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EVALUATION OF CONDITIONING STEELHEAD TROUT IN COLD WATER AFTER REARING AT 15C

by
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by

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ABSTRACT

Steelhead trout transferred to a pond with cold water (4-10C) 8 to 12 weeks before release after being reared in 15C water, returned at higher rates than fish held in 15C water until release. Of six marked groups released in 1979 and 1980, all three groups of fish conditioned in cold water returned at higher rates than the three groups of unconditioned fish. A group of conditioned fish that averaged 227 mm in length when released, returned at twice the rate of other groups. Size and health of fish were important factors in return rates. Fish held in 15C water until release migrated seaward slightly later than conditioned fish.

Steelhead trout released in the Lemhi River during January-March survived poorly because of thermal shock despite eight hours of acclimation during transport. Steelhead released in the upper end of the Lemhi River were captured at Lower Granite Dam at only one-tenth the rate of fish released 69 km further downstream near the mouth of the river. Steelhead released in the upper river may have had difficulty negotiating the 40 or more irrigation diversions when migrating down the Lemhi River.

INTRODUCTION

The need for conditioning of steelhead trout in cold water after being reared in the 15C water of Hagerman Valley hatcheries was evaluated during 1978 to 1984. Conditioning salmon or steelhead trout in cold water after rearing in warm water was proposed by Zaugg and his colleagues (Zaugg et al. 1972) when they found that certain physiological parameters associated with smoltification and migration (Adams et al. 1973) of coastal and lower Columbia River stocks was altered when water temperatures exceeded 13C. In earlier studies of Snake River steelhead stocks, conditioning fish in cold water altered the timing of migration and perhaps the percentage that became smolts (Chrisp and Bjornn 1978, Bjornn et al. 1978, Reingold 1976), but conclusive tests of the need for cold water conditioning were not conducted. To further define the need to condition steelhead trout juveniles in cold water, tests were conducted with Dworshak National Fish Hatchery (NFH) stock steelhead reared at Hagerman NFH conditioned in a pond in the Pahsimeroi River Valley and released in the Lemhi River (Fig. 1).

COLD WATER CONDITIONING--PAHSIMEROI PONDS

Procedures

In the 1979 and 1980 tests, we sought to determine if conditioning in cold water (<13C) prior to release is necessary for steelhead trout reared in 15C water at Hagerman NFH. We placed groups of fish in a pond (3-14C water) in Pahsimeroi Valley up to 12 weeks before release in April and held other groups at the hatchery until release. Migration of smolts to the ocean and adult returns of each group were monitored to evaluate the effects of holding fish in cool water before release.

The studies were undertaken to answer the following questions:

1. Will fish that are conditioned in cold water for 10-12 weeks migrate seaward more readily and result in more returning adults than fish held at the hatchery until mid-April?

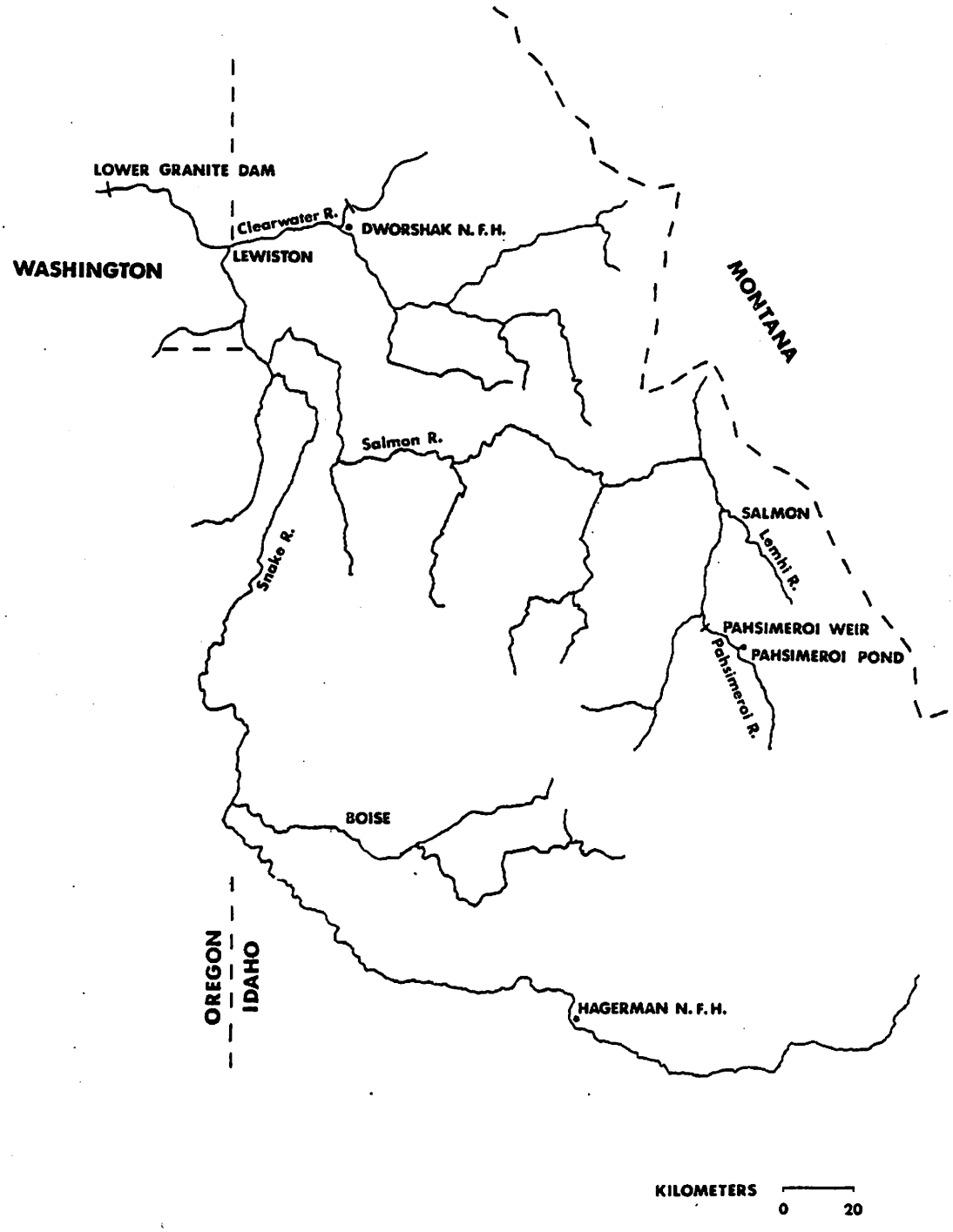

Figure 1. Map of Snake, Clearwater and Salmon River drainages with locations of facilities involved in these studies.

2. Is the need for cold water conditioning size-dependent; i.e., less important for larger fish?
3. How long must fish be conditioned to receive whatever benefits can be obtained from transferring the fish into colder water during the last weeks of the rearing period?
4. If fish placed in ponds for conditioning are allowed to leave when they wish, would they leave in time to reach the estuary before river temperatures warmed too much?

1979 Test Groups

Steelhead from three segments of the egg take at Dworshak NFH were raised at Hagerman NFH in 1978-79 so that fish of appropriate size would be available for the cold water conditioning test. Eyed eggs from the earliest and middle egg takes were delivered to Hagerman NFH on March 16, 1978, and May 5, 1978, respectively. The third group of steelhead came from the late egg takes and were reared at Dworshak NFH until November 30, 1978, when they were delivered to Hagerman NFH at a size of 40 fish/lb.

The three groups of fish in the 1979 cold water conditioning test were: (1) a group placed in the Pahsimeroi Pond for cold water conditioning February 9, 1979; (2) a group from the same lot of eggs, held at the hatchery until mid-April (hereafter referred to as unconditioned-large); and (3) a group from a later take of eggs that were also held at the hatchery until mid-April (hereafter referred to as unconditioned-small). Fish in Groups 1 (conditioned) and 2 (unconditioned) averaged 187mm total length in mid-January. Fish of the conditioned group that migrated from the pond from mid-April to mid-May averaged 231mm in length (Fig. 2). Fish in the unconditioned-large group ended up larger (240mm) than fish placed in the pond in February because of the longer time they spent at the hatchery in 15C water. Fish in the unconditioned-small group were scheduled to be about the same size in April as fish placed in the pond, but they did not grow as fast as expected in the hatchery because of disease problems and averaged only 163.5mm on April 5 (Fig. 2).

