FISH RESEARCH PROJECT - OREGON

SMOLT MIGRATION CHARACTERISTICS AND MAINSTEM SNAKE AND COLUMBIA RIVER DETECTION RATES OF PIT-TAGGED GRANDE RONDE AND IMNAHA RIVER NATURALLY-PRODUCED SPRING CHINOOK SALMON

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CONTENTS

EXECUTIVE SUMMARY

Objectives for 1996

1. Collect and tag with implantable passive integrated transponder (PIT) tags 500 chinook salmon parr from Catherine Creek and 1,000 chinook salmon parr each from the Imnaha, Lostine, Minam, and Wenaha rivers.

2. Determine size frequency distribution and mean length and weight of juvenile chinook salmon from Catherine Creek and the Imnaha, Lostine, Minam, and Wenaha rivers.

3. Submit PIT-tagging data files to the PIT Tag Information System database administered by the Pacific States Marine Fisheries Commission.

4. Determine the short-term (24 h) effect of PIT-tagging on the survival of juvenile chinook salmon.

5. Compare average length of juvenile chinook salmon from Catherine Creek and the Imnaha, Lostine, Minam, and Wenaha rivers. Correlate average length with relative abundance and habitat quality.

6. Determine and compare cumulative detection rates and migration timing in 1996 of juvenile chinook salmon that were tagged and released in Catherine Creek and the Imnaha, Lostine, Minam, and Wenaha rivers in 1995.

Accomplishments in 1996

We were unable to accomplish all of our objectives in 1996. We did not meet our PIT-tagging objectives for the Lostine, Minam, and Wenaha rivers, and mortality tests were not conducted in the Lostine and Wenaha rivers, because sufficient numbers of fish could not be collected. We did not correlate average fish length with relative abundance and habitat quality because information on abundance was insufficient.

Findings in 1996

In all streams but the Imnaha River, we had difficulty locating a sufficient number of juvenile chinook salmon. We expected enough juveniles would be available given spawner escapements in 1995. Severe floods that occurred during the winter and spring preceding our sampling efforts may have affected the survival or distribution of juvenile salmon in 1996.

We tagged and released 2,780 of 3,998 naturally-produced chinook salmon collected in the five study streams. Most of the fish that were not tagged were collected for a captive brood stock program. Only 12 fish, all from the Lostine River, were released because they were too small to tag (less than 60 mm fork length). Thus, we tagged fish that were representative, with respect to length, of those collected.

PIT-tagging did not affect the short-term survival of juvenile salmon. No fish in any of the treatment (handled and tagged) or control (handled only) groups died in 24 h mortality tests.

Based on data expanded for spillway flow, the overall median migration date at Lower Granite Dam for fish from Catherine Creek and the Imnaha, Lostine, Minam, and Wenaha rivers was 28 April. Median dates for individual populations ranged from 21 April (Wenaha River) to 15 May (Lostine River). Migration timing at Lower Granite Dam was significantly different among populations.

One fish tagged in the Grande Ronde River in 1994 (1993 brood) was detected in a dam's juvenile bypass in 1996, one year after the fish was expected to migrate seaward. This fish accounted for 0.7% of the total detections from the 1993 brood of Grande Ronde River fish.

Overall median travel times from Lower Granite Dam to Little Goose, Lower Monumental, and McNary dams were 5.2, 6.6, and 9.2 d, respectively. Individual fish took as many as 15.0, 16.8, and 21.2 d to travel from Lower Granite Dam to Little Goose, Lower Monumental, and McNary dams, respectively.

Cumulative detection rates of individual populations ranged from 15.4% (Minam River) to 18.9% (Imnaha River) and were generally among the highest observed for each population during the past four years. The overall cumulative detection rate in 1996 was the second highest yet observed, despite a condiderable increase in spill at the dams relative to previous years.

Management Implications and Recommendations

Over the past four years, migration timing at Lower Granite Dam varied among populations of naturally-produced chinook salmon smolts from the Grande Ronde and Imnaha River subbasins. Migrants from the Wenaha River were among the earliest to arrive at Lower Granite Dam each year, whereas migrants from the upper Grande Ronde River (when present among PIT-tagged groups) and Catherine Creek were among the latest to arrive at the dam. Our findings, coupled with those of Keefe et al. (1994, 1995) and Jonasson et al. (1996), demonstrate that chinook salmon from northeast Oregon streams exhibit population-specific life history characteristics. A prerequisite to any management activity affecting these populations should be to preserve the array of life history characteristics exhibited by individuals from the various populations. We should continue to monitor the migration characteristics of juvenile chinook salmon from the Grande Ronde and Imnaha subbasins for several reasons: 1) to track changes in migration patterns that might occur over time, 2) so that migration data is collected over a range of environmental conditions, 3) so that the effects of management activities might be assessed, and 4) so that chinook salmon from northeast Oregon streams are represented among PIT-tagged groups emigrating from the Snake River basin each year.

The difficulty we had in locating chinook salmon parr from the 1995 brood may indicate that much of the production from that brood was lost during severe winter and spring floods in 1996. Adult returns produced by spawners in 1995 may be fewer than would be anticipated normally. This possibility

should be taken into account when making future management decisions that rely on run predictions.

Detections of age 33 fish (age recorded by the system of Gilbert and Rich 1927) in the juvenile bypasses of dams in 1996 and previous years indicate that chinook salmon from northeast Oregon streams do not migrate seaward exlusively at age 22. Fish from a wider range of age classes than previously thought possible may be present among freshwater populations of juvenile chinook salmon. Because management of chinook salmon would be improved by a more complete understanding of their biology, we should study populations in the Grande Ronde and Imnaha River subbasins with respect to age at seaward migration. Investigations should focus on the mechanisms governing age at seaward migration and on the frequency of occurrence of the various life history types.

INTRODUCTION

This is the fifth year of a multi-year study to assess smolt migration characteristics and cumulative detection rates of naturally-produced chinook salmon *(Oncorhynchus tshawytscha)* from northeast Oregon streams. The goal of this project is to develop an understanding of interpopulation and interannual variation in several early life history characteristics of naturally-produced chinook salmon from the Grande Ronde and Imnaha River subbasins. This project provides information useful in the recovery of listed Snake River spring/sumner chinook salmon. Specific populations included in the study are (1) Catherine Creek, (2) upper Grande Ronde River, (3) Lostine River, (4) Imnaha River, (5) Wenaha River, and (6) Minam River. In this document, we present findings from research completed in 1996.

Naturally-produced chinook salmon populations in the Grande Ronde and Imnaha River subbasins have declined drastically in recent years (Carmichael et al. 1991) due in part to habitat alterations(ASET 1979; Carmichael 1989; Raymond 1988) and hydropower development (Wedemeyer et al. 1985; Raymond 1988). Declines have continued despite extensive mitigation efforts, including fish passage improvements, artificial production, supplementation, and habitat modification (BPA Division of Fish and Wildlife 1990). Snake River spring/summer chinook salmon (hereafter referred to as chinook salmon), which include naturally-produced chinook salmon in the Grande Ronde and Imnaha River subbasins, have been listed under the Endangered Species Act of 1973 as threatened or endangered since 1992 (National Marine Fisheries Service 1992, 1994).

Information on smolt migration characteristics is essential to recovery efforts focused on fish passage in the Snake and Columbia rivers. With the development of the passive integrated transponder (PIT) tag (Prentice et al. 1990a) and remote PIT tag monitoring systems (Prentice et al.1990b) in the mid-1980's, it became possible to identify individual fish and monitor the smolt migrations of specific populations at Snake and Columbia River dams. From 1989 to 1991 National Marine Fisheries Service (NMFS) personnel investigated the migration characteristics of PIT-tagged, naturally-produced chinook salmon smolts from four populations in northeast Oregon (Matthews et al. 1990, 1992;Achord et al. 1992). Since 1992, investigation of these and two additional populations has been conducted by the Oregon Department of Fish and Wildlife. Through long-term monitoring of the migration timing and detection rates of these populations, we can increase our knowledge of population specific migration patterns, abundances, and responses to management actions designed to improve survival and preserve life history patterns. Our study, along with those conducted by Matthews et al. (1990, 1992) andAchord et al. (1992), is providing information that can be used to develop flow targets (NMFS 1995). This study is also providing information useful in assessing and identifying wild chinook salmon stocks, in accordance with the Oregon Department of Fish and Wildlife's wild fish management policy, and in developing broodstock guidelines and supplementation strategies for future hatchery and captive rearing programs.

METHODS

We used information available from previous years of this study and 1995 spawning ground surveys to select sampling sites for juvenile chinook salmon in 1996. We snorkeled to locate juvenile salmon and collected them either by seining or by herding them into a seine set perpendicular to the stream flow. We collected and PIT-tagged fish from Catherine Creek, and the Imnaha, Lostine, Minam, and Wenaha rivers from 13 August through 9 October (Table 1). We did not attempt to tag fish in the upper Grande Ronde River because juvenile salmon abundance was extremely low.

