SMOLT MONITORING AT THE HEAD OF LOWER GRANITE RESERVOIR AND LOWER GRANITE DAM

1991 Annual Report

by

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ABSTRACT

This project monitored the daily passage of chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *Oncorhynchus mykiss* smelts during the 1991 spring outmigration at migrant traps on the Snake River and the Clearwater River.

Chinook salmon catch at the Snake River trap was similar to 1987, 1988, and 1990, drought years, but considerably less than 1989, a near normal flow year. Trapping effort was the same during the five-year period. Hatchery steelhead trout catch was similar to 1988 through 1990. Wild steelhead trout catch was 20% greater than in any previous year. In 1991, operations at the Snake River trap and a new screw trap were extended through August to collect summer-migrating age O chinook. Operation of the screw trap began on July 2. The screw trap did not collect any age O chinook due to extremely low discharge after that date. The differentiation of age O chinook from spring and summer chinook (age 1) using physical characteristics did not begin until June 16 and 93 age O chinook were collected at the Snake River trap.

Chinook salmon catch at the Clearwater River trap was the second lowest in the past five years. Hatchery steelhead trout trap catch was similar to the second highest catch, which occurred in 1988, but about three times lower than in 1990, which had the highest trap catch. Wild steelhead trout trap catch was similar to the second highest and about half of the highest.

Fish tagged with Passive Integrated Transponder (PIT) tags at the Snake River trap were recovered at the three dams with PIT tag detection systems (Lower Granite, Little Goose, and McNary dams). Cumulative recovery at the three dams for fish marked at the Snake River trap was 68.2% for chinook salmon, 89.7% for hatchery steelhead trout, and 83.3% for wild steelhead trout. Cumulative recovery at the three dams for fish PIT-tagged at the Clearwater River trap was 60.5% for chinook salmon, 83.8% for hatchery steelhead trout, and 74.1% for wild steelhead trout.

Travel time (d) and migration rate (km/d) through Lower Granite Reservoir for PIT-tagged chinook salmon and steelhead trout, marked at the head of the reservoir, were affected by discharge. Statistical analysis showed that a two-fold increase in discharge increased migration rate by 2.3 times for PIT-tagged chinook salmon released from the Snake River trap and for PIT-tagged chinook salmon released from the Clearwater River trap. A two-fold increase in discharge increased migration rate by 3.1 times for PIT-tagged hatchery steelhead trout released from the Snake River trap. Hatchery steelhead trout marked at the Clearwater River trap migrated 1.5 times faster with a two-fold increase in discharge. A two-fold increase in discharge increased migration rate by 2.2 times for PIT-tagged wild steelhead trout released from the Snake River trap and by 2.1 times for PIT-tagged wild steelhead trout released from the Clearwater River trap.

Chinook salmon, hatchery steelhead trout, and wild steelhead trout captured in the Snake River trap had a minimum survival estimate to Lower Granite Dam that was 5.9 to 7.9 percentage points higher than fish that were collected in the Clearwater River trap. This difference may be attributed to the distance fish traveled before encountering the traps or other unknown factors.

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INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NPPC) to develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (BPA) the authority and responsibility to use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system."

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smelt migration. In response to the fishery agencies and Indian tribes recommendations for migration flows, theNPPC Columbia River Basin Fish and Wildlife Program proposed a "Water Budget" for augmenting spring flows.

The NPPC'S water budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the smelt migration. This is the first year since the establishment of the water budget that over a million acre-feet of water were made available. In the past, only about a third of the requested 1.19 million acre-feet has been provided.

To provide information to the Fish Passage Center (FPC) on smelt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smelts at the head of Lower Granite Reservoir. This information allows the FPC to request the limited Snake River water budget for optimal use to provide improved passage and migration conditions.

Smelt monitoring is beneficial for water budget management under all flow conditions and becomes critical when low flow conditions reduce migration rates. In years of low flow (drought years), knowledge of when most smelts have left tributaries and entered areas that can be affected by releases of stored water allows managers to make the most timely use of the limited water budget resource. Four low flow years (1987, 1988, 1990, and 1991) have occurred during this smelt monitoring project. The indications are that judicious use of the water budget can greatly enhance the timing and migration rate of juvenile chinook salmon and steelhead trout.

Additionally, the IDFG smelt monitoring project collects other useful data on relative species composition, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, and migration rate. All age O chinook are PIT-tagged to determine migration rate through Lower Granite Reservoir and minimum survival. All wild steelhead trout smelts are PIT-tagged to determine timing of wild adult steelhead trout one and two years later as they return to spawn. By monitoring smelt passage at the head of Lower Granite Reservoir and at Lower Granite Dam, migration rates (km/d) under various riverine and reservoir conditions can be estimated and compared. Monitoring sites, on both the Snake and Clearwater arms of Lower Granite Reservoir, permit migration timing to be determined for smelts from each drainage. Although not yet achieved, relative abundance of hatchery and wild stocks of steelhead trout can be determined and used to document wild stock rebuilding progress. The Smelt Monitoring Program's information is complementary of other Snake River and Columbia River NPPC-supported projects.

OBJECTIVES

1. Provide daily trap catch data at the head of Lower Granite Reservoir for water budget and fish transportation management purposes.

2. Determine riverine travel time from the point of release to the smelt traps (index sites) at the upper end of Lower Granite Reservoir for freeze brand and Passive Integrated Transponder (PIT) tagged smelts.

3. Provide an interrogation site for PIT-tagged smelts, marked on other projects, at the end of their migration in a riverine environment and the beginning of their migration in a reservoir environment.

4. Determine reservoir travel time for spring/summer chinook salmon, age O chinook salmon, hatchery steelhead trout, and wild steelhead trout from the head of Lower Granite Reservoir to Lower Granite Dam and to Little Goose Dam using PIT-tagged smelts marked at the traps and PIT-tagged smelts passing the traps from upriver hatchery releases and rearing areas.

5. Determine minimum survival during the spring outmigration period for PIT-tagged spring/summer and age O chinook salmon, hatchery, and wild steelhead trout in Lower Granite Reservoir.

6. Correlate smelt migration rate with river flow for fish moving in riverine and reservoir environments.

7. Determine trap efficiency for each species at each trap over a range of discharges.

8. Test the new screw trap to determine effectiveness of the trap to collect age O chinook salmon smelts.

9. PIT tag all age O chinook collected in the Snake River trap and screw trap and determine travel time and minimum survival to Lower Granite and Little Goose dams.

10. Evaluate timing of returning adult wild and natural steelhead crossing Lower Granite Dam.

METHODS

Releases of HatcherV-Produced Smelts

Release information was reported for hatcheries in the Snake River drainage upstream of Lower Granite Dam that released chinook salmon and steelhead trout juveniles which may have contributed to the 1991 outmigration. This information included species, number released, date and location released, and the group-identifying freeze brand, if used.

Smelt Monitoring Traps

During the 1991 outmigration, two smelt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. A scoop trap (Raymond and Collins 1974) was stationed on the Clearwater River and a dipper trap (Mason 1966) was located on the Snake River (Figure 1). A third trap, a screw trap, was installed on July 2 to increase the collection of summer-migrating age 0 chinook. Smelts were captured and removed daily from the traps for examination, enumeration, and released back to the river. Fork length of up to 100 smelts for each species was measured to the nearest millimeter and up to 2,000 fish were examined for hatchery brands. Smelts were anesthetized before handling with tricaine methanesulfonate (MS-222). These fish were allowed to recover from the anesthesia before being returned to the river.

At each trap, water temperature (C) and turbidity were recorded daily using a centigrade thermometer and 20 cm secchi disk. The U.S. Weather Service provided daily information on river discharge (cfs). The Snake River trap discharge was measured at the U.S. Geological Survey (USGS) Anatone gauge (#13334300), 44.4 km upstream from the trap. The Clearwater River trap discharge was measured at the USGS Spalding gauge (#13342500), 8.8 km upstream from the trap.

Snake River Traps

The Snake River migrant dipper trap was positioned approximately 40 m downstream from the Interstate Bridge, between Lewiston, Idaho and Clarkston, Washington, and was attached to bridge piers just east of the draw bridge span by steel cables. This location is at the head of Lower Granite Reservoir, 0.5 km upstream from the convergence of the Snake and Clearwater arms. River width and depth at this location are approximately 260 m and 12 m, respectively.

A new screw trap was added to the Snake River trap location. It was attached to the Interstate Bridge but was attached to bridge piers just west of the draw bridge span.

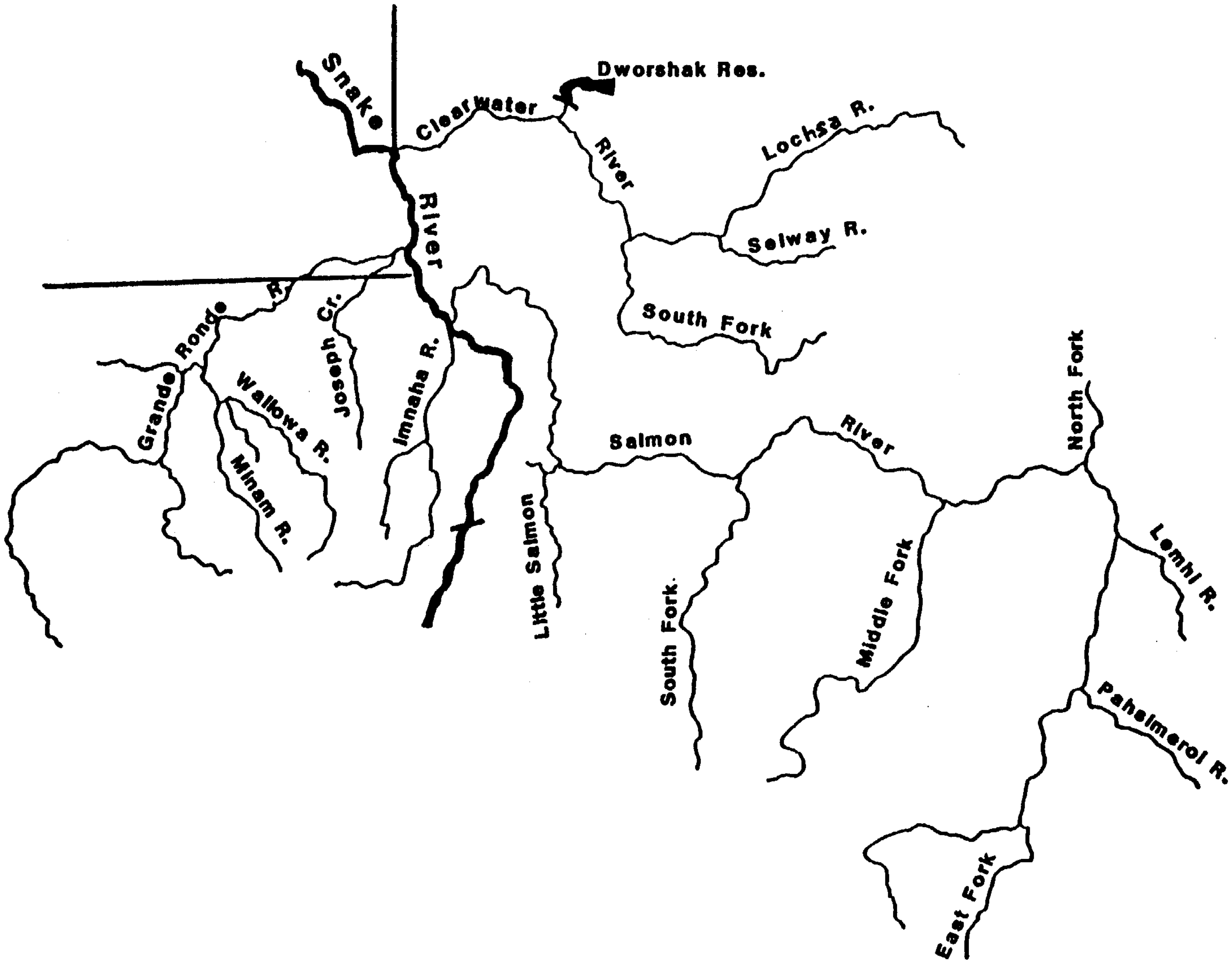

Figure 1. Map of study area.

A juvenile steelhead trout radio tracking study was conducted in 1987 (Liscom and Bartlett 1988). The study showed that during 1987, 7% of the radio-tagged steelhead trout passed the bridge under the span west of the drawbridge, where the trap was positioned, and 30% passed the bridge under the span immediately east of the drawbridge span. Because at least four times more fish were moving under the span of the bridge just east of the drawbridge, the dipper trap was moved to that location on April 27, 1988, after completing installation of an electrical line to the new trap location.

Dipper trap operation in 1991 began March 11 and continued until August 12. There were two major interruptions in trap operation, one due to an extremely heavy debris load from May 20-22 and one due to a mechanical breakdown from June 8-11. There were also 12 times when the trap did not function properly due to a heavy debris build-up in the trap or when the shear pin broke on the dipper pan. The trap was out of operation for less than 15 h on each occasion. There was one occasion when the trap was shut down from 0100-0300 h on May 10 because too many fish were entering the trap and we could not remove them from the live well fast enough.

The screw trap operation began on July 2 and continued until August 9. There was no downtime during the operation season although velocities were so low late in the season that the screw did not turn continuously.

Chinook salmon and steelhead trout smelts were tagged with PIT tags (prentice et al. 1987) at the Snake River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam. Up to 150 chinook salmon, 60 hatchery steelhead trout, all wild steelhead trout, and all age O chinook were PIT-tagged daily, when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow for the median travel time to determine how changes in discharge affected smelt migration rate through Lower Granite Reservoir.

All fish captured in the Snake River dipper trap were passively interrogated for PIT tags as they entered the live well. All fish captured in the screw trap were interrogated when they were examined. The recovery and tagging information was sent to the PTAGIS Data Center (managed by Pacific States Marine Fisheries Commission) daily.

The PIT tag interrogation system on the Snake River trap consists of an 8-inch PVC pipe with two interrogation coils (D-4 and D-6). Each coil is connected to an exciter card and a PIT tag reader. The system does not have the capability to provide exact time of capture. Since it is checked once daily, the interrogation time is set to 00:00 h.

Table 1. River mile & kilometer locations for the Snake River drainage.

	Mouth of Columbia R.		Mouth of Snake River		Lower Granite Dam		Snake River trap site		Clearwater R. trap site		Salmon River trep site	
	mi	km	mi	km	mi	km	mi	km	mi	km	mi	km
Mouth of Snake River	324.3	521.8	0.0	0.0	107.5	172.9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0	0.0	0.0	32.1	51.6	38.3	61.5	133.9	215.4
Clearwater R. trap site	470.0	756.2	145.7	234.4	38.2	61.5	--	--	0.0	0.0	--	--
Highway 95 Boat Launch	473.2	761.4	148.9	239.6	41.5	66.8	--	--	3.2	5.1	--	--
Dworshak NFH	504.3	811.4	180.0	289.6	72.5	116.6	--	--	34.3	55.2	--	--
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7	--	--	71.5	115.0	--	--
Crooked River	604.3	972.3	280.0	450.5	172.5	277.6	--	--	134.3	216.0	--	--
Red River Reering Pond	618.0	994.4	293.7	472.6	186.2	299.6	--	--	148.0	238.1	--	--
Snake River trap site	463.9	746.4	139.6	224.6	32.1	51.6	0.0	0.0	--	--	101.8	163.8
Asotin Creek Rel. Site	470.3	756.7	146.0	234.9	38.5	61.9	6.4	10.3	--	--	--	--
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8	--	--	--	--
Deer Creek	504.3	811.4	180.0	289.6	72.5	116.7	40.4	65.0	--	--	--	--
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0	--	--	--	--
Wildcat Creek	546.2	878.8	221.9	357.0	114.4	184.3	82.3	132.4	--	--	--	--
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4	--	--	--	--
Big Canyon Creek	585.9	942.7	261.6	420.9	154.1	247.9	122.0	196.3	--	--	--	--
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2	--	--	--	--
Catherine Creek	636.9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4	--	--	--	--
Mouth of Salmon River	512.5	824.6	188.2	302.8	80.7	129.8	48.6	78.2	--	--	53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8	--	--	--	--
Little Sheep Creek	553.8	891.1	229.5	369.3	122.0	196.3	89.9	144.6	--	--	--	--
Imnaha Coll. Facility	565.6	910.2	241.3	388.3	133.8	215.4	101.7	163.6	--	--	--	--
Hells Canyon Dam	571.3	919.2	247.0	397.4	139.5	224.5	107.4	172.8	--	--	--	--
Salmon River trap site	565.7	910.2	241.4	388.4	133.9	215.4	101.8	163.8	--	--	0.0	0.0
Rapid River Hatchery	605.8	974.7	281.5	452.9	174.0	280.0	141.9	228.3	--	--	40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154.8	249.1	--	--	53.0	85.3
S.F. Salmon @ Knox Bridge	719.7	1158.0	395.4	636.2	287.9	463.2	255.8	411.6	--	--	154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353.6	568.9	--	--	251.8	405.1
E.F. Salmon @ trap site	873.6	1405.6	549.3	883.8	441.8	710.9	409.7	659.2	--	--	307.9	495.4
Sawtooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8	--	--	331.9	534.0

Clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from ‘the convergence of the Clearwater River and Snake River arms of Lower Granite Reservoir (4.5 km upstream from slack water). The river channel at this location forms a bend and is 150 to 200 m wide and 4 m to 7 m deep, depending on discharge.

Trap operation began March 13 and continued until May 12. Trapping was discontinued because of high discharge and/or debris for four d this season, April 26-30.

Chinook salmon and steelhead trout smelts were tagged with PIT tags at the Clearwater River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam for Clearwater River fish. Up to 150 chinook salmon, 60 hatchery steelhead trout, and all wild steelhead trout were PIT-tagged daily, when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow for the median travel time to determine how changes in discharge affected smelt migration rate through Lower Granite Reservoir.

All fish were interrogated for PIT tags as the fish were removed from the live well. The tagging and interrogation files were sent to the **PTAGIS** Data Center daily.

The PIT tag interrogation system on the Clearwater River trap consists of a 4-inch PVC pipe with two interrogation coils (D-O and D-2). Each coil is attached to an exciter card and a PIT tag reader. This system is battery operated. The system was tested by passing 1,543 test tags through the system. The efficiency for both coils was 98.8%, combined.

Trap Efficiency

The proportion of the migration run being sampled is termed trapping efficiency. Since trap efficiency may change as river discharge changes, efficiency has been estimated several times through the range of discharge at which the trap was operated. A linear regression equation (Ott 1977) describing the relation of trap efficiency and discharge was derived to estimate efficiency at any given discharge.

During the 1991 trap operations, no trap efficiency tests were conducted at either of the traps. **Yearly** trap efficiency estimates are reported in Buettner and Nelson (1990).

Travel Time and Migration Rates

Migration statistics were calculated for hatchery release groups from release sites to traps. Travel time and migration rates to the traps were calculated using median arrival times at the Snake River and Clearwater River traps. Median arrival (or passage) date is the sample date the 50th percentile fish arrived at the trap or collection facility. Smelts were PIT-tagged at the Snake River and Clearwater River traps as the primary method to determine travel time from the head of Lower Granite Reservoir to Lower Granite and Little Goose dams. Distances from release point to recovery location are listed in Table 1. Daily individual arrival times of these fish at Lower Granite and Little Goose dams collection facilities were determined. A minimum recapture number, sufficient for use in travel time and migration rate estimations, was derived from an empirical distribution function of the travel time for each individual release group (Steinhorst et al. 1988). If recapture numbers were less than five or less than the number derived from the empirical distribution function, the daily data were combined with another day's data or the data were not used. If it was combined, it was added to daily data from an adjacent release day that had similar discharge and travel time.

Smelt migration rate/discharge relations through Lower Granite Reservoir were investigated using linear regression analysis after both variables were log (in) transformed (Zar 1984). The 0.05 level was used to determine significance. This analysis was performed for the hatchery freeze-branded chinook salmon and steelhead trout groups and for the PIT-tagged spring/summer chinook salmon, age 0 chinook salmon, hatchery steelhead trout and wild steelhead trout groups marked at the Snake River or Clearwater River traps.

To remove some of the "noise" often associated with biological data and better show the underlying biological relation, migration rate was stratified into 5-kcfs discharge intervals (Mosteller and Tukey 1977). A linear regression analysis was conducted on the grouped data.

A linear regression analysis was performed on the migration rate/discharge data for PIT-tagged fish released from the Snake River and Clearwater River traps and interrogated at Little Goose Dam. Data that had been stratified into 5-kcfs discharge intervals and log transformed were used in the analysis.

The migration rate/discharge relations, for PIT-tagged chinook salmon, hatchery steelhead trout, and wild steelhead trout were individually examined for 1987-1991 to determine if the relations were different between years. Using an analysis of covariance, with the migration rate data stratified by 5-kcfs groups, the first underlying assumption of equality of slopes was tested. If the hypothesis of equality of migration rate/discharge slopes among years was not rejected, then the subsequent analysis of covariance was completed. This was basically a test of whether the regression lines relating migration rate and discharge for each year had a common intercept, or whether one regression line was higher than another. If the final hypothesis of common intercepts was not rejected, there was not a significant difference in the migration rate/discharge relations among years, and the yearly data were pooled. After pooling, a linear regression analysis was run to provide the best fitting equation to describe the relation between migration rate and discharge for an individual species over several years.

Minimum Survival of PIT-Tagged Fish

Estimates of minimum survival of PIT-tagged fish, marked at the head of Lower Granite Reservoir, to Lower Granite Dam collection facility included data from 1988-1991 for the Snake River trap and 1989-1991 for the Clearwater River trap. Using both chinook salmon and steelhead trout smelts marked throughout the sampling season, a "MinimumSurvival Estimate" from the trap to Lower Granite Dam was derived. This minimum estimate consists of fish that were interrogated at Lower Granite, Little Goose, or McNary dams. The data have been examined to ensure that multiple interrogations within a dam and between dams have been removed. The basis for the minimum survival estimate at Lower Granite Dam is that fish that were interrogated at Lower Granite, Little Goose, or McNary dams were alive when they passed Lower Granite Dam. This estimate is held to be a "minimum" estimate because there are fish that passed all three dams without being detected and due to mortality that occurs downstream of Lower Granite Dam.

RESULTS AND DISCUSSION

Hatcherv Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage upstream from Lower Granite Dam were reared at nine locations in Idaho and two in Oregon. The Washington Department of Fisheries released no chinook salmon juveniles in the Snake River drainage upstream from Lower Granite Dam that contributed to the 1991 outmigration. A total of 9,645,205 chinook salmon smelts were released at 16 locations in Idaho and two locations in Oregon (Table 2).

During the late summer and fall of 1990, four groups of chinook salmon juveniles were released from Idaho hatcheries. All other chinook salmon releases for the 1991 outmigration were made in the spring of 1991 (Table 2).

Steelhead Trout

Steelhead trout were reared at four locations in Idaho, one in Washington, and two in Oregon for release into the Snake River drainage upstream from Lower Granite Dam. A total of 9,893,980 steelhead trout smelts were released at 16 locations in Idaho, nine locations in Oregon, and one location in Washington

Table 2. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam contributing to the 1991 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Salmon River				
East Fork Salmon River (Sawtooth)	Spring	3/5	98,300	
Little Salmon River at Hazard Creek (Rapid River)	Spring	3/21	100,100	
Salmon River at Hell Roaring Creek Bridge (Sawtooth)	Spring	8/16/90	2,000	
South Fork Salmon River (McCall)	Spring	3/18-21	708,600	
		(3/20)	(20,122)	RD>O-1
		(3/20)	(22,608)	RA>O-1
		(3/20)	(20,097)	LA>O-1
Pahsimeroi River (Pahsimeroi)	Spring	3/13-22	227,500	
Rapid River (Rapid River)	Spring	3/15-4/5	2,564,900	
		(3/28)	(20,417)	RA>1-1
		(3/28)	(21,398)	RD>1-1
		(3/28)	(19,871)	RD>1-3
Salmon River at Sawtooth Weir (Sawtooth)	Spring	3/8-3/13	650,600	
		(3/13)	(18,190)	LA>1-1
		(3/13)	(19,238)	LD>1-1
		(3/13)	(17,696)	LD>1-3
Yankee Fork (Sawtooth)	Spring	10/10/90	491,290	
	Drainage Total		4,843,290	
Snake River and Non-Idaho Tributaries				
Hells Canyon Dam (Rapid River)	Spring	3/19-22	500,500	
Imnaha River (Imnaha)	Spring	3/22	267,670	
		(3/22)	(20,441)	RDJ-2
		(3/22)	(20,676)	LDJ-2
		(3/22)	(20,668)	RDJ-4
		(3/22)	(20,777)	LDJ-4
		4/9	131,239	

Table 2. Continued.

Release site (hatchery)	Stock	Release date	No. released (No.branded)	Brand
Lookingglass Creek (Lookingglass)	Spring	4/1	331,636	
		(4/1)	(20,799)	RDJ-1
		(4/1)	(20,819)	LDJ-1
		(4/1)	(22,083)	RDJ-3
		(4/1)	(19,375)	LDJ-3
		4/2	504,668	
		6/13	17,404	
	Drainage Total		1,753,117	
Clearwater River				
Clear Creek (Kooskia)	Spring	4/16	396,619	
Crooked River (Crooked River)	Spring	10/17/90	339,100	
Eldorado Creek (Dworshak)	Spring	3/25-26	199,456	
N.F. Clearwater (Dworshak)	Spring	4/3	1,094,884	
		(4/3)	(19,704)	RDIK-1
		(4/3)	(16,884)	RAIK-1
Papoose Creek (Dworshak)	Spring	3/25-26	70,000	
Red River				
(Dworshak)	Spring	3/25	63,004	
(Kooskia)	Spring	3/27	124,071	
(Red River)	Spring	10/23/90	273,800	
Powell				
(Kooskia)	Spring	3/12-4/1	180,764	
(Powell)	Spring	10/23/90	307,100	
	Drainage Total		3,048,798	
	Grand Total		9,645,205	

(Table 3). Fall releases of steelhead trout juveniles have not been included in this total.

Smelt Monitoring Traps

Snake River Trap Operation

The Snake River trap caught 3,834 age 1 chinook salmon, 95 age O chinook salmon, 19,020 hatchery steelhead trout, 4,136 wild steelhead trout, and 801 sockeye/kokanee salmon *Oncorhynchus nerka*. Chinook salmon catch at the Snake River trap for 1991 was similar to other low flow years (1987, 1988, and 1990) and considerably lower than 1984-1986 or 1989, normal or above normal flow years. There appears to be a threshold velocity required within the trap to collect chinook salmon effectively. Below this threshold velocity, which is about 1.6 to 1.8 ft/s, trap efficiency is very low and chinook salmon trap catch may not be representative of the chinook salmon population passing the trap. The threshold velocity is generally exceeded when discharge is above 27,000 to 33,000 Cfs. The outmigration pattern was similar to other years (Figure 2).

This was the first year that physical characteristics were used to differentiate between age O chinook salmon and other chinook salmon. The peak movement of age O chinook salmon was during mid-June. Age O chinook catch in the Snake River trap had virtually stopped by July 14. The lack of age O chinook salmon in the Snake River trap catch was due to either a lack of fish movement or to low velocities in the trap reducing trap efficiency.

There were three major peaks in hatchery steelhead trout passage. The first began in late April and lasted until the end of the month (Figure 3). The second began on May 7 and lasted until May 14. This period had the highest daily catch for the season of 3,122 smelts which occurred on May 10. This daily peak was the highest ever encountered at the Snake River trap and was two times greater than the highest ever previous daily catch of hatchery steelhead trout. The trap was also out of operation for three h during this night (0001-0300 h), because fish were coming into the trap faster than we could work them up. The third peak began on May 18 and lasted until May 26. During this period the trap was out of operation for three days (May 20-22) due to an extremely heavy debris load.

Twelve percent of the hatchery steelhead trout were captured in April, 85% in May, and 3% in June, 1991 The early portion of the run was shifted from late April to early May probably due to a late runoff in the Salmon River drainage. Generally, wild steelhead trout passage is earlier than hatchery steelhead trout, but this year they migrated out of the system at the same time. Eleven percent of the wild steelhead trout were captured in April, 88% in May, and 1% in June (Figure 3). Similar to the hatchery steelhead trout timing, the wild steelhead trout timing was delayed due to the late spring runoff in the Salmon River drainage.

Table 3. Hatchery steelhead trout released into the Snake River system upriver from Lower Granite Dam contributing to the 1991 **outmigration.**

Release site (hatchery)	Stock	Release date	No. released **(No.branded)**	Brand -
Salmon River				
East Fork Salmon River (Magic Valley)	B	4/13	967,800	
Salmon River at Ellis Bridge (Niagara Springs)	A	4/15-17	174,400	
Salmon River at Hammer Creek (Magic Valley)	A	4/22-25	186,300	
Little Salmon River at Hazard Creek				
(Hagerman)	B	4/17-29	457,110	
(Magic Valley)	A	4/26	310,300	
Salmon River at North Fork (Niagara Springs)	A	4/19-22	158,400	
Pahsimeroi River				
(Niagara Springs)	A	4/9-14	475,000	
(Magic Valley)	A	4/18-19	135,100	
Salmon River at Sawtooth Hatchery				
(Hagerman)	A	4/3-16	979,799	
(Magic Valley)	A	4/9-19	364,700	
Salmon River at Shoup Bridge				
(Niagara Springs)	A	4/18	48,200	
(Magic Valley)	A	4/20-21	97,800	
	Drainage Total		4,354,909	
Snake River and Non-Idaho Tributaries				
Big Canyon Pond **(Irrigon)**	A	4/26-5/6	47,187	
Catherine Creek **(Irrigon)**	A	4/11-16	111,464	
Deer Creek **(Irrigon)**	A	4/26	271,980	
		4/26	(20,654	RAJ-2
		4/26	(20,946	**LAJ-2**
		4/26	(20,289	W - 4
		4/26	(20,798	**LAJ-4**

Table 3. Continued

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Grande Ronde R-2 above La Grande, OR (Irrigon)	A	4/8-11	200,466	
Grande Ronde River km 41 (Lyons Ferry)	A	4/16-30	252,799	
Grande Ronde River km 67 (Lyons Ferry)	A	4/30	52,500	
Hells Canyon Dam (Niagara Springs)	A	4/22-5/2	912,000	
Imnaha River (Irrigon)	A	5/1-5/3	86,235	
Little Sheep Creek (Irrigon)	A	4/23	242,982	
		4/23	(19,953)	RAA-3
		4/23	(20,499)	LAA-3
		4/23	(20,000)	RAA-1
		4/23	(19,890)	LAA-l
Spring Creek (Wallowa)	A	4/22	497,148	
		4/22	(20,161)	RAJ-1
		4/22	(20,777)	LAJ-l
		4/22	(20,100)	RAJ-3
		4/22	(20,989)	w - 3
	A	5/2	109,529	
Wildcat Creek (Irrigon)	A	4/30	98,783	
		4/30	(27,055)	RAA-2
		4/30	(26,124)	LAA-2
	Drainage Total		2,883,073	
Clearwater River				
American River (Dworshak)	B	4/15-24	210,874	
Clear Creek (Dworshak)	B	4/15-24	369,190	
Clearwater River at DNFH (Dworshak)	B	4/29-5/1	1,192,503	
		(4/29-5/1)	(4,603)	LA7U-1
		(4/29-5/1)	(14,698)	RD7U-1
		(4/29-5/1)	(5,280)	LD7U-1
		(4/29-5/1)	(14,015)	RA7U-1
		(4/29-5/1)	(4,864)	LA7U-3
		(4/29-5/1)	(9,361)	RD7U-3
		(4/29-5/1)	(4,740)	LD7U-3

Table 3. Continued

Release site (hatchery)	Stock	Release date	No. released (No.branded)	Brand .
Eldorado Creek (Dworshak)	B	4/15-26	201,847	
S.F. Clearwater R. at Mill Creek Bridge (Dworshak)	B	4/15-24	290,421	
S.F. ClearWater R. at Mount Idaho Bridge (Dworshak)	B	4/15-24	177,336	
Red River (Dworshak)	B	4/15-24	213,827	
	Drainage Total		2,655,998	
	Grand Total		9,893,980	

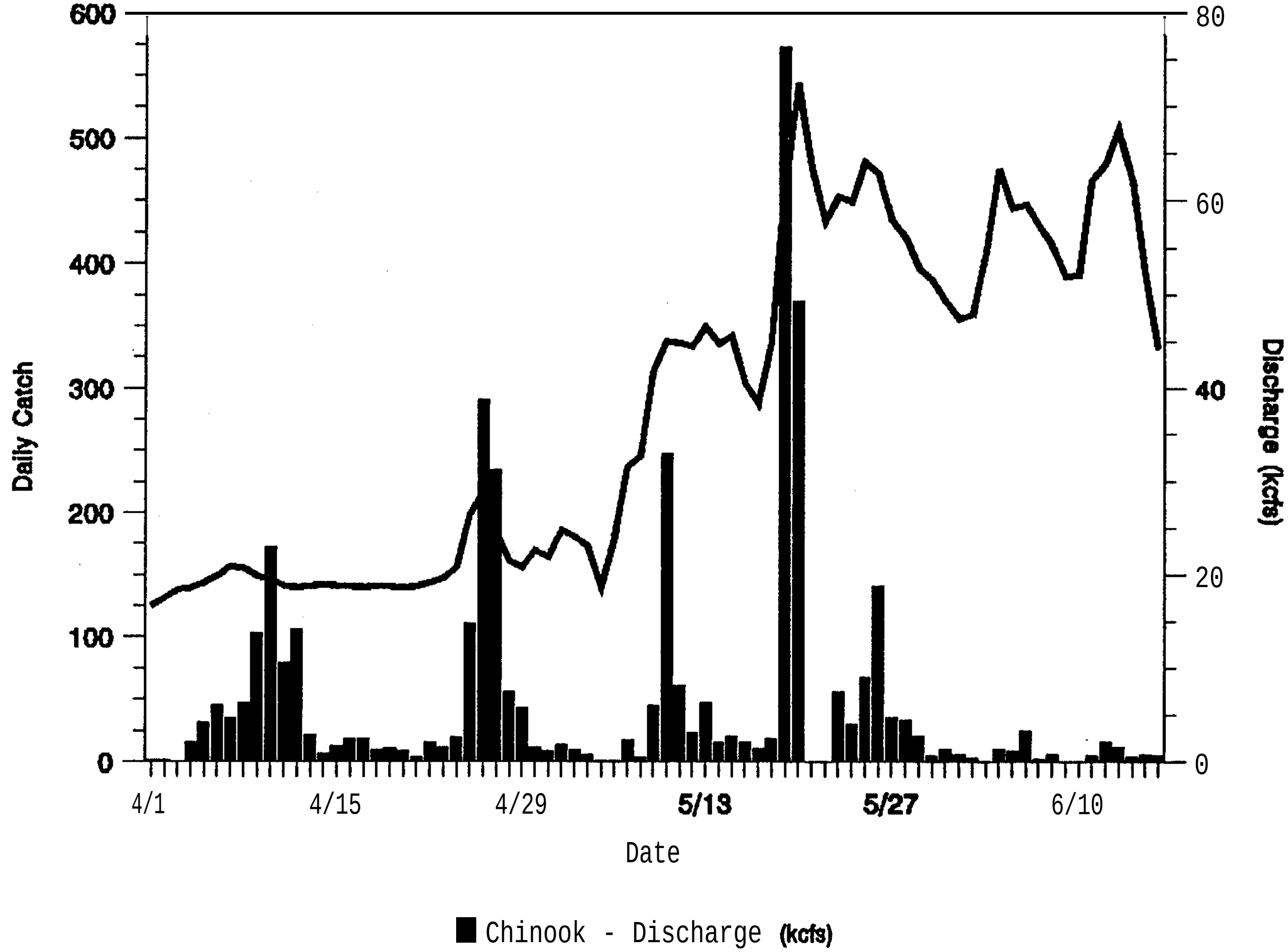

Figure 2. Snake River trap daily catch of age 1 chinook salmon overlaid by the Snake River discharge, 1991.

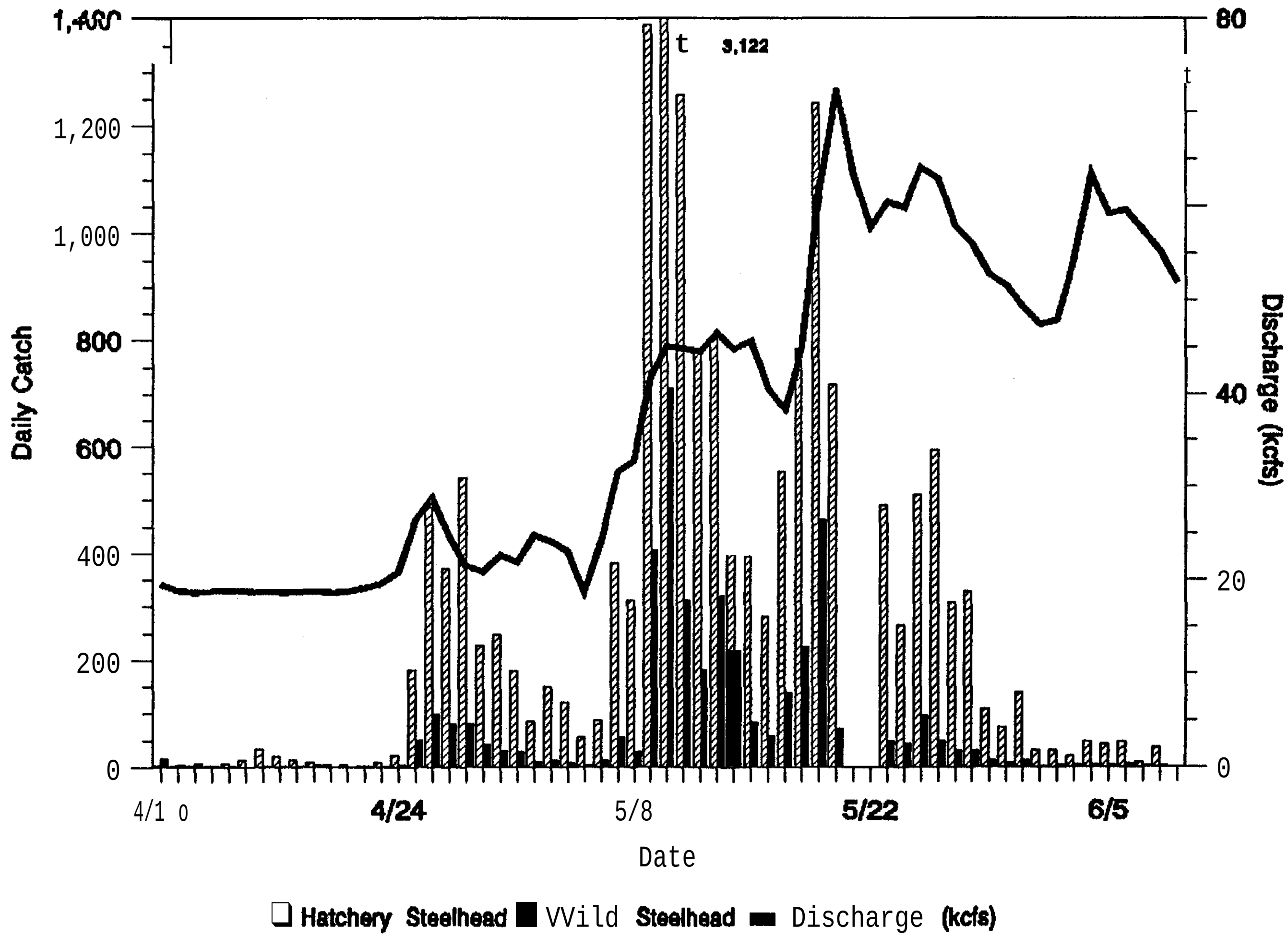

Figure 3. Snake River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Snake River discharge, 1991.

The Snake River trap catch for wild steelhead trout was 1.2 times greater than in any previous year. The daily trap catch of 711 fish on May 10 was more than two times greater than any previous day. The Snake River trap was out of operation from 0001-0300 h that day because fish were coming into the trap faster than we could remove them. This reflects a similar outmigration in wild steelhead trout to 1990 which was greater than in previous years. Wild steelhead trout had three major periods of movement. These coincided with the three major periods of movement for hatchery steelhead trout (Figure 3). Each major period of movement was associated with a substantial increase in Snake River discharge.

Snake River discharge, measured at the Anatone gauge, ranged from 16,300 cfs to 29,100 cfs and averaged 19,100 cfs in March (Figure 3), which was 5,000 cfs lower than in 1990 and 21,500 cfs lower than in 1989. The average April discharge was 20,100 cfs, with a peak of 28,800 cfs on April 26. The April average was 10,800 cfs lower than in 1990 and 38,400 cfs lower than in 1989. Flows remained below 25,000 cfs until May 7. After May 7, discharge began to increase and peaked on May 20 at 72,500 cfs for the month and for the year. The average May discharge was 45,400 cfs, which was 6,600 cfs higher than 1990 and 6,700 cfs lower than in 1989. Flows had dropped to 47,400 cfs by the first of June and began to increase again. A second peak for the season occurred on June 13 at 67,600 cfs. The average June flow was 48,500 cfs and was similar to the 1990 average June flow of 46,100 cfs. The discharge remained fairly high until July 15. After this date, it dropped rapidly to summer low flow conditions of less than 15,000 cfs.

Runoff during the 1991 outmigration season in the Snake River above the mouth of the Clearwater River was delayed in April due to a very cold spring. This increased the amount of runoff which occurred in May, June, and July. The 1991 outmigration season had the best flow conditions late in the season since the drought started in 1987.

Water temperature in the Snake River at the trap steadily increased throughout the sampling season (Figure 4). By the end of the season, August 12, water temperature had risen to 23°C. Water temperatures were similar to 1990 except for May, 1991 when water temperature was slightly lower than May, 1990.

Secchi disk transparency fluctuated throughout the sampling season (Figure 4). Influenced mainly by localized rain or thunderstorm events, secchi transparency shows no biological correlation to discharge ($r^2 = 0.130$, $N = 101$, $P<0.001$). The lowest secchi disk transparency of 0.1 m on May 19 was associated with the maximum discharge for the season.

Clearwater River Trap Operation

The Clearwater River trap caught 39,522 chinook salmon, 9,231 hatchery steelhead trout, 824 wild steelhead trout, and 44 sockeye/kokanee salmon in 1991. The chinook salmon trap catch for 1991 was about 30% less than in 1990 but three times greater than the lowest trap catch of 9,938 in 1989. The 1991 hatchery steelhead trout trap catch was equivalent to the second highest catch which

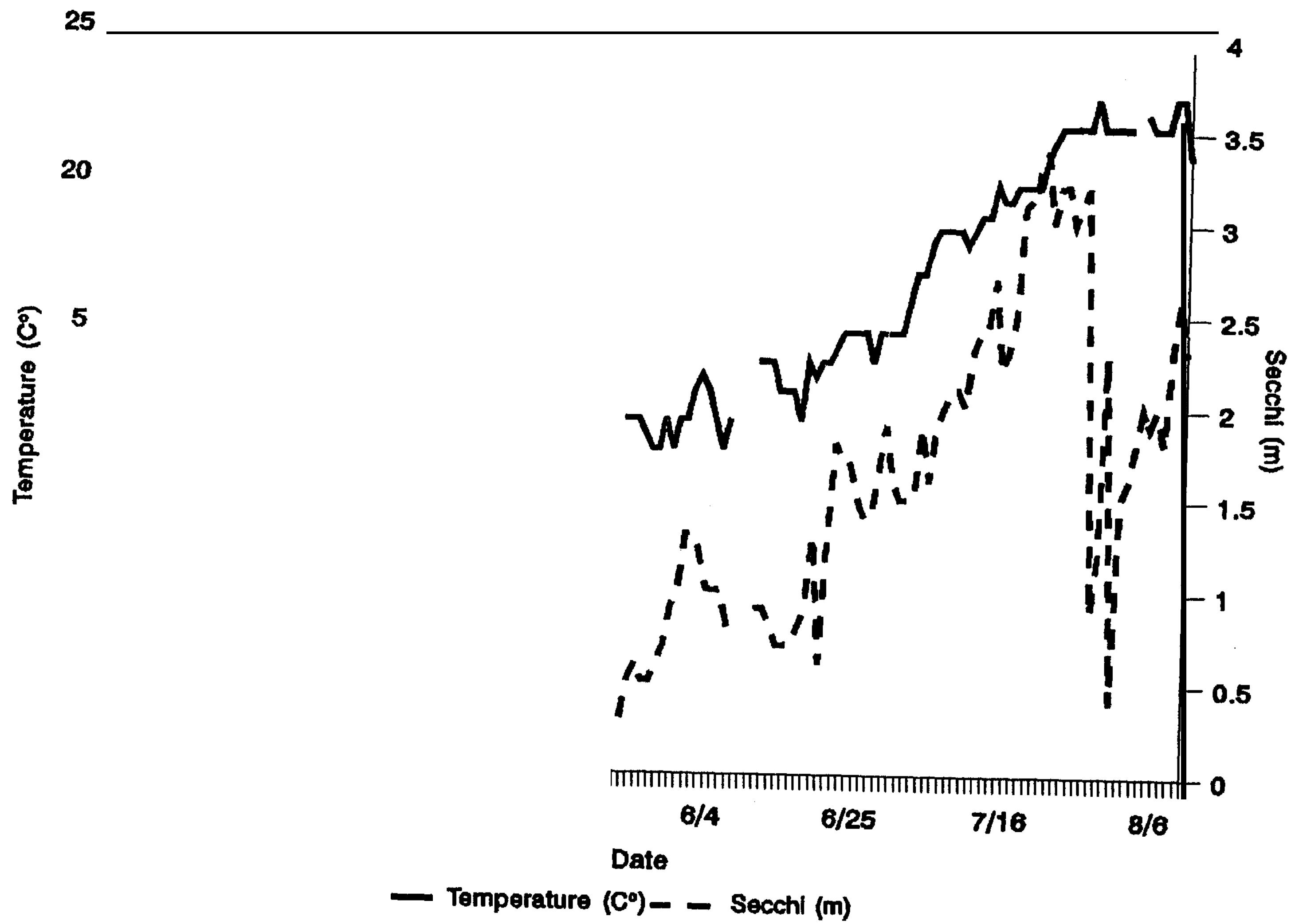

Figure 4. Daily temperature and secchi disk transparency at the Snake River trap, 1991.

occurred in 1988 but three times less than the highest which occurred in 1990. The wild steelhead trout trap catch was similar to the second highest trap catch in 1987 and about half the highest catch which occurred in 1990.

Two major peaks of chinook salmon passage were observed at the Clearwater River trap (Figure 5). The first began on April 3 and peaked on April 5. This peak was associated with chinook salmon passing the trap from Dworshak National Fish Hatchery (DNFH) releases. The second peak was on April 18 through 20 and was probably associated with the releases from Kooskia National Fish Hatchery (KNFH) and fall-released smelts from Powell, Crooked River and Red River rearing ponds. Numbers remained relatively high for several weeks after the second peak. The latter part of the outmigration was not sampled because trap operation was terminated on May 12 due to high discharge.

Hatchery steelhead trout began showing up in the trap catch in low numbers (<100 fish per day) on April 17. There was a major movement of hatchery steelhead trout prior to the DNFH release and was due to movement of smelts outplanted in the Clearwater River upstream from DNFH. The major peak, which occurred on May 2, was associated with the DNFH release (Figure 6). Overall hatchery steelhead trout capture was lower in 1991 than in 1990, because the trap was operated fewer days in the optimum position near the thalweg in 1991, and trap operation was terminated on May 12, 1991 and on May 25, 1990.

Wild steelhead trout were present in the trap catch in low numbers (one to six fish per day) from March 21 until April 6. The first of four peaks began on April 7 and lasted until April 12 (Figure 6). The second began on April 17 through April 19. The third and major peak began on April 22 and was still in progress when trap operation was interrupted on April 26 due to high flow. The last peak began on May 6 through May 11. Trap catch of wild steelhead trout in 1991 was considerably lower than in 1990. This is probably a function of trap location rather than lower number of wild steelhead trout migrating out of the system. The trap was operated fewer days in the optimum location near the thalweg in 1991 due to high flows.

Water temperature at the Clearwater River trap at the beginning of the season was 4.5°C and gradually increased to 10″C by April 23 (Figure 7). Water temperature dropped to 7°C by April 26 and then gradually climbed back to 9°C by the end of the trapping season on May 12. Water temperatures were several degrees cooler than normal throughout the season.

Secchi disk transparency in the Clearwater River fluctuated throughout the trapping season and ranged from 0.4 m to 2.6 m (Figure 7). There was a significant statistical correlation between secchi disk transparency and discharge ($r^2 = 0.171$, $N = 61$, $P = 0.001$), but the relation was weak.

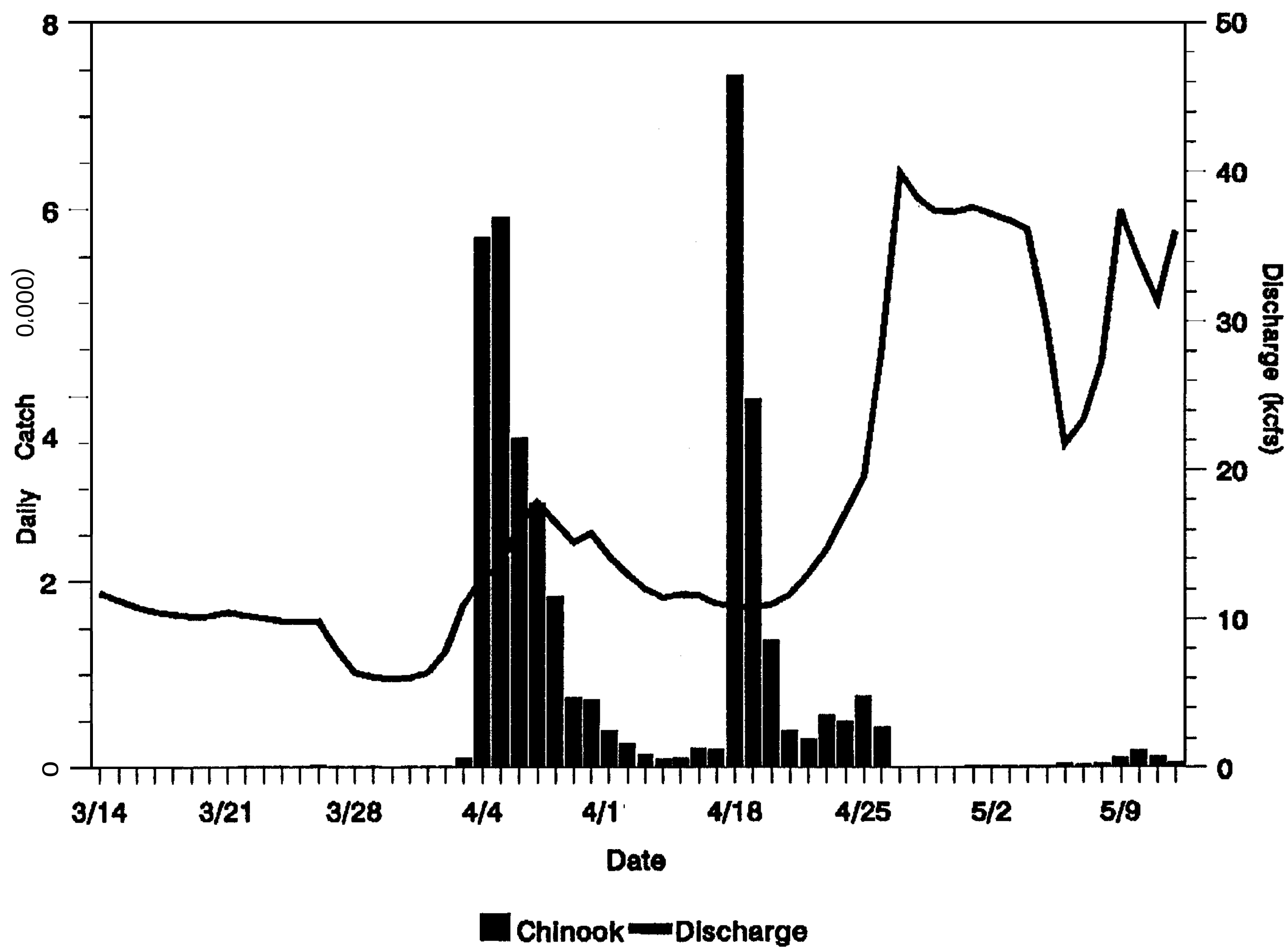

Figure 5. Clearwater River trap daily catch of age 1 chinook salmon overlaid by Clearwater River Discharge, 1991.

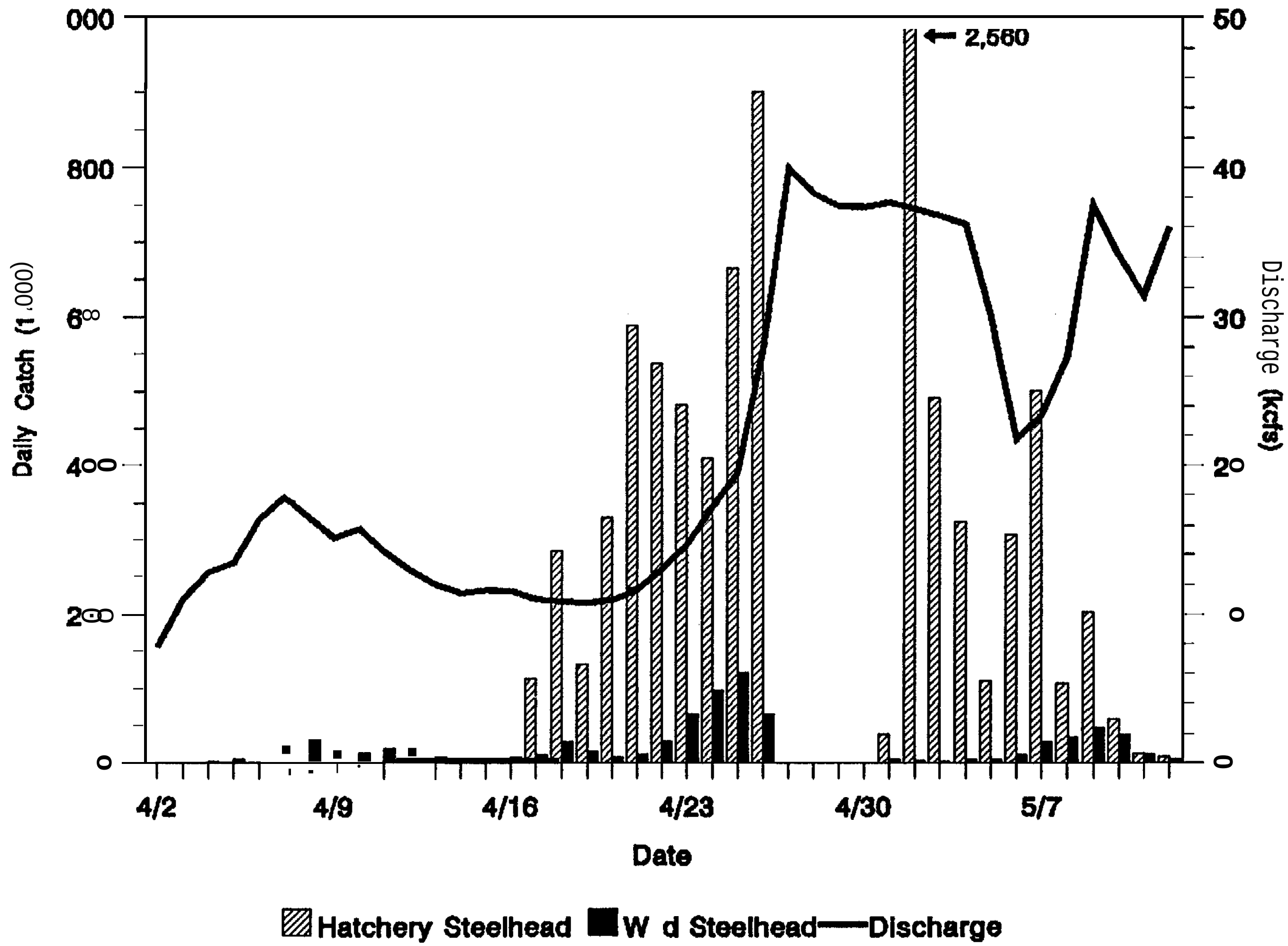

Figure 6. Clearwater River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River discharge, 1991.

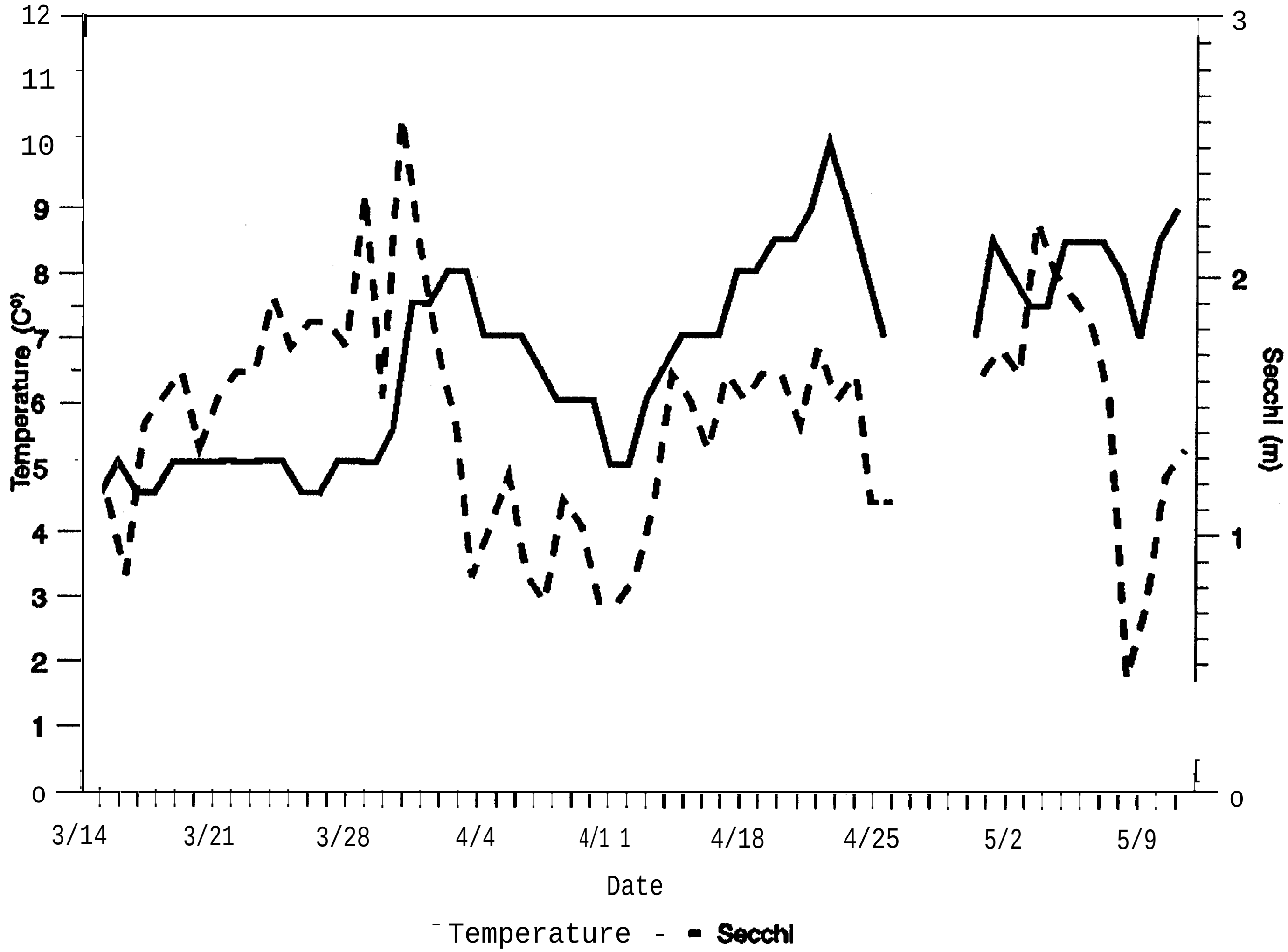

Figure 7. Daily temperature and secchi disk transparency at the Clearwater River trap, 1991. ,

Trap Efficiency

Snake River Trap

Chinook Salmon-Trap efficiency for chinook salmon smelts at the Snake River trap was not tested in 1991. Due to a reduced number of chinook salmon smelts in the trap, sufficient numbers of fish were not available for trap efficiency estimates. The mean trap efficiency for chinook salmon at the Snake River trap, with four yearly estimates during the past seven years, is 1.39%. All four of these estimates were made when the trap was in use on the west side of the river. Trap efficiency estimates for chinook salmon have not been conducted with the trap in use on the east side of the river.

Steelhead trout-No trap efficiency tests were conducted for steelhead trout smelts in 1991. The 1990 data yielded a mean trap efficiency of 0.49% and 95% confidence limits of 0.13% and 1.08%.

The analysis of covariance, to test if trap efficiency varies among years when adjusted for discharge, was not valid due to the limited data available in 1985 and 1986. The analysis was conducted using data from 1988-1990. No significant difference was observed for the three years of data, and the data were pooled. A regression analysis was conducted on the pooled data to determine if there was a relation between discharge and trap efficiency. The analysis failed to show a significant relation (r^2 = 0.001, N = 10, P = 0.937).

To provide a grand mean trap efficiency, all five years of data (1985, 1986, and 1988-1990) were pooled. The five-year grand mean. of the Snake River trap efficiency for hatchery steelhead trout was 0.68% with a 95% confidence interval of 0.43% and 0.97%.

Clearwater River Trap

Chinook salmon-In 1991, two groups of freeze-branded chinook salmon were released from DNFH. The Clearwater River trap efficiency estimate using these two groups was 1.16% which was down from the 1990 estimate, but was within the confidence limits of the 1990 estimate. The 1990 mean trap efficiency was 1.41% with 95% confidence limits of 1.03% and 1.86%. Between 1984 and 1989, an additional 42 trap efficiency tests were conducted on the Clearwater River trap for chinook salmon smelts (Table 4). These data were not added to the previous years information for statistical analysis due to the low numbers of brand groups. The determination of the height of the line within the analysis of covariance on the 1984-1990 log transformed data revealed a significant difference in trap efficiency among years (F = 3.666, N = 51, P = 0.005). Upon examination of the yearly efficiency data 1989 appeared to be significantly different. The 1989 data were removed and the analysis of covariance rerun. Without the 1989 data, the slopes of the other years data were not significantly different (F = 1.295, N = 42, P = 0.292). Continuing with the analysis, the

Table 4. Clearwater River trap efficiency **tests** for chinook salmon smelts, 1984-1991.

Year	Sample Origin	Release Dates	Recaptures/ Mark	Efficiency	Discharge **(kcfs)** .
1991	DNFH	4/3	360/19,704	0.0183	12
		4/3	204/16,884	0.0121	12
1990	Hwy 95	3/21	27/2,609	0.0103	22
	boat	3/26	28/2,266	0.0124	13
	launch	3/28	37/2,195	0.0169	13
		3/30	56/2,061	0.0272	12
		4/2	33/2,136	0.0154	17
	DNFH	4/5	**23/1,418**	0.0162	21
		4/5	180/20,239	0.0089	21
		4/5	163/19,900	0.0082	21
		4/5	282/19,730	0.0143	21
1989	Hwy 95	3/21	7/2,076	0.0034	17
	boat	3/23	10/2,065	0.0048	**15**
	launch	4/3	39/2,094	0.0186	**20**
		4/5	41/2,075	0.0200	21
	DNFH	3/29	66/34,795	0.0019	24
	release	3/29	73/30,503	0.0024	24
		3/30	41/19,087	0.0021	23
		3/30	48/19,545	0.0025	23
		3/30	78/20,084	0.0039	23
1988	Hwy 95	3/14	51/2,197	0.0232	6
	boat	3/17	93/2,197	0.0423	6
	launch	3/21	83/2,197	0.0378	6
		4/1	27/2,195	0.0123	9
		4/6	18/2,194	0.0082	11
		4/13	31/2,193	0.0141	14
	DNFH	3/30	1711/60,631	0.0282	10
	release	3/30	252/8,731	0.0289	10
		3/30	181/6,163	0.0294	10
		3/30	788/20,642	0.0382	10
		3/30	573/22,935	0.0250	10
	Trap	3/24	17/2086	0.0081	9
	caught	3/28	27/1695	0.0159	12
		4/1	16/1631	0.0098	9
		4/2	38/2257	0.0168	8
1987	DNFH	3/20	43/2,160	0.0199	13
	release	4/22	50/2,000	0.0250	6
		4/7	165/1,945	0.0848	10
		4/13	74/2,000	0.0370	13
		4/20&28	103/4,000	0.0258	18

Table 4. Continued.

Year	Sample Origin	Release Dates	Recaptures/ Mark	Efficiency	Discharge **(kcfs)**
1987	Trap **caught**	4/2	33/1,926	0.0171	6
		4/3	**11/1,458**	0.0075	**8**
		4/6	15/1,872	0.0080	9
		4/7	**15/1,163**	0.0129	10
		4/9	**9/450**	0.0200	12
1986	Trap caught	3/27	9/1,555	**0.0058**	22
		4/2	8/1,714	0.0047	29
1985	Trap caught	3/25	14/607	0.0230	9
		3/30	45/1,511	0.0298	9
		4/5	6/1,079	0.0056	18
		4/9	2/940	0.0021	15
		4/16	7/929	0.0075	33
1984	Trap caught	4/5	**4/418**	**0.0096**	21
		4/21	13/806	0.0161	33
		4/25	3/489	0.0061	31
		5/10	14/453	0.0309	24

intercepts (height) of the lines were not found to be significantly different ($F = 1.514$, $N = 42$, $P = 0.211$). The data were pooled, and a linear regression analysis was conducted. The analysis indicated there was a significant statistical correlation between trap efficiency and discharge but only 18% of the variation in efficiency can be attributed to changes in discharge ($r^* = 0.183$, $N = 42$, $P = 0.005$). The mean chinook salmon trap efficiency for the pooled data, excluding 1989 and 1991, was 2.02% with 95% confidence limits of ±0.43%. The mean trap efficiency for 1989 was 1.04%, which was considerable lower than that of the pooled years but similar to the 1991 estimate (1.16%).

The trap efficiency during the first portion of the season was probably similar to the 1989 efficiency which would account for the low numbers of fish captured from the DNFH release. Trap efficiency probably improved after mid-April which is reflected in large trap catches from the KNFH release and the off-site releases. The cause of the low trap efficiency during the first portion of the sample season is unknown. A similar phenomenon occurred in 1989 and 1990.

Steelhead trout-No trap efficiency tests were conducted in 1991. The 1990 mean trap efficiency was 1.90% with 95% confidence limits of 1.42% and 2.46%. This is the highest trap efficiency observed for the Clearwater trap. One possible explanation for this increased efficiency is the trap was in an ideal fishing location, with respect to water conditions, during the test period. This type of positioning is difficult to maintain throughout a sampling season, because such fast water passes through the trap that slight increases in discharge or debris load could be detrimental to the trap's integrity.

During the past six years, Clearwater River trap efficiency for steelhead trout has been tested 20 times. Only 14 of these tests yielded valid results. The other six had recovery numbers less than five and could not be used in the analysis. An analysis of covariance shows a significant difference in trap efficiency among years ($F = 30.439$, $N = 14$, $P<0.001$). Therefore, data from all years were not pooled to derive any statistical inference. Hatchery steelhead trap efficiency ranged from 0.12% to 3.03% during the six years efficiency was tested and is generally below 0.5%.

Travel Time and Migration Rates

Release Sites to Snake River Trap

Chinook salmon-There were nine groups of freeze-branded chinook salmon released in the Salmon River drainage: three each at Sawtooth Hatchery, South Fork Salmon River and Rapid River Hatchery. Four groups were released in the Imnaha River, Oregon and four groups were released in Lookingglass Creek, Oregon.

Because of the extremely low brand recovery at the Snake River trap (146 branded chinook salmon were captured out of the approximately 381,863 branded fish released in 1991), migration rate statistics were calculated for only three release sites; South Fork Salmon River, Imnaha River, and Grande Ronde River. The migration rate for the South Fork Salmon River brand group was the slowest recorded to date (6.9 km/d). The low migration rate is explained by the late runoff from the upper Salmon River drainage which provided the second lowest mean discharge for the migration period in the Salmon River and the lowest mean discharge in the Snake River (Table 5). The Imnaha River brand release had the slowest migration rate for the two years of data (4.0 km/d). The 1991 Lookingglass Creek brand release had the slowest migration rate of six years of data (26.8 km/d). The mean discharge for the migration period for both the Imnaha and Lookingglass brand groups was the lowest since this project was initiated (Table 5). This low discharge was due to the drought situation and to the late spring runoff.

Steelhead trout-In 1991, there were no freeze-branded steelhead trout groups released above the Snake River trap from Idaho hatcheries. Fourteen groups of freeze-branded hatchery steelhead trout were released upstream from the Snake River trap by Oregon hatcheries: two groups of two replicates each from Little Sheep Creek, two groups of two replicates each from Spring Creek, two groups of two replicates each from Deer Creek, and one group of two replicates from Wildcat Creek. Recapture numbers were high enough for the seven combined replicate groups released in Oregon to provide travel time information to the Snake River trap (Table 6).

The two groups released from Spring Creek differed in size at release. Migration rates for the two paired release groups were 17.9 km/d for the four-to-the-pound and 13.1 km/d for the five-to-the-pound group. Migration rate for the combined four groups was 38% slower than for the brand groups from 1990 and the mean discharge for the migration period was down 28%. The migration rate for the Little Sheep Creek groups that were acclimated was 6.6 km/d and the migration rate for the groups that were a direct stream release was 8.0 km/d. The average migration rate for these groups was about half of the lowest year-to-date and mean discharge for the migration period was less than half (Table 6). The Wildcat Creek release traveled about three times slower in 1991 than in previous years (13.2 km/d) although discharge during the migration period was only about 20% less. Added to the standard freeze brand releases were two groups of steelhead trout released in Deer Creek. One group was acclimated and traveled at 4.6 km/d and the other group was a direct stream release and it traveled at 6.5 km/d (Table 6). Average discharge during the migration period was similar for both groups.

Release Sites to the Clearwater Trap

Chinook salmon-In 1991, there was one group of two replicates of freeze-branded chinook salmon released from DNFH on April 3 (Table 7). Travel time for the age 1 chinook salmon was 1 d. This compares to a travel time of 1 d in 1985, 1986, 1988 and 1989, and 4 d in 1987. Average discharge during the migration period in 1987 was 7,200 cfs, and was 25% to 76% less than in previous years. The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time that year.

Table 5. **Migration data for freeze-branded** chinook salmon smelts from release sites tothe Snake River trap, 1984 - 1991.

Release site	Year	Median release date	Median passage date	Number captured	Trave 1 time (days)	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Snake R.
Rapid River	1991	*--	--	--	--	--	--	--
	1990	•--	--	--	--	--	--	--
	1989	3/30	4/18	181	19	12.0	9.0	52.6
	1988	•--	--	--	--	--	--	--
	1987	•--	--	--	--	--	--	--
	1986	3/27	4/10	237	14	16.3	15.4	82.9
	1985	4/2	4/12	320	10	22.8	10.6	67.6
	1984	4/1	4/18	197	17	13.4	10.1	79.3
Hells Canyon	1991	b--	--	--	--	--	--	--
	1990	b--			--	--	--	--
	1989	b--	--		--	--	--	--
	1988	b--	--	--	--	--	--	--
	1987	b--	--		--	--	--	--
	1986	3/26	4/3	269	8	21.6	--	83.8
	1985	3/19	4/3	544	14	12.4	--	43.0
	1984	3/20	3/29	704	9	19.2	--	81.4
S.F. Salmon River	1991	3/20	5/19	80	60	6.9	8.2	24.6
	1990	•--	--		--	--	--	--
	1989	3/21	5/11	21	51	8.1	6.5	57.1
	1988	•--	--	--	--	--	--	--
	1987	•--		--	--	--	--	--
	1986	3/28	4/23	229	26	15.8	16.5	78.6
	1985	4/2	4/17	76	15	27.1	14.0	71.0
	1984	4/10	4/24	238	14	29.0	14.5	91.7
Sawtooth Hatchery	1991	•--	--	--	--	--	--	--
	1990	•--	--		--	--	--	--
	1989	3/15	4/20	14	36	19.4	6.1	51.0
	1988	•--	--	--	--	--	--	--
	1987	•--	--	--	--	--	--	--
	1986	3/17	4/14	49	28	24.9	13.6	81.4
	1985	3/27	4/14	165	18	38.7	9.6	60.1
	1984	3/28	4/21	136	24	29.0	11.8	84.0

Table 5. Continued.

Release site	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Snake R.
Lookingglass Cr.	1991	4/01	4/08	26	7	26.8	--	19.0
	1990	[a]--	--	--	--	--	--	--
	1989	4/03	4/06	212	3	62.5	--	46.1
	1989	4/03	4/05	173	2	93.7	--	45.9
	1989	5/15	5/18	131	3	62.5	--	50.2
	1988	5/13	5/16	52	3	62.5	--	40.6
	1987	[a]--	--	--	--	--	--	--
	1986	4/2	4/5	114	3	62.5	--	82.1
	1985	[b]--	--	--	--	--	--	--
	1984	[b]--	--	--	--	--	--	--
Imnaha River	1991	3/22	4/12	31	21	4.0	--	18.0
	1990	[a]--	--	--	--	--	--	--
	1989	4/05	4/10	247	5	16.8	--	51.6

[a] Insufficient recaptures numbers at the Snake River trap.
[b] No freeze brand releases made in that year.

Table 6. Migration data for freeze-branded steelhead trout smelts from release sites to the Snake River trap, 1985 - 1991.

Release site[a]	Year	Median release date	Median passage date	Number captured	Travel time (d)	Migration rate (km/d)	Mean discharge (kcfs)
Deer Creek	1991	4/26	5/10	79	14	4.6	27.1
		4/26	5/6	88	10	6.5	24.7
Spring Creek	1991	4/22	5/6	35	14	17.9	24.8
		4/22	5/10	38	19	13.1	26.4
	1990	4/17	4/30	115	13	18.6	35.6
		4/19	4/26	116	7	34.6	36.1
		4/17	4/28	125	11	22.0	35.0
	1989	4/24	5/1	84	7	34.6	62.0
		4/22	5/5	70	13	18.6	62.4
		4/22	5/2	83	10	24.2	63.8
	1988	4/17	4/25	28	8	30.3	34.5
		4/17	4/23	28	6	40.4	35.7
		4/17	4/25	30	8	30.3	34.5
		4/17	4/23	14	6	40.4	35.7
		4/18	4/25	38	7	34.6	35.0
		4/18	4/24	21	6	40.4	35.7
	1987	4/26	--[b]	--	--	--	--
	1986	5/1	5/27	14	26	9.3	72.9
		4/30	--[b]	1	--	--	--
		4/3	--[b]	2	--	--	--
	1985	5/9	5/19	36	10	24.2	46.4
		5/9	5/20	31	11	22.0	47.0

Table 6. Continued.

Release site[a]	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean discharge **(kcfs)**
Little sheep Creek	1991	4/23	5/11	59	18	8.0	27.2
		4/23	**5/15**	70	22	6.6	29.9
	1990	4/17	4/26	33	9	16.1	35.2
	1989	4/23	**4/25**	93	2	72.3	70.7
	1987	5/2	--[b]	--	--	.-	--
	1986	4/28	**5/8**	16	10	14.5	72.1
		4/27	--[b]	2	--	--	--
Wildcat Creek	1991	4/30	5/10	121	10	13.2	28.2
	1990	4/25	4/28	84	3	44.2	34.7
	1989	4/26	4/30	134	4	33.2	60.7
	1988	4/23	4/26	152	3	44.2	32.7

[a]**Only** freeze brand **groups from Oregon and Washington were** used in 1989 and 1991 because Idaho did not release any freeze-branded steelhead trout above the Snake River trap during those years.

[b]**Insufficient recaptures** at the Snake River trap to derive fish **movement** data.

Table 7. Migration data for freeze-branded chinook salmon and steelhead trout smelts from release sites to the Clearwater River trap, 1987 - 1991.

Release Site	Year	Sp.	Median release date	Median passage date	Number captured	Travel time (d)	Migration rate (km/d)	Mean discharge (kcfs)
Dworshak NFH	1991	St	4/30	5/02	98	2	27.6	37.4
		Ch	4/03	4/04	465	1	55.1	11.9
Dworshak NFH	1990	St	5/3	5/4	1,060	1	55.0	22.3
		Ch	4/5	4/6	625	1	55.0	21.1
Dworshak NFH	1989	St	5/1	5/2	123	1	55.0	31.2
		Ch	3/29	3/3	139	1	55.0	23.5
		Ch	3/30	3/31	167	1	55.0	23.3
		Ch-O	3/30	4/3	48	4	13.8	22.2
		Ch	9/28/88	3/30	2	183	--	--
Red River	1989	Ch	10/17/88	4/17	19	182		--
Dworshak NFH	1988	St	5/3	5/4	283	1	55.0	16.9
		St	5/4	5/5	202	1	55.0	16.9
		Ch-O	3/30	4/1	239	2	27.5	9.8
		Ch	3/30	3/31	1,711	1	55.0	9.6
		Ch	3/30	3/31	1,359	1	55.0	9.6
		Ch	3/30	3/31	434	1	55.0	9.6
		Ch	9/28/87	3/27	16	182	--	--
Red River	1988	Ch	9/30/87	4/14	18	198	--	--
Crooked River	1987	St	4/14	--	2	--	--	--
Dworshak NFH	1987	St	4/21	4/22	58	--	--	--
		St	5/5	--	--	--	--	--
		Ch	4/1	4/4	1,416	3	18.3	7.2
Clear Creek	1987	St	4/17	4/20	59	3	38.3	14.1

Steelhead trout-There were eight groups of freeze-branded steelhead trout released from DNFH in 1991 totaling 57,561 fish. The median release date was April 30 and median passage date at the Clearwater trap was May 2 (Table 7). Percent brand recovery at the trap was very low, only 0.17%, because of poor trap location caused by very high discharge during this period and poor brand quality. The actual trap recovery of branded steelhead trout was 98 fish, which is a large sample for computing median date of passage. But the low recovery proportion may give an unrepresentative sample from the population. Therefore a 2-day travel time may be biased high since in all other years a l-day estimate was observed. It appears safe to say that DNFH steelhead trout travel time was less than or equal to 2 days.

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook salmon PIT tag groups-In 1991, sufficient numbers of chinook salmon were PIT-tagged daily at the Snake River trap to provide 25 daily release groups (2,131 total pIT-tagged chinook salmon) for estimating travel time and migration rates through Lower Granite Reservoir. The number of PIT-tagged chinook salmon at the Snake River trap was similar to 1990 but was down considerably from normal flow years due to poor trap catch associated with low river flows. Median travel time ranged from 16.4 d early in the migration season to 2.4 d in mid-May (Table 8). Travel time increased again, as discharge dropped after the peak discharge in mid-May. Travel time early in the migration season was similar to the previous year for that same period.

Upon examination of the linear regression analysis of migration rate and discharge a correlation was found. The linear regression of the log of migration rate and log discharge provided the best fit for PIT-tagged chinook salmon groups released from the Snake River trap ($r^2 = 0.851$, $N = 26$, $P = 0.000$):

in (migration rate) = -2.739 + 1.152 in (average discharge).

This analysis indicates that PIT-tagged chinook salmon migration rate increased in Lower Granite Reservoir as discharge increased.

The linear regression analysis on the data stratified by 5-kcfs intervals provided the following best linear regression equation ($r^2 = 0.821$, $N = 14$, $P<0.001$):

in (migration rate) = -3.015 + 1.215 in (mean discharge).

The resulting r^2 shows there is a strong relation between migration rate and discharge. As discharge increases migration rate increases.

In 1991, chinook salmon smelts were PIT-tagged at the Clearwater River trap to provide travel time information through Lower Granite Reservoir for Clearwater River chinook salmon. Twenty-nine daily groups (totaling 3,976 chinook salmon) were released from the Clearwater River trap from April 3 through April 26, and from May 8 through May 12 (Table 9). The linear regression analysis of the

Table 8. PIT-tagged chinook salmon travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Lower	Upper	Number captured	Percent captured (%)	Average discharge (kcfs)
4/667,8	16.40	14.10	18.30	43	35.8	32.37
4/8	16.45	14.30	19.00	36	36.0	31.84
4/9	16.20	14.50	17.60	42	42.0	31.89
4/10	14.20	13.10	14.60	63	41.7	31.23
4/11, 12	12.05	10.20	13.30	32	33.7	30.74
4/12[b],13,16	14.10	12.30	16.00	58	42.3	34.12
4/15[b,c]	16.00	13.20	18.40	69	46.6	41.18
4/17[b]	10.60	9.50	13.00	66	36.7	38.21
4/18[b]	11.50	9.70	11.80	47	35.6	42.38
4/19[b,c]	15.40	10.50	17.50	55	35.9	48.08
4/22[b]	8.00	7.80	11.20	65	43.0	48.68
4/23[b]	8.25	7.30	11.20	62	40.8	52.14
4/25	6.45	4.60	7.80	36	36.4	57.48
4/25[b]	8.45	7.40	11.50	54	35.5	58.30
4/26	7.50	6.70	8.50	63	41.7	60.16
4/26[b]	7.30	3.70	14.30	21	39.6	60.07
4/27	7.80	7.50	9.50	81	53.3	60.49
4/28,29,30, and 5/1	8.20	6.50	9.40	53	42.4	56.78
4/29[b],30[b]	8.50	7.50	9.10	71	35.3	56.58
5/7,9	3.70	3.40	4.70	30	57.7	68.37
5/10	3.60	3.00	4.80	63	40.4	81.14
5/11,12,13	5.00	4.60	5.30	89	51.1	83.38
5/18,19	2.40	2.20	2.60	72	36.5	120.48
5/20	3.20	2.80	4.20	50	35.2	108.92
5/23,24,25	4.90	4.30	6.30	61	16.3	93.56
5/26	6.00	5.10	7.80	67	48.6	88.74
5/27,28,29	6.90	5.20	9.80	29	33.7	87.15
6/6'	10.65	5.70	23.10	8	44.4	89.53
6/11,12,13, 14,15,16	6.90	4.90	10.10	28	37.8	77.98
6/20[c]	12.80	0.00	0.00	1	100.0	65.88
6/25[c]	4.30	0.00	0.00	1	50.0	65.34
6/28[c]	4.30	0.00	0.00	1	100.0	64.56
7/1[c]	5.20	0.00	0.00	1	25.0	63.31
7/3'	21.00	0.00	0.00	1	50.0	45.11

[a]Confidence intervals calculated with nonparametric statistics.
[b]Purse seine tagging groups.
[c]Not used in statistical analysis because analysis showed too few recaptures.

Table 9. PIT-tagged chinook salmon travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Lower	Upper	Number captured	Percent captured (%)	Average discharge (kcfs)
4/03	17.00	14.00	21.60	39	43.8	32.43
4/04	27.60	23.50	31.00	43	28.7	38.96
4/05	25.05	23.30	28.20	52	34.4	37.60
4/06	23.05	21.50	25.30	54	36.0	36.92
4/07	27.55	21.30	31.50	58	38.7	41.88
4/08	20.90	18.40	28.10	64	42.7	36.87
4/09	19.85	18.10	23.00	50	33.1	36.85
4/10	18.40	16.40	22.30	57	38.0	35.68
4/11	21.40	18.30	24.30	62	32.8	40.21
4/12	22.80	20.50	25.10	47	24.6	43.19
4/13	18.50	15.00	22.50	46	31.9	41.03
4/14	20.15	15.10	24.70	30	30.6	43.58
4/15	15.90	13.50	23.50	30	29.7	41.18
4/16	17.60	14.10	21.50	58	38.7	45.04
4/17	20.60	18.00	22.10	51	34.0	47.11
4/18	12.20	11.20	14.10	50	32.1	42.38
4/19	13.65	10.80	16.00	60	40.0	47.17
4/20	13.10	10.30	15.50	47	31.3	48.52
4/21	14.80	11.90	17.00	51	34.0	51.33
4/22	13.45	11.90	16.90	56	37.8	53.15
4/23	11.00	10.10	15.30	47	31.3	54.50
4/24	11.70	9.40	13.70	57	37.7	56.09
4/25	13.10	11.50	14.40	59	39.3	56.62
4/26	13.25	12.20	15.50	64	42.4	57.71
5/01[b]	9.10	6.70	15.10	9	47.4	58.94
5/07[b]	5.20	3.50	13.20	8	28.6	69.94
5/08	5.30	4.60	9.80	22	53.7	75.03
5/09	6.90	5.60	10.20	44	47.3	82.20
5/10	8.30	6.90	9.40	73	47.4	83.07
5/11	8.00	7.30	8.70	69	56.6	85.36
5/12	7.65	7.00	8.50	26	56.5	90.86

[a]Confidence intervals calculated with nonparametric statistics.
[b]Not used in statistical analysis because analysis showed too few recaptures.

Clearwater River chinook salmon PIT tag data showed a strong correlation between migration rate and discharge. (r^2 = 0.759, N = 29, **P<0.001).** The regression equation after stratifyingby **5-kcfs** groups was again significant and was fairly strong (r* = 0.821, N = 10, P<0.001):

in (migration rate) = -3.247 + 1.201 in (mean discharge).

Similar to previous years, 1991 Clearwater River chinook salmon migrated slower than Snake River chinook salmon. There are 18 release groups with comparable release dates for the two traps. The median migration rate for these days was 5.7 km/d for chinook salmon released from the Snake River trap and 4.3 km/d for chinook salmon released from the Clearwater River trap. The reasons that the Clearwater River chinook salmon migrate slower through Lower Granite Reservoir than Snake River fish during the same time period are unclear at this time.

Preliminary ATPase data, collected by the U.S. Fish and Wildlife Service, from chinook salmon smelts collected in the Clearwater and Snake River traps in 1990 (Rondorf et al. in press) were examined. There were only four data points from the Snake and Clearwater River traps that were comparable. The data indicate that smelts from the Snake River trap had significantly higher weekly ATPase levels (μmoles P·mg $Prot^{-1}\cdot h^{-1}$) than smelts from the Clearwater River trap. This demonstrates that Snake River chinook salmon were at a higher level of **smoltification** than Clearwater River fish. Mean seasonal ATPase levels for the four comparable data points were 13.3 μmoles for the Clearwater River smelts and 22.2 μmoles for the Snake River smelts. These ATPase differences probably explain some, but not all, of the difference in migration rate between Snake River and Clearwater River trap-caught chinook salmon.

