JUVENILE RADIO-TAG STUDY:

LOWER GRANITE DAM, 1985

Annual Report of Research

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INTRODUCTION

The concept of using mass releases of juvenile radio tags represents a new and potentially powerful research tool that could be effectively applied to juvenile salmonid passage problems at dams on the Columbia and Snake Rivers. A system of detector antennas, strategically located, that could automatically detect and record individually tagged juvenile salmonids as they pass through the spillway, powerhouse, bypass system, or tailrace areas below the dam would provide an urgently needed research tool. Accurate measurements of spill effectiveness, fish guiding efficiency (FGE), collection efficiency (CE), spillway survival, powerhouse survival, and bypass survival would be possible without handling large numbers of unmarked fish, and because all tagged fish released would in effect be sampled, the numbers of marked fish required for individual experiments could be reduced to a small fraction of those that would be required if conventional marking techniques were used. A prototype juvenile radio-tag system was developed and tested by the National Marine Fisheries Service (NMFS) and Bonneville Power Administration (BPA) at John Day Dam in 1984 (Giorgi and Stuehrenberg 1984). Additional research was conducted at Lower Granite Dam by NMFS and BPA in 1985. The objectives of this research were to: (1) evaluate the effectiveness of the prototype juvenile radio-tag system in a field situation and (2) to test the basic assumptions inherent in using the juvenile radio tag as a research tool.

This two-part report summarizes the results of this research.

PART I: FIELD TESTS

Field testing of the juvenile radio-tag system was conducted at Lower Granite Dam during the spring outmigration in 1985. Research was conducted to evaluate the effectiveness of the system in measuring spillway passage, FGE, spillway survival, powerhouse survival, and collection system efficiency.

Methods and Materials

The juvenile radio tag was developed by NMFS electronics personnel to monitor movements of individual salmonid smolts. The tags are battery powered transmitters that operate on a carrier frequency of approximately 30 megahertz (MHz); tag life was a minimum of 3 days. The transmitter and batteries are coated with Humiseal[1/] and a mixture of paraffin and beeswax to form a flattened cylinder 26x9x6 mm, which weighs approximately 2.9 g in air. A 127-mm flexible whip antenna is attached to one end of the tag. Each tag transmits pulses of information on one of nine frequencies spaced 10 kHz apart (30.17 to 30.25 MHz). The pulse rate was set at two per second. The electronic character of each pulse provided individual identification (codes) for each tag. Tracking range of the tag varied from 100 to 1000 m depending on the output of the tag and the depth of the fish. The tag life was a minimum of 3 days.

The juvenile radio-tag system utilizes a series of strategically located signal monitors. Each monitor is composed of a broad band radio receiver, a pulse decoder, a digital printer, and a cassette tape recorder. The receiver listens to all nine frequencies simultaneously and feeds them to the pulse

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1/ Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

decoder. The decoder scans the nine frequencies and measures the codes of the signals encountered. The amount of time spent on each frequency is set to a period that would cover two pulses from a tag (1,200 milliseconds). When the monitor is set to use both of its antennas, the time period per frequency is doubled. Pulse checking circuits in the decoder determined when two tags on the same frequency were pulsing at the same time, and erroneous codes were not recorded. The output of the monitor was printed on paper and recorded on magnetic tape. The magnetic tape, a new development, allows one person to evaluate data in the field. Data from the tape were fed into a microcomputer for data reduction and analysis.

Three monitors were deployed to detect radio tagged smolts as they approached the dam from the forebay. One monitor covered the powerhouse and one the spillway. The overlap area of these two antenna systems was monitored with a smaller third system to differentiate passage locations in the overlap area. The antennas for the powerhouse and spillway were loop antennas ganged together with line amplifiers. Each amplifier boosted the tag signal lost in the line between antennas. This effectively produced equal tag signals at the monitor for radio tagged fish at both ends of the powerhouse or spillway. The smaller system in the overlap area was made up of a monitor and two underwater antennas which covered the last two turbines of the powerhouse.

Radio tagged smolts were detected in the turbine intake gatewells by another set of monitors utilizing underwater antennas. Each of the antenna inputs (2) for a monitor was capable of monitoring three gatewells and thus gatewell activity was defineable to turbine unit.

A monitor was installed at the fish separator to record tagged fish when they arrived at the fish handling facility. Fish in the facility and/or on barges were differentiated from river fish by the length of time they remained on the monitor and by prior detection in the gatewells.

Fish that were detected entering the powerhouse that were not later detected in the gatewells or fingerling collection facility were assumed to have passed downstream through the turbines. Fish that were detected in the gatewells and then disappeared and were not later detected at the fingerling collection facility were also assumed to have dropped back into the turbine intake and passed downstream through the turbines.

Downstream monitors were placed on three transects below the dam. These monitors were powered by 12-volt batteries and had three-element beam antennas for signal detection. Monitors were positioned on opposite sides of the river, and the directional antennas faced slightly upstream. The first transect was 1.4 km downstream from the dam, the second transect was 3.2 km downstream from the dam, and the third transect was 6.1 km downstream from the dam.

Chinook salmon smolts used for tagging were collected from the fish handling facilities at Lower Granite and McNary Dams. The smolts ranged in size between 150 and 205 mm fork-length (FL) and were free of major descaling. Individual fish were removed from the holding tank and anesthetized in a 20 ppm solution of MS-222. The fish were tagged by placing the tag into the fish's opened mouth and then a plastic soda straw was used to push the tag through the esophagus and into the stomach. Tagged fish were held in a bucket until they recovered from the anesthetic. They were then transferred to a plastic garbage can and held for 12 to 24 h before being released. Just prior to release, the tags were checked for operation and pulse coding. To reduce handling stress, fish with non-functional tags were released along with the fish with good tags, and all dead fish were removed from the garbage cans after the release.

Four experimental releases of at least 100 radio-tagged chinook salmon smolts each were made into the forebay approximately 10 km above Lower Granite Dam during 48 h of continuous spill at levels of 0.8, 0.0, 39.4, and 20.9% of the total river flow. An additional release of 10 live and 10 dead radio tagged fish was made to assess the effectiveness of the downstream detection system and to determine if radio-tagged fish killed passing the dam would drift far enough to be detected at the downstream detector sites.

Results and Discussion

On 10 April, the 10 live and 10 dead radio-tagged fish were released into the tailrace at Lower Granite Dam. Flows at Lower Granite during this test ranged from 81.5 to 110.8 kcfs.

Of the 10 live fish released, 8 were detected downstream and 2 were not. Because all the fish were not detected at each transect line, in the future at least three downstream transects will be used to obtain accurate measurements of downstream passage and survival.

None of the dead fish were detected at the downstream detection sites. Eight hours after release, two of the dead fish were near the water outfall of the adult fish handling facility; two were between the spillway and the navigation lock; and two were near the corner of the earthen fill, north of the navigation lock.

On 12 April 1985, 112 radio-tagged yearling chinook salmon smolts were released into the Snake River approximately 10 km above Lower Granite Dam (Test 1). This test was designed to evaluate tags and detection equipment and to provide powerhouse passage, FGE, CE, and survival estimates under zero spill test conditions. Just prior to release of the tagged fish, low-level spill was initiated by the U.S. Army Corps of Engineers. This spill continued intermittently throughout the peak passage period so the test condition (zero spill) was not met. The powerhouse detection system also failed during this period allowing an unknown number of tagged fish to pass undetected. In addition, the power supply (batteries) for the downstream detection transects also failed prior to the completion of the test.

Of the 112 radio-tagged fish released, 38 fish were detected at the dam (Table 1). Six fish were still above the dam when the test ended. Of the passages, thirty fish (79%) entered the powerhouse, and 2 fish (6%) passed over the spillway. Because of the various problems associated with this test, much of the data are suspect and will be excluded from analysis.

After the problems associated with the detection equipment were solved, a second zero-spill test was conducted. On 2 May 1985, 115 radio-tagged smolts were released approximately 4.8 km above the dam (Test 2). Of these fish, 74 were detected as they approached the dam (Table 1). There were 58 fish that entered the turbine intakes, and 16 fish were still above the dam at the end of the test period. Of the 58 fish detected entering the turbine intakes, 14 fish (24%) were detected in the gatewells and 44 fish (76%) are assumed to have passed through the turbines. Three additional fish were detected in the gatewells that had not been detected on the forebay monitors. Of the 17 fish detected in the gatewells, 11 were detected at the juvenile separator, 2 were removed from the gatewells during the submersible traveling screen (STS) studies, one was still in the gatewell at the end of the test, and three gatewell drop-outs passed through the turbines. Of the 47 fish (44 direct plus 3 gatewell drop-outs) assumed to have passed the turbines, 26 (55%) were detected at the downstream transects.

Table 1.--Detection rates for radio-tagged juvenile chinook salmon smolts released in the forebay of Lower Granite Dam.

Item	Test 1	Test 2	Test 3	Test 4
Number released	112	115	100	101
Percent spill	0.8	0	39.4	20.9
Detected on forebay monitors	38	74	68	76
Powerhouse passage	30	58	26	41
Turbine Passage	5	44	19	26
Downstream transects	1	25	12	18
Gatewells (GW)	25	14	7	15
Removed STS study	0	2	0	2
In GW end of test	2	0	1	0
Turbine passage	6	2	1	0
Downstream transects	0	1	0	0
Juvenile separator	17	10	5	13
Juvenile separator	0	0	0	4
Spillway passage	2	0	38	26
Downstream transects	2	0	31	21
Had not passed dam by end of the test	6	16	4	5
Not on forebay monitors	22	19	9	7
Downstream transects	22	16	8	6
Gatewells	0	3	1	0
In GW end of test	0	1	0	0
Turbine passage	0	1	0	0
Juvenile separator	0	1	1	0
Juvenile separator	0	0	0	1

On 5 May 1985, 100 radio-tagged smolts were released approximately 4.8 km above the dam. Test 3 was designed to evaluate the effects of a 40% spill condition on passage behavior. Sixty-eight (68) fish were detected as they approached the dam (Table 1). Twenty-six smolts (38%) entered the turbine intakes, and 38 (56%) passed through the spillway. Four radio-tagged fish were still above the dam at the end of the test period. Of the 26 fish that entered the turbine intakes, 7 (27%) were detected in the gatewells, whereas 19 fish passed downstream through the turbines. One additional fish was detected in the gatewells that had not previously been detected. Of the eight fish detected in the gatewells, six were detected at the juvenile separator, one was still in the gatewell at the end of the test and one is assumed to have dropped out of the gatewell and passed through the turbine. Of the 20 fish (19 direct and one gatewell dropout) passing through the turbines, 12 (60%) were detected at the downstream transects. Thirty-eight fish passed through the spillway, and 31 (82%) were detected at the downstream transects.

On 31 May 1985, 101 radio-tagged smolts were released approximately 4.8 km above the dam (Test 4). This release was designed to evaluate the effects of a 20% spill condition on passage behavior. During the test, the monitor covering the gatewells of Turbines 1 and 2 failed and allowed fish to pass through the gatewells undetected. Seventy-six radio-tagged smolts were detected as they approached the dam (Table 1). Forty-one smolts (54%) entered the turbine intakes, and 26 (34%) passed through the spillway. Five smolts were still above the dam at the end of the test period. Of the 41 fish that entered the turbine intakes, 15 (37%) were detected in the gatewells, whereas 26 (63%) passed through the turbines. Of the 15 smolts detected in the gatewells, 13 were detected at the juvenile separator and 2 were removed during the STS tests. Four additional smolts were detected at the juvenile separator that were not previously recorded in the gatewells. Three of these fish were detected by the forebay monitors, whereas one was not. Of the 26 fish passing through the turbines, 18 (69%) were detected at the downstream transects. Twenty-six fish passed through the spillway, 21 (81%) were detected at the downstream transects.

Spill Effectiveness

Since some tags were detected below Lower Granite Dam that were not detected passing the dam, a statistical model was developed to evaluate spill effectiveness (Appendix A). Based on this model, powerhouse and spillway passage estimates at 20 and 40% spill levels were generated (Table 2). At 20% spill, spillway passage was estimated at 39% (95% C.I. 28.7 - 49.0%). At 40% spill, spillway passage increased to 61% (95% C.I. 50.5 - 71.1%). These confidence intervals maybe used as a test of the null hypothesis that the observed spill effectiveness is equal to the prevailing spill level (Bickel and Doksum 1977). Because the spill level falls outside the 95% confidence intervals, we reject the null hypothesis at $\alpha = 0.05$ and conclude that the observed spill effectiveness was different from the spill level for both releases. We emphasize that these passage estimates apply only to radio-tagged fish. A variety of assumptions tested under laboratory conditions must be further evaluated before these passage rates can be applied to the general population.

Table 2.--Estimates of powerhouse and spillway passage of radio-tagged yearling chinook salmon smolts at Lower Granite Dam, 1985.

	Test 3 (40% spill)				Test 4 (20% spill)			
	Tag count	Model est.	%	95% CI	Tag count	Model est.	%	95% CI
Powerhouse passage	26	28.6	39	(28.7-49.0)	41	45.3	61	(50.5-71.1)
Spillway passage	38	44.4	61	(50.5-71.1)	26	28.7	39	(28.7-49.0)

Systems Evaluation

The experiments conducted at Lower Granite Dam in 1985 defined certain strengths and weaknesses of the existing radio-tag system. Results indicate that the radio tag can provide acceptable estimates of powerhouse and spillway passage. Evaluation of FGE, CE, and survival in the future will depend upon our ability to improve detection rates at certain monitoring sites and assure that assumptions, discussed later in this report, are met.

The loop antenna system used in 1985 would not detect radio tags at depths greater than 7.6 meters. A larger portion of smolts than anticipated were below this level when they approached the dam. This problem will be addressed in 1986 by adding underwater antennas capable of detecting tags at maximum passage depths.

The scan rate of the monitors was also a factor affecting detection rates in 1985. The existing monitors were capable of monitoring all available frequencies once every 15 seconds. If more than six tags on the same frequency were in a given area, some tag codes may have been missed due to overlapping code pulses. In 1986, the scan rate of the monitors will be shortened by incorporating a micro-processor into the monitor system and by adding additional monitors to the antenna system.

Mechanical problems associated with the monitors and problems with the batteries at the downstream monitors have been corrected and should no longer influence system operations. With the knowledge gained in 1985, design changes for 1986 should result in a significant increase in the tag detection rates at all monitoring sites.

PART II: ASSUMPTION TESTS

Radio tags inserted into the stomachs of yearling chinook salmon may potentially cause unacceptable rates of mortality in test fish or may impair their swimming performance. Effective tag loss can result from regurgitation of the tag or operational failure within the device. All of these factors are important considerations when interpreting results from field tests designed to estimate spill effectiveness, FGE, CE, and survival. The overall objectives of the series of tests described in this section of the report were to assess the effects of the radio tag on yearling chinook salmon and evaluate the performance of the tag.

Bioassay

Test 5.1, as originally proposed, required holding tagged and control fish for 60 h to test the hypothesis that the survival rates of radio-tagged and untagged groups are equal. However, this test condition is not representative of field conditions because during the 60 h following tagging, the fish would not be experiencing stable conditions, but would be intercepting and passing the dam via either the turbines or spillways. Either passage route presents stressful conditions which could significantly affect survival rates. Of the two, the abrupt pressure changes associated with turbine passage represent the most stressful set of conditions. Therefore, a more representative test was designed to measure the mortality rates of tagged and control fish subjected to a simulated turbine passage.

Methods and Materials

The simulated turbine pressure test was run on two groups of river-run yearling chinook salmon. The first group was taken from the collection system at Lower Granite Dam. From this group, 135 controls and 150 test fish were tested at the dam from 16 to 18 April. The second group of chinook salmon was collected at McNary Dam and trucked to the NMFS laboratory at Pasco for testing. There were 149 controls and 149 test fish from this group that were tested from 7 to 9 May.

Test conditions for both groups, were identical and were as follows: test fish were mildly anesthetized with MS-222 and tagged with dummy tags by inserting the tag down the esophagus and into the stomach using a small plastic tube. Control fish were similarly anesthetized and handled, but were not tagged. All fish were then returned to holding tanks and monitored for mortalities for 24 h under ambient conditions. Following this, the fish were anesthetized, placed into a cylindrical pressure chamber (Fig. 1), and subjected to a set of pressure conditions representative of turbine passage. From an ambient condition of 1 atm, the gauge pressure was increased to 55 psi (resulting in an absolute pressure of approximately 4.7 atm) for a period of approximately 1 minute, followed by an instantaneous decrease in pressure to a partial vacuum of 15 in Hg (approximately 0.5 atm) which represents the average pressure experienced by fish passing through the turbines (Sutherland 1972). From this pressure, the fish were instantaneously returned to ambient conditions (1 atm), completing the turbine passage simulation. The entire range of test conditions lasted approximately 1.5 minutes.

Following the test, fish were returned to holding tanks and monitored for mortalities for an additional 24 h. Estimated mortality rates were then compared between tagged and control fish.