PIT tags were implanted using methods similar to those described by Prentice et al. (1986, 1990c) and Matthews et al. (1990, 1992). We tagged fish only at stream temperatures of 15°C or less. Fish were anesthetized with 40-50 ppm MS-222 (Strange and Schreck 1978; Matthews et al. 1990, 1992) and tagged manually using modified 12-gauge hypodermic needles. Needles were disinfected for 10 minutes in 70% ethanol after a single use. We recorded the tag code, fork length (nearest 1 mm), and weight (nearest 0.1 g) of each PIT-tagged chinook salmon. We attempted to tag only fish that were 60 mm fork length or longer and appeared to be in good condition. We did not tag precocious males, fish collected for additional studies, nor fish collected in excess of the numeric goal for each stream. We released fish near the collection site once they had recovered from the anesthesia. Tagging data were incorporated into ASCII files, according to criteria developed by the PIT Tag Steering Committee, and then submitted to the Columbia River Basin PIT Tag Information System (PTAGIS) database, administered by the Pacific States Marine Fisheries Commission.

To determine the short-term effect of PIT-tagging on the survival of juvenile chinook salmon, we held tagged (treatment) and untagged (control) groups for 24 h and recorded all mortalities. Untagged controls were subjected to the same handling conditions as PIT-tagged fish, except they were not injected with a PIT tag. In the Imnaha River, 100 tagged and 50 untagged fish were held in two live cages, each containing 50 tagged and 25 untagged fish. In both Catherine Creek and the Minam River, 50 tagged and 25 untagged fish were held in one live cage.

After the 1996 outmigration was completed, detection data at Lower Granite, Little Goose, Lower Monumental, and McNary dams were downloaded from the PTAGIS database. We pooled migration timing data for the Catherine Creek and Imnaha, Lostine, Minam, and Wenaha River populations to determine overall migration timing at Lower Granite Dam in 1996. In addition, we examined population-specific migration timing at each of the four dams. Because some PIT-tagged fish may have passed undetected over each dam's spillway, and spill varied throughout the migration, migration timing data for pooled and individual populations were expanded for spillway flow. To expand detection data, we determined the arrival dates of fish detected for the first time at each dam, multiplied the number of fish detected each day by an expansion factor (Appendix Table A-l), which was calculated as

(Powerhouse Flow + Spillway Flow)/ Powerhouse Flow,

and rounded the product to the nearest integer. We used expanded daily detections, the Kruskal-Wallis test (Hollander and Wolfe 1973; SAS Institute

Table 1. Collection and tagging information for naturally-produced juvenile chinook salmon from five streams in the Grande Ronde and Imnaha River subbasins 1996. Data exclude recaptured, PIT-tagged fish. Number collected includes fish collected for a captive brood program and a genetics study.

Stream	Dates collected	Number collected	Collection mortality	Number tagged and released	Tagging mortality
Catherine	8/26-8/30	1,177	0	585	0
Imnaha	9/9-9/11	1,057	0	1,017	0
Lostine	8/13-8/17, 8/21-8/23	1,021	0	527	1
Minam	9/3-9/6; 9/12, 9/13, 9/19, 10/8, 10/9	641	0	589	3
Wenaha	8/18-8/20	102	.0	62	0
Total		3,998	0 (0.0%)	2,780	(0.14%)

1988), and a multiple-comparisons procedure (at alpha=0.15; Daniel 1990) to analyze migration timing at Lower Granite Dam.

To estimate travel time between Lower Granite Dam and Little Goose Lower Monumental, and McNary dams, we used observations of individual fish detected at Lower Granite and one or more of the dams downstream. Travel time for each individual was calculated as the difference, in days, between the dates of initial detection within the bypass system at Lower Granite Dam and Little Goose, Lower Monumental, or McNary dams. We calculated median travel times and 95% confidence intervals (Snedecor and Cochran 1980) for each population and all populations pooled.

The final migration characteristic evaluated was cumulative detection rate at Snake and Columbia River dams. To calculate cumulative detection rates for individual populations, we divided the sum of the unexpanded first-time detections for each population by the total number of fish tagged and

released in each stream. We combined detection and tagging numbers for individual populations to calculate an overall cumulative detection rate.

RESULTS AND DISCUSSION

We PIT-tagged and released 2,780 of 3,998 chinook salmon collected from Catherine Creek and the Imnaha, Lostine, Minam, and Wenaha rivers in 1996. The number of fish tagged and released in each stream ranged from 62 in the Wenaha River to 1,017 in Imnaha River (Table 1). We had difficulty locating sufficient numbers of juveniles in all streams except the Imnaha River, despite adequate escapements of adult spawners in 1995. Severe floods that occurred during the winter and spring previous to our sampling efforts may have affected the survival or distribution of juvenile salmon in 1996.

Fork lengths and weights of tagged fish were similar to those of the entire group of fish collected in each stream (Tables 2 and 3), indicating that, at least with respect to size, tagged fish were representative of the fish sampled. Only 12 fish, all from the Lostine River, were released because they were too small to tag (less than 60 mm fork length). Mean fork length and weight varied among populations, increasing positively with timing of collection (Tables 1, 2, and 3).

Results from 24 hr mortality tests indicated that PIT-tagging did not affect the short-term survival of juvenile salmon. No fish in any of the treatment or control groups died-during tests. The mortality rate among all PIT-tagged fish held for 24 h in 1996 (0.0%;n=200) was within the range (0.0 - 1.5%) reported in previous years of this study (Walters et al. 1992, 1993, 1994; Sankovich et al. 1995) and in similar studies in Idaho and Oregon (Matthews et al. 1990, 1992; Achord et al. 1992, 1994, 1995).

Fish PIT-tagged in 1995 were detected at Lower Granite Dam between 10 April and 19 June 1996, inclusive. Through late May, arrival timing of the pooled populations tended to mirror flow patterns at Lower Granite Dam (Figure 1). Virtually all of the detections occurred before peak flow in mid-June. The median date of arrival at Lower Granite Dam was 28 April for the pooled populations (Figure 1). That this was the earliest median date of arrival observed in the last four years (median dates were 8 May in 1993 and 5 May in 1994 and 1995) may be due in part, at least, to the absence of upper Grande Ronde River fish from the pooled populations in 1996. No fish from the upper Grande Ronde River population, which was among the latest to arrive at Lower Granite from 1993 to 1995, were tagged in 1995.

Migration timing of individual populations at Lower Granite, Little Goose, Lower Monumental, and McNary dams is presented in Figures 2-6 and Appendix Tables 8-l through 8-5. The median date of arrival at Lower Granite Dam ranged from 21 April for the Wenaha River population (n=105; Figure 6) to 15 May for the Lostine River population (n=129; Figure 4). The median date of arrival at McNary Dam, the farthest downstream of the four dams, ranged from 27 April for the Wenaha River population (n=ll; Figure 6) to 30 May for the Lostine River population (n=5; Figure 4).

Migration timing at Lower Granite Dam was significantly different among populations (P=0.000l). Multiple comparisons of migration timing indicated

Table 2. Mean fork length (mm) of all naturally-produced juvenile chinook salmon collected, and those PIT-tagged and released, in five streams in the Grande Ronde and lmnaha River subbasins, 1996. SE = standard error, Min = minimum length, Max = maximum length. Number collected includes fish collected for a captive brood program and a genetics study.

	Collected				
Stream	N	Mean	SE	Min	Max
Catherine Cr.	1,106	84.8	0.21	60	109
Imnaha	1,057	85.0	0.21	64	121
Lostine	1,008	77.7	0.29	55	105
Minam	633	91.5	0.29	68	114
Wenaha	101	80.7	0.39	71	89

	PIT-tagged and released				
Stream	N	Mean	SE	Min	Max
CatherineCr.	585	84.5	0.30	60	109
Imnaha	1,017	85.0	0.21	64	121
Lostine	528	76.5	0.37	59	105
Minam	592	91.6	0.30	68	114
Wenaha	62	81.0	0.49	74	89

Table 3. Mean weight (g) of all naturally-produced juvenile chinook salmon collected and those PIT-tagged and released, in five streams in the Grande Ronde and Imnaha River subbasins, 1996. SE = standard error, Min = minimum weight, Max = maximum weight.

