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

Annual Report
for 1989 Operations

**by**

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## ABSTRACT

This project monitored the daily passage of chinook salmon Oncorhvnchus tshawvtscha and steelhead trout Q. mykiss smolts during the 1989 spring outmigration at a migrant trap on the Snake River and the Clearwater River.

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

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

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

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



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# INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NWPPC) to develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (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 NWPPC's Water Budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the 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, 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. Two low flow years (1987 and 1988) 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 Oncorhynchus tshawytscha and steelhead trout Q. mykiss.

Additionally, the IDFG smolt monitoring project collects other useful data on relative species composition, estimated fish passage index, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, and migration rate. By monitoring 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 and a smolt passage index at the head of Lower Granite Reservoir for water budget and fish transportation management purposes.

2. Determine riverine travel time from the point of release to the 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, or their migration in a reservoir environment.

4. Determine reservoir travel time for chinook salmon, hatchery steelhead trout, and wild steelhead trout from the head of Lower Granite Reservoir to Lower Granite Dam using PIT-tagged 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. This information included species, number released, date and location released, and the group identifying freeze brand, if used.

### Smolt Monitoring Traps

During the 1989 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 captured and removed daily from the traps for examination, enumeration, and released back to the river. Fork length of up to 100 smolts were measured to the nearest millimeter, and up to 2,000 fish were examined for hatchery brands.

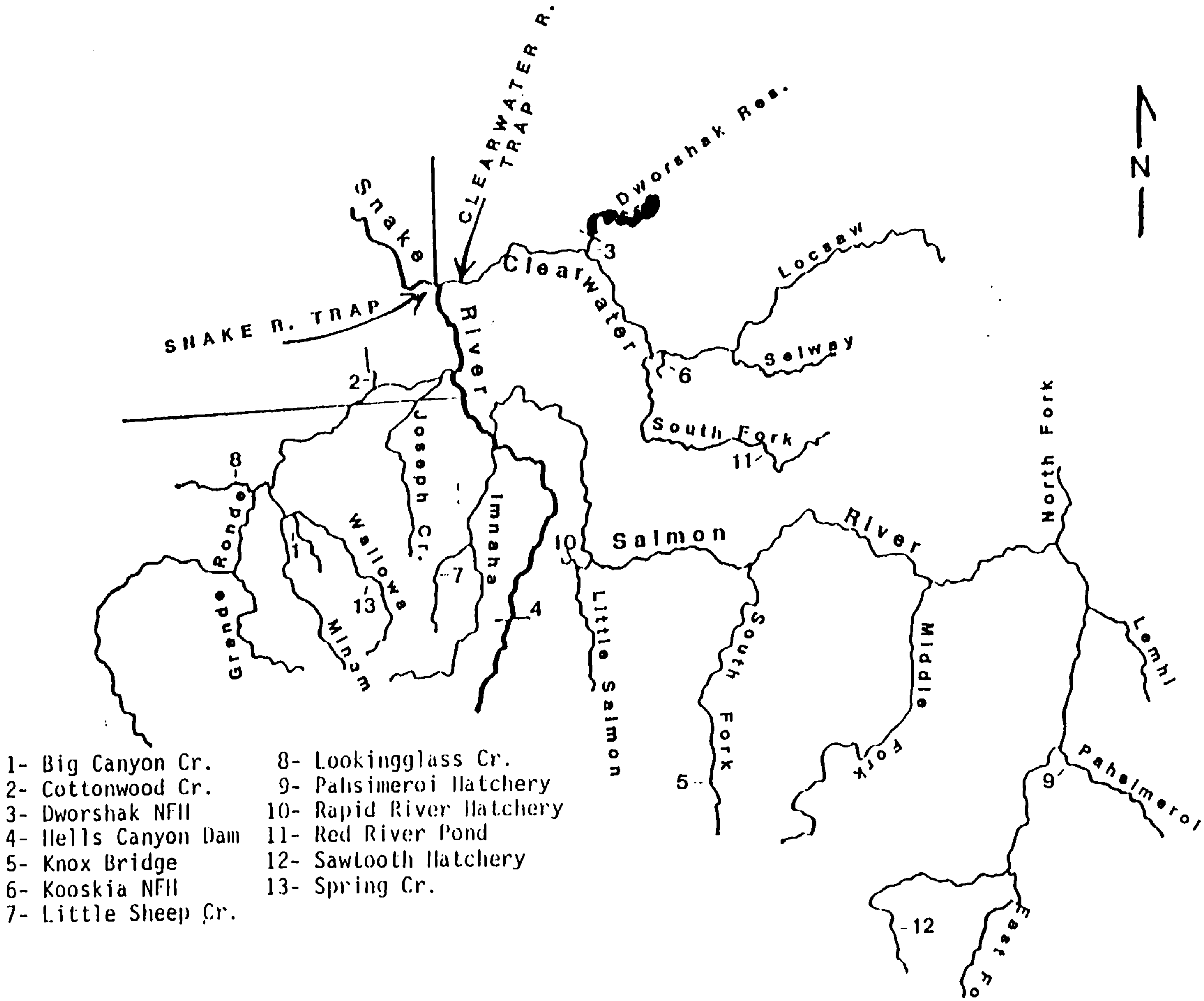



Figure 1. Map of study area.

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

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

## Snake River Trap

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

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

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

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

Clearwater River Trap

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

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

## Trap Efficiency

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

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

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

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

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

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

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

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

Trap efficiency tests were conducted throughout the migration season on the Clearwater River by releasing marked smolts 7 km upriver from the trap site. Four groups of chinook salmon, of approximately 2,000 fish each, were freeze-branded at Dworshak National Fish Hatchery (DNFH) and held there until transported to the release site, 7 to 31 d later. Five groups of freeze-branded age-I chinook salmon, three groups of freeze-branded age-0 chinook salmon, and two of the four groups of freeze-branded steelhead trout released with the DNFH production release were also used to estimate efficiency of the Clearwater River trap.

## Travel Time and Migration Rates

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

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

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

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

# RESULTS AND DISCUSSION

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

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

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

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

Table 1. (Continued)

| Release site (hatchery) | Stock | Release date | No. released (No. branded) | Brand |
|---|---|---|---|---|
| Lookingglass Cr. (Lookingglass) | Spring | 9/23/88 | 85,564 | |
| | | 9/23/88) | (20,248) | RDJ-1 |
| | | (9/23/88) | (20,341) | LDJ-1 |
| | | 11/1/88 | 86,310 | |
| | | 4/3 | 417,354 | |
| | | (4/3) | (20,419) | RDJ-2 |
| | | (4/3) | (17,197) | RDJ-3 |
| | | (4/3) | (19,817) | LDJ-2 |
| | | (4/3) | (18,623) | LDJ-3 |
| | (age-o) | 5/15 | 126,700 | |
| | | (5/15) | (22,757) | LAJ- 1 |
| | | (5/15) | (22,106) | RAJ-1 |
| Imnaha River (Lookingglass) | Spring | 4/5 | 142,320 | |
| | | (4/5 | (20,153) | RDJ-4 |
| | | (4/5) | (20,065) | LDJ-4 |
| | Drainage Total | | 1,530,450 | |
| Clearwater River | | | | |
| Red River Pond (Red River Pond) | Spring | lO/lO-12/88 | 291,200 | |
| | | (10/11/88) | (18,700) | LDR- 1 |
| | | (10/11/88) | (23,875) | LDR-2 |
| | | (10/11/88) | (13,475) | LDR-3 |
| N.F. Clearwater (Dworshak NFH) | Spring | 9/28/88 | 192,090 | |
| | | (9/28/88) | (19,318) | RDR-1 |
| | | (9/28/88) | (18,802) | RDR-2 |
| | | (9/28/88) | (18,737) | RDR-3 |
| | | 3/29-30 | 1,252,923 | |
| | | (3/29) | (30,503) | RDLX-1 |
| | | (3/29) | (34,795) | RDLT-1 |
| | | (3/30) | (19,545) | RD7H-1 |
| | | (3/30) | (20,084) | RD7H-3 |
| | | (3/30) | (19,087) | RA7H-1 |
| | (age-01 | 3/30 | 206,459 | |
| | | (3/30) | (19,992) | RDH- 1 |
| | | (3/30) | (20,716) | RAH-1 |
| | | (3/30) | (21,051) | RDH-2 |

Table 1. (Continued)

| Release site (hatchery) | Stock | Release date | No. released (No. branded) | Brand |
|---|---|---|---|---|
| Clearwater R, Hwy 95 Boat Launch (Dworshak NFH) | Spring | 3/21-4/S | 8,310 | |
| | | (3/21) | (2,076) | RA4-3 |
| | | (3/23) | (2,065) | LD4-1 |
| | | (4/3) | (2,094) | RD4-3 |
| | | (4/5) | (2,075) | RA4-1 |
| Crooked River (Dworshak NFH) | Spring | 3/27-30 | 199,690 | |
| White Sands Cr | | | | |
| (Dworshak NFH) | Spring | 3/28-29 | 200,639 | |
| (Kooskia NFH) | Spring | 3/27 | 102,660 | |
| Clear Creek (Kooskia NFH) | Spring | 3/29 | 384,235 | |
| Eldorado Creek (Kooskia NFH) | Spring | 3/29 | 209,950 | |
| | Drainage Total | | 3,048,156 | |
| | Grand Total | | 11.479.606 | |

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

### Steelhead Trout

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

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

## Smolt Monitoring Traps

### Snake River Trap Operation

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

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

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

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

| Release site (hatchery) | Stock | Release date | No. released (No. branded) | Brand |
|---|---|---|---|---|
| Salmon River | | | | |
| North Fork S.R. (Niagara Springs) | A | 4/13-16 | 208,500 | |
| Pahsimeroi River (Niagara Springs) | A | 4/7-13 | 508,300 | |
| East Fork S.R. | | | | |
| (Hagerman NFH) | B | 4/10-19 | 436,576 | |
| (Magic Valley) | B | 4/l 5-19 | 353,300 | |
| Sawtooth Hatchery | | | | |
| (Hagerman NFH) | A | 4/7-20 | 636,551 | |
| (Magic Valley) | A | 4/10-19 | 857,600 | |
| Slate Creek (Magic Valley) | A | 4/24-27 | 300,600 | |
| Hammer Creek | | | | |
| (Magic Valley) | A | 4/28-29 | 136,000 | |
| (Niagara Springs) | A | 4/29 | 7,200 | |
| Yankee Fork S.R. (Magic Valley) | A | 4/17-20 | 104,400 | |
| S.R. @ Shoup Br. (Niagara Springs) | A | 4/17-20 | 206,700 | |
| Hazard Creek | A | 4/19-26 | 450,900 | |
| | Drainage Total | | 4,206,627 | |
| Snake River and Non-Idaho Tributaries | | | | |
| Hells Canyon (Irrigon) | A | 1l/22/88 | 94,327 | |
| Hells Canyon (Niagara Springs) | A | 4/25 | 735,500 | |
| Little Sheep Cr. (Irrigon) | A | 4/21-24 (4/23) | 249,456 (26,637) | LDJ-1 |

Table 2. (Continued)

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

Table 2. (Continued)

