Smolt Condition and Timing of Arrival at Lower Granite Reservoir

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SMOLT CONDITION AND TIMING OF ARRIVAL
AT LOWER GRANITE RESERVOIR

Annual Report

by

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ABSTRACT

Hatcheries released 9.3 million chinook salmon and 6.3 million steelhead smolts and presmolts upriver from Lower Granite Reservoir for migration in spring, 1984.

We operated smolt monitoring traps at Whitebird from March 14 to May 12, Snake River from March 22 to May 15 and Clearwater from March 29 to May 13. Peak passage of yearling chinook salmon occurred the third week in April at both Whitebird and Snake River traps. Passage of steelhead was still increasing when high water stopped trapping in mid-May.

Median migration rates for branded chinook salmon between release sites and Whitebird were 3, 17 and 15 miles/day for Rapid River, South Fork Salmon and Decker Flat smolts, respectively, an average of 11.6 miles/day. Average migration rate for these three groups between Whitebird and Snake River trap was 28 miles/day. Average migration rate between release sites and Snake River (the head of Lower Granite Reservoir) was 13.2 miles/day and from that point on through the reservoir to the dam, 1.9 miles/day.

Salmon River discharge, when considered along with other environmental factors, had the greatest effect on migration rate of smolts branded both at hatcheries and at the Whitebird trap and migrating to the head of Lower Granite Reservoir.

Migration rate for steelhead released from Dworshak Hatchery and recaptured at the Clearwater trap was 34 miles/day.

Survival rates to the Snake River trap of branded chinook salmon smolts released at Hells Canyon Dam, Rapid River, South Fork Salmon and Decker Fiat were 52%, 65%, 68% and 35%, respectively.

Classical descaling, where at least 40% of the scales are missing from at least two of five areas on the side of a smolt, ranged from 0 to 5.3% at hatcheries for chinook salmon and was less than 1% for steelhead. Descaling rate often increased about 1% at release sites.

Classical descaling at Whitebird, Clearwater and Snake River traps averaged 4.5, 2.5 and 1.5% for chinook salmon, 2.1, 0.4 and 1.4% for wild steelhead and 8.7, 4.1 and 5.5% for hatchery steelhead, respectively.

Scattered descaling, where at least 10% of scales are missing from at least one side of a fish, was always more extensive than was classical descaling, ranging from 2.5 times greater for Clearwater hatchery steelhead to 6.8 times greater for Clearwater wild steelhead.

Mean total length of chinook salmon yearlings was the same at all the traps, i.e., 128 mm (117 mm fork length) $\pm$ 1 mm. The largest chinook salmon smolts came from Dworshak National Fish Hatchery on the Clearwater River. Hatchery steelhead were smallest ($\bar{x}$ = 203 mm) at the Clearwater

R9R2RSSM

trap and largest (x = 239 mm) at the Whitebird trap. Wild steel head were also smallest at Clearwater trap (x = 178 mm) and largest at Whitebird trap (x = 193 mm).

Purse seining to evaluate rates of descaling before and after smolts passed Lower Granite Dam was largely ineffective since we were unable to catch sufficient numbers of smolts in the tailrace, and winds in the forebay area altered descaling rates in sampled smolts.

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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 for hydroelectric generation can severely reduce flows necessary for downstream smolt migration. Thus, the NWPPC Columbia River Basin Fish and Wildlife Program proposed a "water budget" for augmenting spring flows.

The water budget in the Columbia's Snake River tributary is 1.9 million acre-feet of stored water for use between April 15 through June 15. To provide information on smolt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game, through BPA funding, monitors the daily passage of smolts at the head of Lower Granite Reservoir and 102 miles upriver at Whitebird, Idaho, on the Salmon River. This information allows the dam operations personnel to anticipate river discharge needs into Lower Granite Reservoir and plan for effective passage or collection for transport of smolts arriving at Lower Granite Dam.

Additionally, the IDFG smolt monitoring project collects data on relative species composition, hatchery vs. wild ratios, travel time, migration rate, and smolt condition relative to scale loss. By monitoring smolt passage at the head and at the dam of Lower Granite Reservoir, migration rates under riverine and reservoir conditions can be compared and determined under various environmental conditions. By having monitoring sites on both the Snake and Clearwater arms of Lower Granite Reservoir, the migration timing of smolts from each drainage can be determined individually. Also, the relative composition of hatchery and wild stocks of steelhead can be determined as well as information useful to document the rebuilding of wild stocks which is being undertaken in the Fish and Wildlife Program and other projects.

Within the short life span of the smolt monitoring program, we have yet to encounter a lower than normal spring runoff as occurred in 1973 and 1977. We believe smolt monitoring will be most beneficial under such conditions, as low flows will slow the migration. In such a year, knowledge of when most smolts have left tributaries and entered Lower Granite Reservoir will allow water budget managers to make the most timely use of the limited water budget resource. Perfecting the smolt monitoring technique in years prior to such a low water condition will increase the probability that we can maximize smolt survival through water budget management.

During 1983, the initial year of smolt monitoring, we sampled with a migrant dipper trap in the Snake River downstream from the Snake and Clearwater rivers confluence and a migrant scoop trap on the Salmon River near Whitebird. We also tested the applicability of electrofishing as a smolt monitoring technique on stretches of the Snake, Salmon and Clearwater rivers (Scully et al. 1984).

Information obtained in the initial year led us in 1984 to:

1. Again fish the Salmon River scoop trap near Whitebird.
2. Move the Snake River dipper trap above the Snake-Clearwater rivers confluence.
3. Install a new trap at the head of Lower Granite Reservoir on the Clearwater River.
4. Discontinue electrofishing.
5. Purse seine above and below Lower Granite Dam.

The continuing objectives of the project are to:

1. Develop a technique to index the relative abundance of smolts entering Lower Granite Reservoir throughout the outmigration season.
2. Establish timing and success of outmigration for the various groups of hatchery-produced and wild chinook salmon and steelhead smolts as they leave the Salmon River drainage.
3. Establish travel time from the Salmon River index site at Whitebird to the index site at the upper end of Lower Granite Reservoir.
4. Correlate travel time with river flows from index sites to Lower Granite Reservoir and Dam.
5. Assist in estimating total fish abundance and collection efficiency at Lower Granite Dam.
6. Determine where, when and to what extent descaling occurs to chinook salmon and steelhead smolts released from Snake River hatcheries above Lower Granite Dam and develop management alternatives to reduce scale loss.

Additionally, we used a purse seine to evaluate descaling rates on smolts before and after they passed Lower Granite Dam. This objective was based on observations in 1983 (Delarm et al. 1984) of abnormally high descaling rates at the dam (Little Goose) immediately downriver from Lower Granite Dam.

Information obtained by this project is intended to assist the Water Budget Center and Idaho's hatchery and natural anadromous fish emigration. Hatchery smolt release sites and smolt monitoring index sites are shown in Figure 1.

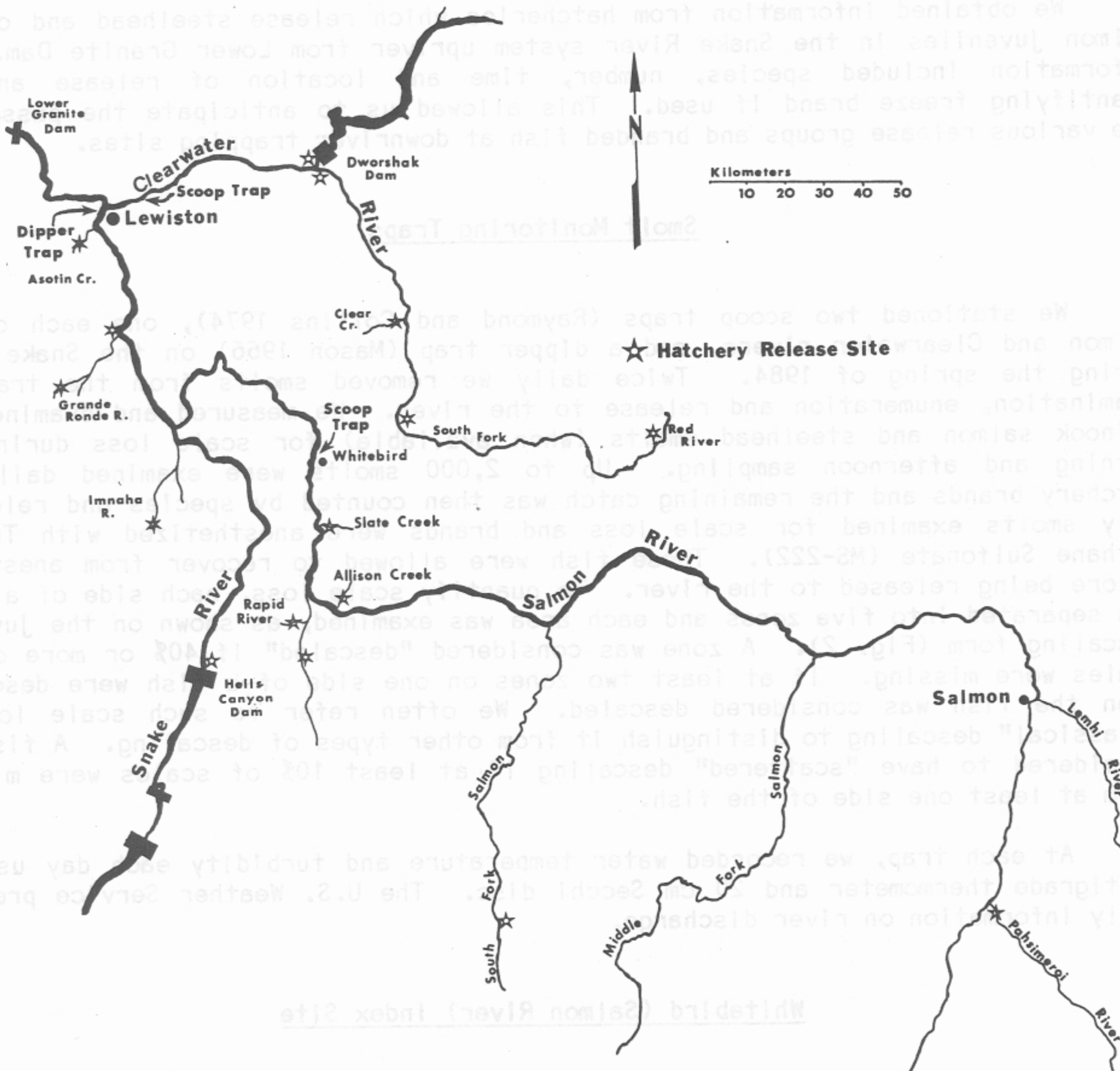


Figure 1. Hatchery release sites, smolt traps, impoundments and river sections relevant to the smolt monitoring project in 1984.

METHODS

Releases of Hatchery-Produced Smolts

We obtained information from hatcheries which release steelhead and chinook salmon Juveniles in the Snake River system upriver from Lower Granite Dam. The information included species, number, time and location of release and the identifying freeze brand if used. This allowed us to anticipate the passage of the various release groups and branded fish at downriver trapping sites.

Smolt Monitoring Traps

We stationed two scoop traps (Raymond and Collins 1974), one each on the Salmon and Clearwater rivers, and a dipper trap (Mason 1966) on the Snake River during the spring of 1984. Twice daily we removed smolts from the trap for examination, enumeration and release to the river. We measured and examined 150 chinook salmon and steelhead smolts (when available) for scale loss during the morning and afternoon sampling. Up to 2,000 smolts were examined daily for hatchery brands and the remaining catch was then counted by species and released. Only smolts examined for scale loss and brands were anesthetized with Tricain Methane Sulfonate (MS-222). These fish were allowed to recover from anesthesia before being released to the river. To quantify scale loss, each side of a smolt was separated into five zones and each area was examined, as shown on the Juvenile descaling form (Fig. 2). A zone was considered "descaled" if 40% or more of the scales were missing. If at least two zones on one side of a fish were descaled, then the fish was considered descaled. We often refer to such scale loss as "classical" descaling to distinguish it from other types of descaling. A fish was considered to have "scattered" descaling if at least 10% of scales were missing from at least one side of the fish.

At each trap, we recorded water temperature and turbidity each day using a centigrade thermometer and 20 cm Secchi disc. The U.S. Weather Service provided daily information on river discharge.

Whitebird (Salmon River) Index Site

We installed the Salmon River scoop trap one kilometer below the mouth of Whitebird Creek (RM 52.6). The trapping site was located on the outside of a bend in the river immediately downriver from a rock shelf, a location which we believe concentrates downstream migrants both laterally and vertically making them more susceptible to capture. River width at this point is about 70 m, and river depth ranged from 2 m at 6,000 cfs to 5 m at 25,000 cfs. We operated the trap from March 14 until May 12, 1984, when high water forced termination. We enlarged the rear drum screen diameter prior to the 1984 season from 45 cm to 60 cm to reduce loss of smolts over the screen during river surges.

TRAP JUVENILE DESCALING FORM (RECORDER________)

DATE________ SITE________ TIME________ SECCHI DISC________

H_2O TEMP.________ DISCHARGE________ TOTAL CHINOOK________ TOTAL STEELHEAD________

TOTAL SOCKEYE________ TOTAL YOY CHINOOK________ TRAP DOWNTIME (HRS.)________

BRAND USED________ DAILY NO. BRANDED________ NO. EXAM. FOR HATCHERY BRANDS:

EFFICIENCY: STEELHEAD________ CHINOOK________

NO. FISH CLIPPED:	NO. EXAM. FOR CLIPS:	NO. CLIPPED RECAPTURES:
CH________	CH________	CH________
SH________	SH________	SH________
SW________	SW________	SW________

REMARKS____

RIGHT LEFT

6. SCATTERED 7. EYE/HEAD INJURIES 8. DEAD

	DESCALED CHINOOK					DESCALED STEELHEAD			
	Length	Descal	Length	Descal		Length	Descal	Length	Descal
1					1				
2					2				
3					3				
4					4				
5					5				
6					6				
7					7				
8					8				
9					9				
10					10				
11					11				
12					12				
13					13				
14					14				
15					15				
16					16				
17					17				
18					18				
19					19				
20					20				
21					21				
22					22				
23					23				
24					24				
25					25				

TOTAL FISH SAMPLED ________ TOTAL FISH SAMPLED ________

TOTAL DESCALED ___ % DESCALED ___ TOTAL DESCALED ___ % DESCALED ___

40% DESCALING (ABOVE BELLY) IN ANY SINGLE (1) AREA CONSTITUTES DESCALING.
ANY TWO (2) AREAS ON THE SAME SIDE RESULTS IN FISH CLASSIFIED AS DESCALED.

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

We freeze branded smolts at Whitebird (Mighell 1969) to use in estimating travel time from the Lower Salmon River to Lower Granite Reservoir. We changed the brand at three-day intervals to document changes in travel time as environmental conditions changed. We branded with 19 unique marks during the 1984 trapping season. We branded 1,000 smolts daily when fish were available and catch was less than 3,000, and up to 2,000 per day when catch exceeded 3,000 per day. The remaining catch was counted and returned to the river.

Trap efficiency tests were conducted from late March until mid April by releasing marked smolts one kilometer upriver for later recapture at the trap. The ratio of recaptures to marks released is the estimate of trap efficiency, i.e., the fraction of smolts passing the trap which are captured. Efficiency tests were not done after mid-April because river surges washed smolts from the trap; thus, efficiency estimates would have been low.

Snake River Index Site

The Snake River migrant dipper trap, which was located at Red Wolf Crossing Bridge below Clarkston, Washington, during spring 1983, was ineffective as a smolt monitoring tool (Scully et al. 1984). Consequently, this trap was moved to the Interstate Bridge on the Snake River between Lewiston, Idaho, and Clarkston, Washington, for the 1984 trapping season. We added additional leads to increase the trap opening from 7.9 m to 12.2 m. Electrical power was provided by a 3,500 watt gasoline-powered generator until mid-May after which time a public utility electrical line was installed at the trap. The dipper trap was positioned about 40 m downstream from the Interstate Bridge and was attached to bridge piers by steel cables. The location is at the head of Lower Granite Reservoir 0.5 km above the confluence of the Snake and Clearwater rivers. River width and depth at this location were approximately 260 m and 12 m, respectively.

Trap operation began March 22, 1984, and terminated on May 15, 1984, due to high river flow. Flows dropped enough by June 10 to renew trapping operations but only until June 15, when flow again became excessive.

To estimate trap efficiency, fish were marked with a caudal fin clip every fourth day and released 5.5 km above the Snake River trap. Fish examined for brands were also checked for caudal fin clips.

Clearwater River Index Site

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

Trap operation began March 14, 1984, but due to a sudden dramatic increase in discharge that evening, the trap incurred structural damage and was not repaired and operational again until March 29. Trap operation continued from that date until May 13, when high water prevented further trap use.

Trap efficiency tests were conducted periodically throughout the season by releasing fin clipped smolts 7 km upriver from the trap. On several occasions, when not enough fish were captured in the Clearwater trap for marking, fish were caudal fin clipped at the Snake River trap and transported to the Clearwater River release site. All fish captured in the trap were examined for brands and fin clips.

We used the Statistical Analysis System (SAS) computer software at the University of Idaho to do stepwise multiple regressions to select models to describe the influence of several abiotic factors on the variable migration rate (miles per day). We did three sets of regressions, one for hatchery branded smolts migrating between release sites and the Whitebird trap, a second for hatchery branded smolts migrating between the Whitebird trap and the Snake River trap and a third for a series of smolt groups which we branded and released at Whitebird then migrated past the Snake River trap.

Variables considered in calculating the models were:

Day length (DL) = the average number of hours of daylight per day minus 12 hours during the migration interval. The migration interval is the time elapsed between the date that 50% of the migrants passed the beginning location until 50% of the migrants passed the ending location.

Date = the number of days after March 1 that hatchery smolts were released.

Year = 1983 or 1984 used as 1 or 2, respectively, in the analysis.

For the regressions of migrations between release sites and Whitebird, we also included the variables:

Salmon River Discharge (Q) = the average daily discharge in 1,000 cfs at the Whitebird gauge during the migration interval.

Salmon River Temperature (T) = the average daily water temperature in degrees C at the Whitebird trap during migration interval.

Salmon River Transparency (S) = the average daily Secchi disc transparency in meters of visibility of the Salmon River at the Whitebird trap during the migration interval.

For the regressions of migrations between Whitebird trap and Snake River trap we also included the variable:

Salmon River Discharge (SmnQ) = the average daily discharge in 1,000 cfs at the Whitebird gauge during the first half of the migration interval.

Salmon River Temperature (SmnT) = the average daily water temperature in degrees C at the Whitebird trap during the first half of the migration interval.

Salmon River Transparency (SmnS) = the average daily Secchi disc transparency in meters of visibility of the Salmon River at the Whitebird trap during the first half of the migration interval.

Snake River Discharge (SnkQ) = the average daily discharge in 1,000 cfs at the Anatone gauge during the last half of the migration interval.

Snake River Temperature (SnkT) = the average daily water temperature in degrees C at the Snake River trap during the last half of the migration period.

Snake River Transparency (SnkS) = the average daily Secchi disc transparency in meters of visibility of the Snake River at the Snake River trap during the last half of the migration period.

Evaluating Smolt Condition at Hatcheries and Release Sites

We examined 100 to 300 smolts from representative groups of chinook salmon and steelhead trout at hatcheries and again at release sites to estimate the percentage of smolts having significant scale loss. The condition of the smolts was compared with that observed at index sites along the migration routes.

Purse Seining

In 1983, smolt descaling rates were much higher in the collection facility at Little Goose Dam than at Lower Granite Dam (Delarm et al. 1984). To determine if smolts were being descaled as they passed Lower Granite Dam or as they entered the collection facility at Little Goose Dam, we seined above and below Lower Granite Dam to compare descaling rates. We wanted to differentiate between spill- and turbine-caused descaling rates by first seining below the dam when all water passing it went through the powerhouse, then seining the same area after spill began, to determine the descaling rate resulting from a mix of spill and turbine passage. To calculate the descaling rate of the spill-passed fish when descaling rate of turbine-passed fish is known, we would use the formula:

$$MDR = \% \text{ Spill } (S) + \% \text{ Turbine } (T)$$

Where MDR = mixed descaling rate
S = descaling rate caused by spillway passage
T = descaling rate caused by turbine passage

and solve for S.

If different regimes of spill and turbine discharge occurred, descaling rates could be determined by using two sets of data and solving the equations simultaneously for both S and T. We would assume that the percentages of smolts in the seined sample which passed the dam via the spillway and powerhouse would be proportional to the percentage of discharge passing these two routes. However, the assumed fraction of smolts in the samples which passed through the turbine would be adjusted depending on the efficiency of the fingerling bypass system.

RESULTS AND DISCUSSION

Hatchery Releases

Chinook

Chinook salmon were reared at six hatcheries in Idaho and two in Oregon for release into the Snake River above Lower Granite Dam in 1984. They were released at nine locations in Idaho, one in Washington and two in Oregon. Ninety-two percent of these smolts were spring, 3.5% were summer and 4.6% were fall chinook salmon (Table 1).

A total of 9.3 million chinook salmon, 80% more than in 1983, were released in 1984. Releases into the Salmon River drainage totaled 4,619,776 spring chinook salmon and 325,683 summer chinook salmon. There were 1,605,000 spring chinook salmon released into the Clearwater River.

Steelhead

In 1984, 6.3 million hatchery-reared steelhead trout were released into the Snake River system above Lower Granite Dam, 82% more than in 1983 (Table 2). There were 1,730,804 "A" steelhead trout and 549,408 "B" steelhead trout released in the Salmon River drainage.

The Snake River system (Hells Canyon, Imnaha River, Grande Ronde River and Asotin Creek) received 2,042,142 "A" steelhead.

The Clearwater River received 1,961,370 "B" steelhead smolts.

Freeze Branded Smolts

Six groups of chinook salmon were branded at hatcheries for release in Idaho. Three of these were released in the Salmon, one in the Snake and two in the Clearwater (Table 1). They made up 1.7%, 3.0% and 1.9% of the hatchery releases to those rivers, respectively.

Table 1. Number of juvenile Chinook salmon released into the Snake River system upriver from Lower Granite Dam between fall, 1983 and summer, 1984.

Release site (hatchery rearing)	Race	Release dates	Number released (branded)	Brand	Remarks
Salmon River					
Rapid River (Rapid River)	Spring	Feb/Mar/84	1,791,650 (23,840)	RDJ-3	
Rapid River (Rapid River)	Spring	April/84	1,454,540		
Decker Flat (McCall)	Spring	3/27-29/84	230,550 (33,930)	LDJ-3	
South Fork (McCall	Summer	4/9-11/84	269,880 (25,560)	LDJ-1	
Pahsimeroi River (Pahsimeroi)	Spring	3/3/84	146,000		
Pahsimeroi River (Pahsimeroi)	Spring	4/3/84	997,030		
Pahsimeroi River (Pahsimeroi)	Summer	4/3/84	55,800		
Snake River and non-Idaho tributaries					
Hells Canyon (Rapid River)	Spring	3/20-21/84	500,850 (85,660)	RDJ-1	
Grande Ronde R. (Lookingglass, OR)	Spring	6/14, 6/18 & 7/17/84	734,180		
Lookingglass Creek (Lookingglass, OR)	Spring	12/22/83	779,560		
Lookingglass Creek (Lookingglass, OR)	Spring	4/5/84	29,920		Pre-smolts
Lookingglass Creek (Lookingglass, OR)	Spring	7/12/84	243,540		Pre-smolts
Imnaha River (Lookingglass, OR)	Spring	4/5/84	29,060		
lmnaha River (Wallowa, OR)	Spring	3/20/84	29,170		
Snake R. at Grande Ronde R. mouth, WA (Hagerman NFH)	Fall	6/5 & 6/13/84	427,191		
Clearwater River					
Red River (Rapid River)	Spring	10/12/83	260,000 (15,000)	LASU-2	
Red River (Rapid River)	Spring	4/16/84	40,000 (15,000)	LASU-4	
Mainstem (RM 40) (Hagerman NFH)	Spring	5/8/84	185,860		

Table 1. Continued.

Release site (hatchery rearing)	Race	Release dates	Number released (branded)	Brand	Remarks
<u>**Clearwater River (continued)**</u>					
Mainstem (RM 40) (Hagerman NFH)	Spring	5/30 $ 6/1/84	233,990		
Clear (Kooskia NFH)	Spring	3/19-21/84	190,600		
Clear Creek (Kooskia NFH)	Spring	3/26/84	47,100		
Mainstem (RM40) (Kooskia NFH)	Spring	3/19-20/84	90,400		
North Fork (Dworshak NFH)	Spring	10/3-4/83	43,860		
North Fork (Dworshak NFH)	Spring	11/2-3/83	31,320		
North Fork (Dworshak NFH)	Spring	3/19-4/4/84	260,520		
Clear Creek (Dworshak NFH)	Spring	3/26/84	169,790		
Clear Creek (Dworshak NFH)	Spring	4/4/84	51,710		

Four groups of branded hatchery steelhead were released in Idaho (Table 2). Two groups went to the Salmon River and one to each of the Snake and Clearwater rivers. Branded steelhead smolts made up 1.9%, 1.0% and 1.0% of the hatchery steelhead released in these three rivers, respectively.

Additionally, we branded 31,411 chinook salmon and 3,066 steelhead trout smolts captured at Whitebird trap on the lower Salmon River (Table 3). Large numbers of chinook salmon began arriving March 22 and continued to be available until late April after which we were unable to obtain the 1,000 smolts daily at the Whitebird trap; a number that we believed were necessary for branding if adequate numbers were to be recaptured at the Snake River trap. Although the steelhead migration past Whitebird began in mid-April, we were never able to capture sufficient steelhead to provide a large release group.

Smolt Monitoring at Migrant Traps

Whitebird Scoop Trap

This trap operated from March 14 until May 12 in 1984 and captured 43,860 yearling chinook salmon, 3,221 steelhead and 3 sockeye smolts. We examined 89% of the chinook salmon for hatchery brands and 100% of steelhead trout arriving at the trap.

Significant passage of chinook salmon began in mid-March and continued until about April 25 (Fig. 3). No significant steelhead passage occurred until April 15 (Fig. 4). Peak passage for chinook was during the interval April 10-17 and for steelhead after April 20. Although trap efficiency appeared to decrease during the later weeks of the season, steelhead catch remained relatively constant, indicating that passage was probably increasing during this period. As was the case in 1983, the relatively small seasonal catch of steelhead is probably attributable to steelhead being larger and migrating deeper in the water column than chinook salmon and passing the trap at a time when trap efficiency is very low. Also, it is believed that brand retention on steelhead was only about 50% (Fred Partridge, IDFG, pers. comm.). We examined 2,945 steelhead and observed that 79% appeared to be of hatchery origin and 21% were wild. Average size of hatchery steelhead was 24% longer, 240 mm vs. 193 mm, and 90% heavier (U.S. Fish and Wildlife Service) than wild steelhead.

River temperature was near 5 C at the initiation of sampling, then rose above 6 C on March 18 and made a slow, erratic rise to near 10 C by May 12 (Fig. 5). Secchi disc transparency ranged from 0.3 to 1.3 meters and fluctuated frequently during the season (Fig. 6). River discharge (Fig. 7) appeared positively correlated with temperature and negatively with transparency. Discharge was lowest at the initiation of sampling (7,500 cfs) and increased to above 20,000 cfs on May 12 when trapping was terminated.

Table 2. Number of juvenile steelhead released into the Snake River system upriver from Lower Granite Dam between fall 1983 and summer 1984.

Release site (hatchery rearinq)	Race	Release dates	Number released (branded)	Brand	Remarks
Salmon River					
Allison Creek (Magic Valley)	B	4/23/84	10,000		
Slate Creek (Magic Valley)	B	4/19-23/84	31,540		
East Fork (Magic Valley)	B	4/25/84	18,860		
Decker Flat (Magic Valley)	A	4/2-25/84	204,170		
Pahsimeroi (Niagara Springs)	A	11/16-20/83	228,800		
Pahsimeroi (Niagara Springs)	A	4/2-24/84	724,250		
Little Salmon River (Hagerman)	A	4/19-26/84	96,430		
Little Salmon River (Hagerman)	B	4/19-26/84	95,600		
East Fork (Hagerman)	B	3/27-4/13/84	393,450		
Decker Flat (Hagerman	A	4/16-17/84	40,320 (21,150)	LAJ-1	
Decker Flat (Hagerman)	A	4/16-17/84	39,760 (22,240)	LAJ-3	
Decker Flat (Hagerman)	A	4/2-5/3/84	397,080		
Hells Canyon (Niagara Springs)	A	11/22-12/3/83	449,070		
Hells Canyon (Niagara Springs)	A	4/30-5/4/84	408,430 (21,620)	RAJ-3	Brands released 4/30
Snake River and non-Idaho tributaries					
Hells Canyon (Hagerman)	A	2/28-3/6/84	50,490		
Grande Ronde River (Wallowa, OR)	A	4/23-5/3/84	541,090		
Imnaha (Lyons Ferry, WA)	A	4/30-5/2/84	330,670		
Grande Ronde River (Lyons Ferry, WA)	A	5/1-3/84	170,790		
Asotin Creek (Lyons Ferry, WA)	A	5/7/84	33,010		

Table 2. Continued.

