the run or species of fish.

Yearling chinook salmon residence times were only minimally affected by release site or spill condition. Residence times for fish released through the spillway or bypass were not significantly different during D30% spill. During N60% spill, bypass fish had significantly longer mean residence times than spillway fish, although the magnitude of the difference was only a few minutes. Fish from all release sites exited the immediate tailrace (exit station 1) within about 10 minutes, regardless of spill condition. The largest difference in residence times between D30% and N60% spill was for bypass fish. During N60%, the mean residence time for bypass fish was 15 min (increased from 9 min during D30%).

Analysis of steelhead residence times was complicated by reduced spill discharge on two release dates. Three releases were planned during N60% spill. On two of these release dates, actual spill was 34%. The third date had actual spill of 54%, with an average spill of 41% for the three releases combined. We were therefore unable to make statistical comparisons between D30% and N60% spill or among release sites within N60% spill. A simple comparison of D30% and N60%, using the residence time data for steelhead released during 54% spill, suggests that bypass fish were delayed during the higher spill period and spillway fish were relatively unaffected. Within each spill condition, steelhead residence times were similar, regardless of release location. Most steelhead exited the immediate tailrace (exit station 1) within 7-8 min. Fish released through the south spillway took somewhat longer, with mean residence times of 12-14 min.

Subyearling chinook salmon released through the bypass had the highest mean residence times of all release sites during both D30% and N60% spill. North fish had the lowest mean residence times. Generally, the mean residence times of spillway fish were lower during N60% spill than during D30% spill. Fish released through the bypass were significantly delayed during the higher spill discharge. Their mean residence time was significantly higher ($P < 0.01$), more than four times as long, at N60% (74 min) compared to D30% (17 min).

Dredge Island Passage

The route of passage (north or south) around the dredge island was influenced by release location and spill condition. During the spring outmigration, fish released through the north spillway passed north of the dredge island and fish released through the juvenile bypass system passed south of the dredge island. Routes of fish released through the middle and south spillway were more variable but middle fish generally passed to the north and south fish generally passed to the south.

During the summer outmigration, passage trends were similar to spring trends for fish released through the spillway. Fish released through the juvenile bypass were strongly affected by spill condition. During D30% spill, most bypass fish used a south island passage route (83%). During the increased spill conditions used at night, the most common passage route was north (75%).

Drogue Releases

During the spring outmigration, the mean residence times of drogues released from the north and middle spillbays were significantly lower than drogues released from the other sites,

regardless of condition. The residence times of fish released through the bypass were well represented by drogues, although this comparison was only made at D30% spill. Drogues appeared to represent the movements of steelhead better than they did yearling chinook salmon.

During the summer outmigration, drogues released at the north spillway had lower residence times than drogues released from the other sites, regardless of spill condition. Drogues released at the middle and south spillway showed periods of delay within the stilling basin that were dependent upon spill condition. These delays were more frequent and of larger magnitude during periods of lower spill. Drogue residence times and fish residence times were most comparable at the north spillway.

INTRODUCTION

A Supplemental Biological Opinion issued by the National Marine Fisheries Service (NMFS) recommended that to increase juvenile salmonid (*Oncorhynchus spp.*) survival, the spill at dams on the Columbia and Snake rivers should be maximized without exceeding the current total dissolved gas cap levels or other project-specific limitations (NMFS 1998). Juvenile salmonids migrating downriver can be diverted from turbine passage routes at the John Day Dam (JDA) by turbine intake bypass systems (such as submerged screens) or by passage over the spillway.

Although spill is capable of passing juvenile salmonids over the dam effectively, spill can produce certain hydraulic conditions within the tailrace that increase fish vulnerability to predation directly or indirectly by extending the amount of time they spend in the immediate tailrace area. Tailrace conditions are an important factor to consider in the effort to move juvenile salmonids past hydroelectric facilities. Shoals, eddies, and other barriers can have a negative impact on tailrace egress. Even specific routes of passage over the spillway (e.g., north vs. south) may influence how effectively or quickly fish are able to exit the immediate tailrace (Liedtke et al. 1998). If, during some test conditions, fish are slower to pass through areas of the tailrace where predators congregate, then those conditions may be modified to reduce the risk.

We released drift buoys (drogues) into the tailrace to evaluate the hydraulic conditions encountered by fish (see Liedtke et al. 2001). The drogues move through the tailrace according to the predominant flows. By releasing drogues at the same sites and during the same conditions as radio-tagged juvenile salmonids, we were able to determine whether our study fish moved with the predominant flows. Some of our drogues were equipped with global positioning

systems (GPS), which allowed us to describe the precise position of the buoy during its drift through the tailrace.

The objectives of this study were to describe the behavior of juvenile salmonids passing through specific sites on the spillway and the juvenile bypass system to determine: 1) residence time in the tailrace, 2) movement patterns of juvenile salmonids in the immediate dam tailrace area (within approximately 2 km), and 3) hydraulic conditions likely experienced by fish through deployment of drift buoys (drogues).

METHODS

Test Conditions

The U. S. Army Corps of Engineers established dam operating conditions for the JDA spillway evaluation. Dam operating conditions are reported according to local convention: discharge in units of thousand cubic feet per second (kcfs) and tailwater elevation in feet. Conditions alternated between day and night spill at approximately 0700 and 1900 hours throughout our study period. Planned test conditions from 0700 to 1859 hours were 0% of the total river flow as spill (0% spill) or 30% of the total river flow as spill (30% spill), alternated in randomly assigned three-day blocks. Test conditions from 1900 to 0659 hours were scheduled to be 60% of the total river flow as spill (60% spill). The study design did not allow separation of spill volume and diel effects because the variables were confounded. Fish could not be released during 0% spill, therefore, comparisons were made between the 30% and 60% spill conditions. The combination of spill percentages and diel periods provided a set of two unique test conditions: daytime 30% (D30%) spill and nighttime 60% (N60%) spill.

Study Design

This study was designed to evaluate tailrace egress by describing the movements of fish passing into the tailrace through the spillway and the juvenile bypass system. During the spring outmigration, yearling chinook salmon and yearling steelhead were studied. Subyearling chinook salmon were evaluated during the summer outmigration. To represent the spillway, release sites were established at the north end (bay 2), the middle (bay 10), and the south end (bay 18). During the summer outmigration, the south end of the spillway was represented by spillbay 14 due to reduced discharge. Radio-tagged fish were also released into the juvenile

bypass system near the fish monitoring facility. The release sites will be referred to as north, middle, south, and bypass.

The study plan was to release equal numbers of fish under each of the two test conditions (D30% and N60%). Releases of fish were initiated at 0900 h during D30% spill and at 2100 h during N60% spill. During the spring outmigration, we planned 12 releases of radio-tagged fish, with six releases under each test condition. During each release, six to seven fish were released from each of the four release sites (north, middle, south, and bypass). Yearling chinook salmon and steelhead were released on alternate days.

During the summer outmigration, we planned 10 releases of radio-tagged fish, with five releases under each test condition. The study plan had to be modified during the summer outmigration because the south spillway release site (spillbay 14) was not used during the D30% spill condition. During each day release, four to seven fish were released from each of the three release sites (north, middle, and bypass). During each night release, four fish were released from each of the four release sites (north, middle, south, and bypass).

Fish Collection and Tagging

Juvenile salmonids were collected at JDA smolt collection facility and held 6-12 h in a 0.8-m diameter circular tank. Radio transmitters used in yearling chinook salmon were 7.3 mm X 18 mm and weighed 1.4 g (in air). Steelhead transmitters were 8.2 mm X 18.9 mm and weighed 1.8 g. Subyearling chinook salmon were implanted with transmitters 5 mm X 12 mm that weighed 0.8 g. Transmitters were gastrically implanted into the fish following the procedures of Martinelli et al. (1998). Tagged fish were held for approximately 24 h before release.

Fish were released in groups of four, one fish at each of the study release sites. On each release date, fish were released in batches separated by 15 to 30 minutes to allow the previous group of fish to exit the immediate tailrace area. Limiting the number of study fish in the tailrace allowed collection of fine-scale movement data on most of the radio-tagged fish.

Spillway Release System

A system modeled after Heisey et al. (1992) was used to release fish through the study spillbays (Figure 1). Platforms were built to support 0.8-m diameter circular tanks approximately 1 m above the parapet wall on the spillway deck. Flexible hose (10-cm diameter) was connected to the lower end of the tank, extended over the parapet wall, and routed to the pier nose on the north side of each study spillbay. The flexible hose was protected from damage by securing it inside a 16-cm steel pipe fastened to the north pier nose wall. The steel pipe extended approximately 3 m above the forebay elevation to a position 1 m above the spillway crest. At its lower end, a sweeping 45^{o} angle piece of conduit guided fish away from the pier nose where they encountered capture velocity and were pulled through the tainter gate. A submersible pump in the forebay supplied water to the release tank at a rate of 200 L/min.

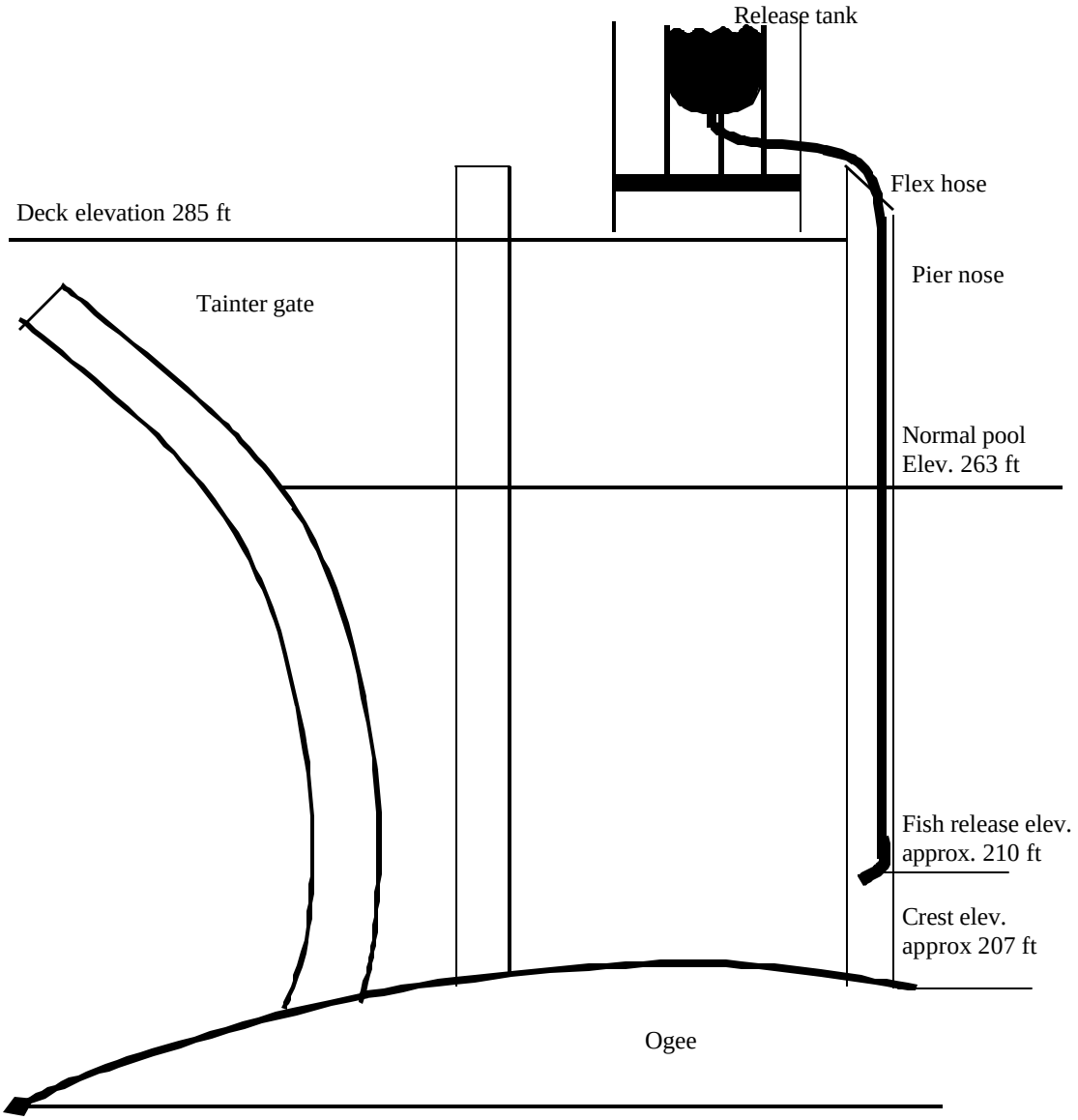


Figure 1. Schematic representation of the release system used to direct fish through specific spillbays into the tailrace of John Day Dam, 2000. Not to scale.

Prior to releasing fish, the pumps were activated to fill the release tanks and eliminate any air pockets within the release hoses. A single radio-tagged fish was placed into each release tank. Fish generally exited the release tank within 5 to 10 s. Water from the submersible pump was simultaneously routed through the tank and hose system to ensure that fish exited the hose at the bottom. Fish were released from all four sites within several minutes of each other.

Monitoring

Three exit sites were established in the tailrace with the use of fixed site monitoring equipment (fixed stations). Fixed stations were used to monitor the behavior and general movements of radio-tagged juvenile salmonids in the tailrace of JDA (Figure 2). The configuration of fixed stations was similar to the design presented in Shively et al. (1995) and Sheer et al. (1997). Exit sites were located at the tip of the navigation lock (exit station 1), the dredge island (exit station 2) located 1.9 km downriver of the dam, and an exit site 5.3 km from the dam (exit station 3; Figure 2). To support fixed station data collection at exit station 1, a team member monitored radio-tagged fish from the western tip of the navigation lock peninsula. Data from exit station 2 was used to determine passage routes of fish as they passed the dredge island.

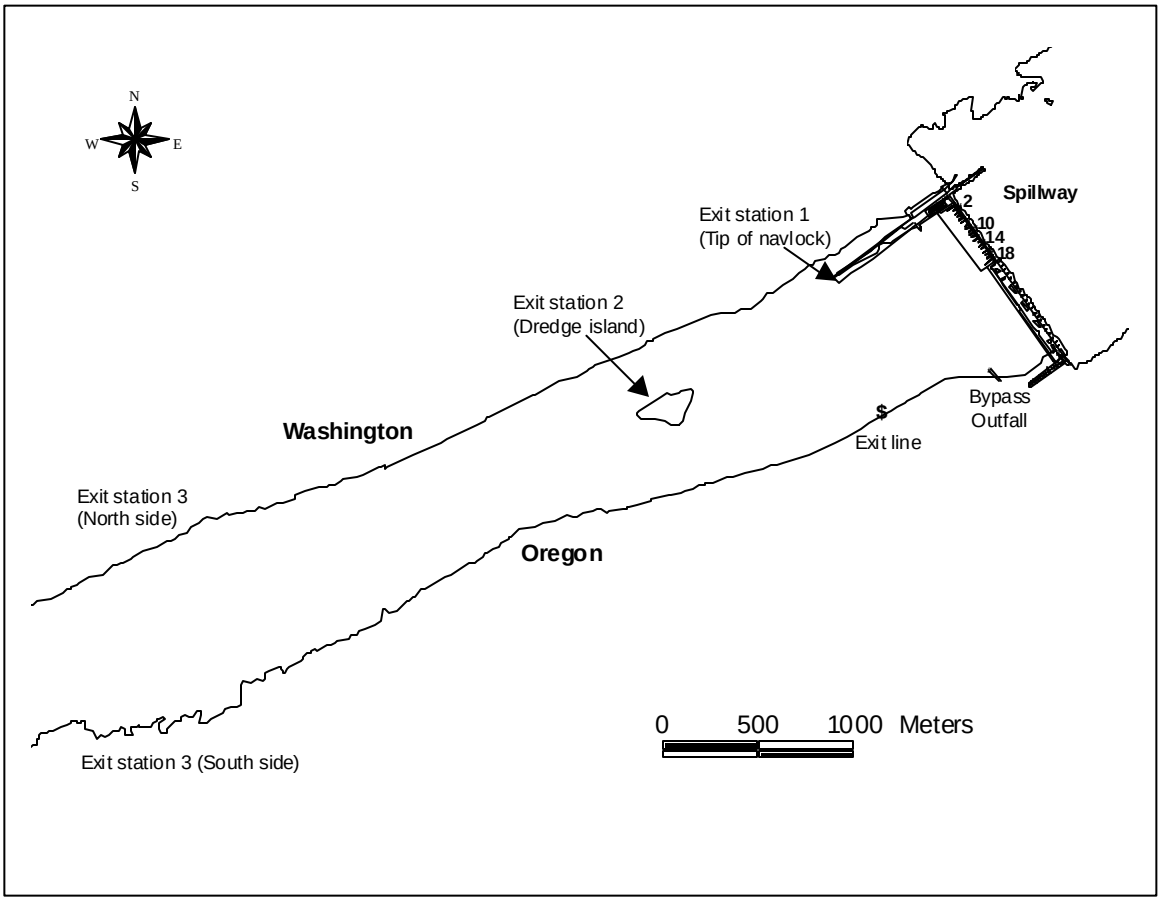


Figure 2. The John Day Dam tailrace study area, 2000. Radio-tagged yearling chinook salmon and steelhead were released from spillbays 2, 10, 18, and the juvenile bypass system during the spring of 2000. Radio-tagged subyearling chinook salmon were released from spillbays 2, 10, 14, and the juvenile bypass system during the summer of 2000.

Within the tailrace of JDA, boat tracking was used to collect fine-scale locations of fish. Boat tracking methods were as described in Hensleigh et al. (1999). Once a fish was detected at close range (15-30 m), the location was recorded using a Global Positioning System (GPS) receiver. Boat tracking was focused on detecting fish at or near exit station 1 to collect residence time data. Due to safety procedures at the dam, we were unable to operate our boat upriver of the navigation lock, except when two boats were available. Since two boats were not regularly available, boat tracking efforts upriver of the navigation lock were minimal. The tracking boat would generally station itself as far upriver as possible and attempt to contact fish as they passed exit station 1. The boat would then move slowly downriver, attempting to get as many GPS

positions on an individual fish as possible. The majority of tracking effort was localized between exit stations 1 and 2. The boat tracking data was used to supplement fixed station data in determining dredge island passage routes, verifying suspected predation events, and determining exit times.

Drogue Deployment

We used drift buoys (drogues) to describe the hydraulic conditions likely encountered by fish in the tailrace. During the spring outmigration, drogue releases were conducted at all study spillbays during D30% and N60% spill conditions. Drogue deployment at the juvenile bypass system was difficult due to the presence of avian control cables and buoys near the bypass outfall. Although we prefer to release drogues and fish through identical routes, this was not possible at the juvenile bypass system. Drogues deployed into the bypass flume would have become entangled in the cables near the outfall. Drogues were therefore deployed by boat. A boat would approach the outfall and avian control cables within a safe distance (6-7 m) and deploy a drogue from the boat so that it was released in the dominant outfall flow. Due to safety concerns (i.e., approaching cables and buoys at night), drogue releases at the bypass were limited to the D0% and D30% spill conditions. During the summer outmigration, drogue releases were conducted at the north, middle and bypass release sites during D30% spill and at all spillway release sites during N60% spill. Drogues were monitored until they had moved downriver of the tip of the navigation lock peninsula (exit station 1). Some drogues were equipped with a GPS. The GPS was configured to collect position information every second in order to accurately describe the dominant path of movement through the tailrace.

