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

Annual Report for 1990 Operations

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

Annual Report
for 1990 Operations

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ABSTRACT

This project monitored the daily passage of chinook salmon Oncorhynchus tshawytscha and steelhead trout Oncorhynchus mvkiss smolts during the 1990 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 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 steelheadtrout, 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 develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4h) 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 smolt 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 smolt 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 smolt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smolts 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.

Smolt 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 smolts 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 smolt 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 smolts 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 smolt 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 smolts 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 smolt 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 smolt traps (index sites) at the upper end of Lower Granite Reservoir for freeze-branded and PIT-tagged smolts.

3. Provide an interrogation site for PIT-tagged smolts, 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 smolts marked at the traps, as well as freeze-branded and PIT-tagged smolts passing the traps from upriver hatchery releases and rearing areas.

5. Correlate smolt 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 Smolts

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.

Smolt Monitoring Traps

During the 1990 outmigration, two smolt 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

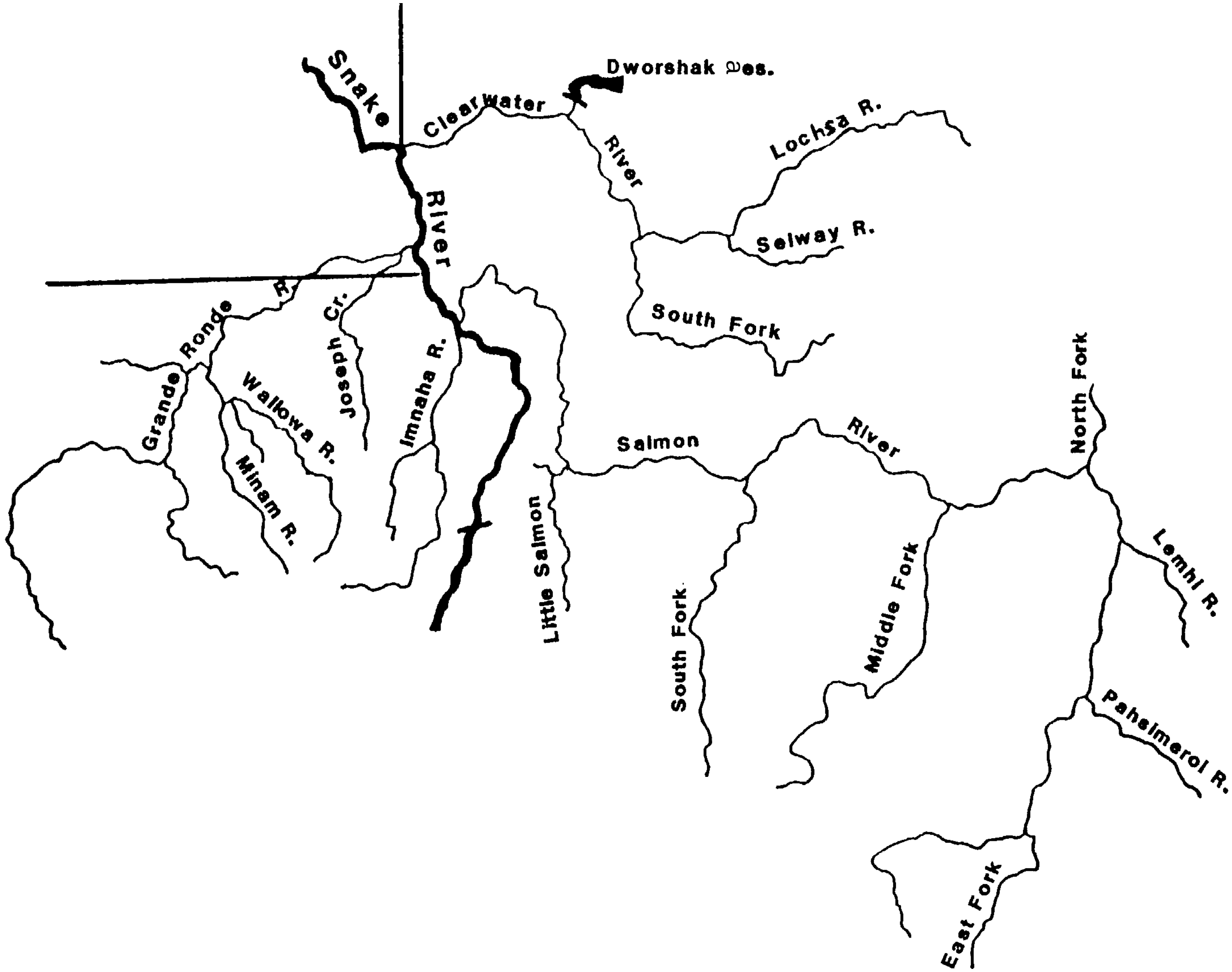

Figure 1. Map of study area.

captured and removed daily from the traps for examination, enumeration, and released back to the river. Fork length of up to 100 smolts for each species were measured to the nearest millimeter, and up to 2,000 fish were examined for hatchery brands. Smolts 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 smolts 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 smolt 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 smolts 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 smolt 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 than 0.2 (20%). These low proportions, (or percentages), form 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 determine 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 smolts 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 smolts 7 km upriver from the trap site.

Travel Time and Misration 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. Smolts 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.

Smolt 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 performed 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 determine if the relations were different between years. Using an analysis of covariance, with the migration rate data averaged by 5-kcfs flows, 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		Clear-water River 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
Clear-water 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 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	685.9	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
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	568.9			251.8	405.1
EF 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

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 smolts 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

Hatchery 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 smolts 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 smolts 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.

Smolt Monitoring Traps

Snake River Trap Operation

The Snake River trap caught 5,258 age 1 chinook salmon, 29 age 0 chinook salmon, 19,940 hatchery steelhead trout, 3,427 wild steelhead trout, and 325 sockeye/kokanee Oncorhvnchus 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 (Sawtooth)	10/12/89	395,400	
		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/Z)	(21,100)	LDT-3
		(3/21)	(20,900)	LDT-4
Johnson Creek (McCall)	Summer	8/9-1 0/89	290,000	
Pahsimeroi River (Pahsimeroi)	Summer	3/19	1,058,OOO	
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	
Clearwater River				
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**
		(4/1)	(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 1		(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	
<u>Clearwater River</u>				
Clearwater River	B	5/3-4	1,166,664	
(Dworshak)		(5/3)	(30,000)	RAT-l
		(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	4/16-25	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	