Release site (hatchery rearing)	Race	Release dates	Number released (branded)	Brand	Remarks
<u>Clearwater River</u>					
Mainstem (RM40) (Dworshak NFH)	B	4/23-5/15/84	1,208,320 (19,970)	RAJ-1	Brands released 5/4
South Fork (Dworshak NFH)	B	4/30-5/6/84	506,930		
Clear Creek	B	5/3-4/84	246,120		

Table 3. Chinook salmon and steelhead trout smolts freeze branded at Whitebird trap In 1984.

Brand	Rotation	Date	Chinook salmon	Steelhead trout
RDE	1	3/19-21	289	0
	2	3/22-24	3,338	3
	3	3/25-25	2,049	0
	4	3/28-30	1,040	1
LDE	1	3/31-4/2	1,443	1
	2	4/3-5	830	0
	3	4/6-8	1,395	1
	4	4/9-11	4,158	5
RAE	1	4/12-14	5,105	2
	2	4/15-17	4,463	25
	3	4/18-20	2,576	454
	4	4/21-23	1,472	353
LAE	1	4/24-26	634	332
	2	4/27-29	483	395
	3	4/30-5/2	550	369
	4	5/3-5	626	254
RDK	1	5/6-8	383	311
	2	5/9-11	287	291
	3	5/12-14	290	269
TOTALS			31,411	3,066

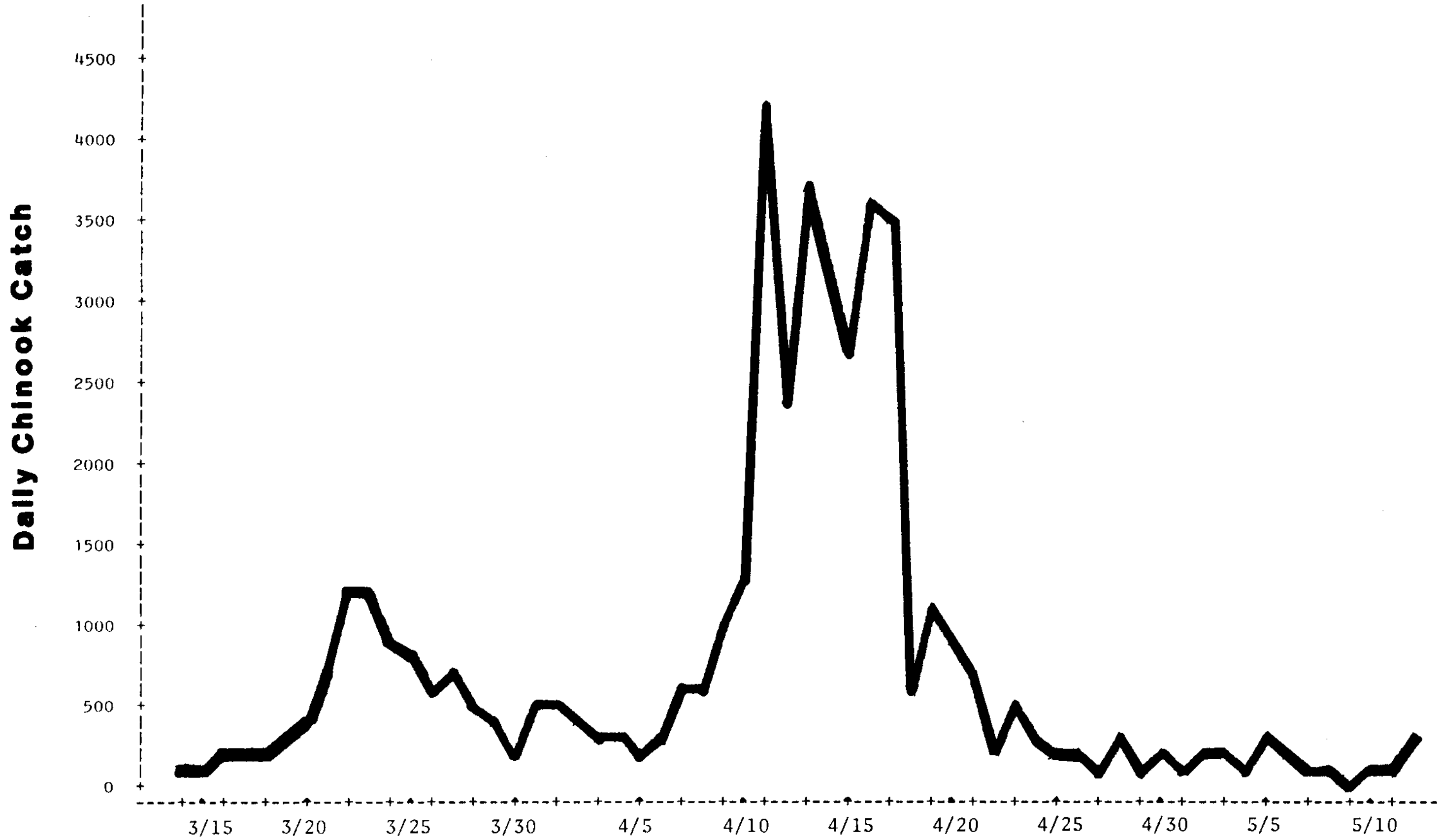


Figure 3. Daily catch of yearling chinook salmon at Whitebird trap, March 14 - May 12, 1984.

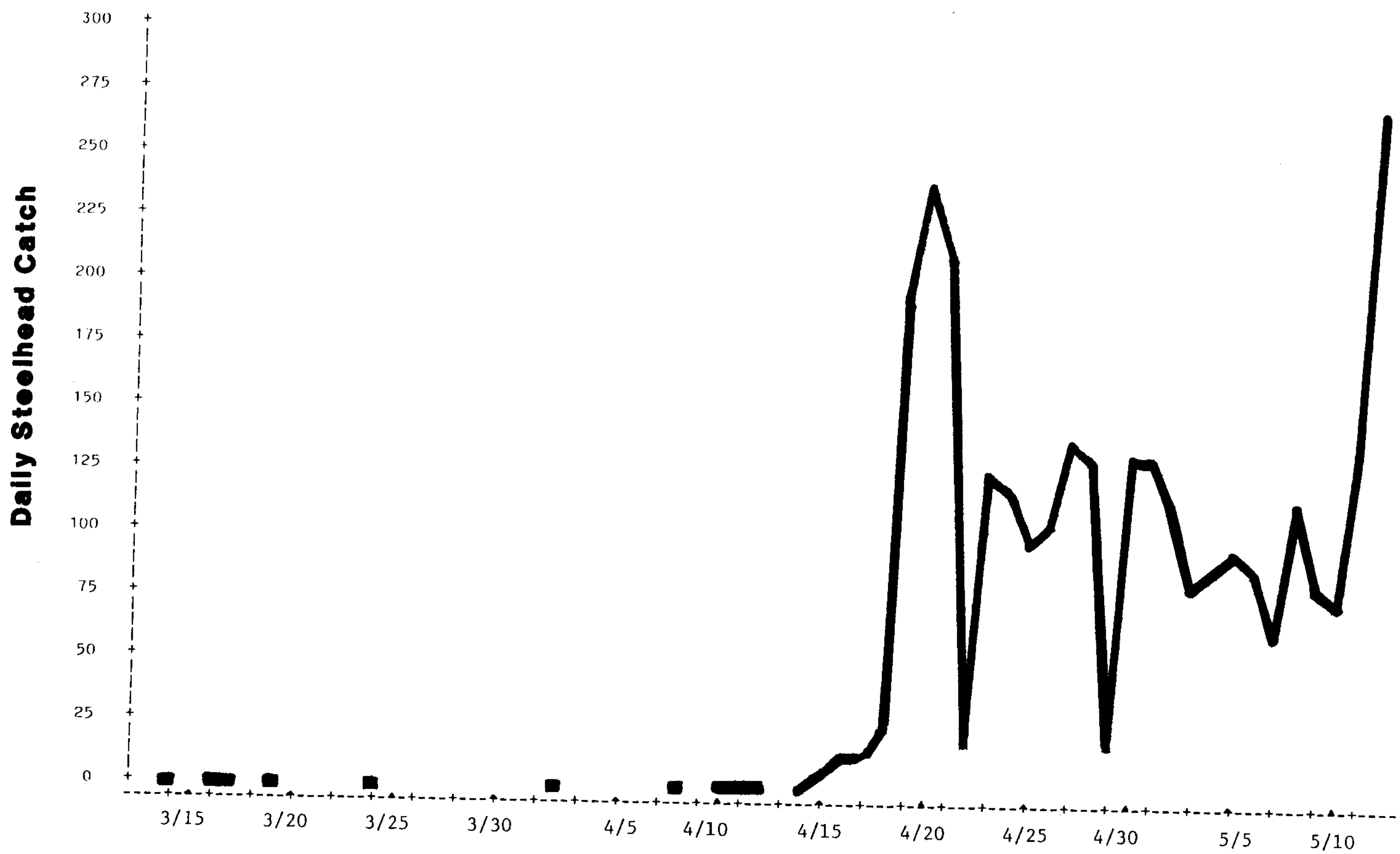


Figure 4. Daily catch of steelhead trout smolts at Whitebird trap, March 14 - May 12, 1984.

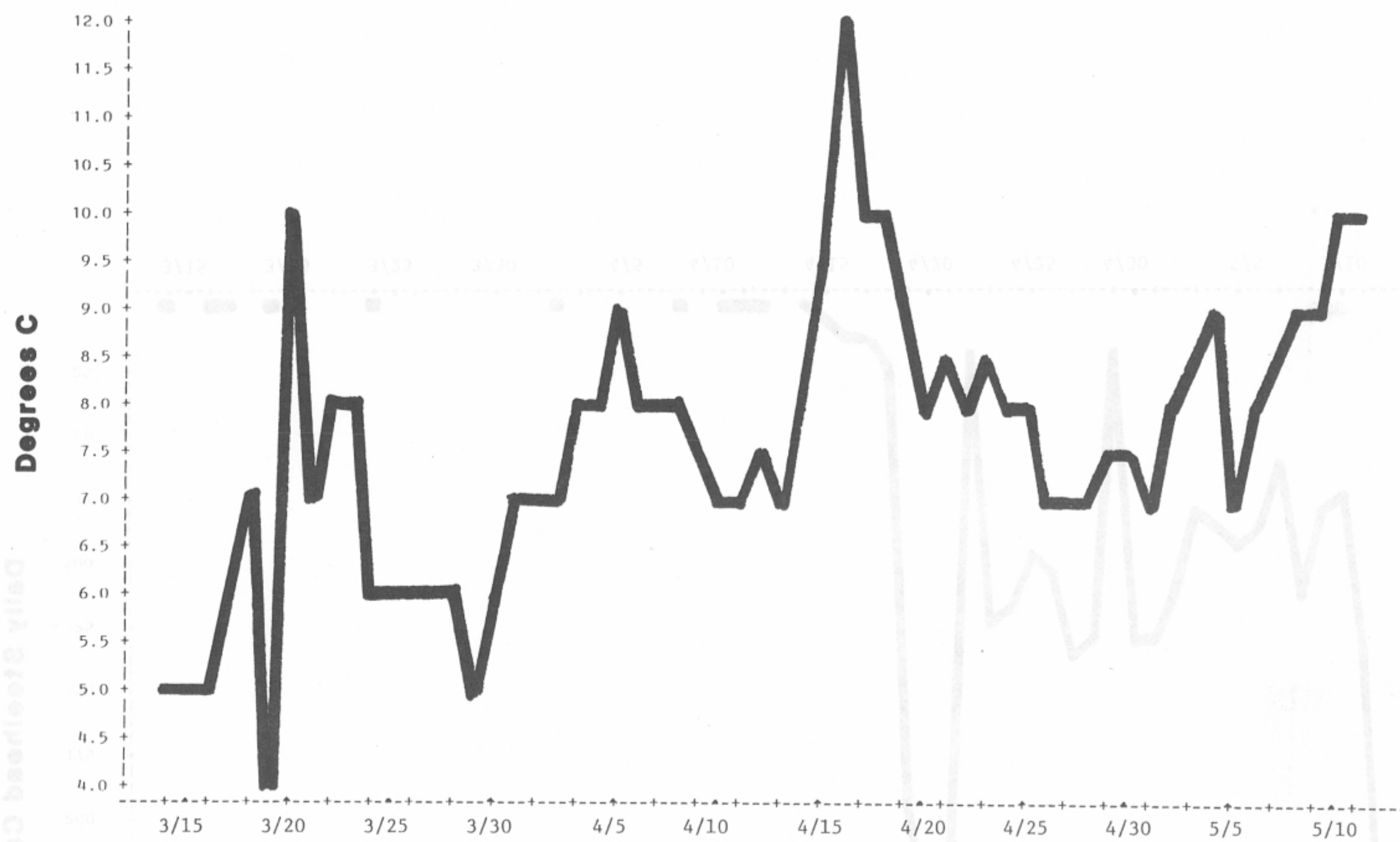


Figure 5. Average daily water temperature in degrees C at Whitebird trap, March 14 - May 12, 1984.

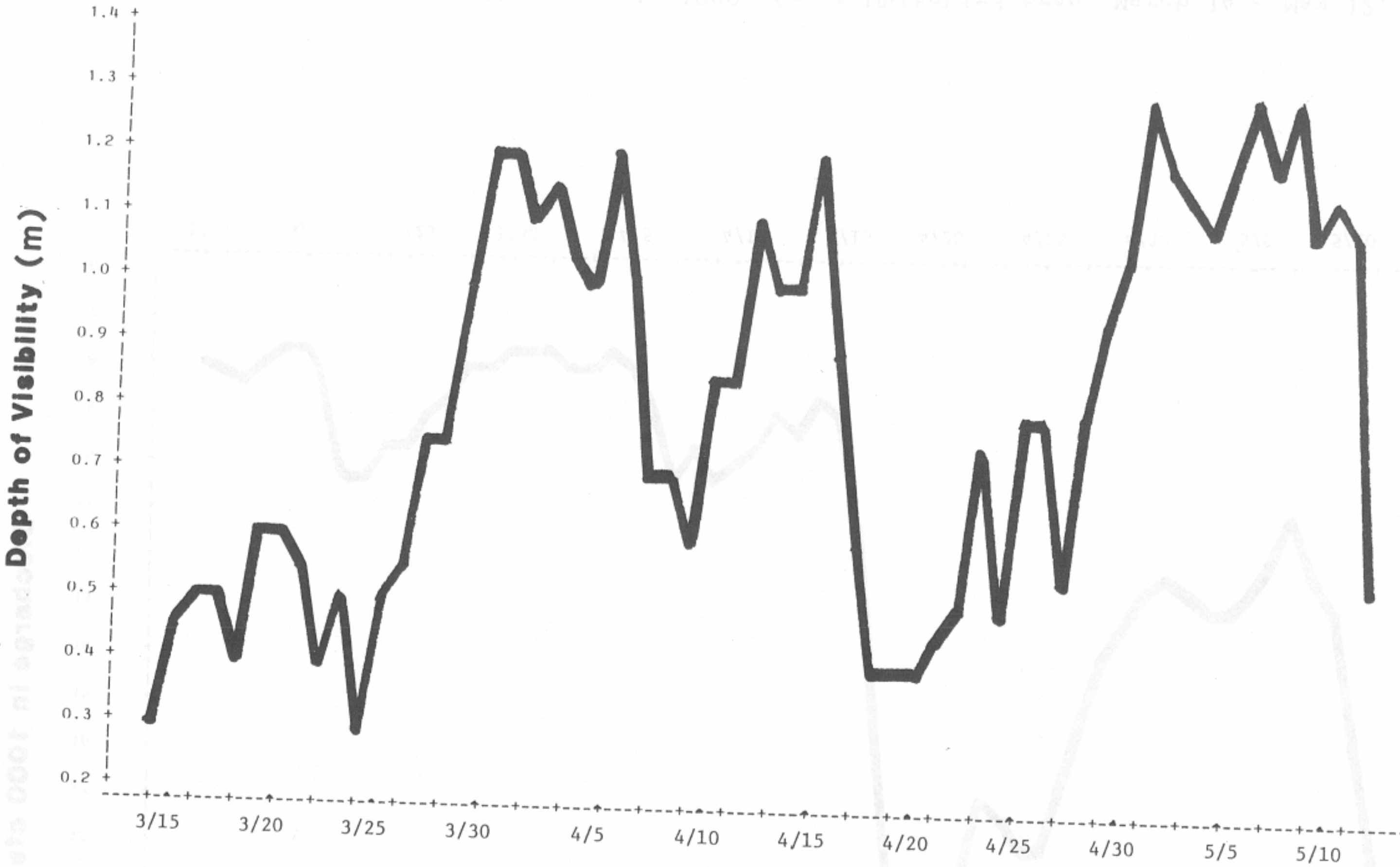


Figure 6. Average daily water transparency in tenths of meters at Whitebird trap, March 14 - May 12, 1984.

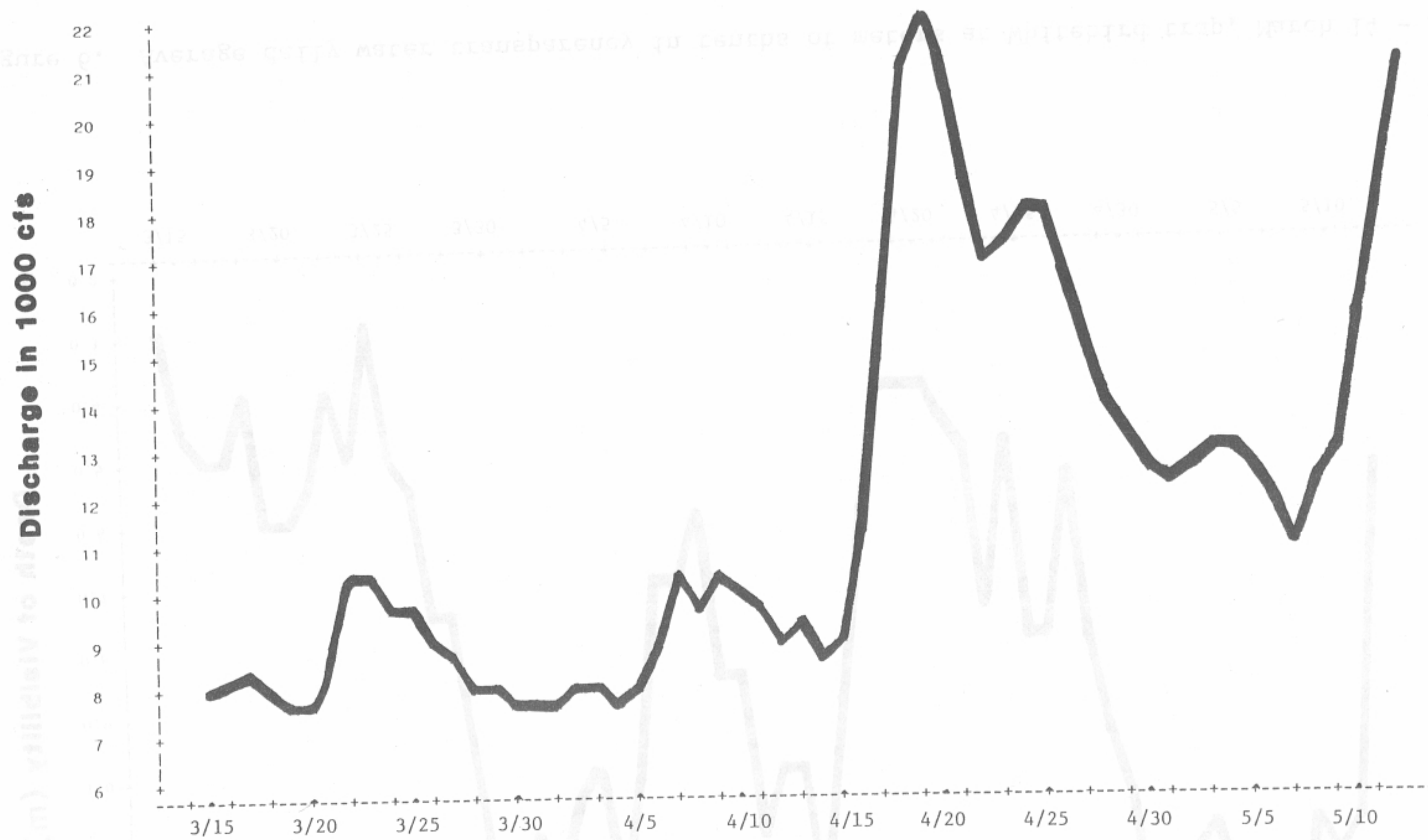


Figure 7. Average daily river discharge in 1000 cfs at Whitebird trap, March 14 - May 12, 1984.

Snake River Dipper Trap

This trap operated from March 22 until May 15 and again from June 10 to June 15 and captured 55,900 yearling chinook salmon, 2,669 zero age chinook salmon, 1,890 steelhead trout (70% hatchery, 30% wild) and 49 sockeye salmon. This catch was nearly 18 times that of 1983 when the trap was located near Red Wolf Crossing Bridge. This year's catch was adequate to document the arrival of chinook salmon smolts at the head of Lower Granite Reservoir. Enough branded smolts from hatchery and Whitebird releases were recaptured to document migration rates and travel time both above and below the Snake River index site. We recaptured 1,495 marked chinook salmon from four hatchery branded chinook salmon groups (total release=169,000) and no branded steelhead trout from three hatchery branded steelhead groups (total release=65,000).

Daily chinook salmon catches were decreasing when we began sampling on March 22 from about 1,400 smolts per day to less than 500 on March 28 (Fig. 8). This probably reflected the passage of chinook salmon which had been released at Hells Canyon March 20 and 21. The major passage of chinook salmon April 17-22 was associated with the first significant increase in discharge from below 80,000 cfs to above 100,000 cfs. Daily catch peaked at near 8,000/day on April 18, and by April 23, daily catch had fallen to less than 2,000. When the major runoff began in mid-May, only a minor increase in chinook salmon passage occurred. We were unable to sample during peak runoff.

Steelhead trout began passing the Snake River trap in significant numbers (more than 25 per day) with the rise in discharge which began April 17, but the major passage began in early May and continued to increase until we stopped sampling on May 15 (Fig. 9).

Age zero chinook and sockeye salmon were never significant in the catch (Figs. 10, 11). Both species began arriving daily on April 30 and continued until sampling terminated May 15. When sampling resumed on June 10, however, the age zero chinook were larger and, presumably, were hatchery-reared smolts released near the Grande Ronde River on June 14.

Discharge at the Snake River trap (Fig. 12) was adequate for rapid smolt passage the entire season, never receding below 70,000 cfs. Two peaks occurred, the first on April 20 at 104,000 cfs and the latter on May 31 at near 187,000 cfs (Scott Kiser, U.S. Weather Service, pers. comm.). We stopped operating the trap May 15 when discharge reached 138,000 cfs.

Water temperature (Fig. 13) was 8 C when we began sampling and slowly rose to near 12 C on May 15. Secchi disc transparency (Fig. 14) stayed in a narrow range from 0.3 to 0.7 m during the entire season. The greatest transparency occurred Just prior to the mid-April rise in discharge. Transparency decreased rapidly from 0.6 to 0.4 m from April 17 to April 18.

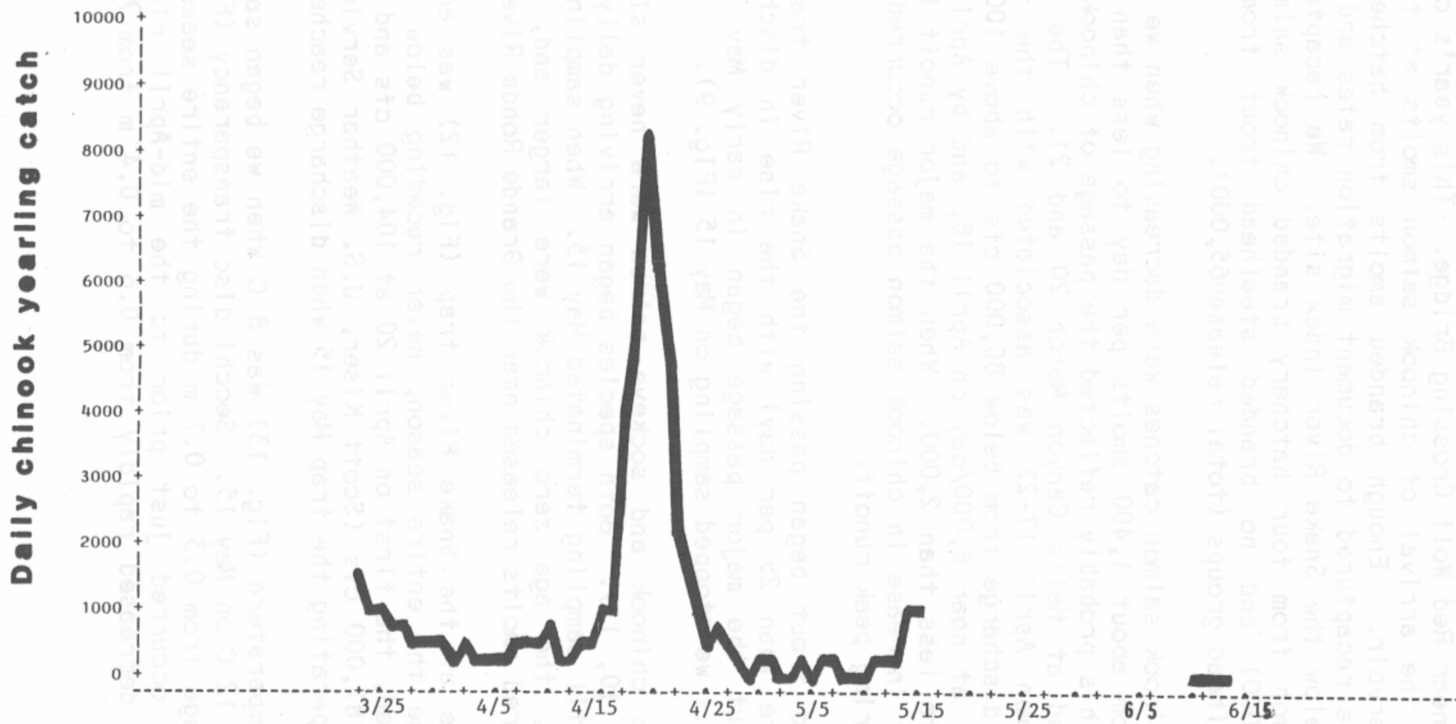


Figure 8. Daily catch of chinook salmon yearlings at Snake River trap, March 23 - June 16, 1984.