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

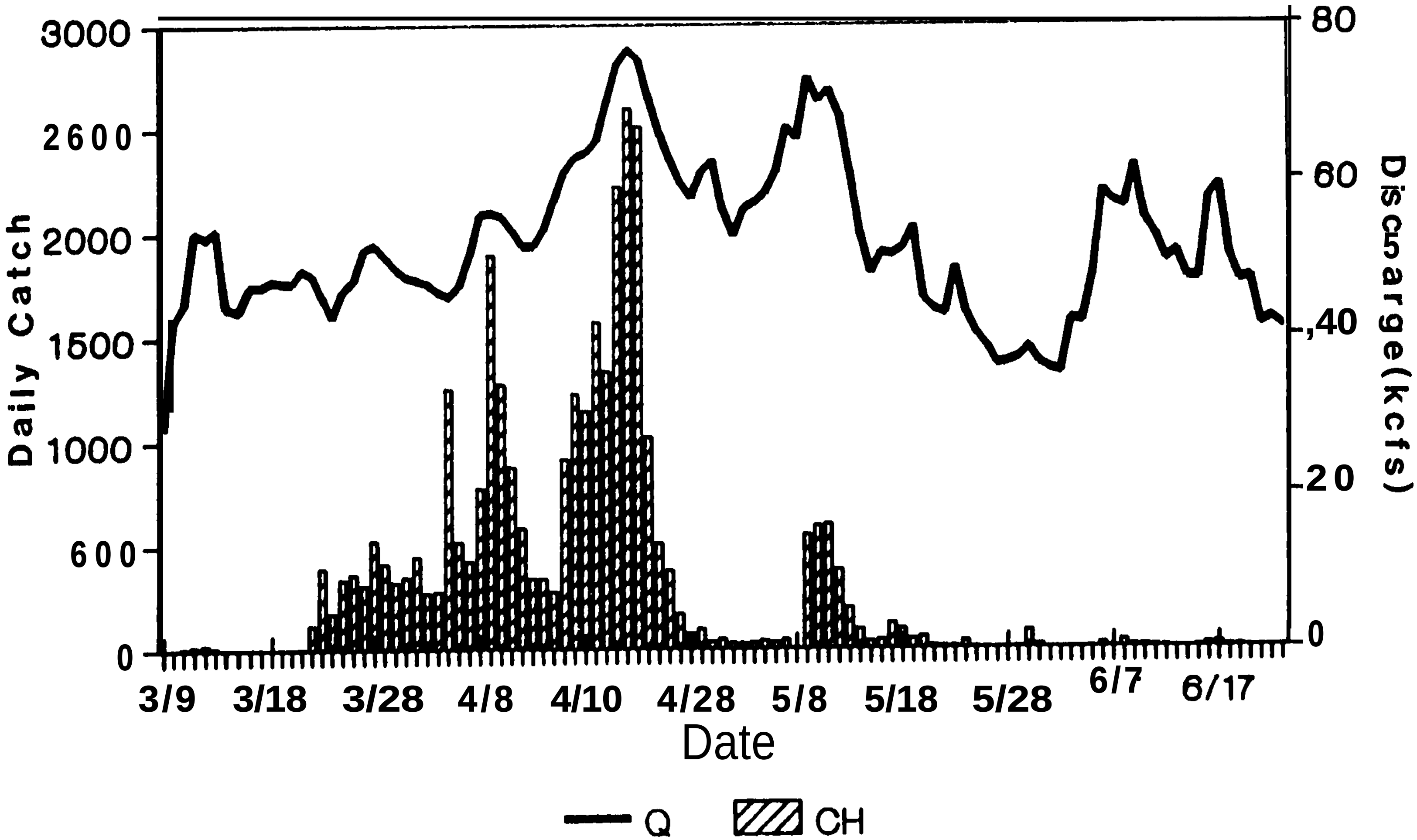



Figure 2: Snake River trap daily catch for age-I chinook salmon overlaid by Snake River discharge 1989.

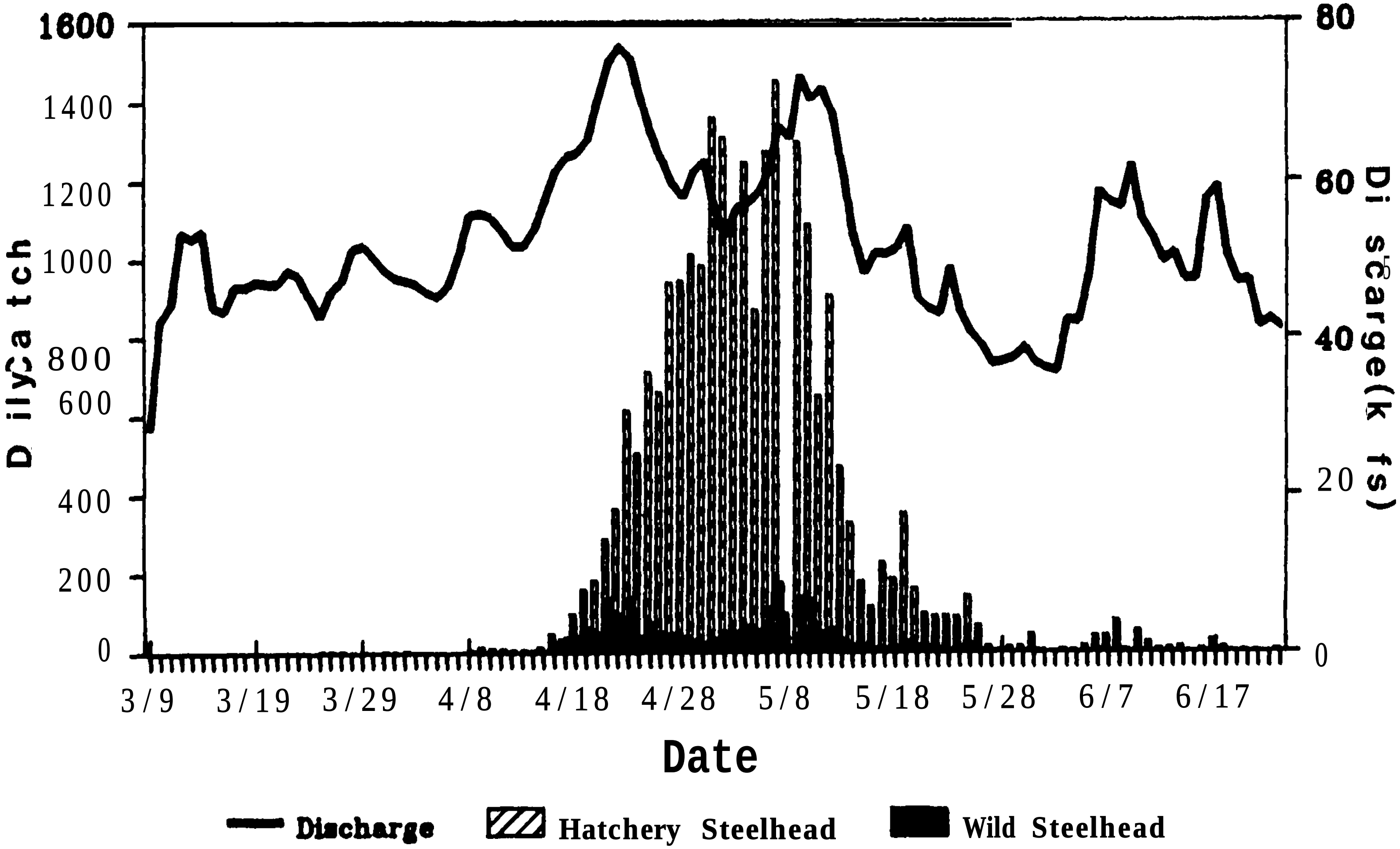



Figure 3: Snake Hiver trap daily catch for hatchery steel head trout and wild steel head trout overl a id by Snake Ri ver di scharge 1989.

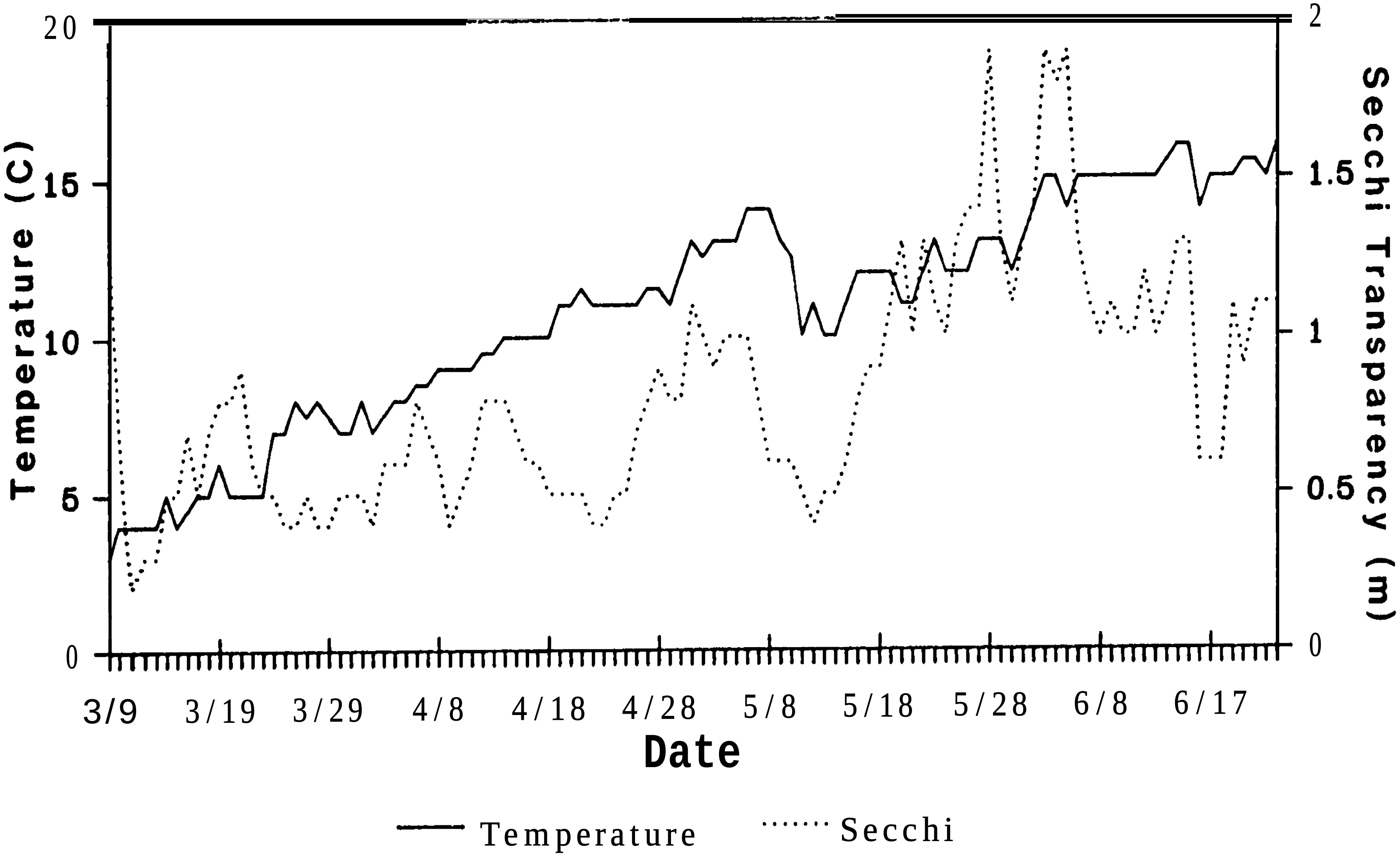



Figure 4: Daily temperature and secchi disk trasparency at the Snake River trap 1989

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

### Clearwater River Trap Operation

The Clearwater River trap caught 9,938 chinook salmon, 1,135 hatchery steelhead trout, 141 wild steelhead trout, and 47 sockeye/kokanee in 1989. Only one major peak of chinook salmon passage was observed at the Clearwater River trap (Figure 5). The peak began on March 29 and was associated with the DNFH release. After this peak the trap was out of operation for three major periods due to high flow, and little information about the 1989 chinook salmon outmigration from the Clearwater River was gained from that point on.

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

Water temperature at the Clearwater River trap was 4°C the beginning of the season and gradually increased to 11°C by the first of May (Figure 7). Water temperatures throughout the season were similar to previous years, although 1987 drought year temperatures were slightly higher.