The chinook salmon migration rate/discharge relation for Snake River trap PIT tag groups was examined to determine if there was a difference in this relation between years (1987-1991). The analysis of covariance was used with the data averaged by 5-kcfs groups. The analysis showed a significant difference in the migration rate/discharge relation between years (slope of the lines) at the 0.05 level of significance (F = 12.212, N = 48, P<0.001). A graph of the data showed that 1989 data had a slightly steeper slope (Figure 8). After removing the 1989 data the analysis was rerun. A significant difference in the slopes could not be detected at the 0.05 level of significance (F = 1.887, N = 38, P = 0.153). The analysis of covariance was continued to test for a difference in the height of the lines for the four years of data. Again, no difference could be detected (F = 2.398, N = 38, P = 0.086), indicating a common migration rate/discharge relation for chinook salmon for the four years.

Upon graphing the 1987 through 1991 migration rate/discharge equations for chinook, it becomes very apparent that in the discharge range between 60 and 100 **kcfs,** all years showed the same basic relation. The amount of increase between 60 and 100 kcfs is consistent for 1987, 1988, 1990, and 1991 (two-fold) but slightly higher for 1989 (three-fold). The same trend exists in all five years; increased flow in Lower Granite Reservoir increases migration rate through the reservoir.

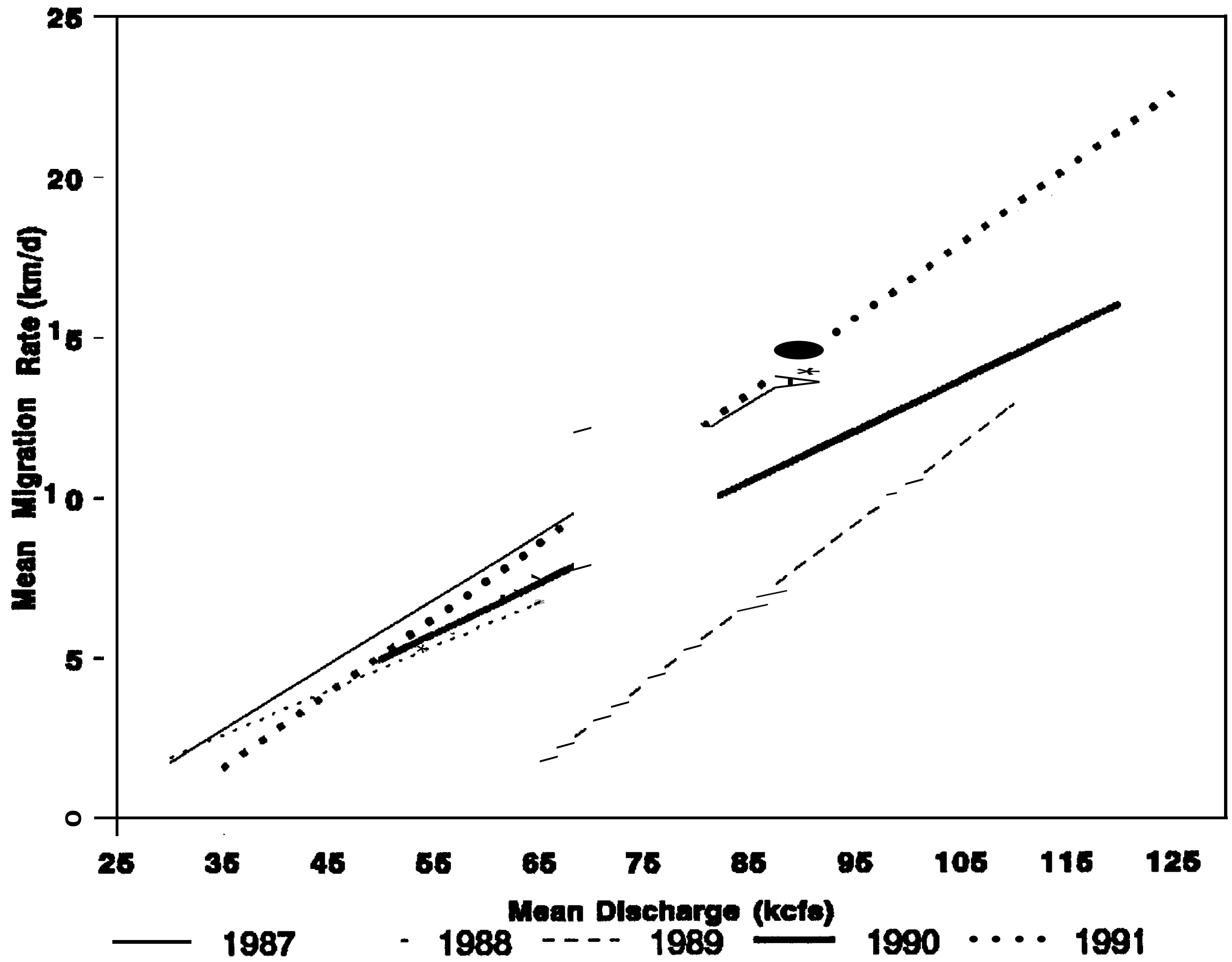

Figure 8. Chinook salmon migration rate/discharge relations for Snake River trap PIT tag groups, 1987-1991.

Percent recovery (interrogation) at Lower Granite Dam of daily groups of chinook salmon PIT-tagged at the Snake River trap ranged between 16.3% and 53.3%. Seasonal cumulative recovery (# recaptured/# marked) of PIT-tagged chinook salmon to Lower Granite Dam was 43.6%. Cumulative recovery progressing downstream to Little Goose Dam was 62.8% and to McNary Dam was 68.2%.

Percent recovery of Clearwater River trap daily release PIT-tagged chinook salmon groups at Lower Granite Dam ranged between 24.6% and 73.2%. Seasonal cumulative recovery of PIT-tagged chinook salmon to Lower Granite Dam was 37.6%. Cumulative recovery progressing downstream to Little Goose Dam was 54.5% and to McNary Dam was 60.5%.

Hatchery steelhead trout PIT tag groups-Sufficient numbers of hatchery steelhead trout were PIT-tagged daily at the Snake River trap to provide 50 daily release groups (2,577 individual fish) to be used in median migration rate calculations through Lower Granite Reservoir. Median travel time ranged from 11.5 to 1.8 d (4.5 km/d to 28.7 km/d migration rate) and averaged 4.5 d, which was the same as 1990 (Table 10).

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite discharge (inflow) for PIT-tagged hatchery steelhead trout groups ($r^2 = 0.849$, N = 50, $P<0.001$). The best linear regression equation was:

$$\ln(\text{migration rate}) = -4.359 + 1.577 \ln(\text{mean discharge}).$$

The linear regression equation for the daily release groups stratified into 5-kcfs discharge intervals was ($r^2 = 0.938$, N = 13, $P<0.001$):

$$\ln(\text{migration rate}) = -4.523 + 1.610 \ln(\text{mean discharge}).$$

The equation shows that as discharge increases, migration rate increases for PIT-tagged hatchery steelhead trout marked at the Snake River trap.

Twenty-two groups of hatchery steelhead trout (1,215 individual fish) were PIT-tagged at the Clearwater River trap in 1991 for use in median migration rate calculations through Lower Granite Reservoir (Table 11). Median travel time ranged from 9.9 to 4.9 d (6.2 km/d to 12.7 km/d) and averaged 7.5 d (8.2 km/d). Average inflow discharge to Lower Granite Reservoir during the migration season was 60.2 kcfs and ranged from 35.8 to 85.0 kcfs.

The linear regression analysis detected a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite inflow discharge for Clearwater River PIT-tagged hatchery steelhead trout ($r^2 = 0.412$, N = 22, P = 0.001). The data, stratified by 5-kcfs discharge groups, likewise, detected a significant relation between discharge and migration rate after stratification ($r^2 = 0.634$, N = 11, P = 0.003):

$$\ln(\text{migration rate}) = -0.054 + 0.537 \ln(\text{mean discharge}).$$

Hatchery steelhead trout migration rate/discharge relation among years for fish PIT-tagged at the Snake River trap was examined to see if the relation was

Table 10. PIT-tagged hatchery **steelhead** travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge **(kcfs)**
4/16	11.50	8.60	16.00	25	73.5	37.55
4/25	7.90	5.70	9.60	57	89.1	58.29
4/26	7.70	4.90	9.40	45	72.6	60.16
4/27	6.55	5.60	9.60	48	76.2	60.67
4/28	6.80	6.30	9.00	48	78.7	59.91
4/29	5.90	4.70	9.80	52	85.2	59.95
4/30	6.10	4.80	10.50	57	81.4	58.37
5/1	7.80	5.60	11.00	47	55.3	56.40
5/2	6.10	4.70	8.80	33	45.2	55.27
5/3	7.30	6.00	8.80	46	76.7	58.43
5/4	7.10	5.60	8.50	44	73.3	61.05
5/5	7.55	5.50	9.20	46	85.2	65.59
5/6	6.40	5.10	8.60	45	75.0	65.93
5/7	5.05	4.10	5.70	44	73.3	69.94
5/8	4.70	3.80	5.00	49	79.0	75.03
5/9	3.70	3.50	4.70	48	80.0	78.78
5/10	3.90	3.60	4.70	52	82.5	81.14
5/11	3.90	3.60	4.70	46	75.4	82.15
5/12	3.90	3.20	4.50	51	85.0	85.18
5/13	3.80	3.40	5.60	50	83.3	86.17
5/14	3.65	2.80	5.40	48	80.0	85.00
5/15	4.45	3.70	5.10	50	82.0	88.58
5/16	3.50	3.00	3.70	48	80.0	96.53
5/17	3.00	2.70	3.20	56	78.9	100.57
5/18	2.00	1.90	2.10	43	86.0	108.84
5/19	1.80	1.60	1.90	55	83.3	120.48
5/20	2.10	1.90	3.50	51	85.0	113.47
5/23	2.00	1.70	3.00	50	83.3	105.32
5/24	2.55	2.10	3.20	52	86.7	104.21
5/25	3.00	2.80	3.80	41	65.1	98.85
5/26	3.20	3.00	4.50	45	75.0	91.68
5/27	2.90	2.70	3.50	54	80.6	86.74
5/28	3.35	2.80	3.80	50	83.3	85.70
5/29	3.10	2.60	5.50	21	35.0	85.80
5/30	4.15	3.20	4.50	38	63.3	85.66
5/31	3.75	3.20	4.50	52	86.7	88.23
6/1	3.45	2.70	4.30	24	85.7	89.12
6/2	3.20	2.80	4.90	21	77.8	96.08
6/3	4.65	1.90	7.10	10	55.6	95.52
6/4	3.15	2.80	3.70	36	81.8	95.92
6/5	3.15	2.80	4.00	30	75.0	92.41
6/6	3.20	2.80	4.20	31	83.8	90.84
6/11	3.20	2.20	4.20	19	76.0	101.81
6/12	3.10	2.90	3.40	47	77.0	98.49
6/13	3.10	2.50	4.00	31	81.6	90.98
6/14	3.95	3.50	4.20	28	93.3	77.00
6/15	3.80	1.80	4.30	9	75.0	71.31
6/16	4.35	2.90	9.30	6	60.0	68.24
6/17	4.20	2.70	5.80	8	61.5	67.74
6/21	3.65	2.90	4.00	16	53.3	65.85

‘Confidence intervals calculated with **nonparametric** statistics.

Table 11. PIT-tagged hatchery steelhead trout travel time, with 95% confidence intervals, from the ClearWater River trapto Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[1] Lower	Upper	Number captured	Percent captured (%)	Average discharge (kcfs)
4/17	9.85	8.20	11.10	40	65.6	35.58
4/18	8.95	8.10	10.40	40	66.7	36.23
4/19	8.25	7.00	9.10	38	59.4	37.06
4/20	7.65	6.90	9.70	48	73.8	41.44
4/21	8.15	6.90	9.20	42	70.0	45.20
4/22	6.35	5.60	7.90	46	75.4	45.25
4/23	7.30	5.90	8.30	48	80.0	51.03
4/24	8.40	5.50	9.70	44	80.0	55.30
4/25	8.30	6.90	10.60	49	83.1	58.29
4/26	7.10	6.40	8.70	45	78.9	60.07
5/1	9.30	5.90	12.50	29	74.4	58.94
5/2	8.05	6.30	10.30	52	85.2	58.87
5/3	9.25	7.40	11.70	44	73.3	62.71
5/4	7.70	6.70	8.60	52	85.2	62.94
5/5	7.75	6.70	9.50	48	80.0	65.59
5/6	6.50	5.60	8.60	42	68.9	68.01
5/7	7.30	5.50	9.90	46	73.0	74.13
5/8	5.70	4.70	7.30	63	94.0	77.32
5/9	4.85	4.50	6.40	50	82.0	80.77
5/10	5.30	3.80	7.50	47	79.7	81.55
5/11	7.40	2.40	18.10	7	53.8	83.63
5/12	5.05	2.80	6.40	6	75.0	85.03

[1]Confidence intervals calculated with nonparametric statistics.

constant over years. Analysis of **covariance** on the log transformed data was used to determine if there was a significant difference between years (1987-1991) in migration rate averaged by **5-kcfs** intervals. The analysis did not detect a difference among years (slopes of the lines) for the hatchery **steelhead** trout migration rate/discharge relation at the 0.05 level of significance (F = 2.402, N = 59, P = 0.062). The analysis was continued to determine if the intercepts (heights) of the lines were different. The analysis showed there was a significant difference in the intercepts of the lines. After examining a graph of the data, the 1987 data were significantly higher than the other years (Figure 9). when the 1987 data were removed and the analysis run again there was not a significant difference in the height of the remaining years data. The 1988 through 1991 data were pooled and the linear regression analysis conducted (r^2 = 0.906, N = 49, **P<0.001**):

in (migration rate) = -4.028 + 1.517 in (mean discharge).

The equation shows that PIT-tagged hatchery steelhead trout from the Snake River trap move more than five times faster through Lower Granite Reservoir at 120 kcfs as they do at 40 kcfs. The analysis shows that the migration rate/discharge relation for these fish is not only consistent during the outmigration season but consistent year to year.

Percent recovery of Snake River trap daily hatchery steelhead trout PIT tag release groups at Lower Granite Dam ranged from 35.0% to 93.3%. Seasonal cumulative recovery of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 78.9%, to Little Goose Dam 89.3%, and to **McNary** Dam 89.7%.

Percent recovery of Clearwater River trap daily hatchery steelhead trout PIT tag release groups at Lower Granite Dam ranged from 53.8% to 94.0%. Seasonal cumulative recovery of PIT-tagged hatchery steelhead trout to Lower Granite **Dam was 76.2%, to Little Goose Dam 83.5%,** and to **McNary** Dam 83.8%. This was 5.9% less than for fish PIT-tagged at the Snake River trap.

Wild steelhead trout PIT tag groups-**Sufficient** numbers of wild steelhead trout were PIT-tagged at the Snake River trap to provide 35 daily release groups (3,570 individual fish) for estimating travel time and migration rate in Lower Granite Reservoir (Table 12). Median travel time ranged from 10.1 d (5.1 km/d) to 1.5d **(34.4 km/d)** and averaged 3.8d **(13.6 km/d)**. Linear regression analysis showed a strong significant relation between median migration rate in Lower Granite Reservoir and mean discharge for PIT-tagged wild steelhead trout groups (r^2 = 0.867, N = 35, **P<0.001**). The best linear regression equation was:

in (migration rate) = -2.004 + 1.091 in (mean discharge).

The analysis shows that as discharge increases migration rate in Lower Granite Reservoir increases.

Linear regression equation for PIT tag groups stratified into **5-kcfs** intervals (r^2 = 0.873, N = 15, **P<0.001**) was:

in (migration rate) = -2.311 + 1.156 in (mean discharge).

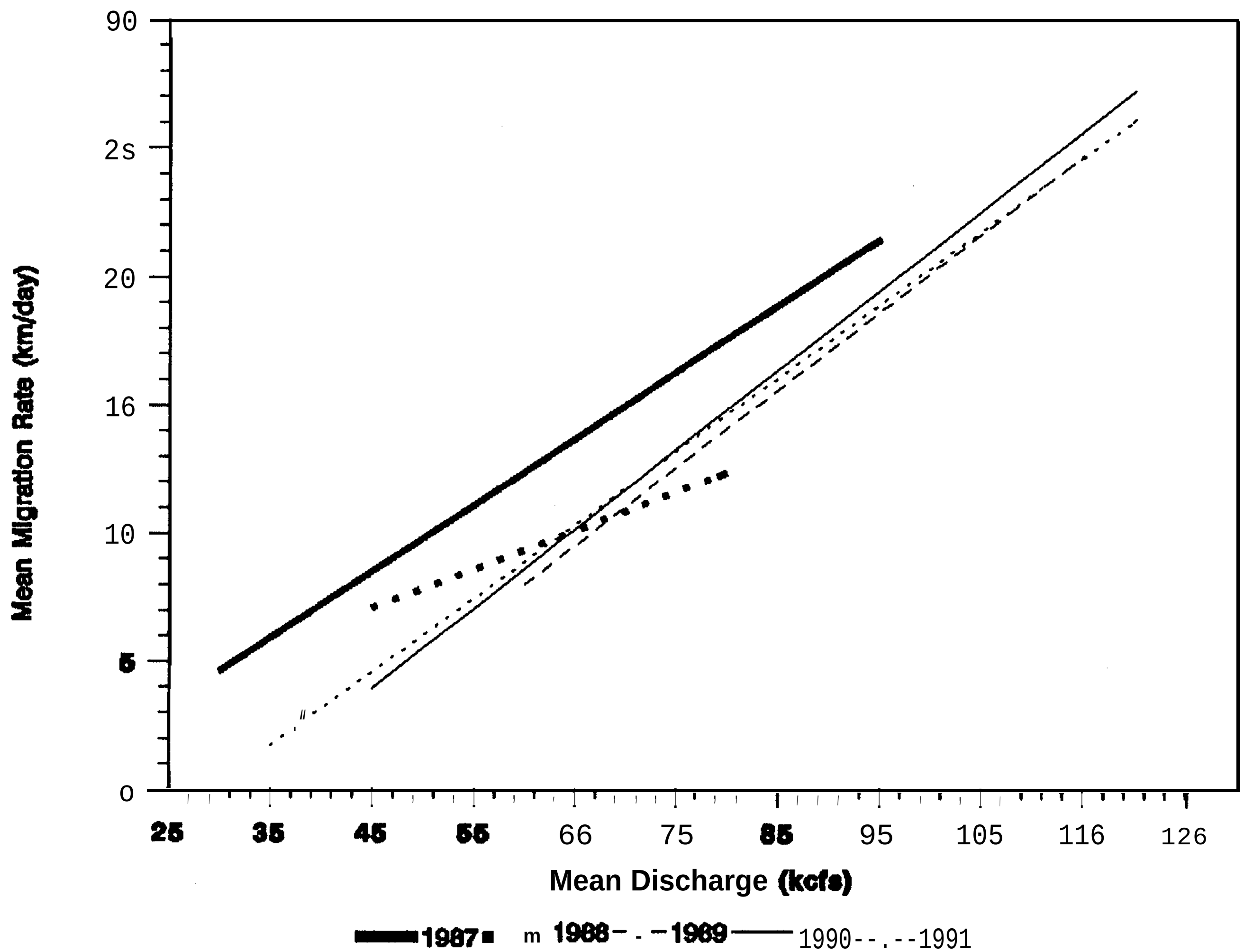

Figure 9. Hatchery Steelhead trout migration rate/discharge relations for Snake River trap PIT tag groups, 1987-1991.

Table 12. PIT tagged wild **steelhead** trout travel time, with **95%** confidence intervals, from the Snake River trap to Lower Granite Dam, 1991.

Release date	Median travel time (day)	Confidence Interval[a] Upper	Lower	Number captured	Percent captured (%)	Average discharge " (kcfs)
04/06,08,09/91	7.25	5.90	22.20	8	57.1	33.34
04/10/91	8.05	5.80	11.20	10	66.7	31.45
04/11,12,13,16/91	10.10	6.90	16.70	10	62.5	30.24
04/25/91	4.25	3.70	5.50	30	71.4	56.69
04/26/91	5.00	4.40	6.00	57	64.8	59.80
04/27/91	4.70	3.90	5*50	50	61.7	60.38
04/28/91	4.50	4.10	5.10	49	61.3	59.86
04/29/91	5.40	3.70	7.00	26	61.9	60.08
04/30/91	3.85	3.50	5.30	18	58.1	60.56
05/01/91	4.70	2.70	9.80	14	48.3	58.05
05/02,04,05/91	4.40	3.60	6.10	11	64.7	52.21
05/06/91	4.40	2.80	10.70	7	50.0	60.05
05/07/91	3.70	3.50	4.30	42	76.4	68.37
05/08/91	3.50	2.90	3.80	21	72.4	73.67
05/09/91	3.40	2.90	3.60	47	68.1	78.22
05/10/91	3.10	3.00	3.40	358	55.4	78.61
05/11/91	3.10	2.80	3.40	188	60.3	81*80
05/12/91	3.20	2.80	3*50	113	61.7	84.13
05/13/91	3.00	2.70	3.50	59	18.5	86.75
05/14/91	3.20	2.80	3.50	84	67.2	85.31
05/15/91	3.60	3.20	4.50	56	68.3	88.58
05/16/91	3.70	2.70	4.10	29	63.0	96.53
05/17/91	2.60	2.50	2.70	85	65.9	100.57
05/18/91	2000	1.90	2.20	152	64.7	108.84
05/19/91	1.50	1.40	1.50	339	73.5	120.48
05/20/91	2.10	1.90	2.40	51	71.8	113.47
05/23/91	2.10	1.80	3.60	32	66.7	105.32
05/24/91	1.85	1.70	2.90	26	74.3	105.93
05/25/91	2.30	2.00	3.00	55	56.7	103.78
05/26/91	2.80	2.50	3.70	35	72.9	91.68
05/27/91	2.70	2.40	3.00	21	65.6	86.74
05/28/91	3.20	2.70	4.00	23	74.2	85.70
05/29/91	2.55	1.80	3.50	10	71.4	85.80
05/31-06/01,02,03/91	4.10	2.60	5.20	10	71.4	95.17
06/04,05,06/91	2.75	2.60	9.20	6	60.0	92.41
06/11,12/91[b]	2.20	0.00	0.00	3	60.0	101.50
06/21,22/91[b]	4.40	0.00	0.00	2	40.0	64.78

[a]Confidence intervals calculated with nonparametric statistics.
[b]Not used in statistical analysis because analysis showed too few recaptures.

This indicates that 87% of the variation immigration rate is accounted for by changes in discharge. In other words, migration rate is very dependent on discharge; the higher the discharge, the faster wild steelhead trout migrate.

Twenty-two wild steelhead trout PIT-tagged groups (713 individual fish) were released from the Clearwater River trap in 1991 for use in median migration rate calculations through Lower Granite Reservoir (Table 13). Median travel time ranged from 9.8 d to 3.4 d (6.3 to 18.1 km/d respectively) and averaged 6.3 d (9.8 km/d). Average discharge for the PIT-tagged wild steelhead trout migration season was 51.1 kcfs.

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average inflow discharge to the Reservoir for wild steelhead trout groups released from the Clearwater River trap (r^2 = 0.924, N = 22, P<0.001). The best linear regression equation was:

in (migration rate) = -1.395 + 0.967 in (mean discharge).

The linear regression equation for PIT tag groups stratified into 5-kcfs intervals (r^2= 0.921, N = 10, P<0.001) was:

in (migration rate) = -1.820 + 1.066 in (mean discharge).

This indicates that 92% of the variation in wild steelhead trout migration rate for fish released from the Clearwater River trap is accounted for by changes in discharge. Discharge is a very important variable associated with the rate of movement of wild steelhead trout. As discharge increases so does migration rate.

Wild steelhead trout migration rate/discharge relation for fish released from the Snake River trap was examined to see if this relation was constant over years. The analysis of covariance was used to determine if there was a significant difference among years (1987-1991) in migration rates using groups averaged by 5-kcfs intervals. The analysis showed no significant difference among years for the slopes of the wild steelhead trout migration rate/discharge relations (F = 1.149, N = 55, P = 0.346) nor was there a significant difference in migration rate (intercept) between years (F = 1.682, N = 55, P = 0.169). The data were pooled and the linear regression analysis was run using the log transformed data (r^2= 0.821, N = 55, P<0.001). The best linear regression equation was:

in (migration rate) = -2.069 + 1.115 in (mean discharge).

The analysis indicates that 82% of the variation immigration rate for PIT-tagged wild steelhead trout released from the Snake River trap between 1987 and 1991 was accounted for by changes in discharge. The equation shows that a two-fold increase in discharge will increase migration rate 2.2 times.

Percent recovery at Lower Granite Dam of daily wild steelhead trout PIT tag groups released from the Snake River trap ranged from 18.5% to 76.4%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout to Lower Granite Dam was 63.9%, to Little Goose Dam 81.5%, and to McNary Dam 83.3%.

Table 13. PIT-tagged wild **steelhead** trout travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite **Dam, 1991.**

Release date	Median travel time (day)	Confidence Interval' Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
4/8	9.80	7.70	13.20	13	59.1	32.38
4/9	9.55	6.50	12.20	10	58.8	31.62
4/10	9.25	6.80	13.20	8	57.1	31.25
4/11	9.40	5.70	12.80	8	40.0	30.61
4/12	9.50	7.40	12.50	10	50.0	30.24
4/13,14	8.30	5.80	13.50	7	58.3	30.05
4/15,16	9.25	5.40	19.70	8	57.1	31.51
4/17	7.20	0.00	0.00	5	41.7	30.76
4/19,21	6.20	5.10	7.70	9	50.0	39.56
4/22	5.70	5.00	8.30	17	56.7	45.25
4/23	5.60	4.90	6.10	37	56.9	49.84
4/24	4.70	4.40	5.40	56	57.7	52.95
4/25	5.10	4.40	6.10	**69**	56.6	56.99
4/26	5.30	4.40	5.70	**29**	58.0	59.80
5/1,2	4.60	0.00	0.00	5	50.0	58.05
5/4,5	5.85	4.30	8.70	6	60.0	61.35
5/6	4.90	3.70	6.70	7	58.3	63.88
5/7	4.00	3.50	4.40	21	72.4	68.37
5/8	3.40	2.60	4.30	17	47.2	72.83
5/9	3.65	3.20	3.90	32	65.3	78.78
5/10	3.50	2.60	3.80	26	66.7	81.14
5/12	3.40	0.00	0.00	5	100.0	84.13

"Confidence intervals calculated with nonparametric statistics.

The percent recovery at the three dams for PIT-tagged hatchery and wild steelhead trout was about the same, 89.7% for hatchery steelhead trout and 83.3% for wild steelhead trout marked at the Snake River trap. Interrogation rates for hatchery and wild steelhead trout marked at the Clearwater River trap were 83.8% and 74.1%, respectively. The cumulative recovery rates at the three dams for both chinook salmon and hatchery and wild steelhead trout were slightly higher in 1991 than in previous years.

Percent recovery of daily wild steelhead trout PIT tag groups released from the Clearwater River trap and interrogated at Lower Granite Dam ranged from 40.0% to 72.4%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout released at the Clearwater River trap to Lower Granite Dam was 56.3%, to Little Goose Dam was 70.3%, and to McNary Dam was 74.1%.

Migration rates for hatchery and wild steelhead trout PIT-tagged at the Snake River trap were significantly different. The slopes of the migration rate/discharge regression lines for hatchery and wild steelhead trout, grouped by 5-kcfs intervals, were tested with the analysis of covariance and found to be significantly different (F = 8.151, N = 29, P = 0.009). In 1991, wild steelhead trout from the Snake River trap migrated 1.5 times faster than hatchery steelhead trout at low discharge (50,000 cfs) and at about the same rate at 120,000 cfs (Figure 10). In 1988 and 1989, there was no difference in the migration rate discharge relation but wild steelhead trout consistently migrated faster than hatchery smelts (2.5 km/d, 3 km/d faster, respectively). It is uncertain as to the reason for this difference. Possible explanations are that wild steelhead trout are stronger and/ormore fully smelted and therefore migrate faster through Lower Granite Reservoir at low discharge. At high discharge the ability of the river to carry fish downstream makes up for the difference in the ability to migrate between hatchery and wild steelhead.

Mean ATPase activity level, an indicator of smoltification, was tested at the Snake River trap between April 20 and June 1, 1990 (Rondorf et al. in press). Preliminary information indicates weekly ATPase levels for hatchery steelhead trout were about 50% lower than wild steelhead trout at the beginning of this period and at about the same level at the end of this period. Hatchery steelhead trout weekly mean ATPase levels started out at 11.4 µmoles P·mg $Prot^{-1} \cdot h^{-1}$, peaked at 25.0 µmoles the week of May 25 and ended at 21.8 µmoles. Wild steelhead trout weekly mean ATPase levels fluctuated little during the sample period, ranging from 18.0 to 23.7 µmoles P·mg $Prot^{-1} \cdot h^{-1}$.

Head of Lower Granite Reservoir to Little Goose Dam

Chinook salmon PIT tag groups-The relation between migration rate and discharge was examined for PIT-tagged chinook salmon released from the Snake River trap and interrogated at Little Goose Dam. The linear regression analysis, on the log transformed data stratified by 5-kcfs intervals (Table 14), showed that 72% of the variation in PIT-tagged chinook salmon migration rate between the Snake River trap and Little Goose dam was accounted for by

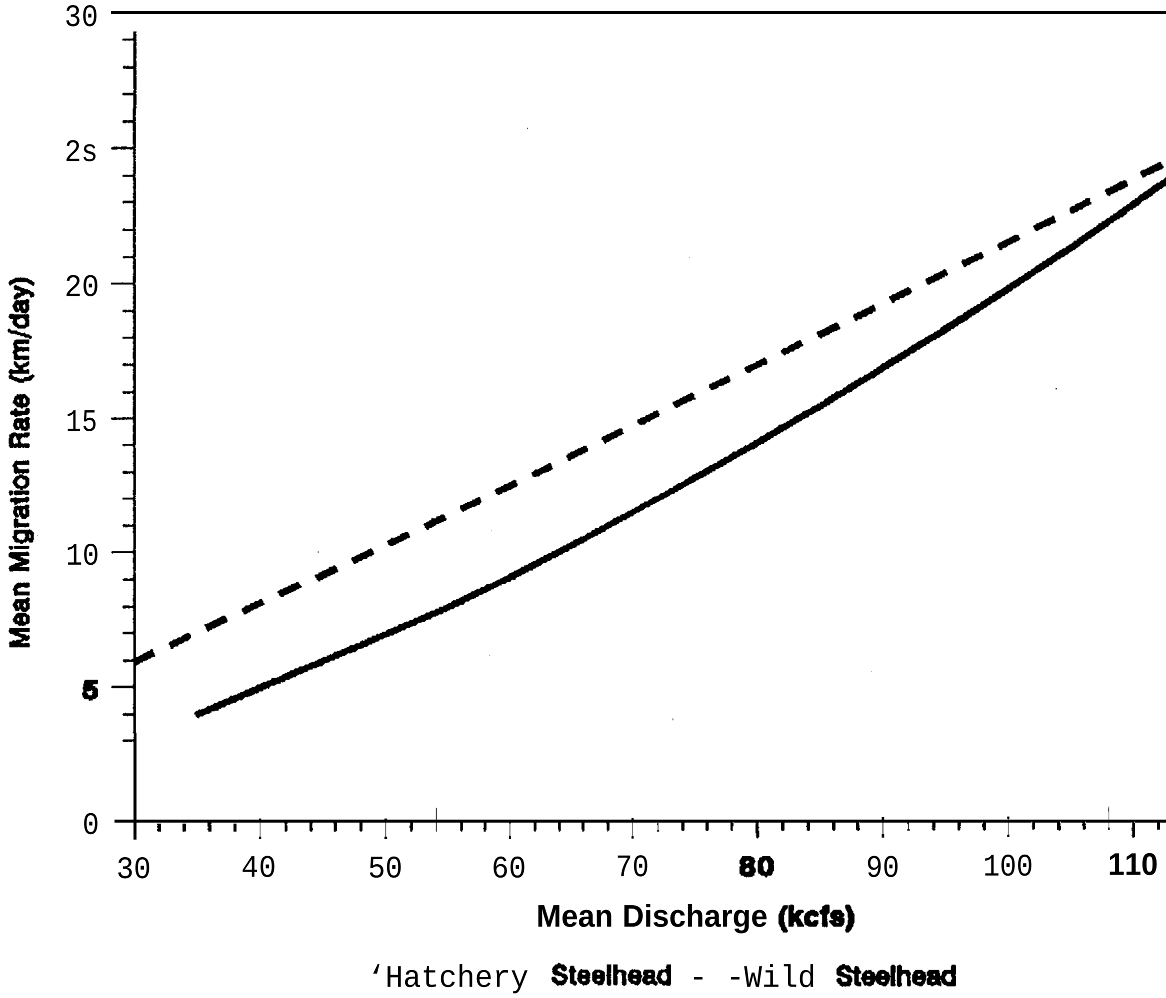

Figure 10. Hatchery and wild steelhead **trout migration rate/discharge relation for** Snake
groups, 1991.

Table 14. Migration data, stratified by **5-kcfs intervals**, for chinook salmon from Snake and Clearwater River traps to Little Goose Dam, 1991.

Discharge Interval	Snake River Trap Migration Rate (km/d)	Clearwater River Trap Migration Rate (km/d)
30 - 35	--	--
35 - 40	5.85	--
40 - 45	--	4.24
45 - 50	--	5.00
50 - 55	--	5.73
55 - 60	9.67	5.37
60 - 65	8.40	6.05
65 - 70	--	6.10
70 - 75	--	--
75 - 80	--	5*50
80 - 85	--	--
85 - 90	12.70	8.10
90 - 95	11.20	9.67
95 - 100	11.40	10.10
100 - 105	12.90	--
105 - 110	24.40	--
110 - 115	26.30	
115 - 120	--	

discharge (r^2 = 0.717, N= 9, P = 0.004). The same analysis was conducted on the PIT tag chinook salmon data from the Clearwater River trap (Table 14). This analysis showed that 83% of the variation in the migration rate for chinook salmon from the Clearwater River trap to Little Goose Dam was accounted for by discharge (r* = 0.826, N = 10, P<0.001).

Hatchery steelhead trout PIT tag groups-The migration rate/discharge relation for PIT-tagged hatchery steelhead trout released from the Snake River trap and interrogated at Little Goose Dam was examined using the linear regression analysis. The data were stratified by 5-kcfs intervals and log transformed (Table 15). Seventy-one percent of the variation in PIT-tagged hatchery steelhead trout migration rate is accounted for by discharge (r^2 = 0.710, N = 10, P = 0.002). Not enough hatchery steelhead trout, PIT-tagged at the Clearwater River trap, were interrogated at Little Goose Dam in 1991 to conduct this analysis.

Wild steelhead trout PIT tag groups-The migration rate/discharge relation for wild steelhead trout PIT-tagged and released from the Snake River trap was examined using the linear regression analysis. The data were stratified by 5-kcfs intervals and log transformed (Table 16). The analysis showed that 93% of the variation in migration rate is accounted for by discharge (r^2 = 0.933, N = 10, P<0.001). Not enough wild steelhead trout, that were PIT-tagged at the Clearwater River trap, were interrogated at Little Goose Dam to perform this analysis. In those instances where enough data exist (Snake River trap data for chinook salmon, hatchery steelhead trout, and wild steelhead trout, and Clearwater River trap data for chinook salmon), the regression shows a significant relation.

Age 0 Chinook vs. Age 1 Chinook Migration Rate and Survival

Five parameters (minimum survival estimate, travel time, migration rate/discharge relation, average length, and growth rate) were examined to determine if age 0 and age 1 chinook salmon could be separated by external physical characteristics at the traps. Minimum survival estimate (age 0 chinook = 51.1%, age 1 chinook = 84.6%) , migration rate/discharge relation, and average length at tagging showed a significant difference between those fish classified as age 0 chinook and age 1 chinook. A t-test was used to determine if a significant difference existed in the mean length of age 0 and age 1 chinook (t = 3.41). The analysis of covariance detected a difference in the slopes of the migration rate/discharge relation equations (F = 6.399, N = 12, P = 0.035). Growth rate (age 0 chinook = 1.12 mm/d, age 1 chinook = 1.08 mm/d) and migration rate are not reliable variables to separate these two groups of chinook. Migration rate may show a difference between age 0 and age 1 chinook (age 0 chinook = 4.0 km/d at an average discharge of 64.3 kcfs, age 1 chinook = 7.1 km/d at an average discharge of 74.9 kcfs), but because the average migration rates were calculated over different average discharges, they are not easily compared.

Table 15. Migration data, stratified by 5-kcfs intervals, for hatchery steelhead trout from Snake and Clearwater River traps to Little Goose Dam, 1991.

Discharge Interval	Snake River Trap Migration Rate (km/d)	Clearwater River Trap Migration Rate (km/d)
30 - 35	--	--
35 - 40	--	. -
40 - 45	--	8.10
45 - 50	--	9.05
50 - 55	--	12.50
55 - 60	11.90	9.90
60 - 65	--	
65 - 70	8.60	--
70 - 75	8.70	8.50
75 - 80	10.90	9.80
80 - 85	16.80	9.70
85 - 90	19.25	13.50
90 - 95	21.75	9.80
95 - 100	20.50	--
100 - 105	18.10	--
105 - 110	--	--
110 - 115	31.80	--
115 - 120	--	--

Table 16. Migration data, stratified by 5-kcfs intervals, for wild **steelhead** trout from Snake and Clearwater River traps to Little Goose Dam, 1991.

Discharge Interval	Snake River Trap Migration Rate (km/d)	Clearwater River Trap Migration Rate (km/d)
30 - 35	8.10	9.10
35 - 40	--	8.47
40 - 45	--	10.00
45 - 50	--	13.20
50 - 55	--	9.60
55 - 60	16.10	14.00
60 - 65	17.50	14.25
65 - 70	--	--
70 - 75	--	12.70
75 - 80	--	16.90
80 - 85	22.10	18.20
85 - 90	23.05	--
90 - 95	19.55	--
95 - 100	29.50	--
100 - 105	31.80	--
105 - 110	27.50	--
110 - 115	31.90	--
115 - 120	--	--

Not enough data are available to perform a statistical analysis between migration rate and discharge for age 0 and age 1 chinook salmon PIT tagged after June 12.

Minimum Survival of PIT-tagged Fish

Minimum survival to Lower Granite Dam (the number of fish that were interrogated at Lower Granite, Little Goose, or McNary dams) for fish PIT- tagged at the Snake River and Clearwater River traps in 1991 was slightly higher than minimum survival estimates from previous years. Chinook salmon and both hatchery and wild steelhead trout PIT-tagged at the Snake River trap survived at a rate 5.9 to 7.9 percentage points higher than fish taggedat the Clearwater River trap (Table 17). This follows a similar trend observed in 1989 and 1990. The difference in minimum survival, in part, can be accounted for by the presenceof DNFH releases. Due to the close proximity of the Clearwater River trap to the hatchery, the rigors of migration have not as yet caused mortality of the weaker fish. Natural mortality of hatchery fish is believed to be greater at the beginning of their river existence as they acclimate to the hazards present in the natural system. The majority of the mortality of hatchery fish in the Snake River takes place prior to the fish passing the trap site. This does not explain the difference in minimum survival for wild steelhead.

Minimum survival to Lower Granite Dam in 1991 for chinook salmon (68.2%), hatchery steelhead trout (89.7%), and wild steelhead trout (83.3%) from the Snake River trap was slightly higher than in 1989 or 1990. The minimum survival estimate to Lower Granite Dam for chinook salmon PIT-tagged at the Clearwater River trap (60.5%), hatchery steelhead trout (83.8%), and wild steelhead trout (74.1%) was slightly higher than observed in 1989 and 1990.

SUMMARY

The number of hatchery-reared chinook salmon and steelhead trout released above Lower Granite Dam was up considerably in 1991. Chinook salmon releases were down 35% and hatchery steelhead trout releases were down 13% from 1990. There was a major decrease in chinook salmon production in the Salmon River drainage and minor reductions in the Clearwater and Grande Ronde rivers in 1991. The majority of the decrease in hatchery steelhead trout production occurred in the Salmon River drainage. Hatchery production of chinook salmon and steelhead trout released above Lower Granite Dam was 19,539,185 (9,645,205 chinook salmon and 9,893,980 steelhead trout) in 1991. Of these, 381,863 chinook salmon and 355,796 steelhead trout (4.0% and 3.6% of the total releases, respectively) were freeze-branded and released as 19 unique chinook salmon groups and 21 unique steelhead trout groups.

The Snake River trap was operated on the east side of the river from March 11 through August 12. The Snake River trap captured 3,834 age 1 chinook salmon, 95 age 0 chinook salmon, 19,020 hatchery steelhead trout, and 4,136 wild

Table 17. Interrogation of PIT-tagged fish from the Snake River trap, 1988-1991, and Clearwater River trap, 1989-1991, at downstream collection facilities.

Tagging Site	Year	Species[a]	Number Tagged	Number Interouated/Site: Lower Granite (%)	Little Goose (%)	McNary (%)	Totals (%)
Snake	1991	CH	2131	929 (43.6)	409 (19.2)	115 (5.4)	1453 (68.2)
		SH	2577	2032 (78.9)	268 (10.4)	11 (0.4)	2311 (89.7)
		Sw	3549	2266 (63.9)	625 (17.6)	66 (1.9)	2957 (83.3)
Clearwater	1991	CH	3943	1483 (37.6)	668 (16.9)	235 (6.0)	2386 (60.5)
		SH	1215	926 (76.2)	89 (7.3)	(0.3;	1018 (83.8)
		Sw	727	409 (56.3)	102 (14.0)	28 (3.9)	539 (74.1)
Snake	1990	CH	2,245	956 (42.6)	310 (13.8)	180 (8.0)	1,446 (64.4)
		SH	3,112	2,272 (73.0)	282 (9.1)	33 (1.1)	2,587 (83.1)
		Sw	3,078	2,016 (65.5)	356 (11.6)	60 (2.0)	2,432 (79.0)
Clearwater	1990	CH	4,242	1,359 (32.0)	674 (15.9)	281 (6.6)	2,314 (54.6)
		SH	1,228	880 (71.7)	63 (5.1)	10 (0.8)	953 (77.6)
		Sw	1,300	767 (59.0)	126 (9.7)	22 (1.7)	915 (70.4)
Snake	1989	CH	6,222	2,384 (38.3)	1,367 (22.0)	482 (7.7)	4,233 (68.0)
		SH	2,525	1,733 (68.6)	268 (10.6)	35 (1.4)	2,036 (80.6)
		Sw	1,798	1,170 (65.1)	240 (13.3)	52 (2.9)	1,462 (81.3)
Clearwater	1989	CH	2,441	756 (31.0)	452 (18.5)	140 (5.7)	1,348 (55.2)
		SH	290	173 (59.7)	16 (5.5)	2 (0.7)	191 (65.9)
		Sw	104	53 (51.0)	16 (15.4)	(2.9;	72 (69.2)
Snake	1988	CH	3,767	1,237 (32.8)	543 (14.4)	299 (7.9)	2,079 (55.2)
		SH	1,743	1,069 (61.3)	190 (10.9)	12 (0.7)	1,271 (72.9)
		Sw	1,186	698 (58.9)	166 (14.0)	20 (1.7)	884 (74.5)

[a] CH = chinook, SH = hatchery steelhead, SW = wild steelhead.

steelhead trout. The wild steelhead trout catch in the trap was greater than in any previous year, up 121% from 1990 which was the second highest year.

The Clearwater River trap was operated from March 13 through May 12, with 4 d down time in late-April and mid-May when the trap was out of operation due to high flow and heavy debris. Clearwater River trap catch was 39,522 age 1 chinook salmon, 9,231 hatchery steelhead trout, and 824 wild steelhead trout. Chinook salmon trap catch was down slightly from 1990 but similar to other drought years. Hatchery steelhead trout trap catch was similar to 1990 and wild steelhead trout trap catch was about half of 1990 but higher than other drought years.

Fish were again PIT-tagged for migration rate statistics at the Snake River trap and Clearwater River trap in 1991. The number of fish PIT-tagged at the Snake River trap was 8,363 and the number of fish PIT-tagged at the Clearwater River trap was 5,904.

Snake River trap chinook salmon efficiency tests were not conducted in 1991 due to the low catch of chinook in the trap. Previous years trap efficiencies provide a pooled average chinook salmon trap efficiency of 1.39% at the Snake River trap.

Snake River trap steelhead trout trap efficiency tests were conducted on three occasions in 1990 and provided a mean trap efficiency of 0.49%.

Chinook salmon trap efficiency at the Clearwater River trap in 1991 was 1.16% which was lower than other years except 1989. Clearwater River trap mean efficiency for hatchery steelhead trout in 1991 was not tested but it was 1.90% in 1990, which is significantly higher than in previous years when trap efficiencies were below 0.4%. The increase in trap efficiency for steelhead trout at the Clearwater River trap was probably due to several trap modifications which were made in 1988 and 1989 and the fact that the trap was fished closer to the thalweg for a greater portion of the 1990 season.

Because of the low chinook salmon freeze brand recovery at the Snake River trap in 1991, migration rate statistics were calculated for only three of the brand groups. The migration rate for all three groups was considerably lower than in previous years due to the below normal and late runoff. Freeze- branded hatchery steelhead trout migration rate to the Snake River trap was considerably slower in 1991 than in previous years.

Migration rates for Clearwater River freeze-branded chinook salmon were similar to rates observed in 1985, 1986, 1988 through 1990. In 1987 migration rate was four times slower than in 1991. Flows were considerable lower for a major portion of the migration in 1987 and probably was the reason for the slower migration that year. An accurate migration rate for hatchery steelhead trout released from DNFH could not be determined in 1991, because the freeze brands were very difficult to read.

PIT-tagged chinook salmon are amuchbetter methodof determining migration rate through Lower Granite Reservoir than using freeze brand groups. Statistical analysis showed a strong relation between migration rate and discharge for chinook salmon PIT-tagged at either trap (Snake River trap: r^2 = 0.885, N = 13, P<0.001; Clearwater River trap: r^2 = 0.821, N = 10, P = 0.008). As discharge increased, migration rate of PIT-tagged chinook salmon through the reservoir also increased. PIT-tagged chinook salmon moved about twice as fast through the reservoir at 100 kcfs than at 50 kcfs. Chinook salmon PIT-tagged at the Clearwater River trap migrated about 30% slower through Lower Granite Reservoir than fish PIT-tagged at the Snake River trap.

Percent interrogation of PIT-tagged chinook salmon released from the Snake River trap was similar to 1989 and 1990. Cumulative interrogation of PIT-tagged chinook salmon at all three dams (Lower Granite, Little Goose, and McNary) was 68.2% in 1991. Percent interrogation of PIT-tagged chinook salmon released from the Clearwater River trap was slightly higher than in 1990.

There is a very strong statistical relation between migration rate and discharge for Snake River trap PIT-tagged hatchery steelhead trout (r^2 = 0.938, N = 13, P<0.001). PIT-tagged hatchery steelhead trout migrated about three times as fast at 100 kcfs as they did at 50 kcfs.

Hatchery steelhead trout PIT-tagged at the Clearwater River trap took three days longer to migrate through Lower Granite Reservoir than fish tagged at the Snake River trap. There was a relation between migration rate and discharge for the Clearwater River trap fish (r^2 = 0.634, N = 11, P = 0.003). The relation was not as strong as the one observed for the Snake River trap hatchery steelhead due to the limited data available.

The Snake River trap PIT tag data for hatchery steelhead trout were examined over years to see if there was a significant difference in the migration rate/discharge relation among years. The analysis showed there was a significant difference among years that was attributable to 1988. If 1988 data were removed, there was no statistical difference in the migration rate/discharge relation for the remaining four years data for hatchery steelhead PIT-tagged at the Snake River trap.

Percent interrogation at all three dams (Lower Granite, Little Goose, and McNary dams) of PIT-tagged hatchery steelhead trout tagged at the Snake River trap was 89.7%. This was slightly greater than in previous years. Percent interrogation at all three dams of PIT-tagged hatchery steelhead trout tagged at the Clearwater River trap was 83.8%, which was slightly higher than in 1990.

The introduction of the PIT tag has provided the opportunity to obtain travel time data through Lower Granite Reservoir for wild steelhead trout. This is because of the low numbers of fish required for marking due to the high recovery rate at Lower Granite Dam. Wild steelhead trout PIT-tagged at the Snake River trap migrated at a rate of 13.6 km/d. The relation between migration rate and discharge for wild steelhead trout was very strong (r^2 = 0.873, N = 15, P<0.001). These fish migrated twice as fast through Lower Granite Reservoir at 100 kcfs as they did at 50 kcfs. PIT-tagged wild steelhead trout migrate slightly faster through Lower Granite Reservoir than did the PIT-tagged hatchery steelhead trout.

Wild steelhead trout were collected and PIT-tagged at the Clearwater River trap in 1991 at a rate to provide enough data to examine migration rate through Lower Granite Reservoir. ClearWater River wild steelhead trout mean migrated at 9.8 km/d through Lower Granite Reservoir. This was 3.8 km/d slower than the mean for wild steelhead trout PIT-tagged at the Snake River trap.

There was a very strong relation between migration rate and discharge for PIT-tagged wild steelhead trout released from the Clearwater River trap ($r^2 = 0.921$, N = 10, $P<0.001$). Clearwater River wild steelhead trout migrated twice as fast at 100 kcfs as they did at 50 kcfs. Migration rate through the reservoir for Clearwater and Snake rivers wild steelhead trout at higher discharge was about the same (e.g., at 100 kcfs, 22.0 km/d and 20.3 km/d, respectively).

The migration rate/discharge relations for wild steelhead trout for 1987-1991 were examined to see if there was a difference among years. There was no significant difference among years (i.e., homogeneous slopes and common intercepts were accepted) for wild steelhead trout, and the data were pooled. The linear regression analysis on this pooled data showed a very strong relation between migration rate and discharge ($r^2 = 0.821$, N = 55, $P<0.001$).

Percent interrogation of PIT-tagged wild steelhead trout marked at the Snake River or Clearwater River traps was slightly higher than in previous years. Cumulative interrogation of PIT-tagged wild steelhead trout at the three dams (Lower Granite, Little Goose, and McNary) was 83.3% for Snake River trap fish and 74.1% for Clearwater River trap fish in 1991. Percent interrogation of PIT-tagged wild steelhead trout from the Clearwater River trap was significantly lower than for fish PIT-tagged at the Snake River trap.

The migration rate/discharge relation for chinook salmon between the traps and Little Goose Dam was examined. The analysis showed that 72% of the variation in migration rate for chinook salmon PIT-tagged at the Snake River trap was accounted for by discharge. It also showed that 83% of the variation in migration rate for Clearwater River chinook salmon was accounted for by changes in discharge.

The migration rate/discharge relation for hatchery steelhead trout between the traps and Little Goose Dam was examined. Seventy-one percent of the variation in migration rate of fish PIT-tagged at the Snake River trap was accounted for by discharge. Not enough data were available to examine the migration rate discharge relation of hatchery steelhead trout marked at the Clearwater River trap.

The migration rate/discharge relation for wild steelhead trout between the traps and Little Goose Dam was examined. The analysis showed that 93% of the variation in migration rate of fish PIT-tagged at the Snake River trap was accounted for by discharge. Not enough data were available to perform the analysis on wild steelhead PIT-tagged at the Clearwater River trap.

Chinook salmon, hatchery steelhead trout, and wild steelhead trout PIT-tagged at the Snake River trap survived at a rate 6% to 9% greater than fish tagged at the Clearwater River trap. This assumes similar fish guiding efficiency at the dams for fish from the both rivers.

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SMOLT MONITORING AT THE HEAD OF LOWER GRANITE RESERVOIR AND LOWER GRANITE DAM

Annual Report
for 1989 Operations

by

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ABSTRACT

This project monitored the daily passage of chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *O. mykiss* smelts during the 1989 spring outmigration at a migrant trap on the Snake River and the Clearwater River.

Chinook salmon catch at the Snake River trap was much higher in 1989 than in either of the 1987 or 1988 drought years. The 1989 Snake River trap catch was similar to 1986. Effort was the same during the four years. Steelhead trout catch was greater than in any previous year.

Chinook salmon and steelhead trout catch at the Clearwater River trap was similar to 1986, even though effort was greatly reduced in 1989 due to high runoff during most of the season. The 1989 Clearwater River trap catch was lower than in the two drought years (1987 and 1988) and was due to the minimal number of days the trap was operated.

Fish tagged with Passive Interrogated Transponder (PIT) tags at the Snake River trap were recovered at the three dams (Lower Granite, Little Goose, and McNary) with PIT tag detection systems. Cumulative recovery was 68.5% for chinook salmon, 82.5% for hatchery steelhead trout, and 81.5% for wild steelhead trout.

Travel time (days) and migration rate (km/d) through Lower Granite Reservoir for PIT-tagged chinook salmon and steelhead trout, marked at the head of the reservoir, was affected by discharge. Statistical analysis showed that as discharge increased from 40 kcfs to 80 kcfs, chinook salmon travel time decreased three-fold and steelhead trout travel time decreased two-fold.

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INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NWPPC) to develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (EPA) the authority and responsibility to use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system."

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smelt migration. In response to the fishery agencies' and Indian tribes' recommendations for migration flows, the NWPPC Columbia River Basin Fish and Wildlife Program proposed a "Water Budget" for augmenting spring flows.

The NWPPC's Water Budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the smelt migration. This amount has never been provided, and actual water made available has been limited. To provide information to the Fish Passage Center (FPC) on smelt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smelts at the head of Lower Granite Reservoir. This information allows the FPC to request the limited Snake River Water Budget for optimal use to provide improved passage and migration conditions.

Smelt monitoring is beneficial for water budget management under all flow conditions and becomes critical when low flow conditions reduce migration rates. In years of low flow, knowledge of when most smelts have left tributaries and entered areas which can be affected by releases of stored water allows managers to make the most timely use of the limited water budget resource. Two low flow years (1987 and 1988) have occurred during this smelt monitoring project. The indications are that judicious use of the water budget can greatly enhance the timing and migration rate of juvenile chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *O. mykiss*.

Additionally, the IDFG smelt monitoring project collects other useful data on relative species composition, estimated fish passage index, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, and migration rate. By monitoring smelt passage at the head of Lower Granite Reservoir and at Lower Granite Dam, migration rates (km/d) under various riverine and reservoir conditions can be estimated and compared. Monitoring sites on both the Snake and Clearwater arms of Lower Granite Reservoir permit migration timing of smelts from each drainage to be determined. Although not yet achieved, relative abundance of hatchery and wild stocks of steelhead trout can be determined and used to document wiid stock rebuilding progress. The Smelt Monitoring Program's information is complimentary of other Snake and Columbia river NWPPC supported projects.

OBJECTIVES

1. Provide daily trap catch data and a smelt passage index at the head of Lower Granite Reservoir for water budget and fish transportation management purposes.

2. Determine riverine travel time from the point of release to the smelt traps (index sites) at the upper end of Lower Granite Reservoir for freeze-branded and PIT-tagged smelts.

3. Provide an interrogation site for PIT-tagged smelts, marked on other projects, at the end of their migration in a riverine environment, and the beginning, or their migration in a reservoir environment.

4. Determine reservoir travel time for chinook salmon, hatchery steelhead trout, and wild steelhead trout from the head of Lower Granite Reservoir to Lower Granite Dam using PIT-tagged smelts marked at the traps, as well as freeze-branded and PIT-tagged smelts passing the traps from upriver hatchery releases and rearing areas.

5. Correlate smelt travel time with river flow for fish moving in riverine and reservoir environments.

6. Determine trap efficiency for each species at each trap over a range of discharges.

METHODS

Releases of Hatchery-Produced Smelts

Release information was reported for hatcheries in the Snake River drainage upstream of Lower Granite Dam that released chinook salmon and steelhead trout juveniles. This information included species, number released, date and location released, and the group identifying freeze brand, if used.

Smelt Monitoring Traps

During the 1989 outmigration, two smelt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. A scoop trap (Raymond and Collins 1974) was stationed on the Clearwater River and a dipper trap (Mason 1966) was located on the Snake River (Figure 1). Smolts were captured and removed daily from the traps for examination, enumeration, and released back to the river. Fork length of up to 100 smelts were measured to the nearest millimeter, and up to 2,000 fish were examined for hatchery brands.

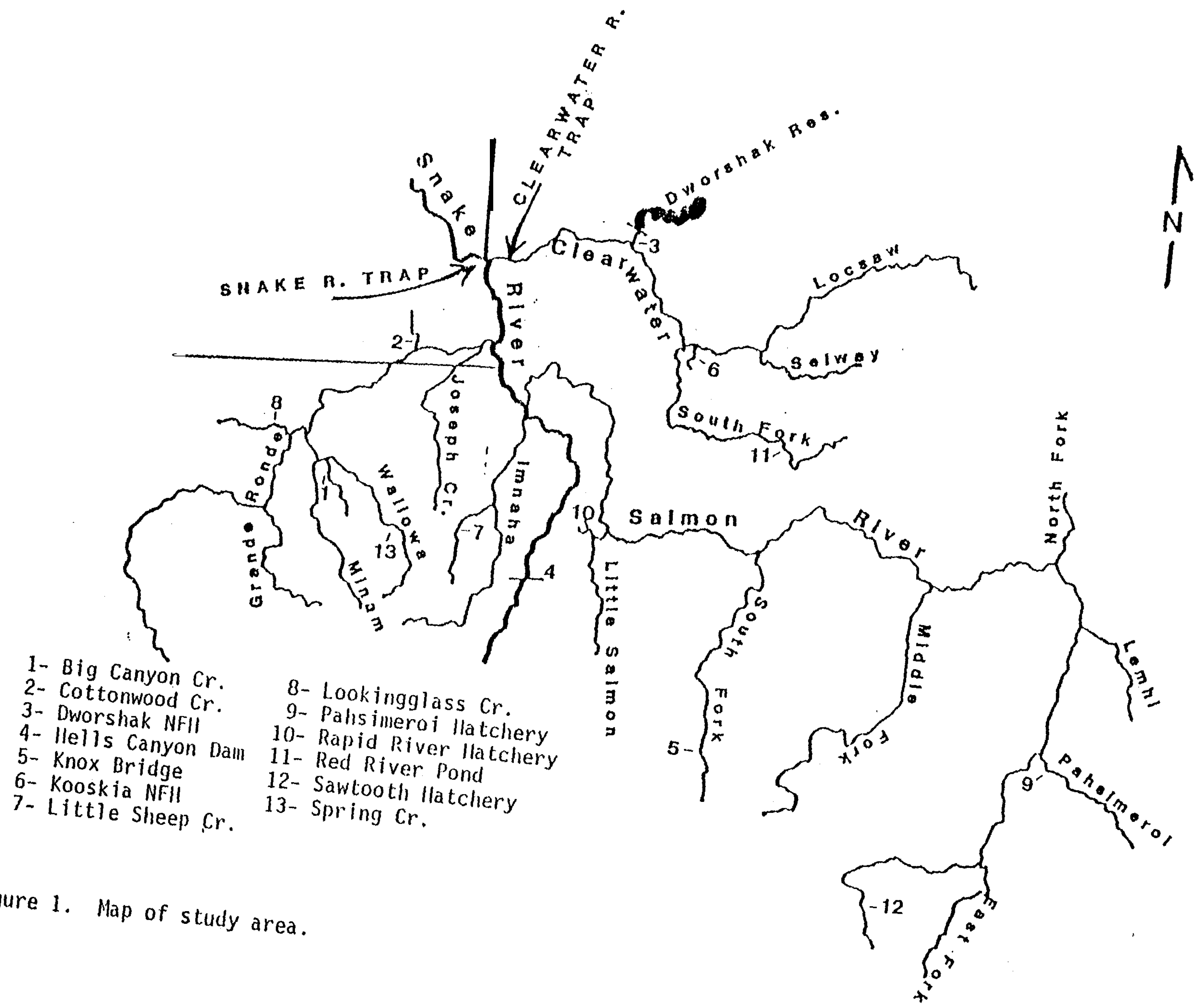

Figure 1. Map of study area.

Smelts handled were anesthetized with Tricaine Methanesulfonate (MS-222). These fish were allowed to recover from the anesthesia before being returned to the river.

At each trap, water temperature (C) and turbidity were recorded daily using a centigrade thermometer and 20 cm Secchi disc. The US Weather Service provided daily information on river discharge (CFS). The Snake River trap discharge was measured at the USGS Anatone gauge (#13334300), 44.4 km upstream from the trap. The Clearwater River trap discharge was measured at the USGS Spalding gauge (#13342500), 8.8 km upstream from the trap.

Snake River Trap

The Snake River migrant dipper trap was positioned approximately 40 m downstream from the Interstate Bridge between Lewiston, Idaho and Clarkston, and Washington, and was attached to bridge piers just west of the drawbridge span by steel cables. This location is near the head of Lower Granite Reservoir, 0.5 km upstream from the convergence of the Snake and Clearwater arms. River width and depth at this location are approximately 260 m and 12 m, respectively.

A juvenile steelhead radio-tagging study was conducted in 1987 (Liscom and Bartlett 1988) which showed that 7% of the radio-tagged steelhead trout passed the bridge under the span the trap was attached to, and 30% passed the bridge under the span immediately east of the drawbridge span. Because at least four times more fish were moving under the span of the bridge just east of the drawbridge, the trap was moved to that location on April 27, 1988, after completion of installing of an electrical line to the new trap location. Because of the lack of information on water velocity and debris loads at the east trap location during a normal flow year, the trap was operated on the west side of the river in 1989. The debris and velocity information to be collected was not since 1989 and had a slightly below normal snow pack and an artificially created low runoff. Spring runoff was stored upriver to recharge reservoirs at low level because of the two previous drought years. Snake River discharge did not exceed 76.8 kcfs, and a minimal debris load occurred.

Trap operation in 1989 began March 7 and continued until June 23. There were two interruptions in trap operation due to mechanical breakdown and power outage, respectively. The first occurred for an undetermined number of hours on April 18. The second occured from 1500 h May 7 to 1630 h May 8.

Chinook salmon and steelhead trout smelts were tagged with Passive Integrated Transponder (PIT) tags (Prentice et al. 1987) at the Snake River trap to estimate travel time from the headof Lower Granite Reservoir to Lower Granite Dam. Up to 150 chinook salmon, 60 hatchery steelhead trout, and 60 wild steelhead trout were PIT-tagged daily, when available. Median travel time, converted to migration rate, of the daily PIT-tagged release groups was correlated with mean Lower Granite Reservoir inflow discharge for the median travel time to determine how changes in discharge affected travel time of smelts through Lower Granite Reservoir.

clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from the convergence of the Clearwater River and Snake River arms of Lower Granite Reservoir (4.5. km upstream from slack water). The river channel at this location forms a bend and is 150 to 200 m wide and 4 m to 7 m deep, depending on discharge.

Trap operation began March 15 and continued until June 5. Trapping was discontinued because of high discharge and/or debris for 37 d this season between April 7 to April 11, April 16 to May 1, and May 3 to May 22. The **number** of days the trap was out of operation due to high discharge was much greater than in past years. In 1985 and 1986, near normal flow years, the trap was down only a few days (one to six) each year. The Clearwater River drainage low elevation snow pack was above normal in 1989 and resulted in high flows early in the runoff season. The remaining ClearWater River drainage snow pack was slightly below normal but provided enough runoff to prevent trap operation.

Trap Efficiency

To estimate the number of smelts passing a trap, it is necessary to know what proportion of the migration is being sampled (trapping efficiency). This efficiency may change as river discharge changes. To describe the relationship between discharge and efficiency, efficiency must be estimated several times through the range of discharge at which the trap is being operated. With sufficient data, a regression equation correlating trap efficiency and discharge can be derived. This regression approach allows efficiency to be estimated for any given discharge.

The ratio of recaptures to marks released is the estimate of trap efficiency (TE = recaptures/marks released). **All** trap efficiency tests conducted on the Snake and Clearwater River traps yielded recapture rates less than 20%. These low proportions, or percentages, form a binomial rather than normal distribution. To normalize the trap efficiency data an arcsin $\bar{x}$ transformation (Zar 1984) was conducted **where:**

$$TE'(\text{or } P') = \tfrac{1}{2}[\arcsin \bar{x}/n+1 + \arcsin \bar{x}+1/n+1].$$

All subsequent analysis including the trap efficiency-discharge regressions were conducted with the transformed data.

A one-way analysis of variance was used to determine if there was a significant different-e in trap efficiencies among years. If no significant difference existed, then the data was subjected to an analysis of covariance to see if trap efficiency varies from year to year when adjusted for discharge.

If no statistical difference existed, the data were pooled over years, and a single regression line fitted between river discharge and trap efficiency. Each test was performed at the 0.05 level of significance.

Trap efficiency tests were conducted with three different release procedures. The first procedure utilized fish released directly from a hatchery or part of a hatchery transported release group, when that hatchery or release group was less than 80 km upriver from the trapping facility. The second procedure utilized small groups of fish, approximately 2,000 fish for chinook salmon and 4,000 fish for steelhead trout, that had been marked at a hatchery and held there until transported to a release site upstream of the trap for release at sunset. Sample size differences between test groups of chinook salmon and steelhead trout juveniles relate to the trap efficiency of the species and the number of recaptures needed for statistical reliability. Five or more recaptures per test were needed for trap efficiency estimates tobe statistically reliable. The third procedureof estimating trap efficiency utilized trap-caught fish that were marked, transported back upstream the same day, captured, and released to pass the trap a second time.

Trap efficiency tests were conducted throughout the migration season on the Snake River by releasing trap-caught, marked smelts 8 km upriver from the trap. Seven groups of trap-caught chinook salmon smelts were caudal clipped and released upriver of the trap for efficiency tests. One of these groups was disallowed because the trap was not in operation during a portion of the test period. Five groups of trap-caught steelhead trout were opercle punched and released upriver of the trap to estimate trap efficiency. Two of these groups were disallowed; one because the trap was not in operation during a portion of the test period, and the other because of low recapture numbers (less than five recaptures).

Trap efficiency tests were conducted throughout the migration season on the Clearwater River by releasing marked smelts 7 km upriver from the trap site. Four groups of chinook salmon, of approximately 2,000 fish each, were freeze-branded at Dworshak National Fish Hatchery (DNFH) and held there until transported to the release site, 7 to 31 d later. Five groups of freeze-branded age-1 chinook salmon, three groups of freeze-branded age-O chinook salmon, and two of the four groups of freeze-branded steelhead trout released with the DNFH production release were also used to estimate efficiency of the Clearwater River trap.

Travel Time and Migration Rates

Migration statistics were calculated for hatchery release groups from release sites to traps and through Lower Granite Reservoir. Travel time and migration rates to the traps and through Lower Granite Reservoir were calculated using median arrival times at the Snake and Clearwater River traps, and at Lower Granite Dam for hatchery brand groups and brand groups used for trap efficiency tests. Smelts were PIT-tagged at the Snake and Clearwater River traps as an additional method to determine travel time. Daily individual arrival times of these fish at Lower Granite Dam collection facility were determined. A minimum recapture number, sufficient for use in travel time and migration rate estimations, was derived from an empirical distribution function of the travel time for each individual release group (Steinhorst et al. 1988). Travel time and migration rate estimates were not calculated if minimum recaptures were not attained.

A linear regression analysis was conducted on the migration rate-discharge relationship through Lower Granite Reservoir after both variables were log transformed. The 0.05 level was used to determine significance. This analysis was performed for the hatchery freeze-branded chinook salmon and steelhead trout groups and for the PIT-tagged chinook salmon, hatchery steelhead trout, and wild steelhead trout groups marked at the Snake or Clearwater River traps.

To remove some of the "noise" often associated with biological data and better show the underlying biological relationship, migration rate was stratified into five kcfs discharge intervals (Mosteller and Tukey 1977:75). A linear regression analysis of the five kcfs grouped data was conducted.

The migration rate-discharge relationship, for PIT-tagged chinook salmon, hatchery steelhead trout, and wild steelhead trout, was individually examined for 1987-1989 to determine if there was a difference in this relationship between years. Using the analysis of covariance, with the migration rate data averaged by 5 kcfs groups, the first underlying assumption of equality of slopes was tested. If the hypothesis of equality of migration rate-discharge slopes among years could not be rejected, then the subsequent analysis of covariance was completed. This was basically a test of whether the regression lines relating migration rate and discharge for each year had a common intercept, or whether one regression line was higher than another. If the final hypothesis of common intercepts could not be rejected, then there was not a significant difference in the migration rate-discharge relationship between years.

RESULTS AND DISCUSSION

Hatcherv Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage upstream from Lower Granite Dam were reared at seven locations in Idaho and one in Oregon. The Washington Department of Fisheries released no chinook salmon juveniles in the Snake River" drainage upstream from Lower Granite Dam that contributed to the 1989 outmigration. A total of 11,479,606 chinook salmon smelts were released at 14 locations in Idaho and four locations in Oregon (Table 1).

During the fall of 1988, three groups of chinook salmon juveniles were released from Idaho hatcheries and two groups were released from Oregon

Table 1. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam contributing to the 1989 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
<u>Salmon River</u>				
Sawtooth Hat. (Sawtooth)	Spring	10/12-13/88	985,100	
		3/15-21	1,101,600	
		(3/15)	(14,900)	LAR-1
		(3/15)	(14,900)	LAR-2
		(3/15)	(16,300)	LAR-3
		(3/15)	(7,000)	LAR-4
East Fork S.R. (Sawtooth)	Spring	3/20	305,300	
Yankee Fork S.R. (Sawtooth)	Spring	3/22	198,200	
South Fork S.R. (McCall)	Summer	3/20-23	.975,000	
		(3/21)	(14,100)	RAR-1
		(3/21)	(13,725)	RAR-2
		(3/21)	(15,825)	RAR-3
		(3/21)	(9,175)	RAR-4
Pahsimeroi R. (Pahsimeroi)	Summer	3/15	1,016,300	
Rapid River (Rapid River)	Spring	3/15-30	2,319,500	
		(3/30)	(17,025)	LD7H-1
		(3/30)	(16,975)	LD7H-3
		(3/30)	(16,025)	LA7H-1
		(3/30)	(9,525)	LA7H-3
	Drainage Total		6,901,000	
<u>Snake River and Non-Idaho Tributaries</u>				
Hells Canyon (Rapid River)	Spring	3/21-23	500,000	
Catherine Creek (Lookingglass)	Spring	4/4	83,100	
Big Canyon Creek (Lookingglass)	Spring	4/6	89,102	

Table 1. (Continued)

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Lookingglass Cr. (Lookingglass)	Spring	9/23/88	85,564	
		(9/23/88)	(20,248)	RDJ-1
		(9/23/88)	(20,341)	LDJ-1
		11/1/88	86,310	
		4/3	417,354	
		(4/3)	(20,419)	RDJ-2
		(4/3)	(17,197)	RDJ-3
		(4/3)	(19,817)	LDJ-2
		(4/3)	(18,623)	LDJ-3
	(age-0)	5/15	126,700	
		(5/15)	(22,757)	LAJ-1
		(5/15)	(22,106)	RAJ-1
Imnaha River (Lookingglass)	Spring	4/5	142,320	
		(4/5)	(20,153)	RDJ-4
		(4/5)	(20,065)	LDJ-4
	Drainage Total		1,530,450	
Clearwater River				
Red River Pond (Red River Pond)	Spring	10/10-12/88	291,200	
		(10/11/88)	(18,700)	LDR-1
		(10/11/88)	(23,875)	LDR-2
		(10/11/88)	(13,475)	LDR-3
N.F. Clearwater (Dworshak NFH)	Spring	9/28/88	192,090	
		(9/28/88)	(19,318)	RDR-1
		(9/28/88)	(18,802)	RDR-2
		(9/28/88)	(18,737)	RDR-3
		3/29-30	1,252,923	
		(3/29)	(30,503)	RDLX-1
		(3/29)	(34,795)	RDLT-1
		(3/30)	(19,545)	RD7H-1
		(3/30)	(20,084)	RD7H-3
		(3/30)	(19,087)	RA7H-1
	(age-0)	3/30	206,459	
		(3/30)	(19,992)	RDH-1
		(3/30)	(20,716)	RAH-1
		(3/30)	(21,051)	RDH-2

Table 1. (Continued)

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
ClearWater R. Hwy 95 Boat Launch (Dworshak NFH)	Spring	3/21-4/5	8,310	
		(3/21)	(2,076)	RA4-3
		(3/23)	(2,065)	LD4-1
		(4/3)	(2,094)	RD4-3
		(4/5)	(2,075)	RA4-1
Crooked River (Dworshak NFH)	Spring	3/27-30	199,690	
White Sands Cr.				
(Dworshak NFH)	Spring	3/28-29	200,639	
(Kooskia NFH)	Spring	3/27	102,660	
Clear Creek (Kooskia NFH)	Spring	3/29	384,235	
Eldorado Creek (Kooskia NFH)	Spring	3/29	209,950	
	Drainage Total		3,048,156	
	Grand Total		**11,479,606**	

hatcheries. All other chinook salmon releases for the 1989 outmigration were made in the spring of 1989 (Table 1).

Steelhead Trout

Steelhead trout were reared at five hatcheries in Idaho, one in Washington, and one in Oregon for release into the Snake River upstream from Lower Granite Dam. A total of 8,750,148 steelhead trout smelts were released at 17 locations in Idaho, 8 locations in Oregon, and 2 locations in Washington (Table 2).

The only fall release of steelhead trout that would have contributed significantly to the 1989 outmigration occurred November 11, 1988. This release consisted of 94,327 juvenile steelhead trout reared by Oregon Department of Fish and Wildlife at Irrigon Fish Hatchery and transported to the Snake River at Hells Canyon. All releases from Idaho and Washington occurred in the spring of 1989 (Table 2).

Smelt Monitoring Traps

Snake River Trap Operation

The Snake River trap caught 32,131 age-1 chinook salmon, 235 age-0 chinook salmon, 23,245 hatchery steelhead trout, 2,194 wild steelhead trout, and 331 sockeye/kokanee *Oncorhynchus nerka*. A large portionof the chinook salmon (80%) were captured during April, while 9.4% were captured in March, 10.1% in May, and 0.5% in June (Figure 2). Thirty-two percent of the hatchery steelhead trout were captured in April, 66% were captured in May, and 2% in June. Wild steelhead trout passage was earlier than hatchery steelhead trout, with 1.3% captured in March, 44.3% in April, 53.4% in May, and 1.0% in June (Figure 3).

Snake River discharge, measured at the Anatone gauge, ranged from 18,300 cfs to 53,600 cfs, and averaged 40,600 cfs in the month of March (Figure 3). The average April discharge was 58,500 cfs, with a peak of 76,800 cfs April 22, which was also the seasonal peak. Flows gradually declined through the first few days of May, and another peak of 73,100 cfs occurred on May 9. After this peak, discharge slowly decreased through early June, when a third peakof 61,800 cfs occurred on June 9. The average May discharge was 52,100 cfs. Flows after the June peak continually dropped until the end of the sampling season on June 23, when discharge was 41,100.

Water temperature in the Snake River at the trap steadily increased throughout the sampling season (Figure 4). By the end of the season, June 23, water temperature had risen to 16°C. Water temperatures were slightly cooler throughout the season in 1989 than in previous years.

Table 2. Hatchery steelhead trout released into the Snake River system upriver from Lower Granite Dam contributing to the 1989 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Salmon River				
North Fork S.R. (Niagara Springs)	A	4/13-16	208,500	
Pahsimeroi River (Niagara Springs)	A	4/7-13	508,300	
East Fork S.R.				
(Hagerman NFH)	B	4/10-19	436,576	
(Magic Valley)	B	4/15-19	353,300	
Sawtooth Hatchery				
(Hagerman NFH)	A	4/7-20	636,551	
(Magic Valley)	A	4/10-19	857,600	
Slate Creek (Magic Valley)	A	4/24-27	300,600	
Hammer Creek				
(Magic Valley)	A	4/28-29	136,000	
(Niagara Springs)	A	4/29	7,200	
Yankee Fork S.R. (Magic Valley)	A	4/17-20	104,400	
S.R. @ Shoup Br. (Niagara Springs)	A	4/17-20	206,700	
Hazard Creek	A	4/19-26	450,900	
	Drainage Total		4,206,627	
Snake River and Non-Idaho Tributaries				
Hells Canyon (Irrigon)	A	11/22/88	94,327	
Hells Canyon (Niagara Springs)	A	4/25	735,500	
Little Sheep Cr. (Irrigon)	A	4/21-24 (4/23)	249,456 (26,637)	LDJ- 1

Table 2. (Continued)

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Spring Creek	A	4/24-30	550,876	
(Irrigon)		(4/24)	(25,037)	LAJ-1
		(4/24)	(25,557)	LAJ-2
		(4/24)	(25,089)	LAJ-3
		(4/24)	(24,951)	RAJ- 1
		(4/24)	(25,463)	RAJ-2
		(4/24)	(24,868)	RAJ-3
Wildcat Creek	A	4/25-27	109,603	
(Irrigon)		(4/26)	(25,458)	LAJ-4
		(4/26)	(24,554)	W - 4
Grande Ronde (R2) (Irrigon)	A	4/1 o-22	234,516	
Catherine Creek (Irrigon)	A	4/10-12	62,601	
Wallowa River (Irrigon)	A	4/19-25	111,052	
Big Canyon Creek (Irrigon)	A	4/27-29	273,496	
Cottonwood Creek (Lyons Ferry)	A	4/18-27	222,050	
Asotin Creek (Lyons Ferry)	A	4/18	29,975	
Imnaha River (Irrigon)	A	5/1-3	72,367	
	Drainage Total		2,745,819	
ClearWater River				
Clearwater River	B	5/1-4	1,073,900	
(Dworshak NFH)		(5/1)	(16,714)	LDIU-1
		(5/1)	(15,854)	LDIS-1
		(5/3)	(15,583)	RDIU-1
		(5/3)	(15,936)	RDIS-1

Table 2. (Continued)

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
South Fork C.R.				
@ Crooked R.	B	4/24	83,431	
@ Mill Cr.	B	4/24-5/3	60,372	
(Hagerman NFH)				
Newsome Creek (Hagerman NFH)	B	4/26-5/1	103,273	
Clear Creek				
(Dworshak NFH)	B	4/24-25	208,201	
(Hagerman NFH)	B	5/8	49,147	
Crooked River (Dworshak NFH)	B	4/25-26	109,898	
Eldorado Creek (Hagerman NFH)	B	5/1-3	109,480	
	Drainage Total		1,797,702	
	Grand Total		8,750,148	

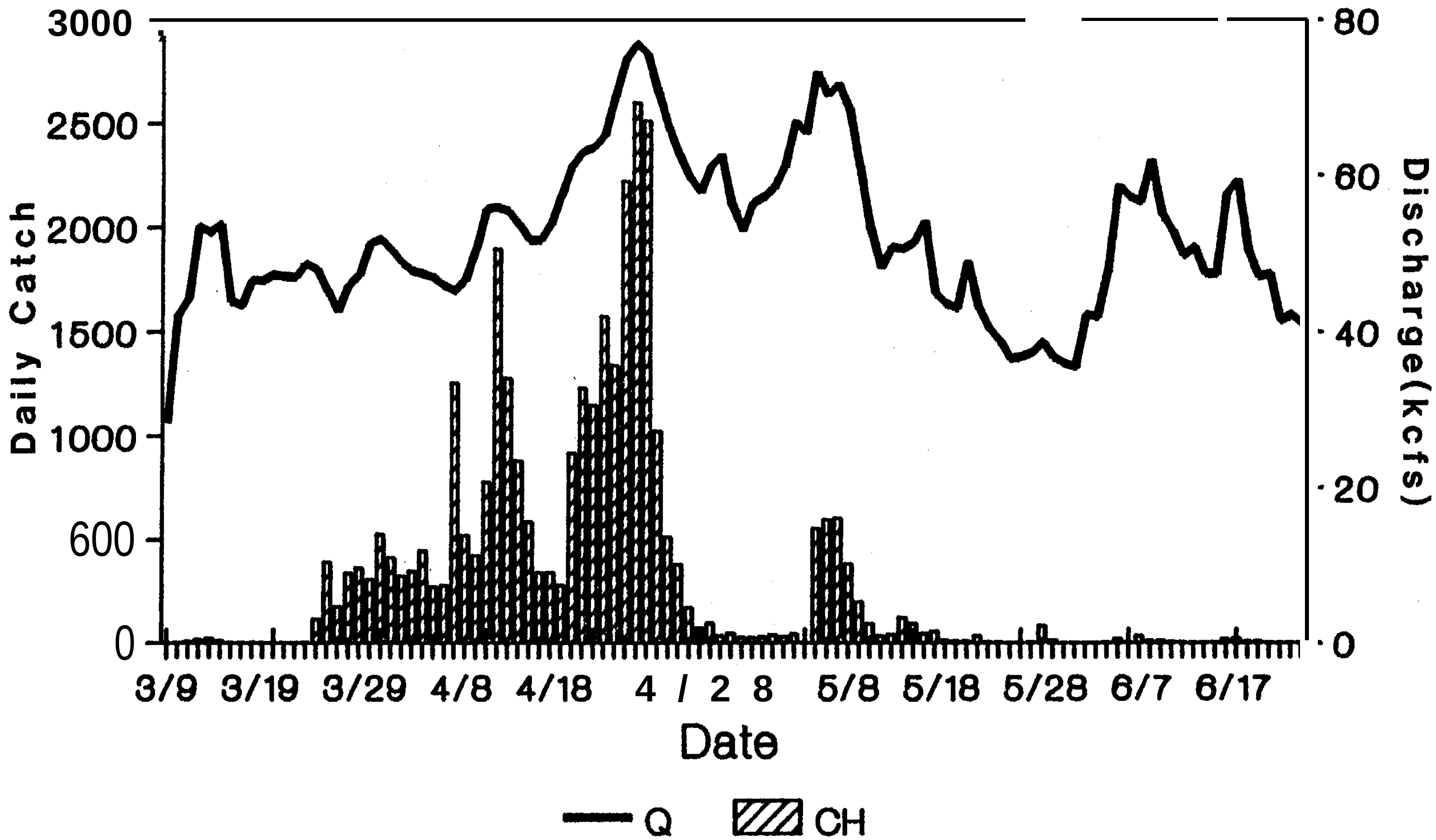

Figure 2: **Snake River trap daily catch forage - 1 chinook salmon overlaid by Snake River discharge,** 1989.

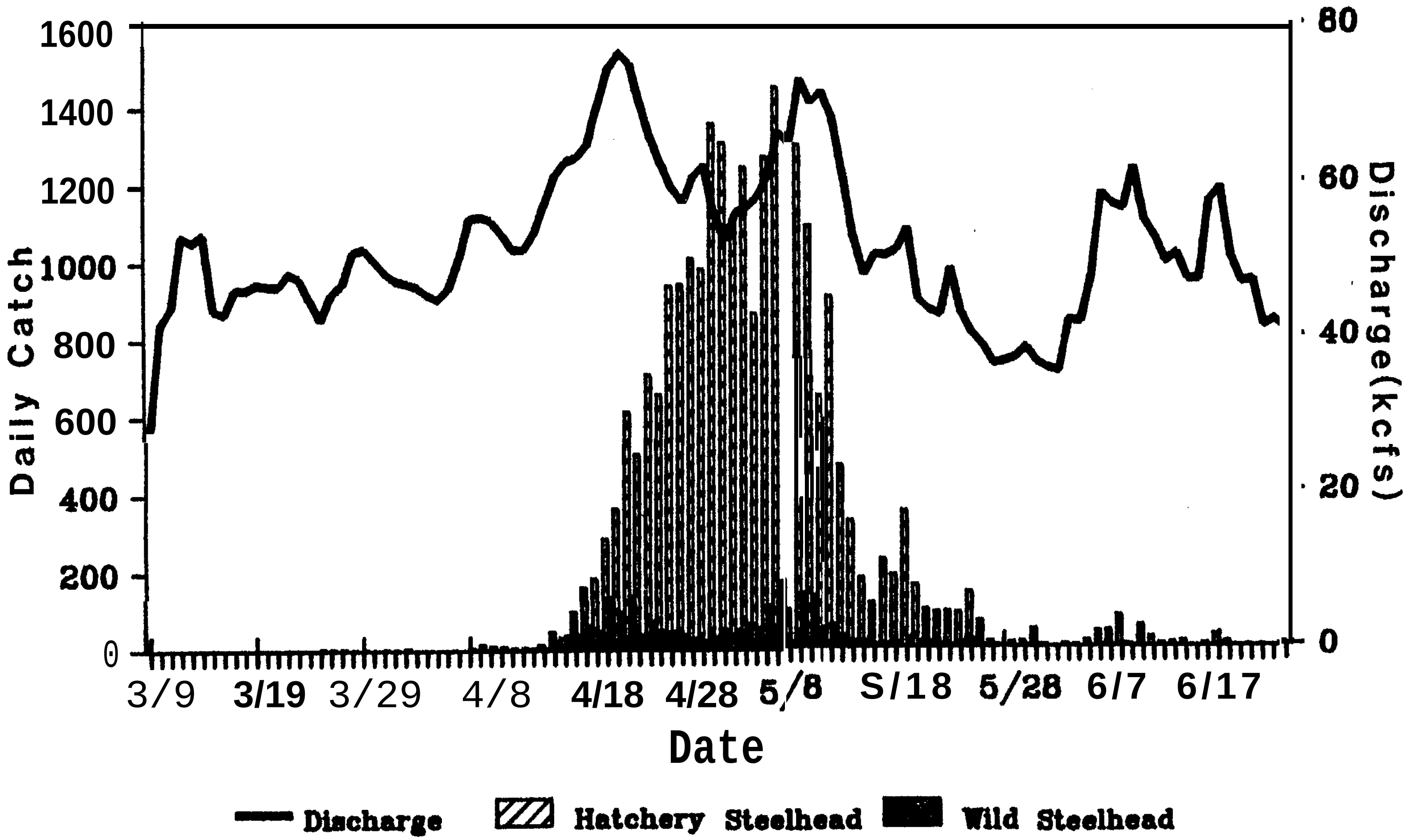

Figure 3: Snake River trap daily catch for hatchery steel head trout and wild steel head trout overlaid by Snake River discharge, 1989.

