# SEAWARD MIGRATION OF DWORSHAK HATCHERY STEELHEAD TROUT IN 1977 AS RELATED TO REARING HISTORY

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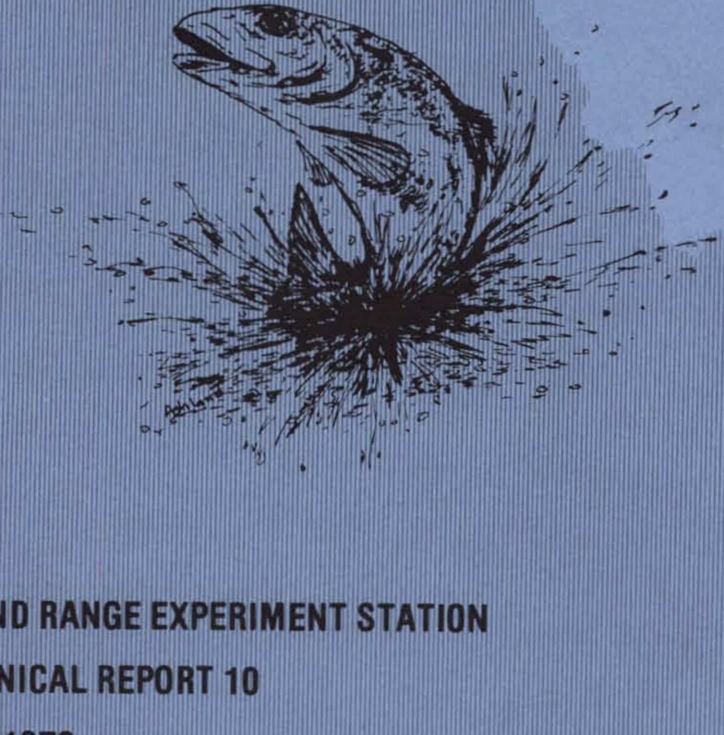
IDAHO COOPERATIVE
FISHERY RESEARCH UNIT





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Dworshak National Fish Hatchery
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ABSTRACT

Selected procedures for rearing and releasing steelhead trout (*Salmo gairdneri*) at Dworshak National Fish Hatchery (DNFH) were evaluated in 1977. Initial evaluation entailed recapturing branded fish from each test group at Lower Granite Dam. Final evaluation will occur when binary coded nose tags are removed from returning adults captured in the fisheries and at the hatchery.

Fish released from systems II and III were in less than optimum health when released in 1977 and some tests were likely impaired by the variation in health. The low flows in the Snake River during the 1977 migration period hampered the downstream movement of smolts through Lower Granite pool and may have had an effect on our tests.

As in 1976, and contrary to our expectations, mortality in ponds before release and incidence of fungus infection when recaptured at the dams for each group were not inversely related to the number of fish recaptured. In fact, the highest recapture rates occurred in those groups with the highest prerelease mortalities and fungus infection rates. Comparison of recapture rates must, therefore, be limited to the planned comparisons.

Length at release was tested again in 1977, but the results were inconsistent. The length test with age II fish followed the pattern of earlier tests with highest recaptures from the fish near 200 mm in length. The recapture rates of age I fish varied widely and without pattern.

Conditioning fish in cold water (less than 10 C) for up to 12 weeks appeared to have some benefits, but again the results are questionable because of the fish health problems. The higher recapture rate of the 12 week conditioned fish compared to those conditioned for 8 or 2 weeks, might be due in part to better health of the fish with a longer period of cold water conditioning.

Seaward migration of hatchery steelhead occurred from early April to early June in 1977. A significant proportion of the smolts were ready to migrate seaward by mid-April. Smaller fish did not migrate in large numbers until May.

Salt treatment before release did not result in more migrants reaching Lower Granite Dam, but malachite treatment after handling and marking did improve a fish's chance of migrating successfully.

Steelhead trout reared for two years and released in 1977 were better smolts than the one-year-old fish released in 1977. More of the two-year fish were recaptured at the dam and they had a lower fungus infection rate than the one-year fish. Precocious maturity of the two-year fish was relatively low (3.4%), perhaps because the average length was only 200 mm.

Many Snake River drainage steelhead (wild and hatchery) were not ready to live in seawater in April or early May even though they were migrating seaward. One-third of the wild fish and 43 percent of the hatchery fish collected at Lower Granite Dam and taken to net pens in Puget Sound did not survive the first 18 days in seawater.

## INTRODUCTION

As part of a program to improve the quality of steelhead trout (*Salmo gairdneri*) produced at Dworshak National Fish Hatchery (DNFH), studies of parr-smolt transformation and seaward migration were continued in 1977. The effects of various rearing regimes and treatments at the hatchery were evaluated in terms of number, timing and size of smolts that migrated downstream and were recaptured at Lower Granite Dam (Fig. 1). Information was collected and tests conducted in 1977 to evaluate length at release, cold water conditioning, date of release, voluntary migration from the hatchery, mortality in the ponds and fungus at the dams as indices of smolt health, timing of migration, treatment with salt and malachite before release, gravity versus pump release of fish, and location of release.

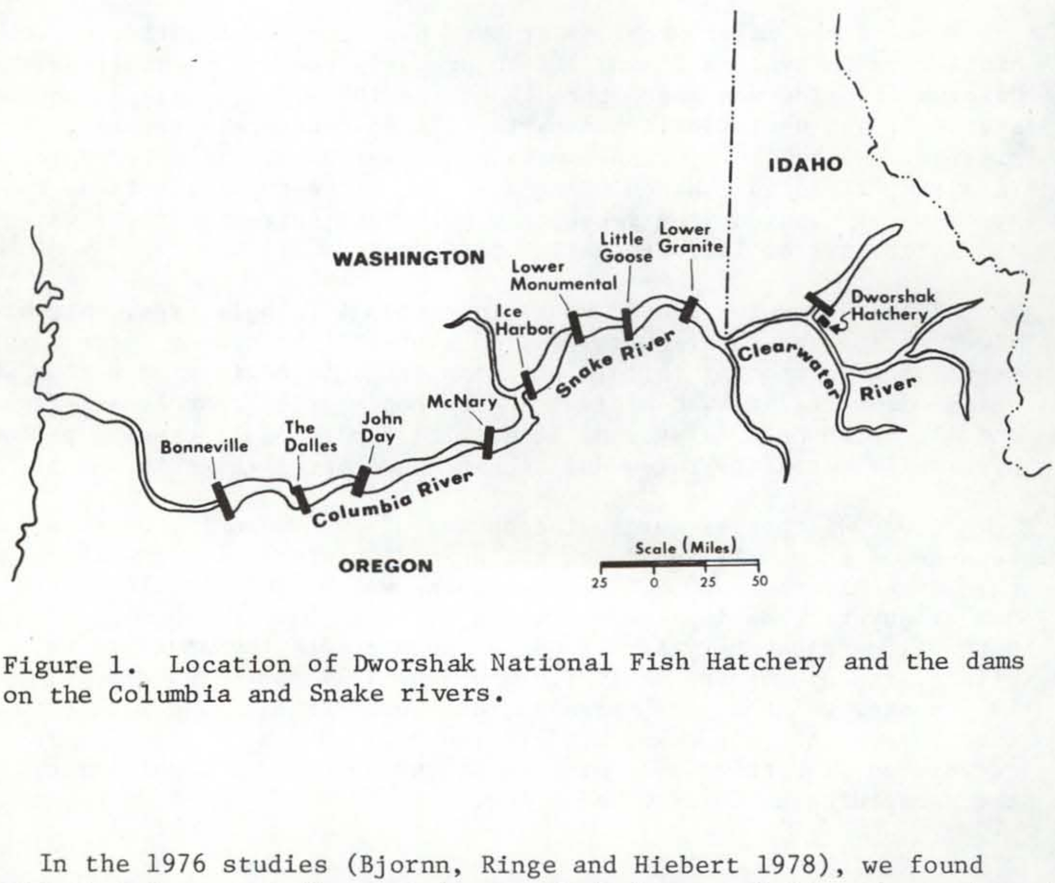


Figure 1. Location of Dworshak National Fish Hatchery and the dams on the Columbia and Snake rivers.

In the 1976 studies (Bjornn, Ringe and Hiebert 1978), we found length at release was the most important factor regulating the number of fish that migrated seaward and were recaptured at the dam. The number of fish from each test group recaptured at the dams was not clearly related to mortality rate in the hatchery before release or to the rate of fungus infection when recaptured at the dams. Conditioning of fish in cold water for 3 or 6 weeks did not result in elevated ATPase activity or in an obvious increase in the number of fish recaptured at the dams. ATPase activity in hatchery fish was only slightly elevated when they were released, but increased as they migrated seaward. We found that many hatchery and wild steelhead smolts migrating through the lower Snake River were not fully prepared for the transition from freshwater to seawater.

Tests conducted in 1977 were designed to provide information on questions unanswered in 1976 and to evaluate problems that developed during the 1976-77 rearing period. The studies reported herein are only a part of the studies undertaken by DNFH and Corps of Engineers staffs and contractors to improve fish cultural operations and quality of steelhead trout produced at the hatchery.

Variable health of the fish produced at DNFH impaired the validity of some tests conducted in 1977. Fish released from systems II and III were in less than optimum health and the results of some tests were likely affected by differences in health of fish in the various groups.

One of the major problems at DNFH has been the inability of the biofilters in systems II and III to properly process metabolites. Calcium chloride was added throughout the 1976-77 rearing period in system II and periodically in system III to counteract the toxicity of nitrite. Mortality of fish increased in system III in early March and in system II in late March (Fig. 2). The water supply in these two systems was changed from reuse to single pass untreated river water in mid March (system III) and early April (system II).

Fish reared for 1 or 2 years in system I (single pass, untreated river water) and the fish moved from system II to system I for 8 to 12 weeks of conditioning in cold water appeared to be in good health when released; mortality was minimal in the ponds prior to release (Figs. 3 and 4). Fish held in systems II and III for the full rearing period had high daily mortality rates during March and April (Figs. 4 and 5).

River discharges during the spring of 1977 were far below average because of the small snow pack the preceding winter. Peak discharge in the Snake River was 60,800 cfs and there was no spill at Lower Granite Dam at any time during the migration season. Downstream migration of both wild and hatchery steelhead was hampered by the small flows. The effect, if any, of the small flows on the 1977 tests is unknown. In the 1976 tests, we used recaptures at both Lower Granite and Little Goose dams to evaluate the seaward migration. In 1977 so few fish were recaptured at Little Goose Dam, we had to base our evaluations solely on the recaptures at Lower Granite Dam.

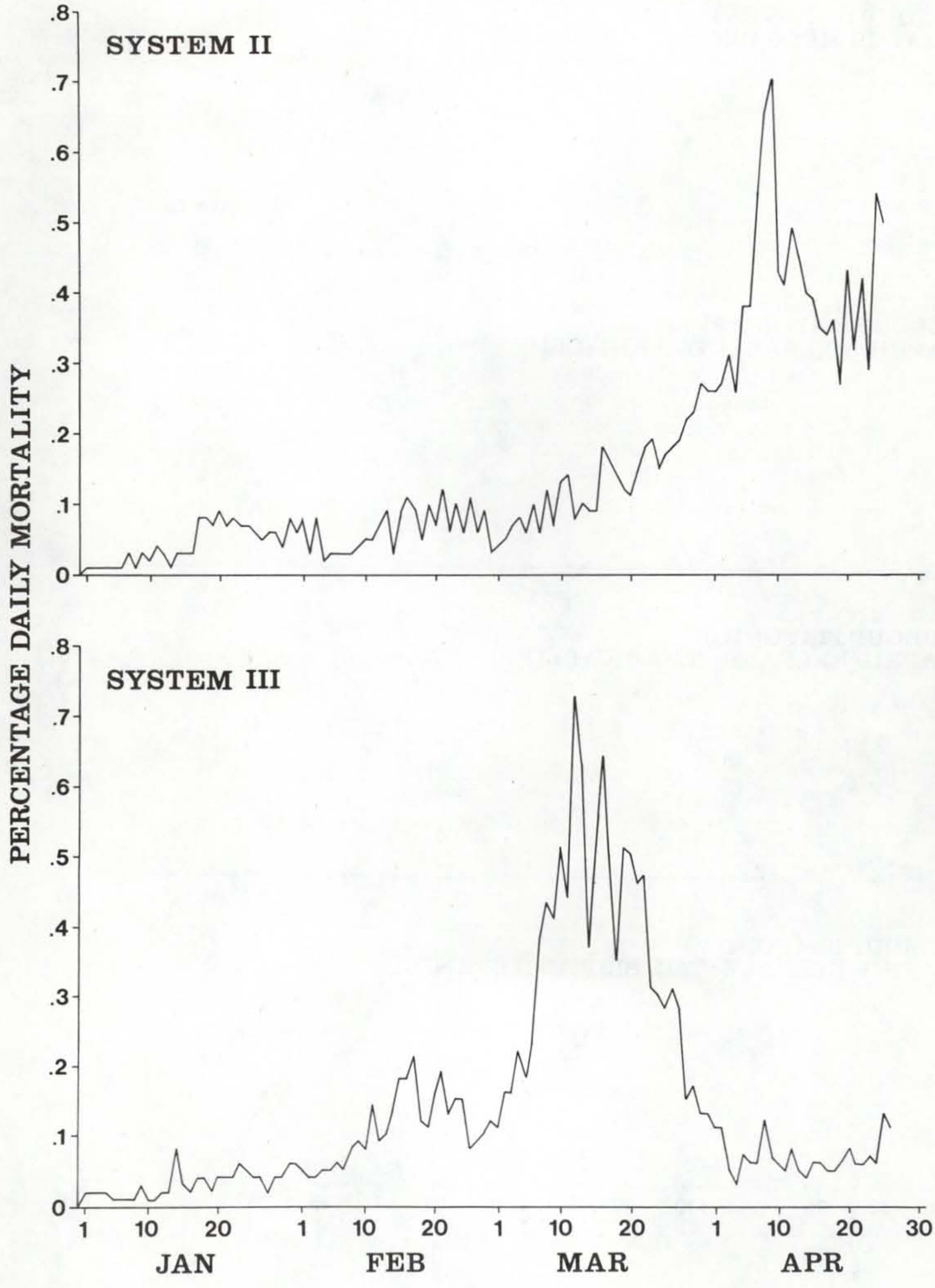


Figure 2. Percentage daily mortality of steelhead trout in system II and III ponds at DNFH in 1977.

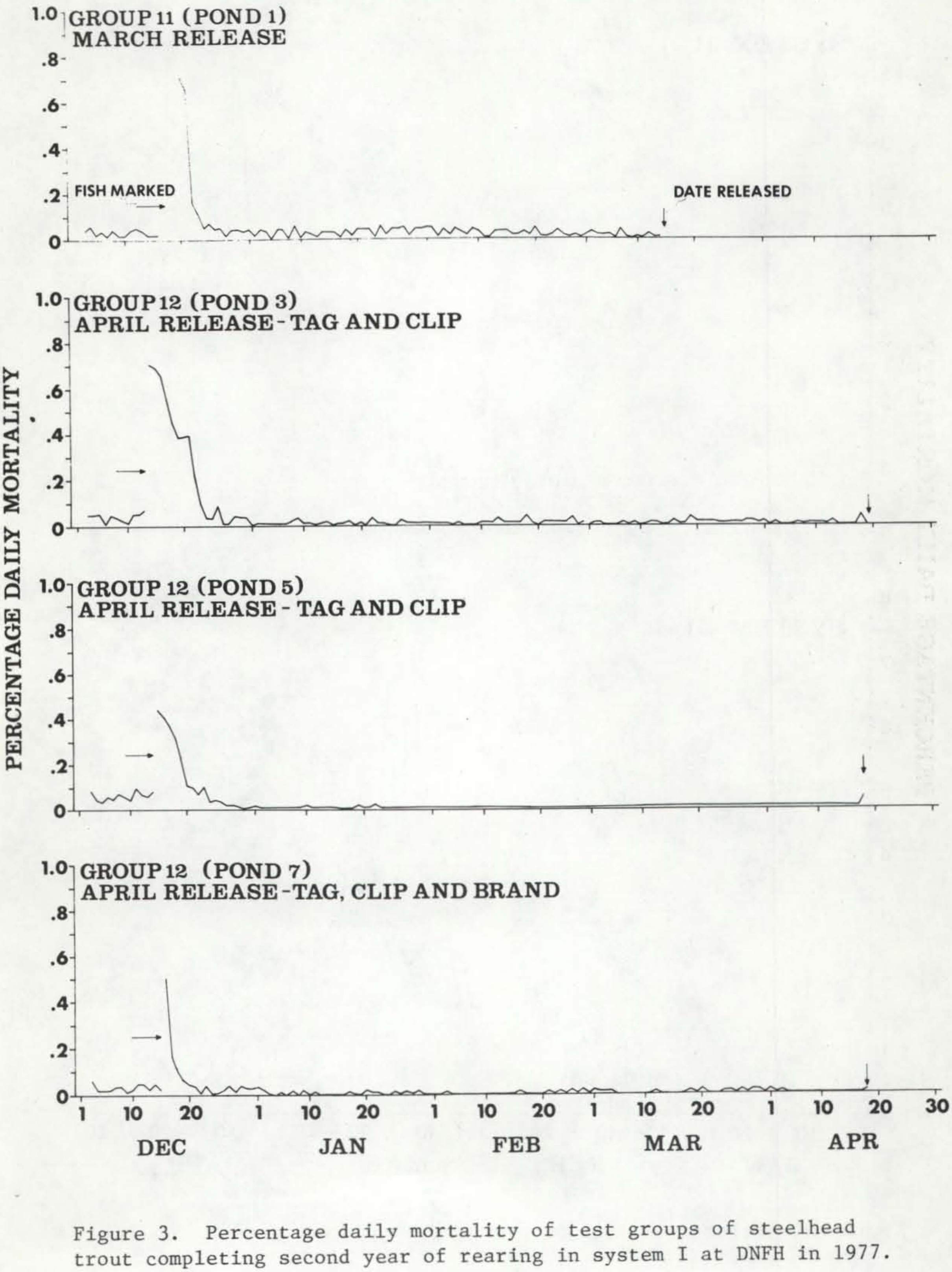


Figure 3. Percentage daily mortality of test groups of steelhead trout completing second year of rearing in system I at DNFH in 1977.

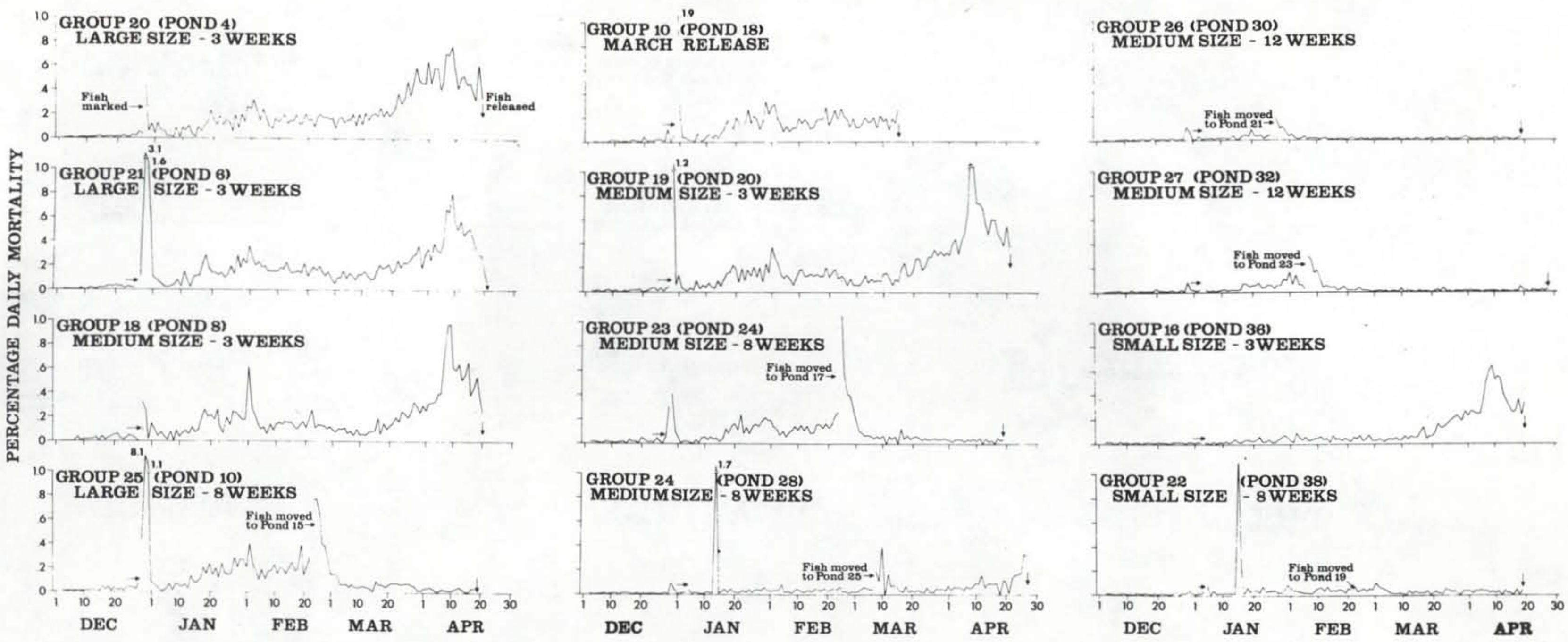


Figure 4. Percentage daily mortality of test groups of steelhead trout in system II and then after being moved to system I (groups 22, 23, 24, 25, 26, 27) at DNFH in 1977.