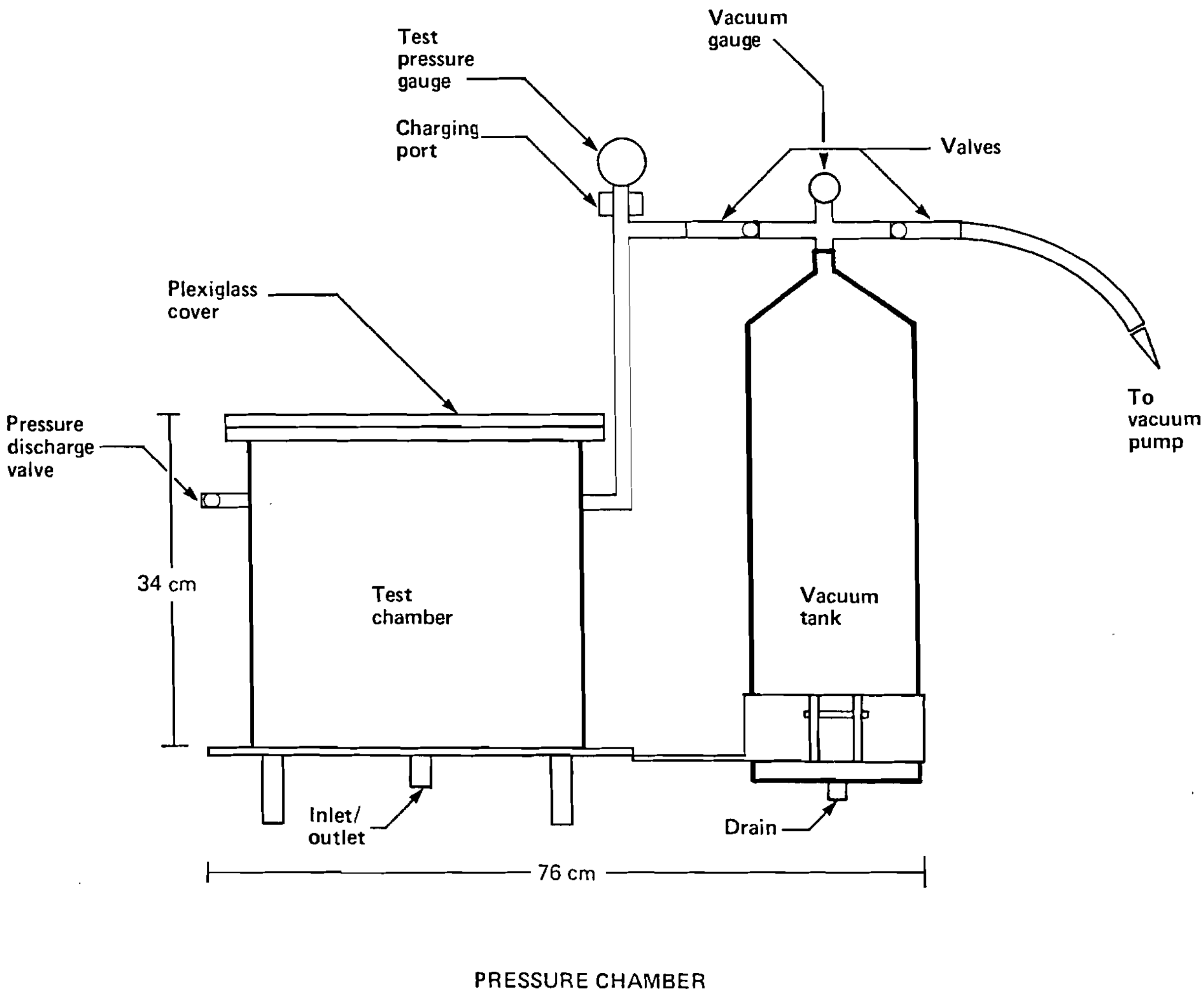

Figure 1 .--Pressure tank apparatus used to simulate turbine passage conditions (Test 5.1) and measure buoyancy (Test 5.6).

Results

Estimates of mortality rates for control fish were calculated according to standard binomial estimation procedures (Zar 1984). Estimates for tagged fish, however, had to be adjusted for losses due to tag regurgitations. This was done according to the life table procedures in Lee (1980).

The results of both bioassays are presented in Tables 3 and 4. Pretest mortality rate estimates (0 to 24 h) for the group of Lower Granite chinook salmon are 0.0% (95% C.I. = 0.0 - 2.7%) for controls and 4.0% (95% C.I. = 0.7 - 7.3%) for test fish. Estimates of mortality rates for the 24 h period following the pressure test are 0.7% (95% C.I. = 0.0 - 4.1%) for controls and 1.6% (95% C.I. = 0.0 - 3.8%) for tagged fish. A comparison of the two posttest rates was made to test the hypothesis that the mortality rates for tagged and nontagged fish are equal. Using a Z-test, we accepted the null hypothesis ($P > 0.05$).

Estimates of the pre-test mortality rates for the McNary chinook salmon are 0.0% (95% C.I. = 0.0 - 2.4%) for controls and 3.4% (95% C.I. = 0.5 - 6.3%) for test fish. Following the pressure test, mortality rates were estimated to be 1.3% (95% C.I. = 0.2 - 4.8%) for controls and 0.7% (95% C.I. 0.0 - 2.1%) for tagged fish. Again, the difference in post-test mortality rates was found to be nonsignificant by a Z test ($P > 0.05$).

The results of both bioassays suggest that radio-tagged fish experiencing a pressure regime simulating that occurring while passing through a turbine die at the same rate as untagged fish experiencing the same conditions.

Tag Decay Rate

Test 5.2 was designed to measure the failure rate of radio tags under ambient test conditions. As originally proposed, 150 tags were to be tested

Table 3.--Number of tag regurgitations and mortalities occurring in the 24 h periods preceding and following the simulated turbine passage tests.

		16 to 18 April 1985, Lower Granite Dam				
		T_{24}				
	T_0	Pretest	Posttest	T_{48}	% mortality posttest	% regurgitation posttest
Radio tagged (N)	150	126	126	123		
Mortalities	0	13	0	2	1.6	--
Regurgitations	0	11	0	1	--	0.8
Controls (N)	135	135	135	134		
Mortalities	0	0	0	1	0.7	--

		7 to 9 May 1985, McNary Dam				
		T_{24}				
	T_0	Pretest	Posttest	T_{48}	% mortality posttest	% regurgitation posttest
Radio tagged (N)	149	140	139	137		
Mortalities	0	5	0	1	0.7	--
Regurgitations	0	4	1	1	--	1.4
Controls (N)	149	149	149	147		
Mortalities	0	0	0	2	1.3	--

Table 4.--Mortality rate estimates and 95% confidence intervals for the 24 h periods preceding and following the simulated turbine passage tests.

Test dates	Experimental group	Pretest 0-24 h		Posttest 24-48 h	
		Estimate	95% C.I.	Estimate	95% C.I.
		(%)	(%)	(%)	(%)
16-18 April	Control	0.0	0.0 - 2.7	0.7	0.0 - 4.1
	Radio-tagged	4.0	0.7 - 7.3	1.6	0.0 - 3.8
07-09 May	Control	0.0	0.0 - 2.4	1.3	0.2 - 4.8
	Radio-tagged	3.4	0.5 - 6.3	0.7	0.0 - 2.1

for each batch of radio tags received. During the course of the season, however, only one shipment of tags was received, and it was only feasible to test 50 of this batch. These tags were activated, inserted into fish, and then monitored for failures to determine a decay curve for tags under controlled test conditions.

Methods and Materials

Fifty juvenile fall chinook salmon held at the NMFS Montlake Facility were tagged with functional radio tags on 12 March and held under ambient conditions. Periodically, tag performance was measured by placing each individual fish in the proximity of a tag detector and noting any tag failures or the inability of the monitor to detect any viable tags. This procedure was continued for 197 h when all 50 tags had failed, yielding a decay curve from which estimates of failure rates were generated.

Results

The results of the tag failure tests are graphed in Figure 2. This decay curve shows that the number of failures is greatest in the first 10 h following activation and after tag life has exceeded 72 h. In between these two times, the rate of tag failure is low and quite stable. It is within the time interval of 10 to 72 h that tag failures will have the greatest effect upon passage or collection estimates, for this represents the time from release to expected detection at the downstream monitors.

An estimate of the failure rate for the first 10 h following activation is 8.0% (95% C.I. = 2.2 - 19.2%). This time frame encompasses the holding period following tagging, and any failures occurring in this interval would be detected prior to release. The estimated failure rate for the period of 10 to 72 h when fish are potentially within the zone of detection is 4.3% (95% C.I. =

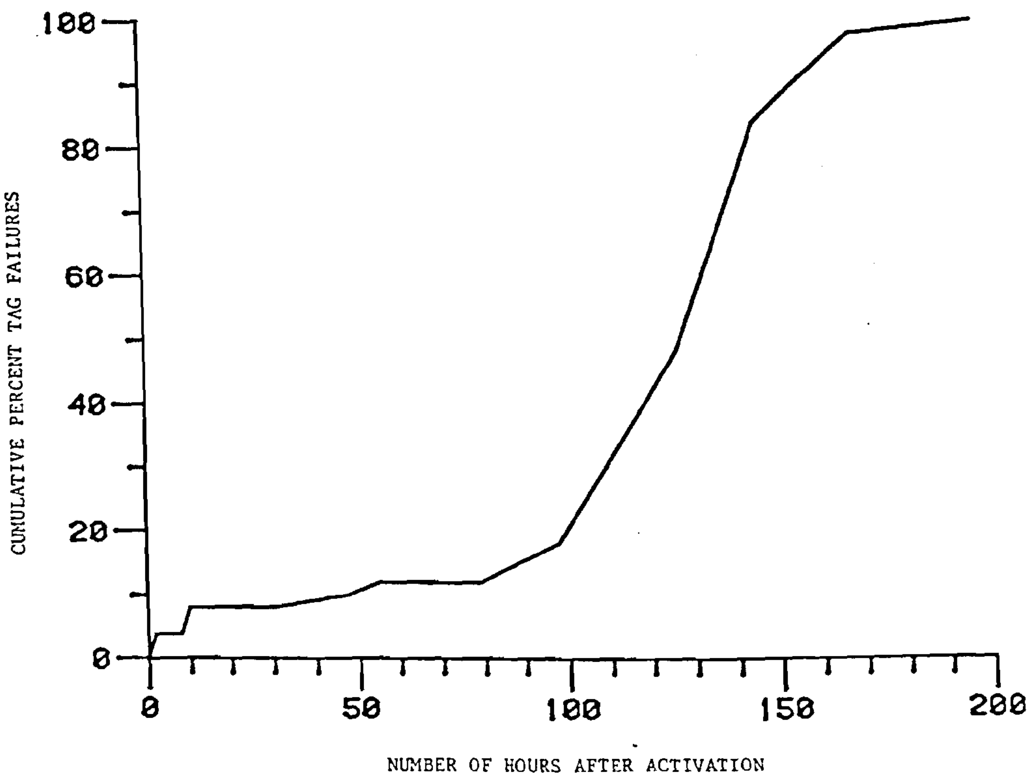

Figure 2.--Rate of tag failure through time, measured on 50 functional radio tags monitored under control test conditions.

0.5 - 14.8%). The shape of the decay curve over this interval shows that the failure rate is consistently low throughout this period, but rapidly increases as tag life exceeds 3 days.

Based on these results, we can expect that most of the tag failures will occur within 10 h following tagging, and recommend this as a minimum holding time prior to release.

Size Distribution

Test 5.3 was designed to compare the length frequencies of chinook salmon entering the gatewells to those captured in fyke nets below the traveling screens. The objective of this test was to determine if there was evidence of size disparity between guided and unguided fish. Because large fish, averaging about 170 mm FL are used for radio-tag studies, it was necessary to assure that the fish were representative of the overall population, especially with respect to guidability.

Methods and Materials

River-run yearling chinook salmon were collected at Lower Granite Dam from Gatewell 4B and from a set of five fyke nets located below the traveling screen on 17 and 24 April and 1 May. Fish dipnetted from the gatewell as well as those in the uppermost gap net were considered guided, whereas those in the closure nets and the lower five fyke nets were considered unguided (Fig. 3). Fork lengths were recorded for all chinook salmon sampled. The size distributions were then compared to test the hypothesis that there is no size difference between guided and nonguided fish.

Results

Fish ranged in size from 60 to 190 mm FL (Fig. 4). For each of the dates (17 and 24 April and 1 May), we tested the hypothesis that the size composition

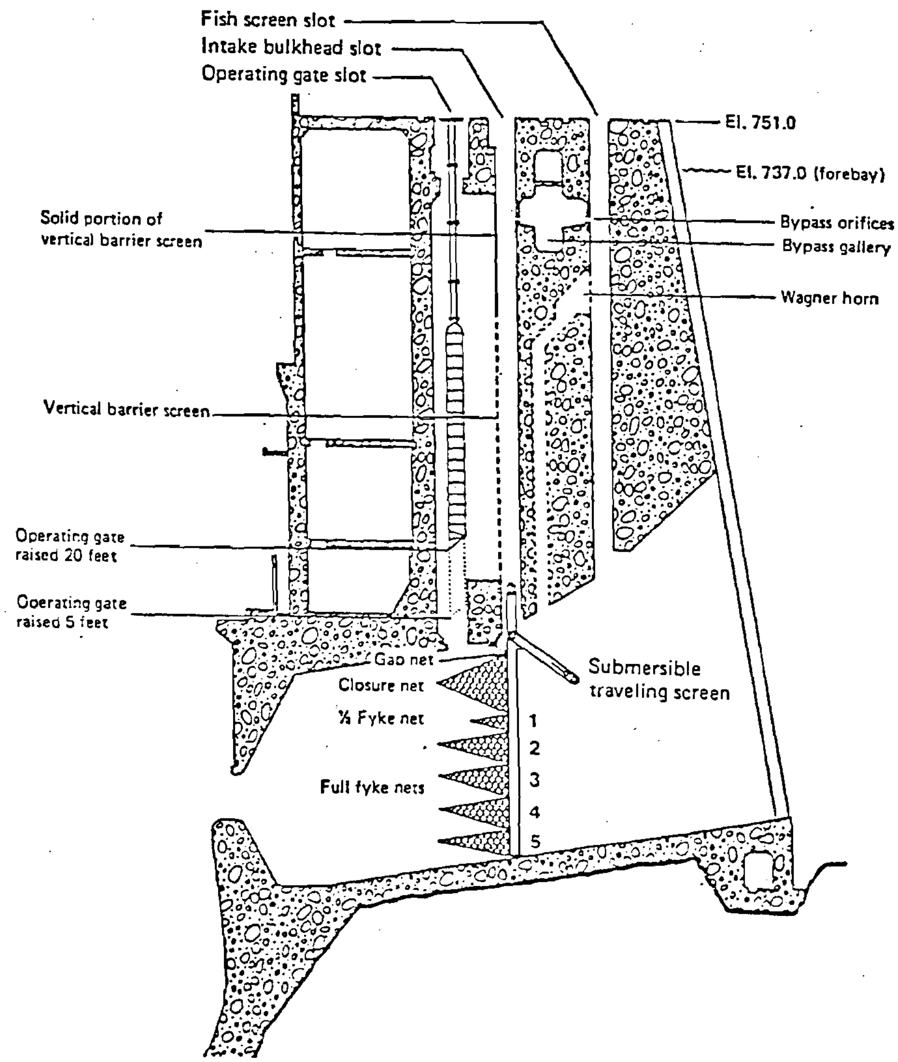

Figure 3 .--Cross section of Unit 4A turbine intake at Lower Granite Dam showing fyke net placement.

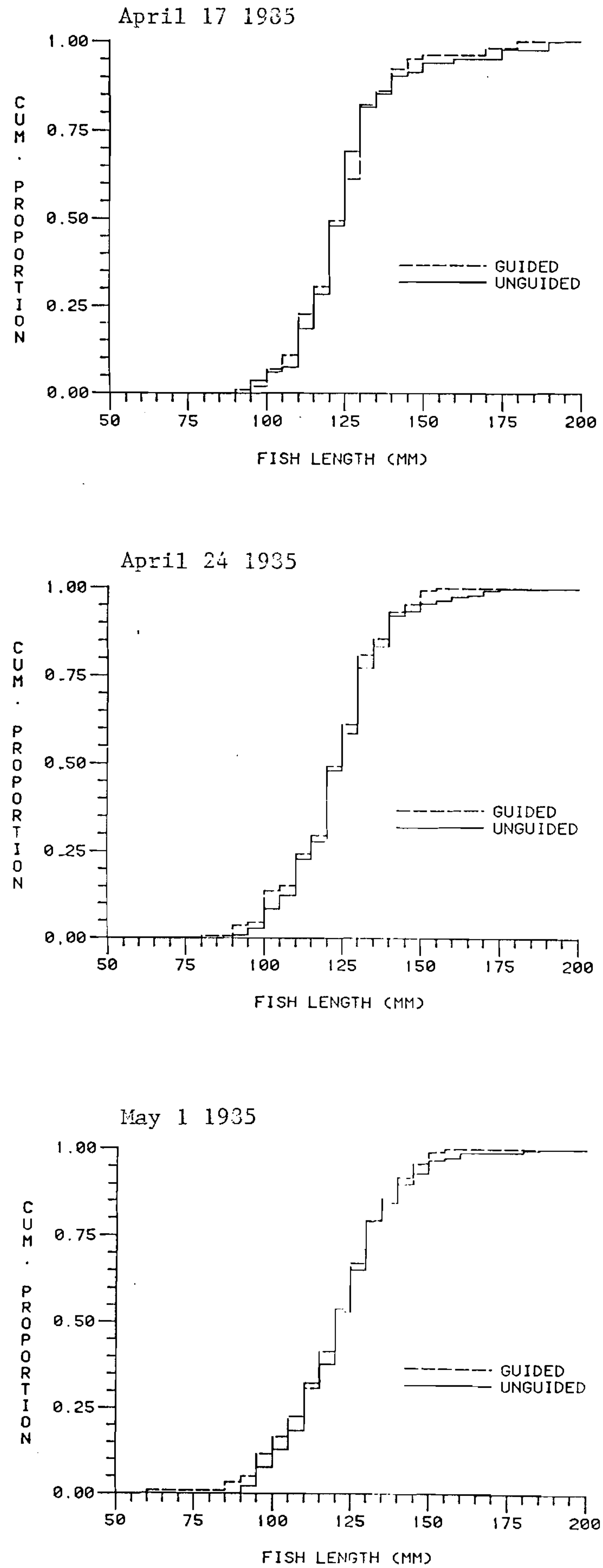

Figure 4.--Cummulative frequency distributions for yearling chinook salmon fork lengths, guided vs. unguided fish.

of the guided and unguided fish was the same. Using the Kolmogorov-Smirnov two sample test (Sokal and Rohlf 1981), we failed to reject the null hypothesis in all three cases. Test results are presented in Table 5 and represented graphically in Figure 4. Based on our tests, we have no evidence to suggest that larger fish are not representative of the general population with respect to guidability.