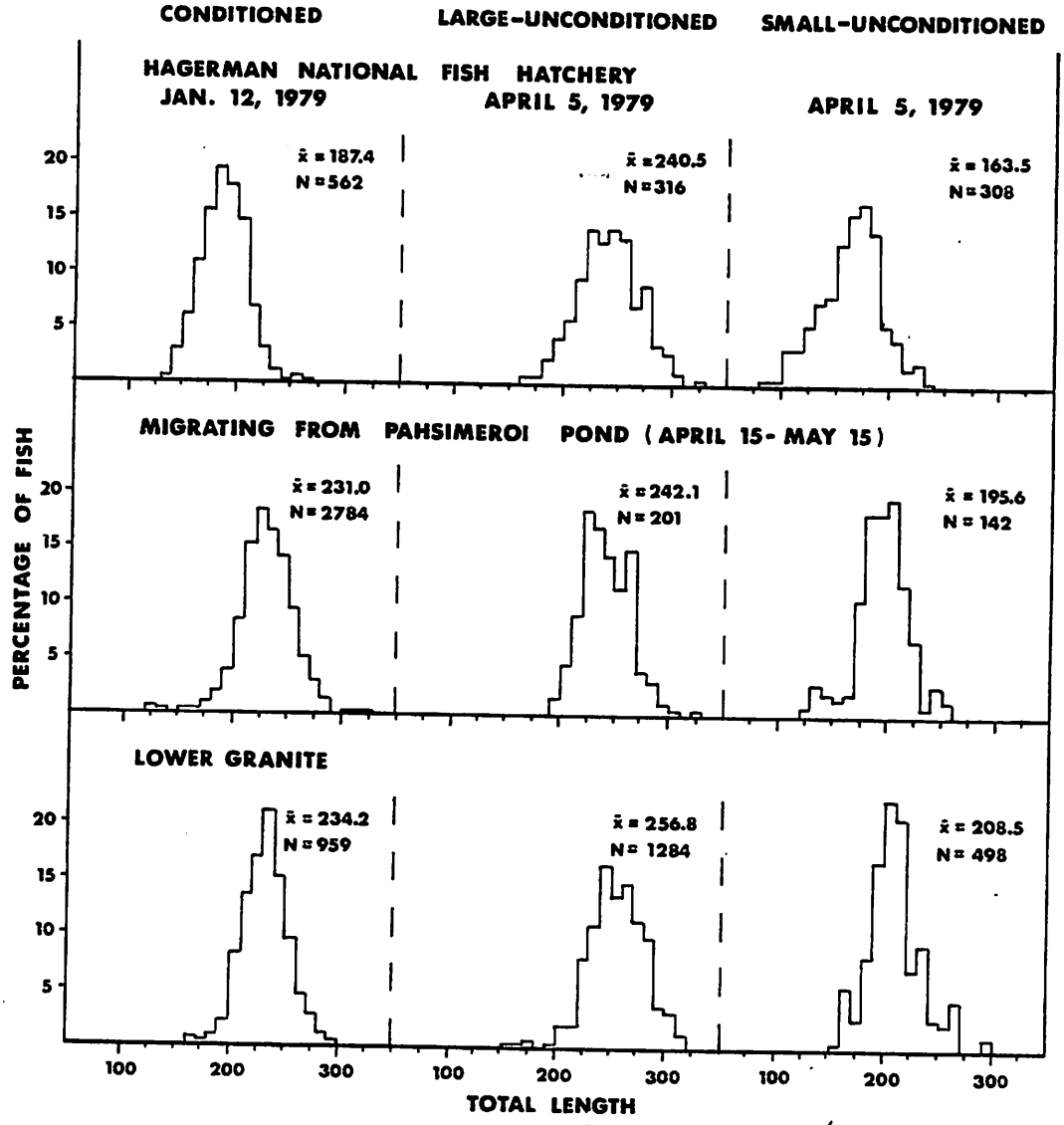

Figure 2. Length-frequency distribution and mean lengths of steelhead trout in January at Hagerman NFH prior to release into the Pahsimeroi Pond February 9-14 (conditioned) or April 5 (unconditioned), when migrating from the pond, and when recaptured at Lower Granite Dam, 1979.

Fish in the conditioned group were placed in a large pond (12 x 150 x 1m) adjacent to the Pahsimeroi River about 12km upstream from the mouth of the river on February 9, 12, and 14, 1979. River water (5 cfs) diverted through the pond ranged between 3-8C during February and March, and 6-14C in April. Fish were allowed to leave the pond, but few did so until April. Fish that remained in the pond until mid-April had 65 days (9 weeks) of conditioning, while those still in the pond on May 5 when we lowered the water level had 85 days (12 weeks) of conditioning.

The two groups of fish without cold water conditioning were not released into the pond in April because Idaho Department of Fish and Game personnel had experienced difficulty in prior years with fish not leaving the pond readily. To avoid such problems, we placed only a portion (5,000) of each of those groups in the pond, and the remainder were released into the Pahsimeroi River at the weir about 3km up from the mouth, April 12-23, 1979. Fish placed in the pond April 12 were branded differently from those put in the river and could have received three to four weeks of conditioning if they did not leave the pond until early May.

A trap was installed at the outlet of the pond to capture fish leaving the pond. We operated the trap continuously for the first four nights after the first fish were delivered in February and then intermittently until April 1 because few fish were leaving the pond. The trap was operated almost continuously starting in April until the pond was cleaned out on May 25.

Starting in early April, we monitored passage of steelhead smolts from the cold water conditioning tests at Lower Granite Dam. A sample of fish entering the collection facility at the dam was examined six days of each week. Fish in the cold water conditioning tests could be identified by their brands or nose tags. Fish with adipose fin clips were subsampled and sacrificed to obtain the nose tag so the group it represented could be identified.

1980 Test Groups

In 1979 we tested the effects of cold water conditioning on relatively large (231mm average total length) steelhead trout reared at Hagerman NFH and found that slightly more of the conditioned fish (61%) migrated to Lower Granite Dam than the unconditioned fish (50%). The test in 1980 was designed to determine if smaller fish (200-210mm average length) should be held in the hatchery in 15C water until release or transferred to colder water.

Eyed eggs were sent from Dworshak NFH to Hagerman NFH for rearing on three dates (March 22, April 25, and June 6, 1979) to provide a range of sizes of fish at smolt stage. Fish were tagged with coded wire tags in October 1979, branded in January, February or March 1980, and hauled to the Pahsimeroi ponds in early February (12 weeks conditioning in cold water), early March (8 weeks conditioning), or late April (no conditioning).

Two groups of fish from Lot 72 (eyed eggs received at Hagerman NFH June 6, 1979) were marked with binary-coded nose tags and adipose fin clips in October 1979, and 10,000 of each group were branded in January, 1980. One group (hereafter referred to as the conditioned-small group, Table 1) was taken to the west IPC (Idaho Power Company) pond in the Pahsimeroi Valley in early February for 12 weeks of conditioning in cold water. The other group (referred to as the unconditioned group) was held in the hatchery until April 21, then delivered to the pond. We estimated that the conditioned fish would average about 180mm in length by April 25, and those held in the hatchery would average about 215mm. Fish placed in the pond in February grew more than expected, and they averaged 210mm by April 25. Fish held in the hatchery grew less than expected and averaged 207mm by April 25. A chronic low-level mortality occurred during February, March and April in all raceways at Hagerman NFH containing fish from Lot 72. The loss during the three-month period amounted to 6-13% of the fish in each raceway. By way of contrast, fish from Lot 71 held until April 21 had almost no mortality (<0.5%).

Table 1. Recovery of smolts at Lower Granite Dam and Columbia River estuary and adults from releases in 1979 and 1980 in the Pahsimeroi River for cold water conditioning tests.

	1979 releases			1980 releases		
	Conditioned	Unconditioned		Conditioned		Unconditioned
		Large	Small	Medium	Small	
Weeks of conditioning	9-12	0	0	12	12	0
Fish released	60,000	56,300	41,400	31,800	38,600	36,500
Binary tag code	5/4/22	5/4/23	5/4/24	5/6/37	5/6/36	5/6/35
Mean total length (mm) at release	231	241	170	227	210	207
Smolts recaptured						
At L. Granite Dam	278	366	76	265	396	452
At estuary	25	20	6	41	28	14
Adults recaptured						
1 year in ocean						
Pahsimeroi Hatchery	4	2	1	24	11	4
Idaho sport fishery	2	-	-	2	2	-
Columbia River fisheries	3	1	-	4	2	2
Deschutes River	-	-	-	-	-	1
2 years in ocean						
Pahsimeroi Hatchery	160	112	55	180	98	98
Idaho sport fishery	16	13	6	42	25	18
Columbia River fisheries	30	36	14	26	19	11
Deschutes River	4	3	-	1	1	2
Dworshak NFH	1	-	1	-	-	-
Ocean fisheries	1	-	-	-	-	-
3 years in ocean						
Pahsimeroi Hatchery	8	4	3	-	-	-
Idaho sport fishery	2	1	1	-	-	-
Columbia River fisheries	1	3	1	-	-	-
Total returns	237	176	84	279	158	136
Percentage return rate	0.40	0.31	0.20	0.88	0.41	0.37

One group of fish from Lot 71 (eyed eggs received at Hagerman NFH April 25, 1979) was tagged and placed in the west pond in February. We expected fish in this group (referred to as conditioned-medium, Table 1) to average about 210mm by late April, but they grew more than expected and averaged 227mm by April 25, just prior to release.