Predation Events

Fixed station and boat tracking data allowed us to quantify suspected predation events. Although radio telemetry does not allow direct confirmation of predation events, it can be used to identify individuals likely to have been depredated based on their data records. A predation event was suspected when a fish was continuously detected by a single fixed station for several hours. During boat tracking, a predation event was suspected when a fish was located in the study area after the majority of fish from the current release had exited the study area. These suspected predation events were supported if further detections were not made by any fixed stations downriver (e.g., at The Dalles Dam), or if the fish was detected during subsequent tracking sessions. Further confirmation of a suspected predation event occurred if fixed station records established movement patterns that were consistent with predator behavior (see Martinelli and Shively 1997). Avian predation events were suspected when a radio tag was detected by several distantly spaced fixed stations simultaneously. One avian predation event was confirmed by recovery of a radio transmitter on a predacious bird colony.

Data Analysis

Residence time was our primary variable of interest. We report residence time (min) to exit station 1 (0.7 km downriver of the dam), exit station 2 (1.9 km downriver), and exit station 3 (5.3 km downriver) starting from time of release. These calculations result in cumulative residence time as the fish move through the study area (i.e., residence time to exit station 2 includes the time from release to exit station 1).

Residence time data were not normally distributed and were therefore natural log transformed to meet assumptions of normality for parametric analysis. Residual plots of raw and

transformed data were used to confirm the appropriate transformation. Residence time means were presented as ln mean (min) in graphs and back-transformed to the original scale in tables.

Throughout the report, statistical findings were reported as significant when $P \leq 0.05$. Multiple comparisons were made with Tukey's Studentized Range Test. Release dates were pooled if no significant release date or interaction effects were detected. If the release date or the interaction was significant, data from each release were presented separately. Pairwise comparisons were made with a *t*-test.

Dam operations that varied from planned conditions complicated analysis of steelhead data. The spill discharge during two of our three steelhead releases was 34% when the proposed condition was N60% spill. The third steelhead release had 54% actual spill. The mean spill percentage for these three releases was 41% when it was planned to be 60%. For this reason, we elected not to make any statistical comparisons between the proposed D30% and N60% conditions for steelhead. The range of spill discharge over the three releases was great enough that we were not able to pool the release dates, therefore no statistical comparisons were made among release sites within N60% spill.

Drogue releases were summarized following the same procedures as fish releases. Drogue and fish residence times to exit station 1 were compared to determine if drogues represented fish movements within the tailrace.

RESULTS

YEARLING FISH

Dam Operating Conditions

Dam operating conditions were similar to those proposed and remained relatively consistent throughout the study period (Table 1). The mean hourly total discharge at JDA between 25 April and 26 May ranged from 216 to 344 kcfs. The mean hourly spill discharge ranged from 71 to 144 kcfs over the same period. The forebay and tailwater elevations were relatively consistent throughout the releases. Dam operating conditions varied from planned conditions during the first two steelhead releases (Table 1). During these two releases (4/25 and 5/01), the planned condition was N60% spill and the actual spill was 34%.

Yearling chinook salmon and steelhead releases during proposed D30% spill had actual spill that ranged from 29% to 31%, with a mean of 30%. During the proposed N60% spill, actual spill ranged from 47% to 57%, with a mean of 52%. Due to reduced discharge, the south spillway gates were closed during the last four release dates, affecting two releases each of yearling chinook salmon and steelhead (Table 1).

Table 1. Dam operating conditions at John Day Dam during releases of radio-tagged yearling chinook salmon (CH1), yearling steelhead (STH) and drogues, spring 2000. Values are means from a twelve-hour period from 0700 to 1900 hours or 1900 to 0700 hours. Discharge means (total and spill) are reported in kcfs. Forebay and tailwater elevations are reported in feet. Proposed 30% and 0% spill was used during daytime only (D30% and D0%). Proposed 60% spill was used during nighttime only (D60%). Data collected from http://www.nwd-wc.usace.army.mil/TMT.

Release Date	Species	Total Discharge (kcfs)	Spill Discharge (kcfs)	Forebay Elevation (ft)	Tailwater Elevation (ft)	Planned Spill %	Actual Spill %
4/28/00	CH1	310.1	92.4	263.6	164.0	D30%	29.8
5/04/00	CH1	297.4	139.6	263.5	163.1	N60%	46.9
5/07/00	CH1	264.8	79.7	263.2	162.5	D30%	30.1
5/09/00	CH1	260.8	138.0	263.3	161.1	N60%	52.9
5/19/00*	CH1	244.2	74.8	263.6	161.6	D30%	30.6
5/26/00*	CH1	215.8	122.8	263.3	161.0	N60%	56.9

Release **Date**	***Species***	***Total*** Discharge (kcfs)	Spill Discharge (kcfs)	Forebay Elevation (ft)	Tailwater Elevation (ft)	Planned Spill %	Actual Spill %
4/25/00	STH	322.2	110.5	263.5	164.1	N60%	34.3
5/01/00	STH	343.7	118.1	263.5	164.5	N60%	34.4
5/12/00	STH	275.4	83.5	263.7	162.6	D30%	30.3
5/17/00	STH	239.7	70.9	263.5	162.0	D30%	29.6
5/21/00*	STH	251.3	134.9	263.5	162.2	N60%	53.7
5/24/00*	STH	271.2	80.0	263.4	163.0	D30%	29.5

Release **Date**	***Species***	***Total*** Discharge (kcfs)	Spill Discharge (kcfs)	Forebay Elevation (ft)	Tailwater Elevation (ft)	Planned Spill %	Actual Spill %
4/27/00	Drogue	325.0	102.1	263.0	164.1	D30%	31.4
5/03/00	Drogue	325.4	132.5	263.4	163.6	N60%	40.7
5/06/00	Drogue	311.6	93.7	263.6	163.6	D30%	30.1
5/08/00	Drogue	303.5	136.2	263.0	163.5	N60%	44.9
5/11/00	Drogue	284.3	85.2	263.6	163.0	D30%	30.0
5/13/00	Drogue	223.8	68.3	263.6	161.6	D30%	30.5
5/16/00	Drogue	221.9	131.6	263.1	161.5	N60%	59.3
5/18/00	Drogue	256.8	77.3	263.5	162.6	D30%	30.1
5/20/00	Drogue	221.0	1.3	263.6	161.6	D0%	0.6
5/22/00	Drogue	271.1	143.0	263.7	162.1	N60%	52.8
5/23/00	Drogue	303.4	91.2	263.7	163.3	D30%	30.1
5/24/00	Drogue	271.2	80.0	263.4	163.0	D30%	29.5
5/25/00	Drogue	259.0	144.3	263.1	162.2	N60%	55.7

* *Spillbay 18, the south release site, was closed at the time of release.*

Number of Fish Released

A total of 144 yearling chinook salmon and 138 steelhead were released between 25 April and 26 May (Tables 2 and 3). Sample sizes were approximately equal at the four study release sites and during the two spill conditions. The mean fork length of radio-tagged yearling chinook salmon released during D30% spill was 166 mm with a mean weight of 46 g (Table 2). During N60% spill, the mean fork length was 179 mm and the mean weight was 57 g. The tag-weight to body-weight ratio (TWBW) for yearling chinook salmon ranged from 2.5% to 3.3% during D30% and from 2.2% to 2.7% during N60% spill. Mean fork lengths and weights of yearling chinook salmon were not significantly different between release sites or release dates at either D30% or N60% spills. Steelhead had a mean fork length of 214 mm and a mean weight of 80 g during D30% spill (Table 3). During N60% spill the fork length and weight means were 214 mm and 84 g (Table 3). The TWBW for steelhead ranged between 2.1% and 2.2% during D30% spill and between 1.8% and 2.2% during N60% spill. Mean fork lengths and weights of steelhead were not significantly different between release sites or release dates at either D30% or N60% spills.

Table 2. Fork lengths and weights of yearling chinook salmon released during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes at John Day Dam, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Fork length (mm)			Weight (g)		
				Median	Mean	95% CI	Median	Mean	95% CI
4/28/00	Bypass	D30%	7	160	162	160 - 174	41.1	43.8	36.3 - 52.8
	North	D30%	7	157	159	153 - 164	42.5	43.8	37.6 - 51.2
	Middle	D30%	7	165	162	150 - 174	49.9	44.0	34.8 - 55.7
	South	D30%	7	149	151	143 - 159	34.6	35.3	30.2 - 41.2
5/07/00	Bypass	D30%	3	182	183	169 - 199	63.3	65.2	53.2 - 79.9
	North	D30%	6	165	167	149 - 188	47.5	47.8	34.1 - 67.0
	Middle	D30%	6	166	170	148 - 195	43.7	49.4	32.0 - 76.0
	South	D30%	6	169	167	152 - 184	49.7	48.1	36.3 - 63.7
5/19/00	Bypass	D30%	6	183	182	166 - 200	61.2	57.8	42.7 - 78.2
	North	D30%	5	184	170	143 - 202	60.7	49.1	29.4 - 82.1
	Middle	D30%	6	164	168	142 - 199	43.6	44.3	26.6 – 73.7
	South*	D30%	0	---	---	---	---	---	---
Total	Bypass	D30%	16	179	174[A]	165 - 182	58.0	54.1[A]	45.3 - 60.5
	North	D30%	18	159	165[A]	157 - 173	46.4	48.4[A]	40.3 - 53.7
	Middle	D30%	19	165	168[A]	157 - 176	45.0	48.9[A]	38.2 - 54.7
	South	D30%	13	153	158[A]	150 - 167	39.7	42.1[A]	34.7 - 47.8
Overall		***D30%***	66	167	166	161 - 170	48.7	46.4	43.0 - 50.1
5/04/00	Bypass	N60%	6	182	178	158 - 201	64.6	58.5	38.3 - 89.3
	North	N60%	6	183	181	170 - 192	63.4	62.1	53.4 - 78.7
	Middle	N60%	6	178	170	150 - 199	54.7	49.8	31.5 - 90.6
	South	N60%	4	172	176	155 - 193	54.3	58.7	38.1 - 72.2
5/09/00	Bypass	N60%	6	188	184	171 - 198	67.1	62.7	52.2 - 75.3
	North	N60%	6	193	185	168 - 203	72.1	66.2	49.1 - 89.2
	Middle	N60%	5	168	167	158 - 175	46.0	45.0	37.0 - 54.8
	South	N60%	5	176	176	166 - 188	55.8	55.5	45.5 - 67.8
5/26/00	Bypass	N60%	11	184	185	175 - 196	65.1	63.6	53.7 - 75.2
	North	N60%	13	183	182	174 - 191	59.3	58.3	50.4 - 67.5
	Middle	N60%	10	167	172	165 - 180	44.5	50.7	42.8 - 60.0
	South*	N60%	0	---	---	---	---	---	---
Total	Bypass	N60%	23	187	84[A]	176 - 190	66.0	64.0[A]	55.1 - 69.7
	North	N60%	25	184	183[A]	177 - 188	61.6	62.5[A]	55.5 - 67.1
	Middle	N60%	21	168	71[A]	165 - 176	46.0	51.0[A]	43.1 - 55.8
	South	N60%	9	176	76[A]	168 - 184	55.7	58.1[A]	48.7 - 66.6
Overall		***N60%***	78	179	179	175 - 182	59.3	57.3	53.9 - 60.9

** Spillbay 18, the south release site, was closed at the time of release.*

Table 3. Fork lengths and weights of yearling steelhead released during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes at John Day Dam, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test ($P<0.05$).

Release Date	Release Site	Spill	N	Fork length (mm)			Weight (g)		
				Median	Mean	95% CI	Median	Mean	95% CI
5/12/00	Bypass	D30%	5	210	217	194 - 243	80.4	84.4	63.4 - 112.1
	North	D30%	6	223	220	202 - 238	95.2	90.2	68.6 - 118.5
	Middle	D30%	6	210	215	198 - 233	75.8	84.3	61.3 - 115.7
	South	D30%	6	217	215	189 - 245	84.4	80.2	53.8 - 119.5
5/17/00	Bypass	D30%	5	201	208	193 - 224	69.4	73.8	62.0 - 87.9
	North	D30%	6	207	209	199 - 220	72.4	76.9	64.4 - 91.8
	Middle	D30%	5	199	201	189 - 214	67.5	69.4	59.7 - 80.6
	South	D30%	6	214	216	206 - 228	80.9	82.2	69.1 - 97.7
5/24/00	Bypass	D30%	11	219	216	208 - 225	83.4	80.5	71.7 - 90.5
	North	D30%	7	215	210	188 - 235	86.2	73.0	52.7 - 101.1
	Middle	D30%	8	221	220	202 - 239	77.4	82.2	62.1 - 108.6
	South*	D30%	0	---	---	---	---	---	---
Total	Bypass	D30%	21	210	215^{A}	208 - 221	75.8	81.0^{A}	73.5 - 86.5
	North	D30%	19	215	214^{A}	204 - 222	86.2	82.1^{A}	69.5 - 90.6
	Middle	D30%	19	210	214^{A}	204 - 222	71.1	82.5^{A}	69.2 - 90.7
	South	D30%	12	214	216^{A}	204 - 228	80.9	84.0^{A}	68.0 - 96.9
Overall		***D30%***	71	210	214	210 - 218	76.8	79.8	75.2 - 84.5
4/25/00	Bypass	N60%	5	205	200	181 - 221	75.2	70.5	52.5 - 94.6
	North	N60%	5	214	209	192 - 226	86.5	78.4	63.2 - 97.3
	Middle	N60%	6	211	209	192 - 229	82.5	82.3	62.2 - 108.7
	South	N60%	6	206	210	192 - 229	76.3	79.4	64.2 - 98.3
5/01/00	Bypass	N60%	6	215	213	187 - 242	82.3	76.3	53.1 - 109.6
	North	N60%	5	220	219	190 - 253	68.4	85.4	42.8 - 170.7
	Middle	N60%	5	213	210	180 - 247	85.6	82.8	50.3 - 136.2
	South	N60%	6	235	237	228 - 246	113.2	112.8	96.2 - 132.4
5/21/00	Bypass	N60%	7	212	221	208 - 236	83.8	91.8	79.4 - 104.0
	North	N60%	9	214	212	202 - 223	83.0	82.3	71.5 - 94.7
	Middle	N60%	7	219	220	211 - 230	80.0	86.3	74.1 - 100.6
	South*	N60%	0	---	---	---	---	---	---
Total	Bypass	N60%	18	211	213^{A}	202 - 223	81.7	82.3^{A}	70.2 - 90.9
	North	N60%	19	214	213^{A}	205 - 221	83.0	85.9^{A}	71.0 - 95.0
	Middle	N60%	18	215	215^{A}	205 - 223	84.3	86.6^{A}	73.7 - 95.7
	South	N60%	12	229	224^{A}	211 - 236	100.4	97.4^{A}	80.7 - 111.1
Overall		***N60%***	67	214	214	210 - 219	84.0	84.1	78.7 - 89.1

** Spillbay 18, the south release site, was closed at the time of release.*

Percent of Radio-Tagged Fish Detected

Overall fixed station detection of radio-tagged yearling chinook salmon (96%) was high, with similar detections during D30% spill (95%) and N60% spill (96%; Table 4). Boat tracking within the JDA tailrace located 40% of the radio-tagged yearling chinook salmon, with higher detection during D30% spill (53%) than D60% spill (29%; Table 4).

Table 4. Number of yearling chinook salmon (CH1) and steelhead (STH) released at John Day Dam (JDA) and the number of fish detected using fixed gear stations and boat tracking during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000.

Species	Release date	Spill	Number of fish released	Fish detected with fixed gear stations at JDA N (%)	Fish located by boat tracking at JDA N (%)
CH1	4/28/00	D30%	28	26 (93)	12 (43)
CH1	5/07/00	D30%	21	20 (95)	12 (57)
CH1	5/19/00	D30%	17	17 (100)	11 (65)
Total		***D30%***	66	63 (95)	35 (53)
CH1	5/04/00	N60%	22	21 (95)	7 (32)
CH1	5/09/00	N60%	22	21 (95)	6 (27)
CH1	5/26/00	N60%	34	33 (97)	10 (29)
Total		N60%	78	75 (96)	23 (29)
Overall			144	138 (96)	58 (40)
STH	5/12/00	D30%	23	22 (96)	12 (52)
STH	5/17/00	D30%	22	21 (95)	11 (50)
STH	5/24/00	D30%	26	22 (85)	13 (50)
Total		***D30%***	71	65 (92)	36 (51)
STH	4/25/00	N60%	22	21 (95)	10 (45)
STH	5/01/00	N60%	22	21 (95)	9 (41)
STH	5/21/00	N60%	23	21 (91)	4 (17)
Total		N60%	67	63 (94)	23 (34)
Overall			138	128 (93)	59 (43)

During D30% spill, total detections (fixed station and boat tracking) were highest at exit station 1 (98%) and reduced at exit stations 2 (59%) and 3 (48%; Table 5). During N60% spill, detections were highest at exit station 1 (95%), similar at exit stations 2 (72%) and 3 (71%; Table 5). Boat tracking locations of yearling chinook salmon by spill condition are presented in Figure 3.

Table 5. Release position, sample size (N), and percent of radio-tagged yearling chinook salmon (CH1) detected at each of three exit stations in the John Day Dam tailrace during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Exit station 1 (Exit 1) was at the western tip of the navigation lock peninsula (0.7 km downriver of the dam). Exit station 2 (Exit 2) was on the dredge island (1.9 km downriver of the dam). Exit station 3 (Exit 3) was located 5.3 km downriver of the dam.