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

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

## Trap Efficiency

### Snake River Trap

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

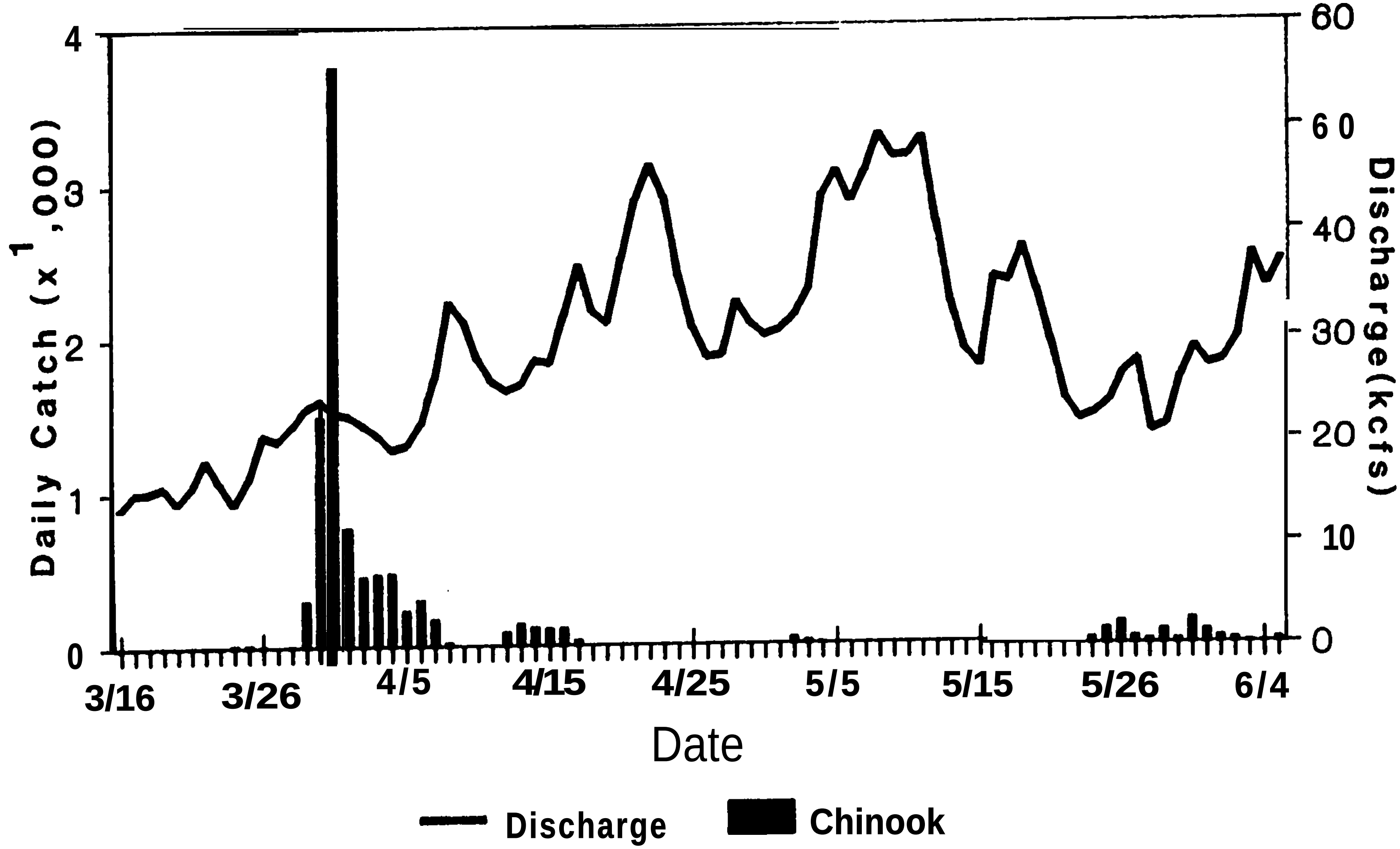
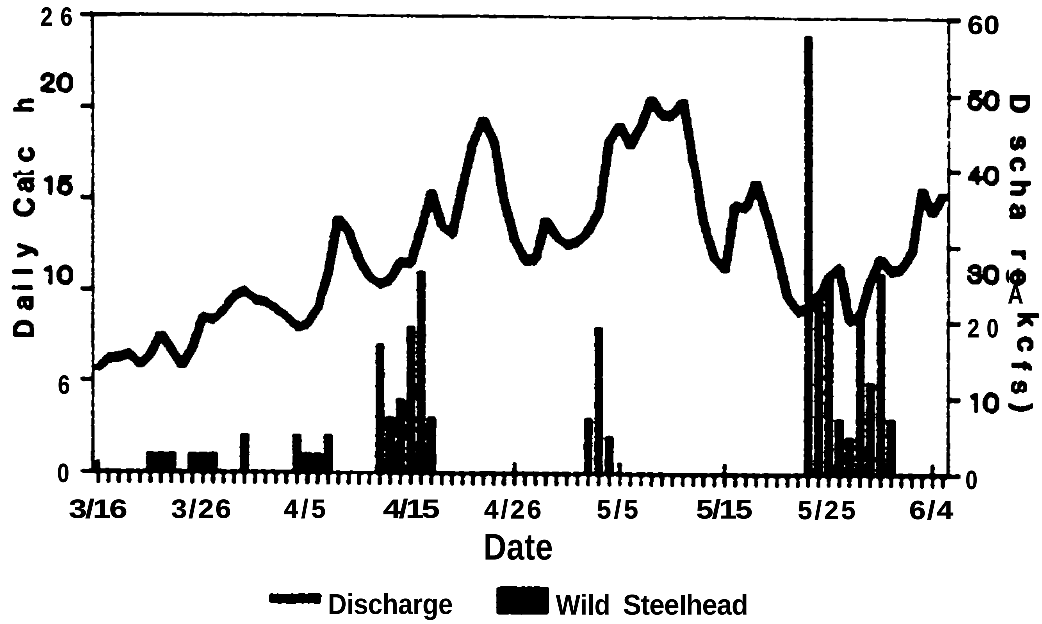



Figure 5: Clearwater River trap daily catch for age - 1 chinook salmon overlaid by Clearwater River discharge, 1939.



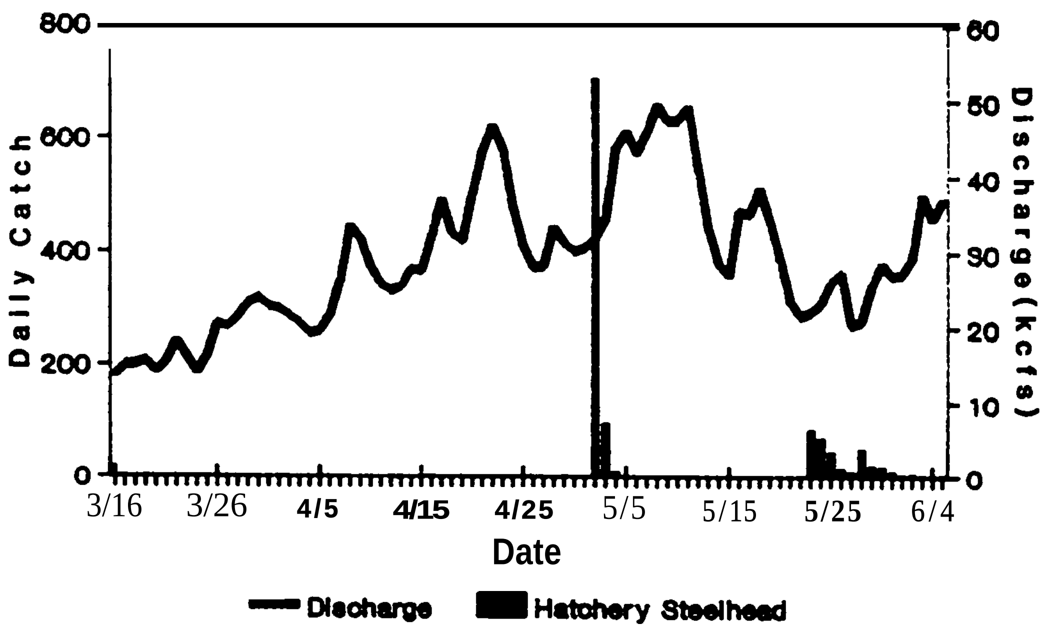




Figure 6: Clearwater River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River discharge, 1989.

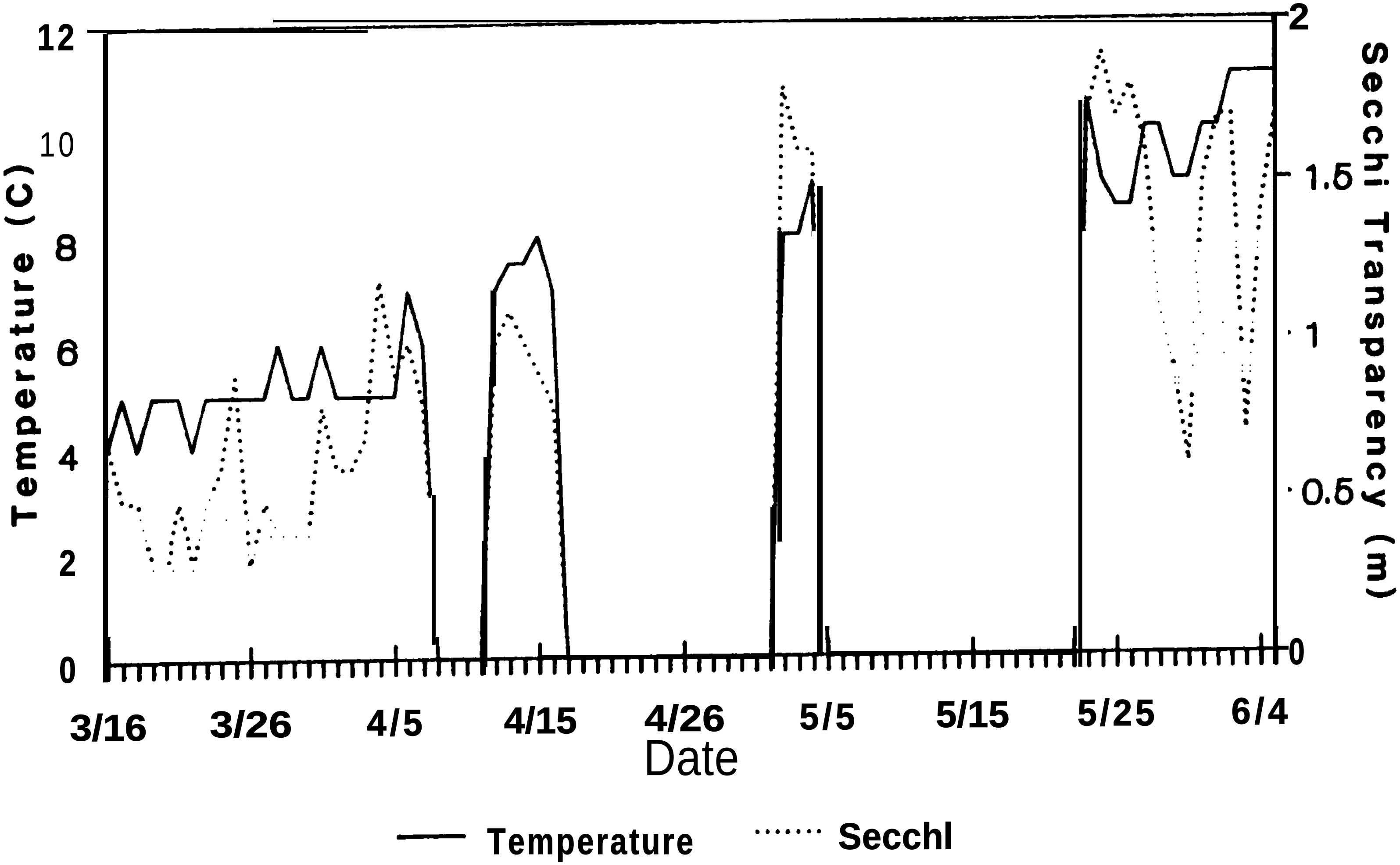



Figure 7: Daily temperature and secchi disk transparency at the Clearwater River trap, 1989