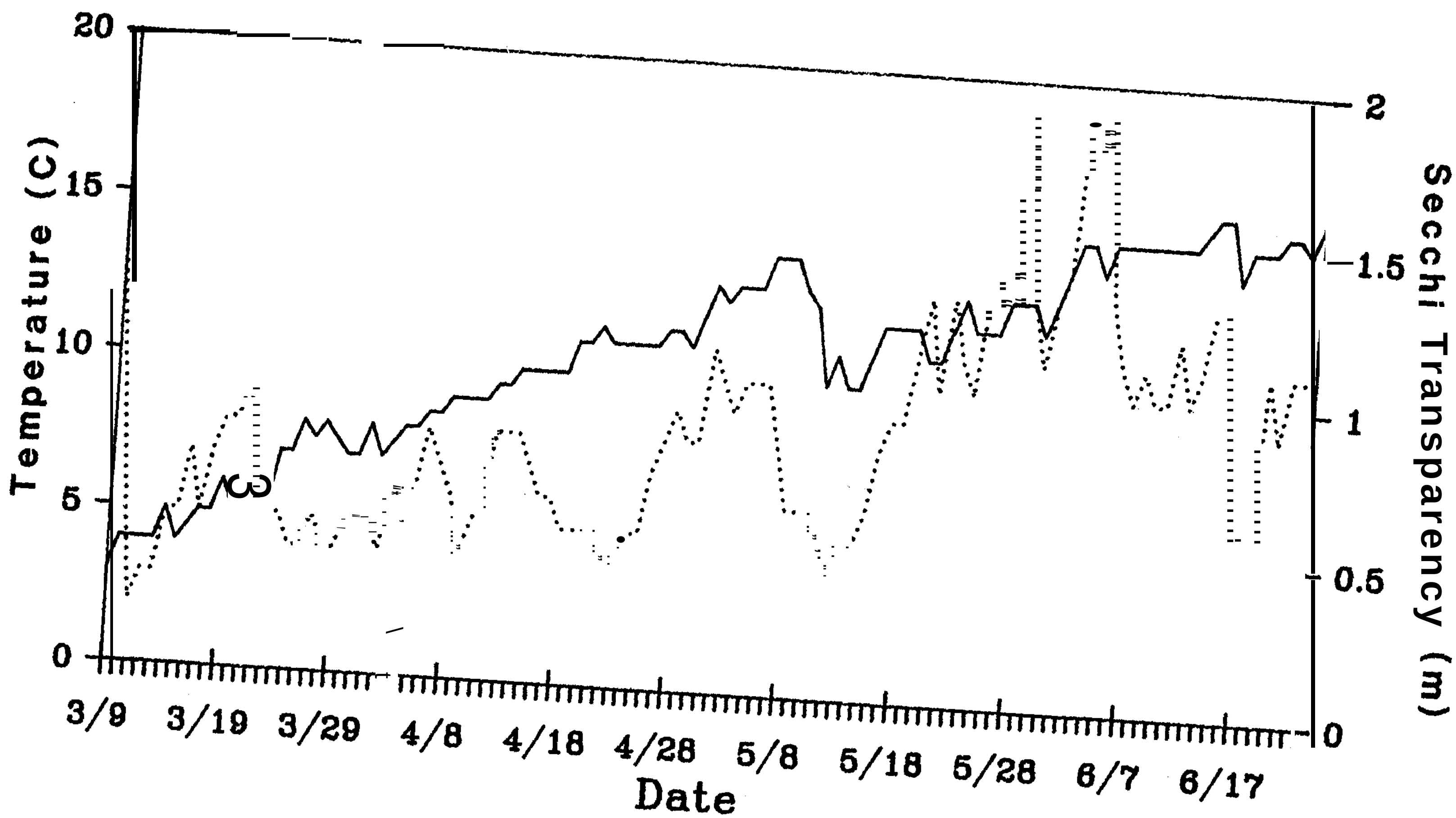

Figure 4: Daily temperature and secchi disk transparency at the Snake River trap, 1989.

Secchi disc transparency fluctuated throughout the sampling season (Figure 4). Influenced mainly by localized rain or thunderstorm events, the secchi transparency shows no obvious correlation to changes in discharge.

Clearwater River Trap Operation

The Clearwater River trap caught 9,938 chinook salmon, 1,135 hatchery steelhead trout, 141 wild steelhead trout, and 47 sockeye/kokanee in 1989. Only one major peak of chinook salmon passage was observed at the Clearwater River trap (Figure S). The peak began on March 29 and was associated with the DNFH release. After this peak the trap was out of operation for three major periods due to high flow, and little information about the 1989 chinook salmon outmigration from the Clearwater River was gained from that point on.

Hatchery steelhead trout began showing up in the trap catch in large numbers on May 2, the day after the DNFH release (Figure 6). On May 3, discharge increased dramatically and trap operation was terminated until discharge dropped below 30,000 cfs. Wild steelhead trout were present in the trap catch in low numbers beginning March 21 and continued to be sampled through the end of May. The peak trap catch of wild steelhead trout occurred May 23 (Figure 6).

Water temperature at the Clearwater River trap was 4°C the beginning of the season and gradually increased to ll°C by the first of May (Figure 7). Water temperatures throughout the season were similar to previous years, although 1987 drought year temperatures were slightly higher.

Discharge at the beginning of the season was 13,500 cfs. Discharge increased to 26,100 on April 7 and remained near or above 30,000 cfs until May 20. During this period there were two major peaks, one on April 23 when discharge reached 43,600 cfs and one on May 8 when discharge reached 49,500 cfs.

Secchi disc transparency in the Clearwater River fluctuated throughout the trapping season and ranged from 0.3 m to 1.9 m (Figure 7).

Trap Efficiency

Snake River Trap

Chinook Salmon-Trap efficiency for chinook salmon smelts at the Snake River smelt trap was tested six times during the 1989 smelt outmigration (Table 3). These were the first chinook salmon efficiency tests conducted on the Snake River smelt trap since 1986. Catch of chinook salmon juveniles during 1987 and 1988 was insufficient to estimate trap efficiency. All tests were conducted using trap-caught fish.

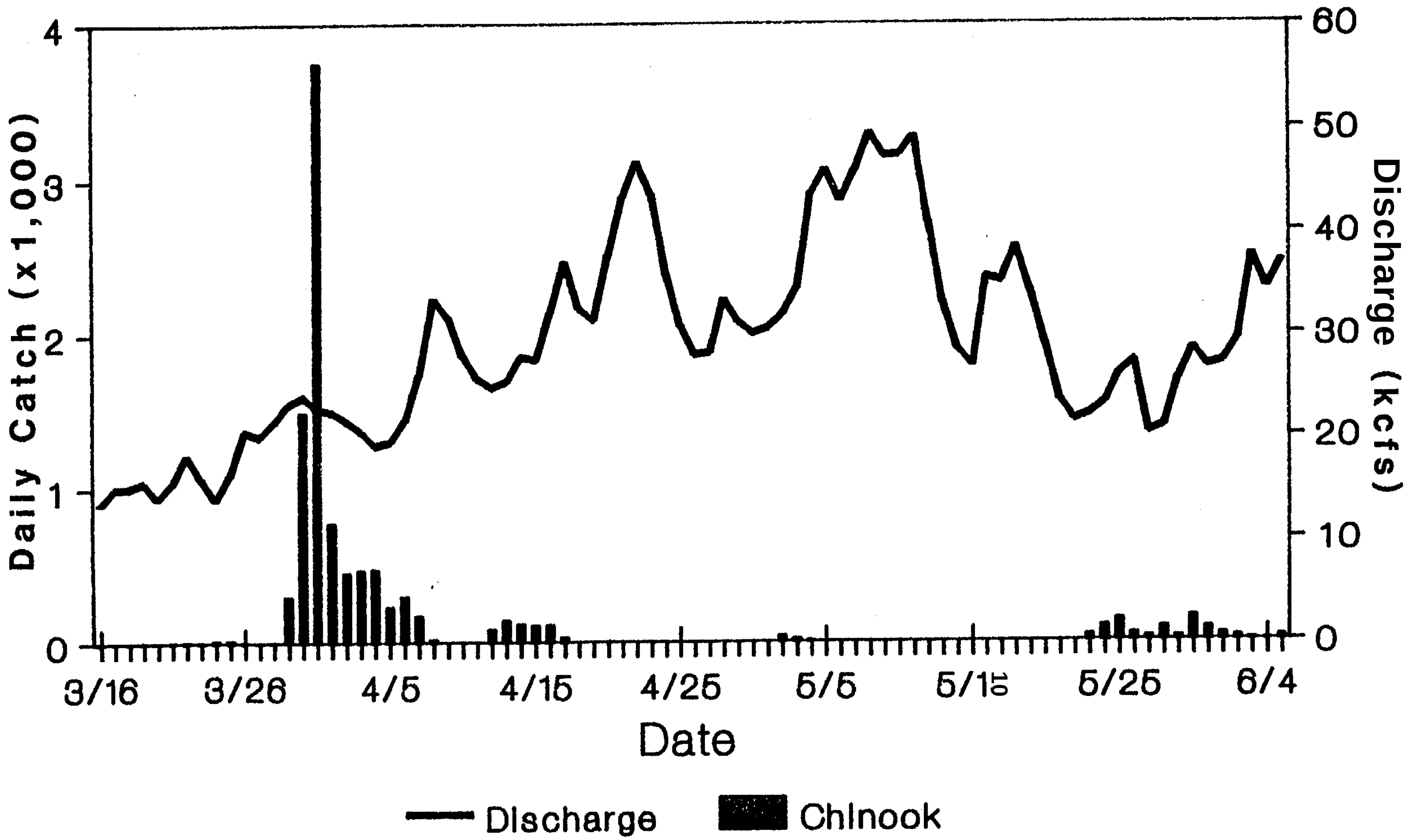

Figure 5: Clearwater River trap daily catch for age 1 chinook salmon overlaid by Clearwater River discharge, 1989.

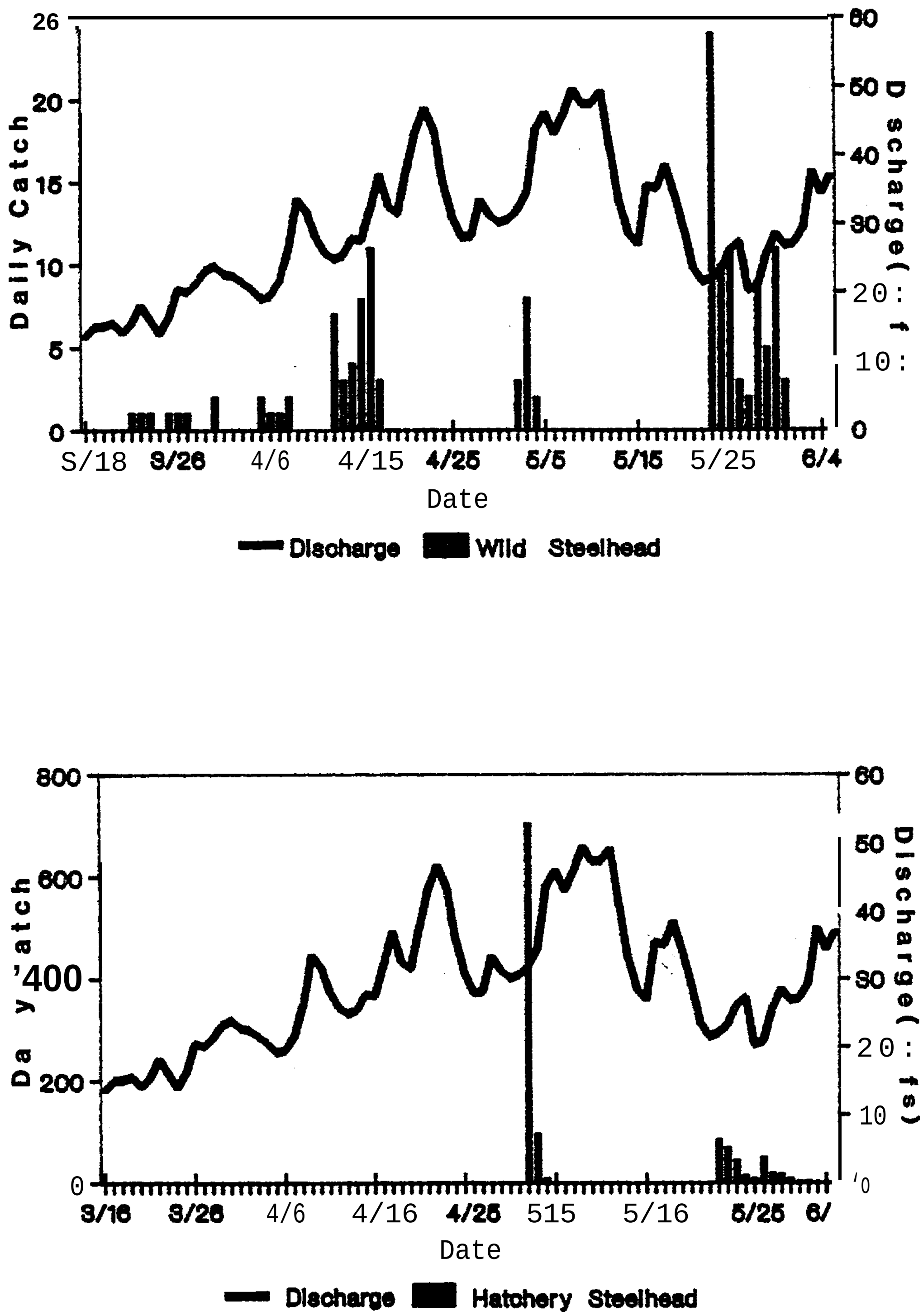

Figure 6: Clearwater River trap daily catch of hatchery steelhead trout and wild steel head trout overlaid by Clearwater River discharge, 1989.

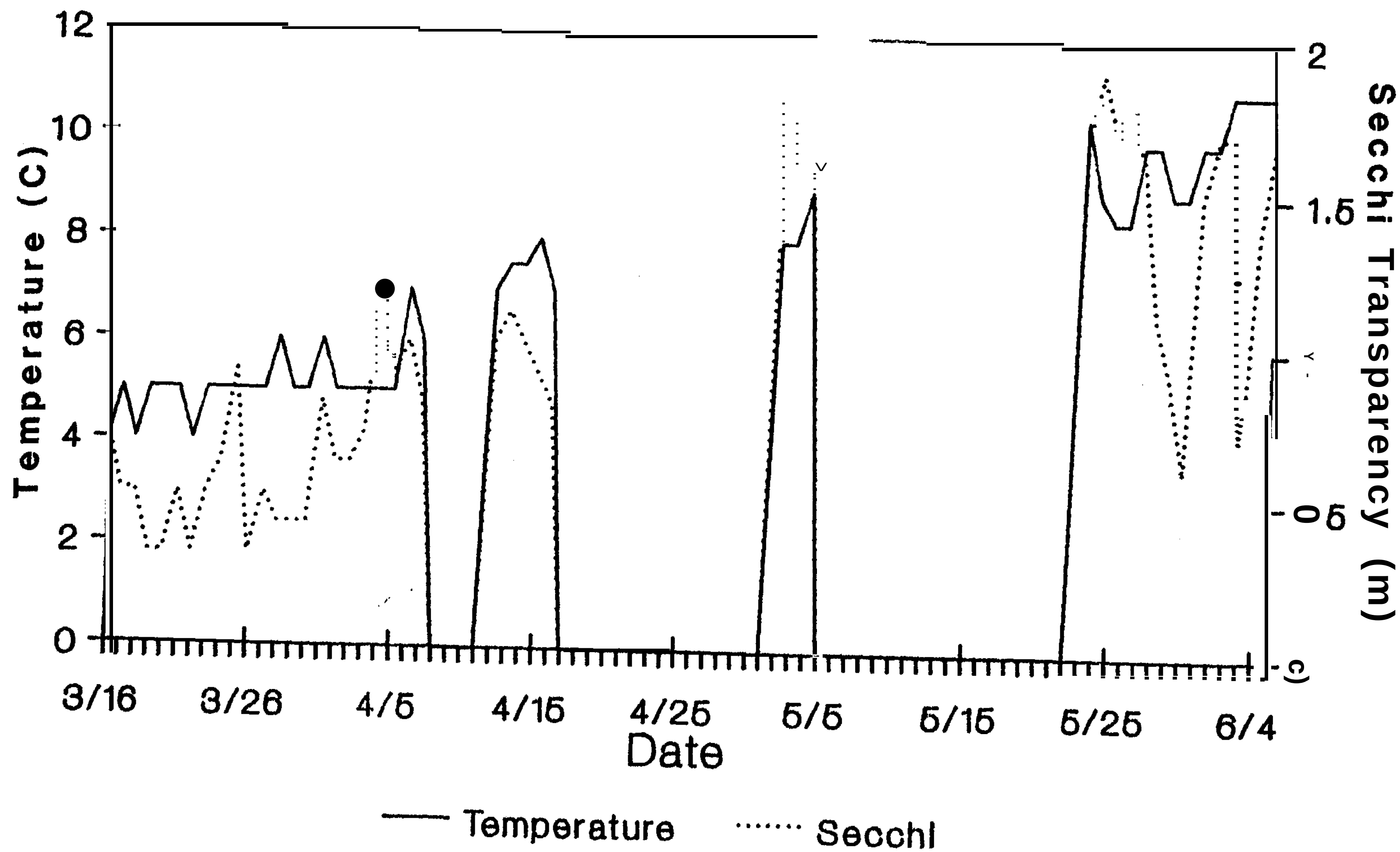

Figure 7: Daily temperature and secch· disk transparency at the Clearwater R·ver trap, 1989.

Table 3. Snake River trap efficiency tests for chinook salmon smelts, 1985 - 1989.

Year	Sample origin	Release dates	Recapture/ mark	Efficiency	Discharge (kcfs)
1984	trap caught	3/2	26/1,388	0.0187	84
		3/28	1 0/545	0.0183	75
		4/8	3/589*	0.0051	77
		4/12	7/309	0.0227	81
		4/16	9/806	0.0112	92
		4/19	23/1,061	0.0217	104
		4/24	8/81 2	0.0098	101
		4/28	5/267	0.0187	86
		5/4	4/179*	0.0223	81
		5/9	2/95*	0.0211	93
1985	trap caught	3/22	11/1,124	0.0098	43
		4/23	1 /840	0.0250	56
		4/6	7/1 ,092	0.0064	64
		4/10	4/1,490*	0.0027	79
		4/12	15/1,276	0.0118	77
		4/16	12/915	0.0131	80
		5/5	4/338*	0.0118	42
1986	trap caught	3/29	23/1,881	0.0122	86
		4/7	13/1,237	0.0105	80
		4/12	26/1,530	0.0170	74
		4/17	2/1,141*	0.0018	67
		4/24	11/1,417	0.0078	80
		4/28	31803*	0.0037	72
		5/19	4/703*	0.0057	76
1987		No efficiency tests conducted for chinook in 1987			
1988		No efficiency tests conducted for chinook in 1988			
1989	trap caught	4/5	13/1,054	0.0123	46
		4/10	23/1,076	0.0214	55
		4/18	14/1,233	0.0114	66
		4/19	9/1,719	0.0052	73
		4/23	10/2,001	0.0050	73
		4/24	5/584	0.0086	68

* Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

Analysis of the 1989 data yielded a trap efficiency of 1.04% and 95% confidence limits of 0.53% and 1.73% for chinook salmon smelts at the Snake River trap. In addition to the six efficiency tests conducted in 1989, a total of 16 other tests took place in 1984 through 1986. Analysis of variance of trap efficiency among years showed no statistical difference. Analysis of **covariance** also showed no significant differences from year to year when adjusted for discharge. With no statistical difference shown at either level, the entire set of 22 data points was pooled, and a single regression line was fit between discharge and trap efficiency in an attempt to show a relationship between the two. This relationship failed at the 0.05 level of significance (N=22, $r^2=0.006$, P=0.737). The pooled data was used to estimate a grand mean trap efficiency of 1.39%, with 95% confidence limits of 1.10% and 1.71%.

Steelhead Trout-Trap efficiency for steelhead trout smelts was tested four times during the 1989 smelt outmigration (Table 4). All tests utilized trap caught fish. One of the test groups yielded a recapture of less than five fish and was excluded from the analysis. The 1989 data yielded a mean trap efficiency of 0.60% and 95% confidence limits of 0.03% and 2.90%.

Because of insufficient data from 1985 through 1989, the analysis of **covariance** to examine differences among years could not be used (Table 4). The four years of data were pooled to calculate a grand mean of 0.74% and 95% confidence limits of 0.13% and 1.84% for trap efficiency of steelhead trout smelts at the Snake River trap.

Clearwater River Trap

Chinook Salmon-During the 1989 field season, chinook salmon smelt trap efficiency at the Clearwater River trap was tested nine times. Five used freeze brand groups that comprised part of the DNFH production release. The remaining four tests used freeze brand marked fish from DNFH that were released at the Highway 95 boat launch. The 1989 mean trap efficiency was 0.55%, with 95% confidence limits of 0.04% and 1.61%. Between 1984 and 1988, an additional 33 trap efficiency tests were conducted on the Clearwater River trap for chinook salmon smelts (Table 5). These data were added to the 1989 information. A **one-**way analysis of variance revealed a significant difference in trap efficiency among years (**N=42,** $r^2=0.382$, P=0.003). The data from all years cannot be pooled to derive any statistical inference. The mean trap efficiency of the five previous years at the Clearwater River trap was 2.0%.

Steelhead Trout-Steelhead trout trap efficiencies at the Clearwater River trap were not tested in 1989. Due to the limited time the trap was operated during the steelhead trout **outmigration,** an insufficient number of smelts were captured to effect a mark-recapture estimate. Trap efficiency for steelhead trout smelts at the Clearwater River trap in previous years has averaged 0.28%, with 95% confidence limits of 0.15% and 0.46%.

Table 4. Snake River trap efficiency tests for steelhead trout smelts, 1985 - 1989.

Year	Sample origin	Release dates	Recapture/ mark	Efficiency	Discharge (kcfs)
1985	trap	5/4	8/81 1	0.0099	55
	caught	5/8	1/185	0.0054*	54
		5/18	1 /492	0.0020*	50
		5/21	2/314	0.0064*	68
1986	trap	4/24	1/179	0.0056*	80
	caught	4/30	12/874	0.0137	72
		5/21	3/1,345	0. 0022*	76
1987	No efficiency tests conducted for steelhead smelts in 1987				
1988	trap	4/18	2/866	0.0023*	32
	caught	5/13	7/2057	0.0034	38
		5/15	5/1822	0.0027	42
	hatchery	5/23	54/3977	0.0136	45
	releases	5/23	32/3996	0.0080	45
1989	trap	4/26-28	6/1,916	0.0031	60
	caught	**5/1&2**	31/2,397	0.0129	55
		5/3&4	7/2,137	0.0033	57
		5/9-12	3/2,535	0.0012*	70

* Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

Table 5. Clearwater River trap efficiency tests for chinook salmon smelts, 1984 - 1989.

Year	Sample origin	Release dates	Recaptures/ mark	Efficiency	Discharge (kcfs)
1984	trap caught	4/5	4/418	0.0096*	21
		4/21	13/806	0.0161	33
		4/25	3/489	0.0061*	31
		5/10	1 4/453	0.0309	24
1985	trap caught	3/25	14/607	0.0230	9
		3/30	45/1,511	0.0298	9
		4/5	6/1 ,079	0.0056	18
		4/9	2/940	0.0021*	15
		4/16	7/929	0.0075	33
1986	trap caught	3/27	9/1 ,555	0.0058	22
		4/2	8/1,714	0.0047	29
1987	DNFH release	3/20	43/2,160	0.0199	13
		4/22	50/2,000	0.0250	6
		4/7	165/1,945	0.0848	10
		4/13	74/2,000	0.0370	13
		4/20&28	103/4,000	0.0258	18
	trap caught	4/2	33/1,926	0.0171	6
		4/3	11/1,458	0.0075	8
		4/6	15/1,872	0.0080	9
		4/7	15/1,163	0.0129	10
		4/9	9/450	0.0200	12
1988	Hwy 95 boat launch	3/14	51/2,197	0.0232	6
		3/17	93/2,197	0.0423	6
		3/21	83/2,197	0.0378	6
		4/1	27/2,195	0.0123	9
		4/6	18/2,194	0.0082	11
		4/13	31/2,193	0.0141	14
	DNFH release	3/30	1711/60,631	0.0282	10
		3/30	252/8,731	0.0289	10
		3/30	181/6,163	0.0294	10
		3/30	788/20,642	0.0382	10
		3/30	573/22,935	0.0250	10
	trap caught	3/24	17/2086	0.0081	9
		3/28	27/1 695	0.0159	12
		4/1	16/1631	0.0098	9
		4/2	38/2257	0.0168	8

Table 5. (continued)

Year	Sample origin	Release dates	Recaptures/ mark	Efficiency	Discharge (kcfs)
1989	Hwy 95 boat launch	3/21	7/2, 076	0.0034	17
		3/23	10/2,065	0.0048	15
		4/3	39/2,094	0.0186	20
		4/5	41/2,075	0.0200	21
	DNFH release	3/29	66/34,795	0.0019	24
		3/29	73/30,503	0.0024	24
		3/30	41/19,087	0.0021	23
		3/30	48/19,545	0.0025	23
		3/30	78/20,084	0.0039	23

* Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

Table 8. Migration data for f maze-branded steel head trout smolts f ran release sites to the Snake River trap, 1985-1989.

Release site 1/	Year	Median release date	Madian passage date	Number captured	Travel time (days)	Migration rats (km/day)	Mean Q (kcfs) Salmon R.	Snake R.
Spring Cr.	1989	4/24	5/01	84	7	34.6		62.0
	1989	4/22	5/05	70	13	18.6		62.4
	1989	4/22	5/02	83	10	24.2		63.8
	1988	4/17	4/25	28	9	26.9		34.5
		4/17	4/23	28	7	34.6		35.7
		4/17	4/25	30	9	26.9		34.5
		4/17	4/23	14	7	34.6		35.7
		4/18	4/25	38	8	30.3		35.0
		4/18	4/24	21	7	34.6		35.7
	1987	4/26	2/					
	1986	5/01	5/27	14	26	9.3		72.9
		4/30	2/	1				
		4/03	2/	2				
	1985	5/09	5/19	36	10	24.2		46.4
		5/09	5/20	31	11	22.0		47.0
Cottonwood Cr.	1987	4/26	4/30	28	5	18.6		39.3
	1986	4/28	5/05	111	7	13.0		72.3
Little Sheep Cr.	1989	4/23	4/25	93	2	72.3		70.7
	1987	5/02	2/					
	1986	4/28	5/08	16	10	12.0		72.1
		4/27	2/	2				
Wildcat Cr.	1989	4/26	4/30	134	4	33.1		60.7
	1988	4/23	4/26	152	4	33.1		32.7

1/ Only freeze brand groups from Oregon and Washington were used in 1989 because Idaho did not release any f reeze-branded steel head trout during 1989 above the Snake River trap.
2/ Insufficient recaptures at the Snake River trap to derive fish movement data.

TABL8

Table 9. Migration date for freeze branded chinook salmon and steelhead trout smelts released upstream of the Clearwater River trap, 1987 - 1989.

Release site	Year	SP.	Median release	Median passage	Number captured	Migration rate km/day	Travel time	Discharge mean kcfs
Crooked River	1987	St	04/14		2			
Dworshak NFH	1987	St	04/21	04/22	58			
		St	05/05					
		Ch	04/01	04/04	1416	13.8	4	7.2
Clear Creek	1987	St	04/1 7	04/20	59	28.8	4	14.1
Dworshak NFH	1988	St	05/03	05/04	283	55.0	1	16.9
		St	05/04	05/05	202	55.0	1	16.9
		Ch-0	03/30	04/01	239	27.5	2	9.8
		Ch	03/30	03/31	1711	55.0	1	9.6
		Ch	03/30	03/31	1359	55.0	1	9.6
		Ch	03/30	03/31	434	55.0	1	9.6
		Ch	09/28/87	03/27	16		182	
Red River	1988	Ch	09/30/87	04/14	18		198	
Dworshak NFH	1989	St	05/01	05/02	123	55.0	1	31.2
		Ch	03/29	03/30	139	55.0	1	23.5
		Ch	03/30	03/31	167	55.0	1	23.3
		Ch-O	03/30	04/03	48	13.8	4	22.2
		Ch	09/28/88	03/30	2		183	
Red River	1989	Ch	10/17/88	04/17	19		182	

TABL9

Table 7. River mile & kilometer location for the Snake River Drainage.

	Mouth of Columbia R.		Mouth of Snake River		Lower Granite Dam		Snake River Trap site		Clearwater R. Trap site		Salmon River Trap Site	
	mi	'km	mi	km	mi	km	mi	km	mi	km	ml	km
Mouth of Snake River	324.3	521.8	0.0	0.0	107.5	172.9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0	0.0	0.0	32.1	51.6	38.3	61.5	133.9	215.4
ClearWater R. Trap Site	470.0	756.2	145.7	234.4	38.2	61.5			0 . 0	0.0		
Highway 95 Boat Launch	473,2	761.4	148.9	239.6	41.5	66.8			3.2	5.1		
Dworshak NFH	504,2	811.3	179.9	289.5	72.4	116.5			34.2	55.0		
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7			71.5	115.0		
Crooked River	604.3	972.3	280.0	450.5	172.5	277.6			134.3	216.0		
Red River Rearing Pond	618.0	994.4	293.7	472.6	186.2	299.6			148.0	238.1		
Snake River Trap Site	463,9	746.4	139.6	224.6	32.1	51.6	0.0	0.0			101.8	163.8
Asotin Creek	469,6	755.6	145.3	233.8	37.8	60.8	5.7	9.2				
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8				
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0				
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4				
Big Canyon Creek	585.9	942.7	261.6	420.9	154.1	247.9	122.0	196.3				
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2				
Catherine Creek	636,9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4				
Mouth of Salmon River	512.5	824.6	188.2	302.8	80,7	129.8	48.6	78.2			53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8				
Little Sheep Creek	553,8	891.1	229.5	369.3	122.0	196.3	89.9	144.6				
Imnaha Col 1. Faci 1 ity	565.6	910.2	241.3	388.3	133,8	215.4	101.7	163.6				
Hel 1s Canyon Dam	571.3	919.2	247.0	397,4	139.5	224.5	107.4	172.8				
Salmon River Trap Site	565.7	910.2	241.4	388.4	133,9	215.4	101.8	163.8			0.0	0.0
Rapid River Hatchery	605,8	974.7	281.5	452.9	174.0	280,0	141.9	228.3			40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154.8	249.1			53.0	85.3
S.F. Salmon @ Knox Bridge	719.7	1158.0	395.4	636.2	287,9	463.2	255.8	411.6			154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353.6	568.9			251.8	405.1
E.F. Salmon @ Trap Site	873.6	1405.6	549.3	883.8	441.8	710.9	409.7	659.2			307.9	495.4
Sawtooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8			331.9	534.0

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five combined replicate groups to provide travel time information to the Snake River trap (Table 8). Migration rates for the Spring Creek groups were similar to previous years. The migration rate for the Little Sheep Creek group was estimated to be considerably higher than in 1986 (1989=72.3 km/d, 1986=12.0 km/d), the only other year recaptures were great enough to estimate travel time. The estimated median passage date in 1986 may not be accurate because only 16 branded fish were recaptured from that group. The Wildcat Creek groups traveled at the same rate as in 1988 (33.1 km/d).

Release Site to the Clearwater Trap

Chinook Salmon-In 1989, there was one group of two replicates of freeze-branded chinook salmon released on March 29, and two groups with three replicates each released from DNFH on March 30. One of these latter sets of three groups was age-O chinook salmon. Average travel time for the three age-0 chinook salmon groups was 4 d (13.8 km/d), and ranged from 2 to 8 d (Table 9). This compares to a travel time of 2 d for the age-O chinook group released in 1988. Travel time for the age-1 chinook salmon was 1 d. This compares to a travel time of 1 d in 1988, 4 d in 1987, and 1 d for 1986 and 1985. Average discharge during the migration period in 1987 was 7,200 cfs, 69% less than in 1989 (23,500), 25% less than in 1988 (9,600), 76% less than in 1986 (29,000 cfs), and 58% less than in 1985 (17,300 cfs). The extremely low discharge in 1987 is most likely responsible for the 75% reduction in travel time that year.

A group of age-O chinook salmon was released from DNFH on September 28, 1988. This group's median passage date at the Clearwater River trap could not be calculated because of the low numbers of freeze brands that were recaptured.

Three duplicate groups of freeze-branded chinook salmon were released from the Red River pond. Branded fish from these groups began arriving at the Clearwater River trap on March 20, and the last recapture was on June 1 with the median passage date of April 17. This estimated median passage date may not be accurate since only 19 branded chinook salmon from this group were recaptured at' the Clearwater River trap, and the trap was out of operation for 37 d during the migration. The median passage date in 1988 was April 14.

Steelhead Trout-There were four groups of freeze-branded steelhead trout released from DNFH; two on May 1 and two on May 3. The two groups released on May 1 hada travel time of 1 d to the trap (55 km/d). The Clearwater River trap was forced to shut down operations on May 3 due to high discharge. Travel time to the trap cannot be estimated for the two groups released on May 3, although it was probably 1 d as in previous years (Table 9).

Travel Time and Migration Rates

Release Site to Snake River Trap

Chinook Salmon-There were 12 groups of freeze-branded chinook salmon released in the Salmon River drainage; four each at Sawtooth Hatchery, South Fork Salmon River, and Rapid River Hatchery. Two groups were released in the Imnaha River, Oregon, and four groups were released in Lookingglass Creek, Oregon. Two groups of age-O spring chinook salmon were released in Lookingglass Creek (Table 6).

The Snake River trap captured approximately 0.28% (1,021) of the branded fish released. Of the freeze-branded chinook salmon releases above Lower Granite Dam, 45% originated in Idaho waters and 55% were released in Oregon. The percentage of branded chinook salmon in the Snake River trap catch was 78% Oregon fish and 22% Idaho fish. This difference may be survival related. Idaho chinook salmon have a greater distance to travel to the Snake River trap than the Oregon chinook salmon. The weaker fish in the release group may have perished before they reached the trap. The shortest migration distance for branded fish from Idaho is 228 km for the Rapid River chinook salmon and the longest is 698 km for the Sawtooth Hatchery chinook salmon. By contrast, the Oregon chinook salmon travel from 164 km in the Imnaha River to 187 km for the Lookingglass Creek chinook salmon (Table 7). Another possible explanation is that the Oregon chinook salmon may have been in better overall health than the Idaho fish.

Migration rate for the three representative Idaho hatchery groups was lower in 1989 than in previous non-drought years (1984-1986). Insufficient numbers of branded fish were recovered at the Snake River trap in 1987 and 1988 drought years from the hatchery releases to estimate travel time. Migration rates for the Rapid River freeze brand group was 12.0 km/d, and the South Fork Salmon River groups was 8.1 km/d. Insufficient numbers of branded chinook salmon from Sawtooth Hatchery were recaptured at the Snake River trap to determine migration rate. The reduction in migration rate in 1989 for the Salmon River chinook salmon freeze brand groups may have been due to a 10-60% reduction in Salmon River discharge and a 15-40% reduction in Snake River discharge during their migration period from previous non-drought years (Table 6). The groups released in Lookingglass Creek traveled at about the same rate as in previous years (62.5-93.7 km/d). In 1989 the Imnaha River brand groups migrated at 16.8 km/d. There is no data from previous years to compare with the 1989 Imnaha data.

Steelhead Trout-In 1989 there were no freeze-branded steelhead trout

Table 6. Migration data for freeze branded chinook salmon smolts from release sites to the Snake River trap, 1984- 1989.

Release site	Year	Median release date	Median passage data	Number captured	Travel time (days)	Migration rate (lan/day)	Maan Q (kcfs) Salmon R.	Snake R.
Rapid River	1989	3/30	4/18	181	19	12.0	9.0	52.6
	1988	1/						
	1987	1/						
	1986	3/27	4/10	237	14	16.3	15.4	82.9
	1985	4/2	4/12	320	10	22.8	10.6	67.6
	984	4/1	4/18	197	17	13.4	10.1	79.3
Hel1s Canyon	1989	2/						
	1988	1/						
	1987	1/						
	1986	3/26	4/3	269	8	21.6		83.8
	1985	3/1 9	4/3	544	14	12.4		43.0
	1984	3/20	3/29	704	9	19.2		81.4
S. F. Salmon River	1989	3/21	5/1 1	21	51	8.1	6.5	57.1
	1988	1/						
	1987	1/						
	1986	3/28	4/23	229	26	15.8	16.5	78.6
	1985	4/2	4/17	76	15	27.1	14.0	71.0
	19&	4/10	4/24	238	14	29.0	14.5	91.7
Sawtooth Hatchery	1989	3/1 5	4/20	14	36	19.4	6.1	51.0
	1988	1/						
	1987	1/						
	1986	3/1 7	4/14	49	28	24.9	13.6	81.4
	1985	3/27	4/14	165	18	38.7	9.6	60.1
	1984	3/28	4/21	136	24	29.0	11.8	84.0
Lookingglass Cr.	98	4/03	4/06	212	3	62.5		46.1
	1989	4/03	4/05	173	2	93.7		45.9
		5/1 5	5/18	131	3	62.5		50.2
	1988	5/13	5/16	52	3	62.5		40.6
	1987	1/						
	1986	4/2	4/5	114	3	62.5		82.1
	1985	No marked release group.						
	1984	No marked release group.						
Imnaha River	1989	4/05	4/1 o	247	5	16.8		51.6

1/ Insufficient recaptures numbers at the Snake River trap.
2/ No freeze brand release made in 1989.

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook Salmon Freeze Brand Groups-In 1989, there were 27 groups of freeze-branded age-1 chinook salmon released above Lower Granite Reservoir. Because of low recapture numbers at the Snake River trap, replicate groups released from the same hatchery were combined. After combining, 11 groups were used for calculating travel time through Lower Granite Reservoir. The 11 groups did not include the age-O chinook salmon releases, the spring chinook salmon groups released in the fall of 1988, or the Sawtooth Hatchery groups. Median travel time through Lower Granite Reservoir for the age-1 chinook salmon freeze brand groups ranged from 45 d for the earliest released groups from the Clearwater River trap efficiency test (released on March 22), to 2 d for the group released from the South Fork Salmon River (Table 10). Median travel time for the age-O chinook salmon ranged from 58 d for the two groups released from DNFH the first of April, to 27 d for the group released from Lookingglass Hatchery in mid-May.

A linear regression analysis of migration rate (km/d) through Lower Granite Reservoir and inflow discharge was run on the 11 combined freeze brand groups released in the spring. The linear regression of the log of migration rate and the log of discharge provided the best fit to the data ($N=11$, $r^2=0.806$, $P=0.000$). In the case of the freeze-branded chinook salmon groups, the regression equation was:

log migration rate = -32.595 + 7.537 log discharge.

The high coefficient of determination (r^2) indicates a strong relationship between chinook salmon migration rate through Lower Granite Reservoir and mean discharge. The low probability (P) indicates this relationship is highly significant. As discharge increased, migration rate increased (travel time through the reservoir decreased).

Chinook Salmon PIT Tag Groups-In 1989, sufficient numbers of chinook salmon were PIT-tagged daily at the Snake River trap to provide 47 daily release groups (6,222 total PIT-tagged chinook salmon) for estimating travel time and migration rates through Lower Granite Reservoir. Median travel time ranged from 19.5 d early in the migration season to 3.6 d late in the season, and then 24.6 d at the end of the migration season (Table 11). Medial travel time changed substantially between April 11 and April 16. Prior to April 11, the average median travel time through Lower Granite Reservoir was 15.9 d (migration rate = 3.2 km/d), and after April 16 the average median travel time was 5.4 d (migration rate = 9.6 km/d). The last two PIT tag release groups (released on 5/18 and 5/19) had the longest travel time of any group released. The majority of the chinook salmon in these two groups, which was determined from freeze

Table 10. Chinook salmon smelt travel time and migration rate from the head of Lower Granite Reservoir to Lower Granite dam using fish passing the Snake and Clearwater River traps from upriver releases, 1985 - 1989.

Year	Brand	Release site	Snake River/ ClearWater River trap: Median passage date	Snake River/ ClearWater River trap: Number Collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGD
1985	LDR-3	Hells Canyon	4/3	544	4/13	7,111	10	5.2	88
	RDR-1	Sawtooth Hat.	4/14	165	5/4	4,313	20	2.6	89
	RDR-3	S. F. Salmon River	4/17	76	5/14	4,193	27	1.9	85
	LDR-1	Rapid River	4/12	370	4/25	9,422	13	4.0	98
	LDR-4	Grande Ronde River	6/4	135	6/23	6,868	19	2.7	79
	RDR-2	Dworshak NFH	4/4	248	4/27	6,403	23	2.7	94
1986	LDY-3	Hells Canyon	4/3	269	4/16	9,898	13	4.0	100
	RDY-1	Sawtooth Hat.	4/14	49	4/23	2,245	9	5.7	89
	RDY-3	S. F. Salmon River	4/23	229	5/3	5,921	10	5.2	98
	LDY-1	Rapid River	4/16	237	4/20	10,589	4	12.9	88
	RAJ-2	Lookingglass Cr.	4/5	38	4/14	3,741	9	5.7	99
	RAJ-3	Lookingglass Cr. 3/	4/4	13	4/9	333	5	10.3	99
	RAJ-4	Lookingglass Cr.	4/5	76	4/21	2,593	16	3.2	95
	RAY-1	Dworshak NFH	4/2	312	4/21	4,703	19	3.2	97
1987	RAR-1	Dworshak NFH	4/4	1,416	4/24	11,069	20	3.1	37
	RD4-1	Clearwater River 1/	3/20	43	4/18	551	29	2.1	33
	RD4-3	Clearwater River 1/	4/2	50	4/20	436	18	3.4	35
	RA4-3	Clearwater River 1/	4/7	165	4/19	438	12	5.1	38
	RA4-1	Clearwater River 1/	4/13	74	4/29	334	16	3.8	46
1988	LAUD-1	Lookingglass Hat. 2/	5/15	29	6/11	3,913	27	1.9	68
	LAUT-1	Lookingglass Hat. 2/	5/16	25	6/12	3,973	27	1.9	68
	ROT-3	Red River Pond 3/	4/15	18	5/13	1,071	28	2.2	58
	LAH-1	Dworshak NFH 2/	4/1	239	5/27	3,457	56	1.1	54
	LAT-2	Dworshak NFH	3/31	1,711	4/20	17,510	20	3.1	38
	LDT-1	Dworshak NFH 3/	3/28	16	4/12	847	15	4.1	30
	RA7N-1	Dworshak NFH	3/31	788	4/20	6,672	20	3.1	38
	RA7N-3	Dworshak NFH	3/31	571	4/21	5,823	21	2.9	39
	RAR-1	Dworshak NFH	3/31	253	4/20	2,040	20	3.1	38
	RAR-3	Dworshak NFH	3/31	181	4/21	1,852	21	2.9	39
	LDK-1	Clearwater R. Trap 1/	3/15	51	4/19	736	35	1.8	32
	LDK-3	Clearwater R. Trap 1/	3/18	93	4/19	643	32	1.9	33
	RDK-1	Clearwater R. Trap 1/	4/2	27	4/23	499	21	2.9	42

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Table 10. (continued)

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number Collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGO
	RDK-2	Clearwater R. Trap 1/	4/7	18	4/22	347	15	4.1	45
	RDK-3	Clearwater R. Trap 1/	3/22	83	4/1 9	575	28	2.2	34
	ROK-4	Clearwater R. Trap 1/	4/14	31	4/30	524	16	3.8	53
1989	RA4-3	ClearWater R. Trap 1/	3/22	7	5/6	319	45	1.4	81
	LD4-1	Clearwater R. Trap 1/	3/24	10	4/25	368	32	1.9	80
	RD4-3	Clearwater R. Trap 1/	4/4	39	5/6	632	32	1.9	88
	RA4-1	Clearwater R. Trap 1/	4/6	41	5/7	324	31	2.0	90
	RDL(T&X)-1	Dworshak NFH	3/30	139	4/23	5,994	24	2.6	82
	RDR-2	Dworshak NFH 3/	3/30	2	6/1	127	63	1.0	83
	** 4/	Dworshak NFH	3/31	167	4/25	13,346	25	2.5	83
	** 5/	Dworshak NFH 2/	4/3	48	5/31	5,740	58	1.1	84
	(R&L)DJ-4	Imnaha River	4/10	247	4/27	3,462	17	3.0	91
	(RI?)LDJ-3	Lookingglass Hat.	4/5	173	4/24	3,038	19	2.7	87
	(R&L)DJ-2	Lookingglass Hat.	4/6	212	4/22	4,171	16	3.2	86
	(R&L)AJ-1	Lookingglass Hat. 2/	5/18	131	6/14	11,622	27	1.9	75
	** 6/	Rapid River	4/18	181	4/23	10,379	5	10.3	105
	LDR-(1 -3)	Red River 3/	4/17	19	5/1 1	2,579	24	2.6	99
	RAR-(1 -4)	S. F. Salmon River	5/11	21	5/13	3,148	2	25.8	104
	LAR-(1-4)	Sawtooth Hat.	4/20	14	4/23	2,155	3	17.2	112

1/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15. 5).
2/ O-Age spring chinook salmon.
3/ Fal 1 release of spring chinook.
** 4/ RA7H-1, RD7H-1, and RD7H-3 combined.
** 5/ RAH-1, RDH-1, and RDH-2 combined.
** 6/ LA7H-1, LA7H-3, LD7H-1, and LD7H-3 combined.

Table 11. PIT-tagged chinook salmon travel time, with 95% confidence interval, from the Snake River trap to Lower Granite Dam, 1989.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
03/24/89	19.5	22	15	48	32.0	69.20
03/27/89	16.2	18	14	61	40.1	70.64
03/28/89	17.7	20	16	57	37.7	71.67
03/29/89	19.1	20	16	55	36.2	73.07
03/30/89	18.6	22	14	45	29.8	74.29
03/31/89	17.7	21	13	57	38.0	74.39
04/01/89	16.2	18	13	54	36.0	73.46
04/02/89	16.7	19	14	57	38.0	76.24
04/03/89	17.8	20	15	47	31.3	79.15
04/04/89	15.5	18	13	52	34.7	78.87
04/05/89	14.5	17	12	45	30.0	79.81
04/06/89	12.8	16	9	33	21.2	80.21
04/07/89	14.2	15	12	43	28.3	83.80
04/08/89	12.8	16	11	34	21.9	84.67
04/09/89	15.0	17	13	54	35.3	90.75
04/10/89	14.2	20	11	43	28.3	91.26
04/11/89	11.4	14	10	55	36.4	87.93
04/12/89	9.7	12	8	48	31.4	89.08
04/13/89	8.7	10	8	53	35.3	90.77
04/14/89	8.3	9	7	66	44.0	92.92
04/15/89	9.1	10	7	51	34.0	99.63
04/16/89	5.9	7	5	68	45.3	97.48
04/17/89	5.7	6	5	64	43.0	102.22
04/18/89	5.1	6	4	66	44.6	103.48
04/19/89	4.7	5	4	63	40.1	107.80
04/20/89	4.6	5	4	59	39.3	109.80
04/21/89	4.8	6	4	62	41.3	107.76
04/22/89	5.5	6	5	60	40.3	99.83
04/23/89	5.5	7	5	69	45.1	94.95
04/24/89	6.1	8	5	61	40.9	90.53
04/25/89	7.1	8	6	70	46.7	87.70
04/26/89	6.3	7	6	66	43.7	87.00
04/27/89	6.5	7	6	66	44.0	85.63
04/28/89	6.4	7	5	37	56.1	86.03
04/29/89	5.7	6	5	34	39.5	87.43
04/30/89	5.4	9	5	15	46.9	87.42
05/01/89	4.8	6	4	18	51.4	89.78
05/02/89	3.8	6	2	8	50.0	90.98
05/03/89	4.4	6	3	11	42.3	95.50
05/09/89	3.6	4	3	64	42.4	111.60
05/10/89	6.2	7	5	62	41.3	96.32
05/11/89	5.9	7	5	65	43.3	91.08

Table 11. (continued)

Release date	Median travel time **(day)**	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge **(kcfs)**
05/12/89	6.4	8	6	61	40.7	85.57
05/13/89	7.4	9	6	84	50.0	83.07
05/14/89	6.8	8	6	37	44.6	80.16
05/18/89	24.6	27	19	34	42.0	74.71
05/19/89	23.2	26	13	24	57.1	73.64

* Confidence intervals calculated with nonparametric statistics

and ranged from 80 to 112 **kcfs.** The average daily discharge for the two age-0 chinook salmon groups was 74.2 **kcfs.** The percent recovery of daily PIT tag groups at the Lower Granite Collection Facility increased from 32.6% prior to April 11, **to** 44.7% after April 16. Gill **Na+K+** ATPase activity level, an indicator of **smoltification,** was tested three times prior to April 11 and after April 16 (Rondorf et al. In Press). The mean gill ATPase activity **(umoles $P_i \cdot mg\ protein^{-1} \cdot hr^{-1}$)** prior to April 11 was 11.5 (range 10.7-12.9), and after April 16 increased to 21.2 (range 17.5-24.1). This indicates a substantial increase in **smoltification** after April 16.

The migration rate for chinook salmon marked at the Snake River trap, both prior to mid-April and after mid-April, was greater in 1989 than in 1988 or 1987. The increase in migration rate in 1989 was probably associated with higher discharge. Average daily discharge prior to and after mid-April was approximately 38,000 cfs higher in 1989 than in 1988.

The linear regression of the log of migration rate and log discharge provided the best fit for **PIT-tagged** chinook salmon groups **($N=47$, $r^2=0.663$,** $p=o.000$):

log migration rate = -14.478 + 3.635 log average discharge.

This analysis indicates that PIT-tagged chinook salmon migration rate increased in Lower Granite Reservoir as discharge increased.

The linear regression analysis on the data stratified by 5 kcfs intervals was conducted and found that the best linear regression equation (N.1O, **$r^2=0.951$,** P=O.000) was:

log migration rate = -13.204 + 3.373 log mean discharge.

Stratifying by 5 kcfs intervals removes some of the noise associated with biological data, and the equation shows there is a very **strong** relationship between migration rate and 'discharge. As discharge **increases** migration rate increases.

In 1989 chinook salmon smelts were PIT-tagged at the Clearwater River trap to provide travel time information through Lower Granite Reservoir for Clearwater River chinook salmon. Seventeen groups (totaling 2,441 chinook salmon) were released from the Clearwater River trap from March 29 through April 16 and from May 24 to May 31 (Table 12). No PIT-tagged groups were released over a five-week period from mid April to the later part of May because the trap was out of operation. Early in the 1989 season, Clearwater River chinook salmon migrated slower than Snake River chinook salmon. Prior to **April** 17, chinook salmon marked at the Snake River trap took 14.2 d to migrate through Lower Granite Reservoir, while chinook salmon marked at the Clearwater River trap took 20.1 d. Comparable information for both traps is not available after April 16. The reason that the Clearwater River chinook salmon migrate slower through Lower Granite Reservoir is not known at this time. Hopefully additional data from futures years will help answer this question.

Table 12. PIT-tagged chinook salmon travel time, with 95% confidence interval, from the Clearwater River trap to Lower Granite Dam, 1989.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
03/29/89	23.2	24	19	47	32.0	77.00
03/30/89	26.7	31	22	33	20.4	82.86
03/31/89	26.1	30	22	51	34.0	83.25
04/01/89	23.6	29	20	39	26.0	83.54
04/02/89	20.7	26	20	40	26.7	81.96
04/03/89	23.6	28	22	51	34.0	85.56
04/04/89	26.1	29	21	48	32.2	86.61
04/05/89	23.1	28	20	43	28.7	87.47
04/06/89	21.9	27	13	33	22.0	88.63
04/07/89	17.6	24	14	42	28.4	90.01
04/12/89	11.2	15	8	23	26.4	91.61
04/13/89	12.6	17	9	37	29.1	95.54
04/15/89	13.8	18	10	28	27.5	96.60
04/16/89	11.0	16	8	35	33.0	99.99
05/03/89	10.1	37	3	6	42.9	104.72
05/23/89	6.9	9	6	10	30.3	62.34
05/24/89	7.4	8	7	39	42.4	61.86
05/25/89	7.4	9	7	51	37.5	61.66
05/30/89	6.1	7	6	62	40.3	67.47
05/31/89	7.1	9	6	38	46.3	73.90

* Confidence intervals calculated with nonparametric statistics

The linear regression analysis of the Clearwater River chinook salmon PIT tag data showed the migration rate-discharge relationship was relatively weak (N=17, r^2=0.277, P=0.030). The strength of the relationship did not increase greatly when the data was stratified by 5 kcfs groups (N=8, r^2=0.368, P=0.111). When the data was pooled, the migration rate-discharge relationship was not significant at the 0.05 level. The lack of PIT tag data from April 16 to May 24, the effect of stock differences, and smoltification status of the late-May migrants are likely causes the relationship was not significant when the data was pooled. These same reasons could account for the low r^2 in the unpooled analysis.

The chinook salmon migration rate-discharge relationship for Snake River trap PIT tag groups was examined to determine if there was a difference in this relationship between years (1987-1989). The analysis of covariance was used with the data averaged by 5 kcfs groups. The analysis showed a significant difference in the migration rate-discharge relationship between years (slope of the lines) at the 0.05 level of significance (N=25, F=21 .886, P=0.000).

Percent recovery (integration) of Snake River trap daily release PIT-tagged chinook salmon groups at Lower Granite Dam ranged between 21.2% and 57.1% and averaged 39.3%. Seasonal cumulative recovery (# recaptured/# marked) of PIT-tagged chinook salmon to Lower Granite was 38.4%. Cumulative recovery progressing downstream to Little Goose Dam was 60.8%, and to McNary Dam was 68.5%.

Percent recovery of Clearwater River trap daily release PIT-tagged chinook salmon groups at Lower Granite Dam ranged between 20.4% and 46.3%., and averaged 32.0%. Seasonal cumulative recovery of PIT-tagged chinook salmon to Lower Granite Dam was 31.0%. Cumulative recovery progressing downstream to Little Goose Dam was 49.9%, and to McNary Dam was 55.6%. Percent recovery of PIT-tagged chinook salmon at Lower Granite Dam that were released from the Clearwater River trap was considerably less than PIT-tagged chinook salmon released from the Snake River trap. There was sufficient data prior to April 17 to compare the percent recovery at Lower Granite Dam of chinook salmon released from the two traps. Using a t-distribution the HO: The mean of the percent recovery at Lower Granite Dam from the beginning of the sample season to April 16 was the same for chinook salmon PIT-tagged at the Snake River trap as it was for chinook salmon PIT-tagged at the Clearwater River trap, was tested. The null hypothesis was rejected, indicating that there was a significant difference at the 0.05 level, between the mean percent recovery of the two groups. Snake River PIT-tagged chinook salmon were recovered at a mean of 33.9%, while Clearwater River PIT-tagged chinook salmon were recovered at a mean of 28.6%. There was not enough data at the Clearwater River trap to compare percent recovery after April 16.

The difference in percent recovery is most likely due to the fact that chinook salmon in the Snake River drainage have much farther to travel. The weak fish may have already perished, whereas the majority of the chinook salmon in the Clearwater River were released from the DNFH only 55 km upstream of the

Clearwater River trap and the weaker fish had not died yet. The slower travel time of the Clearwater PIT-tagged chinook salmon (20.1 d) compared to the Snake River PIT-tagged fish (14.2 d) indicated the ClearWater River chinook salmon may not have been as smelted as the Snake River chinook salmon.

The percent recovered at Little Goose Dam for chinook salmon marked at the Snake River trap was 1.5 times greater in 1989 than in 1988, and more than two times greater than in 1987. The increase was probably due to more chinook salmon passing Lower Granite through a bypass pipe that was accidentally left partially open until discovered on April 24.

Hatcherv Steelhead Trout Freeze Brand Groups-Median passage dates were calculated for nine groups of freeze-branded steelhead trout at the Snake River trap and two groups at the Clearwater River trap. These groups were used to determine migration rate and travel time through Lower Granite Reservoir (Table 13). The slowest moving group through Lower Granite Reservoir was the Little Sheep Creek group (15 d travel time), followed by the six groups released in Spring Creek (ranging from 9 to 15 d), the Wildcat Creek groups (8 d), and the Clearwater River brand groups (5 d).

The relationship between hatchery steelhead trout migration rate through Lower Granite Reservoir and discharge was analyzed using a linear regression model. The analysis showed no statistically significant relationship at the 0.05 level between migration rate and discharge ($N=11$, $r^2=0.108$, $P=0.324$). In past years, this relationship had been significant. In 1989, the number of groups of freeze-branded steelhead trout that were released decreased because the Idaho Department of Fish and Game did not freeze-brand steelhead trout. The data did not show a relationship between migration rate and discharge, probably because all the brand groups moved through Lower Granite Reservoir over a very narrow discharge range (95,000-107,000 cfs). Therefore, when the analysis was conducted there was little variation in the discharge variable.

Hatcherv Steelhead Trout PIT Tag Groups-Sufficient numbers of hatchery steelhead trout were PIT-tagged daily at the Snake River trap to provide 42 daily release groups (2,525 individual fish) to be used in median migration rate calculations through Lower Granite Reservoir. Median travel time ranged from 6.8 to 1.9 d (7.6 km/d to 27.2 km/d migration rate) and averaged 3.7 d, which was about 1.5 times faster than in 1988 (Table 14). Discharge was about 1.4 times higher than in 1988, which probably accounts for the increased migration rate in 1989.

The linear regression analysis showed a significant relationship between migration rate in Lower Granite Reservoir and average Lower Granite discharge (inflow) for PIT-tagged hatchery steelhead trout groups ($N=42$, $r^2=0.728$, $P=0.000$). The best linear regression equation was:

$$\log \text{migration rate} = -4.602 + 1.633 \log \text{discharge}.$$

Table 13. Steel head trout smelt travel time and migration rate f ran the head of Lower Granite Reservoir to Lower Granite dam using fish passing the Snake and Clearwater River traps from upriver releases, 1985- 1989.

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number Collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGD
1985	LDY-1	Hel 1s Canyon	5/3	44	5/1 1	2,821	8	6.5	88
	RDY-1	Sawtooth Hatchery	5/7	23	5/28	3,510	21	2.5	92
	RDY-3	E. F. Salmon River	5/9	22	5/28	2,454	19	2.7	93
	RA17-1	Grande Ronde River	5/20	36	5/22	12,710	2	25.8	102
	RA17-3	Grande Ronde River	5/19	31	5/21	12,022	2	25.8	95
	LDY-2	Dworshak NFH	4/29	88	5/4	6,699	5	12.3	83
1986	RDT-2	Hel 1s Canyon	5/1	38	5/8	5,033	7	7.4	94
	LDT-2	Sawtooth Hatchery	5/21	11	5/29	3,772	8	6.5	120
	LDT-4	E. F. Salmon River	5/23	9	5/29	1,552	6	8.6	119
	RAJ-4	Little Sheep Cr.	5/8	16	5/30	1,340	22	2.3	114
	RAJ-1	Spring Creek	5/27	14	5/26	1,628	Median arrival date at LGD one day before median passage date at Snake R. trap.		
	RAIJ-1	Cottonwood Cr.	5/5	39	5/21	4,468	16	3.2	98
	RAIJ-3	Cottonwood Cr.	5/5	43	5/22	5,151	17	3.0	100
	RAIJ-4	Cottonwood Cr.	5/6	29	5/18	4,114	12	4.3	99
	RDT-4	Dworshak NFH	5/8	18	5/1 7	7,194	9	6.8	99
	LD4-1	Clearwater R. Trap 1/	5/8	2	5/14	1,003	6	10.3	100
	LD4-3	Clearwater R. Trap 1/	5/13	5	5/22	869	9	6.8	98
	RD4-1	Clearwater R, Trap 1/	4/16	7	4/23	371	7	8.8	103
	RD4-3	Clearwater R. Trap 1/	5/1	1	5/8	751	7	8.8	94
1987	RAIC-1	Cottonwood Cr.	4/30	7	5/4	4,886	4	12.9	86
	RAIC-2	Cottonwood Cr.	4/30	6	5/4	5,529	4	12.9	86
	RAIC-3	Cottonwood Cr.	4/30	7	5/4	5,971	4	12.9	86
	RAIC-4	Cottonwood Cr.	4/30	8	5/5	4,936	5	10.3	84
	RAR-3	Clear Cr.	4/20	59	5/1	3,500	11	4.7	59
	RDR-3	Dworshak NFH	4/22	58	5/1	4,917	9	6.8	63
	RDK-1	Clearwater R. Trap 1/	4/13	6	4/26	1,192	13	4.7	41
	RDK-2	Clearwater R. Trap 1/	4/20	9	4/30	999	10	6.2	56
	RDK-4	Clearwater R. Trap 1/	4/20	2	5/4	692	6	10.3	84
1988	LDT-3	Hel 1s Canyon	5/7	38	5/1 5	6,631	8	6.5	69
	LDT-2	Sawtooth Hatchery	5/7	19	5/25	5,332	18	2.9	68

TABL13

Table 13. (continued)

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number Collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGD
	LAI(F&M)-1	Spring Creek	4/25	59	5/1 7	8,711	22	2,3	61
	LAI(F&M)-3	Spring Creek	4/24	42	5/1 2	7,895	18	2.9	58
	RAI(F&M)-3	Spring Creek	4/24	61	5/9	11,562	15	3.4	58
1988	RAI(F&M)-1	Wildcat Creek	4/26	155	5/1 1	28,569	15	3.4	59
	LD4-3	Snake River @ Asotin	5/24	30	5/30	854	6	8.6	76
	RD4-1	Snake River @ Asotin	5/24	55	5/30	994	6	8.6	76
	RAT-1	Dworshak NFH	5/3	107	5/1 1	10,792	B	7.7	72
	RAT-2	Dworshak NFH	5/3	95	5/1 1	7,225	8	7.7	72
	RAT-3	Dworshak NFH	5/3	81	5/9	5,928	6	10.3	73
	RAT-4	Dworshak NFH	5/3	202	5/10	25,335	7	8.8	78
	RA4-1	ClearWater R. Trap 1/	4/14	28	4/22	1,335	8	7.7	57
	RA4-3	Clearwater R. Trap 1/	4/23	8	5/1	1,394	8	7.7	49
	RD4-3	Clearwater R. Trap 1/	4/29	16	5/6	743	7	8.8	50
1989	LDI(S&U)-1	Dworshak NFH	5/2	123	5/7	23,573	5	12.3	93
	(R&L)DJ-1	Little Sheep Creek	4/25	93	5/10	4,420	15	3.4	95
	(R&L)AJ-2	Spring Creek	5/1	84	5/1 2	12,362	11	4.7	101
	(R&L)AJ-1	Spring Creek	5/2	83	5/1 2	10,168	10	5.2	103
	(R&L)AJ-3	Spring Creek	5/5	70	5/14	10,877	9	5.7	104
	(R&L)AJ-4	Wildcat Creek	4/30	134	5/8	15,037	8	6.5	95

1/ Releases made on Clear-water River at U.S. Highway 95 launch(Rkm-15. 5).

TABL13

Table 14. PIT-tagged hatchery steelhead trout travel time, with 95% confidence **interval**, from the Snake River trap to Lower Granite Dam, 1989.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/12/89	2.2	0	0	1	50.0	73.70
04/16/89	6.8	11	5	26	55.3	100.26
04/17/89	3.9	6	3	19	63.3	95.68
04/18/89	3.0	3	2	48	73.8	95.60
04/19/89	2.5	3	2	44	69.8	102.70
04/20/89	2.1	2	2	49	81.7	107.90
04/21/89	2.0	4	2	45	75.0	115.30
04/22/89	2.1	4	2	41	68.3	115.45
04/23/89	2.5	4	2	44	73.3	102.73
04/24/89	3.2	3	3	40	65.6	94.70
04/25/89	3.3	5	3	41	67.2	88.60
04/26/89	2.8	5	2	35	58.3	87.17
04/27/89	4.8	7	3	29	46.8	86.42
04/28/89	3.9	5	4	34	54.8	87.03
04/29/89	4.0	5	3	43	71.7	85.55
04/30/89	3.0	4	3	49	79.0	84.90
05/01/89	3.0	4	3	42	70.0	84.37
05/02/89	3.1	4	3	46	76.7	88.03
05/03/89	3.1	4	3	47	77.0	94.07
05/04/89	2.8	4	3	47	75.8	98.53
05/05/89	2.9	4	2	49	81.7	102.37
05/06/89	2.5	3	2	45	75.0	103.65
05/07/89	2.3	3	2	48	80.0	109.40
05/08/89	1.9	3	2	45	75.0	112.25
05/09/89	2.0	4	2	46	73.0	113.50
05/10/89	2.6	3	2	53	75.7	111.07
05/11/89	2.0	3	2	48	72.7	109.70
05/12/89	3.2	4	3	35	58.3	91.87
05/13/89	3.2	4	3	46	75.4	81.57
05/14/89	3.8	6	3	47	77.0	79.33
05/15/89	3.5	4	3	40	66.7	79.27
05/16/89	3.8	5	3	45	67.2	84.20
05/17/89	3.8	5	4	41	68.3	81.62
05/18/89	4.6	6	3	44	73.3	74.34

Table 14. (continued)

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number caDtured	Percent captured (%)	Average discharge **(kcfs)**
05/19/89	6.8	7	5	40	67.8	69.20
05/20/89	6.8	8	5	38	64.4	66.01
05/21/89	5.8	7	5	48	80.0	65.00
05/22/89	5.1	6	4	41	68.3	64.86
05/23/89	5.8	8	4	45	75.0	62.50
05/24/89	6.0	7	4	41	68.3	61.30
05/25/89	6.1	8	5	44	73.3	61.37
05/26/89	5.2	6	5	43	71.7	60.72
06/08/89	3.1	4	3	36	59.0	97.47

* Confidence intervals calculated with nonparametric statistics

The linear regression analysis conducted on the daily release groups stratified into 5 kcfs discharge intervals showed a significantly higher r^2 value because some of the noise which is often associated with biological data was removed (N=12, r^2=0.916, P=0.000). The best linear regression equation was:

log migration rate = -4.655 + 1.661 log mean discharge.

The equation shows that as discharge increases migration rate increases for PIT-tagged hatchery steelhead trout marked at the Snake River trap.

Hatchery steelhead trout were PIT-tagged at the Clearwater River trap in 1989 (Table 15). Since only five groups were marked, no regression analysis was conducted. Nevertheless, they seem to follow the migration rate-discharge trend observed with the Snake River releases, namely groups migrating under higher flows (May 2-3 releases), took fewer days to travel to Lower Granite Dam than those groups migrating under lower flows (May 23-25 releases).

Hatchery steelhead trout migration rate-discharge relationship between years was examined to see if the relationship was constant over years. Analysis of covariance was used to determine if there was a significant difference between years (1987-1989) in migration rate averaged by 5 kcfs intervals. The analysis showed there was no significant difference between years (slopes of the lines) for the hatchery steelhead trout migration rate-discharge relationship (N=30, F=2.782, P=0.082), but there was a significant difference in migration rate (intercepts) between years (N=30, F=8.822, P=0.001).

Percent recovery of daily hatchery steelhead trout PIT tag release groups at Lower Granite Dam ranged from 46.8% to 81.7%, and averaged 70.1%. Seasonal cumulative recovery of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 68.6%, to Little Goose Dam 79.3%, and to McNary Dam 80.7%. This was considerably higher than 1987 or 1988 when the seasonal recovery at Lower Granite Dam was only 39.2% and 61.3%, respectfully. The higher recovery rate at Lower Granite Dam most likely reflects increased fish guiding efficiency from raised operating gates at the project in 1988, and also increased survival due to more favorable discharge conditions during the migration period in 1989.

Insufficient numbers of hatchery steelhead trout were marked at the Clearwater River trap to determine percent recovery at any of the collection facilities.

Wild Steelhead Trout PIT Tag Groins-Sufficient numbers of wild steelhead trout were PIT-tagged at the Snake River trap to provide 36 daily release groups (1,798 individual fish) for estimating travel time and migration rate in Lower Granite Reservoir (Table 16). Median travel time ranged from 5.4 d (9.5 km/d) to 1.7 d (30.4 km/d), and averaged 3.9 d (13.7 km/d).

Linear regression analysis showed a significant relationship between median migration rate in Lower Granite Reservoir and mean discharge for PIT-tagged wild steelhead trout groups (N=36, r^2=0.702, P=0.000). The best linear regression equation was:

Table 15. PIT-tagged hatchery steelhead trout travel time, with 95% confidence interval, from the Clearwater River trap to Lower Granite Dam, 1989.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
05/02/89	4.6	6	4	47	78.3	92.74
05/03/89	4.9″	6	4	45	75.0	97.90
05/23/89	8.8	11	6	29	38.7	62.78
05/24/89	7.0	9	6	41	69.5	61.86
05/25/89	7.6	12	5	11	31.4	61.69

* Confidence intervals calculated with nonparametric statistics

Table 16. PIT-tagged wild steelhead trout travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1989.

Release date	Median travel time (day)	Confidence Interval* Upper	Confidence Interval* Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/08/89	4.1	0	0	4	57.1	80.90
04/09/89	5.4	8	5	10	66.7	77.38
04/10/89	6.9	12	3	6	54.5	78.61
04/11/89	7.8	10	3	6	66.7	82.39
04/12/89	2.8	0	0	1	16.7	75.00
04/13/89	5.8	0	0	4	57.1	84.80
04/14/89	3.1	0	0	2	33.3	82.33
04/15/89	3.4	0	0	5	71.4	88.43
04/16/89	3.3	5	2	16	69.6	92.27
04/17/89	4.3	5	3	21	56.8	95.68
04/18/89	2.8	4	2	27	67.5	95.60
04/19/89	2.3	3	2	43	69.4	97.20
04/20/89	2.3	3	2	26	65.0	107.90
04/21/89	2.2	4	2	40	66.7	115.30
04/22/89	2.1	3	2	45	72.6	115.45
04/23/89	2.3	3	2	40	65.6	108.15
04/24/89	2.5	3	2	24	60.0	94.70
04/25/89	2.4	3	2	37	58.7	90.90
04/26/89	2.4	3	2	26	50.0	86.95
04/27/89	2.7	4	2	15	39.5	86.37
04/28/89	3.4	5	3	17	43.6	87.70
04/29/89	2.6	3	2	17	54.8	86.83
04/30/89	3.1	4	2	18	81.8	84.90
05/01/89	2.9	3	3	30	88.2	84.37
05/02/89	3.0	3	2	29	67.4	88.03
05/03/89	2.7	3	2	34	64.2	94.07
05/04/89	2.4	3	2	40	70.2	97.90
05/05/89	1.9	2	2	39	68.4	99.80
05/06/89	2.1	2	2	79	73.8	103.65
05/07/89	1.9	2	2	117	68.8	109.40
05/08/89	1.8	3	2	8	57.1	112.25
05/09/89	1.7	2	2	80	63.5	113.50
05/10/89	1.8	2	2	87	65.9	114.80
05/11/89	2.0	3	2	25	59.5	109.70
05/12/89	2.5	3	2	37	60.7	98.05
05/13/89	2.8	3	2	20	62.5	81.57
05/14/89	2.8	5	2	13	72.2	78.20
05/15/89	3.9	5	2	14	82.4	80.78
05/17/89	2.8	0	0	5	62.5	84.80
05/18/89	3.1	0	0	2	100.0	81.27

Table 16. (continued)

Release date	Median travel time (day)	Confidence Interval*		Number captured	Percent captured (%)	Average discharge (kcfs)
		Upper	Lower			
05/19/89	3.4	5	3	19	73.1	74.73
05/20/89	4.8	7	4	10	71.4	66.68
05/21/89	4.6	9	3	7	53.8	65.18
05/22/89	3.7	5	2	6	66.7	65.05
05/24/89	4.3	6	3	12	92.3	62.65
05/26/89	5.7	0	0	2	50.0	61.17
06/08/89	5.9	0	0	5	71.4	90.95

* Confidence intervals calculated with nonparametric statistics

log migration rate = -3.655 + 1.461 log mean discharge.

Again the analysis shows that as discharge increases, migration rate in Lower Granite Reservoir increases.

Linear regression analysis conducted on average migration rates for PIT tag groups stratified into 5 kcfs intervals to remove noise which is often associated with biological data had a higher r^2 value (N=12, r^2=0.933, P=0.000). The equation that best fit the data was:

log migration rate = -3.052 +1.341 log average discharge.

This indicates that 93% of the variation in migration rate is accounted for by changes in discharge. In other words, migration rate is very dependent on discharge; the higher the discharge, the faster wild steelhead trout migrate.

Wild steelhead trout were PIT-tagged at the Clearwater River trap in 1989 (Table 17). Insufficient groups were marked for travel time analysis or to compare travel time between the Snake and Clearwater River wild steelhead trout.

Wild steelhead trout migration rate-discharge relationship was examined to see if the relationship is constant over years. The analysis of covariance was use to determine if there was a significant difference between years (1987-1989) in migration rates using groups averaged by 5 kcfs intervals. The analysis showed no significant difference between years for the slopes of the wild steelhead trout migration rate-discharge relationships (N=25, F=l .214, P=0.319), nor was there a significant difference in migration rate (intercept) between years (N=25, F=1 .301, P=0.293).

Percent recovery of daily wild steelhead trout PIT tag release groups at Lower Granite **Dam ranged** from 39.5% to 92.3%, and averaged 65.8%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout to Lower Granite **Dam was 65.1%, to Little Goose Dam 78.7%, and** to McNary **Dam 81.5%. The percent recovery at the three dams for PIT-tagged hatchery and wild steelhead** trout was about the same; 82.5% for hatchery steelhead trout, and 81.5% for wild steelhead trout. This is slightly higher than in 1988 (10% higher for hatchery steelhead trout and 7% higher for wild steelhead trout), and considerably higher (44% higher for hatchery steelhead trout and 25% higher for wild steelhead trout) than in 1987. The increase in interrogation of both hatchery and wild steelhead trout may be due to increased survival associated with better water conditions during the 1989 migration period than were available in the drought years 1988 and 1987. The dramatic increase over 1987 is partially due to an increased fish guiding efficiency from raising the operating gates at Lower Granite Dam prior to the 1988 migration season.

Migration rates for hatchery and wild steelhead trout were significantly different. The slopes of the migration rate-discharge regression lines for hatchery and wild steelhead trout, grouped by 5 kcfs increments, were tested with the analysis of covariance and found to not be significantly different (N=24, F=2.677, P=0.117). Since the migration rate-discharge relationships for

Table 17. PIT-tagged wild steelhead trout travel time, with 95% confidence intervals, from the Clearwater trap to Lower Granite Dam, 1989.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/04/89	6.7	0	0	1	100.0	72.93
04/05/89	8.0	0	0	1	100.0	74.50
04/06/89	12.6	0	0	1	100.0	80.21
04/07/89	7.7	0	0	1	50.0	77.64
04/12/89	3.8	0	0	2	28.6	76.47
04/13/89	8.1	0	0	2	66.7	87.90
04/15/89	4.1	7	2	6	75.0	89.43
04/16/89	3.2	7	2	8	72.7	92.27
05/03/89	4.4	5	2	7	87.5	95.50
05/23/89	4.0	5	2	9	37.5	65.52
05/24/89	5.2	0	0	5	50.0	61.28
05/25/89	6.5	0	0	3	27.3	61.37
05/30/89	4.8	0	0	4	36.4	66.04
05/31/89	3.8	0	0	3	100.0	66.25

* Confidence intervals calculated with nonparametric statistics

hatchery and wild steelhead trout had a common slope, the heights of the two lines were tested to determine if there was a significant difference in the migration rate of hatchery vs. wild steelhead trout. The heights (or intercepts) of the two regression lines did differ **(N=24, F=18.613, P=0.000).** Wild steelhead trout consistently migrated approximately 3 km/d faster, over the range of discharge observed in 1989, than their hatchery counterparts **(Figure** 8). This same phenomenon was observed in 1988 when wild steelhead trout consistently migrated about 2.5 km/d faster, over the range of discharge observed in 1988, than their hatchery counterparts.

It is uncertain as to the reason for this difference. Possible explanations are that wild steelhead trout are stronger and/or more fully smelted and therefore migrate faster through Lower Granite Reservoir. Mean ATPase activity level, an indicator of **smoltification,** was tested three times at the Snake River trap between April 20-27, 1989 **(Rondorf** et al. In Press). Preliminary information indicates mean ATPase levels for hatchery steelhead trout were 32% lower than wild steelhead trout during this period (hatchery steelhead trout = 13.5, wild steelhead trout = 17.8).

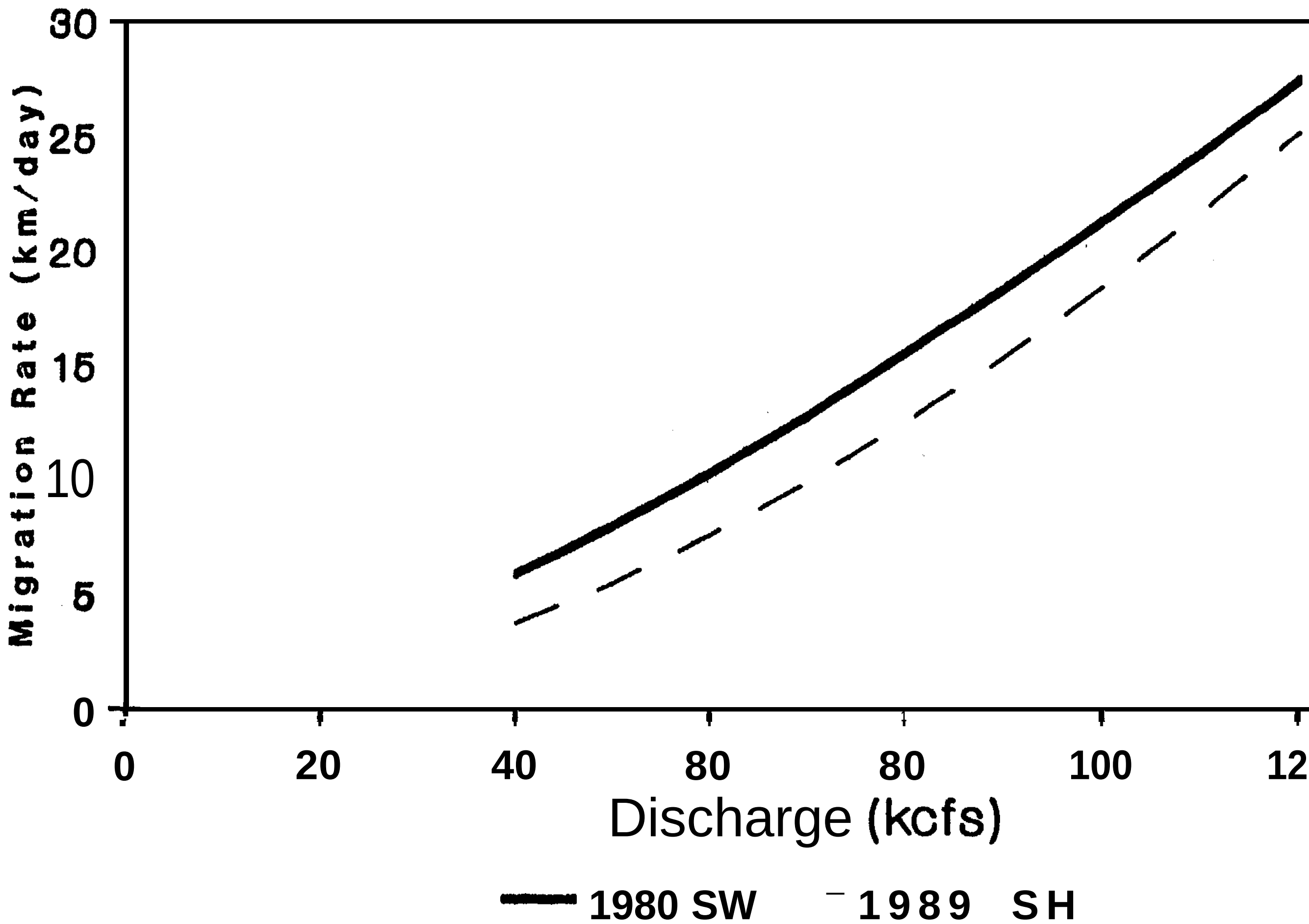

Figure 8. Relationship between travel time through Lower Granite Reservoir for hatchery steelhead trout and wild steelhead trout averaged by groups, 1989.

SUMMARY

The number of chinook salmon released in 1989 was up 2.7%, and the number of steelhead trout released was down 19.0% from 1988. Hatchery production of chinook salmon and steelhead trout released above Lower Granite Dam was 20,229,754 (11,479,606 chinook salmon and 8,750,148 steelhead trout) in 1989. Of these, 674,114 chinook salmon and 291,728 steelhead trout (5.9% and 3.3% of the total releases, respectively) were freeze-branded and released as 40 unique chinook salmon groups and 13 unique steelhead trout groups. The number of freeze-branded chinook salmon and steelhead trout was down 6.7% and 46.9%, respectively, from 1988. Idaho did not brand steelhead trout at any facilities except DNFH in 1989.

The Snake River trap was operated on the east side of the river from March 8 through June 23. The Snake River trap captured 32,131 age-1 chinook salmon, 23,245 hatchery steelhead trout, and 2,194 wild steelhead trout. The hatchery steelhead trout trap catch was better than in any previous year, up 139% from 1988, which was the best previous year.

The Clearwater River trap was operated from March 15 through June 3 with about a one-month period from mid-April to mid-May when the trap was out of operation due to high flow. Clearwater River trap catch was 9,938 chinook salmon, 1,135 hatchery steelhead trout, and 141 wild steelhead trout. Total trap catch of all three species was considerably less than 1988 due to the month-long period in April and May when the trap was out of operation. Fish were again PIT-tagged for migration rate statistics at the Snake River trap and, for the first time, at the Clearwater River trap in 1989.

Tests at the Snake River trap produced a chinook salmon trap efficiency of 1.04% for 1989. Differences in the trap efficiencies in 1989 from previous years were not statistically significant. All the years of chinook salmon trap efficiencies provide a pooled average chinook salmon trap efficiency of 1.39% at the Snake River trap.

Steelhead trout trap efficiency of three test groups at the Snake River trap was 0.6%. The four years of efficiency data were pooled to provide a steelhead trout trap efficiency of 0.74% at the Snake River trap. With the limited data available, year and discharge must be discounted as having any significant effect on trap efficiency of steelhead trout smelts at the Snake River smelt trap.

Chinook salmon trap efficiency tests at the Clearwater River trap in 1989 were significantly different from those of previous years. The 1989 trap efficiency was 0.55%, which is considerably lower than the previous five-year pooled efficiency of 2.0%.

Steelhead trout trap efficiency was not tested at the Clearwater River trap in 1989.

Migration rates (travel time) from points of release to the Snake River trap in 1989 were slower than in previous non-drought years, probably due to a 10-60% reduction in Salmon River discharge anda 15-40% reduction in Snake River discharge from previous years (1984 through 1986). Migration rates for freeze-branded steelhead trout, released in the Grande Ronde River, to the Snake River trap in 1989 were similar to 1988. No branded steelhead trout were released in the Salmon River in 1989.

Migration rates for Clearwater River branded chinook salmon were similar to rates observed in 1985, 1986, and 1988. In 1987, migration rate was 75% slower than in 1989. Flows were considerably lower for a major portion of the migration in 1987 and is probably the reason for the slower migration that year. Steelhead trout migration rate was the same as in previous years.

Migration rates through Lower Granite Reservoir ranged from 45 d for early freeze brand release groups in the Clearwater River, to 2 d for the South Fork Salmon River freeze brand group. The slow migration rates for chinook salmon moving through the reservoir early in the migration season was probably due to the fish being at a lower level of smoltification, and river discharge was lower at that time. The South Fork Salmon River group moved through the reservoir about three weeks later, when the smelts would have been at a higher level of smoltification, and discharge was 20-30 kcfs higher.

PIT-tagged chinook salmon are amuchbetter methodof determining migration rate through Lower Granite Reservoir than freeze brand groups. PIT-tagged chinook salmon migrated considerably slower early in the migration season (mean travel time 15.9 d prior to April 11) compared to later in the migration season (mean travel time 5.4 d after April 16). Prior to April 11, average discharge was 79 kcfs, and after April 16 average discharge was 95 kcfs. Chinook salmon migration rate through Lower Granite Reservoir was greater in 1989 than in 1988 or 1987, probably due to higher discharge in 1989. Statistical analysis showed a very strong relationship between migration rate and discharge ($N=10$, $r^2=0.951$, $P=0.000$). As discharge increases, migration rate of chinook salmon through the reservoir also increases. PIT-tagged chinook salmon moved about six times faster through the reservoir at 100 kcfs than at 60 kcfs.

A strong migration rate-discharge relationship was not obvious for the PIT-tagged chinook salmon groups released from the Clearwater River trap. Not enough data was available in 1989 at the Clearwater River trap to test this relationship because of the extended period the trap was inoperative in April and May.

Percent interrogationof PIT-tagged chinook salmon was higher in 1989 than in previous years. Cumulative interrogationof PIT-tagged chinook salmon at all three dams (Lower Granite, Little Goose, and McNary) was 68.5% in 1989.

Migration rate through Lower Granite Reservoir for hatchery steelhead trout PIT-tagged at the Snake River trap was 1.5 times faster in 1989 than in 1988 (3.7 km/d and 5.6 km/d, respectively). Discharge was 1.4 times higher in 1989, which probably accounts for the increased migration rate. There is a very strong statistical relationship between migration rate and discharge for PIT-tagged hatchery steelhead trout (N=12, r^2=0.916, P=0.000). PIT-tagged hatchery steelhead trout migrated about twice as fast at 100 kcfs as they did at 60 kcfs.

Percent interrogationof PIT-tagged hatchery steelhead trout taggedat the Snake River trap was 10% higher in 1989 than in 1988. Cumulative interrogation of PIT-tagged hatchery steelhead trout at all three dams (Lower Granite, Little Goose, and McNary) was 80.7% in 1989.

The introduction of the PIT tag has provided the opportunity to obtain travel time data through Lower Granite Reservoir for wild steelhead trout. This is because of the low numbers of fish required for marking due to the high recovery rate at Lower Granite Dam. PIT-tagged wild steelhead trout, tagged at the Snake River trap, migrated at the same rate in 1989 and 1988 (3.9 d). The relationship between migration rate and discharge for wild steelhead trout is very strong (N=12, r^2=0.933, P=0.000). These fish migrated twice as fast through Lower Granite Reservoir at 100 kcfs as they did at 60 kcfs. PIT-tagged wild steelhead trout also migrate about 1.5 times faster through Lower Granite Reservoir, at 100 kcfs, than did the PIT-tagged hatchery steelhead trout.

Percent interrogationof PIT-tagged wild steelhead trout was approximately 7% higher in 1989 than in 1988. Cumulative interrogation of PIT-tagged steelhead trout at the three dams (Lower Granite, Little Goose, and McNary) was 81.5% in 1989.

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SPINE

SMOLT MONITORING AT THE HEAD OF LOWER GRANITE RESERVOIR AND LOWER GRANITE DAM

Annual Report
for 1990 Operations

Prepared by

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Project No. 83-323
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ABSTRACT

This project monitored the daily passage of chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *Oncorhynchus mykiss* smelts during the 1990 spring outmigration at migrant traps on the Snake River and the Clearwater River.

Chinook salmon catchat the Snake River trap was similar to 1987 and 1988, drought years, but considerably less than 1989, a near normal flow year. Trapping effort was the same during the four years. Hatchery steelhead trout catch was similar to 1988 and 1989. Wild steelhead trout catch was greater than in any previous year.