Release Date	Release Position	Spill	Number of CH1 released	CH1 Detected Exit 1 N (%)	CH1 Detected Exit 2 N (%)	CH1 Detected Exit 3 N (%)
04/28/00	Bypass	D30%	7	7 (100)	1 (14)	3 (43)
	North	D30%	7	7 (100)	4 (57)	3 (43)
	Middle	D30%	7	7 (100)	5 (71)	3 (43)
	South	D30%	7	7 (100)	5 (71)	1 (14)
05/07/00	Bypass	D30%	3	3 (100)	2 (67)	3 (100)
	North	D30%	6	5 (83)	2 (33)	4 (67)
	Middle	D30%	6	6 (100)	5 (83)	6 (100)
	South	D30%	6	6 (100)	3 (50)	2 (33)
05/19/00	Bypass	D30%	6	6 (100)	4 (67)	3 (50)
	North	D30%	5	5 (100)	3 (60)	1 (20)
	Middle	D30%	6	6 (100)	5 (83)	3 (50)
	South*	D30%	0	---	---	---
Total	Bypass	D30%	16	16 (100)	7 (44)	9 (56)
	North	D30%	18	17 (94)	9 (50)	8 (44)
	Middle	D30%	19	19 (100)	15 (79)	12 (63)
	South	D30%	13	13 (100)	8 (62)	3 (23)
Overall		D30%	66	65 (98)	39 (59)	32 (48)
05/04/00	Bypass	N60%	6	6 (100)	3 (50)	5 (83)
	North	N60%	6	5 (83)	4 (67)	4 (67)
	Middle	N60%	6	6 (100)	6 (100)	5 (83)
	South	N60%	4	4 (100)	1 (25)	4 (100)
05/09/00	Bypass	N60%	6	5 (83)	5 (83)	5 (83)
	North	N60%	6	6 (100)	6 (100)	4 (67)
	Middle	N60%	5	5 (100)	5 (100)	2 (40)
	South	N60%	5	5 (100)	4 (80)	4 (80)
05/26/00	Bypass	N60%	11	11 (100)	5 (45)	5 (45)
	North	N60%	13	13 (100)	11 (85)	10 (91)
	Middle	N60%	10	8 (80)	6 (60)	7 (70)
	South*	N60%	0	---	---	---
Total	Bypass	N60%	23	22 (96)	13 (57)	15 (65)
	North	N60%	25	24 (96)	21 (84)	18 (72)
	Middle	N60%	21	19 (90)	17 (81)	14 (67)
	South	N60%	9	9 (100)	5 (56)	8 (89)
Overall		N60%	78	74 (95)	56 (72)	55 (71)

**Spillbay 18, the south release site, was closed at the time of release.*

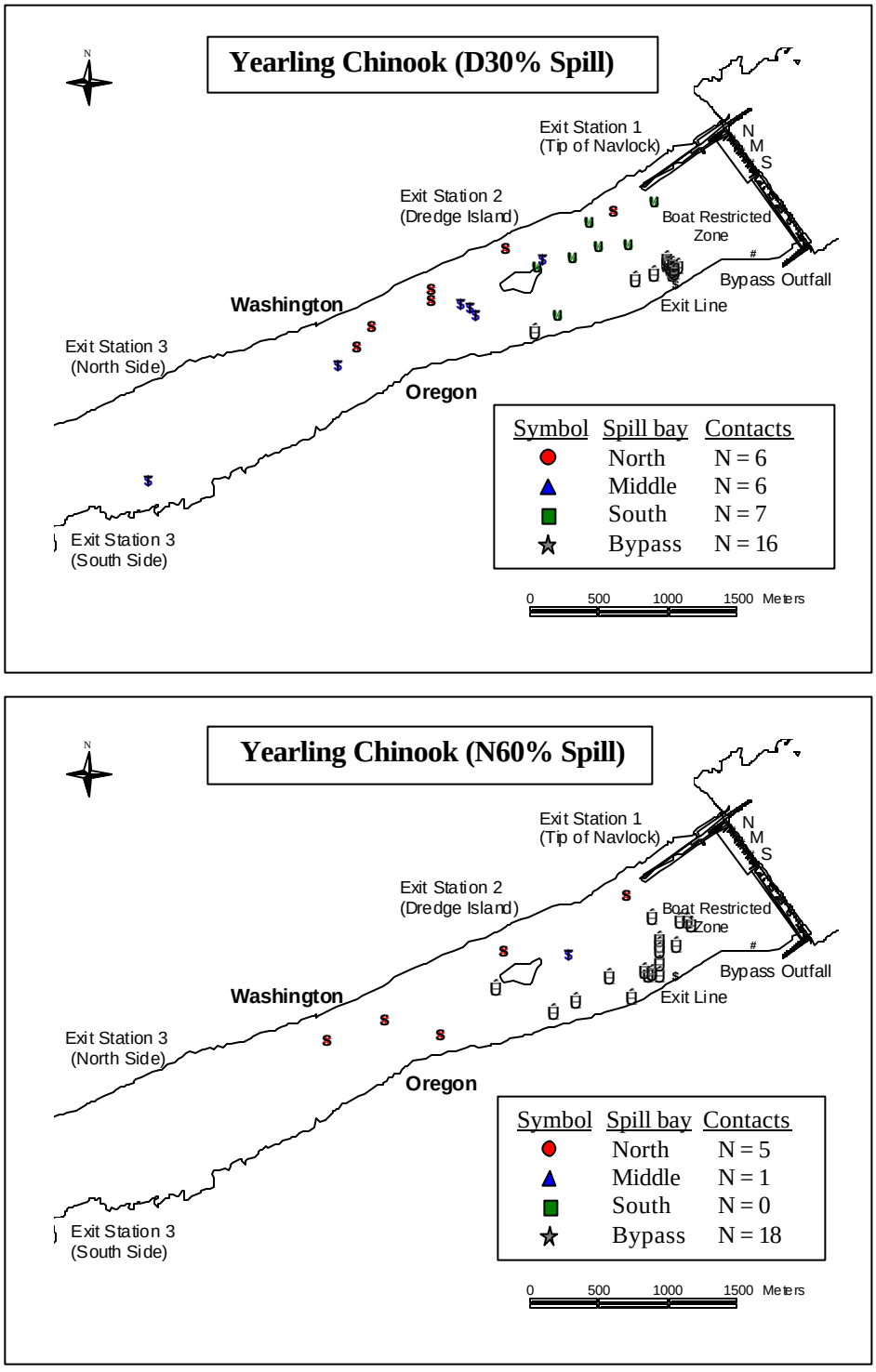


Figure 3. Locations of radio-tagged yearling chinook salmon in the John Day tailrace as determined by boat tracking, during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes. The numbers of individual fish contracted are represented by N. Some individuals were detected more than once.

Overall fixed station detection of radio-tagged steelhead (93%) was high, and detections were similar during D30% spill (92%), and N60% spill (94%; Table 4). Boat tracking within the JDA tailrace located 43% of the fish overall, with higher detection during D30% spill (51%) than N60% spill (34%; Table 4). During D30% spill, total detections were higher at exit station 1 (90%) than at exit stations 2 (62%) and 3 (80%; Table 6). During N60% spill, overall detections were 90%, 66%, and 49% at exit stations 1, 2, and 3, respectively (Table 6). Boat tracking locations of steelhead by spill condition are presented in Figure 4.

Table 6. Release position, sample size (N), and percent of radio-tagged yearling steelhead (STH) detected at each of three exit stations in the John Day Dam tailrace during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Exit station 1 (Exit 1) was at the western tip of the navigation lock peninsula (0.7 km downriver of the dam). Exit station 2 (Exit 2) was on the dredge island (1.9 km downriver of the dam). Exit station 3 (Exit 3) was located 5.3 km downriver of the dam.

Release Date	Release Site	Spill	Number of STH released	STH Detected Exit 1 N (%)	STH Detected Exit 2 N (%)	STH Detected Exit 3 N (%)
05/12/00	Bypass	D30%	5	5 (100)	5 (100)	5 (100)
	North	D30%	6	6 (100)	6 (100)	5 (83)
	Middle	D30%	6	6 (100)	6 (100)	5 (83)
	South	D30%	6	5 (83)	3 (50)	2 (33)
05/17/00	Bypass	D30%	5	5 (100)	4 (60)	5 (100)
	North	D30%	6	6 (100)	4 (67)	5 (83)
	Middle	D30%	5	4 (80)	4 (80)	5 (100)
	South	D30%	6	5 (83)	3 (50)	5 (83)
05/24/00	Bypass	D30%	11	11 (100)	4 (36)	10 (91)
	North	D30%	7	5 (71)	2 (29)	5 (71)
	Middle	D30%	8	6 (75)	3 (38)	5 (63)
	South*	D30%	0	---	---	---
Total	Bypass	D30%	21	21 (100)	13 (62)	20 (95)
	North	D30%	19	17 (89)	12 (63)	15 (79)
	Middle	D30%	19	16 (84)	13 (68)	15 (79)
	South	D30%	12	10 (83)	6 (50)	7 (58)
Overall		D30%	71	64 (90)	44 (62)	57 (80)
04/25/00	Bypass	N60%	5	5 (100)	4 (80)	3 (60)
	North	N60%	5	4 (80)	3 (60)	1 (20)
	Middle	N60%	6	5 (83)	6 (100)	2 (33)
	South	N60%	6	6 (100)	5 (83)	3 (50)
05/01/00	Bypass	N60%	6	6 (100)	3 (50)	5 (83)
	North	N60%	5	4 (80)	1 (20)	1 (20)
	Middle	N60%	5	5 (100)	4 (80)	3 (60)
	South	N60%	6	6 (100)	3 (50)	5 (83)
05/21/00	Bypass	N60%	7	6 (86)	5 (71)	4 (57)
	North	N60%	9	6 (67)	3 (33)	1 (11)
	Middle	N60%	7	7 (100)	7 (100)	5 (71)
	South*	N60%	0	---	---	---
Total	Bypass	N60%	18	17 (94)	12 (67)	12 (67)
	North	N60%	19	14 (74)	7 (37)	3 (16)
	Middle	N60%	18	17 (94)	17 (94)	10 (56)
	South	N60%	12	12 (100)	8 (67)	8 (67)
Overall		N60%	67	60 (90)	44 (66)	33 (49)

**Spillbay 18, the south release site, was closed at the time of release.*

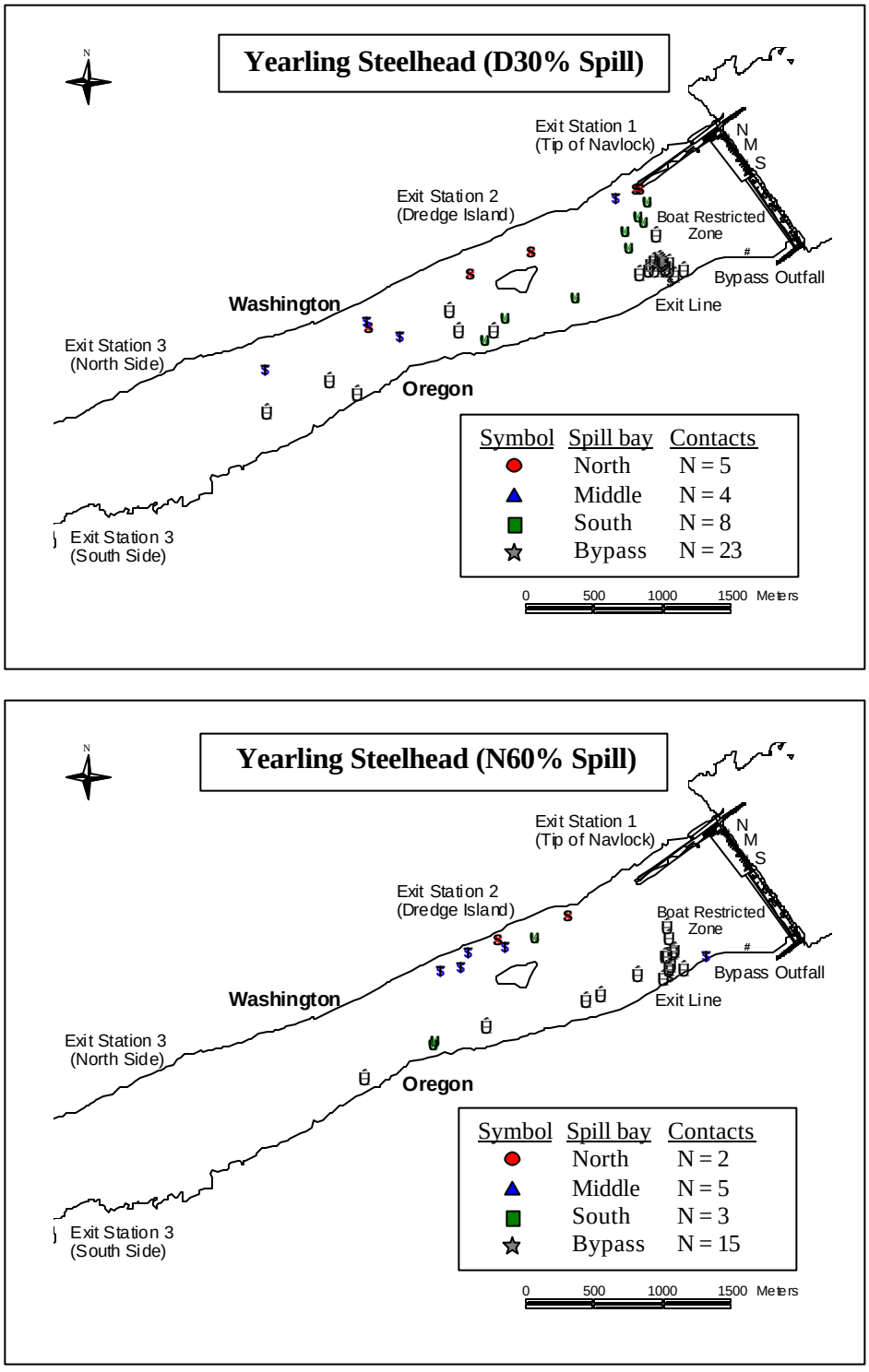


Figure 4. Locations of radio-tagged yearling steelhead in the John Day tailrace as determined by boat tracking, during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes. The number of individual fish detected are represented by N. Some individuals were detected more than once.

Residence Time to Exit Station 1

The mean residence times of north, south, and bypass yearling chinook salmon were significantly different during D30% and N60% spill. South fish showed a significant decrease ($P = 0.03$) in mean residence time from D30% (9 min) to N60% (5 min; Table 7). Fish released through the north spillway demonstrated the opposite trend; their mean residence time at N60% (9 min) was significantly higher ($P = 0.02$) compared to D30% (7 min;). Fish released through the juvenile bypass system demonstrated a trend similar to north fish, but the difference between the mean residence time during N60% (15 min) and D30% (9 min) was only marginally significant ($P=0.05$). During D30% spill, there were no significant differences in mean residence time among release sites (Table 7). During N60% spill, yearling chinook salmon released through the bypass had a significantly higher ($P < 0.01$) overall mean residence time (15 min) than north (9 min) and middle fish (6 min; Table 7).

Residence times of steelhead were similar at all release locations during both spill conditions. The overall mean residence times of steelhead during D30% spill were not significantly different between bypass (8 min), north (8 min), and middle fish (7 min; Table 8). During N60% spill, the mean residence time of middle fish (5 min) was lower than north fish (7 min) and bypass fish (8 min; Table 8). South fish had higher mean residence times than the other release sties during both D30% and N60% spill, but no statistical comparisons were made.

Statistical comparisons between steelhead residence times during D30% and N60% spill were not possible due to low spill discharge (34%) during planned 60% spill. A simple comparison of D30% and N60% can be made by using the steelhead release on 21 May (54% spill) to represent the planned N60% condition. This comparison showed that residence times of north and middle fish were similar under the two spill conditions. Steelhead released through the

bypass during 54% spill had a mean residence time (20 min) more than double the mean residence time during D30% spill (8 min; Table 8). The numbers of fish used for this comparison were low, suggesting that these data be interpreted with caution.

Table 7. Sample size (N) and residence time (min) at exit station 1 (north tip lock peninsula, 0.7 km downriver of the dam) of radio-tagged yearling chinook salmon during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
04/28/00	Bypass	D30%	7	10.1	11.5	8.9 - 15.0
	North	D30%	7	6.5	6.3	4.6 - 8.7
	Middle	D30%	7	4.6	7.0	2.4 - 20.4
	South	D30%	7	10.4	10.8	7.6 - 15.4
05/07/00	Bypass	D30%	3	10.7	10.8	8.7 - 13.7
	North	D30%	5	6.6	6.8	5.4 - 8.6
	Middle	D30%	6	5.7	8.5	2.3 - 31.8
	South	D30%	6	9.0	7.6	2.5 - 22.9
05/19/00	Bypass	D30%	7	6.7	6.2	3.4 - 11.2
	North	D30%	5	4.7	6.6	2.8 - 15.4
	Middle	D30%	7	4.1	4.4	2.8 - 6.8
	South*	D30%	0	---	---	---
Overall	Bypass	D30%	17	9.9	8.8[A]	6.7 - 11.6
	North	D30%	17	6.5	6.5[A]	5.3 - 8.1
	Middle	D30%	20	4.6	6.3[A]	4.0 - 10.0
	South†	D30%	13	9.3	9.2	5.8 - 14.4
05/04/00	Bypass	N60%	6	9.1	7.6	3.4 - 17.3
	North	N60%	5	7.7	9.6	5.2 - 17.8
	Middle	N60%	6	4.6	5.1	3.2 - 8.1
	South	N60%	4	4.4	4.0	2.5 - 6.4
05/09/00	Bypass	N60%	6	22.2	19.6	4.4 - 86.4
	North	N60%	6	6.6	6.9	5.2 - 9.2
	Middle	N60%	5	5.8	5.5	3.5 - 8.5
	South	N60%	5	5.6	5.2	2.2 - 12.2
05/26/00	Bypass	N60%	11	23.0	18.4	10.1 - 33.5
	North	N60%	15	9.8	9.7	7.5 - 12.6
	Middle	N60%	8	6.1	6.2	3.6 - 10.6
	South*	N60%	0	---	---	---
Overall	Bypass	N60%	23	17.6	14.9[A]	9.4 - 23.5
	North	N60%	26	8.1	9.0[B]	4.4 - 7.2
	Middle	N60%	19	5.8	5.6[C]	7.5 - 10.7
	South†	N60%	9	4.8	4.6	3.0 - 7.0

* *Spillbay 18, the south release site, was closed at the time of release.*

† *South fish were not used in this comparson.*

Table 8. Sample size (N) and residence time (min) at exit station 1 (north tip lock peninsula, 0.7 km downriver of the dam) of radio-tagged yearling steelhead during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
05/12/00	Bypass	D30%	5	4.9	5.7	3.7 - 8.9
	North	D30%	6	6.2	6.5	4.3 - 9.8
	Middle	D30%	6	6.5	7.6	3.2 - 18.5
	South	D30%	5	9.1	10.4	5.0 - 21.6
05/17/00	Bypass	D30%	5	10.7	11.6	6.2 - 21.7
	North	D30%	6	6.6	8.1	2.5 - 25.6
	Middle	D30%	4	6.7	6.3	4.2 - 9.6
	South	D30%	5	16.3	18.5	6.2 - 55.2
05/24/00	Bypass	D30%	11	9.2	8.7	5.6 - 13.3
	North	D30%	6	7.6	9.0	5.1 - 15.8
	Middle	D30%	6	5.7	6.9	3.1 - 15.4
	South*	D30%	0	---	---	---
Overall	Bypass	D30%	21	9.2	8.4[A]	6.4 - 11.0
	North	D30%	18	6.7	7.8[A]	5.5 - 11.1
	Middle	D30%	16	6.2	7.0[A]	4.9 - 10.0
	South†	D30%	10	12.7	13.9	8.0 - 24.0
04/25/00	Bypass	N60%	5	1.6	3.2	0.7 - 14.3
	North	N60%	4	8.5	7.2	3.4 - 9.7
	Middle	N60%	5	7.6	6.4	4.6 - 8.9
	South	N60%	6	25.6	17.9	4.2 - 76.0
05/01/00	Bypass	N60%	6	7.5	6.3	3.3 - 11.7
	North	N60%	4	10.3	10.3	6.6 - 15.9
	Middle	N60%	5	3.2	4.6	2.2 - 9.7
	South	N60%	6	8.4	7.4	3.2 - 17.0
05/21/00	Bypass	N60%	6	20.9	20.2	16.3 - 25.2
	North	N60%	6	6.5	5.6	2.5 - 12.3
	Middle	N60%	7	5.1	4.7	3.7 - 6.0
	South*	N60%	0	---	---	---
Overall[?]	Bypass	N60%	17	10.3	7.8	4.6 - 13.3
	North	N60%	14	8.0	7.1	5.1 - 10.1
	Middle	N60%	17	5.1	5.1	4.2 - 6.2
	South	N60%	12	11.2	11.5	5.5 - 24.1

* *Spillbay 18, the south release site, was closed at the time of release.*

† *South fish were not used in this comparison.*

[?] *Release sites were not compared.*

Residence Time to Exit Station 2

Yearling chinook salmon residence times to exit station 2 were significantly different between spill conditions and among release sites. North and bypass yearling chinook salmon had significantly different mean residence times during D30% and N60% spill. The mean residence time of north fish during D30% spill (17 min) was significantly lower ($P < 0.01$) than N60% spill (26 min). This trend was stronger for bypass fish; their mean residence time was significantly higher ($P < 0.01$) and twice as long at N60% (46 min) compared to D30% (24 min). The overall mean residence times of yearling chinook salmon during D30% spill were not significantly different between north fish (17 min), bypass fish (24 min), and middle fish (22 min; Table 9). South fish had an overall mean residence time of 26 min (Table 9). During N60% spill, the mean residence time of fish released from the north spillway (26 min) was significantly higher ($P<0.01$) than middle fish (20 min) and significantly lower than bypass fish (46 min; Table 9). South fish had an overall mean residence time of 14 min (Table 9).

Overall mean residence times of steelhead released during D30% spill were not significantly different between north fish (23 min), bypass fish (29 min), and middle fish (29 min; Table 10). South fish had an overall mean residence time of 35 min at D30% spill and 51 min at N60% spill (Table 10). Middle and north fish had the shortest mean residence times during N60% spill (22-24 min). The residence time of bypass fish during N60% spill was 31 min (Table 10).