	Collected				
Stream	N	Mean	SE	Min	Max
Catherine Cr.	776	7.24	0.07	2	16.9
Imnaha	1,057	7.37	0.06	3	22.3
Lostine	1,007	5.73	0.07	1.9	13.8
Minam	552	8.91	0.09	4.1	18.0
Wenaha	72	6.11	0.12	4.2	8.3

	PIT-tagged and released				
	N	Mean	SE	Min	Max
Catherine Cr.	585	7.02	0.08	2	16.9
Imnaha	1,017	7.38	0.06	3	22.3
Lostine	528	5.51	0.09	1.9	13.8
Minam	512	8.96	0.10	4.1	18.0
Wenaha	62	6.04	0.13	4.2	8.3

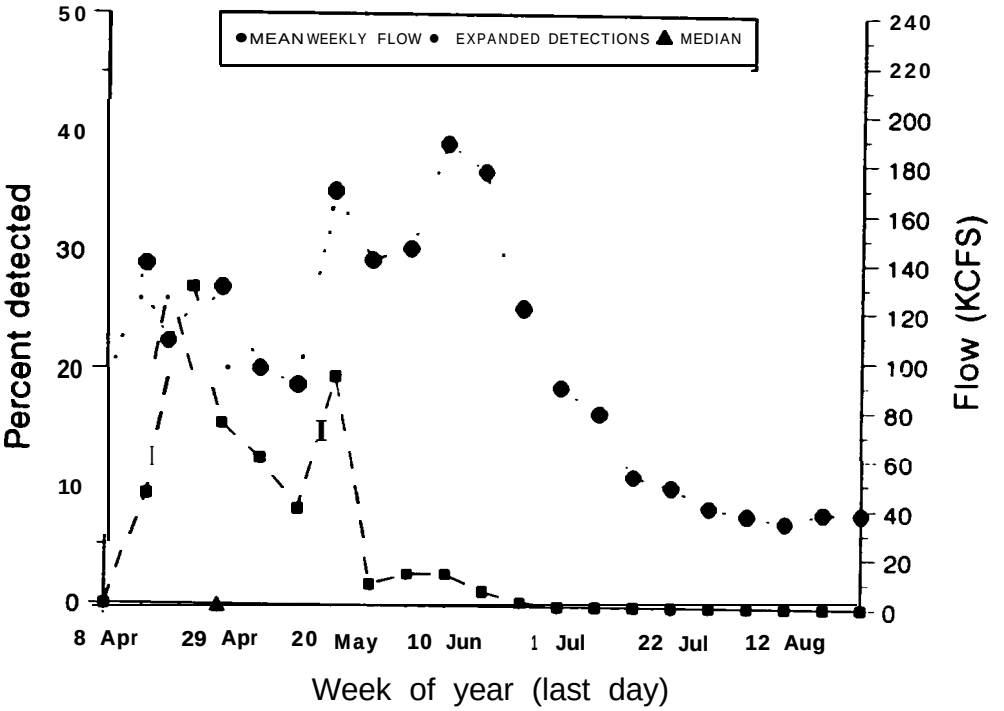

Figure 1. Migration timing of naturally-produced juvenile chinook salmon from the Grande Ronde and lmnaha River subbasins, and flow at Lower Granite Dam, 1996 migration year. ▲ = median arrival date. Daily arrival numbers were expanded for spillway flow.

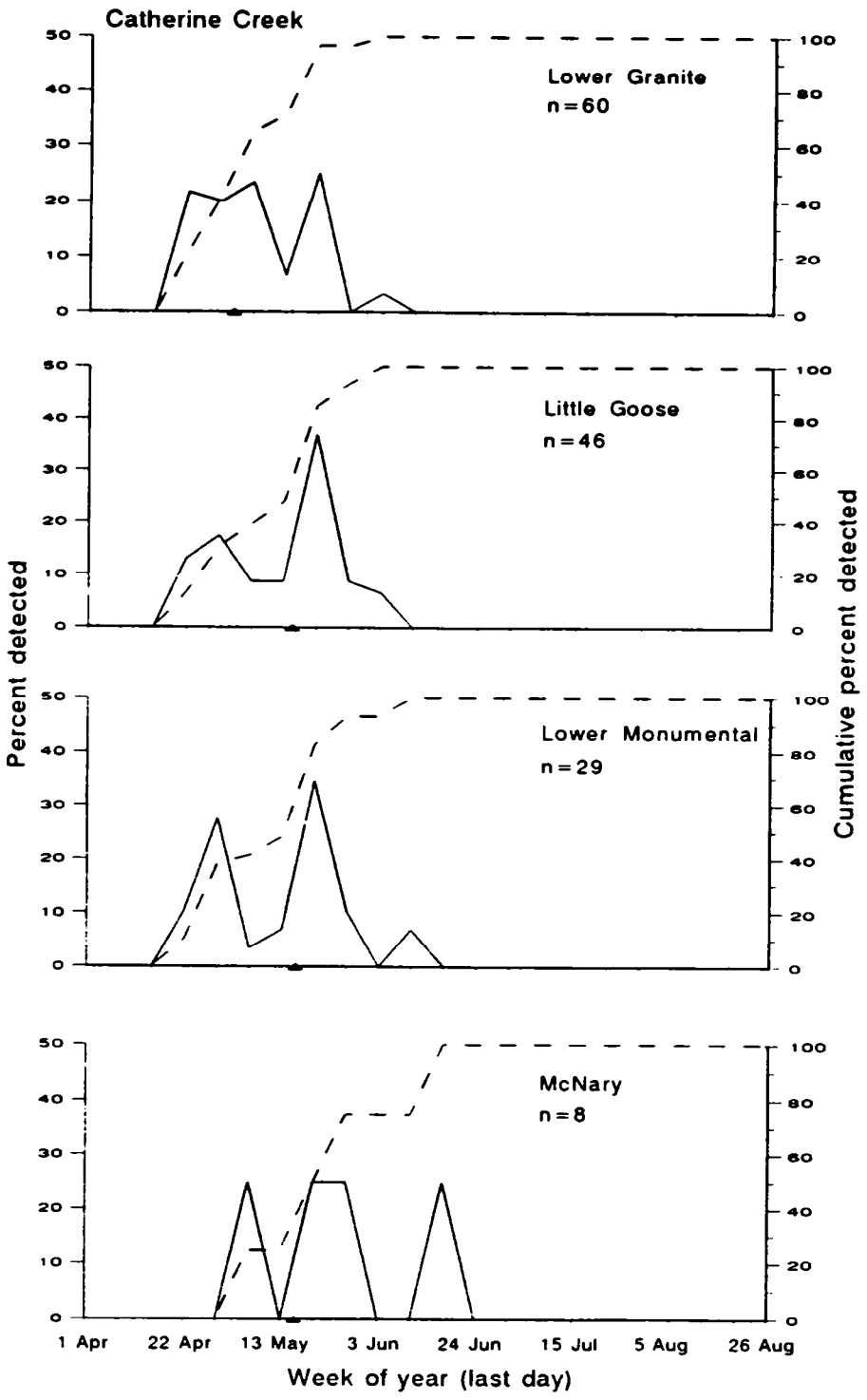

Figure 2. Migration timing at Lower Granite, Little Goose, Lower Monumental, and McNary dams for naturally-produced juvenile chinook salmon from Catherine Creek, 1996 migration year. ▲ = median arrival date. Data were from first-time detections at each dam and were expanded for spillway flow.