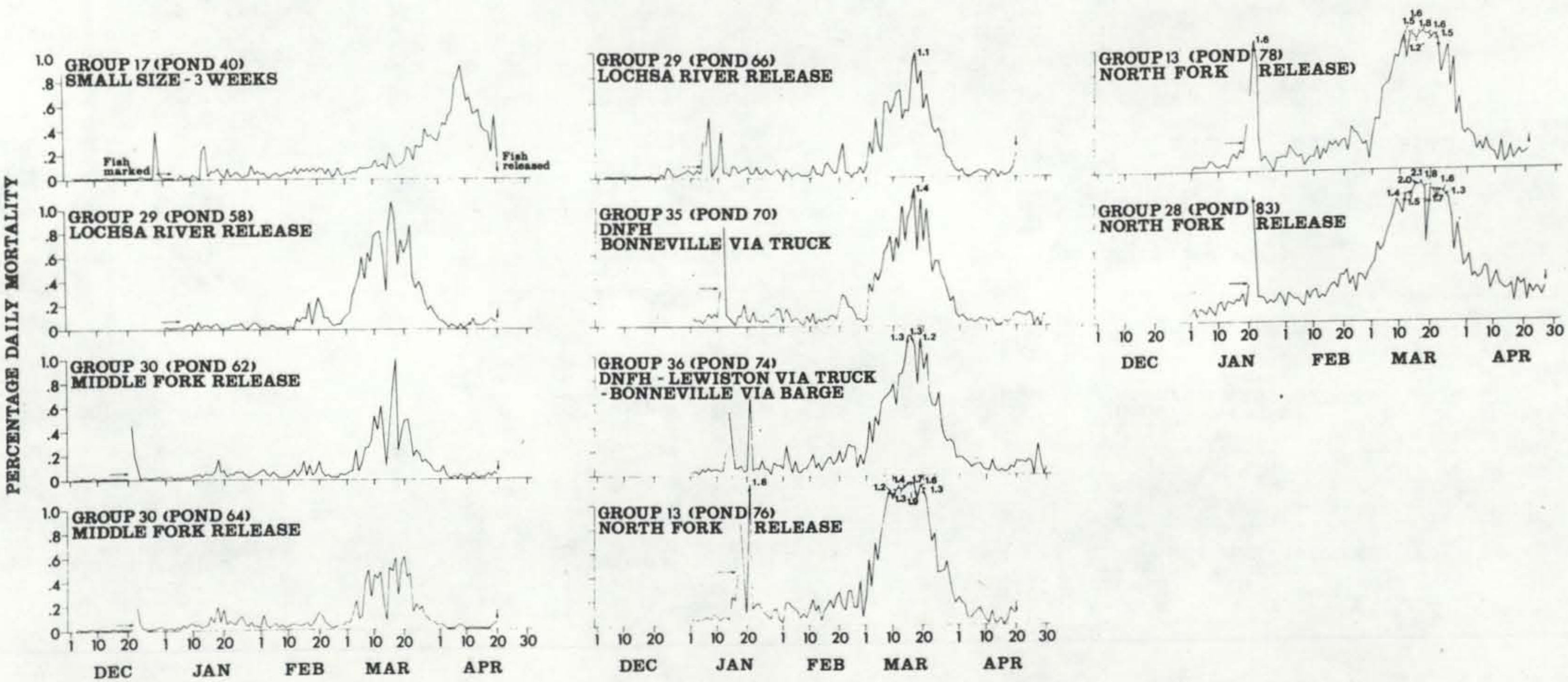


Figure 5. Percentage daily mortality of test groups of steelhead trout in system II (group 17) and system III at DNFH in 1977.

## TEST PROCEDURES

Fish used in the 1977 tests were marked mostly in December 1976 and January 1977; placed back in raceways where the special rearing treatments, if any, were applied; monitored for fish health; checked for tag and brand retention and then released at the scheduled time. The initial evaluation of test groups released in 1977 was accomplished by recapturing fish at Lower Granite Dam. Those groups of fish with coded wire tags and tetracycline marks will be further evaluated when they return past the dams and to the hatchery as adults in the 1978-79, 1979-80 and 1980-81 fish runs.

### Marking of Fish

Initially we planned to mark 28 groups of fish for release in 1977. As the rearing progressed, additional problems developed that we attempted to evaluate and 37 groups were marked and released to evaluate 9 different rearing conditions, release procedures, and smolt criteria (Table 1). Most of the fish were marked during December 1976 and January 1977. A few special groups were marked just prior to release in April, May or June 1977.

Fish were marked with cold brands, binary coded wire nose tags and adipose fin clips. We branded a portion of the fish in all groups so we could identify them when recaptured at Lower Granite Dam and evaluate their seaward migration. Groups of fish listed below were also nose tagged and fin clipped or marked with tetracycline so they could be evaluated as returning adults.

1. Age I fish released in the North Fork.
2. Age I fish released in the Middle Fork.
3. Age I fish released in the Lochsa River.
4. Age II fish released in the North Fork.
5. Age I fish hauled to Lewiston by truck and then by barge to Bonneville Dam.
6. Age I fish hauled by truck to Bonneville Dam.
7. Age II fish marked with a tetracycline ring and hauled by truck to Lewiston and then by barge to Bonneville Dam.

We branded about 10,000 fish in each group and that number provided an adequate number of recaptured fish at Lower Granite Dam. To get adequate adult recoveries, each group released from the hatchery contained about 60,000 tagged and clipped fish and the two groups transported to Bonneville Dam contained about 30,000 fish. The group of age II fish barged to the Lower Columbia River contained an estimated 171,000 fish marked with tetracycline.

All of the age II fish had been held in untreated river water in the ponds or filter beds of system I. Fish used in the 8 and 12 weeks of coldwater conditioning tests were reared initially in reuse water in system II then moved to system I. Fish used in the transportation, location of release, and age I length tests were reared in reuse water in system III.

Table 1. Number of fish marked in each group; description of group; date marked; adjustments for mortality in pond, unknown losses (birds, etc.) and brand or tag loss; estimated number released; and dates released
All fish released into the North Fork of Clearwater River and were age I unless noted otherwise.

| Group number | Description of group | Abbreviated description | Date marked (day/mo/yr) | Number marked: Brand only | Number marked: Brand, tag and clip | Number marked: Tag and clip only | Adjustments (%) for: Mortality in pond | Adjustments (%) for: Unknown losses | Adjustments (%) for: Unreadable brands | Adjustments (%) for: Tag loss | Number released: With readable brands | Number released: Tag and clip | Nose tag binary code | Brand (position and letters) | Dates released (day/mo/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length test | | | | | | | | | | | | | | | |
| 1 | Age I, 160-169 mm | LTI 165 | 6-7/5/77 | 1015 | | | | | | | 1015 | | | RD SI | 7/5/77 |
| 2 | Age I, 180-189 mm | LTI 185 | 6-7/5/77 | 1017 | | | | | | | 1017 | | | RD ~15 | 7/5/77 |
| 3 | Age I, 200-209 mm | LTI 205 | 6-7/5/77 | 1009 | | | | | | | 1009 | | | RD ~15 | 7/5/77 |
| 4 | Age I, 210-230 mm | LTI 220 | 6-7/5/77 | 755 | | | | | | | 755 | | | RD IS | 7/5/77 |
| 5 | Age II, 140-150 mm | LTII 145 | 7/5/77 | 1005 | | | | | | | 1005 | | | LA +I | 7/5/77 |
| 6 | Age II, 160-169 mm | LTII 165 | 7/5/77 | 711 | | | | | | | 711 | | | LA U | 7/5/77 |
| 7 | Age II, 180-189 mm | LTII 185 | 7/5/77 | 1008 | | | | | | | 1008 | | | LA C | 7/5/77 |
| 8 | Age II, 200-209 mm | LTII 205 | 7/5/77 | 1254 | | | | | | | 1254 | | | LA Π | 7/5/77 |
| 9 | Age II, 220-229 mm | LTII 225 | 7/5/77 | 1011 | | | | | | | 1011 | | | LA ⊐ | 7/5/77 |
| March release | | | | | | | | | | | | | | | |
| 10 | Age I | MR I | 30/12/76 | 28029 | | | 11 | $20^{a}$ | 59 | | 8182 | | | LD I+ | 15/3/77 |
| 11 | Age II | MR II | 13/12/76 | 10200 | | | 5 | 0 | 22 | | 7574 | | | LD IS | 15/3/77 |
| April release | | | | | | | | | | | | | | | |
| 12 | Age II | AR II | 13-16/12/76 | | 10200 | 50021 | 3 | 0 | 22 | 2 | 7717 | 57246 | 10/13/10 | LD ~15 | 15,19/4/77 |
| 13 | Age I | AR I | 17-20/1/77 | | 62250 | | 40 | $20^{a}$ | 23 | 2 | 24445 | 31112 | 10/13/13 | LD ~3E | 21/4/77 |
| May release | | | | | | | | | | | | | | | |
| 14 | Age II, w/malachite | MR II M | 27/5/77 | 730 | | | | | | | 730 | | | LA ╪ | 27/5/77 |
| 15 | Age II, w/o malachite | MR II NM | 27/5/77 | 730 | | | | | | | 730 | | | RA ╪ | 27/5/77 |
| Cold water conditioning | | | | | | | | | | | | | | | |
| 16 | Small size, 2 weeks, w/o salt, pump | S 2 NSP | 4/1/77 | 11553 | | | 9 | $20^{a}$ | 51 | | 4121 | | | RD ⊐ | 20/4/77 |
| 17 | Small size, 2 weeks, w/salt, pump | S 2 SP | 5/1/77 | 10585 | | | 12 | $20^{a}$ | 49 | | 3800 | | | RD ~I3 | 21/4/77 |
| 18 | Medium size, 2 weeks, w/salt, gravity | M2SG | 28/12/76 | 11067 | | | 15 | $20^{a}$ | 76 | | 1806 | | | LD ╪ | 21/4/77 |
| 19 | Medium size, 2 weeks, w/o salt, gravity | M 2 NSG | 29/12/76 | 10589 | | | 15 | $20^{a}$ | 58 | | 3024 | | | RD +I | 19/4/77 |
| 20 | Large size, 2 weeks, w/o salt, pump | L 2 NSP | 27/12/76 | 10946 | | | 28 | $20^{a}$ | 31 | | 4350 | | | LD 5I | 19/4/77 |
| 21 | Large size, 2 weeks, w/salt, pump | L 2 SP | 27-28/12/76 | 11508 | | | 21 | $20^{a}$ | 31 | | 5018 | | | LD ~15 | 21/4/77 |

Table 1. cont.

| Group number | Description of group | Abbreviated description | Date marked (day/mo/yr) | Number marked: Brand only | Number marked: Brand, tag and clip | Number marked: Tag and clip only | Adjustments (%) for: Mortality in pond | Adjustments (%) for: Unknown losses | Adjustments (%) for: Unreadable brands | Adjustments (%) for: Tag loss | Number released: With readable brands | Number released: Tag and clip | Nose tag binary code | Brand (position and letters) | Dates released (day/mo/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | Small size, 8 weeks, April release | S 8 A | 4/1/77 | 12168 | | | 8 | 20 [a] | 11 | | 7970 | | | RD ⊓ | 19/4/77 |
| 23 | Medium size, 8 weeks, April release | M 8 A | 29/12/76 | 11208 | | | 11 | 20 [a] | 90 | | 798 | | | RD ± | 18/4/77 |
| 24 | Medium size, 8 weeks, May release | M 8 'M' | 4/1/77 | 11597 | | | 6 | 20 [a] | 57 | | 3750 | | | RD ⊏̄ | 27/4/77 |
| 25 | Large size, 8 weeks, April release | L 8 A | 28/12/76 | 10386 | | | 18 | 20 [a] | 66 | | 2316 | | | RD ∓ | 18/4/77 |
| 26 | Medium size, 12 weeks, April release | M 12 A | 3/1/77 | 11883 | | | 2 | 20 [a] | 26 | | 6894 | | | RD ⊏ | 19/4/77 |
| 27 | Medium size, 12 weeks, May release | M 12 'M' | 3/1/77 | 11119 | | | 4 | 20 [a] | 16 | | 7173 | | | RD ⊔ | 27/4/77 |
| Location of release | | | | | | | | | | | | | | | |
| 28 | 'Gravity' release to North Fork | 'G'NF | 21/1/77 | 11492 | | | 42 | 20 [a] | 25 | | 4016 | | | LD ꟾJ | 22/4/77 |
| 29 | Lochsa River release | LR | 5-10/1/77 | | 11967 | 50651 | 22 | 34 | 65 | 2 | 2156 | 31581 [b] | 10/13/12 | LD +ꟾ | 20/4/77 |
| 30 | Pumped release to Middle Fork | PMF | 20-22/12/76 | | 10617 | 51170 | 17 | 20 [a] | 83 | 2 | 1198 | 40206 | 10/13/11 | LD ± | 20/4/77 |
| Voluntary migration | | | | | | | | | | | | | | | |
| 31 | Voluntary migrants, age I | VM I | Apr-May/77 | 3260 | | | | | | | 3260 | | | LD ՐꟾI | Apr-May/77 |
| 32 | Involuntary migrants, age I | IVM I | 15/5/77 | 5000 | | | | | | | 5000 | | | LD ⊒ | 15/5/77 |
| 33 | Voluntary migrants, age I, 2 year fish | VMI2 | Apr-May/77 | 4019 | | | | | | | 4019 | | | RA ꟾ+ | Apr-May/77 |
| 34 | Voluntary migrants, age I, 2 year fish, June | VMI2J | 2-3/6/77 | 205 | | | | | | | 205 | | | LA ± | 2-3/6/77 |
| Transportation tests | | | | | | | | | | | | | | | |
| 35 | DNFH to Bonneville via truck | DBT I | 11-12/1/77 | | 30539 | | 29 | 20 | 49 | 2 | 8846 | 16999 | 10/13/7 | RD ՐI | 2/5/77 |
| 36 | DNFH to Lewiston via truck, Bonneville via barge | DLTBB I | 13-14/1/77 | | 30950 | | 33 | 15 | 37 | 2 | 11104 | 17274 | 10/13/9 | RD ꟾJ | 5/5/77 |
| 37 | DNFH to Lewiston via truck, Bonneville via barge, Age II | DLTBB II | March/77 | | | | | | | | | 171,000 [c] | | | 5/5/77 |

a Estimated unknown loss

b Some fish may have been killed when held in the truck an extra 5 hours because of a malfunction of the door on the tank.

c 1 tetracycline ring

The fish were marked in December and January in an attempt to avoid some of the mortality that occurs when handling fish at DNFH near the time of release. Mortality increased temporarily at time of marking and amounted to 0.5 to 8.0% of the fish in the pond (Figs. 3, 4, and 5); similar to the mortality that occurred in 1976 when fish were marked in February (Bjornn et al. 1978).

## Release of Fish

The number of marked fish actually released was less than the number marked because of mortality in the ponds between marking and release, losses to birds and other unknown causes, tag loss, and failure of the brand to become readable. Each group of fish marked in December and January was examined before release to get mean length of the fish, rate of tag loss, and proportion of the brands that could be easily distinguished.

Loss of marked fish from mortality in the ponds ranged from a low of 2-5% of the age II fish and fish conditioned for 12 weeks in system I, to a high of 20-40% of the fish in system III (Table 1). Dead fish were removed from the ponds daily by hatchery personnel and examined periodically to determine the proportion of marked fish among the mortality. The reported number of marked fish released from the hatchery was adjusted for the fish that died in the ponds.

A loss of fish between marking and release caused by birds and other unknown factors was found when fish released in the Lochsa River (group 29) and those trucked downstream to the barge (group 36) or to Bonneville Dam (group 35) were weighed and loaded into the trucks. All other groups of fish were released without an inventory after they were marked in December or January. In early January, 62,600 fish scheduled for release into the Lochsa River were marked and placed in two ponds. Up to the time the fish were loaded on the truck, about 13,800 dead fish (22%) had been removed from the ponds, leaving 48,800 fish in the ponds according to the records. When the fish were loaded on the trucks, the ponds contained only 32,000 fish, thus an additional loss of 16,800 fish (34 percent of 48,800) had occurred. In a similar way, we found uncounted losses of 15 and 20 percent of the fish trucked to the barge or Bonneville Dam. After finding that all four ponds that were inventoried at time of release contained substantially fewer fish than our records indicated, we had to decide whether to adjust the number released in all other groups or report only the numbers on our records (number marked minus mortality picked from the ponds). We decided to adjust the number released in all groups downward by 20 percent, except for the age II fish from system I. Although we did not know the exact magnitude of the unknown loss in the other ponds, we concluded that the adjusted number was probably closer to the actual number released than the unadjusted number. Comparisons between groups are hampered, not by the adjustment, but by the likelihood of differential uncounted losses between groups.

The percentage of fish branded in December and January that had unreadable brands at time of release varied between groups (range 11 to

90 percent, Table 1). The percentage of fish with good brands was not related in any consistent way with size of fish, temperature in ponds, or age. Comparisons between groups should be unaffected by failure of brands to become readable on some fish because we inspected each group of fish before release and adjusted the number of fish released in each group to reflect the number with easily recognizable brands.

Loss of the coded wire tag placed in the nose of the fish was minimal (2 percent) and is reflected in the reported number released with nose tags and fin clips (Table 1).

The number of fish released with recognizable brands ended up being substantially less than planned in some groups because of high mortality in some cases and ineffective branding in others. The smaller than anticipated numbers of marked fish released in some groups did not become a serious problem, however. Adequate numbers of marked fish were recaptured at Lower Granite Dam because there was no spill and a higher proportion of the migrating fish were trapped and sampled in 1977 than anticipated.

## Recapture of Marked Fish at the Dam

Marked fish from Dworshak Hatchery were recaptured in downstream migrant collection facilities operated by National Marine Fishery Service (NMFS) personnel at Lower Granite Dam. Fish entering collection facilities at Lower Granite Dam were automatically sorted into raceways according to size. The number of fish entering each raceway was recorded daily on electronic counters. Many of the collected fish were loaded directly from raceways into tank trucks or barges for transportation to the lower Columbia River.

Each working day NMFS personnel moved fish from one or more raceways into the marking building for examination, sorting and marking. As fish were examined and sorted, marked fish from DNFH were set aside in a holding tank where we then reexamined the fish, recorded the brand, total length of the fish, and on many days, the presence or absence of fungus infection. The number of fish recaptured and examined from each of the 34 groups of marked steelhead trout released from the hatchery in 1977 ranged from 0 to 602 (Table 2).

The number of marked fish we examined was adjusted for the proportion of fish sampled from the raceways to obtain an estimate of the number of fish from each group collected at the dam (Table 2). The migration season was divided into 5 day intervals for purposes of determining the proportion of fish sampled and number recaptured from each group. Because there was no spill at the dam in 1977, the efficiency of collection should have been relatively constant and no adjustment for collection efficiency was made in 1977.

The percentage of fish released from DNFH that were subsequently recaptured at the dam (Table 2) is a minimum estimate of the number of

Table 2. Number of steelhead trout of each test group released from DNFH and recaptured at Lower Granite Dam and the percentage recaptured.

| Test groups and numbers | Abbreviated descriptions[a] | Fish released | Recaptured fish examined | Estimated number recaptured | Percentage recaptured |
|---|---|---|---|---|---|
| Length test | | | | | |
| 1 | LTI165 | 1015 | 94 | 284 | 28.0 |
| 2 | LTI185 | 1017 | 99 | 334 | 32.8 |
| 3 | LTI205 | 1009 | 97 | 355 | 35.2 |
| 4 | LTI220 | 755 | 67 | 250 | 33.1 |
| 5 | LTII145 | 1005 | 0 | 0 | 0.0 |
| 6 | LTII165 | 711 | 4 | 9 | 1.3 |
| 7 | LTII185 | 1008 | 34 | 86 | 8.5 |
| 8 | LTII205 | 1254 | 77 | 258 | 20.6 |
| 9 | LTII225 | 1011 | 48 | 165 | 16.3 |
| March release | | | | | |
| 10 | MRI | 8182 | 278 | 324 | 4.0 |
| 11 | MRII | 7572 | 440 | 750 | 9.9 |
| April release | | | | | |
| 12 | ARII | 7717 | 306 | 749 | 9.7 |
| 13 | ARI | 24445 | 602 | 1911 | 7.8 |
| May release - malachite treatment | | | | | |
| 14 | MRIIM | 730 | 53 | 125 | 17.1 |
| 15 | MRIINM | 730 | 30 | 94 | 12.9 |
| Coldwater conditioning - 2 weeks | | | | | |
| 16 | S2NSP | 4121 | 23 | 61 | 1.5 |
| 17 | S2SP | 3800 | 16 | 43 | 1.1 |
| 18 | M2SG | 1806 | 28 | 53 | 2.9 |
| 19 | M2NSG | 3024 | 16 | 50 | 1.7 |
| 20 | L2NSP | 4350 | 183 | 424 | 9.7 |
| 21 | L2SP | 5018 | 124 | 269 | 5.4 |
| Coldwater conditioning - 8 weeks | | | | | |
| 22 | S8A | 7970 | 84 | 313 | 3.9 |
| 23 | M8A | 798 | 7 | 21 | 2.6 |
| 24 | M8'M' | 3750 | 40 | 126 | 3.4 |
| 25 | L8A | 2316 | 7 | 18 | 0.8 |
| Coldwater conditioning - 12 weeks | | | | | |
| 26 | M12A | 6894 | 140 | 376 | 5.4 |
| 27 | M12'M' | 7173 | 196 | 640 | 8.9 |
| Location of release | | | | | |
| 28 | 'G'NF | 4016 | 199 | 745 | 18.5 |
| 29 | LR | 2156 | 26 | 84 | 3.9 |
| 30 | PMF | 1198 | 4 | 7 | 0.6 |
| Voluntary migration | | | | | |
| 31 | VMI | 3260 | 158 | 456 | 14.0 |
| 32 | 1VMI | 5000 | 163 | 500 | 10.0 |
| 33 | VMI2 | 4019 | 105 | 343 | 8.5 |
| 34 | VMI2J | 205 | 6 | 18 | 8.8 |

[a]See Table 1 for full description of group.

fish that migrated downstream as far as Lower Granite Dam. NMFS personnel were unable to estimate the collection efficiency at Lower Granite Dam in 1977 because of the low discharge and subsequent poor migration of fish through the reservoir. Relatively few of the fish not collected at Lower Granite or Little Goose dams in 1977 would have successfully migrated past the remaining dams to reach the ocean. Thus the number of wild and hatchery fish collected at Lower Granite and Little Goose dams is essentially the number of fish that had an opportunity to reach the ocean in 1977.