Tag Regurgitation and Failure

Test 5.4 addresses both tag regurgitation and tag failure rates in response to pressure and turbulence conditions characteristic at dams. To better define these objectives, Test 5.4 was divided into five separate components: tag regurgitation rates were determined under ambient conditions in response to pressure changes and in response to turbulence; tag failure rates were determined in response to pressure changes and turbulence.

Methods and Materials

Tag Regurgitation.--Two stocks of chinook salmon were tagged and monitored through time to determine a rate of regurgitation under ambient and test conditions. Seventy-five juvenile fall chinook salmon held at the Montlake Facility were tested on 23 January, and 146 river-run chinook salmon from McNary Dam were tested on 7 May at Pasco. In both instances, the fish were tagged with dummy tags and immediately returned to holding tanks where the number of regurgitations was monitored throughout a 24-h period to yield a rate of regurgitation under control conditions.

To assess the regurgitation rate following abrupt pressure changes typical of turbine passage conditions, regurgitation data were collected from the two pressure tests previously described in Test 5.1. From these tests, rates of

Table 5.--Results of Kolmogorav-Smirnov (K-S) two sample tests for length differences in guided and unguided fish. For each test, we list the date fish were collected, numbers of guided (N_G) and unguided (N_U) fish sampled, the K-S test statistic (D_{obs}), and the two-sided critical value at ($D_{0.10}$) $\alpha = 0.10$ In each test, $P > 0.10$.

Date	N_G	N_U	D_{obs}	$D_{0.10}$	P
17 April	101	181	0.077	0.183	> 0.10
24 April	132	341	0.051	0.126	> 0.10
01 May	121	186	0.040	0.143	> 0.10

regurgitation for the 24 h following the turbine pressure simulation were determined.

To measure regurgitation following turbulence, 198 river-run yearling chinook salmon collected at McNary Dam and transported to Pasco were tagged with dummy tags on 23 April and held for 24 h. These fish were discharged through a fish cannon (a 20-cm diameter pipe fitted with a nozzle) discharging water at a velocity of approximately 17 ft/sec into a 30-cm deep pond from a height of approximately 1.5 m. These conditions attempt to simulate the turbulent conditions a fish encounters when passing over the spillway. Following the test, the pond was seined and the number of regurgitations noted. The fish were then transported to a raceway and monitored for an additional 22 h to determine the rate of regurgitation following turbulence.

Tag Failure.--The rate of tag failure following turbine pressure simulation was measured on 50 juvenile fall chinook salmon held at the Montlake Facility. These fish were tagged with functional radio tags on 12 March and held for 24 h. All tags were tested for viability immediately preceeding the test. The fish were then subjected to the same pressure conditions as described in Test 5.1. Tag performance was monitored for 15 h following the pressure test, and a failure rate was generated for this period and compared to the control rate.

To assess the rate of tag failure following turbulent conditions, 51 juvenile fall chinook salmon collected from McNary Dam were tagged with live radio tags on 5 July. Within 2 h following the tagging procedure, the fish were placed into the fish cannon at Pasco and subjected to the same turbulence test as described for the regurgitation portion of this section. The fish were seined from the impact pond and monitored for tag performance immediately following the test. A total of 4 h elapsed from tagging to the final reading. An estimate of tag failure rate due to a simulated spillway passage was then determined and compared to the failure rate observed during the first 4 h in the control group.

Results

Tag Regurgitation.--To generate estimates of tag regurgitation rates, it was necessary to account for fish losses due to mortality. When fish died during the observation period, regurgitation rates were adjusted for mortality according to the life table procedures in Lee (1980). In cases where no mortalities occurred, regurgitation rates were calculated according to standard binomial estimation procedures (Zar 1984).

Estimates of regurgitation rates under ambient conditions were generated during the 24-h period following tagging. Estimates of regurgitation rates for the two replicates were determined to be 2.67% (95% C.I. = 0.30 - 9.30%) on 23 January and 2.74% (95% C.I. = 0.10 - 5.40%) on 7 May 1985. The cumulative percent of regurgitations through time are plotted in Figure 5. This graph shows that all regurgitations occurred within the first 4 h following tagging. This indicates that tag regurgitations will be expected to occur during the 8- to 10-h holding period prior to release and not during the interval between release and arrival at the dam.

Upon arrival at the dam, fish may pass via either the turbines or spillway, both of which could potentially affect the rate of tag regurgitation. Estimates of regurgitation rates for a 24-h period following simulated turbine passage conditions were 1.44% (95% C.I. = 0.00 - 3.40%) for McNary Dam river-run fish and 0.80% (95% C.I. = 0.00 - 2.40%) for Lower Granite Dam chinook salmon (Table 1). The rate of regurgitation during a 22-h period

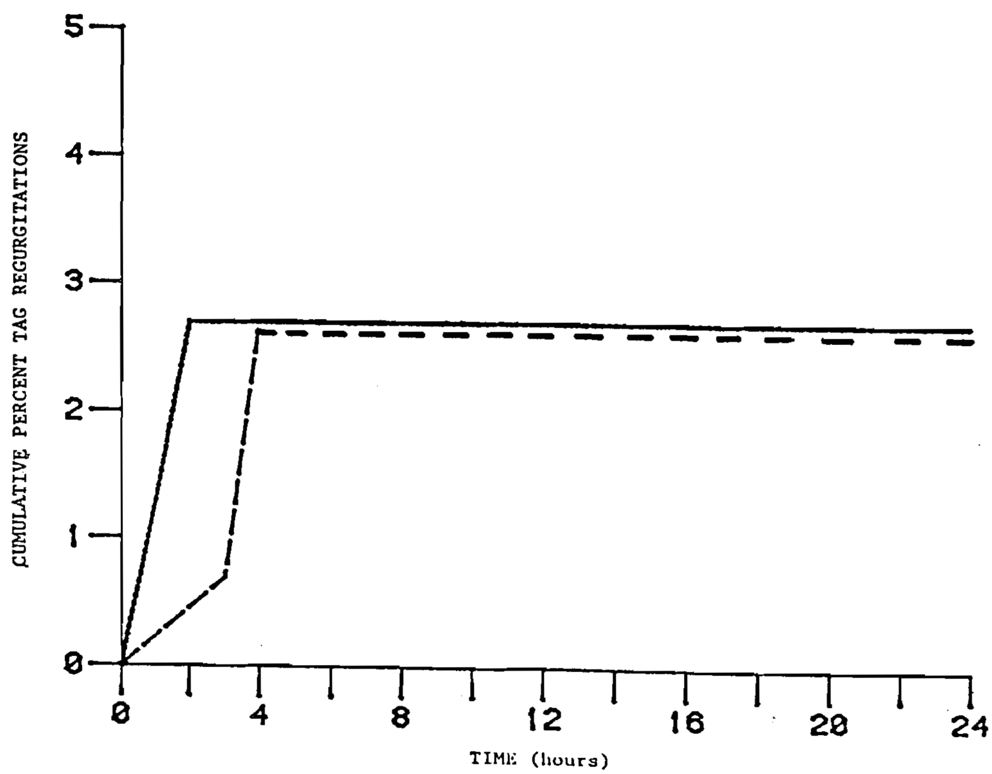

Figure 5.--Regurgitation rates of radio-tagged fish monitored for 24 hours following tagging: test dates are 23 January (solid line) and 7 May 1985 (broken line).

following simulated spillbay passage was 0.00% (95% C.I. = 0.00 - 2.40%) (Table 6). These estimates were made on tagged fish held for 24 h prior to testing and monitored for regurgitations for an additional 22 to 24 h after testing. Therefore, these rates are based upon an approximate 24-h period following tagging and should be compared to a rate under ambient pressure conditions covering the same time frame. Due to limited fish availability, estimates of regurgitation rates under ambient conditions for 24 to 48 h could not be determined. However, the fact that no regurgitations occurred for the period of 4 to 24 h indicates that spontaneous regurgitations are unlikely to occur in subsequent hours. Therefore, it is assumed that the above rates estimate the actual rate of regurgitation in response to the turbulence and pressure test conditions.

Tag Failure.--Tag failures were monitored for 15 h following the turbine passage simulation--from 24 to 39 h after tagging. Only 1 of 48 tags failed in this period, resulting in an estimated failure rate due to pressure conditions of 2.1% (95% C.I. = 0.0 - 11.1%). To compare this failure rate to that observed under ambient pressure conditions, two possible cases had to be considered. The time intervals measured for the ambient pressure conditions were 24 to 30 h and 30 to 48 h, and there was not enough resolution to assign the one failure occurring in the latter period to either the 30- to 39-h (Case 1) or 39- to 48-h interval (Case 2). Therefore, failure rates for 24 to 39 h under ambient pressure conditions were calculated for both possible cases. Each of these rates was then compared to the failure rate generated in the pressure test by using a Fisher's exact test. We failed to reject the null hypothesis in both cases, with $P > 0.05$ for Case 1 and Case 2, and we therefore conclude that the simulated turbine pressure conditions tested do not introduce a significant source of tag failure.

Table 6.--Mortalities and tag regurgitations during the simulated spill passage test. Tests were conducted on 23 April 1985. Subscripts associated the letter "T" indicate the hour following the tagging when the observations were made. The pre and posttest observation were made immediately preceeding and following the simulated spill condition which occurred during the 24th hour. A total of 198 fish were tagged at T_0. The sample size (N) remaining at each subsequent time interval were those still bearing tags.

	T_0	$T_{1.5}$	T_{21}	T_{24} Pretest	T_{24} Posttest	T_{46}	% regurgitations posttest
Sample size (N)	198	164	157	155	155	148	-
Mortalities	0	34	6	2	0	7	-
Regurgitations	0	0	1	0	0	0	0.0

When exposed to the turbulent conditions simulating spillway passage, 8 of 51 tags (15.7%) failed (95% C.I. = 7.0 - 28.6%). A Fisher's exact test was used to test whether that rate was the same as the 2% (1 of 50) tag failure rate observed under ambient pressure conditions during the same time interval. We rejected the null hypothesis (P = 0.02). However, inspection of the tags following the test revealed that four of the eight failures were due to faulty switch mechanisms. Our electronics shop recognizes the shortcoming of the mechanism and is presently designing a more reliable switch. Furthermore, the fish used in this test were substantially smaller than those used for other laboratory tests and considerable effort was required to push the tag into the esophagus. We suspect that this difficulty may have caused tag failures by cracking the water tight wax seal during insertion. This test will be repeated next year with fish of adequate size.

Behavioral Effects

Test 5.5 was originally designed to measure the swimming performance of tagged fish by measuring their ability to maintain themselves in a rapid current on a pass/fail criteria. However, preliminary observations of the swimming behavior of tagged and control fish (Test 5.6) suggested that the tag may impair swimming performance. Tagged fish appeared to be more negatively buoyant than controls and swam with elevated tail beat frequencies. In light of these observations, Test 5.5 was redesigned to better quantify swimming behavior by focusing on two aspects of swimming performance: swimming stamina and buoyancy compensation.

Methods and Materials

Swimming Stamina.--A total of 26 yearling chinook salmon (149-195 mm FL) collected from McNary Dam and transported to the Montlake Facility were tested for swimming stamina between 6 May and 7 June. All tests were run in a modified version of the swim chamber described by Smith and Newcomb (1970).

Test fish were anesthetized, measured, tagged with dummy tags, and held for a minimum of 24 h before testing. Control fish were similarly handled, but not tagged. Each fish was individually placed in the swim chamber, and after a short recovery period, the initial velocity was set to 1.5 body lengths per second (BL/sec). At 15-minute intervals, the water velocity was increased by 0.5 BL/sec until the fish contacted the electric grid, signaling fatigue. Several "tickle" charges were applied to ensure that the fish was truly fatigued and not merely resting. The critical swimming speed (Ucrit) for each fish was calculated by the methods described in Beamish (1978):

$$Ucrit = U_i + [(T_i \ / \ T_{ii}) \ X \ U_{ii}]$$

Where U_i = highest velocity maintained for the prescribed period (BL/sec)

U_{ii} = velocity increment (BL/sec)

T_i = time the fish swam at fatique velocity (minutes)

T_{ii} = time interval (minutes)

Critical swimming speeds were then compared between tagged and control fish to test the hypothesis that the stamina levels in both groups were the same.

Buoyancy Compensation.--Tests of buoyancy compensation were run on 2 and 3 May on a total of 77 yearling chinook salmon collected at McNary Dam and transported to the Montlake Facility. Measurements of neutral buoyancy were made in the pressure chamber described in Test 5.1.

Fish were anesthetized and indivdually placed in the chamber. A partial vaccuum was applied, and the pressure was reduced until the fish just rose off the bottom. The pressure of neutral buoyancy (P_{NB}) was determined by subtracting the reduction in pressure necessary to float the fish (P_R) from the atmospheric pressure (P_A). The P_{NB} approaches atmospheric pressure as buoyancy nears neutrality, and is thus an indirect measure of bladder volume (Saunders 1965).

After initial measurements of P_{NB} were made, the control fish were returned to holding tanks for 24 h to recover. Test fish were similarly anesthetized and decompressed, but were tagged prior to being returned to their holding area. A second buoyancy measurement was made 24 h later on all control and test fish. Post-treatment P_{NB} values were expressed as a percent of pre-treatment values as follows:

$$\text{Percent recovery of } P_{NB} = \frac{P_{NB}\text{ final}}{P_{NB}\text{ initial}} \times 100$$

(Fried et al. 1976). Percent recovery values for controls should fluctuate around 100%. Tagged fish should approach 100% as the bladder is inflated as compensation for the weight of the tag, and neutral buoyancy is regained.

Results

Swimming Stamina.--Critical swimming speeds were higher in the control group than the group fitted with radio tags. The mean Ucrit was 4.43 BL/sec (range was 3.61 to 5.62) for controls and 4.04 (range was 3.05 to 4.65) in the test group (Table 7). However, using a Mann-Whitney one-sided comparison, we failed to reject the null hypothesis ($P = 0.18$) and concluded that radio tagged fish did not display significantly lower stamina levels.

Table 7.--Swimming stamina data for yearling chinook salmon captured at McNary Dam, 1985. Tagged fish were fitted with sham radio tags.

Controls (N=13)			Tagged fish (N=13)		
Length (mm)	Weight (g)	Ucrit (BL/sec)	Length (mm)	Weight (g)	Ucrit (BL/sec)
176	52.8	4.26	168	45.0	4.65
172	52.4	5.11	168	46.5	4.65
149	33.8	5.57	180	62.5	3.53
168	41.4	3.61	178	54.6	4.21
160	40.8	4.50	181	60.3	4.24
151	36.3	5.62	170	52.9	4.10
163	43.1	4.55	182	56.8	3.17
171	47.2	4.01	178	48.6	4.28
150	37.5	4.09	178	61.4	4.15
179	62.2	3.99	156	35.0	4.37
160	31.6	4.50	160	40.0	3.97
195	58.6	4.16	179	56.0	4.19
188	54.8	3.64	189	67.6	3.05

Buoyancy Compensation.--Fish used in this test were 150 to 200 mm FL. Of the 77 yearling chinook salmon tested, P_{NB} values could not be measured for 13 individuals. During decompression, twelve (11 tagged and 1 control) of these never rose off the bottom of the test chamber but emitted gas through their mouth, and the remaining tagged fish floated at the surface at ambient pressure. These responses, gas emission and gas entrainment (floating), indicate that it is not only tag weight that affects buoyancy, but also the size, shape, and placement of the tags.