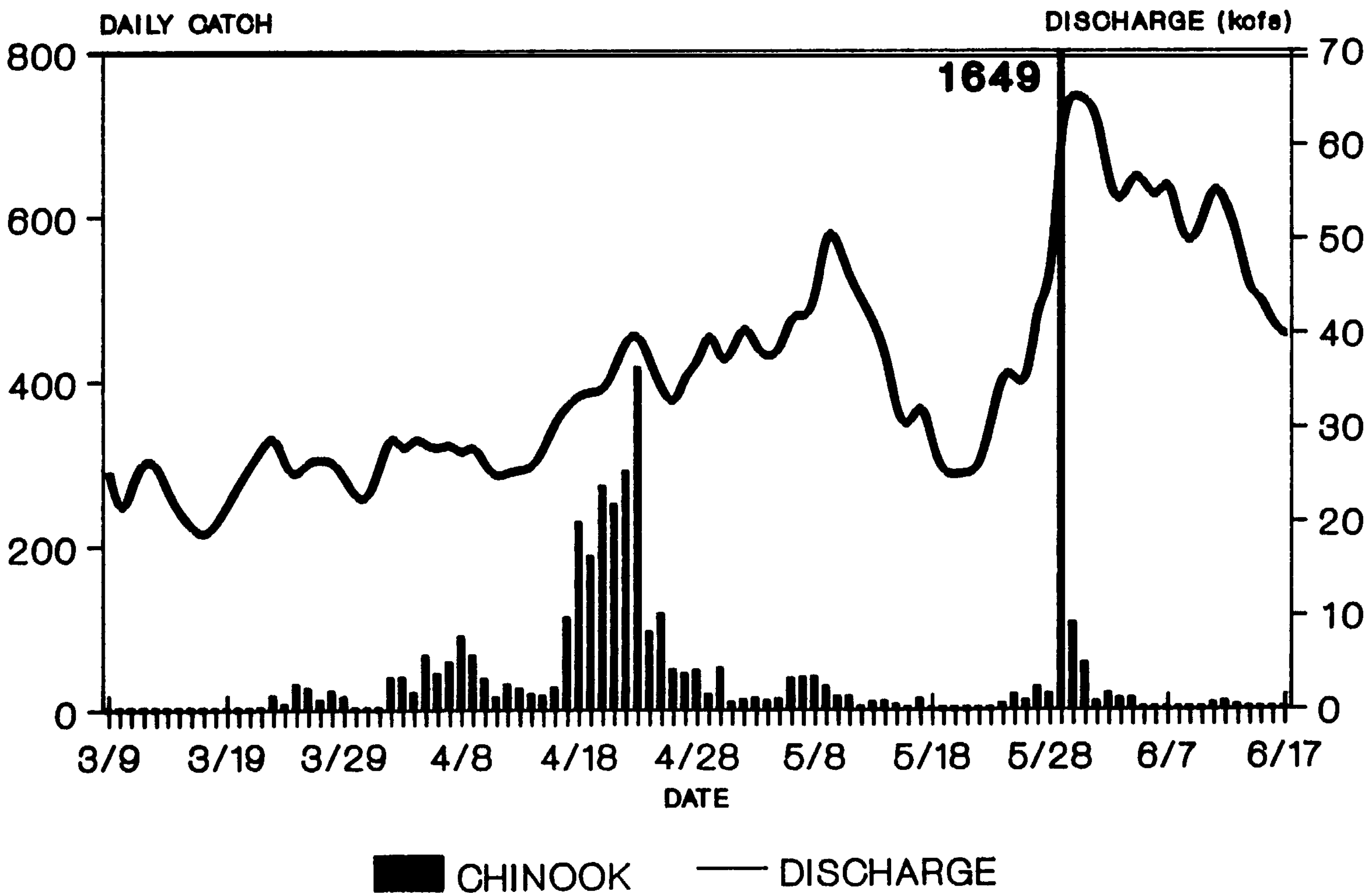

Figure 2. Snake River trap daily catch of age 1 chinook salmon overlaid by the Snake River discharge, 1990.

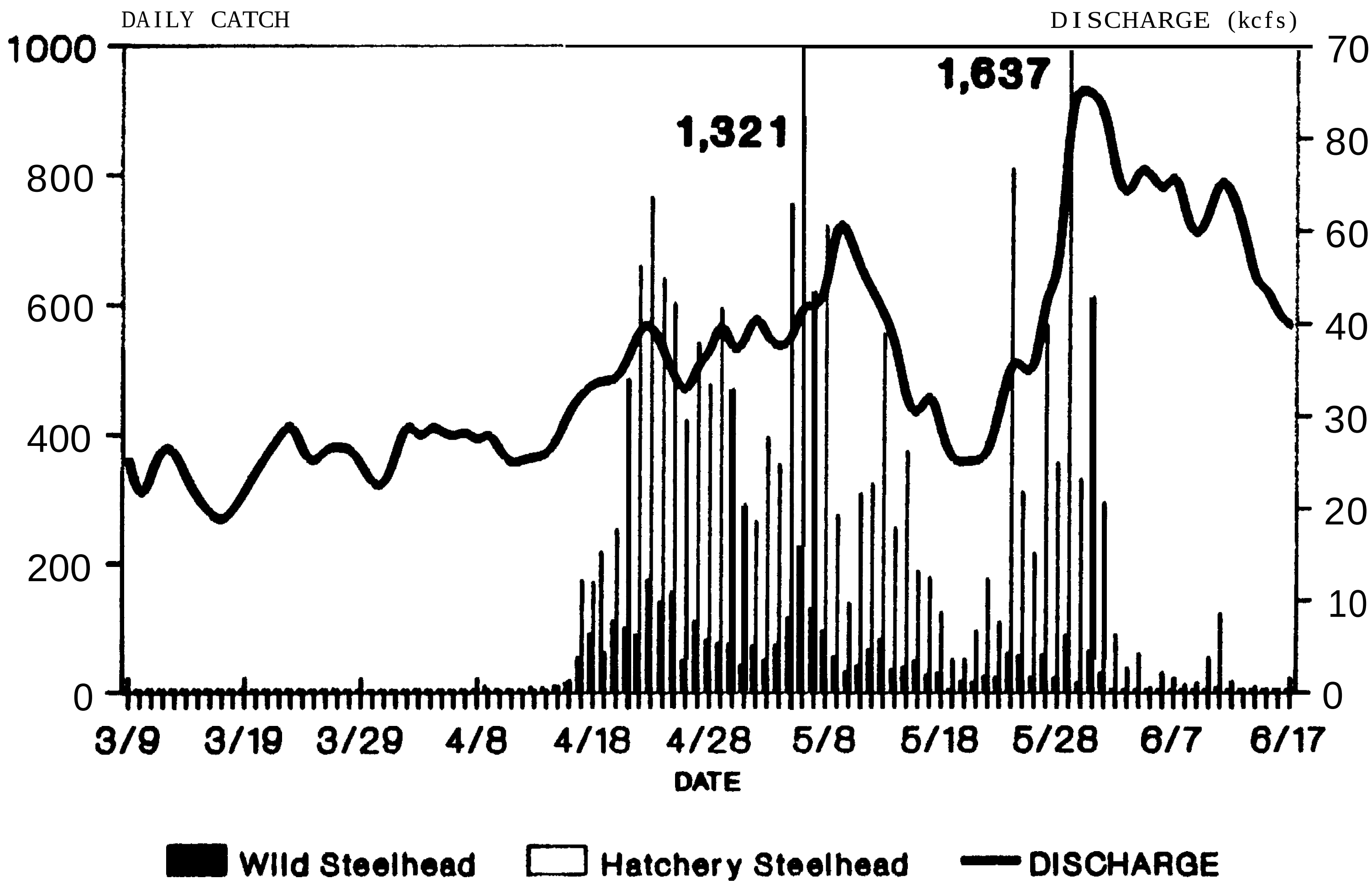

Figure 3. Snake River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Snake River discharge, 1990.