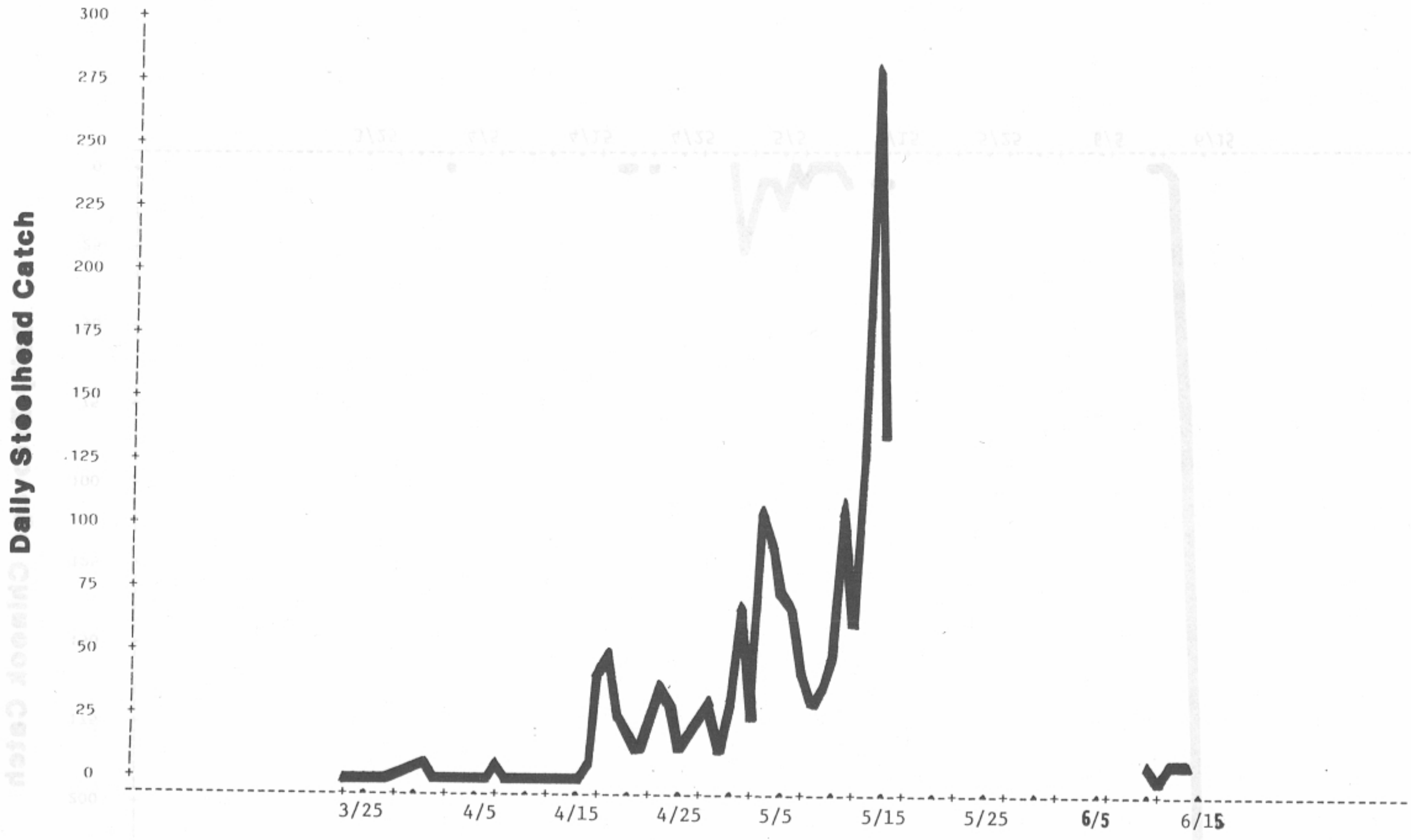


Figure 9. Daily catch of steelhead trout smolts at Snake River trap, March 23 - June 16, 1984.

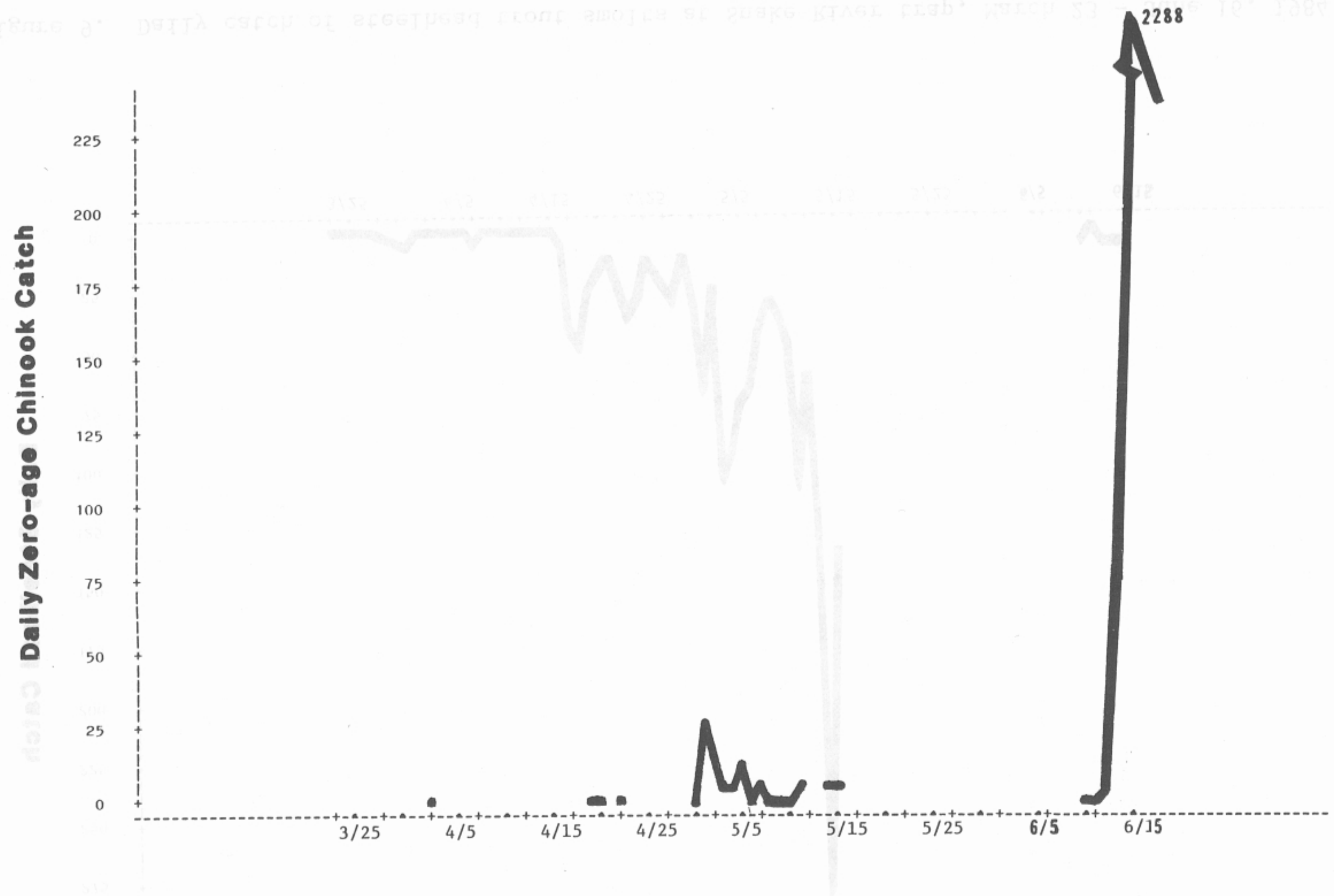


Figure 10. Daily catch of zero-age chinook salmon at the Snake River trap, March 23 - June 16, 1984.

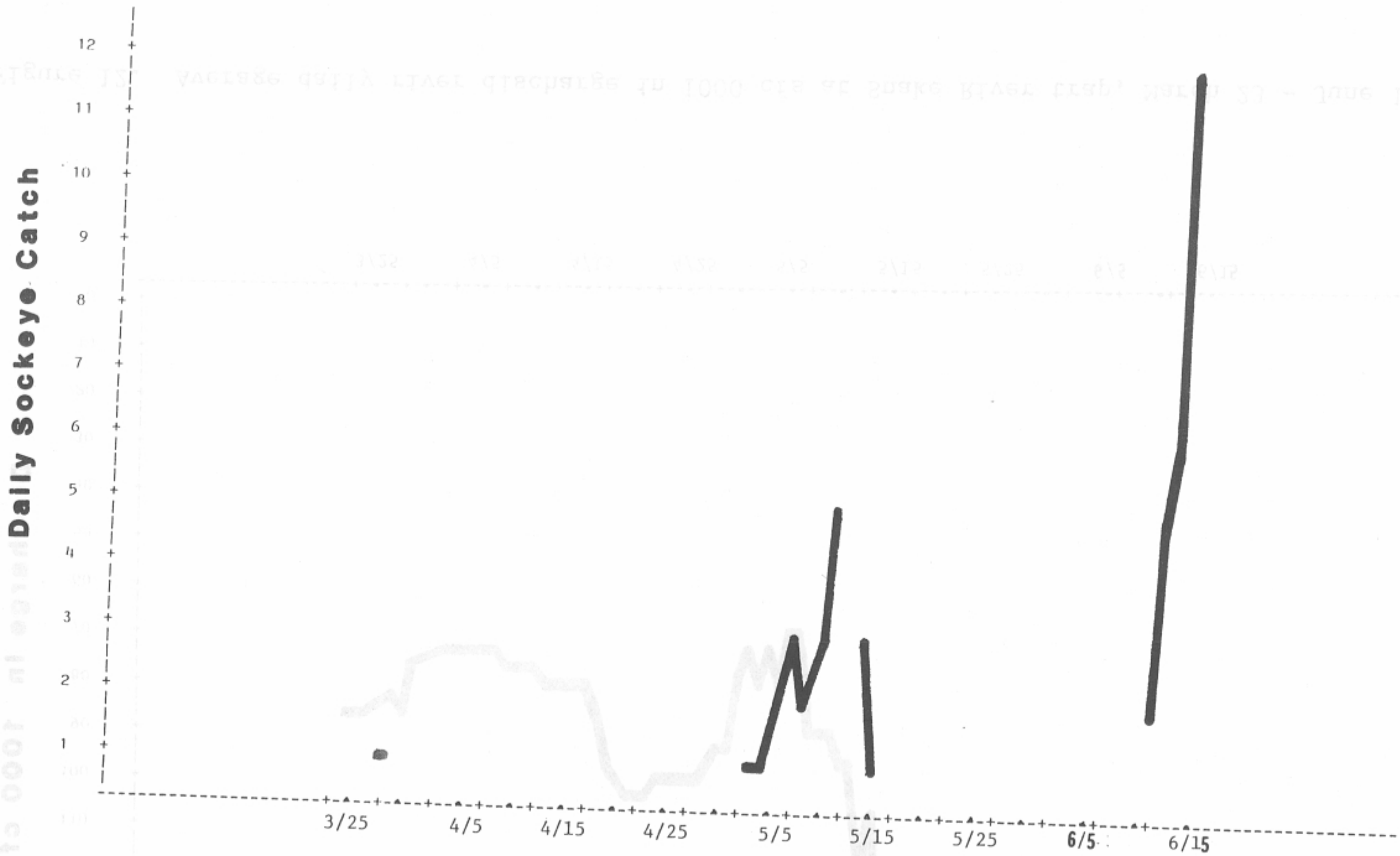


Figure 11. Daily catch of sockeye juveniles at Snake River trap, March 23 - June 16, 1984.

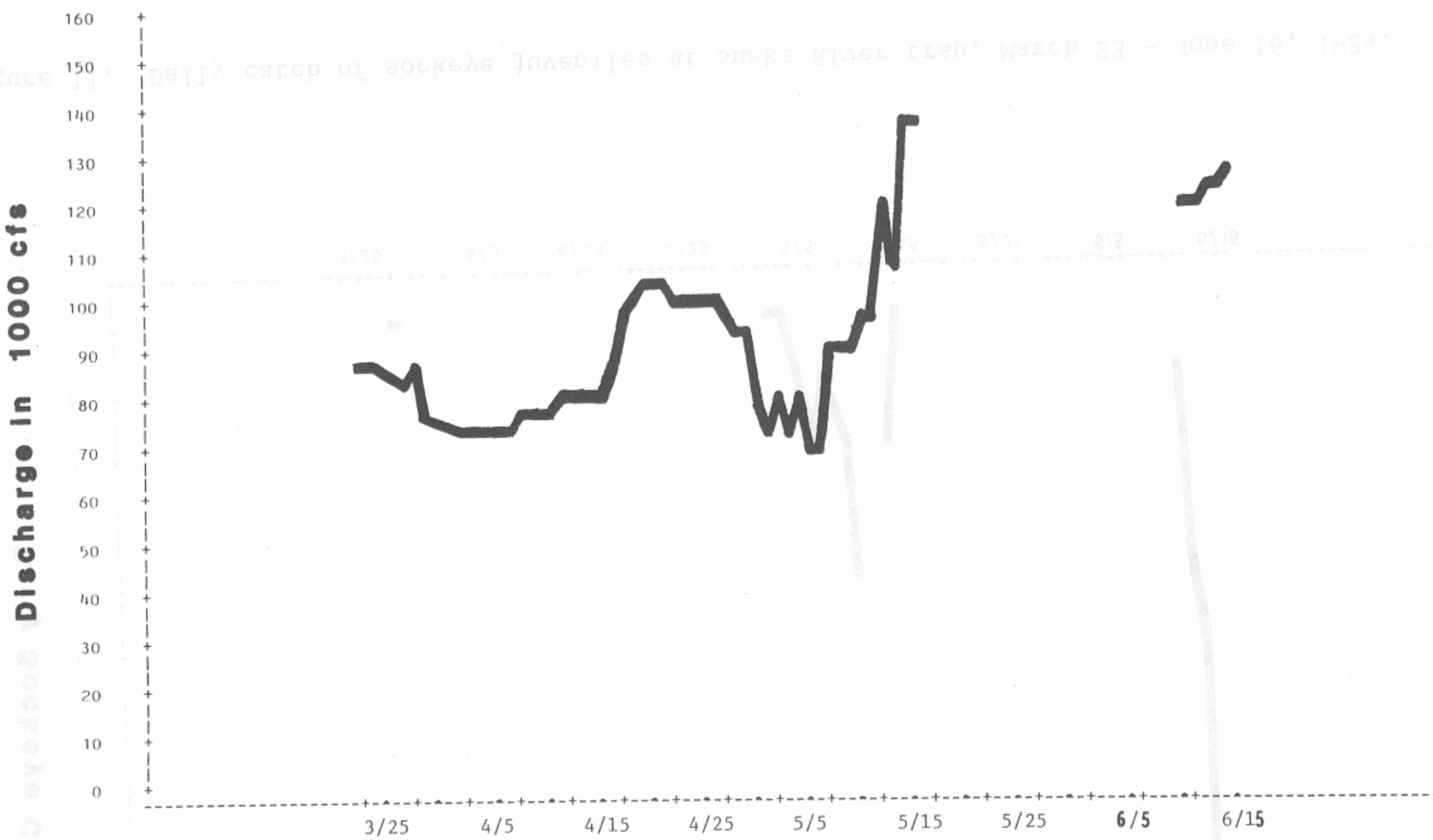


Figure 12. Average daily river discharge in 1000 cfs at Snake River trap, March 23 - June 16, 1984.

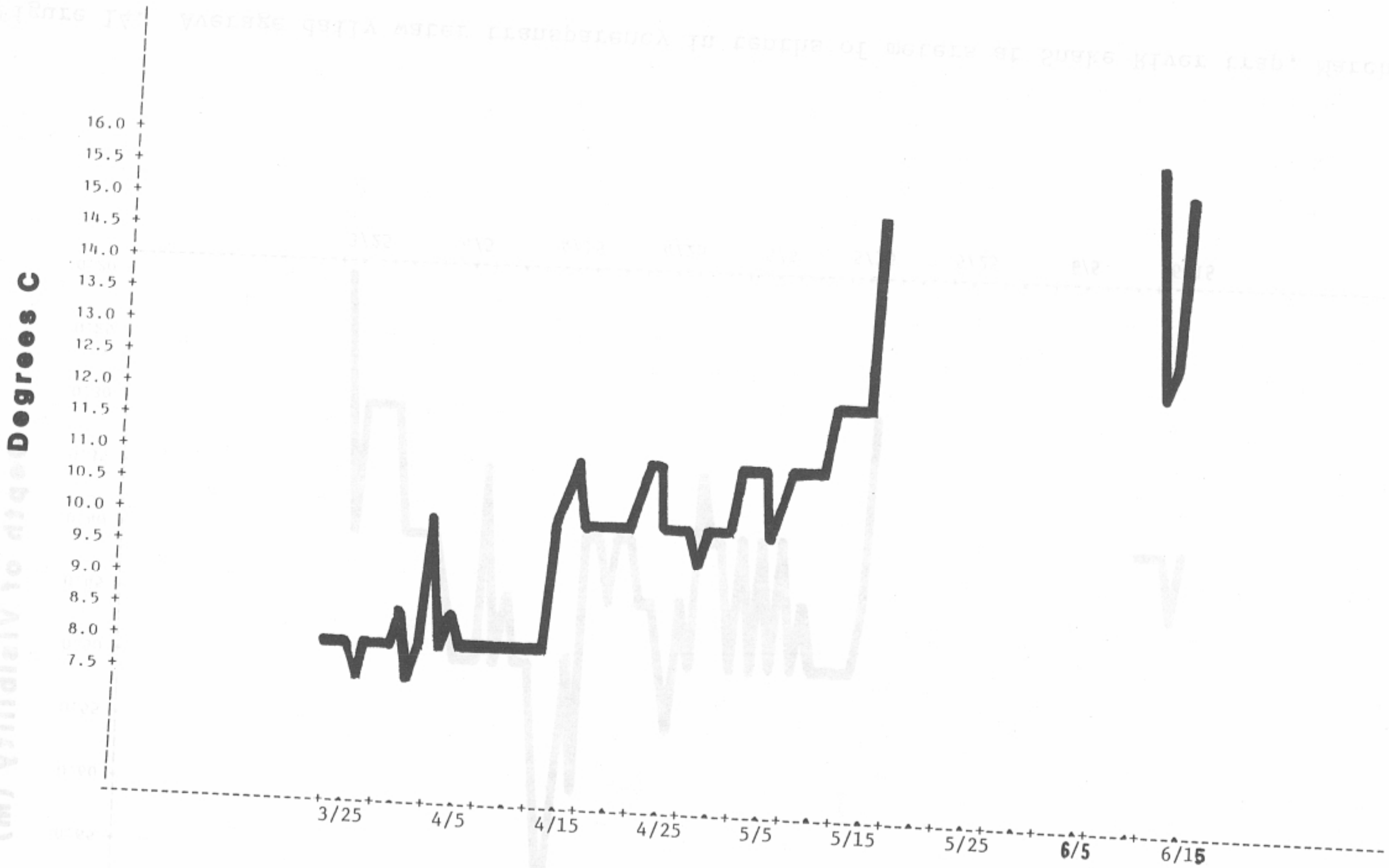


Figure 13. Average daily water temperature in degrees C at Snake River trap, March 23 - June 16, 1984.

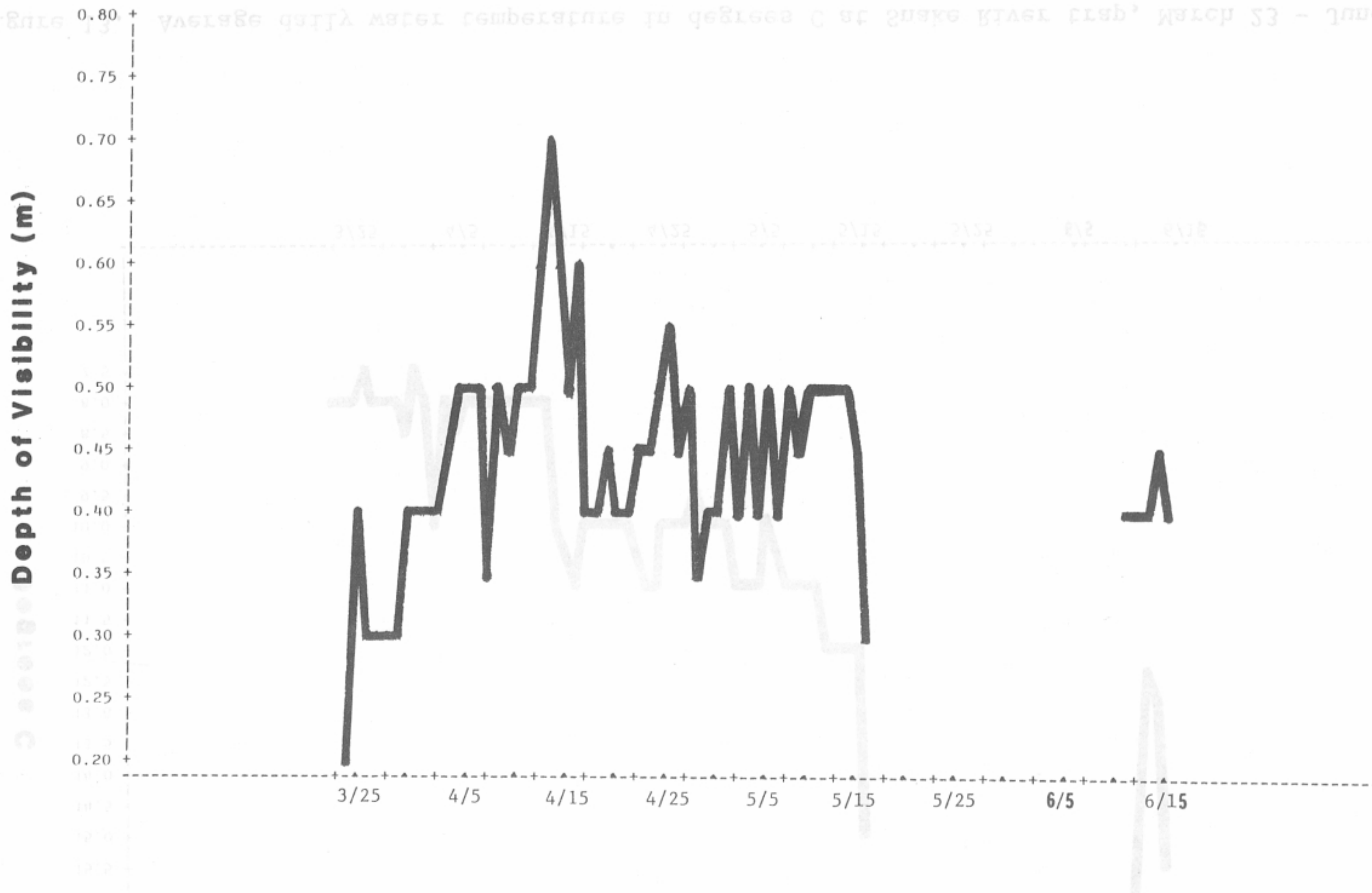


Figure 14. Average daily water transparency in tenths of meters at Snake River trap, March 23 - June 16, 1984.

Clearwater Scoop Trap

We captured 3,660 chinook salmon and 1,304 steelhead (78% hatchery, 22% wild) from March 29 to May 13, 1984. The short season and problems controlling the trap's traveling screen height under the influence of Dworshak Dam power-peaking resulted in a catch inadequate for seasonal smolt monitoring.

Daily chinook salmon catches (Fig. 15) loosely followed the river discharge hydrograph (Fig. 16) with a peak on April 5, several smaller peaks in the following weeks, then a large peak on May 10 as the river began its main rise. Daily steelhead catch (Fig. 17) was low until May 5, after which it increased. Erratic changes in daily catches may reflect the influence of numerous releases of hatchery steelhead during this interval.

Water temperature (Fig. 18) made a slow rise from near 5 C in late March to 10 C on May 12. During most of the season, temperature fluctuated frequently within a range of 6 C to 7 C. Water transparency (Fig. 19) ranged from 0.2 to more than 2.0 m with transparency generally low in April and more than a meter in early May.

Travel Time and Migration Rates

Release Sites to Whitebird

Three groups of branded chinook salmon, containing from 23,000 to 34,000 smolts each, and two groups of branded steelhead of 21,000 and 22,000 smolts each were released upriver from Whitebird trap. Of these, 518 branded chinook salmon and no branded steelhead trout were captured at the Whitebird trap.

Branded chinook salmon were trucked to Decker Flat (Salmon River) and South Fork Salmon River release sites on March 28 and April 10, respectively. Branded chinook salmon were allowed to leave Rapid River Hatchery from late February, but observation indicated that the major exodus occurred on April 1. Distances upriver from Whitebird for these three release sites are 332, 154 and 40 miles, respectively. Branded fish from Decker Flat began arriving April 8 and from South Fork Salmon River on April 18, but the median passage date (April 19) was the same for both groups (Table 4). Migration rates for the three branded chinook salmon groups were 3, 15 and 17 miles per day for Rapid River, Decker Flat and South Fork chinook salmon, respectively. For each of these groups, 95% confidence intervals around mean passage dates were less than ±1 day and two-thirds of each group passed Whitebird within 12-14 day intervals (SD = 6-7 days).

Migration rates were more rapid for upriver (Decker Flat and South Fork Salmon River) releases in 1984 than 1983 and were probably influenced by greater discharges in 1984. This trend was not apparent for Rapid

Table 4. Statistics for branded Chinook salmon migrating from Salmon River drainage release sites past Whitebird trap in 1983 and 1984.

Release site	Dates		Migration		No. brands in trap	Mean discharge @ Whitebird (1,000 cfs)
	Release	Arrival	Miles	Rate (mi/day)		
South Fork	4/10/84	4/19/84	154	17.1	108	12.6
South Fork	4/5/83	4/23/83	154	8.5	134	7.0
Decker Flat	3/28/84	4/19/84	332	15.1	124	10.2
Decker Flat	3/29/83	4/29/83	332	10.7	57	9.5
Rapid River	4/1/84	4/13/84	40	3.3	286	8.8
Rapid River	3/25/83	4/4/83	40	4.4	149	7.2
Pahsimeroi	3/10/83	4/13/83	251	7.4	124	8.4

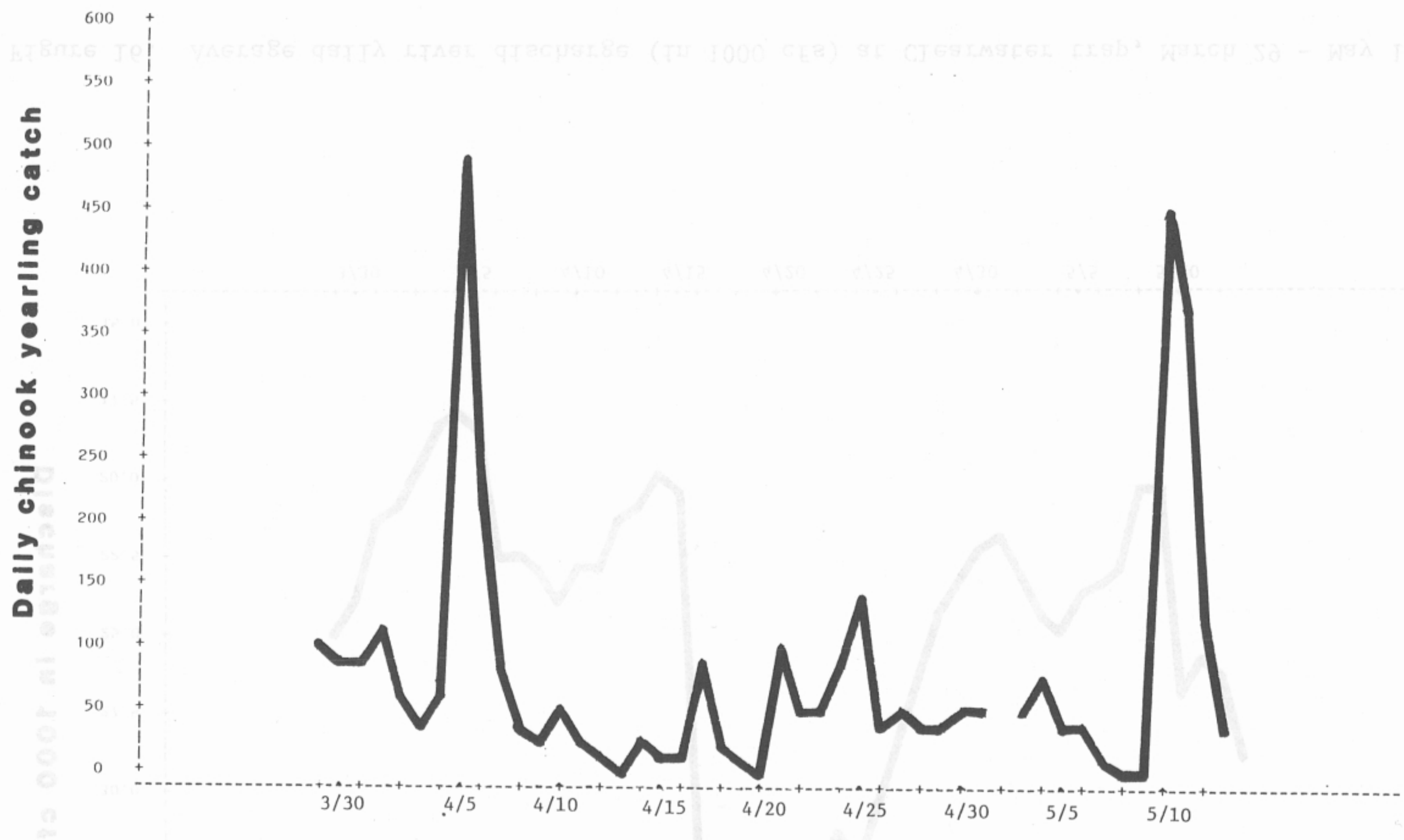


Figure 15. Daily catch of yearling chinook salmon at Clearwater trap, March 29 - May 13, 1984.