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

| Year | Sample origin | Release dates | Recapture/ mark | Efficiency | Discharge (kcfs) |
|---|---|---|---|---|---|
| 1984 | trap caught | 3/2 | 26/1,388 | 0.0187 | 84 |
| | | 3/28 | 10/545 | 0.0183 | 75 |
| | | 4/8 | 3/589* | 0.0051 | 77 |
| | | 4/12 | 7/309 | 0.0227 | 81 |
| | | 4/16 | 9/806 | 0.0112 | 92 |
| | | 4/19 | 23/1,061 | 0.0217 | 104 |
| | | 4/24 | 8/812 | 0.0098 | 101 |
| | | 4/28 | 5/267 | 0.0187 | 86 |
| | | 5/4 | 4/179* | 0.0223 | 81 |
| | | 5/9 | 2/95* | 0.0211 | 93 |
| 1985 | trap caught | 3/22 | 11/1,124 | 0.0098 | 43 |
| | | 4/23 | I/840 | 0.0250 | 56 |
| | | 4/6 | 7/1,092 | 0.0064 | 64 |
| | | 4/10 | 4/1,490* | 0.0027 | 79 |
| | | 4/12 | 15/1,276 | 0.0118 | 77 |
| | | 4/16 | 12/915 | 0.0131 | 80 |
| | | 5/5 | 4/338* | 0.0118 | 42 |
| 1986 | trap caught | 3/29 | 2311,881 | 0.0122 | 86 |
| | | 4/7 | 13/1,237 | 0.0105 | 80 |
| | | 4/12 | 26/1,530 | 0.0170 | 74 |
| | | 4/17 | 2/1,141* | 0.0018 | 67 |
| | | 4/24 | 11/1,417 | 0.0078 | 80 |
| | | 4/28 | 3/803* | 0.0037 | 72 |
| | | 5/19 | 4/703* | 0.0057 | 76 |
| 1987 | | No efficiency tests conducted for chinook in 1987 | | | |
| 1988 | | No efficiency tests conducted for chinook in 1988 | | | |
| 1989 | trap caught | 4/5 | 13/1,054 | 0.0123 | 46 |
| | | 4/10 | 23/1,076 | 0.0214 | 55 |
| | | 4/18 | 14/1,233 | 0.0114 | 66 |
| | | 4/19 | 9/1,719 | 0.0052 | 73 |
| | | 4/23 | 10/2,001 | 0.0050 | 73 |
| | | 4/24 | 5/584 | 0.0086 | 68 |

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

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

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

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

Clearwater River Trap

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

Steelhead Trout-Steelhead trout trap efficiencies at the Clearwater River trap were not tested in 1989. Due to the limited time the trap was operated during the steelhead trout outmigration, an insufficient number of smolts were captured to effect a mark-recapture estimate. Trap efficiency for steelhead trout smolts at the Clearwater River trap in previous years has averaged 0.282, with 95% confidence limits of 0.15% and 0.46%.

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

| Year | Sample orisin | Release dates | Recapture/ mark | Efficiency | Discharge (kcfs) |
|---|---|---|---|---|---|
| 1985 | trap caught | 5/4 | 8/811 | 0.0099 | 55 |
| | | 5/8 | I/185 | o-0054* | 54 |
| | | 5/18 | I/492 | 0.0020* | 50 |
| | | 5/21 | 2/314 | O-0064* | 68 |
| 1986 | trap caught | 4/24 | I/179 | 0.0056* | 80 |
| | | 4/30 | 12/874 | 0.0137 | 72 |
| | | 5/21 | 3/1,345 | o-0022* | 76 |
| 1987 | No efficiency tests conducted for steelhead smolts in 1987 | | | | |
| 1988 | trap caught | 4/18 | 2/866 | O-0023* | 32 |
| | | 5/13 | 7/2057 | 0.0034 | 38 |
| | | 5/15 | 5/1822 | 0.0027 | 42 |
| | hatchery releases | 5/23 | 54/3977 | 0.0136 | 45 |
| | | 5/23 | 32/3996 | 0.0080 | 45 |
| 1989 | trap caught | 4126-28 | 6/I ,916 | 0.0031 | 60 |
| | | 5/I&2 | 31/2,397 | 0.0129 | 55 |
| | | 5/3&4 | 7/2,137 | 0.0033 | 57 |
| | | 5/9-12 | 3/2,535 | 0.0012* | 70 |

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

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

| Year | Sample orisin | Release dates | Recaptures/ mark | Efficiency | Discharge (kcfs) |
|---|---|---|---|---|---|
| 1984 | trap caught | 4/5 | 4/418 | 0.0096" | 21 |
| | | 4/21 | 13/806 | 0.0161 | 33 |
| | | 4/25 | 3/489 | 0.0061" | 31 |
| | | 5/10 | 14/453 | 0.0309 | 24 |
| 1985 | trap caught | 3/25 | 14/607 | 0.0230 | 9 |
| | | 3/30 | 45/1,511 | 0.0298 | 9 |
| | | 4/5 | 611,079 | 0.0056 | 18 |
| | | 4/9 | 2/940 | 0.0021" | 15 |
| | | 4/16 | 7/929 | 0.0075 | 33 |
| 1986 | trap caught | 3/27 | 9/1,555 | 0.0058 | 22 |
| | | 4/2 | 8/1,714 | 0.0047 | 29 |
| 1987 | DNFH release | 3/20 | 4312,160 | 0.0199 | 13 |
| | | 4/22 | 50/2,000 | 0.0250 | 6 |
| | | 4/7 | 165/1,945 | 0.0848 | 10 |
| | | 4/13 | 7412,000 | 0.0370 | 13 |
| | | 4/20&28 | 103/4,000 | 0.0258 | 18 |
| | trap caught | 4/2 | 3311,926 | 0.0171 | 6 |
| | | 4/3 | 11/1,458 | 0.0075 | 8 |
| | | 4/6 | 15/1,872 | 0.0080 | 9 |
| | | 4/7 | 15/1,163 | 0.0129 | 10 |
| | | 4/9 | 9/450 | 0.0200 | 12 |
| 1988 | Hwy 95 boat launch | 3/14 | 51/2,197 | 0.0232 | 6 |
| | | 3/17 | 9312,197 | 0.0423 | 6 |
| | | 3/21 | 83/2,197 | 0.0378 | 6 |
| | | 4/l | 2712,195 | 0.0123 | 9 |
| | | 4/6 | 18/2,194 | 0.0082 | 11 |
| | | 4/13 | 3112,193 | 0.0141 | 14 |
| | DNFH release | 3/30 | 1711/60,631 | 0.0282 | 10 |
| | | 3/30 | 252/8,731 | 0.0289 | 10 |
| | | 3/30 | 181/6,163 | 0.0294 | 10 |
| | | 3/30 | 788/20,642 | 0.0382 | 10 |
| | | 3/30 | 573/22,935 | 0.0250 | 10 |
| | trap caught | 3/24 | 17/2086 | 0.0081 | 9 |
| | | 3/28 | 27/1695 | 0.0159 | 12 |
| | | 4/l | 16/1631 | 0.0098 | 9 |
| | | 4/2 | 38/2257 | 0.0168 | 8 |

Table 5. (continued)

| Year | Sample orisin | Release dates | Recaptures/ mark | Efficiency | Discharge (kcfs) |
|---|---|---|---|---|---|
| 1989 | Hwy 95 | 3/21 | 712,076 | 0.0034 | 17 |
| | boat | 3/23 | 10/2,065 | 0.0048 | 15 |
| | launch | 4/3 | 39/2,094 | 0.0186 | 20 |
| | | 4/5 | 4112,075 | 0.0200 | 21 |
| | DNFH | 3/29 | 66/34,795 | 0.0019 | 24 |
| | release | 3/29 | 73/30,503 | 0.0024 | 24 |
| | | 3/30 | 41/19,087 | 0.0021 | 23 |
| | | 3/30 | 48/19,545 | 0.0025 | 23 |
| | | 3/30 | 78/20,084 | 0.0039 | 23 |

* 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 12 groups of freeze-branded chinook salmon released in the Salmon River drainage; four each at Sawtooth Hatchery, South Fork Salmon River, and Rapid River Hatchery. Two groups were released in the Imnaha River, Oregon, and four groups were released in Lookingglass Creek, Oregon. Two groups of age-0 spring chinook salmon were released in Lookingglass Creek (Table 6).

The Snake River trap captured approximately 0.282 (1,021) of the branded fish released. Of the freeze-branded chinook salmon releases above Lower Granite Dam, 452 originated in Idaho waters and 55% were released in Oregon. The percentage of branded chinook salmon in the Snake River trap catch was 782 Oregon fish and 222 Idaho fish. This difference may be survival related. Idaho chinook salmon have a greater distance to travel to the Snake River trap than the Oregon chinook salmon. The weaker fish in the release group may have perished before they reached the trap. The shortest migration distance for branded fish from Idaho is 228 km for the Rapid River chinook salmon and the longest is 698 km for the Sawtooth Hatchery chinook salmon. By contrast, the Oregon chinook salmon travel from 164 km in the Imnaha River to 187 km for the Lookingglass Creek chinook salmon (Table 7). Another possible explanation is that the Oregon chinook salmon may have been in better overall health than the Idaho fish.

Migration rate for the three representative Idaho hatchery groups was lower in 1989 than in previous non-drought years (1984-1986). Insufficient numbers of branded fish were recovered at the Snake River trap in 1987 and 1988 drought years from the hatchery releases to estimate travel time. Migration rates for the Rapid River freeze brand group was 12.0 km/d, and the South Fork Salmon River groups was 8.1 km/d. Insufficient numbers of branded chinook salmon from Sawtooth Hatchery were recaptured at the Snake River trap to determine migration rate. The reduction in migration rate in 1989 for the Salmon River chinook salmon freeze brand groups may have been due to a 10-60% reduction in Salmon River discharge and a 15-402 reduction in Snake River discharge during their migration period from previous non-drought years (Table 6). The groups released in Lookingglass Creek traveled at about the same rate as in previous years (62.5-93.7 km/d). In 1989 the Imnaha River brand groups migrated at 16.8 km/d. There is no data from previous years to compare with the 1989 Imnaha data.

Steelhead Trout-In 1989 there were no freeze-branded steelhead trout released above the Snake River trap from Idaho hatcheries. Ten groups of freeze-branded hatchery steelhead trout were released upstream from the Snake River trap from Oregon hatcheries; one group of two replicates from Little Sheep Creek, three groups of two replicates each from Spring Creek, and one group of two replicates from Wildcat Creek. Recapture numbers were high enough for the