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 smolt 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 smolts outmigrated this year. Steelhead trout had less chance to avoid the trap with higher velocity, and the

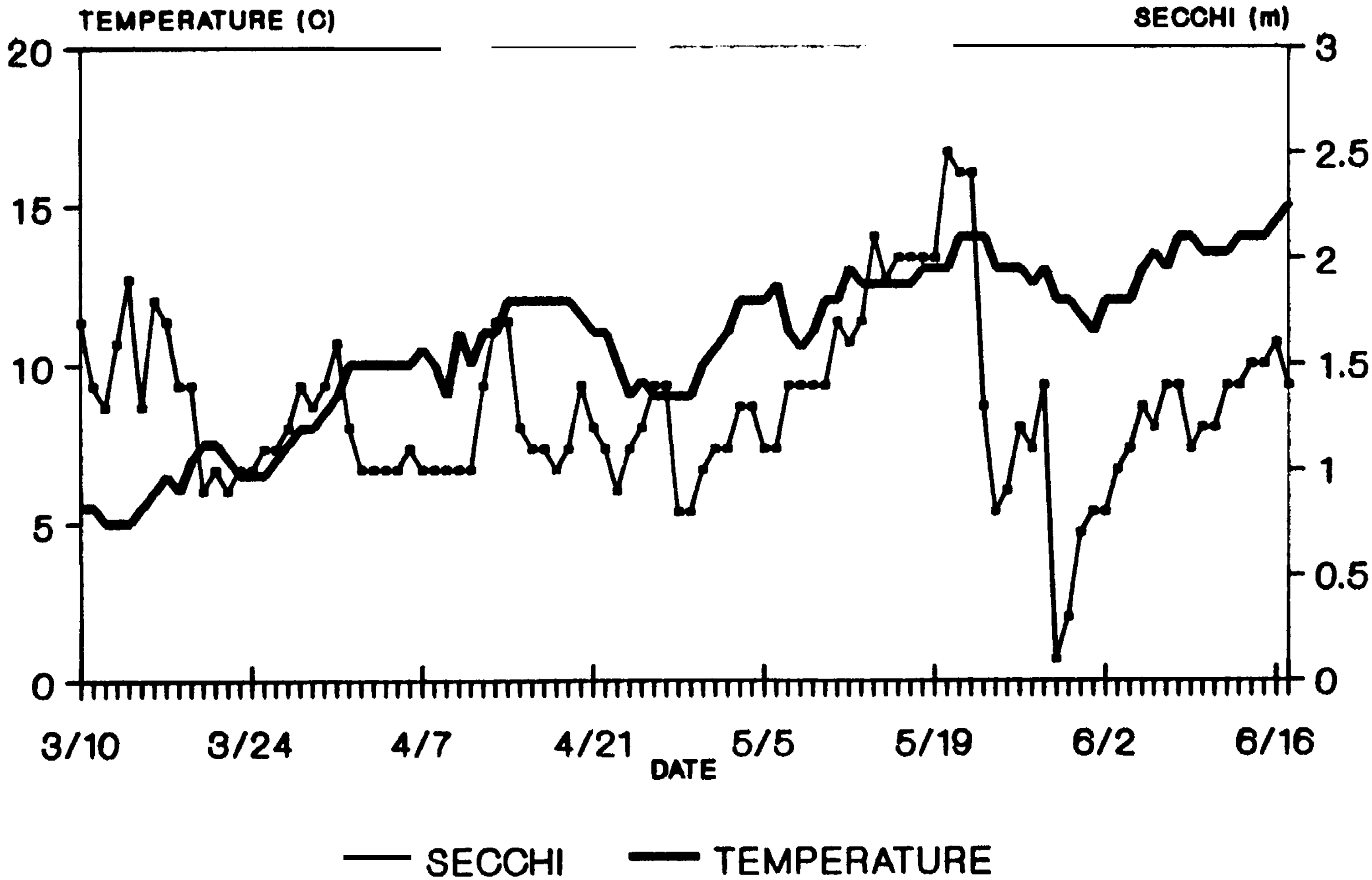

Figure 4. Daily temperature and secchi disk transparency at the Snake River trap, 1990.

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 may 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

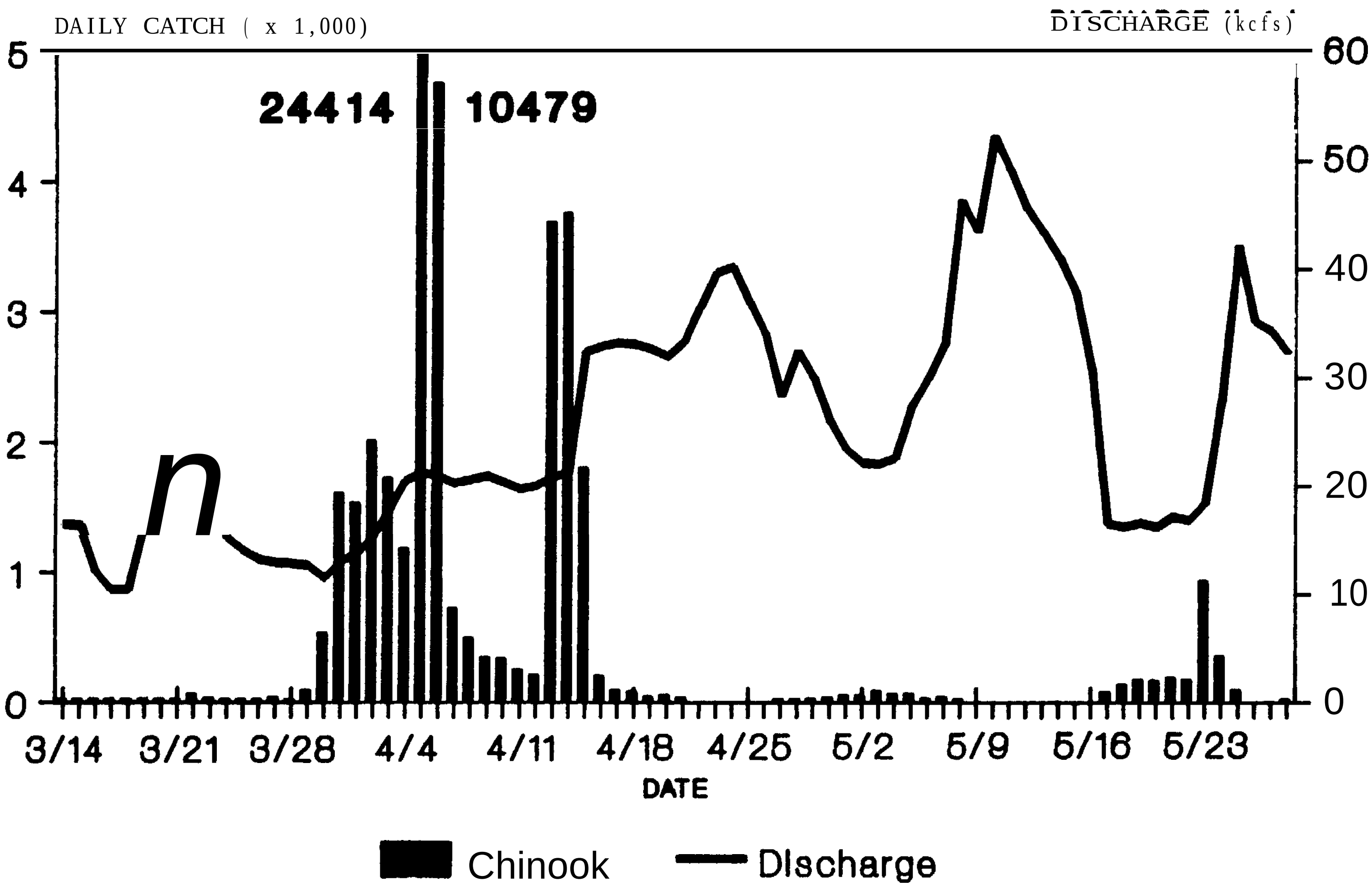

Figure 5. Clearwater River trap daily catch of aqe 1 chinook salmon overlaid by Clearwater River discharge, 1990.