## Specific Tests

### Length at Release

Optimum length at which to release Dworshak Hatchery steelhead trout was tested in 1977 by marking four groups of age I fish (groups 1-4, Table 1) that ranged from 160-169, 180-189, 200-209, 210-230 mm in length and five groups of age II fish (groups 5-9, Table 1) that ranged from 140-149, 160-169, 180-189, 200-209, 220-229 mm in length. By early May, we had determined that collection efficiency at the dam was relatively high and that 1000 marked fish was adequate to get a reasonable number of recaptures and thus evaluate the hypothesis being tested. These test groups were branded May 6 and 7 and released May 7. All lengths in this report are total lengths.

### Cold Water Conditioning

The need to condition fish in cold water (less than 10 C) was evaluated in 1977 by marking 12 groups of age I fish and conditioning them for 2 (groups 16-21, Table 1), 8 (groups 22-25), and 12 (groups 26-27) weeks. We planned to have fish conditioned for 0, 8, and 12 weeks. All test groups were reared initially in reuse water (12 to 15 C) in system II. The temperature of the reuse water was reduced to 10.5-12.2 C February 7 and then changed to 5-6 C untreated river water in early April because of fish health problems. Thus all fish in system II were conditioned in cold water for 2 to 3 weeks depending on date released. Fish scheduled for 8 and 12 weeks of conditioning were moved 8 and 12 weeks before the scheduled release dates to ponds of system I supplied with cold (5-6 C) untreated river water. Water temperatures in system II after February 7 were below the 13 C threshold suggested by Zaugg et al. (1972) where parr-smolt transformation might be retarded, thus all the fish might have had up to 8 weeks in cool enough temperatures to permit normal parr-smolt transformation.

Fish reared in system III also received some conditioning in cold water because the water was changed from 13 C reuse to 5-6 C untreated river water in mid March. Thus the test fish in system III (groups 1-4, 13, 28-32, 35-36, Table 1) were conditioned in cold water for 5-7 weeks depending on date of release.

The groups with 2 weeks of conditioning included two groups of small-sized fish (groups 16-17), two of medium-sized fish (groups 18-19), and two of large-sized fish (groups 20-21). One group of each size category was to be released in April and the other in May. Because the water supply in system II had been switched to untreated river water in early April, we decided to release all the fish April 19-21.

Four groups of fish conditioned for 8 weeks included one group of small-sized fish (group 22), two groups of medium-sized fish (groups 23-24), and one of large-sized fish (group 25). One of the groups with medium-sized fish was to be released in May but was released in April because of the change in water supply in system II.

The two groups of fish conditioned for 12 weeks (groups 26-27) were medium-sized fish and both were released in April.

When the fish were marked, we tried to select ponds with fish of appropriate size (small, medium and large) to determine if cold water conditioning had an effect that varied with size. For the groups with 2 weeks of conditioning, the small-sized fish averaged 188 and 190 mm in length when released, the medium-sized fish 194 and 197 mm, and the large-sized fish 204 and 211 mm (Table 3). The small-sized fish in the groups conditioned for 8 weeks averaged 176 mm, the medium-sized fish 180 and 184 mm, and the large fish 200 mm. The medium-sized fish conditioned for 12 weeks averaged 167 and 169 mm when released; shorter than the other groups of fish because of the longer period in cold water.

Date of Release

To further evaluate in 1977 the optimum date to release steelhead from DNFH, we released a group of age I (group 10) and a group of age II (group 11) fish on March 15 and compared them with fish released in April (groups 12 and 13) and May (groups 14 and 15). The age II fish (groups 11, 12, 14 and 15) had low daily mortality rates before and at the time of release (less than 0.05% per day, Fig. 3) and were in good health. The age I fish released March 15 had daily mortality rates of about 0.2 percent per day and were released just before mortality increased still further in other ponds in system II (Fig. 4). The age I fish released April 21 (group 13) had daily mortality rates up to 1.9 percent per day in mid March but the mortality had dropped to less than 0.2 percent a day by the time the fish were released (Fig. 5).

Voluntary Migration

To assess the willingness of fish to migrate voluntarily from hatchery ponds, we monitored the movements of age I, age II and age I fish on a 2-year rearing program from their hatchery ponds during April and May, 1977. We removed the plates from the end of the ponds and installed pipes leading to traps and counted the fish entering the traps each night.

Table 3. Total length of steelhead trout in the test groups when marked, when released from DNFH, and the length increase between marking and release, 1977.

| Test groups and numbers | Abbreviated description | Length when marked | Length at release | Length increases (mm) Total | Per day |
|---|---|---|---|---|---|
| March release | | | | | |
| 10 | MRI | 143.7 | 181.9 | 38.2 | 0.51 |
| 11 | MRII | 180.0 | 187.6 | 7.6 | 0.08 |
| April release | | | | | |
| 12 | ARII | 180.0 | 199.0 | 19.0 | 0.15 |
| 13 | ARI | 133.0 | 175.1 | 42.1 | 0.46 |
| May release - malachite treatment | | | | | |
| 14 | MRIIM | ~210.0 | ~210.0 | -- | -- |
| 15 | MRIINM | ~210.0 | ~210.0 | -- | -- |
| Coldwater conditioning | | | | | |
| 16 | S2NSP | 133.0 | 188.0 | 55.0 | 0.52 |
| 17 | S2SP | 135.0 | 189.9 | 54.9 | 0.52 |
| 18 | M2SG | 141.1 | 194.2 | 53.1 | 0.47 |
| 19 | M2NSG | 142.0 | 196.7 | 54.7 | 0.49 |
| 20 | L2NSP | 144.7 | 204.1 | 59.4 | 0.53 |
| 21 | L2SP | 149.0 | 211.0 | 62.0 | 0.54 |
| 22 | S8A | 135.0 | 175.9 | 40.9 | 0.39 |
| 23 | M8A | 131.5 | 180.1 | 48.6 | 0.44 |
| 24 | M8'M' | 139.3 | 184.4 | 45.1 | 0.40 |
| 25 | L8A | 141.0 | 200.1 | 59.1 | 0.53 |
| 26 | M12A | 136.0 | 167.1 | 31.1 | 0.29 |
| 27 | M12'M' | 136.2 | 169.1 | 32.9 | 0.29 |
| Location of release | | | | | |
| 28 | 'G'NF | 135.4 | ~175.0 | -- | -- |
| 29 | LR | 126.0 | 180.0 | 54.0 | 0.53 |
| 30 | PMF | 115.0 | 183.8 | 68.8 | 0.57 |
| Voluntary migration | | | | | |
| 31 | VMI | 190.3 | 190.3 | -- | -- |
| 32 | 1VMI | ~181.0 | ~181.0 | -- | -- |
| 33 | VMI2 | 153.4 | 153.4 | -- | -- |
| 34 | VMI2J | 165.6 | 165.6 | -- | -- |
| Transportation tests | | | | | |
| 35 | DBTI | 128.5 | 184.0 | 55.5 | 0.50 |
| 36 | DLTBBI | 126.7 | 178.2 | 51.5 | 0.46 |
| 37 | DLTBBII | -- | ~204.0 | -- | -- |

We branded the age I voluntary migrants (group 31) and those still in the pond May 15 (group 32) to determine if the voluntary migrants were more likely to migrate seaward than those that had not left the pond by mid May. The number of fish recaptured at the dams from the voluntary migrants were compared with those forced out of the pond May 15 and with other groups released from system III at an earlier time; for example, groups 28 and 30 that were released April 20 and 22. The mid May release of fish left in the pond may have decreased their chances of migrating successfully.

We branded the age I voluntary migrants from the ponds with fish scheduled for 2 years of rearing (groups 33 and 34) to determine if the fish that left the ponds after 1 year of rearing were smolts that would migrate to the ocean. We monitored the migration from these ponds and branded migrants until early June. To determine if the June migrants would migrate and reach the dam as successfully as the earlier migrants (group 33), we marked the migrants leaving the pond on June 2 and 3 with a distinctive brand (group 34). The number of migrants recaptured at Lower Granite Dam from group 33 should be compared with the number of migrants recaptured from group 31 and from other regular release groups such as groups 10, 13, 28 and 30.

### Timing of Migration

We monitored the timing of migration of wild and hatchery steelhead trout at Lower Granite Dam and of fish allowed to leave hatchery ponds whenever they so desired to determine the best time and method of releasing hatchery fish. Throughout the 1977 migration season we took random samples of steelhead from the raceways at Lower Granite Dam and examined the fish to determine the proportion of wild vs. hatchery fish. Timing of migration of hatchery fish was related to date of release, age and size of fish.

### Salt Treatment Before Release

Three groups of hatchery fish were given a salt treatment before release to determine if such treatment would reduce the incidence of fungus infection of fish after they left the hatchery. Groups 17, 18 and 21 were given a 10 ppt salt bath for 1 hour the day before release. Groups 16, 19 and 20 were not treated and were used as control groups.

### Malachite Treatment After Marking

The effects of malachite treatment after marking on the incidence of fungus infection of fish when recaptured at the dams was evaluated by marking two groups of fish and treating one group with malachite green. The fish used in this test were age II fish that had been held at the hatchery to evaluate voluntary migration. Two groups of fish (groups 14 and 15) were marked, and one group was treated (group 14) and both were released on May 27, 1977. Rate of infection and number of fish recaptured at Lower Granite Dam were compared between the two groups of fish.

Gravity Versus Pump Release of Fish

To determine if pumping fish from the ponds to the river via a fish pump and hoses has a detrimental effect on steelhead trout, the fish in groups 16, 17, 20 and 21 were pumped to the Middle Fork of the Clearwater River while those in groups 18 and 19 were released by removing the gates on the ponds and allowing them to drain into the sluiceway and then into the Middle Fork. Branded fish recaptured at Lower Granite Dam were used to evaluate the effects of pumping fish from the pond.

Location of Release

To determine if fish released in the Middle Fork will return to the hatchery via the ladder in the North Fork as easily as fish released into the North Fork near the ladder, two groups of fish (group 13 North Fork and 30 Middle Fork) were nose tagged, fin clipped, and a portion branded, and then released into the rivers on either side of the hatchery peninsula. Although seaward migration of the two groups was monitored at Lower Granite Dam, the primary evaluation of this test will be enumeration of adults returning to the dams, adults caught in the Clearwater River fishery and those returning to the hatchery.

Fish were also released into the Lochsa River in 1977 to evaluate the timing of migration of fish released into the upper part of the drainage, the number recaptured at the dams during seaward migration, the number of adults from such releases that will return to the hatchery and the distribution of adults from such releases in the river during the fall and winter fishery. Fish were tagged and clipped as well as being branded. When the fish were hauled to the Lochsa River, the fish had to be held an extra five hours in the tank truck because the release door would not open properly. The truck driver reported that some fish appeared sick and may have died after release. We have not attempted to adjust the release figures for possible mortality at the release site.

Age I Versus Age II Fish

To determine if fish reared for two years in untreated river water are better smolts than fish reared one year in reuse water, we marked two groups of age II fish (groups 11 and 12) that were to be compared with groups of age I fish (groups 10 and 13). Those groups were compared, but the groups of age I fish are probably not the best examples of fish produced in an accelerated rearing program. The age II fish had low rates of daily mortality in the ponds throughout the rearing periods (Fig. 3) while the age I fish had high rates of mortality (Fig 4). A better comparison with the age II fish might be the fish conditioned for 8 weeks in cold water (groups 22-25) because they had low rates of mortality in the ponds. Fish recaptured at Lower Granite Dam were used to evaluate the relative quality of age I versus age II hatchery fish.

### Seawater Survival

In 1977, we tested the ability of hatchery and wild steelhead to survive in seawater by hauling fish to net pens at Manchester (National Marine Fishery Service facility in Puget Sound) on two dates; the first and middle of May, and then recorded daily mortality. Fish from both Dworshak hatchery and Lower Granite Dam were taken to Manchester to compare the survival of migrating fish (collected at the Dam) and fish that had not left the hatchery, even though they could leave if they preferred. Fish taken to the pens on May 18 were divided into size groups to assess the effects of size on seawater survival.

### ATPase Activity

Steelhead from the hatchery and Lower Granite Dam were taken to Cook, Washington, where Dr. W. S. Zaugg measured the ATPase activity. Wild fish and marked fish from DNFH were transported to Dr. Zaugg's lab April 20, May 7, May 19 and June 8.

## HEALTH OF FISH RELEASED

Because the health-quality of fish released from DNFH in 1977 varied between test groups, it was necessary to evaluate the health of fish in each group and determine if the differences in health impaired any of the planned comparisons. The quantitative indices of fish health available to us were mortality in the ponds and the incidence of fungus infection at the dams.

### Mortality in the Ponds

Mortality in the hatchery ponds (dead fish picked from the ponds) between marking in December and January and release in April ranged from 1.8 to 41.8 percent of the initial number of fish (Table 4). Age II fish reared in system I on untreated water and fish moved to system I in late January for 12 weeks of conditioning, had the lowest mortality (groups 11, 12, 26 and 27, 1.8-4.8 percent). Groups of fish transferred to system I in late February for 8 weeks of conditioning averaged 10.5 percent mortality (ranged from 5.8 to 17.6 percent, groups 22-25). Fish that remained in system II until released (groups 16-21) averaged 16.6 percent mortality (range 9.4 to 28.0 percent). The highest mortalities occurred among fish in system III ponds (groups 13, 28-30 and 35-36) with an average of 27.6 percent picked from the ponds and a range of 5.0 to 41.8 percent.

Mortality associated with marking the fish in December and January occurred 1-5 days after marking and ranged from less than 1 percent up to 9 percent, with most groups having mortalities of 1-3 percent (Figs. 3, 4 and 5). The groups of age II fish had little mortality during the

Table 4. Percentage daily mortality of test groups of steelhead trout at DNFH between marking and release and during the last 21 days before release and the percentage of fish with fungus infections when recaptured at Lower Granite Dam, 1977.

| Test groups and numbers | Abbreviated description | Percentage mortality Since marking | Percentage mortality Last 21 days | Incidence of fungus infection (%) |
|---|---|---|---|---|
| Length test | | | | |
| 1 | LTI165 | | | 47.9 |
| 2 | LTI185 | | | 52.5 |
| 3 | LTI205 | | | 49.5 |
| 4 | LTI220 | | | 46.3 |
| 5 | LTII145 | | | -- |
| 6 | LTII165 | | | 0.0 |
| 7 | LTII185 | | | 14.7 |
| 8 | LTII205 | | | 23.4 |
| 9 | LTII225 | | | 14.6 |
| March release | | | | |
| 10 | MRI | 11.2 | 3.0 | 9.7 |
| 11 | MRII | 4.8 | 0.2 | 2.3 |
| April release | | | | |
| 12 | ARII | 2.7 | 0.1 | 2.6 |
| 13 | ARI | 39.8 | 2.1 | 7.0 |
| May release - malachite treatment | | | | |
| 14 | MRIIM | -- | -- | 5.7 |
| 15 | MRIINM | -- | -- | 20.0 |
| Coldwater conditioning - 2 weeks | | | | |
| 16 | S2NSP | 9.4 | 6.1 | 0.0 |
| 17 | S2SP | 11.8 | 5.4 | 12.5 |
| 18 | M2SG | 14.5 | 3.4 | 3.6 |
| 19 | M2NSG | 14.8 | 3.4 | 6.3 |
| 20 | L2NSP | 28.0 | 9.4 | 13.1 |
| 21 | L2SP | 20.9 | 5.3 | 21.0 |
| Coldwater conditioning - 8 weeks | | | | |
| 22 | S8A | 7.6 | 0.4 | 6.0 |
| 23 | M8A | 10.9 | 0.2 | 14.3 |
| 24 | M8'M' | 5.8 | 0.8 | 12.5 |
| 25 | L8A | 17.6 | 0.3 | 14.3 |
| Coldwater conditioning - 12 weeks | | | | |
| 26 | M12A | 1.8 | 0.0 | 4.3 |
| 27 | M12'M' | 3.9 | 0.1 | 7.7 |
| Location of release | | | | |
| 28 | 'G'NF | 41.8 | 3.6 | 14.0 |
| 29 | LR | 18.0 | 0.6 | 0.0 |
| 30 | PMF | 5.0 | 0.1 | 25.0 |
| Voluntary migration | | | | |
| 31 | VMI | 30-40 | -- | 32.3 |
| 32 | 1VMI | | | 47.9 |
| 33 | VMI2 | | | 7.5 |
| 34 | VMI2J | | | 7.5 |
| Transportation tests | | | | |
| 35 | DBTI | 28.6 | 1.3 | -- |
| 36 | DLTBBI | 32.6 | 1.6 | -- |

rearing period, and the marking mortality made up a major portion of the total mortality. For fish held in systems II and III until release, the mortality associated with marking was a small part of the total mortality.

Most of the mortality in system II occurred from mid-March until release with peak losses about April 10 (Figs. 2 and 7). Mortality in the ponds that did not contain marked fish was similar to that in ponds with marked fish, thus the marking did not appear to intensify the losses during March and April. The daily mortality rate in system II had decreased by the time the fish were released in late April, but the fish had probably not recovered fully from whatever caused the mortality.

Mortality in system III occurred mostly during March, with a peak in mid-March (Figs. 2 and 5). By the time the fish were released in late April the daily mortality rate had decreased to low levels (less than 0.2 percent per day), but the fish may not have regained their full health. Both marked and unmarked fish in system III suffered high mortalities in March. Mortality during the last 21 days before release averaged 1.6 percent for the groups of marked fish in system III and 5.5 percent for those in system II (Table 4). Mortality of the age II and age I fish in system I was less than 1 percent during the last 21 days.

Although there was a wide range of mortality from marking to release (1.8 to 41.8 percent) and during the last 21 days before release (0.0 to 9.4 percent), the percentage of fish from each group recaptured at Lower Granite Dam was not significantly related to the mortality during either period of time (Fig. 6). Rather than having fewer fish recaptured from groups with high mortality rates, as might be expected, the trend, if any existed, was for more fish to be recaptured from the groups with high mortality at the hatchery.

## Incidence of Fungus Infection of Fish at the Dam

The incidence of fungus infections of marked groups of hatchery fish when recaptured at Lower Granite Dam in 1977 ranged from 0 to 52 percent (Table 4). The number of fish examined to determine fungus infection rates ranged from 4 to 440 per group (Table 2), with the number examined for most groups exceeding 25 fish.

Fungus infection rates at the dam were lowest for wild steelhead trout (less than 2 percent) and age II fish released in March and April (groups 11 and 12, 2.3 and 2.6 percent, Table 4). Fish moved to system I for 12 weeks conditioning in colder water (group 26 and 27) had fungus infection rates of 4.3 and 7.7 percent and those held for eight weeks in system I (groups 22-25) had 6.0 to 14.3 percent infection rates. Fish held in system II until released at the normal time (groups 10 and 16-21) had infection rates of 0.0 to 21.0 percent when recaptured. None of the 23 small-sized fish conditioned in cold water for 3 weeks (group 16,

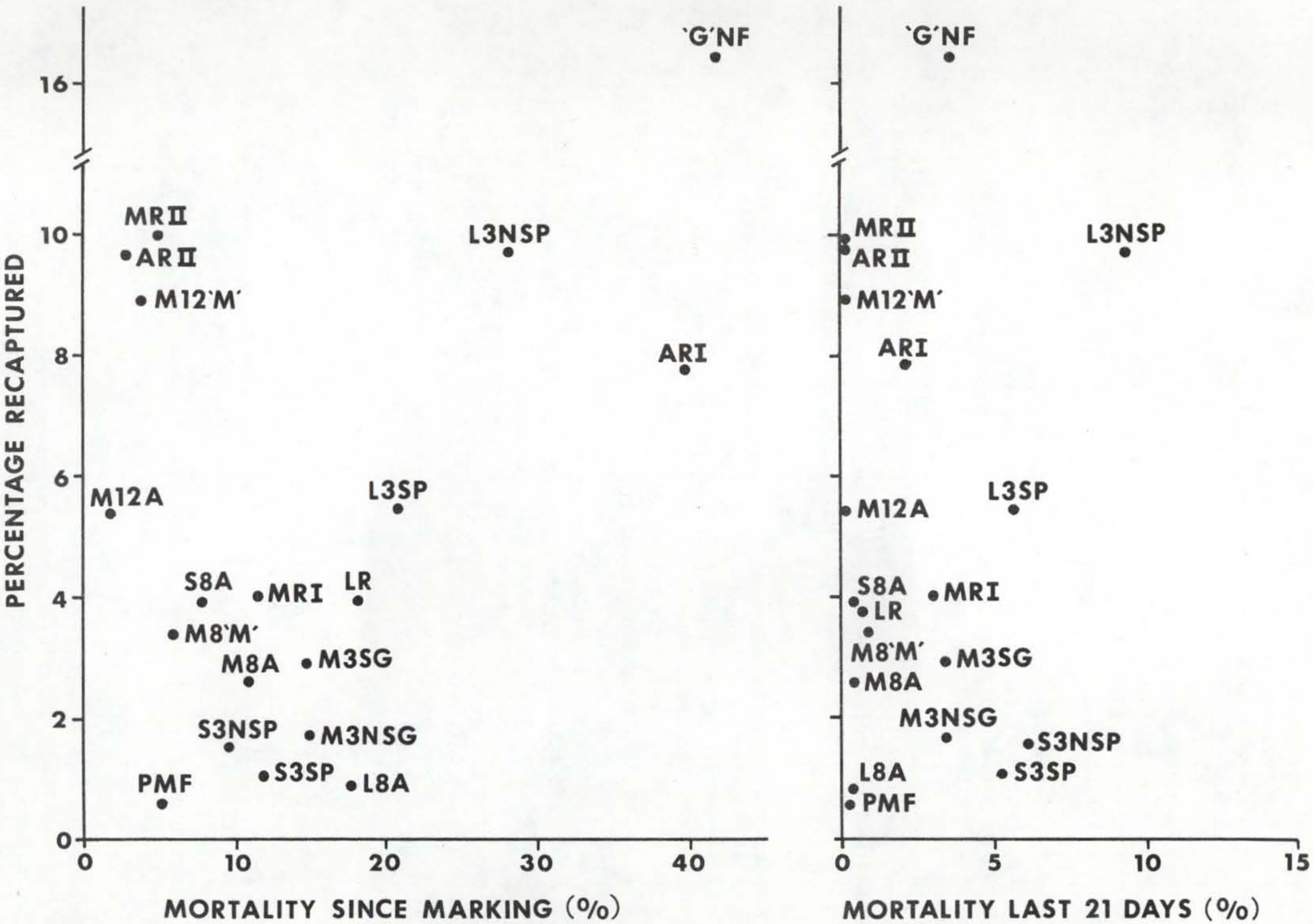


Figure 6. Percentage of each test group of steelhead trout recaptured at Lower Granite Dam as related to the percentage mortality in ponds at DNFH from marking until release and for the last 21 days before release, 1977.