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

| Release site | Year | Median release date | Median passage date | Number captured | Travel time (days) | Migration rate (km/day) | Mean Q (kcfs) Salmon R. | Snake R. |
|---|---|---|---|---|---|---|---|---|
| Rapid River | 1989 | 3/30 | 4/18 | 181 | 19 | 12.0 | 9.0 | 52.6 |
| | 1988 | 1/ | | | | | | |
| | 1987 | 1/ | | | | | | |
| | 1986 | 3/27 | 4/10 | 237 | 14 | 16.3 | 15.4 | 82.9 |
| | 1985 | 4/2 | 4/12 | 320 | 10 | 22.8 | 10.6 | 67.6 |
| | 1984 | 4/1 | 4/18 | 197 | 17 | 13.4 | 10.1 | 79.3 |
| Hells Canyon | 1989 | 2/ | | | | | | |
| | 1986 | 1/ | | | | | | |
| | 1987 | 1/ | | | | | | |
| | 1986 | 3/26 | 4/3 | 269 | 8 | 21.6 | | 83.8 |
| | 1985 | 3/19 | 4/3 | 544 | 14 | 12.4 | | 43.0 |
| | 1904 | 3/20 | 3/29 | 704 | 9 | 19.2 | | 81.4 |
| S.F. Salmon River | 1909 | 3/21 | 5/11 | 21 | 51 | 8.1 | 6.5 | 57.1 |
| | 1988 | 1/ | | | | | | |
| | 1987 | 1/ | | | | | | |
| | 1986 | 3/20 | 4/23 | 229 | 26 | 15.8 | 16.5 | 70.6 |
| | 1985 | 4/2 | 4/17 | 76 | 15 | 27.1 | 14.0 | 71.0 |
| | 1984 | 4/10 | 4/24 | 238 | 14 | 29.0 | 14.5 | 91.7 |
| Sawtooth Hatchery | 1989 | 3/15 | 4/20 | 14 | 36 | 19.4 | 6.1 | 51.0 |
| | 1988 | 1/ | | | | | | |
| | 1987 | 1/ | | | | | | |
| | 1986 | 3/17 | 4/14 | 49 | 28 | 24.9 | 13.6 | 81.4 |
| | 1985 | 3/27 | 4/14 | 165 | 18 | 30.7 | 9.6 | 60.1 |
| | 1984 | 3/28 | 4/21 | 136 | 24 | 29.0 | 11.8 | 84.0 |
| Lookingglass Cr. | 1989 | 4/03 | 4/06 | 212 | 3 | 62.5 | | 46.1 |
| | 1989 | 4/03 | 4/05 | 173 | 2 | 93.7 | | 45.9 |
| | 1989 | 5/15 | 5/18 | 131 | 3 | 62.5 | | 50.2 |
| | 1988 | 5/15 | 5/16 | 52 | 3 | 62.5 | | 40.6 |
| | 1987 | 1/ | | | | | | |
| | 1986 | 4/2 | 4/5 | 114 | 3 | 62.5 | | 82.1 |
| | 1905 | No marked release group. | | | | | | |
| | 1984 | No marked release group. | | | | | | |
| Inmaha River | 1989 | 4/05 | 4/10 | 247 | 5 | 16.8 | | 51.6 |

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

TABL6

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

| | Mouth of Columbia R. | | Mouth of Snake River | | Lower Granite Dam | | Snake River Trap site | | Clearwater R. Trap site | | Salmon River Trap Site | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mi | km | ml | km | mi | km | ml | km | mi | km | ml | km |
| Mouth of Snake Rlver | 324.3 | 521.8 | 0.0 | 0.0 | 107.5 | 172.9 | 139.6 | 224.6 | 145.7 | 234.5 | 241.4 | 388.4 |
| Lower Granite Dam | 431.8 | 694.8 | 107.5 | 173.0 | 0.0 | 0.0 | 32.1 | 51.6 | 38.3 | 61.5 | 133.9 | 215.4 |
| Clearwater R. Trap Site | 470.0 | 756.2 | 145.7 | 234.4 | 38.2 | 61.5 | | | 0.0 | 0.0 | | |
| Highway 95 Boat Launch | 473.2 | 761.4 | 148.9 | 239.6 | 41.5 | 66.8 | | | 3.2 | 5.1 | | |
| Dworshak NFH | 504.2 | 811.3 | 179.9 | 289.5 | 72.4 | 116.5 | | | 34.2 | 55.0 | | |
| Kooskia NFH | 541.6 | 871.4 | 217.3 | 349.6 | 109.8 | 176.7 | | | 71.5 | 115.0 | | |
| Crooked River | 604.3 | 972.3 | 280.0 | 450.5 | 172.5 | 277.6 | | | 134.3 | 216.0 | | |
| Red River Rearing Pond | 618.0 | 994.4 | 293.7 | 472.6 | 186.2 | 299.6 | | | 148.0 | 238.1 | | |
| Snake River Trap Site | 463.9 | 746.4 | 139.6 | 224.6 | 32.1 | 51.6 | 0.0 | 0.0 | | | 101.8 | 163.8 |
| Asotln Creek | 469.6 | 755.6 | 145.3 | 233.8 | 37.8 | 60.8 | 5.7 | 9.2 | | | | |
| Mouth of Grande Ronde R. | 493.0 | 793.2 | 168.7 | 271.4 | 61.2 | 98.5 | 29.1 | 46.8 | | | | |
| Cottonwood Creek | 521.7 | 839.4 | 197.4 | 317.6 | 89.9 | 144.6 | 57.8 | 93.0 | | | | |
| Lookingglass Creek | 580.4 | 933.9 | 256.1 | 412.1 | 148.6 | 239.1 | 116.5 | 187.4 | | | | |
| Big Canyon Creek | 585.9 | 942.7 | 261.6 | 420.9 | 154.1 | 247.9 | 122.0 | 196.3 | | | | |
| Spring Creek | 614.4 | 988.6 | 290.1 | 466.8 | 182.6 | 293.8 | 150.5 | 242.2 | | | | |
| Catherine Creek | 636.9 | 1024.8 | 312.6 | 503.0 | 205.1 | 330.0 | 173.0 | 278.4 | | | | |
| Mouth of Salmon River | 512.5 | 824.6 | 188.2 | 302.8 | 80.7 | 129.8 | 48.6 | 78.2 | | | 53.2 | 85.6 |
| Imnaha River | 516.0 | 830.3 | 191.7 | 309.1 | 84.2 | 135.7 | 52.1 | 83.8 | | | | |
| Little Sheep Creek | 553.8 | 891.1 | 229.5 | 369.3 | 122.0 | 196.3 | 89.9 | 144.6 | | | | |
| Imnaha Coll. Facility | 565.6 | 910.2 | 241.3 | 388.3 | 133.8 | 215.4 | 101.7 | 163.6 | | | | |
| Hells Canyon Dam | 571.3 | 919.2 | 247.0 | 397.4 | 139.5 | 224.5 | 107.4 | 172.8 | | | | |
| Salmon River Trap Site | 565.7 | 910.2 | 241.4 | 368.4 | 133.9 | 215.4 | 101.8 | 163.8 | | | 0.0 | 0.0 |
| Rapid River Hatchery | 605.8 | 974.7 | 281.5 | 452.9 | 174.0 | 280.0 | 141.9 | 228.3 | | | 40.1 | 64.5 |
| Hazard Creek | 618.7 | 995.5 | 294.4 | 473.7 | 186.9 | 300.7 | 154.8 | 249.1 | | | 53.0 | 85.3 |
| S.F. Salmon @ Knox Bridge | 719.7 | 1158.0 | 395.4 | 636.2 | 287.9 | 463.2 | 255.8 | 411.6 | | | 154.0 | 247.8 |
| Pahsimerol Hatchery | 817.5 | 1315.4 | 493.2 | 793.6 | 385.7 | 620.6 | 353.6 | 568.9 | | | 251.8 | 405.1 |
| E.F. Salmon @ Trap Site | 873.6 | 1405.6 | 549.3 | 883.8 | 441.8 | 710.9 | 409.7 | 659.2 | | | 307.9 | 495.4 |
| Sawtooth Hatchery | 096.7 | 1444.2 | 573.3 | 922.4 | 465.8 | 749.5 | 433.7 | 697.8 | | | 331.9 | 534.0 |

TABL7

five combined replicate groups to provide travel time information to the Snake River trap (Table 8). Migration rates for the Spring Creek groups were similar to previous years. The migration rate for the Little Sheep Creek group was estimated to be considerably higher than in 1986 (1989=72.3 km/d, 1986=12-O km/d), the only other year recaptures were great enough to estimate travel time. The estimated median passage date in 1986 may not be accurate because only 16 branded fish were recaptured from that group. The Wildcat Creek groups traveled at the same rate as in 1988 (33.1 km/d).

Release Site to the Clearwater Trap

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

A group of age-0 chinook salmon was released from DNFH on September 28, 1988. This group's median passage date at the Clearwater River trap could not be calculated because of the low numbers of freeze brands that were recaptured.

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

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

Table 8. Migration data for freeze-branded steelhead trout smolts from release sites to the Snake River trap, 1985 - 1989.

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

1/ Only freeze brand groups from Oregon and Washington were used in 1989 because Idaho did not release any freeze-branded steelhead trout during 1989 above the Snake River trap.

2/ Insufficient recaptures at the Snake River trap to derive fish movement data.

TA8L8

Table 9. Migration data for freeze branded chinook salmon and steelhead trout smolts released upstream of the Clear-water River trap, 1997 - 1989.

| Release site | Year | SP. | Median release | Median passage | Number captured | Migration rate km/day | Travel time | Discharge mean kcfs |
|---|---|---|---|---|---|---|---|---|
| Crooked River | 1987 | St | 04/14 | | 2 | - | - | |
| Dworshak NFH | 1987 | St | 04/21 | 04/22 | 58 | - | | |
| | | St | 05/05 | | | | | |
| | | Ch | 04/01 | 04/04 | 1416 | 13.8 | 4 | 7.2 |
| Clear Creek | 1987 | St | 04/17 | 04/20 | 59 | 28.8 | b | 14.1 |
| Dworshak NFH | 1988 | St | 05/03 | 05/04 | 283 | 55.0 | 1 | 16.9 |
| | | St | 05/04 | 05/05 | 202 | 55.0 | 1 | 16.9 |
| | | Ch-0 | 03/30 | 04/01 | 239 | 27.5 | 2 | 9.8 |
| | | Ch | 03/30 | 03/31 | 1711 | 55.0 | 1 | 9.6 |
| | | Ch | 03/30 | 03/31 | 1359 | 55.0 | 1 | 9.6 |
| | | Ch | 03/30 | 03/31 | 434 | 55.0 | 1 | 9.6 |
| | | ch | 09/28/87 | 03/27 | 16 | | 182 | |
| Red River | 1988 | Ch | 09/30/87 | 04/14 | 18 | - | 198 | - |
| Dworshak NFH | 1989 | St | 05/01 | 05/02 | 123 | 55.0 | 1 | 31.2 |
| | | Ch | 03/29 | 03/30 | 139 | 55.0 | 1 | 23.5 |
| | | Ch | 03/30 | 03/31 | 167 | 55.0 | 1 | 23.3 |
| | | Ch-0 | 03/30 | 04/03 | 48 | 13.8 | 4 | 22.2 |
| | | Ch | 09/28/88 | 03/30 | 2 | | 183 | |
| Red River | 1989 | Ch | 10/17/89 | 04/17 | 19 | | 182 | |

TABL9

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook Salmon Freeze Brand Groups-In 1989, there were 27 groups of freeze-branded age-I chinook salmon released above Lower Granite Reservoir. Because of low recapture numbers at the Snake River trap, replicate groups released from the same hatchery were combined. After combining, 11 groups were used for calculating travel time through Lower Granite Reservoir. The 11 groups did not include the age-0 chinook salmon releases, the spring chinook salmon groups released in the fall of 1988, or the Sawtooth Hatchery groups. Median travel time through Lower Granite Reservoir for the age-l chinook salmon freeze brand groups ranged from 45 d for the earliest released groups from the Clearwater River trap efficiency test (released on March 221, to 2 d for the group released from the South Fork Salmon River (Table 10). Median travel time for the age-0 chinook salmon ranged from 58 d for the two groups released from DNFH the first of April, to 27 d for the group released from Lookingglass Hatchery in mid-May.

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

log migration rate = -32.595 + 7.537 log discharge.