Chinook salmon catch at the Clearwater River trap was slightly less than in 1987 or 1988 and considerably higher than in 1989. Hatchery steelhead trout trap catch was 3 to 26 times greater than in previous years. Wild steelhead trout trap catch was 2 to 11 times greater than in previous years.

Fish tagged with Passive Integrated Transponder (PIT) tags at the Snake River trap were recovered at the three dams with PIT tag detection systems (Lower Granite, Little Goose, and McNary dams). Cumulative recovery at the three dams for fish marked at the Snake River trap was 64.4% for chinook salmon, 83.1% for hatchery steelhead trout, and 79.0% for wild steelhead trout. Cumulative recovery at the three dams for fish PIT-tagged at the Clearwater River trap was 54.6% for chinook salmon, 77.6% for hatchery steelhead trout, and 70.4% for wild steelhead trout.

Travel time (days) and migration rate (km/d) through Lower Granite Reservoir for PIT-tagged chinook salmon and steelhead trout, marked at the head of the reservoir, was affected by discharge. Statistical analysis showed that a two-fold increase in discharge increased migration rate by 2.2 times for PIT-tagged chinook salmon released from the Snake River trap and 1.8 times for chinook salmon released from the Clearwater River trap. A two-fold increase in discharge increased migration rate by 3.1 times for PIT-tagged hatchery steelhead trout released from the Snake River trap. Not enough data were available to provide a migration rate discharge relations for hatchery steelhead trout released from the Clearwater River trap. A two-fold increase in discharge increased migration rate by 2.0 times for PIT-tagged wild steelhead trout released from the Snake River trap and by 2.2 times for PIT-tagged wild steelhead trout released from the Clearwater River trap.

Chinook salmon, hatchery steelhead trout, and wild steelhead trout captured in the Snake River trap had a minimum survival estimate to Lower Granite Dam that was 5% to 10% greater than fish that were collected in the Clearwater River trap. This difference may be attributed to the distance fish traveled before encountering the traps or other unknown factors.

The relation between fish length at time of tagging and minimum survival to Lower Granite Dam was examined at the Snake River trap in 1988-1990. The relation was significant for chinook salmon and hatchery steelhead trout in 1988 and for wild steelhead trout in 1990. This relation was also examined at the Clearwater River trap in 1989 and 1990 for chinook salmon and in 1990 for hatchery steelhead and wild steelhead trout. only the hatchery steelhead trout showed a significant relation.

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INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NWPPC) to deveiop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (BPA) the authority and responsibility to. use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system."

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smelt migration. In response to the fishery agencies' and Indian tribes' recommendations for migration flows, the NWPPC Columbia River Basin Fish and Wildlife Program proposed a "Water Budget" for augmenting spring flows.

The Northwest Power Planning Council's "Water Budget" in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the smelt migration. This amount has never been provided, and actual water made available has been limited. To provide information to the Fish Passage Center (FPC) on smelt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smelts at the head of Lower Granite Reservoir. This information allows the FPC to request the limited Snake River water budget for optimal use to provide improved passage and migration conditions.

Smelt monitoring is beneficial for water budget management under all flow conditions and becomes critical when low flow conditions reduce migration rates. In years of low flow (drought years), knowledge of when most smelts have left tributaries and entered areas which can be affected by releases of stored water allows managers to make the most timely use of the limited water budget resource. Three low flow years (1987, 1988, and 1990) have occurred during this smelt monitoring project. The indications are that judicious use of the-water budget can greatly enhance the timing and migration rate of juvenile chinook salmon and steelhead trout.

Additionally, the IDFG Smolt Monitoring project collects other useful data on relative species composition, hatchery steelhead trout versus wild (natural) steelhead trout ratios, travel time, and migration rate. All wild steelhead trout smelts are PIT-tagged (Passive Integrated Transponder) to determine timing of wild adult steelhead trout one and two years later as they return to spawn. By monitoring smelt passage at the head of Lower Granite Reservoir and at Lower Granite Dam, migration rates (km/d) under various riverine and reservoir conditions can be estimated and compared. Monitoring sites, on both the Snake and Clearwater arms of Lower Granite Reservoir, permit migration timingof smelts from each drainage to be determined. Although not yet achieved, relative abundance of hatchery and wild stocks of steelhead trout can be determined and used to document wild stock rebuilding progress. The Smelt Monitoring Program's information is complimentary of other Snake and Columbia river NWPPC-supported projects.

OBJECTIVES

1. Provide daily trap catch data at the head of Lower Granite Reservoir for water budget and fish transportation management purposes.

2. Determine riverine travel time from the point of release to the smelt traps (index sites) at the upper end of Lower Granite Reservoir for freeze-branded and PIT-tagged smelts.

3. Provide an interrogation site for PIT-tagged smelts, marked on other projects, at the end of their migration in a riverine environment and the beginning of their migration in a reservoir environment.

4. Determine reservoir travel time for chinook salmon, hatchery steelhead trout, and wild steelhead trout from the head of Lower Granite Reservoir to Lower Granite Dam and to Little Goose Dam using PIT-tagged smelts marked at the traps, as well as freeze-branded and PIT-tagged smelts passing the traps from upriver hatchery releases and rearing areas.

5. Correlate smelt travel time with river flow for fish moving in riverine and reservoir environments.

6. Determine trap efficiency for each species at each trap over a range of discharges.

METHODS

Releases of Hatchery-Produced Smelts

Release information was reported for hatcheries in the Snake River drainage upstream of Lower Granite Dam that released chinook salmon and steelhead trout juveniles which may have contributed to the 1990 outmigration. This information included species, number released, date and location released, and the group-identifying freeze brand, if used.

Smelt Monitoring Traps

During the 1990 outmigration, two smelt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. A SCOOp trap (Raymond and Collins 1974) was stationed on the Clearwater River and a dipper trap (Mason 1966) was located on the Snake River (Figure 1). Smelts were

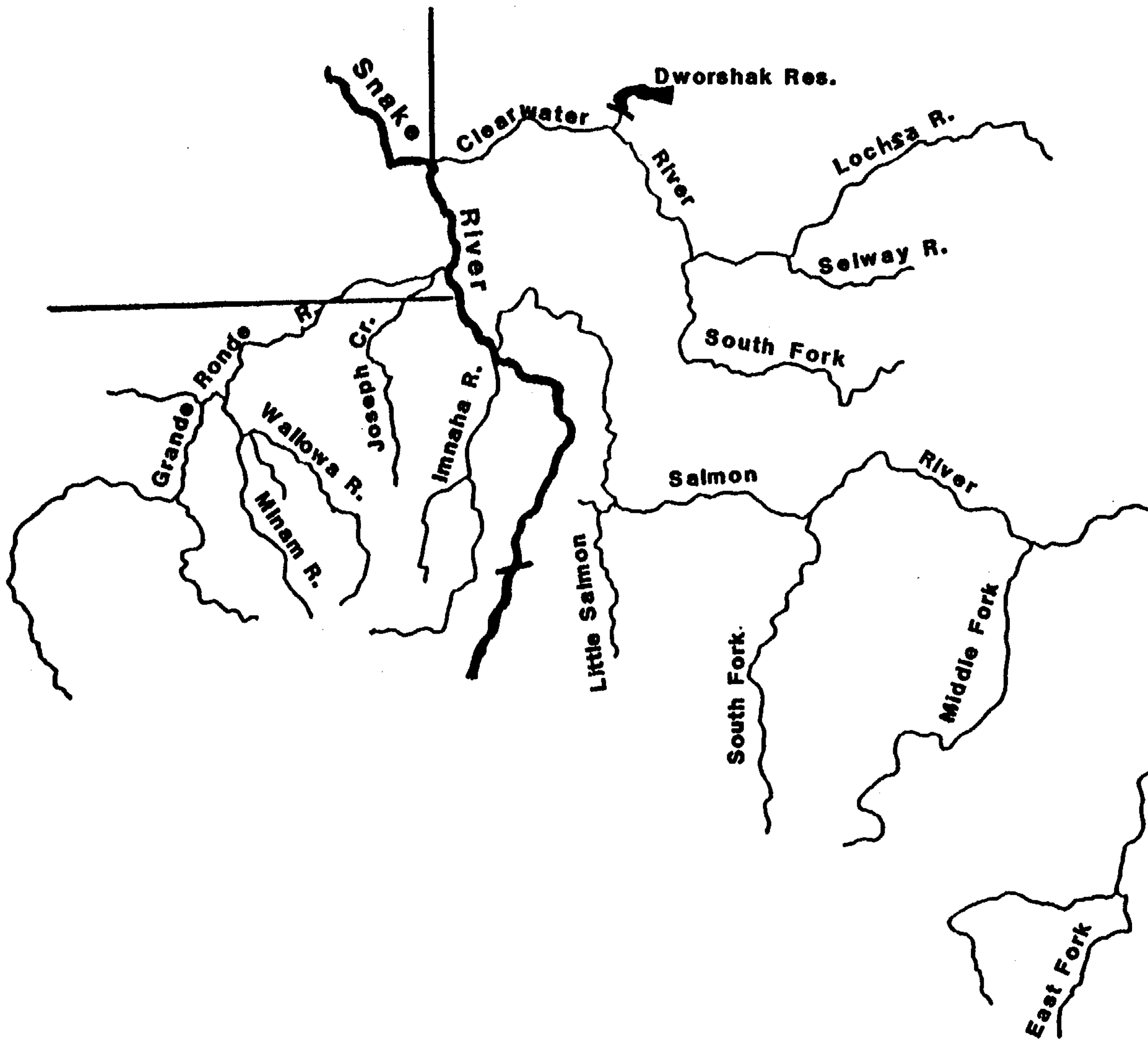

Figure 1. Map of study area,

captured and removed daily from the traps for examination, enumeration, and released back to the river. Fork length of up to 100 smelts for each species were measured to the nearest millimeter, and up to 2,000 fish were examined for hatchery brands. Smelts handled were anesthetized with Tricaine Methanesulfonate (MS-222). These fish were allowed to recover from the anesthesia before being returned to the river.

At each trap, water temperature (C) and turbidity were recorded daily using a centigrade thermometer and 20 cm Secchi disc. The U.S. Weather Service provided daily information on river discharge (CFS). The Snake River trap discharge was measured at the USGS Anatone gauge (#13334300) 44.4 km upstream from the trap. The Clearwater River trap discharge was measured at the USGS Spalding gauge (#13342500) 8.8 km upstream from the trap.

Snake River Trap

The Snake River migrant dipper trap was positioned approximately 40 m downstream from the Interstate Bridge, between Lewiston, Idaho and Clarkston, Washington and was attached to bridge piers just east of the draw bridge span by steel cables. This location is at the head of Lower Granite Reservoir, 0.5 km upstream from the convergence of the Snake and Clearwater arms. River width and depth at this location are approximately 260 m and 12 m, respectively.

A juvenile steelhead trout radio tracking study was conducted in 1987 (Liscom and Bartlett 1988). The study showed that during 1987, 7% of the radio-tagged steelhead trout passed the bridge under the span west of the draw bridge, where the trap was positioned, and 30% passed the bridge under the span immediately east of the draw bridge span. Because at least four times more fish were moving under the span of the bridge just east of the draw bridge, the trap was moved to that location on April 27, 1988 after completing installation of an electrical line to the new trap location. The trap was fished at the east location in 1990 because of the below normal snow pack and subsequent predicted low spring runoff.

Trap operation in 1990 began March 9 and continued until June 19. There were five interruptions in trap operation due to mechanical breakdown, each of an undetermined length of time. There were also three times when the trap did not function properly due to a heavy debris build-up in the trap. The trap was out of operation for less than 15 h on each occasion.

Chinook salmon and steelhead trout smelts were PIT-tagged (Prentice et al. 1987) at the Snake River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam. Up to 150 chinook salmon, 60 hatchery steelhead trout, and all wild steelhead trout were PIT-tagged daily when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow for the median travel time to determine how changes in discharge affected smelt migration rate through Lower Granite Reservoir.

All fish captured in the Snake River trap were passively interrogated for PIT tags as they entered the **livewell.** The recovery and tagging information was sent to the PTAGIS Data Center (managed by Pacific States Marine Fisheries Commission) daily.

The PIT tag interrogation system on the Snake River trap consists of-an 8-inch PVC pipe with two interrogation coils (D-4 and D-6). Each coil is connected to an exciter card and a PIT tag reader. The system does not have the capability to provide exact time of capture. Since it is checked once daily, the time of sampling is used as the interrogation time.

Coil efficiency tests were conducted on the interrogation system. Four hundred test tags were sent through the system. Coil D-4 missed 24 of the test tags and coil D-6 missed 5. Two were missed by both coils so the system had a 99.5% reading efficiency.

Clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from the convergence of the ClearWater River and Snake River arms of Lower Granite Reservoir (4.5 km upstream from slack water). The river channel at this location forms a bend and is 150 to 200 m wide and 4 m to 7 m deep, depending on discharge.

Trap operation began March 14 and continued until May 29. Trapping was discontinued because of high discharge and/or debris for 15 d this season; April 22-26, May 9-16, and May 26-27. The trap was operated in extreme high flows on May 28 and 29 near the north shore where trap efficiency was greatly reduced. Effective trap operation was terminated on **May** 25.

Chinook salmon and steelhead trout smelts were tagged with PIT tags at the Clearwater River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam for Clearwater River fish. Up to 150 chinook salmon, 60 hatchery steelhead trout, and all wild steelhead trout were **PIT-**tagged daily when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow for the median travel time to determine how changes in discharge affected smelt migration rate through Lower Granite Reservoir.

All fish were interrogated for PIT tags as the fish were removed from the **livewell.** The tagging and interrogation files were sent to the **PTAGIS** Data Center daily.

The PIT tag interrogation system on the Clearwater River trap consists of a 4-inch PVC pipe with two interrogation coils (D-O and D-2). Each coil is attached to an exciter card and a PIT tag reader. This system is **battery-**operated. Preliminary data shows reading efficiency of the system is similar to that of the Snake River trap.

Trap Efficiency

The proportion of the migration run being sampled is termed trapping efficiency. Since trap efficiency may change as river discharge changes, efficiency was estimated several times through the range of discharge at which the trap was operated. A linear regression equation (Ott 1977) describing the relation of trap efficiency and discharge was derived to estimate efficiency at any given discharge.

The ratio of recaptures to marks released is the estimate of trap efficiency (TE = recaptures/marks released). All trap efficiency tests conducted on the Snake and Clearwater River traps yielded recapture rates less thanO.2 (20%). These low proportions, (or percentages), fom a binomial rather than normal distribution. To normalize the trap efficiency data, an $\arcsin \sqrt{x}$ transformation (Zar 1984) was used where:

$$TE' (\text{or } P') = \tfrac{1}{2}[\arcsin \sqrt{x/(n+1)} + \arcsin \sqrt{(x+1)/(n+1)}].$$

All subsequent analyses, including the trap efficiency-discharge regressions, were conducted with the transformed data.

The analysis of covariance was used to detemine if there was a significant difference in trap efficiencies among years. If no significant difference existed, the analysis of covariance was continued to determine if trap efficiency varies from year to year when adjusted for discharge. If no statistical difference existed, the data were pooled over years and a single regression line fitted between river discharge and trap efficiency. Each test was performed at the 0.05 level of significance.

Trap efficiency tests can utilize three different release procedures. The first procedure utilizes fish released directly from a hatchery or part of a hatchery-transported release group, when that hatchery or release group was less than 80 km upriver from the trapping facility. The second procedure utilizes small groups of fish, approximately 2,000 fish for chinook salmon and 4,000 fish for steelhead trout, that have been freeze branded (Mighell 1969) at a hatchery and held there until transported to a release site upstream of the trap for release at sunset. Sample size differences between test groups of chinook salmon and steelhead trout juveniles relate to the trap efficiency of the species and the number of recaptures needed for statistical reliability. Five or more recaptures per test were needed for trap efficiency estimates to be statistically reliable. The third procedure of estimating trap efficiency utilizes trap-caught fish that were marked, transported back upstream the same day, and released to pass the trap a second time.

Trap efficiency tests were conducted for steelhead trout throughout the migration season on the Snake River by releasing trap-caught marked smelts 8 km upriver from the trap. Due to the low chinook salmon catch at the Snake River trap in 1990, no chinook salmon trap efficiency tests were conducted.

Trap efficiency tests were conducted throughout the migration season on the Clearwater River by releasing marked smelts 7 km upriver from the trap site.

Travel Time and Migration Rates

Migration statistics were calculated for hatchery release groups from release sites to traps and through Lower Granite Reservoir. Travel time and migration rates to the traps and through Lower Granite Reservoir were calculated using median arrival times at the Snake and Clearwater river traps and at Lower Granite Dam for hatchery brand groups and brand groups used for trap efficiency tests. Median arrival (or passage) date is the sample date the 50th percentile fish arrived at the trap or collection facility. Smelts were PIT-tagged at the Snake and Clearwater river traps as the primary method to determine travel time from the head of Lower Granite Reservoir to Lower Granite and Little Goose dams. Distances from release point to recovery location are listed in Table 1. Daily individual arrival times of these fish at Lower Granite and Little Goose dam collection facilities were determined. A minimum recapture number, sufficient for use in travel time and migration rate estimations, was derived from an empirical distribution function of the travel time for each individual release group (Steinhorst et al. 1988). If recapture numbers were less than five or less than the number derived from the empirical distribution function, the daily data were combined with another days data or the data were not used. If it was combined, it was added to daily data from an adjacent release day which had similar discharge and travel time.

Smelt migration rate-discharge relations through Lower Granite Reservoir were investigated using linear regression analysis after both variables were log (in) transformed (Zar 1984). The 0.05 level was used to determine significance. This analysis was performed for the hatchery freeze-branded chinook salmon and steelhead trout groups and for the PIT-tagged chinook salmon, hatchery steelhead trout and wild steelhead trout groups marked at the Snake or Clearwater river traps.

To remove some of the “noise” often associated with biological data and better show the underlying biological relation, migration rate was stratified into five kcfs discharge intervals (Mosteller and Tukey 1977:75). A linear regression analysis was conducted on this grouped data.

A linear regression analysis was perfomed on the migration rate discharge data for PIT-tagged fish released from the Snake and Clearwater River traps and interrogated at Little Goose Dam. Data that had been stratified into five kcfs discharge intervals and log transformed were used in the analysis.

The migration rate-discharge relations for PIT-tagged chinook salmon, hatchery steelhead trout, and wild steelhead trout were individually examined for 1987-1990 to detemine if the relations were different between years. Using an analysis of covariance, with the migration rate data averaged by 5-kcfs groups, the first underlying assumption of equality of slopes was tested. If the hypothesis of equality of migration rate-discharge slopes among years was

Table 1. River mile and kilometer location for the Snake River drainage.

	Mouth of Columbia River		Mouth of Snake River		Lower Granite Dam		Snake River trap site		Clearwater River trap site		Salmon River trap site	
	mi	km	mi	km	ml	km	mi	km	mi	km	mi	km
Mouth of Snake River	324.3	521.8	0.0	0.0	107.5	172,9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0	0.0	0.0	32.1	51.6	38.3	61.5	133.9	215.4
Clearwater R. trap site	470.0	756.2	145.7	234.4	38.2	61.5			0.0	0.0		
Highway 95 boat launch	473.2	761.4	148.9	239.6	41.5	66.8			3.2	5.1		
Dworshak NFH	504.3	811.4	180.0	289.6	72.5	116.6			34.3	55.2		
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7			71.5	115.0		
Crooked River	604.3	972.3	280.0	460.5	172.5	277.6			134.3	2?6.0		
Red River Rearing Pond	618.0	994.4	293.7	472.6	186.2	299.6			148.0	238.1		
Snake River trap site	463.9	746.4	139.6	224.6	32.1	51.6	0.0	0.0			101.8	163.8
Asotin Creek rel. site	470.3	756.7	146.0	234.9	38.5	61.9	6.4	10.3				
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8				
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0				
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4				
Big Canyon Creek	585.9	942.7	261.6	420.9	164.1	247.9	122.0	196.3				
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2				
Catherine Creek	636.9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4				
Mouth of Salmon River	512.5	824.6	188.2	302.8	80.7	129.8	48.6	78.2			53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8				
Little Sheep Creek	553.8	891.1	229.5	369.3	122.0	196.3	89.9	144.6				
Imnaha coll. facility	665.6	910.2	241.3	388.3	133.8	215.4	101.7	163.6				
Hal 1s Canyon Dam	571.3	919.2	247.0	397.4	139.5	224.5	107.4	172.8				
Salmon River trap site	565.7	910.2	241.4	388.4	133.9	215.4	101.8	163.8			0.0	0.0
Rapid River Hatchery	605.8	974.7	281.5	452.9	174.0	280.0	141.9	228.3			40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154.8	249.1			53.0	85.3
SF Salmon @ Knox Bridge	719.7	1158.0	395.4	636.2	287.9	463.2	255.8	411.6			154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353,6	668.9			251.8	405.1
EF Salmon @ trap site	873.6	1405.6	649.3	883.8	441.8	710.9	409.7	659.2			307.9	495.4
Sawtooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8			331.9	534.0

not rejected, then the subsequent analysis of **covariance** was completed. This was basically a test of whether the regression lines relating migration rate and discharge for each year had a common intercept, or whether one regression line was higher than another. If the final hypothesis of common intercepts was not rejected, then there was not a significant difference in the migration **rate-**discharge relations among years, and the yearly data were pooled. **After** pooling, a linear regression analysis was run to provide the best fitting equation to describe the relation between migration rate and discharge for an individual species over several years.

Minimum Survival of **PIT-tagged** Fish

Estimates of minimum survival of PIT-tagged fish, marked at the head of Lower Granite Reservoir, to Lower Granite Dam collection facility included data from 1988, 1989, and 1990 for the Snake River trap and 1989 and 1990 for the Clearwater River trap. Using both chinook salmon and steelhead trout smelts marked throughout the sampling season, a "Minimum Survival Estimate" from the trap to Lower Granite Dam was derived. This minimum estimate consists of fish that were interrogated at Lower Granite, Little Goose, or McNary dams. The data has been examined to insure that multiple interrogations within a dam and between dams have been removed. The basis for the minimum survival estimate at Lower Granite is that fish that were interrogated at Lower Granite, Little Goose, or McNary dams were alive when they passed Lower Granite. This estimate is held to be a "minimum" estimate because there are fish that passed all three dams without being detected and mortality that occurs downstream of Lower Granite Dam.

Lengths of fish tagged at the Snake and Clearwater River traps, and later interrogated downstream, were grouped by 5-mm intervals for an analysis of minimum survival versus length for PIT-tagged fish. The relations between the size of the fish PIT-tagged and their minimum survival to Lower Granite Dam was examined using 1988, 1989, and 1990 data for the Snake River trap. The data from 1987 was not used in the analysis because it was biased, as only 'quality' looking fish were tagged that year. The Clearwater River trap analysis consisted of 1989 and 1990 data.

RESULTS AND DISCUSSION

Hatcherv Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage upstream from Lower Granite Dam were reared at seven locations in Idaho and three in Oregon. The Washington Department of Fisheries released no chinook salmon juveniles in the

Snake River drainage upstream from Lower Granite Dam that contributed to the 1990 outmigration. A total of 13,282,545 chinook salmon smelts were released at 17 locations in Idaho and 8 locations in Oregon (Table 2).

During the late summer and fall of 1989, four groups of chinook salmon juveniles were released from Idaho hatcheries. All other chinook salmon releases for the 1990 outmigration were made in the spring of 1990 (Table 2).

Steelhead Trout

Steelhead trout were reared at four locations in Idaho, one in Washington, and three in Oregon for release into the Snake River drainage upstream from Lower Granite Dam. A total of 11,377,967 steelhead trout smelts were released at 16 locations in Idaho, 8 locations in Oregon, and 2 locations in Washington (Table 3). Fall releases of steelhead juveniles have not been included in this total.

Smelt Monitoring Traps

Snake River Trap Operation

The Snake River trap caught 5,258 age 1 chinook salmon, 29 age O chinook salmon, 19,940 hatchery steelhead trout, 3,427 wild steelhead trout, and 325 sockeye/kokanee *Oncorhynchus nerka*. Chinook salmon catch at the Snake River trap for 1990 was similar to other low flow years (1987 and 1988) and considerably lower than 1984-1986 or 1989, normal or above normal flow years. There appears to be a threshold velocity within the trap required to effectively collect chinook salmon. Below this threshold velocity, which is about 1.6 to 1.8 feet per second, trap efficiency is very low and chinook salmon trap catch may not be representative of the chinook salmon population passing the trap. The threshold velocity is generally exceeded when discharge is above 27,000 to 33,000 Cfs. The outmigration pattern was similar to other years (Figure 2).

There were three major peaks in hatchery steelhead trout passage. The first began in mid-April and lasted until the end of the month (Figure 3). The second began on May 6 and lasted until May 19. This period had the second highest daily catch for the season of 1,321 hatchery steelhead trout, which occurred on May 7. The third peak began on May 25 and lasted until June 2. This period had the highest daily catch of 1,637 hatchery steelhead trout on May 30.

Thirty percent of the hatchery steelhead trout were captured in April, 63% in May, and 7% in June. This is similar to 1989, although 5% more hatchery steelhead trout migrated in June 1990, indicating that the hatchery steelhead trout migration was slightly delayed this year. Wild steelhead trout passage was earlier than hatchery steelhead trout, with 0.7% captured in March, 44.7%

Table 2. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam contributing to the 1990 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Salmon River				
Sawtooth Hatchery	Spring	10/12/89	395,400	
	(Sawtooth)	3/17-21	1,500,200	
		(3/17)	(19,875)	LAT- 1
		(3/17)	(18,675)	LAT-3
		(3/17)	(18,775)	LAT-4
East Fork Salmon River (Sawtooth)	Spring	3/21	514,600	
Yankee Fork Salmon River (Sawtooth)	Spring	3/20	200,000	
South Fork Salmon River (McCall)	Summer	3/20-22	1,032,500	
		(3/21)	(20,200)	LDT-1
		(3/22)	(21,100)	LDT-3
		(3/21)	(20,900)	LDT-4
Johnson Creek (McCall)	Summer	8/9-10/89	290,000	
Pahsimeroi River (Pahsimeroi)	Summer	3/19	1,058,000	
Rapid River (Rapid River)	Spring	3/22-26	2,520,400	
		(3/22)	(20,600)	RAT- 1
		(3/22)	(20,175)	RAT-2
		(3/22)	(19,975)	RAT-3
Little Salmon River	Spring	3/20	250,000	
	Drainage Total		7,761,900	
Snake River and Non-Idaho Tributaries				
Hells Canyon (Rapid River)	Spring	3/22	551,200	
Catherine Creek (Lookingglass)	Spring	4/9	70,002	
Big Canyon Creek (Lookingglass)	Spring	3/31	91,433	

Table 2. Continued.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Lookingglass Creek (Lookingglass)	Spring	4/2	619,630	
		(4/2)	(20,406)	LAA-2
		(4/2)	(20,841)	RAA-2
		(4/2)	(20,738)	LAA-4
		(4/2)	(20,801)	RAA- 4
Imnaha River (Imnaha Pond)	Spring	3/31	249,793	
		(3/31)	(20,815)	LAA- 1
		(3/31)	(20,170)	RAA- 1
(Lookingglass)		4/2-4	114,722	
Big Sheep Creek (Lookingglass)	Spring	4/2	79,947	
Grand Ronde R-2 (Lookingglass)	Spring	4/9	80,043	
Hurricane Creek (Lookingglass)	Spring	4/10	26,438	
Wallowa River (Lookingglass)	Spring	4/10	26,442	
	Drainage Total		1,909,650	
<u>ClearWater River</u>				
Red River Pond (Red River Pond)	Spring	10/18/89	240,500	
N.F. Clearwater (Dworshak NFH)	Spring	4/4-5	1,240,161	
		(4/5)	(1,418)	LAK-2
		(4/5)	(20,239)	RA7U- 1
		(4/5)	(19,900)	RA7U-3
		(4/5)	(19,730)	LD7U- 1
Clearwater River HWY 95 Boat Launch (Dworshak NFH)	Spring	3/21-4/2	11,266	
		(3/21)	(2,609)	LDK- 1
		(3/26)	(2,266)	LDK-3
		(3/28)	(2,195)	LAK- 1
		(3/30)	(2,061)	LDK-2
		(4/2)	(2,135)	LDK-4
Crooked River (Kooskia NFH)	Spring	3/28	300,400	

Table 2. Continued,

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
White Sands Creek				
(Dworshak NFH)	Spring	3/26-28	236,000	
(Kooskia NFH)	Spring	3/29	53,300	
Walton Creek (Powell Pond)	Spring	10/19/89	314,500	
Clear Creek (Kooskia NFH)	Spring	4/12	403,700	
Eldorado Creek (Dworshak NFH)	Spring	3/26-28	256,900	
Papoose Creek (Kooskia NFH)	Spring	3/29	50,100	
	Drainage Total		3,610,995	
	Grand Total		13,282,545	

Table 3. Hatchery steelhead trout released into the Snake River system upriver from Lower Granite Dam contributing to the 1990 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Salmon River				
Salmon River @ North Fork (Hagerman NFH)	A	4/18-20	199,602	
Pahsimeroi River (Niagara Springs)	A	4/5-15	501,600	
East Fork Salmon River				
(Hagerman NFH)	B	4/11	64,150	
(Magic Valley)	B	4/14-20	924,200	
		(4/14)	(40,907)	RA) (-1
Sawtooth Hatchery				
(Hagerman NFH)	A	4/4-9	301,156	
(Magic Valley)	A	4/12-20	1,198,700	
		(4/12)	(39,454)	LA) (-1
Hammer Creek (Niagara Springs)	A	4/9-20	229,000	
Salmon River @ Ellis (Hagerman NFH)	A	4/9-11	200,295	
Salmon River @ Shoup (Hagerman NFH)	A	4/12-16	200,246	
Hazard Creek				
(Niagara Springs)	A	4/9-17	225,500	
(Hagerman NFH)	A	4/23-5/1	80,465	
	B	4/23-5/1	393,352	
	Drainage Total		5,743,700	
Snake River and Non-Idaho Tributaries				
Hells Canyon (Niagara Springs)	A	4/22-29	947,200	
Little Sheep Creek (Irrigon)	A	4/17	249,564	
		(4/17)	(26,522)	LDJ-3
		(4/17)	(24,500)	RDJ-3

Table 3. Continued.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Spring Creek	A	4/15-23	495,875	
(Irrigon/Wallowa		(4/17)	(24,233)	LDA- 1
accl. pond)		(4/17)	(25,478)	RDA- 1
		(4/17)	(24,903)	LDA-3
		(4/17)	(25,426)	RDA-3
(Irrigon)		4/19	53,747	
		(4/19)	(24,569)	LDA-2
		(4/19)	(24,228)	RDA-2
Wildcat Creek	A	4/24-26	97,605	
(Irrigon)		(4/25)	(24,739)	LDA- 4
		(4/25)	(22,983)	RDA-4
Grande Ronde (R2) (Irrigon)	A	4/12-17	199,013	
Catherine Creek (Irrigon)	A	4/18-23	112,412	
Wallowa River (Irrigon)	A	4/18-27	83,137	
Big Canyon Creek (Irrigon)	A	4/19 & 30	273,415	
Imnaha River (Irrigon)	A	4/25-26	81,902	
Asotin Creek	A	4/17-30	137,847	
(Lyons Ferry)		(4/17)	(20,142)	LAIC-4
		(4/18)	(19,905)	RAIC-4
Cottonwood Creek (Lyons Ferry)		4/15-30	239,000	
	Drainage Total		2,970,717	
Clearwater River				
Clearwater River	B	5/3-4	1,166,664	
(Dworshak)		(5/3)	(30,000)	RAT- 1
		(5/3)	(30,000)	RAZ-1
		(5/3)	(4,120)	RDK- 1
		(5/3)	(4,010)	RDK-2
		(5/3)	(4,160)	RDK-3
		(5/3)	(4,080)	RDK-4
		(5/3)	(4,052)	RAK- 1
		(5/3)	(4,410)	RAK-2

Table 3. Continued.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Mill Creek (Dworshak NFH)	B	4/16-25	287,830	
Newsome Creek (Dworshak NFH)	B	4/16-24	210,836	
Clear Creek (Dworshak NFH)	B	4/1 6-25	374,040	
Crooked River (Dworshak NFH)	B	4/16-20	214,633	
Eldorado Creek (Dworshak NFH)	B	4/23-25	199,700	
American River (Dworshak NFH)	B	4/17-19	209,847	
	Drainage Total		2,663,550	
	Grand Total		11,377.967	

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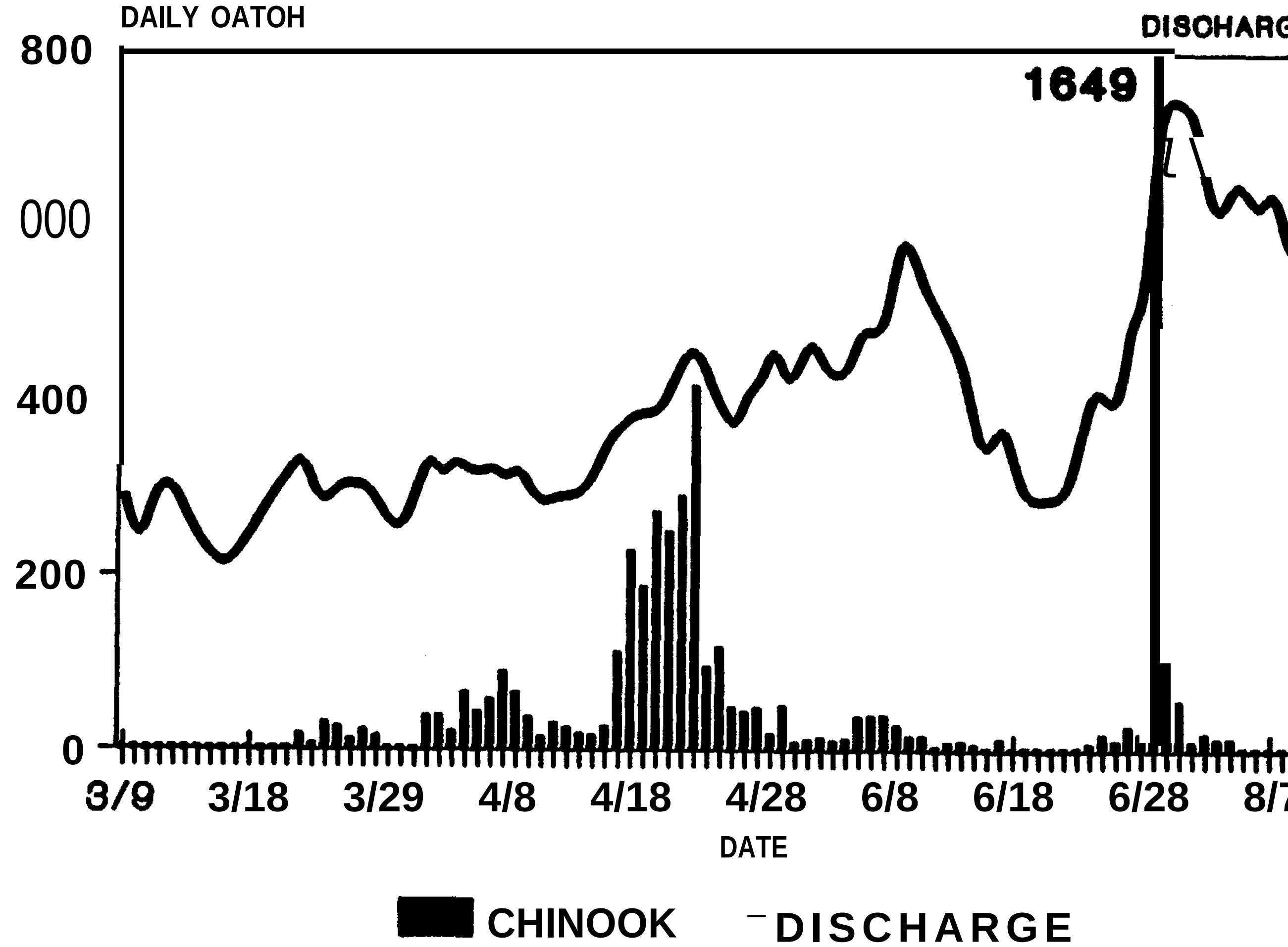

Figure 2. Snake River trap daily catch of age 1 chinook salmon
by the Snake River discharge, 1990.

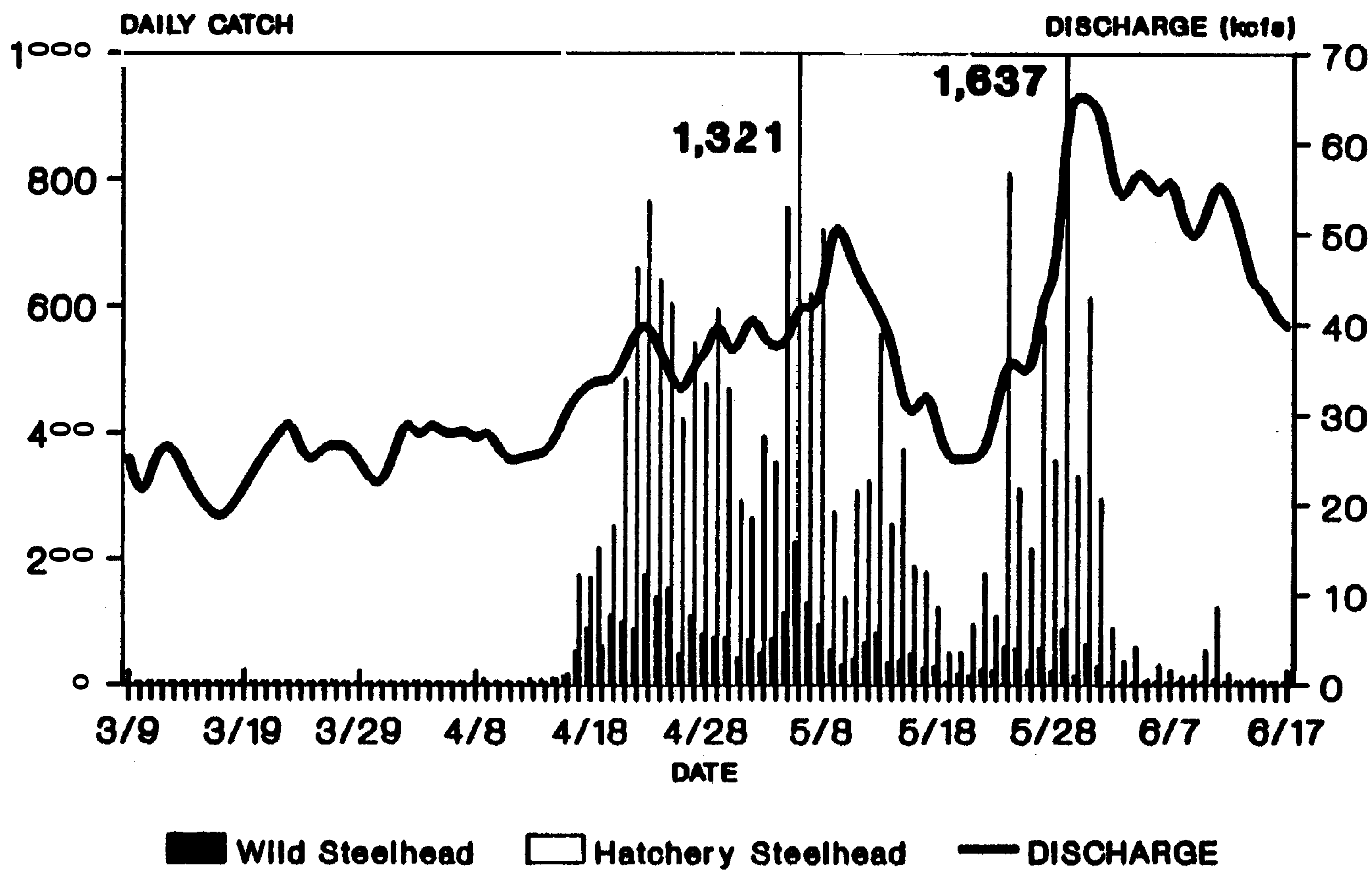

Figure 3. Snake River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Snake River discharge, 1990.

in April, 50.9% in May, and 3.7% in June (Figure 3). The **outmigration** timing was similar to 1989, but as with hatchery steelhead trout, it was slightly delayed.

The Snake River trap catch for wild steelhead trout was 1.3 times greater than in any previous year. This reflects an increase in wild steelhead trout smelt outmigration. A similar trend was observed at Lower Granite Dam, with the 1990 wild steelhead trout collection being 1.3 times greater than in previous years (Ceballos et al. In Press). Wild steelhead trout had three major periods of movement. These coincided with the three major periods of movement for hatchery steelhead trout (Figure 3).

Snake River discharge, measured at the Anatone gauge, ranged from 18,500 cfs to 29,800 cfs and averaged 24,100 cfs in the month of March (Figure 3), which was 16,500 cfs lower than in 1989. The average April discharge was 30,900 cfs, with a peak of 41,300 cfs on April 30. The April average was 27,600 cfs lower than in 1989. Flows gradually declined through the first half of May to a monthly low of 24,900 cfs on May 20. Discharge began gradually increasing through the end of May to the season's peak of 65,400 cfs on May 31. The average May discharge was 38,800 cfs, which was 13,300 cfs lower than in 1989. Flows continually dropped after the end of May until the end of the sampling season on June 19, when discharge was 39,800 cfs. Discharge during the 1990 outmigration season in the Snake River above the mouth of the Clearwater River was slightly greater than discharge during the 1988 drought year and considerably lower than in 1989.

Water temperature in the Snake River at the trap steadily increased throughout the sampling season, except for a decrease of 3°C from April 20 through May 2 and another depression of 3°C in early June (Figure 4). By the end of the season, June 19, water temperature had risen to 15°C. Water temperatures were slightly higher in April and May 1990 than in those months of 1989.

Secchi disc transparency fluctuated throughout the sampling season (Figure 4). Influenced mainly by localized rain or thunderstorm events, secchi transparency shows no biological correlation to discharge ($N=101$, $r^2=0.130$, $P=0.000$).

Clearwater River Trap Operation

The Clearwater River trap caught 58,838 chinook salmon, 29,459 hatchery steelhead trout, 1,520 wild steelhead trout, and 89 sockeye/kokanee in 1990. The chinook salmon trap catch for 1990 was about 10 times greater than in 1989 and similar to 1988. The 1990 hatchery steelhead trout trap catch was 3 times greater than in any previous year. The wild steelhead trout trap catch was 1.7 times greater than in previous years. The reason hatchery and wild steelhead trout trap catch was greater in 1990 was because the trap was fished in faster water and because more wild steelhead trout smelts outmigrated this year. Steelhead trout had less chance to avoid the trap with higher velocity, and the

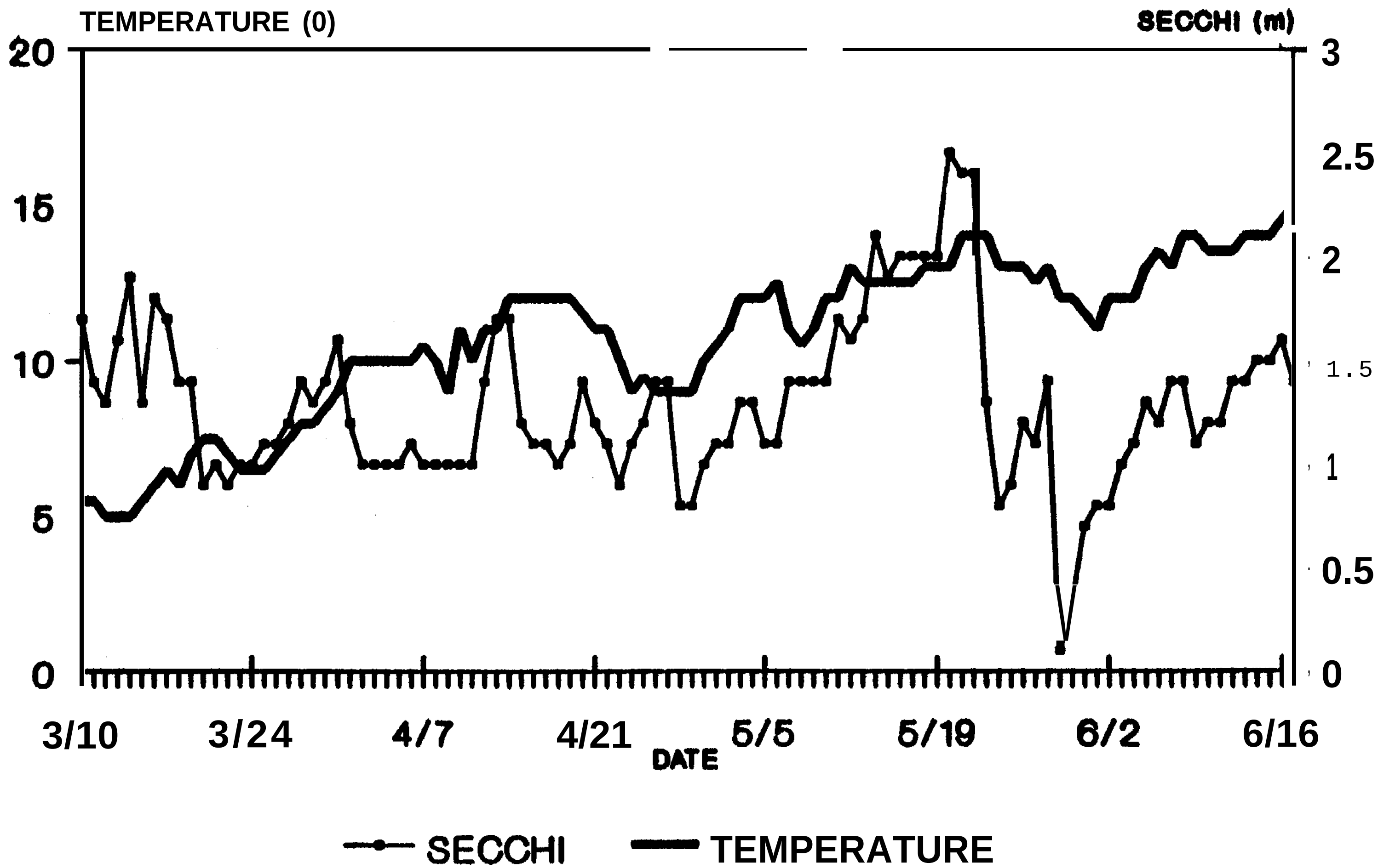

Figure 4. Daily temperature and secchi disk transparency at the Snake River trap, 1990.

trap was fished in the thalweg for a greater portion of the season. The radio tagging study conducted by Liscom and Bartlett (1988) in 1987 showed that radio-tagged hatchery steelhead trout followed the thalweg as they passed the Clearwater River trap location. Chinook salmon probably also follow the thalweg, and so by operating the trap in that location for a greater amount of time, the trap will collect more chinook salmon. This is substantiated by the ten-fold increase in chinook salmon trap catch from 1989 to 1990. During the 1989 field season, the trap was not operated as aggressively as it was in the 1990 field season and, therefore, was not located in the thalweg as long. During the 1987 and 1988 low flow years, when the trap could be fished in the thalweg during most of the outmigration, chinook salmon trap catch was similar to 1990.

Four major peaks of chinook salmon passage were observed at the ClearWater River trap (Figure 5). The first began on March 30 and peaked on April 2. This peak may have been associated with chinook salmon passing the trap from outplants and fall releases from the rearing ponds at Powell and Red River. The second peak was on April 5 and 6 and was associated with the Dworshak National Fish Hatchery (DNFH) release. The third peak was on April 13-16 and was probably associated with fish from the Kooskia National Fish Hatchery (KNFH) release on April 12. The last peak was of low magnitude and fairly broad, lasting from May 18 through May 25. It is uncertain as to the origin of these fish. After this peak, the trapping operation was terminated for the season due to high flows.

Hatchery steelhead trout began showing up in the trap catch in low numbers (>30 fish per day) on April 18. A major peak occurred on May 4 and 5 and was associated with the DNFH release (Figure 6). Discharge increased dramatically on May 8, and trap operation was terminated until discharge dropped below 30,000 Cfs . The trap was put back into operation on May 16. Fish were collected at 250 to 500 fish per day until the end of the season on May 25.

Wild steelhead trout were present in the trap catch in low numbers (one to four fish per day) from March 20 until April 3. Three major peaks of passage occurred. The first began on April 4 and lasted until April 15 (Figure 6). The second began on April 27 and was still occurring when trap operation was terminated due to high flow on May 8. The last and major peak was occurring when the trap was put back into operation on May 17. The peak continued until trap operation was terminated for the season on May 25. This peak my have been a continuation of the peak that occurred in early May. The highest daily trap catch of wild steelhead trout occurred May 23 and 24 (Figure 6).

Water temperature at the Clearwater River trap was 5*C the beginning of the season and gradually increased to 13*C by the end of May (Figure 7). Water temperatures throughout the season were similar to previous years, although 1987 drought year temperatures were slightly higher.

Discharge fluctuated between 10,400 cfs and 22,600 cfs and averaged 17,100 cfs from the beginning of the season until April 14. Discharge increased to 33,200 cfs on April 21 and then dropped back down to 22,000 cfs by May 3. Discharge remained at this level for several days, and on May 5 it began to

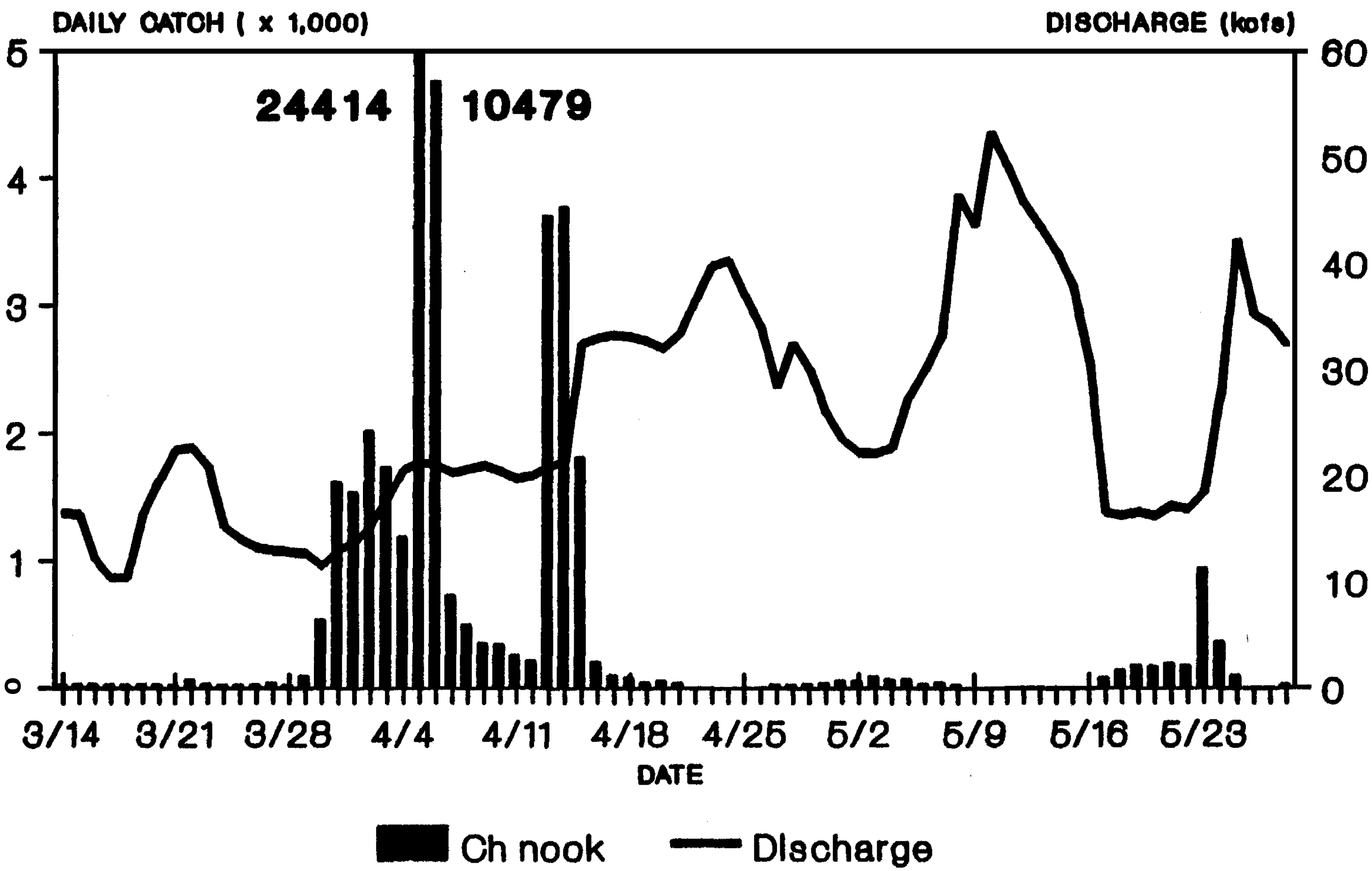

Figure 5. Clearwater River trap daily catch of age 1 chinook salmon overlaid by Clearwater River discharge, 1990.

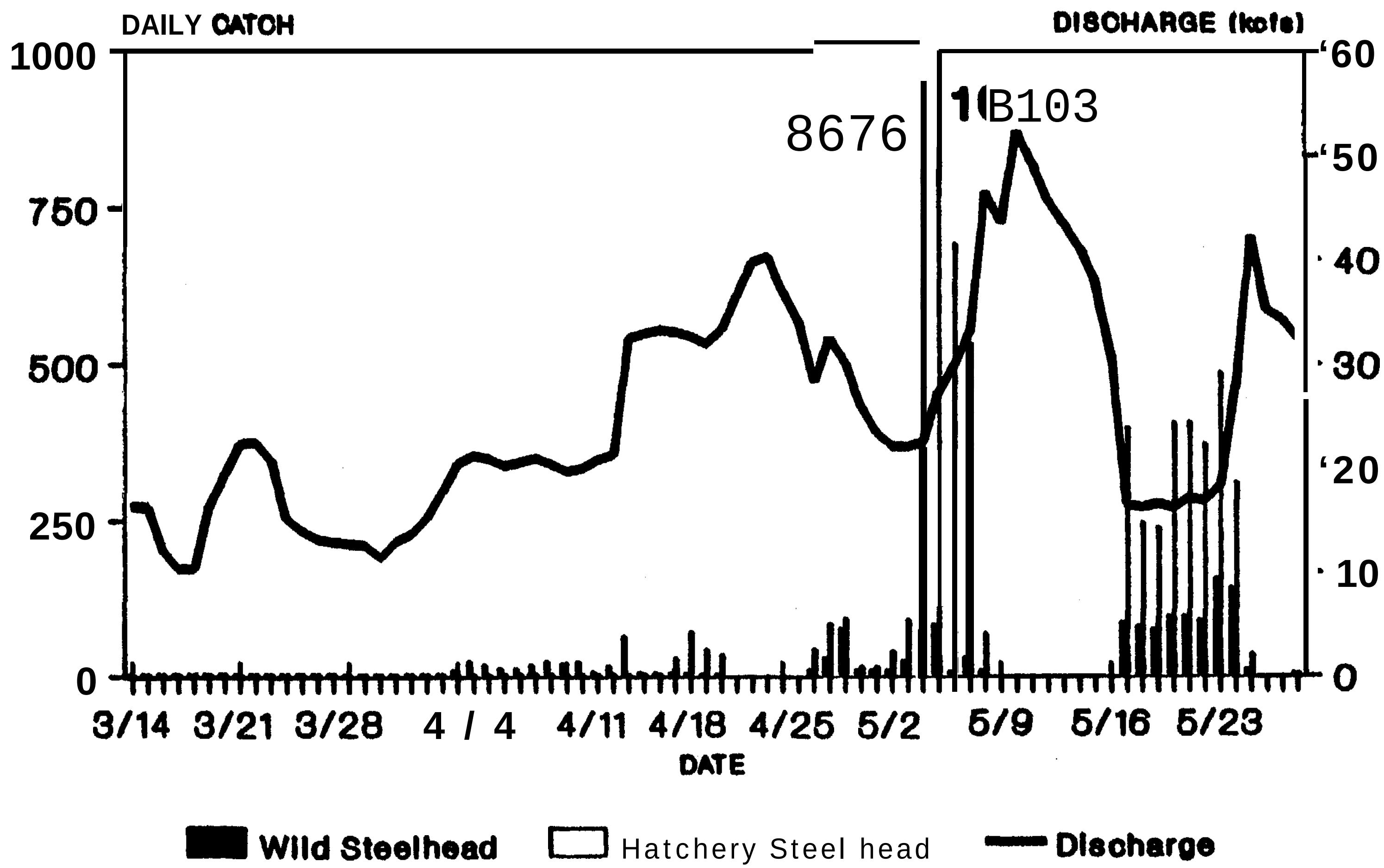

Figure 6. Clearwater River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River discharge, 1990.

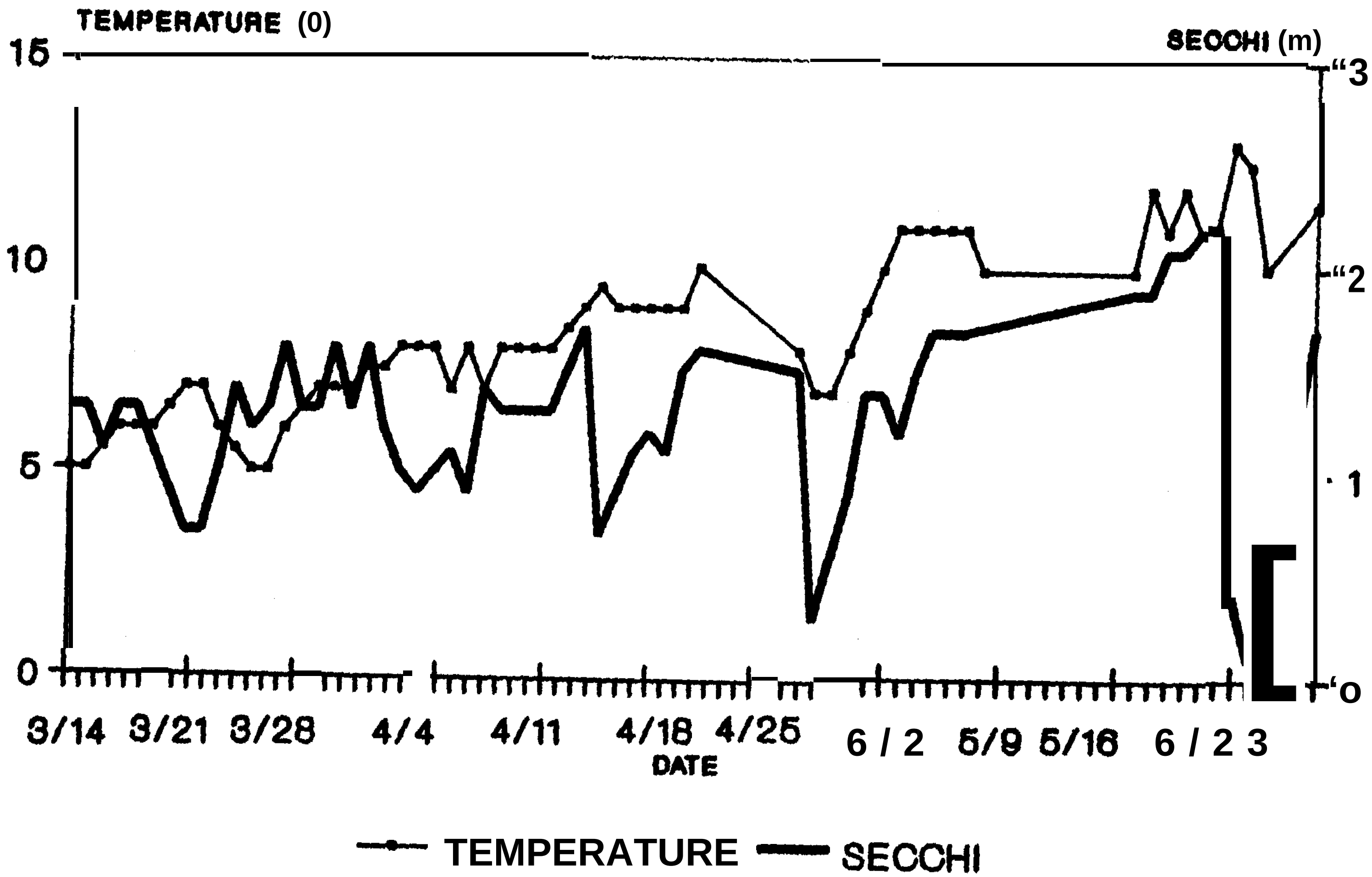

Figure 7. Daily temperature and secchi disk transparency at the ClearWater River trap, 1990.

increase, peaking on May 8 at 46,300 cfs. This last peak was associated with the "water budget."

Secchi disc transparency in the Clearwater River fluctuated throughout the trapping season and ranged from 0.1 meters to 2.2 meters (Figure 7). There was little statistical correlation between secchi disc transparency and discharge (N=61, r^2=0.171, P=0.001).

Trap Efficiency

Snake River Trap

Chinook Salmon-Trap efficiency for chinook salmon smelts at the Snake River trap was not tested in 1990. Due to a reduced number of chinook salmon smelts in the trap, sufficient numbers of fish were not available for trap efficiency estimates. The mean trap efficiency for chinook salmon at the Snake River trap, with four yearly estimates during the past seven years, is 1.39% (Table 4). All four of these estimates were made when the trap was fishing on the west side of the river. Trap efficiency estimates have not been conducted yet for chinook salmon smelts with the trap fishing on the east side of the river.

Steelhead Trout-Trap efficiency for steelhead trout smelts was tested three times during the 1990 smelt outmigration (Table 5). All tests utilized trap-caught fish. Seven groups of trap-caught steelhead trout were opercle punched and released upriver of the trap to estimate trap efficiency. Four of these groups were disallowed; two because of low mark numbers and two because of low recapture numbers (less than five recaptures). The 1990 data yielded a mean trap efficiency of 0.49% and 95% confidence limits of 0.13% and 1.08%.

The analysis of covariance, to test if trap efficiency varies among years when adjusted for discharge, was not valid due to the limited data available in 1985 and 1986. The analysis was conducted using data from 1988-1990. No significant difference was observed for the three years of data, and the data were pooled. A regression analysis was conducted on the pooled data to determine if there was a relation between discharge and trap efficiency. The analysis failed to showed a significant relation (N=10, r^2=0.001, P=0.937).

To provide a grand mean trap efficiency, all five years of data (1985, 1986, and 1988-1990) were pooled. The five-year grand mean of the Snake River trap efficiency for hatchery steelhead trout was 0.68% with a 95% confidence interval of 0.43% and 0.97%.

Table 4. Snake River trap efficiency tests for chinook salmon smelts, 1984 - 1990.

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
1990	No efficiency tests conducted for chinook in 1990				
1989	trap caught	4/5	13/1,054	0.0123	46
		4/10	23/1,076	0.0214	55
		4/18	14/1,233	0.0114	66
		4/19	9/1,719	0.0052	73
		4/23	10/2,001	0.0050	73
		4/24	5/584	0.0086	68
1988	No efficiency tests conducted for chinook in 1988				
1987	No efficiency tests conducted for chinook in 1987				
1986	trap caught	3/29	23/1,881	0.0122	86
		4/7	13/1,237	0.0105	80
		4/12	26/1,530	0.0170	74
		4/24	11/1,417	0.0078	80
1985	trap caught	3/22	11/1,124	0.0098	43
		4/2	31 /840	0.0250	56
		4/6	7/1,092	0.0064	64
		4/12	15/1,276	0.0118	77
		4/16	12/915	0.0131	80
1984	trap caught	3/2	26/1,388	0.0187	84
		3/28	10/545	0.0183	75
		4/12	7/309	0.0227	81
		4/16	9/806	0.0112	92
		4/19	23/1,061	0.0217	104
		4/24	8/812	0.0098	101
		4/28	5/267	0.0187	86

Table 5. Snake River trap efficiency tests for steelhead trout smelts, 1985 - 1990.

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
1990	trap caught	4/23	10/1,484	0.0067	38
		4/26	11/2,400	0.0046	38
		5/7	7/2,306	0.0030	43
1989	trap caught	4/26-28	6/1,916	0.0031	60
		5/1&2	31/2,397	0.0129	55
		5/3&4	7/2, 137	0.0033	57
1988	trap caught	5/13	7/2057	0.0034	38
		5/15	5/1822	0.0027	42
	hatchery releases	5/23	54/3977	0.0136	45
		5/23	32/3996	0.0080	45
1987	No efficiency tests conducted for steelhead smelts in 1987				
1986	trap caught	4/30	12/874	0.0137	72
1985	trap caught	5/4	8/81 1	0.0099	55

Clearwater River Trap

Chinook Salmon-During the 1990 field season, chinook salmon smelt trap efficiency at the Clearwater River trap was tested nine times. Four of the tests used freeze brand groups that comprised part of the DNFH production release. The remaining five tests used freeze brand marked fish from DNFH that were released at the Highway 95 boat launch. The 1990 mean trap efficiency was 1.41% with 95% confidence limits of 1.03% and 1.86%. Between 1984 and 1989, an additional 42 trap efficiency tests were conducted on the ClearWater River trap for chinook salmon smelts (Table 6). These data were added to the 1990 information. The analysis of covariance revealed a significant difference in trap efficiency among years (N=51, F=4.334, P=0.002). Upon examination of the yearly efficiency data, the 1989 appeared to be significantly different. The 1989 data were removed and the analysis of covariance rerun. Without the 1989 data, the slopesof the other years data were not significantly different (N=42, F= 0.696, P=0.630). Continuing with the analysis, the intercepts (height) of the lines were not found to be significantly different (N=42, F=1 .081, P=0.388). The mean chinook salmon trap efficiency for the pooled data, excluding 1989, was 1.87% with 95% confidence limits of 1.51% and 2.26%. The mean trap efficiency for 1989 was 1.04%, which was considerably lower than that of the pooled years.

Steelhead Trout-Steelhead trout trap efficiency at the Clearwater River trap was tested with six groups of freeze-branded steelhead smelts, of approximately 4,000 fish each, in 1990. All six of these groups were released the same day from DNFH, along with the general hatchery production release. Raceway screens to keep the groups separate did not work and the groups mixed. Because the groups were mixed, they had to be released on the same day to be used for efficiency tests, so they were released with the general hatchery production. There were two other groups of freeze-branded hatchery steelhead trout, representative of the general hatchery production, released from DNFH. They were branded in December 1989, and the brands had faded to the point where these two groups could not be used for efficiency tests. The 1990 mean trap efficiency was 1.90% with 95% confidence limits of 1.42% and 2.46% (Table 7). This is the highest trap efficiency observed for the Clearwater trap. One possible explanation for this increased efficiency is the trap was in an ideal fishing location, with respect to water conditions, during the test period. This type of positioning is difficult to maintain throughout a sampling season because the trap fishes such fast water that slight increases in discharge or debris load could be detrimental to the traps integrity.

During the past six years, Clearwater River trap efficiency for steelhead trout has been tested 20 times. Only 14 of these tests yielded valid results (Table 7). The other six had recovery numbers less than five and could not be used in the analysis. An analysis of covariance shows a significant difference in trap efficiency among years (N=14, F=30.439, P=0.000). Therefore, data from all years were not pooled to derive any statistical inference.

Table 6. Clearwater River trap efficiency tests for chinook salmon smelts, 1984 - 1990.

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
1990	Hwy 95 boat launch	3/21	27/2,609	0.0103	22
		3/26	28/2,266	0.0124	13
		3/28	37/2,195	0.0169	13
		3/30	56/2,061	0.0272	12
		4/2	33/2,136	0.0154	17
	DNFH	4/5	23/1,418	0.0162	21
		4/5	180/20,239	0.0089	21
		4/5	163/19,900	0.0082	21
		4/5	282/19,730	0.0143	21
1989	Hwy 95 boat launch	3/21	7/2,076	0.0034	17
		3/23	10/2,065	0.0048	15
		4/3	39/2,094	0.0186	20
		4/5	41/2,075	0.0200	21
	DNFH release	3/29	66/34,795	0.0019	24
		3/29	73/30,503	0.0024	24
		3/30	41/19,087	0.0021	23
		3/30	48/19,545	0.0025	23
		3/30	78/20,084	0.0039	23
1988	Hwy 95 boat launch	3/14	51/2,197	0.0232	6
		3/17	93/2,197	0.0423	6
		3/21	83/2,197	0.0378	6
		4/1	27/2,195	0.0123	9
		4/6	18/2,194	0.0082	11
		4/13	31/2,193	0.0141	14
	DNFH release	3/30	1711/60,631	0.0282	10
		3/30	252/8,731	0.0289	10
		3/30	181/6,163	0.0294	10
		3/30	788/20,642	0.0382	10
		3/30	573/22,935	0.0250	10
	trap caught	3/24	17/2086	0.0081	9
		3/28	27/1695	0.0159	12
		4/1	16/1631	0.0098	9
		4/2	38/2257	0.0168	8
1987	DNFH release	3/20	43/2,160	0.0199	13
		4/22	50/2,000	0.0250	6
		4/7	165/1,945	0.0848	10
		4/13	74/2,000	0.0370	13
		4/20&28	103/4,000	0.0258	18

Table 6. Continued.

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
	trap	4/2	33/1,926	0.0171	6
	caught	4/3	11/1,458	0.0075	8
		4/6	15/1,872	0.0080	9
		4/7	15/1,163	0.0129	10
		4/9	9/450	0.0200	12
1986	trap	3/27	9/1 ,555	0.0058	22
	caught	4/2	8/1,714	0.0047	29
1985	trap	3/25	14/607	0.0230	9
	caught	3/30	45/1,511	0.0298	9
		4/5	6/1,079	0.0056	18
		4/9	2/940	0.0021*	15
		4/16	7/929	0.0075	33
1984	trap	4/5	4/418	0.0096*	21
	caught	4/21	13/806	0.0161	33
		4/25	3/489	0.0061*	31
		5/10	14/453	0.0309	24

* Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

Table 7. Clearwater River trap efficiency for steelhead trout smelts, 1985 - 1990.

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
1990	DNFH	5/3	66/4,052	0.0163	22
	release	5/3	76/4,410	0.0172	22
		5/3	75/4,120	0.0182	22
		5/3	62/4,010	0.0155	22
		5/3	126/4,160	0.0303	22
		5/3	72/4,080	0.0176	22
1989	No efficiency tests conducted for steelhead smelts in 1989				
1988	DNFH	4/13	29/4,000	0.0073	14
	release	4/22	8/3,998	0.0020	27
		4/28	16/3,994	0.0040	16
1987	DNFH	4/13	6/4,071	0.0015	13
	release	4/20	9/4,060	0.0022	16
		4/28	2/4,000	0. 0005*	26
	trap	4/21-22	6/1 ,604	0.0037	13
	caught	4/24	2/775	0.0026*	15
1986		4/14	7/4,140	0.0017	20
		4/30	1/4,190	0.0002*	20
		5/7	2/4,260	0. 0005*	29
		5/11	5/4,247	0.0012	29
1985		5/7	2/464	0. 0043*	29
		5/11	1/384	0.0026*	33

*Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

Travel Time and Migration Rates

Release Site to Snake River Trap

Chinook Salmon-There were nine groups of freeze-branded chinook salmon released in the Salmon River drainage: three each at Sawtooth Hatchery, South Fork Salmon River, and Rapid River Hatchery. Two groups were released in the Imnaha River, Oregon, and four groups were released in Lookingglass Creek, Oregon.

Because of the extremely low brand recovery at the Snake River trap (34 branded chinook salmon were captured out of the approximately 304,000 branded fish released in 1990), migration rate statistics could not be calculated.

Steelhead Trout-In 1990, there were two freeze branded steelhead trout groups released above the Snake River trap from Idaho hatcheries: one as part of the Sawtooth release and one as part of the East Fork Salmon River release. Ten groups of freeze-branded hatchery steelhead trout were released upstream from the Snake River trap from Oregon hatcheries: one group of two replicates each from Little Sheep Creek, three groups of two replicates each from Spring Creek, and one group of two replicates from Wildcat Creek. One group of two replicates was released in Asotin Creek from the Washington hatchery at Lyons Ferry. Recapture numbers were high enough for the five combined replicate groups released in Oregon and the one group released in Asotin Creek to provide travel time information to the Snake River trap (Table 8). No recaptures were made from the Sawtooth and East Fork Salmon River releases.

The three groups released from Spring Creek differed in release strategy and size at release. Migration rates for the three paired release groups from Spring Creek were 34.6 km/d for the five to the pound direct stream release group reared at Irrigon Hatchery, 18.6 km/d for the five to the pound group that was acclimated at Wallowa Hatchery (release site), and 22.0 km/d for the four to the pound group that was acclimated at Wallowa Hatchery. These migration rates were very similar to 1989 releases and slightly faster than the 1988 releases. The migration rate for the Little Sheep Creek group (16.1 km/d) was near that of 1986 (14.5 km/d), no information is available for 1987 and 1988, and four times faster than 1989 (72.3 km/d). The Wildcat Creek release traveled at the same rate as in 1988 (44.2 km/d), with a travel time one day faster than 1989 (33.2 km/d). Added to this years freeze brand releases is a group of steelhead trout released by Washington at Asotin Creek. Travel time for this group was 1 d to the Snake River trap, 9.2 km (Table 8).

Release Site to the Clear'water Trap

Chinook Salmon-In 1990, there was one group of three replicates of freeze-branded chinook salmon released from DNFH on April 5 (Table 9). Travel time

Table 8. Migration data for freeze-branded steel head trout smelts from release sites to the Snake Rive[r] 1985-1990.

Release site[a]	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (lan/day)	Wean Q (k... Salmon R. S...
Spring Creek	1990	4/17	4/30	115	13	18.6	
		4/19	4/26	116	7	34.6	
		4/17	4/28	125	11	22.0	
	1989	4/24	5/01	84	7	34.6	
		4/22	5/05	70	13	18.6	
		4/22	5/02	83	10	24.2	
	1988	4/17	4/25	28	8	30.3	
		4/17	4/23	28	6	40.4	
		4/17	4/25	30	8	30.3	
		4/17	4/23	14	6	40.4	
		4/18	4/25	38	7	34.6	
		4/18	4/24	21	6	40.4	
	1987	4/26	b				
	1986	5/01	5/27	14	26	9.3	
		4/30	b	1			
		4/03	b	2		-	
	1985	5/09	5/19	36	10	24.2	
		5/09	5/20	31	11	22.0	
Cottonwood Creek	1987	4/26	4/30	28	4	23.3	
	1986	4/28	5/05	111	7	13.3	
Little Sheep Creek	1990	4/17	4/26	33	9	16.1	
	1989	4/23	4/25	93	2	72.3	
	1987	5/02	b				
	1986	4/28	5/08	16	10	14.5	
		4/27	b	2			
Wildcat Creek	1990	4/25	4/28	84	3	44.2	
	1989	4/26	4/30	134	4	33.2	
	1988	4/23	4/26	152	3	44.2	
Asotin Creek	1990	4/17	4/18	88	1	9.2	

[a] Only freeze brand groups from Oregon and Washington were used in 1989 because Idaho dld not release any freeze-branded steel head trout during 1989 above the Snake River trap.
[b] Insufficient recaptures at the Snake River trap to derive fish movement data.

Table 9. Migration data for f raeze-branded chinook salmon and steel head trout smelts released upstream of the Clearwater River trap, 1987-1990.

Release site	Year	Sp.	Median re 1 ease	Median passage	Number captured	Migration rate km/day	Travel time	Mean discharge
Dworshak NFH	1990	St	05/03	05/04	1,060	55.0	1	22.3
		Ch	04/05	04/06	625	55.0	1	21.1
Dworshak NFH	1989	St	05/01	05/02	123	55.0	1	31.2
		Ch	03/29	03/30	139	55.0	1	23.5
		Ch	03/30	03/31	167	55.0	1	23.3
		Ch-O	03-30	04/03	48	13.8	4	22.2
		Ch	09/28/88	03/30	2		183	
Red River	1989	Ch	10/17/88	04/1 7	19		182	
Dworshak NFH	1988	St	05/03	05/04	283	55.0	1	16.9
		St	05/04	05/05	202	55.0	1	16.9
		Ch-O	03/30	04/01	239	27.5	2	9.8
		Ch	03/30	03/31	1,711	55.0	1	9.6
		Ch	03/30	03/31	1,359	55.0	1	9.6
		Ch	03/30	03/31	434	55.0	1	9.6
		Ch	09/28/87	03/27	16		182	
Red River	1988	Ch	09/30/87	04/14	18		198	
Crooked River	1987	St	04/1 4		2			
Dworshak NFH	1987	St	04/21	04/22	58			
		St	05/05					
		Ch	04/01	04/04	1,416	18.3	3	7.2
Clear Creek	1987	St	04/1 7	04/20	59	38.3	3	14.1

for the age 1 chinook salmon was 1 d. This compares to a travel time of 1 d in 1985, 1986, 1988, and 1989 and 4 d in 1987. Average discharge during the migration period in 1987 was 7,200 cfs, 66% less than in 1990 (21,100), 69% less than in 1989 (23,500), 25% less than in 1988 (9,600), 76% less than in 1986 (29,000 cfs), and 58% less thanin 1985 (17,300 cfs). The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time that year.

Steelhead Trout-There were eight groups of freeze branded steelhead trout released from DNFH in 1990 totaling 84,832 fish. The median release date was May 5, and median passage date at the Clearwater trap was May 6. This 1 d travel time is consistent with past years data (Table 9).

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook Salmon Freeze Brand Groups-Because of low recapture numbers at the Snake River trap, no brand groups could be used for travel time analysis through Lower Granite Reservoir. There were nine freeze brand groups from the Clearwater River drainage used for calculating travel time through Lower Granite Reservoir. Median travel time through Lower Granite Reservoir for the age 1 chinook salmon freeze brand groups ranged from 28 d for the earliest two release groups from the Clearwater River trap efficiency tests (released on March 22 and 27) to 14 d for a group released from DNFH on April 5 (Table 10).

A linear regression analysis of migration rate (km/d) through Lower Granite Reservoir and inflow discharge was run on the nine combined freeze brand groups which passed the Clearwater River trap. The analysis failed to show a relation between migration rate and discharge ($N=9$, $r^2=0.004$, $P=0.872$). This is likely because the range of discharge for the brand groups was only 44.5-58.2 kcfs. A wide range of variation in migration rate within the narrow discharge interval contributed to the lack of an observed relation between migration rate and discharge.

Chinook Salmon PIT Tag Groups-In 1990, sufficient numbers of chinook salmon were PIT-tagged daily at the Snake River trap to provide 23 daily release groups (2,242 total PIT-tagged chinook salmon) for estimating travel time and migration rates through Lower Granite Reservoir. The number of PIT-tagged chinook salmon at the Snake River trap was down considerably this year due to poor trap catch associated with low river flows. Median travel time ranged from 11.4 d to 2.4 d late in the season (Table 11). The slowest median travel time was not as low in 1990 as in previous years. Chinook salmon were not captured in large enough numbers to be PIT-tagged until April 9. In past years, tagging began on about March 24. These early PIT tag groups typically had very slow

Table 10. Chinook salmon smelt travel time and migration rate from the head of Lower Granite Reservoir to Lower Granite Dam using fish passing the Snake and ClearWater River traps from upriver releases, 1985-1990.

			Snake River/ Clearwater River trap		Lower Granite Dam				
Year	Brand	Release site	Median passage date	Number collected	Median arrival date	Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGO
1990	LOX-1	Clearwater River trap[a]	3/22	27	4/19	1,027	28	2.2	46.0
	LDK-3	Clearwater River trap[a]	3/27	28	4/24	762	28	2.2	50.5
	LAK-1	Clearwater River trap[a]	3/28	37	4/16	265	19	3.2	44.5
	LDK-2	Clearwater River trap[a]	3/31	56	4/22	502	22	2.8	50.6
	LDK-4	Clearwater River trap[a]	4/3	33	4/24	681	21	2.9	54.9
	LAK-2	Dworshak NFH	4/5	37	4/19	150	14	4.4	51.3
	LD7U-1	Dworshak NFH	4/6	2B2	5/6	4*554	26	2.4	58.2
	RA7U-1	Dworshak NFH	4/6	180	4/29	4,922	24	2.6	57.8
	RA7U-3	Dworshak NFH	4/6	163	4/26	5,500	21	2.9	56.7
	Collection numbers of branded chinook at the Snake River trap in 1990 was too low to derive median passage values.								
1989	RA4-3	Clearwater River trap[a]	3/22	7	5/6	319	45	1.4	81
	LD4-1	Clearwater River trap[a]	3/24	10	4/25	368	32	1.9	80
	RD4-3	ClearWater River trap[a]	4/4	39	5/6	632	32	1.9	88
	RA4-1	Clearwater River trap[a]	4/6	41	5/7	324	31	2.0	90
	RDL(T&X)-1	Dworshak NFH	3/30	139	4/23	5,994	24	2.6	82
	RIR-2	Dworshak NFH[c]	3/30	2	6/1	127	63	1.0	83
	**d	Dworshak NFH	3/31	167	4/25	13,346	25	2.5	83
	**e	Dworshak NFH[b]	4/3	48	5/31	5,740	58	1.1	84
	(R&L)DJ-4	Imnaha River	4/10	247	4/27	3,462	17	3.0	91
	(R&L)LDJ-3	Lookingglass Hatchery	4/5	173	4/24	3,038	19	2.7	87
	(R&L)DJ-2	Lookingglass Hatchery[b]	4/6	212	4/22	4,171	16	3.2	86
	(R&L)AJ-1	Lookingglass Hatchery	5/18	131	6/14	11,622	27	1.9	75
	**f	Rapid River	4/18	181	4/23	10,379	5	10.3	105
	LDR-(1-3)	Red River[c]	4/17	19	5/11	2,579	24	2.6	99
	RAR-(1-4)	S.F. Salmon River	5/11	21	5/13	3,148	2	25.8	104
	LAR-(1-4)	Sawtooth Hatchery	4/20	14	4/23	2,155	3	17.2	112
1988	LAUD-1	Lookingglass Hatchery[b]	5/15	29	6/11	3,913	27	1.9	68
	LAUT-1	Lookingglass Hatchery[b]	5/16	25	6/12	3,973	27	1.9	68
	RDT-3	Red River Pond[c]	4/15	18	5/13	1,071	28	2.2	58
	LAH-1	Dworshak NFH[b]	4/1	239	5/27	3,457	56	?.1	54
	LAT-2	Dworshak NFH	3/31	1,711	4/20	17,510	20	3.1	38
	LDT-1	Dworshak NFH[c]	3/28	16	4/12	847	15	4.1	30
	RA7N-1	Dworshak NFH	3/31	788	4/20	6,672	20	3.1	38
	RA7N-3	Dworshak NFH	3/31	571	4/21	5,823	21	2.9	39
	RAR-1	Dworshak NFH	3/31	253	4/20	2,040	20	3.1	38

Table 10. Continued.

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGO
1988	RAR-3	Dworshak NFH	3/31	181	4/21	1,852	21	2.9	39
	LDK-1	Clearwater River trap[a]	3/1 5	51	4/1 9	736	35	1.8	32
	LDK-3	ClearWater River trap[a]	3/18	93	4/19	643	32	1.9	33
	RDK-1	Clearwater River trap[a]	4/2	27	4/23	499	21	2.9	42
	RDK-2	Clearwater River trap[a]	4/7	18	4/22	347	15	4.1	45
	RDK-3	Clearwater River trap[a]	3/22	83	4/19	575	28	2.2	34
	RDK-4	Cl earwater River trap[a]	4/14	31	4/30	524	16	3.8	53
1987	RAR-1	Dworshak NFH	4/4	1,416	4/24	11,069	20	3.1	37
	RD4-1	Clearwater River[a]	3/20	43	4/18	551	29	2.1	33
	RD4-3	Clearwater River[a]	4/2	50	4/20	436	18	3.4	35
	RA4-3	Clearwater River[a]	4/7	165	4/19	438	12	5.1	38
	RA4-1	Cl earwater R iver[a]	4/13	74	4/29	334	16	3.8	46
1986	LDY-3	Hel 1s Canyon	4/3	269	4/16	9,898	13	4.0	100
	RDY-1	Sawtooth Hatchery	4/14	49	4/23	2,245	9	5.7	89
	ROY-3	S.F. Salmon River	4/23	229	5/3	5,921	10	5.2	98
	LDY-1	Rapid River	4/16	237	4/20	10,589	4	12.9	88
	RAJ-2	Lookingglass Creek	4/5	38	4/14	3,741	9	5.7	99
	RAJ-3	Lookingglass Creek[c]	4/4	13	4/9	333	5	10.3	99
	RAJ-4	Lookingglass Creek	4/5	76	4/21	2,593	16	3.2	95
	RAY-1	Dworshak NFH	4/2	312	4/21	4,703	19	3.2	97
1985	LDR-3	Hel 1s Canyon	4/3	544	4/1 3	7,111	10	5.2	88
	RDR-1	Sawtooth Hatchery	4/14	165	5/4	4,313	20	2.6	89
	RDR-3	S.F. Salmon River	4/17	76	5/14	4,193	27	1.9	85
	LDR-1	Rapid River	4/12	370	4/25	9,422	13	4.0	98
	LDR-4	Grande Ronde River	6/4	135	6/23	6,868	19	2.7	79
	RDR-2	Dworshak NFH	4/4	248	4/27	6,403	23	2.7	94

[a] Releases made on Clearwater River at U.S. Highway 95 launch (rkm-15. 5).
[b] 0 age spring chinook salmon.
[c] Fall release of spring chinook.
[d] RA7H-1, RD7H-1, and RD7H-3 combined.
** [e] RAH-1, RDH-1, and RDH-2 combined.
** [f] LA7H-1, LA7H-3, LD7H-1, and LD7H-3 combined.
** [g] LAK-2, LD7U-1, RA7U-1, and RA7U-3 combined.

