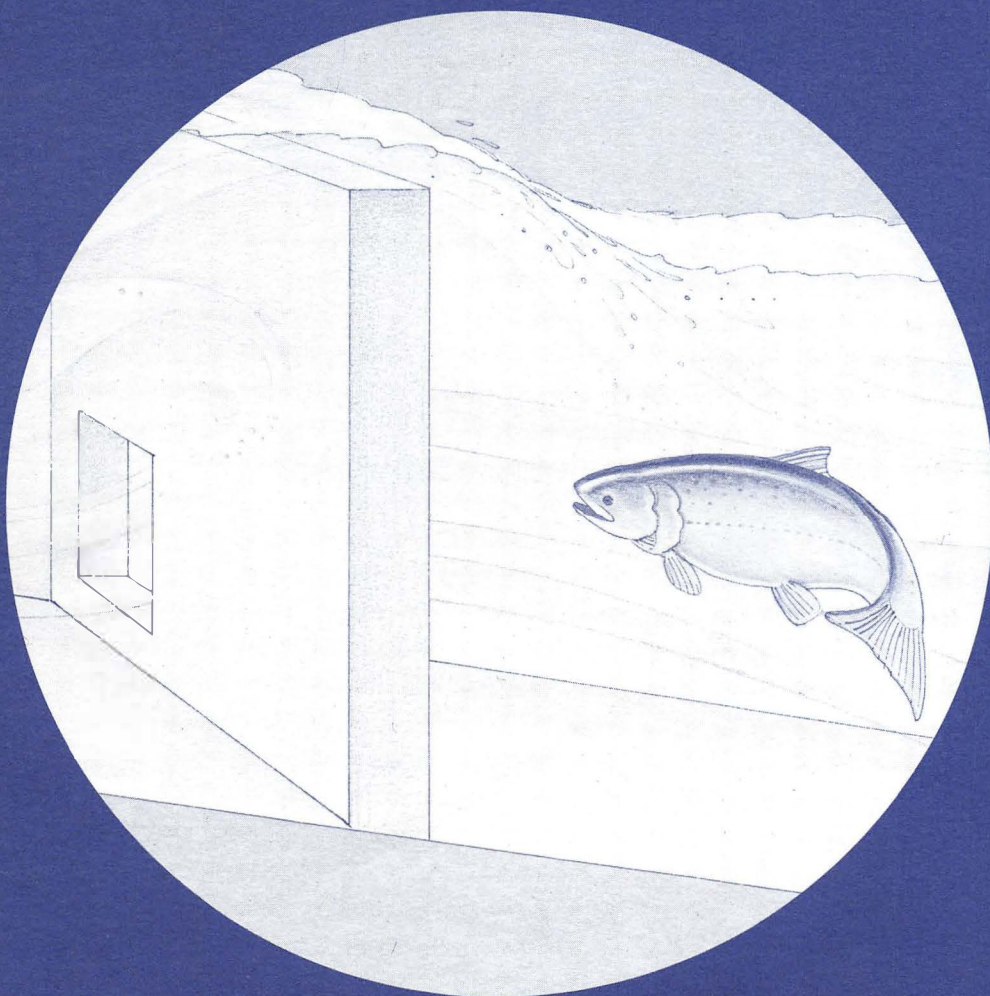


Pit-Tag Studies with Juvenile Salmonids at the Chandler Canal Fish Collection Facility, Yakima River



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U.S. Department of Energy
Bonneville Power Administration
Division of Fish & Wildlife

Coastal Zone and Estuarine
Studies Division
Northwest Fisheries
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**PIT-TAG STUDIES WITH JUVENILE SALMONIDS
AT THE CHANDLER CANAL FISH COLLECTION FACILITY,
YAKIMA RIVER, 1990**

Prepared by:

Thomas E. Ruehle

and

C. Scott McCutcheon

Coastal Zone and Estuarine Studies Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
Seattle, Washington

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INTRODUCTION

Juvenile salmonid survival studies planned for the Yakima Basin will require the release and recapture of large numbers of marked fish. Before these studies can be implemented, information is needed about potential recovery rates of marked fish at proposed sampling sites. The type of mark employed and the efficiency of the equipment used to capture and examine fish for marks must be evaluated since accurate survival estimates depend on their reliability. Recovery rates are expected to vary with species and life stage as well as environmental factors such as river flow and water temperature.

The Chandler Canal originates downstream from Prosser Dam at river kilometer 76 on the Yakima River (Figs. 1 and 2). This canal delivers water for power production (approximately 28.3 m³/second (1000 cfs)) and irrigation (approximately 11.3 m³/second (400 cfs)). A trash removal and fish diversion screen facility is located 1.6 km downstream from the canal headworks. A bypass pipe diverts fish through the Chandler Canal juvenile fish collection facility (Chandler facility) (Fig. 2).

The purpose of this study was to assess the mark-recovery capabilities of the Chandler facility and a mobile juvenile fish trap installed temporarily at West Richland, Washington near the mouth of the Yakima River (Fig. 1). Primary objectives were:

- 1) To determine the efficiency and reliability of the PIT-tag monitoring system at the Chandler facility;

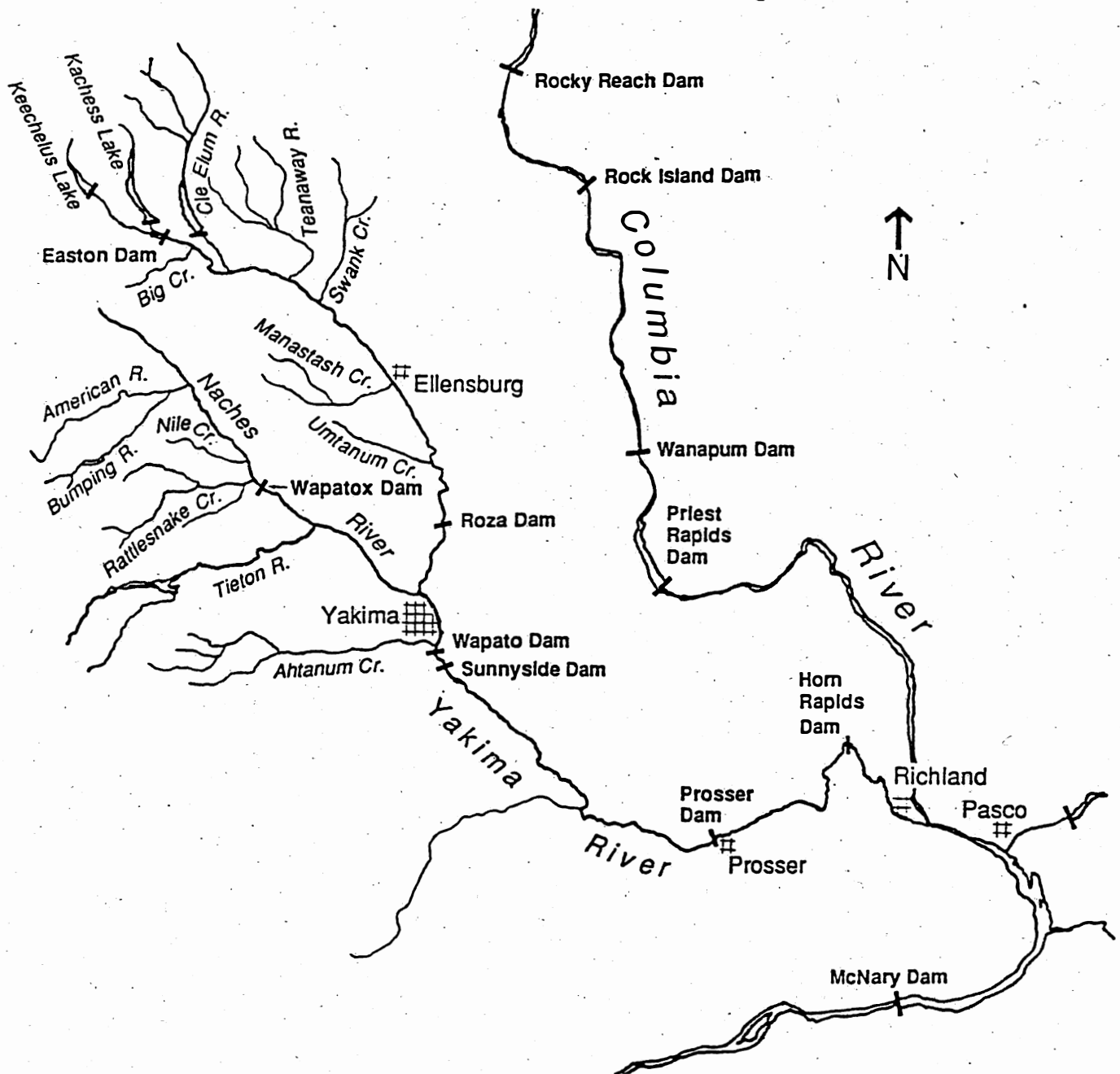


Figure 1.--Map of the Yakima River and the adjacent Columbia River showing locations of major water diversion and hydroelectric dams.