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

Chinook Salmon PIT Tag Groups-In 1989, sufficient numbers of chinook salmon were PIT-tagged daily at the Snake River trap to provide 47 daily release groups (6,222 total PIT-tagged chinook salmon) for estimating travel time and migration rates through Lower Granite Reservoir. Median travel time ranged from 19.5 d early in the migration season to 3.6 d late in the season, and then 24.6 d at the end of the migration season (Table 11). Medial travel time changed substantially between April 11 and April 16. Prior to April 11, the average median travel time through Lower Granite Reservoir was 15.9 d (migration rate = 3.2 km/d), and after April 16 the average median travel time was 5.4 d (migration rate = 9.6 km/d). The last two PIT tag release groups (released on 5/18 and 5/19) had the longest travel time of any group released. The majority of the chinook salmon in these two groups, which was determined from freeze brand recaptures in the trap catch, were from the age-0 chinook salmon released from Lookingglass Hatchery. Recovery of these two groups at Lower Granite Dam was relatively high, averaging 49.6%. Average daily discharge for the PIT tag groups released prior to April 11 was 78.8 kcfs and ranged from 69 to 91 kcfs. Average daily discharge for PIT tag groups released after April 16 was 94.8 kcfs

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 Clearwater River traps from upriver releases, 1965 - 1989.

| Year | Brand | Release site | Snake River/ Clear-water River trap: Median passage date | Snake River/ Clear-water River trap: Number collected | Lower Granite Dam: Median arrival date | Lower Granite Dam: Number collected | Travel time (days) | Migration rate (km/day) | Mean Q( kcfs) at LGD |
|---|---|---|---|---|---|---|---|---|---|
| 1985 | LDR-3 | Hells Canyon | 4/3 | 544 | 4/13 | 7,111 | 10 | 5.2 | 88 |
| | ROR-1 | Sawtooth Hat. | 4/14 | 165 | 5/4 | 4,313 | 20 | 2.6 | 89 |
| | RDR-3 | S. F. Salmon River | 4/17 | 76 | 5/14 | 4,193 | 27 | 1.9 | 85 |
| | LDR-1 | Rapid River | 4/12 | 370 | 4/25 | 9,422 | 13 | 4.0 | 98 |
| | LDR-4 | Grande Ronde River | 6/4 | 135 | 6/23 | 6,868 | 19 | 2.7 | 79 |
| | RDR-2 | Dworshak NFH | 4/4 | 248 | 4/27 | 6,403 | 23 | 2.7 | 94 |
| 1986 | LDY-3 | hells Canyon | 4/3 | 269 | 4/16 | 9,898 | 13 | 4.0 | 100 |
| | RDY-1 | Sawtooth Hat. | 4/14 | 49 | 4/23 | 2,245 | 9 | 5.7 | 89 |
| | ROY-3 | S. F. Salmon River | 4/23 | 229 | 5/3 | 5.921 | 10 | 5.2 | 98 |
| | LDY-1 | Rapid River | 4/16 | 237 | 4/2D | 10,589 | 4 | 12.9 | 88 |
| | RAJ-2 | Lookingglass Cr. | 4/5 | 38 | 4/14 | 3,741 | 9 | 5.7 | 99 |
| | RAJ-3 | Lookingglass Cr. 3/ | 4/4 | 13 | 4/9 | 333 | 5 | 10.3 | 99 |
| | RAJ-4 | Lookingglass Cr. | 4/5 | 76 | 4/21 | 2,593 | 16 | 3.2 | 95 |
| | RAY-l | Dworshak NFH | 4/2 | 312 | 4/21 | 4,703 | 19 | 3.2 | 97 |
| 1987 | RAR-1 | Dworshak NFH | 4/4 | 1,416 | 4/24 | 11,069 | 20 | 3.1 | 37 |
| | RW-1 | Clearwater River 1/ | 3/2D | 43 | 4/18 | 551 | 29 | 2.1 | 33 |
| | RDF-3 | Clearwater River l/ | 4/2 | 50 | 4/20 | 436 | 18 | 3.4 | 35 |
| | RA4-3 | Clearwater River l/ | 4/7 | 165 | 4/19 | 438 | 12 | 5.1 | 38 |
| | RA4-1 | Clearwater River 1/ | 4/13 | 74 | 4/29 | 334 | 16 | 3.8 | 46 |
| 1988 | LAW-1 | Looklngglass Hat. 2/ | 5/15 | 29 | 6/11 | 3,913 | 27 | 1.9 | 68 |
| | LAUT-1 | Lookingglass Hat. 2/ | 5/16 | 25 | 6/12 | 3,973 | 27 | 1.9 | 68 |
| | ROT-3 | Red River Pond 3/ | 4/15 | 18 | 5/13 | 1,071 | 28 | 2.2 | 58 |
| | LAM-1 | Dworshak NFH 2/ | 4/l | 239 | 5/27 | 3,457 | 56 | 1.1 | 54 |
| | LAT-2 | Dworshak NFH | 3/31 | 1,711 | 4/20 | 17,510 | 20 | 3.1 | 38 |
| | LOT-1 | Dworshak NFH 3/ | 3/28 | 16 | 4/12 | 847 | 15 | 4.1 | 30 |
| | RA7N-1 | Dworshak NFH | 3/31 | 786 | 4/20 | 6,672 | 20 | 3.1 | 38 |
| | RA7N-3 | Dworshak NFH | 3/31 | 571 | 4/21 | 5,823 | 21 | 2.9 | 39 |
| | RAR-1 | Dworshak NFH | 3/31 | 253 | 4/20 | 2.040 | 20 | 3.1 | 38 |
| | RAR-3 | Dworshak NFH | 3/31 | 181 | 4/21 | 1,852 | 21 | 2.9 | 39 |
| | LDK-1 | Clear-water R. Trap l/ | 3/15 | 51 | 4/19 | 736 | 35 | 1.8 | 32 |
| | LDU-3 | Clearwater R. Trap 1/ | 3/18 | 93 | 4/19 | 643 | 32 | 1.9 | 33 |
| | RDK-1 | Clear-water R. Trap l/ | 4/2 | 27 | 4/23 | 499 | 21 | 2.9 | 42 |

TABL10

Table 10. (continued)

| Year | Brand | Release slte | Snake River/ Clearwater River trap: Medlan passage date | Snake River/ Clearwater River trap: Number collected | Lover Granite Dam: Median arrival date | Lover Granite Dam: Number collected | Travel time (days) | Migration rate (km/day) | Mean Q(kcfs) at LGD |
|---|---|---|---|---|---|---|---|---|---|
| | RDK-2 | Clearwater R. Trap 1/ | 4/7 | 18 | 4/22 | 347 | 15 | 4.1 | 45 |
| | RDK-3 | Clearwater R. Trap 1/ | 3/22 | 83 | 4/19 | 575 | 28 | 2.2 | 34 |
| | RDK-4 | Clearwater R. Trap l/ | 4/14 | 31 | 4/30 | 524 | 16 | 3.8 | 53 |
| 1989 | RA4-3 | Clearwater R. Trap 1/ | 3/22 | 7 | 5/6 | 319 | 45 | 1.4 | 81 |
| | LW-1 | Clearwater R. Trap 1/ | 3/24 | 10 | 4/25 | 368 | 32 | 1.9 | 80 |
| | RW-3 | Clearwater R. Trap 1/ | 4/4 | 39 | 5/6 | 632 | 32 | 1.9 | 88 |
| | RA4-1 | Clearwater R. Trap l/ | 4/6 | 41 | 5/7 | 324 | 31 | 2.0 | 90 |
| | RDL(T&X)-1 | Dworshak NFH | 3/3D | 139 | 4/23 | 5,994 | 24 | 2.6 | 82 |
| | RDR-2 | Dworshak NFH 3/ | 3/30 | 2 | 6/l | 127 | 63 | 1.0 | 83 |
| | ** 4/ | Dworshak NFH | 3/31 | 167 | 4/25 | 13,346 | 25 | 2.5 | 83 |
| | ** 5/ | Dworshak NFH 2/ | 4/3 | 48 | 5/31 | 5,740 | 58 | 1.1 | 84 |
| | (R&L)DJ-4 | Imnaha River | 4/10 | 247 | 4/27 | 3,462 | 17 | 3.0 | 91 |
| | (R&L)LDJ-3 | Lookingglass Hat. | 4/5 | 173 | 4/24 | 3,038 | 19 | 2.7 | 87 |
| | (R&L)DJ-2 | Lookingglass Hat. | 4/6 | 212 | 4/22 | 4.171 | 16 | 3.2 | 86 |
| | (R&L)AJ-1 | Looktngglass Hat. 2/ | 5/18 | 131 | 6/14 | 11,622 | 27 | 1.9 | 75 |
| | ** 6/ | Rapid River | 4/18 | 181 | 4/23 | 10,379 | 5 | 10.3 | 105 |
| | LDR-(1-3) | Red River 3/ | 4/17 | 19 | 5/11 | 2,579 | 24 | 2.6 | 99 |
| | RAR-(l-4) | S. F. Salmon River | 5/11 | 21 | 5/13 | 3,148 | 2 | 25.8 | 104 |
| | LAR-(1-4) | Sawtooth Hat. | 4/20 | 14 | 4/23 | 2,155 | 3 | 17.2 | 112 |

l/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15.5).
2/ O-Ape spring chinook salmon.
3/ Fall release of spring chinook.
** 4/ RA7H-1, RD7H-1, and RD7H-3 combined.
** 5/ RAH-1, RDH-1, and RDH-2 combined.
** 6/ LA7H-1 LA7H-3, LDM-1, and LD7H-3 combined.



TABL10

Table 11. PIT-tagged chinook salmon travel time, with 952 confidence interval, from the Snake River trap to Lower Granite Dam, 1989.

| Release date | Median travel time (day) | Confidence Interval* Upper | Lower | Number captured | Percent captured (b) | Average discharge (kcfs) |
|---|---|---|---|---|---|---|
| 03/24/89 | 19.5 | 22 | 15 | 48 | 32.0 | 69.20 |
| 03/27/89 | 16.2 | 18 | 14 | 61 | 40.1 | 70.64 |
| 03/28/89 | 17.7 | 20 | 16 | 57 | 37.7 | 71.67 |
| 03/29/89 | 19.1 | 20 | 16 | 55 | 36.2 | 73.07 |
| 03/30/89 | 18.6 | 22 | 14 | 45 | 29.8 | 74.29 |
| 03/31/89 | 17.7 | 21 | 13 | 57 | 38.0 | 74.39 |
| 04/01 /89 | 16.2 | 18 | 13 | 54 | 36.0 | 73.46 |
| 04/02/89 | 16.7 | 19 | 14 | 57 | 38.0 | 76.24 |
| 04/03/89 | 17.8 | 20 | 15 | 47 | 31.3 | 79.15 |
| 04/04/89 | 15.5 | 18 | 13 | 52 | 34.7 | 78.87 |
| 04/05/89 | 14.5 | 17 | 12 | 45 | 30.0 | 79.81 |
| 04/06/89 | 12.8 | 16 | 9 | 33 | 21.2 | 80.21 |
| 04/07/89 | 14.2 | 15 | 12 | 43 | 28.3 | 83.80 |
| 04/08/89 | 12.8 | 16 | 11 | 34 | 21.9 | 84.67 |
| 04/09/89 | 15.0 | 17 | 13 | 54 | 35.3 | 90.75 |
| 04/1 0/89 | 14.2 | 20 | 11 | 43 | 28.3 | 91.26 |
| 04/I I/89 | 11.4 | 14 | 10 | 55 | 36.4 | 87.93 |
| 04/12/89 | 9.7 | 12 | 8 | 48 | 31.4 | 89.08 |
| 04/I 3/89 | 8.7 | 10 | 8 | 53 | 35.3 | 90.77 |
| 04/I 4/89 | 8.3 | 9 | 7 | 66 | 44.0 | 92.92 |
| 04/15/89 | 9.1 | 10 | 7 | 51 | 34.0 | 99.63 |
| 04/I 6/89 | 5.9 | 7 | 5 | 68 | 45.3 | 97.48 |
| 04/I 7/89 | 5.7 | 6 | 5 | 64 | 43.0 | 102.22 |
| 04/18/89 | 5.1 | 6 | 4 | 66 | 44.6 | 103.48 |
| 04/19/89 | 4.7 | 5 | 4 | 63 | 40.1 | 107.80 |
| 04/20/89 | 4.6 | 5 | 4 | 59 | 39.3 | 109.80 |
| 04/21 /89 | 4.8 | 6 | 4 | 62 | 41.3 | 107.76 |
| 04/22/89 | 5.5 | 6 | 5 | 60 | 40.3 | 99.83 |
| 04/23/89 | 5.5 | 7 | 5 | 69 | 45.1 | 94.95 |
| 04/24/89 | 6.1 | 8 | 5 | 61 | 40.9 | 90.53 |
| 04/25/89 | 7.1 | 8 | 6 | 70 | 46.7 | 87.70 |
| 04/26/89 | 6.3 | 7 | 6 | 66 | 43.7 | 87.00 |
| 04/21/89 | 6.5 | 7 | 6 | 66 | 44.0 | 85.63 |
| 04/28/89 | 6.4 | 7 | 5 | 37 | 56.1 | 86.03 |
| 04/29/89 | 5.7 | 6 | 5 | 34 | 39.5 | 87.43 |
| O4/30/89 | 5.4 | 9 | 5 | 15 | 46.9 | 87.42 |
| 05/01/89 | 4.8 | 6 | 4 | 18 | 51.4 | 89.78 |
| 05/02/89 | 3.8 | 6 | 2 | 8 | 50.0 | 90.98 |
| 05/03/89 | 4.4 | 6 | 3 | 11 | 42.3 | 95.50 |
| 05/09/89 | 3.6 | 4 | 3 | 64 | 42.4 | 111.60 |
| 05/10/89 | 6.2 | 7 | 5 | 62 | 41.3 | 96.32 |
| 05/11/89 | 5.9 | 7 | 5 | 65 | 43.3 | 91.08 |

Table 11. (continued)

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

* Confidence intervals calculated with nonparametric statistics

and ranged from 80 to 112 kcfs. The average daily discharge for the two age-0 chinook salmon groups was 74.2 kcfs. The percent recovery of daily PIT tag groups at the Lower Granite Collection Facility increased from 32.6% prior to April 11, to 44.7% after April 16. Gill Na+K+ ATPase activity level, an indicator of smoltification, was tested three times prior to April 11 and after April 16 (Rondorf et al. In Press). The mean gill ATPase activity (umoles $P_i \cdot mg$ protein$^{-1} \cdot hr^{-1}$) prior to April 11 was 11.5 (range 10.7-12.91, and after April 16 increased to 21.2 (range 17.5-24.1). This indicates a substantial increase in smoltification after April 16.