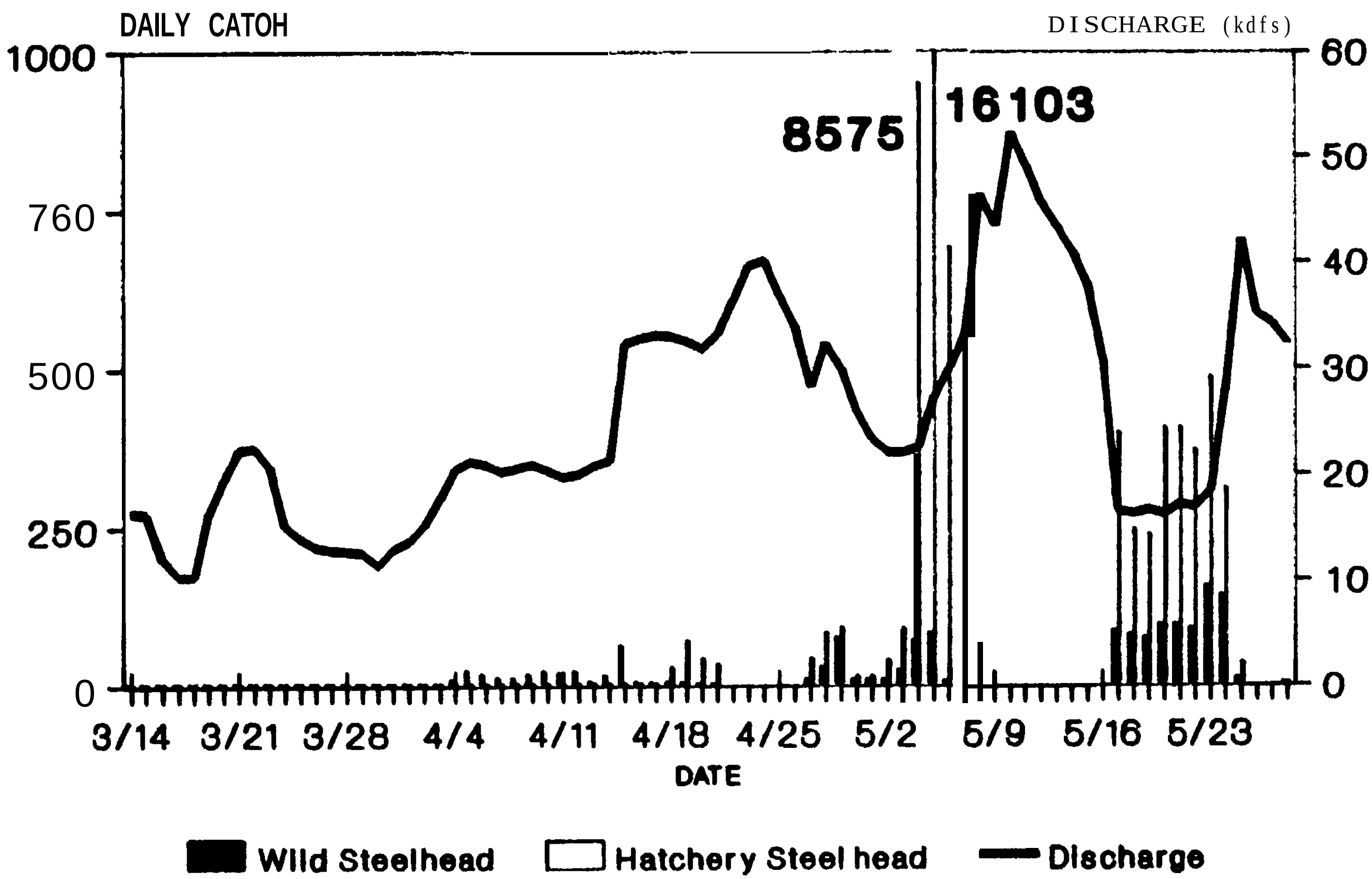

Figure 6. Clearwater River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River discharge, 1990.