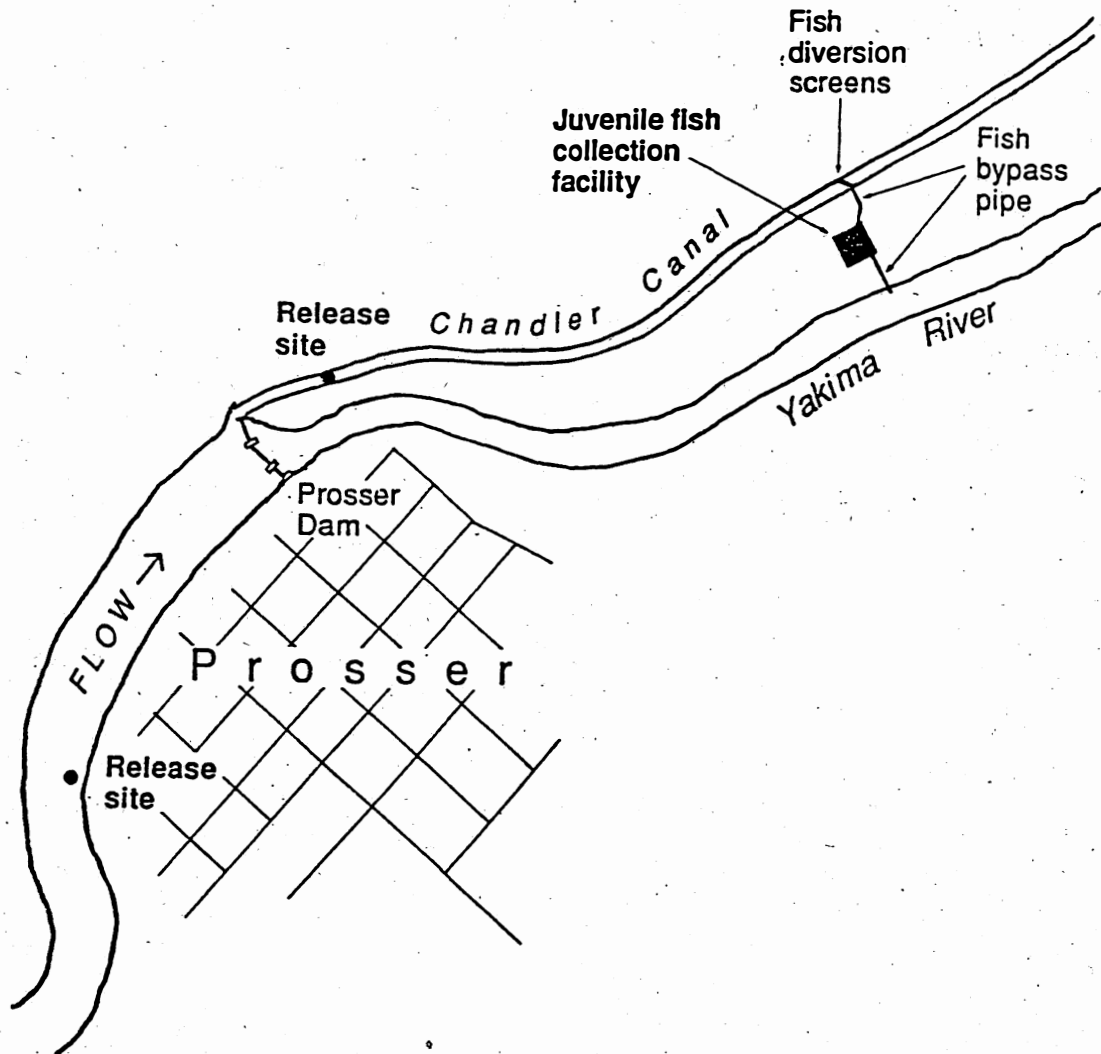


Figure 2.--Yakima River near Prosser showing upper Chandler Canal, mainstem and canal juvenile fish release sites, and the juvenile fish collection facility. (Not drawn to scale).

- 2) To determine the entrainment of juvenile salmonids into Chandler Canal, as a function of river flow;
- 3) To assess the capability of smolt traps in the Yakima River to entrain juvenile salmonids; and
- 4) To assess the effects of Chandler Canal and Chandler facility passage on the survival of juvenile salmonids.

METHODS AND MATERIALS

Yearling chinook salmon (*Oncorhynchus tshawytscha*) used in this study were acquired from juvenile collection facilities at Wapatox Dam on the Naches River (Fig. 1) and the Chandler facility (Fig. 2). Subyearling chinook salmon were taken either from the Chandler facility or from floating net-pens in the Wapato Canal near Yakima, Washington. Yearling steelhead (*O. mykiss*) were obtained from the Yakima Hatchery (Washington Department of Wildlife (WDW)) in Yakima. The sockeye salmon (*O. nerka*) recovered were released into the Cle Elum River for the Cle Elum Lake Sockeye Restoration Feasibility Study. Additional information on the sockeye salmon marking experiments may be found in the report on the Cle Elum Lake Restoration Feasibility Study (Flagg et al. 1991). The species, dates of release, fish sizes, and numbers of fish used in this study are summarized in Appendix Table 1.

Freeze brands were applied using methods described by Mighell (1969). The PIT-tagging procedures and monitoring equipment were similar to those described by Prentice et al. (1990b). Fish were rejected prior to marking if they were

diseased, injured, descaled, previously marked, or were less than 60 mm in length. With the exception of sockeye salmon and subyearling chinook salmon from the Wapato Canal net-pens, all experimental fish were marked at the Chandler facility (Fig. 2). After marking, fish were allowed to recover in portable containers supplied with aerated water from Chandler Canal. Freeze-branded and PIT-tagged fish were held a minimum of 2 days to allow time for brand development and to evaluate delayed mortality.

The collection and monitoring system at the Chandler facility consisted of diversion screens that directed fish into a pipe to a dewatering unit, over a fish separator, and through a PIT-tag detector (Fig. 3). Fish were interrogated for PIT tags as they exited the separator. Groups of fish were then subsampled at timed intervals and following anesthetization, examined for freeze brands. Subsampled fish were enumerated and passed through a second PIT-tag detector before entering a recovery tank. Non-redundant data from both PIT-tag detectors were pooled to estimate detection rates.

Methods specific to each objective and task, as identified in the original work plan, are described below. Note that some tasks apply to more than one objective.

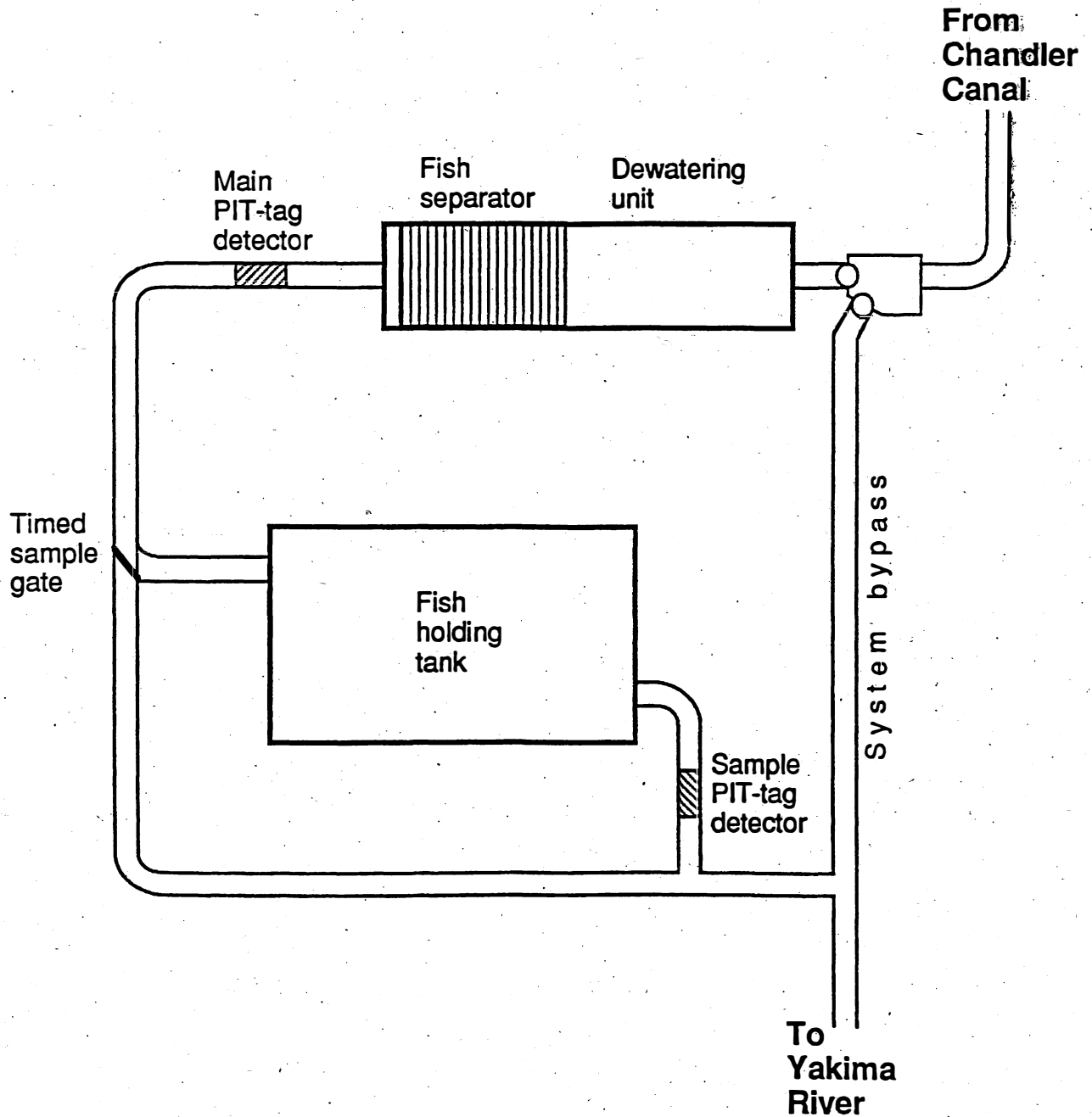


Figure 3.--PIT-tag monitoring system at the Chandler juvenile fish collection facility.

Objective 1: Determine the efficiency and reliability of the PIT-tag monitoring system at the Chandler facility.

Task 1.1--Measure the detection efficiency and reliability of the PIT-tag detector at the Chandler facility.

Two groups of yearling chinook salmon, four groups of subyearling chinook salmon, and two groups of steelhead were PIT tagged and released into the upwell of the dewatering unit on the fish separator at the Chandler facility (Fig. 3). The pipe leading to the PIT-tag detector provided the only egress from the release site. Fish in each group were released at 30-minute intervals in 40-fish lots. The efficiency of PIT-tag detection was estimated as the percentage of released fish that were recorded by the monitor. The detection efficiency was determined once all PIT-tagged fish had passed through the detector.

Task 1.2--Compare the detection proportions of PIT tags and freeze brands at the Chandler facility.

Two groups of yearling and one group of subyearling chinook salmon used in Task 1.1 were double-marked with PIT tags and freeze brands. PIT-tag detections included all non-redundant tags identified by either the main or sample PIT-tag detectors. Observations of freeze brands were adjusted according to the sampling rate.

Objective 2: Determine the entrainment of juvenile salmonids into Chandler Canal, as a function of river flow.

Task 2.1--At the Chandler facility, measure the detection rates of PIT-tagged juvenile salmonids released a short distance upstream from the Prosser Dam and in Chandler Canal.

PIT-tagged yearling or subyearling chinook salmon in groups of approximately 400 each were released 1 km upstream from Prosser Dam on four separate dates. Comparable groups of 100 PIT-tagged juveniles were released simultaneously into Chandler Canal (Fig. 2). The PIT-tagged steelhead were released simultaneously at three locations: in the forebay of Prosser Dam, in Chandler Canal upstream from the Chandler facility, and in the Yakima River immediately below the Chandler facility bypass pipe outfall (Fig. 2). The three groups, each composed of approximately 600 fish, were released at weekly intervals over a 3-week period (27 April-11 May). Release procedures followed those of Fast et al. (1989) to facilitate comparison with historical data.

Subyearling chinook salmon used in the experiment were further divided into two groups: one composed of fish that were collected at the Chandler facility, the other of naive fish (i.e., not previously captured at the Chandler facility) taken from floating net-pens in the Wapato Canal.

The entrainment rate of juvenile salmonids into Chandler Canal was calculated by dividing the Chandler facility detection proportions of forebay-released fish by the detection proportions of the group released directly into Chandler Canal. This

measure, henceforth referred to as a diversion or entrainment rate, assumes that once forebay-released fish enter the canal, their survival is the same as that of fish released into the canal on the same date. All detection rates at the Chandler facility were estimated as the detection proportions divided by a PIT-tag detector efficiency of 0.875 for releases made prior to 6 June and 0.96 for releases made on or after that date. These values were the mean detection rates recorded by the primary PIT-tag detector at the Chandler facility before and after modifications were made to the monitoring system. There was no evidence that detection efficiency varied within these two time periods.