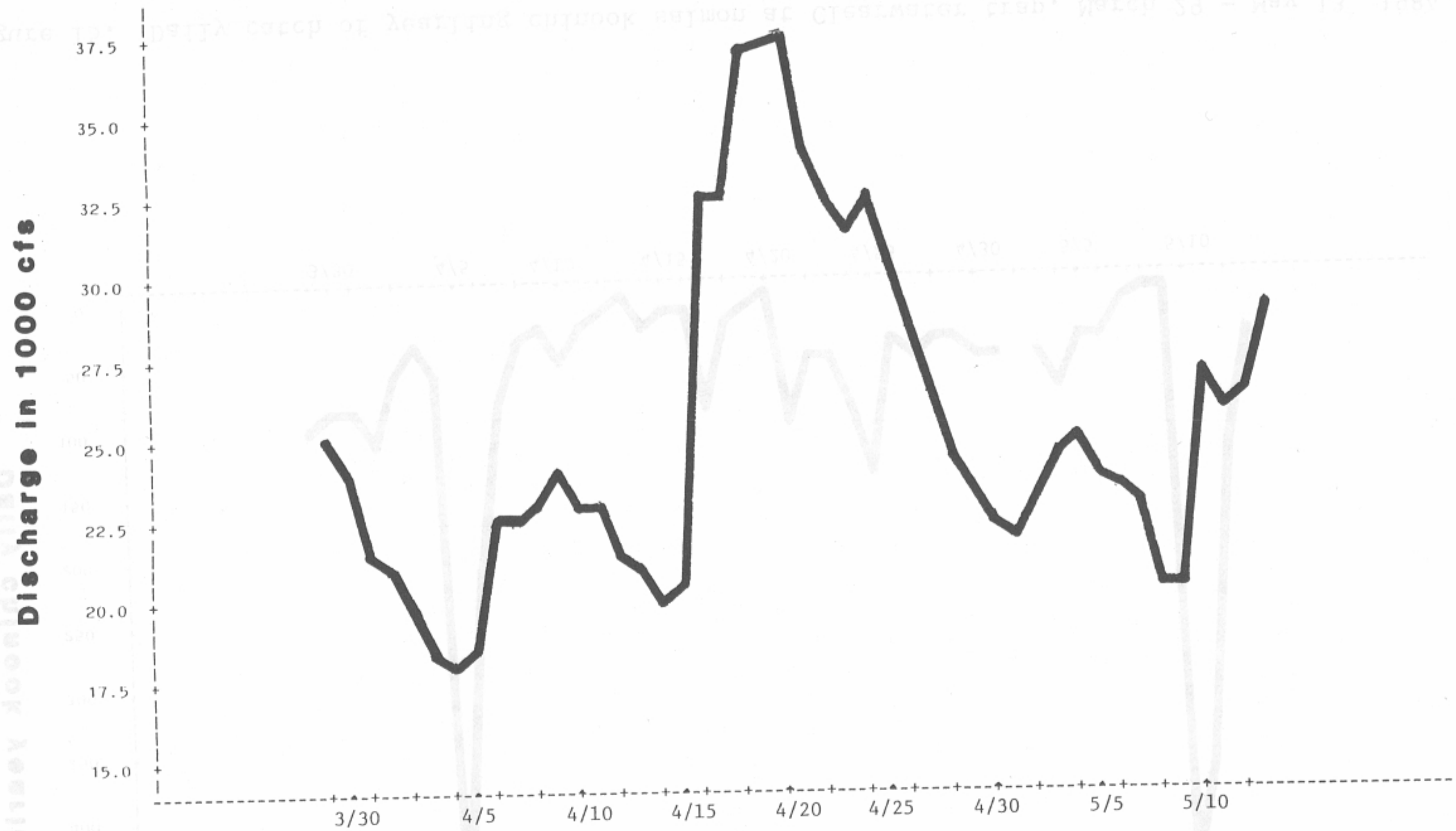


Figure 16. Average daily river discharge (in 1000 cfs) at Clearwater trap, March 29 - May 13, 1984.

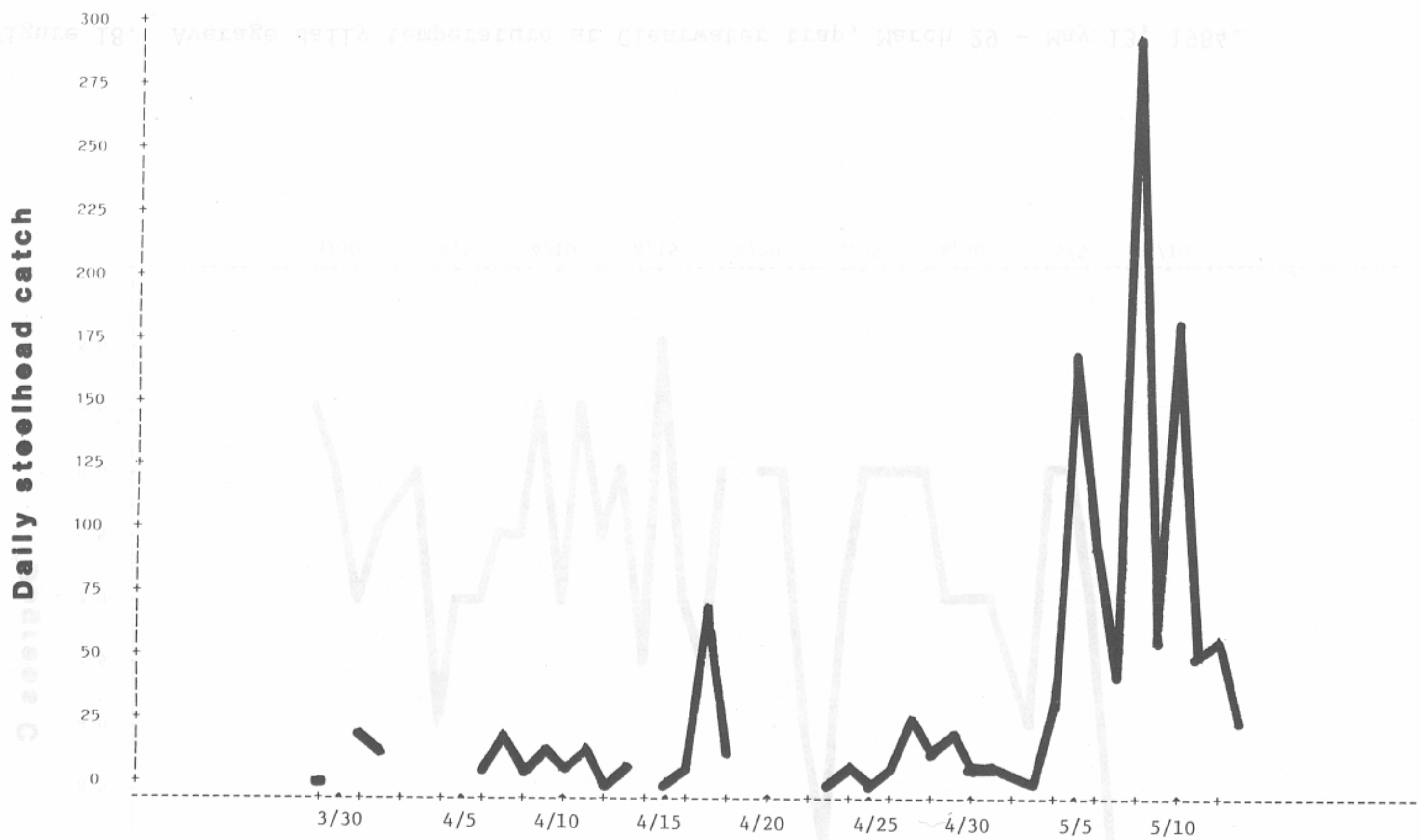


Figure 17. Daily catch of steelhead trout smolts at Clearwater trap, March 29 - May 13, 1984.

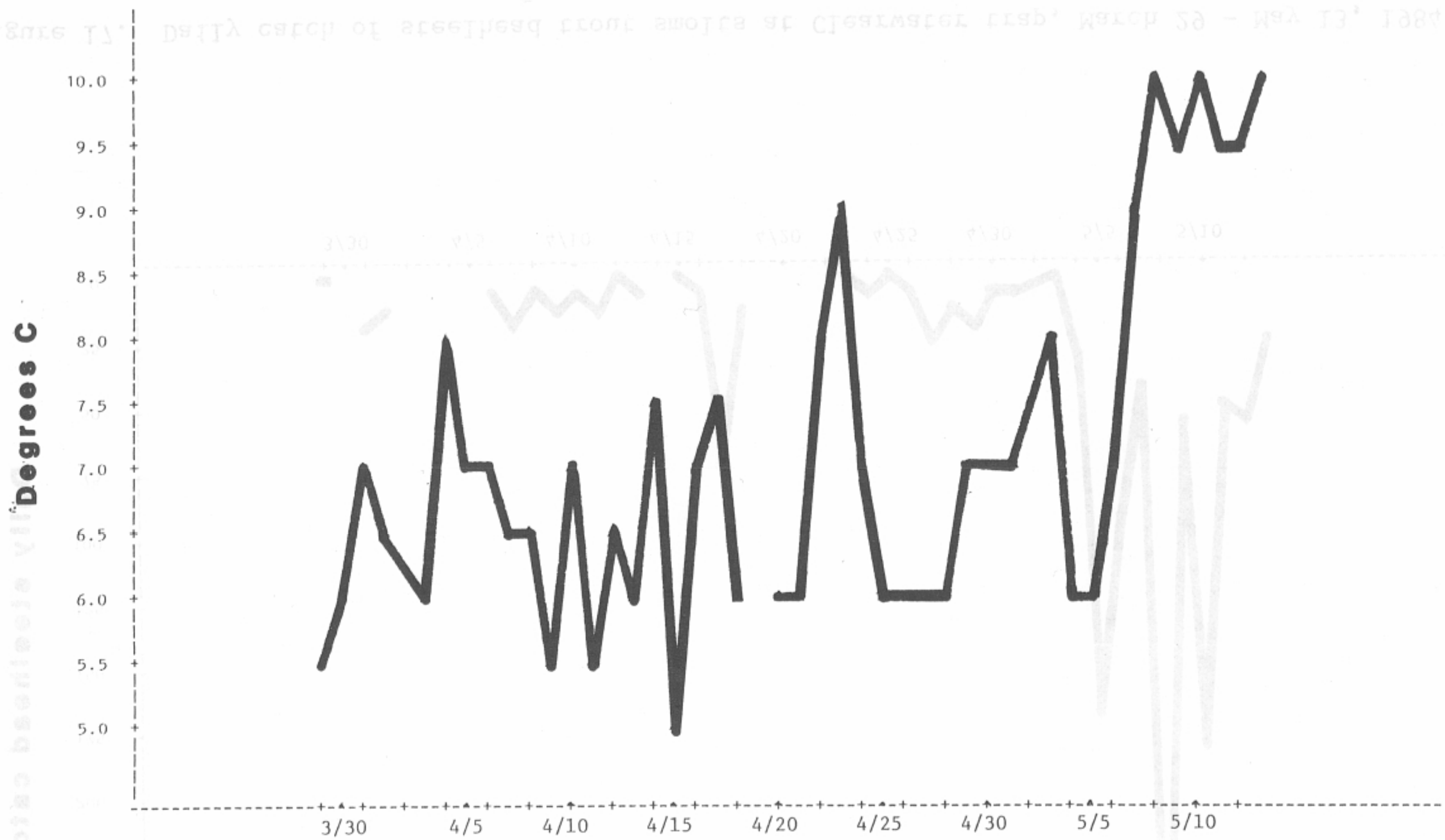


Figure 18. Average daily temperature at Clearwater trap, March 29 - May 13, 1984.

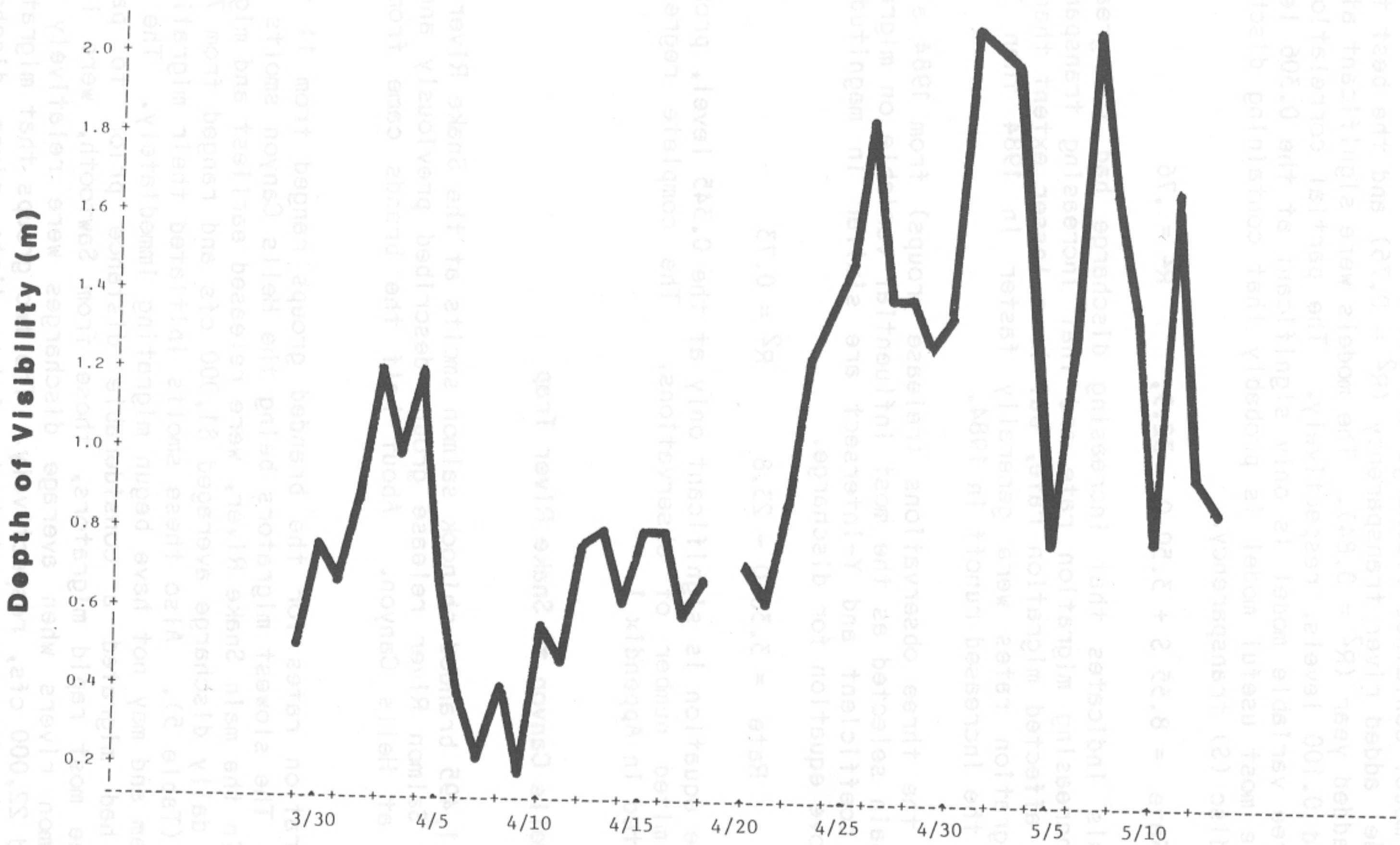


Figure 19. Average daily water transparency in tenths of meters at Clearwater trap, March 29 - May 13, 1984.

River releases, but since the exact time chinook salmon leave Rapid River Hatchery is unclear, travel time from that hatchery is difficult to estimate.

We used stepwise multiple regression analyses to determine the relative influence of several abiotic factors on migration rate. The best single variable model contained discharge and had an R^2 of 0.62. The best two variable model added river transparency ($R^2 = 0.76$) and the best three variable model added year ($R^2 = 0.84$). The models were significant at the 0.036, 0.056 and 0.100 levels, respectively. The partial correlation of year in the three variable model is only significant at the 0.306 level, however, and the most useful model is probably that containing discharge (Q) and Secchi disc (S) transparency.

$$\text{Rate} = 8.55\ S + 3.50\ Q - 32.9, \qquad R^2 = .76$$

This analysis indicates that increasing discharge had the greatest influence on increasing migration rate and that increasing transparency also positively affected migration rate, but to a lesser extent than did discharge. Migration rates were generally faster in 1984 than 1983, possibly due to the increased runoff in 1984.

Considering the three observations (release groups) from 1984 alone, discharge is again selected as the most influential variable on migration rate, and the coefficient and Y-intersect are similar in magnitude to those of the above equation for discharge.

$$\text{Rate} = 3.38\ Q - 23.8 \qquad R^2 = 0.73$$

However, the equation is significant only at the 0.345 level, probably due to the limited number of observations. The complete regression analysis is listed in Appendix 1.

Whitebird and Hells Canyon to Snake River Trap

We trapped 1,495 branded chinook salmon smolts at the Snake River trap from the three Salmon River release groups described previously and one group released at Hells Canyon. About half the brands came from the latter group.

Median migration rates for the branded groups ranged from 11 to 51 miles per day. The slowest migrators being the Hells Canyon smolts which were entirely in the main Snake River, were released earliest and migrated at a time when daily discharge averaged 81,000 cfs and ranged from 76,000 to 86,000 cfs (Table 5). Also these smolts initiated their migration at Hells Canyon Dam and may not have begun migrating immediately. The other three groups had migrated a considerable distance prior to passing Whitebird. The most rapid migrators, those from Sawtooth, were in the Snake and Salmon rivers when average discharges were relatively high, 104,000 cfs and 22,000 cfs, respectively. The two groups that migrated at intermediate rates were subjected to intermediate river discharges. Migration rates generally increased as the season progressed, as they did in 1983.

Another trend seen in both 1984 and 1983 is that chinook salmon smolts migrate faster between Whitebird and Lower Granite Reservoir than they do above Whitebird. Once smolts reach Whitebird they are definitely smolted, and the season is later than when they were first released, a factor which generally corresponds with warmer water temperatures, higher discharge and increased turbidity, all factors which speed migration.

S.A.S. was used to do a stepwise multiple regression (Appendix 2) of abiotic factors on migration rate between Whitebird and Snake River trap for seven hatchery branded chinook salmon groups (four from 1983 and three from 1984).

The best single variable model contained day length, however, the R^2 was only 0.49 and the significance level 0.08. Year was added to the model next, but this addition made only minor improvement to the model R^2 and the correlation was of very low significance, 0.56.

The single variable model is probably the only one of relevance. It indicates that within the time interval that smolts have been released, the later they are released, the faster they migrate.

$$\text{Rate} = 27.6\ \text{DL} - 21.7 \qquad R^2 = 0.49$$

When considering the 1984 branded groups alone (n=3), no significant correlation results. The single variable equation is Snake River temperature, and although $R^2 = 0.81$ is relatively strong, the significance level is 0.29.

Discharge has not strongly affected the migration rate at which hatchery branded smolts migrate from Whitebird to the head of Lower Granite Reservoir.

Unique stock differences may have as much influence on migration rate as the abiotic factors we have measured. In both 1983 and 1984, spring chinook salmon released at Decker Fiat migrated much faster than the Rapid River spring chinook salmon and the South Fork summer chinook salmon. No conclusions were evident.

Smolts Branded at Whitebird

In both 1983 and 1984, we marked and released unique brand groups at Whitebird for recapture at the Snake River trap and Lower Granite Dam. There were nine groups in 1983 and 17 in 1984 from which we had returns at the Snake River trap. We did multiple regression analyses (Appendix 3) on the groups using the same independent variables as described in the previous section on hatchery branded smolts.

The first variable selected by the regression procedure was Salmon River discharge which had a highly significant positive correlation with migration rate although the coefficient of determination a moderate 0.47.

After Salmon River discharge, in order of significance, the procedure selected Salmon River temperature, average day length and date of release. The equation,

$$\text{Rate} = 3.7\ \text{date} + 1.6\ \text{SmnQ} + 4.1\ \text{SmnT} - 77.4\ \text{DL} - 74.4$$
$$(R^2 = 0.69),$$

indicates that smolts move faster with increased discharge, temperature, later release date and with decreased average daylength. The negative coefficient for day length, however, seems unreasonable. Variable coefficients for selected equations for one through seven independent variables are given in Appendix 3.

Considering the 1984 data alone, Salmon River discharge is again the first variable to enter the model, followed by Salmon River transparency and temperature. At this point, $R^2 = 0.91$, and all variables are significant at nearly the .01 level or less.

$$\text{Rate} = 1.31\ \text{SmnQ} + 8.88\ \text{SmnT} - 32.8\ \text{SmnS} - 39.7$$
$$(R^2 = 0.91)$$

When considering both the above two equations together, Salmon River discharge then temperature or transparency most strongly affect migration rate. Change in Snake River variables have much less effect. Possibly, in years when Snake River discharge is much less, a stronger relationship will exist between discharge and migration rate.

Migration rates of chinook salmon between the Whitebird and Snake River traps appear to be correlated with discharge in both the Snake and Salmon rivers when examined graphically (Fig. 20). Migration rates ranged from near 5 miles per day to greater than 30 miles per day with the most rapid migrations being associated with greatest discharge. It also appears that smolts migrate more rapidly when discharge is increasing than when it is decreasing.

Clearwater River

Two lots each of 15,000 branded spring chinook salmon were released at Red River, one in October, 1983; the other the following spring on April 16. We captured 23 of the fall and 43 of the spring release groups and their median passage dates were April 23 and May 1, respectively. The spring released smolts traveled an average of 7.5 miles/day. Since our sampling season was truncated both at the beginning and end of the season, this estimate may differ considerably from the actual value.

Nearly 20,000 branded steelhead were released at Dworshak National Fish Hatchery on May 4. We captured 7 of these between May 5 and May 8, and the median passage date was May 5, one day after release, indicating a median travel rate of 34 miles per day.

Because we sampled only part of the migration season, we did not estimate a percentage survival for smolts at the Clearwater trap. At Lower Granite Dam, survival of the branded chinook salmon smolt groups was

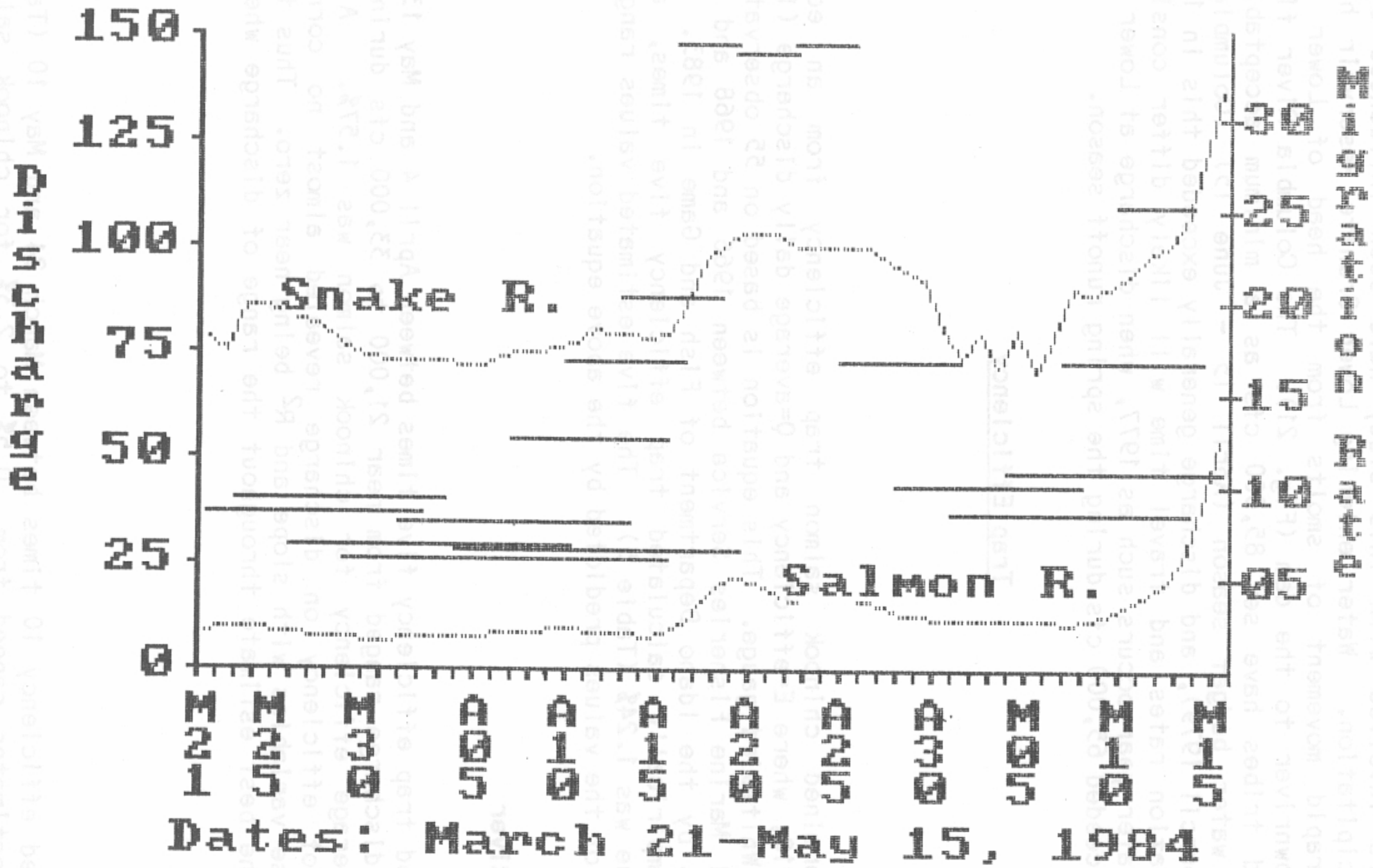


Figure 20. Snake and Salmon River discharge in 1000 cfs (continuous lines) and migration rates in miles per day (line segments) for 18 chinook brand groups marked and released at the Whitebird trap and recaptured at the Snake River trap in 1984. Line segment lengths and their horizontal locations represent travel times and travel time intervals, respectively, for each release group. Height of the line segments represents migration rates for individual brand groups.

13% and 23% for fall and spring released chinook salmon, respectively. Travel time through the reservoir for chinook salmon was 15 days and for steelhead, eight days.

The years involved with this study have been influenced by above average precipitation. Water entering Lower Granite Reservoir has been ample for rapid movement of smolts from the head of Lower Granite Reservoir downriver to the dam (Fig. 21). The Columbia River fisheries agencies and tribes have set 85,000 cfs as a minimum acceptable flow during the water budget season (April 15 - June 15) (Columbia River Fisheries Council 1979), and discharge generally exceeded this in 1983 and 1984. Migration rates and travel time will likely differ considerably when a low water year occurs such as 1977, when discharge at Lower Granite Dam never exceeded 65,000 cfs during the spring runoff season.

Trap Efficiency

Whitebird

We determined chinook salmon trap efficiency from an equation, E=2.825-0.121Q, where E=efficiency and Q=average daily discharge (in 1,000 cfs) at the Whitebird gauge. This equation is based on 55 observations by the National Marine Fisheries Service between 1966 and 1968 and on four observations by the Idaho Department of Fish and Game in 1983. During 1984, we empirically calculated trap efficiency five times, and the average value was 1.24% (Table 5). The five estimated values ranged from 52% to 105% of the values predicted by the above equation.

Clearwater River

We tested trap efficiency five times between April 4 and May 13 (Table 6). River discharge ranged from near 21,000 to 33,000 cfs during these tests. Average efficiency for chinook salmon was 1.57%. A linear regression of efficiency on discharge revealed almost no correlation between these variables with slope and R^2 being near zero. Thus the mean value was the best estimate throughout the range of discharge when tests were done.