Table 4) were infected with fungus. Fish released from system III at the usual time (groups 13 and 28-31) had infection rates of 0.0 to 32.3 percent when recaptured at the dam. None of the 26 fish examined from the Lochsa River release group were infected with fungus.

The fungus infection rate for unmarked hatchery fish, when many marked fish from DNFH were being collected at the dam, was similar to the rate for marked fish (Fig. 7) so that marking did not appear to increase the incidence of fungus.

The incidence of fungus infection at the dams was related to the mortality of fish at the hatchery between marking and release (Fig. 8). Although the mortality rate of the fish decreased during the last few weeks after switching from reuse to untreated river water, the fish had not recovered fully from the causes of the earlier high mortality and their less than optimum health manifest itself in high fungus rates at the dams. Age II fish and fish moved to system I for coldwater conditioning had low mortality rates and low rates of fungus infection similar to wild fish. Groups with high rates of fungus infection had excessive rates of mortality while at the hatchery.

Contrary to what we expected, the groups with the largest percentages of recaptures also had the highest rates of fungus infection. When the percentage of each group recaptured at Lower Granite Dam was plotted against the incidence of fungus infection (Fig. 9), a remarkably good correlation was found to exist. We don't believe the best smolts have high rates of fungus infection, but the smoltification process may lead to high rates of fungus infection when fish are reared in a marginal environment such as the reuse systems at DNFH. We believe that high fungus infection rates result when fish are in less than optimum health and it appears that such fish may drift-migrate more or less passively downstream. Most fish that become infected with fungus probably die before reaching the ocean. Our belief that fish in ill health (indicated by a high fungus infection rate) are not in complete control of their movements, is based on the nearly equal recapture rates for groups 1-4 irrespective of length (Table 2), and the higher than expected recapture rates for fish with high fungus rates.

Hatchery fish that have migrated long distances before reaching Lower Granite Dam have low fungus infection rates, and this leads us to speculate that fish that became infected had died before the migrants reached Lower Granite Dam. Both the fish released in the Lochsa River in 1977 and fish released in the Pahsimeroi River from Niagara Springs Hatchery had low rates of fungus infection by the time the fish reached Lower Granite Dam. DNFH is apparently close enough to Lower Granite Dam that most fish reach the dam even though they may succumb to fungus infections further down the river.

Because of the possibility that larger numbers of fish from some groups reached Lower Granite Dam than might be expected because of ill health, care must be exercised in comparing recaptures between groups of fish released from DNFH in 1977.

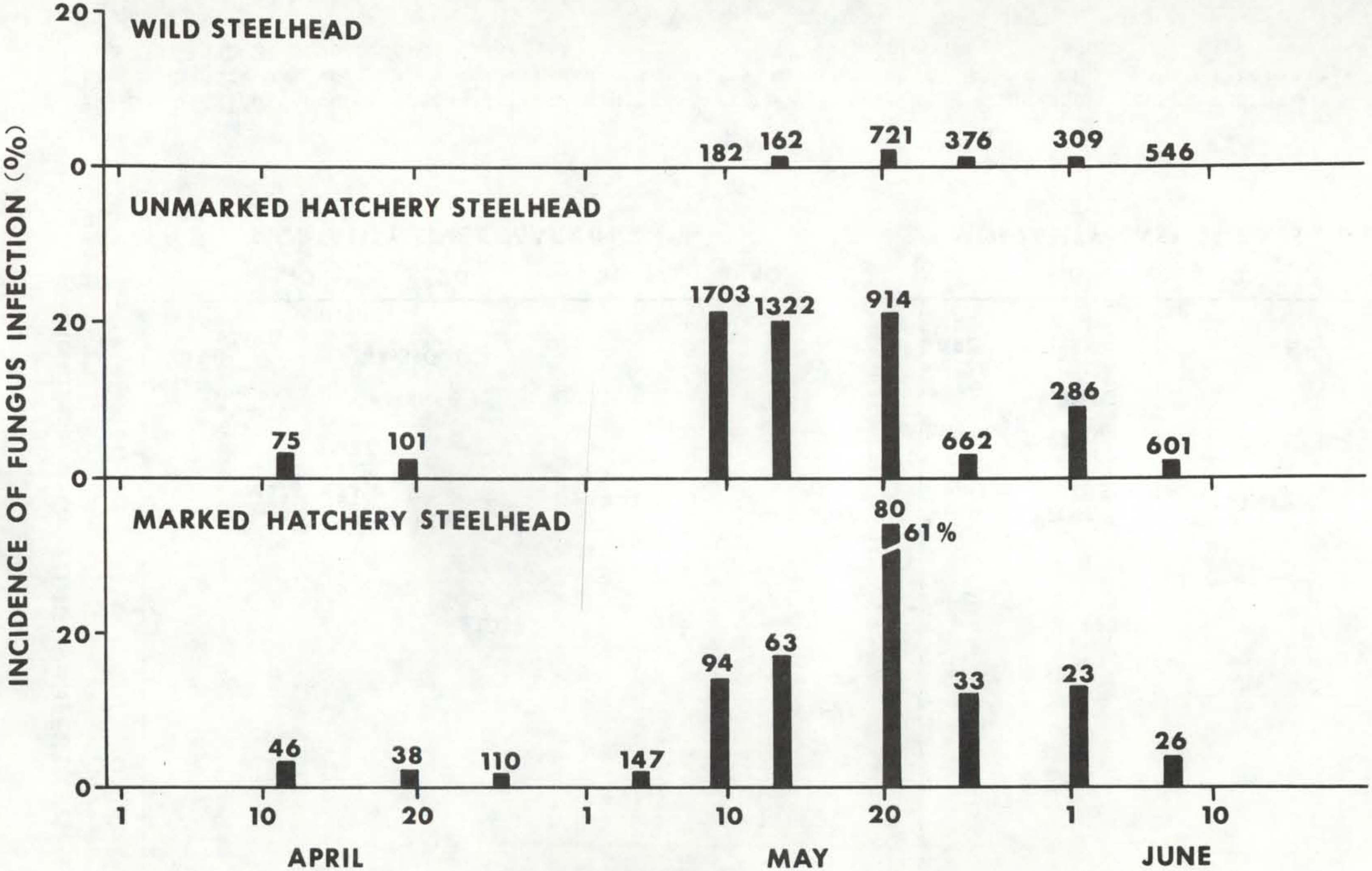


Figure 7. Incidence of fungus infection for samples of wild and DNFH steelhead trout inspected at Lower Granite Dam, 1977. The marked hatchery steelhead were probably from DNFH based on appearance and size. Number above the bar is number of fish in sample.

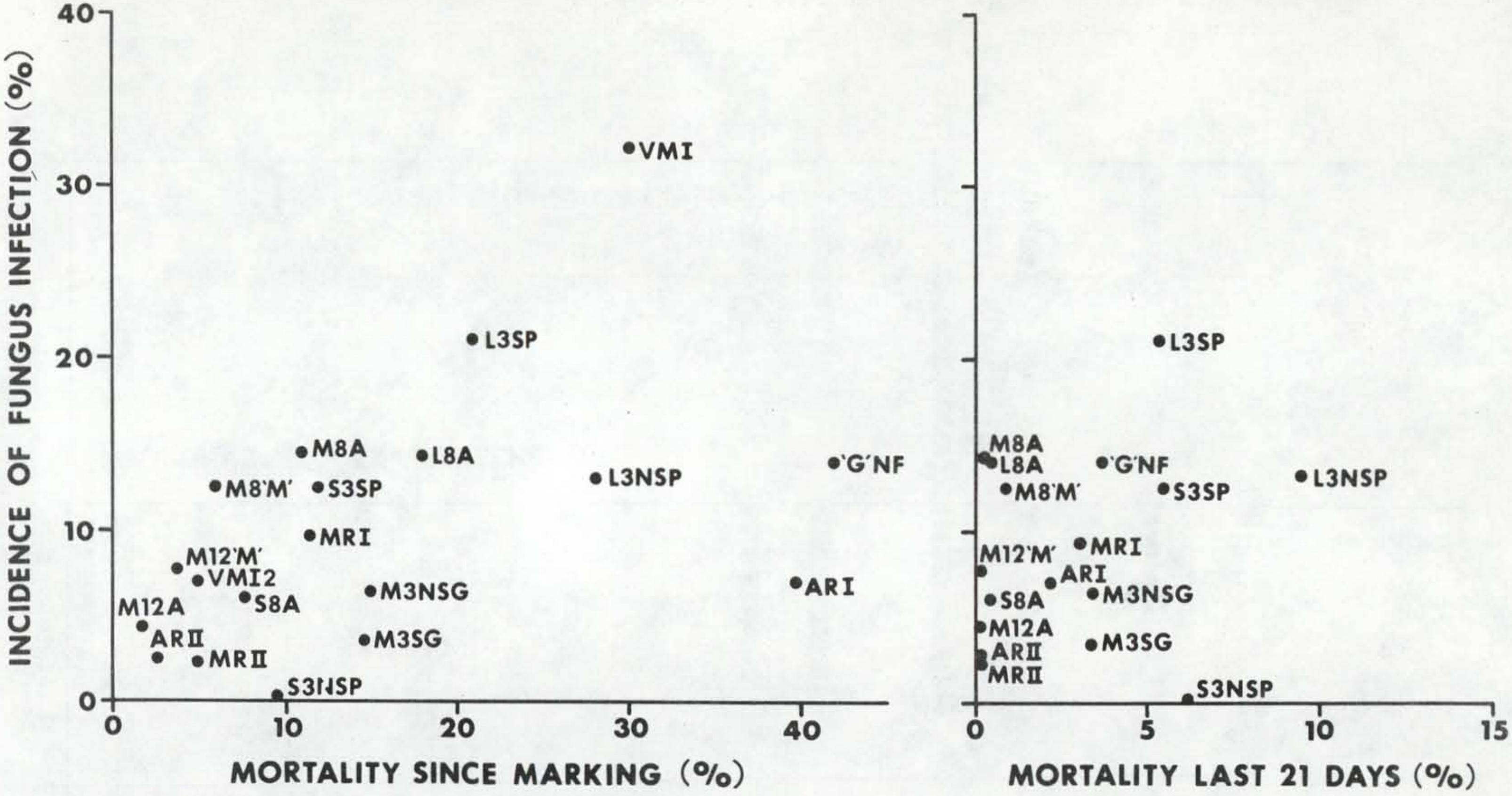


Figure 8. Incidence of fungus infection of test groups of steelhead trout when recaptured at Lower Granite Dam as related to percentage mortality in ponds at DNFH from marking until release and the last 21 days before release, 1977.

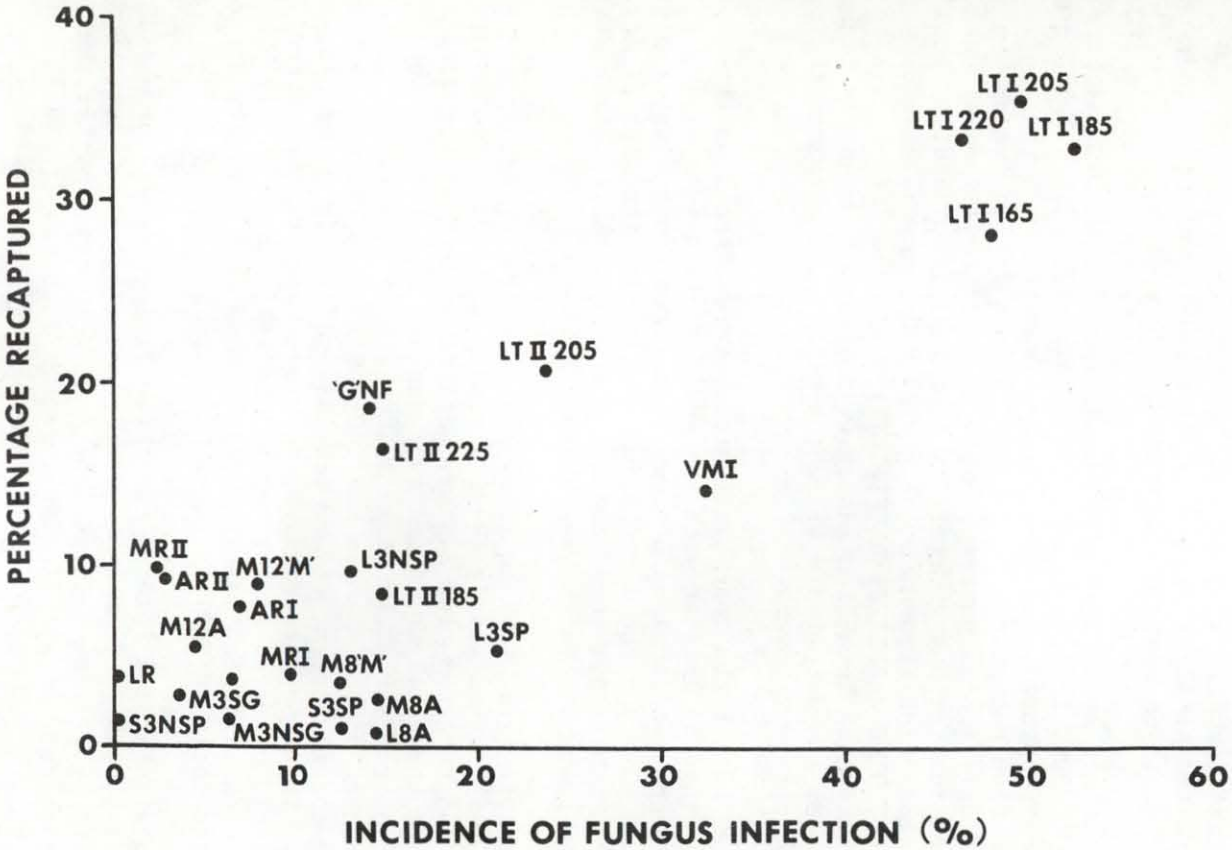


Figure 9. Percentage of each group of DNFH steelhead trout recaptured at Lower Granite Dam as related to the incidence of fungus infection when recaptured, 1977.

## RESULTS OF TESTS

### Length at Release

The percentage of fish of each group recaptured at the dams (Table 2) was related to length at release (Table 3) but the relation was not obvious when data for all the groups was plotted together (Fig. 10). When groups treated similarly but of varying length were compared, then the effect of length on seaward migration was more obvious.

In the test set up to determine the optimum length for hatchery reared smolts (groups 1-9), a higher percentage of the fish 200-209 mm in length were recaptured than the longer or shorter fish (Fig. 11). Percentages of fish recaptured from groups of age I fish (groups 1-4) did not vary widely (28-35 percent, Table 2). The nearly equal rate of recovery of the four groups of age I fish differs from results obtained in 1976 with age I fish (Bjornn et al. 1978) and from the results obtained in 1977 with age II fish (Fig. 11). All four of the age I groups had high fungus infection rates (46-53 percent) when the fish were recovered at the dam (Table 4), which might have affected their seaward migration and recovery.

Fish selected for the four age I groups were taken from three ponds to avoid comparing the largest with the smallest fish from a single pond. Fish in the smaller length groups came from ponds with fish of smaller average size and the larger fish from ponds with fish of larger average size. Fish in all three ponds suffered high mortalities during March so their state of health was probably similar.

The recapture rates for the five groups of age II fish in the size test (groups 5-9) varied widely (0-21 percent, Table 2). No fish from the smallest length group (140-149 mm) were recaptured at the dam. These fish were the smallest of the two year old fish and had the appearance of parr (parr marks obvious and lack of silveriness). Twenty-one percent of the fish in the 200-209 mm group were recaptured compared to 9 and 16 percent of the 180-189 and 220-229 mm groups, respectively. The less than maximum recapture rate for the largest fish follows a pattern observed in earlier studies (Bjornn et al. 1978, Chrisp and Bjornn 1978) and adds to the evidence that hatchery reared fish can be too large as well as too small.

The fungus infection rate of the three largest groups of age II fish (groups 7-9) ranged from 15 to 23 percent (Table 4), less than half the rate of the age I fish (groups 1-4), but 7-10 times higher than the fungus infection rate of age II fish released in March (group 11) or April (group 12). Groups 1-9 in the length tests were released May 6 and 7. The differences in fungus infection rates were due to differences between the groups in fish health, date of release, and malachite treatment when marked. Refer to section on Malachite Treatment for additional information.

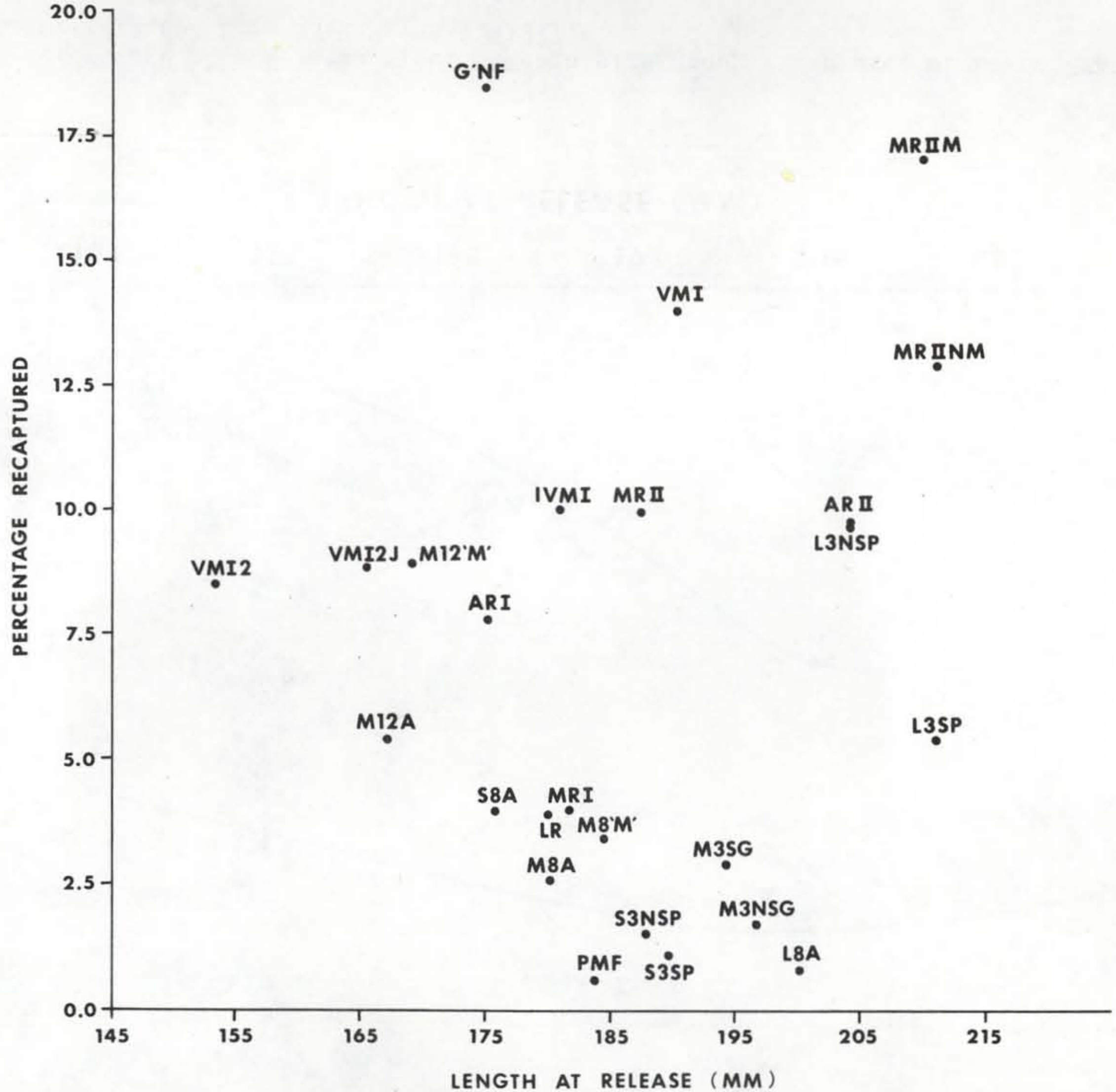


Figure 10. Percentage of each test group of steelhead trout released from DNFH that were recaptured at Lower Granite Dam, 1977.