Air and water temperatures were cold in February of 1980 after the first fish were placed in the pond so drum screens could not be operated without icing. Air temperatures were as low as -20C and water temperature 2.5C during February. By the first of March the weather had moderated so that a drum screen could be placed in the pond outlet to keep fish in the pond until the planned release date in late April. At the inlet water dropped through a finger weir and fish were unable to jump through the spacing on the bars. Fish loading in the 12m-wide x 150m-long x 1m-deep pond was up to 98,000 fish (~13,000 lbs) in March and April. Temperature of the 5 cfs of water entering the pond was as low as 3C during March, but usually ranged daily from 4-9C. In late April maximum inlet temperatures reached 14C on some bright sunny days with minimum temperatures of 6C. The fish were fed Oregon Moist Pellets at the rate of 0.6% body weight per day in February and 0.9% in March and April.

Unconditioned groups of fish were delivered to the pond April 21-23. The outlet drum screen was removed April 27, and one-third to one-half of the fish left the pond that night. On April 28 all dam boards were removed from the outlet headgate, and the water level dropped to 0.6m. By May 4 I estimate there were 10-15,000 fish still in the pond, 5,000 by May 12, and 1,000 by May 19. On May 27 22 fish were netted from the inlet area of the pond and 82% were mature males; an indication that many of the fish that failed to migrate from the pond were precociously mature males. Nearly all of the fish had left the pond of their own volition by mid-May.

Size of Fish Versus Conditioning

To determine if cold water conditioning is more beneficial to smaller fish (~200mm) than to the large fish (~231mm) evaluated in 1979,

three groups of conditioned fish averaging from 210 to 241mm in length were released in 1980. In addition to the conditioned-medium and conditioned-small groups from Lots 71 and 72 that were tagged, a group of 10,000 fish from Lot 69 (eyed eggs received at Hagerman NFH March 22, referred to as conditioned-large) was branded and the left ventral fin clipped before being placed in the west pond in February. These fish averaged 241mm by April 25. Two groups of unconditioned fish were also released in 1980, the tagged fish from lot 72 (average length 207mm when released) and a group of 10,600 from lot 71 (224mm when released) that were branded and given a right ventral fin clip.

Length of Conditioning

To determine if 8 weeks of conditioning in cold water will provide the same benefits as 12 weeks and not alter the timing of seaward migration past the dams, a group of 10,000 fish from Lot 72 was branded and the left ventral fin clipped before delivery to the west pond in early March. They were released beginning April 27 with the other fish in the pond, and seaward migration was evaluated by recapture of branded fish at Lower Granite Dam.

Timing of Migration of Conditioned Fish

To determine when fish placed in ponds for conditioning would voluntarily leave the ponds and their subsequent timing past Snake River dams, four groups of fish (5,000 each) were marked (brand and left ventral fin clip) and released in the east IPC pond in the Pahsimeroi Valley. Fish from Lot 71 were placed in the pond February 4 and March 3 and fish from Lot 72 on March 28 and April 23. Fish in all groups averaged longer than 200mm by April 25. A trap was maintained in the pond outlet from February 6 through June 2 to determine when fish of each group left the pond. Fish were fed a maintenance ration (0.6% body weight per day) while in the pond. Timing of migration past Snake River dams was assessed by recapturing marked fish at Lower Granite Dam.

Results

Conditioning in Cold Water

Conditioning in cold water prior to release may provide some benefits for steelhead trout reared in the warmer water (15C) of Hagerman Valley hatcheries, but is not necessary for successful parr-smolt transformation and seaward migration. Conditioned smolts released in 1979 returned as adults at a one-third higher rate than unconditioned smolts of larger size, but conditioned and unconditioned smolts of similar size released in 1980 returned at similar rates (Table 1).

The conditioned and unconditioned-large fish released in 1979 were from the same lot of eggs and, therefore, depict results from keeping the fish in Hagerman NFH until release or transferring them to a pond with colder water several weeks before release. The unconditioned fish were larger than the conditioned fish (presumably not too large), most were released in the lower end of the Pahsimeroi River rather than in the pond (did not have to negotiate around numerous irrigation diversions), and more of them reached Lower Granite Dam when there was no spill, so more were collected and transported around the dam (usually a benefit for steelhead). Despite these factors favoring the unconditioned-large group, they returned at a lesser rate than the conditioned fish (Table 1).

The unconditioned-small group released in 1979 did not grow as well as expected in the hatchery and were significantly smaller than fish in the other two groups when released. Their smaller size and the fact that fish in this group had a virus disease while in the hatchery could account for their lower adult return rate (Table 1).

The conditioned-small and unconditioned groups of steelhead released in 1980 were from the same lot of fish, nearly identical in size, and had similar adult return rates (Table 1). Taking the fish to Pahsimeroi Pond for cold water conditioning in 1980 appeared to have little benefit over keeping the fish in the hatchery until release.

The two-times higher rate of adult return for the conditioned-medium group of fish released in 1980 over the conditioned-small and unconditioned groups could be due to their larger size (227 versus 210 and 207mm in length) and perhaps fish health. At the hatchery, fish in the lot from which the conditioned-medium fish were taken had almost no loss (<0.5%), while fish in the other lot (conditioned-small and their unconditioned cohorts) suffered up to 13% mortality in the four to five months prior to release.

Relative recapture rates of smolts in the estuary (Dawley et al. 1980 and 1981) was a better indication of adult returns than smolts recaptured at Lower Granite Dam for fish released in both 1979 and 1980 (Table 2). Marked groups recaptured at the highest rate in the estuary, returned as adults at the highest rate.

Size of Fish Versus Conditioning

Cold water conditioning prior to release did not seem to benefit one size steelhead more than another, but evaluation was based on successful migration of smolts to Lower Granite Dam, not on adult returns (Table 3). A higher percentage of the groups of smaller fish were estimated to have been recaptured at Lower Granite Dam than groups of larger fish (Sims et al. 1981), but that occurred in both conditioned and unconditioned groups (Table 3).

Adult returns for the two groups of tagged fish that were conditioned in cold water (227 and 210mm in length) were opposite of recaptures at the dam, with twice as many of the large fish returning versus the smaller fish. Fewer of the large-sized fish may have migrated seaward because more of the males in those groups were precociously mature (Table 3).

Table 2. Comparison of fish released and smolts recaptured at Lower Granite Dam and Columbia River estuary in 1979 and 1980 with adults returning in subsequent years by using ratios with unconditioned fish as the base in each year.

	Fish released	Smolts recaptured		Adult returns
		Lower Granite Dam	Columbia River estuary	
1979 release groups				
Unconditioned-small	1:1	1:1	1:1	1:1
Unconditioned-large	1:1.4	1:4.8	1:3.3	1:2.1
Conditioned	1:1.5	1:3.7	1:4.2	1:2.8
1980 release groups				
Unconditioned	1:1	1:1	1:1	1:1
Conditioned-small	1:1.1	1:0.9	1:2.0	1:1.2
Conditioned-large	1:0.9	1:0.6	1:2.9	1:2.1

Table 3. Steelhead trout of various sizes and weeks of conditioning in cold water released in 1980, recaptured as smolts at Lower Granite Dam and as adults.

	Weeks of conditioning					
	8	12	12	12	0	0
Size of fish released (mm)	207	210	227	241	207	224
Fish recaptured at dam						
Number	364	406	272	220	452	268
Mean length (mm)	222	218	231	253	226	299
Median date of capture	13 May	13 May	10 May	13 May	16 May	20 May
Percentage recaptured at dam	28.1	30.2	23.3	28.9	28.7	17.1
Percentage returned as adults	-	0.41	0.88	-	0.37	-
Percentage precociously mature	1.0	3.0	5.7	8.8	0.8	2.9

Length of Conditioning

Fish conditioned for eight weeks in the pond were recaptured at Lower Granite Dam at a rate similar to that of fish conditioned 12 weeks in the pond (Table 3). Fish conditioned eight weeks were not tagged so we could not compare adult returns.

Timing of smolt migration past Lower Granite Dam of fish conditioned 8 weeks was intermediate between fish conditioned 12 weeks and those that were unconditioned (Fig. 3). Fish conditioned for 12 weeks migrated past Lower Granite Dam mostly in the first half of May. Fish conditioned 8 weeks passed the dam throughout May, and unconditioned fish had peak numbers passing the dam in late May.

Timing of Migration of Conditioned Fish

Steelhead placed in the Pahsimeroi Pond in February of 1979 did not begin migrating from the pond in large numbers until after April 20 (Table 4). Only 3% of the fish placed in the pond had left by April 20, but 19-31% of the conditioned fish left in the next 15 days. On May 5 we removed the trap and lowered the water level in the pond from 1m to 0.5m at the outlet. We did not attempt to count fish leaving the pond while the pond was lowered. On May 10 the trap was reinstalled and counting of migrants continued until May 25 when the pond was drained and the remaining fish removed by seining. Only 4% of the conditioned fish were still in the pond on May 10, and most of those left voluntarily. Less than 1% of the fish placed in the pond had to be removed by seining on May 25.