Snake River

We tested efficiency 10 times between March 24 and May 10 (Table 7). Efficiency estimates ranged from 0.5% to 2.3% for chinook salmon and discharge ranged from 74,500 to 103,900 cfs. A regression analysis, however, indicated no correlation between these two variables. Mean efficiency was 1.7%

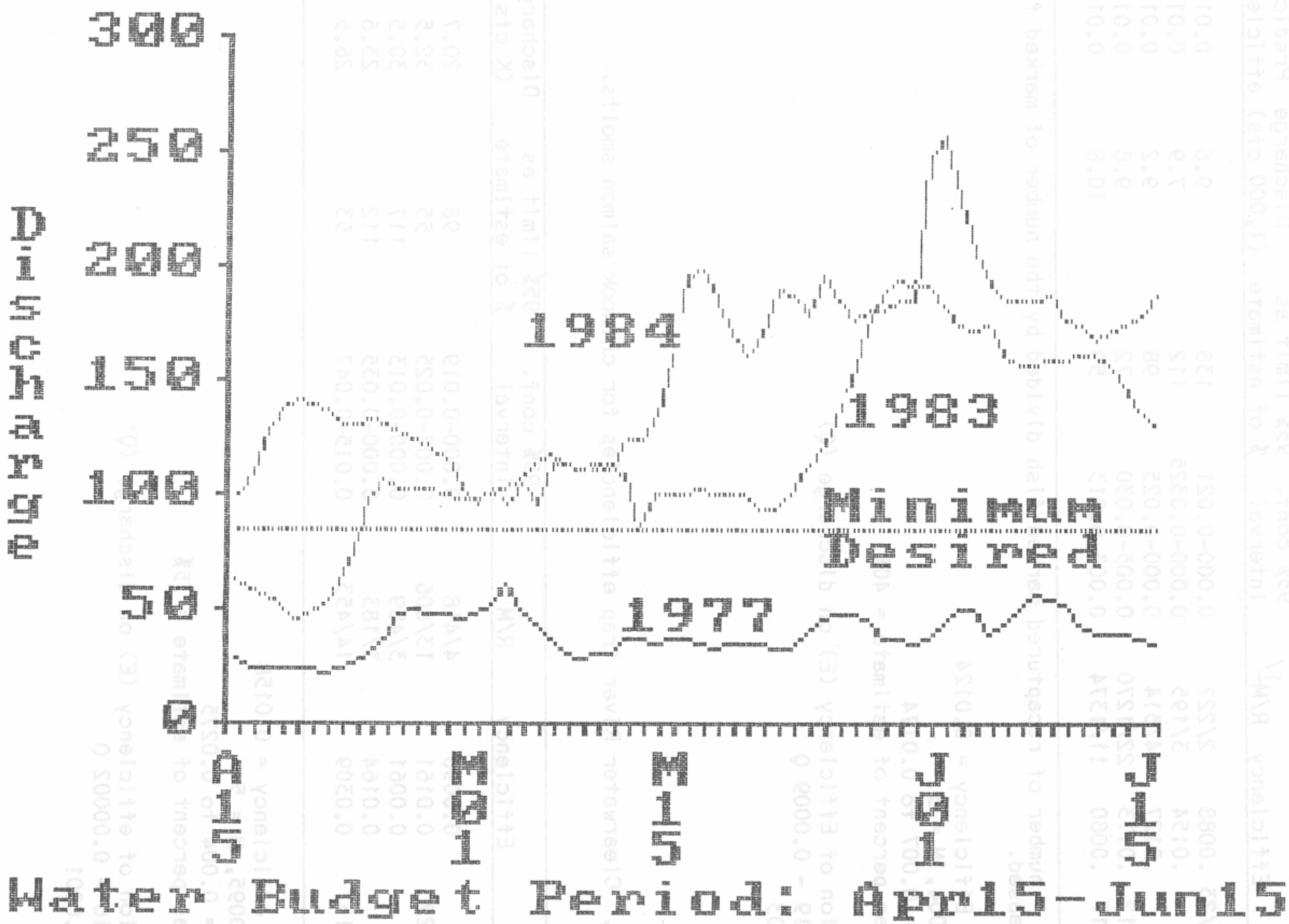


Figure 21. Lower Granite Reservoir discharge in 1000 cfs in Water Budget seasons (April 15 - June 15), 1983 and 1984 and in the recent low water year of 1977. The horizontal line is the desired minimum discharge level of 85,000 cfs during this season.

Table 5. Whitebird trap efficiencies for chinook salmon smolts.

Dates	Efficiency	R/M-	95% conf. interval	95% limit as % of estimate	Discharge (1,000 cfs)	Predicted efficiency
3/21/-	.0088	2/227	0.000-0.021	138	9.6	0.0166
4/2-4/5	.0154	3/195	0.000-	112	7.9	0.0187
4/6-4/8	.0127	4/314	0.000-0.025	98	9.2	0.0171
4/10-4/12	.0173	22/1270	0.005-0.030	72	9.8	0.0164
4/13-4/17	.0080	11/1374	0.003-0.013	59	10.8	0.0152

1/R/M = number of recaptured marked fish divided by the number of marked fish released.

Average Efficiency = 0.0124
SD = 0.004, N = 5
95% Ci = 0.007 to 0.0174
95% CL as percent of estimate = 40%

Regression of Efficiency (E) on discharge (Q)
$E = 0.119 - 0.0009\ Q$
$R^2 = 0.03$

Table 6. Clearwater River trap efficiencies for chinook salmon smolts.

Dates	Efficiency	R/M	95% conf. interval	95% limit as % of estimate	Discharge (K cfs)
4/5-4/6	0.0096	4/418	0.000-0.019	98	20.7
4/21-4/22	0.0161	13/806	0.007-0.025	55	32.5
4/25	0.0061	3/489	0.000-0.013	117	30.5
5/2-5/3	0.0164	3/183	0.000-0.035	112	23.6
5/10-5/13	0.0309	14/453	0.015-0.047	53	26.5

Average efficiency = 0.0158
SD = 0.0095, N = 5
95% CI = 0.004 to 0.0275
95% CL as percent of estimate = 75%

Regression of efficiency (E) on discharge (Q) E
$= 0.016 - 0.00002\ Q$
$R = 0.0001$

Chinook salmon trapping efficiency at the three traps is very similar with mean estimates ranging from 1.2% at Whitebird to 1.7% at Snake River. Fortunately, this level of sampling is consistent with the objectives of the project. Few steelhead were available for efficiency testing and none of those marked were recaptured.

Survival of Chinook Salmon

Based on the average trap efficiency listed in the previous section, we estimated survival rates of hatchery branded groups as they passed each trap (Table 8). Also, we have listed the survival of these groups at Lower Granite Dam as estimated from a National Marine Fisheries Service computer printout of July 27, 1984.

At Whitebird, highest survival (83%) was for Rapid River smolts. South Fork and Decker Flat smolts had about 30% survival each. However, smolts from these two groups were still passing the trap when we stopped sampling so these are minimum estimates.

At the Snake River trap, the survival estimate for Rapid River chinook salmon was reduced to 65%. South Fork smolt survival (68%) was greater than estimated at Whitebird (34%). Due to the consistency of the estimates of trap efficiency at Snake River, survival estimated there is probably the most accurate. There was little change in Decker Flat smolt survival between Whitebird and the Snake River trap. Smolt survival between Hells Canyon Dam and the Snake River trap was 50%.

The estimate of survival at Lower Granite Dam for chinook salmon smolts released at Hells Canyon Dam was relatively low (26%). However, this group was already passing Lower Granite Dam before sampling began on April 1, so the estimate is undoubtedly low.

Survival between the Snake River trap and Lower Granite Dam was similar for both Rapid River and South Fork chinook salmon. The survival estimate for Decker Flat chinook salmon did not change between these two index sites.

We estimated survival at the Clearwater River trap of branded chinook salmon released at Red River to be 10% and 18% for fall and spring releases, respectively. However, many individuals from the fall release may have passed before trap operation began (March 29) and irregular trap operation may have biased the estimates further. However, survival estimates of these groups at Lower Granite Dam were also low, 13 and 23%.

Survival of Whitebird branded chinook salmon smolts to Snake River trap and Lower Granite Dam were estimated at 31% and 43%, respectively. A paired comparison t-test of 18 brand groups passing the two index sites showed no significant difference in the estimates, 37% being the combined average survival at these two sites.

Table 7. Snake River trap efficiencies for chinook salmon smolts, 1984.

Dates	Efficiency	R/M	95% conf. interval	95% limit as % of estimate	Discharge (K cfs)
3/24-3/26	0.0187	26/1388	0.011-0.026	39	83.5
3/28-4/2	0.0183	10/545	0.007-0.030	61	74.5
4/8-4/10	0.0051	3/589	0.000-0.011	112	77.1
4/12-4/16	0.0227	7/309	0.006-0.039	73	80.7
4/16-4/17	0.0112	9/806	0.004-0.019	65	91.5
4/19-4/21	0.0217	23/1061	0.013-0.031	41	103.9
4/24-4/25	0.0098	8/812	0.003-0.017	69	101.0
4/28-5/1	0.0187	5/267	0.009-0.028	50	86.0
5/4-5/7	0.0223	4/179	0.001-0.044	97	80.7
5/9-5/10	0.0211	2/95	0.000-0.050	137	93.2

Average efficiency = 0.0170
SD = 0.006, N = 10
95% CI = 0.013 to 0.021
95% CL as percent of estimate = 26%
Regression of efficiency (E) on discharge (Q) E = 0.000003 Q + 0.017
R = 0.000

Table 8. Survival rate estimates for hatchery-branded chinook salmon at four smolt index sites.

Release site	Brand	Number released	Percent passing			
			Clearwater River	Snake Whitebird	River	L. Granite Dam
Hells Canyon Dam	RDJ1	85,660	NA		52	26
Rapid River	RDJ3	23,840	NA	83	65	46
S.F. Salmon River	LDJ1	25,560	NA	34	68	48
Decker Flat	LDJ3	33,930	NA	29	35	35
Red River[1]	LASU2	15,000	10	NA	NA	13
Red River[2]	LASU4	15,000	18	NA	NA	23

[1] Fall Release
[2] Spring Release

Descaling

Why Monitor Descaling?

In experiments conducted by the National Marine Fisheries Service, Park et al. (1982) found that in a 30 parts per thousand seawater challenge 5-day bioassay with chinook salmon smolts, although only 6% of their test fish were descaled, descaled fish accounted for 37% of the mortality in the experiment. Furthermore, 79% of the smolts that were descaled died.

They also found that smolts transported to below Bonneville Dam from upriver collection dams and held five days in fresh water, suffered similar mortalities relative to descaling. Although descaling rates were 17-20% among the experimental fish, 75% of the mortality occurring waswith descaled fish. They concluded that "descaling has an extremely negative impact on the ability of spring chinook salmon to survive."

Furthermore, in experiments at Lower Granite Dam to measure delayed mortality among spring chinook salmon smolts, Matthews (NMFS, pers. comm.) found that after 25 days, all descaled fish had died even though examination after the experiment was complete (16 days later) demonstrated that overall mortality for smolts with and without descaling was less than 5%.

These recent experiments have confirmed the belief that scale loss is extremely life threatening to migrating chinook salmon smolts, especially when considering the additional stress of dam passage and/or transport.

Part of the smolt monitoring responsibility is to estimate descaling rates at index sites upriver from Lower Granite Reservoir. This can help explain smolt losses prior to Lower Granite Dam, since many which are descaled early in their migration may not survive to be observed at Lower Granite Dam. Stocks from which these smolts came may appear very healthy at Lower Granite Dam since the fraction of the population which was descaled early in the migration is now missing.

In 1983 we observed abnormally high descaling rates on large hatchery smolts at Whitebird. We assumed this was the result of delayed scale loss resulting from pumping and transport, a procedure necessary to move smolts from Hagerman Valley hatcheries to release sites along the Salmon River. To study this possibility, Partridge (IDFG, pers. comm.) held replicated samples of pumped and unpumped steelhead smolts at Hagerman NFH for several weeks and examined them weekly to see if increased scale loss occurred. The results indicated there was no increase in scale loss during the holding period. However, much less scale loss was observed among large hatchery steelhead at Whitebird trap in 1984 than in 1983, also. Thus, we were unable to determine the cause of the high descaling rate of Salmon River hatchery steelhead smolts in 1983.

Descaling at Hatcheries and Release Sites

Chinook salmon. Descaling rate of chinook salmon fingerlings was estimated at all Idaho anadromous fish hatcheries except Pahsimeroi prior to release and at release points (Table 9). Classical descaling ranged from 0.0 to 5.3% at hatcheries and 0.0 to 1.3% at release sites. The highest descaling rates (4.3 and 5.3%) occurred in a Dworshak NFH group of chinook salmon which were Leavenworth stock released directly from the hatchery into the North Fork Clearwater River.

We believe that fish with scales missing in a scattered fashion may be as unhealthy as those which exhibit classical descaling. Scattered descaling at hatcheries ranged from 0.3 to 34.0% with an average of 10.6%. Scattered descaling at release sites ranged from 0 to 4.0% and averaged 1.2%. Scattered descaling measured at hatcheries was higher than at release sites because several groups with high scattered descaling (34.0 and 23.3%) were released directly to a river from a hatchery. The hatchery with the lowest descaling rate (McCall Hatchery) trucks its fish to release sites while the hatchery with the highest descaling rates (Dworshak NFH) releases the majority of its fish directly from the hatchery. Those groups of chinook salmon with the highest classical descaling also had the highest scattered descaling rate.

Hagerman NFH was the only hatchery to release fall chinook salmon. Descaling rate at the hatchery before transport was 0.0% and at the release site 0.6%. Scattered descaling went from 4.1% prior to transport to 9.2% at the release site. These smolts were trucked about 400 miles to the Snake River near the mouth of the Grande Ronde River. Release site rates compared favorably to the 1.5% classical descaling and 29% scattered descaling rates of the Hagerman NFH reared fall chinook salmon released at the same location in June, 1983.

Steelhead trout. Steelhead trout were examined for descaling at hatcheries prior to release and at release sites. Average classical descaling at hatcheries in 1984 was less than 1.0% and ranged from 0 to 0.8% (Table 9), very similar to that seen in 1983. Classical descaling at release sites was slightly higher than at hatcheries (0.0 to 3.3%) but still averaged less than 1.0%.

Scattered descaling ranged from 1.0% to 6.7% at hatcheries and averaged 2.7%. Scattered descaling of steelhead at release sites was slightly higher, averaging 3.9% and ranged from 0 to 9.3%. Scattered descaling was similar to that found in 1983 except Dworshak NFH showed much lower levels this year. In 1983, scattered descaling at Dworshak NFH ranged from 14 to 49.3% and averaged 30.5% compared to 2.3% this year. Eye and head injuries varied little between hatcheries and release sites (1.8 and 2.2%, respectively).

Table 9. Hatchery and release site descaling data, 1984.

SAMPLE DATE 1984	SAMPLE LOCATION	RACEWAY	HATCHERY	SPECIES	TOTAL FISH SAMPLED	TOTAL PERCENT DESCALIN	MEAN LENGTH (mm)	STANDARD DEVIATION	S = SCATTERED DESCALING T = WATER TEMPERATURE HEAD = EYE/HEAD INJURY			
4/4	Hagerman NFH.	53,54 68,69	Hagerman	'A' STHD	300	0	257	35.6	S 2.3%			T=14.5 C
4/5	Decker Flats		Hagerman	'A' STHD	150	0.7	257	35.6	9[9]1.3%	Head=1.3%	Deadh.3%	T= 0 C
4/30	Hagennan NFH	58,73 74,78	Hagerman	'A' STHD	400	0.5	258	48.5	S~.0%			T=14.5 C
5/1	Decker Flats		Hagerman	'A' STHD	150	0	258	48.5	S=3 .3%	Head=-'1.3%		T'6.5 C
3/27	Hagerman NFH	30-04 88,89	Hagerman	'B' STHD	300	0	216	34.1	9=1.O%	Head=1.3%		T=15.0 C
3/28	E. Fork Salmon River		Hagerman	'B' STHD	150	0	218	34.1	S=1.3%	Head'1.3%		T 3.O C
4/10	Hagerman NFH	61,62 98-100	Hagerman	'B' STHD	400	0	222	30.2	S=1.0%	Head 2.5%		T=14.5 C
4/11	East Fork Salmon		Hagerman	'B' STHD	. 150	1.3	222	30.2	9=4.0%	Head-4 .3%	Dead=O .3%	T ~ . 5 C
4/25	Hagerman NFH	49,83, 87	Hagerman	'A&B' STHD	400	0.8	240	27.9	S=3.0%	Head=1.3%	Dead).3%	T=14.5 C
4/26	Hazard Cr. L. Salmon		Hagerman	'ASB' STHD	150	2.0	240	27.9	5=4.7%	Head=1.3%	Dead=1.3%	T 3.O C
4/19	Slate Creek		Hagerman	'B' STHD	300	0	240	29.1				
6/12	Hagerman NFH	5,10, 11	Hagerman	Fall Chin	270	0	87	-	8=4.1% (mean length calculated from #116)			T=15.0 C
B/13	Grande Ronde		Hagerman	Fell Chin	500	0.6	87	-	9-9.2% (mean length calculated from #116)			

Table 9. Continued

SAMPLE DATE 1984	SAMPLE LOCATION	RACEWAY	HATCHERY	SPECIES	TOTAL FISH SAMPLED	TOTAL PERCENT DESCALING	MEAN LENGTH (mm)	STANDARD DEVIATION	S = SCATTERED DESCALING	T = WATER TEMPERATURE	HEAD = EYE/HEAD INJURY	
4/3	Magic Valley Hat.	34.4	Magic Valley	'A' STHD	300	0.3	258	43.7	543.7%	Head~.3%		T=15.0 C
4/4	Decker Flat		Magic Valley	'A STHD	150	0	256	43.7	8=9.3%	Head=0.7%		T=2.0 C
4/10	Magic Valley Hat.	182	Magic Valley	'A' STHD	400	0.5	258	42.7	S 2.9%	Head4l .5%		T=14.5 C
4/11	Decker Flat		Magic Valley	'A' STHD	150	1.3	256	42.7	9=4.7%	Head=0.7%		T~.O C
4/12	Magic Valley Hat.		Magic Valley	'A' STHD	400	0.5	258	38.9		Head O.5%		
4/15	Decker Flat		Magic Valley	'A' STHD	150	2.0			8=7.3%		Dead=0.7%	
3/27	Decker Flat		McCall	Sp. Chin	300	0	-	-	543.0%	Head43.7%		T .0 C
4/9	McCall Hatchery		McCall	Su. Chin	300	0			9=3.3%	Head=1.0%		
4/9	S. Fork Salmon River		McCall	Su. Chin	300	0						
4/1	Niagara Springs Hat.	14	Niagara	'A' STHD	300	0	216	28.4	S 2.O%	Head43.3%		T=14.5 C
4/2	Pahsimeroi		Niagara	'A' S1H D	150	0			8=2.7%	Head=1.3%		T=7.0 C
4/8	Niagara Springs Hat.	10	Niagara	'A' STHD	300	0	192	39.6	S=2 .3%	Head S.7%		T=14.0 C
4/9	Pahsimeroi		Niagara	'A' S1H D	150	0			S=0	Head=2.7%	Dead--4.0%	T~.O C
4/16	Niagara Springs Hat.	9	Niagara	'A' STHD	400	0	224	35.0	S=2.3%	Head43.3%		
4/23	Niagara Springs	8	Niagara	'A' STHD	400	0	220	35	S=2.3%	Head=1 .3%		T=14.5 C
4/24	Pahsimeroi		Niagara	'A' STHD	150	0			8=4.0%	Head=1.3%	Dead S.3%	T=8.3 C
4/30	Niagara Springs Hat.	2	Niagara	'A' STHD	400	0	229	50	S43.3%	Head43.8%		T=14.0 C
5/2	Hells Canyon		Niagara	'A' STH D	150	3.3			S43.3%		Dead=0.7%	

Table 9. Continued

SAMPLE DATE 1984	SAMPLE LOCATION		HATOIERY	SPECIES	TOTAL FISH SAMPLED	TOTAL PERCENT DESCALIN	MEAN LENGTH (mm)	STANDARD DEVIATION	S = SCATTERED DESCALING T = WATER TEMPERATURE HEAD = EYE/HEAD INJURY
5/3	Niagara Springs Hat.	1	Niagara	'A' STHD	400	0.5	232		S . 5 % Head=1.5% T=14.5 C
5/4	Halls Canyon		Niagara	'A' STHD	150	1.3			2.7% Head .8%
3/18	Rapid River Hat.		Rapid River	Sp. Chin	350	0	123	9	S 0.3% Released into Rapid River Hat.
3/20	Hells Canyon Dam		Rapid River	Sp. Chin	299	1.3			T=5.5 C; Trans. Truck T=8.5 C; River T=8 C
3/21	Kooskia NA		Kooskia	Sp. Chin	112	2.7	196	16	S=1.8% Released into Clear Creek
3/26	Kooskia NFH		Kooskia	Sp. Chin	114	0	157	20	S 0.9% Head 2.6%
3/26	Kooskia NFH		Dworshek	Sp. thin	114	0	138	15	S 0.9% Head 3 .5% Kooskia stock raised at Dworshak & released at Kooskia.
4/2	Dworshak NFH	14	Dworshak	Sp. Chin	300	5.3	157	16	S44.0% Head 2.7% Raceway 14 Levenworth stock released N. Fk. Clearwater T 5.5 C
4/2	Dworshak NFH	7	Dworshak	Sp. Chin	300	4.3	209	26	S=23.3% Head4:1.3% Raceway 7 Leverworth stock released N. Fk. Clearwater T=4.5 C
4/24	Dworshak NFH	57, 63-67, 69	Oworshak	'B' STHD	325	0.3	204	33	S 2.8% Release directly to mainstem Clearwater
5/1	Dworehak NFH		Dworshak	'B' STHD	150	0	200	31	S 2.9% HeadB.7%
5/1	S. Fk. Clearwater River		Dworshak	'B'	132	0			S=8.7% Head20.5% Dead=0.8%
5/2	Mari can River		Dworehak	'B' STHD	64	0			S=7.8% Head=1.6% T~5.0 C

Descaling at Fish Traps

<u>Chinook salmon.</u> Weekly descaling rates at Whitebird rose to between 6% and 7% in late March and early April, then fell to between 2% and 4% through mid May (Fig. 22). Descaling rates followed the same seasonal trend at the Snake River trap, but at a lower level, as rates ranged from 1.7% to 3.5%. The chinook salmon descaling rate was lowest at the Clearwater trap where weekly rates ranged from 0.5 to 2.4%. Seasonal descaling rates for chinook salmon were 4.5%, 2.5% and 1.5% forWhitebird, Snake and Clearwater traps, respectively. Chinook salmon descaling at Whitebird in 1984 was generally higher than in 1983 when rates were less than 2% from mid-March until mid-April and then rose only to 4%.

<u>Wild steelhead trout.</u> Weekly descaling rates at Whitebird were generally between 0.5% and 4.5% with no trend over time (Fig. 23). At the Snake River trap, rates rose to near 3% twice, but generally were less than 1%. At the Clearwater trap descaling rate was zero for all but one week when it was 1%. Average seasonal descaling rates were 2.1%, 1.4% and 0.4% for Whitebird, Snake and Clearwater traps, respectively. There was no change in descaling rate between 1983 and 1984.

<u>Hatchery steelhead trout.</u> Descaling rate at Whitebird was near 6% from mid-April to early May then rose to between 12% and 14% (Fig. 24). Descaling rates were considerably less at Whitebird than in 1983. At the Snake River trap the descaling rate was high in late March, 33%, and early May, 16%, but these estimates are from small samples. Large catches began the last week of April, and descaling rates during the following three weeks were near 3%. During the last week of sampling (the third week in May) the descaling rate rose to near 8%. Descaling rate at the Clearwater trap ranged from 2.2 to 13.3% with a decreasing trend from late April through the middle of May.

Seasonal average descaling rates were 8.7%, 5.5% and 4.1% for Whitebird, Snake and Clearwater traps, respectively.

<u>Multiple area descaling.</u> Approximately 90%, 93% and 96% of chinook salmon smolts sampled at Whitebird, Snake River and Clearwater, respectively, were not "descaled" in any area (Table 10). About 4%, 3.4% and 2% of the chinook salmon smolts from Whitebird, Snake River and Clearwater, respectively, had a single area descaled. A very small fraction of the chinook salmon smolts were severely descaled (5 or more areas) at Snake River and Clearwater traps (0.4 and 0.1%, respectively), but 2.1% of the Whitebird chinook salmon smolts were severely descaled.

Hatchery steelhead smolts had no areas descaled in 80%, 88% and 94% of the samples at Whitebird, Snake River and Clearwater traps, respectively. Nearly 8% of hatchery steelhead at Whitebird had a single area descaled, whereas hatchery steelhead at Snake River and Clearwater traps had near 4% and 2% single area descaling, respectively. Severe descaling occurred in only 1.6%, 1.0% and 0.5% of hatchery steelhead at Whitebird, Snake River and Clearwater River, respectively.

Table 10. Percentages of yearling chinook salmon, hatchery steelhead and wild steelhead smolts at Whitebird, Snake River and Clearwater River traps with descaling in 1984.

Number of areas descaled	Whitebird	Snake River	Clearwater
	Yearling Chinook Salmon		
0	90.4	92.8	96.2
1	3.9	3.5	1.8
2	2.4	2.0	1.1
3	1.2	0.6	0.4
4	1.0	0.6	0.4
5-10	2.1	0.4	0.1
Sample Size	14,034	12,286	2,842
	Hatchery Steelhead Trout		
0	80.1	88.4	93.7
1	7.9	3.8	2.1
2	5.7	3.3	2.5
3	2.7	2.3	1.7
4	1.8	1.3	0.7
5-10	1.6	1.0	0.5
Sample Size	2,341	1,187	850
	Wild Steelhead Trout		
0	96.3	95.7	95.9
1	1.2	2.4	2.9
2	1.2	0.8	0.8
3	0.2	0.6	0.4
4	0.5	0.2	0.0
5-10	0.7	0.2	0.0
Sample Size	601	494	241

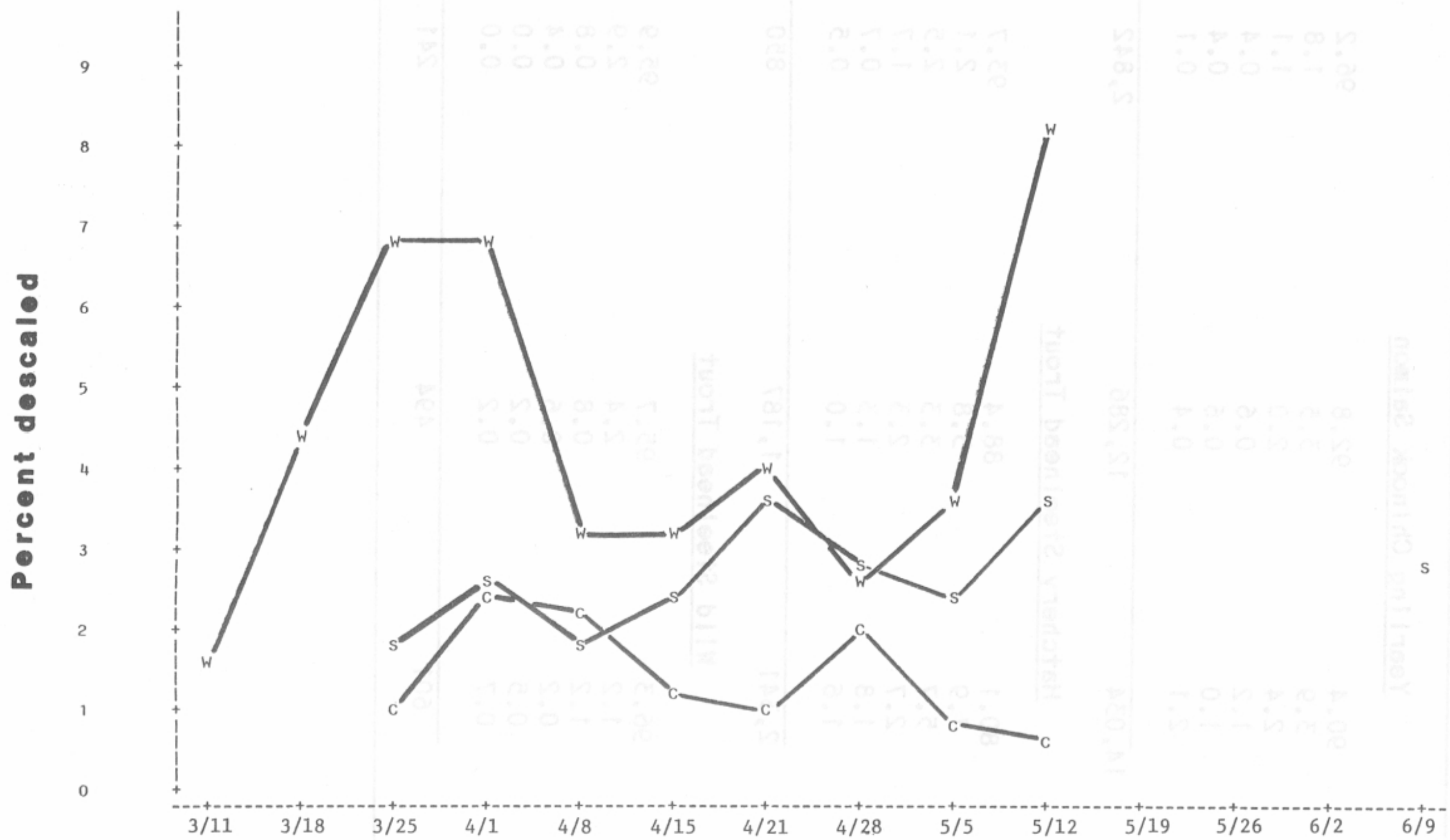


Figure 22. Weekly descaling rates of yearling chinook salmon at Whitebird (W), Snake River (S) and Clearwater (C) traps, March 11 - June 9, 1984.