Table 9. Sample size (N) and residence time (min) at exit station 2 (dredge island, 1.9 km downriver of the dam) of radio-tagged yearling chinook salmon during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
04/28/00	Bypass	D30%	1	23.7	23.7	---
	North	D30%	4	17.0	16.6	13.0 - 20.1
	Middle	D30%	5	16.5	22.8	15.0 - 41.6
	South	D30%	5	29.5	28.7	21.5 - 41.1
05/07/00	Bypass	D30%	2	22.2	22.1	20.6 - 23.8
	North	D30%	2	16.6	16.4	14.4 - 18.7
	Middle	D30%	5	19.3	27.3	16.6 - 130.9
	South	D30%	3	21.6	21.8	20.7 - 23.3
05/19/00	Bypass	D30%	4	26.0	25.3	21.6 - 28.2
	North	D30%	3	17.1	16.7	15.4 - 17.8
	Middle	D30%	5	19.2	17.5	13.9 - 19.7
	South*	D30%	0	---	---	---
Overall	Bypass	D30%	7	23.8	24.0^{A}	20.6 - 28.2
	North	D30%	9	17.1	16.6^{A}	13.0 - 20.1
	Middle	D30%	15	19.2	22.2^{A}	13.9 - 130.9
	South†	D30%	8	23.1	25.8	20.7 - 41.1
05/04/00	Bypass	N60%	3	27.7	24.9	19.7 - 28.3
	North	N60%	4	30.9	28.0	15.2 - 54.5
	Middle	N60%	6	17.8	17.6	13.8 - 21.0
	South	N60%	1	18.1	18.1	---
05/09/00	Bypass	N60%	5	53.7	70.1	47.9 - 139.9
	North	N60%	6	22.5	21.9	16.6 - 27.4
	Middle	N60%	5	19.7	21.7	16.6 - 35.5
	South	N60%	4	17.9	13.4	2.2 - 45.5
05/26/00	Bypass	N60%	5	45.8	42.6	31.5 - 52.6
	North	N60%	11	30.2	28.5	18.3 - 41.7
	Middle	N60%	6	19.9	20.8	17.2 - 26.9
	South*	N60%	0	---	---	---
Overall	Bypass	N60%	13	47.9	45.6^{A}	19.7 - 139.9
	North	N60%	21	27.2	26.3^{B}	15.2 - 54.5
	Middle	N60%	17	19.6	19.9^{C}	13.8 - 35.5
	South†	N60%	5	18.1	14.3	2.2 - 45.5

** Spillbay 18, the south release site, was closed at the time of release.*

† *South fish were not used in this comparison.*

Table 10. Sample size (N) and residence time (min) at exit station 2 (dredge island, 1.9 km downriver of the dam) of radio-tagged yearling steelhead during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
05/12/00	Bypass	D30%	5	28.6	32.0	20.5 - 68.5
	North	D30%	6	18.3	20.0	16.2 - 28.2
	Middle	D30%	6	26.5	35.1	17.3 - 176.7
	South	D30%	3	35.1	34.6	30.5 - 38.7
05/17/00	Bypass	D30%	4	21.2	22.3	20.3 - 27.1
	North	D30%	4	33.2	31.2	12.7 - 74.2
	Middle	D30%	4	24.2	23.7	17.1 - 32.2
	South	D30%	3	34.3	35.1	25.2 - 49.9
05/24/00	Bypass	D30%	4	25.0	33.4	20.7 - 96.5
	North	D30%	2	19.9	19.8	17.5 - 22.3
	Middle	D30%	3	15.8	25.7	14.3 - 75.3
	South*	D30%	0	---	---	---
Overall	Bypass	D30%	13	24.5	29.1[A]	20.3 - 96.5
	North	D30%	12	20.6	23.1[A]	12.7 - 74.2
	Middle	D30%	13	22.0	29.1[A]	14.3 - 176.7
	South†	D30%	6	34.7	34.8	25.2 - 49.9
04/25/00	Bypass	N60%	4	24.2	22.7	14.7 - 30.8
	North	N60%	3	23.3	26.0	23.2 - 32.6
	Middle	N60%	6	19.7	22.4	15.5 - 52.3
	South	N60%	5	57.1	68.0	38.8 - 114.3
05/01/00	Bypass	N60%	3	23.6	23.1	19.8 - 26.6
	North	N60%	1	22.5	22.5	---
	Middle	N60%	4	21.0	27.7	19.4 - 68.8
	South	N60%	3	33.6	31.1	26.5 - 33.9
05/21/00	Bypass	N60%	5	50.0	48.5	36.4 - 64.2
	North	N60%	3	20.2	21.7	17.6 - 28.8
	Middle	N60%	7	17.1	18.9	14.0 - 38.1
	South*	N60%	0	---	---	---
Overall[?]	Bypass	N60%	12	28.7	31.2	14.7 - 64.2
	North	N60%	7	23.2	23.6	17.6 - 32.6
	Middle	N60%	17	19.2	22.0	14.0 - 68.8
	South	N60%	8	47.1	50.9	26.5 - 114.3

** Spillbay 18, the south release site, was closed at the time of release.*

† *South fish were not used in this comparison.*

[?] *Release sites were not compared.*

Residence Time to Exit Station 3

Mean residence times of yearling chinook salmon were not significantly different during D30% and N60% spill. The mean residence time of north yearling chinook salmon during D30% spill (62 min) was not significantly different than middle fish (66 min) or bypass fish (82 min; Table 11). South fish had a mean residence time of 83 min (Table 11). During N60% spill, bypass fish had a significantly higher ($P < 0.01$) mean residence time (91 min) than north fish (73 min) or middle fish (64 min; Table 11). The mean residence time of south fish during N60% spill was 77 min (Table 11).

Mean residence times of steelhead were not significantly different among release sites during D30% spill. The overall mean residence times of middle fish (100 min) was higher than bypass fish (78 min) or north fish (61 min; Table 12). The mean residence time of middle fish was elevated by a fish released on 12 May that had a residence time of 73 h. South fish had an overall mean residence time of 96 min (Table 12). During N60% spill, the mean residence time of south fish (99 min) was higher than north fish (77 min), bypass fish (72 min), and middle fish (65 min; Table 12).

Table 11. Sample size (N) and residence time (min) at exit station 3 (5.3 km downriver of the dam) of radio-tagged yearling chinook salmon during proposed 30% and 60% spill, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
04/28/00	Bypass	D30%	3	81.3	74.9	42.8 - 131.2
	North	D30%	3	52.6	59.4	34.6 - 101.9
	Middle	D30%	3	48.4	49.6	36.5 - 67.4
	South	D30%	1	83.8	83.8	---
05/07/00	Bypass	D30%	3	97.4	96.2	55.0 - 168.4
	North	D30%	4	63.0	64.0	45.7 - 89.6
	Middle	D30%	6	67.0	76.5	49.1 - 119.1
	South	D30%	2	87.0	82.4	1.2 - 5884.6
05/19/00	Bypass	D30%	3	75.1	75.4	69.7 - 81.6
	North	D30%	1	65.3	65.3	---
	Middle	D30%	3	66.1	67.1	35.1 - 128.1
	South*	D30%	0	---	---	---
Overall	Bypass	D30%	9	78.0	81.6^{A}	69.9 - 95.4
	North	D30%	8	63.0	62.4^{A}	53.4 - 72.8
	Middle	D30%	12	63.5	66.4^{A}	52.8 - 83.5
	South†	D30%	3	83.8	82.8	35.9 - 190.9
05/04/00	Bypass	N60%	5	65.0	65.6	57.6 - 74.7
	North	N60%	4	65.5	69.5	40.3 - 119.9
	Middle	N60%	5	49.8	51.7	46.1 - 57.9
	South	N60%	4	63.7	66.1	54.3 - 80.3
05/09/00	Bypass	N60%	5	136.7	123.7	85.7 - 178.6
	North	N60%	4	62.5	63.0	52.9 - 74.8
	Middle	N60%	2	68.8	68.2	13.3 - 350.9
	South	N60%	4	88.6	89.4	65.4 - 122.2
05/26/00	Bypass	N60%	5	95.6	91.7	79.7 - 105.4
	North	N60%	10	72.2	78.7	65.6 - 94.3
	Middle	N60%	7	75.0	72.4	62.6 - 83.7
	South*	N60%	0	---	---	---
Overall	Bypass	N60%	15	86.4	90.6^{A}	75.8 - 108.3
	North	N60%	18	70.1	72.9^{B}	64.1 - 82.8
	Middle	N60%	14	59.9	63.6^{B}	56.5 - 71.7
	South†	N60%	8	75.9	76.9	63.9 - 92.5

** Spillbay 18, the south release site, was closed at the time of release.*

† South fish were not used in this comparison.

Table 12. Sample size (N) and residence time (min) at exit station 3 (5.3 km downriver of the dam) of radio-tagged yearling steelhead during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Within each spill condition, means without letters in common are significantly different based on Tukey's Studentized Range Test ($P<0.05$).

Release Date	Release Site	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
05/12/00	Bypass	D30%	5	71.4	78.0	55.7 - 109.2
	North	D30%	5	63.8	63.9	32.4 - 125.7
	Middle	D30%	5	63.7	188.4	19.1 - 1860.7
	South	D30%	2	81.2	81.0	32.1 - 204.8
05/17/00	Bypass	D30%	5	62.8	77.2	52.3 - 113.9
	North	D30%	5	68.1	65.3	48.0 - 88.8
	Middle	D30%	5	70.0	81.7	55.1 - 121.2
	South	D30%	5	119.1	102.7	72.4 - 145.6
05/24/00	Bypass	D30%	10	65.7	78.1	59.7 - 102.0
	North	D30%	5	56.4	54.9	38.4 - 78.5
	Middle	D30%	5	57.3	64.7	42.9 - 97.8
	South*	D30%	0	---	---	---
Overall	Bypass	D30%	20	65.7	77.8^{A}	67.0 - 84.2
	North	D30%	15	63.8	61.2^{A}	50.0 - 74.8
	Middle	D30%	15	67.0	99.9^{A}	53.7 - 185.9
	South†	D30%	7	87.2	96.0	75.4 - 122.1
04/25/00	Bypass	N60%	3	57.9	61.0	38.0 - 97.9
	North	N60%	1	84.3	84.3	---
	Middle	N60%	2	60.0	59.9	36.3 - 98.9
	South	N60%	3	196.4	243.1	52.8 - 1119.7
05/01/00	Bypass	N60%	5	63.4	64.0	53.1 - 77.1
	North	N60%	1	54.9	54.9	---
	Middle	N60%	3	58.4	69.7	27.9 - 173.9
	South	N60%	5	68.3	58.0	33.4 - 100.7
05/21/00	Bypass	N60%	4	92.9	93.6	69.4 - 126.1
	North	N60%	1	97.2	97.2	---
	Middle	N60%	5	55.9	63.9	46.5 - 87.8
	South*	N60%	0	---	---	---
Overall[?]	Bypass	N60%	12	70.2	71.8	61.2 - 84.2
	North	N60%	3	84.3	76.6	36.6 - 160.3
	Middle	N60%	10	58.0	64.8	54.1 - 77.5
	South	N60%	8	73.9	99.3	47.6 - 206.6

* *Spillbay 18, the south release site, was closed at the time of release.*

† *South fish were not used in this comparison.*

[?] *Release sites were not compared.*

Dredge Island Passage

North and middle fish generally passed to the north side of the dredge island, while south and bypass fish generally passed to the south of the island (Figures 5 and 6). Yearling chinook salmon released from the south spillway passed the island on the south side during N60% spill, but north and south passage was approximately equal during D30% spill (Figure 5). Steelhead released from the middle spillway passed the island via north (38%) and south (46%) routes in roughly equal percentages during D30% spill, but during N60% spill the passage route was predominately north (65%; Figure 6). Steelhead released from the south spillway passed the island on the south side (83%) during both D30% spill (83%) and N60% spill (78%; Figure 6). Bypass fish consistently passed to the south of the island during both D30% and N 60% spill conditions (Figures 5 and 6).

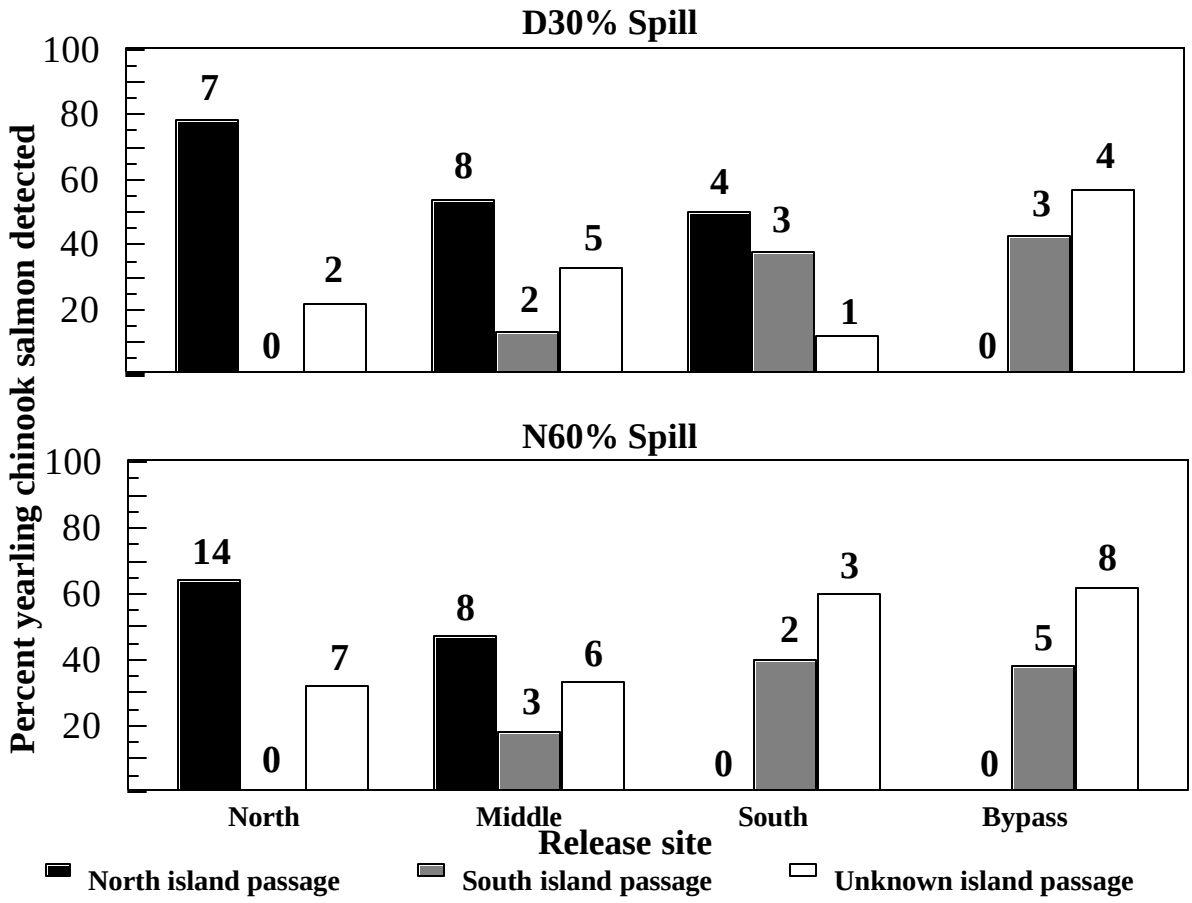


Figure 5. Island passage routes of yearling chinook salmon released at John Day Dam during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Passage was determined using data gathered by the fixed station on the dredge island. Sample sizes are indicated above the bars. The release sites are referred to as north (bay 2), middle (bay 10), south (bay 18), and bypass.

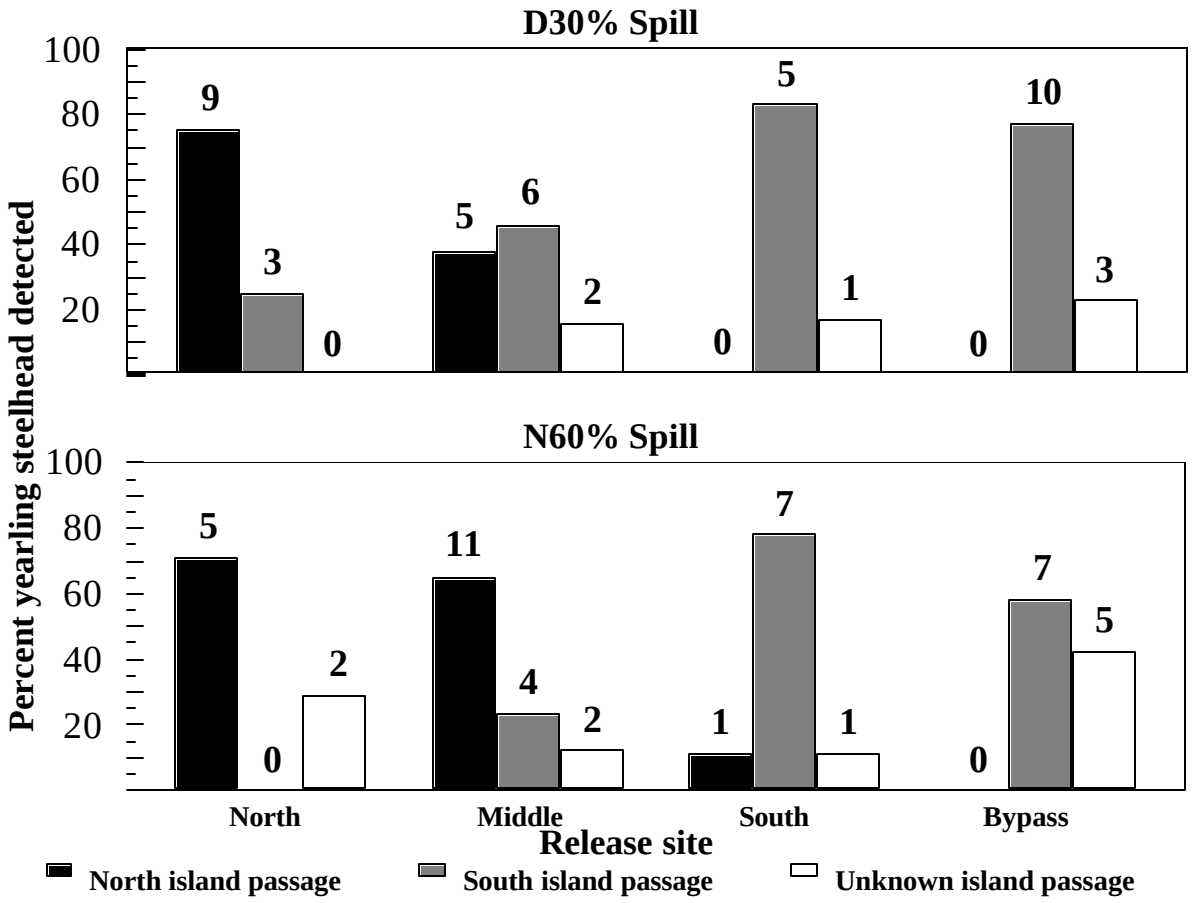


Figure 6. Island passage routes of yearling steelhead released at John Day Dam during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Passage was determined using data gathered by the fixed station on the dredge island. Sample sizes are indicated above the bars. The release sites are referred to as north (bay 2), middle (bay 10), south (bay 18), and bypass.

Drogue Releases

Residence times of north and middle drogues to exit station 1 were significantly lower than south or bypass drogues, regardless of condition. During D30% spill, the mean residence times of north (4 min) and middle drogues (4 min) were similar, and both were significantly lower ($P < 0.01$) than bypass (8 min) and south drogues (19 min; Table 13). During N60%, the mean residence times of north (6 min), middle (3 min), and south (11 min) drogues were significantly different ($P < 0.01$; Table 13). Mean residence times of north drogues ($P=0.04$),

middle drogues (P=0.01) and south drogues (P=0.03) were significantly higher during D30% spill than during N60% spill. Bypass drogue releases were restricted to the D0% and D30% spill conditions. The mean residence time of bypass drogues at D30% spill (8 min) was significantly higher ($P < 0.01$) than at D0% spill (5 min; Table 13).