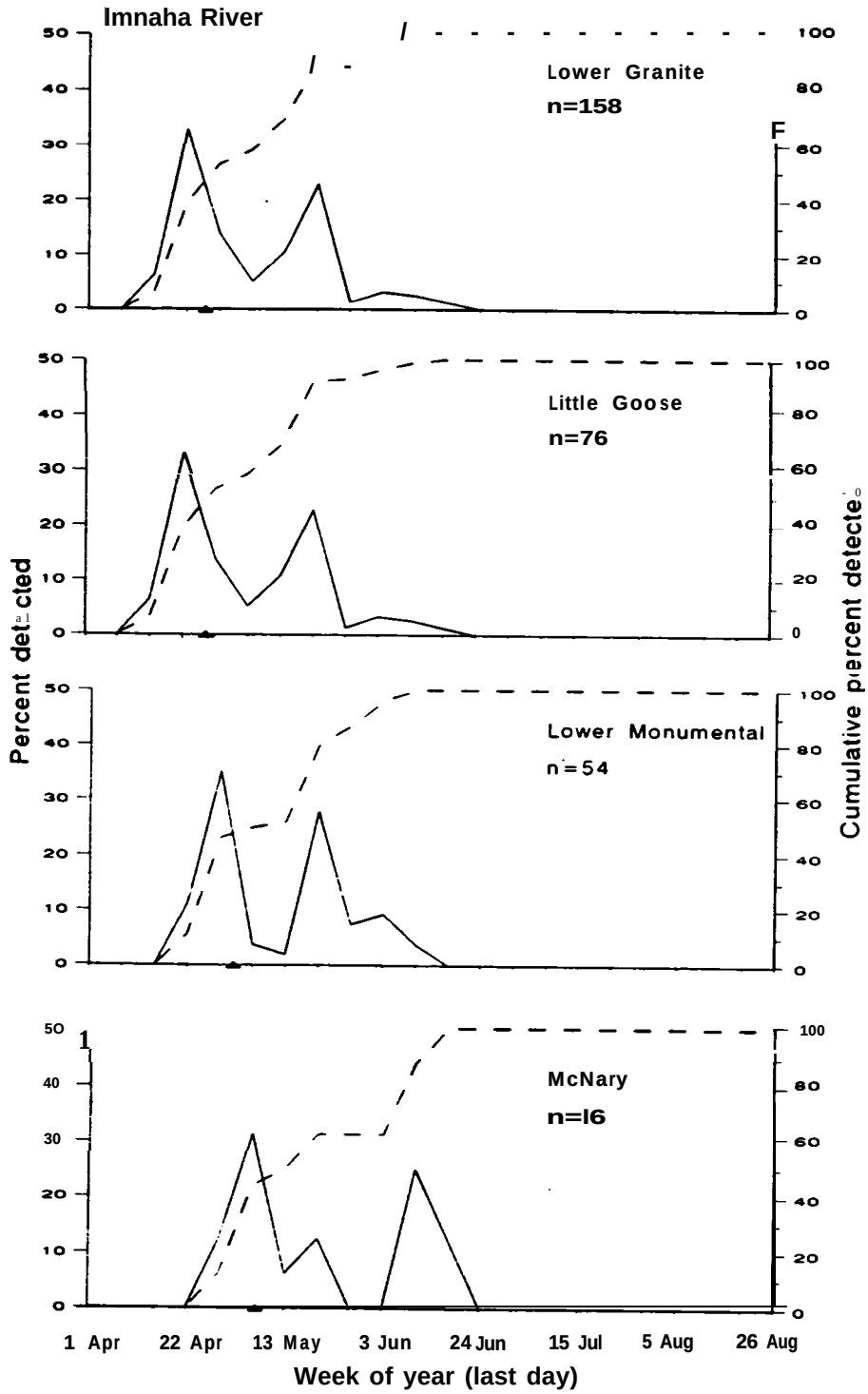

Figure 3. Migration timing at Lower Granite, Little Goose, Lower Monumental and McNary dams for naturally-produced juvenile chinook salmon from the Imnaha River, 1996 migration year. ▲ = median arrival date. Data were from first-time detections at each dam and were expanded for spillway flow.

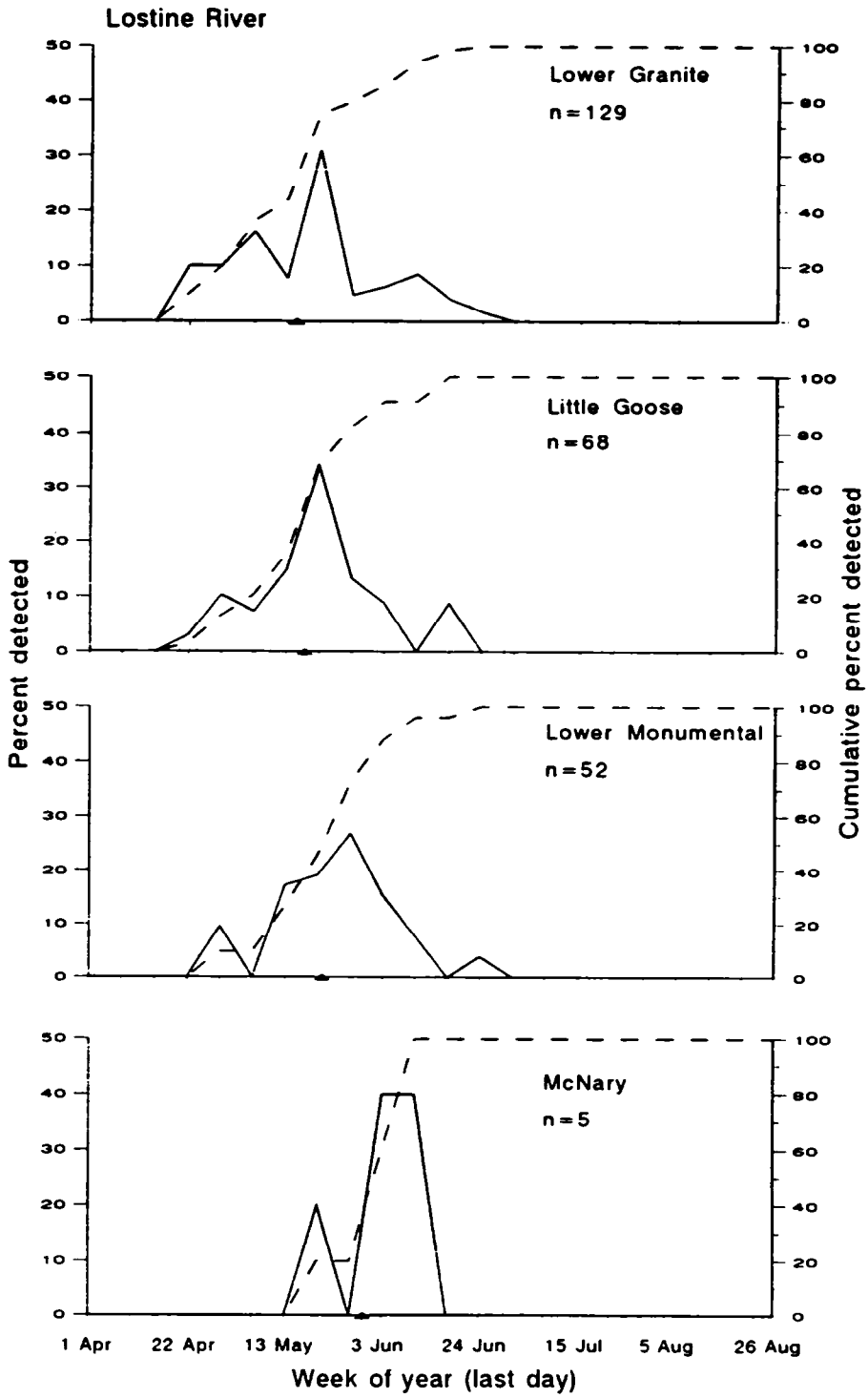

Figure 4. Migration timing at Lower Granite, Little Goose, Lower Monumental, and McNary dams for naturally-produced juvenile chinook salmon from the Lostine River, 1996 migration year. ▲ = median arrival date. Data were from first-time detections at each dam and were expanded for spillway flow.

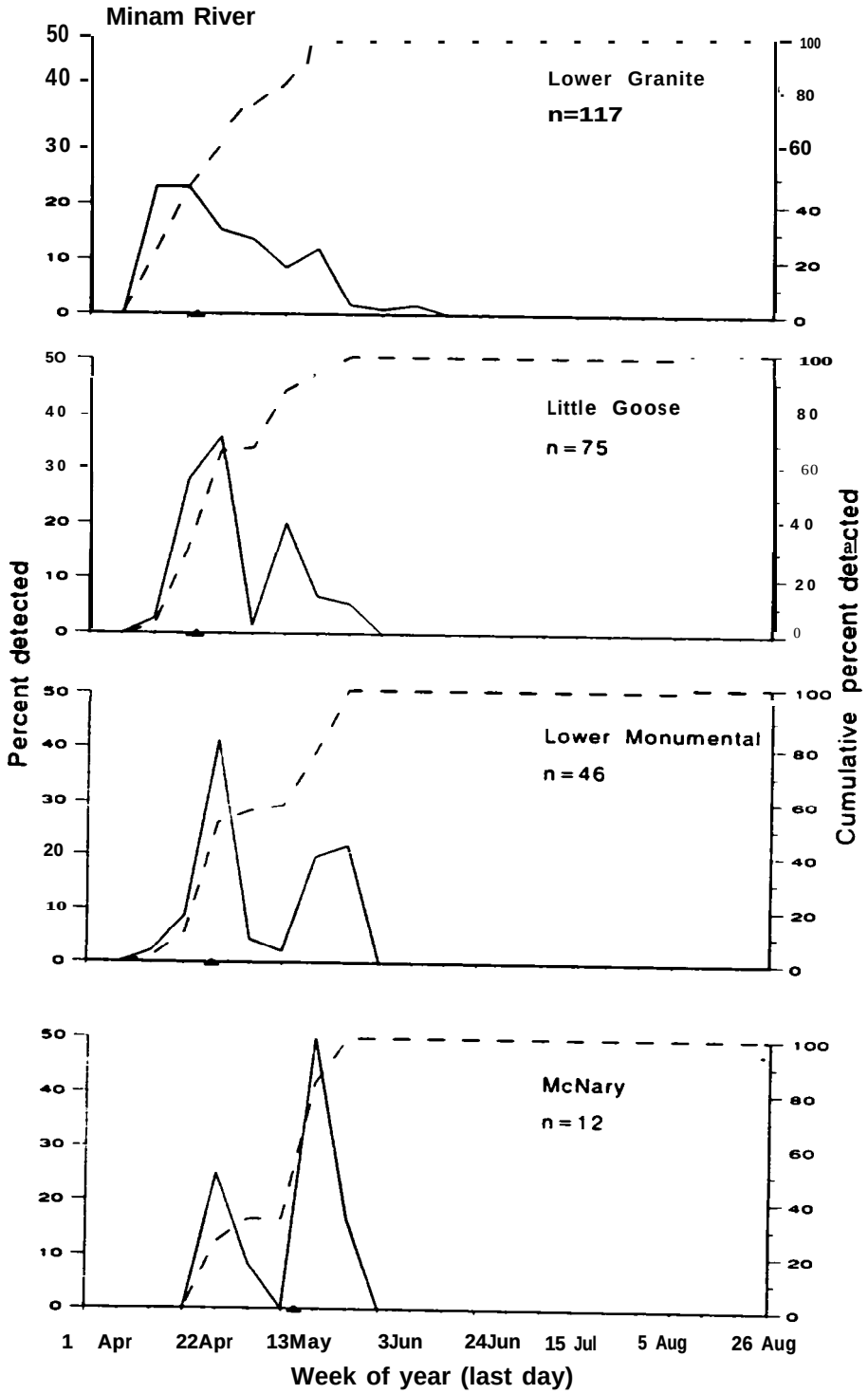

Figure 5. Migration timing at Lower Granite, Little Goose, Lower Monumental and McNary dams for naturally-produced juvenile chinook salmon from the River, 1996 migration year. ▲ = median arrival date. Data were from first-time detections at each dam and were expanded for spillway flow.