Table 11. PIT-tagged chinook salmon travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1990.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/09/90	9.13	11.15	7.05	37	48.1	49.92
04/10/90	8.27	11.33	6.68	22	34.9	50.29
04/11/90	7.55	10.02	6.81	12	32.4	52.22
04/16/90	6.69	10.31	4.52	7	46.7	63.46
04/17/90	5.53	6.08	5.18	73**	40.3	64.33
04/18/90	5.28	5.64	4.97	39	36.8	64.82
04/19/90	5.60	6.46	4.57	54	35.8	68.47
04/20/90	5.58	6.35	5.19	59	39.6	69.12
04/21/90	6.75	7.42	6.10	59	39.3	67.84
04/22/90	6.38	7.65	5.80	66	44.6	68.35
04/23/90	7.47	9.67	5.82	62	41.6	67.27
04/24/90	8.05	9.63	6.95	70	46.7	64.97
04/25/90	11.43	14.25	8.59	36	40.4	62.08
04/26/90	8.84	11.69	6.45	44	46.3	61.37
04/27/90	8.42	11.22	5.11	16	42.1	61.15
04/28/90	8.04	10.75	5.69	12	31.6	61.50
04/29/90	7.79	9.56	6.77	24	50.0	61.55
04/30/90	8.30	12.00	6.30	14	70.0	62.43
05/01/90	8.66	10.97	7.16	22	42.3	67.12
05/02/90	6.30	0.00	0.00	5	55.6	62.75
05/04/90	6.43	0.00	0.00	4	40.0	71.13
05/05/90	7.17	0.00	0.00	3	30.0	77.14
05/07/90	5.14	6.72	3.80	13	36.1	82.38
05/08/90	4.88	5.48	4.12	18	50.0	85.10
05/09/90	4.22	5.44	3.29	22	53.7	85.27
05/10/90	3.22	6.12	2.07	10	40.0	85.67
05/11/90	3.30	0.00	0.00	3	42.9	83.73
05/12/90	4.10	11.31	2.93	9	64.3	81.67
05/13/90	3.72	0.00	0.00	4	80.0	72.70
05/30/90	2.41	2.94	2.06	66	46.2	117.30
05/31/90	4.31	6.78	3.52	23	43.4	106.00
06/01/90	5.11	7.21	3.15	18	50.0	100.40
06/02/90	5.27	0.00	0.00	4	40.0	97.30
06/03/90	5.47	22.39	3.62	11	55.0	94.26
06/04/90	5.26	9.06	2.77	6	42.9	94.34
06/05/90	4.85	17.41	3.35	7	50.0	92.46
06/07/90	23.28***	0.00	0.00	2	66.7	73.03

* Confidence intervals calculated with nonparametric statistics.
** Includes both trap caught and purse seine caught fish.
***Maximum travel times listed for observations of two or less.

The average discharge for the chinook salmon migration season was 21,300 cfs lower in 1990 than in 1989. With the lower discharge in 1990, it was expected that migration rate would be less than in 1989. There is a lack of comparable data between years during late March, early April, and May because of low numbers of fish that were tagged at the trap in 1990. Also, 15 of the 23 data points fall within the discharge rangeof 60-70 kcfs, indicating data is limited over a wide range of discharge. The lack of data during these periods and over a wide range of discharge could possibly explain why the migration rate in 1990 was not less than 1989.

The linear regression of the log of migration rate and log discharge provided the best fit for PIT-tagged chinook salmon groups released from the Snake River trap (N=23, $r^2=0.669$, $p=0.000$):

log migration rate = -3.283 + 1.266 log average discharge.

This analysis indicates that PIT-tagged chinook salmon migration rate increased in Lower Granite Reservoir as discharge increased. The slightly poorer relation in 1990 may be due to a lack of data over a wide range of discharge. Fifteen of the 23 release groups had average discharges between 60 and 70 kcfs for the migration period.

The linear regression analysis on the data stratified by 5- kcfs intervals provided the following best linear regression equation (N=10, $r^2=0.806$, $P=0.000$):

log migration rate = -2.834 + 1.161 log mean discharge.

Stratifying by 5-kcfs intervals removes some of the noise associated with biological data. The resulting r^2 shows there is a strong relation between migration rate and discharge. As discharge increases, migration rate increases. This relation is not as strong as in pervious years.

In 1990, chinook salmon smelts were PIT-tagged at the Clearwater River trap to provide travel time information through Lower Granite Reservoir for Clearwater River chinook salmon. Thirty-five daily groups (totaling 4,242 chinook salmon) were released from the Clearwater River trap from March 30 through April 21 , and then sporadically throughout May (Table 12). During 1990, Clearwater River chinook salmon migrated slower than Snake River chinook salmon. There are only 13 release groups with comparable release dates for the two traps. The median migration rate for these days was 7.9 km/d for chinook salmon released from the Snake River trap and 6.0 km/d for chinook salmon released from the Clearwater River trap. The reasons that the Clearwater River chinook salmon migrate slower through Lower Granite Reservoir than do Snake River fish is unclear at this time.

Preliminary ATPase data, collected by the U.S. Fish and Wildlife Service, from chinook salmon smelts collected in the Clearwater and Snake River traps in 1990 (Rondorf et al. In Press) were examined. There were only four data points from the Snake and Clearwater River traps that were comparable. The data indicates that smelts from the Snake River trap had significantly higher weekly ATPase levels (μmoles $P \cdot mg\ Prot^{-1} \cdot h^{-1}$) than smelts from the Clearwater River

Table 12. PIT-tagged chinook salmon travel **time,** with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1990.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average " discharge (kcfs)
03/30/90	21.54	24.56	18.77	46	30.7	48.43
03/31/90	20.61	23.86	18.33	51	34.0	49.06
04/01/90	20.49	21.44	18.75	40	26.7	49.76
04/02/90	17.17	20.56	14.55	42	28.0	48.99
04/03/90	18.96	21.63	15.62	46	30.7	52.07
04/04/90	16.40	18.90	11.66	45	29.8	50.89
04/05/90	24.96	31.35	19.14	44	29.3	57.44
04/06/90	18.24	29.54	16.21	37	24.8	55.02
04/07/90	16.70	20.60	15.50	42	28.4	55.41
04/08/90	16.56	23.03	13.10	48	32.0	57.13
04/09/90	11.70	15.10	10.10	47	31.8	57.10
04/10/90	12.17	13.32	10.39	43	28.5	54.80
04/11/90	12.03	16.15	9.68	42	27.8	56.52
04/12/90	15.86	21.86	11.24	45	30.0	60.85
04/13/90	16.59	25.37	12.95	48	32.0	62.39
04/14/90	18.45	22.81	14.17	43	28.7	63.32
04/15/90	21.50	23.65	14.79	58	38.7	63.55
04/16/90	11.40	18.34	8.96	55	36.4	65.96
04/17/90	10.88	18.50	6.77	29	32.2	66.12
04/18/90	9.02	17.55	6.91	29	35.8	67.28
04/19/90	13.98	25.73	7.48	7	23.3	64.97
04/20/90	8.69	20.31	7.42	13	28.9	66.97
04/21/90	9.40	15.10	6.90	20	41.7	66.83
04/28/90	11.69	17.88	8.79	10	41.7	66.46
05/02/90	8.39	11.80	7.04	23	44.2	68.12
05/03/90	8.34	9.76	6.86	28	32.9	72.20
05/06/90	9.85	15.27	7.36	13	43.3	80.40
05/17/90	9.05	9.40	7.78	30	38.5	48.39
05/18/90	7.40	8.01	7.01	41	30.6	45.04
05/19/90	7.21	7.59	6.28	36	23.8	48.91
05/20/90	6.21	6.45	5.88	35	23.3	49.63
05/21/90	5.52	5.61	5.42	58	38.2	54.25
05/22/90	4.54	4.59	4.44	37	24.7	56.84
05/23/90	3.68	4.16	3.55	46	30.9	60.78
05/24/90	5.38	5.98	4.34	61	35.9	67.24
05/25/90	5.58	6.91	4.54	27	32.9	81.15

*Confidence intervals calculated with nonparametric statistics.

trap. Mean seasonal ATPase levels for the four comparable data points were 13.3 μmoles for the Clearwater River smelts and 22.2 μmoles for the Snake River smelts. These ATPase differences probably explain some, but not all, of the variation in migration rate for Snake and Clearwater river trap-caught chinook salmon.

Prior to stratification of the data, the linear regression analysis of the Clearwater River chinook salmon PIT tag data showed the migration rate-discharge relation was nonsignificant (N=35, r^2=0.041, P=0.243). After removin9 some of the biological noise by stratifying by 5-kcfs groups, the relation became significant and was fairly strong (N=7, r^2=0.782, P=0.008). The lack of PIT tag data over a wide range of discharge, the effect of stock differences, and smoltification status of the migrants appearad to influence the outcome of the regression analysis prior to stratification.

The chinook salmon migration rate-discharge relation for Snake River trap PIT tag groups was examined to determine if there was a difference in this relation between years (1987-1990). The analysis of covariance was used with the data averaged by 5-kcfs groups. The analysis showed a significant difference in the migration rate-discharge relation between years (slope of the lines) at the 0.05 level of significance (N=35, F=24.763, P=0.000). Agraphof the data showed that the 1987 and 1988 data followed the same pattern (Figure 8). The 1989 data had a slightly steeper slope. The 1990 migration rate data below 95 kcfs followed the 1987-1988 data, and the data above 95 kcfs follows the 1989 data.

Percent recovery (interrogation) of Snake River trap daily release PIT-tagged chinook salmon groups at Lower Granite Dam ranged between 31.6% and 70.0%. Seasonal cumulative recovery (# recaptured/# marked) of PIT-tagged chinook salmon to Lower Granite was 42.6%. Cumulative recovery progressing downstream to Little Goose Dam was 56.4% and to McNary Dam was 64.4%.

Percent recovery of Clearwater River trap daily release PIT-tagged chinook salmon groups at Lower Granite Dam ranged between 23.3% and 60.1%. Seasonal cumulative recovery of PIT-tagged chinook salmon to Lower Granite Dam was 32.0%. Cumulative recovery progressing downstream to Little Goose Dam was 47.9% and to McNary Dam was 54.6%. Percent recovery of PIT-tagged chinook salmon at Lower Granite Dam that were released from the Clearwater River trap was considerably less (32.0%) than PIT-tagged chinook salmon released from the Snake River trap (42.6%).

The difference in percent recovery is most likely due to the fact that chinook salmon in the Snake River drainage have much farther to travel. The weak fish have already perished prior to trap interception, whereas the majority of the chinook salmon in the Clearwater River were released from the DNFH only 55 km upstream of the Clearwater River trap, and the weaker fish have not died yet. The slower travel time of the Clearwater PIT-tagged chinook salmon compared to the Snake River PIT-tagged fish indicated the Clearwater River chinook salmon may not have been as smelted as the Snake River chinook salmon.

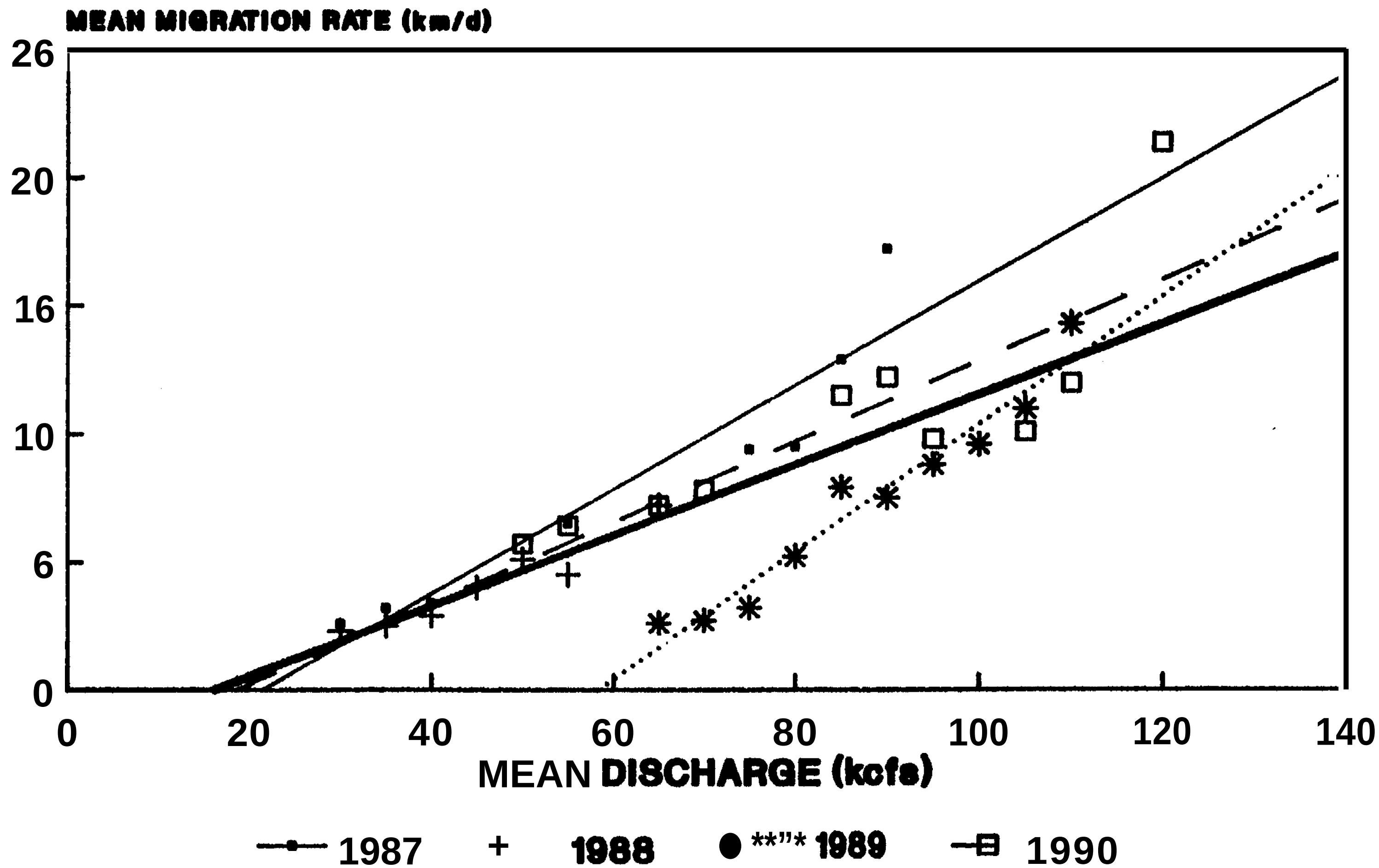

Figure 8. Chinook salmon migration rate/discharge relations for Snake River trap PIT tag groups, 1987-1990.

Hatcherv Steelhead Trout Freeze Brand **Groups**-Median passage dates were calculated for five groups of freeze-branded steelhead **trout at the Snake River** trap and three groups **at** the Clearwater River trap. These groups were used to determine migration rate and travel time through Lower Granite Reservoir (Table 13). The slowest-moving group through Lower Granite Reservoir was the Wildcat Creek group (12 d travel time) followed by one of the Spring Creek groups (10 d). The rest of the groups migrated **at about** the same **rate** (6-8 d).

The relation between hatchery steelhead trout migration rate through Lower Granite Reservoir and discharge was analyzed using a linear regression model. The analysis failed to detect a statistically significant relation, at the 0.05 level, between migration rate and discharge **(N=8,** $r^2=0.227$, **P=0.233).**

The data did not show a relation between migration rate and discharge, probably because all the brand groups moved through Lower Granite Reservoir over a very narrow discharge range (60-78 **kcfs).** Therefore, when the analysis was conducted, there was little variation in the discharge variable.

Hatcherv Steelhead Trout **PIT Taq** Grems-Sufficient numbers of hatchery steelhead trout were PIT-tagged daily at the Snake River trap to provide 58 daily release groups (3,112 individual fish) tobe used in median migration rate calculations through Lower Granite Reservoir. Median travel time ranged from 11.9 to 1.7 d (4.3 km/d to 27,4 km/d migration rate) and averaged 4.8 d, which was about 25% slower than in 1989 (Table 14). Discharge was about 18% less in 1990 than in 1989, which probably accounts for the slower migration rate in 1990.

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite discharge (inflow) for PIT-tagged hatchery steelhead trout groups **(N=58,** $r^2=0.700$, **P=0.000).** The best linear regression equation was:

$$\log \text{migration rate} = -4.247 + 1.576 \log \text{discharge}.$$

The linear regression analysis conducted on the daily release groups stratified into **5-kcfs** discharge intervals showed a significantly higher r^2 value because some of the noise which is often associated with biological data was removed **(N=16,** $r^2=0.914$, **P=0.000).** The best linear regression equation was:

$$\log \text{migration rate} = -4.396 + 1.607 \log \text{mean discharge}.$$

The equation shows that as discharge increases, migration rate increases for PIT-tagged hatchery steelhead trout marked at the Snake River trap.

Twenty-two groups of hatchery steelhead trout (1,228 individual fish) were PIT-tagged at the Clearwater River trap in 1990 for use in median migration rate calculations through Lower Granite Reservoir (Table 15). Median travel time ranged from8.5 to 3.7 d (6.0 km/alto 14.1 km/d) and averaged 4.8 d (13.1 km/d). Average inflow discharge to Lower Granite Reservoir during the migration season was 63.4 kcfs and ranged from 45 to 82.9 kcfs.

Table 13. Steel head trout smelt travel time and migration rate from the head of Lower Granite Reservoir to Lower Granite Dam using fish passing the Snake and Clear-water River traps from upriver releases, 1985-1990.

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number Collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGO
1990	LA)(-I	Sawtooth Hatchery			5/27	5,581			
	RA)(-1	E.F. Salmon River			5/27	5,899			
	**b	Dworshak NFH	5/4	487	5/10	12,493	7	8.8	74
	RAZ-1	Dworshak NFH	5/4	434	5/1 1	12,066	8	7.7	75
	RAT-1	Dworshak NFH	5/5	139	5/12	11,150	8	7.7	78
	LAIC-4	Asoti n Creek	4/18	58	4/24	12,020	7	7.4	68
	RAIC-4	Asoti n Creek	4/19	30	4/25	12,166	7	7.4	68
	(R&L)OA-1&3	Spring Creek	4/30	240	5/5	26,978	6	8.6	60
	(R&L)OA-2	Spring Creek	4/26	116	5/5	10,951	10	5.2	62
	(R&L)OA-4	Wildcat Creek	4/28	120	5/7	12,470	12	4.3	63
	(R&L)OJ-3	Little Sheep Creek	4/26	33	5/3	4,607	8	6.5	62
1989	LDI(S&U)-1	Dworshak NFH	5/2	123	5/7	23,573	5	12.3	93
	(R&L)DJ-1	Little Sheep Creek	4/25	93	5/10	4,420	15	3.4	95
	(R&L)AJ-2	Spring Creek	5/1	84	5/12	12,362	11	4.7	101
	(R&L)AJ-1	Spring Creek	5/2	83	5/12	10,168	10	5.2	103
	(R&L)AJ-3	Spring Creek	5/5	70	5/14	10,877	9	5.7	104
	(R&L)AJ-4	Wildcat Creek	4/30	134	5/8	15,037	8	6.5	95
1988	LDT-3	Hel 1s Canyon	5/7	38	5/15	6,631	8	6.5	69
	LOT-2	Sawtooth Hatchery	5/7	19	5/25	5,332	18	2.9	68
	LAI(F&M)-1	Spring Creek	4/25	59	5/17	8,711	22	2.3	61
	LAI(F&M)-3	Spring Creek	4/24	42	5/12	7*895	18	2.9	58
	RAI(F&M)-3	Spring Creek	4/24	61	5/9	11,562	15	3.4	58
	RAI(F&M)-1	Wildcat Creek	4/26	155	5/11	28,569	15	3.4	59
	LD4-3	Snake River at Asot i n	5/24	30	5/30	854	6	8.6	76
	RD4-1	Snake River at Asot i n	5/24	55	5/30	994	6	8.6	76
	RAT-1	Dworshak NFH	5/3	107	5/1 1	10,792	8	7.7	72
	RAT-2	Dworshak NFH	5/3	95	5/1 1	7,225	8	7.7	72
	RAT-3	Dworshak NFH	5/3	81	5/9	5,928	6	10.3	73
	RAT-4	Dworshak NFH	5/3	202	5/10	25,335	7	8.8	78
	RA4-1	Clearwater River trap[a]	4/14	28	4/22	1,335	8	7.7	57
	RA4-3	Clearwater River trap[a]	4/23	8	5/1	1,384	8	7.7	49
	RD4-3	Clearwater River trap[a]	4/29	16	5/6	743	7	8.8	50

Table 13. Continued.

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGO
1987	RAIC-1	Cottonwood Creek	4/30	7	5/4	4,886	4	12.9	86
	RAIC-2	Cottonwood Creek	4/30	6	5/4	5,529	4	12.9	86
	RAIC-3	Cottonwood Creek	4/30	7	5/4	5,971	4	12.9	86
	RAIC-4	Cottonwood Creek	4/30	8	5/5	4,936	5	10.3	84
	RAR-3	Clear Creek	4/20	59	5/1	3,500	11	4.7	59
	RDR-3	Dworshak NFH	4/22	58	5/1	4,917	9	6.8	63
	RDK-1	Clearwater River trap[a]	4/13	6	4/26	1,192	13	4.7	41
	RDK-2	Clearwater River trap[a]	4/20	9	4/30	999	10	6.2	56
	RDK-4	Clearwater River trap[a]	4/28	2	5/4	692	6	10.3	84
1986	RDT-2	Hel 1s canyon	5/1	38	5/8	5,033	7	7.4	94
	LDT-2	Sawtooth Hatchery	5/21	11	5/29	3,772	8	6.5	120
	LDT-4	E. F. Salmon River	5/23	9	5/29	1,552	6	8.6	119
	RAJ-4	Little Sheep Creek	5/8	16	5/30	1,340	22	2.3	114
	RAJ-1	Spring Creek	5/27	14	5/26	1,628	Median travel time at LGD one		
	RAIJ-1	Cottonwood Creek	5/5	39	5/21	4,468	16	3.2	98
	RAIJ-3	Cottonwood Creek	5/5	43	5/22	5,151	17	3.0	100
	RAIJ-4	Cottonwood Creek	5/6	29	5/18	4,114	12	4.3	99
	RDT-4	Dworshak NFH	5/B	18	5/1 7	7,194	9	6.8	99
	LD4-1	Clearwater River trap[a]	.5/B	2	5/14	1,003	6	10.3	100
	LD4-3	Clearwater River trap[a]	5/13	5	5/22	869	9	6.8	98
	RD4-1	Clearwater River trap[a]	4/16	7	4/23	371	7	8.8	103
	RD4-3	Clearwater River trap[a]	5/1	1	5/8	751	7	8.8	94
19B5	LDY-1	Hel 1s Canyon	5/3	44	5/1 1	2,821	8	6.5	88
	ROY-1	Sawtooth Hatchery	5/7	23	5/28	3,510	21	2.5	92
	RDY-3	E. F. Salmon River	5/9	22	5/28	2,454	19	2.7	93
	RA17-1	Grande Ronde RI ver	5/20	36	5/22	12,710	2	25.8	102
	RA1 7-3	Grande Ronde River	5/19	31	5/21	12,022	2	25.8	95
	LDY-2	Dworshak NFH	4/29	88	5/4	6,699	5	12.3	83

[a] Releases made on Clear-water River at U.S. Highway 95 launch (rkm-15. 5).
[b] RAK-1 & 2 and RDK-1, 2, 3, & 4 combined.

Table 14. PIT-tagged hatchery steelhead trout travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1990.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/16/90	4.00	5.12	2.87	11	100.0	61.95
04/17/90	4.92	5.90	2.99	30**	85.7	63.44
04/18/90	5.13	6.71	4.83	49	80.3	64.82
04/19/90	4.03	4.76	3.82	44	72.1	65.10
04/20/90	3.92	4.90	3.69	50	78.1	67.60
04/21/90	4.11	6.32	3.51	43	71.7	71.00
04/22/90	4.89	7.38	3.09	39	73.6	70.04
04/23/90	5.21	7.67	3.25	48	77.4	68.26
04/24/90	5.59	6.81	4.71	43	71.7	66.15
04/25/90	4.89	7.41	4.39	45	75.0	64.10
04/26/90	5.82	7.13	4.68	47	78.3	62.58
04/27/90	6.96	8.50	5.72	43	71.7	61.51
04/28/90	5.82	6.49	4.69	50	78.1	61.78
04/29/90	6.45	7.40	4.91	44	67.7	60.72
04/30/90	5.91	6.74	4.66	40	66.7	60.40
05/01/90	4.85	5.77	4.30	47	78.3	59.72
05/02/90	6.04	7.76	4.75	42	70.0	62.75
05/03/90	5.53	7.00	4.13	40	65.6	67.58
05/04/90	5.55	9.22	4.66	44	73.3	71.13
05/05/90	4.95	6.33	3.80	50	74.6	73.64
05/06/90	4.03	6.06	3.37	48	80.0	76.38
05/07/90	5.83	7.01	4.26	43	72.9	82.85
05/08/90	4.28	6.49	2.96	46	76.7	85.08
05/09/90	4.76	5.56	3.76	41	68.3	84.66
05/10/90	4.05	6.45	3.77	42	70.0	84.80
05/11/90	6.03	13.76	2.99	39	66.1	76.63
05/12/90	6.00	8.90	3.04	42	70.0	70.13
05/13/90	10.52	13.48	7.88	41	68.3	54.11
05/14/90	11.89	12.37	6.84	43	71.7	53.68
05/15/90	9.87	11.20	6.96	44	73.3	48.81
05/16/90	8.32	10.44	4.86	46	76.7	44.21
05/17/90	8.90	9.39	7.75	42	70.0	48.39
05/18/90	8.43	8.52	8.17	46	76.7	48.84
05/19/90	7.24	7.43	7.00	49	81.7	48.91
05/20/90	6.28	6.65	6.07	27	75.0	49.63
05/21/90	5.12	5.77	4.50	26	68.4	51.44
05/22/90	4.14	4.72	4.01	47	72.3	53.98
05/23/90	3.24	3.39	3.12	40	67.8	58.27
05/24/90	3.12	3.60	2.73	38	63.3	66.47
05/25/90	3.49	4.08	3.19	41	68.3	69.20
05/26/90	3.13	3.91	2.89	35	58.3	68.37

Table 14. Continued.

Release date	Median travel time (day)	Confidence Interval* uDDer	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
05/27/90	3.01	3.42	2.64	45	77.6	74.67
05/28/90	2.71	2.89	2.48	47	78.3	93.10
05/29/90	1.88	2.12	1.75	49	83.1	103.20
05/30/90	1.70	2.05	1.51	47	75.8	117.30
05/31/90	2.08	2.67	1.77	51	85.0	112.05
06/01/90	2.34	2.79	1.99	49	81.7	107.65
06/02/90	2.12	2.71	1.96	45	75.0	99.95
06/03/90	2.23	2.82	2.10	43	69.4	94.10
06/04/90	2.71	3.61	2.05	20	66.7	95.53
06/05/90	2.98	3.82	2.79	37	68.5	94.37
06/06/90	3.50	0.00	0.00	4	100.0	90.95
06/07/90	3.19	4.88	2.33	13	76.5	90.20
06/08/90	2.91	4.13	2.54	9	81.8	88.10
06/09/90	2.93	4.68	2.37	8	66.7	86.97
06/10/90	2.54	3.72	1.64	11	73.3	90.57
06/11/90	2.74	3.17	2.06	31	58.5	92.33
06/12/90	3.05	4.19	2.64	38	63.3	91.17
06/13/90	2.99	7.81	2.23	10	66.7	82.53

* Confidence intervals calculated with nonparametric statistics.
**Includes both trap caught and purse seine caught fish.

Table 15. PIT-tagged hatchery steelhead trout travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1990.

Release date	Median travel time (dav)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/04/90	4.45**	0.00	0.00	1	100.0	47.48
04/12/90	3.49**	0.00	0.00	1	100.0	44.30
04/15/90	6.24**	0.00	0.00	1	100.0	60.97
04/18/90	5.70	7.91	4.52	19	65.5	66.35
04/19/90	6.17	8.50	4.18	42	72.4	68.47
04/20/90	3.98	5.14	3.54	27	65.9	67.60
04/21/90	6.30	11.40	3.70	20	76.9	67.84
04/27/90	5.46	7.09	4.52	30	69.8	62.48
04/28/90	7.50	8.90	6.78	62	76.5	61.33
04/29/90	7.76	8.82	6.60	62	83.8	61.55
05/02/90	6.86	8.26	4.87	28	70.0	65.84
05/03/90	6.00	7.56	5.21	50	79.4	67.58
05/04/90	5.41	8.12	4.83	47	79.7	68.54
05/05/90	5.99	7.96	4.51	44	73.3	76.03
05/06/90	3.67	4.34	3.20	47	78.3	76.38
05/07/90	6.21	6.87	5.47	46	76.7	82.85
05/17/90	7.95	9.12	7.56	44	72.1	45.01
05/18/90	8.14	8.80	7.59	46	76.7	48.84
05/19/90	7.13	7.64	6.86	27	45.0	48.91
05/20/90	6.42	6.90	5.89	28	46.7	49.63
05/21/90	6.14	6.62	5.32	41	65.1	54.25
05/22/90	4.50	4.86	4.05	31	50.8	56.84
05/23/90	3.92	4.23	3.58	54	88.5	60.78
05/24/90	4.23	5.17	3.71	51	83.6	65.83
05/25/90	5.08	5.89	4.87	25	71.4	73.54

* Confidence Intervals calculated with nonparametric statistics.
**Maximum travel times listed for observations of two or less.

The linear regression analysis failed to detect a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite inflow discharge for Clearwater River PIT-tagged hatchery steelhead trout (N=22, r^2=0.166, P=0.060). The data were stratified by 5-kcfs discharge groups, and the analysis was run again. The analysis failed to detect a significant relation between discharge and migration rate after stratification (N=8, r^2=0.205, P=0.260). The data were graphed, and an obvious relation was observed (Figure 9). There were two outliers. Each outlier was an average of only one data point for that 5-kcfs discharge interval. There probably was a migration rate discharge relation for hatchery steelhead trout PIT-tagged at the Clearwater River trap, but there was not enough data and the discharge range was to narrow to show the relation.

Hatchery steelhead trout migration rate-discharge relation among years for fish PIT-tagged at the Snake River trap was examined to see if the relation was constant over years. Analysis of covariance on the log-transformed data was used to determine if there was a significant difference between years (1987-1990) in migration rate averagedby 5-kcfs intervals. The analysis showed there was a significant difference among years (slopes of the lines) for the hatchery steelhead trout migration rate-discharge relation (N=46, F=3.052, P=0.040). A graphic representation of the data showed one year's data (1988) was causing the difference (Figure 10). The slope of the 1988 data was considerably different from the other three years. The 1988 data were removed, the analysis re-run, and the slopes were not found to be significantly different (N=38, F=2.979, P=0.065). The analysis was continued on the three years of data to determine if the intercept (height) of the lines were different. The analysis showed there was a significant difference in the intercept of the three lines. After examining a graph of the data, the 1987 data were significantly higher than the other two years. When the 1987 data were removed and the analysis run again, there was not a significant difference in the height of the remaining two years data. The 1988 and 1990 data were pooled and the linear regression analysis conducted (N=28, r^2=0.915, P=0.000):

log migration rate = -4.427 + 1.612 log mean discharge.

The equation shows that PIT-tagged hatchery steelhead trout from the Snake River trap move about six times faster through Lower Granite Reservoir at 120 kcfs as they do at 40 kcfs.

Percent recovery of Snake River trap daily hatchery steelhead trout PIT tag release groups at Lower Granite Dam ranged from 58.3% to 100% and averaged 73.0%. Seasonal cumulative recovery of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 73.0%, to Little Goose Dam 82.1%, and to McNary Dam 83.1%.

Percent recovery of Clearwater River trap daily hatchery steelhead trout PIT tag release groups at Lower Granite Dam ranged from 45.0% to 88.5% and averaged 71.7%. Seasonal cumulative recovery of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 71.7%, to Little Goose Dam 76.8%, and to McNary Dam 77.6%. This was 5.5% less than for fish PIT-tagged at the Snake River trap.

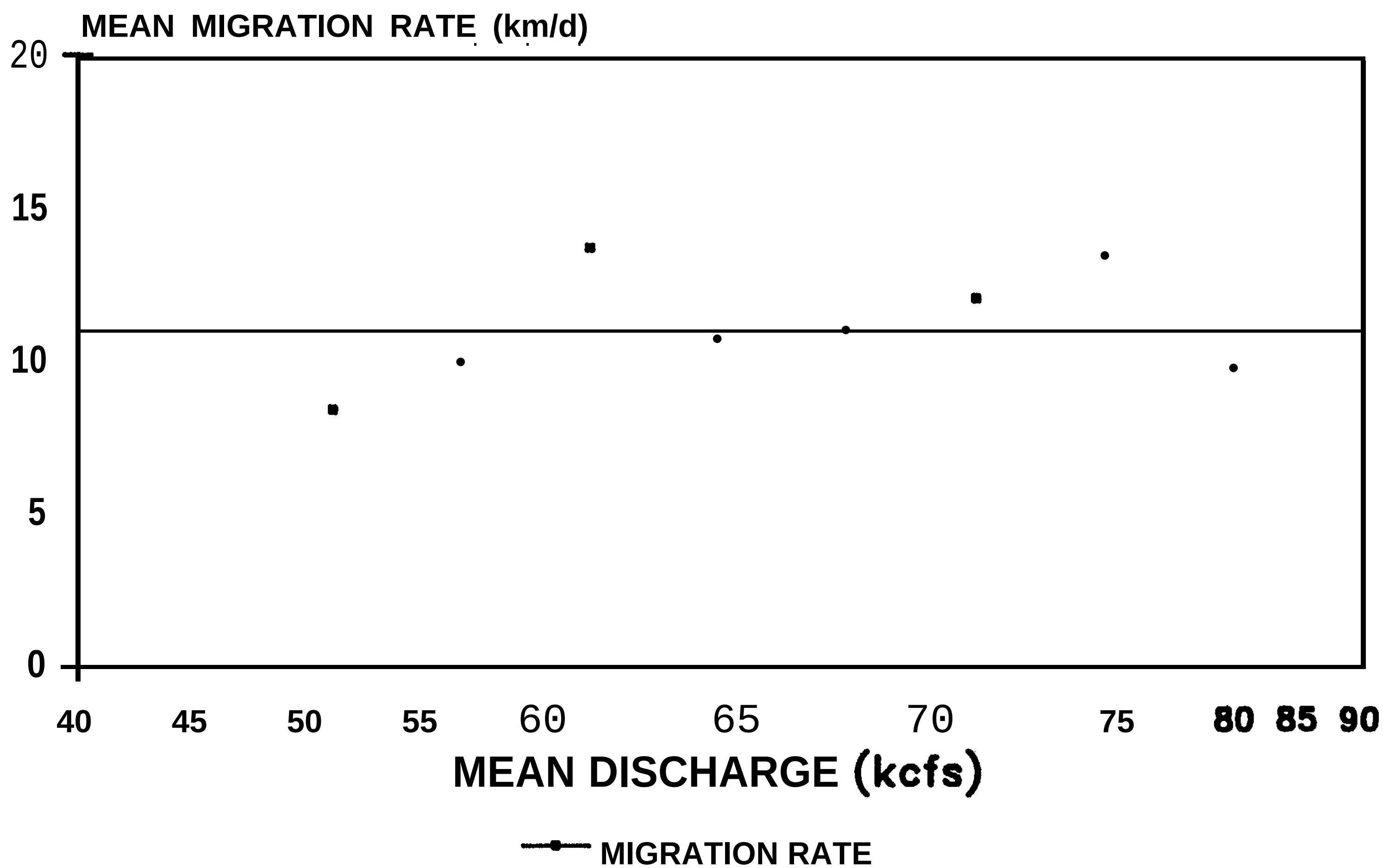

Figure 9. Hatchery steelhead trout migration rate/discharge relation for Clearwater River trap PIT tag groups, 1990.

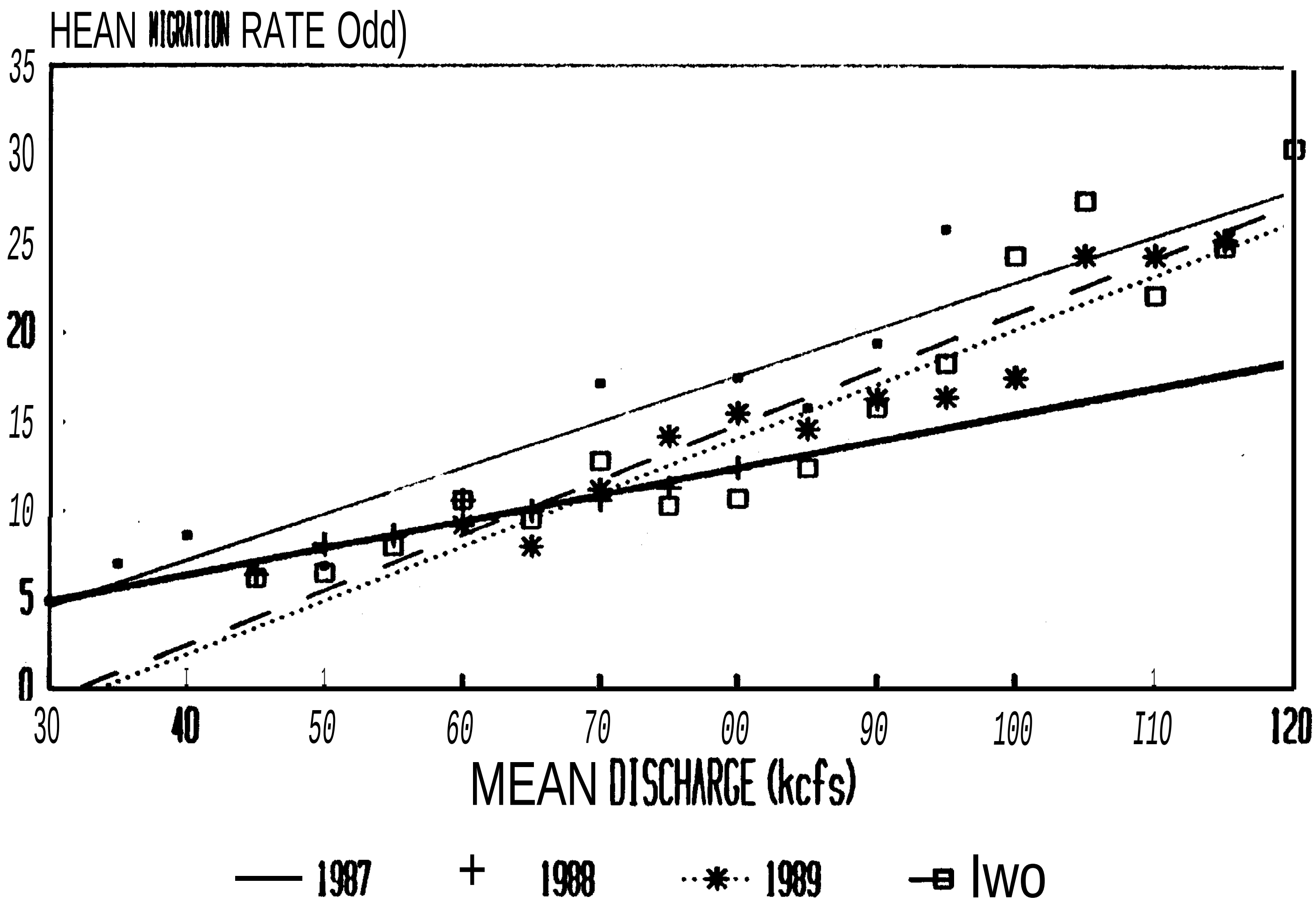

Figure 10. Hatchery steelhead trout migration rate/discharge relations, for Snake River trap PIT tag groups, 1987-1990.

Wild Steelhead Trout PIT Tag Groups-Sufficient numbers of wild steelhead trout were PIT-tagged at the Snake River trap to provide 50 daily release groups (3,076 individual fish) for estimating travel time and migration rate in Lower Granite Reservoir (Table 16). Median travel time ranged from 7.3 d (7.1 km/d) to 1.7 d (30.1 km/d) and averaged 3.9 d (14.6 km/d). Linear regression analysis showed a significant relation between median migration rate in Lower Granite Reservoir and mean discharge for PIT-tagged wild steelhead trout groups (N=50, r^2=0.646, P=0.000). The best linear regression equation was:

log migration rate = -1.001 + 0.867 log mean discharge.

Again the analysis shows that as discharge increases migration rate in Lower Granite Reservoir increases.

Linear regression analysis conducted on average migration rates for PIT tag groups stratified into 5-kcfs intervals to remove noise which is often associated with biological data had higher r^2 value (N=15, r^2=0.830, P=0.000). The equation that best fit the data was:

log migration rate = -1.481 + 0.976 log average discharge.

This indicates that 83% of the variation in migration rate is accounted for by changes in discharge. In other words, migration rate is very dependent on discharge; the higher the discharge, the faster wild steelhead trout migrate.

Twenty-nine wild steelhead trout PIT-tagged groups (1,300 individual fish) were released from the Clearwater River trap in 1990 for use in median migration rate calculations through Lower Granite Reservoir (Table 17). Median travel time ranged from 7.5 d to 3.5 d (8.2 to 17.8 km/d, respectfully) and averaged 5.0 d (12.3 km/d). Average discharge for the PIT-tagged wild steelhead trout migration season was 58.0 kcfs.

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average inflow discharge to the reservoir for wild steelhead trout groups released from the Clearwater River trap (N=29, r^2=0.635, P=0.000). The best linear regression equation was:

log migration rate = -2.103 + 1.134 log discharge.

Linear regression analysis conducted on averaged migration rates for PIT tag groups stratified into 5-kcfs intervals had a considerably higher r^2 value (N=8, r^2=0.947, P=0.000). The best linear regression equation was:

log migration rate = -1.849 + 1.063 log discharge.

Table 16. PIT-tagged wild steelhead trout time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1990.

Release date	Median travel time (day)	Confidence Interval* Upper	Confidence Interval* Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/09/90	4.41	0.00	0.00	3	75.0	45.90
04/10/90	4.39	0.00	0.00	3	30.0	45.10
04/11/90	4.19	0.00	0.00	3	60.0	44.70
04/15/90	3.98	9.38	2.80	7	87.5	59.75
04/16/90	3.18	6.18	2.39	7	63.6	61.27
04/17/90	3.08	4.25	2.57	25**	69.4	63.20
04/18/90	3.56	4.24	3.27	36	69.2	63.83
04/19/90	3.59	4.09	3.42	51	63.7	65.10
04/20/90	3.13	3.33	2.93	37	59.7	65.47
04/21/90	3.12	3.45	2.75	69	62.7	69.20
04/22/90	2.82	3.14	2.53	72	74.2	73.07
04/23/90	3.42	4.31	2.81	52	59.1	72.77
04/24/90	3.62	3.82	3.44	111	64.5	66.83
04/25/90	3.93	4.37	3.70	86	61.4	63.98
04/26/90	3.95	4.17	3.77	95	66.4	63.15
04/27/90	3.70	4.93	2.96	22	55.0	63.33
04/28/90	4.42	4.54	4.15	66	60.6	63.12
04/29/90	4.57	5.33	3.88	55	67.9	61.14
04/30/90	4.54	5.24	4.18	50	66.7	59.94
05/01/90	4.47	5.31	3.73	49	64.5	58.98
05/02/90	3.74	4.32	3.41	27	64.3	59.88
05/03/90	3.67	4.61	3.52	45	72.6	62.38
05/04/90	3.86	4.55	3.27	27	67.5	64.58
05/05/90	3.57	3.99	3.42	53	73.6	71.03
05/06/90	3.14	3.70	2.80	80	70.2	73.80
05/07/90	3.47	3.65	3.38	147	65.3	80.03
05/08/90	3.53	3.97	3.14	87	67.4	85.08
05/09/90	3.16	3.56	2.84	55	57.3	85.30
05/10/90	3.07	3.65	2.68	36	67.9	85.67
05/11/90	3.92	6.05	2.73	16	72.7	82.95
05/12/90	3.43	5.16	2.72	23	56.1	82.67
05/13/90	5.57	7.05	4.18	45	68.2	63.98
05/14/90	5.76	6.59	4.79	50	61.0	57.72
05/15/90	5.20	6.47	4.64	17	50.0	53.14
05/16/90	4.84	7.14	4.42	27	75.0	45.52
05/17/90	4.65	4.89	3.85	30	76.9	43.92
05/18/90	7.29	9.03	4.75	11	64.7	45.04
05/19/90	6.21	7.11	5.58	20	66.7	44.50
05/20/90	6.29	0.00	0.00	4	100.0	49.63
05/21/90	4.43	5.92	3.83	10	62.5	45.45
05/22/90	4.00	5.21	3.10	8	57.1	53.98

Table 16. Continued.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
05/23/90	3.06	3.62	2.53	14	56.0	58.27
05/24/90	3.54	5.12	2.31	8	61.5	65.83
05/25/90	3.41	4.32	2.96	32	64.0	69.20
05/26/90	3.58	4.14	2.99	28	50.0	73.08
05/27/90	3.07	4.26	2.54	11	45.8	74.67
05/28/90	2.55	2.69	2.41	41	70.7	93.10
05/29/90	1.98	2.92	1.66	16	72.7	103.20
05/30/90	1.71	1.97	1.61	62	77.5	117.30
05/31/90	1.90	4.41	1.45	8	53.3	112.05
06/01/90	2.49	3.18	1.98	36	85.7	107.65
06/02/90	3.40	4.00	1.90	22	73.3	98.27
06/03/90	1.87	0.00	0.00	3	75.0	94.10
06/05/90	5. 06***	0.00	0.00	2	100.0	92.46
06/08/90	9. 07***	0.00	0.00	2	66.7	85.48
06/09/90	3.53	0.00	0.00	4	100.0	89.30
06/12/90	3.55	0.00	0.00	4	50.0	85.97
06/13/90	2.97	0.00	0.00	3	75.0	82.53
06/14/90	3.07	0.00	0.00	3	100.0	76.00

* Confidence intervals calculated with nonparametric statistics.
** Includes both trap caught and purse seine caught fish.
***Maximum travel time listed for observations of two or less.

Table 17. PIT-tagged wild steelhead trout travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1990.

Release date	Median travel time (day)	Confidence Interval* Upper	Confidence Interval* Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/04/90	6.80	9.44	3.53	8	72.7	47.50
04/05/90	7.54	12.83	5.66	6	54.5	46.92
04/07/90	7.20	13.60	4.36	8	57.1	52.45
04/09/90	7.50	9.40	5.70	9	47.4	51.30
04/10/90	7.19	9.48	5.37	11	47.8	48.63
04/11/90	5.33	8.06	4.47	10	47.6	46.80
04/12/90	6.58	10.61	4.45	10	41.7	53.13
04/13/90	7.94	0.00	0.00	4	50.0	57.02
04/14/90	5.10	10.38	4.41	6	35.3	57.12
04/15/90	4.73	6.33	3.80	36	56.2	60.60
04/16/90	4.37	0.00	0.00	4	57.1	61.95
04/17/90	5.36**	0.00	0.00	2	33.3	63.44
04/18/90	3.49	0.00	0.00	3	42.9	63.50
04/19/90	6.82	0.00	0.00	4	66.7	68.39
04/20/90	4.90	0.00	0.00	3	100.0	69.36
04/21/90	10 .00**	0.00	0.00	2	66.7	66.83
04/27/90	5.68	0.00	0.00	5	45.5	61.30
04/28/90	5.51	6.16	4.61	21	65.6	61.78
04/29/90	5.60	6.87	4.75	48	64.0	60.72
04/30/90	4.91	7.03	4.42	9	90.0	59.94
05/01/90	4.61	6.98	3.90	7	70.0	59.72
05/02/90	4.39	6.57	3.39	6	60.0	59.88
05/03/90	4.29	5.44	4.23	13	52.0	62.38
05/04/90	4.22	4.94	3.46	10	55.6	64.58
05/05/90	4.33	16.08	2.84	7	46.7	71.03
05/06/90	3.46	18.51	2.78	6	75.0	73.80
05/07/90	3.50	5.45	3.26	17	58.6	82.03
05/17/90	6.92	7.64	5.43	53	60.9	43.49
05/18/90	7.36	8.29	6.43	37	46.3	45.04
05/19/90	6.58	6.91	6.23	47	62.7	48.91
05/20/90	5.83	6.44	5.55	42	43.3	49.63
05/21/90	4.81	5.12	4.48	55	56.7	51.44
05/22/90	4.31	4.54	4.14	42	48.3	53.98
05/23/90	3.50	3.73	3.43	118	78.7	60.78
05/24/90	3.83	4.22	3.35	90	63.4	65.83
05/25/90	3.93	8.00	3.07	8	66.7	70.12

* Confidence Intervals were calculated with nonparametric statistics.
**Maximum travel time listed for observations of two or less.

Wild steelhead trout migration rate-discharge relation for fish released from the Snake River trap was examined to see if this relation was constant over years. The analysis of covariance was used to determine if there was a significant difference among years (1987-1990) in migration rates using groups averaged by 5-kcfs intervals. The analysis showed no significant difference among years for the slopes of the wild steelhead trout migration rate-discharge relations (N=40, F=1 .588, P=0.211), nor was there a significant difference in migration rate (intercept) between years (N=40, F=l .340, P=O.329). The data were pooled, and the linear regression analysis was run using the log-transformed data (N=40, r^2=0.811, P=0.000). The best linear regression equation was:

log migration rate = -1.970 +1 .097 log discharge.

The analysis indicates that 81% of the variation in migration rate for PIT-tagged wild steelhead trout released from the Snake River trap between 1987 and 1990 was accounted for by changes in discharge. The equation shows that a two-fold increase in discharge will increase migration rate two-fold.

Percent recovery at Lower Granite Dam of daily wild steelhead trout PIT tag groups released from the Snake River trap ranged from 45.8% to 85.7% and averaged 65.5%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout to Lower Granite Dam was 65.5%, to Little Goose Dam 77.1%, and to McNary Dam 79.0%. The percent recovery at the three dams for PIT-tagged hatchery and wild steelhead trout was about the same; 83.1 for hatchery steelhead trout and 79.0% for wild steelhead trout. The cumulative recovery rates at the three dams for both hatchery and wild steelhead trout was similar to 1989.

Percent recovery of daily wild steelhead trout PIT tag groups released from the Clearwater River trap and interrogated at Lower Granite Dam ranged from 41.7 to 89.5% and averaged 59.2%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout released at the Clearwater River trap to Lower Granite Dam was 59.0%, to Little Goose Dam was 68.7%, and to McNary Dam was 70.4%.

Migration rates for hatchery and wild steelhead trout PIT-tagged at the Snake River trap were significantly different. The slopes of the migration rate-discharge regression lines for hatchery and wild steelhead trout, grouped by 5-kcfs intervals, were tested with the analysis of covariance and found to be significantly different (N=31, F=12.277, P= 0.002). In 1990 wild steelhead trout from the Snake River trap migrated faster than hatchery steelhead trout at low discharge (50,000 cfs), at the same rate at 100,000 cfs, and slightly slower at 120,000 cfs (Figure 11). In 1988 and 1989, there was no difference in the migration rate discharge relation, but wild steelhead trout consistently migrated faster than hatchery smelts (2.5 km/d, 3 km/d faster, respectively).

It is uncertain as to the reason for this difference. Possible explamtions are that wild steelhead trout are stronger and/or more fully smelted and, therefore, migrate faster through Lower Granite Reservoir. Mean ATPase activity level, an indicator of smoltification, was tested at the Snake River trap between April 20 and June 1, 1990 (Rondorf et al. In Press).

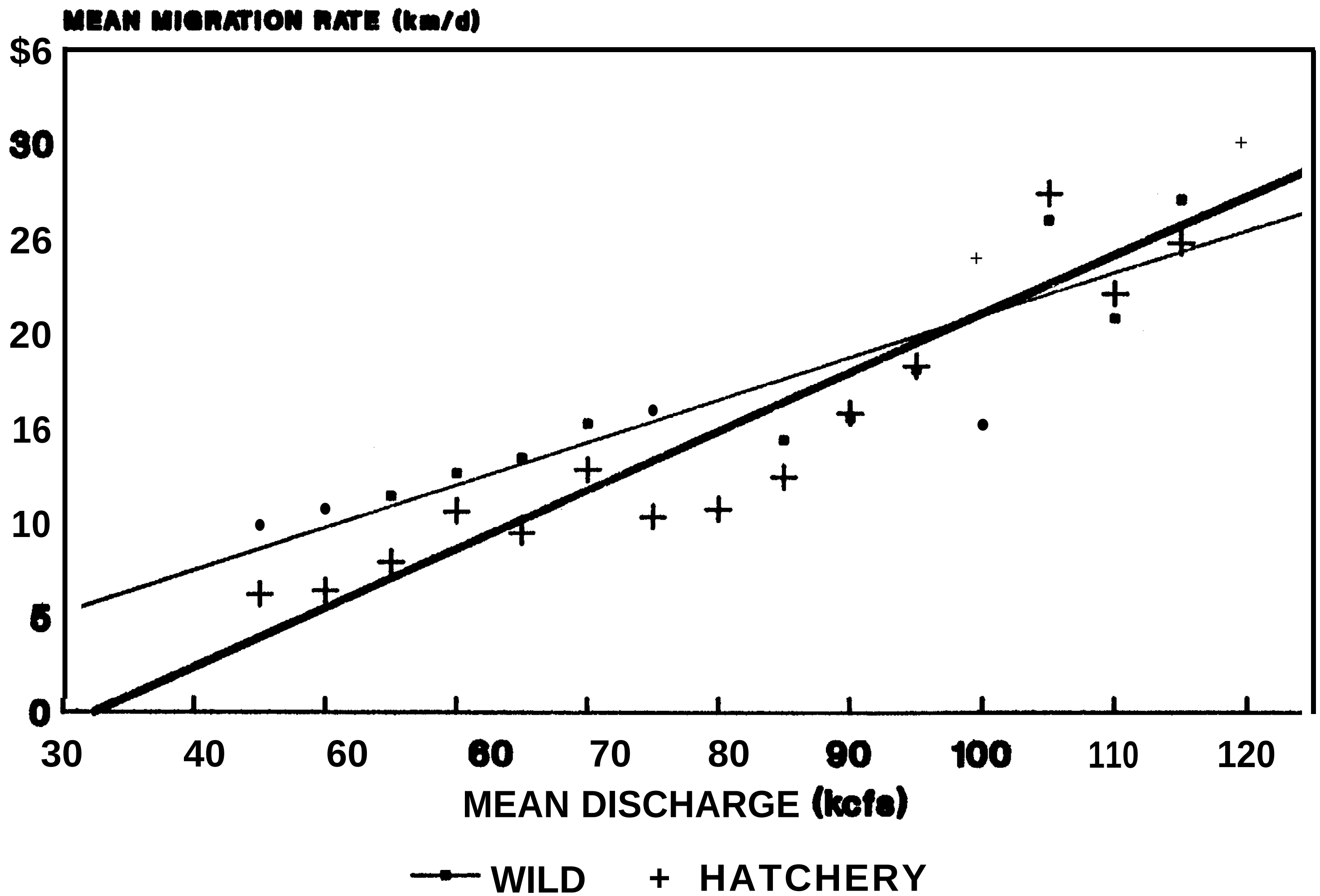

Figure 11. Hatchery and wild steelhead trout migration rate/discharge relations for Snake River trap PIT tag groups, 1990.

Preliminary information indicates **weekly** ATPase levels for hatchery steelhead trout were about 50% lower than wild steelhead trout at the beginning of this period and at about the same level at the end of this period. Hatchery steelhead trout weekly mean ATPase levels started out at 11.4 **µmoles P·mg Prot^{-1}·h^{-1}**, peaked at 25.0 **µmoles** the week of May 25, and ended at 21.8 **µmoles.** Wild steelhead trout weekly mean ATPase levels **fluctuated** little during the **sample** period, ranging from 18.0 to 23.7 **µmoles P·mg Prot^{-1}·h^{-1}.**

Head of Lower **Granite** Reservoir to Little Goose Dam

Chinook Salmon PIT **Tag** Groins-The relation between migration rate and discharge was examined for PIT-tagged chinook salmon released from the Snake River trap and interrogated at Little Goose Dam. The linear regression analysis, on the log transformed data stratifiedby **5-kcfs** intervals (Table 18), show that 53% of the variation in PIT-tagged chinook salmon migration rate between the Snake River trap and Little Goose Dam was accounted for by discharge **(N=10,** r^2=0.534, **P=0.016).** The same analysis was conducted on the PIT tag chinook salmon data from the Clearwater River trap (Table 18). This analysis showed that 88% of the variation in the migration rate for chinook salmon from the Clearwater River trap to Little Goose Dam was accounted for by discharge **(N=7,** r^2=0.879, **P=0.002).**

Hatcherv Steelhead Trout PIT **Tag** Groups-The migration rate discharge relation for PIT-tagged hatchery steelhead trout released from the Snake River trap and interrogated at Little Goose Dam was examined using the linear regression analysis. The data were stratified by **5-kcfs** intervals and log transformed (Table 19). Eighty-seven percent of the variation in PIT-tagged hatchery steelhead trout migration rate is accounted for by discharge **(N=13, r^2=0.874, P=0.000).** The same analysis was conducted on PIT-tagged hatchery steelhead trout released from the Clearwater River trap (Table 19). The relation is not significant at the 0.05 level **(N=6,** r^2=0.205, P=0.367). The lack of significance for the ClearWater River data is probably due to a low number of data points **(N=6)** and because the data is limited to a very small range in discharge. Only 63 PIT-tagged hatchery steelhead trout released from the Clearwater River trap were interrogated at Little Goose Dam, whereas 282 hatchery steelhead trout from the Snake River trap were interrogated.

Wild **Steelhead** Trout PIT **Tag Groups-The** migration rate discharge relation for wild steelhead trout PIT-tagged and released from the Snake River trap was examined using the linear regression analysis. The data were stratified by **5-**kcfs intervals and log transformed (Table 20). The analysis showed that 75% of the variation in migration rate is accounted for by discharge **(N=14,** r^2=0.749,

Table 18. Migration data, stratified by 5-kcfs intervals, for chinook salmon from Snake and Clearwater River traps to Little Goose Dam, 1990.

Discharge interval	Snake River trap migration rate (km/d)	Clearwater River trap migration rate (km/d)
50 - 55	9.00	5.62
55 - 60	7.35	6.96
60 - 65	6.87	7.33
65 - 70	7.22	6.88
70 - 75	9.24	11.00
75 - 80		
80 - 85	14.60	14.80
85 - 90	7.90	
90 - 95	10.65	14.10
95 - 100	12.70	
100 - 105		
105 - 110	21.80	

Table 19. Migration data, stratified by 5-kcfs intervals, for hatchery steelhead trout from the Snake and Clearwater River traps to Little Goose Dam, 1990.

Discharge interval	Snake River trap migration rate (km/d)	Clearwater River trap migration rate (km/d)
50 - 55	9.70	
55 - 60	7.42	11.95
60 - 65	9.84	10.27
65 - 70	9.04	11.80
70 - 75	13.83	8.80
75 - 80	10.57	12.55
80 - 85	16.90	16.50
85 - 90	21.00	
90 - 95	20.47	
95 - 100	27.85	
100 - 105	24.30	
105 - 110	32.95	
110 - 115	27.10	

Table 20. Migration data, stratified by 5-kcfs intervals, for wild steelhead trout from the Snake and Clearwater River traps to Little Goose Dam, 1990.

Discharge interval	Snake River trap migration rate (km/d)	Clearwater River trap migration rate (km/d)
45 - 50	14.25	16.70
50 - 55	11.45	11.42
55 - 60	9.30	13.10
60 - 65	12.89	15.14
65 - 70	15.53	11.41
70 - 75	15.13	19.40
75 - 80	15.37	15.05
80 - 85	17.04	15.50
85 - 90	15.80	17.10
90 - 95	18.65	
95 - 100	31.15	
100 - 105	26.70	
105 - 110	26.90	
110 - 115	31.60	

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Clearwater River smelts probably does exist, but because of a lack of data, the analysis does not show the relation. In those instances where enough data exist (Snake River trap data for chinook salmon, hatchery steelhead trout, and wild steelhead trout, and Clearwater River trap data for chinook salmon), the regression does show a significant relation. Only when interrogation numbers are low at Little Goose Dam does the regression analysis fail to detect a significant relation.

Minimum Survival of PIT-tagged Fish

Minimum Survival Estimates

Minimum survival to Lower Granite Dam (the number of fish that were interrogated at Lower Granite, Little Goose, and McNary dams) for fish PIT-tagged at the Snake and Clearwater River traps in 1990 was similar to minimum survival rates observed in previous years. Chinook salmon and both hatchery and wild steelhead trout PIT-tagged at the Snake River trap survived at a rate 5% to 10% higher than fish taggedat the Clearwater River trap (Table 21). This follows a similar trend observed in 1989, when minimum survival of Snake River trap PIT-tagged fish ranged from approximately 12% to 16% higher than fish PIT-tagged at the Clearwater River trap. The difference in minimum survival, in part, can be accounted for by the presence of DNFH releases. Due to the close proximity of the Clearwater River trap to the hatchery, the rigors of migration have not as yet caused mortality of the weaker fish. Natural mortality of hatchery fish is believed to be greater at the beginning of their river existence as they acclimate to the hazards present in a natural system. The majority of the mortality of hatchery fish in the Snake River takes place prior to the fish passing the trap site. Minimum survival to Lower Granite Dam in 1990 for chinook salmon (64.4%), hatchery steelhead trout (83.1%), and wild steelhead trout (79.0%) from the Snake River trap was similar to that of 1989 and greater than 1988 or 1987. The minimum survival estimate to Lower Granite Dam for chinook salmon PIT-tagged at the Clearwater River trap (54.6%) was similar to 1989. Insufficient numbers of hatchery and wild steelhead trout were PIT-tagged at the Clearwater River trap to make a comparison.

Minimum Survival Versus Length of PIT-tagged Fish

Snake River Trap-PIT tag interrogations of groups of chinook salmon from the Snake River trap were tested with an analysis of covariance to determine if all years (1988, 1989, and 1990) data could be combined. The analysis failed ($N=63$, $F=19.075$, $P=0.000$), indicating the data could not be combined overbears. Combining data over years was desirable to increase sample numbers at the smaller and larger fish lengths. The hatchery and wild steelhead trout data were subjected to the same analysis. Neither hatchery nor wild steelhead trout data could be combined over years (hatchery steelhead trout: $N=72$, $F=13.939$,

Table 21. Interrogation of PIT-tagged fish from the Snake River trap, 1987-1990, and Clearwater River trap, 1989-1990, at downstream collection facilities.

Tagging site	year	specie*	Number tagged	Number Interogated/Site: Lower Granite (%)	Little Goose (%)	McNary (%)	Totals (%)
Snake	1990	CH	2,245	956 (42.6)	310 (13.8)	180 (8.0)	1,446 (64.4)
		SH	3,112	2,272 (73.0)	282 (9.1)	33 (1.1)	2,587 (83.1)
		SW	3,078	2,016 (65.5)	356 (11.6)	60 (2.0)	2,432 (79.0)
Clearwater	1990	CH	4,242	1,359 (32.0)	674 (15.9)	281 (6.6)	2,314 (54.6)
		SH	1,228	880 (71.7)	63 (5.1)	10 (0.8)	953 (77.6)
		SW	1,300	767 (59.0)	126 (9.7)	22 (1.7)	915 (70.4)
Snake	1989	CH	6,222	2,384 (38.3)	1,367 (22.0)	482 (7.7)	4,233 (68.0)
		SH	2,525	1,773 (70.2)	268 (10.6)	35 (1.4)	2,076 (82.2)
		SW	1,798	1,170 (65.1)	240 (13.3)	52 (2.9)	1,462 (81.3)
Clearwater	1989	CH	2,441	756 (31.0)	452 (18.5)	140 (5.7)	1,348 (55.2)
		SH	290	173 (59.7)	16 (5.5)	2 (0.7)	191 (65.9)
		SW	104	53 (51.0)	16 (15.4)	3 (2.9)	72 (69.2)
Snake	1988	CH	3,767	1,237 (32.8)	543 (14.4)	299 (7.9)	2,079 (55.2)
		SH	1,743	1,069 (61.3)	190 (10.9)	12 (0.7)	1,271 (72.9)
		SW	1,186	698 (58.9)	166 (14.0)	20 (1.7)	884 (74.5)
Snake	1987**	CH	3,275	1,067 (32.9)	338 (10.3)	308 (9.4)	1,713 (52.3)
		SH	827	324 (39.2)	52 (6.3)	6 (0.7)	382 (46.2)
		SW	464	229 (49.4)	48 (10.3)	8 (1.7)	285 (61.4)

*CH = chinook, SH = hatchery steelhead, SW = wild steelhead.
**bias may exist as only 'quality' fish were tagged.

P=0.000; wild steelhead trout: N=54, F=8.953, P=0.000). Therefore, all analysis of Snake River trap data were done on a by year basis, only.

The linear regression analysis failed to detect a relation between length and chinook salmon minimum survival to Lower Granite Dam in 1988, 1989, and 1990 (1988: N=32, r^2=0.304, P=0.001; 1989: N=18, r^2=0.166, P=0.093; 1990: N=13, r^2=0.237, P=0.092). The relation between minimum survival and length was significant for 1988 chinook salmon (N=27, r^2=0.616, P=0.000) after five outliers were removed from the data set using the Studentized Residual (Myers 1990).

The linear regression analysis of hatchery steelhead trout minimum survival versus length for 1989 and 1990 failed to show a statistically significant relation (1989: N=25, r^2=0.110, P=0.105; 1990: N=27, r^2=0.102, P=0.105). The 1988 hatchery steelhead trout data did show a statistically significant relation between minimum survival and length at tagging, N=20, r^2=0.668, P=0.000. When the Studentized Residual was run on the hatchery steelhead trout data, one outlier was found in the 1988 data. The linear regression improved after the removal of this data point, N=19, r^2=0.747, P=0.000. Wild steelhead trout minimum survival versus length showed a different pattern than the chinook salmon or hatchery steelhead trout. It was the 1990 data that yielded a statistically significant relation (N=17, r^2=0.665, P=0.000). No outliers were removed from this data set. The 1988 and 1989 wild steelhead trout minimum survival versus length regression failed to detect a statistically significant relation (1988: N=18, r^2=0.273, P=0.002; 1989: N=19, r^2=0.010, P=0.683).

Clearwater River Trap-The 1989 and 1990 chinook salmon PIT tag minimum survival versus length data from the Clearwater River trap were subjected to the analysis of covariance to determine if there was a significant difference between years. There was not a significant difference between years (N=33, F=0.641, P=0.429). The analysis also indicated that there was not a difference in the slopes (N=33, F=0.049, P=0.826) or intercepts (N=33, F=0.551, P=0.463) of the two lines. When a regression analysis was run on the combined data (1989 and 1990), no relation between minimum survival and length was shown (N=33, r^2=0.046, P=0.232).

The numbers of hatchery and wild steelhead trout PIT-tagged at the Clearwater River trap in 1989 were too low, 290 fish and 104 fish, respectively, to provide a reliable sample size. For this reason, the 1989 minimum survival versus length data were not used. Hatchery steelhead trout minimum survival versus length in 1990 for fish PIT-tagged at the CLearwater River trap showed a very strong statistical relation (N=18, r^2=0.855, P=0.000). The linear regression of wild steelhead trout failed to showed a relation between minimum survival and length in 1990 (N=14, r^2=0.162, P=0.153).

SUMMARY

The number of hatchery-reared chinook salmon and steelhead trout released above Lower Granite Dam was up considerable in 1990. Chinook salmon releases were up 16.6%, and hatchery steelhead trout releases were up 27.1% from 1989. The increase in chinook salmon production occurred in all three major drainages, whereas the increase in production of hatchery steelhead occurred in the Salmon and Clearwater River drainages. Hatchery production of chinook salmon and steelhead trout released above Lower Granite Dam was 24,500,010 (13,282,545 chinook salmon and 11,377,967 steelhead trout) in 1990. Of these, 358,599 chinook salmon and 452,821 steelhead trout (2.7% and 4.0% of the total releases, respectively) were freeze branded and released as 24 unique chinook salmon groups and 22 unique steelhead trout groups. The number of freeze-branded chinook salmon was down 46.8% and the number of freeze-branded hatchery steelhead trout was up 55.2% from 1989.

The Snake River trap was operated on the east side of the river from March 9 through June 19. The Snake River trap captured 5,258 age 1 chinook salmon, 29 age O chinook salmon, 19,940 hatchery steelhead trout, and 3,427 wild steelhead trout. The wild steelhead trout catch in the trap was greater than in any previous year, up 156% from 1989, which was the second highest year.

The Clearwater River trap was operated from March 14 through May 29, with 15 d downtime in late April and mid-May when the trap was out of operation due to high flow and heavy debris. ClearWater River trap catch was 58,838 age 1 chinook salmon, 29,459 hatchery steelhead trout, and 1,520 wild steelhead trout. Chinook salmon trap catch was up 592% from 1989 and similar to other drought years. Hatchery steelhead trout trap catch was up 300% from the best year-to-date, which was 1988. In 1990, the Clearwater River trap was fished more aggressively than in previous years. This meant that the trap was fished for a greater portion of the season in or near the thalweg, where water velocity is higher. With higher water velocity, fish have a harder time avoiding the trap.

Fish were again PIT-tagged for migration rate statistics at the Snake River trap and Clearwater River trap in 1990. The number of fish PIT-tagged at the Snake River trap was 8,435 and the number of fish PIT-tagged at the Clearwater River trap was 6,770.

Snake River trap chinook salmon efficiency tests were not conducted in 1990 due to the low catch of chinook in the trap. Previous years' trap efficiencies provide a pooled average chinook salmon trap efficiency of 1.39% at the Snake River trap.

Snake River trap steelhead trout trap efficiency tests were conducted on three occasions and provided a mean trap efficiency of 0.49%. With the limited data available, year and discharge did not have any significant effect on trap efficiency of steelhead trout smelts at the Snake River trap.

Chinook salmon trap efficiency tests at the Clearwater River trap in 1990 were significantly different from 1989 but similar to 1984-1988. The 1990 trap efficiency was 1.41%. The mean trap efficiency for all years except 1989 was 1. 87%

ClearWater River trap mean efficiency for hatchery steelhead trout in 1990 was 1.90%, which is significantly higher than in previous years, when trap efficiencies were below 0.4%. The increase in trap efficiency for steelhead trout at the Clearwater River trap was probably due to several trap modifications which were made in 1988 and 1989 and the fact that the trap was fished closer to the thalweg for a greater portion of the 1990 season.

Because of the low chinook salmon freeze brand recovery at the Snake River trap in 1990, migration rate statistics could not be calculated. Freeze-branded hatchery steelhead trout migration rates to the Snake River trap were similar to previous years, except for the brand group released in Little Sheep Creek. In 1990, they migrated at about the same rate as in 1986, but considerably slower than in 1989.

Migration rates for ClearWater River freeze branded chinook salmon were similar to rates observed in 1985, 1986, 1988, and 1989. In 1987 migration rate was four times slower than in 1990. Flows were considerably lower for a major portion of the migration in 1987 and probably was the reason for the slower migration that year. Steelhead trout migration rate was the same as in previous years.

Migration rates through Lower Granite Reservoir ranged from 28 d for early freeze brand release groups in the Clearwater River to 14 d for groups released from DNFH. The slow migration rates for freeze-branded chinook salmon moving through the reservoir early in the migration season was probably due to the fish being at a lower level of smoltification and the river being at a lower discharge at that time.

Using PIT-tagged chinook salmon groups was a much better method of determining migration rate through Lower Granite Reservoir than were freeze brand groups. Chinook salmon PIT-tagged at the Snake River trap migrated faster in 1990 than in 1989. Due to poor trap catch of chinook salmon early in the migration season, the slower moving chinook were not PIT-tagged this year. Statistical analysis showed a strong relation between migration rate and discharge (N=10, $r^2=0.806$, P=0.000). As discharge increased, migration rate of PIT-tagged chinook salmon through the reservoir also increased. PIT-tagged chinook salmon moved about twice as fast through the reservoir at 100 kcfs than at 50 kcfs.

The mean migration rate for chinook salmon PIT-tagged at the Clearwater River trap was 1.9 km/d slower through Lower Granite Reservoir than the mean migration rate for Snake River trap fish. The reason for the slower migration rate of the Clearwater River chinook salmon is not known, but may be due partially to differences in the level of smoltification of the two groups of fish. Statistical analysis showed a strong relation between migration rate and discharge for chinook salmon PIT-tagged at the Clearwater River trap (N=7, $r^2=0.782$, P=0.008).

Percent interrogation of PIT-tagged chinook salmon released from the Snake River trap was similar to 1989. Cumulative interrogation of PIT-tagged chinook salmon at all three dams (Lower Granite, Little Goose, and McNary) was 64.4% in

1990. Percent interrogation of PIT-tagged chinook salmon released from the Clearwater River trap was 54.6%, about 10% less than for fish released from the Snake River trap.

Migration rate through Lower Granite Reservoir for hatchery steelhead trout PIT-tagged at the Snake River trap in 1990 was about 6% slower than in 1989 (13.1 km/d and 13.9 km/d, respectively). Discharge was 18% lower in 1990 compared to 1989, which probably accounts for the decrease in migration rate. There is a very strong statistical relation between migration rate and discharge for Snake River trap PIT-tagged hatchery steelhead trout **($N=16, r^2=0.914, P=0.000$).** PIT-tagged hatchery steelhead trout migrated about three times as fast at 100 kcfs as they did at 50 kcfs.

Hatchery steelhead trout PIT-tagged at the Clearwater River trap migrated only slightly slower (6%) than fish tagged at the Snake River trap. There was not a strong relation between migration rate and discharge for the Clearwater River trap fish. The poor relation was probably due to the limited data available, rather than a lack of a relation existing.

The Snake River trap data were examined over years to see if there was a significant difference in the migration rate discharge relation among years. The analysis showed that there was a significant difference among years that was attributable to 1988. If 1988 data were removed, there was no statistical difference in the migration rate discharge relation for the remaining years data for hatchery steelhead PIT-tagged at the Snake River trap.

Percent interrogation at all three dams (Lower Granite, Little Goose, and McNary dams) of PIT-tagged hatchery steelhead trout tagged at the Snake River trap was 83.1%. This was similar to 1989, when percent interrogation was 80.7%.

Percent interrogation at all three dams of PIT-tagged hatchery steelhead trout tagged at the CLearwater River trap was 77.6%. This was 5.5% less than that of fish PIT-tagged at the Snake River trap.

The introduction of the PIT tag has provided the opportunity to obtain travel time data through Lower Granite Reservoir for wild steelhead trout. This is because of the low numbers of fish required for marking due to the high recovery rate at Lower Granite Dam. Wild steelhead trout PIT-tagged at the Snake River trap migrated at a rate of 14.2 km/d. The relation between migration rate and discharge for wild steelhead trout was very strong **($N=15, r^2=0.830, P=0.000$).** These fish migrated twice as fast through Lower Granite Reservoir at 100 kcfs as they did at 50 **kcfs.** PIT-tagged wild steelhead trout migrate at the same rate through Lower Granite Reservoir at 100 kcfs as did the PIT-tagged hatchery steelhead trout. In 1990, wild fish migrated 1.5 times faster at 50 kcfs than did hatchery steelhead trout.

Wild steelhead trout were collected and PIT-tagged at the Clearwater River trap in **1990 at a rate to** provide enough data to examine migration rate through Lower Granite reservoir. Clearwater River wild steelhead trout **migrated at** 12.3 km/d through Lower Granite Reservoir. This was 1.9 km/d slower than wild steelhead trout PIT-tagged at the Snake River trap.

There was a very strong relation between migration rate and discharge for PIT-tagged wild steelhead trout released from the ClearWater River **trap** (N=8, r^2=0.947, P=0.000). Clearwater River wild steelhead trout migrated twiceas fast at 100 kcfs as they did at 50 kcfs. Migration rate through the reservoir for Clearwater and Snake River wild steelhead trout at a given discharge was about the same (e.g., at 100 kcfs, 21.0 km/d and 20.4 km/d, respectively).

The migration rate discharge relation for wild steelhead trout for 1987-1990 were examined to see if there was a difference among years. There was no significant difference among years (i.e., homogeneous slopes and common intercepts were accepted) for wild steelhead trout, and the data were pooled. The linear regression analysis on this pooled data showed a very strong relation between migration rate and discharge (N=40, r^2=0.811, P=0.000).

Percent interrogation of PIT-tagged wild steelhead trout PIT-tagged at the Snake River trap was similar in 1989 and 1990. Cumulative interrogation of PIT-tagged steelhead trout at the three dams (Lower Granite, Little Goose, and McNary) was 79.0% in 1990.

Percent interrogation at the three dams (Lower Granite, Little Goose, and McNary) of wild steelhead trout PIT-tagged at the ClearWater River trap was 70.4%. Percent interrogation of PIT-tagged wild steelhead trout from the Clearwater River trap was significantly lower than for fish PIT-tagged at the Snake River trap (70.4%, 79.0%, respectively).

The migration rate discharge relation for chinook salmon between the traps and Little Goose Dam was examined. The analysis showed that 53% of the variation in migration rate for chinook salmon PIT-tagged at the Snake River trap was accounted for by discharge. It also showed that 88% of the variation in migration rate for Clearwater River chinook salmon was accounted for by changes in discharge.

The migration rate discharge relation for hatchery steelhead trout between the traps and Little Goose Dam was examined. Eighty-seven percent of the variation in migration rate of fish PIT-tagged at the Snake River trap was accounted for by discharge. Not enough data were available to examine the migration rate discharge relation of hatchery steelhead trout marked at the Clearwater River trap.

The migration rate discharge relation for wild steelhead trout between the traps and Little Goose Dam was examined. The analysis showed that 75% of the variation in migration rate of fish PIT-tagged at the Snake River trap was accounted for by discharge. Not enough data were available to perform the analysis on wild steelhead PIT-tagged at the Clearwater River trap.

Chinook salmon, hatchery steelhead trout, and wild steelhead trout PIT-tagged at the Snake River trap survived at a rate 5% to 10% greater than fish tagged at the Clearwater River trap.

Fish length versus minimum survival to Lower Granite Dam for chinook salmon, hatchery steelhead trout, and wild steelhead trout PIT-tagged at the Snake River trap was examined for 1988-1990. Minimum survival is defined as the number of fish from an individual release group that are interrogated at Lower

Granite, Little Goose, and McNary dams. Chinook salmon data from 1988 showed a relation between length and minimum survival after removing outliers ($N=27$, $r^2=0.616$, $P=0.000$), as did hatchery steelhead trout data ($N=19$, $r^2=0.747$, $P=0.000$). In 1988, a 50 mm increase in fish length would account for a 5% increase in minimum survival of chinook salmon and a 12% increase in minimum survival for hatchery steelhead smelts at Lower Granite Dam. Data for wild steelhead trout PIT-tagged at the Snake River trap for 1990 showed a relation between length and minimum survival without removing outliers ($N=17$, $r^2=0.665$, $P=0.000$). In 1990, a 50 mm increase in fish length accounted for a 10% increase in wild steelhead minimum survival to Lower Granite Dam.

There was no obvious relation between length and minimum survival to Lower Granite Dam for chinook salmon PIT-tagged at the Clearwater River trap in 1989 or 1990. Hatchery steelhead trout data from the Clearwater River trap for 1990 showed a strong relation between length and minimum survival ($N=18$, $r^2=0.855$, $P=0.000$). In 1990, a 50 mm increase in hatchery steelhead trout length accounted for a 22% increase in minimum survival to Lower Granite Dam. No relation between length and survival was shown for wild steelhead trout.

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SMOLT CONDITION AND TIMING OF ARRIVAL AT LOWER GRANITE RESERVOIR

Annual Report
for 1988 operations

by

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and
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ABSTRACT

This project monitored the daily passage of smelts during the 1988 spring outmigration at two migrant traps; one each on the Snake and ClearWater rivers.

Due to the low runoff year, chinook salmon catch at the Snake River trap was very low. Steelhead trout catch was higher than normal, probably due to trap modifications and because the trap was moved to the east side of the river.

Chinook salmon and steelhead trout catch at the Clearwater River trap was similar to 1987.

Total cumulative recovery of PIT tagged fish at the three dams, with PIT tag detection systems was: 55% for chinook salmon, 73% for hatchery steelhead trout, and 75% for wild steelhead trout.

Travel time through Lower Granite Reservoir for PIT tagged chinook salmon and steelhead trout, marked at the head of the reservoir, was affected by discharge. Statistical analysis showed that as discharge increased from 40 kcfs to 80 kcfs, chinook salmon travel time decreased three fold, and steelhead trout travel time decreased two fold. There was a statistical difference between estimates of travel time through Lower Granite Reservoir for PIT tagged and freeze branded steelhead trout, but not for chinook salmon. These differences may be related to the estimation techniques used for PIT tagged and freeze branded groups, rather than real differences in travel time.

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INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NWPPC) to develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (BPA) the authority and responsibility to use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system".

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smelt migration. In response to the Fishery Agencies' and Indian Tribes' recommendations for migration flows, the NWPPC Columbia River Basin Fish and Wildlife Program proposed a "Water Budget" for augmenting spring flows.

The NWPPC's Water Budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the smelt migration but has never been provided in full. To provide information to the Fish Passage Center (FPC) on smelt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smelts at the head of Lower Granite Reservoir. This information allows the FPC to optimize the use of the limited Snake River water budget to provide improved passage and migration conditions.

Additionally, the IDFG smelt monitoring project collects data on relative species composition, estimated fish passage index, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, migration rate, and smelt condition relative to scale loss. By monitoring smelt passage at Lower Granite Dam and at the head of Lower Granite Reservoir, migration rates under riverine and reservoir conditions can be estimated and compared under various environmental conditions. Monitoring sites, on both the Snake and Clearwater arms of Lower Granite Reservoir, permit migration timing of smelts from each drainage to be determined. Also, when possible, relative abundance of hatchery and wild stocks of steelhead trout can be determined. This can be useful information for documenting the rebuilding of wild stocks which is being attempted by other NWPPC projects. Project personnel continually strive to improve smelt trap design and location to assure that the best possible information is provided for water budget management purposes, which will maximize smelt survival.

Smelt monitoring is beneficial for water budget management under all flow conditions, and becomes critical in low flow conditions, when migration rates are slower than during normal or above normal run-off years. In such a year, knowledge of when most smelts have left tributaries and entered areas which can be affected by releases of stored waters allows managers to make the most timely use of the limited water budget resource. Two low flow years (1987 and 1988) have occurred during this smelt monitoring project. The indications are that judicious use of the water budget can greatly enhance the timing and migration rate of juvenile chinook salmon and steelhead trout.

OBJECTIVES

1. Establish timing of the out-migration for the various groups of hatchery-produced and wild chinook salmon and steelhead trout smelts as they leave the Salmon River drainage during low flow years.

2. Establish smelt travel time from the Salmon River index site at White Bird or from release sites to the index sites at the upper end of Lower Granite Reservoir.

3. Correlate travel time with river flows from index sites to Lower Granite Reservoir and Lower Granite Dam.

4. Determine where, when, and to what extent descalinq occurs to hatchery reared chinook salmon and steelhead trout smelts released upstream from Lower Granite Dam, and develop management alternatives to reduce scale loss .

METHODS

Releases of Hatcherv-Produced Smelts

Information was obtained from hatcheries which release steelhead trout and chinook salmon juveniles in the Snake River system upstream from Lower Granite Dam. This information included species, number released, date and location of release, and the group identifying freeze brand if used. This allowed us to anticipate the passage of the various release groups and branded fish at downriver trapping sites.

Smelt Monitorinq Traps

During the 1988 outmigration, two smelt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. A scoop trap (Raymond and Collins 1974) was stationed on the Clearwater River and a dipper trap (Mason 1966) was located on the Snake River (Fig. 1). Captured smelts were removed daily from the traps for examination, enumeration, and released back to the river. When available, between 150 to 300 chinook salmon and steelhead trout smelts were examined each day for scale loss. up to 100

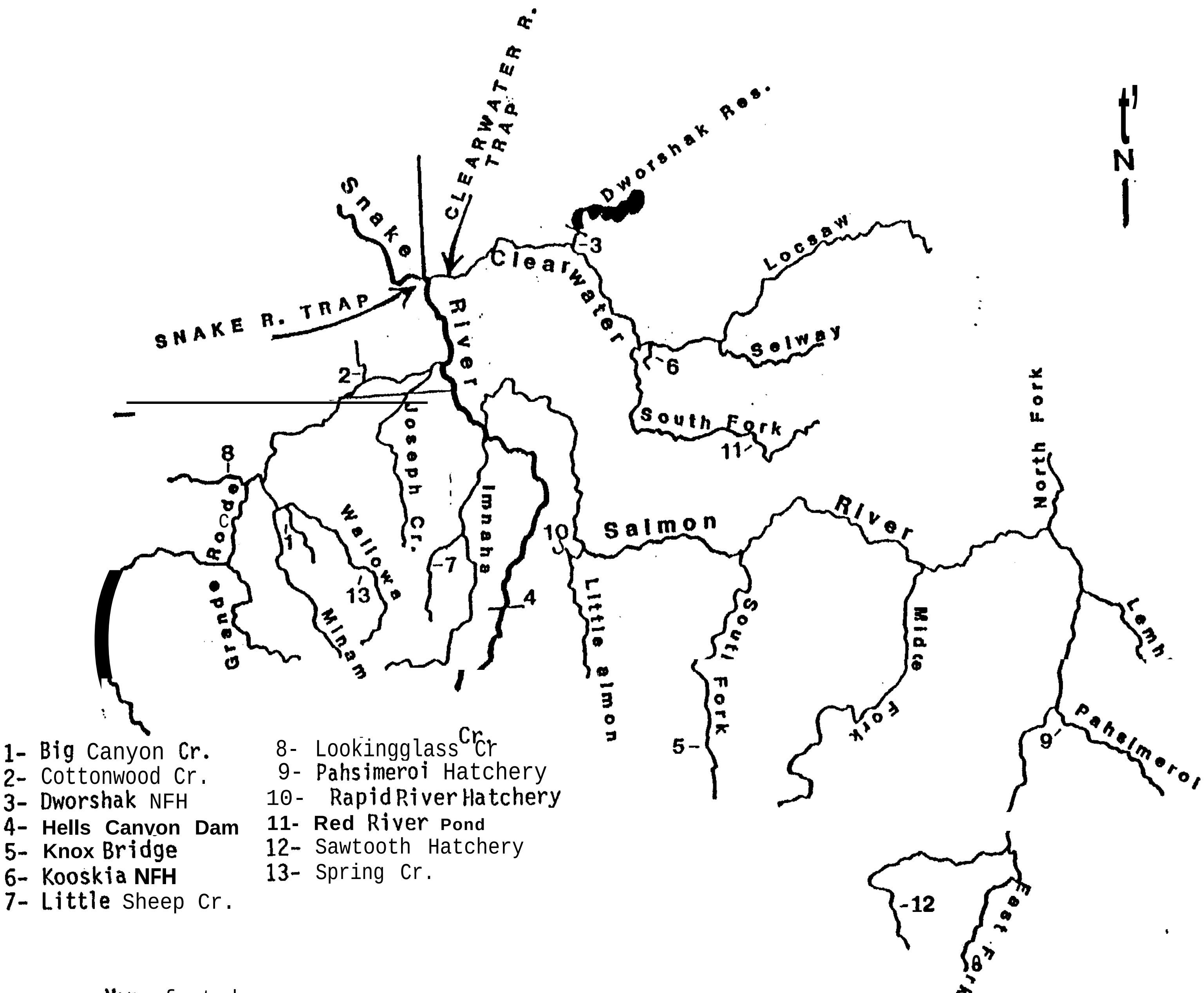


Figure 1. Map of study area.

smolts were measured to the nearest millimeter and up to 2,000 fish were examined for hatchery brands, the remaining catch was enumerated by species and released. Smelts handled were anesthetized with Tricaine Methanesulfonate (MS-222). These fish were allowed to recover from the anesthesia before being returned to the river.