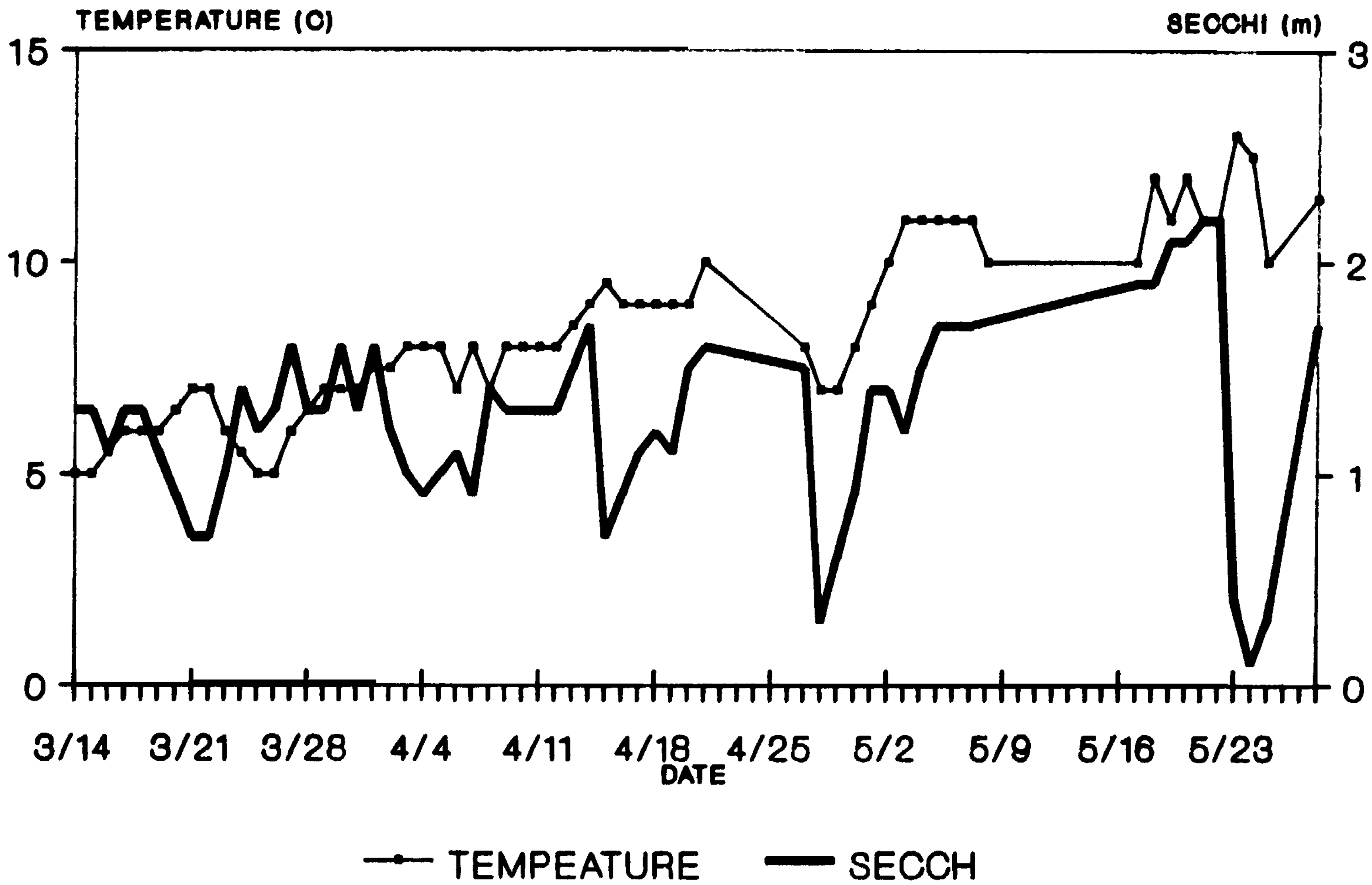

Figure 7. Daily temperature and secchi disk transparency at the Clearwater River trap, 1990.

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 smolts at the Snake River trap was not tested in 1990. Due to a reduced number of chinook salmon smolts 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 smolts with the trap fishing on the east side of the river.

Steelhead Trout-Trap efficiency for steelhead trout smolts was tested three times during the 1990 smolt 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 smolts, 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 smolts, 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	3112,397	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	5413977	0.0136	45
		5/23	32/3996	0.0080	45
1987	No efficiency tests conducted for steelhead smolts in 1987				
1986	trap caught	4/30	12/874	0.0137	72
1985	trap caught	5/4	8/811	0.0099	55

Clearwater River Trap

Chinook Salmon-During the 1990 field season, chinook salmon smolt 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 smolts (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=O.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 slopes of the other years data were not significantly different (N=42, F= 0.696, P=O.630). Continuing with the analysis, the intercepts (height) of the lines were not found to be significantly different (N=42, F=1.081, P=O.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 smolts, 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=l4, F=30.439, P=O.OOO). Therefore, data from all years were not pooled to derive any statistical inference.

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

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
1990	Hwy 95	3/21	27/2,609	0.0103	22
	boat	3/26	28/2,266	0.0124	13
	launch	3/28	3712,195	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	282119,730	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	66134,795	0.0019	24
	release	3/29	73/30,503	0.0024	24
		3/30	41/19,087	0.0021	23
		3/30	48119,545	0.0025	23
		3/30	78120,084	0.0039	23
1988	Hwy 95	3/14	5112,197	0.0232	6
	boat	3/17	93/2,197	0.0423	6
	launch	3/21	83/2,197	0.0378	6
		4/1	2712,195	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 6. Continued.

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
	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

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

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

Year	Sample Origin	Release Dates	Recapture/ Mark	Efficiency	Discharge (kcfs)
1990	DNFH release	5/3	66/4,052	0.0163	22
		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 smolts in 1989				
1988	DNFH release	4/13	29/4,000	0.0073	14
		4/22	8/3,998	0.0020	27
		4/28	16/3,994	0.0040	16
1987	DNFH release	4/13	6/4,071	0.0015	13
		4/20	9/4,060	0.0022	16
		4/28	2/4,000	0.0005*	26
	trap caught	4/21-22	6/1,604	0.0037	13
		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 19901, 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 steelhead trout smolts from release sites to the Snake River trap, 1985-1990.

Release site[a]	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.
Spring Creek	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	5/01	84	7	34.6	-	62.0
		4/22	5/05	70	13	18.6		62.4
		4/22	5/02	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	5/01	5/27	14	26	9.3	-	72.9
		4/30		1				
		4/03	b	2				
	1985	5/09	5/19	36	10	24.2		46.4
		5/09	5/20	31	11	22.0	-	47.0
Cottonwood Creek	1987	4/26	4/30	28	4	23.3	-	39.3
	1986	4/28	5/05	111	7	13.3		72.3
Little Sheep Creek	1990	4/17	4/26	33	9	16.1	-	35.2
	1989	4/23	4/25	93	2	72.3	-	70.7
	1987	5/02	b	-	-	-	-	-
	1986	4/28	5/08	16	10	14.5		72.1
		4/27		2				
Wildcat Creek	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
Asotin Creek	1990	4/17	4/18	88	1	9.2		31.7

[a] Only freeze brand groups from Oregon and Washington were used in 1989 because Idaho did not release any freeze-branded steelhead 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 freeze-branded chinook salmon and steelhead trout smotls released upstream of the Clearwater River trap, 1987-1990.

Release site	Year	sp.	Median release	Median passage	Number captured	Migration rate km/day	Travel time	Mean di scharge
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-0	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	
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	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	04/14		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	04/17	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 than in 1985 (17,300 cfs). The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time that year.

<u>Steelhead Trout</u>-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

<u>Chinook Salmon Freeze Brand</u> <u>Groups</u>-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.

<u>Chinook Salmon PIT Tas</u> <u>Groups</u>-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 travel time and were absent in the 1990 data.

There was no statistical difference in the mean seasonal migration rate for chinook salmon PIT-tagged at the Snake River trap between 1990 and 1989.

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

			Snake River/ Clearwater River trap		Lower Granite Dam				
Year	Brand	Release site	Median passage date	Number col lected	Median arrival date	Number collected	Travel time (days)	Migration rate (km/day)	Mean Q(kcfs) at LGO
1990	LDK-1	Clear-water 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 trapa[a]		37	4/16	265	19	3.2	44.5
	LOK-2	Clearwater River trap[a]	3/31	56	4/22	502	22	2.8	50.6
	LDK-4	Cleat-water 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	282	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	Clear-water 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”	4/4	39	5/6	632	32	1.9	88
	RA4-1	Cleat-water 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
	RDR-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	4/6	272	4/22	4,171	16	3.2	86
	(R&L)AJ-1	Lookingglass Hatchery[b]	5/18	131	6/14	11,622	27	1.9	75
	**	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		2,155	3	17.2	112
1988	LAUO-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	1.1	54
	LAT-2	Dworshak NFH	3/31	1,711	4/20	17,510	20	3.1	238
	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 LGD
1988	RAR-3	Dworshak NFH	3/31	181	4/21	1,852	21	2.9	39
	LDK-1	Clear-water River trap[a]	3/15	51	4/l 9	736	35	1.8	32
	LDK-3	Clearwater River trap[a]	3/18	93	4/19	643	32	1.9	33
	RDK-1	Cleat-water 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	Clearwater River trapa	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	Cleat-water 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	Clearwater River[a]	4/13	74	4/29	334	16	3.8	46
1986	LDY-3	Hells 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
	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 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-l	Dworshak NFH	4/2	312	4/21	4,703	19	3.2	97
1985	LDR-3	Hells Canyon	4/3	544	4/13	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	Confidence Interval* 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	a.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	a.59	36	40.4	62.08
04/26/90	8.84	11.69	6.45	44	46.3	61.37
04/27/90	a.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	1a	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 range of 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, r2=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 smolts 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 smolts 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 smolts from the Snake River trap had significantly higher weekly ATPase levels (umoles P*mg $Prot^{-1} \cdot h^{-1}$) than smolts 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	la.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	a.39	11.80	7.04	23	44.2	68.12
05/03/90	a.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 umoles for the Clearwater River smolts and 22.2 pmoles for the Snake River smolts. 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 not significant (N=35, r^2=0.041, P=0.243). After removing 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 appeared 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). A graph of 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 smolted as the Snake River chinook salmon.