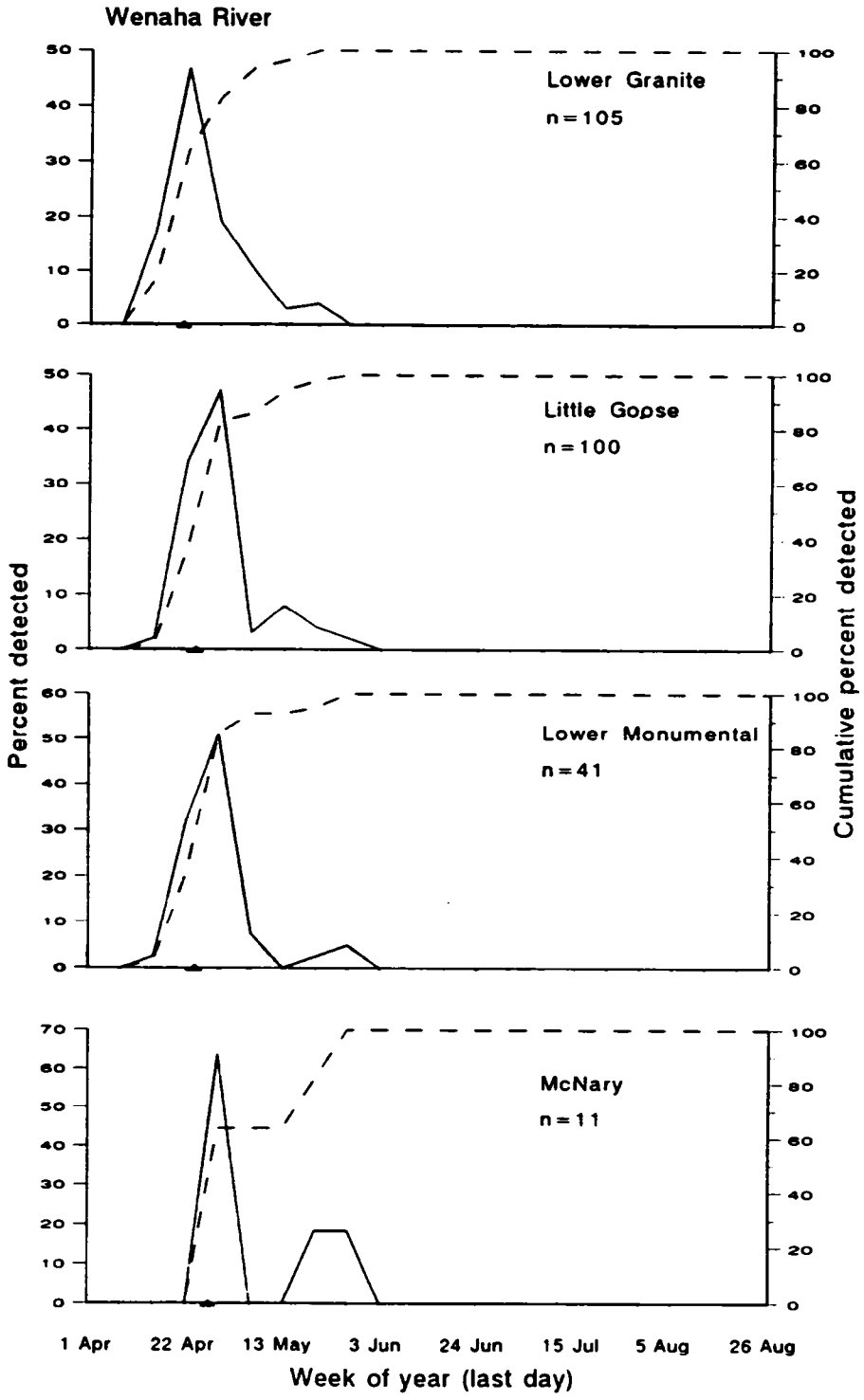

Figure 6. Migration timing at Lower Granite, Little Goose, Lower Monumental, and McNary dams for naturally-produced juvenile chinook salmon from the Wenaha River, 1996 migration year. ▲ = median arrival date. Data were from first-time detections at each dam and were expanded for spillway flow.

that migrants from the Lostine River arrived later than migrants from the remaining rivers, and that Minam and Wenaha River migrants arrived earlier than those from Catherine Creek and the Imnaha River (Figure 7). In each migration from 1993 to 1996, migrants from the Wenaha River were among the earliest to arrive at Lower Granite Dam. Fish from either Catherine Creek or the Grande Ronde River arrived latest at Lower Granite Dam from 1993 to 1995. The 1996 migration was the first in which Lostine River migrants arrived later than migrants from Catherine Creek. It was also the first in which Lostine River migrants arrived last; however, it is uncertain if this would have been the case had fall-tagged fish from the Grande Ronde River been available for detection. For each population except that from the Lostine River, the median date of arrival at Lower Granite Dam in 1996 was the earliest yet observed. The Lostine River population arrived later in 1996 than in previous years.

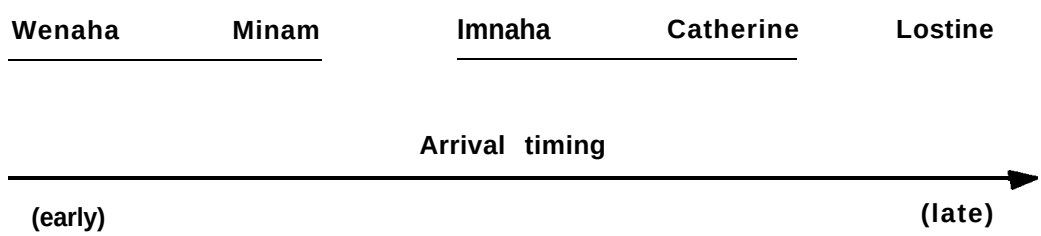

Figure 7. Results of multiple comparisons of arrival timing at Lower Granite Dam for juvenile chinook salmon migrants from Catherine Creek and the Imnaha, Lostine, Minam, and Wenaha (mainstem and South Fork) rivers, 1996. Arrival timing was significantly different for populations that do not share a line.

One fish that was expected to migrate seaward in 1995 was detected in a dam's juvenile bypass in 1996. This fish was tagged in the Grande Ronde River in 1994 (1993 brood) and was detected at Little Goose Dam on 23 April 1996. It accounted for 0.7% (1 of 143) of the total detections from the 1993 brood of Grande Ronde River fish.

Estimates of travel time between Lower Granite and the dams downstream are presented in Figure 8 and Appendix Table C-1. For the pooled populations, median travel times (95% confidence interval) from Lower Granite Dam to Little Goose, Lower Monumental, and McNary dams were 5.2 (4.8-5.6), 6.6 (5.6-7.5), and 9.2 (8.6-10.5) d, respectively. For individual populations, median travel times ranged from 5.0 to 7.0 d (Lower Granite to Little Goose), 6.2 to 8.1 d (Lower Granite to Lower Monumental), and 8.6 to 12.3 d (Lower Granite to McNary). Individual fish took as many as 15.0, 16.8, and 21.2 d to travel from Lower Granite to Little Goose, Lower Monumental, and McNary dams, respectively.