Steelhead in the 1979 unconditioned groups (placed in the ponds April 12) did not migrate as early as the conditioned fish (Table 4). Six and 10% of the large and small, respectively, unconditioned fish left the pond in the 3-4 days after release, but only 9% of the large-size fish and 18% of the small-size fish left from April 20 to May 5. Most of the unconditioned fish left the pond while it was drawn down May 5-10. Only

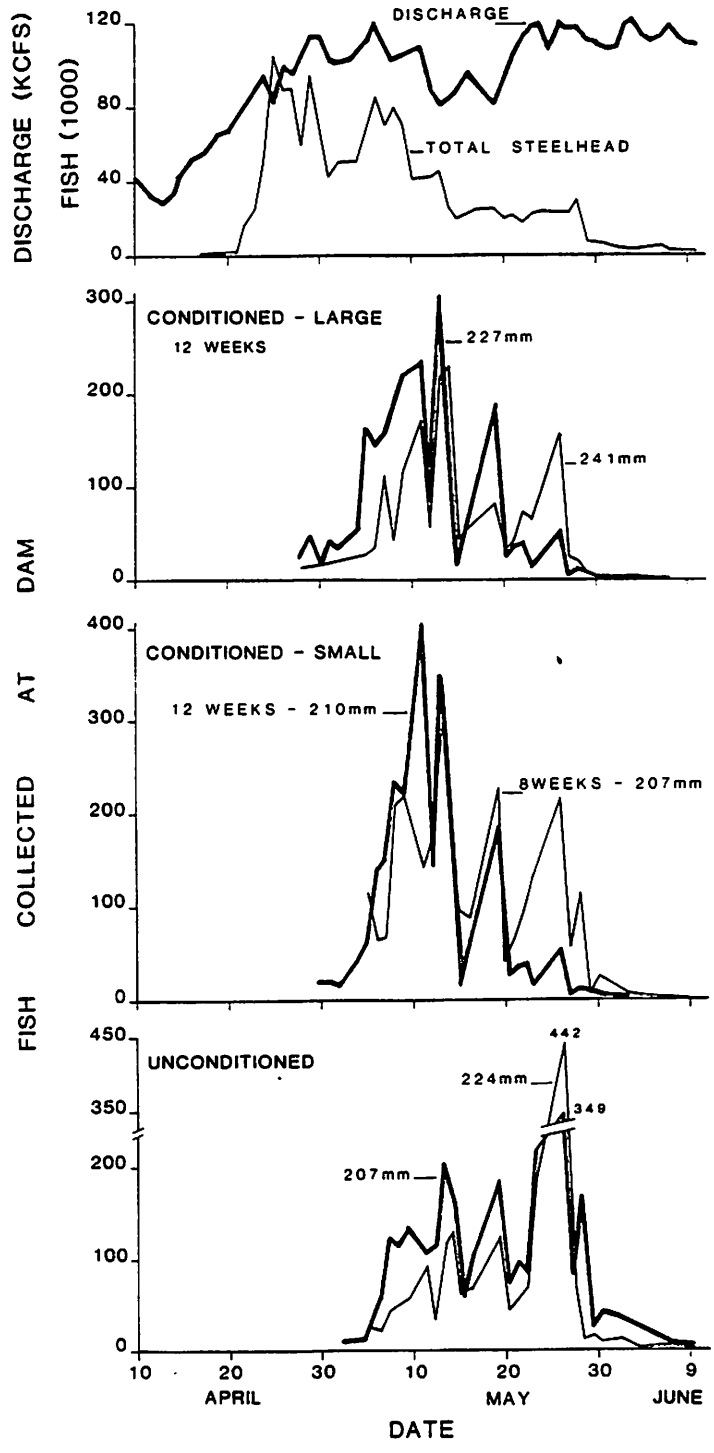

Figure 3. Timing of migration of steelhead trout in 1980 cold water conditioning test past Lower Granite Dam as related to timing of all steelhead (wild and hatchery) and discharge in the Snake River. Mean length and weeks of conditioning listed for each group.

Table 4. The number and percentage of each group of steelhead that left the Pahsimeroi holding pond during various time periods, 1979.

	Water temperatures (C)		Cold water conditioned (Released in pond February 9-14)						Without conditioning (Released in pond April 12)			
			Unbranded		January brand		April brand		Large		Small	
	Mean	Range	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Number into pond			43,601	--	11,238	--	5,161	--	5,300	--	5,100	--
Number migrating from pond												
Feb 10 - Mar 30	5	4-9	775[a]	1								
Apr 2 - 12	-	-	465	1	36	<1						
Apr 13 - 19	7	5-10	588	1	291	3			534	10	303	6
Apr 20 - May 5	9	6-14	13,332	31	3,238	29	999	19	462	9	942	18
May 6 - 10	-	-	27,052[b]	62	7,364[b]	66	3,952	77	3,997[b]	74	3,656[b]	72
May 11 - 25	9	-	1,431	3	83	1	152	3	230	4	97	2
Number in pond when drained May 26			162	<1	32	<1	58	1	177	3	102	2

[a]Includes both branded and unbranded fish.

[b]Estimated (number released minus number counted out of pond). Trap was removed and pond drawn down to 18" of depth during this period.

4-7% of the unconditioned fish placed in the pond were still present on May 10.

In 1980, timing of migration of steelhead smolts from the east pond, where they could migrate seaward when they chose, depended mainly on when they were placed in the pond, but most fish from all groups had left the pond by mid-May (Fig. 4). Twenty percent of the fish placed in the pond in early February left the pond in the latter half of February and another 40% in late March, with the last peak of migrants in early May. Fish placed in the pond in early March also left in large numbers in late March and early May. Early May was the period of peak migration for fish put in the pond in late March and late April.

Fish that left the east pond prior to mid-April did not migrate downstream without delay. Steelhead from the ponds did not begin passing Lower Granite Dam until the last few days of April regardless of when they left the ponds (Fig. 4). Fish released from the west pond on April 27 started showing up at the Dam by May 5 and half the eventual migrants had passed there by May 20. Thus, steelhead that left the east pond in February, March or early April may have left the pond in response to stimuli other than the urge to migrate seaward.

Factors that triggered early emigrations from the east pond were not obvious. The first group of fish left the pond in mid-February at the new moon, but subsequent peaks in movement did not coincide with new moon phases (Fig. 4). River temperatures or turbidity were not unusual at times when large numbers of fish from each of the groups chose to emigrate.

In 1979, timing of migration past Lower Granite Dam was similar for both conditioned and unconditioned smolts placed in the pond (Fig. 5). Unconditioned-large fish released in the Pahsimeroi River near its mouth in mid-April migrated past the dam in large numbers May 7-15 and again in late May. The small, unconditioned fish were not delivered to the Pahsimeroi River until April 23 and relatively few of those fish reached the dam prior to late May. Most of the conditioned and unconditioned