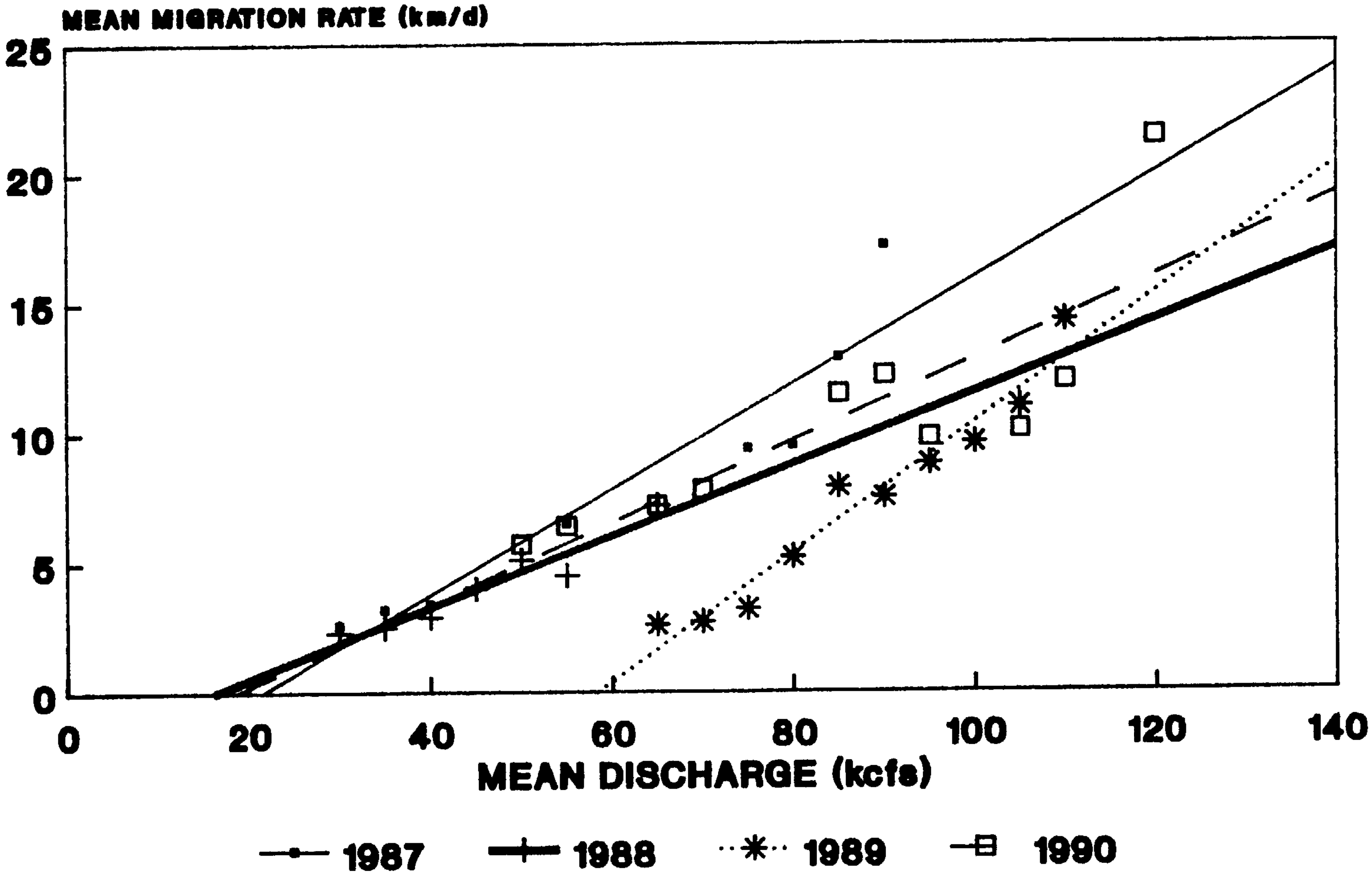

Figure 8. Chinook salmon migration rate/discharge relations for Snake River trap PIT tag groups, 1987-1990.

Hatchery 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.

Hatchery Steelhead Trout PIT Taq Groups-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) to be 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 from 8.5 to 3.7 d (6.0 km/d to 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. Steelhead trout smolt travel time and migration rate from the head of Lover Granite Reservoir to Lower Granite Dam using fish passing the Snake and Clear-water River traps from upriver releases, 1985-1990.

			Snake River/ Clear-water 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 LGC
1990	***LA)(-1***	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	5/11	12,066	8	7.7	75
	RAT-l	Dworshak NFH	5/5	139	5/12	11,150	8	7.7	78
	LAIC-4	Asotin Creek	4/18	58	4/24	12.020	7	7.4	68
	RAIC-4	Asotin Creek	4/19	30	4/25	12,166	7	7.4	68
	(R&L)OA-l&3	Spring Creek	4/30	240	5/5	26,970	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	4/20	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/l	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	s/a	15,037	8	6.5	95
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
	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 Asotin	5/24	30	5/30	854	6	8.6	76
	RD4-1	Snake River at Asotin	5/24	55	5/30	994	6	8.6	76
	RAT-l	Dworshak NFH	5/3	107	5/11	10,792	8	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	70
	RA4-1	Clearwater River trap[a]		28	4/22	1,335	8	7.7	57
	RA4-3	Clear-water River trap[a]	4/23	8	5/l	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	Cottonwocd 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	Cleawater River trap[a]	4/13	6	4/26	1,192	13	4.7	41
	RDK-2	Clear-water 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	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 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	5/8	18	5/17	7,194	9	6.8	99
	LD4-1	Clear-water River trap[a]	5/8	2	5/14	1,003	6	10.3	100
	LD4-3	Clear-water 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	Clear-water River trap[a]	5/1	1	5/8	751	7	8.8	94
1985	LDY-1	Hells Canyon	5/3	44	5/11	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

[a] Releases made on Cleat-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	Confidence Interval* 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* Upper	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 (day)	Confidence Interval* Upper	Confidence Interval* Lower	Number captured	Percent captured (%I	Average discharge (kcfs)
04/04/90	4.45**	0.00	0.00		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, r2=0.166, P=O.O60). 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, r2=0.205, P=O.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 averaged by 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=O.O40). 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=O.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.