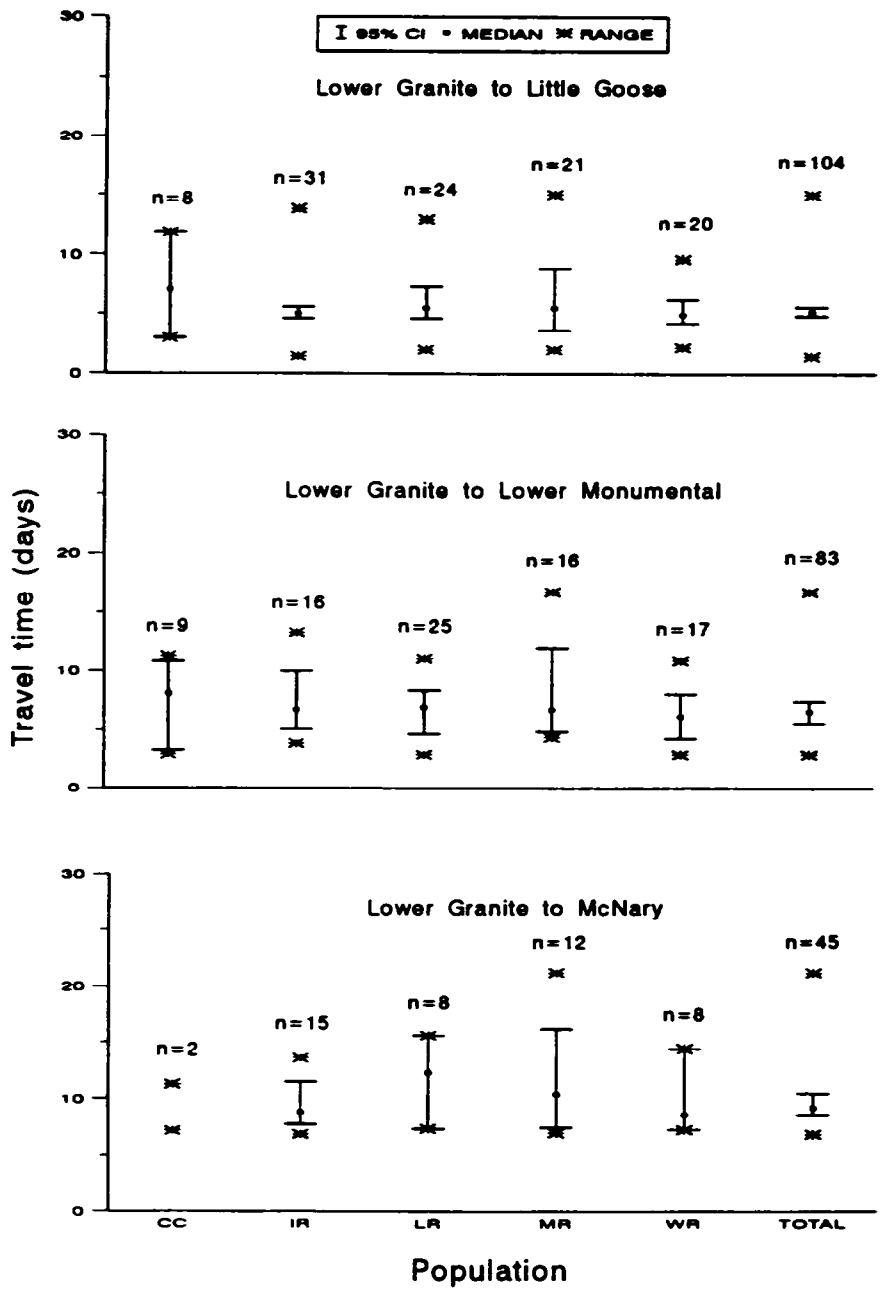

Figure 8. Travel time (in days) between Lower Granite Dam and Little Goose, Lower Monumental, and McNary dams for naturally-produced juvenile chinook salmon from northeast Oregon streams, 1996 migration year. Travel times were based on data from individual fish and on differences between initial detection times in the bypass systems at each dam. CC = Catherine Creek, IR = Imnaha River, LR = Lostine River, MR = Minam River, and WR = Wenaha River (mainstem and South Fork).

Cumulative detection rates of individual populations ranged from 15.4% (Minam River) to 18.9% (Imnaha River) in 1996 (Table 4). The cumulative detection rate for all populations combined in 1996 (16.7%; Table 4) was higher than that in 1994 (14.5%) and 1995 (13.8%) but lower than that in 1993 (17.2%). For each population except that from the Lostine River, detection rates in 1996 were among the highest observed in the last four years, despite a considerable increase in spill at the dams (i.e., a theoretical decrease in the probability of detection) relative to previous years. At Lower Granite Dam, for example, 31% of the flow (spill plus turbine discharge) was spilled between 1 April and 31 August in 1996, whereas less than 12% was spilled during that same period each year from 1993 to 1995. After four years of data collection, no distinct trends in cumulative detection rates are evident. No population has been detected at rates consistently among the lowest or highest observed each year.

Table 4. First-time detections by dam site (percent of release) during the 1996 migration year for naturally-produced juvenile chinook salmon PIT-tagged on five streams in the Grande Ronde and Imnaha River subbasins in 1995. Data were not expanded for spillway flow.

Stream	Number released	Lower Granite	Little Goose	Lower Monumental	McNary	Total
Catherine	499	40 (8.0)	27 (5.4)	18 (3.6)	4 (0.8)	89 (17.8)
Imnaha	997	97 (9.7)	46 (4.6)	35 (3.5)	10 (1.0)	188 (18.9)
Lostine	978	81 (8.3)	40 (4.1)	31 (3.1)	3 (0.3)	155 (15.9)
Minam	998	68 (6.8)	49 (4.9)	29 (2.9)	8 (0.8)	154 (15.4)
Wenaha	997	59 (5.9)	65 (6.5)	28 (2.8)	6 (0.6)	158 (15.9)
TOTAL	4,469	345 (7.7)	227 (5.1)	141 (3.2)	31 (0.7)	744 (16.7)

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APPENDIX A

Expansion factors used to adjust PIT tag detection data from mainstem Snake and Columbia River dams, 1996

Appendix Table A-l. Expansion factors used to adjust PIT tag detection data from mainstem Snake and Columbia River dams, 1996. Expansion factor is (spillway flow + powerhouse flow)/powerhouse flow.

DATE	LOWER GRANITE EXPANSION	LITTLE GOOSE EXPANSION	LOWER MONUMENTAL EXPANSION	MCNARY EXPANSION
4/01/96	1.10	1.00	1.00	1.42
4/02/96	1.13	1.11	1.01	1.41
4/03/96	1.22	1.16	1.08	1.35
4/04/96	1.39	1.18	1.12	1.36
4/05/96	1.53	1.17	1.10	1.41
4/06/96	2.07	1.26	1.27	1.59
4/07/96	2.01	1.52	1.36	1.65
4/08/96	1.83	1.12	1.02	1.42
4/09/96	2.14	1.41	1.13	1.69
4/10/96	2.00	1.34	1.24	1.92
4/11/96	3.08	1.38	1.42	1.94
4/12/96	3.58	1.41	1.44	1.90
4/ 13/96	3.53	1.42	1.41	1.86
4/14/96	3.27	1.72	1.69	2.21
4/15/96	2.39	1.65	1.50	2.05
4/ 16/96	1.68	1.65	1.51	1.92
4/17/96	1.82	1.42	1.36	2.13
4/18/96	1.81	1.41	1.30	1.93
4/19/96	1.75	1.38	1.36	1.81
4/20/96	1.72	1.64	1.52	2.05
4/21/96	2.10	1.60	1.49	1.96
4/22/96	2.15	1.15	1.10	1.81
4/23/96	1.75	1.42	1.38	1.84
4/24/96	1.35	1.60	1.63	2.02
4/25/96	1.31	1.52	1.65	2.07
4/26/96	1.22	1.28	1.33	2.09
4/27/96	1.31	1.79	1.83	2.10
4/28/96	1.24	2.33	1.75	2.61
4/29/96	1.28	1.69	1.84	2.40
4/30/96	1.29	1.59	1.64	2.26
5/01/96	1.28	1.26	1.29	2.07
5/02/96	1.32	1.16	1.11	1.80
5/03/96	1.31	1.31	1.27	1.82
5/04/96	1.36	1.79	1.48	1.79
5/05/96	1.35	2.22	1.55	1.78
5/06/96	1.30	1.64	1.34	1.95
5/07/96	1.47	1.55	1.35	1.73
5/08/96	2.00	1.57	1.27	1.72
5/09/96	2.16	1.60	1.36	1.77
5/10/96	1.39	1.52	1.28	1.68
5/11/96	1.41	1.63	1.33	1.69
5/12/96	1.39	1.51	1.41	1.72
5/13/96	1.33	1.43	1.24	1.52

Appendix Table A-l, Continued (spillway expansion factors).

DATE	LOWER GRANITE EXPANSION	LITTLE GOOSE EXPANSION	LOWER MONUMENTAL EXPANSION	MCNARY EXPANSION
5/14/96	1.51	1.38	1.38	1.67
5/15/96	1.51	1.39	1.40	1.80
5/16/96	1.63	1.49	1.53	1.91
5/17/96	1.74	1.66	1.62	2.37
5/18/96	1.97	2.06	1.90	2.52
5/19/96	2.16	1.93	2.00	2.57
5/20/96	2.19	2.02	1.79	2.83
5/21/96	1.97	1.71	1.68	2.12
5/22/96	1.67	1.62	1.54	2.15
5/23/96	1.64	1.89	1.64	2.22
5/24/96	1.72	1.80	1.67	2.86
5/25/96	1.71	1.94	1.58	2.97
5/26/96	1.54	2.39	2.02	3.35
5/27/96	1.54	2.04	1.82	3.19
5/28/96	1.48	2.19	1.80	3.49
5/29/96	1.52	1.63	1.78	3.76
5/30/96	1.62	2.10	1.77	3.40
5/31/96	1.51	2.03	1.89	2.84
6/01/96	1.46	3.02	2.18	3.19
6/02/96	1.47	1.96	1.90	3.20
6/03/96	1.41	1.44	1.43	2.83
6/04/96	1.51	1.42	1.62	2.84
6/05/96	1.57	1.42	1.75	2.82
6/06/96	1.65	1.55	1.87	2.84
6/07/96	1.57	1.56	1.56	2.73
6/08/96	1.68	2.06	1.88	3.13
6/09/96	1.71	1.85	1.80	3.13
6/10/96	1.75	1.88	1.79	3.04
6/11/96	1.67	1.74	1.89	3.15
6/12/96	1.64	1.96	2.01	3.09
6/13/96	1.64	2.25	2.16	3.24
6/14/96	1.64	1.93	1.92	3.24
6/15/96	1.65	2.15	2.00	3.25
6/ 16/96	1.79	2.14	2.11	3.79
6/17/96	1.75	1.73	2.01	3.62
6/18/96	1.82	2.17	1.95	3.48
6/19/96	1.54	1.56	1.76	2.71
6/20/96	1.90	2.15	2.00	2.54
6/21/96	1.46	1.60	1.48	2.54
6/22/96	1.40	1.55	1.48	2.13
6/23/96	1.25	1.34	1.30	2.45
6/24/96	1.29	1.39	1.49	2.43

APPENDIX B

Observation data for juvenile chinook salmon PIT-tagged on northeast Oregon streams in 1995 and observed at dams in 1996

Appendix Table B-1. Freqency of tag observations by date for juvenile chinook salmon PIT-tagged on Catherine Creek in 1995 and observed at various dams in 1996. A = first observation of individual tags, B = tags previously detected at one dam, C = tags previously detected at two dams, D = tags previously detected at three dams, and Σ = sum of all tag observations by date at a particular dam.