A floating fish indicates that air is trapped in the bladder and cannot be expelled. This may be caused by the tag being in a position to block the pneumatic duct, preventing entrained air from escaping. In the situation where gas was emitted upon decompression, it may be that the bulk of the tag is so large that there is insufficient volume in the body cavity for the bladder to expand to the volume necessary to achieve neutral buoyancy. Whatever the exact mechanism, the proportion of fish exhibiting either of these responses is different in the tagged and control groups (chi-square = 13.8, df = 1, $P < 0.001$). Estimates of the percent of the population displaying gas emission or floating responses are 2.5% (95% C.I. = 0.0 - 13.1%) for controls and 35.1% (95% C.I. = 20.2 - 52.5%) for tagged fish. The percent of recovery to initial P_{NB} was measured for 64 fish (39 controls and 25 tagged fish) which did not exhibit gas emission or floating.

The mean percent of recovery value for control fish was 107.8% (range 79.6 - 157.3%), and for tagged fish was 85.4% (range 22.4 - 144.4%). Data are detailed in Table 8. A Mann-Whitney comparison of the two samples yielded a P value of 0.0725. Using $\alpha = 0.05$, we cannot reject the null hypothesis that the percent recovery of neutral buoyancy is the same for tagged and control fish.

Table 8.--Buoyancy compensation data for yearling chinook salmon, 1985.

Control fish (N = 40)			
Length (mm)	Weight (g)	% recovery of initial P_{NB}	Comments (P_R = in Hg)
167	40.8	99.7	
160	42.1	101.5	
176	49.6	97.8	
170	45.2	103.7	
180	50.3	101.5	
159	30.0	94.3	
174	52.2	99.7	
166	40.2	108.0	
169	44.0	157.3	
200	83.8	148.5	
188	59.1	94.4	
155	44.6	86.1	
177	53.8	124.8	
190	55.9	128.4	
183	63.2	116.4	
193	70.7	137.1	
184	54.4	95.8	
188	60.6	<26.0	gas emitted P_R >27
190	63.0	95.1	
178	53.1	101.6	
161	41.5	79.6	
166	37.9	93.9	
178	52.9	99.7	
179	53.1	113.0	
173	50.8	116.7	
181	61.4	109.3	
160	40.3	99.6	
166	41.0	105.9	
191	70.0	105.4	
150	33.8	103.5	
158	37.1	107.5	
171	51.4	119.0	
190	78.1	103.7	
167	47.8	106.0	
200	85.1	101.6	
185	56.7	103.7	
158	36.5	108.1	
168	41.3	107.7	
170	45.6	132.1	

Table 8.--continued.

		Tagged fish (N = 37)	
Length (mm)	Weight (g)	% recovery of initial P_{NB}	Comments (P_R = in Hg)
170	49.1	107.6	
180	44.2	116.4	
169	48.1	116.4	
174	48.6	105.6	
190	62.4	109.9	
158	37.3	35.4	
182	63.6	113.1	
177	57.5	>126.9	floating fish
183	62.9	71.1	
181	69.3	<12.4	gas emitted P_R >27
170	46.5	22.4	
171	45.6	79.9	
168	46.2	103.4	
160	45.0	24.5	gas emitted P_R >19
173	42.6	52.6	
190	69.1	112.5	
188	62.1	17.3	gas emitted P_R >16
190	57.1	107.7	
176	50.5	<13.2	gas emitted P_R >16
178	52.7	47.1	
172	53.5	125.4	
180	65.3	38.4	gas emitted P_R >18
161	40.3	48.4	
185	64.7	56.0	
170	49.0	29.8	
190	67.0	105.5	
182	58.6	<11.2	gas emitted P_R >20
220	119.5	75.8	
165	41.6	<11.2	gas emitted P_R >12
167	40.7	49.6	
182	65.2	97.8	
160	37.0	<14.7	gas emitted P_R >20
178	52.0	144.4	
197	72.9	36.0	gas emitted P_R >18
170	47.3	<14.4	gas emitted P_R >20
176	50.2	101.6	
168	41.6	30.3	gas emitted P_R >18

General Observations

The objective of Test 5.6 was to observe the general behavior of tagged and control fish and determine if any qualitative differences in swimming behavior or relative distribution in the water column could be detected. These observations were used to design some of the experiments executed in Tasks 5.1 through 5.5.

Methods and Materials

Qualitative observations of swimming behavior were made in the large annular tank located in Pasco. Two groups of chinook salmon were observed. A preliminary test in January, consisted of six tagged and six control juvenile fall chinook salmon observed 24 h after handling and/or tagging. These fish were relatively small, ranging in length from 150 to 170 mm FL. The second group, tested on 25 April consisted of 16 tagged and 15 control river run yearling chinook salmon collected at McNary Dam. These fish were larger, ranging from 160 to 190 mm FL. They were observed 48 h after tagging.

Results

Observations of the smaller fall chinook salmon indicated that the tag may impair swimming performance. Fish swam with their caudal fins dropped below the horizontal axis and exhibited elevated tailbeat frequency and extreme negative buoyancy.

Of the larger yearling chinook salmon tested in April, however, only 1 of the 16 tagged fish exhibited negative buoyancy and an elevated tailbeat frequency, whereas the remaining 15 tagged fish and the 15 controls exhibited normal swimming behavior. It is notable that the one affected fish was also the smallest ($\leq$ 150 mm FL). These observations suggest that the weight and size of the tag may cause a greater effect on the swimming behavior of small fish. Therefore, we used the largest fish available for our field tests.

Conclusions

Results from the assumption tests indicate that the effects of radio tags on yearling chinook salmon were minimal and acceptable. Tagged fish did not incur higher mortality than untagged individuals. Whether tagged or not, fish exposed to pressure changes simulating those experienced during turbine passage died at the same rate. Tagged fish appear to be representative of the general population with respect to survival.

Tag regurgitation was minimal, ranging from 0 to 2.7%. Regardless of the treatment (simulated turbine passage, simulated spill passage, or ambient conditions), regurgitation rates were about the same. Thus we would expect no differential tag loss due to regurgitation resulting from passage through a particular conduit, e.g., spillway or powerhouse.

Radio tags did not significantly reduce swimming stamina, even though depression in stamina was evident. We conclude that radio tags did not grossly impact the swimming ability of large (149 to 195 mm FL) yearling chinook salmon, although some impairment was suggested.

Of the biological responses we examined, buoyancy compensation was the most difficult to interpret. Radio tags did interfere with the fish's ability to adjust swim bladder volume. Of the tagged fish, 35% displayed signs of swim bladder dysfunction. The most common problem was the inability to entrain a volume of air sufficient to attain neutral buoyancy. This impairment may account for the observed minor reduction in swimming stamina. If this is the only manifestation of impaired buoyancy control, it may not be a significant problem with respect to most of the information we are attempting to estimate using radio tags. However, the possibility that decreased buoyancy may affect vertical distribution and ultimately FGE or CE cannot be ignored. In FY86, we plan on investigating this aspect further.

In our field studies, we selected the largest fish available since they could better accommodate the tag. There was some concern that these fish were not representative of the general population, especially with respect to their guidability by submersible traveling screens. However, when examined, the size composition of guided and unguided fish were the same, indicating that the screens were not size selective.

Overall, radio-tag performance was acceptable. Most failures observed within the 72-h test period for field studies occurred within 10 h following activation and insertion, and we recommend this as a minimum holding time prior to release. During the potential detection period (10 to 72 h) for field studies, the tag decay or failure rate was only 4.3%. Furthermore, the decay rate was the same whether the fish were held at ambient conditions or exposed to simulated turbine passage. Results from the spillway passage simulation were inconclusive and will be repeated in FY86.

Based on the results of the field tests, we believe that radio telemetry techniques can be used to assess spill effectiveness. Given the spill rates tested (20 and 40% of the total river flow), the results indicate that a significantly higher proportion of the yearling chinook salmon population will pass through the spillway than the proportion of the river flow being spilled.

Estimates of FGE, CE, and survival will depend upon further developments of antenna systems and monitor equipment, the results of further tests of radio-tagged live and dead fish movement through the downstream transects, bouyancy compensation by tagged fish, and the effects of spill passage on tag failure rate.

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APPENDIX A

A Mathematical Model for Estimating Spill Effectiveness

In deriving estimation procedures for spill effectiveness, only fish that reach the dam will be considered. Fish that do not reach the dam with functional tags because of mortality, tag regurgitation, tag failure, or the fish's failure to migrate downstream are not included in the following procedures.

The number of fish reaching the dam (N_d) are divided into fish passing through the powerhouse (N_p) and those passing through the spillway (N_s). Assuming that there is no other passage route, $N_d = N_s + N_p$.

As each fish passes through the dam, it may be detected by the spillway monitors. For this event to occur, fish must (1) pass through the spillway and (2) be detected by the monitors. If each fish's detection is an independent event, and if the probability of occurrence is the same for each fish, then N_{fs}, the number of fish detected at the spillway is binomially distributed with parameters N_d and $P_s P_{fs}$. Here, P_s is the probability that a fish will pass through the spillway, and P_{fs} is the probability of detection given spillway passage.

The task of estimating spill effectiveness is one of estimating P_s. From the binomial distribution of N_{fs},

$$E(N_{fs}) = N_d P_s P_{fs},$$

so an estimator for P_s is

$$\hat{P}_s = N_{fs}/N_d P_{fs},$$

where N_{fs} is the number of fish actually detected at the spillway, and N_d is the actual number of fish passing the dam. In practice, n_d and P_{fs} will have to be estimated, so

$$P_s = \frac{n_{fs}}{\hat{n}_d \ \hat{P}_{fs}}.$$

ESTIMATING n_d

Those fish entering the powerhouse may either pass through the turbines or enter the gatewell/bypass system. It will be assumed that all fish entering the gatewell eventually make their way to the fish separator. If we divide N_p, the number of fish passing through the powerhouse, into N_t and N_g fish passing through the turbines or into the gatewell, respectively, then

$$N_d = N_s + N_t + N_g.$$

Estimating N_d may be accomplished by adding estimates of N_s, N_t, and N_g. Because of structural differences in the dam, fish approaching and passing the dam are detected at different rates depending on which monitor they approach. It is assumed that all fish entering the gatewell system are detected by monitors in either the gatewell or separator. However, some fish will pass the spillway and powerhouse forebay monitors undetected. Estimating N_t and N_s using numbers of fish detected must therefore take these potential detection differences into account.

ESTIMATING N_t and N_s

If N_s, N_{fs}, and P_{fs} are as defined above, P_{fs} is the same for each fish approaching the spillway, and detection of each fish is an independent event, then n_{fs} is distributed binomially with parameters N_s and P_{fs}. Because $E\ (n_{fs}) = N_s\ P_{fs}$, a method of moments estimator for N_s is:

$$\hat{N}_s = n_{fs}\ /\ \hat{P}_{fs}.$$

Parallel reasoning leads to a similar estimator for N_t. If n_{ft} fish passing through the turbines are detected by the forebay monitors with probability P_{ft}, and if the appropriate assumptions hold concerning constant P_{ft} and independent detection from fish to fish, n_{ft} is also binomially distributed and

$$\hat{N}_t = n_{ft}/\hat{P}_{ft}.$$

ESTIMATING P_{ft}

One simple approach to estimating the probability that fish passing a monitor are detected is to choose a group of fish that one knows passed a monitor and compute the proportion of those fish that were actually detected.

It is reasonable to assume that fish detected in the gatewell and separator were exposed to forebay monitors as they entered the powerhouse. Suppose n_g fish were detected by gatewell monitors and that of these, n_{fg} were also detected in the forebay, each with probability P_{ft}. Then under the appropriate binomial assumptions, n_{fg} is distributed binomially with parameters n_g and P_{ft}. The maximum likelihood estimator for P_{ft} is:

$$\hat{P}_{ft} = \frac{n_{fg}}{n_g}$$

with $$\hat{V}\left(\hat{P}_{ft}\right) = \frac{P_{ft}\left(1 - P_{ft}\right)}{n_g},$$ where $\hat{V}\ (\hat{P}_{ft})$ is the estimated variance of $\hat{P}_{ft}$.

Note that for this model to be useful, fish detected in the gatewell must be representative of all tagged fish entering the powerhouse. Gatewell fish and nongatewell fish should be, on the average, equally detectable by forebay powerhouse monitors.

1985 Field Data

0% spill condition: $n_g = 17$, $n_{fg} = 14$, $\hat{P}_{ft} = 0.824$, $\hat{V}(\hat{P}_{ft}) = 0.00855$

20% spill condition: $n_g = 20$, $n_{fg} = 19$, $\hat{P}_{ft} = 0.950$, $\hat{V}(\hat{P}_{ft}) = 0.00238$

40% spill condition: $n_g = 8$, $n_{fg} = 7$, $\hat{P}_{ft} = 0.875$, $\hat{V}(\hat{P}_{ft}) = 0.01367$

We believe that changing the percent spill condition is unlikely to alter the probability that a tagged fish is detected by powerhouse forebay monitors and that the $\hat{p}_{ft}$ from each test condition estimates a common parameter. Because each estimate is independent and unbiased under the proposed model, we may estimate the common parameter p_{ft} and its variance as follows (Seber 1982, p.6):

$$\bar{\hat{P}}_{ft} = \sum_{i=1}^{3} \hat{P}_{ft_i} \Big/ 3$$

$$V\left(\bar{\hat{P}}_{ft}\right) = \sum_{i=1}^{3} \left(P_{ft_i} - \bar{\hat{P}}_{ft}\right)^2 \Big/ 6$$

where $P_{ft,i}$ denotes the P_{ft} from the ith spill condition.

For these data $\hat{P}_{ft} = 0.883$ and $V(\hat{P}_{ft}) = 0.001348$.

ESTIMATING P_{fs}

It is assumed that all fish detected by the downstream monitoring system passed through the spillway or turbine orifices. These downstream fish may be divided into four categories:

a. Spillway fish detected by forebay monitors (n_{ds})

b. Spillway fish <u>not</u> detected by forebay monitors. (n_{dus})

c. Turbine fish detected by forebay monitors. (n_{dt})

d. Turbine fish <u>not</u> detected by forebay monitors. (n_{dut})

In this list, the $n_{(.)}$ denote the number of fish in each category. Note that n_{ds} and n_{dt} are clearly identified in the data set by detection at both forebay and downstream monitors. However, n_{dus} and n_{dut} are by nature not directly identifiable: Because they were not detected at the dam, we do not know which passage route these fish actually took. However, it is possible to estimate n_{dut} and n_{dus} by making use of our above estimate of P_{ft},

Given that a total of n_{dd} fish are detected by downstream monitors, and that:

$$n_{dd} = n_{ds} + n_{dus} + n_{dt} + n_{dut},$$

the four categories of fish may be modeled by a multinomial distribution with parameters n_{dd}, Π_{ds}, Π_{dus}, Π_{dt}, and Π_{dvt} where $\Pi_{(.)}$ is the probability that a fish detected downstream had the corresponding passage route and detection at the dam. For this model to be useful, the $\Pi_{(.)}$ must be constant from fish to fish, each fish's route and detection must be independent of those other fish, and fish detected downstream should not differ from other fish in their dam passage and detectability.

Let:

P_{lt}, P_{ls} = probability that a fish passing the dam via turbines or spillway, respectively, is lost to detection downstream due to mortality, tag failure, tag regurgitation, or failure to migrate.

P_d = probability that a fish passing the downstream monitors is detected. We assume that dam passage route is irrelevant to this probability.

Then:

$$E\ (n_{ds}) = N_s\ P_{fs}\ (1-P_{ls})\ P_d$$

$$E\ (n_{dus}) = N_s\ (1-P_{fs})\ (1-P_{ls})\ P_d$$

$$E\ (n_{dt}) = N_t\ P_{ft}\ (1-P_{lt})\ P_d$$

$$E\ (n_{dut}) = N_t\ (1-P_{ft})\ (1-P_{lt})\ P_d$$

Letting $r = n_{ds} / n_{dus}$ and replacing n_{ds} and n_{dus} by their expectations,

$$r = {}^{n_{ds}} / n_{dus} = {}^{P_{fs}} / 1-P_{fs},\ \text{and}$$

(1) $P_{fs} = n_{ds} / n_{ds} + n_{dus}$

Therefore, estimating p_{fs} requires an estimate of n_{dus} it is assumed that

$$n_{du} = N_{dus} + N_{dut},$$

where n_{dv} is the total number of fish detected downstream that were undetected at the dam, so that

(2) $$n_{dus} = n_{du} - n_{dut}.$$

Now, letting $q = n_{dut} / n_{dt}$ and replacing n_{dut} and n_{dt} by their expectations,

$$q = n_{dut} / n_{dt} = 1-P_{ft} / P_{ft}, \text{ so that}$$

(3) $$n_{dut} = n_{dt} \left(\frac{1-P_{ft}}{P_{ft}}\right).$$

Substituting (3) into (2) and (1),

$$P_{fs} = \frac{n_{ds}}{n_{du} + n_{ds} + n_{dt} \left(1 - \frac{1}{P_{ft}}\right)}$$

P_{fs} can be estimated by substituting $\hat{P}_{ft}$ for P_{ft}.