Objective 3: Assess the capability of the smolt traps in the Yakima River to entrain juvenile salmonids.

Task 3.1--Record numbers of PIT-tagged juvenile salmonids caught in the West Richland screw trap.

A screw trap, cabled to the Van Giessen Bridge at river kilometer 11.5, was operated by WDF at West Richland, Washington. This floating trap resembled a horizontal cone tapering from a 3.6-m opening to a 0.5-m discharge pipe leading to a collection box. Internal baffles used the force of the river current to rotate the cone on its axis and auger fish into a collection box. Two PIT-tag monitoring systems were installed on this fish trap. The first detector ran on AC electricity and resembled the PIT-tag detectors at the Chandler facility. The second detector was an experimental DC-powered unit that was built specifically for

this project. Fish entering the trap were diverted from the collection box into a holding area where they were anesthetized, evaluated for brands, measured, identified by species, and passed through both PIT-tag detectors before being placed in a recovery container. The trap design, monitoring system, and experimental results relating to the West Richland trap will be reported separately by WDF personnel.

Objective 4: Assess the effects of Chandler Canal and Chandler facility passage on the survival of juvenile salmonids.

Task 4.1--Utilize PIT-tag detections at the Chandler facility and at downstream sites to compare detection rates of mainstem- and canal-released juvenile salmonids.

The PIT-tagged fish detections from the Chandler facility, West Richland screw trap, and McNary Dam were analyzed for comparisons of recovery rates. All fish passing through the McNary Dam fish collection and bypass system, located on the Columbia River 69.5 km downstream from the mouth of the Yakima River, were interrogated by PIT-tag detectors at the exit flume from the fish separator. The daily percentage of fish entering this collection system varied depending upon levels of spill and the collection efficiency of the submerged traveling fish screens. Fish that were PIT tagged and released in the vicinity of the Chandler Canal were also monitored for PIT tags at McNary Dam.

Analysis of variance was used to evaluate the effects of release location (Chandler Canal and Prosser Dam forebay) and

previous detection history (detected vs. not detected at the Chandler facility) on detection proportions at McNary Dam. The mean detection proportions among the following groups were compared:

- 1) Fish released in the canal, detected at the Chandler facility.
- 2) Fish released in the canal, not detected at the Chandler facility.
- 3) Fish released in the forebay, detected at the Chandler facility.
- 4) Fish released in the forebay, not detected at the Chandler facility.

Task 4.2--Monitor and compare detection rates of fish released in upstream areas of the Yakima River.

Three groups of subyearling chinook salmon, each consisting of approximately 1,000 fish, were PIT tagged and released into the Wapato Canal, 95 km upstream from the Chandler facility. The first group was released two days prior to the release of the main net-pen population, the second group was released with the main net-pen population, and the third group was released eight days later.

PIT-tagged sockeye salmon released into the Cle Elum River were also monitored.

RESULTS

Approximately 16,170 juvenile chinook salmon and steelhead were marked and released in this study. An additional 3,517 PIT-tagged sockeye salmon that had been released in the Cle Elum River were detected.

Detailed release and detection data are presented in Appendix Tables 1-18.

Objective 1

Task 1.1--Of the 1,808 PIT-tagged fish released into the Chandler facility, 1,592 were detected by the main PIT-tag detector (Table 1). Tag detection proportions for the eight test groups of fish ranged from 0.85 to 0.98. After changes were made to the system on 6 June, the mean efficiency of the system PIT-tag detections increased to 0.96.

Approximately 1,170 of the test fish were diverted through the sampling system and interrogated by the second (sample) PIT-tag detector. Only 137 of the PIT-tagged fish had not been detected by the main detector. Sampling was continuous on all except two dates--16 April and 26 May--when fish were sampled 50 and 25% of the time, respectively. To account for reductions in sampling time, we multiplied the number of PIT tags detected by the second detector, but not the first detector, on these dates by 2 and 4, respectively.

Table 1. --Resultsof PIT-tag detection efficiency tests conducted at the Chandler Canal fish collection facility, 1990.

Date of release	Mark	Number released	Main detector		Sample detector			System total	
			Number detected	Proportion detected	Number sampled	New detections	Proportion detected	Number detected ^d	Proportion detected
Yearling Chinook Salmon									
7 April	PIT	263	229	0.87	253	33	0.13	262	1.00
16 April	PIT	499	432	0.87	400 ^a	56 ^a	0.14	488 ^c	0.98
Steelhead									
3 May	PIT	147	125	0.85	87	12	0.14	137	0.93
11 May	PIT	223	207	0.93	109	6	0.06	213	0.96
Subyearling Chinook Salmon									
26 May	PIT	499	432	0.87	256 ^b	28 ^b	0.11	460 ^c	0.92
29 May	PIT	53	48	0.91	6	1	0.17	49	0.92
29 May	PIT	44	43	0.98	19	0	0.00	43	0.98
29 May	PIT	80	76	0.95	37	1	0.03	77	0.96
Totals or means		1,808	1,592	0.88	1,167	137	0.12	1,729	0.96

^a Detections were multiplied by 2 to adjust for a 50% sampling rate.

^b Detections were multiplied by 4 to adjust for a 25% sampling rate.

^c Includes adjusted new detections at the sample detector.

^d First time detections only.

An adjusted total of 1,729 first-time detections were made by the main or sample PIT-tag detectors. The combined Chandler facility detection efficiency was 0.96 (range, 0.92-1.00). Since this value was based on tests run prior to 6 June (when modifications improved the efficiency of the primary PIT-tag detector), the combined detection efficiency at the Chandler facility now probably exceeds 0.96.

Task 1.2--Two groups of yearling chinook salmon and one group of subyearling chinook salmon bearing both PIT-tags and freeze brands were released directly into the Chandler facility. As with the PIT-tags, the number of freeze brands observed during sampling of fish released on 16 April and 26 May were multiplied by 2 and 4, respectively, to account for non-continuous sampling rates. Freeze brands on the double-marked fish were recorded at the examination station at significantly lower rates ($P < 0.01$) than the PIT tags at the sample detector. For yearling chinook salmon, 0.87 of the PIT tags were detected compared with 0.66 of the brands; for subyearling chinook salmon, 0.87 of the PIT tags were detected compared with 0.37 of the brands.

Objective 2

Task 2.1--Of the 1,541 yearling chinook salmon that were introduced into the forebay of Prosser Dam, 476 (0.31) were diverted into Chandler Canal and detected at the main PIT-tag monitor at the fish facility (Table 2, Appendix Table 2). For the four releases into the forebay, the proportions detected

Table 2.--Release data, Chandler Canal fish collection facility PIT-tag detections, and estimated survival and diversion rates for yearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Date of release	Release site	Number released	Number detected	Proportion detected	Canal survival ^a	Diversion rate
7 April	Canal	100	92	0.92	1.00 ^b	-
	Forebay	400	73	0.18	-	0.20
13 April	Canal	100	81	0.81	0.93	-
	Forebay	400	255	0.64	-	0.79
19 April	Canal	99	89	0.90	1.00 ^c	-
	Forebay	399	13	0.03	-	0.03
10 May	Canal	75	61	0.81	0.93	-
	Forebay	342	135	0.39	-	0.48
Totals or means	Canal	374	323	0.86	0.96	-
	Forebay	1,541	476	0.31	-	0.38

^a A detection efficiency of 0.875 was used to calculate survival rates for all groups of canal-released fish.

^b Computed estimate was 1.06.

^c Computed estimate was 1.03.

ranged from 0.03 to 0.64. In contrast, 323 (0.86) of the 374 fish released directly into Chandler Canal were detected, with proportions ranging between 0.81 and 0.92.

Paired releases of PIT-tagged subyearling chinook salmon yielded results that were similar to those observed for yearling chinook salmon, although differences in proportion of canal- and forebay-released fish detected were not as pronounced. For subyearling chinook salmon collected at the Chandler facility and released upstream, mean detection proportions (Table 3; Appendix Table 3) were as follows: forebay releases--654 of 1,566 tagged fish detected (mean 0.42 with a range of 0.15 to 0.76); canal releases--264 of 371 tagged fish detected (mean 0.71 with a range of 0.57 to 0.82).

Detection proportions for subyearling chinook salmon taken from the Wapato Canal net-pens were lower than for comparable groups collected at the Chandler facility (Table 4, Appendix Table 4). Of the forebay-released fish, 286 of 1,585 were detected at the fish facility (mean 0.18 with a range of 0.05 to 0.32). And for canal-released fish, 244 of 404 (mean 0.62 and range of 0.45 to 0.74) were detected.

After adjusting for PIT-tag detector efficiency, mean survival rates for the following canal-released fish were estimated: 0.96 for yearling chinook salmon (Table 2), 0.80 for subyearling chinook salmon originally collected at Prosser Dam (Table 3), and 0.69 for subyearling chinook salmon obtained from the Wapato Canal net-pens (Table 4). Mean survival rate was

Table 3.--Release data, Chandler Canal fish collection facility PIT-tag detections, and estimated survival and diversion rates for subyearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Date of release	Release site	Number released	Number detected	Proportion detected	Canal survival ^a	Diversion rate
18 May	Canal	73	49	0.67	0.77	-
	Forebay	347	264	0.76	-	1.00 ^b
22 May	Canal	99	56	0.57	0.66	-
	Forebay	400	264	0.66	-	1.00 ^c
31 May	Canal	99	77	0.78	0.90	-
	Forebay	423	67	0.16	-	0.21
6 June	Canal	100	82	0.82	0.85	-
	Forebay	396	59	0.15	-	0.18
Totals or means	Canal	371	264	0.71	0.80	-
	Forebay	1,566	654	0.42	-	0.60

^a A detection efficiency of 0.875 was used to calculate survival rates for fish released in May; an efficiency of 0.96 was used for the June release group.

^b Computed estimate was 1.13.

^c Computed estimate was 1.16

Table 4.--Release data, Chandler Canal fish collection facility PIT-tag detections, and estimated survival and diversion rates for subyearling chinook salmon from the Wapato Canal net-pens that were marked and released near Prosser, 1990.

Date of release	Release site	Number released	Number detected	Proportion detected	Canal survival ^a	Diversion rate
18 May	Canal	105	47	0.45	0.52	-
	Forebay	395	105	0.27	-	0.60
22 May	Canal	100	51	0.51	0.59	-
	Forebay	400	128	0.32	-	0.63
31 May	Canal	100	74	0.74	0.89	-
	Forebay	393	21	0.05	-	0.06
6 June	Canal	99	72	0.73	0.76	-
	Forebay	397	32	0.08	-	0.11
Totals or means	Canal	404	244	0.62	0.69	-
	Forebay	1,585	286	0.18	-	0.35

^a A detection efficiency of 0.875 was used to calculate survival and diversion rates for fish released in May; an efficiency of 0.96 was used for the June release group.

calculated as the unweighted average of group survival rates. Individual group survival rates were assumed to equal 1.0 if the adjusted rate exceeded this value.