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
15	4/10/96													
15	4/11/96													
15	4/12/96													
15	4/13/96													
15	4/14/96													
16	4/15/96													
16	4/16/96													
16	4/17/96	1												
16	4/18/96													
16	4/19/96	2	1		1									
16	4/20/96	2	1		1	2			2					
16	4/21/96	1	1		1									
17	4/22/96	1	1		1		2		2					
17	4/23/96		2		2	1			1					
17	4/24/96		3	1	4	1	1		2					
17	4/25/96	1		1	1	1	4		5					
17	4/26/96	7				2			2					
17	4/27/96	1					1		1		1			1
17	4/28/96										2			2
18	4/29/96	1												
18	4/30/96	2								1				1
18	5/01/96	1												
18	5/02/96	2	1		1		1		1		1			1
18	5/03/96	2	2		2									
18	5/04/96	2				1			1					
18	5/05/96	1												
19	5/06/96													
19	5/07/96	1												
19	5/08/96													
19	5/09/96			2	2									
19	5/10/96		1		1						1			1
19	5/11/96						1		1		1			1
19	5/12/96		1		1	1			1					
20	5/13/96	2				1			1					
20	5/14/96						1		1					
20	5/15/96	3	1		1		3		3					

Appendix Table B-1, Continued (Catherine Creek).

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
20	5/16/96	2	2		2	1	1		2	1				1
20	5/17/96	3	2		2									
20	5/18/96	1		1	1	3	1		4		1			1
20	5/19/96		1		1	1	1		2					
21	5/20/96		4	1	5		1		1					
21	5/21/96					2	2		4					
21	5/22/96									1				1
21	5/23/96										1			1
21	5/24/96		1		1									
21	5/25/96		1	1	2									
21	5/26/96													
22	5/27/96													
22	5/28/96						1		1					
22	5/29/96	1												
22	5/30/96													
22	5/31/96													
22	6/01/96		1		1									
22	6/02/96													
23	6/03/96													
23	6/04/96													
23	6/05/96			1	1									
23	6/06/96													
23	6/07/96													
23	6/08/96													
23	6/09/96													
24	6/10/96					1			1					
24	6/11/96									1				1
24	6/12/96													
24	6/13/96													
24	6/14/96													
24	6/15/96													
24	6/16/96													
25	6/17/96													
25	6/18/96													
25	6/19/96													
25	6/20/96													
Total		40	27	8	35	18	21	0	39	4	8	0	0	12

Appendix Table B-2. Frequency of tag observations by date for juvenile chinook salmon PIT-tagged on the Imnaha River in 1995 and observed at various dams in 1996. A = first observation of individual tags, B = tags previously detected at one dam, C = tags previously detected at two dams, D = tags previously detected at three dams, and Σ = sum of all tag observations by date at a particular dam.

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
15	4/10/96													
15	4/11/96													
15	4/12/96													
15	4/13/96													
15	4/14/96	1												
16	4/15/96	3												
16	4/16/96	6				2			2					
16	4/17/96	5												
16	4/18/96	2	2		2									
16	4/19/96	8	1		1	1			1					
16	4/20/96	4	4		4									
16	4/21/96	4	2	1	3									
17	4/22/96		2	2	4	2	1		3					
17	4/23/96	3	1	5	6	1	3		4					
17	4/24/96	4	4	1	5	2	1	1	4					
17	4/25/96	2	5	1	6	2	1		3					
17	4/26/96	4	3	2	5	6	2		8		1	2		3
17	4/27/96	2	2	3	5	1	2		3	1	5	2		8
17	4/28/96	1	1		1		2	1	3		1			1
18	4/29/96			1	1	1			1					
18	4/30/96	1								1	1	2		4
18	5/01/96	1								1		1		2
18	5/02/96	1		2	2	2			2	2	1	1		4
18	5/03/96	1						1	1					
18	5/04/96	1		1	1			1	1					
18	5/05/96	2									2			2
19	5/06/96			1	1									
19	5/07/96	1								1				1
19	5/08/96													
19	5/09/96										1		1	2
19	5/10/96		1		1	1		1	2					
19	5/11/96	2						1	1					
19	5/12/96	3	1	1	2		1		1		1			1
20	5/13/96	7	2		2									
20	5/14/96	6					2							
20	5/15/96	2	2	1	3	2			2					

Appendix Table 8-2, Continued (Imnaha River).

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
20	5/16/96	4	2	1	3	1	1		2					
20	5/17/96	5	1	5	6									
20	5/18/96	4	4		4	2	2		4					
20	5/19/96		1		1	1	2		3	1	1			2
21	5/20/96		4	1	5	2			2		1			1
21	5/21/96					1	3		4		1			1
21	5/22/96						1		1		2			2
21	5/23/96		1		1	1		1	2					
21	5/24/96	1												
21	5/25/96			1	1						1			1
21	5/26/96										1			1
22	5/27/96						1		1					
22	5/28/96					1			1					
22	5/29/96					1			1					
22	5/30/96	1												
22	5/31/96													
22	6/01/96	2												
22	6/02/96													
23	6/03/96					1			1					
23	6/04/96	1												
23	6/05/96					1			1					
23	6/06/96									1				1
23	6/07/96										1			1
23	6/08/96													
23	6/09/96			1	1									
24	6/10/96	1								1				1
24	6/11/96													
24	6/12/96	1												
24	6/13/96									1				1
24	6/14/96													
24	6/15/96													
24	6/16/96													
25	6/17/96													
25	6/18/96													
25	6/19/96													
25	6/20/96													
Total		97	46	31	77	35	25	7	67	10	21	8	1	40

Appendix Table B-3. Frequency of tag observations by date for juvenile chinook salmon PIT-tagged on the Lostine River in 1995 and observed at various dams in 1996. A = first observation of individual tags, B = tags previously detected at one dam, C = tags previously detected at two dams, D = tags previously detected at three dams, and Σ = sum of all tag observations by date at a particular dam.

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
15	4/10/96													
15	4/11/96													
15	4/12/96													
15	4/13/96													
15	4/14/96													
16	4/15/96													
16	4/16/96													
16	4/17/96	1												
16	4/18/96	1												
16	4/19/96	2												
16	4/20/96	2												
16	4/21/96													
17	4/22/96	1	2		2									
17	4/23/96	2	1	1	2									
17	4/24/96	1	1	2	3									
17	4/25/96	2		1	1									
17	4/26/96	1		2	2	2	1	1	4		1			1
17	4/27/96	2	2		2						1			1
17	4/28/96	1												
18	4/29/96					1			1					
18	4/30/96	3					1		1					
18	5/01/96	4												
18	5/02/96			1	1									
18	5/03/96	3	2		2			1	1			1		1
18	5/04/96	1												
18	5/05/96	3	1	1	2									
19	5/06/96	2		2	2		1		1					
19	5/07/96	1	1	1	2		1		1					
19	5/08/96	1				1			1					
19	5/09/96		1		1									
19	5/10/96	2		1	1		1		1					
19	5/11/96	2				2	1		3					
19	5/12/96	1		3	3	1	1		2			2		2
20	5/13/96		4	1	5	3			3		1			1
20	5/14/96	2	3	3	6		2		2	1	1	1		3
20	5/15/96	8	2		2	3	2	2	7					

Appendix Table B-3, Continued (Lostine River).