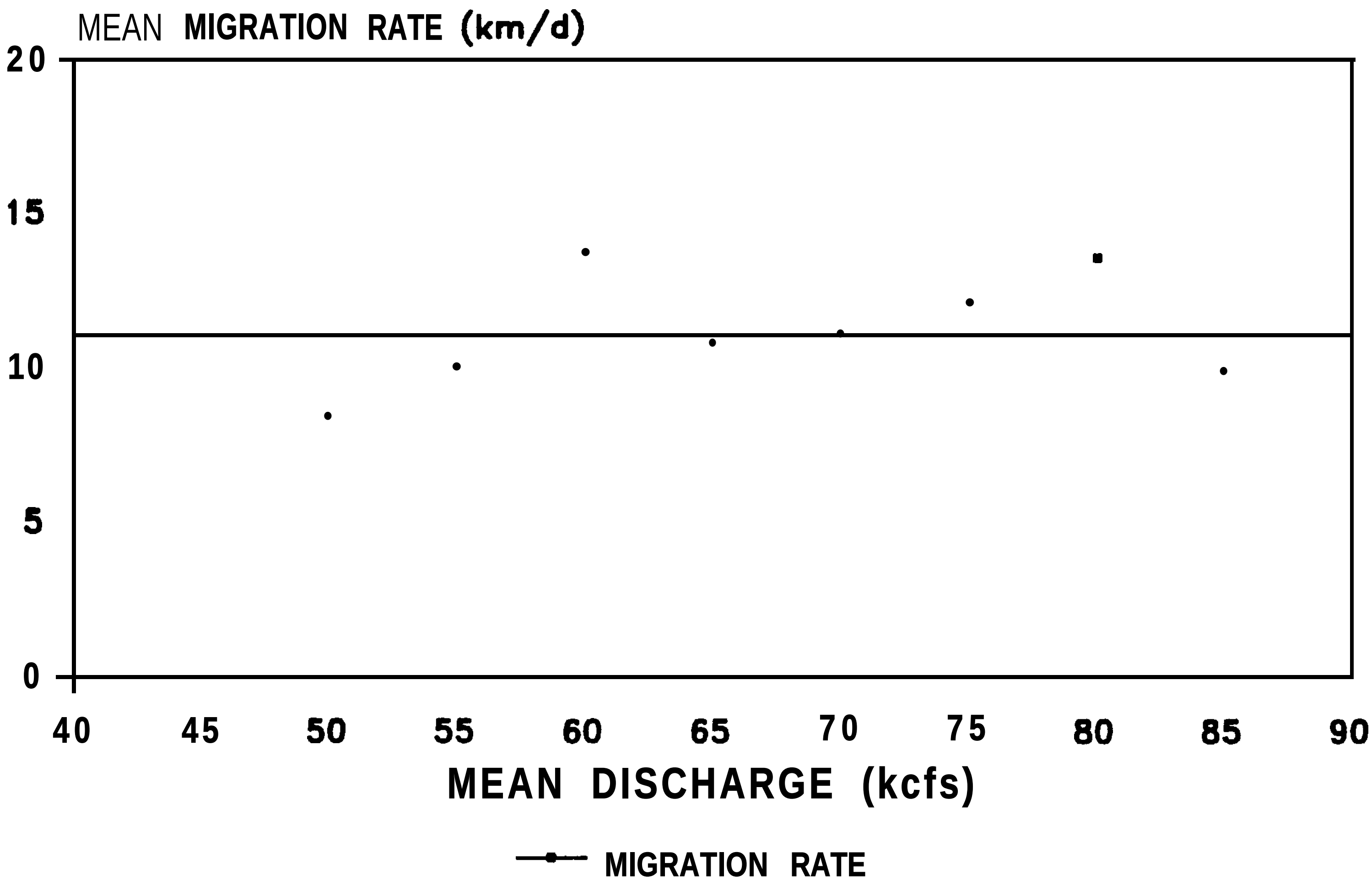

Figure 9. Hatchery steelhead trout Migration rate/discharge relation for Clearwater River trap PIT tag groups, 1990.

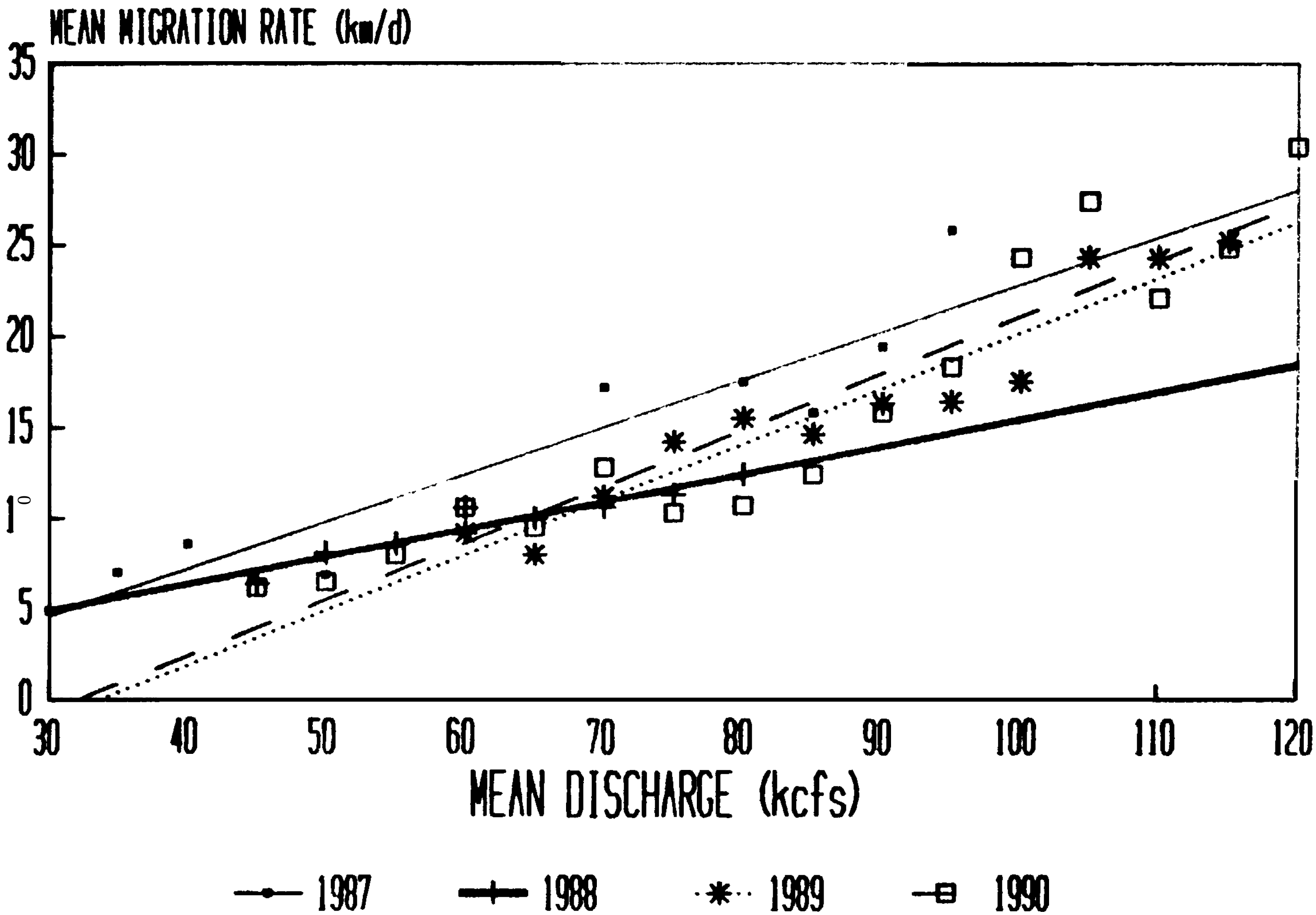

Figure 1°. Hatchery steelhead trout migration rate/discharge relations for Snake River trap PIT tag groups. 1987–1990.

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.

This indicates that 95% 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.

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=1.340, P=0.329). 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 smolts (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/or more fully smolted 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).