Table 13. Drogue residence times during daytime 0% (D0%), daytime 30% (D30%) and nighttime 60% (N60%) spill volumes at John Day Dam, spring 2000. Drogue residence times were calculated at exit station 1 (tip of the navigation lock peninsula, 0.7 downriver of the dam). Within each spill volume, means without letters in common are significantly different based on Tukey's Studentized Range Test ($P<0.05$).

Release Site	Spill	N	Residence Time (min)		
			Median	Mean	95% CI
Bypass	D0%	15	5.6	5.4	4.9 - 5.8
Bypass	D30%	8	7.2	7.5[B]	6.9 - 8.2
North	D30%	25	3.8	4.1[C]	3.6 - 4.7
Middle	D30%	29	3.4	3.7[C]	3.3 - 4.0
South	D30%	14	20.1	19.1[A]	15.5 - 23.3
North	N60%	20	5.4	5.5[B]	4.3 - 7.2
Middle	N60%	20	3.2	3.2[C]	3.0 - 3.4
South	N60%	8	10.1	11.0[A]	5.5 - 22.2

Drogues equipped with GPS units allowed visualization of the drift path through the tailrace. Drogues released from the south spillway during D30% spill generally became caught in eddies within the boat restricted zone (BRZ) and traveled north of the release site (Figure 7). The extreme residence times of south drogues (20 min or more) occurred when drogues followed this route. Two of the 25 drogues released from the north spillway stalled in eddies near the tip of the navigation lock peninsula during D30% spill (Figure 7). During N60% spill, none of the north drogues were delayed. All middle drogues moved directly downriver during both spill conditions. Bypass drogues followed the contours of the south shoreline (Figure 7). Two

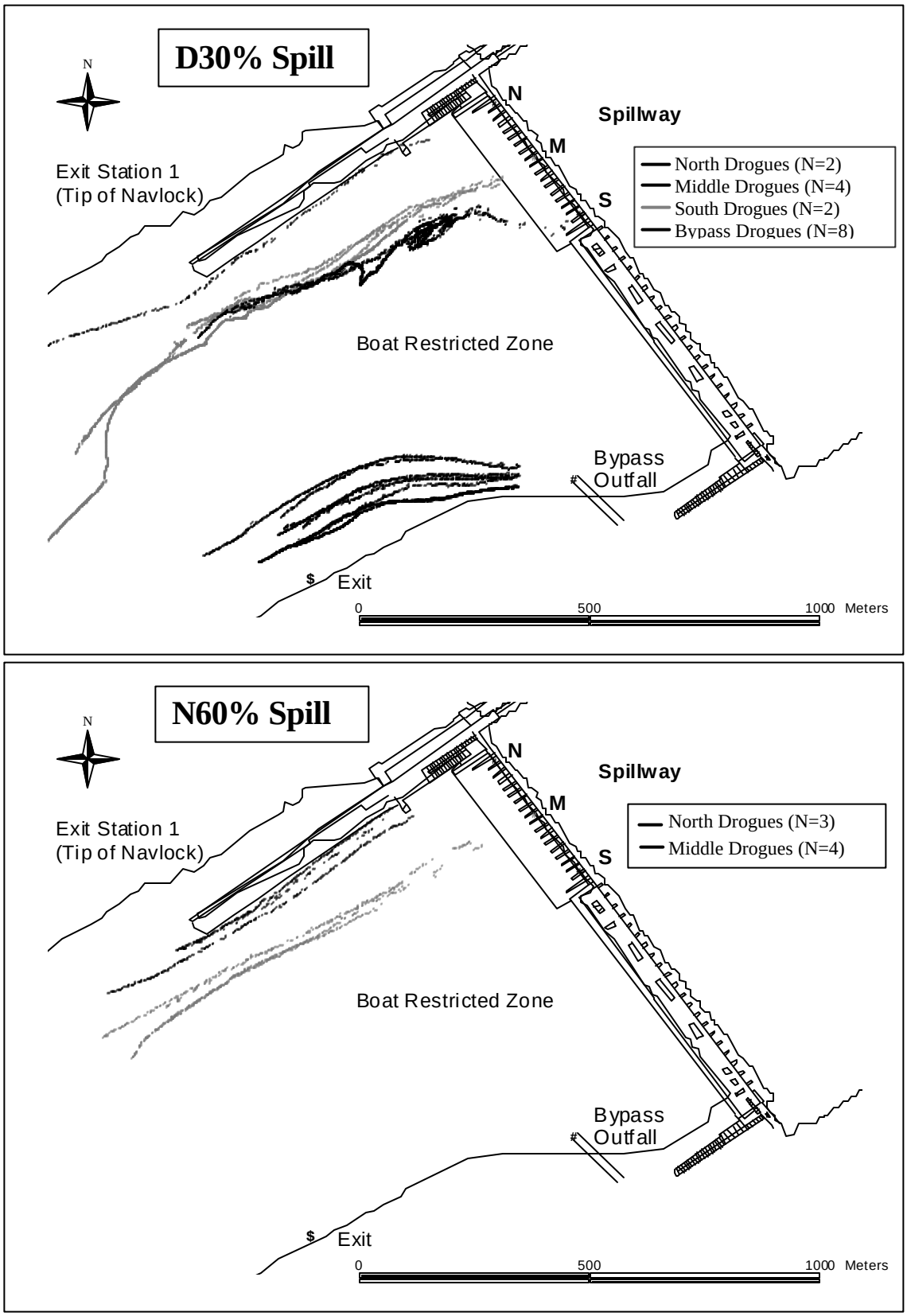


Figure 7. Drogues released from the north, middle, south spillway, and the juvenile bypass system, during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes at the John Day Dam, spring 2000. The lines shown indicate the route taken by drogues equipped with Global Positioning System units.

drogues were allowed to drift further downriver (Figure 8). The path of the middle drogue suggests a possible path of middle fish as they pass south of the dredge island.

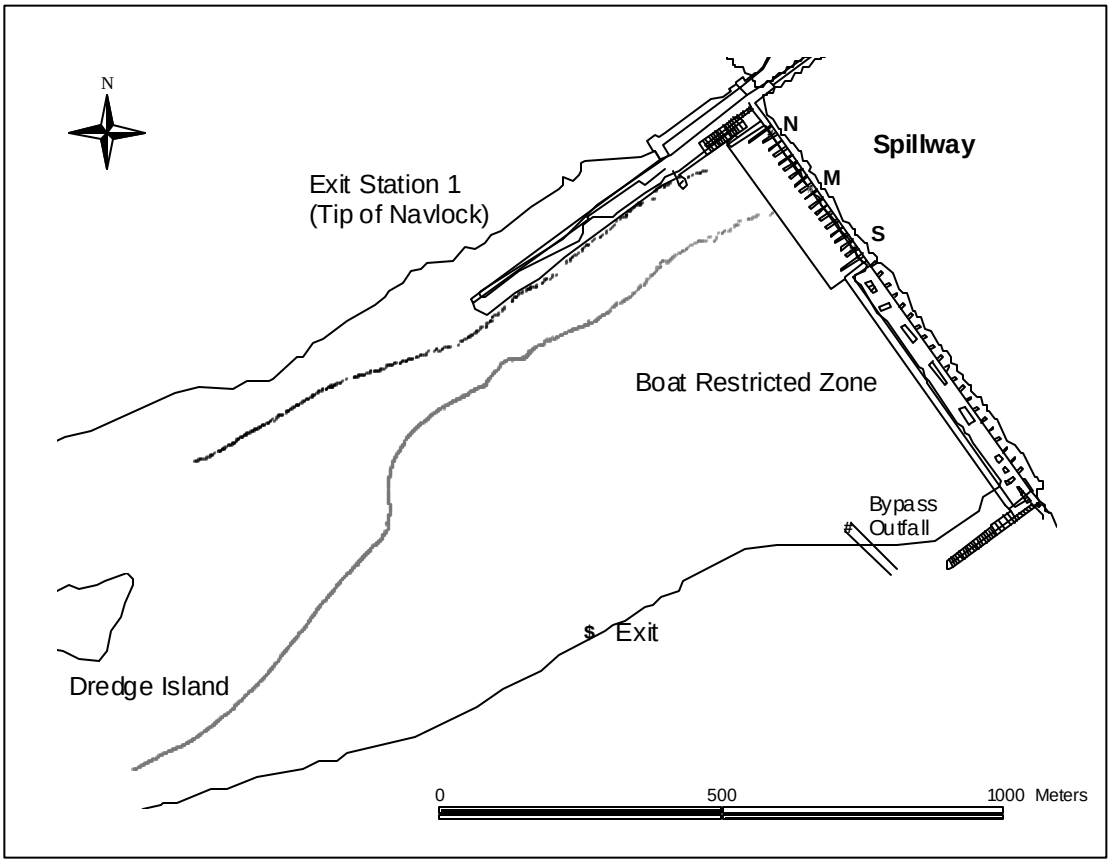


Figure 8. Route of drogues released from the north and middle spillway during daytime 30% (D30%) spill volumes at the John Day Dam, spring 2000. The drogues were equipped with Global Positioning System units.

Drogues appeared to represent the movements of steelhead better than they did yearling chinook salmon. During both D30% and N60% spill, the mean residence times of drogues and yearling chinook salmon were significantly different at the north ($P < 0.01$), middle ($P < 0.01$) and south spillway ($P < 0.01$) (Figure 9). Drogue and steelhead mean residence times were significantly different at the middle spillway release sites during both spill conditions ($P<0.01$; Figure 9). At the north release site, mean residence times of drogues and steelhead were significantly different during D30% spill ($P<0.01$), but not significantly different during N60% spill (Figure 9). Regardless of spill condition, mean residence times of drogues and steelhead

released through the south spillway were not significantly different. At the juvenile bypass outfall, the residence times of drogues were not significantly different from chinook or steelhead during D30% spill. Drogues were not released during N60% spill, therefore no comparisons were made.

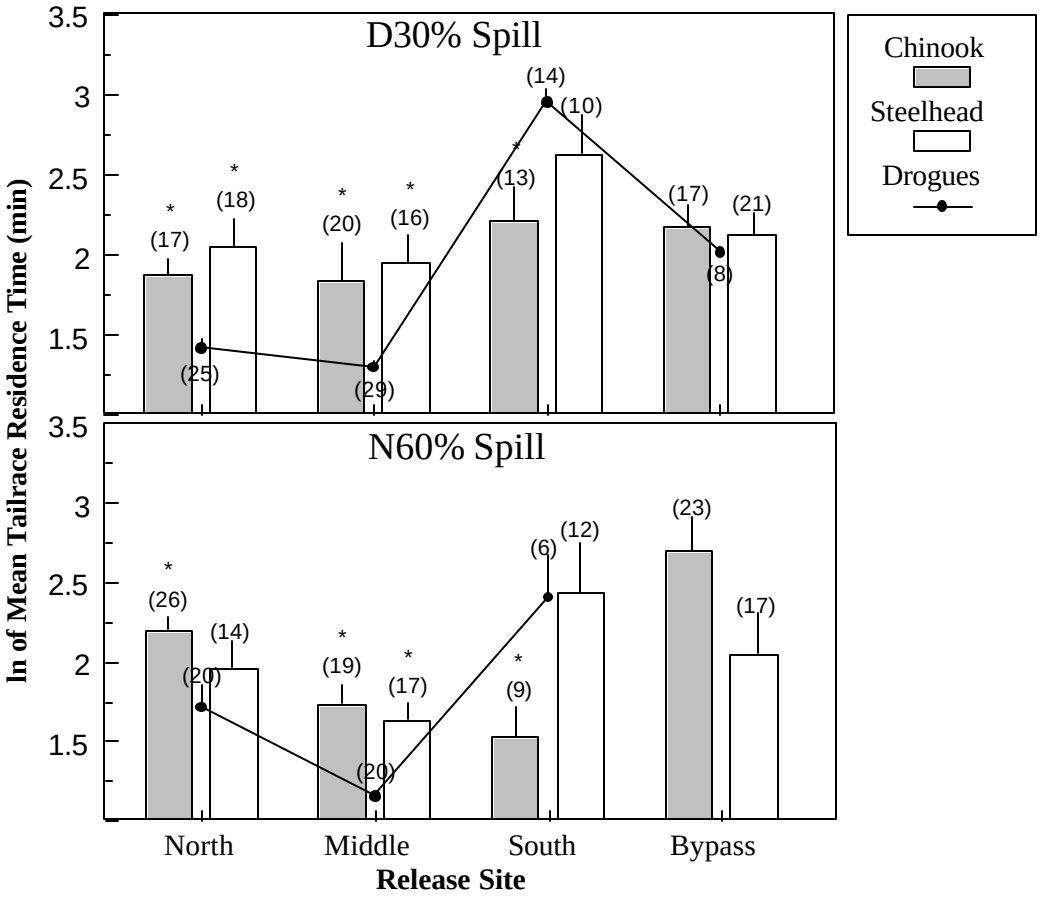


Figure 9. Mean residence times of drogues, yearling chinook salmon and yearling steelhead, during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, spring 2000. Sample sizes are indicated in parentheses. Vertical lines represent one standard error of the mean. Within each release site, significant differences between drogues, yearling chinook salmon and yearling steelhead are indicated by *, based on the *t*-test where $P < 0.05$. Drogues were not released from the bypass during N60%.

Where significant differences existed between the residence times of drogues and steelhead, the drogues consistently had the lower residence time (Figure 9). Yearling chinook salmon traveled significantly slower than drogues when released at the north and middle

spillway locations, but traveled significantly faster than drogues when released at the south spillway (Figure 9). Drogue residence times that were significantly different from fish residence times suggest that fish did not behave like passive particles.

Predation Events

Fixed station records and boat tracking locations suggest that seven radio-tagged yearling chinook salmon and five radio-tagged steelhead were preyed upon within the JDA tailrace. All predation events involved fish released through the north spillway. The seven yearling chinook salmon were consumed during D30% spill. Two steelhead were eaten during D30% spill, and three predation events occurred during N60% spill. All predation events are suspected to have occurred near the navigation lock, within the BRZ.

Six avian predation events were documented. Radio transmitters from six steelhead released at JDA were recovered at predacious bird colonies within the Columbia River and the estuary. Based on fixed station records, all of these fish left our study area before they were consumed.

SUBYEARLING FISH

Dam Operating Conditions

Dam operating conditions were similar to those proposed and remained relatively consistent throughout the study period (Table 14). The mean hourly total discharge during releases of radio-tagged fish between 01 July and 18 July ranged from 112 to 187 kcfs. The mean hourly spill discharge ranged from 33 to 102 kcfs over the same period (Table 14). The forebay and tailwater elevations were relatively consistent throughout our releases.

Table 14. Dam operating conditions at John Day Dam during releases of radio-tagged subyearling chinook salmon (CH0) and drogues, summer 2000. Values are means from a twelve hour period from 0700 to 1859 hours or 1900 to 0659 hours. Spillbay 14, the south release site, was closed during 30% spill. Discharge means (total and spill) are reported in kcfs. Forebay and tailwater elevations are reported in feet. Proposed 30% and 0% spill was used during daytime only (D30% and D0%). Proposed 60% spill was used during nighttime only (N60%). Data collected from http://www.nwd-wc.usace.army.mil/TMT.

Release **Date**	***Species***	***Total*** Discharge (kcfs)	Spill Discharge (kcfs)	Forebay Elevation (ft)	Tailwater Elevation (ft)	Planned Spill %	Actual Spill %
7/01/00	CH0	154.0	46.1	263.4	160.3	D30%	29.9
7/03/00	CH0	111.5	33.2	263.2	159.6	D30%	29.8
7/05/00	CH0	182.5	99.7	263.5	161.1	N60%	54.6
7/06/00	CH0	187.4	101.7	263.9	161.4	N60%	54.3
7/08/00	CH0	176.7	54.1	263.8	160.5	D30%	30.6
7/10/00	CH0	167.1	87.3	263.7	160.1	N60%	52.2
7/12/00	CH0	165.4	88.8	263.6	159.9	N60%	53.7
7/14/00	CH0	172.2	92.7	263.8	160.1	N60%	53.8
7/16/00	CH0	139.3	41.6	263.7	160.2	D30%	29.9
7/18/00	CH0	180.8	52.9	264.0	161.0	D30%	29.3

Release **Date**	***Species***	***Total*** Discharge (kcfs)	Spill Discharge (kcfs)	Forebay Elevation (ft)	Tailwater Elevation (ft)	Planned Spill %	Actual Spill %
7/02/00	Drogue	156.4	47.6	263.6	160.2	D30%	30.4
7/07/00	Drogue	236.6	70.3	263.9	162.0	D30%	29.7
7/09/00	Drogue	184.5	54.8	264.0	161.4	D30%	29.7
7/11/00	Drogue	178.1	94.3	263.7	163.2	N60%	52.9
7/12/00	Drogue	179.9	1.5	264.0	161.2	D0%	0.8
7/13/00	Drogue	182.6	97.9	263.8	160.5	N60%	53.6
7/17/00	Drogue	148.1	44.3	263.9	160.7	D30%	29.9

During proposed D30% spill, actual spill ranged from 29% to 31%, with a mean of 30%. During proposed N60% spill, actual spill ranged from 52% to 55%, with a mean of 54%. Due to reduced river flows, the south spillway was closed during day releases.

Number of Fish Released

One hundred fifty subyearling chinook salmon were released between 01 July and 18 July. Sample sizes were approximately equal at the four study release sites and during the two spill conditions. Fish released during D30% spill had an overall mean fork length of 120 mm and a mean weight of 20 g (Table 15). Fish released during N60% spill had an overall mean fork length of 118 mm with a mean weight of 19 g (Table 16). The TWBW ratio for subyearling chinook salmon released during D30% ranged between 3.9% and 4.0%. During N60% the ratio ranged between 4.1% and 4.3%. Mean fork lengths and weights of subyearling chinook salmon were not significantly different between release sites or release dates at either D30% or N60% spill levels.