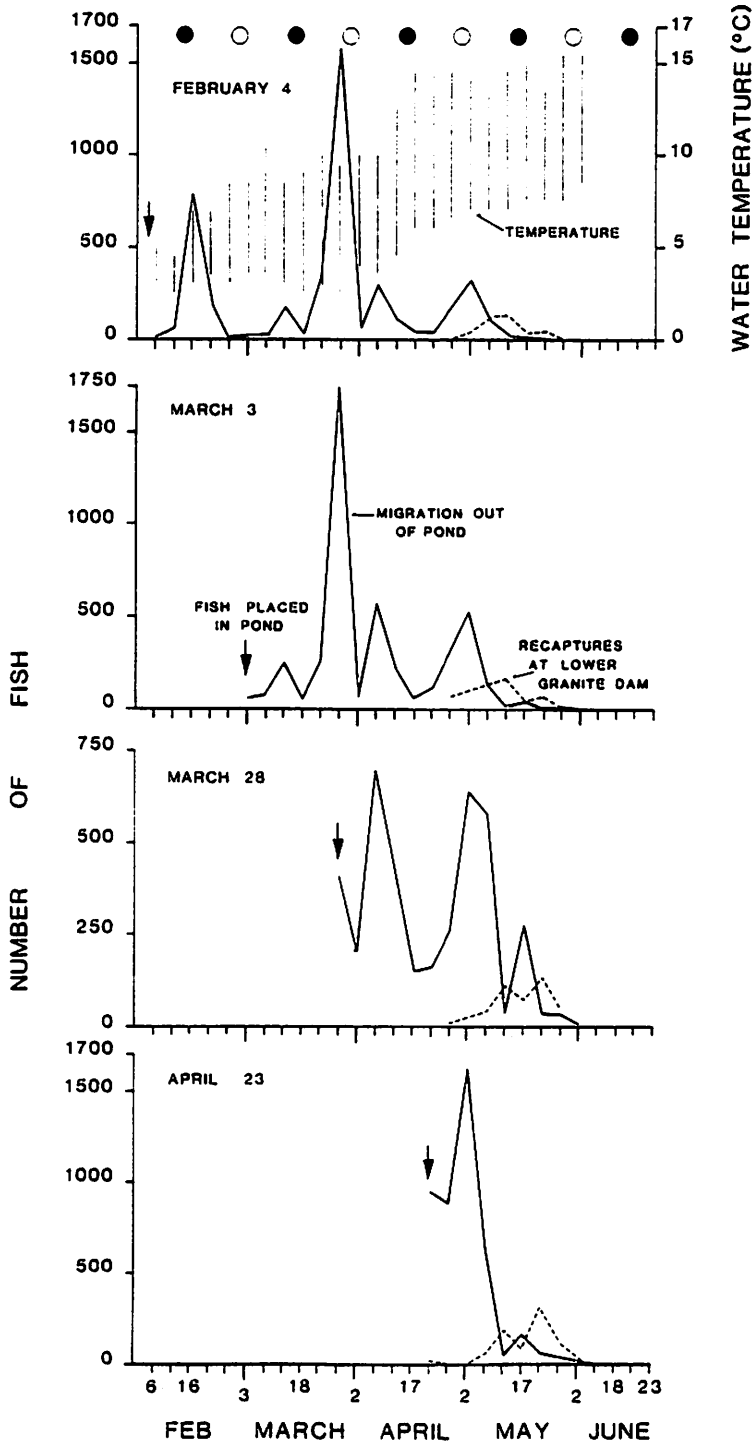

Figure 4. Timing of steelhead trout migration out of east pond in Pahsimeroi Valley and at Lower Granite Dam. Temperature range for water in the pond and timing of new (closed circle) and full (open circle) moon phases in 1980.

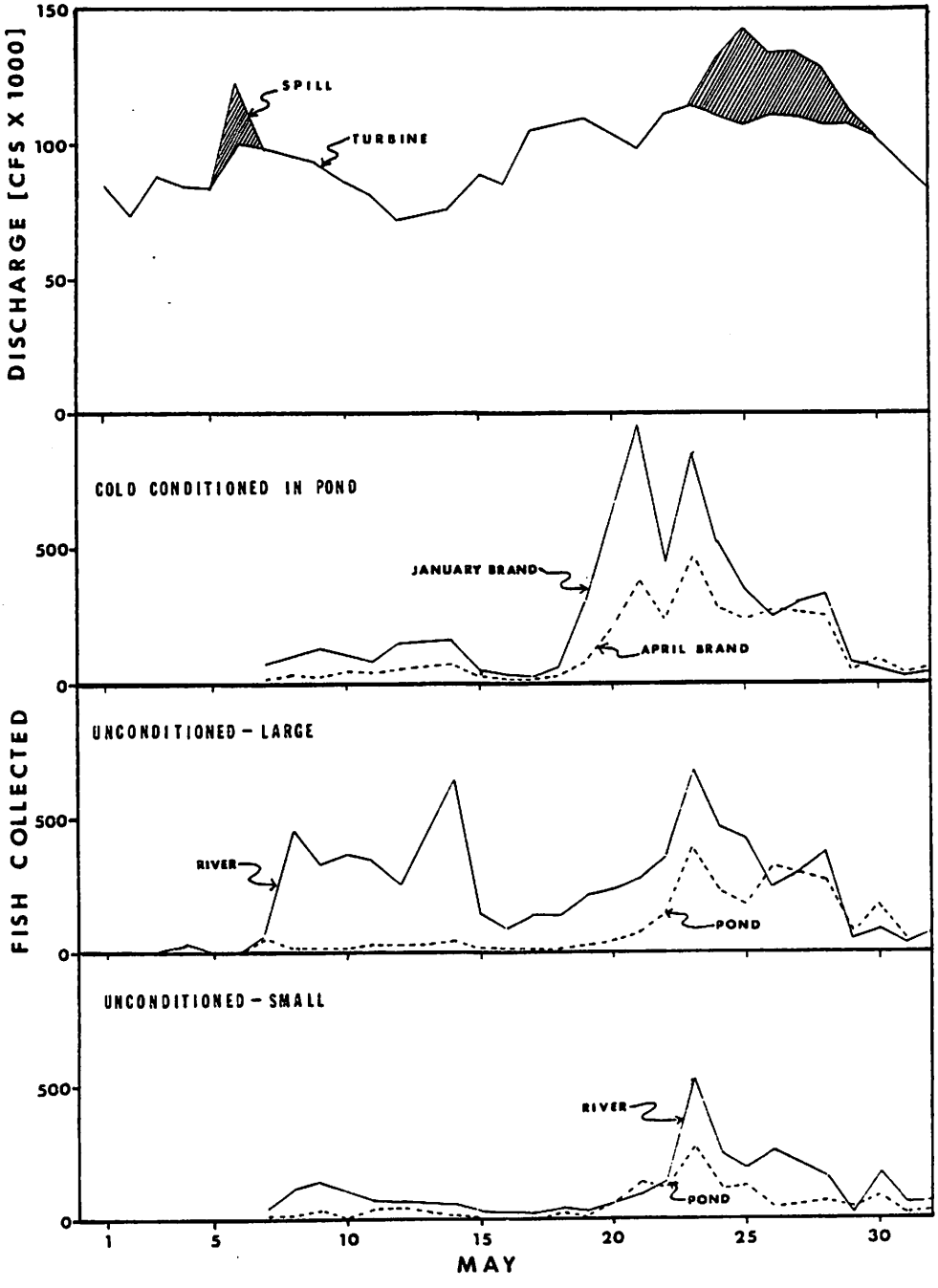

Figure 5. Discharge of the Snake River at Lower Granite Dam (spillway and turbine), and estimated numbers of conditioned and unconditioned steelhead trout released in the Pahsimeroi Pond or River that were collected at the dams in 1979.

fish placed in the pond did not leave in 1979 until after May 5, thus it was not surprising that they passed the dam in late May.

In 1980, conditioned fish arrived at Lower Granite Dam a few days earlier than unconditioned fish released from the west pond on April 27 (Fig. 3). Median dates of capture (date 50% of fish recaptured) for the conditioned groups ranged from 8 to 13 May versus 16 to 20 May for the unconditioned groups. Ninety percent or more of the successful migrants from all groups had migrated past the dam by the 28th of May.

Large numbers of steelhead smolts passed Lower Granite Dam in early May of 1979 and the last week of April in 1980 before most of the fish from the cold water conditioning tests arrived (Fig. 3). The early migrating fish in both years were wild fish and other hatchery fish.

Fish stocked in the east pond in February and March were not recaptured at Lower Granite Dam at as high a rate as fish stocked in April (Table 5). The higher recapture rate of the fish stocked in April could be due to their larger size when placed in the pond and the late date of stocking, which was shortly before the time most steelhead migrate actively to the sea. Fish stocked in April were larger when migrating from the pond, because they had stayed longer in the warmer water of Hagerman NFH.

Fish that migrated from the east pond when they chose were recovered at lower rates at Lower Granite Dam than fish placed in the west pond and held there until April 27 (Table 6). Low recovery rates for fish placed in the east pond in February and March might be due to poor survival of those fish that left the pond before late April. The 17.6% recovery rate for fish placed in the east pond in April is higher than for fish stocked earlier, but low in relation to some of the groups released from the west pond.

Fish of each group placed in the east pond were nearly identical in mean length when recaptured at Lower Granite Dam despite differences in size when most fish of each group left the pond (Table 5). Fish from the

Table 5. Mean length of fish migrating from the east pond in Pahsimeroi Valley and those recaptured at Lower Granite Dam in 1980, with the estimated percentage of each group recaptured at the dam.

Date released into pond	Migrants from pond			Fish recaptured at dam		Percent recaptured at dam
	Date	Number	Length	Number	Length	
4 February	23-29 March	1012	202.8	45	225.9	7.0
3 March	23-29 March	1048	204.9	85	228.5	12.5
28 March	23 April - 3 May	470	213.7	86	224.1	10.1
23 April	23 April - 3 May	517	222.4	162	227.6	17.6

Table 6. Recapture rates at Lower Granite Dam of various groups of steelhead trout released from ponds in the Pahsimeroi Valley in 1980.

Group description	Marked fish released		Estimated number recaptured		Percent recaptured	
	Tag	Brand	Tag	Branded	Tag	Brand
West pond						
Conditioned 12 weeks						
Large (241 mm)	-	8,200	-	1,547	-	18.9
Medium (227 mm)	31,800	10,000	7,384	2,330	23.2	23.3
Small (210 mm)	38,600	10,400	9,651	3,139	25.0	30.2
Conditioned 8 weeks						
Small (207 mm)	-	9,400	-	2,643	-	28.1
Unconditioned						
Medium (224 mm)	-	10,600	-	1,778	-	16.8
Small (207 mm)	36,500	9,400	12,907	2,696	35.4	28.7
East pond						
February 4 (202 mm)	-	5,400	-	381	-	7.0
March 3 (205 mm)	-	5,100	-	639	-	12.5
March 28 (205 mm)	-	5,000	-	510	-	10.1
April 23 (222 mm)	-	5,100	-	893	-	17.6

groups stocked in March undoubtedly grew some while in the rivers, but smaller fish may not have been as successful as larger fish in migrating to the dam.