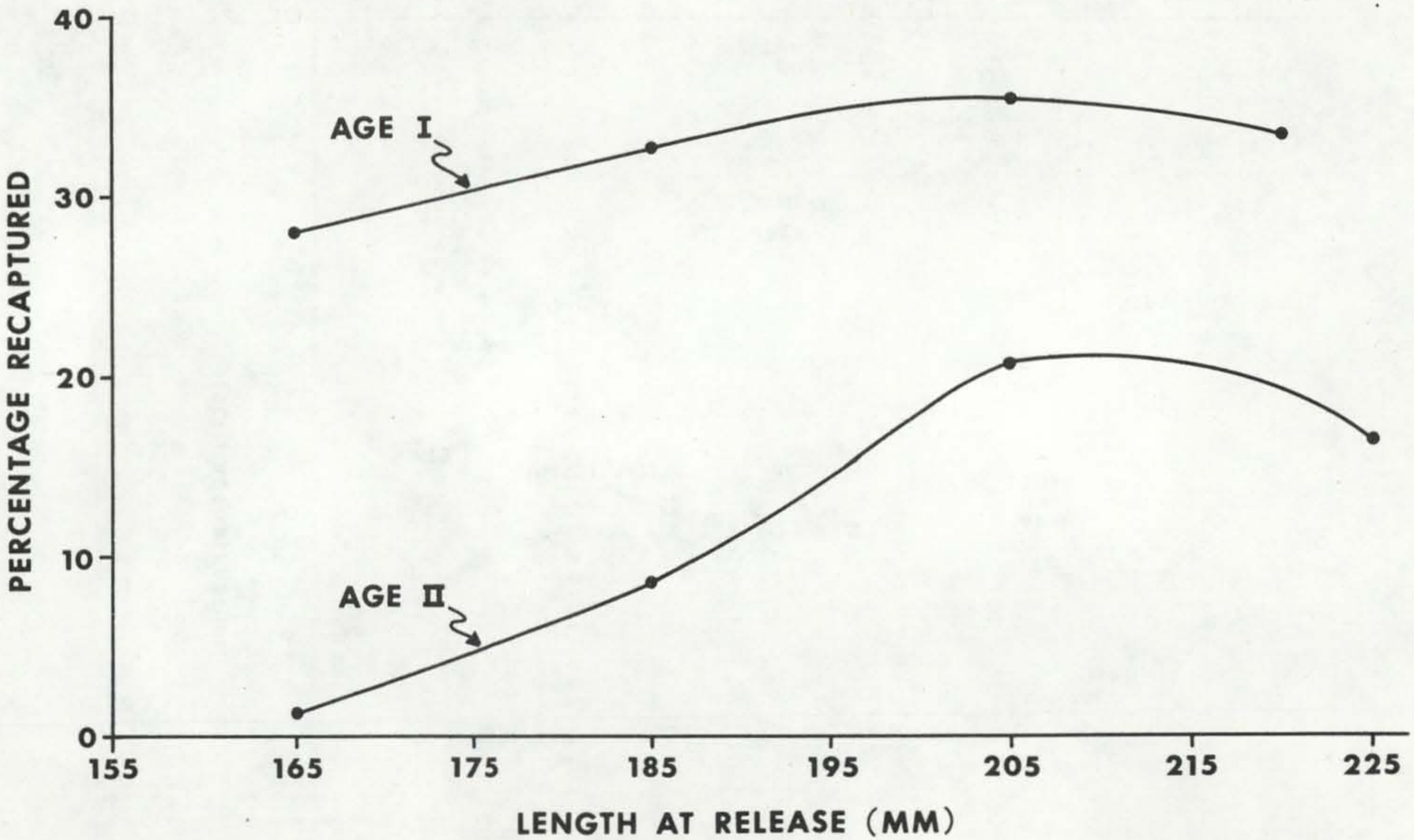


Figure 11. Percentage of steelhead trout of each size group recaptured at Lower Granite Dam after being released from DNFH May 6-7, 1977.

Age I fish in the length test moved downstream more rapidly than age II fish (Fig. 12). May 10-15 was the period of peak recaptures for the age I fish while May 16-20 was the peak period for age II fish. A substantial number of the age II fish passed the dam after May 20, but relatively few of the age I fish.

The higher recapture rates for age I fish in the length test (groups 1-4) versus the age II fish (groups 5-9) is inconsistent with other test results. Despite their higher mortality while in hatchery ponds and fungus infection rates, age I fish were recaptured at 1.7 to 21.5 times the rates of the age II fish of similar length (Table 2). Recapture rates of other age II groups of fish (groups 11-12 and 14-15) exceeded that of all but two groups (groups 28 and 31) of the age I fish (not including groups 1-4). The reason for the unusually high recapture rate of the age I fish in the length test is unclear to us. The small discharge in 1977 and length of Lower Granite Reservoir would make it seem unlikely that the age I fish were involuntarily washed downstream to the dam.

Groups of fish in the cold water conditioning tests also provided information on the importance of length in seaward migration. Groups 16-21, conditioned for two weeks, consisted of two groups we termed small fish (188-190 mm in length), two referred to as medium-sized fish (194-197 mm), and two large-sized (204-211 mm, Table 3). These six groups were released April 19-21. The percentages of fish collected at the dam were 5.4 and 9.7 percent for the two groups of large fish, 2.9 and 1.7 percent for the medium-sized fish and 1.5 and 1.1 percent for the small fish (Fig. 13, Table 2).

Groups 22-25, conditioned for eight weeks contained one group we termed small fish (176 mm in length), two of medium-sized fish (180-184 mm), and one of large-sized fish (200 mm, Table 3). These fish were released April 18-27. The percentage recaptured ranged from 0.8 to 3.9 percent (Table 2). For some reason the large fish were recaptured at a lesser rate than the smaller fish (Fig. 13). The fungus infection rate of the large fish was not higher than the other groups (Table 7). The groups of fish conditioned for 12 weeks contained only one size of fish.

Groups from system III treated sufficiently alike to warrant length comparisons were the fish released into the North Fork in April (groups 13 and 28) and fish released into the Middle Fork (group 30). Group 13 fish averaged 175 mm in length when released, group 28 also about 175 mm and group 30 fish were 187 mm (Table 3). The recapture rates for the three groups were 7.8, 18.5 and 0.6 percent, respectively, with the larger fish released in the Middle Fork recaptured at the smallest rate (Table 2). We cannot explain the low rate of recapture of the fish released in the Middle Fork.

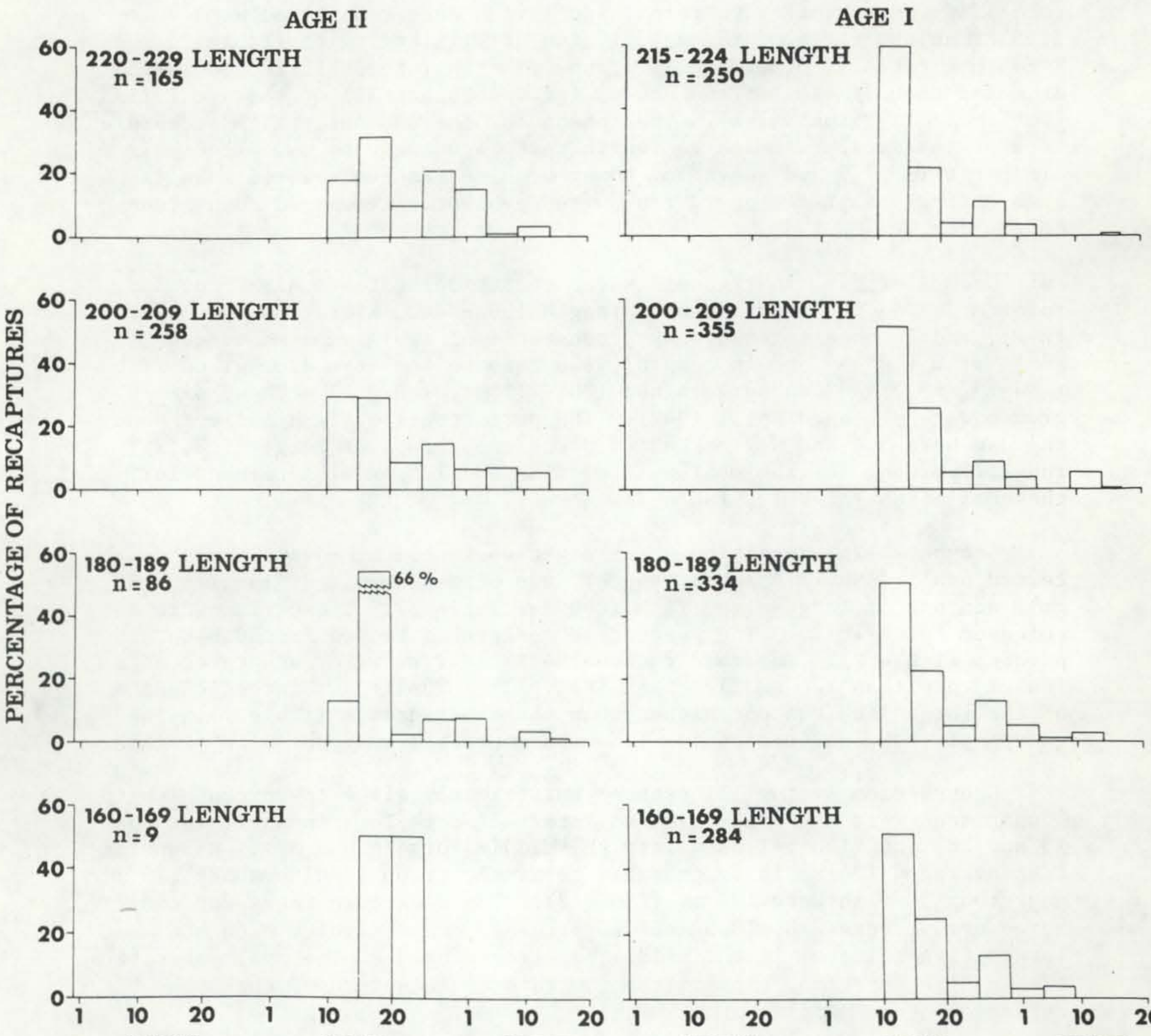


Figure 12. Timing of recapture at Lower Granite Dam of age I and age II steelhead trout in the length tests at DNFH, 1977.

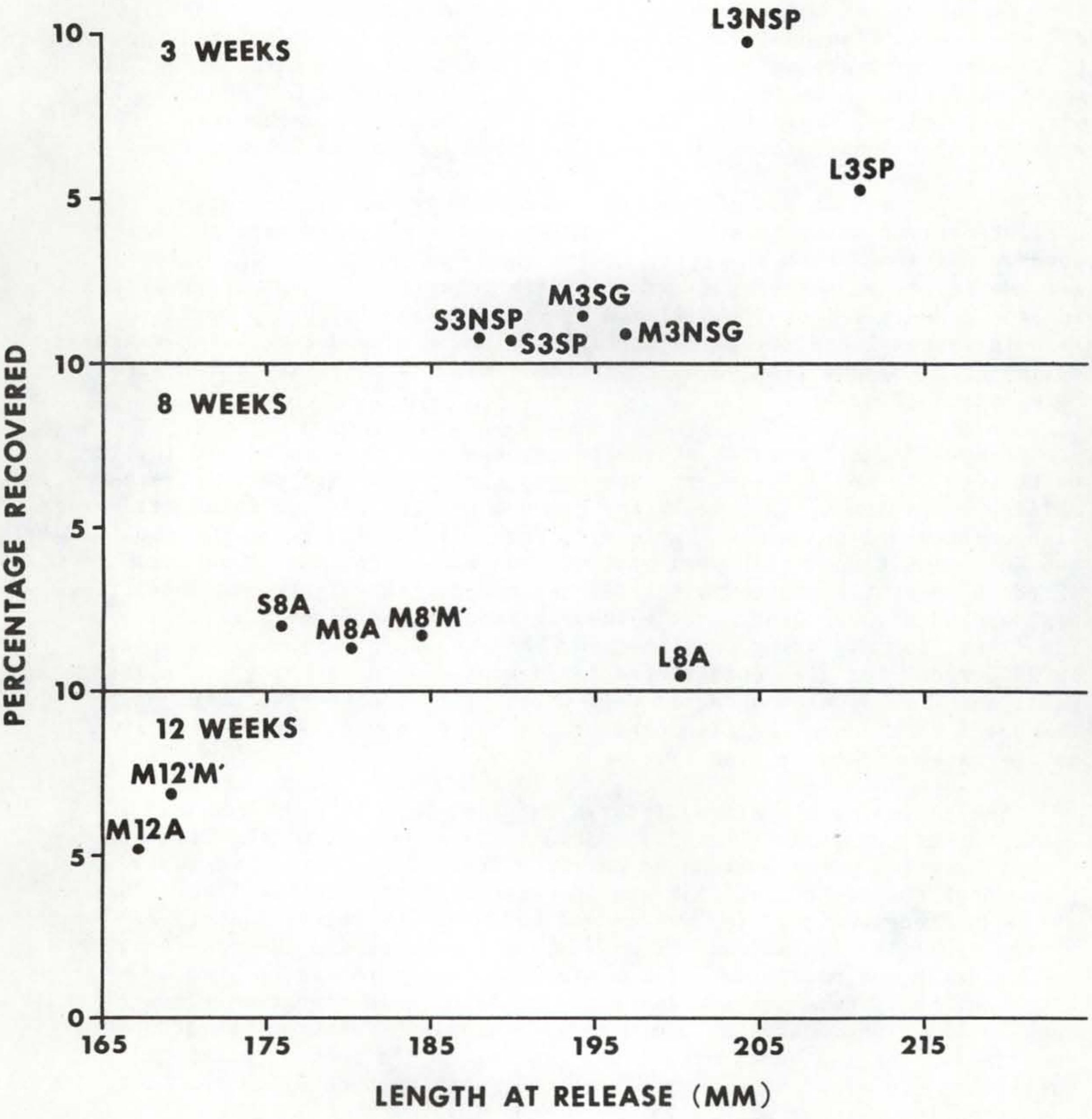


Figure 13. Percentage of steelhead trout recaptured at Lower Granite Dam after being conditioned in cold water (4-6 c) for 2, 8, or 12 weeks and the length of each group at release, 1977.

## Cold Water Conditioning

Conditioning fish in cold water (less than 10 C) for up to 12 weeks appeared to increase the percentage of fish that migrated downstream and were recaptured at Lower Granite Dam, but the results are confounded by differences in fish health. Fish in groups 26 and 27, conditioned for 12 weeks in untreated river water in system I, were recaptured at relatively high rates (5.4 and 8.9 percent, Table 2) despite their small size (167-169 mm, Fig. 14). Fish conditioned for eight weeks were recaptured at lesser rates (0.8 to 3.9 percent) than the 12-week fish.

Moving the fish out of the reuse water of system II and into untreated river water in system I before release may have kept the cold water conditioned fish in better health than fish remaining in system II. Mortality of marked and unmarked fish in system II began to increase in late January (Figs. 2 and 4) and increased markedly during April. Fish in system I had low daily mortality rates throughout the winter and spring (Fig. 3) and fish moved to system I had low mortality rates after being moved (Fig. 4).

Fungus infection rates of the two groups of fish conditioned for 12 weeks were 4.3 and 7.7 percent; less than the 6.0 to 14.3 percent rates of fish conditioned eight weeks and the 0.0 to 21.0 percent rates of fish conditioned two weeks (Table 4). Fungus infection rates for the two week conditioned fish when most of them passed the dam ranged from 12 to 20 percent compared to 4 to 17 percent for the eight week conditioned fish and 3 to 15 percent for the 12-week conditioned fish (Fig. 15). The first fish migrating past the dams had fungus infection rates of 12 to 20 percent for fish conditioned three weeks, 4 percent for eight week fish, and 0 to 3 percent for 12-week fish. Fungus infection rates of the age I fish, even the fish conditioned for 12 weeks, were not as low as the rates of age II fish.

The timing of migration differed for fish conditioned eight and 12 weeks versus two weeks (Fig. 15). Seventy-five percent of the fish conditioned two weeks passed the dam from April 25 to May 4, versus 33 percent of the eight week fish and 18 percent of the 12-week fish. Part of the difference in timing was caused by the later release (April 27 versus April 18-21, Table 1) of a group of the eight and 12-week fish. By comparing the percentage of the migrants recaptured at the dam a given number of days after release the difference in migration timing because of release dates is minimized. Migrating fish from the groups conditioned for two weeks passed the dam faster (75 percent within 15 days) than the eight week fish (43 percent within 15 days) or the 12-week fish (44 percent within 15 days, Fig. 16).

Although most groups of conditioned fish had some fish that passed the dam in June, only from the group of small-sized fish conditioned for two weeks (groups 16 and 17) did more than 10 percent migrate after May 30 (Fig. 17). Twenty-two and 26 percent of the migrants from the two groups of small-sized fish migrated after May 30. In prior tests of

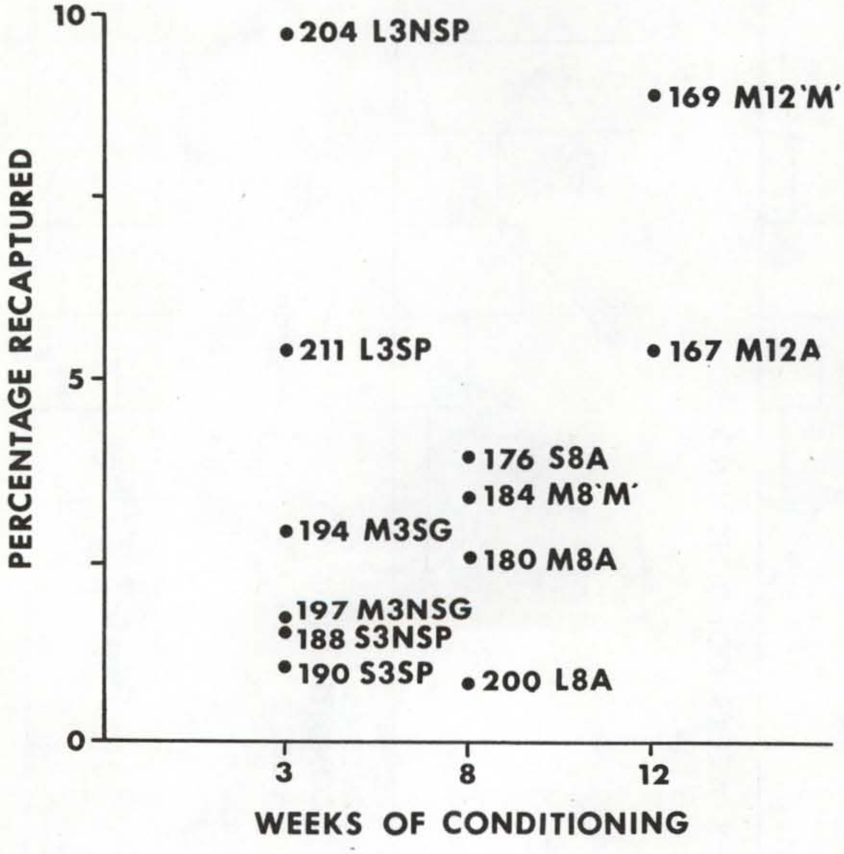


Figure 14. Percentage of steelhead trout recaptured at Lower Granite Dam after being conditioned in cold water (4-6 c) for 2, 8, or 12 weeks at DNFH, 1977.

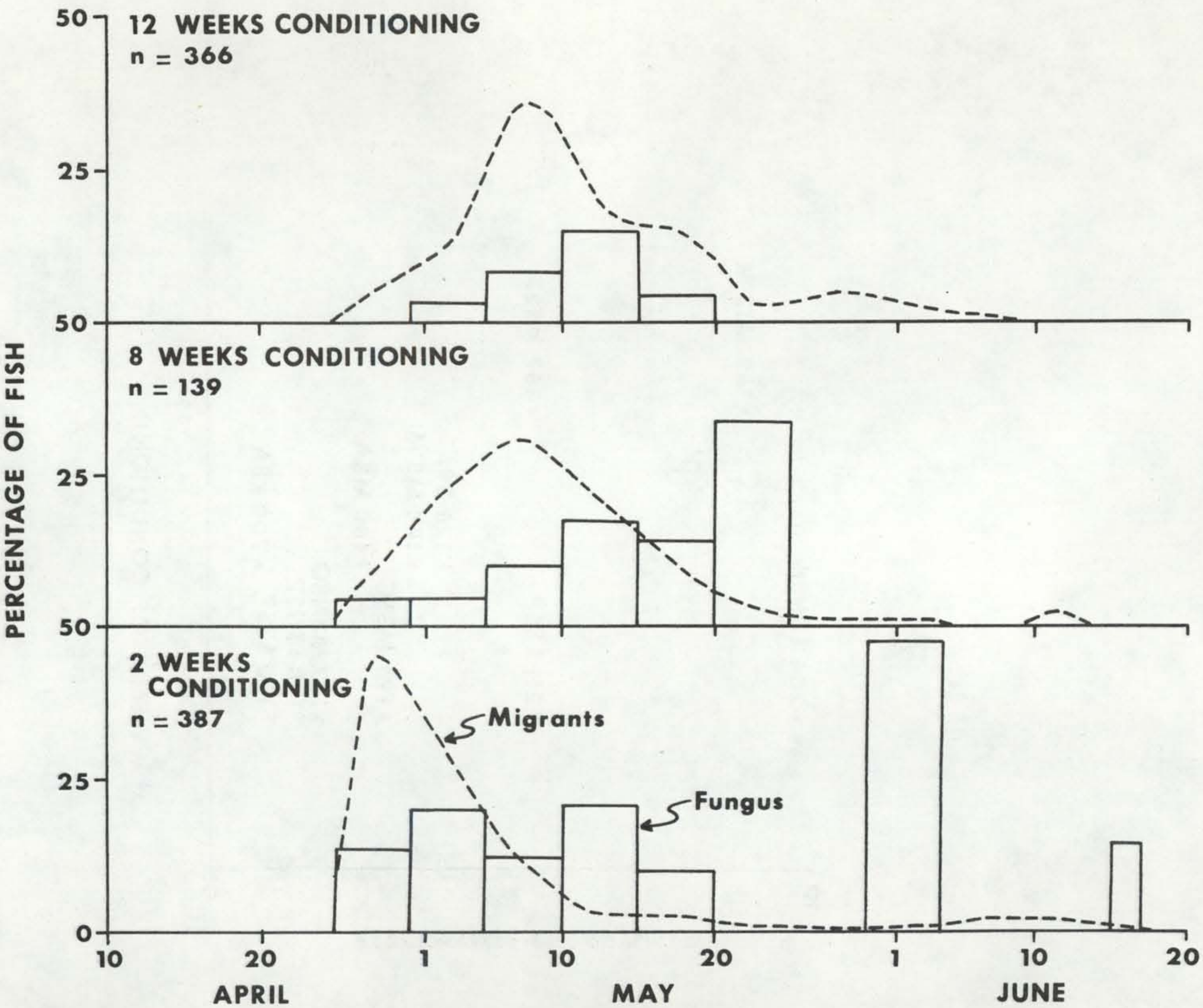


Figure 15. Percentage of steelhead trout migrants passing Lower Granite Dam during April-June, and the percentage with fungus infections that were conditioned in cold water (4-6 c) at DNFH for 2, 8, or 12 weeks, 1977.