1985 Field Data

Only one spill condition, 40%, is appropriate as an estimate of P_{fs} under the present model. In this case, $n_{ds} = 31$, $n_{dt} = 12$, $n_{du} = 8$, and P_{ft} is as above, so $P_{fs} = 0.829$. Because we have no replications, variance estimation is by means of the delta method (Seber 1982, Brownie et al. 1978):

$$V(\hat{P}_{fs}) = \frac{P_{fs}^4}{n_{ds}^2} \left\{ \left[\frac{n_{du} + n_{dt}\left(1 - \frac{1}{P_{ft}}\right)}{n_{ds}}\right]^2 \sigma^2_{n_{ds}} + \sigma^2_{n_{du}} + \left(1 - \frac{1}{P_{ft}}\right)^2 \sigma^2_{n_{dt}} + \frac{n_{dt}^2}{P_{ft}^4} \sigma^2_{P_{ft}} \right\}$$

we consider n_{du} a single category (i.e., pooling n_{dus} and n_{dut}), then n_{ds}, n_{dt}, and n_{du} are distributed trinomially with parameters n_{dd}, Π_{ds}, Π_{dt}, and Π_{du}. Here, Π_{du}, $= \Pi_{dus} + \Pi_{dut}$. Then a method of moments estimators for Π_{ds} is:

$$\hat{\Pi}_{ds} = \frac{n_{ds}}{n_{dd}},$$

and we may estimate $\sigma^2_{n_{ds}}$ by substituting Π_{ds} in the formula for the variance of a multimomial random variable:

$$\sigma^2_{n_{ds}} = n_{dd} \ \hat{\Pi}_{ds} \ (1 - \hat{\Pi}_{ds}).$$

Estimates of Π and σ^2 for n_{dt} and n_{du} are obtained similarly.

Incorporating these estimates into the formula for $\hat{V}(\hat{P}_{fs})$, we have:

$$\hat{V}(\hat{P}_{fs}) = 0.003801$$

Incorporating these estimates into the estimator for P_s, we have:

20% spill condition: $\hat{P}_s = 0.388$

40% spill condition: $\hat{P}_s = 0.608$

VARIANCE OF $\hat{P}_s$

To simplify obtaining variance estimate using the delta method, we will rewrite the spill efficiency estimator as:

$$P_s = \frac{\dfrac{n_{fs}}{P_{fs}}}{\dfrac{n_{fs}}{P_{fs}} + \dfrac{n_{ft}}{P_{ft}} + n_g} \ . \text{ Then :}$$

$$V(\hat{P}_s) \approx \hat{P}_s^4 \left(\frac{P_{fs}}{n_{fs}}\right)^2 \left\{ \left[\frac{n_{ft} + P_{ft}\ n_g}{P_{ft}\ n_{fs}}\right]^2 \sigma^2_{n_{fs}} + \left[\frac{-1}{P_{ft}}\right]^2 \sigma^2_{n_{ft}} \right.$$

$$\left. + \sigma^2_{n_g} + \left[\frac{-(n_{ft} + P_{ft}\ n_g)}{P_{ft}\ P_{fs}}\right]^2 \sigma^2_{P_{fs}} + \left[\frac{n_{ft}}{P_{ft}}\right]^2 \sigma^2_{P_{ft}} \right\}$$

The variances of $\hat{P}_{fs}$ and $\hat{P}_{ft}$ have already been estimated. It remains to estimate $\sigma^2_{n_{fs}}$, $\sigma^2_{n_{ft}}$, and $\sigma^2_{n_g}$.

As modeled above, $n_{fs} \sim \text{Bin}(N_s, P_{fs})$. In addition, N_s, N_t, and N_g are trinomially distributed with parameters N_d, P_s, P_t, and P_g. If we define random variable Z_i:

$$Z_i = \begin{cases} 1 & \text{if fish in spillway is detected} \\ 0 & \text{if fish in spillway is not detected,} \end{cases}$$

then $n_{fs} = \sum_{i=1}^{N_s} Z_i$. Thus, n_{fs} is the sum of a random number of random variables and by a result from probability theory (Mood et al. 1974, p. 197):

$$\sigma^2_{n_{fs}} = \mu_{N_s}\ \sigma^2_z + \sigma^2_{N_s}\ \mu^2_z\ .$$

Since $\mu_{N_s} = N_d P_s$, $\sigma^2_{N_s} = N_d\ P_s\ (1-P_s)$, $\mu_z = P_{fs}$, and $\sigma^2_z = P_{fs}\ (1 - P_{fs})$,

we have $\sigma^2_{N_{fs}} = N_d\ P_s\ P_{fs}\ (1 - P_s\ P_{fs})$.

By parallel reasoning, we can also obtain: $\sigma^2_{n_{ft}} = N_d\ P_t\ P_{ft}\ (1 - P_t\ P_{ft})$.

Finally, we assume that all fish entering the gatewell system are detected by the gatewell monitors, so $N_g = n_g$ and according to the above trinomial model,

$$\sigma^2_{n_g} = N_d \, P_g \, (1-P_g).$$

We may estimate these variances by substituting our estimates of N_D and $P_{(.)}$.

<u>20% Spill condition:</u> $\hat{V}\ (\hat{P}_s) = 0.002679807$

<u>40% Spill condition:</u> $\hat{V}\ (\hat{P}_s) = 0.002749107.$

Although we believe that these estimates of P_s are useful, we are currently developing a multinomial model of the fish detection process that offers advantages over the current approach:

1. We will include information about fish not detected, as well as those detected.

2. The new model is simpler and easier to understand and use.

3. We will be able to assess the utility of the new model using a goodness of fit test. The current approach allows no such appraisal.

LITERATURE CITED

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NOTATION

*N_d , n_d	The number of released fish that reach the dam with functional tags.
N_p	The number of fish with functional tags that enter the powerhouse.
N_t	The number of fish passing through the turbine.
N_g	The number of fish entering the gatewell.
N_s	The number of fish passing through the spillway.
*N_{fs}, n_{fs}	The number of fish detected passing through the spillway.
n_{ft}	The number of fish detected passing through the turbines.
n_g	The number of fish detected in the gatewell.
n_{fg}	The number of fish detected in both the forebay and gatewell.
n_{dd}	The number of fish detected by the downstream monitors.
n_{ds}	The number of fish detected downstream that were also detected passing through the spillway.
n_{dt}	The number of fish detected downstream that were also detected passing through the turbines.
n_{du}	The number of fish detected downstream that were not detected at the dam and whose route of dam passage is unknown.
n_{dus}	The number of fish detected downstream that were not detected at the dam but actually passed through the spillway.
n_{dut}	The number of fish detected downstream that were not detected at the dam but actually passed through the turbines.
P_s	Probability that a fish reaching the dam will pass through the spillway.
P_{fs}	Probability that a fish passing through the spillway will be detected.
P_{ft}	Probability that a fish passing through the turbines will be detected.
P_{ls}	Probability that a fish, having passed through the spillway, will be lost to downstream detection due to mortality, tag failure, or tag regurgitation.
P_{lt}	Probability that a fish, having passed through the turbines, will be lost to downstream detection due to mortality, tag failure, or tag regurgitation.

P_d Probability that a fish passing the downstream monitors will be detected.

Π_{ds} Probability that a fish detected downstream passed through the spillway.

Π_{dt} Probability that fish detected downstream passed through the turbines.

Π_{dus} Probability that a fish detected downstream was not detected at the dam, but actually passed through the spillway.

Π_{dut} Probability that a fish detected downstream was not detected at the dam, but actually passed through the turbines.

* Upper case letter denotes the random variable, whereas lower case letter denotes the value that actually occurred.

APPENDIX B

Passage Data for Radio-Tagged Chinook Salmon

Smolts Released into the Forebay of Lower Granite Dam, 1985

APPENDIX COLUMN INDEX FOR TABLES B1, B2, B3, and B4

Column Number	Data Type
1	Tag Code
2	Fish Length (mm fork length)
3	Holding Barrel
4	Release Day
5	Release Time (Hours and decimal hours H.HH)
6	Dam Arrival Day
7	Dam Arrival Time (H.HH)
8	Dam Arrival Site (1&2-powerhouse, 3-spillway)
9	Dam Passage Day
10	Dam Passage Time (H.HH)
11	Dam Passage Site (1-powerhouse, 2-spillway)
12	Gatewell Exit Day
13	Gatewell Exit Time (H.HH)
14	Fish Seperator Arrival Day
15	Fish Seperator Time (H.HH)
16	Turbine Used to Enter Bypass (1-6)
17	Enter Downstream Transect #1, Day
18	Enter Downstream Transect #1, Time (H.HH)
19	Exit Downstream Transect #1, Day
20	Exit Downstream Transect #1, Time (H.HH)
21	Monitors Recording Tag on Transect #1
22	Enter Downstream Transect #2, Day
23	Enter Downstream Transect #2, Time (H.HH)
24	Exit Downstream Transect #2, Day
25	Exit Downstream Transect #2, Time (H.HH)
26	Monitors Recording Tag on Transect #2
27	Enter Downstream Transect #3, Day
28	Enter Downstream Transect #3, Time (H.HH)
29	Exit Downstream Transect #3, Day
30	Exit Downstream Transect #3, Time (H.HH)
31	Monitors Recording Tag on Transect #3
32	In Study Area End Test, Day
33	In Study Area End Test, Time (H.HH)
34	In Study Area End Test, Site (1,2,3,20-forebay: 12,34,56-gatewells: 4-9 downstream transects)
35	Heard in The Forbay Not Downstream (1- yes)
36	Heard Downstream Not in the Forebay (1-yes, 2-no)

Appendix Table B1.--Passage data for radio-tagged chinook salmon smolts released into the forebay of Lower Granite Dam on 12 April 1985.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
1	1046	182	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
2	1058	154	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
3	1063	175	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
4	1074	152	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
5	1082	178	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
6	1090	165	2	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	12	23.23	12	23.23	1	12	23.88	13	0.13	1	0	0.00	0	0	1
7	1097	180	2	12	9.75	13	3.36	1	13	3.36	1	13	5.20	13	5.23	3	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
8	1101	181	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	13	5.01	13	5.08	1	13	6.15	13	6.53	2	0	0.00	0	0	1
9	1107	185	4	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
10	2023	178	5	12	9.75	14	4.73	1	14	4.73	1	14	23.08	0	0.00	6	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
11	2029	157	5	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	14	23.31	14	23.36	1	0	0.00	0	0.00	0	15	1.98	15	2.31	2	0	0.00	0	0	1
12	2034	150	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
13	2040	176	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	13	6.11	13	6.18	1	0	0.00	0	0.00	0	0	0.00	0	0	1
14	2046	160	7	12	9.75	14	3.86	1	14	3.86	1	0	0.00	0	0.00	6	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	10.00	1	0	0
15	2050	159	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	14	21.31	14	21.40	2	0	0.00	0	0.00	0	14	22.85	14	23.11	2	0	0.00	0	0	1
16	2056	165	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
17	2062	170	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	13	1.60	13	1.61	1	13	2.58	13	2.60	1	0	0.00	0	0	1
18	2068	180	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
19	2073	182	1	12	9.75	14	5.80	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	9.80	1	0	0
20	2078	175	2	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
21	2084	180	2	12	9.75	13	1.78	1	13	1.78	1	13	1.98	14	[illegible]	6	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
22	2088	190	3	12	9.75	15	1.63	1	15	2.58	1	15	9.46	15	[illegible]	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
23	2092	161	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
24	2097	164	4	12	9.75	14	18.18	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	9.00	1	0	0
25	2101	182	4	12	9.75	15	8.70	1	15	8.93	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	0
26	2106	190	4	12	9.75	12	21.01	3	12	21.01	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	12	22.43	12	23.46	2	0	0.00	0	0	0
27	3027	176	5	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
28	3034	162	5	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	13	19.33	13	19.60	1	0	0.00	0	0.00	0	0	0.00	0	0	1
29	3041	159	6	12	9.75	13	5.58	1	13	5.58	1	13	12.78	13	[illegible]	5	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
30	3047	180	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
31	3058	151	7	12	9,75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
32	3052	170	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	12	23.08	12	23.11	2	12	23.41	12	23.48	1	13	0.11	13	0.23	1	0	0.00	0	0	1
33	3069	166	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
34	3073	157	8	12	9.75	12	23.53	1	12	23.53	1	12	23.55	12	23.65	5	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
35	3064	166	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
36	3077	160	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
37	3082	178	2	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
38	3086	202	2	12	9.75	14	21.26	3	14	21.26	2	0	0.00	0	0.00	0	14	22.73	14	22.81	2	0	0.00	0	0.00	0	14	23.98	14	0.10	2	0	0.00	0	0	0
39	3091	171	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	13	5.55	13	9.75	2	13	10.00	13	10.93	1	0	0.00	0	0	1
40	3097	162	3	12	9.75	12	21.35	1	12	21.96	1	12	22.05	12	22.06	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
41	3101	170	4	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	13	20.71	13	21.56	1	0	0.00	0	0.00	0	13	23.35	13	23.46	1	0	0.00	0	0	1
42	3105	162	4	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
43	4034	160	5	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
44	4041	170	6	12	9.75	13	2.75	1	13	2.83	1	13	4.31	13	4.35	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
45	4045	172	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
46	4051	186	7	12	9.75	13	2.40	1	13	2.63	1	13	2.63	13	2.65	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
47	4058	179	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	13	19.88	13	19.95	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
48	4063	190	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	13	1.18	13	1.21	1	13	2.36	13	2.68	2	0	0.00	0	0	1
49	4069	187	8	12	9.75	13	8.21	1	13	8.31	1	0	0.00	0	0.00	0	13	20.13	13	20.16	1	0	0.00	0	0.00	0	13	23.10	13	23.25	1	0	0.00	0	0	0
50	4073	158	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
51	4079	180	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
52	4083	188	2	12	9.75	14	2.96	1	14	2.96	1	14	6.30	0	0.00	5	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
53	4088	190	2	12	9.75	12	22.86	1	12	22.86	1	12	23.03	12	23.05	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0

Appendix Table.B1.--cont.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
54	4094	157	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
55	4098	162	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
56	4104	174	4	12	9.75	12	22.83	1	12	22.83	1	12	23.05	12	23.10	6	0	0.00
57	5029	181	5	12	9.75	12	18.70	1	12	19.70	1	13	1.50	14	12.16	4	0	0.00
58	5034	160	5	12	9.75	12	22.80	1	12	22.80	1	13	1.03	13	1.13	5	0	0.00
59	5051	175	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
60	5055	189	7	12	9.75	13	4.86	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
61	5060	168	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
62	5064	200	8	12	9.75	13	2.00	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
63	5068	180	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
64	5073	178	1	12	9.75	13	19.76	1	13	19.76	1	13	20.70	0	0.00	4	0	0.00
65	5081	159	2	12	9.75	13	9.33	1	13	9.33	1	13	11.11	0	0.00	6	0	0.00
66	5085	180	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	13	4.95
67	5096	158	4	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
68	5100	157	4	12	9.75	13	9.35	1	13	9.35	1	13	11.90	0	0.00	6	0	0.00
69	5105	190	4	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
70	6034	180	5	12	9.75	14	6.26	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
71	6050	168	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
72	6057	172	7	12	9.75	13	22.95	1	13	22.95	1	13	23.00	0	0.00	4	0	0.00
73	6062	170	7	12	9.75	12	22.86	1	12	23.18	1	12	23.31	12	23.58	2	0	0.00
74	6067	173	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
75	6072	192	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
76	6080	170	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
77	6084	178	1	12	9.75	15	1.65	1	15	6.71	1	0	0.00	0	0.00	0	0	0.00
78	6088	162	2	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
79	6097	172	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
80	6101	190	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	13	21.25
81	6106	165	4	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
82	7027	187	5	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
83	7067	180	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
84	7071	152	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
85	7075	159	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
86	7080	182	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
87	7084	162	2	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	15	1.45
88	7088	188	2	12	9.75	14	11.00	1	15	6.06	1	0	0.00	0	0.00	0	0	0.00
89	8028	172	5	12	9.75	14	18.15	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
90	8039	185	6	12	9.75	13	5.03	1	13	5.03	1	13	5.10	14	12.16	1	0	0.00
91	8046	175	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
92	8050	175	7	12	9.75	15	7.40	1	15	7.95	1	0	0.00	0	0.00	0	0	0.00
93	8057	168	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
94	8063	183	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
95	8068	186	8	12	9.75	14	5.05	1	14	5.05	1	0	0.00	0	0.00	5	0	0.00
96	8073	176	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
97	8078	186	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
98	8087	173	3	12	9.75	13	5.18	1	13	5.18	1	14	18.66	14	23.13	5	0	0.00
99	8092	190	3	12	9.75	13	1.63	1	13	1.63	1	13	20.78	13	23.61	1	0	0.00
100	9028	178	5	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
101	9041	192	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
102	9046	187	6	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
103	9052	165	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
104	9058	170	7	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
105	9064	170	8	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
106	9068	170	8	12	9.75	13	2.65	1	13	2.65	1	13	18.46	13	20.58	3	0	0.00