During the test period from 7 April to 6 June, river flow at Prosser Dam fluctuated between 2,100 and 8,100cfs. The flow diverted into Chandler Canal ranged from 16.4% to 61.8% of the total river flow. Diversion rates calculated for PIT-tagged fish that were released in the forebay area of Prosser Dam and subsequently detected at the Chandler facility were 0.03 to 0.79 for yearling chinook salmon, 0.18 to 1.00 for subyearling chinook salmon originally collected at Prosser Dam, and 0.06 to 0.63 for subyearling chinook salmon obtained from the Wapato Canal netpens. Although a relationship between entrainment and flow was evident (Fig. 4), too few releases were made to develop a statistically valid relationship.

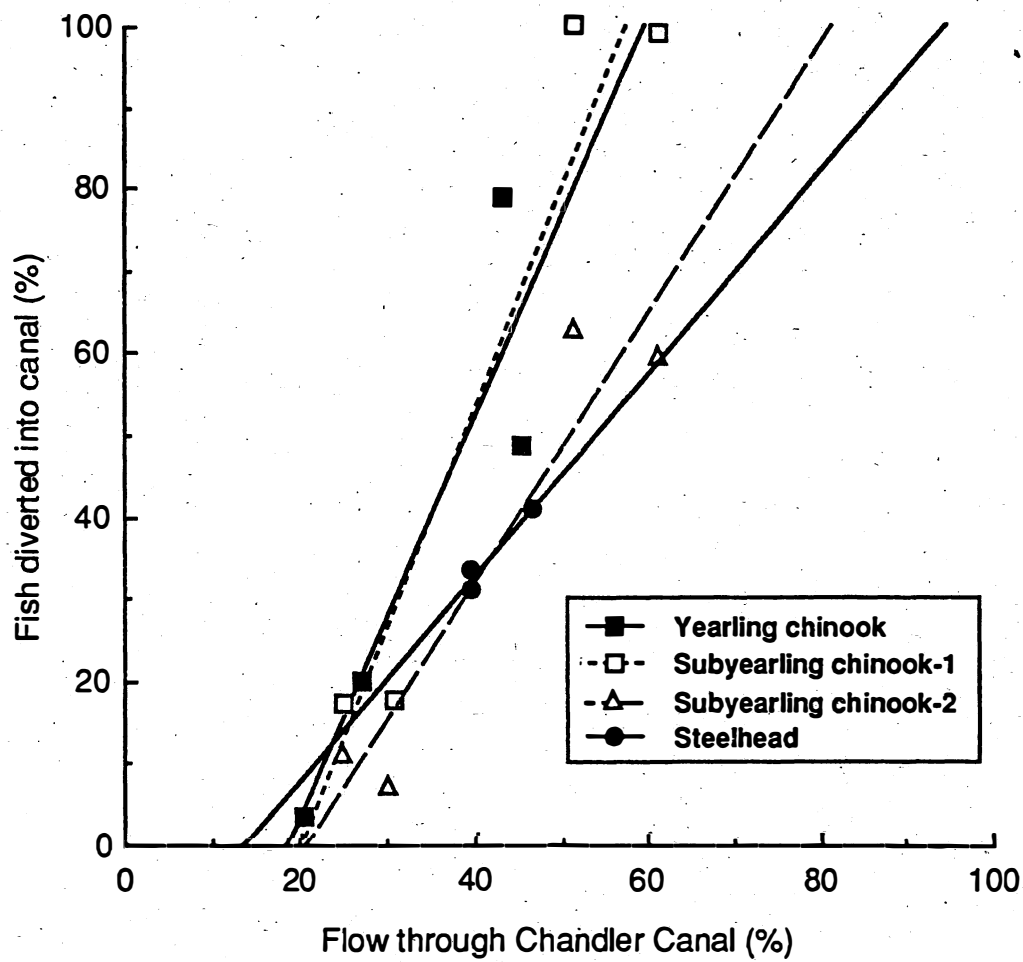


Figure 4.--The percentage of juvenile fish entrained in Chandler Canal as a function of the percentage of mainstem discharge diverted into the canal.

Objective 3

Task 3.1--The West Richland screw trap was installed on 24 April and removed on 12 June 1990. Trapping was discontinued earlier than originally planned because of equipment damage. In all, only 106 PIT-tagged fish were detected by PIT-tag monitoring systems at the West Richland trap (Appendix Tables 5-9). Because the trap was installed after all test groups of yearling chinook salmon had been released, only one PIT-tagged yearling chinook salmon was recovered. For the other species, too few fish of any release group were recovered to provide any meaningful results.

Objective 4

Task 4.1--Yearling chinook salmon--Of the 1,915 yearling chinook salmon released in the canal and forebay areas, 905 (47%) were detected at McNary Dam (Table 5, Appendix Table 10). Detections included 0.34 of canal-released and 0.50 of forebay-released fish. A total of 340 (0.43) PIT-tagged yearling chinook salmon detected at McNary Dam had already been recorded at the Chandler facility. The group of fish released in the forebay on 19 April was not included in the ANOVA because detections at the Chandler facility (13 fish) were much lower than those in other tests (73, 255, and 135 fish), and the proportion subsequently detected at McNary Dam was much larger (0.85) than that obtained in other tests (0.41, 0.47, and 0.43).

Table 5.--PIT-tag detections at McNary Dam of yearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Release		Detected at both Chandler facility and McNary Dam				Detected only at McNary Dam			Total McNary detections	
Date	Location	Number	First det. at Chandler	Second det. at McNary	(M C) ^a	Missed at Chandler	First det. at McNary	(M NC) ^b	Detected at McNary	(M) ^c
7 Apr	Canal Forebay	100	92	26	0.28	8	1	0.13	27	0.27
		400	73	30	0.41	327	152	0.46	182	0.46
13 Apr	Canal Forebay	100	81	29	0.36	19	4	0.21	33	0.33
		400	255	121	0.47	145	53	0.37	174	0.44
19 Apr	Canal Forebay	99	89	38	0.43	10	3	0.30	41	0.41
		399	13	11	0.85	386	241	0.62	252	0.63
10 May	Canal Forebay	75	61	27	0.44	14	0	0.00	27	0.36
		342	135	58	0.43	207	111	0.54	169	0.49
Totals or means	Canal Forebay	374	323	120	0.37	51	8	0.16	128	0.34
		1,541	476	220	0.46	1,065	557	0.52	777	0.50
All Sites		1,915	799	340	0.43	1,116	565	0.51	905	0.47

^a Proportion of fish detected at McNary Dam that were previously detected at the Chandler facility.

^b Proportion of fish detected at McNary Dam that were not previously detected at the Chandler facility.

^c Total proportion of fish detected at McNary Dam observed only for those fish that had not previously been detected at the Chandler facility. Detection history had no effect on detection proportions of forebay-released fish.

Although canal-released fish had generally lower detection proportions at McNary Dam than forebay-released fish, significantly lower detection proportions ($P < 0.05$) were observed only for fish not previously detected at the Chandler facility. Detection history had no effect of detection proportions of forebay-released fish.

Subyearling chinook salmon--There was no significant difference in McNary Dam detections between forebay- and canal-released subyearling chinook salmon from either the Wapato Canal net-pens or the Chandler facility if they were previously detected at the Chandler facility (Tables 6-7, Appendix Tables 11-12). As with yearling fish, only a few fish released into the Chandler Canal and not detected at the Chandler facility were detected at McNary Dam.

An ANOVA similar to that performed for yearling chinook salmon indicated that subyearling chinook salmon originally collected at the Chandler facility were recovered at significantly higher proportions ($P < 0.01$) at McNary Dam than were subyearlings that had been taken from the Wapato Canal net-pens, regardless of release location (Table 8). Detection proportions (both first- and second-time observations) were 0.22 for Chandler facility fish, compared to 0.16 for fish of Wapato Canal origin.

Table 6.--PIT-tag detections at McNary Dam of subyearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Release		Detected at both Chandler facility and McNary				Detected only at McNary			Total McNary detections	
Date	Location	Number	First det. at Chandler	Second det. at McNary	(M C) ^a	Missed at Chandler	First det. at McNary	(M NC) ^b	Detected at McNary	(M) ^c
18 May	Canal Forebay	73	49	11	0.22	24	1	0.04	12	0.16
		347	264	62	0.23	83	17	0.20	81	0.23
22 May	Canal Forebay	99	56	14	0.25	43	0	0.00	14	0.14
		400	264	79	0.30	136	31	0.23	110	0.28
31 May	Canal Forebay	99	77	17	0.22	22	0	0.00	17	0.17
		423	67	13	0.19	356	89	0.25	99	0.23
6 June	Canal Forebay	100	82	18	0.22	18	0	0.00	19	0.19
		396	59	23	0.39	337	56	0.17	79	0.20
Totals or means	Canal Forebay	371	264	60	0.23	107	1	0.01	62	0.17
		1,566	654	177	0.27	912	193	0.21	369	0.24
All Sites		1,937	918	237	0.26	1,019	194	0.19	431	0.22

^a Proportion of fish detected at McNary Dam that were previously detected at the Chandler facility.

^b Proportion of fish detected at McNary Dam that were not previously detected at the Chandler facility.

^c Total proportion of fish detected at McNary Dam.

Table 7.--PIT-tag detections at McNary Dam of subyearling chinook salmon that were reared in net-pens in the Wapato Canal, and marked and released near Prosser, 1990.

Release		Detected at both Chandler facility and McNary				Detected only at McNary			Total McNary detections	
Date	Location	Number	First det. at Chandler	Second det. at McNary	(M C) ^a	Missed at Chandler	First det. at McNary	(M NC) ^b	Detected at McNary	(M) ^c
18 May	Canal	105	47	7	0.15	58	0	0.00	7	0.07
	Forebay	395	105	19	0.18	290	52	0.18	73	0.18
22 May	Canal	100	51	8	0.16	49	0	0.00	8	0.08
	Forebay	400	128	25	0.20	272	43	0.16	69	0.17
31 May	Canal	99	74	8	0.11	25	0	0.00	9	0.09
	Forebay	397	21	2	0.10	376	47	0.13	53	0.13
6 June	Canal	100	72	17	0.24	28	4	0.14	26	0.26
	Forebay	396	32	3	0.09	364	67	0.18	82	0.21
Totals		404	244	40	0.16	160	4	0.03	50	0.12
or means		1,588	286	49	0.17	1,302	209	0.16	277	0.17
All sites		1,992	530	89	0.17	1,462	213	0.15	327	0.16

^a Proportion of fish detected at McNary Dam that were previously detected at the Chandler facility.

^b Proportion of fish detected at McNary Dam that were not previously detected at the Chandler facility.

^c Total proportion of fish detected at McNary Dam.

Table 8.--Analysis of variance of recovery proportions at the Chandler facility of PIT-tagged subyearling chinook salmon taken either from the Chandler facility or Wapato Canal net-pens and released at each of two locations.