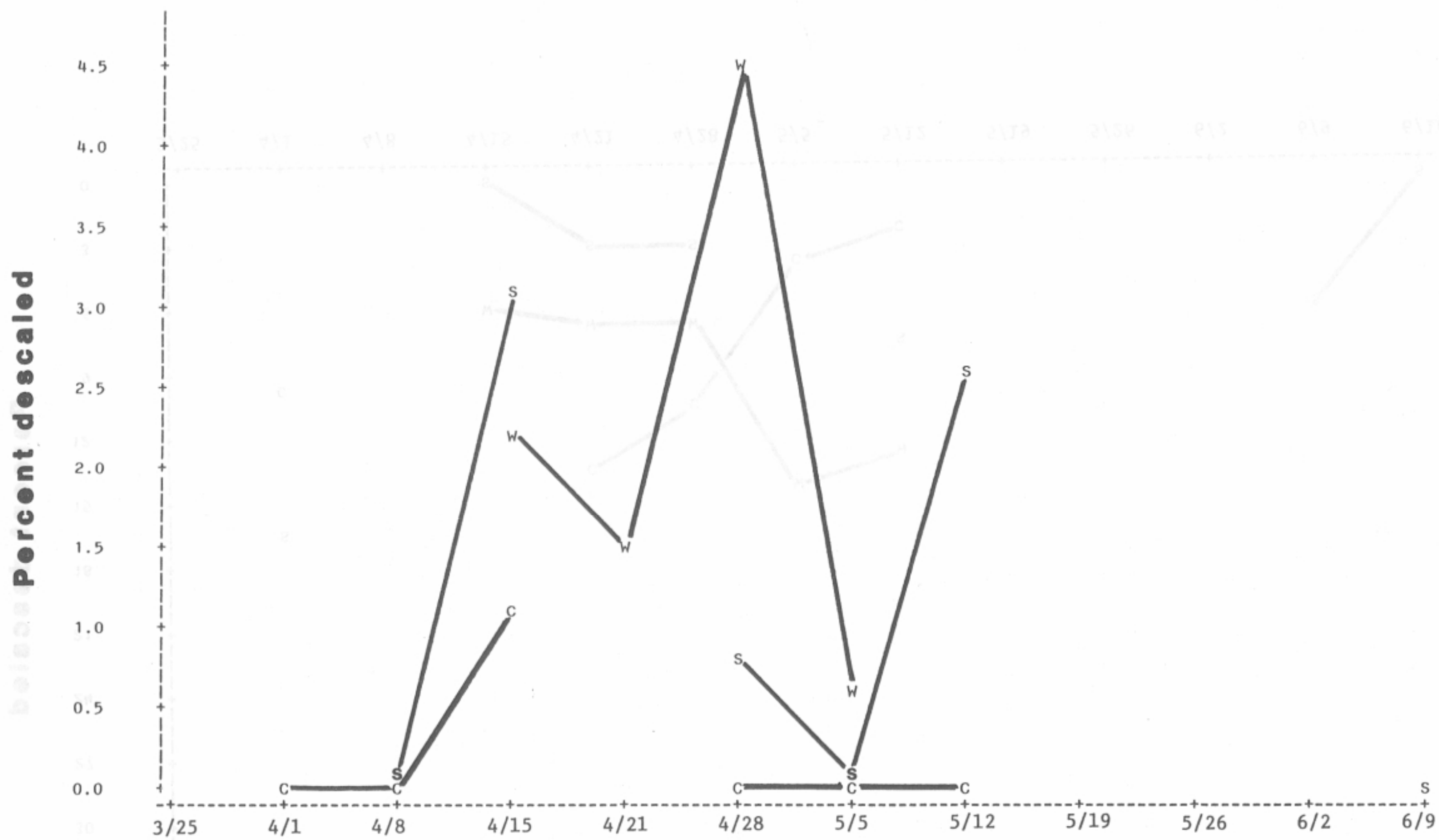


Figure 23. Weekly descaling rates of wild steelhead trout smolts at Whitebird (W), Snake River (S) and Clearwater (C) traps, March 25 - June 9, 1984.

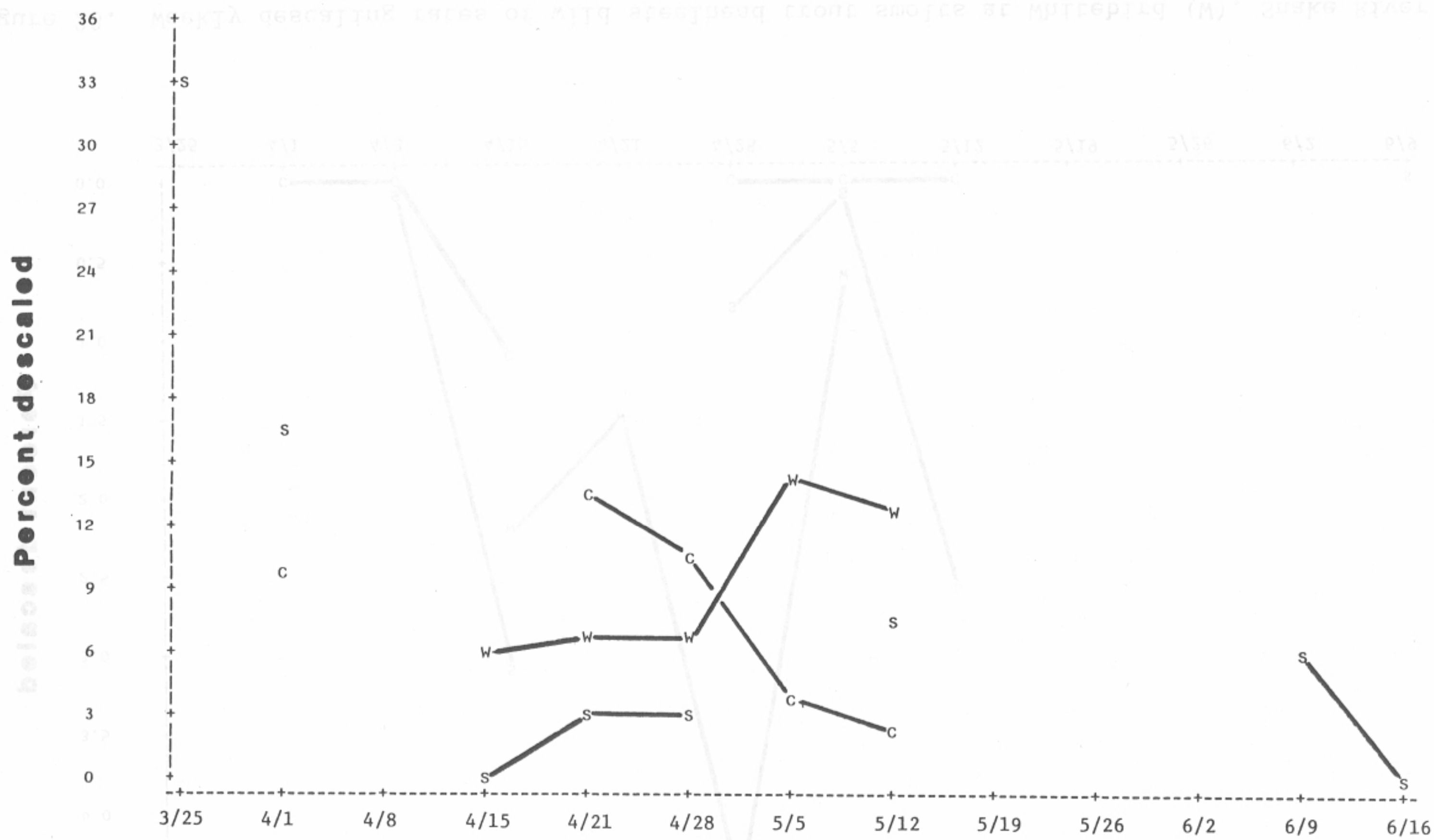


Figure 24. Weekly descaling rates for hatchery steelhead trout smolts at Whitebird (W), Snake River (S) and Clearwater (C) traps from March 25 - June 16, 1984.

About 96% of wild steelhead at all three trap sites had no descaled areas. Single area descaling was significant compared to multiple area descaling. Single area descaling was 1.2%, 2.4% and 2.9% at Whitebird, Snake River and Clearwater, respectively. Severe descaling rate was 0.7% at Whitebird, 0.2% at Snake River and did not occur in the sample at Clearwater trap.

Classical descaling. Classical descaling was lowest for wild steelhead, highest for hatchery steelhead, and chinook salmon had an intermediate descaling rate at all three traps (Table 11). Also, for all three species groups, classical descaling is lowest at the Clearwater and highest at the Whitebird trap. The lowest descaling rate was for Clearwater wild steelhead, 0.4% (N=241).

Other types of descaling. Scattered descaling for all three species groups and traps was in each case greater than classical descaling, ranging from 2.5 times greater for Clearwater hatchery steelhead to 6.8 times greater for Clearwater wild steelhead. The overall mean ratio was 4.8:1 for scattered to classical descaling rates.

We considered a third descaling classification, "two-area" descaling, which includes both classical and scattered descaling together. Two-area descaling exists when the sum of the number of areas on a fish which are at least 40% descaled and the number of sides of a fish which have scattered descaling is at least two. This type of descaling averaged 3.5 times greater than classical descaling. The range in increase over classical descaling across traps and species groups was 1.9 times for wild steelhead to 4.4 times for chinook salmon, both at the Snake River trap.

The highest rates of two-area descaling were for hatchery steelhead at Whitebird (35%) and Snake River (19%) and for chinook salmon at Whitebird (16%). The highest seasonal two-area descaling rate for wild steelhead was 7.5% at Whitebird and was only 1.6% at the Clearwater trap and 2.6% at the Snake River trap. Hatchery steelhead suffered at least five times the two-area descaling rate as did wild steelhead.

Classical descaling rate, by length interval. Descaling rates of smolts separated into 20 mm intervals indicate that yearling chinook salmon larger than 160 mm are descaled at a higher rate than are smaller chinook salmon (Table 12). This is especially obvious at Whitebird and, to a lesser extent, at the Snake River trap.

Both hatchery and wild steelhead demonstrate little change in descaling rate with change in length in 1984. Hatchery steelhead captured at Whitebird actually showed a lower descaling rate with increase in length, the reverse of that observed in 1983.

In conclusion, hatchery chinook salmon and steelhead had very low descaling rates at hatcheries and release sites, generally less than 1%, but the rates were higher at fish traps. Either traps select for fish in

Table 11. Percent classical, 2-area and scattered descaling at three migrant traps, 1984

	Clearwater River			Snake			Whitebird		
	Class.	Two areas	Scat.	Class	Two areas	Scat.	Class	Two areas	Scat
Chinook Salmon Yearlings	1.5	6.0	8.4	2.5	11.1	16.8	4.5	16.0	21.6
Steel head (Hatchery)	4.2	8.5	10.3	5.7	19.4	23.7	8.7	35.4	39.7
Steelhead (Wild)	0.4	1.6	2.7	1.4	2.6	4.4	2.0	7.5	9.9

Table 12. Percent classical descaling, by 20 mm length intervals for yearling chinook salmon, hatchery and wild steelhead at Clearwater (CW), Snake River (SR) and Whitebird (WB) traps, 1984.

Length interval	Chinook Salmon			Steelhead Hatchery			Steelhead Wild		
	CW	SR	WB	CW	SR	WB	CW	SR	WB
81-100	0.4	2.2	1.8						
101-120	1.1	2.1	4.2						
121-140	1.8	2.3	4.7						
141-160	1.5	3.3	4.2	8.3	6.3	11.1	0.0	3.1	5.0
161-180	0.0	4.7	9.3	5.8	3.9	13.0	1.2	2.1	0.7
181-200	4.0	5.3	16.7	5.1	4.6	7.0	0.0	1.3	2.2
201-220	0.0			4.1	6.6	9.2	0.0	0.0	0.8
221-240	10.7			1.4	6.7	8.5	0.0	0.0	2.3
241-260	0.0			3.6	5.8	9.2		0.0	10.0
261-280					2.0	9.0			
281-300					3.1	5.8			
301+						0.0			

poor health or many hatchery fish become descaled prior to arriving at the fish traps. The ranges of average descaling rates for chinook salmon and hatchery steelhead at the three traps were 1.5% to 4.5% and 4.1% to 8.7%, respectively. Wild steelhead descaling rates ranged from 0.4% to 2.1%.

Smolts with scattered descaling and two-area descaling were 4.8 and 3.5 times more common, respectively, than smolts with classical descaling. These types of descaling may be as damaging to fish as is classical descaling and should be included in the index to fish condition.

Length Frequency Distributions

Yearling Chinook Salmon

Mean total lengths of yearling chinook salmon were essentially the same at all three traps (Table 13) at 128 (117 mm fork length) ± 1 mm. However, the length distribution for Clearwater chinook salmon was much wider and skewed towards larger fish than at the other two traps (Fig. 25, 26 and 27). Whitebird and Snake River trapped chinook salmon were 93 to 94% between 100 mm and 150 mm, whereas only 83% of Clearwater chinook salmon fell within this range and 5.5% of the Clearwater chinook salmon were 200 mm or larger.

Weekly mean lengths of chinook salmon at Whitebird (Table 14) were less than 120 mm in mid-March then increased slowly to 135 mm through the remaining season. Mean lengths at the Snake River trap were the same as at Whitebird for the time the former was operating. Mean length at the Clearwater trap was 128 mm the fourth week of March then increased for two weeks to near 150 mm. In late April, mean length decreased to 114 mm and stayed low until the end of the season.

Hatchery Steelhead Trout

Mean total length of hatchery steelhead was smallest at Clearwater trap (203 mm) and largest at the Whitebird trap (239 mm) (Table 13). Mean length of hatchery steelhead at Snake River trap was intermediate (228 mm) and had the largest standard deviation, probably a result ofmixed stocks from Hells Canyon, Salmon, Grande Ronde and Imnaha rivers. Also, pre-smolts were released in Hells Canyon in December and would probably migrate at a smaller size than most hatchery smolts. Most hatchery steelhead (92-93%) were within length ranges of 170 to 240 mm at the Clearwater trap (Fig. 28), 170 to 270 mm at the Snake River trap (Fig. 29) and 200 to 280 mm at the Whitebird trap (Fig. 30). There was no obvious change in mean lengths as the migration season progressed.

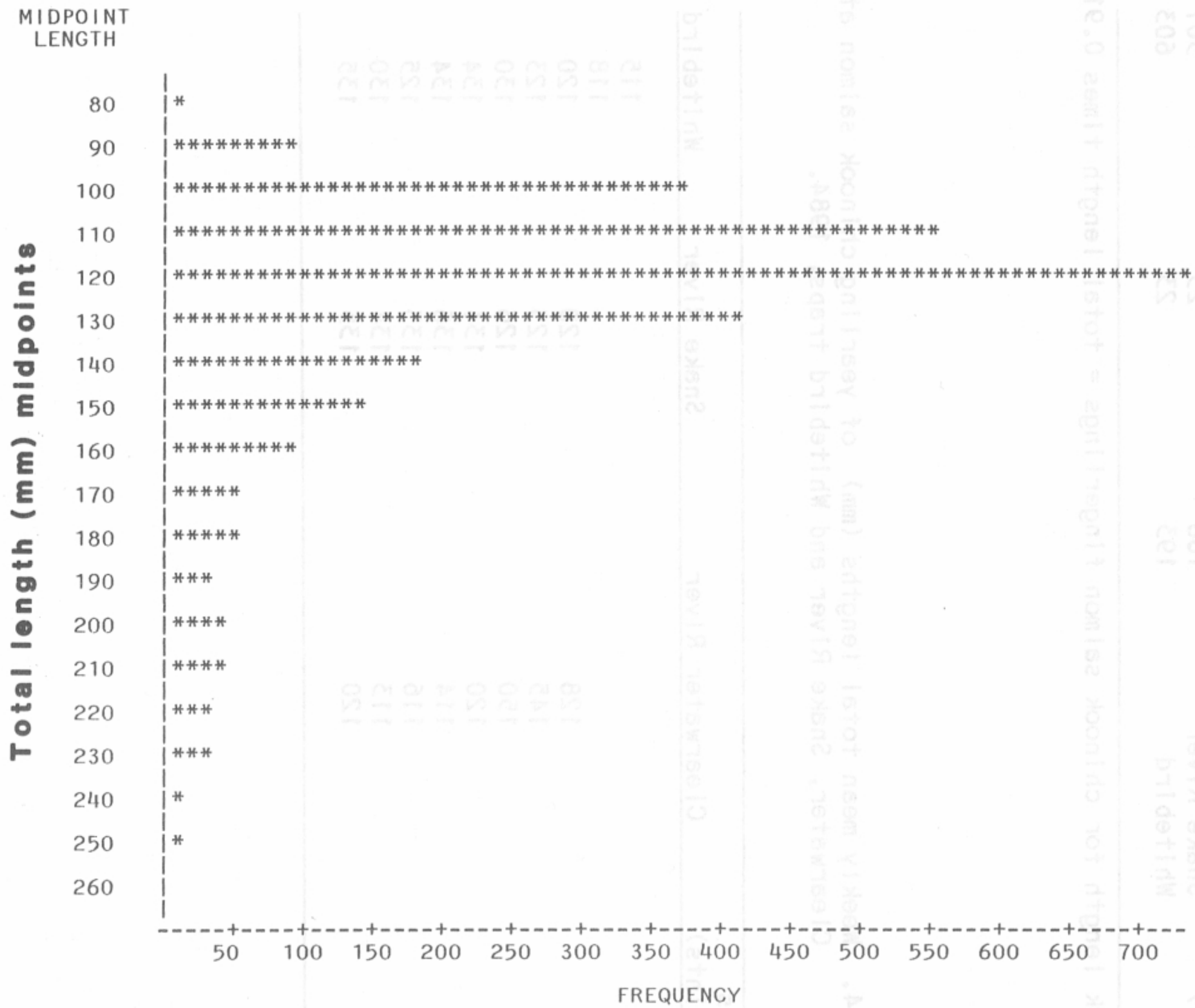
Table 13. Mean total lengths (mm) of yearling chinook salmon and hatchery and wild steelhead smolts captured at Clearwater, Snake River and Whitebird traps.

Species	Location	Mean total length	Standard deviation	Sample size
Chinook 1's	Clearwater River	128[1]	29	2842
	Snake River	129[1]	17	12,287
	Whitebird	127[1]	17	13,902
Steelhead (Hatchery)	Clearwater River	203	21	853
	Snake River	228	33	1,190
	Whitebird	239	25	2,342
Steelhead (wild)	Clearwater River	179	20	241
	Snake River	188	25	501
	Whitebird	193	23	603

[1] Fork length for chinook salmon fingerlings = total length times 0.915.

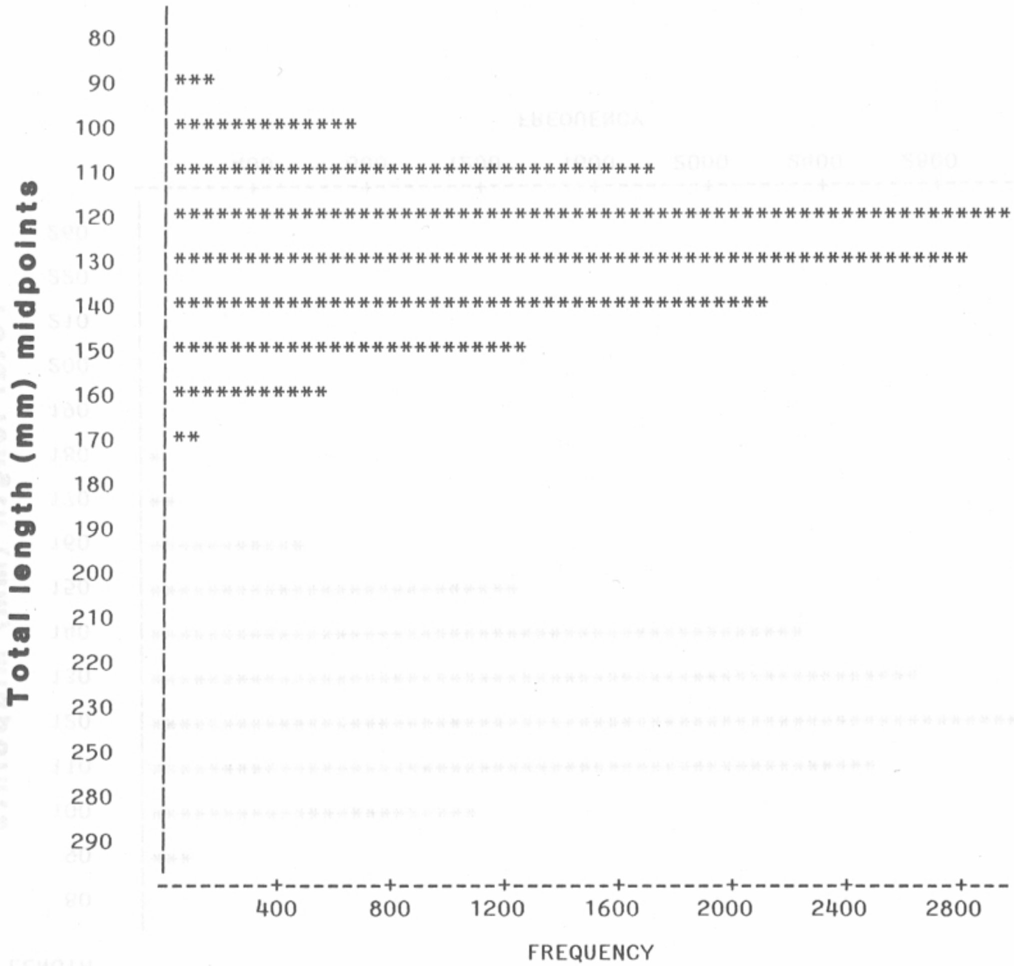
Table 14. Weekly mean total lengths (mm) of yearling chinook salmon at Clearwater, Snake River and Whitebird traps, 1984.

Weeks (mid points)	Clearwater River	Snake River	Whitebird
3/11			115
3/18			118
3/25	128	120	120
4/1	145	125	123
4/8	150	126	130
4/15	120	134	134
4/22	114	136	134
4/29	116	133	125
5/6	113	134	130
5/13	120	135	135



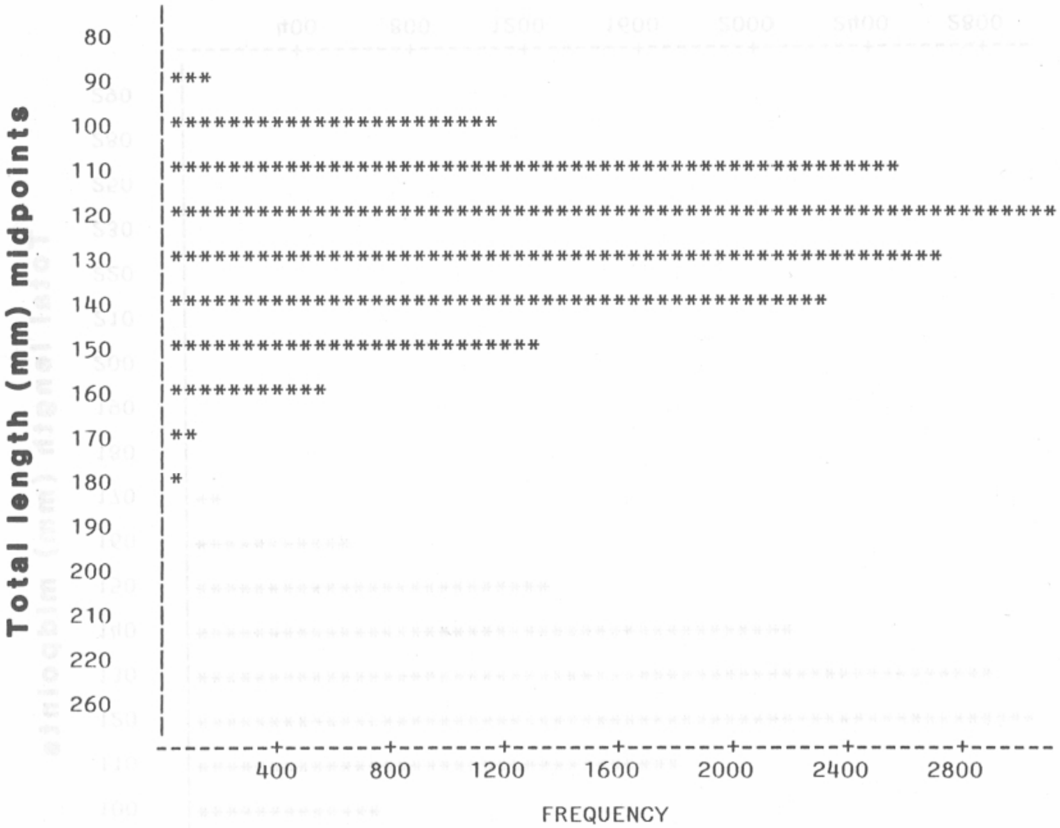
FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
9	9	0.32	0.32
89	98	3.13	3.45
366	464	12.88	16.33
546	1010	19.21	35.54
727	1737	25.58	61.12
413	2150	14.53	75.65
181	2331	6.37	82.02
135	2466	4.75	86.77
94	2560	3.31	90.08
53	2613	1.86	91.94
45	2658	1.58	93.53
28	2686	0.99	94.51
40	2726	1.41	95.92
38	2764	1.34	97.26
28	2792	0.99	98.24
29	2821	1.02	99.26
12	2833	0.42	99.68
6	2839	0.21	99.89
3	2842	0.11	100.00

Figure 25. Seasonal length frequency distribution of yearling chinook salmon at Clearwater trap, 1984.