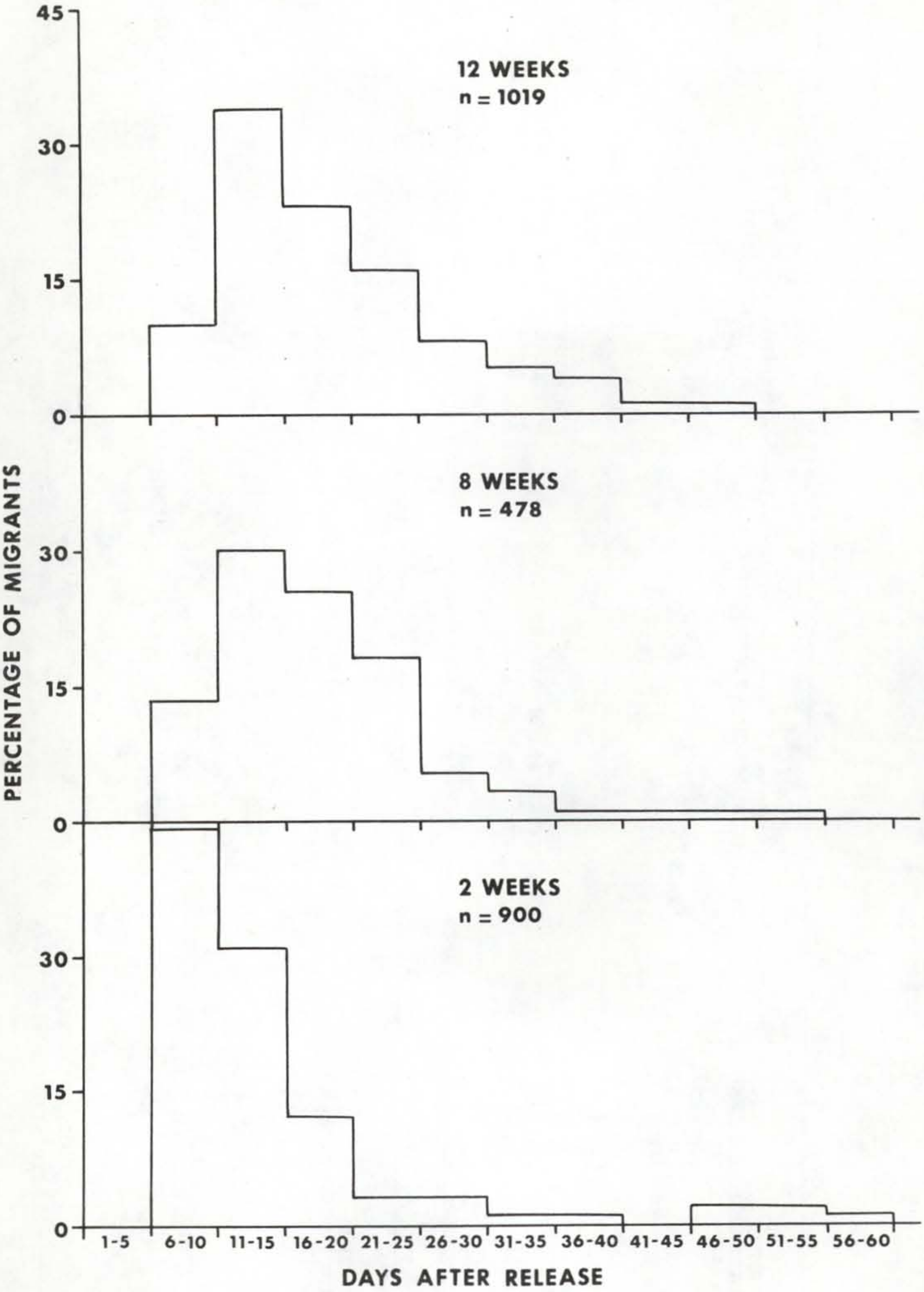


Figure 16. The timing of migration past Lower Granite Dam of steelhead trout conditioned in cold water (less than 10 c) for 2, 8, or 12 weeks before release from DNFH, 1977.

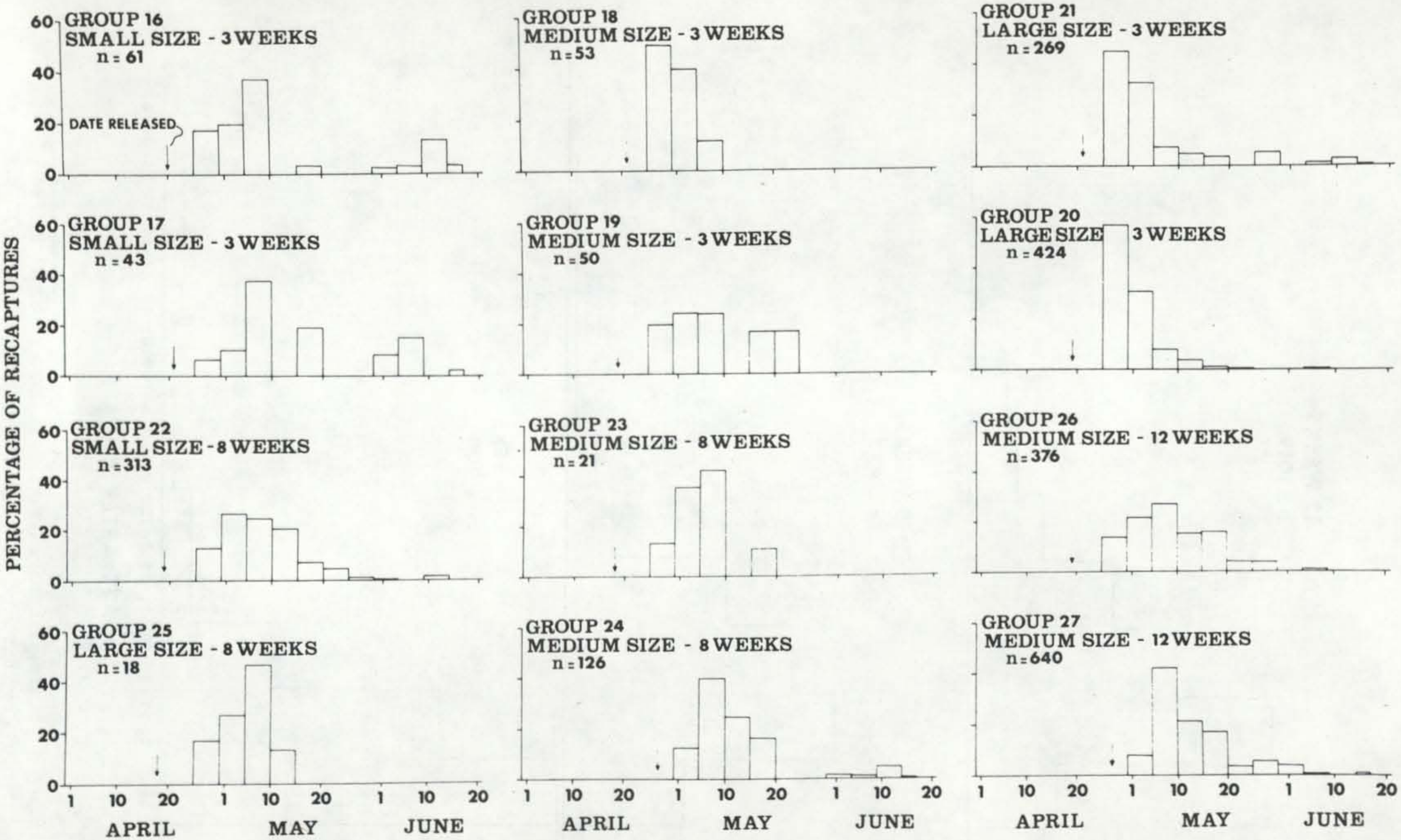


Figure 17. Timing of recapture at Lower Granite Dam of steelhead trout from various test groups released from DNFH, 1977.

conditioning in cold water (Chrisp and Bjornn 1978, Bjornn et al. 1978) fish with 3-6 weeks of conditioning often had a bimodal migration pattern, one peak soon after release and another in late May or early June.

If the fish conditioned for eight or 12 weeks in cold water were in better health when released than the fish held in system II until release, then the higher rate of recapture for the fish conditioned for 12 weeks many have resulted from the cold water conditioning or better health. Additional tests with all fish in good health are needed to determine if there are benefits from conditioning fish in cold water for eight to 12 weeks before release.

## Date of Release

Hatchery steelhead smolts should be released when they are ready to migrate seaward. Readiness to migrate seaward was assessed at DNFH in 1977 by trapping voluntary migrants from hatchery ponds and by releasing fish on various dates and noting when they were recaptured at Lower Granite Dam.

On the basis of voluntary migration from the hatchery ponds, large numbers of fish were ready to migrate seaward in late April and early May (Fig. 18). Small numbers of fish began migrating from hatchery ponds in late March but peak numbers of fish did not leave until after late April.

Large numbers of steelhead released in mid March and mid to late April were recaptured at the dam in April and early May indicating that fish were ready to migrate earlier than was indicated from the pond trapping data. Fish released in mid March did not migrate downstream as rapidly as fish released in late April or May but they did not wait until early May to begin their downstream migration (Fig. 19). Age I fish released in March (group 10, Fig. 19) began showing up at Lower Granite Dam in early April with peak numbers recaptured April 10 to 15. Migration past the dam of age II fish released in March (group 11, Fig. 19) occurred mainly from April 10 to May 20 with peak numbers in late April.

Large numbers of fish released after mid April migrated downstream immediately and peak numbers were usually recaptured from the various groups within 15 days. Most of the fish that migrated from groups released April 15-27 had passed the dam by May 20 in 1977 (Figs. 17 and 19). Fish released in May, that migrated downstream, took less time to reach the dam than fish released in either April or March (groups 14, 15 and 32, Fig. 19).

The percentages of the fish recaptured at the dam from groups released in March were similar to the recapture rates of those released

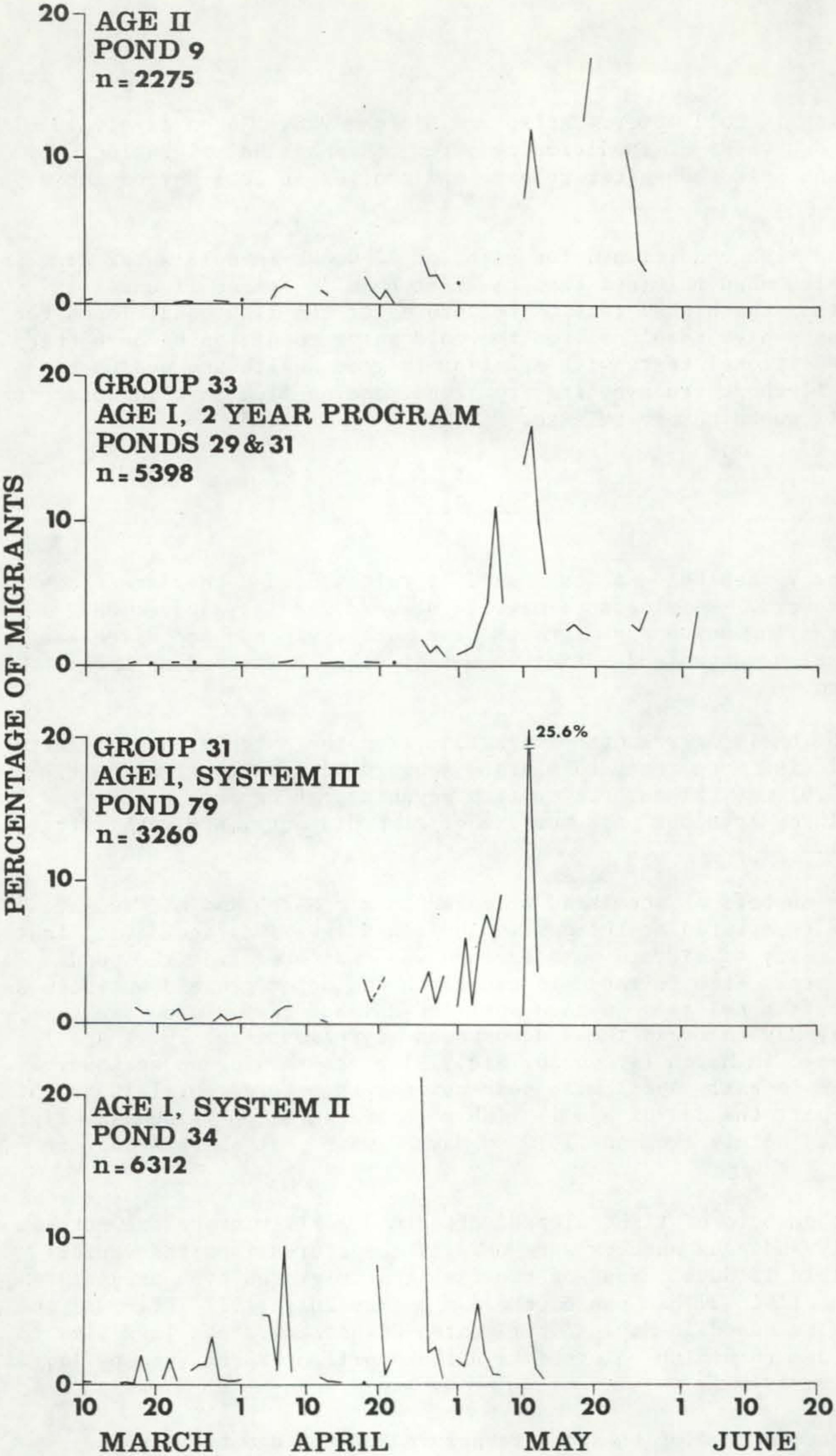


Figure 18. Percentage of the tested number of steelhead trout that migrated voluntarily from ponds at DNFH that migrated each day, 1977.

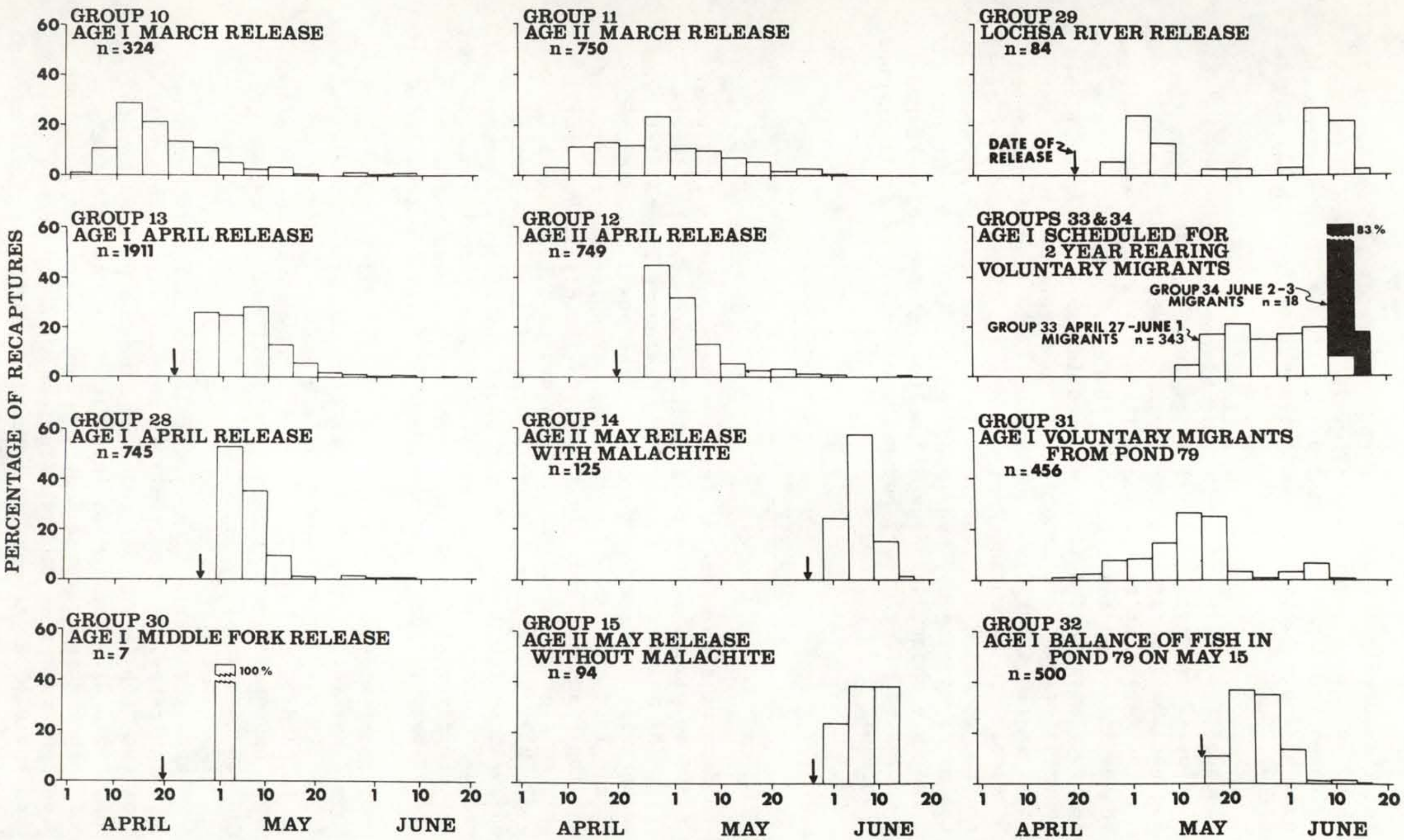


Figure 19. Timing of recapture at Lower Granite Dam of steelhead trout from various test groups released from DNFH, 1977.

in April, but they were a little lower than the rates for the special groups released in May or early June (Fig. 20). The length test fish that were released May 7 were not included in Figure 20 because of the high incidence of fungus infection among these fish, especially the age I fish (Table 4).

The groups of fish released in May had higher recapture rates than most groups released in March or April (Fig. 20 and Table 2) but the May releases also had the highest rates of fungus infection (Table 4). The age I fish in the length at release test (groups 1-4) that were released May 7 had fungus infection rates of 46-53 percent, about five times the average rate found among age I fish released in March and April (Table 4). The fungus infection rate among age II fish released in May was not as high as that in the age I fish, but higher (3-10 times) than among age II fish released in March and April (Table 4). The voluntary age I migrants from the ponds on a 2-year rearing program (groups 33 and 34) that migrated mainly during May had infection rates of 7.5 percent; higher than the rate observed in age II smolts that were also reared in single-pass untreated river water, but released in May or April (groups 11 and 12, Table 4).

## Voluntary Migration

Large numbers of fish migrated from hatchery ponds in 1977 even though the traps we placed on the pond outlets were operated intermittently (Fig. 18) and the design may have discouraged some fish from migrating voluntarily. Nearly 58 percent of the age I fish in pond 34 of system II had left the pond by May 13 when trapping was terminated and the remaining fish released. Of the approximately 12,900 age II fish available to migrate from pond nine in system 1 from March 10 through May 27, 2639 (20.4 percent) left voluntarily. Age I fish leaving pond 79 in system 3 were trapped until May 15 and 24 percent of the fish in the pond migrated voluntarily. Fish in ponds 29 and 31 that had completed the first of two years of rearing and were ready to migrate, were allowed to leave the ponds and 5398 (19.6 percent) did so.

Peak numbers of migrants from ponds 9, 29, 31 and 79 were caught in the traps in mid May (Fig. 18). Fish that migrated from pond 34 did so mainly during April with peak numbers in late April. Trapping was discontinued in pond 34 on May 13 so we don't know what the pattern of migration might have been later in May, but small numbers were migrating when the trap was removed.

Marked voluntary migrants from pond 79 (group 31) were recaptured at relatively high rates (14.0 percent) at Lower Granite Dam but so were the balance of the fish (group 32) released from the pond on May 15 (10.0 percent, Table 2). The fungus infection rate was relatively high among fish of both groups recaptured at the dam; 32 percent for group 31 fish and 48 percent for group 32 fish (Table 4). Other groups from system III had lower (0.6 percent for group 30) and higher (18.5 percent for group 28) recapture rates at the dam.