Table 15. Fork lengths and weights of subyearling chinook released during daytime 30% (D30%) spill volume at John Day Dam, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Fork length (mm)			Weight (g)		
				Median	Mean	95% CI	Median	Mean	95% CI
7/01/00	Bypass	D30%	4	127.5	127.2	122.0 - 132.6	22.1	22.5	19.2 - 26.3
	North	D30%	4	119.9	120.7	111.1 - 131.0	18.6	19.0	14.1 - 25.5
	Middle	D30%	4	121.5	120.7	112.4 - 129.5	19.0	19.2	15.5 - 23.7
7/03/00	Bypass	D30%	4	114.0	114.2	111.1 - 117.6	17.3	17.5	15.5 - 19.8
	North	D30%	4	115.5	115.7	110.6 - 121.0	17.3	17.5	14.6 - 21.1
	Middle	D30%	4	117.4	117.4	108.5 - 127.0	18.3	18.7	13.5 - 26.1
7/08/00	Bypass	D30%	4	122.7	124.0	104.7 - 146.8	21.2	21.6	12.4 - 37.9
	North	D30%	4	113.5	115.1	107.1 - 123.7	16.6	17.3	13.0 - 23.2
	Middle	D30%	3	114.0	114.7	105.0 - 125.1	17.0	17.4	13.6 - 22.2
7/16/00	Bypass	D30%	6	120.5	125.3	111.4 - 140.9	19.6	22.0	15.8 - 30.6
	North	D30%	6	127.5	127.2	118.7 - 136.5	24.7	24.1	19.4 - 29.9
	Middle	D30%	7	126.0	128.4	120.8 - 136.3	24.2	25.5	22.1 - 29.9
7/18/00	Bypass	D30%	7	116.0	116.5	115.1 - 117.9	19.4	19.2	18.1 - 20.5
	North	D30%	7	116.0	115.1	112.3 - 118.4	19.2	18.6	17.4 - 19.8
	Middle	D30%	7	116.0	116.3	114.2 - 118.0	18.8	18.5	17.2 - 20.0
Total	Bypass	D30%	25	118.0	121.0^{A}	117.3 - 125.0	19.5	20.5^{A}	18.7 - 22.4
	North	D30%	25	116.0	18.9^{A}	116.0 - 121.9	19.2	19.5^{A}	18.0 - 21.1
	Middle	D30%	25	119.0	120.2^{A}	117.2 - 123.3	19.6	20.2^{A}	18.7 - 21.9
Overall		**D30%**	75	118.0	120.1	118.3 - 121.9	19.5	20.0	19.1 - 21.0

Table 16. Fork lengths and weights of subyearling chinook released during nighttime 60% (N60%) spill volume at John Day Dam, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Site	Spill	N	Fork length (mm)			Weight (g)		
				Median	Mean	95% CI	Median	Mean	95% CI
7/05/00	Bypass	N60%	3	114.0	113.0	108.7 - 117.4	16.7	16.5	13.1 - 20.7
	North	N60%	3	121.0	125.5	105.4 - 149.3	22.7	24.5	15.8 - 37.8
	Middle	N60%	3	116.0	116.6	107.0 - 127.1	18.4	18.6	12.8 - 27.0
	South	N60%	3	128.0	125.5	107.4 - 146.6	24.8	23.6	12.5 - 44.5
7/06/00	Bypass	N60%	3	117.0	116.3	142.7 - 124.2	19.2	18.3	13.6 - 24.8
	North	N60%	3	116.0	120.1	97.6 - 147.7	17.4	20.1	10.4 - 38.6
	Middle	N60%	3	114.0	115.9	105.7 - 127.2	19.0	18.3	13.0 - 25.6
	South	N60%	3	114.0	114.3	110.6 - 118.2	16.6	16.8	15.4 - 18.2
7/10/00	Bypass	N60%	4	119.5	121.0	106.8 - 137.0	20.9	21.3	14.0 - 32.5
	North	N60%	4	111.1	113.0	106.9 - 119.3	16.5	16.8	13.9 - 20.3
	Middle	N60%	3	121.0	119.9	111.3 - 129.3	20.5	19.6	14.1 - 27.5
	South	N60%	4	117.9	119.6	107.8 - 132.7	19.4	19.5	12.1 - 31.3
7/12/00	Bypass	N60%	4	111.1	111.7	109.4 - 114.1	15.3	15.1	14.3 - 15.9
	North	N60%	5	111.9	115.5	106.8 - 124.7	15.3	16.7	14.2 - 19.7
	Middle	N60%	5	113.0	116.9	109.7 - 124.6	17.3	18.8	14.6 - 24.1
	South	N60%	4	116.5	117.2	110.5 - 124.2	18.2	17.9	16.7 - 19.3
7/14/00	Bypass	N60%	5	115.0	117.7	110.3 - 125.6	19.6	20.1	16.0 - 25.3
	North	N60%	4	117.4	121.8	103.8 - 143.0	19.0	20.2	13.0 - 31.3
	Middle	N60%	4	119.0	118.6	109.6 - 128.4	19.7	19.7	15.1 - 25.7
	South	N60%	5	119.9	119.6	110.9 - 129.0	19.2	20.1	16.3 - 25.0
Total	Bypass	N60%	19	114.0	116.2^{A}	113.3 - 119.0	17.4	18.3	16.6 - 20.1
	North	N60%	19	116.0	118.5^{A}	114.3 - 122.7	17.9	19.0	17.1 - 21.2
	Middle	N60%	18	116.0	117.6^{A}	115.2 - 119.9	18.7	19.0	17.1 - 20.5
	South	N60%	19	117.0	119.1^{A}	116.0 - 122.4	18.2	19.5	17.6 - 21.4
Overall		**N60%**	75	116.0	117.8	116.3 - 119.3	18.2	19.0	18.1 - 19.8

Percent of Radio-Tagged Fish Detected

Overall fixed station detection of radio-tagged subyearling chinook salmon was high (90%), with higher detection during D30% spill (96%) than N60% spill (84%; Table 17). Boat

tracking within the JDA tailrace located 65% of the fish, with higher detection during D30% spill (69%) than N60% spill (61%; Table 17). During D30% and N60% spill, combined detections (fixed station and boat tracking) were higher at exit station 1 (96% and 87%, respectively) than at exit station 2 (35% and 45%, respectively) or 3 (80% and 80%, respectively; Tables 18 and 19). Boat tracking locations of subyearling chinook salmon by spill condition are presented in Figure 10.

Table 17. Number of subyearling chinook salmon (CH0) released at John Day Dam (JDA) and the number of fish detected using fixed gear stations and boat tracking during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, summer 2000.

Species	Release date	Spill	Number of CH0 released	CH0 detected with fixed gear stations at JDA N (%)	CH0 located by boat tracking at JDA N (%)
CH0	7/01/00	D30%	12	12 (100)	7 (58)
CH0	7/03/00	D30%	12	11 (92)	6 (50)
CH0	7/08/00	D30%	11	11 (100)	10 (91)
CH0	7/16/00	D30%	19	18 (95)	14 (74)
CH0	7/18/00	D30%	21	20 (95)	15 (71)
Total		D30%	75	72 (96)	52 (69)
CH0	7/05/00	N60%	12	10 (83)	6 (50)
CH0	7/06/00	N60%	12	10 (83)	9 (75)
CH0	7/10/00	N60%	15	12 (80)	4 (27)*
CH0	7/12/00	N60%	18	16 (89)	14 (78)
CH0	7/14/00	N60%	18	15 (83)	13 (72)
Total		N60%	75	63 (84)	46 (61)
Overall			150	135 (90)	98 (65)

**Boat experienced mechanical failure.*

Table 18. Release position, sample size (N), and percent of radio-tagged subyearling chinook (CH0) salmon detected at each of three exit stations in the John Day Dam tailrace during daytime 30% (D30%) spill volume, summer 2000. Exit station 1 (Exit 1) was at the western tip of the navigation lock peninsula (0.7 km downriver of the dam). Exit station 2 (Exit 2) was on the dredge island (1.9 km downriver of the dam). Exit station 3 (Exit 3) was located 5.3 km downriver of the dam.

Release Date	Release Position	Spill	Number of CH0 released	CH0 Detected Exit 1 N (%)	CH0 Detected Exit 2 N (%)	CH0 Detected Exit 3 N (%)
7/01/00	Bypass	D30%	4	4 (100)	0 (0)	4 (100)
	North	D30%	4	4 (100)	1 (25)	3 (75)
	Middle	D30%	4	4 (100)	1 (25)	2 (50)
7/03/00	Bypass	D30%	4	4 (100)	0 (0)	4 (100)
	North	D30%	4	3 (75)	2 (50)	3 (75)
	Middle	D30%	4	4 (100)	1 (25)	3 (75)
7/08/00	Bypass	D30%	4	4 (100)	1 (25)	4 (100)
	North	D30%	4	4 (100)	4 (100)	4 (100)
	Middle	D30%	3	3 (100)	0 (0)	3 (100)
7/16/00	Bypass	D30%	6	6 (100)	3 (50)	4 (67)
	North	D30%	6	6 (100)	4 (67)	5 (83)
	Middle	D30%	7	6 (86)	4 (57)	4 (57)
7/18/00	Bypass	D30%	7	6 (86)	2 (29)	7 (100)
	North	D30%	7	7 (100)	2 (29)	5 (71)
	Middle	D30%	7	7 (100)	1 (14)	5 (71)
Total	Bypass	D30%	25	24 (96)	6 (24)	23 (92)
	North	D30%	25	24 (96)	13 (52)	20 (80)
	Middle	D30%	25	24 (96)	7 (28)	17 (68)
Overall		D30%	75	72 (96)	26 (35)	60 (80)

Table 19. Release position, sample size (N), and percent of radio-tagged subyearling chinook (CH0) salmon detected at each of three exit stations in the John Day Dam tailrace during nighttime 60% (N60%) spill volume, summer 2000. Exit station 1 (Exit 1) was at the western tip of the navigation lock peninsula (0.7 km downriver of the dam). Exit station 2 (Exit 2) was on the dredge island (1.9 km downriver of the dam). Exit station 3 (Exit 3) was located 5.3 km downriver of the dam.

Release Date	Release Position	Spill	Number of CH0 released	CH0 Detected Exit 1 N (%)	CH0 Detected Exit 2 N (%)	CH0 Detected Exit 3 N (%)
7/05/00	Bypass	N60%	3	0 (0)	0 (0)	1 (33)
	North	N60%	3	3 (100)	2 (67)	3 (100)
	Middle	N60%	3	3 (100)	1 (33)	3 (100)
	South	N60%	3	3 (100)	3 (100)	2 (67)
7/06/00	Bypass	N60%	3	2 (67)	1 (33)	1 (33)
	North	N60%	3	3 (100)	2 (67)	3 (100)
	Middle	N60%	3	3 (100)	1 (33)	3 (100)
	South	N60%	3	3 (100)	0 (0)	2 (67)
7/10/00	Bypass	N60%	4	2 (50)	1 (25)	1 (25)
	North	N60%	4	4 (100)	3 (75)	4 (100)
	Middle	N60%	3	2 (67)	3 (100)	3 (100)
	South	N60%	4	4 (100)	1 (25)	4 (100)
7/12/00	Bypass	N60%	4	3 (75)	2 (50)	3 (75)
	North	N60%	5	5 (100)	1 (20)	5 (100)
	Middle	N60%	5	5 (100)	2 (40)	4 (80)
	South	N60%	4	4 (100)	2 (40)	4 (100)
7/14/00	Bypass	N60%	5	3 (60)	0 (0)	2 (40)
	North	N60%	4	4 (100)	3 (75)	3 (75)
	Middle	N60%	4	4 (100)	1 (25)	4 (100)
	South	N60%	5	5 (100)	5 (100)	5 (100)
Total	Bypass	N60%	19	10 (53)	4 (21)	8 (42)
	North	N60%	19	19 (100)	11 (58)	18 (95)
	Middle	N60%	18	17 (94)	8 (44)	17 (94)
	South	N60%	19	19 (100)	11 (58)	17 (89)
Overall		N60%	75	65 (87)	34 (45)	60 (80)

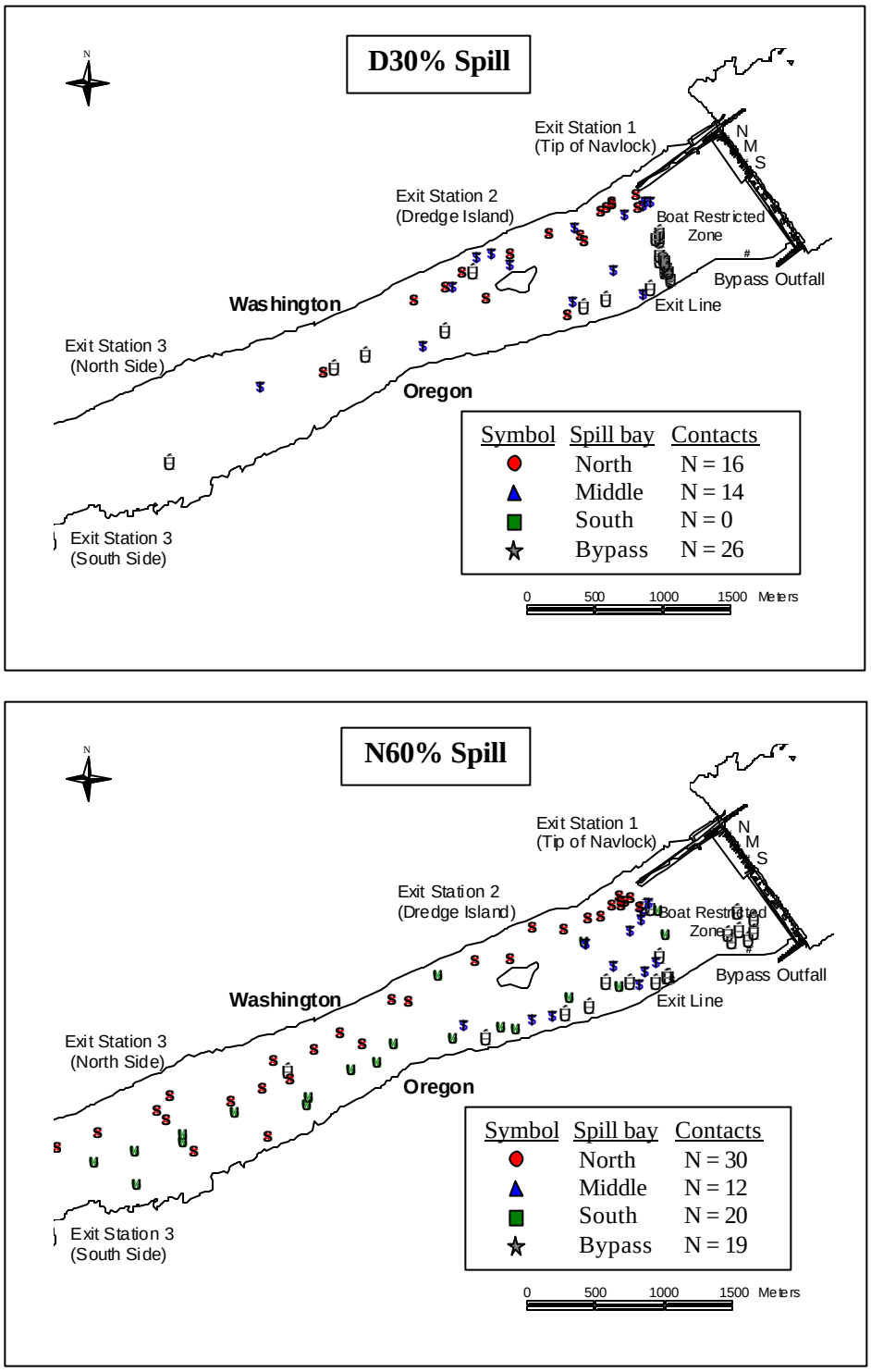


Figure 10. Locations of radio-tagged subyearling chinook salmon in the John Day tailrace as determined by mobile tracking, during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes. The number of individual fish detected are represented by N. Some individuals were detected more than once.

Residence Time to Exit Station 1

Subyearling chinook salmon released through the middle spillway and the juvenile bypass system were significantly affected by spill condition. The mean residence time of middle fish was significantly lower (P = 0.02) during N60% spill (6 min) than D30% spill (9 min; Table 20 and 21). Bypass fish demonstrated the opposite trend. Their mean residence time was

Table 20. Sample size (N) and residence time (min) at exit station 1 of radio-tagged subyearling chinook salmon during daytime 30% (D30%) spill volume, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Position	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
7/01/00	Bypass	D30%	4	16.7	16.6	14.6 - 19.0
	North	D30%	4	4.8	4.9	4.0 - 5.9
	Middle	D30%	4	7.2	7.4	5.0 - 10.8
7/03/00	Bypass	D30%	4	16.9	16.5	14.8 - 18.4
	North	D30%	3	5.4	12.0	0.4 - 384.1
	Middle	D30%	4	12.6	13.1	9.0 - 19.2
7/08/00	Bypass	D30%	4	19.4	18.5	13.9 - 24.6
	North	D30%	4	5.8	5.8	3.7 - 9.1
	Middle	D30%	3	5.9	5.9	5.8 - 6.1
7/16/00	Bypass	D30%	6	25.1	21.9	10.9 - 44.1
	North	D30%	6	5.3	5.5	4.8 - 6.4
	Middle	D30%	6	15.6	13.5	6.9 - 26.2
7/18/00	Bypass	D30%	6	12.2	12.0	8.6 - 16.8
	North	D30%	7	6.1	5.8	4.8 - 7.0
	Middle	D30%	7	6.0	6.7	5.0 - 9.1
Overall	Bypass	D30%	24	16.9	16.7^{A}	14.0 - 19.9
	North	D30%	24	5.3	6.1^{C}	4.9 - 7.6
	Middle	D30%	24	7.4	8.9^{B}	7.2 - 11.0

significantly higher (P < 0.01), more than four times as long, during N60% spill (74 min) compared to D30% spill (17 min). The mean residence time of north fish was 6 min during both D30% and N60% spill.

Fish released through the bypass had significantly longer residence times than other release sites during both spill conditions. During D30% spill, the overall mean residence time of subyearling chinook salmon released from the bypass (17 min) was significantly ($P < 0.01$) higher than north (6 min) and middle fish (9 min; Table 20). During N60% spill, bypass fish had a significantly higher ($P < 0.01$) overall mean residence time (74 min) than north (6 min), middle (6 min), and south fish (7min; Table 21).

Table 21. Sample size (N) and residence time (min) at exit station 1 (north tip lock peninsula, 0.7 km downriver of the dam) of radio-tagged subyearling chinook salmon during nighttime 60% (N60%) spill volume, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test ($P<0.05$).

Release Date	Release Position	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
7/05/00	Bypass	N60%	0	---	---	---
	North	N60%	3	5.5	5.6	5.0 - 6.2
	Middle	N60%	3	6.4	6.2	4.3 - 8.6
	South	N60%	3	6.6	6.3	3.4 - 11.6
7/06/00	Bypass	N60%	2	37.9	37.0	2.2 - 619.0
	North	N60%	3	5.7	7.5	2.3 - 23.9
	Middle	N60%	3	9.0	7.2	2.2 - 23.2
	South	N60%	3	6.4	7.7	1.5 - 40.4
7/10/00	Bypass	N60%	2	53.3	49.1	0.3 - 9069.8
	North	N60%	4	5.0	5.1	3.7 - 7.1
	Middle	N60%	2	4.5	4.5	1.7 - 12.1
	South	N60%	4	7.6	7.4	4.8 - 11.6
7/12/00	Bypass	N60%	3	192.9	128.8	18.8 - 884.0
	North	N60%	5	5.7	5.5	4.2 - 7.4
	Middle	N60%	5	6.4	7.3	4.0 - 13.4
	South	N60%	4	5.0	6.5	2.5 - 17.0
7/14/00	Bypass	N60%	3	132.9	89.8	9.0 - 899.7
	North	N60%	4	7.7	7.3	3.8 - 14.0
	Middle	N60%	4	6.0	6.0	4.2 - 8.5
	South	N60%	5	6.7	6.5	4.2 - 10.2
Overall	Bypass	N60%	10	63.4	74.3^{A}	42.1 - 131.2
	North	N60%	19	5.7	6.1^{B}	5.2 - 7.0
	Middle	N60%	17	6.4	6.4^{B}	5.3 - 7.6
	South	N60%	19	6.4	6.8^{B}	5.6 - 8.3

Residence Time to Exit Station 2

Mean residence times of subyearling chinook salmon were not significantly affected by spill condition but were significantly different among release sites. During D30% spill, the overall mean residence time of bypass fish (57 min) was significantly higher ($P < 0.01$) than north fish (23 min) and middle fish (31 min; Table 22). During N60% spill, there were no significant differences between the overall mean residence times of subyearling chinook salmon released from the bypass (38 min), middle (22 min), north (22 min), and south spillway (23 min; Table 23).

Table 22. Sample size (N) and residence time (min) at exit station 2 (dredge island, 1.9 km downriver of the dam) of radio-tagged subyearling chinook salmon during daytime 30% (D30%) spill volume, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test ($P<0.05$).