WEEK	DATE	LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
		A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
20	5/16/96	5	1		1	1			1		3			3
20	5/17/96	3	2		2		1	2	3		1			1
20	5/18/96	4	1	1	2	2	2		4					
20	5/19/96	1	1	1	2			1	1					
21	5/20/96	1	4		4		2		2			1		1
21	5/21/96	1	1		1	1	4		5		1			1
21	5/22/96	1	2	1	3	2	1		3			1		1
21	5/23/96		1		1	1			1			1		1
21	5/24/96		1		1	2			2		1			1
21	5/25/96	1												
21	5/26/96					1			1					
22	5/27/96			1	1	1	1		2		1			1
22	5/28/96	1				1	1		2					
22	5/29/96	1	1		1	1			1					
22	5/30/96	2				2			2	1				1
22	5/31/96	1					1		1					
22	6/01/96		1		1						1			1
22	6/02/96													
23	6/03/96		1		1		1		1					
23	6/04/96	1												
23	6/05/96			1	1						1			1
23	6/06/96						1		1	1				1
23	6/07/96	3												
23	6/08/96	1					1		1					
23	6/09/96	1				1			1					
24	6/10/96					1			1					
24	6/11/96	2	1		1									
24	6/12/96		1		1		1		1					
24	6/13/96		1		1						1			1
24	6/14/96	1					1		1					
24	6/15/96													
24	6/16/96													
25	6/17/96													
25	6/18/96													
25	6/19/96	1												
25	6/20/96					1			1					
Total		81	40	24	64	31	29	7	67	3	14	7	0	24

Appendix Table B-4. Frequency of tag observations by date for juvenile chinook salmon PIT-tagged on the Minam River in 1995 and observed at various dams in 1996. A = first observation of individual tags, B = tags previously detected at one dam, C = tags previously detected at two dams, D = tags previously detected at three dams, and Σ = sum of all tag observations by date at a particular dam.

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
15	4/10/96	1												
15	4/11/96													
15	4/12/96	1												
15	4/13/96	1												
15	4/14/96	2	1		1									
16	4/15/96	4				1			1					
16	4/16/96	3	1		1									
16	4/17/96		1		1									
16	4/18/96	1					1		1					
16	4/19/96	5	2		2									
16	4/20/96	5	2		2	2			2					
16	4/21/96	1	4		4									
17	4/22/96		5	1	6	1			1					
17	4/23/96	1	5		5	3	1		4					
17	4/24/96	2	5	1	6	3	6		9					
17	4/25/96	4	3	1	4	4	4		8		1			1
17	4/26/96	1	4	1	5	1	6		7	1	2			3
17	4/27/96		1	2	3		2		2	1	4	2		7
17	4/28/96	5				1	1		2			2		2
18	4/29/96	1						1	1					
18	4/30/96					1			1		1			1
18	5/01/96	2		1	1					1	1			2
18	5/02/96	3	1		1						1			1
18	5/03/96	3												
18	5/04/96	2												
18	5/05/96	1						1	1		1			1
19	5/06/96	1					1		1		1			1
19	5/07/96													
19	5/08/96	1				1			1					
19	5/09/96	1												
19	5/10/96	1	1	2	3									
19	5/11/96	1	3	1	4								1	1
19	5/12/96		3	1	4									
20	5/13/96	3	2	2	4		1		1					
20	5/14/96	1				1	4		5	1				1
20	5/15/96	2		1	1		1	1	2					

Appendix Table B-4, Continued (Minam River).

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	∑	A	B	C	∑	A	B	C	D	∑
20	5/16/96		1	2	3		1	1	2	2	1			3
20	5/17/96	2	1	1	2	1			1					
20	5/18/96	1	1	1	2		1		2		1			1
20	5/19/96	2				1	1		2	1	1			2
21	5/20/96			j	1	1			1			2	1	3
21	5/21/96	1	1		1	3	2		5	1		1		2
21	5/22/96					1		1	2					
21	5/23/96		1		1	2	1		3					
21	5/24/96													1
21	5/25/96													
21	5/26/96						1		1					
22	5/27/96													
22	5/28/96													
22	5/29/96													
22	5/30/96													
22	5/31/96													
22	6/01/96													
22	6/02/96	1												
23	6/03/96													
23	6/04/96													
23	6/05/96			1	1									
23	6/06/96													
23	6/07/96	1												
23	6/08/96													
23	6/09/96													
24	6/10/96													
24	6/11/96			1	1									
24	6/12/96													
24	6/13/96													
24	6/14/96													
24	6/15/96													
24	6/16/96													
25	6/17/96													
25	6/18/96													
25	6/19/96													
25	6/20/96													
Total		68	49	21	70	29	35	5	69	8	16	7	2	33

Appendix Table B-5. Frequency of tag observations by date for juvenile chinook salmon PIT-tagged on the Wenaha River in 1995 and observed at various dams in 1996. A = first observation of individual tags, B = tags previously detected at one dam, C = tags previously detected at two dams, D = tags previously detected at three dams, and Σ = sum of all tag observations by date at a particular dam.

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
15	4/10/96													
15	4/11/96													
15	4/12/96													
15	4/13/96	1												
15	4/14/96	2												
16	4/15/96	3	1		1	1			1					
16	4/16/96	3	2		2									
16	4/17/96	3	3	1	4	1			1					
16	4/18/96	1	1		1		1		1					
16	4/19/96	6	5		5		1		1					
16	4/20/96	5	7	3	10	2	2		4		1			1
16	4/21/96	3	4	1	5	4	1		5					
17	4/22/96	5	2		2	3	1		4					
17	4/23/96	3	8	1	9	2	3	1	6					
17	4/24/96	4	12	3	15	3	7	1	11					
17	4/25/96	5	6	1	7	2	3	1	6					
17	4/26/96		3	3	6	3	8	2	13	2	3	1		6
17	4/27/96	1	1	2	3	1			1	2	4	1		7
17	4/28/96	1	1		1	2	6		8		1	1		2
18	4/29/96	1						1	1					
18	4/30/96	1				1			1			2		2
18	5/01/96	2												
18	5/02/96	3	1		1							1		1
18	5/03/96			1	1									
18	5/04/96					1			1					
18	5/05/96	2	1		1		1		1					
19	5/06/96													
19	5/07/96		1	1	2									
19	5/08/96		1		1									
19	5/09/96													
19	5/10/96		1	1	2		1	1	2					
19	5/11/96	2												
19	5/12/96		1		1									
20	5/13/96						1		1					
20	5/14/96	1		1	1									
20	5/15/96					1			1					

Appendix Table B-5, Continued (Wenaha River).

		LOWER GRANITE	LITTLE GOOSE			LOWER MONUMENTAL				MCNARY				
WEEK	DATE	A	A	B	Σ	A	B	C	Σ	A	B	C	D	Σ
20	5/16/96	1					1		1	1	1			2
20	5/17/96		1		1		1		1			1		1
20	5/18/96			1	1									
20	5/19/96											2		2
21	5/20/96		1				1		1					
21	5/21/96					1			1					
21	5/22/96													
21	5/23/96						1		1	1				1
21	5/24/96		1		1									1
21	5/25/96													
21	5/26/96													
22	5/27/96						1		1					
22	5/28/96													
22	5/29/96													
22	5/30/96													
22	5/31/96													
22	6/01/96													
22	6/02/96													
23	6/03/96													
23	6/04/96													
23	6/05/96													
23	6/06/96													
23	6/07/96													
23	6/08/96													
23	6/09/96													
24	6/10/96													
24	6/11/96													
24	6/12/96													
24	6/13/96													
24	6/14/96													
24	6/15/96													
24	6/16/96													
25	6/17/96													
25	6/18/96													
25	6/19/96													
25	6/20/96													
Total		**59**	**65**	**20**	**85**	**28**	**41**	**7**	**76**	**6**	**11**	**9**	**0**	**26**

APPENDIX C

Travel times (in days) of juvenile chinook salmon between Lower Granite Dam and dams downstream, 1996 migration year

Appendix Table C-l. Travel time (in days) of individual chinook salmon between Lower Granite Dam and dams downstream, 1996 migration year. Fish were PIT-tagged and released in five streams in the Grande Ronde and Imnaha River subbasins in 1995. Travel times were based on initial detection within the bypass system at each dam.

Stream	Travel time (d) from Lower Granite to: Little Goose	Lower Monumental	McNary
Catherine Creek			
Median days	7.0	8.1	--
Range	3.0-11.8	2.9-11.3	7.2-11.3
95% CI	3.0-11.8	3.3-10.8	--
n	8	9	2
Imnaha River			
Median days	5.0	6.8	8.8
Range	1.4-13.8	3.9-13.3 3	6.9-13.6
95% CI	4.6-5.6	5.1-10.0	7.8-11.5
n	31	16	15
Lostine River			
Median days	5.5	7.0	12.3
Range	2.0-12.9	2.9-11.1	7.4-15.6
95% CI	4.6-7.2	4.7-8.4	7.4-15.6
n	24	25	8
Minam River			
Median days	5.5	6.8	10.4
Range	2.0-15.0	4.4-16.8	7.0-21.2
95% CI	3.6-8.7	4.9-12.0	7.5-16.2
n	21	16	12
Wenaha River			
Median days	4.9	6.2	8.6
Range	2.2-9.6	2.9-10.9	7.3-14.4
95% CI	4.2-6.2	4.3-8.1	7.3-14.4
n	20	17	8
Total			
Median days	5.2	6.6	9.2
Range	1.4-15.0	2.9-16.8	6.9-21.2
95% CI	4.8-5.6	5.6-7.5	8.6-10.5
n	104	83	45