ROW	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
54	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
55	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
56	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
57	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
58	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
59	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
60	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	10.20	1	0	0
61	0	0.00	0	13	3.46	13	3.50	1	13	4.33	13	4.68	2	0	0.00	0	0	1
62	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	7.48	1	0	0
63	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
64	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
65	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
66	13	4.96	1	13	5.26	13	12.76	2	0	0.00	0	0.00	0	0	0.00	0	0	1
67	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
68	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
69	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
70	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	9.86	1	0	0
71	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
72	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
73	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
74	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
75	0	0.00	0	13	2.20	13	2.21	1	13	2.45	13	2.60	1	0	0.00	0	0	1
76	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
77	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	0
78	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
79	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
80	13	21.26	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
81	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
82	0	0.00	0	0	0.00	0	0.00	0	14	4.03	15	2.95	0	0	0.00	0	0	1
83	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
84	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
85	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
86	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
87	15	1.50	2	0	0.00	0	0.00	0	15	2.78	14	2.95	1	0	0.00	0	0	1
88	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	0
89	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	10.23	1	0	0
90	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
91	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
92	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	0
93	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
94	0	0.00	0	0	0.00	0	0.00	0	14	5.06	14	5.33	1	0	0.00	0	0	1
95	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	15	9.78	1	0	0
96	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
97	0	0.00	0	12	21.88	12	22.03	2	12	22.75	12	22.83	1	0	0.00	0	0	1
98	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
99	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
100	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
101	0	0.00	0	13	4.56	13	8.91	2	13	10.01	13	11.28	2	0	0.00	0	0	1
102	0	0.00	0	13	1.95	13	1.96	1	13	3.25	13	3.31	1	0	0.00	0	0	1
103	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
104	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
105	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
106	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0

Appendix Table B1.--cont.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
107	9074	189	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
108	9078	180	1	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
109	9082	175	2	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
110	9086	168	2	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	13	15.71	13	15.71	1	13	16.03	13	16.16	1	13	16.85	14	6.68	1	0	0.00	0	0	1
111	9091	166	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	14	4.91	14	4.91	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	1
112	9096	188	3	12	9.75	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0

Appendix Table B2.--Passage data for radio-tagged chinook salmon smolts released into the forebay of Lower Granite Dam on 2 May 1985.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
1	1028	179	1	2	9.83	2	16.03	1	4	21.68	1	5	0.08	5	0.08	1	0	0.00
2	1039	175	2	2	9.83	2	18.40	1	2	20.10	1	0	0.00	0	0.00	0	2	20.80
3	1055	162	4	2	9.83	3	3.86	1	5	6.60	1	0	0.00	0	0.00	0	0	0.00
4	1059	178	4	2	9.83	2	16.03	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
5	1063	156	5	2	9.83	3	14.35	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
6	1070	157	5	2	9.83	2	19.90	1	4	21.90	1	0	0.00	0	0.00	0	4	22.15
7	1080	175	6	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	3	2.38
8	1088	175	6	2	9.83	3	4.85	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
9	1093	160	7	2	9.83	3	7.28	1	5	6.00	1	0	0.00	0	0.00	0	0	0.00
10	1098	176	7	2	9.83	2	17.31	2	4	23.91	1	0	0.00	0	0.00	0	0	0.00
11	1105	169	8	2	9.83	2	16.50	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
12	1111	180	8	2	9.83	2	17.96	1	3	9.38	1	0	0.00	0	0.00	0	4	6.15
13	2029	162	1	2	9.83	3	4.85	1	3	19.61	1	0	0.00	0	0.00	0	3	19.98
14	2046	152	2	2	9.83	2	18.06	1	5	5.88	1	0	0.00	0	0.00	0	0	0.00
15	2051	186	3	2	9.83	2	16.43	2	0	0.00	0	0	0.00	0	0.00	0	0	0.00
16	2057	170	3	2	9.83	3	3.88	1	3	16.33	1	4	8.35	[illegible]	8.35	1	0	0.00
17	2064	160	4	2	9.83	3	2.81	1	3	19.58	1	4	6.15	[illegible]	0.00	1	0	0.00
18	2074	152	4	2	9.83	2	13.96	2	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
19	2078	177	5	2	9.83	4	15.91	1	4	16.76	1	0	0.00	[illegible]	0.00	0	0	0.00
20	2084	172	5	2	9.83	2	22.96	1	5	4.78	1	0	0.00	[illegible]	0.00	0	0	0.00
21	2089	156	6	2	9.83	2	17.11	1	4	16.31	1	0	0.00	[illegible]	0.00	0	0	0.00
22	2099	156	7	2	9.83	0	0.00	0	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
23	2104	155	7	2	9.83	0	0.00	0	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
24	2109	157	8	2	9.83	0	0.00	0	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
25	3029	152	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	[illegible]	0.00	0	2	21.65
26	3034	180	1	2	9.83	2	12.85	1	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
27	3041	176	2	2	9.83	2	17.93	2	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
28	3047	160	2	2	9.83	2	20.60	1	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
29	3052	150	3	2	9.83	3	2.05	1	3	4.65	1	0	0.00	[illegible]	0.00	0	0	0.00
30	3056	170	3	2	9.83	0	0.00	0	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
31	3061	178	4	2	9.83	2	16.03	1	5	5.45	1	0	0.00	[illegible]	0.00	0	0	0.00
32	3064	167	4	2	9.83	0	0.00	0	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
33	3068	168	4	2	9.83	2	18.11	1	3	5.05	1	0	0.00	[illegible]	0.00	0	0	0.00
34	3072	155	5	2	9.83	0	0.00	0	0	0.00	0	[illegible]	0.00	[illegible]	0.00	0	0	0.00
35	3077	161	5	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
36	3083	167	6	2	9.83	3	17.66	1	3	18.43	1	0	0.00	0	0.00	0	3	18.93
37	3095	164	6	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
38	3103	160	7	2	9.83	2	16.46	1	2	23.05	1	0	0.00	0	0.00	0	3	2.08
39	3107	168	8	2	9.83	2	19.46	1	3	17.13	1	0	0.00	0	0.00	0	3	20.68
40	4028	168	1	2	9.83	3	8.53	1	0	0.00	0	0	0.00	[illegible]	0.00	0	0	0.00
41	4033	174	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	[illegible]	0.00	0	2	21.98
42	4040	170	2	2	9.83	2	16.01	1	2	22.26	1	3	6.31	3	10.75	1	0	0.00
43	4045	180	2	2	9.83	2	22.63	1	2	22.63	1	0	0.00	[illegible]	0.00	0	2	22.66
44	4051	182	3	2	9.83	4	9.76	1	4	9.85	1	0	0.00	0	0.00	0	0	0.00
45	4059	173	3	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
46	4063	160	4	2	9.83	2	13.36	2	2	14.21	1	0	0.00	0	0.00	0	3	4.31
47	4069	185	4	2	9.83	2	15.03	2	3	6.91	1	0	0.00	0	0.00	0	0	0.00
48	4072	157	5	2	9.83	2	15.65	2	4	10.65	1	0	0.00	0	0.00	0	5	6.00
49	4076	162	5	2	9.83	3	4.15	1	3	4.16	1	0	0.00	0	0.00	0	0	0.00
50	4080	154	6	2	9.83	2	17.98	1	5	3.76	1	0	0.00	0	0.00	0	0	0.00
51	4084	185	6	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	2	22.01
52	4088	183	7	2	9.83	2	14.38	2	3	20.45	1	3	20.75	3	20.75	1	0	0.00
53	4094	172	7	2	9.83	2	16.45	1	5	2.38	1	0	0.00	0	0.00	0	0	0.00

ROW	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
1	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
2	2	20.88	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
3	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
4	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	8.26	1	0	0
5	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	8.28	1	0	0
6	4	22.35	2	4	22.36	4	22.76	2	4	23.55	4	23.78	2	0	0.00	0	0	2
7	3	2.38	1	3	3.05	3	3.08	1	3	4.40	3	4.95	2	0	0.00	0	0	1
8	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	10.08	1	0	0
9	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
10	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
11	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	11.20	1	0	0
12	4	6.28	2	4	6.60	4	6.73	2	4	7.53	4	7.60	1	0	0.00	0	0	2
13	3	20.08	2	3	20.50	3	20.61	1	3	21.40	3	21.45	2	0	0.00	0	0	2
14	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
15	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	12.08	1	0	0
16	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
17	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
18	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	8.00	1	0	0
19	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
20	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
21	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
22	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
23	0	0.00	0	3	0.40	3	0.48	1	3	2.63	3	2.75	0	0	0.00	0	0	1
24	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
25	2	21.81	2	2	22.11	2	22.25	1	2	23.51	2	23.51	0	0	0.00	0	0	1
26	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	9.20	1	0	0
27	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	11.43	1	0	0
28	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	8.11	1	0	0
29	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
30	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
31	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
32	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
33	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
34	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
35	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
36	3	19.01	2	3	19.26	3	19.38	2	3	19.91	3	20.08	2	0	0.00	0	0	2
37	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
38	3	2.08	1	3	2.46	3	2.65	1	3	3.55	3	3.73	2	0	0.00	0	0	2
39	3	20.71	1	3	21.05	3	21.08	1	3	21.83	3	22.05	2	0	0.00	0	0	2
40	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	11.06	1	0	0
41	2	22.15	2	2	22.41	2	22.58	1	3	0.00	3	0.15	2	0	0.00	0	0	1
42	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
43	2	22.75	1	2	23.03	2	23.18	1	3	0.15	3	0.30	2	0	0.00	0	0	2
44	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
45	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
46	3	4.31	1	3	5.00	3	6.95	2	4	3.65	4	3.93	2	0	0.00	0	0	2
47	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
48	5	6.05	2	5	6.51	5	6.60	2	5	7.63	5	7.70	2	0	0.00	0	0	2
49	0	0.00	0	3	4.20	3	4.31	2	3	5.30	3	5.58	2	0	0.00	0	0	2
50	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
51	2	22.11	2	2	22.36	2	22.55	2	2	23.40	2	23.51	1	0	0.00	0	0	1
52	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
53	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2

Appendix Table B2.--cont.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
54	4098	198	8	2	9.83	3	7.23	1	3	8.03	1	0	0.00	0	0.00	0	0	0.00
55	4105	162	8	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
56	5030	188	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
57	5040	171	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
58	5044	170	2	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
59	5057	169	2	2	9.83	2	15.80	2	2	22.00	1	0	0.00	0	0.00	0	2	22.58
60	5063	170	3	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
61	5071	171	4	2	9.83	2	12.43	2	0	0.00	0	0	0.00	0	0.00	0	0	0.00
62	5082	159	4	2	9.83	2	16.03	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
63	5087	188	5	2	9.83	3	10.11	1	5	2.30	1	0	0.00	0	0.00	0	5	2.38
64	5091	170	5	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	2	20.38
65	5097	171	6	2	9.83	3	15.75	1	3	15.93	1	0	0.00	0	0.00	0	4	3.20
66	5101	169	6	2	9.83	2	19.63	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
67	5107	155	7	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
68	6028	168	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
69	6034	200	1	2	9.83	2	12.45	2	2	21.21	1	2	21.81	2	21.81	2	0	0.00
70	6039	170	2	2	9.83	2	15.51	2	2	18.45	1	0	0.00	0	0.00	0	2	23.48
71	6046	168	3	2	9.83	2	16.50	1	2	16.90	1	0	0.00	0	0.00	0	0	0.00
72	6051	175	3	2	9.83	3	0.35	1	3	0.35	1	5	0.58	0	0.00	1	0	0.00
73	6057	163	4	2	9.83	2	16.48	1	2	21.78	1	5	0.78	5	1.26	1	0	0.00
74	6068	176	5	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	3	8.58
75	6072	169	5	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
76	6082	178	6	2	9.83	2	21.81	2	2	22.03	1	0	0.00	0	0.00	0	2	22.43
77	6086	178	6	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	3	0.31
78	6098	187	7	2	9.83	2	12.98	1	4	0.48	1	0	0.00	0	0.00	0	4	1.75
79	6103	168	8	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	5	5.25
80	7028	171	1	2	9.83	2	20.36	1	5	5.55	1	0	0.00	0	0.00	0	0	0.00
81	7034	169	1	2	9.83	2	11.66	2	4	16.80	1	0	0.00	0	0.00	0	0	0.00
82	7041	179	2	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
83	7052	170	3	2	9.83	2	20.36	2	2	20.43	1	0	0.00	0	0.00	0	2	20.73
84	7058	172	4	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
85	7063	168	5	2	9.83	3	2.73	1	3	2.73	1	0	0.00	0	0.00	1	0	0.00
86	7069	182	5	2	9.83	2	14.15	2	2	22.56	1	0	0.00	0	0.00	4	0	0.00
87	7074	179	6	2	9.83	3	3.46	1	4	16.76	1	4	16.81	4	16.93	5	0	0.00
88	7082	154	6	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
89	7087	170	7	2	9.83	2	22.11	1	2	22.11	1	3	18.58	3	20.15	1	0	0.00
90	7095	162	7	2	9.83	2	17.20	2	2	21.43	1	3	8.48	3	8.63	3	0	0.00
91	7099	181	8	2	9.83	2	16.78	2	2	21.16	1	0	0.00	0	0.00	0	2	21.48
92	7103	154	8	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
93	7108	188	8	2	9.83	2	19.51	2	5	2.46	1	0	0.00	0	0.00	0	5	3.18
94	8038	170	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
95	8047	159	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	2	12.95
96	8057	174	2	2	9.83	3	14.36	1	4	21.53	1	0	0.00	0	0.00	0	0	0.00
97	8068	160	3	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	2	22.66
98	8079	160	4	2	9.83	2	21.70	2	0	0.00	0	0	0.00	0	0.00	0	0	0.00
99	8083	155	5	2	9.83	2	16.55	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
100	8087	165	5	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	2	21.18
101	8095	157	6	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
102	8101	175	7	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
103	8105	180	8	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
104	9028	155	1	2	9.83	2	22.41	1	2	22.48	1	2	22.51	2	22.53	2	0	0.00
105	9034	182	1	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	2	13.31
106	9041	161	2	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	2	22.06

ROW	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
54	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
55	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
56	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
57	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
58	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
59	2	22.70	1	2	22.88	2	23.08	2	2	23.88	2	23.98	2	0	0.00	0	0	2
60	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
61	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	12.11	1	0	0
62	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	12.11	1	0	0
63	5	2.45	2	5	2.76	5	2.88	2	5	3.66	5	3.80	2	0	0.00	0	0	2
64	2	20.43	1	2	20.81	2	21.00	1	2	21.93	2	22.08	2	0	0.00	0	0	1
65	4	3.28	2	4	3.66	4	3.76	1	4	11.81	4	12.01	1	0	0.00	0	0	2
66	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	12.10	1	0	0
67	0	0.00	0	3	2.93	3	3.18	1	3	4.71	3	5.41	2	0	0.00	0	0	1
68	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
69	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
70	2	23.48	1	2	23.91	3	0.10	1	3	2.10	3	2.91	1	0	0.00	0	0	2
71	0	0.00	0	2	22.78	3	2.53	1	3	3.65	3	3.91	2	0	0.00	0	0	2
72	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	1
73	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
74	3	8.71	1	3	8.91	3	9.13	2	3	9.83	3	10.16	1	0	0.00	0	0	1
75	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
76	2	22.58	2	2	22.73	2	23.11	2	3	0.11	3	0.33	2	0	0.00	0	0	2
77	3	0.31	1	3	0.83	3	1.40	2	3	2.76	3	3.06	2	0	0.00	0	0	1
78	4	1.85	2	4	2.26	4	2.40	2	4	3.18	4	3.35	2	0	0.00	0	0	2
79	5	7.35	2	3	1.80	4	23.90	2	0	0.00	0	0.00	0	0	0.00	0	0	1
80	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
81	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
82	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
83	2	20.85	2	2	21.01	2	21.28	2	2	21.90	2	22.03	2	0	0.00	0	0	2
84	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
85	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	12.26	1	0	1
86	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
87	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
88	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
89	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	1
90	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
91	2	21.55	2	2	21.83	2	21.90	1	2	22.86	2	22.93	2	0	0.00	0	0	2
92	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
93	5	3.28	1	5	3.66	5	4.03	2	5	5.16	5	5.38	2	0	0.00	0	0	2
94	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
95	2	13.11	2	2	13.25	2	13.55	2	2	14.35	2	14.70	2	0	0.00	0	0	1
96	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
97	2	22.88	2	2	23.23	2	0.05	2	3	2.28	3	9.56	2	0	0.00	0	0	1
98	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	7.83	1	0	0
99	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	5	8.18	1	0	0
100	2	21.31	2	2	21.55	2	21.73	2	2	22.48	2	22.63	0	0	0.00	0	0	1
101	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
102	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
103	0	0.00	0	2	23.46	2	23.93	2	3	1.01	3	1.20	2	0	0.00	0	0	1
104	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
105	2	13.41	2	2	13.68	2	13.96	1	2	15.06	2	15.38	2	0	0.00	0	0	1
106	2	22.13	2	2	22.58	2	22.71	1	2	23.88	2	23.96	1	0	0.00	0	0	1

Appendix Table B2.--cont.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
107	9046	179	2	2	9.83	2	16.03	1	4	11.78	1	0	0.00	0	0.00	0	0	0.00
108	9052	188	3	2	9.83	3	15.16	1	3	15.58	1	0	0.00	0	0.00	0	3	21.83
109	9061	169	4	2	9.83	2	18.18	1	5	6.31	1	0	0.00	0	0.00	0	0	0.00
110	9069	171	5	2	9.83	2	18.50	1	2	19.58	1	2	19.68	2	19.68	2	0	0.00
111	9084	182	6	2	9.83	2	22.33	1	4	4.50	1	0	0.00	0	0.00	0	5	11.38
112	9088	186	8	2	9.83	2	18.53	1	2	19.90	1	0	0.00	0	0.00	4	0	0.00
113	9093	168	7	2	9.83	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
114	9102	166	7	2	9.83	2	17.80	2	3	19.63	1	0	0.00	0	0.00	0	3	19.88
115	9109	195	8	2	9.83	3	6.95	1	3	19.83	1	4	8.30	0	0.00	2	0	0.00