To quantify scale loss, each side of a smelt was separated into five areas and each area was examined (Koski et al. 1986). An area was considered "descaled" if 40% or more of the scales were missing. If at least two areas on one side of a fish were descaled, then the fish was considered descaled. Scale loss of this degree is often referred to as “standard” descaling (classical descaling) to distinguish it from other types of descaling. Additionally, beginning in 1985, a fish was also considered to have standard descaling if a band of scales were missing from at least one side of a fish (#9’s), and the amount of missing scales was equal to or greater than the loss of 40% or more scales from two areas on a side of a fish as described above. A second classification is “scattered” descaling, which occurred when at least 10% of the scales were missing from at least one side of the fish. Another classification for descaling is “two-area”, which exists when the sum of the number of the ten areas on a fish (Fig. 2), which are at least 40% descaled, and the number of sides of a fish which exhibit scattered descaling, equals two or more. The two-area classification includes fish that exhibit standard descaling, as well as fish that would not meet the criteria for the standard category because there was only one descaled area per side. This type of descaling is likely to be as detrimental to fish health as standard descaling.

At each trap, water temperature and turbidity were recorded daily using a centigrade thermometer and 20 cm Secchi disc. The U.S. Weather Service provided daily information on river discharge. The Snake River trap discharge was measured at the USGS Anatone gauge (#13334300). The Clearwater River trap discharge was measured at the USGS Spalding gauge (#13342500).

Salmon River Trap

Due to a lack of funding, the Salmon River trap was not operated in 1988, even though it was a below normal water year. Normally the Salmon River trap is operated only if the February Soil Conservation Service - Snow Survey stream flow forecast at White Bird, Idaho, is less than 90% of the 25-year average. A tentative decision to operate the trap is made in early February using the January stream flow forecast. If the January forecast is below 90% of normal preparation to operate, the Salmon River trap will begin. The final decision is then made using the February forecast, available in early March. Information during near normal to above normal flow years is available at the Salmon River trap for 1983, 1984 and 1985.

TRAP JUVENILE DESCALING FORM (RECORDER ____________)

DATE _______ SITE ____________ TIME __________ SECCHI DISC ________ M

H2O TEMP ____ C VELOCITY ______ TRAP POSITION ____________

Efficiency Tests: Trap down time (hrs) ______
(# fish marked/released and mark used)
Chinook ________________ SH ________________ SW ________________

Remarks: ____

DESCALING

RIGHT LEFT

6. SCATTERED 7. EYE/HEAD INJURIES 8. DEAD 9. DESCALED BAND

CHIN : STEEL:	CHIN : STEEL:	CHIN : STEEL:	CHIN : STEEL
descale: brand:	descale: brand:	descale: brand:	descale: brand
1.	1.	1.	1.
2.	2.	2.	2.
3.	3.	3.	3.
4.	4.	4.	4.
5.	5.	5.	5.
6.	6.	6.	6.
7.	7.	7.	7.
8.	8.	8.	8.
9.	9.	9.	9.
10.	10.	10.	10.
11.	11.	11.	11.
12.	12.	12.	12.
13.	13.	13.	13.
14.	14.	14.	14.
15.	15.	15.	15.
16.	16.	16.	16.
17.	17.	17.	17.
18.	18.	18.	18.
19.	19.	19.	19.
20.	20.	20.	20.
21.	21.	21.	21.
22.	22.	22.	22.
23.	23.	23.	23.
24.	24.	24.	24.
25.	25.	25.	25.

FISH SAMPLED: CHINOOK ________ HATCHERY STEEL ________ WILD STEEL ________

Form: TJD-88

Figure 2. Form used to record smolt passage and descaling information. Drawings show the five areas on each side of a smolt which are considered independently for scale loss.

Snake River Trap

The Snake River migrant dipper trap was positioned approximately 40 m downstream from the Interstate Bridge and was attached to bridge piers just west of the draw bridge span by steel cables. This location is near the head of Lower Granite Reservoir, 0.5 km upstream from the confluence of the Snake and Clearwater rivers. River width and depth at this location are approximately 260 m and 12 m, respectively.

A juvenile steelhead radio tagging study was conducted in 1987 (Liscom and Bartlett 1988) which showed that during 1987, 7% of the radio tagged steelhead passed the bridge under the span the trap was attached to, and 30% passed the bridge under the span immediately east of the draw bridge span. Because at least four times more fish were moving under the span of the bridge just east of the draw bridge, the trap was moved to that location on April 27, 1988, after completion of installing an electrical line to the new trap location.

Trap operation in 1988 began March 5 and continued until June 20. There were two interruptions in trap operation due to mechanical breakdown. One for an undetermined amount of time on April 28, and one for four days on May 18 through May 21.

Chinook salmon and steelhead trout smelts were PIT (Passive Integrated Transponder) tagged (Prentice et al. 1987) at the Snake River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam. When fish were available, up to 150 chinook salmon, 60 hatchery steelhead trout, and 60 wild steelhead trout were PIT tagged daily. Early in the chinook smelt migration, when Clearwater River trap chinook catch is high and Snake River trap chinook catch is low, chinook are transported from the Clearwater River trap to the Snake River trap, PIT tagged, and released. Individual daily release group travel time was correlated with the abiotic parameters present during the migration period to determine how changes in these parameters affected travel time of smelts through Lower Granite Pool.

Clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from the river mouth, 4.5 km upstream from the head of Lower Granite Reservoir. The river channel at this location forms a bend and is 150 to 200 m wide and 4 m to 7 m deep, depending on discharge.

Trap operation began March 8 and continued until June 12 when trap operation was terminated for the season. The trap was down because of excessive debris March 27, and high flow prevented trap operations on April 19 and from May 4 to May 21.

Descaling

DeScaling estimates were made on both chinook salmon and steelhead trout at the Snake and Clearwater river trap sites. These values were compared to previous years data to indicate the general condition of the migrating smelts. No descaling information was collected at hatchery facilities in 1988, as had been in previous years. Past data indicates that very little, if any, descaling occurs at the hatcheries or during transport to release sites.

Trap Efficiency

To estimate the number of smelts passing a trap, it is necessary to know what proportion of the migration is being sampled. Additionally, this proportion, which is the trapping efficiency, may change as river discharge changes. To create an equation which describes the relationship between discharge and efficiency, efficiency must reestimated several times through the range of discharge the trap is being operated at. With sufficient information, a regression of efficiency on discharge could then be calculated from the data. With this type of approach an efficiency can then be estimated from any given discharge. The ratio of recaptures to marks released is the estimate of trap efficiency (TE = recaptures/marks released).

Trap efficiency tests were conducted periodically throughout the season on the Clearwater River trap by releasing marked smelts 7 km upriver from the trap site. When trap catch allowed, up to 2,000 chinook salmon were caudal clipped and 2,000 steelhead trout were opercle punched and released upstream. In addition to these fish, six groups of chinook salmon of approximately 2,200 each, and three groups of steelhead trout of approximately 4,000 each, were freeze branded at Dworshak NFH, held there, and transported to the Clearwater River release site and released during the spring smelt migration to estimate trap efficiency. Four groups of freeze branded chinook and three groups of freeze branded steelhead released with the DNFH general release were also used to estimate efficiencies on the Clearwater River trap.

Three hatchery steelhead release groups and three trap caught steelhead groups were used to conduct trap efficiency tests at the Snake River trap. Inadequate numbers of chinook were available in 1988 to conduct efficiency tests on the Snake River trap.

Travel Time and Migration Rates

Migration parameters were calculated on hatchery release groups from release sites to traps sites. Travel time and migration rates through Lower Granite Reservoir were calculated using median arrival times at the Snake and Clearwater River traps, and at Lower Granite Dam for hatchery brand groups and brand groups used for trap efficiency tests. Smelts were PIT tagged at the Snake River trap as an additional method to determine travel time, and daily individual arrival times were calculated at Lower Granite Dam collection facility.

RESULTS AND DISCUSSION

Hatchery Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage above Lower Granite Dam were reared at seven locations in Idaho end one in Oregon. Washington Department of Fisheries made no release of chinook salmon juveniles in the Snake River drainage upstream from Lower Granite Dam that contributed to the 1988 outmigration. A total of 11,176,084 chinook salmon smelts were released at 15 locations in Idaho and Oregon (Table 1).

Sawtooth Hatchery made a fall release of 100,600 spring chinook salmon in the Salmon River in 1987. Dworshak NFH had a fall release of 192,330 spring chinook, and Red River Pond also released 233,100 spring chinook salmon in Clearwater River drainage in the fall of 1987. Lookingglass Hatchery also made a fall release of 164,347 spring chinook salmon juveniles at Lookingglass Creek, Oregon in 1987. All other chinook salmon releases for the 1987 outmigration were made in the spring of 1988 (Table 1).

Steelhead Trout

Steelhead trout were reared at four hatcheries in Idaho, one in Washington, and one in Oregon for release upriver from Lower Granite Dam. A total of 10,798,379 steelhead trout smelts were released at 23 locations in Idaho, eight locations in Oregon, and three locations in Washington (Table 2).

Niagara Springs Hatchery and Hagerman NFH released a total of 748,049 steelhead trout juveniles in the Snake River at Hells Canyon during the fall of 1987. The remainder of steelhead trout releases contributing to the 1988 outmigration occurred in the spring of 1988 (Table 2).

Table 1. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam contributing to the 1988 outmigration.

Release site (hatchery)	Stock	Release date	No. released (no. branded)	Brand
<u>Salmon River</u>				
Sawtooth Hat.	Spring	3/15	1,604,900	
(Sawtooth)		(3/15)	(52,300)	RDT-1
		10/6/87	100,600	
E.F. Salmon R. (Sawtooth)	Spring	3/15-16	249,200	
Yankee F. Sal. R. (Sawtooth)	Spring	3/14-18	725,300	
S.F. Salmon R.	Summer	3/21-24	1,060,400	
(McCall)		(3/23)	(53,900)	RDT-2
Pahsimeroi R. (Pahsimeroi)	Summer	3/15-19	598,500	
Rapid River	Spring	3/15-25	2,630,200	
(Rapid River)		(3/18)	(54,500)	RDT-4
	Drainage Total		6,969,100	
<u>Snake River and Non-Idaho Tributaries</u>				
Hells Canyon	Spring	3/22-23	400,600	
(Rapid River)		(3/22)	(53,900)	LDT-4
Lookingglass Cr.	Spring	4/1-5/13	345,943	
(Lookingglass)		(4/1)	(20,128)	LAIM-1
		(4/1)	(19,712)	RAIM-1
		(4/1)	(21,731)	LAIF-3
		(4/1)	(21,659)	RAIF-3
		(5/13)	(21,019)	LAUO-1
		(5/13)	(20,473)	LAUT-1
		9/18-11/3/87	164,347	
		(9/18/87)	(20,030)	RAIF-1
		(9/18/87)	(20,076)	LAIF-1
Catherine Creek (Lookingglass)	Spring	3/31-4/5	151,888	
Big Canyon Creek (Lookingglass)	Spring	3/30-4/8	186,309	

Table 1. (Continued)

Release site (hatchery)	Stock	Release date	No. released (no. branded)	Brand
Imnaha River (Lookingglass)	Spring	3/21-4/21	199,066	
		(3/22)	(20,440)	LAIM-3
		(4/20)	(20,602)	RAIM-3
	Drainage Total		1,448,153	
Clearwater River				
Red River Pond (Red River Pond)	Spring	9/28-10/2/87	233,100	
		(9/30)	(46,100)	RDT-3
N.F. ClearWater (Dworshak NFH)	Spring	3/30	1,132,152	
		(3/30)	(20,642)	RA7N-1
		(3/30)	(8,731)	RAR-1
		(3/30)	(22,935)	RA7N-3
		(3/30)	(6,163)	RAR-3
		(3/30)	(60,631)	LAT-2
		3/30	222,737	
		9/28/87	192,330	
		(9/28/87)	(64,425)	LDT-1
		(3/30)	(59,283)	LAH-1
Clearwater R Hwy 95 Boat Launch (Dworshak NFH)	Spring	3/14-4/13	13,173	
		(4/1)	(2,195)	RDK-1
		(4/6)	(2,194)	RDK-2
		(3/21)	(2,197)	RDK-3
		(4/13)	(2,193)	RDK-4
		(3/14)	(2,197)	LDK-1
		(3/17)	(2,197)	LDK-3
White Sands Cr. (Dworshak NFH)	Spring	3/14	200,105	
Clear Creek (Kooskia NFH)	Spring	3/22	778,407	
	Drainage Total		2,758,831	
	Grande Total		11,176,084	

Table 2. Hatchery steelhead trout released into the Snake River system upriver from Lower Granite Dam contributing to the 1988 outmigration.

Release site (hatchery)	Stock	Release date	No. released (no. branded)	Brand
Salmon River				
Shoup Bridge (Niagara Springs)	A	4/11-12	103,500	
Pahsimeroi River (Niagara Springs)	A	4/8	665,800	
Panther Creek (Niagara Springs)	A	4/12-13	102,800	
E.F. Salmon River (Hagerman NFH)	B	4/6-8	303,564	
Sawtooth Hatchery (Hagerman NFH)	A	4/14-19 (4/15)	1,195,745 (48,745)	LDT-2
Slate Creek (Hagerman NFH)	B	4/25	50,722	
Hazard Creek (Magic Valley)	A	4/12-23	701,300	
N.F. Salmon River (Magic Valley)	A	4/4-1 o	253,100	
Yankee Fork (Magic Valley)	A	4/4-7	208,000	
Shoup Bridge (Magic Valley)	A	4/6-10	147,500	
Sawtooth Hatchery (Magic Valley)	A	4/6-9	57,700	
Panther Creek (Magic Valley)	A	4/11	162,800	
French Creek (Magic Valley)	A	4/11-14	100,000	
Slate Creek (Magic Valley)	A	4/18-25	346,100	
Hammer Creek (Magic Valley)	A	4/23-25	87,200	
	Drainage Total		4,485,831	

Table 2. (Continued)

Release site (hatchery)	Stock	Release date	No. Released (no. branded)	Brand
Snake River and Non-Idaho Tributaries				
Hells Canyon (Niagara Springs)	A	4/23-25	877,400	
		(4/24)	(46,400)	LDT-3
	A	10/19-21/87	404,000	
Hells Canyon (Hagerman NFH)	A	10/22-11/5/87	344,049	
Snake R.@ Asotin (Dworshak NFH)	B	5/1 6-23	11,969	
		(5/16)	(3,996)	LD4-1
		(5/23)	(3,996)	LD4-3
		(5/23)	(3,977)	RD4-1
Little Sheep Cr. (Irrigon)	A	4/13-14	246,994	
		(4/14)	(24,026)	LAIM-2
		(4/14)	(26,023)	LAIF-2
Spring Creek (Irrigon)	A	4/16-18	526,877	
		(4/17)	(25,268)	LAIM- 1
		(4/17)	(25,452)	LAIF- 1
		(4/17)	(25,131)	LAIM-3
		(4/17)	(25,182)	LAIF-3
		(4/18)	(25,604)	RAIM-3
		(4/18)	(24,980)	RAIF-3
Wildcat Creek (Irrigon)	A	4/16-5/2	200,625	
		(4/20-22)	(49,100)	RAIM- 1
		(4/22-26)	(50,555)	RAIF- 1
Grande Ronde (R2) (Irrigon)	A	4/5-8	199,905	
Catherine Creek (Irrigon)	A	4/4-8	62,520	
Wallowa River (Irrigon)	A	4/13-19	134,000	
Big Canyon Creek (Irrigon)	A	4/13	223,196	
Imnaha River (Irrigon)	A	4/21 -28	84,503	
Asotin Creek (Lyons Ferry)	A	4/20	28,975	

Table 2. (Continued)

Release site (hatchery)	Stock	Release date	No. Released (no. branded)	Brand
Cottonwood Creek (Lyons Ferry)	A	4/15-29	202,676	
Whisky Creek (Lyons Ferry)	A	4/28	50,640	
	Drainage	Total	3,598,329	
Clearwater River				
ClearWater River (Dworshak NFH)	B	5/3-4	1,432,125	
		(5/3)	(47,601)	RAT- 1
		(5/3)	(22,220)	RAT-2
		(5/3)	(14,476)	RAT-3
		(5/4)	(44,446)	RAT-4
S.F. Clearwater R (Dworshak NFH)	B	4/19-28	165,055	
Newsome Creek (Dworshak NFH)	B	4/20-21	190,708	
American River (Dworshak NFH)	B	4/20-21	56,885	
Clear Creek (Dworshak NFH)	B	4/19-22	254,898	
Crooked River (Dworshak NFH)	B	4/18-19	201,325	
Lolo Creek (Dworshak NFH)	B	4/25-27	200,425	
Eldorado Creek (Dworshak NFH)	B	4/20-22	200,806	
Hwy 95 Bridge (Dworshak NFH)	B	4/1 3-22	11,992	
		(4/13)	(4,000)	RA4-1
		(4/22)	(3,998)	RA4-3
		(4/22)	(3,994)	RD4-3
	Drainage	Total	2,714,219	
	Grande Total		10,798,379	

Smelt Monitoring Traps

Snake River Trap Operation

The Snake River trap was operated from March 5 through June 20, 1988. Trap catch during this period was 3,758 yearling chinook salmon, 2,604 wild steelhead trout, and 16,772 hatchery steelhead trout. A large portion of the chinook salmon (53%) were captured during April while 33% were captured in May (Fig. 3). Twenty-five percent of the hatchery steelhead trout were captured during April, 68% were captured in May, and 7% in June (Fig. 4). Wild steelhead trout passage coincides with hatchery steelhead passage, with 34% of the smelts being captured in April, 64% in May, and 2% in June (Fig. 4).

The Chinook salmon catch at the Snake River trap was very low in 1988 (less than 10% of normal). There appears to be a threshold velocity at the mouth of the trap, below which the trap is relatively ineffective at collecting fish. Chinook catch was affected the greatest because velocities were very low during the majority of the chinook outmigration. An eastern trap location on the Interstate bridge was prepared and the trap was moved to that location on April 27. The majority of the chinook had passed the Snake River trap by the time the trap was relocated so it is not certain whether the new location will provide adequate chinook catches in low flow years.

Snake River discharge, measured at the Anatone gauge, ranged from 21,500 cfs to 30,300 cfs in the month of March (Fig. 4). The average April discharge was 26,000 cfs, with a peak of 40,000 cfs April 22. The average May discharge was 40,300 cfs and the season peak discharge of 52,900 occurred May 25. Flows remained above 40,000 cfs until June 8. After that time flows dropped rapidly to 29,000 by the end of the trapping season on June 20.

Water temperature in the Snake River, at the trap, was between 5° and 7°C during March (Fig. 5). Temperature steadily increased throughout the season. By the end of the trapping season, June 20, water temperature had risen to 19°C.

Secchi disc transparency fluctuated throughout the sampling season (Fig. 5). Influenced mainly by localized rain or thunderstorm events, the secchi transparency shows no obvious correlation to changes in discharge.

Clearwater River Trap Operation

The Clearwater River trap operated from March 8 through June 12. Total trap catch for the season was 63,983 chinook salmon, 9,940 hatchery steelhead trout and 458 wild steelhead trout in 1988. Two peaks of chinook salmon passage were observed at the Clearwater River trap. The first peak began on March 24, prior to the Dworshak NFH release, and was presumed to be from the White Sands Creek, Red River pond, Kooskia NFH release made in Clear Creek and natural production. The second peak was mainly comprised of the Dworshak NFH release

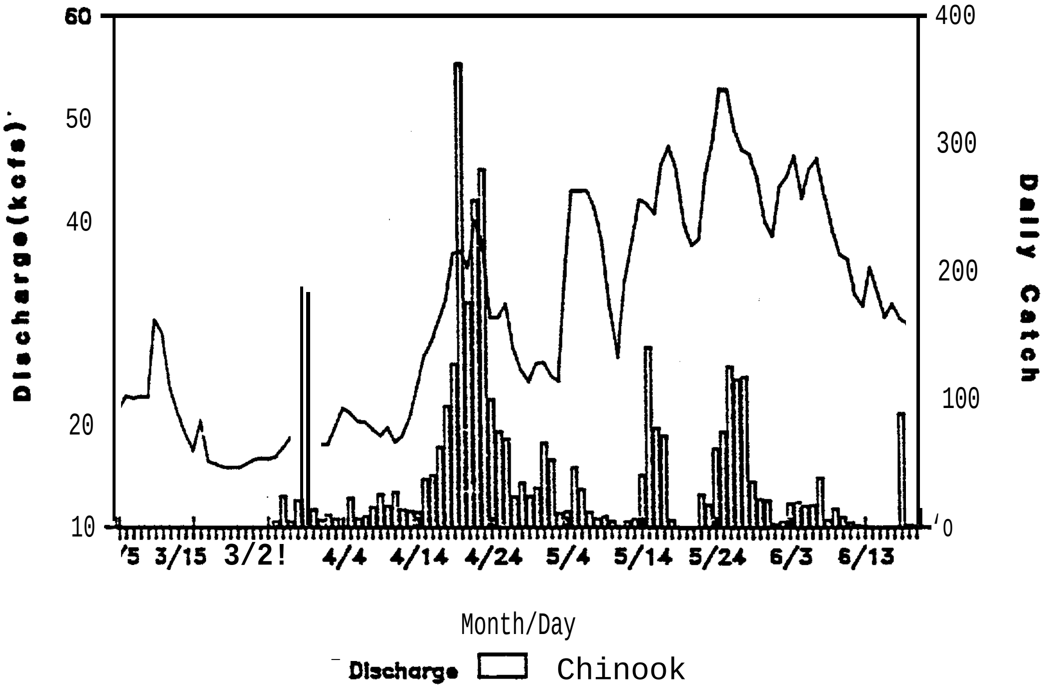
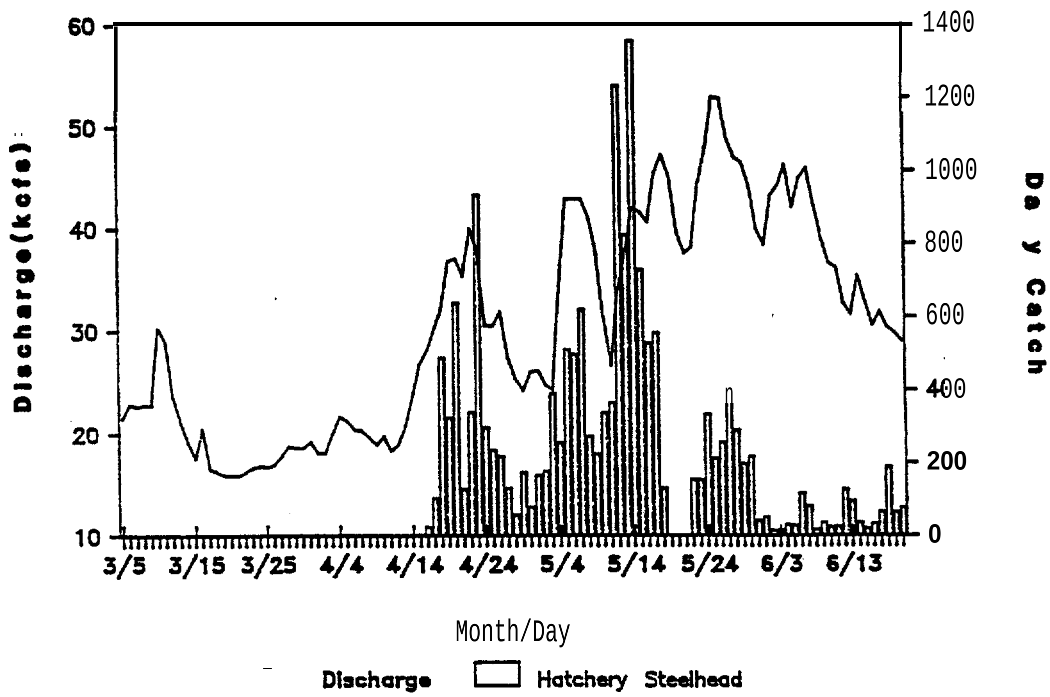


Figure 3. Snake River trap daily catch for yearling chinook salmon overlaid by Snake River discharge, 1988.



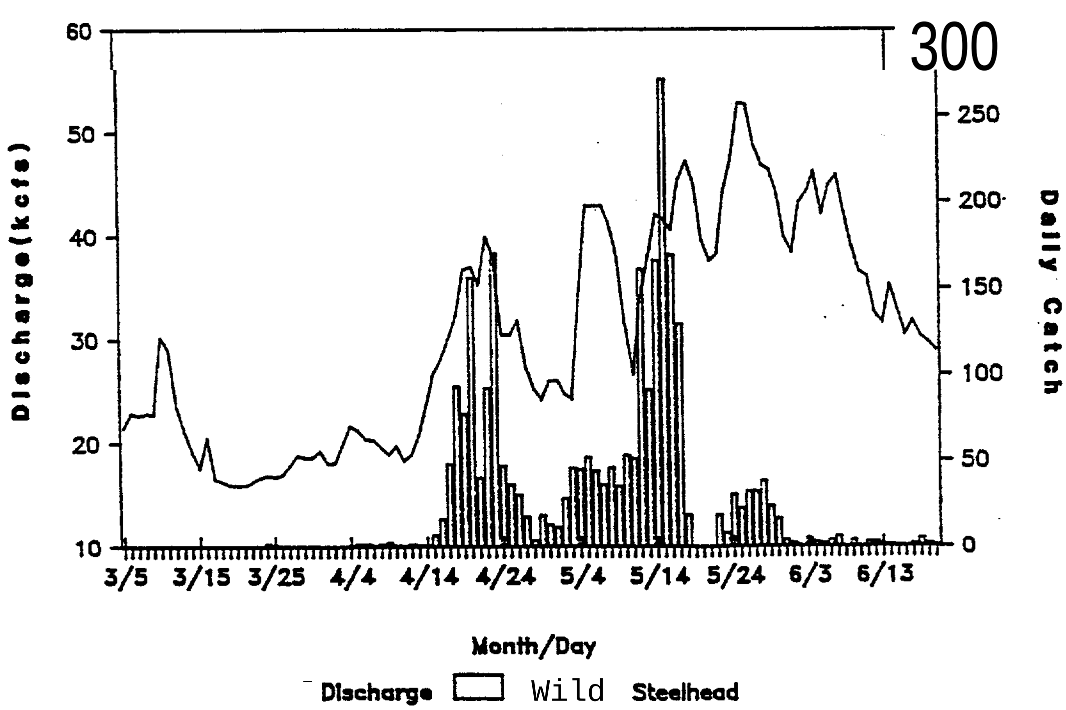
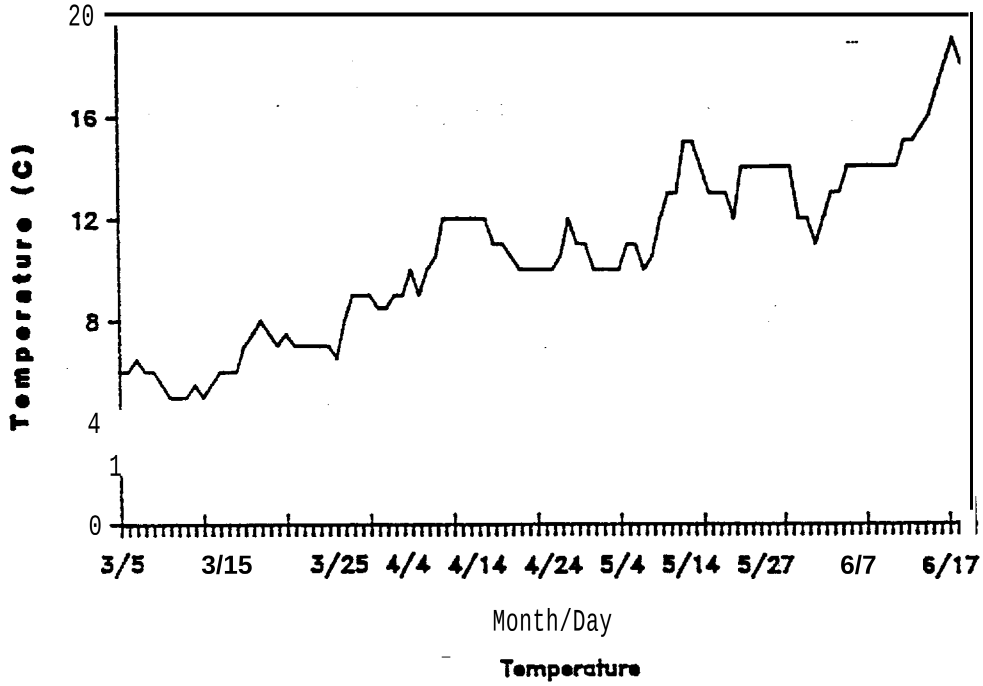


Figure 4. Snake River trap **daily** catch for hatchery steel head trout and wild steelhead trout overlaid by Snake River discharge, 1988.



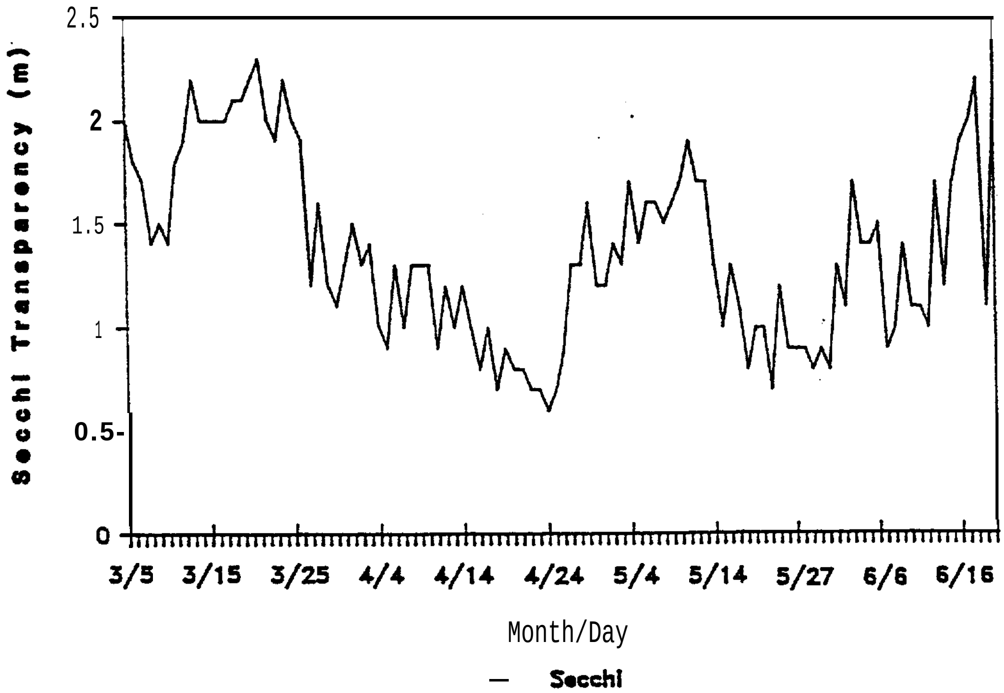


Figure 5. Daily temperature and secchi disk transparency at the Snake River trap, 1988.

made in the North Fork of the Clearwater River (Fig. 6). Dworshak NFH released it's entire chinook production from the hatchery during a 12 hour period, which caused the Clearwater River trap to have a daily catch of 25,929 on March 31, the day after the release.

Daily hatchery steelhead trap catch on the Clearwater River trap peaked on May 3, coinciding with the release of Dworshak NFH steelhead trout smelts from the hatchery and from off-hatchery planting sites (Fig. 7).

Water temperature at the Clearwater River trap was 5.5°C the beginning of the season, March 8, and remained low through April, exceeding 10°C only three times by the end of April (Fig. 8). The high temperature for the season (14.5°C) was recorded the last-day of operation, June 12.

Discharge at the beginning of the season was 7,100 cfs and remained below 20,000 cfs until April 15 (Fig. 6). A peak in the hydrography (maximum discharge for the peak was 35,700 cfs) was seen between April 15 and April 25. Another peak occurred between May 4 and May 10 (maximum discharge for the peak was 43,400 cfs). Discharge remained between 20,000 to 35,000 cfs until the end of the season, June 12. The trap was out of operation during the high discharge from May 6 until May 21.

Secchi disc transparency in the Clearwater River fluctuated throughout the trapping season, and ranged from 0.4 meters to two meters and greater (Fig. 8).

Descaling

Chinook Salmon Descaling

The 1988 standard descaling rate for yearling chinook salmon at the Snake River trap averaged 5.5%. This compares to a previous high of 10.4% in 1987 and a low of 2.5% in 1984 (Table 3).

Standard descaling of yearling chinook salmon observed at the Clearwater River trap in 1988 averaged 0.5%. This value is a five year low and compares to a high of 4.3% in 1987 (Table 3).

Neither the Snake nor Clearwater River trap sample descaling rates were considered detrimentally high. The comparison of this data from year to year can provide an overall picture of general fish health. However, the main function of this data is to access the day to day operation of the traps. An increase in descaling rates during the season may indicate that a problem in the operation of the trap is injuring fish.

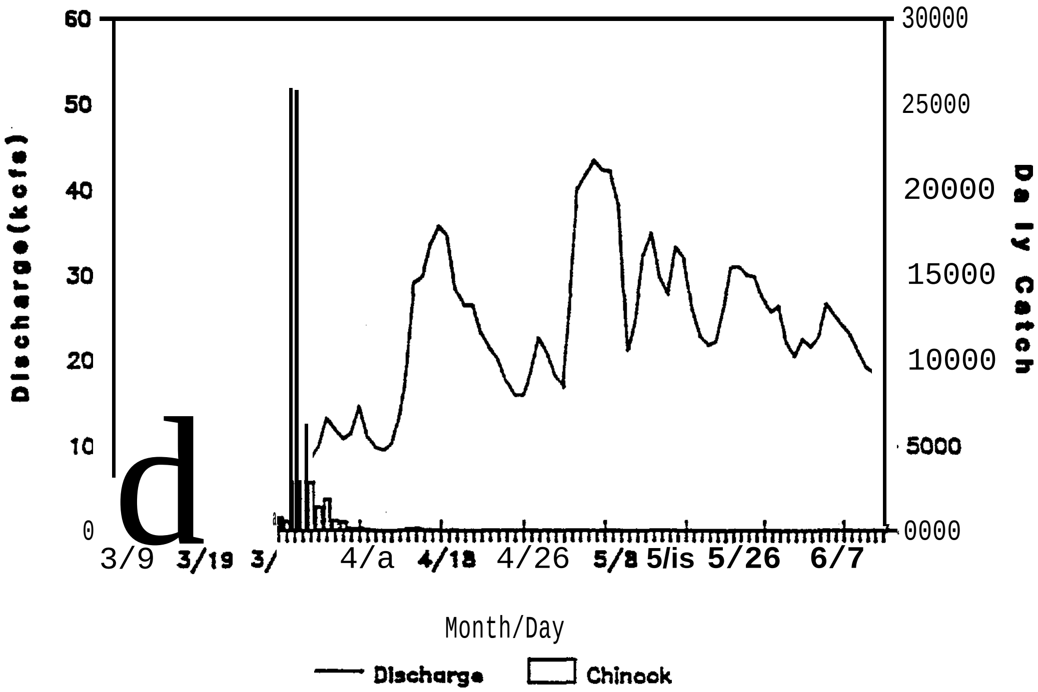


Figure 6. Clear'water River trap daily catch for yearling chinook salmon overlaid by Clearwater River trap discharge, 1988.

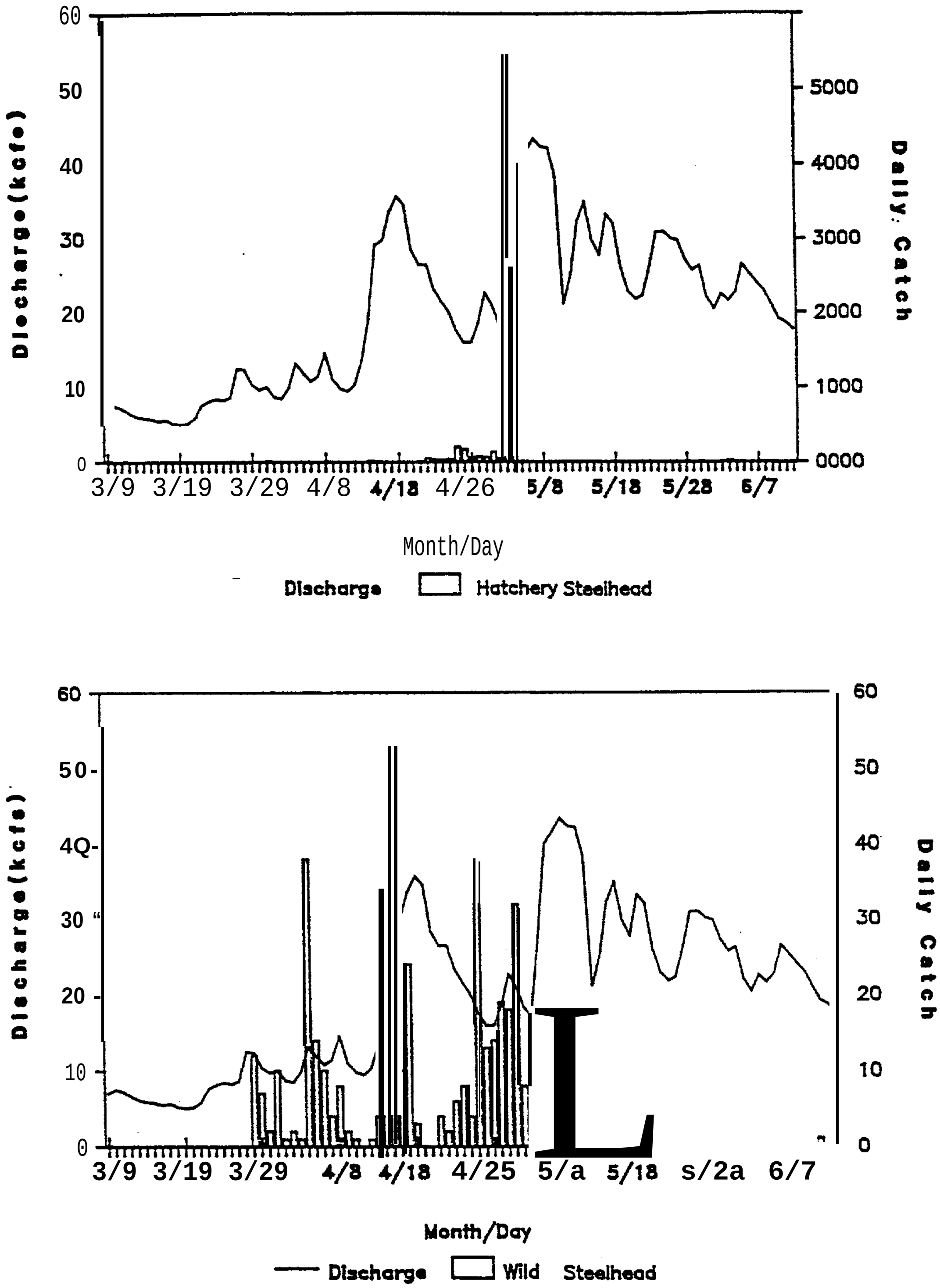


Figure 7. Clearwater River trap daily catch for hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River trap discharge, 1988.

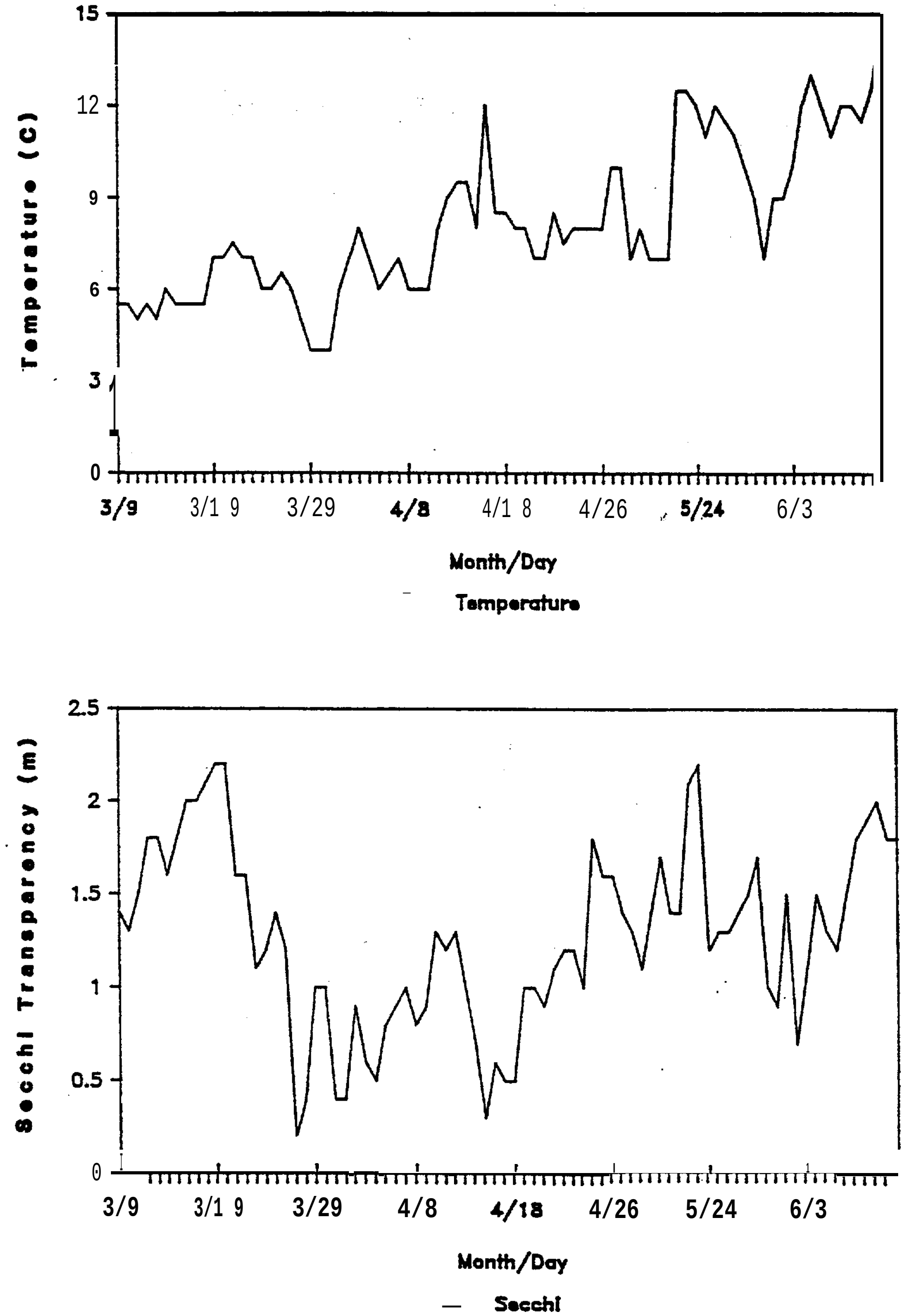


Figure 8. Daily temperature and secchi disk transparency at the Clearwater River trap, 1988.

Table 3. Seasonal mean standard **descaling** rates (percent) for **yearling** chinook salmon, hatchery steelhead trout, and wild steelhead trout at the Snake River and Clearwater River traps, 1984 through 1988, and Salmon River trap, 1984 through 1987.

Species	Year	Salmon River	Snake River	Clearwater River
Yearling chinook salmon	1984	4.5	2.5	1.5
	1985	2.4	2.6	0.6
	1986		3.8	0.7
	1987	2.0	10.4	4.3
	1988		5.5	0.5
Hatchery steelhead trout	1984	8.7	5.5	4.1
	1985	10.1	6.2	2.1
	1986		14.5	6.3
	1987	6.2	6.2	4.0
	1988		5.9	3.2
Wild steelhead trout	1984	2.1	1.4	0.4
	1985	0.7	0.8	0.7
	1986		2.7	0.8
	1987	2.5	3.3	1.3
	1988		1.4	1.8

Steelhead Trout Descaling

The 1988 standard descaling rate of hatchery steelhead trout smelts at the Snake River trap averaged 5.5%, whereas wild steelhead trout averaged 1.4%. These values compares to previous highs of 14.7% in 1986 for hatchery steelhead trout, and 3.3% in 1987 for wild steelhead trout. Comparative low descaling rates for the same period were 5.5% in 1984 for hatchery steelhead trout, and 0.8% in 1985 for wild steelhead trout (Table 3). As with the descaling data from chinook salmon smelts, this information can be used to compare the general health of the smelt population from year to year, but it is more appropriately used at this time as an indicator of the day to day trap operation effects on trap caught fish.

Trap Efficiency

Snake River Trap

The daily catch of yearling chinook salmon at the Snake River trap during the 1988 smelt outmigration provided too few fish to conduct trap efficiency tests. With low water conditions, similar to the 1987 season, the velocities at the mouth of the trap throughout the chinook migration were generally less than 1.5 fps. A threshold water velocity of between 1.5 and 2.0 fps at the mouth of the trap is required before the trap will effectively collect chinook smelts. A gross estimate of the 1988 trap efficiency could be comparable to that of 1987 which was 10 to 30 times less than the 1.2% trap efficiency of previous years. The only data available for this estimate is the number of hatchery fish released upstream from the Snake River trap, or potential fish captures, divided by the actual trap catch and comparing this to previous years data.

Trap efficiency for steelhead trout smelts was tested a total of five times during the 1988 smelt outmigration (Table 4). Three of these tests were conducted using trap caught fish, and two tests used hatchery released fish (held at DNFH). One of the tests, using trap caught fish, yeilded a recapture of less than five fish and was not included in any of the analysis. Due to trap efficiencies of less than 20% the data was transformed to arcsin $\sqrt{x}$ values (Zar 1984) in this and subsequent analysis, such that:

$$P' = \tfrac{1}{2}[\arcsin \sqrt{x/n+1} + \arcsin \sqrt{x+1/n+1}].$$

Analyzing the four valid sets of 1988 data shows a trap efficiency, for steelhead trout at the Snake River trap, of 0.65% with confidence limits of:

$$0.0012 \leq 0.0065 \leq 0.0160.$$

Table **4.** Snake River trap efficiency tests for steelhead trout smelts, 1985 through 1988.

	Release date	Recapture/ mark	Efficiency	Discharge **(kcfs)**
1985	5/4	8/811	0.0099	55
	5/8	1/185	0.0054*	54
	5/18	1/492	0.0020*	50
	5/21	2/314	0.0064*	68
1986	**4/24**	1/179	0.0056*	80
	4/30	12/874	0.0137	72
	5/21	3/1,345	0.0022*	76
1987	No efficiency tests conducted for steelhead smelts in 1987.			
1988				
trap caught	4/18	2/866	0.0023*	32
	5/13	7/2057	0.0034	38
	5/15	5/1822	0.0027	42
hatchery releases	5/23	54/3977	0.0136	45
	5/23	32/3996	0.0080	45

*Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

If the two valid trap efficiency tests from 1985 and 1986 are included in the equation, the resulting trap efficiency equals 0.82% with confidence limits of:

$$0.0038 \leq 0.0082 \leq 0.0144.$$

Due to several major factors that varried in 1988 and influenced trap efficiency greatly (trap position and river discharge), the combined data from 1985, 1986, and 1988 is considered not to be the most acurate overall trap efficiency estimate. In fact, there is too little data available at this time to accurately estimate any trap efficiency of steelhead trout at the Snake River smelt trap. Also, due to the minimal amount of data avaiable, no further analysis of the data or correlation of trap efficiency to other parameters was done.

Clearwater River Trap

Since 1984, 33 valid trap efficiency tests for chinook salmon have been conducted on the Clearwater River smelt trap over a wide range of river discharges; 15 of these tests took place during the 1988 sampling season (Table 5). Of these, five test groups were part of the DNFH general release, March 30. Six of the tests were conducted with fish that were marked and held at DNFH until they were transported, via truck, from the hatchery and released at the Highway 95 boat launch. These releases took place at approximately one week intervals during March and April. The remaining four groups consisted of trap caught fish that were marked and transported back upstream for release. These four tests took place during late March and early April.

Trap efficiency can vary under differing flow conditions and from year to year. A one way analysis of variance was used to determine if there was a difference in trap efficiency among years. There were no significant differences among years. Again, due to recapture rates of less than 20%, arcsin $\sqrt{x}$ transformations (Zar 1984) of the data were used in the analysis of the trap efficiencies. Since the data from each year was collected under a variety of discharge conditions, an analysis of covariance was run to see if trap efficiency differed from year to year when adjusted for discharge.

First the underlying assumption of equality of slopes was tested. The hypothesis of equality of the trap efficiency-discharge slopes among years could not be rejected. The subsequent analysis of covariance showed no significant differences due to year when the trap efficiencies were adjusted for discharge. This is basically a test of whether the regression lines relating discharge and trap efficiency for each year have a common intercept, or whether one regression line is higher than another. The data shows no statistically discernible differences for trap efficiencies among years even after adjusting for discharge.

Table 5. Clearwater River trap efficiency tests for chinook salmon smelts, 1984 through 1988.

	Release date	Recaptures/ Mark	Efficiency	Discharge (kcfs)
1984	4/5	4/418	0.0096*	21
	4/21	13/806	0.0161	33
	4/25	3/489	0.0061*	31
	5/10	14/453	0.0309	24
1985	3/25	14/607	0.0230	9
	3/30	45/1,511	0.0298	9
	4/5	6/1 ,079	0.0056	18
	4/9	2/940	0.0021*	15
	4/16	7/929	0.0075	33
1986	3/27	9/1 ,555	0.0058	22
	4/2	8/1,714	0.0047	29
1987				
DNFH releases	3/20	43/2,160	0.0199	13
	4/22	50/2,000	0.0250	6
	4/7	165/1,945	0.0848	10
	4/13	74/2,000	0.0370	13
	4/20&28	103/4,000	0.0258	18
trap caught	**4/2**	33/1,926	0.0171	6
	4/3	11/1,458	0.0075	8
	4/6	15/1,872	0.0080	9
	4/7	15/1,163	0.0129	10
	4/9	9/450	0.0200	12
1988				
Hwy 95 boat launch	3/14	51/2,197	0.0232	6
	3/17	93/2,197	0.0423	6
	3/21	83/2,197	0.0378	6
	4/1	27/2,195	0.0123	9
	4/6	18/2,194	0.0082	11
	4/13	31/2,193	0.0141	14
DNFH release	**3/30**	1711/60,631	0.0282	10
	3/30	252/8,731	0.0289	10
	3/30	181/6,163	0.0294	10
	3/30	788/20,642	0.0382	10
	3/30	573/22,935	0.0250	10
trap caught	3/24	17/2086	0.0081	9
	3/28	27/1 695	0.0159	12
	4/1	16/1631	0.0098	9
	4/2	38/2257	0.0168	8

*Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

The data was then pooled over years and a single regression line was fit between discharge and trap efficiency. This relationship was statistically significant (F=6.103, **P=0.019),** but the R^2 was only 0.152 indicating no interpretable biological meaning can be ascribed to the relationship.

At this point, year and discharge were discounted as significant factors in explaining trap efficiency of chinook salmon at the Clearwater River trap and the average trap efficiency over the 33 tests was calculated along with its 95% confidence limits:

$$0.0155 \leq 0.0200 \leq 0.0250.$$

Additional **data** may help to clarify the variables affecting trap efficiency for chinook salmon at the ClearWater River trap.

Steelhead trout trap efficiency at the Clearwater River trap was successfully tested three times during the 1988 season. The estimated efficiency ranged from 0.20% to 0.73%. This data was added to four valid trap efficiency **tests** that were conducted in 1986 and 1987 (Table 6). When subjected to the same progressive statistical analysis as the chinook data collected on the Clearwater River trap, the steelhead data failed to **meet** the criteria for pooling of the four years of data. The **slopes were** homogeneous, but the intercepts were significantly different **(F=3.981, P=0.000).** This outcome differed from the 1987 analysis of the data in that there was no difference shown at this point at the 0.05 level; but one did exist at the 0.10 level (1987; **P=0.071, F=3.761).** A significant difference did occur in 1987 when river discharge was added to the equation. It is difficult to determine if indeed the difference occurs **between** years or between levels of river discharges. This discrepancy should be clarified with the addition of more data in future years.

The 1988 $\arcsin \sqrt{x}$ transformed (Zar 1984) trap efficiency data **was analyzed** by itself, due **to** the significance of the yearly variation, **to** derive an average trap efficiency of 0.43% with confidence limits of:

$$0.0003 \leq 0.0043 \leq 0.0132.$$

Travel Time and Migration Rates

Release Sites to Salmon River Trap

The Salmon River trap was **not** operated in 1988 due to lack of funding.

Table 6. Clearwater River trap efficiency for steelhead trout smelts, 1985 through 1988.

	Release date	Recaptures/ Mark	Efficiency	Discharge (kcfs)
1985	5/7	2/464	0.0043*	29
	5/11	1 /384	0. 0026*	33
1986	4/14	7/4,140	0.0017	20
	4/30	1/4,190	0.0002*	20
	5/7	2/4,260	0.0005*	29
	5/11	5/4,247	0.0012	29
1987				
DNFH	4/13	6/4,071	0.0015	13
releases	4/20	9/4,060	0.0022	16
	4/28	2/4,000	0.0005*	26
trap	4/21 -22	6/1 ,604	0.0037	13
caught	4/24	2/775	0.0026*	15
1988				
DNFH	4/13	29/4,000	0.0073	14
releases	4/22	8/3,998	0.0020	27
	4/28	16/3,994	0.0040	16

*Efficiency tests with less than five recaptures were not included in mean trap efficiency estimates.

Release Site to Snake River Trap

Chinook salmon. Due to extreme low discharge during the 1988 juvenile migration, Snake River trap efficiency was very low and the number of branded chinook collected was much smaller than in previous years. As a result, travel time and migration rates could only be calculated between release points and the Snake River trap for two chinook brand groups. Distances from release point to recovery location are represented in Table 7. These fish were released from the Lookingglass Hatchery late in the season when the trap had been moved to the east side of the river and discharge was greater than 40,000 cfs. These two groups were O-age spring chinook released on May 15. Median travel time to the Snake River trap was three days for one group and four days for the other. Migration statistics for 1984 through 1988 are presented in Table 8.

Steelhead trout. In 1988 a large portion of the steelhead migration occurred after the Snake River trap was moved to the east side of the river and when river discharge was greater than 30,000 cfs. There were 12 groups of freeze branded steelhead trout released above the Snake River trap. Recaptures were high enough for ten of the groups to provide travel time information to the Snake River trap.

The migration rate for the Hells Canyon freeze brand group was four times faster in 1988 (12.3 km/day) than in 1987 (3.1 km/day), but the group was released 29 days earlier in 1987 which probably accounts for most of the difference. The migration rate was considerably slower (5 to 7 times) in 1988 than in years when flows were higher, such as 1985 and 1986 (Table 9).

The Sawtooth group migrated at 29.1 km/day during the 1988 spring migration. A comparison with the 1987 migration rate can't be made because not enough marked steelhead were captured from the Sawtooth group. The migration rate in 1988 was considerably faster than in 1986 (16.6 km/day), although the flow conditions in 1986 were considerably better in both the upper and lower Salmon River. The 1988 migration rate was similar to the 1985 rate (24.9 km/day), and flow conditions were similar both years.

Six of the ten brand groups recaptured at the Snake River trap were released from Spring Creek, a tributary of the Wallowa River. Migration rates for the six groups ranged from 26.9 to 34.6 km/day and averaged 31.3 km/day. Not enough fish were captured at the Snake River trap in 1987 to estimate migration rate for the Spring Creek release site. Migration rate in 1986 was 9.3 km/day and 23.1 km/day in 1985. Flows and release dates varied considerably between these years so it's difficult to compare migration rates between years for this release location.

Two groups of branded steelhead were released from Wildcat Creek, a tributary of the Grande Ronde River. Both groups migrated at 33.2 km/day. This was the first year marked fish were released from this site.

Table 7. River mile & kilometer index for the Snake River Drainage.

	Mouth of Columbia R.		Mouth of Snake River		Lower Granite Dam		Snake River Trap Site		Clearwater R. Trap Site		Salmon River Trap Site	
	mi	km	mi	km	mi	km	mi	km	mi	km	mi	km
Mouth of Snake River	324.3	521.8	0.0	0.0	107.5	172.9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0	0.0	0.0	32.1	51.6	38.3	61.5	133.9	215.4
ClearWater R. Trap Site	470.0	756.2	145.7	234.4	38.2	61.5	-	-	0.0	0.0	-	-
Highway 95 Boat Launch	473.2	761.4	148.9	239.6	41.5	66.8	-	-	3.2	5.1	-	-
Dworshak NFH	504.2	911.3	179.9	289.5	72.4	116.5	-	-	34.2	55.0	-	-
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7	-	-	71.5	115.0	-	-
Crooked River	604.3	972.3	280.0	450.5	172.5	277.6	-	-	134.3	216.0	-	-
Red River Rearing Pond	618.0	994.4	293.7	472.6	186.2	299.6	-		148.0	238.1	-	-
Snake River Trap Site	463.9	746.4	139.6	224.6	32.1	51.6	0.0	0.0	-	-	101.8	163.8
Asotin Creek	469.6	755.6	145.3	233.8	37.8	60.8	5.7	9.2	-	-	-	-
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8	-	-	-	-
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0	-	-	-	-
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4	-	-	-	-
Big Canyon Creek	585.9	942.7	261.6	420.9	154.1	247.9	122.0	196.3	-	-	-	-
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2	-	-	-	-
Catherine Creek	636.9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4	-	-	-	-
Mouth of Salmon River	512.5	824.6	188.2	302.8	80.7	129.8	48.6	78.2	-	-	53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8	-	-	-	-
Little Sheep Creek	553.8	891.1	229.5	369.3	122.0	196.3	89.9	144.6	-	-	-	-
Imnaha Coll. Facility	565.6	910.2	241.3	388.3	133.8	215.4	101.7	163.6				
Hells Canyon Dam	571.3	919.2	247.0	397.4	139.5	224.5	107.4	172.8	-	-	-	-
Salmon River Trap Site	565.7	910.2	241.4	388.4	133.9	215.4	101.8	163.8	-	-	0.0	0.0
Rapid River Hatchery	605.8	974.7	281.5	452.9	174.0	280.0	141.9	228.3	-	-	40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154	249.1	-	-	53.0	85.3
S.F. Salmon @Knox Bridge	719.7	1158.0	395.4	636.2	287.9	463.2	255.8	411.6	-	-	154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353.6	568.9	-	-	251.8	405.1
E.F. Salmon @ Trap Site	873.6	1405.6	549.3	883.8	441.8	710.9	409.7	659.2	-	-	307.9	495.4
Sawtooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8	-	-	331.9	534.0

Table 8. Migration statistics for freeze branded chinook smelts from release sites to the Snake River trap, 1984 through 1988.

Release site	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Mean Q (kcfs) Snake R.
Rapid River	1988	1/						
	1987	1/						
	1986	3/27	4/10	237	14	16.3	15.4	82.9
	1985	4/2	4/12	320	10	22.8	10.6	67.6
	1984	4/1	4/18	197	17	13.4	10.1	79.3
Hells Canyon	1988	1/						
	1987	1/						
	1986	3/26	4/3	269	8	21.6		83.8
	1985	3/19	4/3	544	14	12.4		43.0
	1984	3/20	3/29	704	9	19.2		81.4
S.F. Salmon River	1988	1/						
	1987	1/						
	1986	3/28	4/23	229	26	15.8	16.5	78.6
	1985	4/2	4/17	76	15	27.1	14.0	71.0
	1984	4/10	4/24	238	14	29.0	14.5	91.7
Sawtooth Hatchery	1988	1/						
	1987	1/						
	1986	3/17	4/14		28	24.9	13.6	81.4
	1985	3/27	4/14	1:;	18	38.7	9.6	60.1
	1984	3/28	4/21	136	24	29.0	11.8	84.0
Lookingglass Cr.	1988	5/13	5/15	28	3	62.5		40.6
	1988	5/13	5/16	24	4	46.9		40.6
	1987	1/						
	1986	4/2	4/5	114	3	62.3		82.1
	1985	No marked release group.						
	1984	No marked release group.						

1/ Not enough recaptures at the Snake River trap.

Table 9. Migration statistics for freeze branded steelhead trout smelts from release sites to the Snake River trap, 1984 through 1988.

Release site	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Mean Q (kcfs) Snake R.
Sawtooth Hatchery	1988	4/15	5/8	17	24	29.1	15.1	32.7
	1987	4/14		5		Not enough recaptures at the Snake R. trap.		
	1986	4/9	5/21	11	42	16.6	24.0	73.4
	1985	4/9	5/7	23	28	24.9	19.5	62.6
E.F. Salmon River	1987	4/8		5		Not enough recaptures at the Snake R. trap.		
	1986	4/8	5/24	9	45	14.6	24.7	73.9
	1985	4/17	5/1	22	22	30.0	20.6	56.4
Hells Canyon	1988	4/24	5/7	38	14	12.3		31.0
	1987	3/26	5/19	16	55	3.1		33.5
	1986	4/29	5/1	38	2	86.4		69.1
	1985	4/30	5/3	44	3	57.6		52.9
Spring Cr.	1988	4/17	4/25	28	9	26.9		34.5
		4/17	4/23	28	7	34.6		35.7
		4/17	4/25	30	9	26.9		34.5
		4/17	4/23	14	7	34.6		35.7
		4/18	4/25	38	8	30.3		35.0
		4/18	4/24	21	7	34.6		35.7
	1987	4/26			-	Not enough recaptures at the Snake R. trap.		
	1986	5/1	5/27	14	26	9.3		72.9
		4/30		1		Not enough recaptures at the Snake R. trap.		
		4/3		2		Not enough recaptures at the Snake R. trap.		
	1985	5/9	5/19	36	10	24.2		46.4
		5/9	5/20	31	11	22.0		47.0
Cottonwood Cr.	1987	4/26	4/30	28	5	18.6		39.3
	1986	4/28	5/5	39	7	13.0		72.3
		4/28	5/5	30	7	13.0		72.3
		4/28	5/5	42	7	13.0		72.3
Little Sheep Cr.	1987	5/2				Not enough recaptures at the Snake R. trap.		
	1986	4/28	5/8	16	10	12.0		72.1
		4/27		2		Not enough recaptures at the Snake R. trap.		
Wildcat Cr.	1988	4/23	4/26	86	4	33.2		32.7
		4/23	4/26	66	4	33.2		32.7

Release Site to the Clearwater Trap

Chinook salmon. Six groups of freeze branded chinook salmon were released from Dworshak NFH on March 30, 1988. The travel time for these groups was one day (Table 10). This compares to a travel time of four days in 1987 and one-day for 1986 and 1985. Average discharge during the migration period in 1987 was 7,200 cfs, 76% less than in 1986 (29,000 cfs) and 58% less than in 1985 (17,300 Cfs) . Discharge in 1988 was 9,600 cfs, 14% higher than in 1987. The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time.

One group of O-age chinook was released from Dworshak NFH on March 30. This group moved slower (travel time = 2 days) than the normal hatchery production (travel time = 1 day).

A group of O-age chinook was released from Dworshak NFH on September 28, 1987. This groups median passage at the Clearwater River trap was March 27. The first chinook from this group arrived at the trap on March 17, and marks continued to be captured for the next two weeks.

The Red River group began arriving on March 29 and the last recapture was on June 6 with the median passage on April 15.

Steelhead trout. There were four groups of freeze branded steelhead released from Dworshak April 3 and 4. The median travel time for all four groups was one day, producing a migration rate of 55.0 km/day. In previous years the travel time for the Dworshak brand groups was one day (Table 11).

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook salmon freeze brand groups. In 1988, only eight of the 28 groups of freeze branded yearling chinook salmon could be used for travel time calculations through Lower Granite Reservoir because of the operational problems at the Snake River trap discussed earlier. All usable groups were from the Clearwater River drainage. There were also three groups of O-age spring chinook; two released from the Lookingglass Hatchery and one from Dworshak NFH. Average travel time through lower Granite Pool for the Clearwater River yearling chinook salmon freeze brand group ranged from 21 days for the groups released the last of March, to 35 days for the group released in mid March (Table 11). Average travel time for the O-age chinook ranged from 28 for the two groups released in mid May, to 57 days for the group released from Dworshak NFH on April 1.

Table 10. Migration statistics for branded chinook salmon and steelhead trout released above the Clearwater River trap, 1987 and 1988.

Release Site	Year	SD.	Median Release	Median Passage	Number Captured	Migration Rate Km/day	Travel Time	Mean Discharge
Crooked River	1987	St	04/14	-	2			
Dworshak NFH	1987	St	04/21	04/22	58		-	
		St	05/05	-	-	-	-	
		Ch	04/01	04/04	1416	13.8	4	7.2
Clear Creek		St	04/17	04/20	59	28.8	4	14.1
Dworshak NFH	1988	St	05/03	05/04	107	55.0	1	16.9
		St	05/03	05/04	95	55.0	1	16.9
		St	05/03	05/04	81	55.0	1	16.9
		St	05/04	05/05	202	55.0	1	16.9
		Ch	03/30	04/01	239	27.5	2	9.8
		Ch	03/30	03/31	1711	55.0	1	9.6
		Ch	03/30	03/31	788	55.0	1	9.6
		Ch	03/30	03/31	571	55.0	1	9.6
		Ch	03/30	03/31	253	55.0	1	9.6
		Ch	03/30	03/31	181	55.0	1	9.6
		Ch	09/28/87	03/27	16		182	
Red River		Ch	09/30/87	04/14	18		198	

Table 11. Chinook salmon smolt travel time and migration rate to Lower Granite Dam from the head of Lower Granite pool using fish passing the Snake River trap from upriver releases, 1905 through 1988.

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGD
1985	LDR-3	Hells Canyon	4/3	544	4/13	7,111	10	5.2	88
	RDR-1	Sawtooth Hat.	4/14	165	5/4	4,313	20	2.6	89
	RDR-3	S. F. Salmon River	4/17	76	5/14	4,193	27	1.9	85
	LDR-1	Rapid River	4/ 12	370	4/25	9,422	13	4.0	90
	LDR-4	Grande Ronde River	6/4	135	6/23	6,868	19	2.7	79
	RDR-2	Dworshak NFH	4/4	240	4/27	6,403	23	2.7	94
1986	LDY-3	Hells Canyon	4/3	269	4/16	9,898	13	4.0	100
	RDY-1	Sawtooth Hat.	4/14	49	4/23	2,245	9	5.7	89
	RDY-3	S. F. Salmon River	4/23	229	5/3	5,921	10	5.2	98
	LDY-1	Rapid River	4/16	237	4/20	10, 589	4	12.9	88
	RAJ-2	Lookingglass Cr.	4/5	38	4/14	3,741	9	5.7	99
	RRJ-3	Lookingglass Cr. 3/	4/4	13	4/9	333	5	10.3	99
	RAJ-4	Lookingglass Cr.	4/5	76	4/2 1	2,593	16	3.2	95
	RAY-1	Dworshak NFH	4/2	312	4/21	4,703	19	3.2	97
198?	RAR-1	Dworshak NFH	4/4	1,416	4/24	11,069	20	3.1	37
	RD4-1	Clearwater River 1/	3/20	43	4/18	551	29	2.1	33
	RD4-3	Clearwater River 1/	4/2	50	4/20	436	18	3.4	35
	RA4-3	Clearwater River 1/	4/7	165	4/19	438	12	5.1	30
	RA4-1	Clearwater River 1/	4/13	74	4?29	334	16	3.8	46
1988	LAUO-1	Lookingglass Hat. 2/	5/15	29	6/11	3,913	27	1.9	68
	LAUT-1	Lookingglass Hat. 2/	5/16	25	6/12	3,973	27	1.9	68
	RDT-3	Red River Pond 3/	4/ 15	18	5/13	1,071	28	2.2	58
	LAH-1	Dworshak NFH 2/	4/1	239	5/27	3,457	56	1.1	54
	LAT-2	Dworshak NFH	3/31	1,711	4/20	17,510	20	3.1	38
	LDT-1	Dworshak NFH 3/	3/28	16	4/12	847	15	4.1	30
	RA7N-1	Dworshak NFH	3/3 1		4/20	6,672	20	3.1	30
	RA7N-3	Dworshak NFH	3/31	571	4/2 1	5,%23	21	2.9	39
	RAR-1	Dworshak NFH	3/3 1	253	4/20	2,040	20	3.1	38
	RAR-3	Dworshak NFH	3/3 1	181	4/2 1	1,852	21	2.9	39
	LDK- 1	Clearwater R. Trap 1/	3/15	51	4/ 19	736	35	1.8	32
	LDK-3	Clearwater R. Trap 1/	3/18	93	4/19	643	32	1.9	33
	RDK- 1	Clearwater R. Trap 1/	4/2	27	4/23	499	21	2.9	42
	RDK-2	Clearwater R. Trap 1/	4?7	18	4/22	347	15	4.1	45
	RDK-3	Clearwater R. Trap 1/	3/22	83	4/ 19	575	20	2.2	34
	RDK-4	Clearwater R. Trap 1/	4/14	31	4/30	524	16	3.8	53

1/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15.5).
2/ 0-Age spring chinook salmon.
3/ Fall release of spring chinook.

log of discharge provided the best fit (N=8, r^2=0.950, P= 0.000):

log migration rate = -8.717 + 2.'677 log discharge.

This indicates that as discharge increased, travel time through the reservoir decreased (migration rate increases).

Chinook salmon PIT tag groups. In 1988, sufficient numbers of chinook salmon were PIT tagged daily at the Snake River trap to provide 23 daily release groups (3,767 total) for estimating travel time and migration rates through Lower Granite Reservoir. Median travel time ranged from 23 days early in the migration season to six days late in the season (Table 12). There was a substantial change in median travel time between April 8 and April 18. Prior to April 8, the average median travel time through Lower Granite pool was 19.7 days (migration rate = 2.6 km/day), and after April 18 the average median travel time was 8.6 days (migration rate = 6.0 km/day). Average daily discharge for the PIT tag groups released prior to April 8 was 40.3 kcfs and ranged from 31 to 48 kcfs. Average daily discharge for PIT tag groups released after April 18 was 56.9 kcfs and ranged from 49 to 69 kcfs.

A linear regression of travel time and discharge was calculated and showed a strong relationship between the two variables. The linear regression of the log of migration rate and log discharge provided the best fit (N=23, r^2=0.840, p=o.000):

log migration rate = -5.209 + 1.715 log average discharge.

This analysis indicates that chinook salmon travel time in Lower Granite Pool decreases as discharge increases.

An analysis of covariance of travel time through Lower Granite Reservoir for freeze branded and PIT tagged chinook salmon showed no statistical difference at the 0.5 level. PIT tagged and freeze branded chinook salmon migrated at about the same rate through the reservoir (Fig 9).

Percent recovery (integration) of daily release PIT tagged chinook groups at Lower Granite Dam ranged between 25.8% and 45.7%, and averaged 32.9%. Seasonal cumulative percent recovery of pit tagged chinook salmon to Lower Granite was 32.8%, to Little Goose it was 47.3%, and to McNary it was 55.2%. These numbers are cumulative percents as you progress downstream.

Hatchery steelhead trout freeze brand groups . In 1988 median passage dates were calculated for 11 groups of freeze branded steelhead trout at the Snake River trap and seven groups at the Clearwater River trap. These groups were used to determine migration rate and travel time through Lower Granite Reservoir (Table 13). The five groups released in Spring Creek, that were used in the travel time calculations, were the slowest moving groups in Lower Granite pool with travel times ranging from 13 to 23 days (average = 18 days). The next slowest groups were the Wildcat Creek groups (16 days). The Clearwater River brand groups and the Hells Canyon brand group moved through the reservoir at the fastest rate, ranging from six to nine days and averaged eight days.

Table 12. Chinook salmon PIT tag travel time, with 95% confidence interval, from the head of Lower Granite Pool to Lower Granite Dam, 1988.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured	Average discharge (kcfs)
03/25/88	22.2	24	20	72	35.8	30.73
03/26/88	23.6	25	22	66	33.0	34.85
03/28/88	23.0	25	22	69	34.5	36.96
03/29/88	21.6	25	21	70	35.0	37.27
03/30/88	20.4	23	18	71	35.5	36.13
03/31/88	20.8	22	19	53	26.4	39.45
04/01/88	19.3	21	18	65	32.0	38.67
04/02/88	21.9	27	20	54	26.9	43.65
04/04/88	15.6	18	15	61	30.3	40.83
04/05/88	16.5	19	15	64	30.8	43.84
04/06/88	18.7	24	16	61	30.5	46.94
04/07/88	18.5	26	16	42	27.3	47.87
04/08/88	14.1	16	12	33	27.3	46.68
04/18/88	11.4	13	10	76	40.4	56.67
04/19/88	11.0	14	10	69	34.5	54.44
04/20/88	9.5	11	9	51	34.2	54.26
04/21/88	9.7	13	8	48	32.0	51.28
04/22/88	10.4	13	8	62	41.1	49.87
04/25/88	11.1	12	10	49	34.8	49.24
04/26/88	10.5	17	8	16	30.2	49.23
05/15/88	8.3	18	5	36	32.7	67.79
05/16/88	6.3	13	4	32	45.7	68.70
05/17/88	7.2	12	4	17	25.8	67.46

*confidence intervals calculated with nonparametric statistics

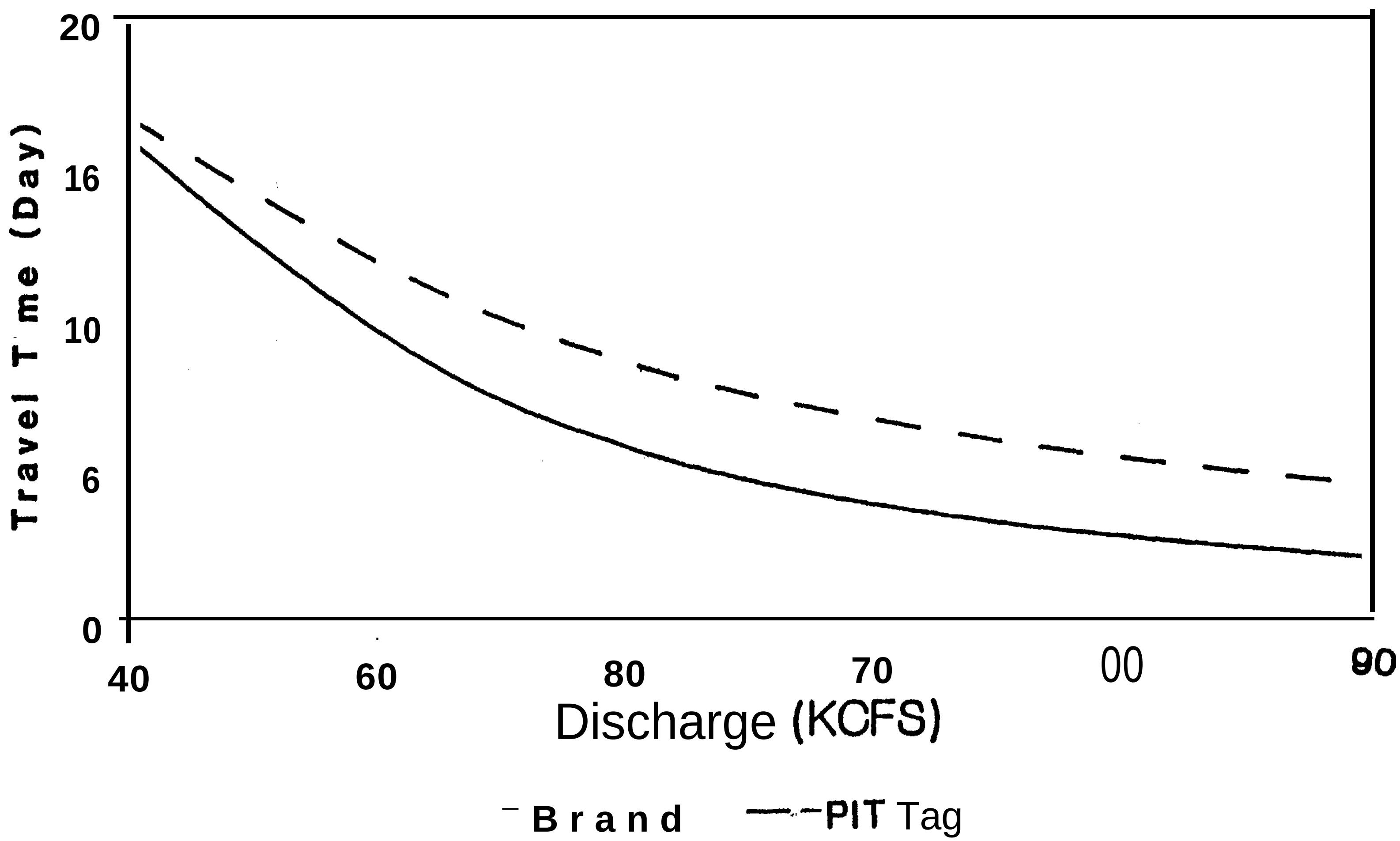


Figure 9. Relationship between travel time through Lower Granite Reservoir and discharge for freeze branded and PIT tagged chinook, 1988.

Table 13. Steelhead trout smolt travel tine and migration rate to Lower Granite Dam fron the head of Loner Granite pool using fish passing the Snake River trap fron upriver releases, 1985 through 1988.

			Snake Rivet-f Clearwater River trap		Lower Granite Dan				
Year	Brand	Release site	Hedi an passage date	Number collected	Hedi an arrival date	Number collected	Travel tine (days)	Migration rate (km/day)	Hean R (kcfs) at LGD
1985	LDY-1	Hells Canyon	5?3	44	5/11	2,821	8	6.5	%8
	RDY-1	Sawtooth Hatchery	5/7	23	5/28	3,510	21	2.5	92
	RDY-3	E. F. Salmon River	5/9	22	5/28	2,454	19	2.7	93
	RA17-1	Grande Ronde River	5/20	36	5/22	12,710	2	25.0	102
	RA17-3	Grande Ronde River	5/19	31	5/2 1	12,022	2	25.8	95
	LDY-2	Dworshak NFH	4/29	88	5/4	6,699	5	12.3	03
1986	RDT-2	Hells Canyon	5/1	38	5/8	5,033	7	7.4	94
	LDT-2	Sawtooth Hatchery	5/21	11	5/29	3,772	8	6.5	120
	LDT-4	E. F. Salmon River	5/23	9	5/29	1,552	6	8.6	119
	RAJ-4	Little Sheep Cr.	5/8	16	5/30	1,340	22	2.3	114
	RAJ-1	Spring Creek	5/27	14	5/26	1,628	Hedian arrival date at LGD one day before median passage date at Snake R. trap.		
	RRI J-1	Cottonwood Cr.	5/5	39	5/2 1	4,460	16	3.2	98
	RRI J-3	Cottonwood Cr.	5/5	43	5/22	5,151	17	3.0	100
	RRI J-4	Cottonwood Cr.	5/6	29	5/18	4,114	12	4.3	99
	RDT-4	Dworshak NFH	5/8	18	5/ 17	7,194	9	6.8	99
	LD4-1	Clearwater R. Trap 1/	5/8	2	5/14	1,003	6	10.3	100
	LD4-3	Clearwater R. Trap 1/	5/ 13	5	5?22	869	9	6.8	90
	RD4-1	Clearwater R. Trap 1/	4/16	7	4/23	371	7	8.8	103
	RD4-3	Clearwater R. Trap 1/	5/1	1	5/8	751	7	8.8	94
1987	RAIC-1	Cottonwood Cr.	4/30	7	5/4	4,886	4	12.9	86
	RAIC-2	Cottonwood Cr.	4/30	6	5/4	5,529	4	12.9	86
	RAIC-3	Cottonwood Cr.	4?30	7	5/4	5,971	4	12.9	86
	RAIC-4	Cottonwood Cr.	4/30	e	5/5	4,936	5	10.3	84
	RAR-3	Clear Cr.	4/20	59	5/1	3,500	11	4.7	59
	RDR-3	Dworshak NFH	4/22	58	5/1	4,917	9	6.0	63
	RDK-1	Clearwater R. Trap 1/	4/13	6	4/26	1,192	13	4.7	41
	RDK-2	Clearwater R. Trap 1/	4/20	9	4/30	999	10	6.2	56
	RDK-4	Clearwater R. Trap 1/	4/28	2	5/4	692	6	10.3	84
1988	LDT-3	Hells Canyon	5/7	38	5/15	6,631	8	6.5	69
	LDT-2	Sawtooth Hatchery	5/7	19	5/25	5,332	18	2.9	68
	LAIF-1	Spring Creek	4/25	30	5? 17	4,912	22	2.3	59
	LAIF-3	Spring Creek	4/24	28	5/7	3,065	13	4.0	54
	RRI F-3	Spring Creek	4?24	30	5/7	6,502	13	4.0	53
	LAIM-1	Spring Creek	4/25	29	5/17	3,799	22	2.3	59
	LRI H-3	Spring Creek	4/23	14	5/16	4,030	23	2.2	59
	RAIM-3	Spring Creek	4/24	23	5/11	5,060	17	3.0	58
	RAIF-1	Wildcat Creek	4/26	88	5/ 10	14,820	14	3.7	58
	RRI H-1	Wildcat Creek	4/26	67	5/11	13,749	15	3.4	58
	LD4-3	Snake River @Asotin	5/24	30	5?30	854	6	8.6	76
	RD4-1	Snake River @Asotin	5/24	55	5/30	994	6	8.6	76

Table 13. (continued}

Year	Brand	Release site	Snake River/ Clearwater River trap: Median passage date	Snake River/ Clearwater River trap: Number collected	Lower Granite Dam: Median arrival date	Lower Granite Dam: Number collected	Travel time (days)	Migration rate (km/day)	Mean Q (kcfs) at LGD
1988	RAT-1	Dworshak NFH	5/3	10?	5/11	10,792	G	7.7	72
	RAT-2	Dworshak NFH	5/3	95	5?11	7,225	8	7.7	72
	RAT-3	Dworshak NFH	5/3	81	5/9	5,928	6	10.3	73
	RAT-4	Dworshak NFH	5/3	202	5/10	25,335	7	8.8	7a
	RA4-1	Clearwater R. Trap 1/	4/14	28	4/22	1,335	0	7.7	57
	RA4-3	Clearwater R. Trap 1/	4/23	G	5/1	1,304	0	7.7	49
	RD4-3	Clearwater R. Trap 1/	4/29	16	5/6	743	7	8.8	50

1/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15.5).

The relationship between hatchery steelhead migration rate through Lower Granite pool and discharge was analyzed using a linear regression model. The best fitting equation (N=17, r^2=0.343, P=0.013) was:

log migration rate = -5.446 + 1.698 log average discharge.

This equation indicates that as discharge increases migration rate increases. When this data is compared to 1987 data, hatchery steelhead rate of movement through the reservoir was about the same for both years.

<u>Hatcherv steelhead trout PIT tag groups .</u> In 1988 sufficient numbers of hatchery steelhead trout were PIT tagged daily at the Snake River trap providing 29 daily release groups (1,743 individual fish) to be used in median migration rate calculations through Lower Granite Pool. Median travel time ranged from 10.4 to 3.5days (5.0 km/day to 14.7 km/day), and averaged 5.6days (Table 14). A linear regression analysis between migration rate in Lower Granite Pool and average Lower Granite discharge per PIT tag group was conducted. The best linear regression equation (N=29, r^2=0.366, P=0.001) was:

log median migration rate = -2.133 + 1.053 log discharge.

The fact that only 37 of the variation in median travel time is accounted for by change in discharge may be due to the low numbers of data points at discharges other than 60,000 and 70,000 cfs.

To remove some of the noise which is often associated with biological data and better show the underlying biological relationship, migration rate was calculated by 5 kcfs discharge groups (Mosteller and Tukey 1977:75). A linear regression analysis was conducted and found that the best linear regression equation (N=8, r^2=0.905, P=0.000) was:

log migration rate = -1.904 + 1.010 log mean discharge.

The high coefficient of determination (r^2) indicates a strong relationship between hatchery steelhead trout migration rate through Lower Granite Reservoir and mean discharge. The low probability (P) indicates this relationship is highly significant. The equation shows that as discharge increases migration rate increases.

Percent recovery of daily hatchery steelhead PIT tag release groups at Lower Granite Dam ranged from 18.3% to 81.7% and averaged 61.3%. Overall seasonal cumulative recovery of PIT tagged hatchery steelhead to Lower Granite was 61.3%, to Little Goose it was 72.2%, and to McNary it was 72.9%. This was considerable higher than in 1987 when the seasonal recovery at Lower Granite was only 39.2%, and most likely reflects an increased FGE from raised operating gates at the project.

<u>Wild steelhead trout PIT tag groups.</u> In 1988 sufficient numbers of wild steelhead trout were PIT tagged at the Snake River trap to provide 24 daily release PIT tag groups (1186 individual fish) for median travel time calculations (Table 15). Only since the introduction of the PIT tag have

Table 14. Hatchery steelhead trout PIT tag travel time, with 95% confidence interval, from the head of Lower Granite pool to Lower Granite Dam, 1988.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number caDtured	Percent captured (%)	Average discharge (kcfs)
04/18/88	4.8	6	4	40	65.6	65.04
04/19/88	5.0	7	4	48	80.0	64.22
04/20/88	4.7	9	4	34	56.7	60.98
04/21/88	6.0	8	5	44	73.3	56.48
04/22/88	6.4	8	6	38	62.3	53.62
04/25/88	10.4	1	2	94	68.3	46.09
04/26/88	9.7	11	8	37	61.7	49.23
04/28/88	7.6	9	6	27	52.9	49.88
04/29/88	6.0	7	5	36	60.0	46.25
05/02/88	5.8	8	5	41	68.3	64.88
05/03/88	3.7	5	3	39	65.0	65.45
05/04/88	4.6	6	3	37	61.7	77.54
05/05/88	4.0	5	3	49	81.7	82.45
05/06/88	4.3	6	4	45	73.8	82.10
05/09/88	5.3	6	4	37	61.7	64.68
05/10/88	4.5	5	4	35	56.5	63.88
05/11/88	4.0	6	4	39	65.0	62.03
05/12/88	3.5	4	3	40	67.8	67.80
05/13/88	3.7	6	3	40	66.7	70.38
05/14/88	8.1	11	6	38	63.3	69.76
05/15/88	5.3	7	5	42	68.9	72.46
05/16/88	6.5	10	4	31	51.7	67.39
05/17/88	6.3	7	5	42	66.7	67.43
05/18/88	6.5	7	5	36	60.0	66.08
05/23/88	3.7	10	3	34	56.7	76.62
05/24/88	4.8	7	4	34	55.7	78.04
05/25/88	5.5	8	5	25	42.4	75.98
05/26/88	6.4	7	5	27	44.3	72.83
06/07/88	5.3	9	5	11	18.3	60.90

* Confidence intervals calculated with nonparametric statistics

Table 15. Wild steelhead trout PIT tag travel time, with 95% confidence intervals, from the head of Lower Granite pool to Lower Granite Dam, 1988.