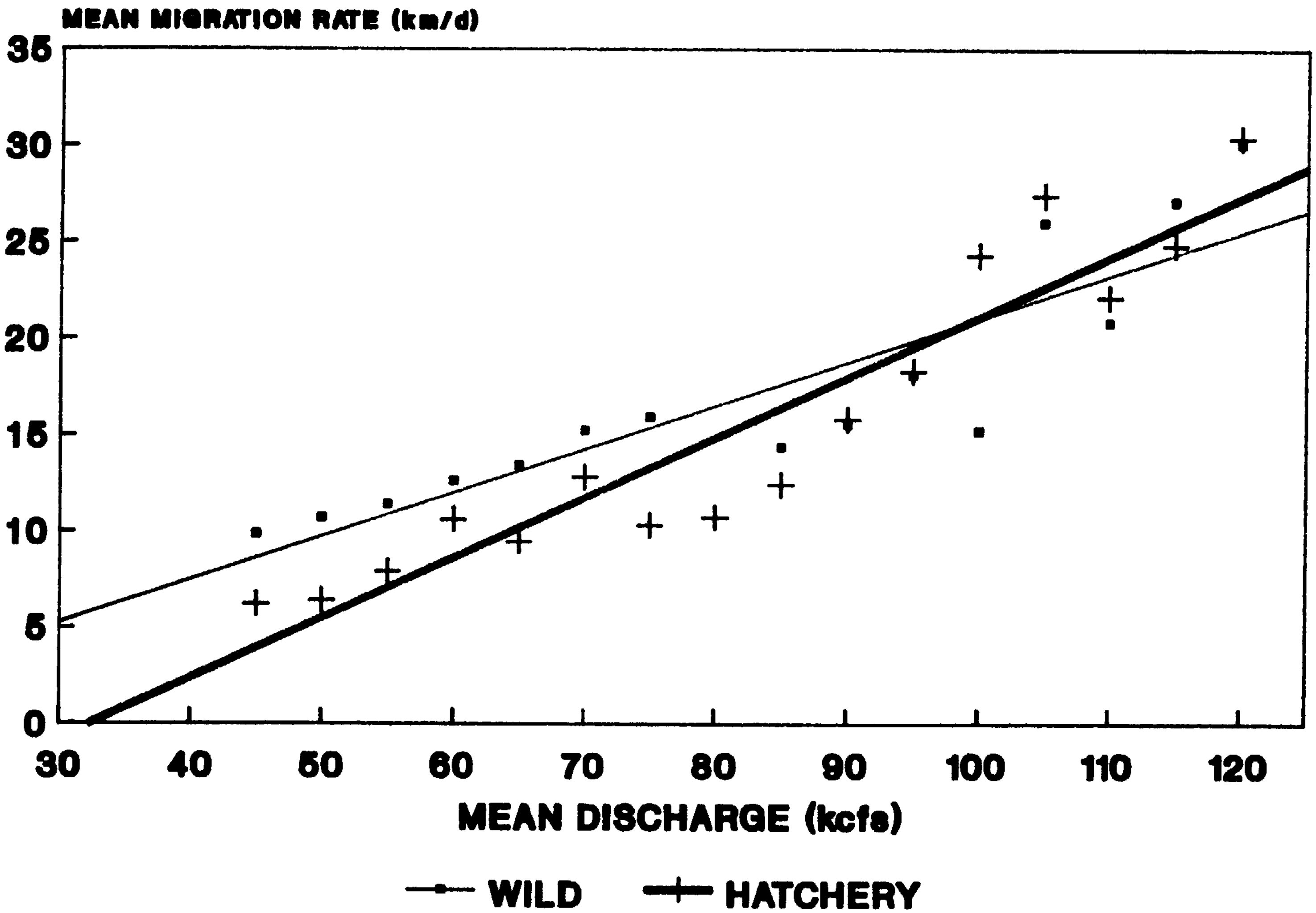

Figure 11. Hatchery and wild steelhead trout migration rate/discharge relations for Snake River trap PIT tag groups, 1990.

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 umoles P.mg Prot- .h- , peaked at 25.0 umoles the week of May 25, and ended at 21.8 umoles. Wild steelhead trout weekly mean ATPase levels fluctuated little during the sample period, ranging from 18.0 to 23.7 poles P.mg $Prot^{-1} \cdot h^{-1}$.

Head of Lower Granite Reservoir to Little Goose Dam

Chinook Salmon PIT Taq 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 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).

Hatchery Steelhead Trout PIT Taq 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 Taq 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, P=0.000). The same analysis was conducted on the Clearwater River trap wild steelhead trout PIT-tagged data (Table 20). The regression analysis was not significant at the 0.05 level. The **lack** of significance was probably due to low numbers of interrogations at Little Goose Dam, similar to the hatchery steelhead trout data. It seems that a relation between migration rate and discharge for

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 .oo
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	-

Clearwater River smolts 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 tagged at 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 over years. 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 Interogates/Site: Lower Granite (%)	Little Goose (%)	McNary %	Totals (%)
Snake	1990	CH	2,245	956	310	180	1,446
				(42.6)	(13.8)	(8.0)	(64.4)
		SH	3,112	2,272	282	33	2,587
				(73.0)	(9.1)	(1.1)	(83.1)
		SW	3,078	2,016	356	60	2,432
				(65.5)	(11.6)	(2.0)	(79.0)
Clearwater	1990	CH	4,242	1,359	674	281	2,314
				(32.0)	(15.9)	(6.6)	(54.6)
		SH	1,228	880	63	10	953
				(71.7)	(5.1)	(0.8)	(77.6)
		SW	1,300	767	126	22	915
				(59.0)	(9.7)	(1.7)	(70.4)
Snake	1989	CH	6,222	2,384	1,367	482	4,233
				(38.3)	(22.0)	(7.7)	(68.0)
		SH	2,525	1,773	268	35	2,076
				(70.2)	(10.6)	(1.4)	(82.2)
		SW	1,798	1,170	240	52	1,462
				(65.1)	(13.3)	(2.9)	(81.3)
Clearwater	1989	CH	2,441	756	452	140	1,348
				(31.0)	(18.5)	(5.7)	(55.2)
		SH	290	173	16	2	191
				(59.7)	(5.5)	(0.7)	(65.9)
		SW	104	53	16	3	72
				(51.0)	(15.4)	(2.9)	(69.2)
Snake	1988	CH	3,767	1,237	543	299	2,079
				(32.8)	(14.4)	(7.9)	(55.2)
		SH	1,743	1,069	190	12	1,271
				(61.3)	(10.9)	(0.7)	(72.9)
		SW	1,186	698	166	20	884
				(58.9)	(14.0)	(1.7)	(74.5)
Snake	1987**	CH	3,275	1,067	338	308	1,713
				(32.9)	(10.3)	(9.4)	(52.3)
		SH	827	324	52	6	382
				(39.2)	(6.3)	(0.7)	(46.2)
		SW	464	229	48	8	285
				(49.4)	(10.3)	(1.7)	(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=0.00l; 1989: N=l8, 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.l05; 1990: N=27, r^2=0.102, P=0.l05). 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=l8, 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=l8, 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=l4, r^2=0.162, P=0.l53).

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,OlO (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 0 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 smolts 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 twice as 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., homogenous 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 smolts 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=l7, r2=0.665, P=O.OOO). 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=O.OOO). 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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