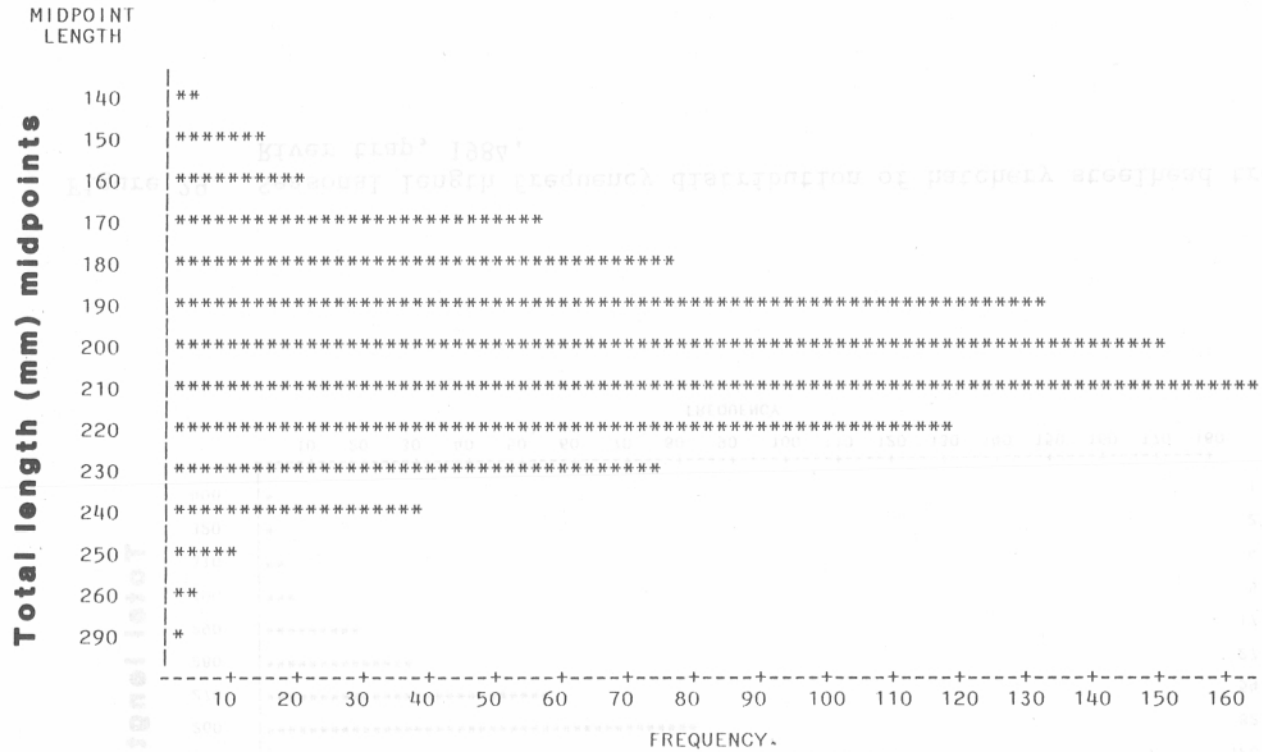
MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
80	17	17	0.14	0.14
90	144	161	1.17	1.31
100	631	792	5.14	6.45
110	1717	2509	13.97	20.42
120	2928	5437	23.83	44.25
130	2795	8232	22.75	67.00
140	2088	10320	16.99	83.99
150	1245	11565	10.13	94.12
160	553	12118	4.50	98.62
170	118	12236	0.96	99.58
180	24	12260	0.20	99.78
190	10	12270	0.08	99.86
200	4	12274	0.03	99.89
210	4	12278	0.03	99.93
220	2	12280	0.02	99.94
230	3	12283	0.02	99.97
250	2	12285	0.02	99.98
280	1	12286	0.01	99.99
290	1	12287	0.01	100.00

Figure 26. Seasonal length frequency distribution of yearling chinook salmon at Snake River trap, 1984.



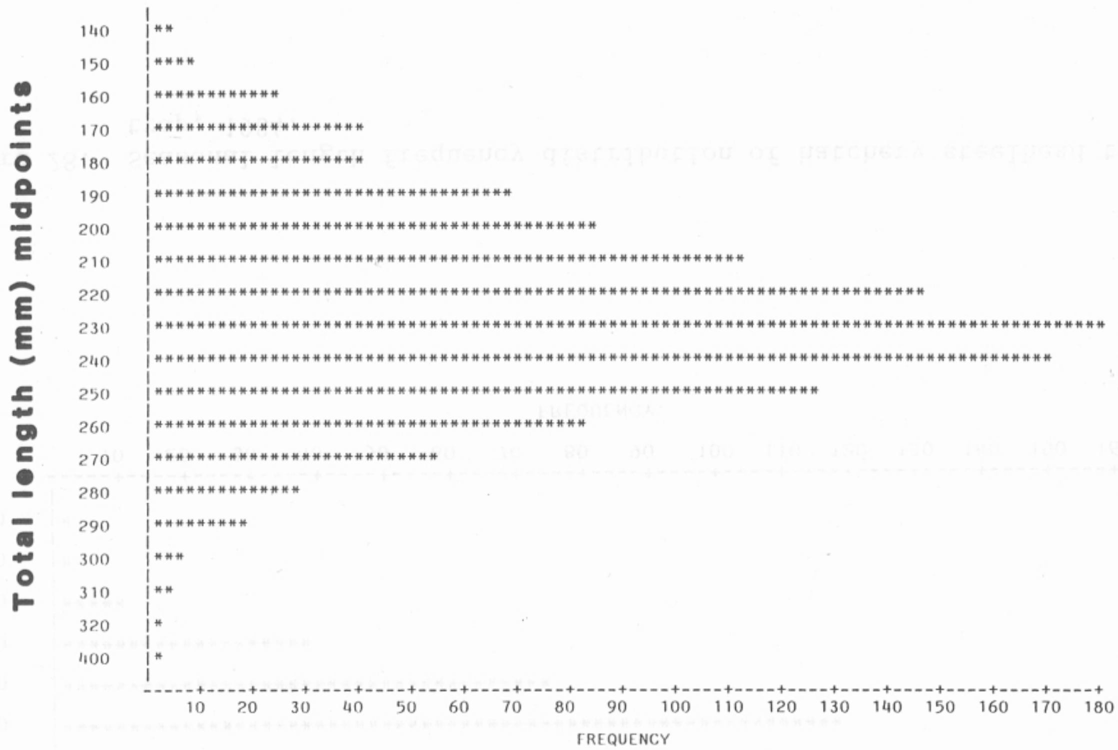
MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
80	4	4	0.03	0.03
90	159	163	1.14	1.17
100	1128	1291	8.11	9.29
110	2561	3852	18.42	27.71
120	3080	6932	22.16	49.86
130	2712	9644	19.51	69.37
140	2276	11920	16.37	85.74
150	1292	13212	9.29	95.04
160	525	13737	3.78	98.81
170	123	13860	0.88	99.70
180	28	13888	0.20	99.90
190	6	13894	0.04	99.94
200	2	13896	0.01	99.96
210	1	13897	0.01	99.96
220	4	13901	0.03	99.99
260	1	13902	0.01	100.00

Figure 27. Seasonal length frequency distribution of yearling chinook salmon at Whitebird trap, 1984.



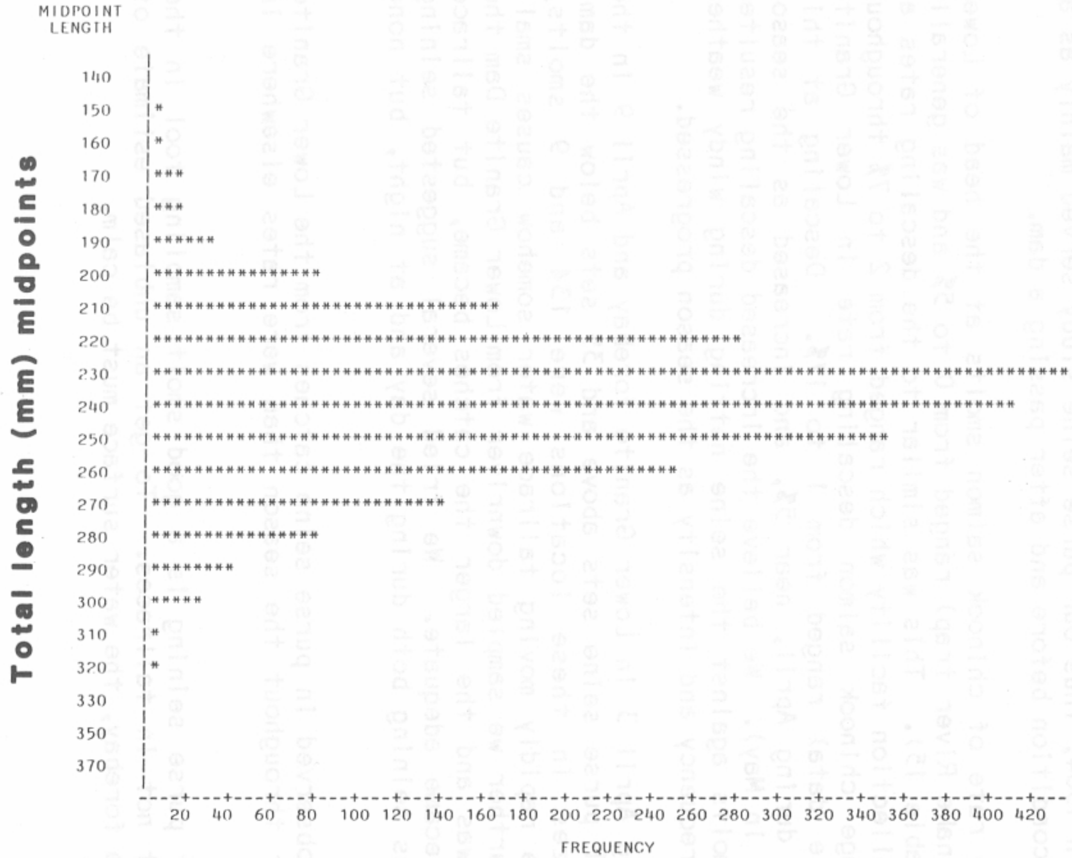
MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
140	4	4	0.47	0.47
150	14	18	1.64	2.11
160	19	37	2.23	4.34
170	55	92	6.45	10.79
180	75	167	8.79	19.58
190	131	298	15.36	34.94
200	150	448	17.58	52.52
210	164	612	19.23	71.75
220	117	729	13.72	85.46
230	73	802	8.56	94.02
240	37	839	4.34	98.36
250	9	848	1.06	99.41
260	4	852	0.47	99.88
290	1	853	0.12	100.00

Figure 28. Seasonal length frequency distribution of hatchery steelhead trout smolts at Clearwater trap, 1984.



MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
140	4	4	0.34	0.34
150	8	12	0.67	1.01
160	24	36	2.02	3.03
170	39	75	3.28	6.30
180	39	114	3.28	9.58
190	68	182	5.71	15.29
200	83	265	6.97	22.27
210	112	377	9.41	31.68
220	145	522	12.18	43.87
230	180	702	15.13	58.99
240	170	872	14.29	73.28
250	126	998	10.59	83.87
260	82	1080	6.89	90.76
270	54	1134	4.54	95.29
280	27	1161	2.27	97.56
290	17	1178	1.43	98.99
300	5	1183	0.42	99.41
310	4	1187	0.34	99.75
320	2	1189	0.17	99.92
400	1	1190	0.08	100.00

Figure 29. Seasonal length frequency distribution of hatchery steelhead trout smolts at Snake River trap, 1984.



MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
140	1	1	0.04	0.04
150	5	6	0.21	0.26
160	7	13	0.30	0.56
170	13	26	0.56	1.11
180	15	41	0.64	1.75
190	31	72	1.32	3.07
200	80	152	3.42	6.49
210	167	319	7.13	13.62
220	282	601	12.04	25.66
230	435	1036	18.57	44.24
240	408	1444	17.42	61.66
250	350	1794	14.94	76.60
260	250	2044	10.67	87.28
270	139	2183	5.94	93.21
280	80	2263	3.42	96.63
290	38	2301	1.62	98.25
300	24	2325	1.02	99.27
310	6	2331	0.26	99.53
320	6	2337	0.26	99.79
330	2	2339	0.09	99.87
350	1	2340	0.04	99.91
370	2	2342	0.09	100.00

Figure 30. Seasonal length frequency distribution of hatchery steelhead trout smolts at Whitebird trap, 1984.

Wild Steelhead Trout

Wild steelhead mean total lengths differ slightly between traps with Clearwater having the smallest (179 mm) and Whitebird the largest (193 mm).

Most (91-92%) wild steelhead were within the length range of 150 to 210 mm at the Clearwater (Fig. 31), 150 to 220 mm at the Snake River (Fig. 32) and 160 to 230 mm at Whitebird trap (Fig. 33). There was no obvious change in mean length as the migration progressed.

Purse Seining

Descaling rate differential between Lower Granite and Little Goose dams did not occur in 1984, thus our purse seine study served mainly as an evaluation of smolt condition before and after passing a dam.

Weekly descaling rate of chinook salmon smolts at the head of Lower Granite Reservoir (Snake River trap) ranged from 0 to 5% and was generally between 2 and 3% (Table 15). This was similar to the descaling rates at Lower Granite Dam collection facility which ranged from 2 to 7% throughout the season. Average chinook salmon descaling rate in Lower Granite forebay (purse seine data) ranged from 1 to 17%. Descaling at this location was lowest during April, near 5%, and increased as the season progressed (near 15% in May). We believe the increased descaling resulted from abrasion of smolts against the seine netting during windy weather which increased in frequency and intensity as the season progressed.

We began sampling April 3 in Lower Granite forebay and April 9 in the tailrace and made 31 purse seine sets above and 35 sets below the dam. Average sample sizes in these locations were 134 and 9 smolts, respectively, as the rapidly moving tailrace water somehow causes small catch rates. The further we sampled downriver from Lower Granite Dam the slower the current was and the larger the catches became, but tailrace sample size never became adequate. We tried several suggested seining techniques as well as seining both during the day and at night, but none proved successful.

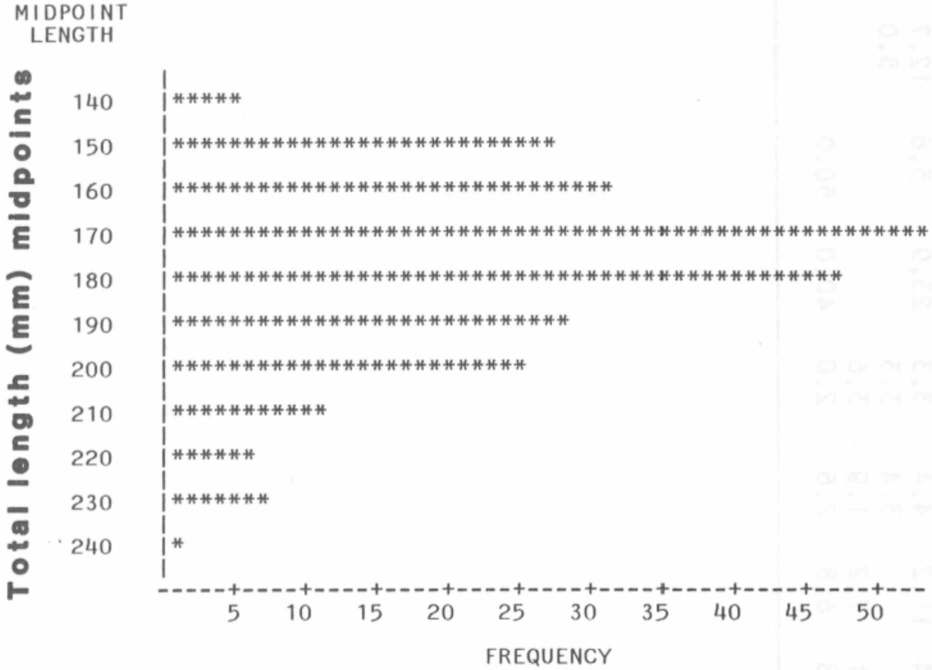
Descaling rates observed in purse seine catches from the Lower Granite tailrace were higher throughout the season than were rates elsewhere in the river.

We conclude that purse seining is a good smolt sampling tool in the forebay of dams, but not in tailraces. To get an unbiased estimate of descaling rate in the forebay, the water surface must be calm.

Table 15. Weekly descaling rates of chinook salmon and steelhead (hatchery and wild combined) smolts at three Lower Snake River index sites: Snake River trap, Lower Granite Dam and Little Goose Dam and in the forebay and tailrace of Lower Granite Dam, 1984.

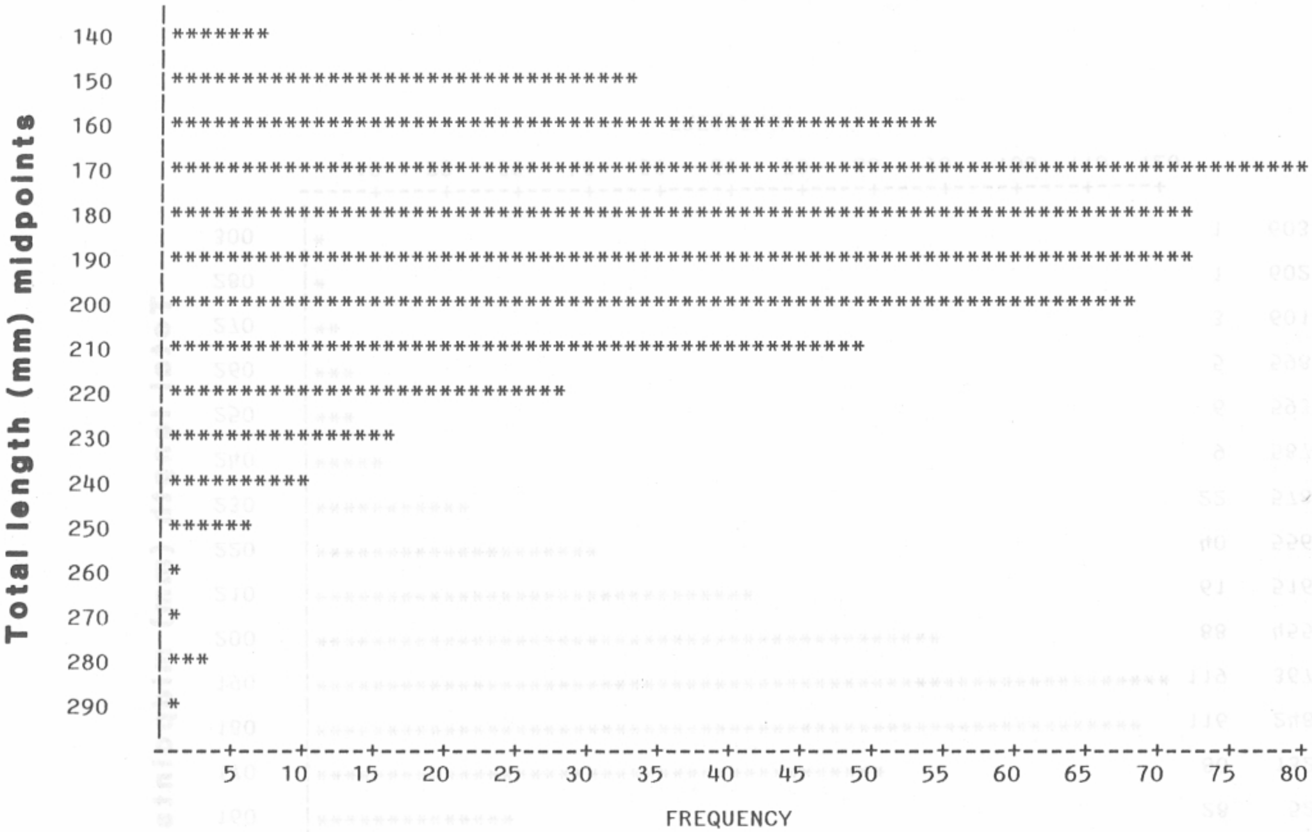
Weeks	Snake River Trap		Above Lower Granite		Lower Granite collection facility		Below Lower Granite		Little Goose collection facility	
	CH.[1/]	ST.[2/]	CH.	ST.	CH.	ST.	CH.	ST.	CH.	ST.
Apr 1-7	2.6	9.5			2.4	1.8			3.9	1.0
8-14	1.7	0	1.4	0	3.2	3.1			3.8	0.3
15-21	2.3	5.2	7.8	5.2	3.2	1.1	1.4		4.1	3.5
22-28	3.6	3.2	2.3	1.4	6.5	4.6	20.0		6.1	1.3
29-5	2.6	3.0	7.6	2.4	3.5	1.9	3.9		7.3	1.6
May 6-12	2.3	3.7	12.7	4.9	5.2	1.9	8.3	1.6	10.0	2.1
13-19	3.5	6.8	17.4	11.2	4.4	3.3	23.9	5.6	12.7	4.
20-26					3.4	3.3			5.0	3.9
27-1			13.1	7.2	1.9	3.6				
Jun 3-9			15.8	6.8	2.6	2.0	40.0	50.0		

1/ CH = chinook salmon.
2/ST = steelhead trout.



MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
140	5	5	2.07	2.07
150	27	32	11.20	13.28
160	31	63	12.86	26.14
170	53	116	21.99	48.13
180	47	163	19.50	67.63
190	28	191	11.62	79.25
200	25	216	10.37	89.63
210	11	227	4.56	94.19
220	6	233	2.49	96.68
230	7	240	2.90	99.59
240	1	241	0.41	100.00

Figure 31. Seasonal length frequency distribution of wild steelhead trout captured at Clearwater trap, 1984.



MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
140	7	7	1.40	1.40
150	33	40	6.59	7.98
160	54	94	10.78	18.76
170	80	174	15.97	34.73
180	72	246	14.37	49.10
190	72	318	14.37	63.47
200	68	386	13.57	77.05
210	49	435	9.78	86.83
220	28	463	5.59	92.42
230	16	479	3.19	95.61
240	10	489	2.00	97.60
250	6	495	1.20	98.80
260	1	496	0.20	99.00
270	1	497	0.20	99.20
280	3	500	0.60	99.80
290	1	501	0.20	100.00

Figure 32. Seasonal length frequency distribution of wild steelhead trout captured at Snake River trap, 1984.

Total length (mm) midpoints

MIDPOINT LENGTH		FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
140	****	7	7	1.16	1.16
150	*********	17	24	2.82	3.98
160	**************	28	52	4.64	8.62
170	**	80	132	13.27	21.89
180	**	116	248	19.24	41.13
190	**	119	367	19.73	60.86
200	**	88	455	14.59	75.46
210	*******************************	61	516	10.12	85.57
220	********************	40	556	6.63	92.21
230	***********	22	578	3.65	95.85
240	*****	9	587	1.49	97.35
250	***	6	593	1.00	98.34
260	***	5	598	0.83	99.17
270	**	3	601	0.50	99.67
280	*	1	602	0.17	99.83
300	*	1	603	0.17	100.00

10 20 30 40 50 60 70 80 90 100 110 120

FREQUENCY

Figure 33. Seasonal length frequency distribution of wild steelhead trout captured at Whitebird trap, 1984.

SUMMARY

We monitored condition and abundance of hatchery-reared smolts prior to release into Idaho rivers and daily passage of wild and hatchery-reared smolts at migrant traps on the Salmon, Snake and Clearwater rivers between mid-March and mid-May. Hatcheries produced 9.3 million chinook salmon and 6.3 million steelhead smolts for release into the Snake River system above Lower Granite Reservoir for outmigration in spring 1984.

Six groups of chinook salmon and four groups of steelhead were freeze branded at hatcheries and released in Idaho rivers. One to three percent of the hatchery production for each of the Clearwater, Snake and Salmon rivers were branded. Additionally, we branded 31,411 chinook salmon and 3,066 steelhead at Whitebird.

We operated the Whitebird trap from March 14 to May 12 and captured 43,860 yearling chinook salmon, 3,221 steelhead (69% hatchery, 21% wild) and 3 sockeye smolts. Peak passage of chinook salmon occurred April 10 to 17 and from April 20 onward for steelhead.

The Snake River trap operated from March 22 until May 15. We had planned to fish this trap until the end of June, but there were only five days in June when discharge was low enough to allow trap operation. The trap caught 55,900 yearling chinook salmon, 2,669 zero age chinook salmon, 1,890 steelhead (70% hatchery, 30% wild) and 49 sockeye. A significant catch of chinook salmon occurred the day trapping began, as 500,000 spring chinook salmon had been released in Hells Canyon two days earlier. The main chinook salmon passage began April 17 as river discharge rose from near 80,000 cfs to above 100,000 cfs. Daily catch peaked at near 8,000 chinook salmon on April 18. Steelhead began passing the trap with this same rise in discharge and continued to pass after we stopped sampling May 15. Sockeye and zero-age chinook salmon entered the trap nearly every day after April 30. Discharge was abundant the entire season, never dropping below 70,000 cfs and peaking at 187,000 cfs on May 31.

The Clearwater trap captured 3,660 chinook salmon and 1,304 steelhead (78% hatchery and 22% wild) during the March 29 to May 13 season. Trap start-up problems and frequent debris-bearing freshets prevented this trap from obtaining adequate catches.

Three groups of branded chinook salmon (23,000 to 34,000 each) and two of steelhead (21,000 and 22,000) smolts were released upriver from the Whitebird trap. We captured 518 of the branded chinook salmon and no branded steelhead at the Whitebird trap. Migration rates for branded chinook smolts from Rapid River, South Fork and Decker Flat to Whitebird were 3, 17 and 15 miles/day respectively.

We measured the influence of Salmon River discharge, transparency, day length, year and release date on migration rate between release sites and Whitebird and found that discharge, and to a lesser extent, transparency, had the greatest effect.

We trapped 1,495 hatchery branded chinook salmon smolts at the Snake River trap which came from three brand groups released in the Salmon River and one group released in Hells Canyon. Median migration rates for the branded groups migrating from the Whitebird trap and Hells Canyon Dam to the Snake River trap ranged from 11 miles/day for the Hells Canyon release to 51 miles/day for the Decker Flat group. Discharge was not strongly correlated with migration rate of hatchery branded smolts migrating between the Whitebird and Snake River trap in 1983 and 1984. None of the abiotic parameters that we measured were significantly correlated with migration rate of these hatchery groups in this river section.

Migration rates between release sites and the head of Lower Granite Reservoir at the Snake River trap for hatchery branded chinook salmon averaged 13.2 miles/day and from this point through the reservoir, average migration rate decreased to 1.9 miles/day, a seven-fold decrease.

In 1983 and 1984, we marked and released a total of 26 unique brand groups at Whitebird for recapture at the Snake River trap. Multiple regression analysis of their migration rates on the independent variables mentioned above indicated that Salmon River discharge and Salmon River temperature were the first and second most influential variables on migration rate. Variation in Snake River discharge and temperature had much less influence on migration rate between the Whitebird and Snake River traps. Migration rates in this river section ranged from 5 to 30 miles/day with the most rapid rates associated with greatest discharge.

Red River pond, on the South Fork of the Clearwater River, released 15,000 branded chinook salmon smolts in the fall of 1983 and again in the spring of 1984. The Clearwater trap caught 23 of the former and 43 of the latter. The spring-released smolts had a median migration rate of 7.5 miles/day. The Clearwater trap also caught 7 of 20,000 branded steelhead released from Dworshak. Median migration rate for these smolts released on May 4 was 34 miles/day.

We evaluated trap efficiency by recovering marked smolts at the traps. We estimated efficiency 5, 5 and 10 times at the Whitebird, Clearwater and Snake River traps, respectively. Average efficiencies for these three traps were 1.24%, 1.57% and 1.70%, respectively. There was little correlation between efficiency and discharge at the Snake and Clearwater River traps.

Survival rates of smolts from hatchery release sites to the head of Lower Granite Reservoir were estimated based on the fraction of released branded smolts which were estimated to have passed the Snake River trap. Survival estimates for Rapid River, South Fork Salmon River, Decker Flat and Hells Canyon branded chinook salmon smolts were 65%, 68%, 35% and 52%. Estimated average survival of Whitebird branded smolts was 31%; however, since these brands were more difficult to detect because of their newness, the mean survival estimate at Lower Granite Dam of 43% was probably a minimum estimate for survival to the Snake River trap.

We monitored scale loss of smolts at hatcheries, release sites and migrant traps as a measure of fish health prior to and during migration. Classical descaling, where at least 40% of scales are missing from at least two out of five areas on one side of a fish, ranged from zero to

5.3% at hatcheries for chinook salmon and was generally less than 1%. Scattered descaling, where at least 10% of scales are missing from at least one side of a fish, ranged from 0.3% to 34%, but was generally less than 5%. Descaling rates generally increased another 1% after transport to release sites.

Classical descaling of steelhead was less than 1% at all hatcheries and the maximum recorded at release sites was 3.3%. The average descaling rate at release sites was 0.7%.

Chinook salmon descaling rates at Whitebird rose to between 6 and 7% in late March and early April, then decreased to near 3% through mid-May. Descaling rates at the Snake River trap followed the same trend but at a lower rate, ranging from 1.7 to 3.5%. Weekly descaling rate for chinook salmon was lowest at the Clearwater trap, ranging from 0.5 to 2.4%. Seasonal averages were 4.5%, 2.5% and 1.5% for the Whitebird, Snake and Clearwater traps, respectively.

Weekly descaling rates for wild steelhead ranged from 0.5% to 4.5% at Whitebird, 0.5% to 3% at the Snake River trap and 0.0 to 1.0% at the Clearwater trap. Seasonal averages for these three sites were 2.1%, 1.4% and 0.4%, respectively.

Weekly descaling rates for hatchery-reared steelhead ranged from 6% to 14% at Whitebird, 3% to 8% at the Snake River trap (when large samples were available) and 2.2% to 13.3% at the Clearwater trap. Seasonal descaling rates for these three sites were 8.7%, 5.5% and 4.1%, respectively.