Release date	Median travel time (day)	Confidence Interval* Upper	Confidence Interval* Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04/18/88	3.5	4	3	29	49.2	65.23
04/19/88	3.5	4	3	31	50.0	64.70
04/20/88	4.0	4	3	33	54.1	63.10
04/21/88	4.5	6	4	36	60.0	59.97
04/22/88	4.6	6	4	32	53.3	55.62
04/25/88	6.6	9	5	25	52.1	45.66
04/26/88	6.1	7	5	25	64.1	45.05
05/02/88	3.8	5	3	32	68.1	55.50
05/03/88	3.5	4	3	21	48.8	59.57
05/04/88	3.2	4	3	22	51.2	73.90
05/05/88	3.4	4	2	29	60.4	82.67
05/06/88	3.7	4	3	27	62.8	82.10
05/09/88	4.3	6	3	16	47.1	63.72
05/10/88	3.6	4	3	36	70.6	61.02
05/11/88	3.4	5	3	30	58.8	57.60
05/12/88	2.7	3	2	35	60.3	66.87
05/13/88	2.9	3	3	38	63.3	71.47
05/14/88	3.8	5	3	37	61.7	72.17
05/15/88	3.7	5	3	34	55.7	72.80
05/16/88	3.5	4	3	42	70.0	73.53
05/17/88	3.3	3	3	43	70.5	74.87
05/24/88	3.7	4	3	19	63.3	79.05
05/25/88	4.7	8	3	13	65.0	77.00
05/26/88	4.0	13	2	10	55.6	76.10

* Confidence intervals calculated with nonparametric statistics

sufficient numbers of wild steelhead trout been marked to provide travel time data through Lower Granite Reservoir. The PIT tag is the only tool available that can provide this type of data because of the low numbers of fish required for marking due to the high recovery rate at Lower Granite **Dam**. Median travel time for wild steelhead trout ranged from 6.6 days (7.8 km/day) to 2.7 days (19.1 km/day), and averaged 3.9 days (13.7 km/day). There is a significant difference in median travel time between hatchery and wild steelhead trout. The slopes of the two lines, migration rate/discharge for hatchery and wild steelhead **trout,** were tested with the analysis of covariance and found to not be significantly different at the 0.5 level. Then the height of the two lines were tested and there was a significant difference in the migration rate of hatchery vs. wild steelhead trout. It is uncertain as to the reason for this difference. A possible explanation is that wild steelhead may be stronger and/or more fully smelted and therefore travel faster as they migrated through Lower Granite Reservoir.

A linear regression analysis between median migration rate in Lower Granite Reservoir and mean discharge for each PIT tag group was conducted. The best linear regression equation **(N=24,** r^2=0.381, P=O.001) was:

log migration rate = -0.576 + 0.758 log mean discharge.

This analysis shows that as discharge increases, travel time in Lower Granite Reservoir decreases.

A linear regression analysis was conducted on average travel time separated into 5 kcfs groups. The analysis showed that the equation:

log migration rate = -1.020 +0.868 log average discharge

had the best fit **(N=7,** r^2=0.526, P=O.065).

An analysis of the slope of the migration rate/discharge relationship for freeze brand data, the hatchery steelhead trout PIT tag data, the wild steelhead trout PIT tag data, the hatchery steelhead trout PIT tag data averagedby 5 kcfs groups, and the wild steelhead trout PIT tag data averaged by 5 kcfs groups was conducted to see if there was a significant difference between the five groups of data (Fig. 10). The analysis of variance showed there was not a significant difference between the slopes at the 0.05 level, but the relationship was significant at the 0.1 level **(N=87, F=2.196, P=0.077).** When a graphic representation of the slopes of the five sets of data was examined, it was obvious the freeze brand data was significantly different from the other four sets of data. When the freeze brand data was removed from the analysis there no longer was a significant difference between the slopes of the other four sets of data **(N=68, F=1.076, P=0.336).** The difference between the freeze brand data and the PIT tag data is probably an artifact of the technique used to estimate migration rate rather than a real difference in migration rate between the two mark methods.

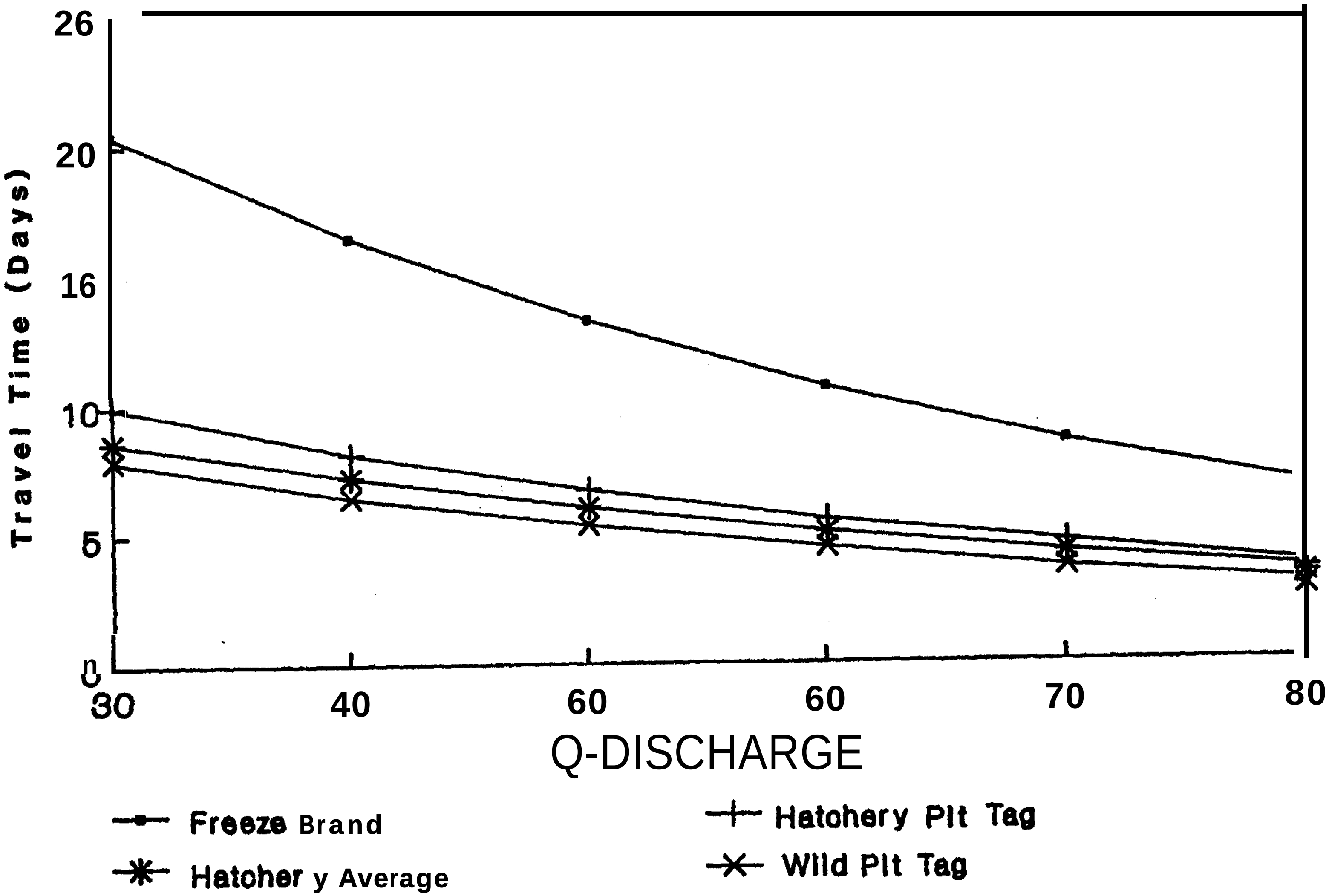


Figure 10. Relationship between travel time through Lower Granite Reservoir and discharge for freeze branded steelhead (FB), PIT tagged hatchery and wild steelhead (SH and SW), and PIT tagged hatchery and wild steelhead averaged by 5 kcfs groups (SH by 5 kcfs and SW by 5 kcfs), 1988.

The height of the lines was tested and found there was a significant difference between the hatchery and wild steelhead migration rate/discharge relationship. Wild steelhead trout estimated migration rate through Lower Granite Reservoir at 45,000 cfs is 9.8 km/day, while hatchery stelhead is 7.0 km/day. At 85,000 cfs, wild steelhead estimated migration rate is 17.1 km/day, and hatchery steelhead estimated migration rate is 13.2 km/day. Wild steelhead trout migrate through Lower Granite Reservoir faster than hatchery steelhead trout.

The PIT tag data provides the ability to get a travel time to average discharge relationship over a broader range of flows and time than the freeze brand data because of the ability to release more marked groups. This makes the PIT tag a much more valuable tool for estimating travel time through Lower Granite Pool than freeze brands.

Percent recovery of daily wild steelhead trout PIT tag release groups at Lower Granite Dam ranged from 47.1% to 70.6% and averaged 59.0%. Overall seasonal cumulative recovery of PIT tagged wild steelhead trout to Lower Granite Dam was 58.9%, to Little Goose it was 72.8%, and to McNary it was 74.5%. The percent recovery at the three dams for PIT tagged hatchery and wild steelhead was about the same in 1988.

SUMMARY

Hatchery production of chinook salmon and steelhead trout for release above Lower Granite Dam in 1988 was 21,974,463 (11,176,084 chinook salmon and 10,798,379 steelhead trout). Of these, 722,553 chinook salmon and 549,170 steelhead trout (6.5% and 5.1% of the total release, respectively) were freeze branded and released in 28 unique groups for chinook salmon and 23 unique groups for steelhead trout. The number of freeze branded chinook salmon and steelhead trout was up 162% and 112%, respectively, in 1988.

The Snake River trap was operated from March 5 through June 29. The trap was moved to the east side of the Snake River on April 27 where it was believed the trap would be more efficient at collecting smelts during a low water year. The Snake River trap captured 3,758 yearling chinook, 2,604 wild steelhead trout, and 16,772 hatchery steelhead trout. Most of the chinook salmon smelts had already passed the trap by the time the trap was moved to the east side of the river so the chinook catch was only slightly better than in 1987. The steelhead trout (wild and hatchery) trap catch was better than in any previous year and nearly 200% better than 1987’s low water conditions.

The Clearwater River trap was operated from March 8 through June 12 with a 15 day period in mid-May when the trap was out of operation due to high discharge. Clearwater River trap catch was 63,983 chinook salmon, 458 wild steelhead trout and 9,940 hatchery steelhead trout. In 1988 trap catch of chinook salmon was down 12% from 1987 but the percent of hatchery chinook released in 1988 was down 28%. The increase in percent chinook trap catch in 1988 can be attributed to either improvements in the trap livewell velocity barrier and/or an increase in wild escapement.

The Clearwater River trap catch of hatchery steelhead trout was up 79% in 1988. The number of hatchery steelhead trout released was up 29% from 1987, but the ratio of hatchery steelhead trout caught in the trap compared to the number of hatchery steelhead trout released was up 39%. This 10% difference may be attributed to natural variation and/or to the trap modification mentioned above. Trap catch of wild steelhead trout was down 49% in 1988 from 1987.

No trap efficiency tests were conducted on the Snake River trap for chinook salmon in 1988 due to the low trap catch. A best guess estimate of trap efficiency for 1988 would be similar to that experienced in 1987 which was 10 to 30 times less than the 1.2% trap efficiency of previous years. Trap efficiency tests on the Clearwater River trap in 1988 were combined with four previous years data, for a total of 36 tests, the resulting efficiency value was 2.69%, with a 95% confidence interval of 0.08%. The 1988 data by itself yielded an efficiency value of 2.80%, with a 95% confidence interval of 0.09%.

River discharge values were combined with the trap efficiency data for both the Snake and Clearwater river traps in an attempt to create a predictive equation. The only set of data that showed a significant relationship between trap efficiency and river discharge was the Clearwater River trap chinook data. A significant statistical interaction was shown at the 0.05 level with P=O.019 and F=6.103, but further analysis showed an R^2 of 0.152, indicating no practical or biological significance. This anomaly indicates the possibility that some other variable also has an influence on trap efficiency in addition to river discharge.

Trap efficiencies for steelhead trout at the Snake River trap, using trap caught fish (three test groups) to provide the best estimate, for 1988 averaged 0.30%. Steelhead trout trap efficiencies at the Clearwater River trap in 1988 were tested only twice and yielded an average of 0.44%. The steelhead trout efficiency estimates at both the Snake and Clearwater river traps were made with the 1988 tests only because the data for all years failed to meet the statistical criteria for pooling.

Migration rate from point of release to the Snake River trap was not calculated for spring chinook because of the low chinook trap catch. Migration rates for branded steelhead trout to the Snake River trap was better in 1988 than in 1987 because flows during the major steelhead migration period were more conducive to migration in 1988.

Migration rate for Clearwater River branded chinook salmon was faster than in 1987 and similar to 1986 and 1985. Flows were 2,000 to 4,000 cfs higher for a major portion of the migration in 1988 as compared to 1987. Steelhead migration rate was the same as in previous years.

Migration rate (travel time) through Lower Granite Reservoir for Clearwater River freeze branded chinook salmon was similar to 1987, but considerably lower than the normal flow year of 1986. No data is available for chinook salmon migrating from the Snake River above the Clearwater River through Lower Granite Reservoir.

PIT tagged chinook salmon migrated at the same rate as the freeze branded smelts. Prior to April 8, when discharge was below 40 kcfs, PIT tagged chinook salmon travel time through the reservoir averaged 19.7 days. After April 18, when discharged averaged 57 kcfs, travel time through the reservoir averaged 8.6 days. Statistical analysis showeda strong relationship between travel time and discharge, as discharge increases travel time for chinook salmon through the reservoir decreases dramatically. PIT tagged chinook salmon moved more than three times as fast through the reservoir at 80 kcfs as they did at 40 kcfs.

There was a statistical significant difference, at the 0.1 level, in travel time through Lower Granite Reservoir for freeze branded and PIT tagged steelhead trout. At low discharge, freeze branded steelhead trout move much slower than do PIT tagged steelhead trout. At higher discharges (100 kcfs) the difference is much less.

There is a very strong statistical relationship between travel time and discharge for PIT tagged hatchery steelhead trout. PIT tagged hatchery steelhead trout migrated twice as fast at 80 kcfs as they did at 40 kcfs.

Wild and hatchery PIT tagged steelhead trout migrate at about the same rate. The relationship between migration rate and discharge for wild steelhead trout is not as strong as for hatchery steelhead, but a good relationship still exists. PIT tagged wild steelhead trout migrate twice as fast through Lower Granite Reservoir, at 90 kcfs, as they did at 40 kcfs.

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SMOLT CONDITION AND TIMING OF ARRIVAL AT LOWER GRANITE RESERVOIR

Annual Report

for 1967 Operations

by

Edwin W. Buettner, Sr. Fishery Research Biologist

and

V. Lance Nelson, Sr. Fishery Technician

Idaho Department of Fish and Game

Boise, ID S3707

Funded by

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Division of Fish and Wildlife

Mr. Dale Johnson, Project Manager

Contract No. DE-AI79-83BP1 1631

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Project No. 83-323 B

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ABSTRACT

This project monitored the daily passage of smelts during the 1987 spring outmigration at three migrant traps; one each on the Snake, Clearwater, and Salmon rivers. Daily mark recapture, species - composition, and total catch were provided to the Fish Passage Center and other agencies interested in juvenile chinook salmon and steelhead trout outmigration on a daily basis for water budget and passage management decisions.

Average travel time for PIT-tagged chinook salmon smelts from the head of Lower Granite Reservoir to Lower Granite Dam was 18 days prior to April 15 and 5 days after April 22. PIT-tagged hatchery steelhead trout average travel time from the head of Lower Granite Reservoir to Lower Granite Dam was about 9.5 days for a brief period early in the migration season and 4.5 days for the majority of the migration season. Wild steelhead trout average travel time from the head of Lower Granite Reservoir to Lower Granite Dam was 3.5 days during the migration season.

The chinook salmon smelt migration begins in earnest when Salmon River discharge makes a significant rise in early to mid-April. Most yearling chinook salmon pass into Lower Granite Reservoir in April, followed by passage of steelhead trout in May. Chinook salmon smelt recapture data from the Snake River trap suggests a strong dependence of migration rate in the free flowing portions of the rivers above Lower Granite Reservoir on quantity of Snake and Salmon River discharge, although no statistical correlation can be shown at this time.

Daily and seasonal descaling rates were calculated for each species at each trap. Descaling rates were highest for hatchery steelhead trout, intermediate for yearling chinook salmon, and lowest for wild steelhead trout. Descaling rates were generally higher in 1987 than those observed in 1984 through 1986.

The steelhead radio tagging study showed that only 7% of the radio-tagged steelhead passed under the span of the Interstate Bridge that the Snake River trap was attached to and 30% passed under one span of the Interstate Bridge just east of the drawbridge section in 1987. The study showed that on the Clearwater River, radio-tagged steelhead passed close to the trap and that there may be some avoidance of the trap.

INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NWPPC) to develop programs to mitigate for fish and wildlife losses in . the Columbia River basin resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (BPA) the authority and responsibility to use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system."

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smelt migration. In response to the Columbia Basin Fish and Wildlife Authority (CBFWA) recommendations for migration flows, the NWPPC Columbia River Basin Fish and Wildlife Program proposed a "water budget" for augmenting spring flows.

The Northwest Power Planning Council's water budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to provide improved passage and migration conditions.

To provide information to the Fish Passage Center (FPC) on smelt movement prior to arrival at the lower Snake River dams and reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smelts at the head of Lower Granite Reservoir and 164 kilometers upriver at White Bird, Idaho, on the Salmon River. The Salmon River trap is operated only during low runoff years. This information allows the FPC to optimize the use of the limited Snake River water budget.

Additionally, the IDFG smelt monitoring project collects data on relative species composition, estimated fish passage index, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, migration rate, and smelt condition relative to scale loss. By monitoring smelt passage at Lower Granite Dam and at the head of Lower Granite Reservoir, migration rates under riverine and reservoir conditions can be estimated and compared under various flow and temperature conditions. By having monitoring sites on both the Snake and Clearwater arms of Lower Granite Reservoir, the migration timing of smelts from each drainage can be determined individually. Also, the relative composition of hatchery and wild stocks of steelhead trout can be determined--information useful to document the rebuilding of wild stocks which is being undertaken in other NWPPC projects. Wild/hatchery ratios for steelhead trout at the Clearwater River trap cannot be used because a large portion of the wild fish migrate prior to the release of hatchery fish and the trap is out of service when flows exceed 35,000 cfs. This allows for a disproportionate collection of wild or hatchery steelhead, depending on when the trap was out of service.

Smelt monitoring is beneficial for water budget management under all flow conditions but most valuable in low flow conditions, when migration rates are slower than during normal or above normal run-off years. In low flow years, knowledge of when most smelts have left tributaries and entered areas which can be affected by releases of stored waters allows managers to make the most timely use of the limited water budget resource. Project personnel continually strive to improve smelt trap design and location in years prior to such a low water condition to assure the best possible information is provided for water budget management purposes which will maximize smelt survival. Within the duration of the Smelt Monitoring Project, only one such low flow year has been experienced: 1987. Indications are that judicious use of the water budget can greatly enhance the migration timing and rate of juvenile chinook salmon and steelhead trout.

OBJECTIVES

1. Determine timing of the outmigration for the various groups of hatchery-produced and wild chinook salmon and steelhead trout smelts as they leave the Salmon River drainage during low flow years.

2. Establish smelt travel time from the Salmon River index site at White Bird and from release sites to the index sites at the upper end of Lower Granite Reservoir.

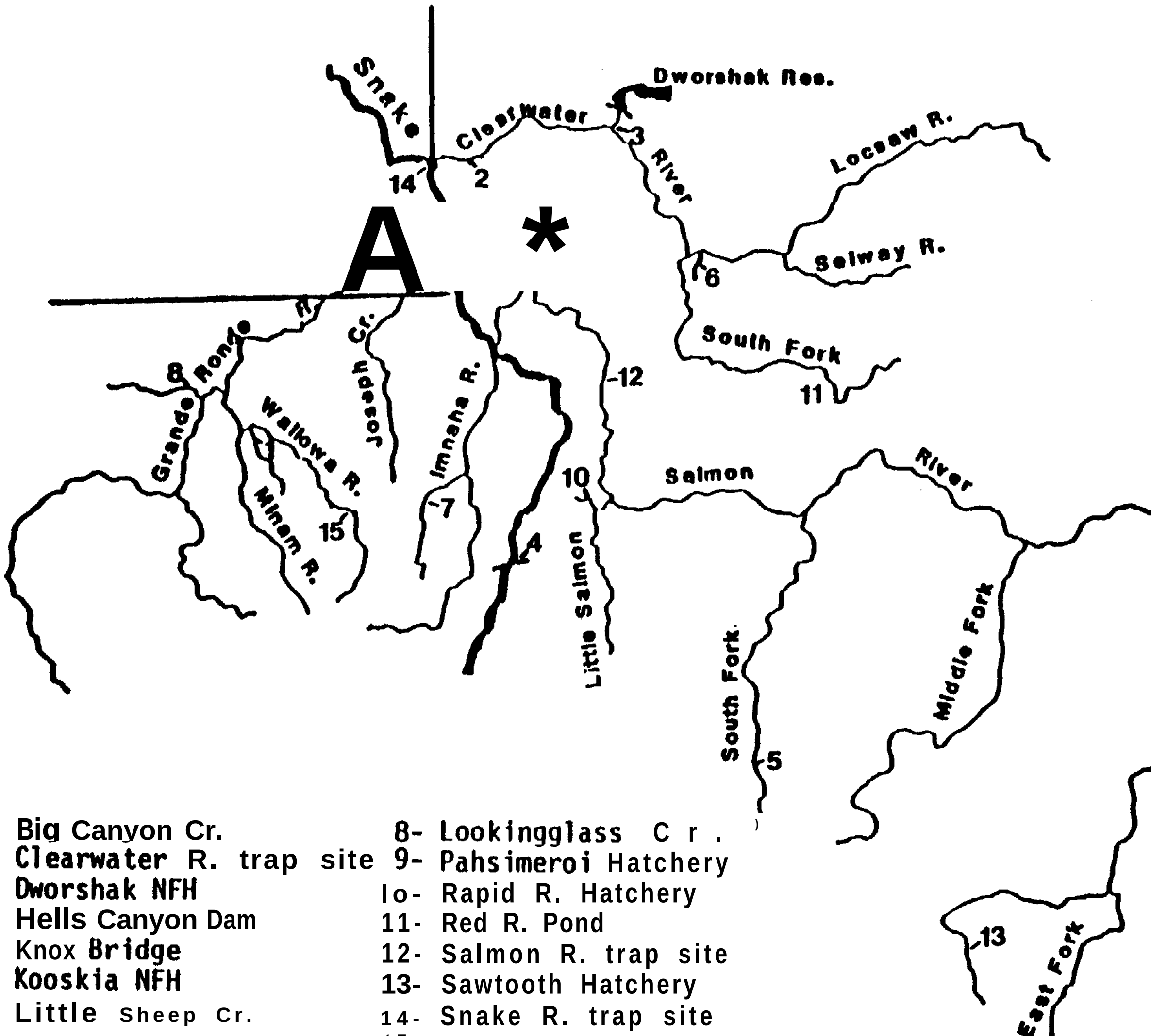
3. Correlate travel time with river flows from index sites to Lower Granite Reservoir and Lower Granite Dam.

4. Determine where, when, and to what extent descaling occurs to hatchery-reared chinook salmon and steelhead trout smelts released upstream from Lower Granite Dam and develop management alternatives to reduce scale loss.

METHODS

Releases of Hatchery-Produced Smelts

We obtained information from hatcheries which release steelhead trout and chinook salmon juveniles in the Snake River system upstream from Lower Granite Dam. This information included species, number released, time and location of release, and the group identifying freeze brand, if used. This allowed us to anticipate the passage of the various release groups and branded fish at downriver trapping sites.



1- Big Canyon Cr.
2- Clearwater R. trap site
3- Dworshak NFH
4- Hells Canyon Dam
5- Knox Bridge
6- Kooskia NFH
7- Little Sheep Cr.
8- Lookingglass Cr.
9- Pahsimeroi Hatchery
lo- Rapid R. Hatchery
11- Red R. Pond
12- Salmon R. trap site
13- Sawtooth Hatchery
14- Snake R. trap site
15- Spring Cr.

Figure 1. Map of study area.

Smelt Monitoring Traps

During the 1987 outmigration, three smelt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. One scoop trap (Raymond and Collins 1974) was stationed on the ClearWater River and one was stationed on the Salmon River. A dipper trap (Mason 1966) was located on the Snake River (Fig. 1). Trap-caught smelts were removed daily from the traps for examination, enumeration, and release back to the river. When available, between 150 to 300 chinook salmon and steelhead trout smelts were examined each day for scale loss. Up to 2,000 smelts were examined daily for hatchery brands. The remaining catch was enumerated by species and released. Prior to examination for scale loss and freeze brands, fish were anesthetized with Tricaine Methanesulfonate (MS-222). These fish were allowed to recover from anesthesia before being returned to the river.

To quantify scale loss, each side of a smelt was separated into five areas and each area was examined (Koski et al. 1986). An area was considered "descaled" if 40% or more of the scales within the area were missing. If at least two areas on one side of a fish were descaled, then the fish was considered descaled. Scale loss of this degree is often referred to as "standard" descaling. Additionally, beginning in 1985, a fish was considered to have standard descaling if a band of scales was missing from at least one side of a fish and the amount of missing scales was equal to or greater than the loss of 40% or more scales from two areas on a side of a fish as described above. This type of descaling is known as Number "9" descaling.

A second descaling classification is "scattered" descaling, which occurs when at least 10% of the scales were missing from at least one side of the fish. A third descaling classification is "two-area" descaling, which exists when the sum of the number of the ten areas on a fish (Fig. 2) which are at least 40Z descaled and the number of sides of a fish which exhibit scattered descaling equals two or more. The two-area classification includes fish that exhibit standard descaling, as well as fish that would not meet the criteria for the standard category because there was only one descaled area per side. This type of descaling is likely to be as detrimental to fish health as standard descaling.

At each trap, water temperature and turbidity were recorded each day using a centigrade thermometer and 20 cm Secchi disc. The U.S. Weather Service provided daily information on river discharge. The Snake River trap discharge was measured at the USGS Anatone gauge (#13334300). The ClearWater River trap discharge was measured at the USGS Spalding gauge (#13342500). The Salmon River trap discharge was measured at the USGS White Bird gauge (#13317000).

TRAP JUVENILE DESCALING FORM (RECORDER____________)

DATE__________ SITE___________ TIRE___________ SECCHI DISC______ M

H2O TEMP______ C VELOCITY______ TRAP POSITION______________

Efficiency Tests: Trap down time (hrs)______________
(#fish marked/released and mark used)
Chinook______________ SH______________ SW______________

Remarks:____

DESACALING

RIGHT LEFT

6. SCATTERED 7. EYE/HEAD INJURIES 8. DEAD 9. DESCALED BAND

	CHIN : STEEL: descale	brand		CHIN : STEEL: descale	brand		CHIN : STEEL: descale	brand		CHIN : STEEL: descale	brand
1.			1.			1.			1.		
2.			2.			2.			2.		
3.			3.			3.			3.		
4.			4.			4.			4.		
5.			5.			5.			5.		
6.			6.			6.			6.		
7.			7.			7.			7.		
8.			8.			8.			8.		
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12.			12.			12.			12.		
13.			13.			13.			13.		
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16.			16.			16.			16.		
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18.			18.			18.			18.		
19.			19.			19.			19.		
20.			20.			20.			20.		
21.			21.			21.			21.		
22.			22.			22.			22.		
23.			23.			23.			23.		
24.			24.			24.			24.		
25.			25.			25.			25.		

FISH SAMPLED: CHINOOK______ HATCHERY STEEL______ WILD STEEL______

Form: TJD-88

Figure 2. Form used to record smelt passage and descaling information, Drawings show the five areas on each side of a smolt which are considered independently for scale loss.

Salmon River Trap

Information during near normal to above normal flow years is available at the Salmon River trap for 1983, 1984, and 1985. Therefore, this trap is operated only if the February Soil Conservation . Service - Snow Survey Streamflow Fore'cast at White Bird is less than 90% of the 25-year average. A tentative decision to operate the trap is made in early February using the January streamflow forecast. If the January forecast is below 902 of normal, preparation to operate the Salmon River trap will begin. The final decision is then made using the February forecast, available in early March.

The January streamflow forecast in 1987 was 68% of normal; by the first of March the prediction had fallen to 59Z of normal. At this time, the decision to operate the Salmon River trap was made.

The trapping site for the Salmon River trap is located one kilometer downstream from the mouth of White Bird Creek (rkm 86). When river flows permit, the trap is situated on the outside of a bend in the river, near the south bank, immediately downstream from a rock shelf. This location was chosen because juvenile migrants are concentrated both laterally and vertically due to the morphology of the site, thus making them more vulnerable to capture. River width at this site is approximately 70 m and depth ranges from 2 m at 6,000 cfs to 5 m at 25,000 cfs. The trap was operated from March 5 until April 28, 1987, when high runoff forced termination of trap operations.

Chinook salmon' smelts were freeze branded (Mighell 1969) and released at the Salmon River trap to estimate travel time from the lower Salmon River drainage to the head of Lower Granite Reservoir. The brand was changed at three-day intervals to document changes in travel time as environmental conditions changed. When available, up to 3,000 chinook salmon were branded daily with a goal of 6,000 per unique brand group. Nine unique freeze brands were used at the Salmon River trap during the 1987 field season on chinook salmon juveniles. Seven of the nine chinook salmon brand groups were also used for trap efficiency tests by transporting the marked fish one kilometer upstream from the trap site by boat and releasing them for subsequent recapture.

Capture rate of steelhead trout smelts at the Salmon River trap is considerably less than that of chinook salmon. Sufficient numbers of steelhead trout could not be obtained to determine trap efficiency and document travel time to downriver collection sites, as is done with the chinook salmon. Therefore, steelhead trout were freeze branded at Hagerman NFH and transported to the Salmon River and released approximately one kilometer upstream from the trap site. Three unique brand groups of steelhead trout, containing from 4,400 to 4,700 fish each, were released during the 1987 field season. These releases were also used to estimate trap efficiency at the Salmon River trap.

Snake River Trap

The Snake River migrant dipper trap was attached to the downstream side of the Interstate Bridge by steel cables. This location is at the head of Lower Granite Reservoir 0.5 km upstream from the confluence of the Snake and Clearwater rivers. River width and depth at this location are approximately 260 m and 12 m, respectively.

Trap operation in 1987 began February 28 and continued until June 29. There were no interruptions in trap operation due to mechanical breakdown or excessive runoff conditions.

Chinook salmon and steelhead trout smelts were PIT (Passive Integrated Transponder) tagged (Prentice et al. 1987) at the Snake River trap in 1987 to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam. Up to 300 chinook salmon and 60 steelhead trout (30 of which were wild fish, if available) were PIT-tagged daily. Individual daily release group travel time to Lower Granite Dam was correlated with flow present during the migration period to determine how changes in this parameter affected travel time of smelts through Lower Granite Pool.

Clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from the river's mouth, 4.5 km upstream from the head of Lower Granite Reservoir. The river channel at this location forms a bend and is 150 to 200 m wide and 4 to 7 m deep, depending on discharge.

Trap operation began February 19, 1987 and continued until June 25 when trap operation was terminated for the season.

Trap efficiency tests were conducted periodically throughout the season by releasing marked smelts 7 km upriver from the trap site. When trap catch allowed, up to 2,000 chinook salmon were caudal clipped, and 2,000 steelhead trout were opercle punched and released upstream. These fish were held in trash cans supplied with oxygen and carried upstream to the release site by boat and released. In addition to these fish, six groups of chinook salmon of approximately 2,000 each and three groups of steelhead trout of approximately 4,000 each were freeze branded at Dworshak NFH and transported to the release site and released at one-week intervals during late April and May to estimate trap efficiency.

Descaling

Chinook salmon descaling rates were estimated at four of Idaho's chinook salmon hatcheries prior to smelt release. Descaling rates were also estimated at the time of release for the South Fork Salmon River off-hatchery release group (McCall Hatchery) and for the Crooked River and White Sands Creek off-hatchery release groups (Sawtooth Hatchery). Sawtooth Hatchery also releases chinook salmon smelts directly from the hatchery, as do Kooskia NFH, Dworshak NFH, Rapid River, and Pahsimeroi hatcheries. During 1987, Rapid River and Pahsimeroi hatcheries made releases of spring chinook salmon in the Snake River at Hells Canyon Dam; descaling data was not recorded from these groups at the release site.

Steelhead trout descaling rates were estimated at two of Idaho's hatcheries prior to release and at four release sites at the time of release.

Examination of 200 to 900 smelts from representative groups of chinook salmon and steelhead trout was conducted at selected hatcheries and again at release sites to estimate the percentage of smelts having significant scale loss. The condition of the smelts was compared with that observed at trapping sites along the migration routes where up to 300 chinook salmon and steelhead trout smelts were examined daily.

Trap Efficiency

To estimate the number of smelts passing a trap it is necessary to know what proportion of the migration is being sampled. Additionally, this proportion, which is the trapping efficiency, may change as river discharge changes. To create an equation which describes the relationship between discharge and efficiency, efficiency must be estimated several times through the range of discharge during which the trap is operated. A linear regression of efficiency on discharge is then calculated from the data, after which an efficiency can be estimated from a known discharge. The ratio of recaptures to marks released is the estimate of trap efficiency (TE = recaptures/marks released).

Several techniques were used to estimate trap efficiency in 1987. Trap efficiency tests are conducted every four days using trap-caught fish that were marked, transported back upstream, and released, if enough smelts are available to mark. During 1987, six groups of chinook salmon smelts of 2,000 fish each and three groups of steelhead trout smelts of 4,000 fish each were freeze branded and held at Dworshak NFH. These groups were released at one-week intervals upstream from the Clearwater River trap for efficiency tests. These groups were also used to determine travel time through Lower Granite Reservoir.

Trap-caught chinook were marked and used for efficiency tests at the Salmon River trap with groups of one to two thousand being released every four days, when available. Three groups of steelhead trout smelts, of approximately 4,500 fish each, were freeze branded and held at Hagerman NFH until transport to a release site on the Salmon River upstream from the trap site. These groups were released at approximately one-week intervals for trap efficiency tests on the

Salmon River trap, as well as to estimate travel time from the lower Salmon River drainage to the head of Lower Granite Reservoir and to Lower Granite Dam.

No trap efficiency tests were conducted at the Snake River trap in 1987 because of the low trap catch associated with the extremely low - flow year.

Travel Time and Migration Rates

Migration statistics were calculated on hatchery release groups from release sites to trap sites. Travel time and migration rates through Lower Granite Reservoir were calculated using median arrival times at the Snake River trap and at Lower Granite Dam for hatchery brand groups and brand groups used for trap efficiency tests. Smelts were PIT tagged (Prentice et al. 1987) at the Snake River trap as an additional method to determine travel time, and daily individual arrival times were calculated at Lower Granite Dam collection facility. Early in the season, chinook were collected at the Clearwater River trap, transported to the Snake River trap for PIT tagging, and released. When adequate numbers of chinook were being collected at the Snake trap, transportation of chinook from the Clearwater River trap was discontinued. All steelhead that were PIT tagged were collected at the Snake River trap. Later in the season, when trap collection did not provide adequate numbers of chinook and steelhead, additional fish were collected immediately behind the Snake River trap with purse seine equipment.

Steelhead Trout Radio Tracking Study

The migrant dipper trap on the Snake River and the scoop traps on the ClearWater and Salmon rivers all effectively collect chinook salmon smelts in large enough numbers to meet project goals but are relatively ineffective at collecting steelhead trout smelts. It is uncertain whether low steelhead trout catch is due to trap avoidance or if the traps are not in the main migrational path of steelhead smelts. In 1987, a radio tracking study was conducted at the Snake and ClearWater River traps to determine if fish were avoiding the trap or if the trap could be moved to a more productive location. The objective of the study was to determine steelhead trout smelt reaction to the traps and horizontal distribution of the steelhead trout smelts in the vicinity of the traps. Fish to be radio tagged were taken from the Snake and Clearwater River traps.

A contract was developed with the Coastal Zone and Estuarine Studies Division of the National Marine Fisheries “Service (NMFS), Seattle, Washington, for the services of their Radio Tracking Subtask (Liscom and Bartlett 1988). The study was initiated in mid-April and terminated in mid-May, 1987. Sixty juvenile steelhead trout were radio tagged and released in the Snake River, and 61 juvenile steelhead trout were radio tagged and released in the Clearwater River upstream from the trap sites, during a five- to six-day time period. Radio-tagged fish were individually tracked past each trap site and their path plotted in relation to fixed geographical locations (Fig. 3).

RESULTS AND DISCUSSION

Hatchery Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage above Lower Granite Dam were reared at seven locations in Idaho and one in Oregon. Washington Department of Fisheries made no release of chinook salmon juveniles in the Snake River drainage upstream from Lower Granite Dam that contributed to the 1987 outmigration. A total of 11,291,583 chinook salmon smelts were released at 15 locations in Idaho and Oregon (Table 1).

Sawtooth Hatchery made three releases of spring chinook salmon in the Clearwater River drainage at Red River, Crooked River, and White Sands Creek in the fall of 1986 for a total 696,120 fish. Lookingglass Hatchery also made a fall release of 328,161 spring chinook salmon juveniles at Lookingglass Creek, Oregon, in 1986. All other chinook salmon releases for the 1987 outmigration were made in the spring of 1987.

Steelhead Trout

Steelhead trout were reared at three hatcheries in Idaho, one in Washington, and one in Oregon for release upriver from Lower Granite Dam. A total of 7,436,384 steelhead trout smelts were released at 14 locations in Idaho, 10 locations in Oregon, and 3 locations in Washington (Table 2).

Niagara Springs Hatchery released 39,995 steelhead trout juveniles in the Snake River at Hells Canyon during the fall of 1986. The remainder of steelhead trout releases contributing to the 1987 outmigration occurred in the spring of 1987.

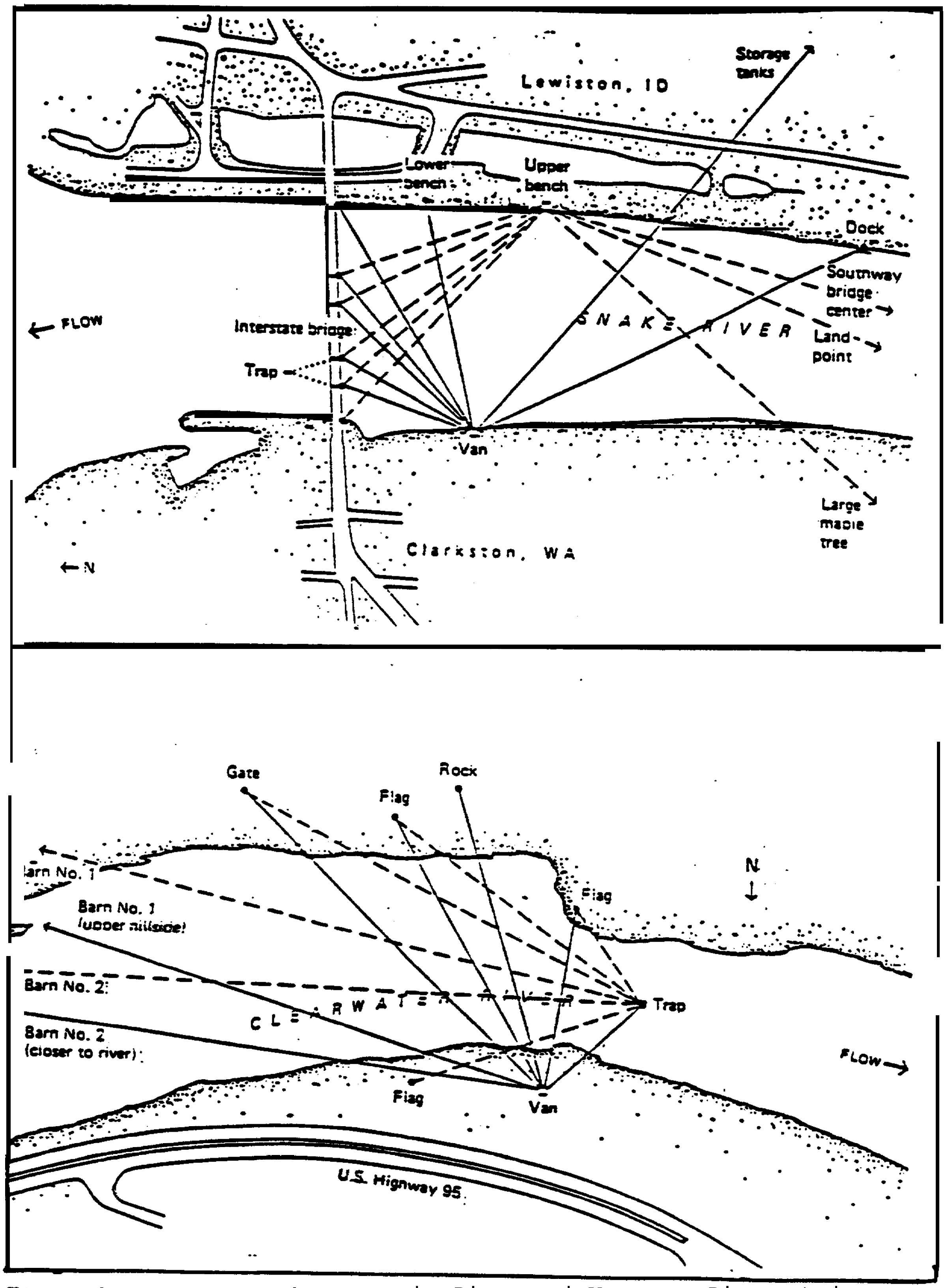


Figure 3. Diagrammatic view os snake River and Clearwater River study areas showing grid lines used for radio tracking.

Table 1. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam, 1987.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Salmon River				
Sawtooth Hat. (Sawtooth)	Spring	3/13 (3/13) 10/10/86	1,081,400 (58,400) 103,661	 RDR- 1
E.F. Salmon R. (Sawtooth)	Spring	3/17-19	195,100	
S.F. Salmon R. (McCall)	Summer	3/30-4/2 (3/31)	958,300 (56,500)	 LDR- 3
Pahsimeroi R. (Pahsimeroi)	Summer	3/23	258,600	
Rapid River (Rapid River)	Spring	3/18-4/7 (3/27)	2,836,400 (53,500)	 LDR-2 **
	Drainage Total		5,433,461	
Snake River and Non-Idaho Tributaries				
Hells Canyon (Rapid River)	Spring	3/23 (3/23)	103,000 (51,350)	 LDR-4 **
Hells Canyon (Pahsimeroi)	Spring	3/2-6	444,700	
Lookingglass Cr. (Lookingglass)	Spring	4/1-5/20 (4/1) (4/1) (4/20) (4/20) (5/20) (5/20)	855,658 (20,194) (20,415) (20,925) (20,890) (20,303) (20,375)	 LAJ-2 LAJ-4 LDJ- 1 LDJ-3 LDJ-2 LDJ- 4
Lookingglass Cr. (Lookingglass)	Spring	9/24 & 11/1 (9/24) (9/24)	328,161 (20,431) (20,522)	 LAJ- 1 W - 3
Grande Ronde (R2) (Lookingglass)	Spring	4/6	111,711	
Catherine Creek (Lookingglass)	Spring	2/26	88,667	

Table 1. Continued

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Big Canyon Creek (Lookingglass)	Spring	3/30 "	84,295	
	Drainage	Total	2,016,192	
Clearwater River				
Red River Pond (Sawtooth)	Spring	3/18 10/8/86	98,800 96,400	
Crooked River (Sawtooth)	Spring	3/16,18 10/8,15/86	227,500 251,300	
White Sands Creek (Sawtooth)	Spring	3/16/18 10/7,14/86	344,900 348,420	
N.F. ClearWater (Dworshak NFH)	Spring	4/1-2 (4/2)	1,710,710 (61,580)	RAR- 1
Clear Creek (Kooskia NFH)	Spring	3/24	763,900	
	Drainage	Total	3,841,930	
	Grand Total		11,291,583	

** Brand groups mixed at hatchery prior to transport

Table 2. Hatchery steelhead trout released into the Snake River system upriver from Lower Granite Dam, 1987.

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Salmon River				
Pahsimeroi River (Niagara Springs)	A	3/30-4/9	712,200	
Panther Creek (Niagara Springs)	A	4/9-13	299,700	
E.F. Salmon River (Hagerman NFH)	B	3/27-4/15	485,078	
		(4/8)	(52,811)	RDR-4
Hazard Creek (Hagerman NFH)	A	4/16-30	299,098	
		(4/30)	(4,522)	LDK- 2
Sawtooth Hatchery (Hagerman NFH)	A	3/26-4/15	687,634	
		(4/14)	(51,887)	RDR- 2
Slate Creek (Hagerman NFH)	B	3/24	49,740	
Salmon R.@Deer Cr.	B	4/8-22	13,801	
		(4/8)	(4,700)	LDK- 1
		(4/22)	(4,690)	LDK- 3
		(4/15)	(4,408)	LDK-4
	Drainage	Total	2,547,251	
Snake River and Non-Idaho Tributaries				
Hells Canyon (Niagara Springs)	A	3/23-30	800,000	
		(3/26)	(51,600)	LDR- 1
Hells Canyon (Niagara Springs)	A	10/21/86	39,995	
Little Sheep Cr. (Irrigon)	A	5/1-5	93,716	
		(5/3)	(15,642)	LDJ- 4
		(5/2)	(15,660)	RDJ-4
Spring Creek (Irrigon)	A	4/24-28	587,406	
		(4/26)	(14,638)	LDJ-1
		(4/26)	(14,598)	LDJ-3
		(4/26)	(14,485)	RDJ- 1
		(4/26)	(14,534)	RDJ-3
Grande Ronde (RI) (Irrigon)	A	4/15-23	151,053	

Table 2. Continued

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Wildcat Creek (Irrigon)	A	4/28-29	52,335	
Grande Ronde (R2) (Irrigon)	A	4/8-24	291,332	
Catherine Creek (Irrigon)	A	4/13-27	72,438	
Wallowa River (Irrigon)	A	4/14-30	160,032	
Big Canyon Creek (Irrigon)	A	4/25	222,526	
Prairie Creek (Irrigon)	A	4/29	24,257	
Hurricane Creek (Irrigon)	A	4/29	12,000	
Cottonwood Cr. (Lyonns Ferry)	A	4/20-30	200,845	
		(4/26)	(20,099)	RAIC-1
		(4/26)	(20,083)	RAIC-2
		(4/26)	(20,115)	RAIC-3
		(4/26)	(20,164)	RAIC-4
Asotin Creek (Lyonns Ferry)	A	4/22	22,950	
Whisky Creek (Lyonns Ferry)	A	4/28-29	52,500	
	Drainage	Total	2,783,385	
Clearwater River				
Clearwater River (Dworshak NFH)	B	4/20-23	1,206,580	
		(4/22)	(58,508)	RDR- 3
		(5/5)	(4,073)	RDK- 3
S.F.Clearwater R. (Dworshak NFH)	B	4/13-17	298,070	
Newsome Creek (Dworshak NFH)	B	4/14-17	202,857	
American River (Dworshak NFH)	B	4/14-17	41,527	

Table 2. Continued

Release site (hatchery)	Stock	Release date	No. released (No. branded)	Brand
Clear Creek (Dworshak NFH)	B	4/13-17 (4/17)	156,552 (33,897)	RAR-3
Crooked River (Dworshak NFH)	B	4/13-17 (4/14)	200,162 (48,557)	LAR-3
	Drainage Total		2,105,748	
	Grand Total		7,436,384	

Smelt Monitoring Traps

Snake River Trap Operation

The Snake River trap was operated from February 28 through June 29, 1987. Trap catch during this period was 1,887 yearling chinook salmon, 56 sub-yearling chinook salmon, 935 wild steelhead trout, 8,754 hatchery steelhead trout, and 5 sockeye salmon.

The majority of the chinook salmon (57%) were captured during May; sub-yearling chinook salmon (chinook smelts less than 80 millimeters) passage began in mid-March and peaked the first week of May. Fifty-five percent of the steelhead trout were captured during June (Figs. 4 and 5). Wild steelhead trout passed earlier, 46% in May and 34% in June, than did hatchery steelhead trout, 36% in May and 57% in June. The ratio of wild and hatchery steelhead trout in the catch was 1:9.

The chinook salmon catch at the Snake River trap was less than 10% of the 1984-1986 average. There appears to be a threshold velocity at the mouth of the trap: below this threshold the trap is relatively ineffective at collecting fish. Chinook catch was effected the greatest because velocities were very low during the majority of the chinook outmigration. Velocities were generally higher during the steelhead trout outmigration.

Snake River discharge, measured at the Anatone gauge, ranged from 16,860 cfs to 34,440 cfs in March (Fig. 4). The average April discharge was 26,310 cfs, with a peak of 42,210 cfs April 30. The season peak discharge of 57,090 occurred May 14. From that time until the end of the trap operation, the discharge decreased steadily to 17,000 Cfs.

Water temperature in the Snake River when trap operation began, February 28, was 2° C and increased to 7° C by the end of March (Fig. 6). By the end of the trapping season, June 29, water temperature had risen to 20.5° C.

Secchi disc transparency fluctuated throughout the sampling season (Fig. 6). Influenced mainly by localized rain or thunderstorm events, the secchi transparency shows no obvious correlation to changes in discharge.

Clearwater River Trap Operation

The Clearwater River trap operated from February 19 through April 29 and again from May 20 until June 25. During the period April 30 to May 19, trap operation was suspended due to high discharge in the Clearwater River.

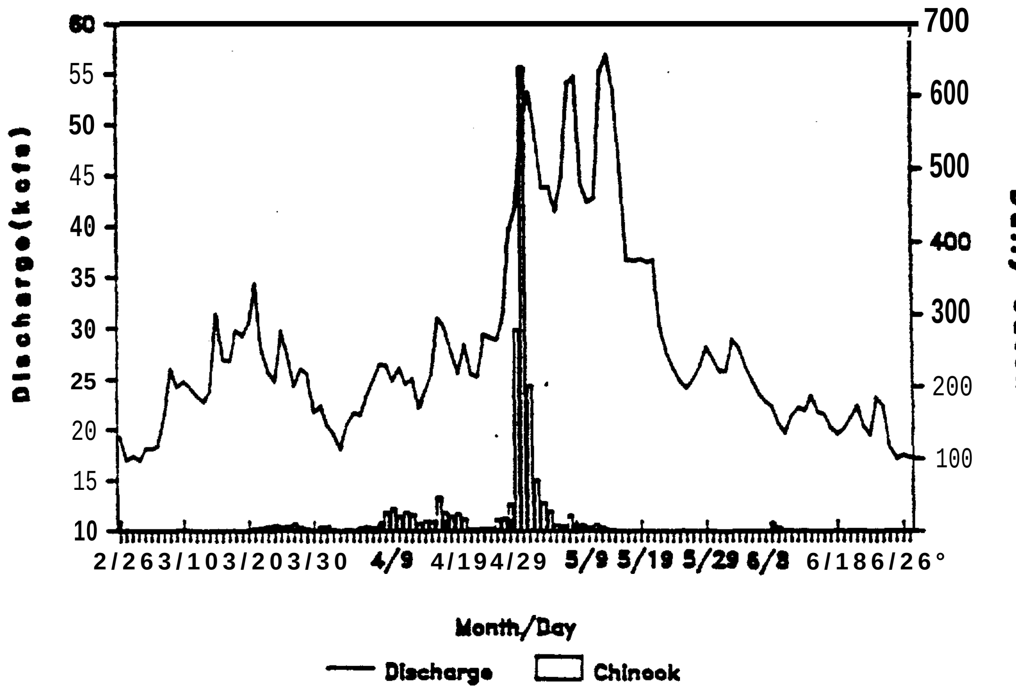
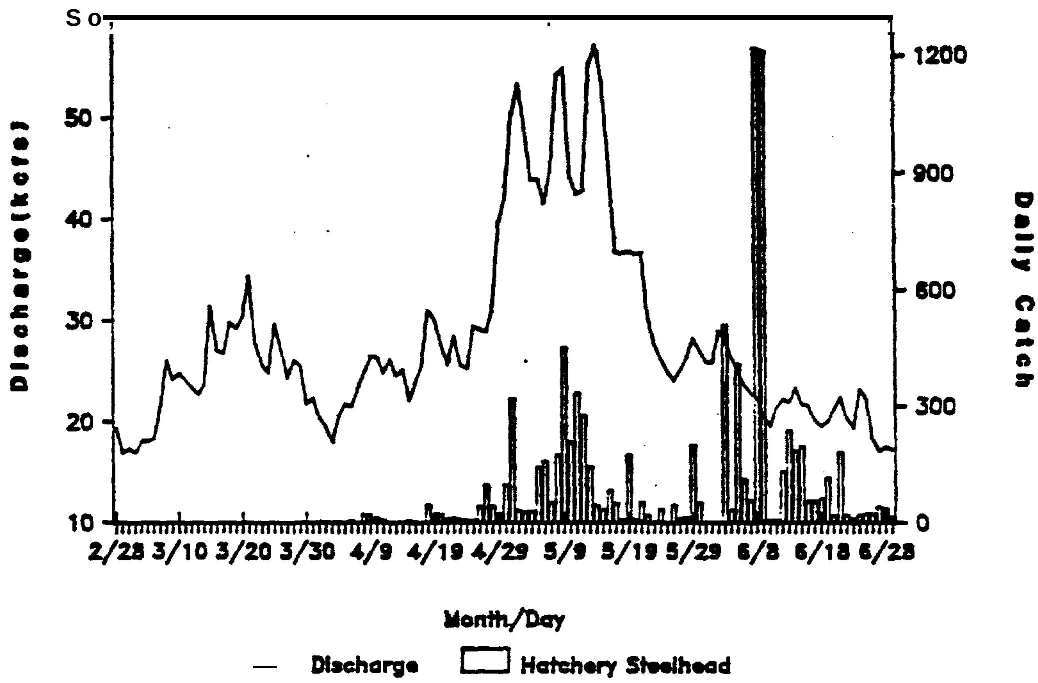


Figure 4. Snake River trap daily catch for yearling chinook salmon overlaid by Snake River discharge, 1987.



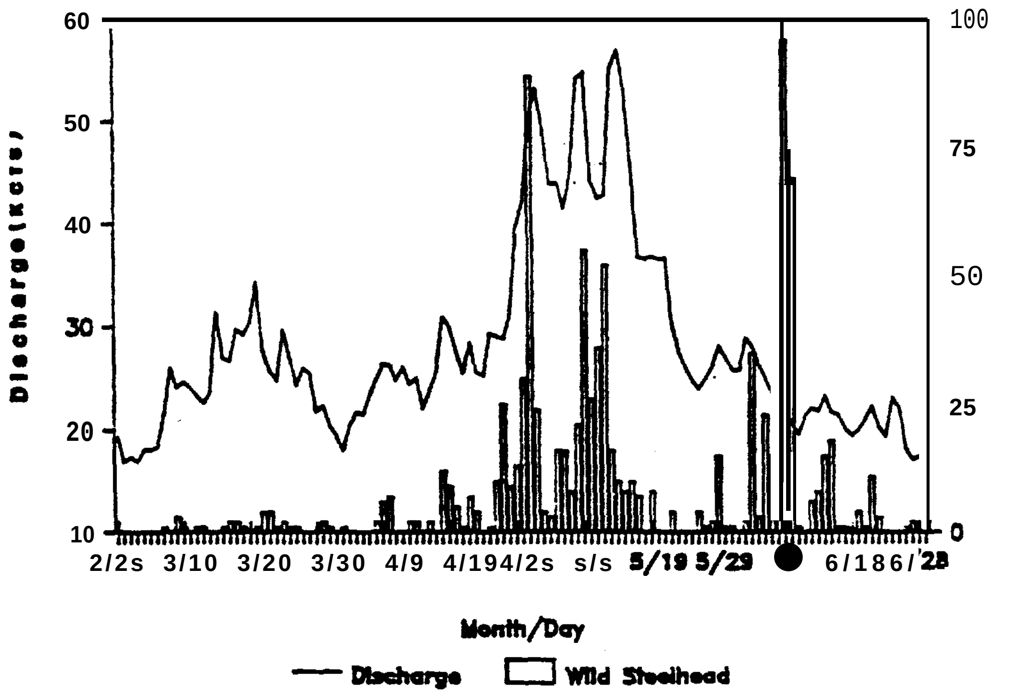
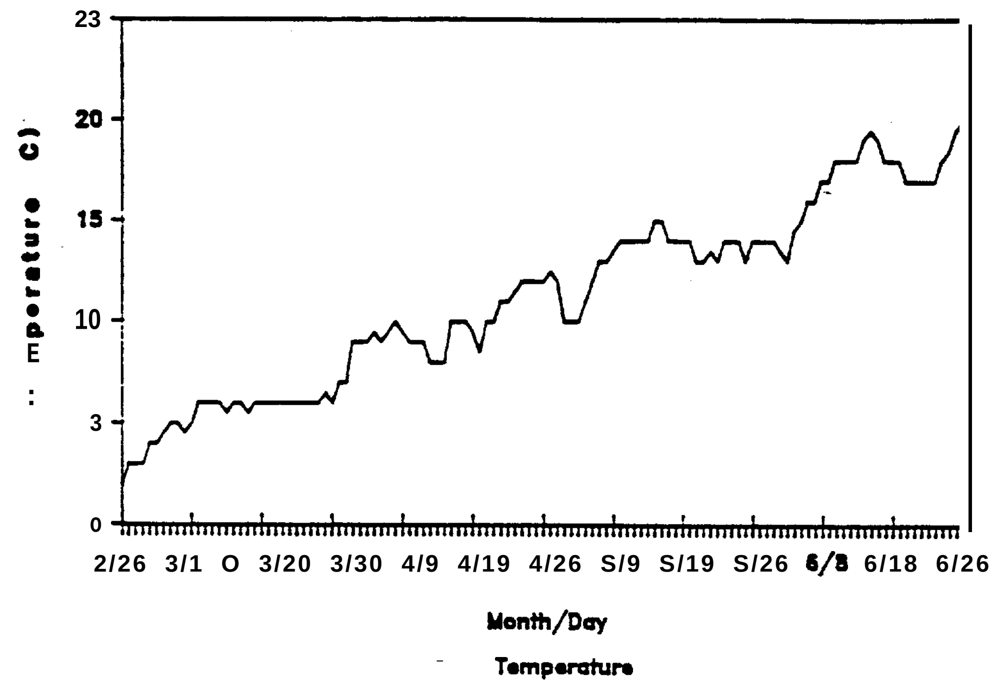


Figure 5. Snake River trap daily catch for wild steelhead trout and hatchery steelhead trout overlaid by Snake River discharge, 1987.



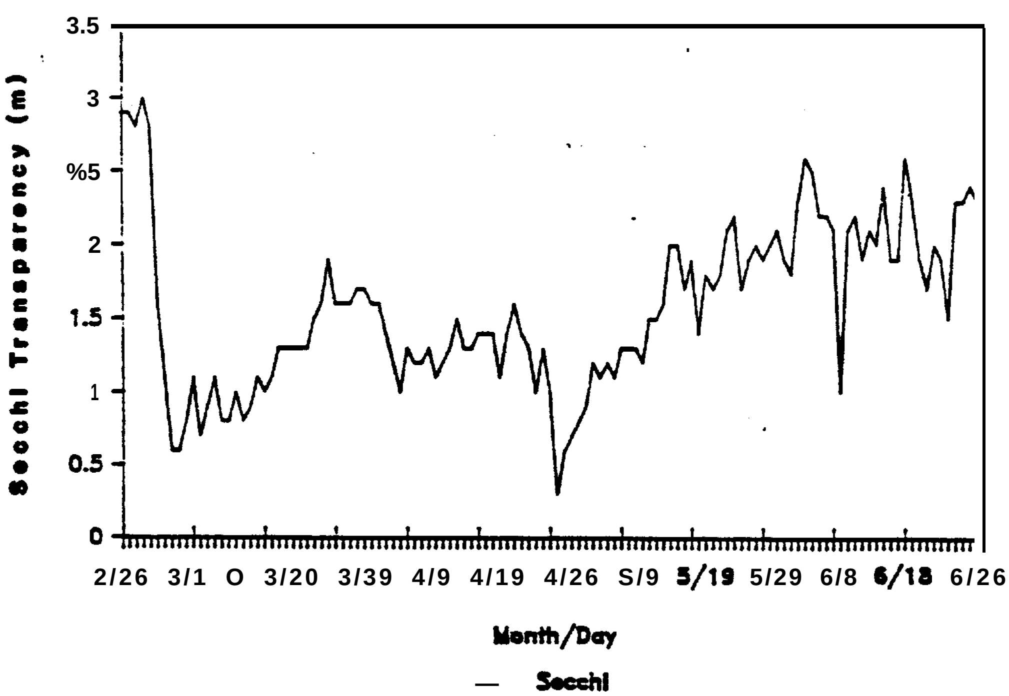


Figure 6. Daily temperature and secchi disk transparency at the Snake River trap, 1987.

The Clearwater River trap captured 72,707 chinook salmon, of which 34 were classed as sub-yearling and the remainder were yearlings: 5,567 hatchery steelhead trout; and 896 wild steelhead trout in 1987. Two peaks of chinook salmon passage were observed at the Clearwater River trap. The first peak in late March, prior to the Dworshak NFH release, was presumed to be from the Sawtooth Hatchery releases made in Red - River, Crooked River, and White Sands Creek, and the Kooskia NFH release made in Clear Creek. The second peak was comprised of the Dworshak NFH release made in the North Fork "of the Clearwater River (Fig. 7).

The ratio of wild to hatchery steelhead trout in the Clearwater River catch was approximately 1:6. Trap catches of steelhead trout on the Clearwater River peaked the third week of April, coinciding with the release of Dworshak NFH steelhead trout smelts from the hatchery and from off-hatchery planting sites (Fig. 8).

Water temperature at the Clearwater River trap ranged from a low of 3° C the beginning of the season, February 19, and rose to 10° C by the second week of April (Fig. 9). The high temperature for the season of 19.5° C was recorded June 15.

Discharge during the first two months of operation ranged from 3,760 cfs to 16,000 cfs (Fig. 7). A small peak in the hydrography was seen in late April and early May when discharge reached 44,680 cfs and then dropped back to approximately 15,000 cfs for the remainder of the trapping season. During this period of high runoff, April 30 to May 19, the Clearwater River trap was not operated.

Secchi disc transparency in the ClearWater River fluctuated throughout the trapping season and ranged from near 0.5 meters to 2 meters and greater (Fig. 9).

Salmon River Trap Operation

The March streamflow forecast for the Salmon River drainage above White Bird was 56% of normal, which fell well below the 90% criteria established for determining which years the Salmon River trap would be operated. Trap operation was initiated March 5 and terminated April 28. During this period, the trap captured 51,557 yearling chinook salmon, 46 sub-yearling chinook salmon, 598 wild steelhead trout, and 615 hatchery steelhead trout. Essentially, all (96%) of the chinook passage occurred in April at the Salmon River trap, with the peak occurring mid-month (Fig. 10). Both wild and hatchery steelhead trout passage at the Salmon River trap also occurred in April (98%), with the peak occurring at the end of the month (Fig. 11). Unlike the Snake and Clearwater River traps the Salmon River trap ratio of wild to hatchery steelhead trout was approximately 1:1.

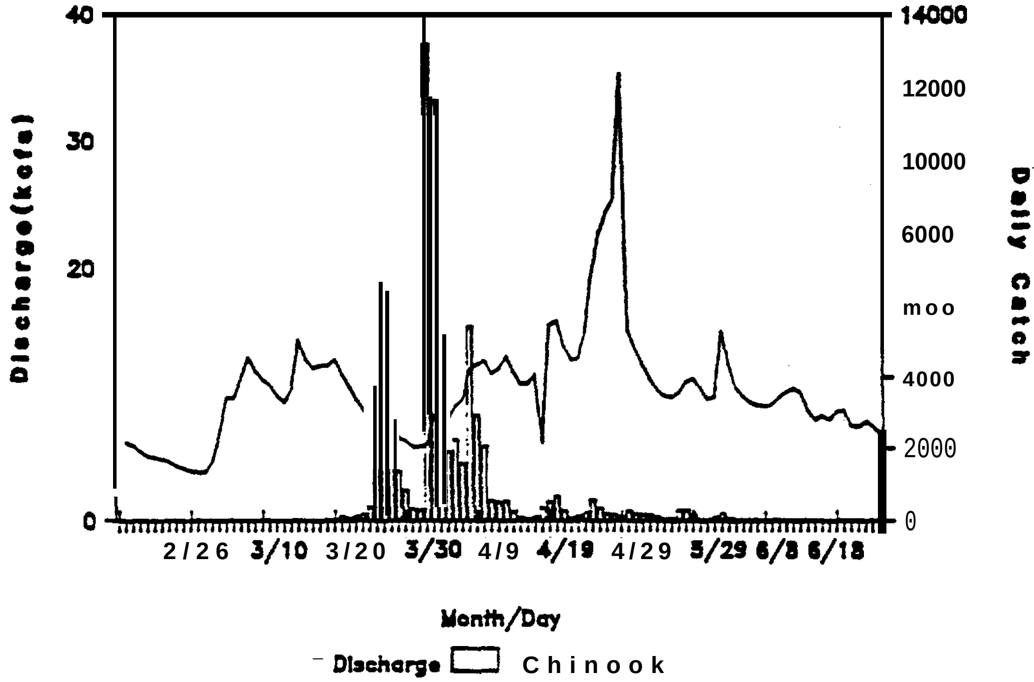
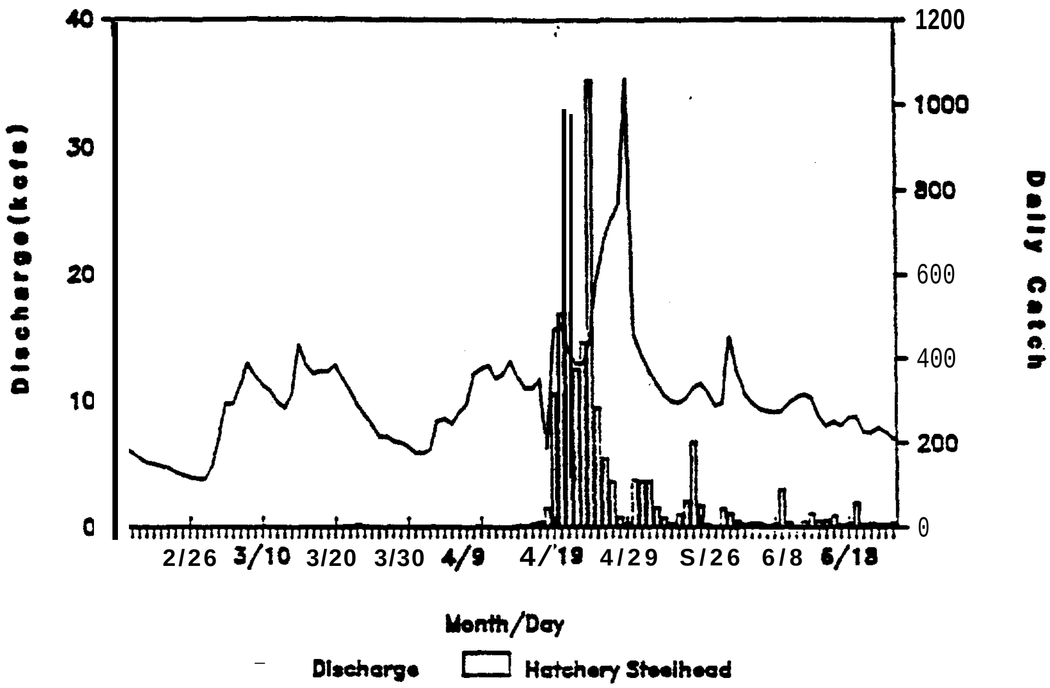


Figure 7. Clearwater River! trap daily catch for yearling chinook salmon overlaid by Clearwater River discharge, 1987.



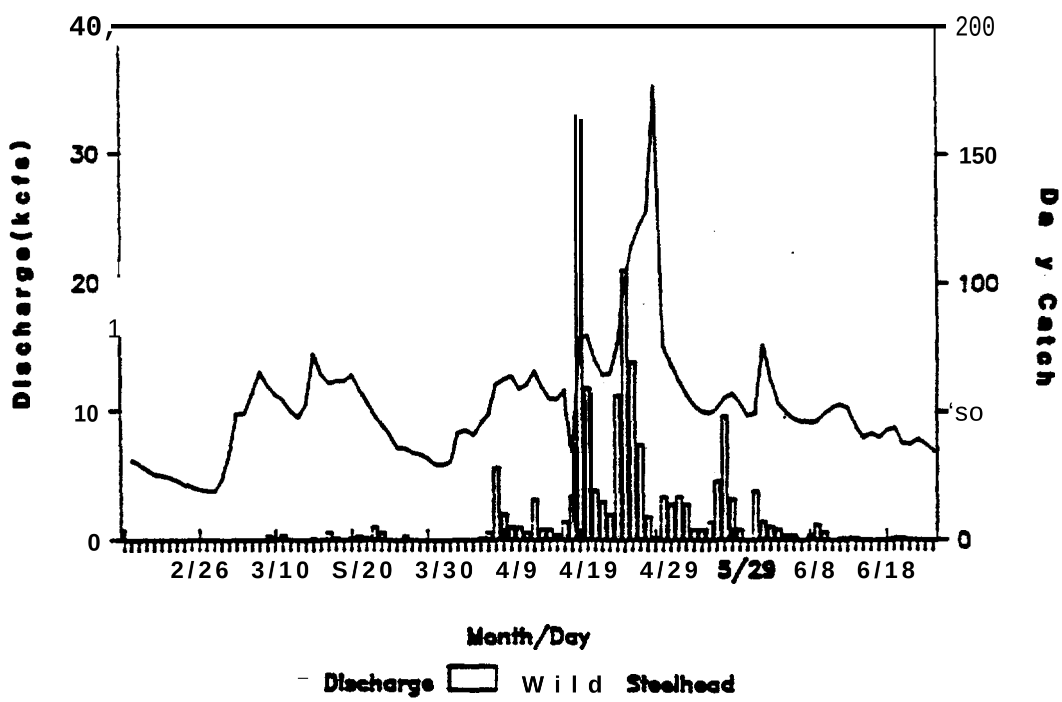


Figure 8. ClearWater River trap daily catch for wild steelhead trout and hatchery steel head trout overlaid by Clearwater River discharge, 1987.

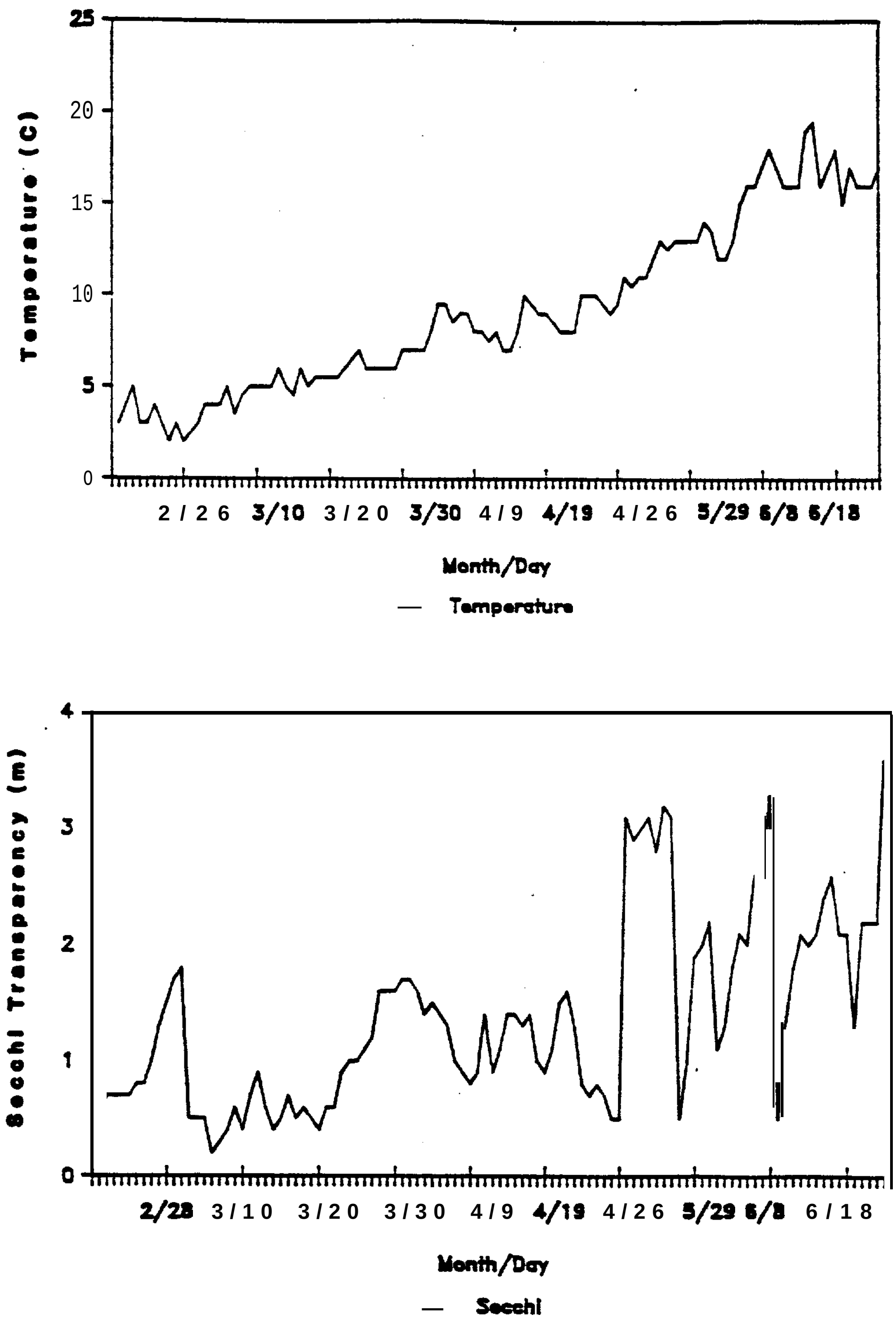


Figure 9. Daily temperature and secchi disk transparency at the Clearwater River trap, 1987.

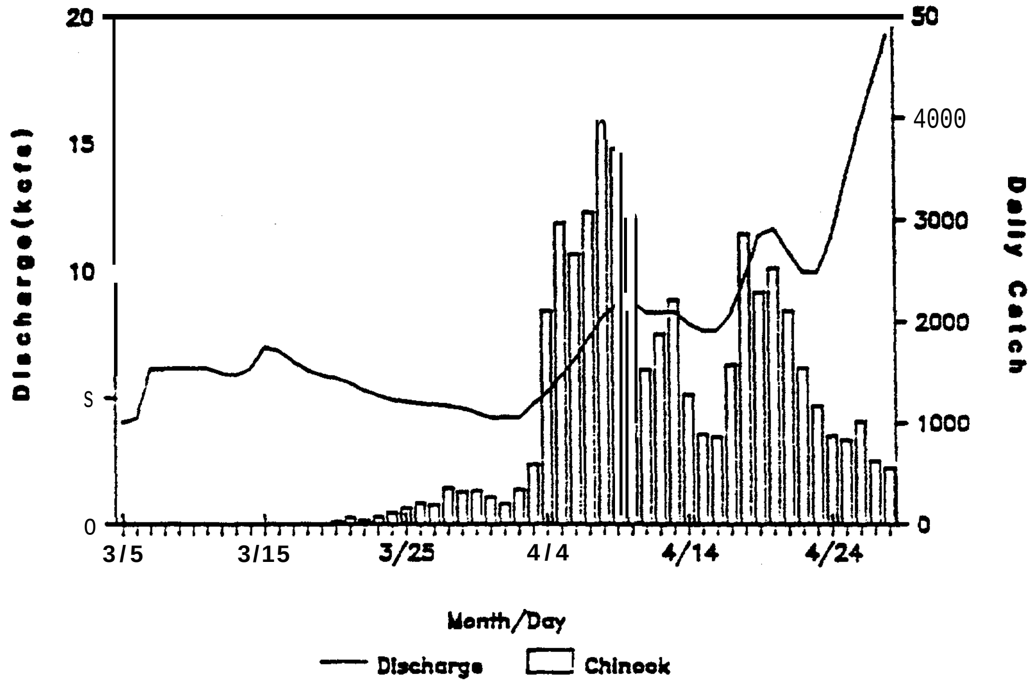


Figure 10. Salmon River trap daily catch for yearling chinook salmon overlaid by Salmon River discharge, 1987.

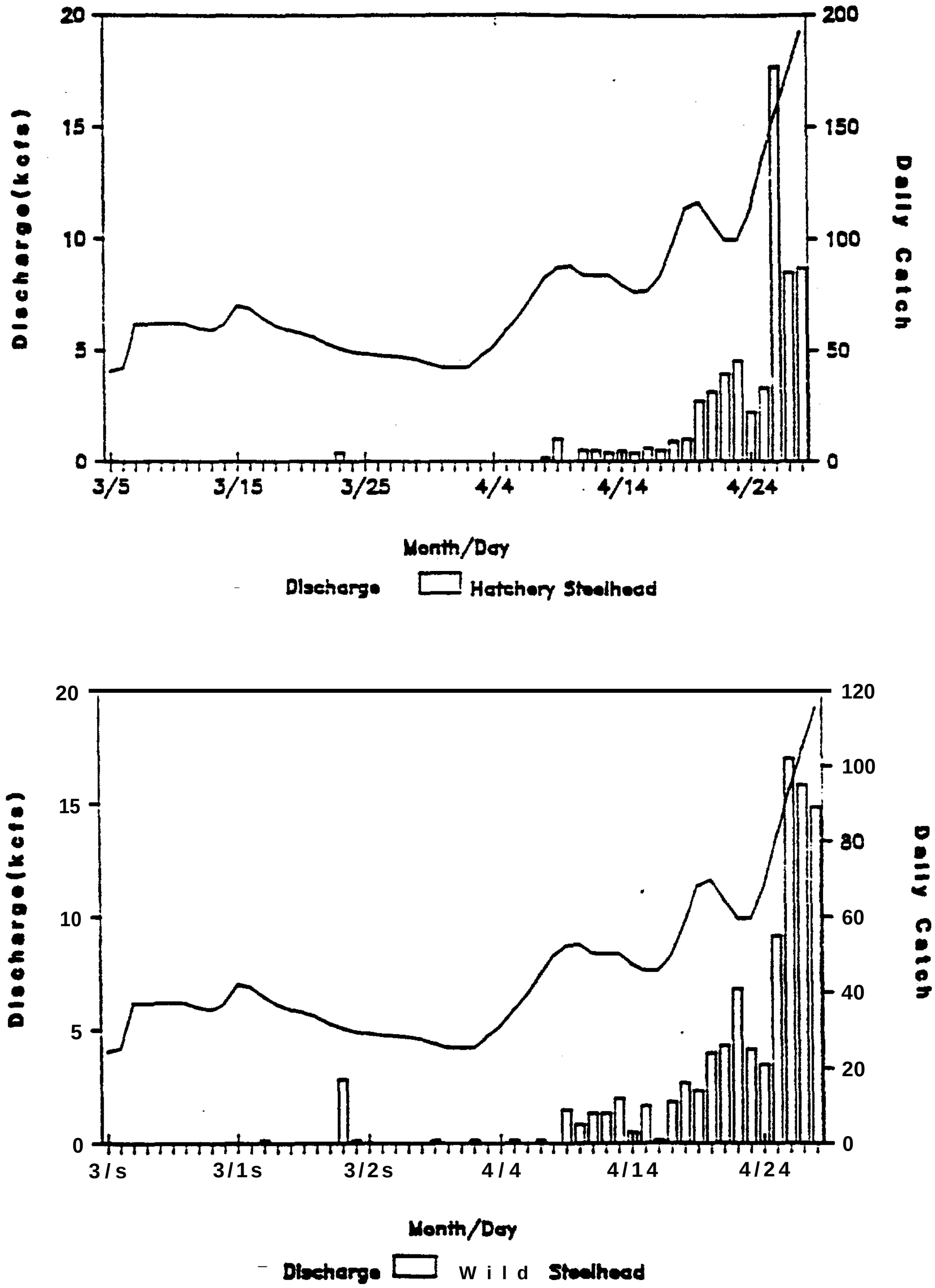


Figure 11. Salmon River trap daily catch for wild steel head trout and hatchery steelhead trout overlaid by Salmon River discharge, 1987.

Discharge in the Salmon River, measured at the White Bird gauge, ranged from 4,050 cfs at the beginning of the trapping season, to 19,240 cfs when trapping was discontinued for the year, April 28 (Fig. lo). The average discharge for the majority of the season was below 8,000 cfs.

Water temperature in the Salmon River at the beginning of the trap operation was 5.5° C, March 5, and increased to 7.0° C by the end of March. When trap operation was discontinued for the season, the water temperature had risen to 12° C (Fig. 12).

Secchi disc transparency fluctuated throughout the season, ranging from 0.6 meters to 3 meters (Fig. 12).

Descaling

Descaling of Chinook Salmon Smelts at Hatcheries and Release Sites

The standard descaling rate at four of Idaho's chinook salmon hatcheries in the spring of 1987 was 0.3% (Table 3). This is the lowest descaling rate yet observed at Idaho hatcheries since the inception of the monitoring process in 1983.

Standard descaling of chinook salmon from Sawtooth Hatchery at two observed off-hatchery release sites, Crooked River and White Sands Creek, was 0.6%. Descaling rates were not estimated at Sawtooth Hatchery prior to transport but from past years' averages there appears to be little, if any, increase in descaling due to transport from hatcheries to release sites in either of these release groups.

The off-site releases of McCall Hatchery chinook salmon in the South Fork of the Salmon River at Knox Bridge showed no increase in standard descaling rates from that observed at the hatchery prior to transport (Table 3).

Chinook salmon "scattered" descaling at the hatcheries ranged from 0% at Dworshak NFH to 4.6% at Kooskia NFH. McCall Hatchery showed 1.2Z and Rapid River Hatchery, 1.8%. Scattered descaling at the observed off-hatchery release sites was 0.3Z at the South Fork of the Salmon River release (McCall Hatchery), 5.6Z at the Crooked River release, and 6.7Z at the White Sands Creek (Sawtooth Hatchery) release. There was no comparison available to on-hatchery descaling rates for the Crooked River and White Sands Creek releases, but the South Fork Salmon River release site descaling rate, compared to the McCall Hatchery descaling rate (hatchery of origin), actually showed a decrease in scattered descaling of fourfold in the transported group. This inverse difference was only 0.9Z and is attributed to natural variability between samples due to small sample size (Table 3).

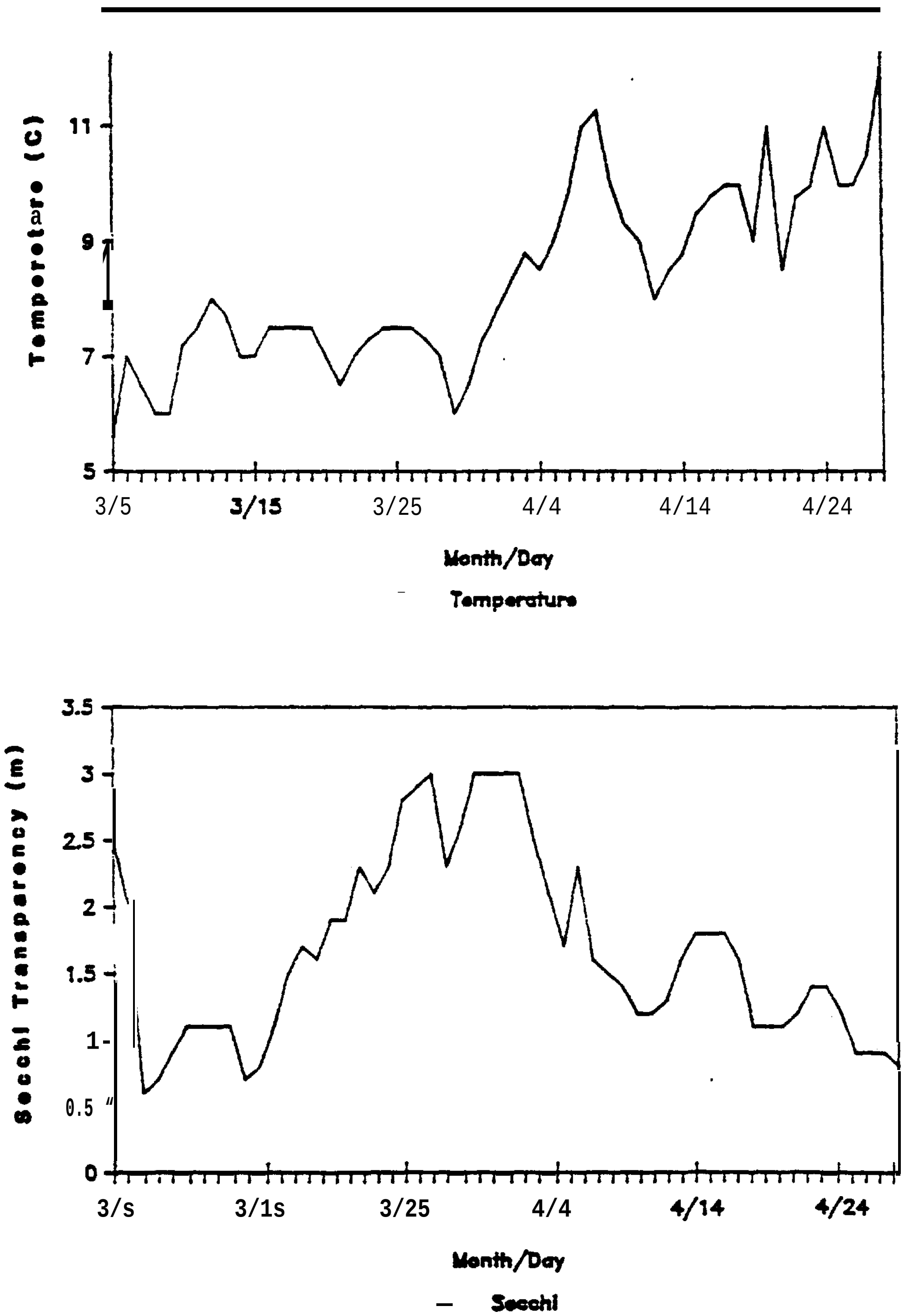


Figure 12. Daily temperature and secchi disk transparency at the Salmon River trap, 1987.