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

The linear regression of the log of migration rate and log discharge provided the best fit for PIT-tagged chinook salmon groups (N=47, $r^2$=0.663, p=0.000):

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

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

The linear regression analysis on the data stratified by 5 kcfs intervals was conducted and found that the best linear regression equation (N=IO, $r^2$=0.951, P=0.000) was:

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

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

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

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

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

* Confidence intervals calculated with nonparametric statistics

The linear regression analysis of the Clearwater River chinook salmon PIT tag data showed the migration rate-discharge relationship was relatively weak (N=17, $r^2$=0.277, P=O.O30). The strength of the relationship did not increase greatly when the data was stratified by 5 kcfs groups (N=8, $r^2$=0.368, P=O.lll). When the data was pooled, the migration rate-discharge relationship was not significant at the 0.05 level. The lack of PIT tag data from April 16 to May 24, the effect of stock differences, and smoltification status of the late-May migrants are likely causes the relationship was not significant when the data was pooled. These same reasons could account for the low $r^2$ in the unpooled analysis.

The chinook salmon migration rate-discharge relationship for Snake River trap PIT tag groups was examined to determine if there was a difference in this relationship between years (1987-1989). The analysis of covariance was used with the data averaged by 5 kcfs groups. The analysis showed a significant difference in the migration rate-discharge relationship between years (slope of the lines) at the 0.05 level of significance (N=25, F=21.886, P=O.OOO).

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

Percent recovery of Clear-water River trap daily release PIT-tagged chinook salmon groups at Lower Granite Dam ranged between 20.4% and 46.3%., and averaged 32.0%. Seasonal cumulative recovery of PIT-tagged chinook salmon to Lower Granite Dam was 31.0%. Cumulative recovery progressing downstream to Little Goose Dam was 49.9%, and to McNary Dam was 55.6%. Percent recovery of PIT-tagged chinook salmon at Lower Granite Dam that were released from the Clearwater River trap was considerably less than PIT-tagged chinook salmon released from the Snake River trap. There was sufficient data prior to April 17 to compare the percent recovery at Lower Granite Dam of chinook salmon released from the two traps. Using a t-distribution the $H_o$: The mean of the percent recovery at Lower Granite Dam from the beginning of the sample season to April 16 was the same for chinook salmon PIT-tagged at the Snake River trap as it was for chinook salmon PIT-tagged at the Clearwater River trap, was tested. The null hypothesis was rejected, indicating that there was a significant difference at the 0.05 level, between the mean percent recovery of the two groups. Snake River PIT-tagged chinook salmon were recovered at a mean of 33.99, while Clearwater River PIT-tagged chinook salmon were recovered at a mean of 28.6%. There was not enough data at the Clearwater River trap to compare percent recovery after April 16.

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

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

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

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

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

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

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

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

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

| | | | Snake River/ Clear-water 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 LGD |
| 1985 | LDV-1 | Hells Canyon | 5/3 | 44 | 5/11 | 2,821 | 8 | 6.5 | 88 |
| | RDV-1 | Sawtooth Hatchery | 5/7 | 23 | 5/28 | 3,510 | 21 | 2.5 | 92 |
| | RDV-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 |
| | LDV-2 | Dworshak NFH | 4/29 | 88 | 5/4 | 6,699 | 5 | 12.3 | 83 |
| 1986 | RDT-2 | Hells Canyon | 5/l | 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 | 6.6 | 119 |
| | RAJ-4 | Little Sheep Cr. | 5/8 | 16 | 5/30 | 1,340 | 22 | 2.3 | 114 |
| | RAJ-1 | Spring Creek | 5/27 | 14 | 5/26 | 1,628 | Median arrival date at LGD one day before median passage date at Snake R. trap. | | |
| | RAIJ-1 | Cottonwood Cr. | 5/5 | 39 | 5/21 | 4,468 | 16 | 3.2 | 98 |
| | RAIJ-3 | Cottonwood Cr. | 5/5 | 43 | 5/22 | 5,151 | 17 | 3.0 | 100 |
| | RAIJ-4 | Cottonwood Cr. | 5/6 | 29 | 5/18 | 4,114 | 12 | 4.3 | 99 |
| | RDT-4 | Duorshak NFH | 5/8 | 18 | 5/17 | 7,194 | 9 | 6.6 | 99 |
| | LD4-1 | Clearwater R. Trap 1/ | 5/8 | 2 | 5/14 | 1,003 | 6 | 10.3 | 100 |
| | LD4-3 | Clearwater R. Trap 1/ | 5/13 | 5 | 5/22 | 869 | 9 | 6.8 | 98 |
| | RIM-1 | Clearwater R. Trap 1/ | 4/16 | 7 | 4/23 | 371 | 7 | 8.8 | 103 |
| | RD4-3 | Clearwater R. Trap 1/ | 5/l | 1 | 5/8 | 751 | 7 | 8.8 | 94 |
| 1907 | RAIC-1 | Cottonwood Cr. | 4/30 | 7 | 5/4 | 4,886 | 4 | 12.9 | 86 |
| | RAIC-2 | Cottonwood Cr. | 4/30 | 6 | 5/4 | 5,529 | 4 | 12.9 | 06 |
| | RAIC-3 | Cottonwood Cr. | 4/30 | 7 | 5/4 | 5,971 | 4 | 12.9 | 86 |
| | RAIC-4 | Cottonwood Cr. | 4/30 | 8 | 5/5 | 4,936 | 5 | 10.3 | 04 |
| | RAR-3 | Clear Cr. | 4/20 | 59 | 5/l | 3,500 | 11 | 4.7 | 59 |
| | RDR-3 | Dworshak NFH | 4/22 | 58 | 5/l | 4,917 | 9 | 6.8 | 63 |
| | RDK-1 | Clear-water R. Trap 1/ | 4/13 | 6 | 4/26 | 1,192 | 13 | 4.7 | 41 |
| | RDK-2 | Clearwater R. Trap 1/ | 4/20 | 9 | 4/30 | 999 | 10 | 6.2 | 56 |
| | RDK-4 | Clearwater R. Trap 1/ | 4/28 | 2 | 5/4 | 692 | 6 | 10.3 | 84 |
| 1988 | LDT-3 | Hells Canyon | 5/7 | 38 | 5/15 | 6,631 | 8 | 6.5 | 69 |
| | LDT-2 | Sawtooth Hatchery | 5/7 | 19 | 5/25 | 5,332 | 18 | 2.9 | 68 |

TABL13

Table 13. (continued)

| Year | Brand | Release site | Snake River/ Clearwater River trap: Median passage date | Snake River/ Clearwater River trap: Number collected | Lower Granite Dam: Median arrival data | Lower Granite Dam: Number collected | Travel time (days) | Migration rate (km/day) | Mean Q(kcfs) at LGD |
|---|---|---|---|---|---|---|---|---|---|
| | LAI(FW)-1 | Spring Creek | 4/25 | 59 | 5/17 | 8,711 | 22 | 2.3 | 61 |
| | LAI(FiPl)-3 | Spring Creek | 4/24 | 42 | 5/12 | 7,095 | 18 | 2.9 | 58 |
| | RAI(F&M)-3 | Spring Creek | 4/24 | 61 | 5/9 | 11,562 | 15 | 3.4 | 58 |
| 1988 | RAI(F&M)-1 | Wildcat Creek | 4/26 | 155 | 5/11 | 28,569 | 15 | 3.4 | 59 |
| | LD4-3 | Snake River @ Asotln | 5/24 | 30 | 5/30 | 854 | 6 | 8.6 | 76 |
| | RD4-1 | Snake River @ Asotin | 5/24 | 55 | 5/30 | 994 | 6 | 8.6 | 76 |
| | RAT-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 R. Trap l/ | 4/14 | 28 | 4/22 | 1,335 | 8 | 7.7 | 57 |
| | RA4-3 | Clearwater R. Trap l/ | 4/23 | 8 | 5/l | 1,384 | 8 | 7.7 | 49 |
| | RD4-3 | Clearwater R. Trap l/ | 4/29 | 16 | 5/6 | 743 | 7 | 8.8 | 50 |
| 1989 | LDI(S&U)-1 | Dworshak NFH | 5/2 | 123 | 5/7 | 23,573 | 5 | 12.3 | 93 |
| | (R&L)DJ-1 | Little Sheep Creek | 4/25 | 93 | 5/10 | 4,420 | 15 | 3.4 | 95 |
| | (R&L)AJ-2 | Spring Creek | 5/l | a4 | 5/12 | 12,362 | 11 | 4.7 | 101 |
| | (R&L)AJ-1 | Spring Creek | 5/2 | 83 | 5/12 | 10,168 | 10 | 5.2 | 103 |
| | (R&L)AJ-3 | Spring Creek | 5/5 | 70 | 5/14 | 10,877 | 9 | 5.7 | 104 |
| | (R&L)AJ-4 | Wildcat Creek | 4/30 | 134 | 5/8 | 15,037 | 8 | 6.5 | 95 |

l/ Releases made on Clearwater River at U.S. Highway 95 launch (Rkm-15.5).

TABL13

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

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

Table 14. (continued)

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

* Confidence intervals calculated with nonparametric statistics

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

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

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

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

Hatchery steelhead trout migration rate-discharge relationship between years was examined to see if the relationship was constant over years. Analysis of covariance was used to determine if there was a significant difference between years (1987-1989) in migration rate averaged by 5 kcfs intervals. The analysis showed there was no significant difference between years (slopes of the lines) for the hatchery steelhead trout migration rate-discharge relationship (N=30, F=2.782, P=0.082), but there was a significant difference in migration rate (intercepts) between years (N=30, F=8.822, P=0.00l).