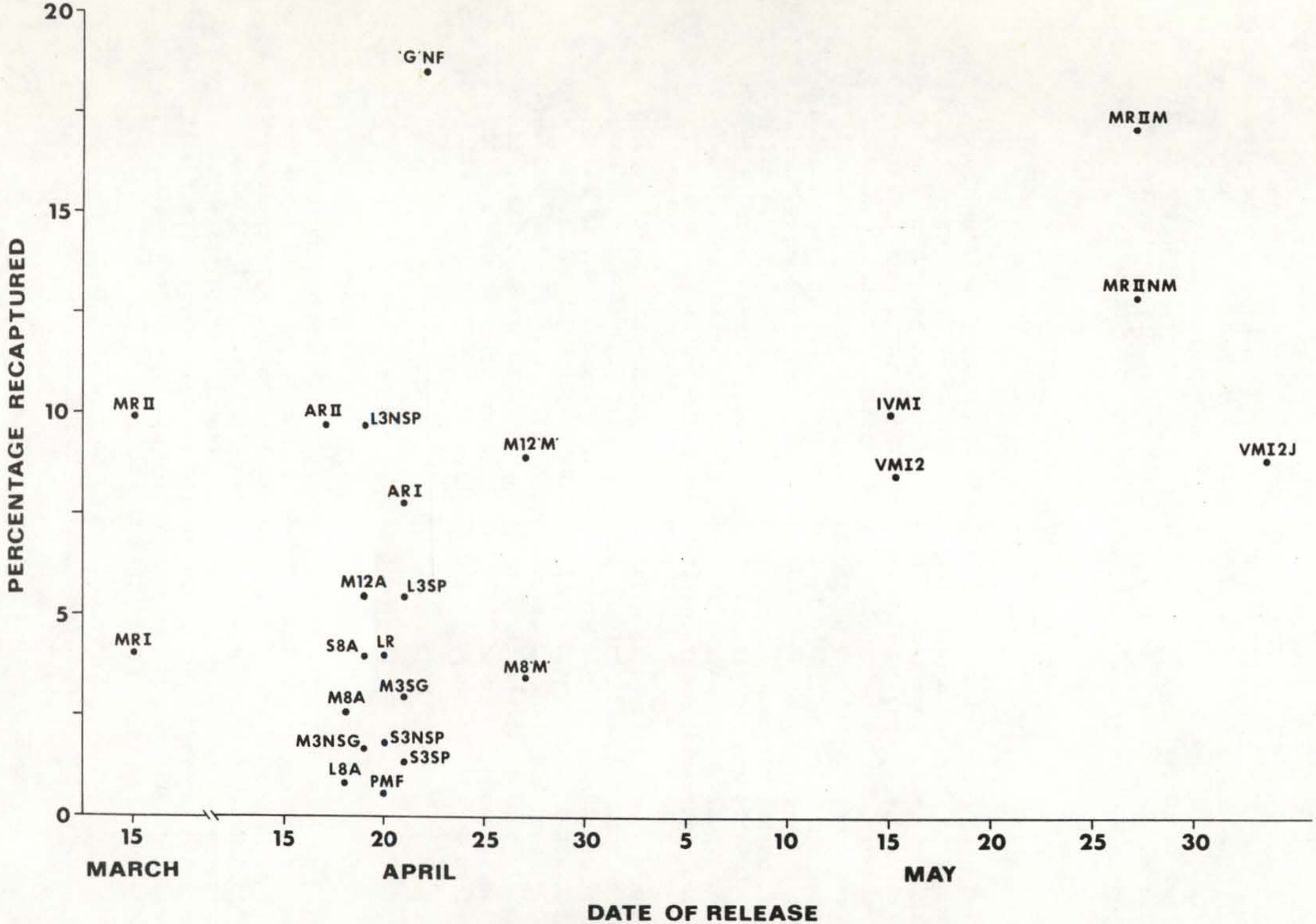


Figure 20. Percentage of test groups of steelhead trout released from DNFH on various dates that were recaptured at Lower Granite Dam, 1977.

The other voluntary migrants marked in 1977 were the first year fish from ponds 29 and 31. The recapture rates of those migrants (8.5 and 8.8 percent for groups 33 and 34) were nearly as good as those for the age II fish (9.9 and 9.7 percent for groups 11 and 12) that were also raised in system 1 (Table 2). The fungus infection rates of the age I fish in groups 33 and 34 were higher (7.5 percent) than the age II fish (2.3 and 2.6 percent, Table 4), but not enough higher that we questioned the validity of the timing of migration or recapture rates.

## Timing of Migration

Timing of the downstream migration of steelhead trout past Lower Granite Dam in 1977 was unusual (Fig. 21), probably because of the small discharge. A large proportion of the migrating fish passed the dam in late April and early May. Relatively few fish migrated past the dam during mid May, the normal period of peak migration. Later in May and early June increased numbers of migrants passed the dam. The bimodal pattern of migration in 1977 coincided with variations in river discharge (Fig. 21). Discharge was 50-60,000 cfs in late April and early May, when most of the migrants passed the dam. Discharge declined in mid May to 30-40,000 cfs and few fish passed the dam until flows increased in late May. Whenever discharges of 50-60,000 cfs occurred in late May and early June, increased numbers of fish were collected at the dam.

Most of the steelhead released from DNFH in March or April, that passed the dam, did so in late April and early May, soon after release (Figs. 17 and 19). The only groups with significant numbers of fish migrating after mid May were the fish released in the Lochsa River (group 29) that had a longer distance to migrate, the voluntary migrants (groups 31, 33 and 34) that were released mainly in mid May, the left-over fish released from pond 79 on May 15 (group 32), and the age II fish released May 27 (groups 14 and 15, Fig. 17).

## Salt Treatment Before Release

Fish given a salt treatment (10 ppt salt bath for one hour) before release did not migrate to Lower Granite Dam in larger numbers and the fungus infection rate was no lower than fish without a salt treatment (Table 5). We conducted these tests because National Marine Fishery Service personnel routinely transport migrants in 5 or 10 ppt salt concentrations to reduce stress and mortality. We theorized that salt treatment might reduce the fungus infection rate and increase the proportion of fish that migrate downstream.

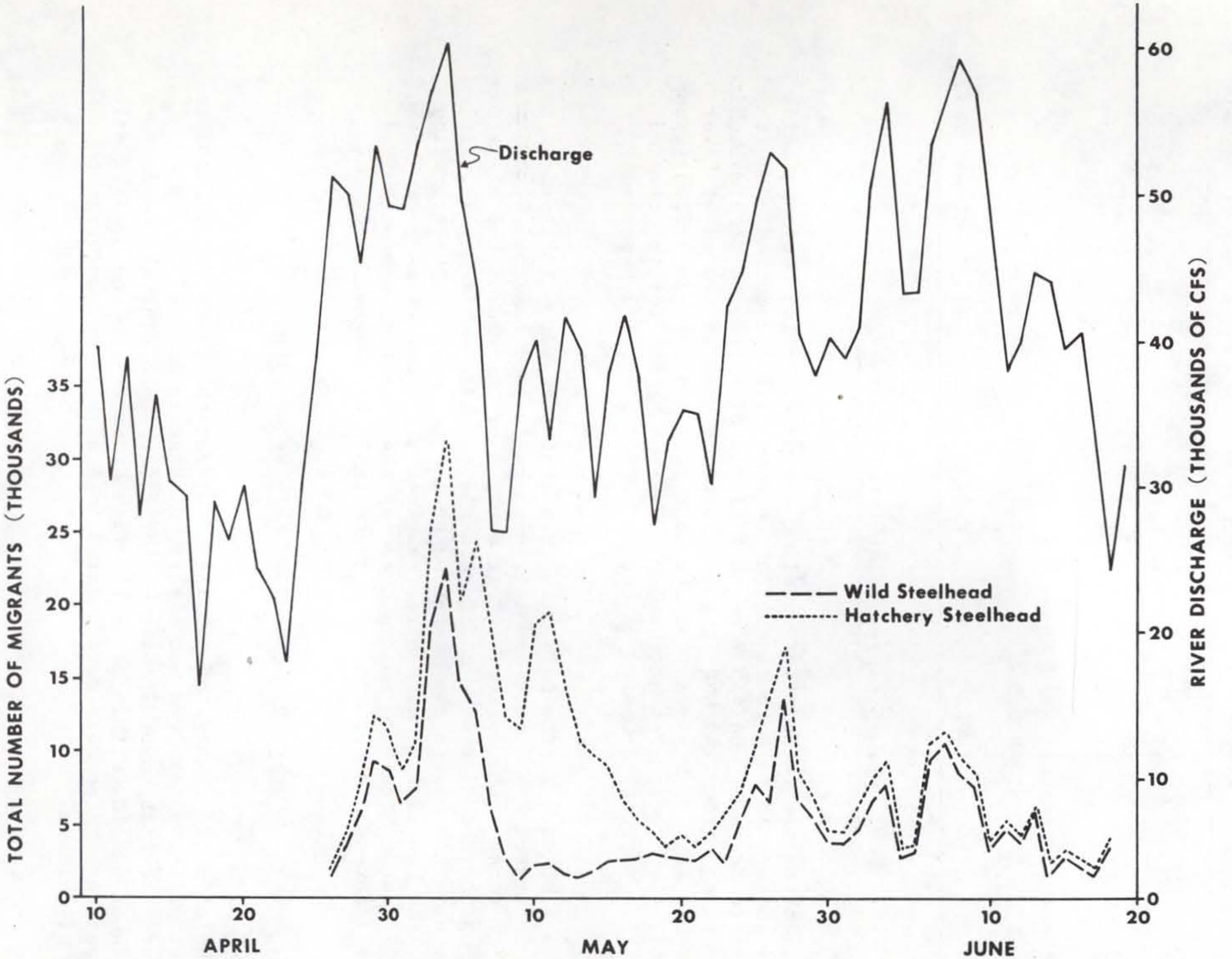


Figure 21. Snake River discharge and timing of seaward steelhead trout migration past Lower Granite Dam, 1977.

Table 5. Number of fish recaptured at Lower Granite Dam and fungus infection rates for groups of steelhead given a salt treatment (10 ppt for one hour) versus those not treated before release from DNFH, 1977.

| Treatment | Group number | Percentage recaptured | Fungus infection rate (%) |
|---|---|---|---|
| With salt treatment | | | |
| | 17 | 1.1 | 12.5 |
| | 18 | 2.9 | 3.6 |
| | 21 | 5.4 | 21.0 |
| Without salt treatment | | | |
| | 16 | 1.5 | 0.0 |
| | 19 | 1.7 | 6.3 |
| | 20 | 9.7 | 13.1 |

## Malachite Treatment After Marking

Malachite treatment after handling and marking fish had beneficial effects and should be a routine practice when fish are marked a short time before release. Only 5.7 percent of the fish treated with malachite after marking (group 14) had fungus infections when recovered at Lower Granite Dam versus 20 percent of the untreated control group fish (group 15, Table 4). Recaptures at the dam were also higher for the treated group (17.1 percent) compared to the untreated group (12.9 percent, Table 2).

The fish used in the malachite treatment test were age II fish reared in system I and were considered to be in good health. We did not decide to conduct the malachite test until near the end of the migration season and so the fish were not marked and released until May 27. If fish were marked before the migration period or early in the migration season, the benefits of malachite treatment might not be as great as in our 1977 test. Steelhead confined during the migration season seemed to be under increased stress and more susceptible to fungus infections.

## Gravity Versus Pump Release of Fish

The effects, if any, of pumping fish from the ponds versus draining fish out of the ponds were not clearly evident in our 1977 tests. Recapture rates at Lower Granite Dam of fish pumped from the ponds were both higher and lower than rates for fish drained from the ponds (Table 6). Recapture rates were more related to length at release than to method of release.

Table 6. Mean length at release, percentage of fish recaptured at Lower Granite Dam and fungus infection rates of fish pumped from ponds to the river versus those allowed to drain into the river via the sluiceway at DNFH, 1977.

| Treatment | Group number | Length of fish (mm) | Percentage recaptured | Fungus infection rate (%) |
|---|---|---|---|---|
| Pumped from ponds | | | | |
| | 16 | 188.0 | 1.5 | 0.0 |
| | 17 | 189.9 | 1.1 | 12.5 |
| | 20 | 204.1 | 9.7 | 13.1 |
| | 21 | 211.0 | 5.4 | 21.0 |
| Drained into sluiceway | | | | |
| | 18 | 194.2 | 2.9 | 3.6 |
| | 19 | 196.7 | 1.7 | 6.3 |

Fungus infection rates in three of the four groups pumped from the ponds were higher than those of fish drained from the ponds (Table 6) an indication that pumping may be an added stress on the smolts. Except for group 16, the pumped fish had fungus infection rates that were three times higher than the non-pumped fish. Additional tests seem warranted.

## Location of Release

The preliminary evaluation of releasing fish from DNFH in either the North Fork or the Middle Fork of the Clearwater rivers was impaired because a high percentage of the brands on fish released into the Middle Fork were not easily seen (Table 1). The reported numbers of branded fish released were adjusted downward because of the lack of brand retention but the adjustment may not have been sufficiently accurate. Evaluation of the location of release should be based primarily on returns of nose-tagged adults to the fisheries and to the hatchery.

If the numbers of branded smolts recaptured at Lower Granite Dam are taken at face value, few of the fish released in the Middle Fork (0.6 percent, group 30, Table 2) migrated to the dam compared to those released in the North Fork (7.8 percent, group 13). The fish released in the North Fork were smaller (175.1 mm long) than the fish released in the Middle Fork (183.8 mm long). Thus we might have expected fewer of the North Fork fish to be smolts. Too few branded fish released in the Middle Fork were recaptured at the dam (4 fish) to provide valid comparisons of fungus infection rates. The few fish from the Middle Fork group that were recaptured, were recaptured in early May, the same timing as fish released in the North Fork (Fig. 19).

The percentage of fish released in the Lochsa River that were recaptured at the dam (3.9 percent, group 29) was similar to recapture rates for many other groups released at the hatchery (Table 2). The fish released in the Lochsa River were similar in size to other groups of fish (Table 3). Unlike other groups, none of the 26 Lochsa River fish recaptured at the dam had fungus infections. Perhaps fish that developed fungus infections soon after release did not survive the extra 80 miles of migration to the dam. Timing of migration of the Lochsa River release group was bimodel, perhaps because of the additional distance they were required to migrate and the small discharges in mid May. Some fish were recaptured at the dam in early May but half were recaptured in early June. Many of the fish released in the Lochsa River failed to migrate seaward and were taken by sport fishermen in the summer of 1977. Lindland (personal correspondence 1978) estimated that 632 of the marked fish (2 percent of those released) were harvested from the Lochsa River during June and July by anglers. The primary evaluation of this release group will occur in 1979-80 when adults return to the hatchery and are caught in the fisheries.

## One Versus Two Years of Rearing

Steelhead released in 1977 from DNFH after two years of rearing had less mortality while at the hatchery, a smaller incidence of fungus infection when recaptured at Lower Granite Dam, and a higher percentage migrated seaward and were recaptured at the dam than fish reared for one year (Table 7). The two-year fish released in 1977 appeared to be in better health than most fish reared on a one-year program. Mortality of two-year fish during the last three to four months of rearing was only 3 to 5 percent versus 11 to 40 percent (groups 10 and 13, Table 7) for typical one-year fish. One-year fish transferred to ponds with 4.6 C water 12 weeks before release (groups 26 and 27) had mortality rates similar to the two-year fish but were smaller when released than other one-year fish kept in ponds supplied with warmer water (Table 7).

The high incidence of fungus infection among one-year fish and low incidence among two-year fish recaptured at Lower Granite Dam was also evidence that one-year fish were less healthy. The incidence of fungus infection of two-year fish (2 to 3 percent) was only slightly higher than that of wild fish examined in 1977 (less than 2 percent). One-year fish had infection rates that were generally higher (up to 15 times) than the two-year fish (Table 4 and 7).

A larger percentage of the two-year fish were recaptured at Lower Granite Dam than one-year fish (Table 7), but the recapture rates for the groups of one-year fish were variable. The percentage of one-year fish recaptured at the dam in 1977 ranged from less than one percent to nearly 10 percent for the regular test groups and 35 percent for the special length test groups. The groups of one-year fish that were similar to two-year fish in terms of date, method and location of release are presented in Table 7. The percentage of one-year fish recaptured from groups 13, 20 and 27 was nearly as high as for the two-year fish but the other eleven groups had significantly fewer fish recaptured at the dam.

Table 7. Comparison of steelhead reared for one versus two years at DFNH and released in 1977. Two year fish were reared in cold water (4-6 C) during winter months and one year fish in heated water. Fish conditioned in cold water for 8 or 12 weeks were transferred to ponds supplied with untreated river water (4-6 C) 8 to 12 weeks before the scheduled release date.

| Group numbers and descriptions | Length at release (mm) | Mortality at hatchery (%) | Fungus at dam (%) | Recaptured at dam (%) |
|---|---|---|---|---|
| One year smolts | | | | |
| 10 - March release | 182 | 11 | 10 | 4.0 |
| 13 - April release | 175 | 40 | 7 | 7.8 |
| 16 - April - small size | 188 | 9 | 0 | 1.5 |
| 17 - April - small size | 190 | 12 | 13 | 1.1 |
| 18 - April - medium size | 194 | 15 | 4 | 2.9 |
| 19 - April - medium size | 197 | 15 | 6 | 1.7 |
| 20 - April - large size | 204 | 28 | 13 | 9.7 |
| 21 - April - large size | 211 | 21 | 21 | 5.4 |
| 22 - 8 weeks conditioning | 176 | 8 | 6 | 3.9 |
| 23 - 8 weeks conditioning | 180 | 11 | 14 | 2.6 |
| 24 - 8 weeks conditioning | 184 | 6 | 13 | 3.4 |
| 25 - 8 weeks conditioning | 200 | 18 | 14 | 0.8 |
| 26 - 12 weeks conditioning | 167 | 2 | 4 | 5.4 |
| 27 - 12 weeks conditioning | 169 | 4 | 8 | 8.9 |
| Two year smolts | | | | |
| 11 - March release | 188 | 5 | 2 | 9.9 |
| 12 - April release | 199 | 3 | 3 | 9.7 |

The length-frequency distribution of the two year fish was bimodal with most fish in the 170-240 mm length range and a small number in the 130-160 range (groups 11 and 12, Fig. 22). The smaller fish did not have the appearance of smolts when released and none of the smaller fish in the age II length test were recaptured at Lower Granite Dam (Table 2).

Precocious maturity, particularly among males, can be a problem in two year rearing programs but the percentage of mature fish in the 1977 release was relatively low. Of 204 fish examined when the fish were released in 1977, only 7 (3.4 percent) were mature. The low rate of precocious maturity in 1977 may be related to the rate of growth and size of the fish when released. In 1977, the two-year fish averaged 200 mm (including the runts) in mid April (group 12 fish, Fig. 22, were larger than average). If fish less than 160 mm had been excluded from the sample, the average size would have been 211 mm. In 1976, the two-year fish averaged 220 mm and one third were precociously mature males. The two-year fish in 1976 may not have been representative of larger two-year fish because most of the fish escaped from the adult pond they were being held in, and the leftovers that we examined may have contained an abnormally high proportion of non smolts.

## Seawater Survival

The smoltification process, change from parr to smolt, is not complete when steelhead begin migrating seaward from tributaries of the Snake River. None of the groups of steelhead taken to the seawater pens at Manchester on May 2 had 100 percent survival. Fish collected at Lower Granite Dam had the lowest first day and longer term mortality (Table 8), but one third of the fish died during the first 18 days in the pens. Most of the fish that died did so in the first few days after being placed in the pen, and the dying fish had typical dehydration symptoms indicating they were having osmoregulation troubles.

Migrants from DNFH collected at Lower Granite Dam the first of May had seawater survival rates almost as high as the wild fish. Eleven percent of the fish died the first day in seawater and 43 percent after 18 days (Table 8). Steelhead taken directly from DNFH to Manchester on May 2 had higher mortality rates than Dworshak Hatchery fish collected at Lower Granite Dam. Ninety-six percent of the age I fish and 70 percent of the age II fish taken from the hatchery failed to survive 18 days in seawater (Table 8). Fish taken from the hatchery included fish that may never have become smolts in 1977, and downstream migration might stimulate the smoltification process.

Many fish migrating seaward down the Snake River later in mid May were not fully ready to survive in seawater. Six of 104 wild steelhead collected at Lower Granite Dam died the first day in seawater. Some of those fish were noticeably descaled which probably contributed to their inability to survive in seawater (Table 8). Of 95 migrating hatchery fish collected at the dam, 11 died the first day in seawater. First day

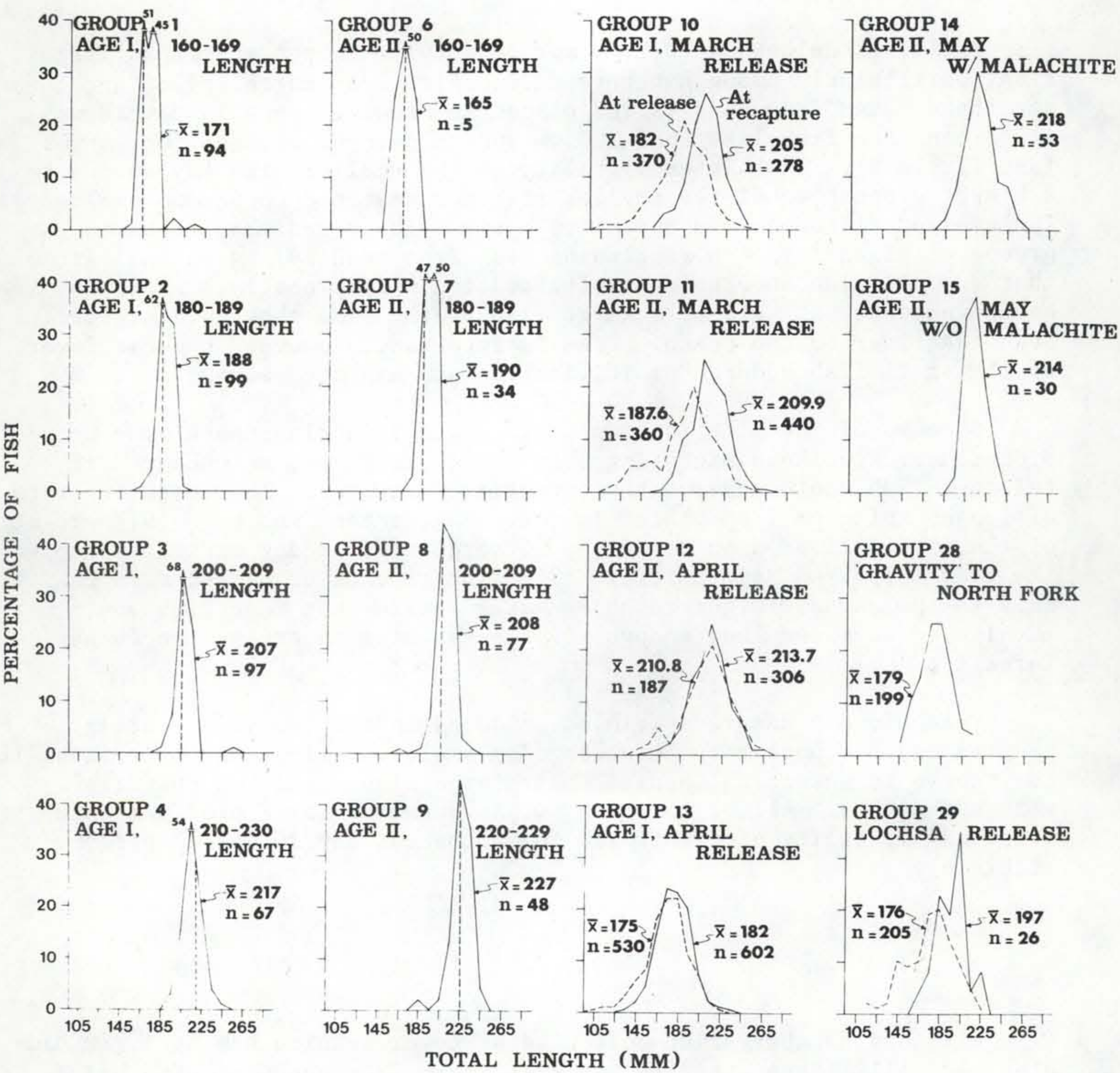


Figure 22. Length-frequency distribution of test groups of steelhead trout when released from DNFH and when recaptured at Lower Granite Dam, 1977.

mortality was 21 percent for the age I fish and 8 percent for the age II fish that had not voluntarily left hatchery ponds by mid May (Table 8).