Two-area descaling at DNFH was the same as standard descaling, 0.3%; three other chinook salmon hatcheries in Idaho showed increases of less than 1.5% in two-area descaling over the standard descaling rates (Table 3). Transported release groups showed no significant increase in the two-area descaling from that observed at the hatcheries prior to release and, in fact, one group from McCall Hatchery showed a decrease of 0.6% (Table 3).

Descaling of Steelhead Trout at Hatcheries and Release Sites

Standard descaling rate for steelhead trout at Niagara Springs and Hagerman NFH was 0.1% and 0.2%, respectively (Table 4). These values compare closely to 1985 rates, 0.1% and 0%, and are less than the 1986 rates, 1.4% and 1.5%.

Scattered descaling of steelhead trout at Niagara Springs and Hagerman NFH showed a slight increase from 1986. Niagara Springs Hatchery in 1987 had scattered descaling rates of 4.3% as compared to 2.92 in 1986. Hagerman NFH in 1987 showed 3.2%; in 1986 it was 2.8%. There was a slight decrease in two-area descaling at the two hatcheries from 1986 to 1987. Niagara Springs in 1987 was 1.0% and in 1986 was 3.2%. Hagerman NFH in 1987 was 1.1% and in 1986 it was 3.6%. These differences in the percent of the descaling rates are small enough to be due to chance variability only and cannot be shown to be statistically significant.

Both scattered and two-area descaling rates at the observed off-hatchery release sites showed no detectable difference from the rates observed prior to release (Table 4). As with the samples taken from the chinook salmon at hatcheries and at release sites, the difference in descaling rates for steelhead trout at the hatchery and at release sites is minimal and is not influenced by the transport methods.

Chinook Salmon Descaling at Traps

Weekly standard descaling rates for yearling chinook salmon at the Snake River trap ranged from 02 to 15.9%, the peak occurring in late April. Standard descaling at the Clearwater River trap ranged from 1.2Z in early April to 9.9% during the third week of April. The Salmon River trap had weekly extremes of 0.9Z and 3.2Z standard descaling the first and third week of April, respectively. Seasonal averages at the Snake and Clearwater River traps were up over the 1986 averages (Table 5). In 1987, the Snake River trap showed the highest average standard descaling in chinook salmon (10.4%) that has been observed at that trap. This value is somewhat exaggerated due to the trapping conditions encountered in 1987. The low water conditions and reduced velocity at the trap site had an influence on the fish captured; the descaled and weaker fish were captured at a greater rate than healthy fish. The 1987 descaling data for chinook salmon at the Snake River

Table 3. Chinook salmon descaling rates (percent) at hatcheries and release sites, 1987.

Hatchery (release site)	Standard	Two-area	Scattered
Rapid River Hatchery (Rapid River)	0.3	1.2	1.8
McCall Hatchery	0.3	0.6	1.2
(S.F. Salmon R.)	0	0	0.3
Sawtooth Hatchery	No observation made at hatchery		
(Crooked River)	0.6	2.2	5.6
(White Sands Creek)	0.6	1.7	6.7
Kooskia NFH (Clear Creek)	0.3	1.7	4.6
Dworshak NFH (N.F. Clearwater River)	0.3	0.3	0

Table 4. Steelhead trout descaling rates (percent) at hatcheries and release sites, 1987.

Hatchery (release site)	Classical	Two-area	Scattered
Niagara Springs Hatchery	0.1	1.0	4.3
(Snake R. @ Hells Canyon Dam)	0.7	0.7	4.6
(Pahsimeroi River)	0	0.6	4.7
Hagerman NFH	0.2	1.1	3.2
(Salmon R. @ Sawtooth Hat.)	O	0.3	2.6
(Slate Creek)	0	1.6	4.0

Table 5. Seasonal mean standard descaling rates (percent) for yearling chinook salmon, hatchery steelhead trout, and wild steelhead trout at the Snake, Clearwater, and Salmon river traps, 1984 through 1987.

Species	Year	Salmon River	Snake River	Clearwater River
Yearling chinook salmon				
	1984	4.5	2.5	1.5
	1985	2.4	2.6	0.6
	1986	-	3.8	0.7
	1987	2.0	10.4	4.3
Hatchery steelhead trout				
	1984	8.7	5.5	4.1
	1985	10.1	6.2	2.1
	1986	-	14.5	6.3
	1987	6.2	6.2	4.0
Wild steelhead trout				
	1984	2.1	1.4	0.4
	1985	0.7	0.8	0.7
	1986		2.7	0.8
	1987	2.5	3.3	1.3

trap should not be considered representative of the condition of the 1987 chinook outmigration due to the propensity of the trap to select for weaker fish when river velocities are very low.

Increases of standard descaling rates of chinook salmon catches at the Clearwater River trap were also greater than seen in previous years. There are several explanations for this increase. The first explanation is the fact that the live box on the Clearwater River trap was modified in 1987 and this modification. caused some increased turbulence in the live box that resulted in increased descaling and stress on the fish. Another problem associated with the live box of the trap was the fact that the new design allowed for a greater retention of fish captured, and over crowding in the live box was a severe problem on several occasions when in excess of 10,000 fish were collected in one evening. The problems associated with the trap live box have been corrected and these problems are not expected to reoccur in the future.

Standard descaling rates observed at the Salmon River trap in 1987 were similar to descaling rates in 1985 and 55% less than rates in 1984. At 2.0% standard descaling, the Salmon River trap was the lowest of the three traps in 1987.

Weekly descaling rates of chinook salmon at Lower Granite Dam ranged from 1.1% in mid-July. to 5.0% in early May. The average descaling rate at Lower Granite Dam for the 1987 season was 4.4%. This compares to an average rate of 3.5% in 1986.

There was no observed descaling of sub-yearling chinook salmon at any of the trap sites. Sub-yearling chinook salmon are not differentiated at Lower Granite Dam, due to the extreme difficulty in identifying age-O chinook. Therefore, a comparison between descaling of sub-yearling chinook at the traps and Lower Granite Dam is not available.

Hatchery Steelhead Trout Descaling at Traps

Standard descaling of hatchery steelhead trout at both the Snake River and Clearwater River traps i-n 1987 decreased from 1986 and were similar to the rates seen in 1984 and 1985 (Table 5). The problems encountered with chinook salmon descaling at the Snake and Clearwater River traps was not witnessed in steelhead trout sampled in 1987. The weekly averages at the Snake River trap ranged from 3.3% to 11.8%, with the peak occurring in late May. The seasonal average was 6.2%.

The Clearwater River trap averaged 4.0% for the season and ranged weekly from 1.3% in late April to 18.5% the last week of June.

Hatchery steelhead trout sampled at the Salmon River trap showed standard descaling rates of 6.2% for the season average. This is the lowest seasonal rate yet observed at the Salmon River trap. Weekly rates ranged from 5.8% the end of April to 9.1% two weeks earlier.

Weekly descaling rates of hatchery steelhead trout at Lower Granite Dam ranged from 0.3% the first week of July to 4.4% in mid-May.

Wild Steelhead Trout Descaling at Traps

Standard descaling of wild steelhead trout at all three trap sites in 1987 was greater than the rates observed in previous years (Table 5). The increase in wild steelhead trout descaling while the hatchery contingent showed a decrease in descaling cannot be explained. The Snake River trap averaged 3.3% for the season, with a range of 1.82 to 5.62 occurring in early June and late April. The Clearwater River trap ranged from 0.3% to 16.7% in late April and late March, respectively, with a seasonal average of 1.3%. The Salmon River trap catch of wild steelhead trout showed a range in the weekly standard descaling rate of 2.3% in late April to 11.1% in late March. The seasonal average was 2.5%.

Descaling of wild steelhead trout at Lower Granite Dam during 1987 ranged from 0.7% the second week of June to 3.5% the second week of May.

When comparing standard descaling rates from 1984 to later years, it should be noted that the 1984 descaling criterion does not include fish that had scales missing in a longitudinal band (#9's). This condition was added in 1985 and increased the descaling rate slightly; therefore, the 1984 descaling rates are somewhat low relative to 1985, 1986, and 1987 rates.

Trap Efficiency

Snake River Trap

The Snake River trap daily catch of yearling chinook salmon was too low to mark fish for trap efficiency tests in 1987. About the same number of chinook salmon smelts passed the trap as in previous years, so the trap efficiency for chinook salmon must have been greatly reduced. A rough estimate of trap efficiency would be 10 to 30 times less than the 1.2% of previous years, although there is little data to substantiate this estimate.

The reduced trap catch in 1987 is attributed to low water velocities associated with the extremely low runoff conditions. A threshold water velocity of about 2 feet per second at the mouth of the trap is required before the trap will effectively collect chinook smelts. Velocity at the mouth of the trap rarely exceeded 2.3 feet per second and was generally near 1.5 feet per second during the 1987 field season.

The total catch of steelhead trout smelts at the Snake River trap was comparable to other years. Efficiency tests were not conducted due to sporadic and unpredictable catch rates and to poor condition of steelhead trout smelts. Smelt condition was especially poor in June when daily steelhead trout catch was over 1,000 fish. At this time, the steelhead trout smelts that were collected showed signs of starvation, possibly due to the large number of smelts that had stalled . in Lower Granite Reservoir, due to the low flow year, and the intense competition for food.

Clearwater River Trap

Trap efficiency for yearling chinook salmon was tested a total of 24 times over a discharge range of 6,000 cfs to 33,000 cfs during the past four years: 1984 through 1987 (Table 6). Efficiency estimates ranged from 0.21% to 8.48%. An analysis of variance, with efficiency data normalized by the $\arcsin\sqrt{x}$ transformation, showed no significant difference in trap efficiency between years, at the 0.05 level of significance ($F=1.609$, $P=0.224$). An analysis of variance of the slopes of the lines of the four years of data were tested and no significant difference was found between the slope ($F=0.344$, $P=0.794$). Discharge was added to the equation of efficiency and years to see if it had an effect on efficiency between years and again there was no significant difference (years $F=0.775$, $P=0.525$; discharge $F=0.440$ $P=0.517$). Since no significant difference was found, the four years of data were pooled to estimate trap efficiency. An analysis of variance showed no relationship between efficiency and discharge at the 0.05 level ($F-2.886$, $P=0.106$). The mean chinook salmon smelt trap efficiency was 2.18% with a 95% confidence interval of 0.17% at the Clearwater River trap:

$$\bar{x} \pm cl = 0.0218 \pm 0.0017.$$

Trap efficiency for hatchery steelhead trout was tested 11 times between 1985 and 1987 over a discharge range of 13,000 cfs to 33,000 Cfs. Efficiency estimates ranged from 0.02% to 0.43% (Table 7). An analysis of variance, with efficiency data normalized by the $\arcsin\sqrt{x}$ transformation, showed significant difference, at the 0.1 level, in efficiency between years ($F=3.761$, $P=0.071$). It's difficult to determine whether this relationship truly exists or if it is an artifact of small sample size. The slope of the lines of the three years of data were tested and no significant difference was found ($F=1.035$, $P=0.421$). Discharge was added to the equation to see if it had an effect on efficiency between years. The slope of the lines was not discernible from zero ($F=2.633$, $P=0.149$) but there was a significant difference in the relationship between efficiency and discharge by year (year $F=5.670$, $P=0.034$). It appears there is a year affect on efficiency when adjusted for discharge. Efficiency varied by year, below the 0.05 level of significance, only when the variable discharge was added to the equation. Because of the effect of year on

Table 6. Clearwater River trap efficiency tests for chinook salmon smolts, 1984 through 1987.

Release date		Recaptures/ Mark	Efficiency	Mean Q Cfs
1984	4/5	4/418	0.0096	21
	4/21	13/806	0.0161	33
	4/25	3/489	0.0061	31
	5/10	14/453	0.0309	24
1985	3/25	14/607	0.0230	9
	3/30	45/1,511	0.0298	9
	4/5	6/1,079	0.0056	18
	4/9	2/940	0.0021	15
	4/16	7/929	0.007s	33
1986	3/27	9/1,555	0.0058	22
	4/2	8/1,714	0.0047	29
1987				
hatchery releases	3/20	43/2,160	0.0199	13
	4/22	50/2,000	0.02s0	6
	4/7	165/1,945	0.0848	10
	4/13	74/2,000	0.0370	13
	4/20&28	103/4,000	0.0258	18
trap caught	4/2	33/1,926	0.0171	6
	4/3	11/1,458	0.0075	8
	4/6	15/1,872	0.0080	9
	4/7	15/1,163	0.0129	10
	4/9	9/450	0.0200	12

Overall efficiency and 95% confidence limits:

0.0218 ± 0.0017

Limit as percent of estimate = 7.84

Table 7. Clearwater River trap efficiency for steelhead trout smelts, 1985 through 1987.

Release date		Recaptures/ Mark	Efficiency	Mean Q cfs)
1985	5/7	2/464	0.0043 .	29
	5/11	1 /384	0.0026	33
1986	4/14	7/4,140	0.0017	20
	4/30	1/4,190	0.0002	20
	5/7	2/4,260	0.0005	29
	5/11	5/4,247	0.0012	29
1987				
hatchery	4/13	6/4,071	0.0015	13
brands	4/20	9/4,060	0.0022	16
	4/28	2/4,000	0.0005	26
trap	4/21-22	6/1,604	0.0037	13
caught	4/24	2/775	0.0026	15

1987 efficiency and 95% confidence limits:

0.0021 ± 0.00085

Limit as percent of estimate = 40%.

efficiency, the data cannot be pooled, and the mean efficiency for 1987 was:

$$\bar{x} \pm cl = 0.0021 \pm 0.00085.$$

Salmon River Trap

Chinook salmon trap efficiency at the Salmon River trap has been estimated 15 times from 1984 through 1987 (Table 8). An analysis of variance with efficiency data, normalized by an $\arcsin\sqrt{x}$ transformation showed no significant difference in trap efficiency between years at the 0.05 level of significance (F=1.693, P=0.225). The slope of the line of the three years of data were tested, and no significant difference was found between the slopes (F=0.813, P=0.474). Discharge was added to the equation to see if it had an effect on efficiency between years. This analysis showed that the slope of the lines was discernible from zero (F=16.366, P=0.002) and that there was a significant difference in trap efficiency between years which was due to the effect of discharge (F=10.635, P=0.003). Because of the differences in trap efficiency between years, the data cannot be pooled and the trap efficiency for 1987 was used:

$$\bar{x} + cl = 0.0085 \pm 0.0018.$$

An analysis of variance was conducted to see if there was a relationship between efficiency and discharge when only the 1987 data was used. The analysis showed there was a significant relationship at the 0.05 level (N=8, r^2=0.734, P=0.007) and that the equation for predicting efficiency was:

$$\arcsin\sqrt{\text{efficiency}} = 11.149 - 0.813 \text{ discharge}$$

The Salmon River trap captures too few steelhead trout smelts for trap efficiency tests. Therefore, in 1987, steelhead trout smelts were marked at hatcheries and transported to the Salmon River approximately 2 km upstream from the trap location and released for efficiency tests. Three such groups were released at approximately seven-day intervals. Mean steelhead trap efficiency at the Salmon River was 0.25%:

$$\bar{x} \pm cl = 0.0025 \pm 0.0009.$$

Not enough data points are available to do a regression between steelhead trap efficiency and discharge. It is difficult to perform more steelhead efficiency test with hatchery-marked fish because of the time involved in freeze branding, limited hatchery space to keep the individual groups separated, and the difficulty associated with transporting branded groups to the trap site.

Table 8. Salmon River trap efficiency tests for yearling chinook salmon smelts, 1984, 1985 and 1987.

	Release date	Recaptures] Mark	Efficiency	Mean Q (kcfs)
1984	4/6-7	4/314	0.0127	9.2
	4/10-11	22/1270	0.0173	9.0
	4/13-17	11/1374	0.12080	10. S
1985	4/4-S	7/423	0.0165	8.6
	4/7-9	23/1168	0.0197	9.B
	4/10-11	20/ 1288	0.0155	13.4
	4/28-30	4/538	0.0074	12.3
19B7	3/2B-31	31/1225	0.0253	4.4
	4/2-4	2711502	0. 0180	4.7
	4/6	5/1478	0.0034	6.6
	4/9	5/1467	0.0034	B.7
	4/12	8/1500	0.0053	B. 4
	4/16.-17	11/1534	0.0072	8.0
	4/20	3/1282	0.0023	11.7
	4/23	3/1024	0.0029	9.9

overall efficiency and 95% confidence interval:

X = 0.0106 ± 0.0016

Limit as percent of estimate = 15%

Travel Time and Migration Rates

Release Sites to Salmon River Trap

Chinook salmon. There were four' groups of freeze branded chinook salmon released in the Salmon River: one from Sawtooth Hatchery, one from South Fork Salmon River, and two groups from Rapid River Hatchery. Generally, only one freeze-branded group is released from Rapid River, but in 1987 the Hells Canyon freeze-brand group was accidentally mixed with the Rapid River fish. The combined mark groups were useful for determining travel time estimates in the Salmon River but useless for determining travel time between Hells Canyon and the Snake River trap.

Median release dates for branded chinook salmon at Sawtooth Hatchery, South Fork Salmon River, and Rapid River Hatchery were March 12, March 31, and April 2, respectively. Distances from point of release to the Salmon River trap are represented in Table 9. Branded chinook from the first Rapid River group began arriving on March 20, followed by the second Rapid River group on March 22. The Sawtooth group began arriving on March 23, and the South Fork Salmon River group on April 7 (Figs. 13 and 14). Median passage of these groups followed the same order, with both Rapid River groups passing on April 4, the Sawtooth group passing on April 13, and the South Fork Salmon River group passing on April 18.

The Sawtooth Hatchery chinook brand group migrated fastest (16.2 km/d), followed by the South Fork Salmon River group (13.0 km/d), and the two Rapid River groups (9.2 km/d). The 1987 travel time of the Sawtooth and South Fork Salmon River groups was similar to that observed in 1983. Average discharge during the migration period for the South Fork Salmon River group in 1983 and 1987 was the same and lowest of the four years examined (Table 10). Average discharge during the migration period for the Sawtooth Hatchery group was 3,500 cfs lower in 1987. The slow rate of movement of the Sawtooth group in 1987 may be attributed to lower than normal flows and an early release date. The Sawtooth chinook were released two weeks earlier than normal, and it is suspected that they moved very slowly until the water temperature warmed.

The majority of the two Rapid River brand groups passed the Salmon River trap with a 5,000 cfs increase in discharge that occurred from April 4 to 9 (Fig. 13). The South Fork Salmon River chinook brand group began moving with this same peak in discharge although they did not start to arrive until April 8. This is probably when the brand group first reached this portion of the river on their down stream migration. As this peak begins to subside, the South Fork fish movement slows. The South Fork brand group began moving again with the next peak in discharge, which occurred from April 17 to 24. Most of the South Fork Salmon River fish had passed the trap by April 24. The Sawtooth chinook brand group began arriving in large numbers earlier than the other brand groups (Fig. 13). The peak movement of the

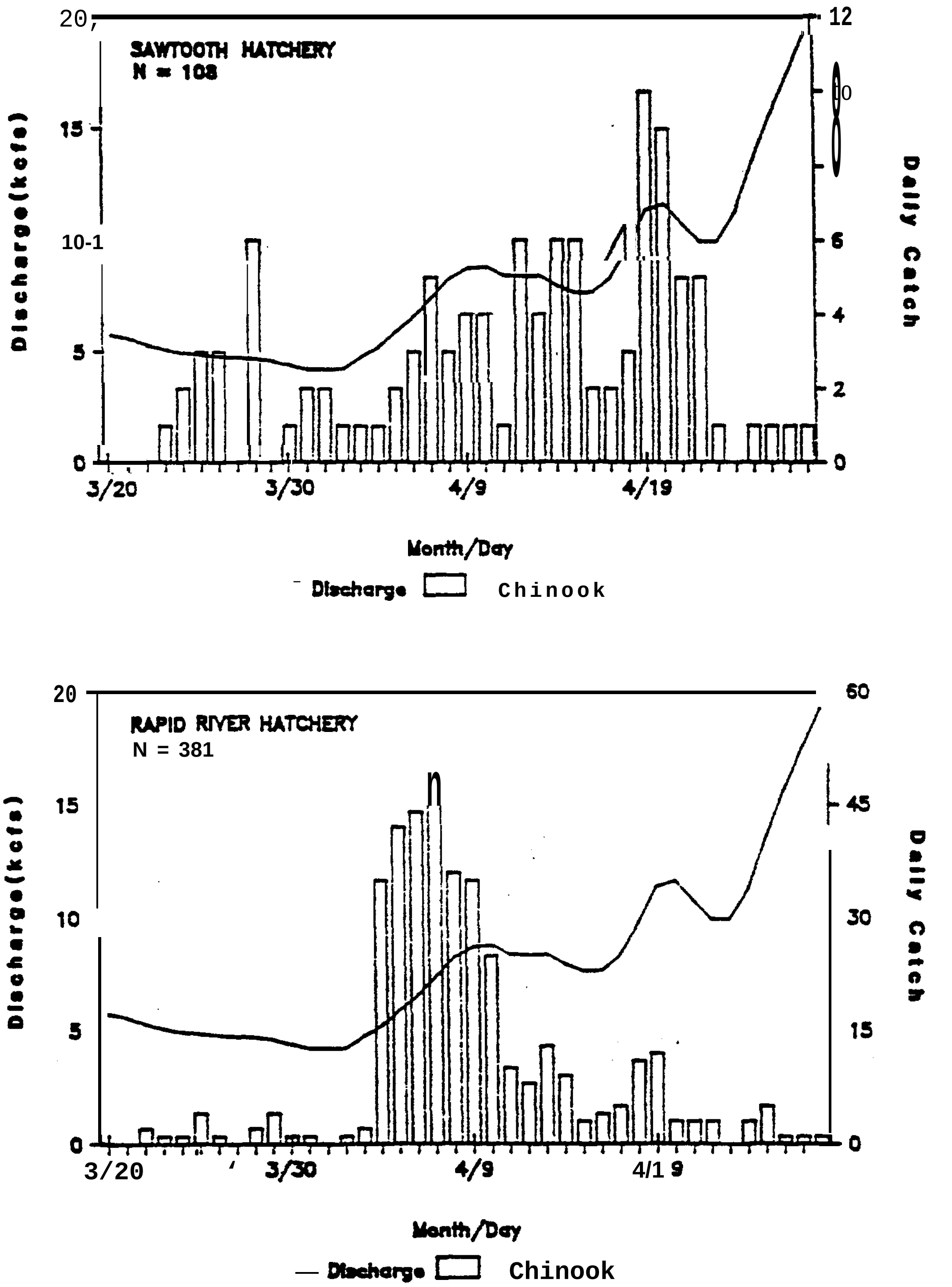
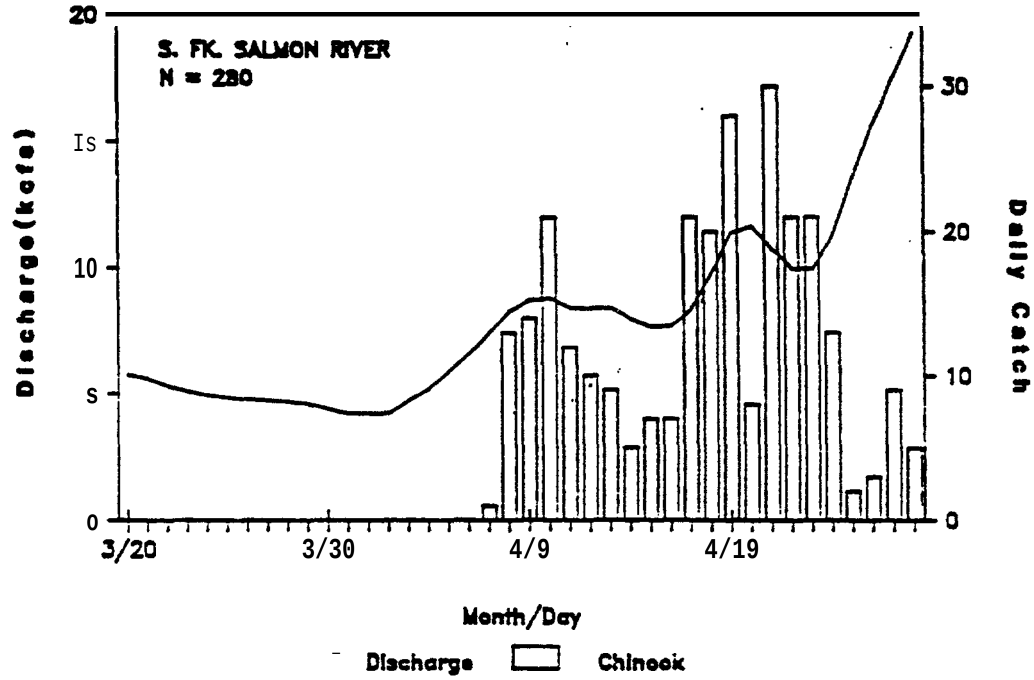


Figure 13. Daily catch for two unique hatchery chinook salmon brand groups at the Salmon River trap overlaid with Salmon River discharge, 1987.



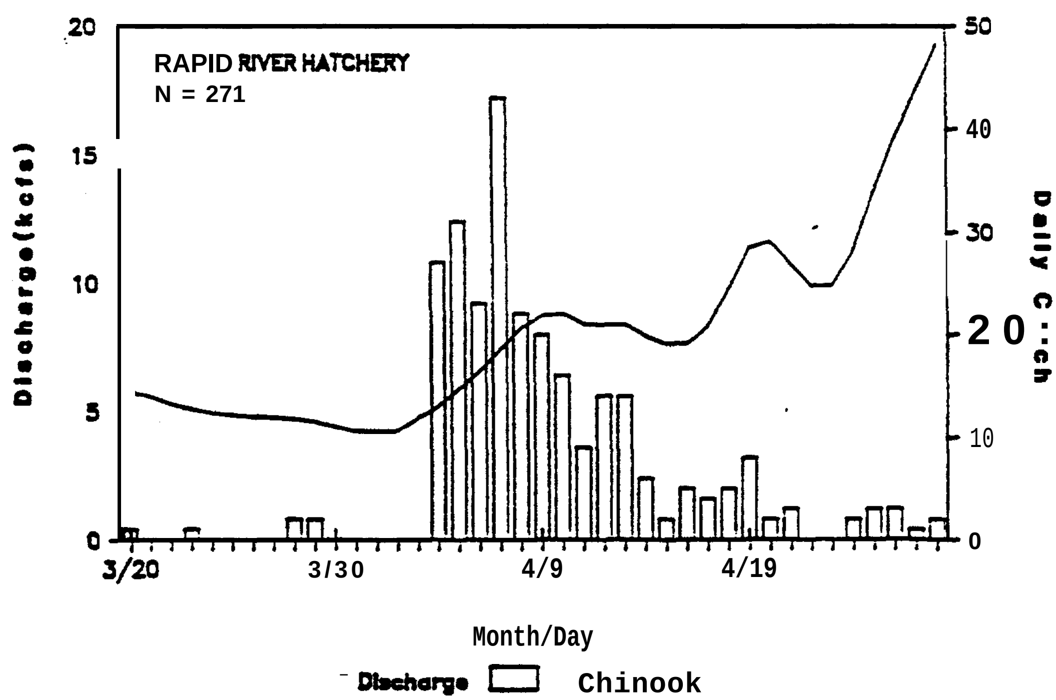


Figure 14. Daily catch for two unique hatchery chinook salmon brand groups at the Salmon River trap overlaid with Salmon River discharge, 1987.

Table 9. River mile & kilometer index for the Snake River Drainage.

	Mouth of Columbia R.		Mouth of Snake River		Lower Granite Dam		Snake River Trap Site		Clearwater R. Trap Site		Salmon River Trap Site	
	mi	km	mi	km	mi	km	mi	km	mi	km	mi	km
Mouth of Snake River	324.3	521.8	0.0	0.0	107.5	172.9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0	0.0	0.0	32.1	51.6	38.3	61.5	133.9	215.4
Clearwater R. Trap Site	470.0	756.2	145.7	234.4	38.2	61.5	-	-	0.0	0.0	-	-
Highway 95 Boat Launch	473.2	761.4	148.9	239.6	41.5	66.8	-	-	3.2	5.1	-	-
Dworshak NFH	504.2	811.3	179.9	289.5	72.4	116.5	-	-	34.2	55.0	-	-
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7	-	-	71.5	115.0	-	-
Crooked River	604.3	972.3	280.0	450.5	172.5	277.6	-	-	134.3	216.0	-	-
Red River Rearing Pond	618.0	994.4	293.7	472.6	186.2	299.6	-	-	148.0	238.1	-	-
Snake River Trap Site	463.9	746.4	139.6	224.6	32.1	51.6	0.0	0.0	-	-	101.8	163.8
Asotin Creek	469.6	755.6	145.3	233.8	37.8	60.8	5.7	9.2	-	-	-	-
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8	-	-	-	-
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0	-	-	-	-
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4	-	-	-	-
Big Canyon Creek	585.9	942.7	261.6	420.9	154.1	247.9	122.0	196.3	-	-	-	-
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2	-	-	-	-
Catherine Creek	636.9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4	-	-	-	-
Mouth of Salmon River	512.5	824.6	188.2	302.8	80.7	129.8	48.6	78.2	-	-	53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8	-	-	-	-
Little Sheep Creek	553.8	891.1	229.5	369.3	122.0	196.3	89.9	144.6	-	-	-	-
Imnaha Coll. Facility	565.6	910.2	241.3	388.3	133.8	215.4	101.7	163.6	-	-	-	-
Hells Canyon Dam	571.3	919.2	247.0	397.4	139.5	224.5	107.4	172.8	-	-	-	-
Salmon River Trap Site	565.7	910.2	241.4	388.4	133.9	215.4	101.8	163.8	-	-	0.0	0.0
Rapid River Hatchery	605.8	974.7	281.5	452.9	174.0	280.0	141.9	228.3	-	-	40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154.8	249.1	-	-	53.0	85.3
S.F. Salmon @Knox Bridge	719.7	1158.0	395.4	636.2	287.9	463.2	255.8	411.6	-	-	154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353.6	568.9	-	-	251.8	405.1
E.F. Salmon @ Trap Site	873.6	1405.6	549.3	883.8	441.8	710.9	409.7	659.2	-	-	307.9	495.4
Sawtooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8	-	-	331.9	534.0

Table 10. Migration statistics for branded chinook salmon smolts released at three sits on the Salmon River and migrating past the Salmon River trap. 1983 through 1997.

Release Sites	Dates: Release	Dates: Arrival	Distance (Km)	Migration rate (Km/day)	brands recap.	White Bird Mean Q (kcfs)
South Fork Salmon River						
	4/05/83	4/23/83	240	13.7	134	?.0
	4/10/84	4/19/84	240	27.5	108	12.6
	4/02/6S	4/12/85	240	24.8	70	10.2
	3/31/87	4/18/87	240	13.0	290	7.1
		x = 19.8				
Sawtooth Hatchery						
	3/29/83	4/29/93	534	17.2	57	9.s
	3/20/84	4/19/84	534	24.3	124	10.2
	3/27/85	●/11/85	534	35.6	123	7.9
	3/12/87	4/13/87	534	16.3	108	6.0
		x = 23.4				
Rapid River						
	3/25/83	4/04/83	65	7.1	149	7.2
	4/01/84	4013/e4	6S	5.3	286	8.8
	●/02/e5	4/09/85	6S	8.2	453	8.5
	4/02/87	4/08/87	65	9.2	381	6.1
	4/02/87	4/08/87	6S	9.2	271	6.1
		x = 7.8				

Sawtooth brand group lagged behind changes in discharge by two to three days and again the majority of the brand group passed the trap by April 23.

Steelhead trout. Steelhead are not captured in large enough numbers to determine travel time from point of release to the Salmon River Trap.

Release Site to Snake River Trap

Due to extreme low discharge during the 1987 juvenile outmigration, the Snake River trap efficiency was very low (probably less than 0.012) and, therefore, the number of branded chinook collected was much lower than in previous years. As a result, travel time and migration rates could not be calculated between release points and the Snake River trap. Migration statistics for 1984 through 1986 are represented in Tables 11 and 12.

Release Site to the Clearwater Trap

Chinook salmon. One group of freeze-branded chinook salmon was released from Dworshak NFH on April 2, 1987. The travel time to the Clearwater River trap for this group was four days (Table 13). This compares to a travel time of one day for the two previous years (1985 & 1986). Average discharge during the migration period in 1987 was 7,200 cfs; 76% less than in 1986 (29,000 cfs) and 58% less than in 1985 (17,300 cfs). The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time. Discharge at the time of the release was approximately 7,000 cfs (Fig. 15).

Steelhead trout. Three groups of freeze-branded steelhead trout were released above the Clearwater River trap in 1987. The Crooked River release group, the farthest upstream release group, was released on April 14 and had not passed the Clearwater River trap by April 29, when trapping was terminated for 22 days due to high water (Table 13). The Clear Creek group was released on April 17 and the travel time was four days (28.8 km/d). There is no previous information with which to compare these upriver releases. The Dworshak release was made from April 20 to 23. Because the release was made over a four-day period, migration rate cannot be calculated over such a short distance. Large numbers of branded" steelhead were collected the day after releases; the travel time may be about one or two days (Fig. 16). In previous years, the travel time for the Dworshak group was one day.

Table 11. Migration statistics For freeze branded chinook smelts from release sites to the Snake River trap, 1984 through 1987.

Release site	Year	Median re 1 ease date	Median passage date	Number captured	Travel time (days >	Migration rate (km/day)	Mean 0 (kcfs) Salmon R.	Mean 0 (kcfs) Snake R.
Rapid River	1997	1/						
	1996	3/27	4/10	237	14	16.3	15.4	82.9
	1905	4/2	4/12	320	10	22.9	10.6	67.6
	1984	4/1	4/18	197	17	13.4	10.1	79.3
Hells Canyon	1997	1/						
	1996	3/26	4/3	269	8	21.6		83.8
	1985	3/19	4/3	544	14	12.4		43.0
	1984	3/20	3/29	704	9	19.2		81.4
S.F. Salmon River	1997	1/						
	1996	3/28	4/23	229	26	15.8	16.5	78.6
	1985	4/2	4/17	76	15	27.1	14.0	71.0"
	1 994	4/10	4/24	230	14	29.0	14.5	91.7
Sawtooth Hatchery	1997	1/						
	1996	3/17	4/14	49	29	24.9	13.6	81.4
	1985	3/27	4/14	165	18	39.7	9.6	'60.1
	1904	3/28	4/2 1	136	24	29.0	11.8	94.0
Lookingglass Cr.	1987	1/						
	1996	4/2	4/5	114	3	62.3	-	92.1
	1985	No marked release group.						
	1984	No marked release group.						

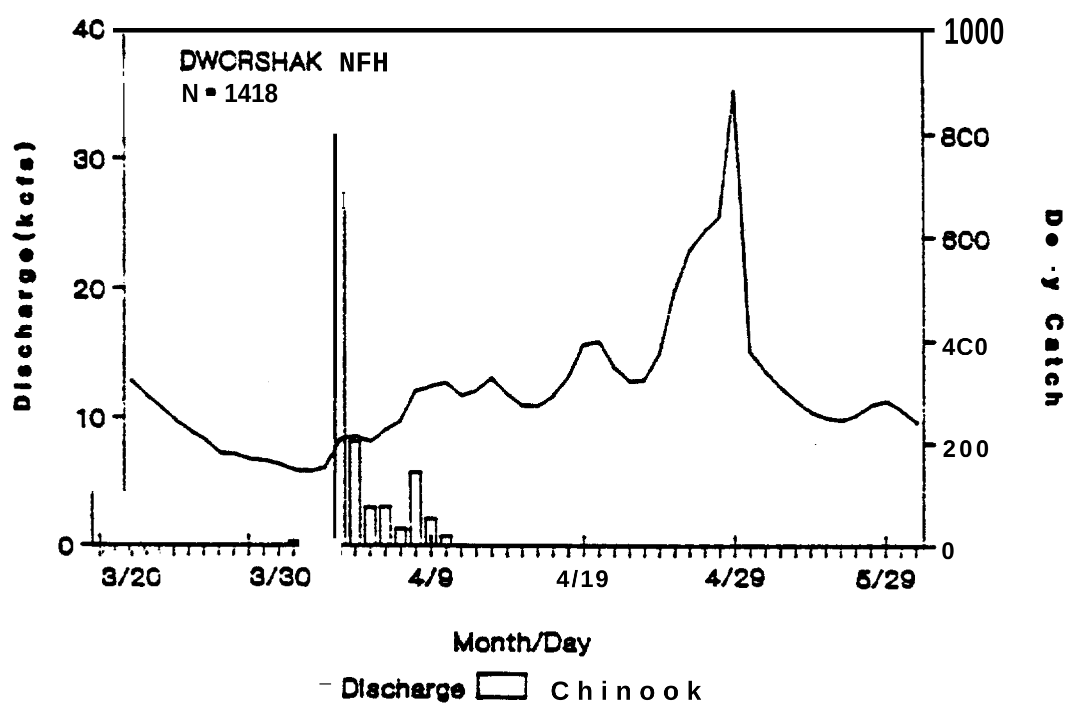
1/ Not enough recaptures at the Snake River trap.

Table 12. Migration statistics for freeze branded steelhead trout smelts from release sites to the Snake River trap, 1985 through 1987.

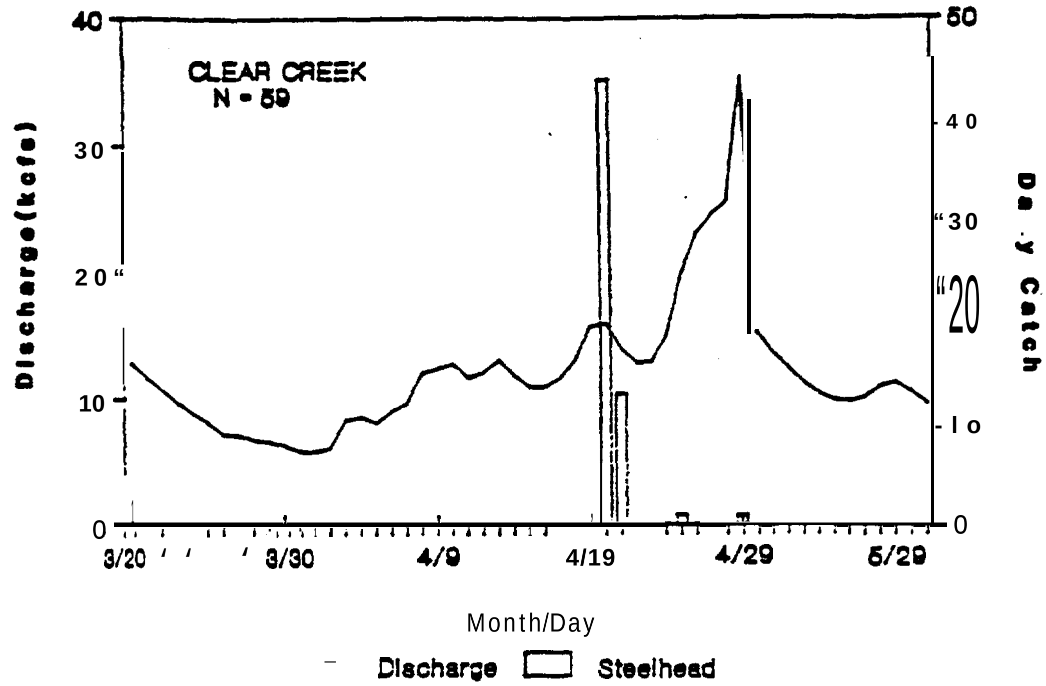
Release site	Year	Median release date	Median passage date	Number captured	Travel time (days>	Migration rate (km/day)	Mean Q (kcfs) Salmon R.	Mean Q (kcfs) Snake R.
Sawtooth Hatchery	1987	4/14		5		Not enough recaptures at the Snake R. trap.		
	1936	4/9	5/'21	11	42	16.6	24.0	73.4
	1985	4/9	s/7		28	24.9	19.5	62.6
E.F. Salmon River	1987	4/8		5		Not enough recaptures at the Snake R. trap.		
	1936	4/8	5/24	9	45	14.6	24.7	73.9
	1905	4/17	5/1		22	30.0	20.6	56.4
Hells Canyon	1937	3/26	5019	16	55			33.5
	1936	4/29	5/1	38	2	86.4		69.1
	1985	4/30	5/3		3	57.6		52.9
Spring Cr.	1937	4/26				Not enough recaptures at the Snake R. trap.		
	1936	5/1	5/27	14	26	9.3		72.9
		4/30		1		Not enough recaptures at the Snake R. trap.		
		4/3		2		Not enough recaptures at the Snake R. trap.		
	193!5	5/9	5/19		10	24.2		46.4
Cottonwood Cr.	1987	4/26	4/30		5			39.3
	1906	4/28	5/5	1::	13	13.0		72.3
		4/28	5/6	29	8	12.0		72.2
		4/20	5/5	42	7	13.0		72.3
Little Sheep Cr.	1987	5/2				Not enough recaptures at the Snake R. trap.		
	1986	4/20	5/8	16	10	12.0		72.1
		4/27		2		Not enough recaptures at the Snake R. trap.		

Table 13. Migration statistics for freeze branded chinook salmon and steelhead trout released ● txwm the Clearwater River trap, 1987.

Species	Release Site	Median Dates Release	Median Dates Passage	Number Released	Number Recap.	Migration rate Km/day	Travel Time	Mean Q (kcfs)
Chinook	Dworshak HFH	04/0 1	04/04	61,560	1416	13.8	4	7.2
Steelhead	Crooked River	04/14	-	413,557	2			
Steelhead	Clear Creek	04/17	04/20	33,097	S9	28.8	4	14.1
Steelhead	Dworshak HFH	04/2 1	04/22	43,081	58			



DWCRSHAK NFH
N = 1418
Discharge(kcfs)
De .y Catch
40
30
20
10
0
1000
8C0
8C0
4C0
200
0
3/20
3/30
4/9
4/19
4/29
5/29
Month/Day
Discharge
Chinook



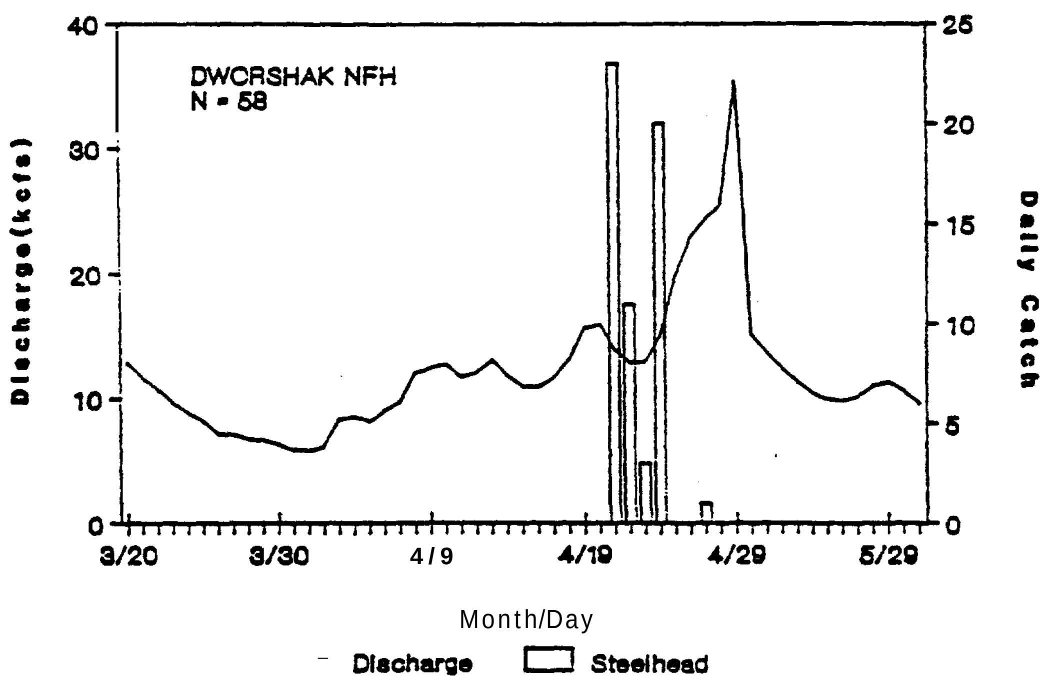


Figure 16. Daily catch of two unique steel head trout brand groups at the Clearwater River trap overlaid with ClearWater River discharge, 1987.

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook salmon freeze-brand groups. In 1987, only 5 of the 27 groups of freeze-branded chinook salmon could be used for travel time calculations through Lower Granite Reservoir because of the operational problems at the Snake River trap discussed earlier. All 5 of these groups were from the Clearwater River drainage. Average travel time from the Clearwater River to Lower Granite Dam for the Clearwater River chinook salmon freeze-brand group ranged from 13 to 30 days (Table 14).

Chinook salmon PIT-tag groups. In 1987, sufficient numbers of chinook salmon were PIT tagged (Prentice et al. 1987) daily at the Snake River trap to provide 25 groups (3,275 total) to estimate travel time and migration rate through Lower Granite Reservoir. Individual chinook salmon smelt travel times from the Snake River trap to Lower Granite Reservoir ranged from 4 to 22 days. Median travel time ranged from 22 days early in the migration season to 3 days late in the season (Table 15). There was a substantial change in median travel time between April 14 and April 22 related to an increase in discharge. Prior to April 14, the average median travel time through Lower Granite pool was 18.0 days (migration rate = 2.9 km/day) and after April 22 the average median travel time was 5.6 days (migration rate = 11.9 km/day) . Average daily discharge for the PIT-tag groups released prior to April 14 was 33.5 kcfs and ranged from 31 to 41 kcfs. Average daily discharge for PIT-tag groups released after April 22 was 79.3 kcfs and ranged from 55 to 94 kcfs. A linear regression of travel time and discharge was calculated and showed a strong relationship between the two variables ($N=24$; $r^2=0.877$; $P=0.000$).

In an attempt to better illustrate the relationship, travel time and discharge were plotted on equal-interval scale graph paper. The relationship between the two variables was slightly curvilinear. Therefore, to linearize the relationship, several log transformations were tested and found that the linear regression of the log of travel time and discharge provides the best fit ($N=24$; $r^2=0.938$; $p=0.000$):

log median travel time = 3.863 - 0.027 average discharge.

PIT-tagged fish can be individually identified within each daily release group and, therefore, mean travel time can be calculated on a daily basis in addition to median travel time. Mean daily chinook travel time ranged from 23.1 to 3 days (2.2 km/day to 17.2 km/day). Mean daily travel time differed only slightly from median daily travel time. Early in the season, mean travel time was 23.1 days, while median travel time was 22.5 days. Late in the season, mean and median travel time was 3.0 days.

A linear regression analysis of mean travel time and discharge was done ($n=24$; $r^2=0.956$; $P=0.000$). There was only a slight difference in the coefficient of determination between mean and median travel time (mean $r^2=0.956$, median $r^2=0.938$).

Table 14. Chinook smelt travel time and migration rate to Lower Granite Dam from the head of Lower Granite pool using fish passing the Snake River trap from upriver releases, 1985 through 1987.

			Snake/Clearwater trap		Lower Granite Dam				
Year	Brand	Release Site	Median passage date	Number captured	Median arrival date LGO	Number captured	Travel time (days)	Migration rate (km/day)	Mean Q at LGO (kcfs)
1985	RDR-1	Sawtooth Hatchery	4/14	165	5/4	4,313	20	2.6	89
	RDR-3	S. F. Salmon River	4/17	76	5/14	4,193	27	1.9	85
	LDR-1	Rapid River	4/12	370	4/25	9,422	13	4.0	98
	LDR-3	Hells canyon	4/3	544	4/13	7,111	10	5.1	88
	LDR-4	Grands Ronde River	6/4	13s	6/23	6,668	19	2.7	79
	RDR-2	Dworshak NFH	4/4	248	4/27	6,403	23	2.7	94
1986	RAJ-1	Lookingglass Cr. (fall)	3/25	3	4/11	159	17	3.1	105
	RAJ-2	Lookingglass Cr.	4/5	38	4/14	3,741	9	5.8	99
	RAJ-3	Lookingglass Cr. (fall)	4/4	13	4/9	333	5	10.3	99
	RAJ-4	Lookingglass Cr.	4/5	76	4/21	2.593	16	3.2	95
	LDY-1	Rapid River	4/16	237	4/20	10,599	4	12.9	88
	LDY-3	Hells Canyon	4/3	269	4/16	9,898	13	4.0	100
	RAY-1	Dworshak NFH	4/2	312	4/21	4,703	19	3.2	97
	ROY-1	Sawtooth Hatchery	4/14	49	4/23	2,245	9	5.8	89
	ROY-3	S. F. Salmon River	4/23	229	5/3	5,921	10	5.1	98
19e7	RAR-1	Dworshak MFH	4/4	1,416	4/24	11,069	21	5.1	37
	RD4-1	Clearwater River 1/	3/20	release	4/18	551	30	2.2	33
	RD4-3	Clearwater River 1/	4/2	release	4/20	436	19	3.5	35
	RA4-3	Clearwater River 1/	4/7	release	4/19	430	13	5.2	38
	RA4-1	Clearwater River 1/	4/13	release	4/29	334	17	3.9	46

1/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15.5).

Table 15. Chinook salmon PIT tag travel time, with 95% confidence intervals, from the head of Lower Granite Pool to Lower Granite Dam, 1967.

Release date	Median travel time (day)	Confidence Interval* Upper	Lower	Number captured	Percent captured	Average discharge (kcfs)
03/23/87	19.0	25	17	14	23.3	31.5
03/24/87	21.0	24	17	31	33.0	32.2
03/25/87	20.0	22	16	31	32.6	31.9
03/26/87	21.0	24	20	30	29.7	31.9
03/27/87	21.0	23	19	35	29.9	32.1
03/30/87	22.5	25	18	24	28.9	34.1
03/31/87	18.5	22	17	36	36.0	33.1
04/01/87	18.0	19	17	33	28.9	34.2
04/02/87	18.0	20	16	76	39.4	35.2
04/03/87	19.0	22	17	65	31.6	36.1
04/06/87	19.0	20	17	75	36.1	38.1
04/07/87	17.0	18	15	57	31.3	38.0
04/08/87	18.0	21	15	59	29.2	39.3
04/09/87	18.0	20	16	49	28.5	40.1
04/10/87	15.0	16	13	55	34.6	38.7
04/13/87	11.0	13	10	20	26.3	38.2
04/14/87	13.0	15	12	33	30.8	41.3
04/22/87	8.0	9	7	12	26.1	55.3
04/28/87	4.0	4	3	85	37.4	87.4
04/30/87	3.0	4	3	54	21.2	93.6
05/01/87	5.0	7	4	134	43.5	81.9
05/04/87	6.0	8	4	22	40.0	80.0
05/05/87	7.0	9	4	10	40.0	77.7
/06/87	6.5	12	4	8	8.1	79.0

* Confidence intervals calculated with nonparametric statistics

Percent recovery (integration) of daily release PIT-tagged chinook groups at Lower Granite Dam ranged between 20.9% and 43.5% and averaged 39.2%. Seasonal percent recovery of pit tagged chinook salmon to Lower Granite was 32.6%, to Little Goose it was 42.9%, and to McNary it was 52.3%.

Hatchery steelhead trout freeze-brand groups. In 1987, median passage dates were calculated for four groups of freeze-branded steelhead trout at the Snake River trap and five groups at the Clearwater River trap. These groups were used to determine migration rate and travel time through Lower Granite Reservoir (Table 16). The earliest arriving freeze-brand groups at Lower Granite Reservoir migrated through the reservoir at the slowest rate: 15 to 5 days (4.1 to 10.3 km/d). The fastest moving groups in the reservoir entered Lower Granite Reservoir last (April 30) and migrated through the reservoir in five days (10.3 km/d).

The relationship between hatchery steelhead trout travel time through Lower Granite Reservoir and average discharge during each freeze-brand group migration was plotted on standard graph paper and showed a slight curvilinear relationship. Therefore, several linear regression models were calculated by logging both variables. The best fitting equation (N-7: r^2=0.846; P=0.003) was:

log travel time = 3.678 - 0.022 average discharge.

Hatchery steelhead trout PIT-tag groups. In 1987, sufficient numbers of hatchery steelhead trout were PIT tagged daily at the Snake River trap allowing 19 groups (827 individual-fish) to be used in median migration rate calculations. Median travel time ranged from 10.5 to 2.0 days (4.7 km/d to 25.8 km/d) and averaged 4.7 days (Table 17). A linear regression analysis between median travel time in Lower Granite Pool and average Lower Granite discharge per PIT-tag group was conducted. The best linear regression equation (N-16; r^2=0.758; P=0.001) was:

median travel time = 31.773 - 6.406 log mean discharge.

The fact that only 76Z of the variation in median travel time is accounted for by charge in discharge may be due to the low numbers of data points at discharges below 50,000 cfs. To remove some of the variability in the data and provide a more biologically meaningful relationship, averaged travel time was calculated by 10 kcfs discharge groups. A linear regression analysis was conducted and found that the best linear regression equation (N=6; r^2=0.892; P=0.005) was:

log average median travel time = 2.689 - 0.018 mean discharge.

The high coefficient of determination (r^2) indicates a strong relationship between hatchery steelhead trout median travel time through Lower Granite Reservoir and mean discharge. The low probability (P) indicates this relationship is highly significant.

Table 16. Steelhead trout smolt travel time and migration rate to Lower Granite Dam from the head of Lo
1987 .

Year	Brand	Release site	Snake/Clearwater River trap: Median passage date	Snake/Clearwater River trap: Number captured	Lower Granite Dam: Median arrival date LGD	Lower Granite Dam: Number captured	Trave <da
1985	RDY-1	Sawtooth Hatchery	5/7	23	5/28	3.510	2
	RW-3	E.F. Salmon River	5/9	22	5/28	2; 454	1
	LDY-1	Hells Canyon	5/3	44	5/11	2,021	
	RA 17-1	Grande Ronde River	5/20	36	5/22	12,710	
	RA 17-3	Grands Ronde River	5/ 19	31	5/21	12,022	
	LDY-2	Dworshak NFH	4/29	GO	5/4	6,699	
1986	RRI J-1	Cottonwood Cr.	5?5	39	5/21	4,460	1
	RAIJ-3	Cottonwood Cr.	5/5	43	5/22	5,151	1
	RAIJ-4	Cottonwood Cr.	5/6	29	5/18	4,114	1
	LAJ-1	Wallowa River	5/26	1	5/30	808	Not tr
	LAJ-3	Wallowa River	5/5	2	6/1	450	Not tr
	RAJ-1	Mallows River	5/27	14	5/26	1,628	Medi da at
	RAJ-2	Little Sheep Cr.	5/5	2	6/2	734	Not tr
	RAJ-3	Mallows River	5/8	2	5/30	1,326	Not tr
	RAJ-4	Little Sheep Cr.	5/8	16	5/30	1,340	2
	LDT-2	Sawtooth Hatchery	5/21	11	5/29	3,772	
	LDT-4	E.F. Salmon River	5/23	9	5/29	1,552	
	ROT-2	Hells canyon	5/ 1	38	5/8	5,033	
	RDT-4	Dworshak NFH	5/G	18	5/ 17	7,194	
	LD4-1	Clearwater R. Trap 1/	5/8		5/ 14	1,003	
	LD4-3	Clearwater R. Trap 1/	5/13		5/22	869	
	RD4-1	Clearwater R. Trap 1/	4/16		4/23	371	
	RD4-3	Clearwater R. Trap 1/	5/ 1		5/8	751	
1987	RAI C-1	Cottonwood Cr.	4/30	7	5/4	4,886	
	RAIC-2	Cottonwood Cr.	4f30	6	5/4	5,529	
	RAI C-3	Cottonwood Cr.	4f30	7	5/4	5,971	
	RAIC-4	Cottonwood Cr.	4/30	8	5/5	4.936	
	RAR-3	Clear Cr.	4/20	59	5/ 1	3,500	1
	RDR-3	Dworshak NFH	4/22	58	5/ 1	4,917	1
	RDK-1	Clearwater R. Trap 1/	4/ 13	release	4/26	1,192	1
	RDK-2	Clearwater R. Trap 1/	4/20	release	4f30	999	1
	RDK-4	Clearwater R. Trap 1/	4/28	release	5/4	692	

1/ Releases made on Clearwater River at U.S. Highway 95 la

Table 17. Hatchery steelhead trout PIT tag travel time, with 95% confidence interval, from the head of Lower Granite pool to Lower Granite Dam, 1987.

Release date	Median travel time dav)	Confidence Interval* U	Lower	Number captured	Percent captured	Average discharge cfs)
04/08/87	7.0	18	5	8	40.0	36.7
04/10/87	10.0	11	8	9	7s.0	37.7
04/22/87	7.5	11	6	12	30.0	50.9
04/27/87	4.0	5	3	24	61.5	76.2
04/28/87	3.0	4	3	17	63.0	83.4
04/30/87	2.0	3	2	22	68.8	95.4
05/01/87	2.0	3	2	23	74.2	94.7
05/04/87	3.0	4	3	16	55.2	72.5
05/05/87	3.0	6	2	24	77.4	79.6
05/06/87	3.0	6	2	22	73.3	88.0
05/07/87	3.0	5	2	22	73.3	87.5
05/11/87	2.0	3	2	26	39.4	81.6
05/12/87	4.0	5	2	16	50.0	93.5
05/13/87	4.0	5	3	17	43.6	89.8
05/14/87	5.5	11	4	12	28.6	81.7
05/15/87	4.5	9	2	8	25.0	76.8
05/19/87	6.0	8	3	7	09.6	41.5
05/29/87	6.0	16	5	9	09.4	38.4
87	10.5			8	.2	31.5

* Confidence intervals calculated with nonparametric statistics

PIT-tagged steelhead can be individually identified within each daily release group and, therefore, mean travel time and migration rate can be calculated in addition to median travel time and median migration rate. Mean hatchery steelhead travel time ranged from 14 to 2.5 days (3.6 km/d to 20.0 km/d) and averaged 5 days (10.3 km/d). A linear regression analysis between mean travel time in Lower Granite Reservoir and mean discharge at Lower Granite Dam was conducted. The best linear regression equation (N-19; r^2=0.602; P=0.000) was:

log travel time = 3.011 - 0.019 mean discharge.

The coefficient of determination (r^2) decreased significantly when mean travel time was used in the linear regression instead of median travel time (mean r^2=0.602, median r^2=0.892, respectively).

Percent recovery of daily hatchery steelhead PIT-tag release groups at Lower Granite Dam ranged from 6.3% to 77.4% and averaged 48.2%. Overall seasonal recovery of PIT-tagged hatchery steelhead to Lower Granite was 39.2%, to Little Goose it was 45.5%, and to MeNary it was 46.3%.

Wild steelhead trout PIT-tag groups. In 1987, sufficient numbers of wild steelhead trout were PIT tagged at the Snake River trap to provide 12 daily PIT-tag groups (464 individual fish) for median travel time calculations (Table 18). This is the first time sufficient numbers of wild steelhead trout have been marked to provide travel time data to Lower Granite Dam. The PIT tag is the only tool available that can provide this type of data because of the low numbers of fish required for marking. Median migration rates for wild steelhead trout ranged from 7.9 km/d to 25.8 km/d and averaged 18 km/d. There is a difference in median migration rates between hatchery and wild steelhead trout. It is uncertain as to the reason for this difference. Two possible factors are that wild steelhead may be stronger and, therefore, travel faster and secondly, that the wild steelhead groups migrated through Lower Granite Reservoir when discharge was greater than did the hatchery steelhead trout groups. There were only 2 groups of wild steelhead trout that moved through Lower Granite Reservoir when average discharge was less than 70,000 Cfs, while there were 7 groups of hatchery steelhead trout that migrated through the reservoir when average discharge was less than 70,000 Cfs.

A linear regression analysis between median travel time in Lower Granite Reservoir and mean discharge for each PIT-tag group was conducted. The best linear regression equation (N-12; r^2=0.642; P=0.002) was:

median travel time = 24.901 - 5.009 log mean discharge.

Therefore, 64% of the variation in median travel time can be accounted for by discharge.

An analysis of the slopes of the four sets of data, the freeze-brand data, the hatchery steelhead trout PIT-tag data, the wild steelhead trout PIT-tag data, and the average travel time by 10,000 cfs

Table 18. Wild steel head trout PIT tag t-ravel time, with 95% confidence intervals, from the head of Lower Granite pool to Lower Granite Dam, 1987.

Release date	Medi an travel time (day)	Confidence Interval * Upper	Lower	Number captured	Percent captured (%)	Average discharge (kcfs)
04122/87	6.5	12	6	8	23.5	47.3
04/27/07	3.0	4	2	11	57.9	71.1
04/28/87	3.0	3	2	34	70..5	83.4
04/30/87	2 . 0	3	2	16	55.2	9s.4
05/01/87	2 . 0	3	2	18	58.1	94.7
0S/04/87	3.0	4	2	21	70.0	72.S
05/05/87	2.0	3	2	18	60.0	72.1
05/06/87	3 . 0	3	2	13	52.0	88.0
05/07/87	3 . 5	4	2	18	62.1	87.5
05/11/87	2.0	2	2	20	41.7	81.6
05/12/87	2 . 0	3	2	19	52.8	96.2
05/13/87	3.0	5	7	9	56.2	93.1

* Confidence intervals calculated with nonparametric statistics

intervals for hatchery steelhead trout PIT-tag data was conducted to see if there was a significant difference between the slopes (Fig. 17). The analysis of variance showed there was a significant difference between the slopes (F-4.499, P=0.009). Figure 17 indicates the freeze-brand data provides the slope that is different as the freeze-brand data was removed from the data and the analysis was run again. This time there was not a significant difference in the slopes of the three lines (F=0.667, P=0.520). The PIT-tag data provides a broader relationship between travel time and average discharge than the freeze-brand data because of the ability to release more marked groups over a wider range of discharge. This may make the PIT-tag data much more valuable for travel time information to Lower Granite Dam.

PIT-tagged wild steelhead trout can be individually identified within each daily release group and, therefore, mean travel time can be calculated on a daily basis, in addition to median travel time. Mean daily wild steelhead migration rate ranged from 6.5 km/d to 22.1 km/d and averaged 17.4 km/d. A linear regression analysis between mean travel time in Lower Granite Reservoir and mean discharge at Lower Granite Dam was conducted. The best linear regression equation (N-12; r^2=0.701; P=0.001) was:

log mean travel time = 8.700 - 1.711 log mean discharge.

The coefficient of determination (r^2) was not improved when mean travel time was used in the linear regression instead of median travel time (mean r^2=0.701, median r^2=0.642, respectively).

Percent recovery of daily wild steelhead trout PIT-tag release groups at Lower Granite Dam ranged from 23.4% to 70.6% and averaged 56.4%. Overall seasonal recovery of PIT-tagged wild steelhead trout to Lower Granite Dam was 49.4%, to Little Goose it was 59.7%, and to McNary it was 61.4%. This compares with hatchery steelhead trout which had 48.2% and 39.2% recovery rates for daily and seasonal recovery to lower Granite Dam, respectively. Recovery of hatchery steelhead trout dropped off toward the end of the migration period, after May 13.

A linear regression analysis was not conducted on average wild steelhead trout travel time that was broken down by 10,000 cfs increments because of the low number of data points (N-4).

Release Site to Lower Granite Dam

Chinook salmon. There were 26 chinook salmon freeze-brand groups released above Lower Granite Dam in 1987. Migration rates ranged from an average of 3.7 km/d for the four groups of Dworshak Hatchery fish released 5.6 km above the Clearwater River trap (trap efficiency test groups) to 19.6 km/d for two groups of fish marked at the Salmon River trap and 19.9 km/d for the two groups released in Lookingglass Creek, Oregon (Table 19). At release sites, where multiple groups were released over time (Salmon and Clearwater River traps), we found an inverse relationship between migration rate and time of release. The

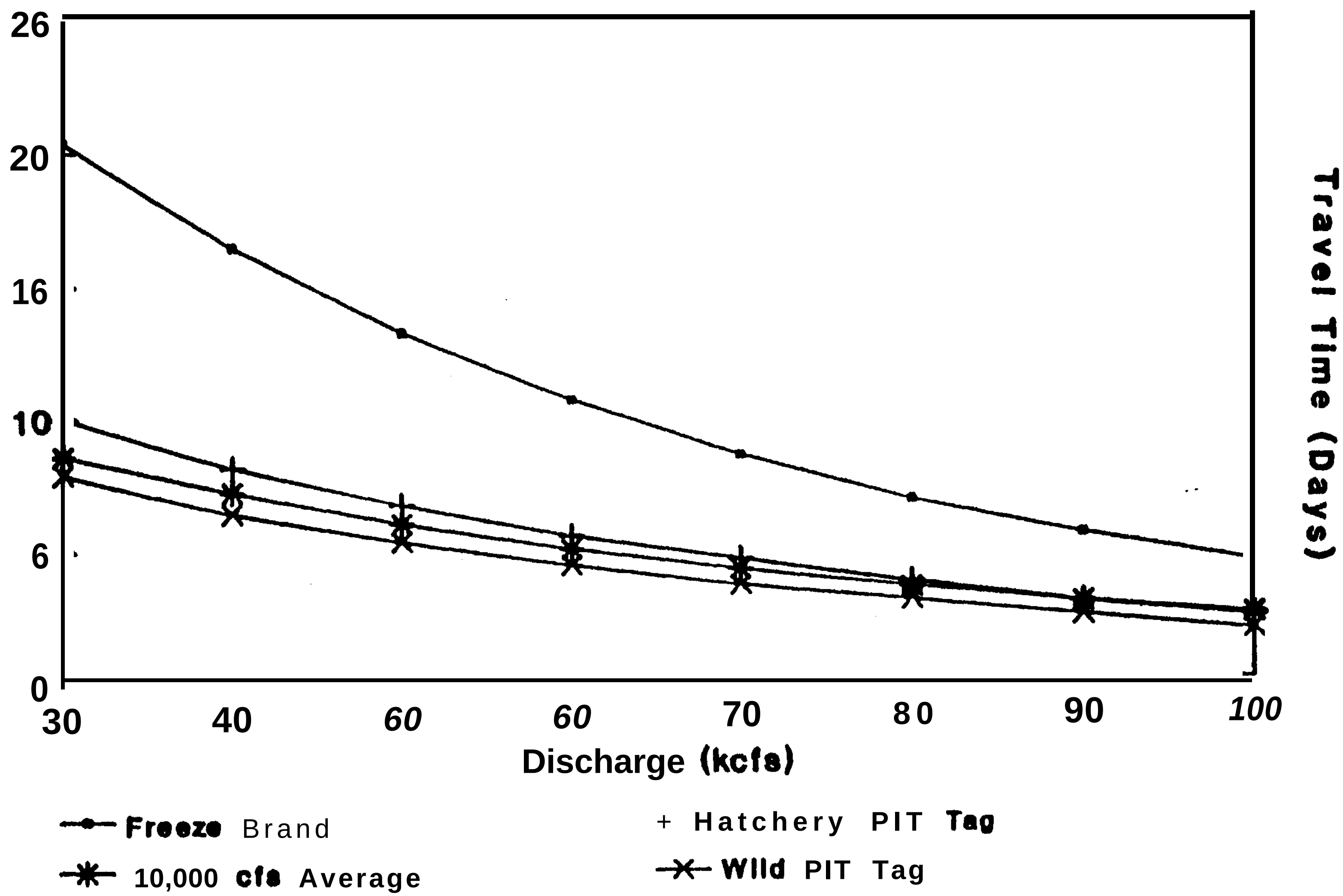


Fig. 17 Relationship between travel time through Lower Granite Reservoir and discharge for freeze branded, PIT tagged and migration rate averaged by 10,000 cfs groups for hatchery steelhead and PIT tagged wild steelhead trout, 1987.

Table 19. Migration statistics for branded chinook salmon from point of release to Lower Granite Dam, 1937.

Release Site	Median Release	Median Passage	Number Recaptured	Percent Recovered	Migration Rate Km/day	Travel Time	Mean Discharge
Sawtooth Hatchery	03/13/87	04/27/87	1128	1.90	16.30	46.00	37 .03
South Fork Salmon R.	03/31/87	05/02/87	1956	3.50	14.00	33.00	45.00
Rapid River Hatchery	03/27/07	04/26/07	3367	7.20	9.03	31.00	35.84
Salmon River Trap	03/30/87	04/21/97	434	30.80	9.40	23.00	34.33
Salmon River Trap	04/04/87	04/23/07	197s	34.00	10.80	20.00	36.71
Salmon River Trap	04/07/87	04/25/07	1039	le. 10	11.30	19.00	39. 18
Salmon River Trap	04/09/87	04/29/87		14.50	10.30	21.00	44.57
Salmon River Trap	04/13/87	04/20/07	1 : :	18.90	13.50	16.00	43.69
Salmon River Trap	04/18/87	05/01/67	1234	20.50	15.40	14.00	57.06
Salmon River Trap	04/21/97	05/01/87	1098	20.00	19.60	11.00	61.15
Salmon River Trap	04/25/87	05/04/07	393	9.60	18.60	10.00	74.07
Lookingglass Creek	04/01/87	04/23/07	2488	12.30	10.40	23.00	35.36
Lookingglass Creek	04/01/97	04/24/07	2531	12.40	10.00	24.00	35.88
Lookingglass Creek	04/20/97	05/01/87	099	4.30	19.90	12.00	59.25
Lookingglass Creek	04/20/87	05/01/87	1012	4.80	19.90	12.00	59.25
Lookingglass Creek	05/20/87	06/ 13#'e7	1929	9.50	10.00	25.00	35.26
Lookingglass Creek	050%20/87	06/ 14/e7	1919	9.40	9.60	26.00	34.92
Dworshak NFH	04/02/87	04/24/97	11069	18.00	5.10	23.00	36.33
Hwy. 95 Launch	03/20/87	04/18/87	551	25.s0	2.20	30. m	33. 86
Hwy. 95 Launch	04/02/07	04/20/07	436	21.60	3.50	19.00 .	35.34
Hwy. 95 Launch	04/07/87	04/19/87	438	22.50	5.20	13.00	37.73
Hwy. 95 Launch	04/13/97	04/29/07	334	16.70	3.90	17.00	46.20

fastest moving migrants had the latest release dates. This coincides with increased discharge at Lower Granite Dam and a higher degree of smoltification in these later fish. A linear regression of migration rate and Lower Granite Dam discharge was calculated on the eight groups of freeze-branded chinook salmon released from the Salmon River trap and showed that 942 of the variation in migration rate was accounted - for by changes in discharge (r^2=0.944). This is mainly attributed to an increase in migration rate over time in Lower Granite Pool, which will be discussed later in this report. Migration rate was also related to the distance from the release site to Lower Granite Dam. The freeze-brand groups released the greatest distance from Lower Granite Dam migrated at the fastest rate. These fish spend more time in the free flowing sections of the river, where migration rate is much greater than in Lower Granite Pool, than do fish released closer to the reservoir.

Chinook salmon travel time and average Lower Granite discharge for the median migration period was calculated from point of release to Lower Granite Dam for chinook brand groups from 1985 through 1987 (Table 20). The general chinook outmigration was slightly slower in 1987, an extreme low water year, than in the two previous years. Discharge at Lower Granite Dam does not correlate well with travel time from point of release to Lower Granite Dam because of the large distances between release site and the collection facility at Lower Granite Dam. A large portion of a migrant’s time is spent in streams in which discharge may not be well represented by discharge at Lower Granite Dam.

<u>Steelhead trout.</u> There were 25 hatchery steelhead trout freeze-brand groups released above Lower Granite Reservoir in 1987. Migration rate ranged from 6.8 km/d for the Hells Canyon group to an average of 33.6 km/d for four groups released from the Wallowa Hatchery (Table 21). Discharge at Lower Granite Dam during the migration period ranged from 36,000 cfs to 84,000 cfs.

Multiple groups of freeze-branded steelhead trout were released from both the Clearwater and Salmon River traps over a two-week period. Migration rates for the later released groups were more than twice as fast as for the earliest released groups. This is probably a factor of increased discharge during the migration period and a higher level of smoltification for the later groups (Muir et al. 1987).

Hatchery steelhead trout travel time and average Lower Granite discharge for the median migration period was calculated and compared from point of release to Lower Granite Dam for freeze-brand groups released in 1985 through 1987 (Table 22). In 1987, most of the steelhead trout freeze-brand groups median passage times at Lower Granite Dam were in early May, whereas in 1986 and 1985 the median

Table 20. Chinook salmon smelt travel time and migration rate from point of release to Lower Granite Dam, 1985-1987.

	Travel time (Days) and Mean Discharge (kcfs)					
	1985		1986		1987	
Release Site	Days	kcfs	Days	kcfs	Days	kcfs
Sawtooth Hatchery	40	79.03	38	101.93	46	37.08
S. F. Salmon River	42	85.41	37	97.94	33	45.00
Rapid River	23	90.48	25	99.66	31	35. 84
Hells Canyon	26	64.92	22	102.00	34	35.09
Lookingglass Cr.			13	101.S2	23	3S. 36
Lookingglass Cr.			20	96.82	24	35.88
Dworshak NFH	24	89.54	20	96.82	23	36.33

Table 21. Migration statistics for branded steelhead trout from point of release to Lower Granite Dan, 1987.

Release Site	Median Release	Median Passage	Number Recaptured	Percent Recovered	Migration Rate Km/day	Travel Time	Mean Discharge
Sawtooth Hatchery	04/14/87	05/11/07	490	1.10	26.00	28.00	61.61
Salmon River Trap	04/08/87	05/03/87	1196	25.30	8.30	26.00	51.21
Salmon River Trap	04/15/07	05/07/87	905	20.50	9.40	23.00	60.30
Salmon River Trap	04/22/87	05/03/87	1o11	21.60	18.00	12.00	66.70
Hells canyon	03/26/87	04/27/87	31E5	6.20	6.00	33.00	36.23
Wallowa NFH	04/26?87	05/03/87	409	3.30	36.70	0.00	78.00
Wallowa NFH	04/26/07	05/03/07	169	1.20	36.70	8.00	70.00
Wallowa NFH	04/26/87	05/03/87	402	3.30	36.70	0.00	70.00
Wallowa NFH	04/26/87	05/07/87	105	1.30	24.50	12.00	78.01
Cottonwood Creek	04?26/97	05/04/87	5529	27.50	16.10	9.00	77.47
Cottonwood Creek	04/26/87	05/04/87	5971	29.70	16.10	9.00	77.47
Cottonwood Creek	04/26/87	05/04/87	4086	24.30	16.10	9.00	77.47
Cottonwood Creek	04/26/07	05/05/97	4936	24.50	14.50	10.00	76.74
Crooked River	04/14/87	05/23/07	2363	4.90	6.90	40.00	63.51
Clear Creek	04/17/87	05/01/87	3500	10.30	11.00	15.00	55.99
Dworshak NFH	04/22/87	05/01/87	4917	11.40	11.70	10.00	63.34
Dworshak NFH	05/05/87	05/10/07	406	10.00	19.40	6.00	79.32
Hwy 95 Boat Launch	04/ 13/87	04/26/87	1192	29.30	4.80	14.00	40.86
Hwy 95 Boat Launch	04/20/87	04/30/87	999	24.60	6.10	11.00	55.61
Hwy 95 Boat Launch	04/28/87	05/04/87	692	17.30	9.60	7.00	84.26

Table 22. Steelhead trout travel time and migration rate from point of release to Lower Granite Dam, 1985-1987.

	Travel time (Days) and Mean Discharge (kcfs)					
	1985		1986		1987	
Release Site	Days	kcfs	Days	kcfs	Days	kcfs
Sawtooth Hatchery	50	89.83	51	101.39	28	61.61
E. F. Salmon River	42	88.01	52	101.31	43	61.61
Hells Canyon	12	85.32	30	95.32	33	36.23
Little Sheep Cr.			36	116.07		
Little Sheep Cr.			33	107.53		
Spring Creek			31	10S.46	8	78.00
Spring Creek			33	114.60	8	78.00
Spring Creek			26	99.38	8	78.00
Spring Creek			29	109.64	12	78.01
Cottonwood Cr.	14	82.22	24	96.50	9	77.47
Cottonwood Cr.	13	80.49	25	97.60	9	77.47
Cottonwood Cr.			21	95.22	9	77.47
Cottonwood Cr.					10	76.74
Dworshak NFH	6	81.98	11	97.65	10	63.34

generally lasts until about the first of June. Fish did not really move faster in 1987, but the portion of the population that normally migrates in the later part of the migration season stalled in Lower Granite Reservoir.

Release date also plays an important role in travel time. Travel time for the Hells Canyon group in 1987 and 1986 was about a month and this group was released on March 26 in 1987 and April 9 in 1986. In 1985, travel time for this group was 12 days and the release date was April 30.

Steelhead Trout Radio Tracking

Snake River

The first release of six radio-tagged hatchery steelhead trout smelts in the Snake River was made on April 29. Six additional releases of nine fish each were made through May 5, for a total of 60 fish . Of these, 48 were tracked through the study area. The majority of these fish, 45, passed under the interstate bridge at the middle or east spans. Only three of the tagged fish were tracked under the west span in the vicinity of the trap (Fig. 18).

Liscom and Bartlett's (1988) major conclusions of the Snake River tracking effort were:

1. The major migration route for steelhead trout was through the middle and eastern spans of the Lewiston-Clarkston Interstate Bridge (the trap was located under the west span).
2. Insufficient numbers of fish passed near the trap to determine if there was a trap avoidance problem.

Clearwater River

Radio tracking on the ClearWater River began April 20, when six radio-tagged hatchery steelhead trout smelts were released 5.6 km upstream from the trap site. Over the next four days, releases continued until a total of 61 radio-tagged fish had been released. Of these, 35 were tracked at the trap site. Two of these fish passed the trap on the north side of the river, 25 passed on the south side, and 8 swam directly toward the trap but avoided it (Fig. 18).

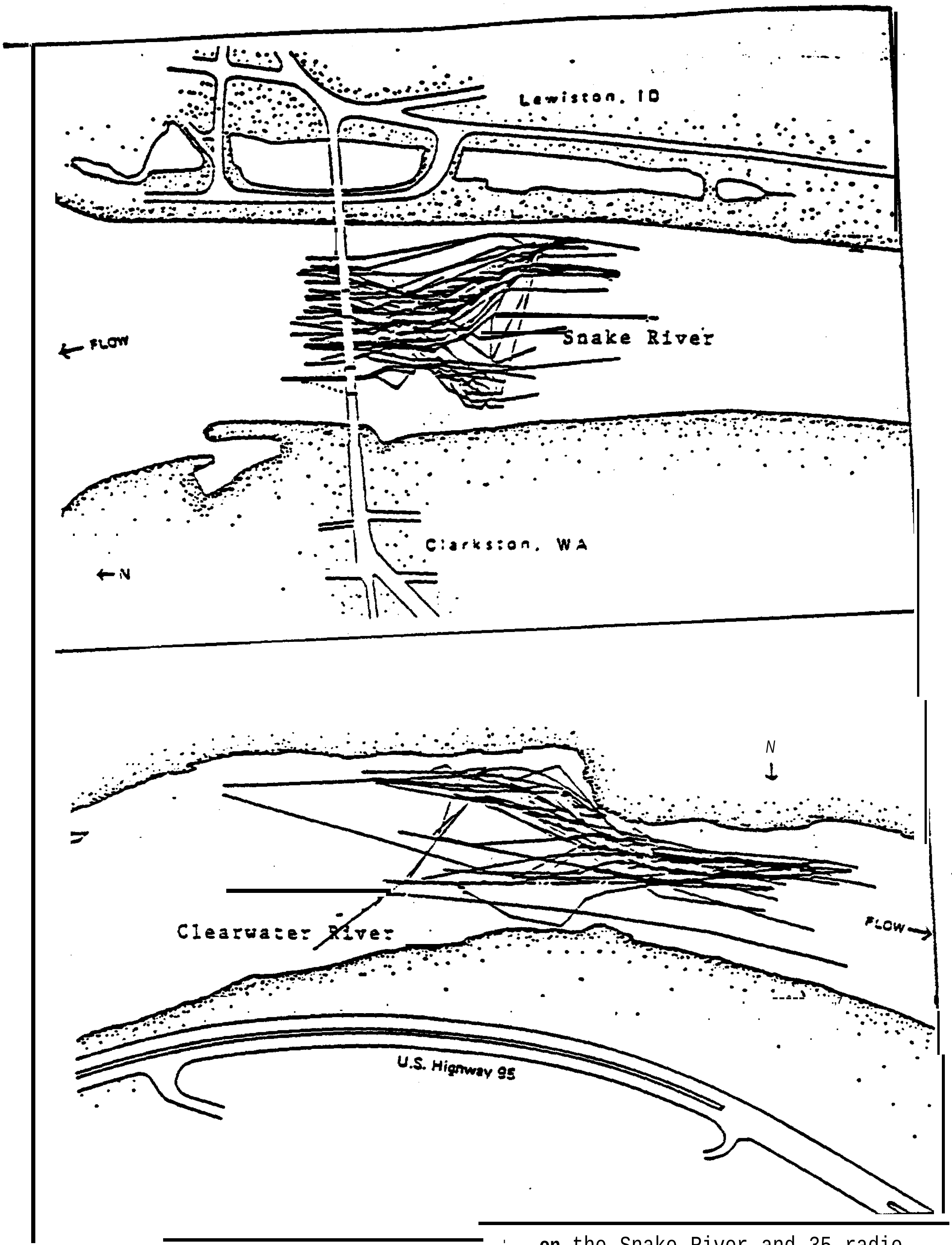


Figure 18. Composite of 48 radio tracks on the Snake River and 35 radio tracks on the Clearwater River completed on juvenile steelhead trout, 1987.

SUMMARY

In addition to wild and natural chinook salmon and steelhead trout production, 11,291,583 chinook salmon and 7,436,384 steelhead trout juveniles were reared at hatcheries in Idaho, Oregon, and Washington . for release upriver from Lower Granite Reservoir contributing to the 1987 outmigration. Of these, 445,385 chinook salmon and 489,671 steelhead trout smelts (3.9% and 6.62 of the total release, respectively) were freeze branded and released *in* 13 unique groups for chinook salmon and 21 unique groups for steelhead trout.

The Snake River trap operated from February 28 through June 29. The Snake River trap captured 1,887 yearling chinook salmon, 56 sub-yearling chinook salmon, 935 wild steelhead trout, 8,754 hatchery steelhead trout, and 5 sockeye salmon. Approximately 0.022 (67) of the hatchery-branded steelhead trout smelts released in the Snake River drainage upstream from the Snake River trap were captured by the Snake River trap. The Snake River trap did not catch more branded chinook salmon in 1987 because of the extremely low water conditions.

Average migration rate from point of release to the Snake River trap for hatchery-branded chinook salmon in 1987 was not calculated because of lack of data, due to the low water conditions. Average migration rate for branded chinook salmon from the Snake River trap to Lower Granite Dam in 1987 was, again, not calculated due to lack of data. Average migration rate from the Snake River trap to Lower Granite Dam was determined with the PIT tag. Prior to April 14 median travel time was 18.0 days and discharge was below 40.0 kcfs. After April 22, the average medial travel time was five days, and mean discharge was above 50.0 kcfs. Because of the low number of branded steelhead trout captured in the Snake River trap in 1987, average migration rate from point of release to the Snake River trap was not calculated. Average migration rate from the Snake River trap to Lower Granite Dam was estimated in 1987 using the PIT tag. Average migration rate from the Snake River trap to Lower Granite Reservoir in 1987 was similar to the migration rate in 1985 but was twice as fast as it was in 1986 (13.6 km/d in 1987, 6.6 km/d in 1986 and 12.5 km/d in 1985). Two branded steelhead trout groups released in the Grande Ronde River in 1985 greatly skewed the data. If the average migration rates are calculated without these two groups, the 1986 movement is slightly faster than 1985, 6.6 km/d in 1986 and 5.9 km/d in 1985 and the 1987 movement was twice as fast as either of the previous years. Freeze-branded steelhead trout smelts move approximately three to four times faster in the free flowing river section than they do in Lower Granite Reservoir.

There was little temporal overlap in the passage of yearling chinook salmon smelts and steelhead trout smelts at the Snake River trap. The majority of the chinook salmon passed in April and most of the steelhead trout in May.

The Clearwater River trap operated from February 19 to April 29 and again from May 20 to June 25. The trap captured 72,707 yearling chinook salmon smelts, 5,567 hatchery steelhead trout smelts, and 896 wild steelhead trout smelts. The ratio of wild to hatchery steelhead trout smelts in the Clearwater River trap catch was about 1:6. Freeze-branded chinook salmon smolts released form Dworshak NFH - generally have an average migration rate to the Clearwater River trap of one day (migration rate = 57 km/d), but in 1987, the average migration rate was 13.8 km/d.

The Salmon River trap was operated from March 5 to April 28. The Salmon River trap catch was 51,557 yearling chinook salmon, 46 sub-yearling chinook salmon, 598 wild steelhead trout, and 615 hatchery steelhead trout. The wild-hatchery steelhead trout ratio for the Salmon River trap cannot be calculated from this data because the trap operation was terminated prior to the major hatchery steelhead trout movement. The majority of the chinook passed the trap in April and the wild and hatchery steelhead trap catch was on the increase when trap operation was terminated the end of April.

No correlation between discharge and trap efficiency was detected at any of the traps. Mean trap efficiency for yearling chinook salmon and steelhead trout smelts at the Snake River trap was 1.202 and 0.67%, respectively. Mean trap efficiency for yearling chinook salmon and steelhead trout smelts at the Clearwater River trap was 2.18% and 0.13%, respectively. Mean trap efficiency for yearling chinook salmon and steelhead trout at the Salmon River trap was 1.06% and 0.25%, respectively.

Average weekly standard descaling rates for yearling chinook salmon smelts was 10.4% at the Snake River trap, 4.3% at the Clearwater River trap, and 2.0% at the Salmon River trap. The extremely high average standard descaling observed at the Snake River trap is not representative of the overall chinook salmon population in the head of Lower Granite Reservoir. Average standard descaling for hatchery steelhead trout at all three traps was similar to previous years. Wild steelhead trout average classical (standard) descaling was slightly higher than in previous years. Descaling of hatchery steelhead trout smelts was much greater than that seen in wild steelhead trout smelts at all three traps.

Descaling of chinook salmon and steelhead trout smelts at hatcheries was less than 0.52. There was no noticeable increase in descaling for chinook salmon or steelhead trout due to transportation from hatchery to release site. Degree of scale loss is likely associated with illness or other stresses fish have undergone prior to being transported. There is, however, a question of what happens to the fish after they have been released into the stream system. The rate of descaling that occurs to hatchery fish unfamiliar with stream hazards is not fully known and may contribute greatly to the descaling and mortality of these fish.

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