ROW	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
107	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
108	3	21.85	2	3	22.13	3	22.26	1	3	23.11	3	23.16	1	0	0.00	0	0	2
109	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
110	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
111	5	11.38	1	5	11.53	5	11.53	1	0	0.00	0	0.00	0	0	0.00	0	0	2
112	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
113	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
114	3	19.98	2	3	20.16	3	20.30	2	3	20.75	3	20.03	2	0	0.00	0	0	2
115	0	0.00	0	4	11.61	4	11.63	1	0	0.00	0	0.00	0	0	0.00	0	0	2

Appendix Table B3.--Passage data for radio-tagged chinook salmon smolts released into the forebay of Lower Granite Dam on 5 May 1985.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
1	1028	179	1	5	18	6	0.16	1	6	18.98	2	0
2	1040	160	2	5	18	6	2.65	1	6	22.51	1	0
3	1045	176	2	5	18	0	0.00	0	0	0.00	0	0
4	1065	163	3	5	18	6	4.51	3	6	5.30	1	0
5	1073	173	5	5	18	6	5.58	1	6	6.40	1	0
6	1077	168	6	5	18	6	3.48	2	7	4.98	1	0
7	1088	166	8	5	18	5	18.20	2	7	0.36	1	0
8	2029	170	1	5	18	0	0.00	0	0	0.00	0	0
9	2040	163	3	5	18	0	0.00	0	0	0.00	0	0
10	2057	171	4	5	18	0	0.00	0	0	0.00	0	0
11	2065	169	4	5	18	6	1.55	1	7	5.36	2	0
12	2071	162	5	5	18	5	18.60	3	5	20.26	1	5
13	2075	160	5	5	18	0	0.00	0	0	0.00	0	0
14	2089	163	6	5	18	5	23.11	1	6	0.93	2	0
15	2095	167	7	5	18	0	0.00	0	0	0.00	0	0
16	2100	173	7	5	18	0	0.00	0	0	0.00	0	0
17	2104	175	8	5	18	6	7.60	1	6	22.31	1	6
18	2110	160	8	5	18	6	3.21	1	6	3.26	1	0
19	3030	176	1	5	18	5	19.75	1	5	23.41	2	0
20	3035	163	2	5	18	5	20.46	1	5	21.35	2	0
21	3048	162	2	5	18	0	0.00	0	0	0.00	0	0
22	3052	153	3	5	18	5	23.78	1	6	3.83	1	0
23	3065	178	4	5	18	0	0.00	0	0	0.00	0	0
24	3068	165	4	5	18	5	20.98	1	6	15.46	2	0
25	3073	165	5	5	18	0	0.00	0	0	0.00	0	0
26	3078	175	5	5	18	5	21.46	1	6	3.50	1	0
27	3083	174	6	5	18	0	0.00	0	0	0.00	0	0
28	3086	171	6	5	18	0	0.00	0	0	0.00	0	0
29	3092	162	7	5	18	0	0.00	0	0	0.00	0	0
30	3096	161	7	5	18	0	0.00	0	0	0.00	0	0
31	3101	169	8	5	18	0	0.00	0	0	0.00	0	0
32	3106	173	8	5	18	0	0.00	0	0	0.00	0	0
33	4052	175	2	5	18	5	21.15	1	5	21.30	1	0
34	4057	163	3	5	18	6	2.55	3	6	2.63	2	[illegible]
35	4066	174	4	5	18	0	0.00	0	0	0.00	0	0
36	4070	161	5	5	18	0	0.00	0	0	0.00	0	0
37	4083	176	6	5	18	0	0.00	0	0	0.00	0	0
38	4087	186	7	5	18	6	3.13	3	6	3.41	2	0
39	4095	165	7	5	18	0	0.00	0	0	0.00	0	0
40	4098	160	8	5	18	0	0.00	0	0	0.00	0	0
41	4105	171	8	5	18	6	3.46	3	6	3.46	2	0
42	5030	162	1	5	18	6	2.38	3	6	2.50	2	0
43	5033	170	1	5	18	0	0.00	0	0	0.00	0	0
44	5041	165	2	5	18	5	22.13	3	5	22.20	2	0
45	5049	165	3	5	18	5	19.20	2	6	1.16	2	0
46	5053	159	4	5	18	5	19.23	2	6	0.31	2	0
47	5061	180	5	5	18	6	4.43	3	6	4.45	2	0
48	5065	160	6	5	18	5	18.38	1	5	23.83	2	0
49	5070	182	7	5	18	5	18.21	1	5	20.70	1	0
50	5073	159	6	5	18	5	19.18	2	6	0.10	1	0
51	5078	161	7	5	18	5	23.56	1	7	21.41	1	7
52	5092	160	8	5	18	5	23.18	3	5	23.21	2	0
53	5106	160	8	5	18	6	3.75	3	6	3.95	2	0

ROW	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24
1	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
2	0.00	0	0.00	0	6	22.95	6	23.05	2	6	23.43	6
3	0.00	0	0.00	0	6	1.61	6	4.78	2	6	2.26	6
4	0.00	0	0.00	0	6	5.61	6	5.71	2	6	6.03	6
5	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
6	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
7	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
8	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
9	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
10	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
11	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
12	23.78	0	0.00	3	0	0.00	0	0.00	0	0	0.00	0
13	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
14	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
15	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
16	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
17	22.48	7	0.45	1	0	0.00	0	0.00	0	0	0.00	0
18	0.00	0	0.00	0	6	3.55	6	6.98	2	7	0.21	0
19	0.00	0	0.00	0	5	23.55	5	23.68	2	6	0.11	6
20	0.00	0	0.00	0	5	21.51	5	21.61	2	5	21.93	5
21	0.00	0	0.00	0	6	4.08	6	4.18	2	6	4.61	6
22	0.00	0	0.00	0	6	4.85	6	4.95	2	6	5.25	6
23	0.00	0	0.00	0	6	3.61	6	3.81	2	6	4.15	6
24	0.00	0	0.00	0	6	23.23	6	23.31	2	6	23.81	6
25	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
26	0.00	0	0.00	0	6	3.88	6	4.05	2	6	4.33	6
27	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
28	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
29	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
30	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
31	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
32	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
33	0.00	0	0.00	0	5	21.83	5	21.95	2	5	22.31	5
34	0.00	0	0.00	0	6	3.50	6	4.01	2	6	5.46	6
35	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
36	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
37	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
38	0.00	0	0.00	0	6	3.48	6	3.61	2	6	3.90	6
39	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
40	0.00	0	0.00	0	6	4.60	6	4.68	2	0	0.00	0
41	0.00	0	0.00	0	6	3.58	6	3.68	2	6	3.96	6
42	0.00	0	0.00	0	6	2.61	6	2.75	2	6	3.13	6
43	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
44	0.00	0	0.00	0	5	22.23	5	22.31	2	5	22.63	5
45	0.00	0	0.00	0	6	1.26	6	1.45	2	6	1.75	6
46	0.00	0	0.00	0	6	0.51	6	0.68	2	6	0.95	6
47	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0
48	0.00	0	0.00	0	6	1.88	6	1.98	2	6	2.25	6
49	0.00	0	0.00	0	6	4.33	6	4.41	2	6	4.76	6
50	0.00	0	0.00	0	6	7.78	6	7.88	2	6	8.11	6
51	21.56	8	0.81	2	0	0.00	0	0.00	0	0	0.00	0
52	0.00	0	0.00	0	5	23.25	8	9.00	2	0	0.00	0
53	0.00	0	0.00	0	6	4.16	6	4.25	2	6	4.65	6

ROW	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
1	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
2	23.51	2	7	0.31	7	0.41	2	0	0.00	0	0	2
3	2.61	2	6	3.90	6	4.15	2	0	0.00	0	0	1
4	6.13	1	6	6.83	6	7.01	2	0	0.00	0	0	2
5	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
6	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
7	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
8	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
9	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
10	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
11	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
12	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
13	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
14	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
15	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
16	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
17	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
18	0.00	2	0	0.00	0	0.00	0	8	17.18	6	0	2
19	0.20	1	6	1.23	6	1.38	2	0	0.00	0	0	2
20	22.05	1	5	22.71	5	22.90	2	0	0.00	0	0	2
21	4.76	1	6	5.68	6	5.76	2	0	0.00	0	0	1
22	5.41	2	6	6.03	6	6.21	2	0	0.00	0	0	2
23	4.36	2	6	5.40	6	5.60	2	0	0.00	0	0	1
24	23.88	1	7	0.70	7	0.88	2	0	0.00	0	0	2
25	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
26	4.63	2	6	5.20	6	5.43	2	0	0.00	0	0	2
27	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
28	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
29	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
30	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
31	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
32	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
33	22.45	1	5	23.30	5	23.45	2	0	0.00	0	0	2
34	10.18	1	0	0.00	0	0.00	0	0	0.00	0	0	2
35	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
36	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
37	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
38	4.21	2	6	5.18	6	5.40	2	0	0.00	0	0	2
39	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
40	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	1
41	4.45	2	6	5.01	6	5.48	2	0	0.00	0	0	2
42	4.85	2	6	5.78	6	8.13	2	0	0.00	0	0	2
43	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
44	22.75	1	6	0.81	6	1.05	1	0	0.00	0	0	2
45	1.98	2	6	2.78	6	3.03	2	0	0.00	0	0	2
46	1.16	2	6	1.81	6	2.08	2	0	0.00	0	0	2
47	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
48	2.46	2	6	3.23	6	3.66	2	0	0.00	0	0	2
49	4.96	2	6	5.51	6	5.88	2	0	0.00	0	0	2
50	8.43	2	6	9.83	6	10.01	2	0	0.00	0	0	2
51	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
52	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
53	5.01	2	6	6.98	0	0.00	0	8	18.96	8	0	2

Appendix Table B3.--cont.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
54	6029	195	1	5	18	5	22.00	3	5	22.06	2	0	0.00	0	0.00	0	5	22.21	5	22.38	2	5	22.80	5	23.00	1	6	0.05	6	0.28	2	0	0.00	0	0	2
55	6035	170	1	5	18	6	15.03	3	6	19.98	1	0	0.00	0	0.00	0	6	20.91	6	21.01	2	6	21.35	6	21.48	2	6	22.10	6	22.36	2	0	0.00	0	0	2
56	6041	171	2	5	18	6	4.41	3	6	4.43	2	0	0.00	0	0.00	0	6	4.50	6	4.61	2	6	5.00	6	5.11	2	6	5.76	6	6.16	2	0	0.00	0	0	2
57	6046	164	2	5	18	8	0.81	1	8	1.18	2	0	0.00	0	0.00	0	8	1.20	8	1.38	2	8	1.70	8	1.95	2	8	2.53	8	2.85	2	0	0.00	0	0	2
58	6053	152	3	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
59	6059	160	3	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
60	6065	162	4	5	18	6	0.46	3	6	0.65	2	0	0.00	0	0.00	0	6	0.68	6	0.81	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
61	6070	191	4	5	18	6	0.46	3	6	0.51	2	0	0.00	0	0.00	0	6	0.68	6	0.75	2	6	1.16	6	1.23	2	6	2.06	6	2.15	2	0	0.00	0	0	2
62	6083	168	6	5	18	6	1.41	1	7	1.05	1	7	1.41	7	1.43	3	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
63	8086	177	6	5	18	6	0.70	3	6	2.50	1	6	22.96	7	0.28	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
64	8099	169	7	5	18	6	2.06	1	6	10.08	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
65	7040	168	1	5	18	6	5.41	3	6	5.80	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
66	7047	170	2	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
67	7053	167	2	5	18	6	3.31	1	6	6.83	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	6	8.75	6	9.21	1	0	0.00	0	0	2
68	7056	173	3	5	18	5	21.40	3	5	21.81	2	0	0.00	0	0.00	0	5	21.86	5	21.98	2	5	22.41	5	22.68	2	5	23.56	5	23.90	2	0	0.00	0	0	2
69	7070	160	4	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
70	7074	164	5	5	18	5	23.03	1	6	0.55	1	0	0.00	0	0.00	0	6	1.30	6	1.40	2	6	1.78	6	1.93	2	6	2.66	6	2.83	2	0	0.00	0	0	2
71	7083	172	6	5	18	6	3.03	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	8	16.48	1	0	0
72	7089	170	6	5	18	6	5.21	3	7	1.46	2	0	0.00	0	0.00	0	7	1.58	7	1.68	2	7	2.03	7	2.26	2	7	2.95	7	3.21	2	0	0.00	0	0	2
73	7093	169	7	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	6	7.95	6	8.08	2	6	8.33	6	8.43	2	6	8.68	6	9.53	2	0	0.00	0	0	1
74	7099	172	7	5	18	6	3.96	3	6	7.66	2	0	0.00	0	0.00	0	6	7.68	6	7.81	2	6	8.06	6	8.21	2	6	8.66	6	8.90	2	0	0.00	0	0	2
75	7102	174	8	5	18	6	3.98	3	8	7.66	1	0	0.00	0	0.00	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	8	18.55	1	0	2
76	8029	180	1	5	18	5	23.55	3	5	23.95	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
77	8034	169	2	5	18	5	22.63	1	5	23.01	2	0	0.00	0	0.00	0	5	23.16	5	23.31	2	5	23.70	5	23.85	1	6	0.55	6	0.93	2	0	0.00	0	0	2
78	8040	174	3	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	5	22.81	5	22.93	2	5	23.23	5	23.45	2	6	0.48	6	0.76	2	0	0.00	0	0	1
79	8053	178	5	5	18	6	0.98	2	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
80	8058	162	5	5	18	6	6.85	3	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	8	17.26	1	0	0
81	8064	166	6	5	18	6	0.71	3	6	1.65	2	0	0.00	0	0.00	0	6	1.71	6	1.81	2	6	2.11	6	2.23	2	6	3.11	6	3.68	2	0	0.00	0	0	2
82	8069	166	6	5	18	5	23.55	3	6	1.10	2	0	0.00	0	0.00	0	6	1.40	6	1.51	2	6	1.90	6	2.03	2	6	2.78	6	3.05	2	0	0.00	0	0	2
83	8088	189	7	5	18	6	4.60	1	7	17.01	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
84	8094	178	7	5	18	5	21.33	3	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	8	18.25	1	0	0
85	8100	163	8	5	18	6	16.16	1	6	16.75	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
86	8104	176	8	5	18	5	23.60	1	6	1.85	1	0	0.00	0	0.00	0	6	1.85	6	2.01	2	6	2.31	6	2.50	2	6	3.60	6	3.76	2	0	0.00	0	0	2
87	9028	162	1	5	18	6	6.78	1	6	12.66	1	[illegible]	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
88	9034	171	2	5	18	5	23.46	1	5	23.46	1	6	2.06	6	2.08	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	1
89	9041	185	2	5	18	6	2.66	3	6	2.68	2	0	0.00	0	0.00	0	6	2.78	6	2.91	2	0	0.00	0	0.00	0	6	4.36	6	4.68	2	0	0.00	0	0	2
90	9045	183	3	5	18	6	0.71	3	6	7.98	2	0	0.00	0	0.00	0	6	8.00	6	8.11	2	6	8.31	6	8.51	2	6	9.20	6	9.75	2	0	0.00	0	0	2
91	9048	168	4	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	5	21.71	5	21.75	1	5	22.35	5	22.45	1	5	23.13	5	23.28	2	0	0.00	0	0	1
92	9053	164	4	5	18	5	22.65	3	5	22.71	2	0	0.00	0	0.00	0	5	22.80	5	22.95	2	6	10.16	0	0.00	0	0	0.00	0	0.00	0	8	14.13	6	0	2
93	9068	183	5	5	18	6	10.68	3	6	10.98	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
94	9074	167	5	5	18	5	23.93	3	6	0.10	2	0	0.00	0	0.00	0	6	0.16	6	0.35	2	6	0.75	6	0.88	2	6	1.58	6	1.78	2	0	0.00	0	0	2
95	9080	163	6	5	18	6	10.23	1	6	21.98	1	6	22.83	7	0.28	3	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
96	9085	170	6	5	18	6	11.18	3	6	23.41	2	0	0.00	0	0.00	0	6	23.41	6	23.55	2	6	23.83	7	0.06	2	7	0.61	7	0.83	2	0	0.00	0	0	2
97	9089	182	7	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	6	3.91	6	4.05	2	6	4.43	6	4.51	1	6	5.41	6	5.55	2	0	0.00	0	0	1
98	9094	192	7	5	18	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
99	9109	163	8	5	18	6	22.10	3	6	22.11	2	0	0.00	0	0.00	0	6	22.53	6	22.61	2	6	22.96	6	23.10	2	6	23.76	6	23.91	2	0	0.00	0	0	2
100	7034	173	1	5	18	5	23.63	3	5	23.88	2	0	0.00	0	0.00	0	6	0.03	6	0.20	2	6	0.56	6	0.76	2	6	1.66	6	1.85	2	0	0.00	0	0	2