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

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

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

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

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

| Release date | Median travel time 'day' | Confidence Interval* Upper | Lower | Number captured | Percent captured (%) | Average discharge (kcfs) |
|---|---|---|---|---|---|---|
| 05/02/89 | 4.6 | 6 | 4 | 47 | 78.3 | 92.74 |
| 05/03/89 | 4.9 | 6 | 4 | 45 | 75.0 | 97.90 |
| E/23/89 | 8'.8 | 11 | 6 | 29 | 38.7 | 62.78 |
| 05/24/89 | 7.0 | 9 | 6 | 41 | 69.5 | 61.86 |
| 25/25/09 | 7.6 | 15 | 5 | 11 | 31.4 | 61.69 |

* 'Confidence intervals calculated with nonparametric statistics

Table 16. PIT-tagged wild steelhead trout travel time, with 95% confidence intervals, from the Snake River trap to tower Granite Dam, 1969.

| Release date | Median travel time (day) | Confidence Interval* Upper | Lower | Number captured | Percent captured (%) | Average discharge (kcfs) |
|---|---|---|---|---|---|---|
| 04/08/89 | 4.1 | 0 | 0 | 4 | 57.1 | 80.90 |
| 04/09/89 | 5.4 | 8 | 5 | 10 | 66.7 | 77.38 |
| 04/10/89 | 6.9 | 12 | 3 | 6 | 54:5 | 78.61 |
| 04/11/89 | 7.8 | 10 | 3 | 6 | 66,67 | 82.39 |
| 04/12/89 | 2.8 | 0 | 0 | 1 | 16.17 | '75.00 |
| 04/13/89 | 5.8 | 0 | 0 | 4 | 57 .41 | 84.80 |
| 04/14/89 | 3.1 | 0 | 0 | 2 | 33.23 | -82.33 |
| 04/15/89 | 3.4 | 0 | 0 | 5 | 71.54 | 88.43 |
| 04/16/89 | 3.3 | 5 | 2 | 16 | 69.66 | 92.27 |
| 04/17/89 | 4.3 | 5 | 3 | 21 | 56.18 | 95.68 |
| 04/18/89 | 2.8 | 4 | 2 | 27 | 67.75 | 95.60 |
| 04/19/89 | 2.3 | 3 | 2 | 43 | 69.34 | 97 '20 |
| 04/20/89 | 2.3 | 3 | 2 | 26 | 65.60 | 107.90 |
| 04/21/89 | 2.2 | 4 | 2 | 40 | 66..7 | 115.30 |
| 04/22/89 | 2.1 | 3 | 2 | 45 | 72.6 | 135.45 |
| 04/23/89 | 2.3 | 3 | 2 | 40 | 6416 | 108.15 |
| 04/24/89 | 2.5 | 3 | 2 | 24 | 60. 0 | 94.70 |
| 04/25/89 | 2.4 | 3 | 2 | 37 | 58.77 | 90.90 |
| 04/26/89 | 2.4 | 3 | 2 | 26 | 50. 0 | 86.95 |
| 04/27/89 | 2.7 | 4 | 2 | 15 | 39.55 | 86.37 |
| 04/28/89 | 3.4 | 5 | 3 | 17 | 43.36 | 87.70 |
| 04/29/89 | 2.6 | 3 | 2 | 17 | 54. 8 | '86.83 |
| 04/30/89 | 3.1 | 4 | 2 | 18 | 81 . 8 | 84.90 |
| 05/01 /89 | 2.9 | 3 | 3 | 30 | 88.2 | 84.37 |
| 05/02/89 | 3.0 | 3 | 2 | 29 | 67. 4 | 88.03 |
| 05/03/89 | 2.7 | 3 | 2 | 34 | 64.2 | 94.07 |
| 05/04/89 | 2.4 | 3 | 2 | 40 | 70.2 | 9.7.95 |
| 05/05/89 | 1.9 | 2 | 2 | 39 | 68.4 | 99.80 |
| 05/06/89 | 2.1 | 2 | 2 | 79 | 73.8 | 103.65 |
| 05/07/89 | 1.9 | 2 | 2 | 117 | 68.8 | 109.40 |
| 05/08/89 | 1.8 | 3 | 2 | 8 | 57.1 | 112.25 |
| 05/09/89 | 1.7 | 2 | 2 | 80 | 63.5 | 113.55 |
| 05/10/89 | 1.8 | 2 | 2 | 87 | 65.9 | 114.80 |
| 05/11/89 | 2.0 | 3 | 2 | 25 | 59.5 | 109.70 |
| 05/12/89 | 2.5 | 3 | 2 | 37 | 80.7 | 98.05 |
| 05/13/89 | 2.8 | 3 | 2 | 20 | 62.5 | 628.57 |
| 05/14/89 | 2.8 | 5 | 2 | 13 | 72.2 | 727.20 |
| 05/15/89 | 3.9 | 5 | 2 | 14 | 88.4 | '-80.78 |
| 05/l 7/89 | 2.8 | 0 | 0 | 5 | 62.5 | 628.80 |
| 05/18/89 | 3.1 | 0 | 0 | 2 | 100.0 | 10080.27 |

Table 16. (continued)

| Release date | Median travel time (day) | Confidence Interval* Upper | Lower | Number captured | Percent captured (%) | Average discharge (kcfs) |
|---|---|---|---|---|---|---|
| 05/19/89 | 3.4 | 5 | 3 | 19 | 73.1 | 74.73 |
| 05/20/89 | 4.8 | 7 | 4 | 10 | 71.4 | 66.68 |
| 05/21/89 | 4.6 | 9 | 3 | 7 | 53.8 | 65.18 |
| 05/22/89 | 3.7 | 5 | 2 | 6 | 66.7 | 65.05 |
| OS/24189 | 4.3 | 6 | 3 | 12 | 92.3 | 62.65 |
| 05/26/89 | 5.7 | 0 | 0 | 2 | 50.0 | 61.17 |
| 06/08/89 | 5.9 | 0 | 0 | 5 | 71.4 | 90.95 |

* Confidence intervals calculated with nonparametric statistics

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

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

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

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

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

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

Wild steelhead trout migration rate-discharge relationship was examined to see if the relationship is constant over years. The analysis of covariance was use to determine if there was a significant difference between years (1987-1989) in migration rates using groups averaged by 5 kcfs intervals. The analysis showed no significant difference between years for the slopes of the wild steelhead trout migration rate-discharge relationships (N=25, F=l.214, P=O.319), nor was there a significant difference in migration rate (intercept) between years (N=25, P=l.301, P=0.293).

Percent recovery of daily wild steelhead trout PIT tag release groups at Lower Granite Dam ranged from 39.5% to 92.32, and averaged 65.8%. Seasonal cumulative recovery of PIT-tagged wild steelhead trout to Lower Granite Dam was 65.1%, to Little Goose Dam 78.7%, and to McNary Dam 81.5%. The percent recovery at the three dams for PIT-tagged hatchery and wild steelhead trout was about the same; 82.5% for hatchery steelhead trout, and 81.5% for wild steelhead trout. This is slightly higher than in 1988 (10% higher for hatchery steelhead trout and 7% higher for wild steelhead trout), and considerably higher (44% higher for hatchery steelhead trout and 25% higher for wild steelhead trout) than in 1987. The increase in interrogation of both hatchery and wild steelhead trout may be due to increased survival associated with better water conditions during the 1989 migration period than were available in the drought years 1988 and 1987. The dramatic increase over 1987 is partially due to an increased fish guiding efficiency from raising the operating gates at Lower Granite Dam prior to the 1988 migration season.

Uigration rates for hatchery and wild steelhead trout were significantly different. The slopes of the migration rate-discharge regression lines for hatchery and wild steelhead trout, grouped by 5 kcfs increments, were tested with the analysis of covariance and found to not be significantly different (N=24, F=2.677, P=O.117). Since the migration rate-discharge relationships for

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

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

* Confidence intervals calculated with nonparametric statistics

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

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

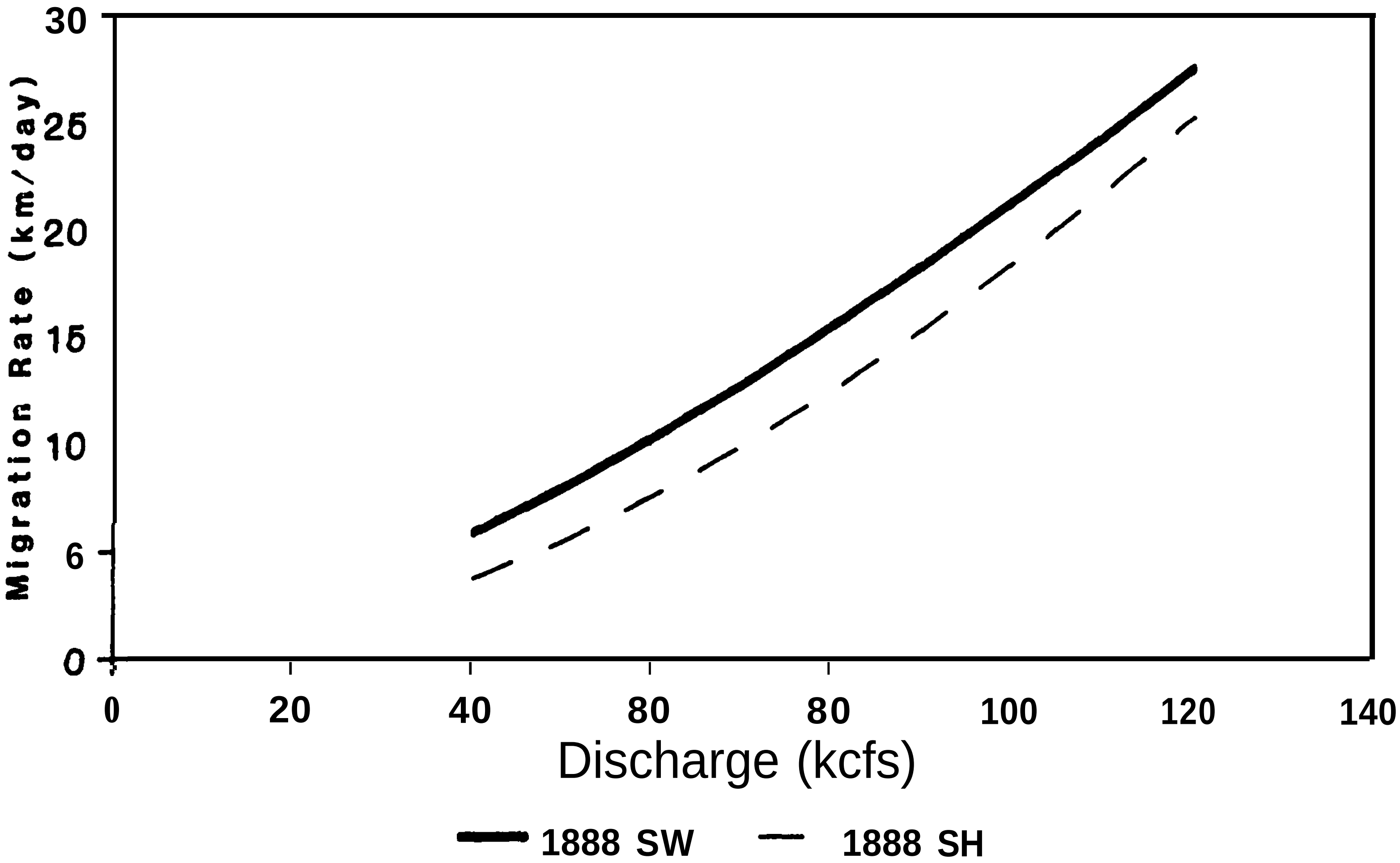



Figure 8. Relationship between travel time through Lower Granite Reservoir and discharge for hatchery steelhead trout and wild steelhead trout averaged by 5,000 cfs groups, 1989.

## SUMMARY

The number of chinook salmon released in 1989 was up 2.79, and the number of steelhead trout released was down 19.0% from 1988. Hatchery production of chinook salmon and steelhead trout released above Lower Granite Dam was 20,229,754 (11,479,606 chinook salmon and 8,750,148 steelhead trout) in 1989. Of these, 674,114 chinook salmon and 291,728 steelhead trout (5.9% and 3.3% of the total releases, respectively) were freeze-branded and released as 40 unique chinook salmon groups and 13 unique steelhead trout groups. The number of freeze-branded chinook salmon and steelhead trout was down 6.7% and 46.92, respectively, from 1988. Idaho did not brand steelhead trout at any facilities except DNFH in 1989.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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