Source of variation	df	Sum of squares	Mean square	F value	P
Origin (O)	1	0.03	0.03	10.10	<0.01
Release location (R)	1	0.07	0.07	29.07	<0.01
Chandler detection (C)	1	0.09	0.09	37.28	<0.01
O x R	1	0.01	0.01	3.86	0.06
O x C	1	0.02	0.02	6.43	0.02
R x C	1	0.04	0.04	15.71	<0.01
O x R x C	1	< 0.01	<0.01	0.01	0.92
Error	24	0.06	<0.01		
Total	31	0.31			

The proportion of subyearling chinook salmon recovered from Chandler Canal releases was lower than the proportion recovered from forebay releases, as was the case for yearling chinook salmon. Of fish originally collected at the Chandler facility, 0.17 of canal releases were recovered at McNary Dam, compared to 0.24 of forebay releases at Prosser Dam. For net-pen-reared salmon, the percentages recovered were 0.12 and 0.17, respectively.

Steelhead--Groups of PIT-tagged juvenile steelhead were released simultaneously in 1) Chandler Canal, 2) the forebay of Prosser Dam, and 3) the outfall of the Chandler Canal fish collection facility (Fig. 3). The experiment was repeated once each week over a 3-week period. Detections at the Chandler facility were as follows: Chandler Canal--1,425 (0.80) of 1,783 fish released; Prosser Dam forebay--507 (0.28) of 1,793 released; Chandler facility outfall--5 (0.003) of 1,797 fish released (Appendix Tables 1 and 13). Variability in detection proportions was generally low among groups released at the same location. After adjusting for the detection efficiency of the primary PIT-tag detector at the Chandler facility, the survival rates of juvenile steelhead released into Chandler Canal were 0.89, 0.88, and 0.99 over the three successive tests (mean, 0.92). The proportion of PIT-tagged steelhead recovered at monitoring sites downstream from the Chandler facility did not vary significantly either within or between groups of fish released at different locations. Few detections were made at the West Richland trap (Appendix Table 9). Detections of steelhead at McNary Dam

released from Chandler Canal, Prosser Dam forebay, and the Chandler facility outfall were 131 (0.07), 130 (0.07), and 157 (0.09), respectively (Appendix Table 14). Of the canal- and forebay-released juvenile steelhead that were subsequently detected at McNary Dam, 0.64 had been detected previously at the Chandler facility.

Task 4.2: Of the 2,989 PIT-tagged subyearling chinook salmon released into the Wapato Canal, 318 (0.11) were detected at the Chandler, 3 (0.001) were detected at the West Richland trap, and 328 (0.11) were detected at McNary Dam (Table 9, Appendix Tables 8, 15-16). There was little between-group variation in the proportion of fish detected at the three detection sites.

Of the 3,517 sockeye salmon released into the Cle Elum River (223 km upstream from Prosser Dam), 248 (0.07) were detected at the Chandler facility, none were detected at the West Richland trap, and 271 (0.08) were detected at McNary Dam (Appendix Tables 17 and 18).

Table 9.--Data for first-time detections of PIT-tagged subyearling chinook salmon that were captured, marked, and released into Wapato Canal, 1990.

Release		Detections							
Date	Number	<u>Chandler facility</u>		<u>West Richland trap</u>		<u>McNary Dam</u>		<u>Total</u>	
		Number	Proportion	Number	Proportion	Number	Proportion	Number	Proportion
16 May	991	105	0.11	2	<0.01	96	0.10	203	0.20
18 May	998	104	0.10	1	<0.01	110	0.11	215	0.22
26 May	1,000	109	0.11	0	0.00	122	0.12	231	0.23
Totals or means	2,989	318	0.11	3	<0.001	328	0.11	649	0.22

DISCUSSION

The PIT-tag detectors at the Chandler facility did not detect all of the tagged fish. This was likely the result of non-detection of PIT tags or fish escaping from the upwell or separator upstream from the detector. The former explanation is more likely since periodic flow surges and dewatering in the system sometimes caused several fish to swim through the PIT-tag detector simultaneously. Signal interference caused by the presence of more than one PIT tag in the excitation field of a PIT-tag detector can prevent reading of a PIT-tag (Prentice 1990a).

We noted a negative bias at the lowest sampling rate evaluated: only 0.13 of the PIT-tagged fish were detected by the sample detector when sampling was conducted 25% of the time. This may have resulted from flow fluctuations and unequal passage of fish during timed samples.

Yearling spring chinook salmon, regardless of where they were released, were detected at higher rates than the other test species at the Chandler facility. For example, the estimated mean survival for fish released in Chandler Canal and subsequently detected at the Chandler facility ranged from 0.67 for subyearling chinook salmon to over 0.90 for yearling chinook salmon and steelhead.

Fish released in Chandler Canal were more likely to be recovered at the Chandler facility but were less likely to be

detected at McNary Dam than were fish released in the mainstem forebay area of Prosser Dam. Differences in detection proportions at McNary Dam may indicate either delayed effects caused by passage through the Chandler facility or a problem with the outfall site. The latter supposition is supported by observations of bird predation on juvenile salmonids in the vicinity of the outfall site.

Subyearling chinook salmon reared in net-pens in the Wapato Canal were recovered at the Chandler facility at lower rates than were subyearlings that had been captured, marked, and recaptured at the Chandler facility. Differences were most pronounced among groups of forebay-released fish, suggesting that survival rates among the two groups of fish may have influenced detection proportions. The Wapato Canal-released fish migrated slowly to Prosser Dam (Appendix Table 15), with the peak of detection occurring 30 days after the first release. Predation and other mortality agents acting during this period may have been responsible for the lower detection proportions observed for this group of fish. Proportionally fewer net-pen reared juveniles released in Wapato Canal were recovered at McNary Dam than at the Chandler facility, regardless of release location and detection history.

Diversion rates into the Chandler Canal for chinook salmon and steelhead that were released in the Prosser Dam forebay appeared to be positively correlated with the proportion of mainstem flow diverted into the Chandler Canal. Too few releases were made, however, to infer valid statistical relationships.

From a theoretical standpoint, the relationship between flow and entrainment is probably nonlinear, species- and size-specific, and dependent on the migrational status of the fish in question.

The number of PIT-tagged fish collected at the West Richland screw trap was low for several reasons: water levels in the Yakima River were higher than normal, sampling was suspended on several occasions because of damage to the trap, and the operational time frame was quite narrow. The trap was installed after all of the yearling chinook salmon and a large portion of the sockeye salmon were released. It was removed several days prior to the peak arrival of subyearling chinook salmon.

Low detection proportions at the Chandler facility and McNary Dam for hatchery-reared steelhead may be related to the relatively small size and lack of smolt characteristics in these fish at the time of release. Most of the juvenile steelhead that were detected at both the Chandler facility and McNary Dam migrated slowly to McNary Dam (Appendix Tables 13 and 14). We believe that significant numbers of steelhead did not migrate as smolts. Evidence for this includes the detection at the Chandler facility of five juvenile steelhead from groups of fish that had been released well downstream from the entrance to Chandler Canal. Access to the Chandler Canal from downstream areas is possible, but requires successful navigation of the adult fish ladder at Prosser Dam.

RECOMMENDATIONS

1. PIT tags should be used preferentially over freeze brands as a mark for juvenile salmonids except when visible external marks are required. Additional study of the detection rates obtained with the two marks is not recommended.
2. The reliability of all PIT-tag detectors should be routinely evaluated under normal operating conditions. Detection efficiencies need to be quantified to calculate survival rates.
3. A permanent PIT-tag detector should be installed between the sample tank and the sample station. This subsystem should be a part of the central database.
4. The relationship between subsampling time and the proportion of fish sampled at the Chandler facility should be more fully evaluated.
5. Future comparisons between detection rates for fish naive to the Chandler facility and those previously exposed to the facility should be conducted using actively migrating smolts. Naive fish should be collected from several locations. Hatchery and wild fish should be tested separately.
6. The relationships between mainstem flow, the amount of water diverted into Chandler Canal, and the proportion of fish entrained in the canal should be further evaluated.

7. The potential for increased mortality among fish passing through the Chandler facility related to the location of the outfall should be tested.

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Appendix Table 1.--Summary of PIT tagging and release information for yearling chinook salmon, subyearling chinook, steelhead, and sockeye salmon released in the Yakima River, 1990.

Species/ stock	Rearing type	Capture/ rearing site	Mean		Tagged number	Release				Site	River kilometer ¹
			Weight (g)	Length (mm)		Number	Date	Water Time (h)	Temp. (C)		
Yearling chinook salmon											
Yakima	Wild	Wapatox	-	98	54	54	7 April	1955	11.0	Chandler	539+74
Yakima	Wild	Prosser	-	146	500	263	7 April	1429	12.0	Separator	539+74
Yakima	Wild	Prosser	28.1	133	400	400	7 April	1920	11.0	Forebay	539+75
Yakima	Wild	Prosser	-	136	100	100	7 April	1955	12.0	Chandler	539+74
Yakima	Wild	Prosser	26.9	137	400	400	13 April	1930	11.0	Forebay	539+75
Yakima	Wild	Prosser	25.4	136	100	100	13 April	2000	11.0	Chandler	539+74
Yakima	Wild	Prosser	-	135	500	499	16 April	900	12.0	Separator	539+74
Yakima	Wild	Prosser	23.5	132	400	399	19 April	1930	14.5	Forebay	539+75
Yakima	Wild	Prosser	27.1	134	100	99	19 April	2000	14.0	Chandler	539+74
Yakima	Wild	Prosser	18.3	120	346	342	10 May	1900	11.0	Forebay	539+75
Yakima	Wild	Prosser	19.0	120	75	75	10 May	1930	11.0	Chandler	539+74
Subyearling chinook salmon											
LWS ²	Hatchery	Wapato	4.7	71	1000	991	16 May	2000	10.0	Wapato	539+172
LWS	Hatchery	Wapato	4.6	72	395	395	18 May	1900	13.0	Forebay	539+75
LWS	Hatchery	Wapato	5.7	73	105	105	18 May	2000	13.0	Chandler	539+74
Unknown	Unknown	Prosser	8.1	96	369	347	18 May	1900	15.5	Forebay	539+75
Unknown	Unknown	Prosser	11.2	100	76	74	18 May	2000	15.5	Chandler	539+74
LWS	Hatchery	Wapato	5.3	73	1000	998	18 May	2030	11.0	Wapato	539+172
LWS	Hatchery	Wapato	5.1	75	1000	1000	26 May	2030	10.0	Wapato	539+172
Unknown	Unknown	Prosser	9.1	95	400	400	22 May	1900	17.0	Forebay	539+75
Unknown	Unknown	Prosser	8.4	95	100	99	22 May	1930	16.0	Chandler	539+74
LWS	Hatchery	Wapato	4.9	78	400	400	22 May	1900	15.5	Forebay	539+75
LWS	Hatchery	Wapato	5.2	75	100	100	22 May	1930	15.5	Chandler	539+74
Unknown	Unknown	Prosser	8.4	91	500	499	26 May	930	13.0	Separator	539+74
Unknown	Unknown	Prosser	-	95	55	53	29 May	1530	16.0	Separator	539+74
Unknown	Unknown	Prosser	8.5	95	423	423	31 May	2000	16.5	Forebay	539+75
Unknown	Unknown	Prosser	8.4	95	100	99	31 May	2030	16.0	Chandler	539+74
LWS	Hatchery	Wapato	5.2	78	400	393	31 May	2000	15.0	Forebay	539+75
LWS	Hatchery	Wapato	5.2	78	100	100	31 May	2030	16.0	Chandler	539+74
Unknown	Unknown	Prosser	7.8	90	400	396	6 June	2000	16.0	Forebay	539+75
Unknown	Unknown	Prosser	8.6	90	99	100	6 June	2030	16.0	Chandler	539+74
LWS	Hatchery	Wapato	5.0	79	400	397	6 June	2000	15.0	Forebay	539+75

Appendix Table 1.--Continued.