Appendix Table B4.--Passage data for radio-tagged chinook salmon smolts released into the forebay of Lower Granite Dam on 31 May 1985.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
1	1029	167	1	0	19.55	1	1.23	1	1	1.36	1	1	2.83	1	3.13	2	0	0.00
2	1035	171	1	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
3	1045	158	2	0	19.55	1	20.26	3	1	20.53	2	0	0.00	0	0.00	0	1	20.88
4	1052	169	3	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
5	1058	169	3	0	19.55	1	3.30	1	1	3.53	1	0	0.00	0	0.00	0	1	3.81
6	1062	167	4	0	19.55	1	2.88	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
7	1066	166	4	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
8	1075	164	5	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	1	2.55
9	1081	170	5	0	19.55	1	1.21	3	1	1.41	2	0	0.00	0	0.00	0	1	1.41
10	1090	158	6	0	19.55	1	1.60	1	1	21.91	1	0	0.00	0	0.00	0	1	22.65
11	1094	159	6	0	19.55	1	1.56	3	1	1.83	1	0	0.00	0	0.00	0	1	6.31
12	1098	160	7	0	19.55	1	5.43	3	1	6.03	2	0	0.00	0	0.00	0	1	6.28
13	1101	184	7	0	19.55	1	0.43	1	3	3.88	1	0	0.00	3	4.65	0	0	0.00
14	1106	158	8	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
15	2041	176	1	0	19.55	0	0.00	0	0	0.00	1	0	0.00	1	0.68	0	0	0.00
16	2046	182	1	0	19.55	1	4.48	1	1	5.11	1	0	0.00	0	0.00	0	0	0.00
17	2052	163	2	0	19.55	1	1.43	3	3	0.48	1	0	0.00	3	0.55	0	0	0.00
18	2058	160	2	0	19.55	1	3.43	1	1	3.53	1	0	0.00	0	0.00	0	0	0.00
19	2074	172	3	0	19.55	1	1.75	1	1	19.76	1	0	0.00	0	0.00	0	0	0.00
20	2077	160	4	0	19.55	1	4.55	3	1	15.73	1	1	19.96	1	20.03	1	0	0.00
21	2081	158	4	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
22	2085	200	5	0	19.55	1	3.11	3	1	15.60	1	0	0.00	0	0.00	0	0	0.00
23	2091	159	5	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
24	2102	156	6	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
25	3036	170	1	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
26	3039	175	1	0	19.55	1	0.26	1	1	0.31	1	1	0.95	0	0.00	4	0	0.00
27	3054	158	2	0	19.55	1	0.40	1	1	0.53	1	0	0.00	0	0.00	0	1	0.78
28	3059	162	3	0	19.55	1	7.46	1	2	20.81	1	2	20.90	2	21.35	2	0	0.00
29	3066	163	3	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	1	3.68
30	3080	175	4	0	19.55	1	14.65	3	3	0.95	1	0	0.00	0	0.00	0	0	0.00
31	3085	156	5	0	19.55	1	0.38	1	1	0.55	1	0	0.00	0	0.00	0	1	0.88
32	3089	195	5	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
33	3101	166	7	0	19.55	1	1.66	1	1	1.68	1	0	0.00	0	0.00	0	1	2.21
34	3104	159	6	0	19.55	1	6.65	1	1	8.13	1	[illegible]	0.00	0	0.00	0	1	8.93
35	3107	158	8	0	19.55	1	3.38	1	1	3.71	1	0	0.00	0	0.00	0	1	6.51
36	4029	173	8	0	19.55	1	14.51	3	0	0.00	0	0	0.00	0	0.00	0	0	0.00
37	4034	180	8	0	19.55	0	23.05	3	0	0.00	0	0	0.00	0	0.00	0	0	0.00
38	4042	182	7	0	19.55	1	12.25	3	1	22.40	2	0	0.00	0	0.00	0	1	22.61
39	4047	203	7	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
40	4059	165	6	0	19.55	1	1.11	3	1	1.25	1	1	2.16	1	2.98	4	0	0.00
41	4079	182	5	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
42	4082	175	4	0	19.55	1	0.93	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
43	4089	166	3	0	19.55	1	0.13	3	1	1.53	2	0	0.00	0	0.00	0	1	1.68
44	4096	169	2	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	1	1.38
45	4107	164	1	0	19.55	1	1.38	3	1	1.66	2	0	0.00	0	0.00	0	1	1.81
46	5042	161	8	0	19.55	1	14.83	3	1	21.35	2	0	0.00	0	0.00	0	1	21.51
47	5050	165	8	0	19.55	1	9.03	3	2	9.41	1	3	1.20	3	1.20	1	0	0.00
48	5061	164	7	0	19.55	1	1.73	3	1	1.73	2	0	0.00	0	0.00	0	1	1.95
49	5065	158	7	0	19.55	1	2.16	3	1	2.63	2	0	0.00	0	0.00	0	1	2.71
50	5070	175	6	0	19.55	1	3.26	1	1	3.63	1	0	0.00	0	0.00	0	0	0.00
51	5073	175	6	0	19.55	1	2.66	1	1	2.80	1	2	12.71	2	15.60	1	0	0.00
52	5083	175	5	0	19.55	1	20.76	3	1	20.85	2	0	0.00	0	0.00	0	1	22.45
53	5091	175	4	0	19.55	1	5.96	1	1	22.56	2	0	0.00	0	0.00	0	1	22.75

ROW	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
1	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
2	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
3	1	20.98	2	1	21.30	1	21.43	2	1	22.11	1	22.35	2	0	0.00	0	0	2
4	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
5	1	3.95	1	1	4.25	1	4.33	1	1	6.23	1	7.33	2	0	0.00	0	0	2
6	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	3	11.13	1	0	0
7	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
8	1	2.61	1	0	0.00	0	0.00	0	1	4.00	1	4.31	2	0	0.00	0	0	1
9	1	1.55	1	1	1.83	1	1.91	1	1	2.63	1	2.86	2	0	0.00	0	0	2
10	1	22.75	1	1	22.98	1	23.18	2	1	23.66	1	23.93	2	0	0.00	0	0	2
11	1	6.38	2	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
12	1	6.33	2	1	6.65	1	6.76	2	1	7.66	1	7.85	2	0	0.00	0	0	2
13	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
14	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
15	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	1
16	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
17	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
18	0	0.00	0	1	4.18	1	4.40	1	1	4.98	1	5.35	2	0	0.00	0	0	2
19	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
20	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
21	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
22	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
23	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
24	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
25	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
26	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
27	1	0.95	1	1	1.11	1	1.31	2	1	1.91	1	2.15	2	0	0.00	0	0	2
28	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
29	1	3.75	1	1	4.03	1	4.16	2	1	4.81	1	5.01	2	0	0.00	0	0	1
30	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
31	1	1.00	2	1	1.16	1	1.38	2	1	1.96	1	2.26	2	0	0.00	0	0	2
32	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
33	1	2.28	2	1	2.56	1	2.61	2	1	3.40	1	3.63	2	0	0.00	0	0	2
34	1	8.96	1	1	9.31	1	9.51	2	1	10.26	1	10.45	2	0	0.00	0	0	2
35	3	4.98	2	2	7.40	2	20.11	2	0	0.00	0	0.00	0	0	0.00	0	0	2
36	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	3	11.13	1	0	0
37	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	3	10.75	1	0	0
38	1	22.65	2	1	22.90	1	23.05	2	1	23.63	1	23.83	2	0	0.00	0	0	2
39	0	[illegible]	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
40	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
41	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
42	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	3	11.01	1	0	0
43	1	1.78	1	1	2.03	1	2.33	2	1	13.60	1	14.03	2	0	0.00	0	0	2
44	1	1.45	1	1	1.75	1	1.86	1	1	2.48	1	2.65	2	0	0.00	0	0	1
45	1	1.95	1	1	2.23	1	2.38	1	1	2.98	1	3.16	2	0	0.00	0	0	2
46	1	21.58	1	1	21.78	1	21.95	2	1	22.48	1	22.70	2	0	0.00	0	0	2
47	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
48	1	2.05	1	1	2.26	1	2.43	2	1	3.01	1	3.28	1	0	0.00	0	0	2
49	1	2.85	1	1	3.11	1	3.31	2	1	3.86	1	4.56	2	0	0.00	0	0	2
50	0	0.00	0	1	4.06	1	4.35	2	1	4.35	1	5.26	2	0	0.00	0	0	2
51	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
52	1	22.55	1	1	22.73	1	22.96	2	1	23.51	1	23.80	2	0	0.00	0	0	2
53	1	22.85	1	1	23.06	1	23.41	2	2	0.05	2	0.33	2	0	0.00	0	0	2

Appendix Table B4.--cont.

ROW	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
54	5098	162	3	0	19.55	1	4.11	3	1	19.50	1	0	0.00	0	0.00	0	0	0.00
55	5104	170	2	0	19.55	1	0.45	1	1	0.75	1	0	0.00	0	0.00	0	0	0.00
56	6030	165	8	0	19.55	1	0.05	3	1	1.43	1	1	1.66	1	2.95	5	0	0.00
57	6034	171	8	0	19.55	1	0.60	3	1	0.78	1	1	0.93	1	1.16	1	0	0.00
58	6041	157	7	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
59	6047	177	7	0	19.55	1	1.53	3	3	4.75	2	0	0.00	0	0.00	0	0	0.00
60	6050	167	6	0	19.55	1	12.48	1	1	21.56	1	0	0.00	0	0.00	0	1	22.01
61	6068	155	5	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
62	6074	190	5	0	19.55	1	1.85	3	1	2.51	2	0	0.00	0	0.00	0	1	2.68
63	6077	173	4	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	1	21.21
64	6080	200	4	0	19.55	1	3.63	1	1	3.80	1	1	3.80	1	3.80	2	0	0.00
65	6085	157	3	0	19.55	0	23.35	3	1	0.91	2	0	0.00	0	0.00	0	1	1.01
66	6094	183	2	0	19.55	0	23.70	1	-1	23.70	1	0	0.00	0	0.00	0	1	0.21
67	6105	187	1	0	19.55	1	9.35	1	2	20.45	1	0	0.00	0	0.00	0	2	20.71
68	7029	166	8	0	19.55	1	5.66	1	0	0.00	0	0	0.00	0	0.00	0	0	0.00
69	7041	180	8	0	19.55	1	2.26	3	1	2.35	2	0	0.00	0	0.00	0	1	2.48
70	7047	183	7	0	19.55	1	18.40	2	1	20.10	1	0	0.00	0	0.00	0	1	20.51
71	7063	173	6	0	19.55	1	11.33	1	2	6.21	1	0	0.00	0	0.00	0	0	0.00
72	7082	171	4	0	19.55	1	0.35	3	1	0.36	2	0	0.00	0	0.00	0	1	0.81
73	7089	183	3	0	19.55	1	4.53	1	1	15.26	1	0	0.00	0	0.00	0	0	0.00
74	7092	205	2	0	19.55	1	2.73	3	1	2.83	1	1	3.13	1	3.21	5	0	0.00
75	7102	165	1	0	19.55	1	1.90	1	1	2.78	1	0	0.00	1	7.61	0	0	0.00
76	7106	173	1	0	19.55	1	4.30	1	2	20.65	2	0	0.00	0	0.00	0	2	21.05
77	8029	178	1	0	19.55	1	4.88	1	1	5.51	1	0	0.00	0	0.00	0	1	6.01
78	8034	182	2	0	19.55	1	1.93	1	1	2.10	1	0	0.00	0	0.00	0	1	4.95
79	8041	180	3	0	19.55	1	0.50	1	1	0.65	1	0	0.00	0	0.00	0	1	1.05
80	8049	186	3	0	19.55	1	1.08	1	1	1.31	1	1	1.31	1	2.96	1	0	0.00
81	8053	172	4	0	19.55	1	8.91	1	3	4.91	2	0	0.00	0	0.00	0	0	0.00
82	8058	162	4	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
83	8065	159	5	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	1	0.38
84	8070	170	5	0	19.55	1	0.50	1	1	1.38	2	0	0.00	0	0.00	0	1	1.65
85	8079	164	6	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
86	8082	156	6	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
87	8085	163	7	0	19.55	0	23.51	3	-1	23.96	1	[illegible]	0.91	0	0.00	4	0	0.00
88	8090	175	7	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
89	8101	172	8	0	19.55	1	18.66	3	1	20.58	2	0	0.00	0	0.00	0	1	20.71
90	9028	167	1	0	19.55	1	2.21	1	1	21.45	1	0	0.00	0	0.00	0	1	21.88
91	9034	162	2	0	19.55	1	1.80	3	1	1.80	2	0	0.00	0	0.00	0	1	1.95
92	9042	180	3	0	19.55	1	3.10	1	1	13.53	2	0	0.00	0	0.00	0	0	0.00
93	9047	179	4	0	19.55	1	6.91	3	1	7.03	2	0	0.00	0	0.00	0	0	0.00
94	9059	165	5	0	19.55	1	1.96	1	1	2.13	1	0	0.00	1	3.45	0	0	0.00
95	9062	187	5	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00
96	9069	200	6	0	19.55	1	1.36	3	1	1.43	2	0	0.00	0	0.00	0	1	1.65
97	9074	199	6	0	19.55	1	4.13	1	1	21.91	1	1	22.15	1	22.16	2	0	0.00
98	9088	165	7	0	19.55	1	4.65	1	1	4.80	1	1	18.08	1	20.75	2	0	0.00
99	9093	167	7	0	19.55	1	20.08	3	1	20.90	2	0	0.00	0	0.00	0	0	0.00
100	9100	186	8	0	19.55	1	5.51	1	2	0.53	2	0	0.00	0	0.00	0	2	0.65
101	9103	178	8	0	19.55	0	0.00	0	0	0.00	0	0	0.00	0	0.00	0	0	0.00

ROW	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36
54	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
55	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
56	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
57	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
58	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
59	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
60	1	22.08	1	1	23.36	1	22.60	2	1	23.10	1	23.35	2	0	0.00	0	0	2
61	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
62	1	2.81	1	1	3.08	1	3.26	2	1	3.93	1	4.20	2	0	0.00	0	0	2
63	1	21.31	1	1	21.55	1	21.76	2	1	22.45	1	22.66	2	0	0.00	0	0	1
64	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
65	1	1.11	1	1	1.31	1	1.53	2	1	2.01	1	2.30	2	0	0.00	0	0	2
66	1	0.28	1	1	0.35	1	0.68	2	1	1.23	1	1.35	2	0	0.00	0	0	2
67	2	20.78	1	2	21.06	2	21.16	2	2	21.95	2	22.11	2	0	0.00	0	0	2
68	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	3	11.13	1	0	0
69	1	2.58	1	1	2.81	1	2.98	2	1	3.55	1	3.78	2	0	0.00	0	0	2
70	1	20.55	1	1	20.95	1	20.96	1	1	22.26	1	22.40	1	0	0.00	0	0	2
71	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
72	1	0.85	1	1	1.13	1	1.15	1	1	2.06	1	2.18	1	0	0.00	0	0	2
73	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
74	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
75	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
76	2	21.15	1	2	21.40	2	21.60	2	2	22.25	2	22.45	2	0	0.00	0	0	2
77	1	6.11	1	1	6.40	1	6.60	2	1	7.26	1	7.45	2	0	0.00	0	0	2
78	1	10.21	1	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
79	1	1.11	2	1	1.36	1	1.51	1	1	1.65	1	2.55	2	0	0.00	0	0	2
80	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
81	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
82	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
83	1	0.45	1	1	0.71	1	0.86	2	1	1.61	1	1.71	2	0	0.00	0	0	1
84	1	1.75	1	1	2.15	1	2.33	2	1	3.06	1	3.28	2	0	0.00	0	0	2
85	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
86	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
87	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
88	0	0.00	0	1	3.51	1	3.65	2	1	9.85	1	9.98	2	0	0.00	0	0	1
89	1	20.81	1	1	21.16	1	21.36	2	1	22.21	1	22.30	1	0	0.00	0	0	2
90	1	21.91	1	1	22.16	1	22.46	2	1	23.28	1	23.45	2	0	0.00	0	0	2
91	1	2.05	1	1	2.30	1	2.43	2	1	3.01	1	3.16	2	0	0.00	0	0	2
92	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
93	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
94	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
95	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0
96	1	1.75	1	1	2.03	1	2.15	2	1	2.91	1	3.13	2	0	0.00	0	0	2
97	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
98	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	2
99	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	1	2
100	2	0.78	1	2	1.05	2	1.18	1	2	1.81	2	2.06	2	0	0.00	0	0	2
101	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0.00	0	0	0

APPENDIX C

Budgetary Summary

A. Summary of expenditures

1.	Personnel	158.0
2.	Travel & transportation of persons	5.7
3.	Transportation of things	5.8
4.	Rent, communication, & utilities	6.9
5.	Printing & reproduction	0.0
4.	Contracts & other services	16.7
5.	Supplies and Materials	69.9
6.	Equipment	9.8
7.	Grants	0.0
7.	Support (NOAA, DOC)	62.4
	Total	335.3

B. Major property items

1. None