Scattered descaling for all three species groups and traps was in each case greater than classical descaling, ranging from 2.5 times greater for Clearwater hatchery steelhead to 6.8 times greater for Clearwater wild steelhead.

Chinook salmon smolts larger than 160 mm total length are descaled at higher rates than are smaller chinook salmon whereas steelhead, both hatchery and wild, showed no obvious change in descaling rate with length.

A mean fork length of 117 mm (128 mm total length) for yearling chinook salmon was the same at the three trap sites. However, there was a larger percentage of large smolts at the Clearwater trap than at other traps. Mean total length of hatchery steelhead was smallest at the Clearwater trap (203 mm) and largest at the Whitebird trap (239 mm). Wild steelhead mean lengths mirrored this relationship at the Clearwater (178 mm) and Whitebird (193 mm) traps.

Purse seining as a method to measure smolt descaling rates before and after passing Lower Granite Dam was not successful. We could not catch adequate sample sizes below the dam and windy weather caused the seine to descale fish, especially in the forebay. Additionally, the two projects, Lower Granite and Little Goose, reported similar descaling rates so there was little actual difference in descaling rate to detect. In calm forebay waters, large smolt samples were obtained by purse seining and descaling measurements were probably near that of the actual population.

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APPENDICES

Appendix 1. Data set, programs and analysis for migration rate regressions of hatchery branded chinook smolts released into the Salmon River and recaptured at Whitebird trap.

```
DATA HTCHTOWB;
INPUT RATE DL TEMP SECCHI Q DATE YEAR;     CARDS;
10.7 1.45 08.5 1.4 09.5 26 1
09.0 1.45 08.4 1.8 07.0 36 1
04.5 0.70 07.8 1.5 07.2 26 1
07.8 0.46 07.1 1.5 08.4 10 1
03.1 1.16 07.9 0.9 08.8 32 2
15.1 1.18 08.1 0.9 10.2 28 2
17.1 1.53 09.0 0.8 12.6 41 2
PROC STEPWISE DATA=HTCHTOWB;
MODEL RATE=DL TEMP SECCHI Q DATE YEAR/MAXR;
TITLE MIGRATION RATES FOR SALMON RIVER CHINOOK SMOLTS;
TITLL2 BETWEEN RELEASE SITES AND WHITEBIRD(OBS=7);
DATA FOUR; SET HTCHTOWB; IF YEAR=1 THEN DELETE;
PROC STEPWISE DATA=FOUR;
MODEL RATE=DL TEMP SECCHI Q DATE/MAXR;
TITLE MIGRATION RATES:RELEASE TO WHITEBIRD 1984(OBS=3);
```

MIGRATION RATES FOR SALMON RIVER CHINOOK SMOLTS
BETWEEN RELEASE SITES AND WHITEBIRD(OBS=7)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 1 VARIABLE Q ENTERED R SQUARE = 0.62037498 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	98.99234923	98.99234923	8.17	0.0355
ERROR	5	60.57622219	12.11524444		
TOTAL	6	159.56857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-9.59318503				
Q	2.11071107	0.73840404	98.99234923	8.17	0.0355

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE SECCHI ENTERED R SQUARE = 0.76408071 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	121.92326693	60.96163347	6.48	0.0557
ERROR	4	37.64530450	9.41132612		
TOTAL	6	159.56857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-32.93988071				
SECCHI	8.54723729	5.47571019	22.93091770	2.44	0.1936
Q	3.49550199	1.10026989	94.98859678	10.09	0.0336

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

STEP 3 VARIABLE YEAR ENTERED R SQUARE = 0.84317241 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	134.54381750	44.84793917	5.38	0.1003
ERROR	3	25.02475393	8.34158464		
TOTAL	6	159.56857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-66.25934831				
SECCHI	21.81299625	11.95366016	27.77649233	3.33	0.1655
Q	3.94749064	1.09909952	107.60110814	12.90	0.0370
YEAR	8.77059176	7.13040218	12.62055056	1.51	0.3063

THE ABOVE MODEL IS THE BEST 3 VARIABLE MODEL FOUND.

MIGRATION RATES FOR SALMON RIVER CHINOOK SMOLTS
BETWEEN RELEASE SITES AND WHITEBIRD(OBS=7)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 4 VARIABLE DATE ENTERED R SQUARE = 0.85382372 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	136.24343071	34.06085768	2.92	0.2710
ERROR	2	23.32514072	11.66257036		
TOTAL	6	159.56857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-74.35925490				
SECCHI	25.38457201	16.95020191	26.15677618	2.24	0.2729
Q	4.17833052	1.43339169	99.09918748	8.50	0.1003
DATE	-0.07500517	0.19647771	1.69961321	0.15	0.7394
YEAR	11.31969255	10.75510731	12.91915305	1.11	0.4030

THE ABOVE MODEL IS THE BEST 4 VARIABLE MODEL FOUND.

STEP 5 VARIABLE TEMP ENTERED R SQUARE = 0.90118818 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	143.80131010	28.76026202	1.82	0.5077
ERROR	1	15.76726132	15.76726132		
TOTAL	6	159.56857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-128.61413743				
TEMP	9.05484567	13.07853824	7.55787940	0.48	0.6145
SECCHI	26.56665299	19.78242062	28.43616911	1.80	0.4075
Q	2.54189371	2.89213308	12.17964110	0.77	0.5410
DATE	-0.58842392	0.77595777	9.06693977	0.58	0.5870
YEAR	17.46749125	15.33729411	20.45124930	1.30	0.4587

STEP 5 Q REPLACED BY DL R SQUARE = 0.99991888 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	159.55562766	31.91112553	2465.37	0.0153
ERROR	1	0.01294377	0.01294377		
TOTAL	6	159.56857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-305.96330942				
DL	-18.21851171	0.39217235	27.93395866	2158.10	0.0137
TEMP	33.98010013	0.39799914	94.35081868	7289.29	0.0075
SECCHI	39.50796414	0.66970576	45.04658459	3480.18	0.0108
DATE	-1.41340453	0.01730372	86.36035884	6671.97	0.0078
YEAR	35.70436937	0.53544706	57.55330778	4446.41	0.0095

THE ABOVE MODEL IS THE BEST 5 VARIABLE MODEL FOUND.

MIGRATION RATES FOR SALMON RIVER CHINOOK SMOLTS
BETWEEN RELEASE SITES AND WHITEBIRD(OBS=7)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 6 VARIABLE Q ENTERED R SQUARE = 1.00000000 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	159.56857143	26.59476190	999999.99	0.0001
ERROR	0	0.00000000	0.00000000		
TOTAL	6	159.56857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-301.85501402				
DL	-17.88851688	0	15.76726132	999999.99	0.0001
TEMP	33.29854312	0	23.03968465	999999.99	0.0001
SECCHI	39.41677676	0	44.02271720	999999.99	0.0001
Q	0.10829789	0	0.01294377	999999.99	0.0001
DATE	-1.38661117	0	24.46355520	999999.99	0.0001
YEAR	35.29531988	0	35.51526580	999999.99	0.0001

THE ABOVE MODEL IS THE BEST 6 VARIABLE MODEL FOUND.

MIGRATION RATES:RELEASE TO WHITEBIRD 1984(OBS=3)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 1 VARIABLE Q ENTERED R SQUARE = 0.73396440 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	84.16125150	84.16125150	2.76	0.3450
ERROR	1	30.50541516	30.50541516		
TOTAL	2	114.66666667			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-23.78808664				
Q	3.37545126	2.03218958	84.16125150	2.76	0.3450

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE DATE ENTERED R SQUARE = 1.00000000 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	114.66666667	57.33333333	999999.99	0.0001
ERROR	0	0.00000000	0.00000000		
TOTAL	2	114.66666667			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-18.88561151				
Q	5.89928058	0	101.11278195	999999.99	0.0001
DATE	-0.93525180	0	30.50541516	999999.99	0.0001

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

NO FURTHER IMPROVEMENT IN R-SQUARE IS POSSIBLE.

Appendix 2. Data set, programs and analysis for migration rate regressions of hatchery branded chinook salmon smolts migrating between Whitebird trap and Snake River trap.

```
DATA WBTOLWH;
INPUT RATE SMNQ SMNT SMNDISC SNKQ SNKT SNKDISC DL YEAR; CARDS;
     25.5  9.7 10.0 1.0  94.8 10.3 0.6 1.61 2
     50.5 21.6  8.8 0.4 104.0 10.0 0.4 1.82 2
     20.2 20.6  8.4 0.4 100.7 10.7 0.4 1.89 2
      9.6 18.2  9.9 0.6  80.5   .    .  1.20 1
     35.3 14.9  9.2 0.7  79.1   .    .  2.30 1
      7.1  6.8  7.3 1.6  55.4   .    .  1.30 1
     21.1  6.1  7.1 2.1  49.5   .    .  1.50 1
PROC STEPWISE DATA=WBTOLWH;
MODEL RATE=SMNQ SMNT SMNDISC SNKQ DL YEAR/MAXR;
    TITLE MIGRATION RATES FOR HATCHERY CHINOOK FROM WHITEBIRD;
    TITLE2 TO LEWISTON: 1983 & 1984 COMBINED DATA (OBS=7);
DATA TWO;SET WBTOLWH;IF YEAR=3 THEN DELETE;
PROC STEPWISE DATA=TWO;
MODEL RATE=SMNQ SMNT SMNDISC SNKQ SNKT SNKDISC DL/MAXR;
    TITLE MIGRATION RATES FOR HATCHERY CHINOOK FROM ;
    TITLE2   WHITEBIRD TO LEWISTON IN 1984 (OBS=3);
```

MIGRATION RATES FOR HATCHERY CHINOOK FROM WHITEBIRD
TO LEWISTON: 1983 & 1984 COMBINED DATA (OBS=7)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 1 VARIABLE DL ENTERED R SQUARE = 0.48586389 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	654.83207954	654.83207954	4.73	0.0818
ERROR	5	692.93649189	138.58729838		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-21.68983971				
DL	27.63587590	12.71364190	654.83207954	4.73	0.0818

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE YEAR ENTERED R SQUARE = 0.58120984 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	783.33635762	391.66817881	2.78	0.1754
ERROR	4	564.43221381	141.10805345		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-28.63793409				
DL	24.05903203	13.36507860	457.26195286	3.24	0.1462
YEAR	9.01995865	9.45195519	128.50427808	0.91	0.3940

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

STEP 3 VARIABLE SMNQ ENTERED R SQUARE = 0.58898926 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	793.82120798	264.60706933	1.43	0.3873
ERROR	3	553.94736345	184.64912115		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-28.55109793				
SMNQ	0.24166022	1.01413942	10.48485035	0.06	0.8270
DL	22.99537629	15.92693994	384.91390648	2.08	0.2445
YEAR	7.82928778	11.91107242	79.77926447	0.43	0.5579

THE ABOVE MODEL IS THE BEST 3 VARIABLE MODEL FOUND.

MIGRATION RATES FOR HATCHERY CHINOOK FROM WHITEBIRD
TO LEWISTON: 1983 & 1984 COMBINED DATA (OBS=7)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 4 VARIABLE SMNDISC ENTERED R SQUARE = 0.63655496 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	857.92876306	214.48219076	0.88	0.5948
ERROR	2	489.83980837	244.91990419		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-65.97803448				
SMNQ	1.46558776	2.66218237	74.22874767	0.30	0.6372
SMNDISC	14.45443652	28.25261163	64.10755508	0.26	0.6598
DL	25.16519724	18.82693343	437.58818187	1.79	0.3131
YEAR	9.69554396	14.19466494	114.26629572	0.47	0.5651

STEP 4 YEAR REPLACED BY SNKQ R SQUARE = 0.69071078 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	930.91827498	232.72956875	1.12	0.5229
ERROR	2	416.85029645	208.42514822		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-116.84859455				
SMNQ	1.68619167	2.47509662	96.73412034	0.46	0.5660
SMNDISC	29.69662826	32.99458420	168.84145440	0.81	0.4631
SNKQ	0.59687351	0.62970873	187.25580765	0.90	0.4432
DL	24.40518629	17.41188382	409.47071948	1.96	0.2961

THE ABOVE MODEL IS THE BEST 4 VARIABLE MODEL FOUND.

STEP 5 VARIABLE YEAR ENTERED R SQUARE = 0.76812371 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	1035.25299749	207.05059950	0.66	0.7261
ERROR	1	312.51557394	312.51557394		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-246.22598703				
SMNQ	2.23295196	3.17505986	154.57049140	0.49	0.6098
SMNDISC	69.06161568	79.20780190	237.57963509	0.76	0.5435
SNKQ	2.31895715	3.07853793	177.32423444	0.57	0.5890
DL	22.94786695	21.46961258	357.03261910	1.14	0.4788
YEAR	-36.98891200	64.01665194	104.33472251	0.33	0.6665

MIGRATION RATES FOR HATCHERY CHINOOK FROM WHITEBIRD
TO LEWISTON: 1983 & 1984 COMBINED DATA (OBS=7)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 5 DL REPLACED BY SMNT R SQUARE = 0.93309476 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	1257.59579099	251.51915820	2.79	0.4246
ERROR	1	90.17278044	90.17278044		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-344.82284330				
SMNQ	-2.01048279	2.35790423	65.55772302	0.73	0.5505
SMNT	-30.48579474	12.02694214	579.37541259	6.43	0.2392
SMNDISC	142.78409299	50.85417952	710.85629176	7.88	0.2178
SNKQ	9.98587172	3.28433078	833.59220824	9.24	0.2023
YEAR	-197.25895712	69.08677449	735.12144619	8.15	0.2145

THE ABOVE MODEL IS THE BEST 5 VARIABLE MODEL FOUND.

STEP 6 VARIABLE DL ENTERED R SQUARE = 1.00000000 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	1347.76857143	224.62809524	999999.99	0.0001
ERROR	0	0.00000000	0.00000000		
TOTAL	6	1347.76857143			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-438.85696820				
SMNQ	-6.28846718	0	149.44414887	999999.99	0.0001
SMNT	-60.91802999	0	312.51557393	999999.99	0.0001
SMNDISC	217.48878540	0	522.26377568	999999.99	0.0001
SNKQ	17.80583415	0	397.40916563	999999.99	0.0001
DL	-31.37752129	0	90.17278044	999999.99	0.0001
YEAR	-360.21432675	0	373.48450520	999999.99	0.0001

THE ABOVE MODEL IS THE BEST 6 VARIABLE MODEL FOUND.

MIGRATION RATES FOR HATCHERY CHINOOK FROM
WHITEBIRD TO LEWISTON IN 1984 (OBS=3)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

WARNING: 4 OBSERVATIONS DELETED DUE TO MISSING VALUES.

STEP 1 VARIABLE SNKT ENTERED R SQUARE = 0.81750306 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	428.14815315	428.14815315	4.48	0.2810
ERROR	1	95.57851351	95.57851351		
TOTAL	2	523.72666667			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	462.57567568				
SNKT	-41.66216216	19.68452337	428.14815315	4.48	0.2810

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE SNKQ ENTERED R SQUARE = 1.00000000 C(P) = .

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	523.72666667	261.86333333	999999.99	0.0001
ERROR	0	0.00000000	0.00000000		
TOTAL	2	523.72666667			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	250.12568807				
SNKQ	1.54311927	0	95.57851351	999999.99	0.0001
SNKT	-36.01100917	0	295.51931564	999999.99	0.0001

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

NO FURTHER IMPROVEMENT IN R-SQUARE IS POSSIBLE.

Appendix 3. Data set, programs and analysis for migration rate regressions of chinook salmon branded at Whitebird, released and recaptured at Snake River trap.

```
DATA OURBRAND;
INPUT RATE YEAR DATE SMNQ SMNT SMNDISC SNKQ SNKT SNKDISC DL;
CARDS;
09.2 2 20 08.4 06.6 0.48 076.1 8.1 0.35 0.34
14.2 2 23 09.6 06.4 0.49 077.7 8.0 0.33 0.39
06.7 2 26 08.1 06.6 0.93 074.8 8.5 0.48 0.68
05.9 2 29 08.0 07.5 1.06 078.5 9.1 0.54 0.86
07.8 2 32 08.3 07.8 1.01 078.7 9.1 0.57 0.98
07.2 2 35 09.2 07.8 0.86 085.5 10.0 0.54 1.18
16.8 2 38 09.8 07.6 0.71 079.8 9.0 0.58 1.22
14.4 2 41 09.4 07.8 0.93 085.4 10.5 0.54 1.38
20.2 2 44 08.8 09.1 1.03 094.8 10.3 0.47 1.50
50.5 2 47 13.9 10.8 0.75 099.5 10.0 0.40 1.64
50.5 2 50 21.6 08.8 0.38 102.5 10.0 0.40 1.79
50.5 2 53 17.3 08.9 0.68 100.5 11.0 0.45 1.95
33.7 2 56 17.4 08.1 0.68 096.0 9.5 0.40 2.10
10.1 2 59 13.0 07.7 1.06 080.8 10.4 0.45 2.35
07.2 2 62 12.4 08.3 1.06 105.0 11.6 0.42 2.54
10.1 2 65 12.4 08.8 1.19 101.9 11.6 0.49 2.65
20.2 2 68 12.1 09.2 1.20 097.8 11.5 0.48 2.69
17.7 1 37 06.8 07.7 1.80 067.2          .  1.24
11.8 1 41 06.3 07.5 2.02 051.2          .  1.54
10.6 1 44 06.3 09.6 1.92 045.0          .  1.72
17.7 1 47 05.4 11.3 1.83 043.2          .  1.77
26.5 1 51 09.7 11.3 1.03 058.8          .  1.92
17.7 1 53 15.4 11.0 0.70 078.5          .  2.05
26.5 1 55 21.2 09.5 0.45 079.8          .  2.12
35.3 1 58 17.9 08.0 0.65 079.3          .  2.25
21.2 1 62 16.4 10.0 1.10 090.8     .    .  2.49
PROC STEPWISE DATA=OURBRAND;
MODEL  RATE=YEAR  DATE  SMNQ  SMNT  SMNDISC  SNKQ  DL/MAXR;
TITLE  MIGRATION  RATES  FOR  WHITEBIRD  BRANDED  CHINOOK;
TITLE2              1983-1984 COMBINED(OBS=26);

DATA THREE;SET OURBRAND;IF YEAR=1 THEN DELETE;
PROC STEPWISE DATA=THREE;
MODEL RATE=DATE SMNQ SMNT SMNDISC SNKQ SNKT SNKDISC DL/MAXR;
TITLE MIGRATION RATES FOR WI-IITEBIRD BRANDED CHINOOK IN 1984;
```

MIGRATION RATES FOR WHITEBIRD BRANDED CHINOOK
1983-1984 COMBINED(OBS=26)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 1 VARIABLE SMNQ ENTERED R SQUARE = 0.47012589 C(P) = 30.31904187

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	2214.35805372	2214.35805372	21.29	0.0001
ERROR	24	2495.78040782	103.99085033		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-3.81999244				
SMNQ	2.03054672	0.44003440	2214.35805372	21.29	0.0001

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE SMNT ENTERED R SQUARE = 0.53576340 C(P) = 25.83808417

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	2523.51981726	1261.75990863	13.27	0.0001
ERROR	23	2186.61864428	95.07037584		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-23.67064415				
SMNQ	1.85523460	0.43182349	1754.81101077	18.46	0.0003
SMNT	2.54628821	1.41200839	309.16176354	3.25	0.0845

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

STEP 3 VARIABLE DL ENTERED R SQUARE = 0.60138147 C(P) = 21.35904648

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	2832.58999018	944.19666339	11.06	0.0001
ERROR	22	1877.54847136	85.34311233		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-30.62538209				
SMNQ	2.31256035	0.47449325	2027.19041919	23.75	0.0001
SMNT	4.15547003	1.58265539	588.35041241	6.89	0.0154
DL	-7.35304282	3.86387249	309.07017292	3.62	0.0702

THE ABOVE MODEL IS THE BEST 3 VARIABLE MODEL FOUND.

MIGRATION RATES FOR WHITEBIRD BRANDED CHINOOK
1983-1984 COMBINED(OBS=26)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 4 VARIABLE DATE ENTERED R SQUARE = 0.68519077 C(P) = 15.08383141

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	3227.34339018	806.83584754	11.43	0.0001
ERROR	21	1482.79507136	70.60928911		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-74.42514751				
DATE	3.68439643	1.55823994	394.75340000	5.59	0.0278
SMNQ	1.61178727	0.52355917	669.18429265	9.48	0.0057
SMNT	4.06517504	1.44007728	562.66349601	7.97	0.0102
DL	-77.35164378	29.81236137	475.34417867	6.73	0.0169

STEP 4 SMNT REPLACED BY SMNDISC R SQUARE = 0.70266012 C(P) = 13.35893192

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	3309.62644025	827.40661006	12.41	0.0001
ERROR	21	1400.51202129	66.69104863		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-113.14050135				
DATE	6.34691360	1.72103948	907.00785868	13.60	0.0014
SMNQ	3.36158506	0.79380783	1195.98297777	17.93	0.0004
SMNDISC	24.43260782	7.85672833	644.94654608	9.67	0.0053
DL	-133.59305561	34.67349904	990.01089160	14.84	0.0009

THE ABOVE MODEL IS THE BEST 4 VARIABLE MODEL FOUND.

STEP 5 VARIABLE SMNT ENTERED R SQUARE = 0.80297854 C(P) = 5.45362878

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	3782.14009168	756.42801834	16.30	0.0001
ERROR	20	927.99836986	46.39991849		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-132.76545088				
DATE	6.06280778	1.43829927	824.45375033	17.77	0.0004
SMNQ	3.36913659	0.66212958	1201.34703237	25.89	0.0001
SMNT	3.73755627	1.17122186	472.51365143	10.18	0.0046
SMNDISC	22.73529415	6.57494692	554.79670150	11.96	0.0025
DL	-132.30615934	28.92442405	970.84053962	20.92	0.0002

THE ABOVE MODEL IS THE BEST 5 VARIABLE MODEL FOUND.

MIGRATION RATES FOR WHITEBIRD BRANDED CHINOOK
1983-1984 COMBINED(OBS=26)

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 6 VARIABLE YEAR ENTERED R SQUARE = 0.81431278 C(P) = 6.33450081

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	3835.52596327	639.25432721	13.89	0.0001
ERROR	19	874.61249827	46.03223675		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-144.71625583				
YEAR	4.66967187	4.33614938	53.38587159	1.16	0.2950
DATE	5.48201136	1.53074221	590.38841063	12.83	0.0020
SMNQ	3.76608414	0.75551620	1143.81174160	24.85	0.0001
SMNT	4.49235633	1.36093247	501.57666010	10.90	0.0038
SMNDISC	26.42499738	7.39094225	588.42669452	12.78	0.0020
DL	-122.64608066	30.17376195	760.51976825	16.52	0.0007

THE ABOVE MODEL IS THE BEST 6 VARIABLE MODEL FOUND.

STEP 7 VARIABLE SNKQ ENTERED R SQUARE = 0.81770052 C(P) = 8.00000000

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	7	3851.48268851	550.21181264	11.53	0.0001
ERROR	18	858.65577303	47.70309850		
TOTAL	25	4710.13846154			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-144.78272818				
YEAR	7.32594415	6.37009697	63.09307721	1.32	0.2652
DATE	5.64006448	1.58205693	606.27618866	12.71	0.0022
SMNQ	3.92213320	0.81505984	1104.61839404	23.16	0.0001
SMNT	4.46335351	1.38631890	494.47332957	10.37	0.0048
SMNDISC	26.23843165	7.53079539	579.08276249	12.14	0.0026
SNKQ	-0.11475238	0.19840979	15.95672525	0.33	0.5702
DL	-124.85583277	30.95320985	776.16289363	16.27	0.0008

THE ABOVE MODEL IS THE BEST 7 VARIABLE MODEL FOUND.

MIGRATION RATES FOR WHITEBIRD BRANDED CHINOOK IN 1984

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 1 VARIABLE SMNQ ENTERED R SQUARE = 0.66126500 C(P) = 77.82079505

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	2788.74277173	2788.74277173	29.28	0.0001
ERROR	15	1428.54193415	95.23612894		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-19.78898334				
SMNQ	3.36310825	0.62149478	2788.74277173	29.28	0.0001

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE SMNT ENTERED R SQUARE = 0.74481150 C(P) = 57.42051173

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	3141.08216764	1570.54108382	20.43	0.0001
ERROR	14	1076.20253824	76.87160987		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-51.36291136				
SMNQ	2.67831998	0.64349308	1331.68998954	17.32	0.0010
SMNT	4.88758341	2.28295088	352.33939591	4.58	0.0504

STEP 2 SMNQ REPLACED BY SMNDISC R SQUARE = 0.85961198 C(P) = 26.64049148

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	3625.22844305	1812.61422152	42.86	0.0001
ERROR	14	592.05626284	42.28973306		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-38.14846108				
SMNT	11.68990083	1.50315872	2557.68417390	60.48	0.0001
SMNDISC	-43.25134458	6.60052898	1815.83626494	42.94	0.0001

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

MIGRATION RATES FOR WHITEBIRD BRANDED CHINOOK IN 1984

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 3 VARIABLE SMNQ ENTERED R SQUARE = 0.90977744 C(P) = 15.19025072

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	3836.79048614	1278.93016205	43.70	0.0001
ERROR	13	380.49421975	29.26878613		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-39.65818486				
SMNQ	1.30793589	0.48648554	211.56204309	7.23	0.0186
SMNT	8.88100719	1.62951783	869.38255072	29.70	0.0001
SMNDISC	-32.80058244	6.72775725	695.70831849	23.77	0.0003

STEP 3 SMNDISC REPLACED BY DL R SQUARE = 0.93044976 C(P) = 9.64763929

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	3923.97154247	1307.99051416	57.97	0.0001
ERROR	13	293.31316341	22.56255103		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-75.01092340				
SMNQ	3.49988378	0.37548594	1960.23481902	86.88	0.0001
SMNT	9.05303486	1.42470359	911.01923633	40.38	0.0001
DL	-12.80675675	2.17411775	782.88937483	34.70	0.0001

THE ABOVE MODEL IS THE BEST 3 VARIABLE MODEL FOUND.

STEP 4 VARIABLE DATE ENTERED R SQUARE = 0.96143298 C(P) = 3.34049427

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	4054.63660672	1013.65915168	74.79	0.0001
ERROR	12	162.64809916	13.55400826		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-103.77815841				
DATE	2.96296794	0.95429156	130.66506425	9.64	0.0091
SMNQ	3.02595527	0.32862684	1149.17638664	84.78	0.0001
SMNT	7.91994143	1.16298357	628.58574662	46.38	0.0001
DL	-69.07479110	18.20058107	195.22543516	14.40	0.0026

THE ABOVE MODEL IS THE BEST 4 VARIABLE MODEL FOUND.

MIGRATION RATES FOR WHITEBIRD BRANDED CHINOOK IN 1984

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE RATE

STEP 5 VARIABLE SNKQ ENTERED R SQUARE = 0.96270035 C(P) = 5.00068932

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	4059.98147973	811.99629595	56.78	0.0001
ERROR	11	157.30322616	14.30029329		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-98.80871061				
DATE	2.94767465	0.98053039	129.23552717	9.04	0.0119
SMNQ	3.13327810	0.38047201	969.83399314	67.82	0.0001
SMNT	8.46691825	1.49247174	460.23902895	32.18	0.0001
SNKQ	-0.12825182	0.20978156	5.34487301	0.37	0.5534
DL	-68.14136982	18.75717286	188.72607270	13.20	0.0039

THE ABOVE MODEL IS THE BEST 5 VARIABLE MODEL FOUND.

STEP 6 VARIABLE SMNDISC ENTERED R SQUARE = 0.96270293 C(P) = 7.00000000

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	4059.99232220	676.66538703	43.02	0.0001
ERROR	10	157.29238368	15.72923837		
TOTAL	16	4217.28470588			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-98.33483414				
DATE	2.93504592	1.13528687	105.12990366	6.68	0.0272
SMNQ	3.11797193	0.70646551	306.38688661	19.48	0.0013
SMNT	8.48439438	1.70091664	391.36621152	24.88	0.0005
SMNDISC	-0.30087528	11.45977567	0.01084248	0.00	0.9796
SNKQ	-0.13000238	0.22989435	5.02983455	0.32	0.5842
DL	-67.79631915	23.65816854	129.16881704	8.21	0.0168

THE ABOVE MODEL IS THE BEST 6 VARIABLE MODEL FOUND.