Species/ stock	Rearing type	Capture/ rearing site	Mean		Number tagged	Number Released	Date	Release		Site	River kilometer ¹
			Weight (g)	Length (mm)				Water Time (h)	Temp. (°C)		
Subyearling chinook salmon											
LWS	Hatchery	Wapato	5.6	80	100	99	6 June	2030	16.1	Chandler	539+74
Unknown	Unknown	Prosser	-	88	46	44	6 June	1030	15.0	Separator	539+74
Unknown	Unknown	Prosser	8.3	90	100	100	13 June	2000	15.0	Chandler	539+74
Unknown	Unknown	Prosser	-	96	80	80	16 June	1330	15.5	Separator	539+74
Steelhead											
Yakima	Hatchery	Yakima	38.5	146	600	598	27 April	1930	13.0	Forebay	539+75
Yakima	Hatchery	Yakima	34.5	147	600	584	27 April	2000	12.0	Chandler	539+74
Yakima	Hatchery	Yakima	37.9	150	600	598	27 April	2030	14.0	Outfall	539+73
Yakima	Hatchery	Yakima	-	145	150	147	3 May	1200	14.0	Separator	539+74
Yakima	Hatchery	Yakima	39.1	150	600	599	4 May	1930	12.0	Forebay	539+75
Yakima	Hatchery	Yakima	37.7	149	600	599	4 May	2000	13.0	Chandler	539+74
Yakima	Hatchery	Yakima	38.6	148	600	597	4 May	2030	13.0	Outfall	539+73
Yakima	Hatchery	Yakima	38.8	149	600	596	11 May	1900	11.7	Forebay	539+75
Yakima	Hatchery	Yakima	38.7	151	600	600	11 April	2000	11.0	Chandler	539+74
Yakima	Hatchery	Yakima	37.6	149	602	602	11 May	2000	12.5	Outfall	539+73
Yakima	Hatchery	Yakima	28.4	138	225	223	11 May	1500	14.0	Separator	539+74
Sockeye											
Wenatchee	Hatchery	Montlake	8.2	89	-	507	28 September	1200	13.0	Cle Elum	539+299+12
Wenatchee	Hatchery	Montlake	18.6	119	-	511	16 March	1200	05.0	Cle Elum	539+299+12
Wenatchee	Hatchery	Montlake	20.9	123	-	500	30 March	1200	05.0	Cle Elum	539+299+12
Wenatchee	Hatchery	Montlake	16.6	116	-	500	12 April	1200	05.0	Cle Elum	539+299+12
Wenatchee	Hatchery	Montlake	19.3	120	-	497	1 May	1200	05.0	Cle Elum	539+299+12
Wenatchee	Hatchery	Montlake	19.1	117	-	502	17 May	1200	05.0	Cle Elum	539+299+12
Wenatchee	Hatchery	Montlake	15.6	110	-	500	1 June	1200	05.0	Cle Elum	539+299+12

¹Individual tributaries are separated by plus signs (+) with the final number being the actual river kilometer on the tributary. The Yakima River is 539 kilometers from the mouth of the Columbia River and the Cle Elum River is 299 kilometers from the mouth of the Yakima River.

²LWS is a stock of up-river bright subyearling chinook salmon obtained at the Little White Salmon Hatchery.

Appendix Table 2.--PIT-tag recoveries at the Chandler Canal juvenile collection facility of yearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Detection date	Release dates and locations								Total
	7 April		13 April		19 April		10 May		
	Forebay	Canal	Forebay	Canal	Forebay	Canal	Forebay	Canal	
7 April	43	86	0	0	0	0	0	0	129
8 April	21	5	0	0	0	0	0	0	26
9 April	7	1	0	0	0	0	0	0	8
12 April	1	0	0	0	0	0	0	0	1
13 April	0	0	157	60	0	0	0	0	217
14 April	0	0	75	11	0	0	0	0	86
14 April	0	0	15	3	0	0	0	0	18
16 April	0	0	6	1	0	0	0	0	7
17 April	0	0	0	5	0	0	0	0	5
18 April	0	0	2	0	0	0	0	0	2
19 April	0	0	0	1	10	81	0	0	92
20 April	0	0	0	0	2	7	0	0	9
25 April	0	0	0	0	0	1	0	0	1
10 May	0	0	0	0	0	0	103	46	149
11 May	0	0	0	0	0	0	25	12	37
12 May	1	0	0	0	0	0	1	2	4
13 May	0	0	0	0	0	0	1	1	2
15 May	0	0	0	0	0	0	1	0	1
16 May	0	0	0	0	0	0	1	0	1
19 May	0	0	0	0	0	0	1	0	1
20 May	0	0	0	0	1	0	0	0	1
23 May	0	0	0	0	0	0	1	0	1
29 May	0	0	0	0	0	0	1	0	1
	73	92	255	81	13	89	135	61	799

¹ Yearling chinook salmon captured at Wapatox Dam.

Appendix Table 3.--PIT-tag detections at the Prosser juvenile collection facility of subyearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Detection date	Release dates and locations								Total
	18 May		22 May		31 May		6 June		
	Forebay	Canal	Forebay	Canal	Forebay	Canal	Forebay	Canal	
18 May	190	28	0	0	0	0	0	0	218
19 May	64	16	0	0	0	0	0	0	80
20 May	5	3	0	0	0	0	0	0	8
21 May	1	1	0	0	0	0	0	0	2
22 May	0	1	244	53	0	0	0	0	298
23 May	1	0	19	2	0	0	0	0	22
24 May	2	0	1	1	0	0	0	0	4
31 May	0	0	0	0	61	75	0	0	136
1 June	0	0	0	0	5	2	0	0	7
6 June	0	0	0	0	0	0	57	82	139
7 June	0	0	0	0	0	0	2	0	2
8 June	1	0	0	0	0	0	0	0	1
18 June	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>
	264	49	264	56	67	77	59	82	918

Appendix Table 4.--PIT-tag detections at the Chandler Canal juvenile collection facility of subyearling chinook salmon that were reared in net-pens in the Wapato Canal, and marked and released near Prosser, 1990.

Detection date	Release dates and locations								Total
	18 May		22 May		31 May		6 June		
	Forebay	Canal	Forebay	Canal	Forebay	Canal	Forebay	Canal	
18 May	14	30	0	0	0	0	0	0	44
19 May	26	17	0	0	0	0	0	0	43
20 May	8	0	0	0	0	0	0	0	8
22 May	3	0	71	46	0	0	0	0	120
23 May	3	0	15	5	0	0	0	0	23
24 May	0	0	7	0	0	0	0	0	7
25 May	0	0	2	0	0	0	0	0	2
26 May	3	0	2	0	0	0	0	0	5
27 May	2	0	0	0	0	0	0	0	2
28 May	1	0	1	0	0	0	0	0	2
29 May	0	0	1	0	0	0	0	0	1
30 May	3	0	2	0	0	0	0	0	5
31 May	1	0	2	0	13	70	0	0	86
1 June	1	0	1	0	4	4	0	0	10
2 June	0	0	1	0	0	0	0	0	1
3 June	2	0	0	0	0	0	0	0	2
4 June	1	0	2	0	0	0	0	0	3
5 June	3	0	0	0	0	0	0	0	3
6 June	0	0	0	0	0	0	29	72	101
7 June	1	0	2	0	0	0	3	0	6
8 June	2	0	2	0	0	0	0	0	4
9 June	1	0	0	0	0	0	0	0	1
11 June	1	0	0	0	0	0	0	0	1
12 June	0	0	1	0	0	0	0	0	1
16 June	7	0	0	0	1	0	0	0	8
17 June	10	0	9	0	1	0	0	0	20
18 June	8	0	4	0	1	0	0	0	13
19 June	1	0	1	0	0	0	0	0	2
20 June	1	0	2	0	0	0	0	0	3
21 June	1	0	0	0	0	0	0	0	1
29 June	1	0	0	0	1	0	0	0	2
	105	47	128	51	21	74	32	72	530

Appendix Table 5.--PIT-tag detections at the West Richland trap of yearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Recovery date	Canal	Total
16 May	$\frac{1}{1}$	$\frac{1}{1}$

Appendix Table 6.--PIT-tag detections at the West Richland trap of subyearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Detection date	Release dates and locations						Total
	18 May		20 May		31 May	6 June	
	Forebay	Canal	Forebay	Canal	Forebay	Forebay	
20 May	5	0	0	0	0	0	5
21 May	3	1	0	0	0	0	4
23 May	0	0	2	0	0	0	2
24 May	0	0	8	1	0	0	9
1 June	0	0	0	0	11	0	11
7 June	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>6</u>	<u>6</u>
	8	1	10	1	11	6	37

Appendix Table 7.--PIT-tag recoveries at the West Richland trap of subyearling chinook salmon that were reared in net-pens in the Wapato Canal, and marked and released near Prosser, 1990.

Detection date	Release dates and locations								Total
	18 May		20 May		31 May		6 June		
	Forebay	Canal	Forebay	Canal	Forebay	Canal	Forebay	Canal	
21 May	1	0	0	0	0	0	0	0	1
25 May	1	0	1	0	0	0	0	0	2
26 May	1	0	1	1	0	0	0	0	3
27 May	1	0	6	0	0	0	0	0	7
28 May	1	0	1	0	0	0	0	0	2
30 May	1	0	1	0	0	0	0	0	2
1 June	1	0	0	0	3	0	0	0	4
2 June	0	0	1	0	3	0	0	0	4
3 June	0	0	0	0	1	0	0	0	1
7 June	0	0	0	0	0	0	2	0	2
8 June	0	0	0	0	0	0	2	0	2
10 June	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>
	7	0	11	1	7	0	5	0	31

Appendix Table 8.--PIT-tag recoveries at the West Richland trap of subyearling chinook salmon that were reared in net-pens in the Wapato Canal, and marked and released in the Wapato Canal, 1990.

Detection date	Release dates			Total
	16 May	18 May	26 May	
31 May	0	1	0	1
7 June	1	0	0	1
8 June	<u>1</u>	<u>0</u>	<u>0</u>	<u>1</u>
	2	1	0	3

Appendix Table 9.--PIT-tag recoveries at the West Richland trap of steelhead trout that were reared at the Yakima Hatchery (WDG), and marked and released near Prosser, 1990.