Rates of recovery at Lower Granite Dam of fish placed in the west pond in 1980 did not seem to be related to health of fish in the hatchery. Fish from lot 72 (unconditioned-small, conditioned-small, conditioned 8 weeks) had chronic low-level losses during the last four months of rearing in the hatchery, but those groups had the highest percentages of fish recaptured at the dam (Table 6). Smolts from lots 69 and 71 were larger and presumably had no health problems, but were recaptured at the dam at lesser rates than the smaller fish from lot 72.

Groups of steelhead with mean lengths of 207-210mm were recaptured at Lower Granite Dam at a higher rate than groups with larger fish, but the group of large-sized fish had more adult returns than the two groups with smaller fish (Fig. 6).

Both growth and selection for larger fish occurred while the fish migrated from the Pahsimeroi River to Lower Granite Dam. Coldwater-conditioned fish collected at Lower Granite Dam in 1979 were only slightly larger than those migrating from the pond (231 versus 234mm) (Fig. 2). Most coldwater-conditioned fish left the pond in early May and were collected at the dam in late May, 2-3 weeks later so that relatively little growth was possible. Unconditioned-large fish released in 1979 averaged 241mm on April 5 at the hatchery, 242mm when migrating from the pond April 15 to May 15, and 256mm when recaptured at the dam. Unconditioned-small fish in 1979 averaged about 170mm when placed in the pond, but those that migrated voluntarily averaged 196mm. Fish of that group collected at the dam averaged 208mm, an indication that mostly larger fish successfully migrated to the dam.

In 1980, steelhead recaptured at Lower Granite Dam were larger than fish released from Pahsimeroi ponds. The differential in length was smaller (4-15mm) among the conditioned groups of fish (Fig. 7) than in the unconditioned groups (6-25mm, Fig. 8). Some growth could have

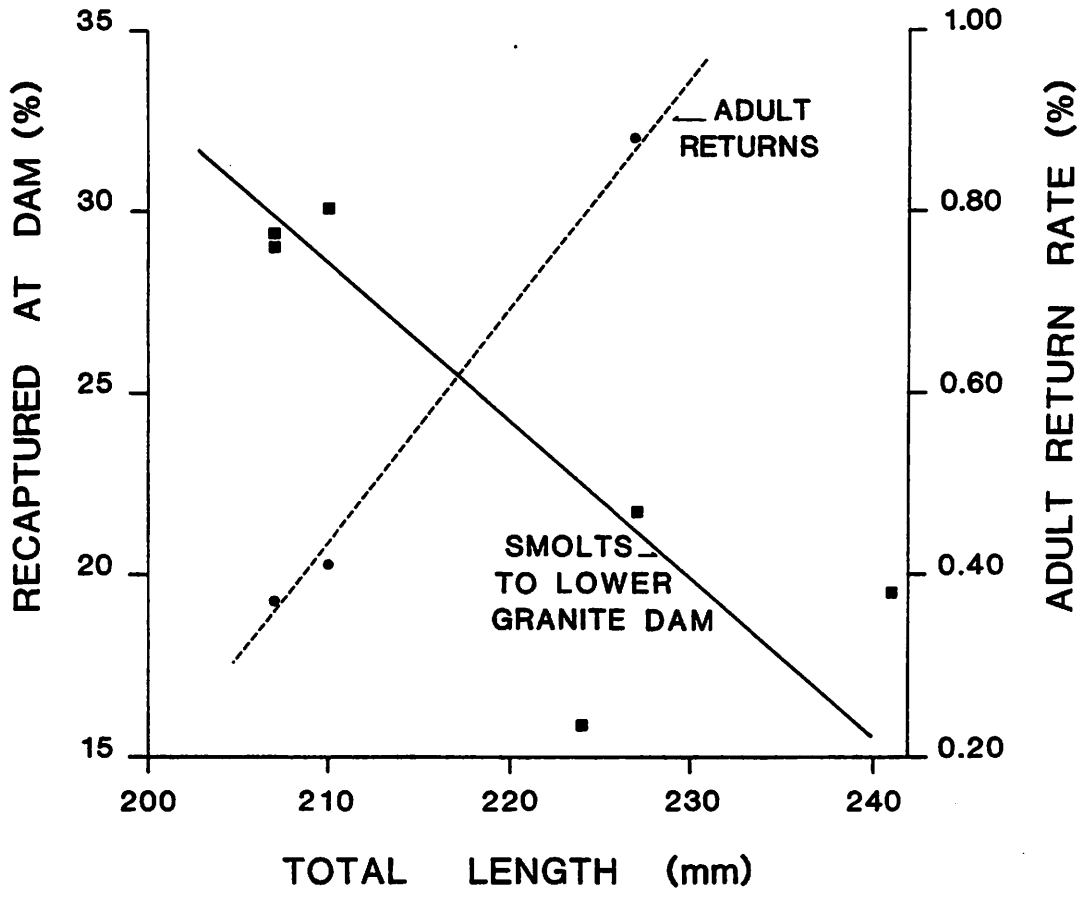

Figure 6. Percentage of smolts recaptured at Lower Granite Dam in 1980 and adult returns from groups of fish with different mean lengths in cold water conditioning test, 1980.

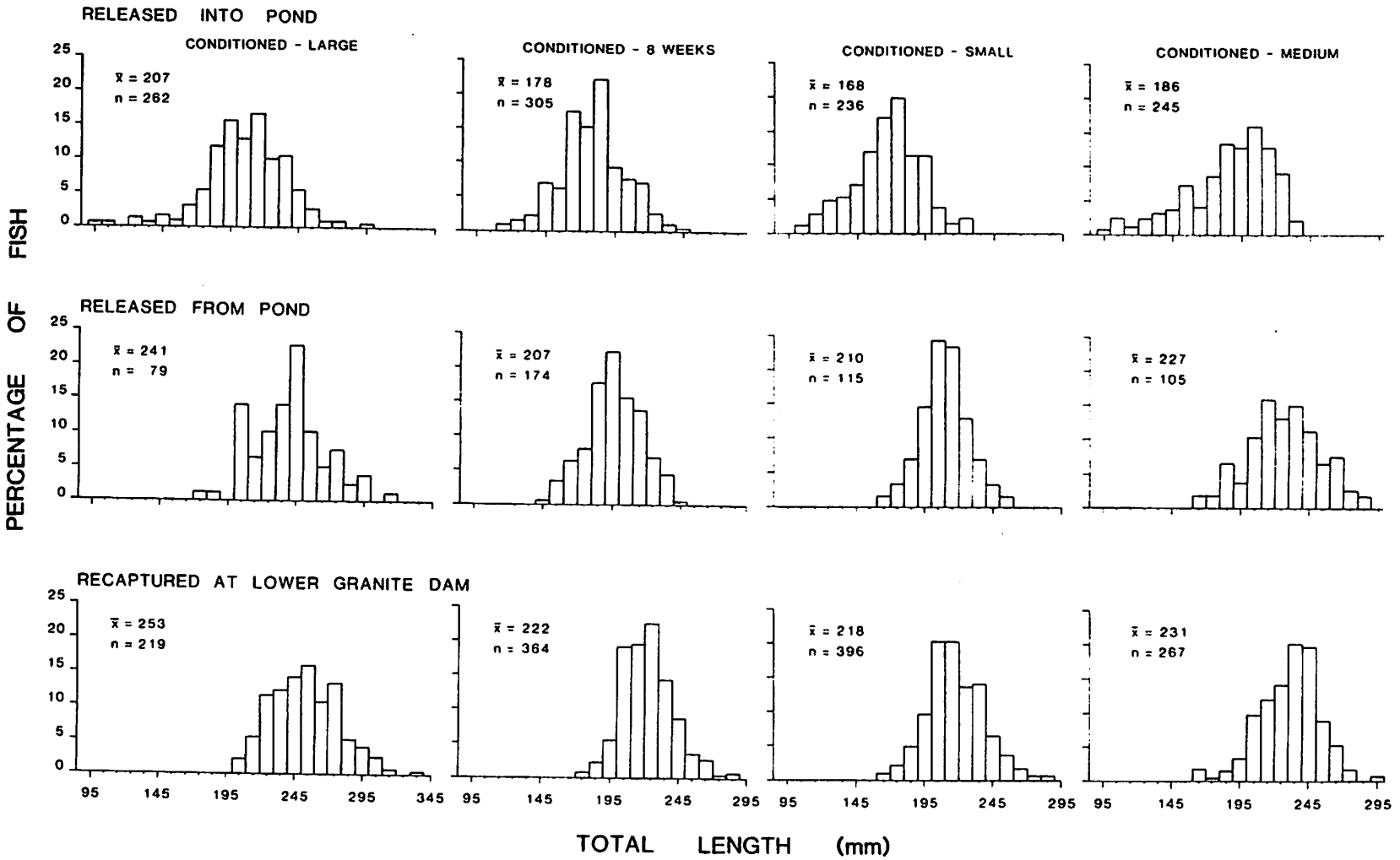

Figure 7. Length-frequency distribution of steelhead trout groups conditioned in cold water at time released into pond, when released from pond, and when recaptured at Lower Granite Dam in 1980.