Release Date	Release Position	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
7/01/00	Bypass	D30%	0	---	---	---
	North	D30%	1	18.0	18.0	---
	Middle	D30%	1	25.8	25.8	---
7/03/00	Bypass	D30%	0	---	---	---
	North	D30%	2	75.3	53.7	0.0 - >21600
	Middle	D30%	1	29.0	29.0	---
7/08/00	Bypass	D30%	1	37.7	37.7	---
	North	D30%	4	22.4	23.0	16.4 - 32.2
	Middle	D30%	0	---	---	---
7/16/00	Bypass	D30%	3	51.6	63.6	23.0 - 175.8
	North	D30%	4	18.4	18.7	13.9 - 25.0
	Middle	D30%	4	38.3	38.7	34.8 - 43.0
7/18/00	Bypass	D30%	2	64.6	58.8	0.2 - 16229
	North	D30%	2	18.1	18.0	6.8 - 47.5
	Middle	D30%	1	17.5	17.5	---
Overall	Bypass	D30%	6	50.2	56.8^{A}	36.1 - 89.4
	North	D30%	13	19.7	23.2^{B}	16.7 - 32.3
	Middle	D30%	7	36.6	31.3^{B}	23.5 - 41.6

Table 23. Sample size (N) and residence time (min) at exit station 2 (dredge island, 1.9 km downriver of the dam) of radio-tagged subyearling chinook salmon during nighttime 60% (N60%) spill volume, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Position	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
7/05/00	Bypass	N60%	0	---	---	---
	North	N60%	2	23.8	22.1	0.2 - 2838.1
	Middle	N60%	1	15.7	15.7	---
	South	N60%	3	25.4	24.6	17.8 - 34.1
7/06/00	Bypass	N60%	1	49.0	49.0	---
	North	N60%	2	25.4	24.3	0.6 - 993.9
	Middle	N60%	1	17.7	17.7	---
	South	N60%	0	---	---	---
7/10/00	Bypass	N60%	1	41.4	41.4	---
	North	N60%	3	17.6	23.4	4.7 - 116.8
	Middle	N60%	3	16.1	18.2	6.5 - 51.0
	South	N60%	1	20.4	20.4	---
7/12/00	Bypass	N60%	2	35.1	32.6	0.2 - 4805.9
	North	N60%	1	28.6	28.6	---
	Middle	N60%	2	67.8	43.5	0.0 - >21600
	South	N60%	2	30.9	30.2	2.2 - 409.3
7/14/00	Bypass	N60%	0	---	---	---
	North	N60%	3	17.6	17.8	12.2 - 26.0
	Middle	N60%	1	15.1	15.1	---
	South	N60%	5	20.8	20.7	13.1 - 32.6
Overall	Bypass	N60%	4	44.8	38.3^{A}	21.0 - 69.9
	North	N60%	11	18.2	22.0^{A}	16.9 - 28.8
	Middle	N60%	8	16.0	21.6^{A}	11.8 - 39.8
	South	N60%	11	24.6	23.2^{A}	19.0 - 28.4

Residence Time to Exit Station 3

At each release location, the mean residence times of subyearling chinook salmon were not significantly affected by spill level. Bypass fish had significantly longer mean residence times than the other groups. The mean residence time of bypass subyearling chinook salmon during D30% spill (110 min) was significantly higher ($P < 0.01$) than north (90 min), or middle fish (93 min; Table 24). During N60% spill, bypass fish had a significantly higher ($P = 0.03$)

mean residence time (130 min) than north (88 min), middle (98 min), and south fish (101 min; Table 25).

Table 24. Sample size (N) and residence time (min) at exit station 3 (5.3 km downriver of the dam) of radio-tagged subyearling chinook salmon during daytime 30% (D30%) spill volume, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Position	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
7/01/00	Bypass	D30%	4	102.0	102.4	92.5 - 113.3
	North	D30%	3	95.7	88.2	44.3 - 175.7
	Middle	D30%	2	85.5	84.5	12.4 - 575.5
7/03/00	Bypass	D30%	4	165.5	156.8	121.3 - 202.8
	North	D30%	3	101.7	111.3	69.4 - 178.5
	Middle	D30%	3	144.2	129.7	74.3 - 226.6
7/08/00	Bypass	D30%	4	113.1	115.5	100.4 - 132.9
	North	D30%	4	84.2	83.3	67.0 - 103.6
	Middle	D30%	3	107.2	94.2	52.1 - 170.3
7/16/00	Bypass	D30%	4	107.8	107.1	66.3 - 173.1
	North	D30%	5	102.3	101.3	85.5 - 120.0
	Middle	D30%	4	102.4	104.4	82.5 - 132.2
7/18/00	Bypass	D30%	7	93.2	95.0	76.2 - 118.4
	North	D30%	5	78.0	75.4	65.0 - 87.4
	Middle	D30%	5	71.8	72.3	60.6 - 86.3
Overall	Bypass	D30%	23	106.6	110.1^{A}	99.4 - 123.8
	North	D30%	20	90.9	89.9^{B}	81.6 - 98.9
	Middle	D30%	17	96.3	93.3^{B}	81.4 - 106.9

Table 25. Sample size (N) and residence time (min) at exit station 3 (5.3 km downriver of the dam) of radio-tagged subyearling chinook salmon during nighttime 60% (N60%) spill volume, summer 2000. Means without letters in common are significantly different based on Tukey's Studentized Range Test (P<0.05).

Release Date	Release Position	Spill	N	Residence Time (min)		
				Median	Mean	95% CI
7/05/00	Bypass	N60%	1	145.1	145.1	---
	North	N60%	3	81.9	86.4	55.2 - 135.3
	Middle	N60%	3	82.5	85.8	62.9 - 117.0
	South	N60%	2	95.6	95.5	74.3 - 226.6
7/06/00	Bypass	N60%	1	119.0	119.0	---
	North	N60%	3	88.4	87.0	72.3 - 104.7
	Middle	N60%	3	91.8	86.6	66.7 - 112.5
	South	N60%	2	90.7	90.0	17.8 - 456.0
7/10/00	Bypass	N60%	1	96.0	96.0	---
	North	N60%	4	92.4	97.5	70.1 - 135.6
	Middle	N60%	3	71.5	89.6	31.1 - 258.1
	South	N60%	4	107.4	112.1	75.9 - 165.7
7/12/00	Bypass	N60%	3	104.6	130.5	36.8 - 462.3
	North	N60%	5	77.3	79.0	75.4 - 82.8
	Middle	N60%	4	111.8	119.4	76.2 - 187.3
	South	N60%	4	100.7	111.4	70.9 - 174.9
7/14/00	Bypass	N60%	2	154.3	149.3	5.7 - 3885.1
	North	N60%	3	106.2	96.5	55.4 - 168.1
	Middle	N60%	4	109.4	104.2	70.7 - 153.7
	South	N60%	5	86.9	92.0	68.5 - 123.6
Overall	Bypass	N60%	8	117.3	130.1^{A}	98.1 - 172.6
	North	N60%	18	82.3	88.3^{B}	81.5 - 95.6
	Middle	N60%	17	94.5	98.0^{B}	85.5 - 112.3
	South	N60%	17	101.2	101.0^{B}	89.8 - 113.7

Dredge Island Passage

Using fixed station data from exit station 2 and boat tracking, we were able to identify the general route of passage taken by radio-tagged fish as they passed the dredge island (Figures 10 and 11). The dominant passage route around the island was to the south, however, passage route did depend somewhat upon spill conditions and release site. During D30% spill, north fish passed to the north side (54%) and south side (46%) in approximately equal numbers (Figure 11). Middle and bypass fish generally passed south of the island. Twenty-nine percent of

middle fish passed north of the island and 71% passed south. Seventeen percent of bypass fish were detected north of the island, and 83% passed south of the island. During N60% spill, fish released through the spillway (north, middle, and south) showed strong south island passage (Figure 11). Seventy-five percent of bypass fish passed on the north side of the island during N60% spill.

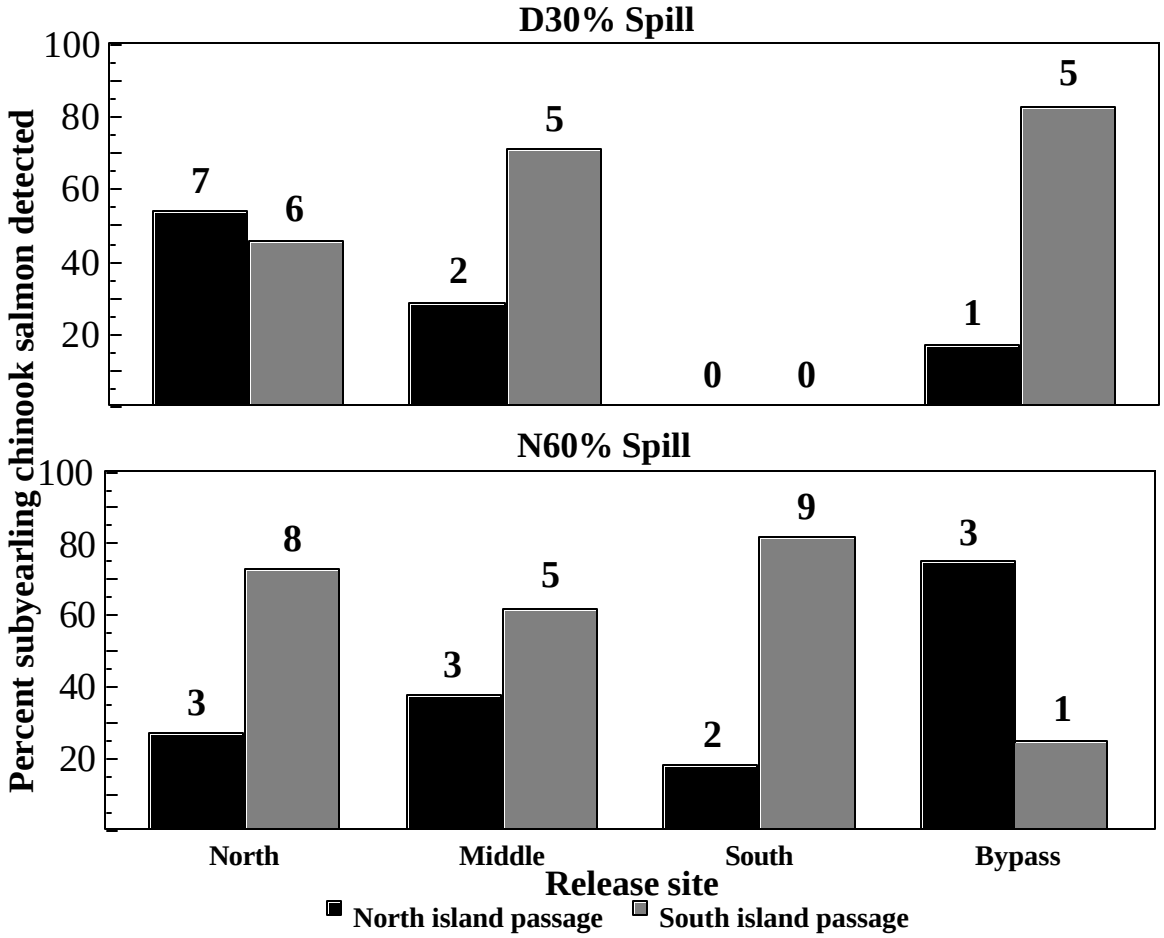


Figure 11. Island passage routes of subyearling chinook salmon released at John Day Dam during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes, summer 2000. Passage was determined using data gathered by the fixed station on the dredge island. Sample sizes are indicated above the bars. The release sites refer to north (bay 2), middle (bay 10), south (bay 14), and bypass. South fish were not released during D30%.

The island passage route of bypass fish appeared to be influenced by spill condition. During D30% spill, bypass fish most commonly used a south island passage route (83%).

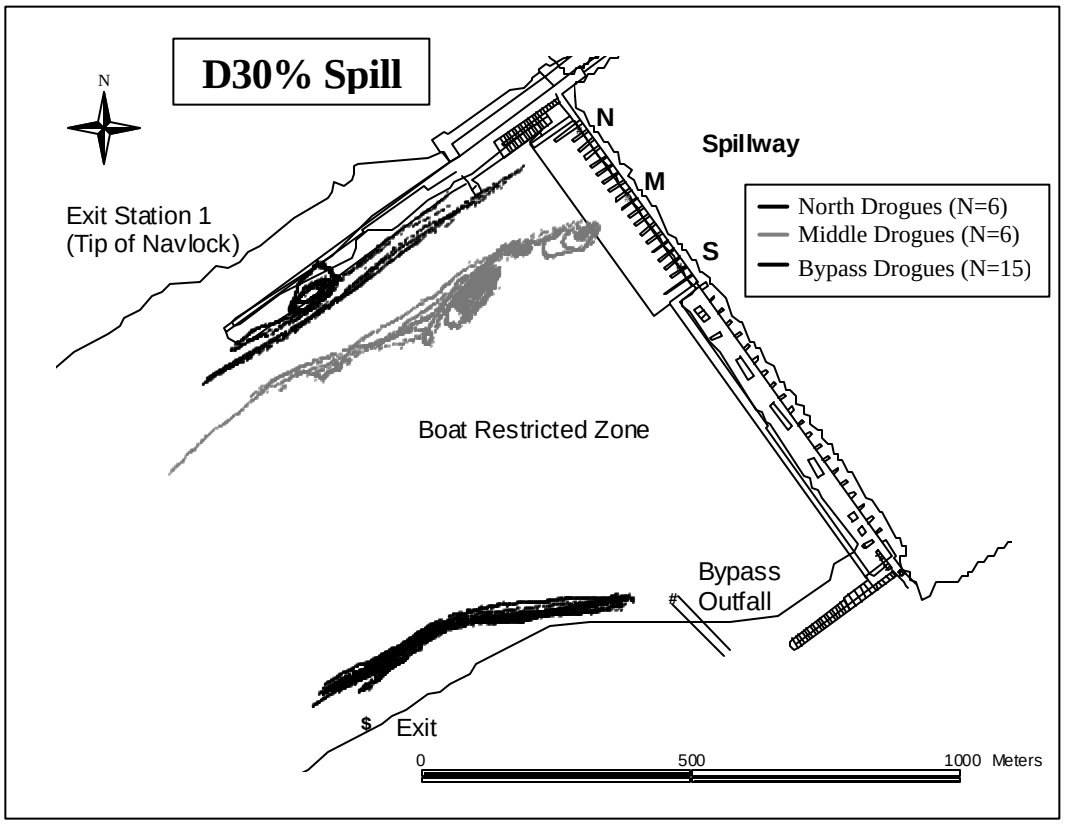
During the higher spill of N60%, the dominant passage route was north (75%). We were only able to assign an island passage route to a limited number of bypass fish (6 at D30% and 4 at N60%), but boat tracking data support the island passage trend. Subyearling chinook salmon were frequently located near the western tip of the navigation lock peninsula following bypass passage during N60% spill. The movement across the stilling basin occurred within the BRZ. Fish located near the navigation lock generally passed the dredge island in the north channel.

Drogue Releases

Drogue residence times were generally not affected by release location. During D30% spill, the mean residence times of bypass drogues (8 min) and north drogues (5 min) were significantly lower ($P < 0.01$) than middle drogues (13 min; Table 26). The mean residence time of bypass drogues at D30% spill (8 min) was not significantly different than at D0% spill (8 min). During N60% spill, the mean residence times of middle drogues (4 min), and south drogues (6 min) were significantly different ($P = 0.03$) from each other, but not significantly different from north drogues (5 min; Table 26).

Table 26. Drogue residence times during daytime 0% (D0%), daytime 30% (D30%) and nighttime 60% (N60%) spill volumes at John Day Dam, summer 2000. Drogue residence times were calculated at exit station 1 (tip of the navigation lock peninsula, 0.7 downriver of the dam). Within each spill volume, means without letters in common are significantly different based on Tukey's Studentized Range Test ($P<0.05$).

Release Site	Spill	N	Residence Time (min)		
			Median	Mean	95% CI
Bypass	D0%	16	7.3	7.5	7.0 - 8.2
Bypass	D30%	16	7.6	7.8^{B}	7.4 - 8.2
North	D30%	25	4.7	5.3^{B}	4.2 - 6.8
Middle	D30%	26	11.4	13.3^{A}	9.4 - 18.8
North	N60%	13	4.5	5.4^{AB}	3.8 - 7.6
Middle	N60%	12	3.5	3.6^{B}	3.8 - 7.6
South	N60%	11	5.2	5.8^{A}	4.2 - 7.9



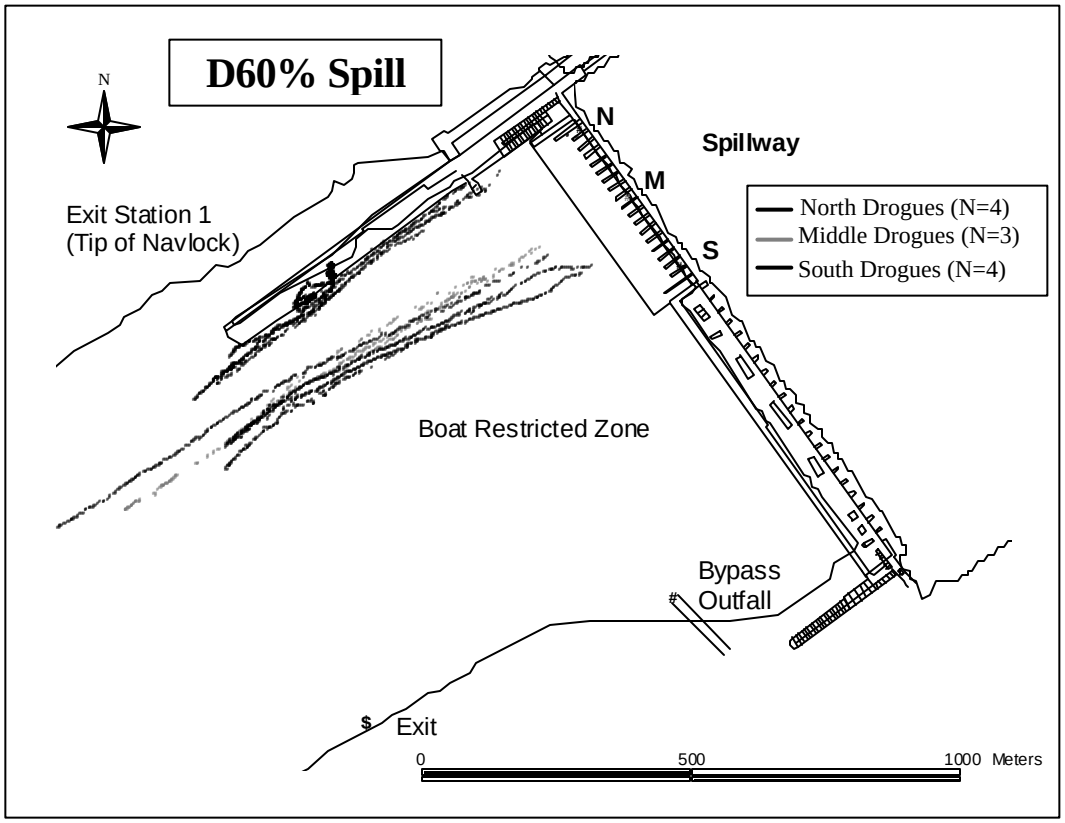


Figure 12. Drogues released from the north, middle, south spillway and the juvenile bypass system, during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes at the John Day Dam, summer 2000. The lines shown indicate the route taken by drogues equipped with Global Positioning System units.