Release dates and locations										
Detection date	27 April			4 May			11 May			Total
	Forebay	Outfall	Canal	Forebay	Outfall	Canal	Forebay	Outfall	Canal	
11 May	0	0	0	0	1	0	0	0	0	1
15 May	0	0	1	0	0	0	0	0	0	1
18 May	0	0	0	0	0	0	1	0	0	1
19 May	0	0	0	0	0	0	0	0	1	1
20 May	2	0	0	0	0	0	0	0	0	2
21 May	1	1	0	0	0	0	0	0	0	2
24 May	0	0	1	1	1	1	0	1	0	5
25 May	1	1	0	0	1	0	0	0	1	4
26 May	0	2	1	1	1	0	2	1	0	8
27 May	0	0	0	0	0	0	0	0	1	1
28 May	1	0	0	0	1	1	0	0	1	4
30 May	0	0	0	1	0	1	0	0	1	3
31 May	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>
	6	4	3	3	5	3	3	2	5	34

Appendix Table 10.--PIT-tag recoveries at McNary Dam of yearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Detection date	Release Dates and Locations								Total
	7 April		13 April		19 April		10 May		
	Forebay	Canal	Forebay	Canal	Forebay	Canal	Forebay	Canal	
18 April	8	3	3	1	0	0	0	0	15
19 April	18	2	21	3	0	0	0	0	44
20 April	17	4	27	6	0	0	0	0	54
21 April	11	1	15	3	0	0	0	0	30
22 April	12	2	12	5	12	1	0	0	44
23 April	10	1	14	3	39	4	0	0	71
24 April	9	1	9	4	53	6	0	0	82
25 April	11	0	8	1	37	8	0	0	65
26 April	2	1	8	1	25	7	0	0	44
27 April	6	1	9	0	18	2	0	0	36
28 April	8	0	6	0	14	2	0	0	30
29 April	13	2	6	2	8	3	0	0	34
30 April	14	1	3	0	17	3	0	0	38
1 May	11	0	13	1	6	2	0	0	33
2 May	9	2	9	0	10	0	0	0	30
3 May	6	4	7	1	5	0	0	0	23
4 May	7	1	0	0	3	3	0	0	14
5 May	3	0	1	0	2	0	0	0	6
6 May	1	0	0	0	0	0	0	0	1
7 May	1	0	1	1	1	0	0	0	4
8 May	2	0	2	0	1	0	0	0	5
9 May	1	0	0	0	0	0	0	0	1
10 May	0	0	0	0	0	0	0	0	0
11 May	0	1	0	1	0	0	0	0	2
12 May	1	0	0	0	1	0	0	0	2
13 May	0	0	0	0	0	0	19	0	19
14 May	0	0	0	0	0	0	68	5	73
15 May	1	0	0	0	0	0	31	3	35
16 May	0	0	0	0	0	0	19	9	28
17 May	0	0	0	0	0	0	8	3	11
18 May	0	0	0	0	0	0	6	1	7
19 May	0	0	0	0	0	0	6	2	8
20 May	0	0	0	0	0	0	6	1	7
21 May	0	0	0	0	0	0	4	2	6
22 May	0	0	0	0	0	0	0	1	1
23 May	0	0	0	0	0	0	1	0	1
26 May	0	0	0	0	0	0	1	0	1
	182	27	174	33	252	41	169	27	905

¹ Yearling chinook salmon caught at Wapotox and Roza Dams.

Appendix Table 11.--PIT-tag recoveries at McNary Dam of subyearling chinook salmon that were captured, marked, and released near Prosser, 1990.

Release dates and locations									
Detection date	18 May		22 May		31 May		6 June		Total
	Forebay	Canal	Forebay	Canal	Forebay	Canal	Forebay	Canal	
22 May	1	0	0	0	0	0	0	0	1
23 May	5	0	0	0	0	0	0	0	5
24 May	1	1	0	0	0	0	0	0	2
25 May	9	1	0	0	0	0	0	0	10
26 May	14	2	4	1	0	0	0	0	21
27 May	9	3	5	1	0	0	0	0	18
28 May	8	1	10	0	0	0	0	0	19
29 May	8	2	12	1	0	0	0	0	23
30 May	7	0	14	0	0	0	0	0	21
31 May	4	0	23	5	0	0	0	0	32
1 June	3	1	10	4	0	0	0	0	18
2 June	3	1	10	1	0	0	0	0	15
3 June	1	0	8	0	7	0	0	0	16
4 June	4	0	6	0	34	5	0	0	49
5 June	2	0	4	0	17	3	0	0	26
6 June	1	0	3	0	18	5	0	0	27
7 June	0	0	1	0	12	3	0	0	16
8 June	0	0	0	0	3	0	0	0	3
9 June	0	0	0	0	4	0	22	5	31
10 June	0	0	0	0	0	0	5	0	5
11 June	0	0	0	1	3	0	7	1	12
12 June	0	0	0	0	0	0	9	1	10
13 June	0	0	0	0	1	0	17	5	23
14 June	0	0	0	0	0	0	11	6	17
15 June	0	0	0	0	0	1	3	0	4
16 June	0	0	0	0	0	0	1	0	1
17 June	0	0	0	0	0	0	1	0	1
18 June	0	0	0	0	0	0	0	1	1
19 June	0	0	0	0	0	0	1	0	1
20 June	0	0	0	0	0	0	2	0	2
28 June	1	0	0	0	0	0	0	0	1
	81	12	110	14	99	17	79	19	431

Appendix Table 12.--PIT-tag detections at McNary Dam of subyearling chinook salmon that were reared in net-pens in the Wapato Canal, and marked and released near Prosser, 1990.

Release Dates and Locations									
Detection date	18 May		22 May		31 May		6 June		Total
	Forebay	Canal	Forebay	Canal	Forebay	Canal	Forebay	Canal	
31 May	1	0	0	0	1	0	0	0	2
3 June	1	0	3	0	0	0	0	0	4
4 June	3	0	1	0	0	0	0	0	4
5 June	2	1	1	1	0	0	0	0	5
6 June	3	1	5	0	0	0	0	0	9
7 June	4	0	8	0	2	0	0	0	14
8 June	1	0	4	1	4	2	0	0	12
9 June	1	0	4	0	2	0	0	0	7
10 June	3	1	2	0	1	0	0	1	8
12 June	0	0	0	1	0	0	0	0	1
13 June	1	1	3	0	3	1	2	1	12
14 June	5	1	1	0	7	1	8	2	25
15 June	3	1	3	3	3	0	4	0	17
16 June	2	0	0	0	1	0	3	0	6
17 June	3	0	2	0	0	0	2	1	8
18 June	4	0	1	0	4	0	4	3	16
19 June	5	0	4	0	4	0	3	0	16
20 June	4	0	5	0	3	1	6	2	21
21 June	5	0	0	0	4	0	3	1	13
22 June	4	0	5	0	0	1	6	1	17
23 June	3	0	5	0	4	1	1	2	16
24 June	2	0	4	0	1	1	7	3	18
25 June	5	0	2	2	0	0	4	1	14
26 June	0	0	3	0	1	0	5	2	11
27 June	1	0	0	0	0	0	3	0	4
28 June	3	1	1	0	0	0	1	1	7
29 June	1	0	0	0	0	0	6	0	7
30 June	0	0	0	0	0	0	1	0	1
1 July	0	0	1	0	1	0	0	0	2
2 July	1	0	0	0	3	0	1	0	5
3 July	2	0	0	0	0	0	2	0	4
4 July	0	0	0	0	0	0	1	1	2
5 July	0	0	1	0	1	0	1	0	3
6 July	0	0	0	0	0	0	1	0	1
7 July	0	0	0	0	0	0	1	0	1
8 July	0	0	0	0	1	1	1	1	4
9 July	0	0	0	0	0	0	1	2	3
10 July	0	0	0	0	0	0	0	1	1
11 July	0	0	0	0	1	0	0	0	1
12 July	0	0	0	0	0	0	1	0	1
13 July	0	0	0	0	0	0	1	0	1
16 July	0	0	0	0	0	0	1	0	1
22 July	0	0	0	0	1	0	0	0	1
28 July	0	0	0	0	0	0	1	0	1
	73	7	69	8	53	9	82	26	327

Appendix Table 13.--PIT-tag detections at the Chandler Canal juvenile collection facility of steelhead that were reared at the Yakima Hatchery (WDG), marked and released near Prosser, 1990.

Release dates and locations										
Detection date	27 April			4 May			11 May			Total
	Forebay	Outfall	Canal	Forebay	Outfall	Canal	Forebay	Outfall	Canal	
8 April	2	0	0	0	0	0	1	0	0	3
17 April	0	0	0	1	0	0	0	0	0	1
18 April	0	0	0	0	0	0	1	0	0	1
27 April	7	0	78	0	0	0	0	0	0	85
28 April	32	0	159	0	0	0	0	0	0	191
29 April	36	0	152	0	0	0	0	0	0	188
30 April	4	0	15	0	0	0	0	0	0	19
1 May	5	0	12	0	0	0	0	0	0	17
2 May	5	0	9	0	0	0	0	0	0	14
3 May	8	0	3	0	0	0	0	0	0	11
4 May	6	1	6	16	0	99	0	0	0	12
5 May	0	0	1	88	0	291	0	0	0	380
6 May	2	0	0	15	0	23	0	0	0	40
7 May	3	0	0	5	0	10	0	0	0	18
8 May	0	0	2	7	0	22	0	0	0	31
9 May	0	0	1	1	0	2	0	0	0	4
11 May	4	0	0	0	0	0	12	0	75	91
12 May	1	0	2	0	0	0	51	1	174	229
13 May	1	0	0	1	0	1	49	0	94	146
14 May	2	0	0	0	0	0	13	0	35	50
15 May	3	0	0	1	0	0	16	0	31	51
16 May	0	0	2	0	0	1	21	0	34	58
17 May	1	0	1	2	0	0	10	0	12	26
18 May	8	0	0	2	0	0	8	0	10	28
19 May	3	0	2	1	0	0	4	0	14	24
20 May	0	0	1	0	0	2	12	0	14	29
21 May	0	0	0	1	0	0	2	0	1	4
22 May	2	0	0	2	1	0	2	0	1	8
23 May	0	0	0	1	0	1	2	0	2	6
24 May	0	0	0	0	0	0	0	0	1	1
25 May	0	0	0	1	0	0	0	0	1	2
26 May	1	0	1	1	0	0	0	0	3	6
27 May	2	0	1	0	0	0	1	0	0	4
28 May	1	0	0	0	0	0	1	0	2	4
30 May	0	0	0	0	0	0	1	0	10	11
1 June	0	1	0	1	0	1	0	0	1	4
2 June	1	0	0	2	0	0	0	0	1	4
5 June	0	0	1	0	0	0	1	0	0	2
6 June	0	0	0	0	0	1	0	0	0	1
7 June	2	0	0	1	0	0	0	0	1	4
11 June	0	0	0	0	0	1	0	0	0	1
12 June	0	0	0	1	0	0	0	0	0	1
13 June	0	0	0	0	0	1	0	0	0	1
16 June	0	0	0	1	0	0	0	0	0	1
20 June	0	0	0	0	0	1	0	0	0	1
21 June	1	0	0	0	0	0	0	0	0	1
26 June	0	0	0	0	0	0	1	0	0	1
27 June	0	0	0	1	0	0	0	0	0	1
28 June	0	0	1	0	0	0	0	0	0	1
1 July	0	0	1	0	0	0	0	0	0	1
2 July	0	0	0	0	1	0	0	0	0	1
3 July	1	0	0	0	0	0	0	0	0	1
6 July	0	0	0	0	0	0	1	0	0	1
	144	2	451	153	2	457	210	1	517	1,937

Appendix Table 14.--PIT-tag recoveries at McNary Dam of steelhead trout that were reared at the Yakima Hatchery (WDG), and marked and released near Prosser, 1990.