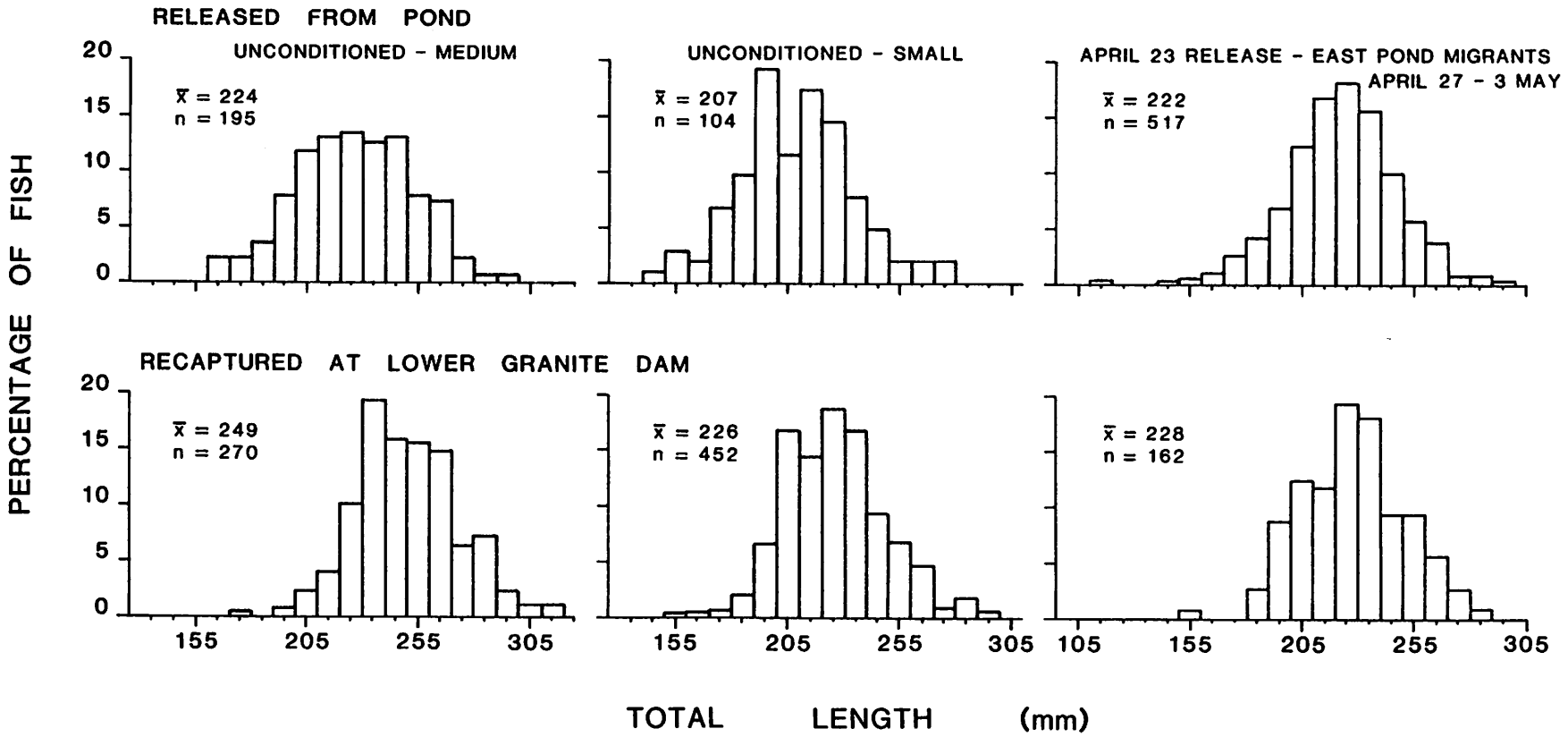

Figure 8. Length-frequency distribution of unconditioned steelhead trout groups released from pond in Pahsimeroi Valley and recaptured at Lower Granite Dam in 1980.

occurred between the time fish left the west pond (most between April 27 and May 4) and arrival at the dam (May 10-20 median recapture dates), but it appears larger fish were more likely to migrate successfully to the dam, especially in the unconditioned groups.

Growth rate of fish in the west Pahsimeroi pond in 1980 was relatively good (Table 7). Growth of the four groups that were in the pond for 57-85 days ranged from 0.40 to 0.51mm/day. Growth of the one group (conditioned, Fig. 2) placed in the pond for 12 weeks in 1979 was approximately 25mm/day. At Hagerman hatchery, growth of steelhead in 1978-79 ranged up to 1.0mm/day, depending on size and health of fish (Bjornn et al. 1979).

LEMHI RIVER RELEASES

Excess steelhead reared at Hagerman NFH in 1978-79 were released in the Lemhi River beginning in January 1979 because of over-crowding at the hatchery. Few of the steelhead released in 1979, including those released in April, migrated successfully to Lower Granite Dam. Cold water shock caused losses of fish released in winter, but we suspected that few fish released in April in the upper end of the river migrated successfully to the mouth of the Lemhi River. In 1980, marked groups were released in the upper and lower ends of the Lemhi River to determine if smolts released in the spring could successfully migrate past the numerous diversions in the Lemhi River.

1979 Releases

Procedures

In 1979, as part of the pilot rearing program at Hagerman NFH, 272,000 steelhead were available for release, but the fish had to be moved from the hatchery beginning in January because of over-crowding. Temperatures of most rivers in Idaho usually do not exceed 4C during January and February, and often they are choked with ice. Transferring steelhead from the 15C water at the hatchery to the icy water in most

Table 7. Growth of steelhead trout in the west Pahsimeroi pond for the February through April period in 1980.

Group description	Total length (mm)		Δ length (mm)	Days in pond	Average growth (mm/day)
	Start	End			
Conditioned-large	207	241	34	85	0.40
Conditioned-medium	186	227	41	85	0.48
Conditioned-small	168	210	42	85	0.49
Conditioned 8 weeks	178	207	29	57	0.51

rivers would likely cause thermal shock, so we elected to release the fish in the upper Lemhi River that is fed partially by groundwater springs of 4-5C.

The first two loads of steelhead were delivered to the Lemhi River on January 22, 1979, and released about 15km downstream from Leadore, Idaho. Temperature in the river was 3-4C at 4 p.m. when the fish were unloaded. The fish were loaded in 15C water at the hatchery and the temperature lowered to 7C during the 8-hour trip. When the trucks arrived at the river, water was pumped into the tanks to reduce the temperature to 4-5C, and then the fish were released. The fish acted normal when placed in the river. The air temperature was below freezing at the time of release and dropped to -18C overnight.

The next two loads were delivered on January 24 and released about 20-25km downstream from Leadore. Temperature of the river was less than 4C. Idaho Department of Fish and Game personnel checked the first release site on January 25 and found 38 dead fish and numerous live fish. We surmised that if 38 dead fish could be found, more fish had died and likely drifted downstream out of sight.

At that time, we deferred the release of additional fish until we could conduct cold water tolerance tests at Hagerman NFH and Dworshak NFH. In the tolerance tests we found that most fish could not survive in water less than 2C, even with extended (up to 48 hours) acclimation. Fish could survive being placed in 3-4C water, but if the temperature declined overnight to 0-2C, then mortality occurred.

Following the tolerance tests, we decided to release no more fish until crowding at the hatchery made it absolutely necessary. On February 20, two loads of fish were delivered to the Lemhi River, and we released the fish at Leadore, closer to the groundwater inflows. River temperature was 4C in daytime, but dropped to 1C overnight. On February 21, we checked the river downstream from Leadore and found approximately 200 dead fish and large numbers in shallow water that were lethargic. We deferred the fish stocking scheduled for February 22 in hopes that the

weather would soon moderate and river temperatures would not go below 3C overnight.

By March 1, fish had to be taken out of the hatchery and three loads were released into the Lemhi River. Despite 10C air and 4.5C daytime river temperatures, overnight water temperatures dipped to 1C, and some fish died from thermal shock. Because of overloading at the hatchery, additional fish were delivered March 6, 8, 13, 15, 19, 22, and 26, and the last fish were delivered April 9. By March 16, water temperatures at Leadore had warmed to a daily range of 2-5C. Fewer fish died from thermal shock with the warmer water.

We began operating the Lemhi River downstream migrant trap March 9 to monitor the seaward migration of the fish. Two groups of fish were branded in January and early February and released in the Lemhi River in March and April.

Results

Small numbers of the hatchery steelhead migrated downstream past the weir site near Lemhi, Idaho, during March, but the largest numbers were captured at the weir in April (Table 8). Discharge in the upper Lemhi River was unusually low during May, and fewer fish were recaptured at the weir than in April. Wild steelhead usually migrate seaward from the Lemhi River mainly in May (Bjornn 1978).