Steelhead voluntarily migrating out of pond 29 in mid May were apparently ready to live in seawater despite their small size. Only one of 50 migrants taken to Manchester died the first day in seawater (Table 8). Fish in pond 29 were scheduled for two years of rearing but those fish that wanted to migrate seaward after the first year were allowed to leave the pond. None of the fish were larger than 190 mm and the average size was 153 mm.

Smaller steelhead were less apt to survive in seawater than large fish, particularly among hatchery fish. First day mortality of age I steelhead taken from pond 79 and placed in seawater pens on May 18 was 41 percent for fish less than 180 mm and 16 percent or less for larger fish (Table 8). The higher mortality of the smaller fish may be due to a higher proportion of the smaller fish not destined to become smolts. The smaller difference in mortality between large and small fish in the groups of migrating fish (including fish from pond 29) is an indication that a small fish undergoing smoltification will probably be able to handle seawater as well as a large fish by the time they have migrated down the river to the ocean. Size is important, however, because fewer of the small fish undergo smoltification and migrate seaward.

Because of the high incidence of fungus infection among some groups of hatchery steelhead migrating down the Snake River, we wondered if infected fish would survive the entry into seawater. The mortality rate of fungus infected fish placed in the seawater pens was high (91 percent of the fish delivered on May 2 and 26 percent first day mortality among the fish delivered May 18, Table 8). Fish trucked or barged from the dams to the estuary might reach seawater earlier but most fish would not survive in seawater long enough for the seawater to arrest the fungus infection.

Precociously mature steelhead produced in the two year rearing program did not appear to be undergoing smoltification and their inability to survive in seawater (despite their large size) confirms that they were not smolts. All of the fish put in seawater May 2 died and the first day mortality of fish taken to Manchester May 18 was 27 percent (Table 8).

## ATPase Activity

Wild and hatchery fish collected at Lower Granite Dam April 20 had elevated gill ATPase activity but fish taken from ponds at DNFH had activity levels that were only slightly elevated (Fig. 23). The activity level of fish at the hatchery or for those held at the lab for later sampling had increased by early May and ranged from 7 to 14 μ moles of ATP per hour, the same as was found in fish migrating past Lower Granite Dam. Fish migrating past the dam in the latter part of the migration

Table 8. Mortality of steelhead trout from DNFH and Lower Granite Dam in seawater net pens at Manchester during May 1977.

| Date delivered to net pens | Number released in pen | First day mortality (%) | Mortality after 18 days (%) |
|---|---|---|---|
| May 2, 1977 | | | |
| From DNFH | | | |
| Age I | 169 | 20 | 96 |
| Age II | 152 | 9 | 70 |
| Precocious | 10 | 50 | 100 |
| From Lower Granite Dam | | | |
| Wild fish | 116 | 3 | 33 |
| Branded from DNFH | 151 | 11 | 43 |
| Hatchery fish with fungus | 44 | 68 | 91 |
| May 18, 1977 | | | |
| From DNFH | | | |
| Age I - Pond 79 | | | |
| 160-179 mm | 51 | 41 | |
| 180-199 mm | 50 | 16 | |
| 200-219 mm | 25 | 12 | |
| 220+ | 25 | 0 | |
| Age II - Pond 9 | | | |
| 130-179 | 50 | 12 | |
| 180-209 | 50 | 10 | |
| 210-220 | 25 | 4 | |
| 220+ | 25 | 0 | |
| Precocious males | 11 | 27 | |
| Age I - Pond 29 (from 2 year program) | | | |
| less than 160 mm | 25 | 4 | |
| more than 160 mm | 25 | 0 | |
| From Lower Granite Dam | | | |
| Various hatchery branded fish | | | |
| 160-179 mm | 46 | 15 | |
| 180-199 | 26 | 8 | |
| 200+ | 23 | 9 | |
| Pahsimeroi - Niagara | 5 | 60 | |
| Wild | | | |
| 160-180 mm | 16 | 13 | |
| 180-200 mm | 39 | 10 | |
| 200+ | 49 | 0 | |
| Fungused fish | 23 | 26 | |

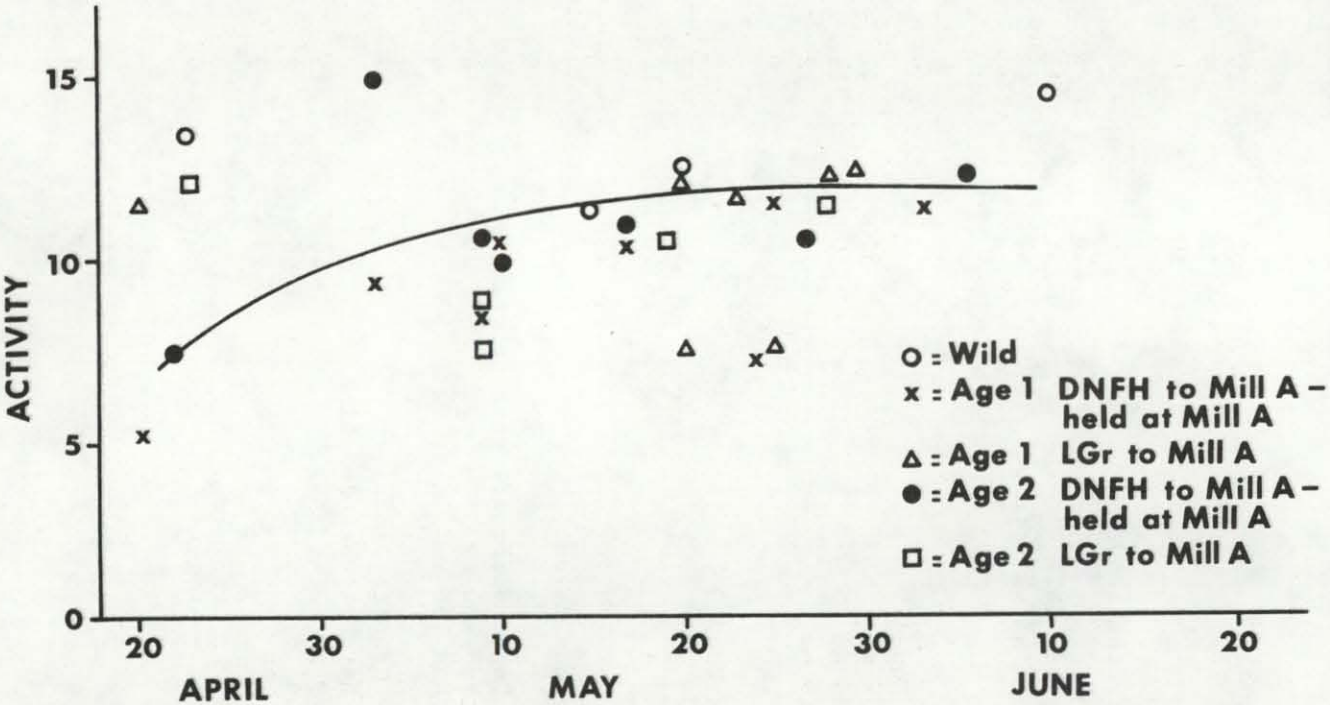


Figure 23. ATPase activity of steelhead trout taken from DNFH or Lower Granite Dam to the Mill A Lab or Dr. W. S. Zaugg in 1977. Age 1 and age 2 fish were DNFH steelhead taken directly to the lab or those allowed to migrate to the dam and then delivered to the lab.

season did not have any higher ATPase activity than fish migrating in the early part of the migration.

## DISCUSSION

Evaluation in 1977 of certain groups of fish, rearing practices and release procedures at DNFH was impaired by the less than optimum health of fish reared in systems II and III, marginal brand retention of fish marked 3-4 months before release, questionable numbers released in many groups and perhaps by the small discharge in the Snake River during May. Symptoms of deteriorating fish health were evident at the hatchery in February and water temperatures were reduced (from 13-14 C to 10-12 C in system II on February 4, and on February 22 in system III) in an attempt to maintain the fish in good health. Fish health continued to deteriorate, however, and fish began dying in large numbers in March (system III) and April (system II, Fig. 2). System III was switched from reuse water to untreated river water (single pass, 4-5 C) on March 18 and the daily mortality rate subsequently declined, but the fish were not in top health when released. System II was switched to untreated river water on April 5 but the daily mortality rate was still high when the fish were released. The substandard health of the fish from those systems was reflected in the high fungus rates among those fish when recaptured at the dam.

Tests that were particularly impaired by poor fish health were those to determine if cold water conditioning is necessary, the optimum length for hatchery smolts at release, and the quality of smolts produced in one year of rearing in a reuse water system versus fish reared two years in a single pass system with untreated river water.

Many fish branded in December 1976 and January 1977 did not have easily readable brands when released in April. Because of the lack of brand retention, we sampled the fish in each group at time of release to determine the proportion with readable brands and adjusted the number released accordingly. The actual number of branded fish released in each group may have been in error because of the brand retention problem and because the total number released in many groups was not precisely known. Fish numbers in many of the groups were not inventoried between marking and release because of the marginal health of the fish. We originally thought that subtracting the dead fish removed from the ponds, from the number marked, would give us an accurate estimate of the number released. Smaller than expected numbers of fish found in a few ponds that were inventoried at time of release subsequently led us to believe that the number of fish marked minus the dead fish removed from the ponds was probably not an accurate estimate of the number released. We adjusted the number of fish released for groups that were not inventoried by an adjustment factor obtained from the groups that were inventoried. By using the same average adjustment factor for all groups we may have under or over estimated the number released in individual groups.

Because of the unusually small discharge down the Snake River in May of 1977 (Fig. 21), many wild and hatchery steelhead and salmon smolts did not migrate successfully through Lower Granite Reservoir to the dam. Only an estimated 5-15 percent of the major groups of steelhead released from DNFH in 1977 were recaptured at the dam and transported downstream. If downstream migration conditions had been more favorable, the outcome of some tests may have been altered, particularly for groups with marginal health or degree of smoltification.

Despite the problems that developed in the 1977 tests, helpful information was obtained on a number of questions. The best time to release steelhead from DNFH appears to be mid to late April. Both age I and age II fish released in mid March did not begin migrating downstream until April with peak numbers of those fish recaptured at Lower Granite Dam in late April and early May. Fish began migrating out of the ponds voluntarily in April and fish released after mid April were collected at the dam 4 to 5 days after release; an indication of immediate migration. Not all fish were ready to migrate in April, however. Peak numbers of fish migrated from some ponds in early and mid May (Fig. 18), the same timing as the peak of migration past the Snake River dams. Although some fish released in April may not be ready to migrate, we believe it is better to release all the fish when the first 10-20 percent are ready to migrate because confining fish that are ready to migrate seems to be stressful and usually results in fungus infections and increased mortality. A properly designed discharge system that would allow fish to voluntarily leave the hatchery ponds when ready would probably yield the largest number of seaward migrants.

In 1977, we found that some of the fish in the two year rearing program were ready to migrate seaward after their first year of rearing despite their small size (136 mm, groups 33 and 34, Fig. 24). Fish that migrated voluntarily from the ponds migrated downstream without delay and were recaptured at the dam at rates similar to those of age II fish released from the hatchery. The proportion of two-year fish that would migrate seaward after their first year is probably related to size; a larger proportion with larger fish. If these first year smolts survive as well as larger or older smolts, then all fish that want to migrate should be released and only those that are not smolts held over for a second year. The fate of first year smolts that are held for a second year in the hatchery is being studied.

Although the 1977 coldwater conditioning tests were impaired by the fish health problems, there was some evidence that holding fish in cold water (4-5 C) for 10-12 weeks before release may produce better smolts than when continued in warmer water (10 C or warmer) until release. The fish transferred to cold water ponds 12 weeks before release were recaptured at the dam at higher rates than most other groups of age I fish despite their small size (167-169 mm) from the long stay in cold water. Conditioning fish in cold water for eight weeks did not result in high recapture rates indicating that whatever benefits are possible from cold water conditioning were not obtained in eight weeks. The higher rate of recapture of fish transferred to cold water ponds in late

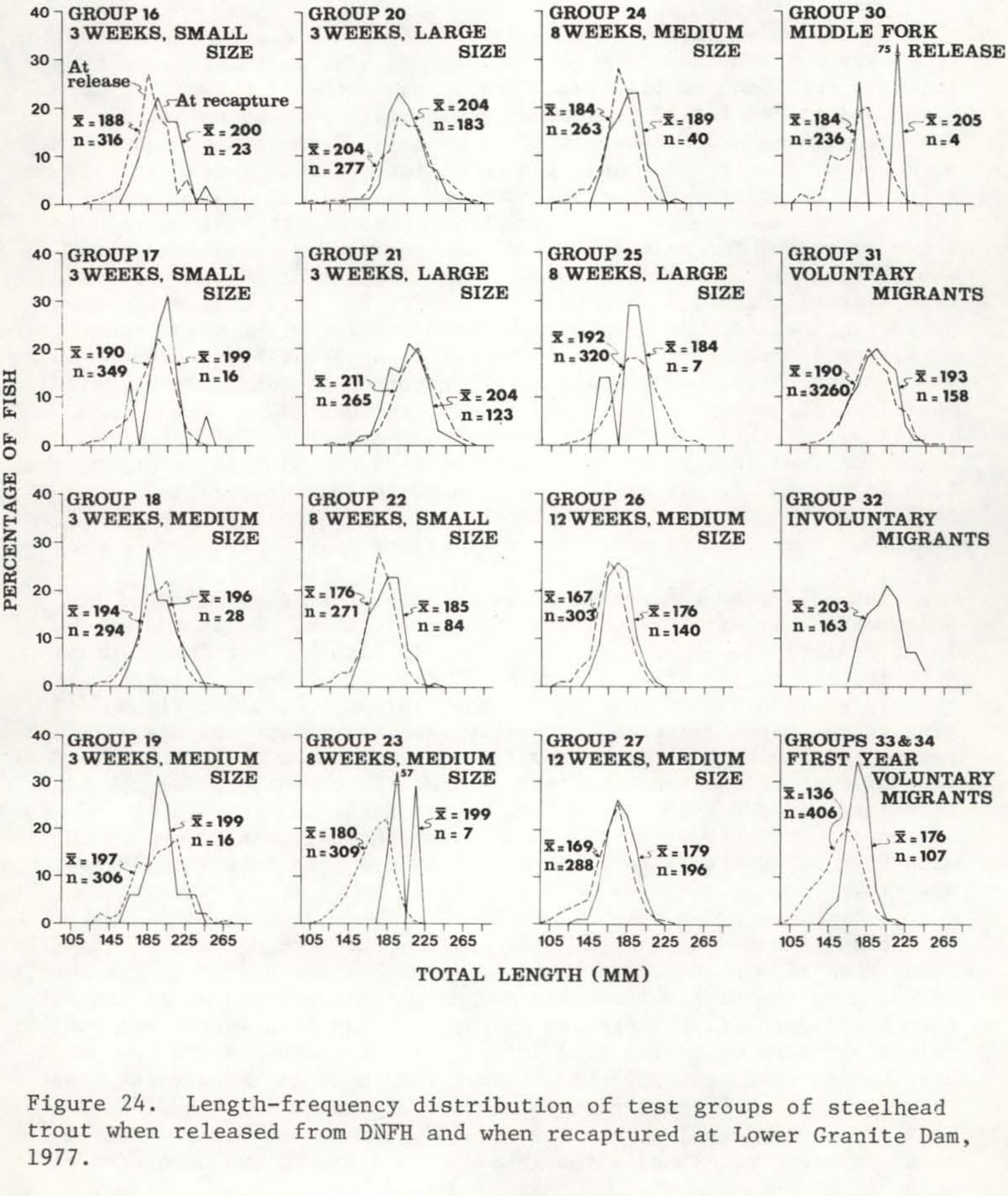


Figure 24. Length-frequency distribution of test groups of steelhead trout when released from DNFH and when recaptured at Lower Granite Dam, 1977.

January and early February may have resulted from those fish being transferred from system II and not being exposed to whatever factors caused the deterioration of fish health in that system. The relatively high recapture rates of large fish (200 mm) without cold water conditioning, the lack of benefits from conditioning for eight weeks, and practice of switching to cold water to reduce the recurring high mortalities in the reuse systems in March and April make it imperative that the effect, if any, of cold water conditioning on smoltification be established.

Conditioning fish in cold water results in a significant reduction in growth and the trade-off between size of fish at release and time required for adequate cold water conditioning is not known. In 1977, fish conditioned for 12 weeks grew at the rate of 0.29 mm per day between marking and release (3 1/2-4 months), fish conditioned for eight weeks at 0.45 mm per day and fish conditioned for two weeks at 0.53 mm per day. The difference in size between conditioned and unconditioned fish in a 12 week period would be 20 mm or more with healthy fish in reuse systems. The reduced size of the cold water conditioned fish would result in a one-third to a one-half reduction in the proportion of fish migrating seaward (Bjornn et al. 1978, Fig. 11) unless there were offsetting benefits from cold water conditioning. The water temperature in system II from early February to early April was less than the 13 C which Zaugg, Adams and McClain (1972) reported as inhibiting ATPase activity. Because the water was relatively cool (10-12 C), ATPase activity and other physiological processes associated with the transformation from parr to smolt may not have been inhibited in any of the fish in system II. If such was the case, the higher recapture rate of the 12 week conditioned fish could be attributed solely to better fish health of the fish transferred out of system II.

The 1977 test to determine best length at release followed the pattern seen in earlier tests (Bjornn et al. 1978, Chrisp and Bjornn 1978, Reingold 1978) in the case of age II fish but was inconclusive with the age I fish (Fig. 11). Age II fish 200-209 mm in length were recaptured at a higher rate than either larger or smaller fish. All size groups were recaptured at nearly equal rates for the age I fish but because of the high fungus rates (50 percent) among those fish, we doubt the validity of the test with age I fish. We cannot explain the high recapture rates for the age I length test fish; the recapture rates were higher than for any other groups and seem inconsistent if we expect fish with high fungus rates to be less healthy and less likely to migrate seaward.

Fish released in May migrated rapidly and were recaptured at higher rates than fish released in April or March but the higher fungus infection rates among the fish released in May may negate any potential benefit from holding the fish in the hatchery until May. The increased fungus infection rates of smolts held in the hatchery into May and the rapid development of fungus infections among fish held in raceways at Lower Granite Dam for extended periods of time (Bjornn et al. 1978) is an indication that confinement is a stressful situation for a steelhead ready to migrate. Thus, although additional growth may be needed in some years, holding fish past late April may be counterproductive if the fish are stressed and develop fungus infections. Additional testing would be beneficial to better determine the optimum date of release, especially if large numbers of fish are going to be transported to the lower Columbia River.

The age II fish released from Dworshak Hatchery in 1977 appeared to be healthy smolts and were recaptured at Lower Granite Dam at a higher rate than most groups of age I fish released from the hatchery. The comparisons between age I and age II fish released from the hatchery in 1977, however, are not valid comparisons unless no better one year fish can be reared in the reuse systems at DNFH. The two year rearing program at Dworshak produced good quality smolts in 1977 and could presumably do so every year. If good quality fish could be produced in a one year program at Dworshak, we believe they would be just as good a smolt as the two year fish. Two year hatchery rearing programs for steelhead are not without drawbacks. In 1977, we found a significant number of runts (fish less than 160 mm) that did not become smolts. Two year rearing programs must also be well planned to prevent large numbers of fish from becoming precociously mature.

In general, the amount of flow down the Snake River during April and May 1977 was not sufficient to carry most of the salmon and steelhead downstream through Lower Granite Reservoir. When flows increased to daily averages of 60,000 cfs, increased numbers of fish were recaptured at the dam (Fig. 21) but we could not determine if continuous flows of 60,000 cfs for all of May would have drawn most of the fish through the reservoir.

Marking of fish has been a problem at DNFH over the years. Increased mortality has usually resulted when fish in the reuse systems have been handled because of the substandard health; especially at the end of the growing period. In 1977, the marking was done in December and January to avoid stressing the fish. The coded wire tagging was successful but branding the fish 4-5 months before seaward migration was only marginally successful.

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