Release dates and locations										
Detection date	27 April			4 May			11 May			Total
	Forebay	Outfall	Canal	Forebay	Outfall	Canal	Forebay	Outfall	Canal	
2 May	0	1	0	0	0	0	0	0	0	1
3 May	0	0	3	0	0	0	0	0	0	3
4 May	0	2	0	0	0	0	0	0	0	2
5 May	1	1	1	0	0	0	0	0	0	3
6 May	1	0	0	0	0	0	0	0	0	1
7 May	2	1	1	0	0	0	0	0	0	4
8 May	3	0	1	0	1	0	0	0	0	5
9 May	0	9	3	2	2	5	0	0	0	21
10 May	1	1	3	2	1	0	0	0	0	8
11 May	5	3	1	1	2	3	0	0	0	15
12 May	0	2	0	1	0	1	0	0	0	4
13 May	1	3	0	3	0	0	0	0	0	7
14 May	1	2	3	2	4	0	0	0	0	12
15 May	0	0	2	0	2	2	0	2	0	8
16 May	0	3	2	1	3	0	1	0	1	11
17 May	0	2	1	0	1	4	1	1	1	11
18 May	1	2	1	0	3	1	1	2	0	11
19 May	3	1	0	1	3	0	2	1	1	12
20 May	0	1	2	2	0	1	1	2	1	10
21 May	1	0	0	0	0	1	1	0	1	4
22 May	1	0	0	0	1	0	1	4	1	8
23 May	1	0	2	3	1	4	0	1	1	13
24 May	1	1	2	3	2	1	0	0	0	10
25 May	0	3	1	1	2	0	0	0	0	7
26 May	2	3	2	1	5	3	0	2	1	19
27 May	4	2	2	5	3	0	0	1	2	19
28 May	2	2	3	3	7	4	8	1	4	34
29 May	2	2	6	2	6	0	1	4	7	30
30 May	2	3	4	1	4	4	4	4	1	27
31 May	3	0	0	3	0	1	2	2	3	14
1 June	1	2	0	2	0	2	2	3	4	16
2 June	0	3	2	1	3	0	1	0	2	12
3 June	0	0	1	0	0	0	3	2	2	8
4 June	1	1	0	3	1	3	3	3	2	17
5 June	2	1	0	0	0	0	0	1	0	4
6 June	0	0	0	0	1	1	3	1	1	7
7 June	3	0	0	0	1	0	1	1	1	7
8 June	0	0	0	0	0	0	2	1	0	3
9 June	0	0	1	1	0	0	1	2	0	5
10 June	0	0	0	0	0	0	0	0	1	1
13 June	0	0	0	1	0	0	1	0	0	2
14 June	0	0	0	0	0	0	0	0	1	1
26 June	0	0	1	0	0	0	0	0	0	1
	45	57	51	45	59	41	40	41	39	418

Appendix Table 15.--PIT-tag detections at the Chandler Canal juvenile collection facility of subyearling chinook salmon that were reared in net-pens, marked and released in the Wapato Canal, 1990.

Detection date	Release dates			Total
	16 May	18 May	26 May	
17 April	1	0	1	2
12 May	1	0	0	1
17 May	0	1	0	1
19 May	1	0	0	1
27 May	1	1	0	2
28 May	1	1	0	2
29 May	3	1	1	5
30 May	1	0	1	2
31 May	2	2	0	4
1 June	5	2	1	8
2 June	3	3	0	6
3 June	4	1	1	6
4 June	4	2	1	7
5 June	1	2	2	5
6 June	1	0	0	1
7 June	4	5	4	13
8 June	1	4	3	8
9 June	4	2	1	7
10 June	2	0	0	2
11 June	2	3	5	10
12 June	2	1	2	5
13 June	0	0	3	3
14 June	3	0	1	4
15 June	1	2	0	3
16 June	5	5	5	15
17 June	21	19	24	64
18 June	15	20	19	54
19 June	6	12	18	36
20 June	3	8	5	16
21 June	4	2	5	11
25 June	0	1	1	2
28 June	1	1	0	2
29 June	2	0	1	3
30 June	0	2	1	3
1 July	0	1	1	2
2 July	0	0	1	1
3 July	0	0	1	1
	<u>105</u>	<u>104</u>	<u>109</u>	<u>318</u>

Appendix Table 16.--PIT-tag detections at McNary Dam of subyearling chinook salmon that were reared in net-pens in the Wapato Canal, and marked and released in the Wapato Canal, 1990.

Detection date	Release dates			Total
	16 May	18 May	26 May	
3 June	0	2	0	2
4 June	1	1	0	2
5 June	0	1	1	2
6 June	3	0	0	3
7 June	2	1	0	3
8 June	5	1	2	8
9 June	4	4	2	10
11 June	1	1	0	2
12 June	1	1	1	3
13 June	5	8	5	18
14 June	8	6	4	18
15 June	2	3	4	9
16 June	1	4	5	10
17 June	5	0	3	8
18 June	4	3	7	14
19 June	5	3	2	10
20 June	5	9	8	22
21 June	4	6	4	14
22 June	7	7	9	23
23 June	9	14	15	38
24 June	10	9	17	36
24 June	5	5	11	21
26 June	4	4	8	16
27 June	3	8	5	16
28 June	1	7	4	12
29 June	1	1	1	3
2 July	0	0	2	2
3 July	0	1	1	2
5 July	0	0	1	1
	96	110	122	328

Appendix Table 17.--PIT-tag detections at the Chandler Canal juvenile collection facility of sockeye salmon that were captured, marked, and released in the Cle Elum River, 1990.

Detection date	Release dates							Total
	28 September	16 March	30 March	12 April	1 May	17 May	1 June	
21 March	0	12	0	0	0	0	0	12
22 March	0	22	0	0	0	0	0	22
23 March	0	5	0	0	0	0	0	5
24 March	0	6	0	0	0	0	0	6
25 March	0	4	0	0	0	0	0	4
26 March	0	1	0	0	0	0	0	1
27 March	0	1	0	0	0	0	0	1
1 April	0	1	0	0	0	0	0	1
2 April	0	0	3	0	0	0	0	3
3 April	1	4	36	0	0	0	0	41
4 April	1	4	10	0	0	0	0	15
5 April	1	2	1	0	0	0	0	4
7 April	0	1	0	0	0	0	0	1
8 April	0	0	2	0	0	0	0	2
13 April	1	0	0	0	0	0	0	1
14 April	0	0	1	0	0	0	0	1
15 April	0	2	0	0	0	0	0	2
16 April	0	5	0	16	0	0	0	21
17 April	0	5	2	10	0	0	0	17
18 April	0	2	0	3	0	0	0	5
19 April	0	0	0	1	0	0	0	1
20 April	0	1	0	0	0	0	0	1
5 May	0	1	0	0	0	0	0	1
6 May	0	0	1	0	0	0	0	1
7 May	1	0	0	0	1	0	0	2
8 May	0	1	0	0	9	0	0	10
9 May	1	0	0	0	6	0	0	7
10 May	0	0	0	0	2	0	0	2
11 May	0	0	0	0	3	0	0	3
12 May	0	0	0	0	2	0	0	2
13 May	0	0	0	0	1	0	0	1
14 May	0	0	0	0	1	0	0	1
18 May	0	0	0	0	1	0	0	1
20 May	0	1	0	0	0	0	0	1
23 May	0	0	2	0	0	1	0	3
24 May	0	0	0	0	0	2	0	2
26 May	0	0	0	0	0	1	0	1
28 May	0	0	0	0	0	1	0	1
29 May	0	0	0	0	0	1	0	1
1 June	0	0	0	0	0	1	0	1
2 June	0	0	0	0	1	1	0	2
5 June	0	0	0	0	0	0	33	33
6 June	0	0	0	0	0	0	5	5
	6	81	58	30	27	8	38	248

Appendix Table 18.--PIT-tag detections at McNary Dam of sockeye salmon that were captured, marked, and released in the Cle Elum River, 1990.

Detection date	Release dates							Total
	28 Sep.	16 Mar.	30 Mar.	12 Apr.	1 May	17 May	1 Jun.	
18 April	0	1	2	0	0	0	0	3
19 April	0	2	0	3	0	0	0	5
20 April	0	1	1	5	0	0	0	7
21 April	0	2	0	7	0	0	0	9
22 April	0	8	2	6	0	0	0	16
23 April	0	7	1	10	0	0	0	18
24 April	0	3	4	11	0	0	0	18
25 April	0	2	1	5	0	0	0	8
26 April	1	7	5	7	0	0	0	20
27 April	0	2	10	3	0	0	0	15
28 April	0	3	2	5	0	0	0	10
29 April	0	4	5	7	0	0	0	16
30 April	0	7	10	5	0	0	0	22
1 May	0	1	8	4	0	0	0	13
2 May	0	3	7	3	0	0	0	13
3 May	0	0	2	1	0	0	0	3
4 May	0	1	1	0	0	0	0	2
5 May	0	0	0	1	0	0	0	1
6 May	0	0	3	1	0	0	0	4
7 May	0	0	1	0	0	0	0	1
8 May	1	1	2	1	0	0	0	5
9 May	0	1	1	0	0	0	0	2
10 May	1	0	2	0	0	0	0	3
11 May	0	0	1	0	3	0	0	4
12 May	0	0	0	0	4	0	0	4
13 May	0	0	1	0	4	0	0	5
14 May	0	0	1	1	3	0	0	5
16 May	0	0	3	0	0	0	0	3
17 May	0	0	1	0	0	0	0	1
18 May	1	0	1	0	1	0	0	3
19 May	0	0	1	0	0	0	0	1
20 May	0	0	1	0	0	0	0	1
22 May	0	0	1	0	0	0	0	1
23 May	0	1	0	0	0	0	0	1
24 May	0	1	0	0	0	0	0	1
25 May	0	0	1	1	1	0	0	3
28 May	0	0	0	1	0	1	0	2
29 May	0	0	1	0	0	0	0	1
30 May	1	0	0	0	0	0	0	1
3 June	0	0	0	0	0	1	0	1
7 June	0	0	0	0	0	1	7	8
8 June	0	0	0	0	0	0	2	2
9 June	0	0	0	0	0	0	5	5
10 June	0	0	0	0	0	0	1	1
11 June	0	0	0	0	0	0	1	1
12 June	0	0	0	0	0	0	1	1
13 June	0	0	0	0	0	0	1	1
	5	58	83	88	16	3	18	271