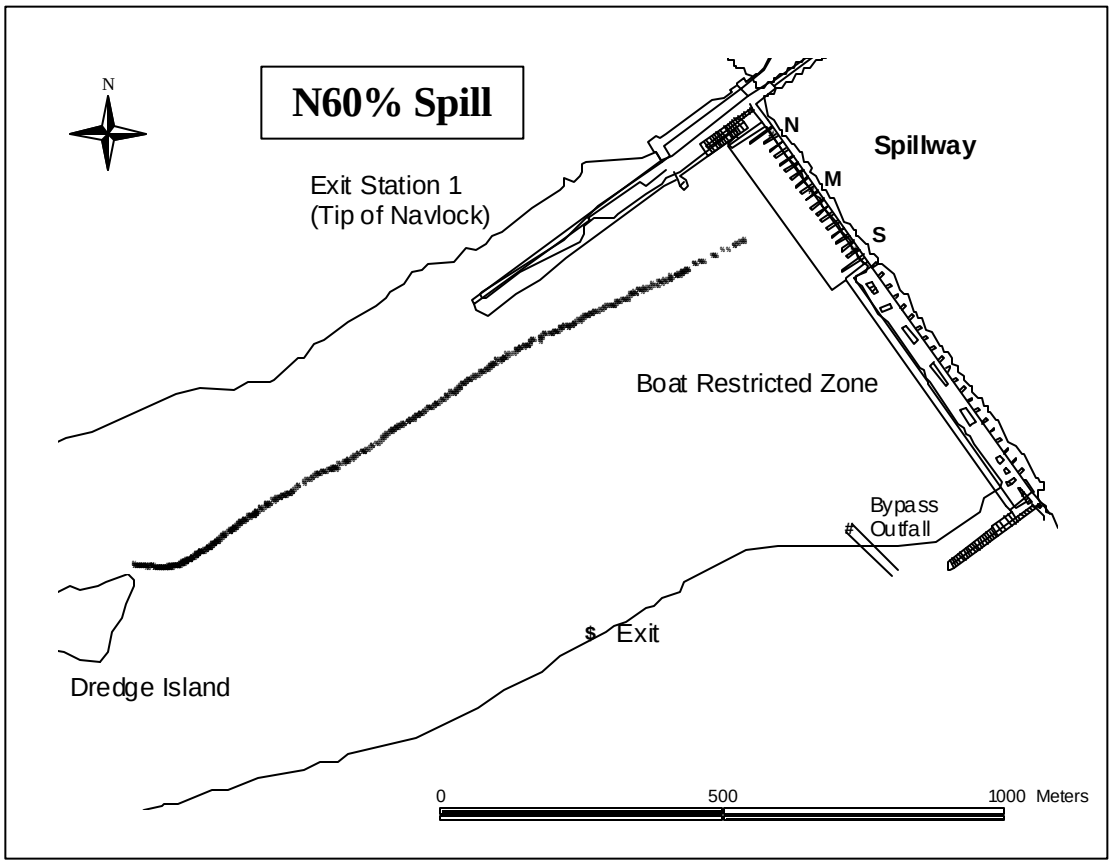


Figure 13. Route of drogue released from south spillway, during nighttime 60% (N60%) spill volumes at the John Day Dam, summer 2000. The drogue was equipped with a Global Positioning System unit.

Spill conditions affected the drogue route of drift through the tailrace. Thirteen of the 26 drogues released from the middle spillway during D30% spill were delayed in eddies upriver of exit station 1 (Figure 12). The extended residence times of middle drogues (20 min or more) occurred when drogues were delayed in this area. The remaining middle drogues generally drifted directly downriver. Middle drogues released during N60% spill were not delayed in the tailrace. Three of the 25 drogues released from the north spillway delayed in an eddy along the navigation lock peninsula during D30% spill (Figure 12). During N60% spill, three of the 13 released north drogues were caught in this eddy. The extreme residence times of north drogues (20 min or more) occurred when drogues followed this route. The remaining north drogues drifted directly downriver (Figure 12). Three of the 11 south drogues were delayed in eddies for

short periods during N60% spill. The remaining south drogues generally drifted north and passed exit station 1 in roughly the same area as middle drogues. One south drogue was allowed to drift to the east end of the dredge island (Figure 13). All bypass drogues followed the contours of the south shoreline (Figure 12).

Drogue residence times were most comparable to fish residence times at the north spillway release location. During both D30% and N60% spill, there were no significant differences between the mean residence time of north drogues and north fish (Figure 14). Fish and drogues released through the middle spillway had significantly different residence times. During N60% spill, drogues moved significantly faster ($P<0.01$) than fish (Figure 14). During D30% spill, fish moved through the tailrace significantly faster ($P=0.05$) than drogues, although the significance level was marginal.

Bypass drogues and fish were only compared at D30% spill. Drogues released through the bypass had a significantly ($P<0.01$) lower mean residence time than bypass fish. South drogues and fish were compared at N60% spill and there were no significant differences between residence times (Figure 14).

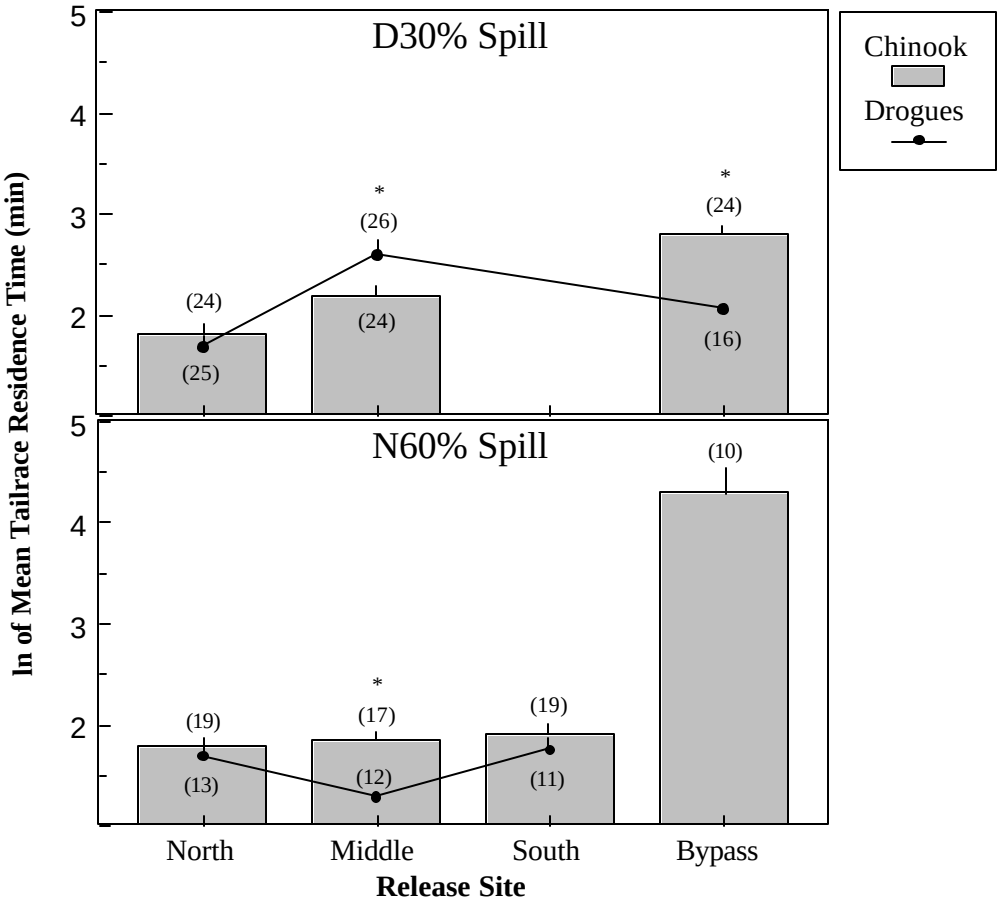


Figure 14. Mean residence times of drogues and subyearling chinook salmon during daytime 30% (D30%) and nighttime 60% (N60%) spill volumes. Sample sizes are indicated in parentheses. Vertical lines represent one standard error of the mean. Within each release site, significant differences between drogues and subyearling chinook salmon are indicated by *, based on the *t*-test where $P < 0.05$. Drogues were not released from the south release site during D30% or the bypass during N60%.

Predation Events

Interpretation of fixed station data and boat tracking data suggests that seven radio-tagged subyearling chinook salmon were preyed upon within the JDA tailrace. Two predation events occurred during D30% spill. Both fish were released from the middle spillway, and the predation events occurred along the navigation lock peninsula. Five predation events occurred

during N60%. All five events were bypass fish suspected to have been consumed within close proximity to the bypass outfall.

One avian predation event was documented. The transmitter from a fish released through the north spillway was recovered on Little Miller Island (approximate river km 40), the site of a predacious bird colony.

DISCUSSION

The objectives of this study were to compare the tailrace egress of fish released through the north spillway, middle spillway, south spillway, and the juvenile bypass system during two spill regimes. The study design involved 30% spill during the day (D30%) and 60% spill at night (N60%). Two main effects, diel period and spill condition, were therefore confounded. When comparisons were made between fish residence time during D30% and N60% spill, the influence of increased spill could not be separated from diel effects on fish behavior. This is an important consideration at JDA where there is a strong diel passage effect.

Dam operations were not ideal for our evaluations of the south spillway or for releases of steelhead. The spillway release system required that release pipes be mounted in specific study spillbays. During the spring run, spillbay 18 was used to represent the south spillway. Bay 18 was closed, however, on four of 12 release dates (33%). During analyses, the sample sizes at the south spillway were lower than other release sites and were therefore omitted from statistical comparisons. During the summer study period, spillbay 14 was used to represent the south spillway. A release system was installed at bay 14 in anticipation of reduced summer flow. Unfortunately, bay 14 was not used during the D30% spill condition. Therefore, we were unable to compare the south spillway release site under the two spill regimes. Due to these limitations, we consider the evaluation of the south spillway to be incomplete. Analysis of steelhead data was limited due to reduced spill discharge during planned N60% spill conditions. Steelhead were released on three dates with planned N60% spill. The actual spill percentage on two of these dates was 34%. The third date had 54% spill. The average spill over the three dates was 41% instead of the planned N60%. For this reason, we elected not to make statistical comparisons between spill conditions. We reported trends in steelhead residence times based on

the single release date (April 21, 2000) with relatively high spill (54%). Since few fish were released on a given release date, comparisons between 54% spill and 30% are not statistically robust.

Comparisons of release sites within each spill condition indicated that spillway passage generally resulted in more rapid egress than did bypass passage. During the spring, this trend was not statistically significant. During the summer, bypass fish took significantly more time to exit the tailrace than did the spillway release groups. Within the spillway, the middle and north release sites had the fastest egress during both the spring and summer study periods. In terms of tailrace egress, south passage appears to be the least desirable route through the spillway, although the south spillway evaluation was incomplete.

Residence time differences between spill regimes were most evident for fish released through the bypass. The residence times of spillway fish during N60% spill were similar to, or lower than residence times during D30% spill. Often the differences in residence times were small (1-2 min), not statistically significant, and may not have any biological significance. Bypass fish had consistently longer residence times during N60% compared to D30% spill. The residence times of yearling chinook salmon and steelhead at N60% were approximately twice as long as during D30% spill. The mean residence time of subyearling chinook salmon released into the bypass was more than four times longer at N60% than at D30% spill. The difference in mean residence time between spill regimes for subyearling chinook salmon was almost an hour.

Not all statistically significant findings that are reported are likely to have biological meaning. When residence times were compared among release sites or spill regimes, some differences of 3-4 minutes were found to be statistically significant. Considering that most fish were able to egress the immediate tailrace (to exit station 1) within 15 minutes, regardless of

release site or spill condition, time differences of a few minutes likely did not have any biologically significant effects. Subyearling chinook salmon released through the juvenile bypass system showed the largest delays of all groups released. During D30% spill their mean residence time was 8-10 min longer than the other release sites, but all groups passed exit station 1 within 17 min. Subyearling fish released through the bypass during N60% spill had a mean residence time 12 times longer than other release sites. Compared to spillway fish, bypass fish had over an hour of additional residence time. An extra hour spent in the area between the dam and exit station 1 could affect how likely a fish was to survive. The dangers to fish in this zone include exposure to predators and turbulence. The predators, being limited by their ability to hold station in high velocities, can generally only congregate in the eddy along the navigation lock wall and on the south shoreline, above and below the bypass outfall (USGS, T. Liedtke, unpublished data). The turbulence may stress or disorient fish and could therefore affect predator avoidance ability. Many of the subyearling chinook salmon released through the bypass during N60% spill delayed in areas where predators tend to congregate. Combined with their extended residence times, this finding suggests that subyearling fish incurred a biologically meaningful delay when released through the bypass during N60% spill. None of the other release groups showed a large delay combined with an exposure to predators, therefore, no biological meaning was linked to the statistical differences that were detected.

Large differences in residence times among release sites were evident at all three exit stations, but smaller differences were minimized as fish moved downriver. During the spring, residence time differences among release sites were detected during N60% spill at exit station 1. The differences between the three spillway release sites were smaller than the difference between the spillway and the bypass. At exit stations 2 and 3, the significant differences among spillway

sites were lost, but the bypass residence time was still significantly higher than the spillway sites. During the summer, the bypass group was much slower than any of the spillway groups were and significant differences among the sites were present at exit stations 1, 2, and 3. Our 1998 evaluation of tailrace egress at JDA compared three spillway release locations and found that differences in residence time based on release site were most prominent at exit station 1 (Liedtke et al. 2001). Since the differences among release sites on the spillway were relatively small, the effect of release site was minimized as fish moved downriver. The finding of significant differences between the bypass and the spillway release sites at exit station 3 during 2000 suggests that the influence of release site can have a far-reaching effect.

The dredge island passage route of subyearling chinook salmon released through the bypass was affected by spill condition. Yearling chinook salmon and steelhead released through the bypass consistently passed to the south of the dredge island. Most subyearling chinook salmon released through the bypass during D30% spill passed to the south of the island. The island passage route was very different during N60% spill. Most subyearling chinook salmon passed to the north of the island during N60% spill, suggesting that they were not directed immediately downriver, but somewhat north. Although we were not able to collect island passage information on a large number of bypass fish, the dominant north passage route during N60% spill was supported by boat tracking data. During the summer study period, bypass fish were frequently located near the tip of the navigation lock peninsula. These fish moved north significantly more than they moved downriver. This lateral movement of bypass fish during N60% spill may explain their increased residence times relative to spillway fish.

Drogue data suggests that fish passing through the middle of a spill pattern will have the shortest residence times and least chance of become entrained in eddies. During both the spring

and summer study periods, north and middle drogues moved through the tailrace significantly faster than did south drogues. North drogues sometimes became entrained in eddies along the navigation lock peninsula, causing a delay in egress. A similar result was found for drogues released through the north spillway in 1998 (Liedtke et al. 2001). During both years of study, the delay in eddies along the navigation lock was generally not extended, and had only a minimal effect on the residence time of north drogues. Drogues released nearest the southernmost open spillbay were frequently delayed in eddies and had extended residence times. During the spring outmigration, the southernmost open spillbay was near the south spillway release site. During the summer, the southernmost open bay was near the middle spillway during D30% spill and the south spillway during N60% spill. Drogues released near the south end of the open spillbays experienced an edge effect where they tended to become entrained in flow that circulated eastward and to the south of the open spillbays. These flow patterns resulted in extended drogue residence times.

Drogues were deployed to record the movement of the dominant flow in the tailrace. We released drogues and fish from the same location and compared their residence times as an indication of how well drogues represent the movements of fish or how likely it is that fish tend to act like passive particles, moving with the dominant flow. During the spring, drogues released at the north and middle spillway moved significantly faster than fish, suggesting a fish behavioral effect. Fish appeared to be able to resist the dominant flow, changing path or holding position more than would be possible for a passive particle. Fish released through the north spillway during the summer had residence times that were not significantly different from drogues. This finding suggests that subyearling chinook salmon were unable to resist the dominant flow and were carried along like passive particles, similar to the drogues. At the south

spillway, during the spring, fish generally moved faster than drogues. Drogues appeared to be more susceptible to edge effects and became entrained in eddies that yearling fish were able to avoid. During the summer, the south spillway release site was only used during N60% spill, and drogue and fish residence times were not significantly different. This again suggests that subyearling chinook salmon tend to behave more like passive particles than do the yearling fish. At the juvenile bypass system, drogue and fish residence times were only compared during D30% spill. During the spring, drogue residence times were similar to fish residence times. During the summer, drogues moved significantly faster than fish. Generally, we would predict a behavioral effect by the fish when drogue and fish residence times are not similar. For the comparison of fish and drogues at the juvenile bypass system, the differences in deployment methods for fish and drogues could prove to be a larger issue. Study fish were released into the juvenile bypass system and allowed to enter the tailrace via the outfall. We were unable to release drogues in this manner due to the presence of avian deterrence devices (cables and floats) near the outfall. Drogues were instead released into the dominant flow, downriver of the outfall, using boats. We think that this difference in deployment may have influenced the comparison of fish and drogue residence times, especially during the summer study period. The drogues released into the dominant flow followed the outline of the south shoreline and exited the tailrace without delay. Boat tracking data showed that subyearling chinook salmon released through the bypass were sometimes located upriver of the outfall and to the extreme north end of the BRZ, near the navigation lock wall. These fish did not move in a manner similar to the drogues released near the bypass outfall. Considering the differences in release locations between drogues and fish at the juvenile bypass system, we consider the comparison of fish and drogue residence times to be a poor one. During the spring, drogue and fish residence times were

statistically similar and boat tracking data support the concept that yearling chinook salmon and steelhead moved directly downriver, similar to the drogues. During the summer, however, drogue movements and boat tracking data of subyearling chinook salmon conflict, making conclusions unclear. For future research addressing tailrace egress following passage through the juvenile bypass system, we would advise that drogues be deployed through the outfall, in a manner similar to fish. This would involve the removal or redesign of the avian deterrence devices.

Several predation events were documented within the JDA tailrace. Radio telemetry can provide direct evidence of predation only under limited circumstances (e.g., recovery of a tag within a predator). Interpretation of fixed data records and boat tracking data can, however, provide indirect evidence of predation events. Through this process of data review, we reported 12 predation events during the spring study period and 7 events during the summer. Fish released through the north spillway during D30% spill had the greatest risk of predation during the spring. Predation events were localized near the navigation lock wall and appeared to occur when fish were delayed in eddies in this area. During the summer run, most predation events involved fish released through the bypass during N60% spill. These events were localized within the BRZ, both upriver and downriver of the bypass outfall. Boat tracking records show that these fish were generally not able to travel far from the outfall prior to being consumed. Since there were no documented predation events involving bypass fish during D30% spill, either the spill condition or diel period could explain the difference in the risk of predation.

In summary, our evaluation of tailrace egress following passage through the JDA spillway and juvenile bypass system was limited by confounded study elements and imperfect dam operational conditions. In general, passage through the spillway resulted in improved

egress compared to bypass passage. The differences in residence time between the spillway and bypass fish were still significant 5 km downriver of the dam. Within the spillway, middle and north passage routes had shorter residence times than south routes. When the risk of predation is considered, fish passing through the middle spillway appear to have the best opportunity for successful tailrace egress. This finding is well supported by drogue data and the 1998 JDA spillway evaluation (Liedtke et al. 2001). When the two spill regimes were compared, fish released through the bypass were most strongly affected. The residence times of bypass fish were higher during N60% spill than during D30% spill. The residence time difference was greatest for summer fish, which were detected near the navigation lock wall and shifted to a north passage route around the basin island. Fish released at the spillway generally had similar residence times during both D30% and N60% spill. Often the residence times were reduced somewhat during the higher spill period, but the reduction was not significant. The risk of predation, especially for north spillway fish, was somewhat elevated during D30% spill. Overall, subyearling chinook salmon were more affected by release site and spill regime differences than were yearling fish. Drogue data suggests that summer fish often moved through the tailrace similar to passive particles, whereas yearling fish were able to resist the dominant flow.

In conclusion, the use of N60% spill instead of D30% spill marginally reduced egress times for fish passing through the spillway, and may have reduced the risk of predation somewhat. Fish passing through the juvenile bypass system, however, had longer egress times during N60% than D30% spill. Subyearling chinook salmon had an additional hour of egress time during N60% spill compared to D30% spill. Considering the amount of time needed to exit

the immediate tailrace, such a delay could begin to have an influence on the survival of these fish.

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