Only a fraction of the downstream migrants entered the trap at the weir, so we conducted a mark-recapture program to estimate the total number of fish passing the weir site. From April 13 to May 4 we estimate 29% of the downstream migrants were entering the trap. Expanding the 575 fish caught in the trap during March 9-May 15, 1979, (Table 8) by 3.43 (100/29 = 3.43) would give an estimate of 1,972 fish migrating downstream past the weir. Our estimate of fish leaving the upper Lemhi River is probably low, however, because (1) many of the steelhead developed fungus infections and may have been more likely to enter the trap because it was on a side of the stream, (2) recapture rates for wild steelhead at the

Table 8. Steelhead trout from Hagerman NFH released in the Lemhi River between January 22 and April 9, 1979, that were captured at the weir near Lemhi, Idaho.

Trapping period	Range of river temperatures (C)	Steelhead captured		
		Unmarked	March release	April release
March 9-31	0-8	16	1	-
April 1-15	1-9	215	7	1
April 16-30	2-8	270	2	8
May 1-15	4-11	74	1	2
May 16-31	6-12	29	2	1
June 1-15	4-13	48	2	2
June 16-30	8-17	14	0	0

Discharge extremely low May 7 to May 28.

Lemhi weir have been smaller, and (3) more than 1,972 fish are estimated to have been collected at Lower Granite Dam.

Based on branded steelhead released in the Lemhi River and later recaptured at Lower Granite Dam, we estimate that 1,012 of the 10,700 branded fish released in April and 393 of the 10,000 branded fish released in March entered the collection facilities at Lower Granite Dam. The low recapture rate for the fish released in March was not unexpected. The small number recaptured from the fish released in April, when thermal shock should not have been a problem, makes us suspect that other factors contributed to the small number that migrated seaward successfully.

Fish released in the Lemhi River were in good health and exceeded the optimum size, but many deteriorated in health during their stay in the river. During April and May 66% of the fish captured at the weir had fungus infections. By June only 13% had fungus infections.

On May 3, we collected hatchery steelhead from the upper Lemhi River near Leadore to assess the condition of the fish. Of the 91 fish examined, only 2 were in good condition, 74 were judged fair (thin and significant scale loss), 12 were poor (sores or fungus infections), and 3 were precociously mature males. On June 15, after the migration was mostly complete, we electrofished sections of the river again to determine how many fish were left and their condition. Because of the small number migrating past the weir, we expected to find large numbers of fish in the river, but such was not the case. Only one hatchery steelhead was collected in 150m of stream at the McFarland Recreation Area, 1 in 100m downstream from Cottam Lane, 5 in 200m at the mouth of Big Springs Creek and 19 in 100m 1-2km downstream from Leadore. Five of the fish were in good condition, 16 fair, and 5 in poor health. Most of the fish did not have a smolt appearance, and 2 were precociously mature males.

1980 Releases

Procedures

To determine if steelhead smolts have a difficult time migrating downstream out of the Lemhi River, we released a group of branded fish (9,800) at Cottam Lane bridge (river km 69) and a second group (9,500) at a bridge 3km upstream from the mouth of the river. Recapture of smolts at Lower Granite Dam was the means of evaluating their migration success.

Both groups were branded at Hagerman NFH in mid-March 1980. These fish were from lot 72, the lot of fish that had chronic mortality during the final months of rearing. In the three months between branding and release on April 22 and 24, the two groups experienced 7.7 and 9.6% mortality. When branded, the fish averaged 180.2 and 182.3mm total length (n = 281 and 230). Of the fish examined externally during branding, 0.7 and 0.9% were precociously mature males.

Fishery Unit and NMFS personnel monitored the passage and collection of marked groups of fish at Lower Granite Dam from April through June. Estimates of the percentage of each group collected at the dam are based on procedures and data presented by Sims et al. (1981).

Results

Steelhead released in the upper Lemhi River in April of 1980 apparently had difficulty migrating down to the mouth of the river. An estimated 14.4% of the steelhead released near the mouth of the Lemhi River were collected at Lower Granite Dam in spring 1980, versus only 1.5% of the group released near the upper end of the river.

Fish from the upper river release that were recaptured and examined at the dam were larger (255.8mm total length, n = 25) than the fish released near the mouth (225.4mm, n = 270). Steelhead released in the upper Lemhi River arrived at the dam a few days later than fish released near the mouth (median recapture dates, 16 versus 20 May).

DISCUSSION

Conditioning steelhead trout in cold water for 8-12 weeks before release does not appear necessary for fish reared in the relatively warm (15C) water of Hagerman Valley hatcheries. Steelhead kept in the hatchery until late April may migrate seaward up to a week later than fish conditioned in cold water, but their migration appeared to be well within the normal timing. Conditioned steelhead released in 1979 returned as adults at a higher rate (0.40 versus 0.31%) than their cohorts kept in the hatchery until April, but adult returns from groups tested in 1980 were only slightly in favor of the conditioned fish (0.41 versus 0.37%).

Steelhead trout reared at Niagara Springs SFH and released in the Pahsimeroi River in April of 1979 and 1980, returned as adults (Duke 1983) at about the same rates (0.41-0.49%) as groups reared at Hagerman NFH. The Niagara Springs fish would be similar to the unconditioned fish in our tests, in that they were kept in the hatchery in 15C water until release in early to mid April. Fish in the Niagara Springs SFH groups were from A-group steelhead (early adult migrants into Columbia River) whereas the fish released from Hagerman NFH in those years were B-group fish (late adult migrants into Columbia River).

Rearing in the 15C water may have less affect on upriver than lower Columbia River stocks of anadromous fish because of the larger distance the upriver stocks must migrate to reach the sea. Certain physiological processes, such as elevation of gill ATPase, are usually not fully developed when the upriver fish start to migrate seaward. If rearing in 15C water does not seriously alter migratory behavior, then some physiological and cellular changes could take place as the fish migrates downstream.

Size of fish released is probably more important in regulating adult return rates than conditioning in cold water. The larger fish (conditioned or unconditioned) released in 1979 returned at half again higher rates than the smallest fish (Table 1). The large, conditioned fish released in 1980 returned at about twice the rate (0.88%) of the two

groups of smaller fish from Hagerman NFH (Table 1) and smaller fish released from Niagara Springs SFH.

Conditioning steelhead in cold water prior to release, if not clearly beneficial, was not detrimental. Fish held in the Pahsimeroi ponds in both 1979 and 1980 were some of the best looking hatchery smolts we have worked with. Placing fish in ponds like the Pahsimeroi Valley ponds would be a good way to avoid producing overly large smolts in Hagerman Valley hatcheries. Rather than selecting for the latest spawning fish or retarding embryo development, fish could be transferred to such ponds before they reach target size. Growth in the ponds would be slower, and high quality smolts would be produced.

The following guidelines may be useful in the operation of ponds similar to those in the Pahsimeroi Valley.

1. Fish from hatcheries with water warmer than 5C should not be put in the ponds when pond temperatures will go below 2.5C during the 3-4 days following stocking. Cold water shock will occur and cause mortality.
2. Fish will feed actively at mean daily temperatures of 4-5C and quickly learn to feed around automatic feeders.
3. The pond inlet and outlet should be screened to prevent fish from leaving the pond until the desired release date. Fish that leave early do not survive as well as fish that stay in the pond. If the fish are of the proper size (200-230mm), they will leave the pond quickly when given the opportunity during the normal migration season. Late April seems to be a good date to release steelhead in the upper Salmon River. released near the mouth (225.4mm, n = 270). Steelhead released in the upper Lemhi River arrived at the dam a few days later than fish released near the mouth (median recapture dates, 16 versus 20 May).

Releasing hatchery steelhead during the January-March period, such as was done in the upper Lemhi River in 1979, should not be a routine

program for steelhead raised in Hagerman Valley hatcheries. Late winter-early spring releases would have the best chance of success in rivers such as the Lemhi or Pahsimeroi because they have warmer temperatures, but fish released in the Lemhi in 1979 did not survive or migrate seaward at acceptable rates. Thermal shock was a major reason for the poor survival. Fish that survived the winter were not in good health after they had been in the river with little or no feed for 1-3 months. In contrast, fish placed in the pond supplied with Pahsimeroi River water February 9 and fed a maintenance ration were in excellent health when released in early May.

Suspicions arising from the 1979 tests that smolts might have difficulty getting from the upper river to the mouth, were verified in the 1980 test releases. Fish released in the upper Lemhi River in April of 1980 showed up at Lower Granite Dam at only one-tenth the rate of fish released near the mouth. Fate of fish released in the upper Lemhi River was not determined, but we suspect the more than 50 irrigation diversions may have been a factor in the small outmigration.

Irrigation diversions from the Lemhi River are screened to prevent fish losses. Fish can get from ditches back to the river through 6-inch diameter bypass pipes, or swim back up the ditches to diversion points. If steelhead are reluctant to use the bypass pipe, large numbers of fish could get trapped or delayed between the screen and diversion point. We have observed that steelhead can be more easily discouraged from migrating seaward than chinook salmon.

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